Woodside Energy

PROPOSED BROWSE TO NORTH WEST SHELF PROJECT

Supplement Report to the Draft Environment Impact Statement (EPBC 2018/8319)

Under the Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)

JULY 2022

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LIST OF ACRONYMS

Acronym	Meaning
°C	Degrees Celsius
2TL	Second trunkline
ACCU	Australian Carbon Credit Unit
ACEC	Albany Community Environment Centre
AFZ	Australian Fishing Zone
AHO	Australian Hydrogeographic Office
AIMS	Australian Institute of Marine Science
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
AMCS	Australian Marine Conservation Society
AMP	Australian Marine Parks
AMSA	Australian Maritime Safety Association
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
APPEA	Australian Petroleum Production and Exploration Association
AUV	Autonomous Underwater Vehicle
B	Billion
BIA	Biologically Important Area
BJV	Browse Joint Venture
BP	BP Developments Australia Pty Ltd
BTL	Browse Trunkline
CAGR	compound annual growth rate
CCS	Carbon Capture and Storage
CCUS	Carbon Capture Use and Storage
CCWA	Conservation Council of Western Australia
CDP	Carbon Disclosure Project
CER	Clean Energy Regulator
c/kWh	Cents per kilowatt hour
cm	Centimetres
CMP	Conservation Management Plan
CO_2	Carbon Dioxide
CO_2-e	Carbon Dioxide Equivalent
COP	Conference of the Parties
cP	centipoise
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAS	Distributed Acoustic Sensing
DAWE	Department of Agriculture, Water and the Environment

Acronym	Meaning
DMIRS	Department of Mining, Industry Regulation and Safety
DNP	Director of National Parks
DoEE	Department of the Environment and Energy
DP	Dynamic Positioning
DPAW	Department of Parks and Wildlife
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EISG/ESD	Environmental Impacts Statement Guidelines/ Environmental Scoping Document
EMBA	Environment that May be Affected
EP	Environment Plan
EP Act	Environmental Protection Act 1986
EPA	Environmental Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EQMP	Environmental Quality Management Plan
EQP	Environmental Quality Plan
ERD	Environmental Review Document
ERM	Environmental Resources Management
ESD	Environmentally Sustainable Development
FARA	Friends of Australian Rock Art
FCTV	Fast Crew Transfer Vessels
FEED	Front End Engineering and Design
FID	Final Investment Decision
FLNG	Floating Liquified Natural Gas
FPSO	Floating Production Storage and Offloading
FY	Fiscal Year
GCF	Green Climate Fund
GDP	Gross Domestic Profit
GHG	Greenhouse Gas
GHGe	Greenhouse Gas emissions
GHGMP	Greenhouse Gas Management Plan
GTG	Gas turbine generator
GWA	Goodwin Alpha
GWP	Global Warming Potential
Hg	Mercury
HUC	Hook up and commissioning
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IEA	International Energy Agency
IFL	InterField Line
IMMR	Inspection, maintenance, monitoring and repair
IMS	Invasive Marine Species
IPCC	Intergovernmental Panel on Climate Change
IPIECA	International Petroleum Industry Environmental Conservation Association
IRPCS	International Rules for Preventing Collisions at Sea

Acronym	Meaning
ITOPF	International Tanker Owners Pollution Federation
IUCN	International Union for the Conservation of Nature
JRCC	Joint Rescue Coordination Centre
JV	Joint Venture
KEF	Key Ecological Feature
Kg/l	Kilograms per litre
KGP	Karratha Gas Plant
KLC	Kimberley Land Council
Km	Kilometre
KRCI	Kullari Regional Communities Incorporated
LAU	Local Assessment Unit
LCA	Life Cycle Assessment
LEP	Level of Ecological Protection
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
Ltd	Limited
m	Meter
m^3/hr	Cubic metres per hour
MARPOL	The International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978
MDO	Marine Diesel Oil
MEG	Monoethylene Glycol
MeHg	Methyl-mercury
mg/L	Milligrams per litre
MIMI	Japan Australia LNG (MIMI Browse) Pty Ltd
MMscfd	Million standard cubic feet per day
MMSI	Maritime Mobile Service Identity
MNES	Matters of National Environmental Significance
MODU	Mobile offshore drilling unit
MoU	Memorandum of Understanding
MP	Management Plan
MPPE	Macro Porous Polymer Extraction
MRU	Mercury Recovery Unit
MSI	Maritime Safety Information
MSL	Mean sea level
Mt	Million tonnes
Mt CO_2-e	Metric tonnes of carbon dioxide equivalent
MToe	Million tonnes of energy
MTPA	Million tonnes per annum
MW	Megawatt
MWh	Megawatt hour
NCMIP	National Carbon Mapping and Infrastructure Plan
NDC	Nationally Determined Contributions
NGER	National Greenhouse and Energy Reporting

Acronym	Meaning
NGERS	National Greenhouse and Energy Reporting System
NGO	Non-governmental Organisation
nm	Nautical miles
NOAA	National Oceanic and Atmospheric Administration
NOEC	No observable effects concentration
NOx	Oxides of nitrogen
NOPSEMA	National Offshore Petroleum Safety and Environment Management Authority
NPAT	Net profit after tax
NRC	North Rankin Complex
NTM	Notice to Mariners
NWBF	Non-water Based Fluids
NWMR	North-west Marine Region
NWS	North West Shelf
NWSJV	North West Shelf Joint Venture
OOC	Oil-on-cuttings
OPGGS Act	Offshore Petroleum and Greenhouse Gas Storage Act 2006
OPGGS (E) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
OSV	Offshore support vessel
PetroChina	PetroChina International Investment (Australia) Pty Ltd
POB	Persons onboard
PSV	Platform supply vessel
PTS	Permanent Threshold Shift
PW	Produced water
Ramsar	Ramsar Convention on Wetlands of International Importance
SCE	Solids control equipment
SDS	Sustainable Development Scenarios
SGM	Safeguard Mechanism
Shell	Shell Australia Pty Ltd
SURF	Subsea umbilicals, risers and flowlines
SOLAS	Safety of life at sea
SPL	Sound pressure level
t	tonne
tcf	Trillion cubic feet
TCFD	Task Force for Climate Related Financial Disclosure
TSS	Total suspended solids
TTS	Temporary Threshold Shift
TWh	TeraWatt hours
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
USD	United States Dollars
UWA	University of Western Australia

Acronym	Meaning
VSP	Vertical seismic profiling
VHF	Very High Frequency
VSP	Vertical Seismic Profiling
WA	Western Australia
WAFIC	Western Australian Fishing Industry Council
WBDF	Water based drilling fluid
WEL	Woodside Energy Limited
WEO	World Energy Outlook
Woodside	Woodside Energy Limited

1. INTRODUCTION

1.1 Proposed Browse Project overview

The Browse hydrocarbon resource is located in the Brecknock, Calliance, and Torosa reservoirs, approximately 425 km north of Broome and approximately 290 km off the Kimberley coastline of Western Australia (WA). These three fields will be collectively referred to as the Browse hydrocarbon resources. Hydrocarbon resources contained in these fields are predominately gas, with contingent resources (2C, 100%) of 13.9 trillion cubic feet (tcf) of dry gas, and approximately 390 million barrels of condensate (Woodside resource estimate).

Woodside Energy Ltd (Woodside) is Operator for and on behalf of the Browse Joint Venture (BJV). The participants in the BJV are:

- Woodside Browse Pty Ltd
- Shell Australia Pty Ltd (Shell)
- BP Developments Australia Pty Ltd (BP)
- Japan Australia LNG (MIMI Browse) Pty Ltd (MIMI)
- PetroChina International Investment (Australia) Pty Ltd (PetroChina).

The BJV proposes to develop the Browse hydrocarbon resources using two 1100 million standard cubic feet per day (MMscfd) (annual daily export average) Floating Production Storage and Offloading (FPSO) facilities. The FPSO facilities will be supplied by a subsea production system and will transport gas to existing North West Shelf (NWS) Project infrastructure via a pipeline which will tie in near the existing North Rankin Complex (NRC) in Commonwealth waters (Note: The NRC is owned by the NWS Joint Venture (NWSJV)[1]).

At the time of preparation of this document, the Australian and global environment has been impacted by COVID-19 which has resulted in a delay to the targeted final investment decision (FID) for the proposed Browse to NWS Project (hereafter, referred to as the proposed Browse Project). Subject to market conditions, all necessary regulatory approvals, joint venture approvals and commercial agreements, execution of the proposed Browse Project would be targeted to commence mid-2020s with operations expected for up to 44 years.

As described in Chapter 2 of the draft EIS/ERD, the overall Project Area (encompassing both State and Commonwealth components) comprises:

- the proposed Browse Development Area (in which the Brecknock, Calliance, and Torosa fields, the FPSO facilities and the subsea production systems, including wells, will be located) (**Figure 1-1**)
- the pipeline corridor within which the proposed Browse Trunkline (BTL) and inter-field spur line will be located (**Figure 1-2**).

The proposed Browse Project will comprise subsea infrastructure and two floating production storage offtake (FPSO) facilities, connected to existing NWS Project infrastructure via the ~900 km BTL.

The key characteristics of the proposed Browse Project are described below:

- hydrocarbon extraction will require up to 50[2] wells with associated subsea infrastructure, including manifolds and flowlines
- extracted hydrocarbons will be transferred via subsea infrastructure, including wellheads, manifolds and flowlines, up to the FPSO facilities, which are located in Commonwealth waters
- condensate stabilisation and storage will occur on the FPSO facilities prior to offtake to condensate tankers for delivery to market

1 *The NWSJV comprises six companies; Woodside Energy Ltd. (Operator), BHP Billiton Petroleum (North West Shelf) Pty Ltd, BP Developments Australia Ltd, Chevron Australia Pty Ltd, Japan Australia LNG (MIMI) Pty Ltd, and Shell Australia Pty Ltd. The NWS Joint Venture owns the infrastructure used as part of the North West Shelf Project.*

2 *Proposed maximum well count reduced from 54 proposed in draft EIS to 50 as described in* **Section 2**.

- gas processing will also occur on the FPSO facilities prior to export via the inter-field spur line and BTL to existing NWS Project infrastructure.

The BTL will tie into the existing second trunkline (2TL) near NRC. The NWS Joint Venture (NWSJV) is pursuing approvals for the NWS Project Extension Proposal; the long- term processing of third party gas and fluids and NWSJV field resources using NWS Project infrastructure until around 2070 (EPBC 2018/8335 and EPA 2186). Transmission of the gas from the tie in point and onshore processing of the gas would be undertaken using existing NWS Project infrastructure.

A detailed description of the proposed Browse Project infrastructure is provided in **Section 3.6** of the draft EIS/ERD. The proposed Browse Development Area and the notional field layout is shown in **Figure 1-1**. The proposed BTL and interfield spur line routes are shown in **Figure 1-2**.

Activities associated with the proposed Browse Project include:

- piling for mooring the FPSO facilities, securing the export riser bases and potentially for mooring the mobile offshore drilling units (MODUs). Suction piling is the most likely option for pile installation, however, depending on the seabed substrate, alternate piling methods such as drilling and cementing or impact piling may be selected
- development drilling and completions for the development of up to 502 production wells
- installation and commissioning of the subsea umbilicals, risers and flowlines (SURF)
- installation and commissioning of the BTL and inter-field spur line
- installation, hook up and commissioning of the FPSO facilities
- operations including hydrocarbon extraction, gas processing and export and condensate offloading
- inspection, maintenance, monitoring and repair activities (IMMR) to ensure the integrity of the infrastructure and identify any problems before they present a risk of loss of containment
- support activities including logistics support, project vessels and helicopters.

At the end of the proposed Browse Project life, the infrastructure will be decommissioned in accordance with good oilfield practice and relevant legislation and practice at the time. This is likely to include well suspension, plugging and abandoning wells and removing the subsea infrastructure. All infrastructure installed above the seabed will be designed to allow removal.

A detailed description of the activities associated with the proposed Browse Project is provided in **Section 3.7** of the draft EIS/ERD.

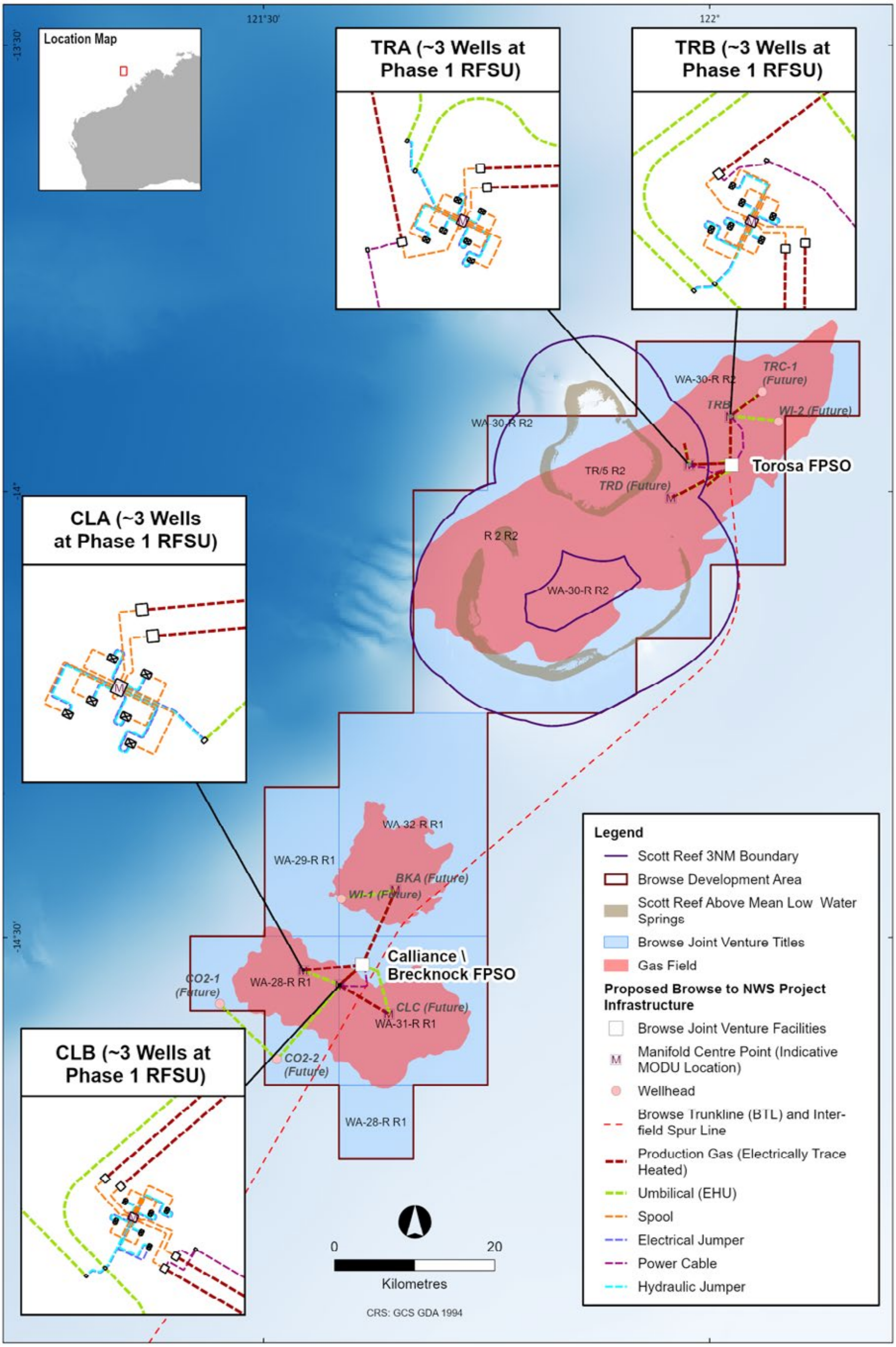

Figure 1-1 Proposed Browse Development Area and notional field layout

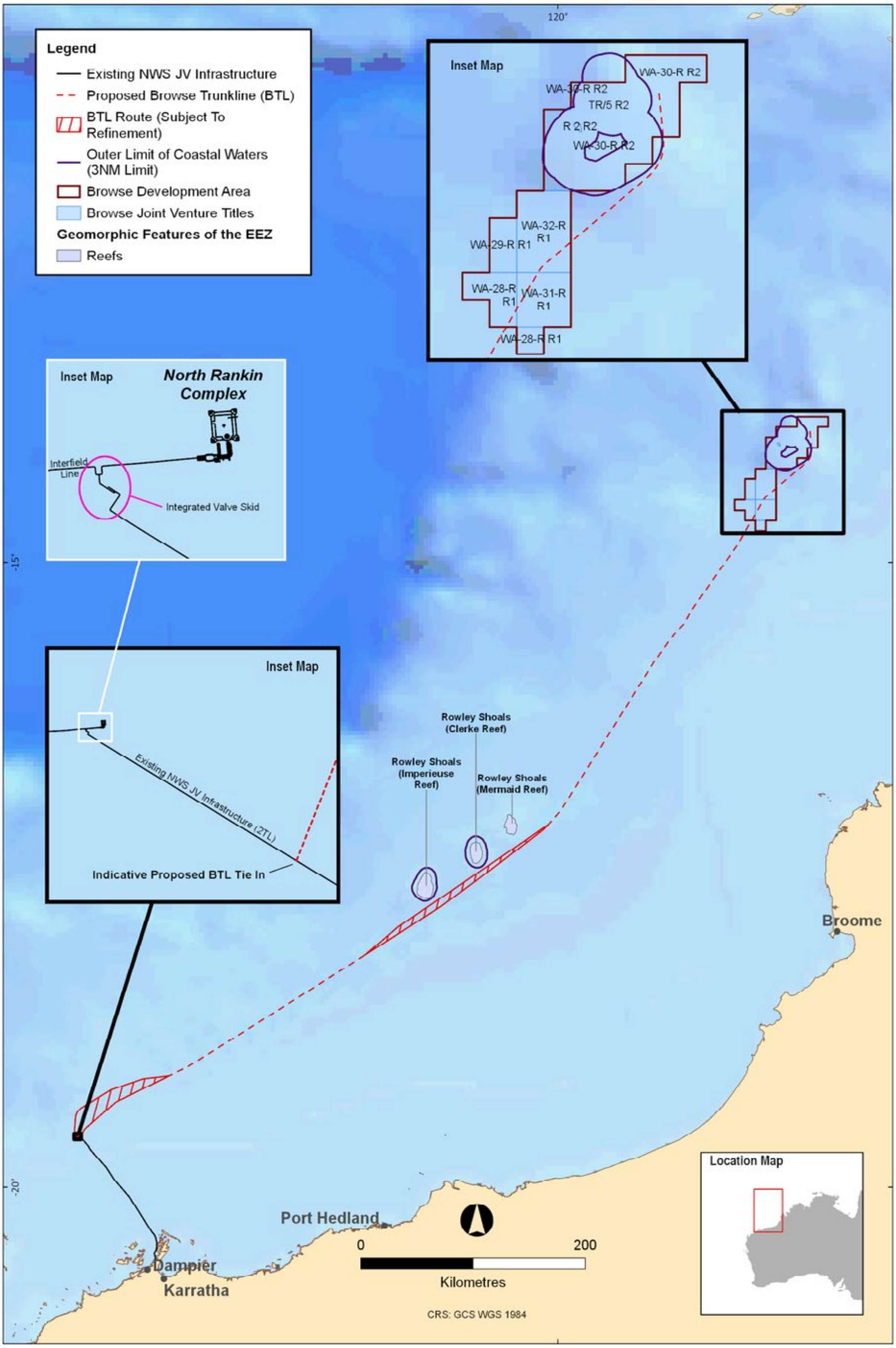

Figure 1-2 Proposed Browse Trunkline (BTL) route

1.2 EPBC Act assessment process

The proposed Browse Project was referred to the Commonwealth Department of Agriculture, Water and the Environment (DAWE) (the then Department of the Environment and Energy (DoEE)) under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) in October 2018.

On the 22 February 2019, the DoEE determined that the proposed Browse Project is a controlled action and would be assessed at an EIS level of assessment. The decision notice identified the following Matters of National Environmental Significance (MNES) as being the protected matters relevant to the proposed Browse Project:

- National heritage values of a National Heritage Place
- Listed threatened species and communities
- Listed migratory species
- The Commonwealth marine area, the protected matter being the environment generally.

Woodside prepared a draft Environmental Impact Statement / Environmental Review Document (draft EIS/ERD) which conformed with the EIS Guidelines/Environmental Scoping Document (EISG/ESD) approved by the DoEE on 5 July 2019 and the Western Australian Environmental Protection Authority (EPA) on 4 July 2019, respectively (Chapter 10, Appendix A of the draft EIS/ERD). Following the finalisation of various supporting technical reports and the draft EIS/ERD, the draft EIS/ERD was released for public review on 18 December 2019 for a period of eight weeks (note - as the public comment period ran over the Christmas period, it was extended by two weeks from the originally planned six weeks). The public comment period concluded on 12 February 2020.

Public submissions were received through both the EPA and DAWE. The EPA and the DAWE advised that the EPA would coordinate the State and Commonwealth consultation processes via its Consultation Hub.

This document presents the submissions received in relation to the Commonwealth assessment of the proposed Browse Project and provides Woodside's responses to submissions and Commonwealth agency comments. Note that a Response to Submissions on State ERD has also been prepared separately which provides Woodside's response to submissions and agency comments relating to the State environmental impact assessment process. The State process involves the assessment of the proposed Browse Project components within the State jurisdiction under the Western Australia *Environmental Protection Act 1986* (EP Act). While a single environmental impact document (the draft EIS/ERD which includes the State ERD) was prepared for public review for both the Commonwealth and State processes; and the public review periods were run in parallel; they are separate but related processes being undertaken pursuant to the EPBC Act and the EP Act respectively. Submissions relating to components within State jurisdiction have again been noted in a separate Response to Submissions on State ERD document for ease of consideration.

1.3 Summary of submissions

1.3.1 Commonwealth agency submissions and ongoing consultation

Woodside has continued to consult with DAWE with respect to the proposed Browse Project draft EIS/ERD. As part of this process, DAWE requested further information and provided advice in relation to the environmental impacts and risk associated with the proposed Browse Project. In responding to these requests, Woodside committed to providing relevant responses and additional information within this Supplement Report to the draft EIS/ERD (refer to **Section 3.1**).

A submission was also received from the DAWE Marine Parks Branch in relation to the proposed Browse Project activities within Australian Marine Parks (AMPs). This submission and Woodside's response is provided in **Section 3.2.**

1.3.2 Public submissions

A total of 19,899 submissions on the draft EIS/ERD were received from the public. These comprised of:

- Five proforma submission with a total number received of 19,789. Within these submissions, 545 submitters made additional comment to standard proforma text. The proformas related to both the Commonwealth proposed action and State proposal.
- 99 standard submission submissions were received through the EPA Consultation Hub (including 83 uploaded documents (including seven repeated submissions). Uploaded documents are appended in **Appendix D**.
- 11 submissions via other pathways.

The proforma submissions and additional comments to the standard proforma text were generally against the proposed action proceeding, although one additional comment submission expressed support for the proposed action.

Of the 99 standard submissions through the EPA Consultation Hub, 59 (three bespoke and 56 support letters) expressed support for the proposed action, 37 were against the proposed action and three provided comments, questions and recommendations without specifying support or objection to the proposed action.

Of the 11 submissions received via other pathways, 10 were against the proposed action and one expressed intent to provide a letter of support at a later date.

Issued raised were primarily in relation to:

- greenhouse gas (GHG) emissions
- potential impacts to Burrup Peninsula rock art
- potential impacts to threatened and migratory marine fauna
- potential impacts to wetlands
- potential impacts to Scott Reef[3]
- potential impacts to AMPs.

1.3.3 Approach to responding to public submissions

Upon receipt of the public review comments on the draft EIS/ERD, Woodside:

- reviewed each submission
- identified the common themes that were present in the submissions (that is, where multiple submissions raise concerns or objections relating to the same aspect, receptor or topic)
- developed responses to the common themes that were present in the submissions (these responses are presented in **Section 5**)
- developed responses to submissions or parts of submissions that did not fit within a common theme (these responses are provided in **Section 7.2**).

In developing the responses, Woodside has utilised:

- environmental specialists from the proposed Browse Project's primary environmental consultancy
- subject matter experts via specialist providers
- internal Woodside subject matter experts
- BJV subject matter experts.

Where applicable, further studies and evaluation has been undertaken as part of the response to both regulatory comments and public submissions. This includes a desktop lighting assessment and light modelling in relation to potential impacts on green turtles utilising Sandy Islet, and further assessment of underwater noise emissions. A key component of this was the further evaluation of the project with respect to the aims and objectives of species conservation plans, and the review and refinement of the proposed environmental objectives. Four new management plans and one new management approach have also been developed during the process of responding to public submissions as follows:

- Greenhouse Gas Management Plan (GHG MP) (**Appendix C.1**)
- Environmental Quality Management Plan (EQMP) (**Appendix C.2**) (pertaining to discharges to the marine environment within or contacting State waters as detailed in **Section 5.15**)
- Turtle Management Plan (TMP) (**Appendix C.3**)
- Hydrocarbon Spill Risk Management Approach (HSRMP) (**Appendix C.4**)
- Pygmy Blue Whale Management Plan (PBW MP) (**Appendix C.5**).

3 *For the purpose of the environmental impact and risk assessment presented in the draft EIS/ERD, Scott Reef, which encompasses the reef system including all coral habitats and communities, is considered as the area "**above the 75 m bathymetric contour within the 3 nm State waters boundary and the Scott Reef and Surrounds - Commonwealth Area which comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef**".*

In presenting the responses to the public submissions, Woodside engaged with regulators with respect to developing an efficient and easy-to-follow approach to presenting the public submissions and Woodsides responses. The approach taken has been to present all bespoke and proforma (including additional text) submissions received via the consultation hub, and summary of the key themes from each uploaded document (with a link to the appendix where the full uploaded document is provided) in a response table (**Table 7-1**). Each of these include the name of the organisation that provided the submission, or the anonymous identifier assigned by the EPA (e.g. ANON-57NR-WV58-6). Woodsides response to each public submission is also included within **Table 7-1**. Where appropriate, this response refers to common responses to address the points raised in the submission. Bespoke responses are provided where a common response does not apply.

Where comments were received pertaining to the Burrup National Heritage Place, a reference has been provided to the "Response to Submissions on the North West Shelf Project Extension Environment Review Document". This document was prepared by the North West Shelf Joint Venture, which is pursuing approvals for the NWS Project Extension Proposal; the long-term processing of third party gas and fluids and NWSJV field resources using NWS Project infrastructure until around 2070 (EPBC 2018/8335 and EPA 2186). The Response to Submissions and relevant management plans are available at the EPA website here: https://www.epa.wa.gov.au/proposals/north-west-shelf-project-extension or on the Woodside website here: https://www.woodside.com/what-we-do/developments-and-exploration/NWS-project-extension.

Upon completion of the preparation of the Supplement Report to the draft EIS/ERD, the document was reviewed by DAWE to assess the adequacy of responses to agency and public submissions prior to public release. Woodside has considered advise from DAWE with respect to adequacy and updated the document where required.

2. CLARIFICATIONS AND REFINEMENTS TO PROPOSED ACTION

The proposed Browse Project continues to be subject to detailed design and refinement. In addition, in responding to the public submissions, Woodside has identified some aspects of the proposed action where further clarification may assist the reader. These clarifications, and refinements to the proposed action that have occurred since the commencement of the public comment period are provided in **Table 2-1**. The proposed action remains within the environmental impact envelope and environmental risks presented in the draft EIS/ERD.

Woodside has reviewed these clarifications and refinements with respect to the key characteristics of the proposed action as presented in **Table 3-1** of the draft EIS/ERD. This review concluded that with the exception of the removal of the TRE drill centre and associated sub-sea infrastructure, the proposed Browse Project clarifications and refinements presented in **Table 2-1**, do not alter the key characteristics of the proposed action. The removal of the TRE drill centre and associated sub-sea infrastructure alters the key characteristics by:

- reducing the number of wells to 50 and reduce the extent of the flowlines
- reducing marine discharges, noise and light emissions associated with the drilling and completion of the wells
- reducing the extent of seabed disturbance.

Table 2-1 Proposed Browse Project clarifications and refinements

Clarification and/or refinement and rationale	Aspects	Jurisdiction	Significance of clarification and/or refinement

Removal of TRE drill centre and associated sub-sea infrastructure.
 	
Further review and engineering refinement has identified that the proposed Browse Project objectives can be met without the TRE well centres and associated flowlines. This reduces the potential environmental impacts of the project.
	Seabed disturbance
	
	Light
	
	Underwater noise
	
	Drilling and completions discharges
	
	Marine discharges
		State Proposal Area	The removal of TRE drill centre and associated sub-sea infrastructure results in:
			• Reduces number of wells by 4 to up to 50 and reduces flowline length.
			• Reduced direct and indirect seabed disturbance as a result of removing the TRE wells (including disturbance related to discharge of drill cuttings and cement during development drilling activities) and associated subsea infrastructure resulting in:
			  • a reduction in of direct seabed disturbance (permanent loss) by 0.07 km^2 to 0.73 km^2 (including 25% contingency).
			  • a reduction in indirect seabed disturbance (reversible loss) by 0.72 km^2 to 8.23 km^2 ((including 25% contingency).
			• Removal of construction light emissions at TRE. The TRE drill centre was the closest drill centre to the green turtle nesting habitat at Sandy Islet, so the removal of these emissions reduces risks to nesting female turtles and hatchling. The nearest potential light impacts are now associated with temporary construction activities at TRD, approximately 18 kilometres from Sandy Islet.
			• Removal of construction and operational underwater noise emissions at TRE. The TRE drill centre was located with the pygmy blue whale possible foraging biological important area (BIA), so the removal of these emissions reduces the risk of displacing foraging pygmy blue whales from the possible foraging BIA.
			• Removal of drilling and completions discharges at TRE. This reduces water quality impacts resulting from the discharge of cuttings and reduces the risk of cutting fines impacting Scott Reef.
			• Minor reduction in marine discharges, light and noise emissions associated with construction vessel, minor reduction in hydrotest fluid discharge and a minor reduction in produced water (PW) discharged from the MODU.

Clarification and/or refinement and rationale	Aspects	Jurisdiction	Significance of clarification and/or refinement
The draft EIS/ERD identified the maximum distance at which direct light may be visible from any of the FPSO facilities under routine operational conditions, based on modelling of the previously proposed FLNG facilities (Jacobs and SKM, 2014). The modelling was based on a FLNG flare tip height of approximately 154 m above the waterline. **Section 6.3.3.3** of the draft EIS/ERD stated that "The FPSO flare at the Brecknock location was estimated to be visible from a portion of south Scott Reef, but not from Sandy Islet (**Figure 6-6**)." It has since been recognized the total flare tower height, including the height of the forecastle deck, is currently designed such that the flare tip will extend up to 181 m high above MSL. The design height is determined by the distance required to ensure that gas can be flared safely, however this estimate also accounts for the effect of a light vessel draught (when the FPSO is lightly loaded and so sits relatively high in the water). This would represent the approximate height of the flare as a light source under routine operational conditions.	Light	Commonwealth waters activity with indirect impact to the State Proposal Area	This clarification results in the flare tip being visible from slightly longer distances according to line of sight modelling (an increase from 47.7 km to 51.9 km according to Young's method, based on 181 m flare height above MSL). Line of sight estimates are typically made using Young's Method, a formula which estimates the maximum distance a height above MSL can be visible from, given that a point will eventually be hidden behind the curvature of the earth. This distance is given by: $d \approx 3.86 \sqrt{h}$ For a height h of 181 m above sea level, maximum observable distance d = 51.9 km. For clarity, the only effect of this clarification is that the height above MSL that the flare tip will extend up to. No changes have been proposed that would affect the intensity of light received at the current identified receptors. This clarification has been incorporated into the impact assessment presented in both section MF-2 and into the proposed Browse Project Desktop Lighting Assessment and Turtle Management Plan (**Appendix C.3**). This slight increase in the line of sight distance during routine operations does not reach any additional receptors that were previously outside of the line of sight of the facility flare. Direct light from the Brecknock/Calliance FPSO flare tip is still not expected to be visible from Sandy Islet during routine operations. Given the slight increase in line of sight does not reach any additional receptors, the small increase in line of sight distances is not considered material with respect to the environmental impact assessment.

Clarification and/or refinement and rationale	Aspects	Jurisdiction	Significance of clarification and/or refinement
During large maintenance campaigns it is proposed that some personnel may live on one FPSO and transport by crew vessel to work on the other. In this scenario the maximum persons onboard (POB) on an FPSO would be 240 POB during daytime instead of 180 POB. This does not increase the planned POB of the two FPSOs in total nor increase the combined effluent. However, it allows flexibility in personnel planning (for example, reduced transfer of personnel between FPSO facilities during major maintenance).	Sewage and sullage discharge	Commonwealth waters activity	A small increase from 180 POB to 240 POB (during temporary major maintenance periods), will result in increased treated sewage and sullage discharge (approximate increased from ~70 m^3/day to ~90 m^3/day). Note that the FPSO facilities continue to be equipped with sewage treatment systems compliant with the MARPOL73/78 **Section 9.1.1** requirements. It is also expected that, as during operations the additional 60 POB would be accommodated on the other FPSO, the treated sewage and sullage discharge total for the two FPSOs would not increase beyond the volume described in the draft EIS/ERD (~140m^3 day total two FPSOs). Given rapid dilution of treated sewage and sullage discharges, no new or increased impact to the environment is predicted.
The draft EIS/ERD **Section 6.3.8.1** describes the FPSO as having thrusters which are used for 'dynamic positioning' (DP). Dynamic positioning (DP) is a computer-controlled system to automatically maintain a vessel's position and heading by using its own propellers and thrusters. Each FPSO will be moored via a turret mooring system and will weathervane around the turret. They will be equipped with two thrusters at the stern of the vessel to control the heading of the facility for operational reasons.	Underwater noise emissions	Commonwealth waters activity with indirect impact to the State Proposal Area	This clarification is only that the FPSO thruster system should not be referred to as a 'DP' system as the FPSO system is moored as described in Chapter 3 of the draft EIS/ERD. The underwater noise impact and subsea disturbance impact as predicted in the draft EIS/ERD does not change.
Due to ongoing engineering refinement, the FPSO thruster sizes may increase up to 2 x 3.5 MW from 3 MW, noting that the draft EIS/ERD conservatively presented modelling for 2 x 5 MW thrusters.	Underwater noise emissions	Commonwealth waters activity with indirect impact to the State Proposal Area	While the FPSO thruster size has increased from that described in the draft EIS/ERD, the modelling presented in the draft EIS/ERD assumed a thruster size of 2 x 5 MW. As such the potential impact remains within that predicted in the draft EIS/ERD.

Clarification and/or refinement and rationale	Aspects	Jurisdiction	Significance of clarification and/or refinement
An error has been identified in **Section 6.3.8.1** of the draft EIS/ERD which provides a description of McCauley's (2002) findings on wellhead noise.	Underwater noise emissions	State Proposal Area and Commonwealth waters activities	Woodside notes that the draft EIS/ERD described that McCauley's (2002) estimated the broadband source level noise of wellheads associated with the Cossack Pioneer FPSO to be 161.5 dB re 1 µPa·m (SPL). This estimate was actually developed by Duncan (2010) using the source spectra in McCauley's (2002) in a modelling study. The estimated source level for Browse wellheads remains 161.5 dB re 1 µPa @ 1m (no change from the draft EIS/ERD).
Section 3.7.9.2 of the draft EIS/ERD states that If helicopters are used, it is anticipated that up to five personnel transfers a week per FPSO facility will be required during normal operations. If fast crew transfer vessels are used, it is anticipated that one transfer per day would occur during normal operations, with additional transfers during shut downs and major maintenance. This is also reflected in **Section 6.3.7** of the draft EIS/ERD.	Atmospheric Noise	State Proposal Area and Commonwealth waters activities	For clarity, more helicopter transfers and fast crew vessel transits may be required during installation and commissioning, shut downs and major maintenance.
Heated risers for the FPSOs may not be available for the proposed Browse Project to use, as they may not pass technology qualification. This would likely result in an increase in discharged MEG volumes, as MEG would be used in the risers to manage hydrate formation during start-up and shutdown.	PW discharge	Commonwealth waters activity	Woodside remains committed to managing the Browse Project FPSO PW discharges in a manner that ensures the defined threshold values (e.g. 99% species protection or no effect concentrations) are met at the State waters 3 nm boundary, 95% of the time based on dispersion modelling results. Woodside also remains committed to the PW discharge specifications presented in **Section 6.3.12.2** of the draft EIS/ERD. As such, this change will have no material effect on the State Proposal Area, and no change to the anticipated mixing zone is predicted.

Clarification and/or refinement and rationale	Aspects	Jurisdiction	Significance of clarification and/or refinement
Woodside provides a clarification with respect to a mitigation measure presented in Table 141 of the draft EIS/ERD which read: "Project vessels will not travel at speeds greater than 12 knots within the State Proposal Area, or 6 knots in the Scott Reef channel". Woodside wishes to clarify that operational vessels may travel faster than the proposed speed restrictions in an emergency event, where Safety of Life at Sea (SOLAS) may be in jeopardy.	Unplanned vessel interactions with marine fauna	State Proposal Area	The proposed mitigation measure reads: "Project vessels will not travel at speeds greater than 12 knots within the State Proposal Area, or 6 knots in the Scott Reef channel unless required for SOLAS (i.e. in situations where the vessel master considers that complying with the requirement would adversely affect the safety or security of the vessel or its passengers or crew, or in situations where the vessel master is bound to provide assistance (under SOLAS Chapter V) upon receiving a distress signal from any source that persons are in distress at sea)." Given the infrequent occurrence of such an event, it is not considered that this clarification affects the outcomes of the assessment provided in the draft EIS/ERD.
The draft EIS/ERD describes flushing of the 2TL as occurring from near infrastructure located near NRC to the KGP. Flexibility is required for the flushing operation to be able to occur in either direction, with the 2TL inventory displaced into the inter field line (IFL) and into NRC.	Activity description	Commonwealth Waters	This change allows for flexibility for the 2TL to be flushed in either direction. In the case of flushing towards NRC, the NRC will be the recipient of the residual trunkline inventory via the GWA IFL. Receipt of hydrocarbons and fluids at the GWA IFL is outside the scope of the draft EIS/ERD. As described in the draft EIS/ERD, minor releases of hydrocarbons may be associated with this activity.
The draft EIS/ERD describes one of the measures for mitigating processing GHG emissions on the FPSO is to incorporate batteries into the design to manage peak power supply. Batteries are included in the FPSO design as a GHG emissions mitigation, however it is more accurate to say that the batteries provide 'spinning reserve' which ensures that the facility can continue to operate if a gas turbine generator (GTG) comes offline. Typically, spinning reserve would be provided by having an extra GTG running, which would be consuming fuel gas.	GHG emissions	Commonwealth waters activity	This clarification is for the description of how the battery operates as a mitigation measure only. The estimated mitigated emissions does not change as this was based on the use of batteries to provide spinning reserve.

Clarification and/or refinement and rationale	Aspects	Jurisdiction	Significance of clarification and/or refinement
During the drafting of the draft EIS/ERD, it was not considered that the design of the FPSO would require Hydrofluorocarbons (HFCs), as these are being phased down through implementation of the Montreal Protocol. It has since been identified that the alternatives to HFCs have not yet passed the technology qualification required to reliably incorporate them into the design of the FPSO.	GHG emissions	Commonwealth waters activity	Woodside will pursue technology qualification of suitable alternatives to HFCs as part of the detailed design of the FPSO. However, should suitable alternatives not be available for use, the design of the FPSO HVAC system may require HFCs to be used. The inclusion of HFCs on the FPSO has an immaterial impact on the emissions profile of the proposed Browse Project and is expected to contribute less than 1,000 tCO_2e/pa. The proposed Browse Project will continue to comply with the Montreal Protocol, which allows for continued use of HFCs, subject to a phase down of import quotas at the national level.
The GHG emissions estimates presented in Chapter 7 of the draft EIS/ERD presents an estimate for GHG contribution from flaring. This estimate is based on a single FPSO, not two FPSOs. This estimate includes both continuous flaring described in the draft EIS/ERD (pilot gas and compressor seal gas) as well as intermittent flaring (i.e. shutdowns), which has been annualised based on expected reliability data.	GHG emissions	Commonwealth waters activity	The draft EIS/ERD presented a “processing emissions” estimate, which covered fuel gas, flaring and fugitive emissions. This had been revised to provide separate estimates for emissions from flaring and fugitives. The underestimation of flaring emissions is therefore accompanied by a commensurate overestimation in fuel gas emissions. The upstream total remains unchanged. The updated emissions table is presented in **Table 2-2**.

Clarification and/or refinement and rationale	Aspects	Jurisdiction	Significance of clarification and/or refinement
Section 3.7.2.1 and **Section 6.3.15.3** of the draft EIS/ERD, and **Section 8.2.4.8** of the State ERD includes a table of indicative cuttings volumes and fluid type for a typical Browse well. As a result of further engineering the "indicative fluids volumes" have been updated for the 16", 12¼" and 97/8" hole sections, as well as "indicative fluid type" for the 16" hole section. Note that this fluids volume represents both fluids (water based fluids (WBF)/non-water based fluids (NWBF) on cuttings, as well as WBF fluids discharged via the mud pits.	Drill cuttings and fluids	State Proposal Area and Commonwealth waters activities	The change in drilling fluids volume from ~4,435 m^3 to ~5,757 m^3 is within the bounds of the potential impact predicted within the draft EIS/ERD and State ERD. This is largely due to the following: Clarification relates to a refinement of indicative fluids volumes, while there is no change to the indicative cuttings' volumes, which is the primary impact pathway for potential smothering of deepwater receptors. Management approach for Torosa wells in the State Proposal Area, as defined in the **Appendix A** of the proposed Browse Project EQMP (**Appendix C.2**), applies and hence no increased risk to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry). The "indicative fluid type" for the 16" hole section has been updated from Weighted Gel (Bentonite) WBF to WBF broadly, to allow flexibility as this section may be drilled riserless or with a riser. The updated table of indicative cuttings volumes and fluid type for a typical Browse well is presented in **Table 2-3**.

Clarification and/or refinement and rationale	Aspects	Jurisdiction	Significance of clarification and/or refinement
The draft EIS/ERD described that if a well is underperforming, or surveillance indicates debris is contained within the well, the contents of the wellbore may be flowed to a MODU. This displaces the well fluids (i.e. suspension/completion fluids). These are discharged overboard, as potential gas content makes it too dangerous for personnel to filter or treat them. Woodside wishes to provide clarification that: • should there be wellbore fluids contaminated with hydrocarbons or NWBFs, they will be captured and stored on the MODU for discharge if oil concentration is <1% by volume, or returned to shore if discharge requirements cannot be met. • should there be wellbore solids contaminated with hydrocarbons, they will be treated as hazardous waste as per draft EIS/ERD **Section 6.3**.14.	Drill cuttings and fluids	State Proposal Area and Commonwealth waters activities	During drilling and completion activities (including planned and unplanned contingencies), it may be necessary to circulate wellbore fluids to the MODU or flow them to a temporary production system. Wellbore fluids typically contain completion fluids which are usually brines (i.e. a mixture of seawater or formation water) with additives that can include chlorides (often sodium, potassium or calcium), bromides, hydrate inhibitor (MEG), biocide and/or oxygen scavenger. They are designed to have the proper density and flow characteristics to be compatible with the reservoir formation. Completion fluids may also include solids-free fluid, gravel pack carrier fluid and loss circulation material. In a well intervention and/or repair scenario, the wellbore fluid may be contaminated with hydrocarbons from the reservoir or NWBF that were used during well construction. The clarification made here confirms that untreated contaminated wellbore fluids and contaminated wellbore solids will be treated as hazardous waste as per draft EIS/ERD **Section 6.3.14**. This provides a better environmental outcome than previously indicated.

Table 2-2 Proposed Browse Project refinement: forecast scope 1 (BJV) GHG emissions summary (update to Table 7-5 of the draft EIS/ERD)

CO_2-e MT[1]	Average Year	Peak Production Year	Total Expected Field Life (30 years)	Total Extended Field Life (44 years)
Reservoir emissions[2]	2.3 (2.6)[3]	4.0 (4.6)	70 (81)	93 (107)
Fuel gas	1.2	2.1	38	50
Flaring	0.14	0.14	4	6
Fugitives	0.01	0.02	0.3	0.4
Upstream total[2]	**3.6 (4.0)**	**6.2 (6.8)**	**112 (123)**	**149 (163)**

1 *Scenarios defined as per* **Table 7-2** *of the draft EIS/ERD.*

2 *Upstream reservoir emissions have been estimated based on the maximum expected case given a gas export specification target of 2.5mol% CO_2. Estimates of emission implications for a 1 mol% to 2.8 mol% CO_2 gas export specification are presented in* **Table 7-7** *of the draft EIS/ERD. Note the gas export specification is dependent on the outcome of final commercial arrangements.*

3 *Bracketed emissions refer to high reservoir CO_2 composition scenario.*

Table 2-3 Proposed Browse Project refinement: Indicative cuttings volumes and fluid type for a typical Browse well (update to Table 3-3 and Table 6-119 of the draft EIS/ERD; and Table 8-3 of the State ERD)

Indicative Well Section Diameter	Indicative Drill Length (m)	Indicative Cuttings Volume (m^3)	Indicative Fluids Volume (m^3)	Indicative Fluid Type
42”	100	89	427	Seawater with bentonite sweeps
26”	440	151	1327	Seawater with bentonite sweeps
16”	2970	385	1892	WBF
12 ¼”	2799	213	1478*	WBF or NWBF
9 ⅞”	243	12	633*	WBF or NWBF
Total per well	**6,552 m**	**850 m^3**	**5,757 m^3**	

**Is the WBF volume, which is the larger volume of the two fluid types*

3. RESPONSE TO COMMONWEALTH AGENCY COMMENTS ON THE DRAFT EIS/ERD

3.1 Department of Agriculture, Water and the Environment – Major Projects comments

Table 3-1 DAWE Major Projects comments and Proponent's response

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response
1. Environmental objectives and evaluation to demonstrate objectives can be met		**Context** **Table 6-7** provides an overview of environmental receptor sensitivity, environmental objectives and a summary of environmental context. ***Issues identified from adequacy check and initial preliminary review*** Proposed environmental objectives are currently high-level include ambiguous terminology and do not establish a measurable basis on which to compare predicted levels of impact and inform monitoring and adaptive management.	WEL should review the environmental objectives outlined in the draft EIS to ensure that objectives are measurable, specific and achievable. Updated objectives should be provided in the Supplementary Report along with sufficient information to:	In preparing responses to the regulatory and public submissions on the draft EIS/ERD, Woodside has reviewed and where appropriate revised the environmental objectives for the proposed Browse Project to make them more specific and measurable. The full list of environmental objectives is provided in **Section 6.**

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
	The objectives set need to be measurable, achievable and specific (to the activity or aspect of the project) and the environment that may be affected. Examples of inadequacies are provided below. If the Minister were to approve the proposed action, these objectives could be the basis of outcomes-based conditions that may be attached to an approval. For further information on outcomes based conditions please refer to the Outcomes-Based conditions policy (2016) available at https://www.environment.gov.au/system/files/resources/4519549d-7496-4146-8dd4-58d55a7457cb/files/outcomes-based-conditions-policy.pdf. **Marine reptiles** Proposed objectives for marine reptiles are inadequate because: • Objective 12 is not specific to the habitats critical to survival and BIAs for marine turtle populations that utilise Sandy Islet for nesting and Scott Reef for inter-nesting and foraging. In addition, there is no measurability to the term 'substantial' so that it is clear what extent, duration and severity of habitat modification is proposed to be acceptable. • Objective 13 uses the term 'seriously' which is not defined and the objective does not specifically apply to relevant marine turtle stocks and associated life stages potentially affected.	• demonstrate clearer connection to and consistency with relevant statutory requirements. (This should include requirements of recovery plans for listed threatened species). • demonstrate how the objectives are able to be met through logical, well-reasoned and scientifically supported discussion. In framing up the objectives, WEL should consider the requirements outlined under section 139(1)(b) of the Environment Protection and Biodiversity Act 1999 (EPBC Act), specifically that: *'in deciding whether or not to approve for the purposes of a subsection of section 18 or section 18A the taking of an action, and what conditions to attach to such an approval, the Minister must not act inconsistently with … (b) a recovery plan or threat abatement plan. …'.*	

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response

		• Objective 16 does not appear to be measurable as the information contained in the content of the EIS/ERD does not demonstrate that there is sufficient baseline data upon which to measure changes in the distribution of a population.
		• The objectives do not capture key recovery plan requirements and do not set levels of environmental performance at levels that are clearly not inconsistent with recovery plans. Relevant recovery plan requirements include:
		  • Adaptively manage turtle stocks to reduce risk and build resilience to climate change and variability.
		  • Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival.
		  • Manage anthropogenic activities in Biologically Important Areas to ensure that biologically important behaviour can continue.
		Marine mammals
		Proposed objectives for marine mammals are inadequate because:
		• Objective 12 is not specific to the BIAs for blue whales that may forage in waters off Scott Reef. In addition, the term 'substantial' is not defined or clearly measurable. It is therefore unclear what extent, duration and severity of habitat modification is proposed to be acceptable.
			In particular, WEL need to demonstrate that the proposed action is not inconsistent with any relevant recovery plan or threat abatement plan under the EPBC Act, including, but not limited to:
			• Department of the Environment and Energy (2017). *Recovery Plan for Marine Turtles in Australia.* Australian Government, Canberra.
			• Department of the Environment (2015). *Conservation Management Plan for the Blue Whale - A Recovery Plan under the Environment Protection and Biodiversity Conservation Act 1999.* Canberra, ACT: Commonwealth of Australia.
			This should include consideration of specific statements within the recovery plans; for example, recovery action tasks, priority actions and recovery objectives.	

Topic		Issue	Advice on key considerations for Woodside	Proponent’s Response

		• Objective 13 refers to the term ‘seriously’ which is not defined and does not specifically apply to relevant marine mammal populations.
		• Objective 15 to not have a ‘substantial adverse effect on a population…or the spatial distribution of a population’ is not measurable and the content of the EIS/ERD does not demonstrate access to adequate baseline data to measure whether any changes to population distribution or health have occurred.
		• The objectives do not reflect key requirements from the Conservation Management Plan (CMP), which is a recovery plan made under the EPBC Act in effect from 3 October 2015, for blue whales or set a level of environmental performance that would ensure the project is managed in a manner not inconsistent with the requirements of the CMP for blue whales. Specifically:
		  • Manage anthropogenic noise in biologically important areas such that any blue whale can continue to utilise the area without injury, and is not displaced from a foraging area (Action Area A.2).
		  • Ensure the risk of vessel strikes on blue whales is considered when assessing actions that increase vessel traffic in areas where blue whales occur and if required appropriate mitigation measures are implemented (Action Area A.4).
		  • Continue to meet Australia’s International commitments to reduce greenhouse gas emissions (Action Area A.3).
			For context, since the approval (14 August 2015) of the previous Browse FLNG assessment (EPBC 2013/7079), there is new relevant context that is important for informing the environmental impact assessment presented in the EIS. Examples include the Conservation Management Plan for the Blue Whale (2015), the Recovery Plan for Marine Turtles in Australia (2017) and National Light Pollution Guidelines for Wildlife (Final released in January 2020 and available here: https://environment.gov.au/biodiversity/publications/national-light-pollution-guidelines-wildlife).	

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response
2. Threatened species	a. Whales	**Context**: The pygmy blue whale (East-Indian Ocean) is a subspecies of blue whale that is listed as data-deficient on the IUCN red list, though the blue whale at the species level is listed as endangered under the EPBC Act and the definition of a species in the EPBC Act includes a sub-species therefore encompassing the pygmy blue whale under the endangered listing. The waters surrounding Scott Reef are identified in DAWE published resources as a *'possible foraging BIA'* for the pygmy blue whale. Under the CMP for the Blue Whale, the requirements that apply to foraging BIAs also apply to *'possible foraging areas'*. The CMP for the Blue Whale identifies four key threats inhibiting the recovery of blue whales. Of these four threats, three reflect potential impacts and risks of the proposed Browse Project. • Noise interference – specifically the impact of seismic, drilling, gas processing, and shipping noise on the ability of blue whales to find food or a mate, masking of biologically important cues, behavioural disturbance, displacement from essential resources, and the potential for injury/death. • Vessel disturbance – specifically the risk of vessel strike and the behavioural disturbance of whales from industrial, recreational and commercial activities.	WEL should provide clearer, logical and robust impact and risk evaluation that acknowledges the potential for blue whales to occur within the project area and the potential ongoing importance of the Scott Reef foraging BIA for the population. The EIA for whales should demonstrate the impacts and the risks of the activity both in isolation and cumulatively. The EIA and objectives will need to demonstrate consistency with the Conservation Management Plan for Blue Whale including the actions and objectives within the plan and how the proposed action is not inconsistent with the CMP for the Blue Whale and would not result in an unacceptable impact.	The draft EIS/ERD acknowledges the potential for pygmy blue whales to occur in the project area, and the potential ongoing importance of the Scott Reef possible foraging BIA for the population. In response to this and related questions on this topic, a Pygmy Blue Whale Management Plan (PBWMP) has been prepared (**Appendix C.5**). Woodside considers that the management approach outlined in this plan demonstrates, with a high level of confidence, that unacceptable impacts to pygmy blue whales will be avoided, by minimising the risk of injury to pygmy blue whales or displacement of pygmy blue whales from the Scott Reef possible foraging BIA, as a result of underwater noise emissions associated with the proposed Browse Project.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
	• Climate change and variability – specifically the impact of ocean warming on changing species ranges, ocean dynamics and the subsequent availability of krill, as well as the impact of ocean acidification on the fecundity and sustainability of krill populations. In general, the outcomes of the evaluation are largely supported by the assumption that the presence of blue whales within the project area is unlikely. Given limitations associated with current data and contemporary knowledge on distribution and abundance, as well as habitat utilisation at Scott Reef, this isn't a situation that lends itself to supporting the position that the presence of blue whales in the project area is unlikely. ***<u>Issues identified from adequacy check and initial preliminary review</u>*** **Aspect - Noise** Based on the CMP for Blue Whales, the potential impacts of industrial noise are ranked as '*moderate*' with climate change and variability ranked as '*high*'. Oil and gas platforms are identified as a threat for displacement of blue whales in offshore waters (CMP p.27) with the associated noise impacts assessed as '*minor*' and '*almost certain*'. By contrast, the Draft EIS indicates the potential for noise impacts to be unlikely with a consequence of '*minor*' (p.369). The conclusions of the risk assessment in the Draft EIS are based on the evaluation that "*low numbers of transient marine mammals within the vicinity of the*	In order to respond to the issues identified to date, WEL could consider committing to further studies and monitoring. This could include ongoing monitoring of received levels relative to adopted impact thresholds to verify the acceptability of received levels of underwater noise to cetaceans, and targeted acoustic and tracking studies. Any future survey design to understand the distribution and abundance of blue whales in this habitat would need to adequately take into account inter-annual variation in blue whale habitat use and distribution so that appropriately designed to capture temporal variability at seasonal and annual timeframes.	

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
	noise source may occur… Given that relatively low numbers of transient marine mammals are expected to occur seasonally within the project area, only slight behavioural modifications are expected to occur with no long term effects at a species population level" (p.15). Based on the evaluation provided to support this conclusion, it does not appear that the environmental impact assessment has taken into consideration important context from the CMP for Blue Whales, or the importance of the Scott Reef area as a foraging BIA for blue whales. Further, the outcomes and conclusions of the environmental impact assessment do not appear to be supported by modelling outputs and sufficient baseline data to justify assumptions that underlie the evaluation. For example: • Outcomes of acoustic recording studies do not appear to have been taken into account in the draft EIS/ERD – e.g. "Woodside Kimberley Sea Noise Logger Program September 2006 to June 2009 Whales, Fish and Man Made Noise. Specifically the year round presence of Bryde's whales and regular presence of Blue Whales. Specifically between September 2008 and June 2009 (1 season) a minimum of 14 blue whales were detected singing within the Scott Reef channel. The above report also demonstrates annual variability meaning a number of years of data is needed to understand blue whale distribution and habitat use at Scott Reef. Given inter-annual variability and population growth, Scott Reef may be a more important habitat than is recognised in the draft EIS.	In order to respond to the issues identified to date, WEL could consider committing to further studies and monitoring. This could include ongoing monitoring of received levels relative to adopted impact thresholds to verify the acceptability of received levels of underwater noise to cetaceans, and targeted acoustic and tracking studies. Any future survey design to understand the distribution and abundance of blue whales in this habitat would need to adequately take into account inter-annual variation in blue whale habitat use and distribution so that appropriately designed to capture temporal variability at seasonal and annual timeframes.	

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response

	Taking into account the proposed duration of the project, this context is important for supporting an evaluation of impacts and risks to blue whales now and into the future and in demonstrating that the project can be managed consistent with the CMP.
	• There are numerous sources of anthropogenic noise from the project, some are shorter term inputs to the marine soundscape while others (such as the operation of the FPSO and choke noise from wellheads) represent a more chronic input to the marine soundscape at Scott Reef. In the context of low frequency cetaceans, modelling study results indicate:
	  • Choke noise modelling (2 transects) did not consider transmission of sound perpendicular to the chosen transect along the deeper water of the channel. Based on the proposed location of the well heads and the presented modelling outputs there is the possibility for behavioural disturbance in blue whales within the narrow corridor of the Scott Reef channel where they have been observed and acoustically detected. This matter has been inadequately recognised and evaluated in the EIS / ERD.
	  • The potential for:
	    • behavioural disturbance from vessel activities out to 10.5 km (MODU), 2.25 km (OSV), 8.77 km (FPSO with DP), 0.57 km (FPSO without DP) and 8.89 km (FPSO offtake) within the PBW foraging BIA.		

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response
		• TTS in marine mammals at distances of 1.69 km for VSP, and 1.6 km from FPSO offtake activities. • PTS and TTS for marine mammals from pile driving activities to extend to 5.35 km and 29.46 km respectively for low frequency cetaceans based on one pile being hammered per day. Given these ranges appear to be beyond what proposed controls can effectively mitigate, the EIS/ERD does not demonstrate that it is possible to manage project activities to not be inconsistent with the CMP. • Based on ANIMAT modelling, 1.65 and 1.64 (3.39%) animals are predicted to experience TTS within the migratory and foraging areas respectively. This modelling is considered to be a more realistic tool for assessing potential impacts on animals as it incorporates the movement patterns of animals, resulting in a prediction of realistic exposures that generally decreases the modelled range to potential impacts. A 2 km exclusion zone has been applied in the modelling which discounts any animats within 2 km of the sound source. Despite this, blue whales within the foraging and migratory BIAs are still predicted to experience temporary injury outside the 2 km exclusion zone. By excluding all animats within 2 km of the sound source, the modelling methods assume that the exclusion zone will be 100% effective in mitigating noise impacts and consequently may underestimate the number of whales that could experience injury from the activity.		

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response
		Given the points above (i.e. potential for injury and behavioural disturbance within the foraging BIA) the EIS/ERD does not demonstrate that that the impacts from noise generating activities of the proposed project can be managed such that they will not be inconsistent with the CMP. **Aspect – Vessel interactions** With respect to vessel operations, there is a commitment to only travel 6 knots in the Scott Reef channel and a maximum 30 knots in sensitive areas at sensitive times. The acceptability evaluation in relation to vessel disturbance is underpinned by the low observation rates of pygmy blue whales during WEL's surveys leading to conclusions that they are not likely to be encountered (p.591) and that the FCT vessel can slow down rapidly. However, given the dive patterns of pygmy blue whales and their size, it is possible for a whale to be very close to the surface before being visible to the eye. It is unclear based on the risk evaluation how the level of vessel activity can be managed to adequately address the threat of vessel interactions with blue whales. **Cumulative impacts** Based on the specific threats and actions identified in the CMP for Blue Whales, the nature and scale of the project including its associated noise emissions and vessel traffic in a sensitive area, it is not clear how the project (including all different potential impacts) is proposed to be managed to be not inconsistent with the CMP.		

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response
		In addition, the CMP for Blue Whales states that "*the cumulative impacts of listed threats should also be considered*" and it is unclear that the full extent and severity of impacts and risks has been considered. For example, there is the potential for the project to impact blue whales directly through noise emissions and vessel traffic, and indirectly through impacts to krill availability and climate change. Climate change may result in additional pressures including changing blue whale migratory ranges, changes to the availability and fecundity of krill (through ocean acidification, changes in ocean dynamics, changes in sea temperature), as well as potential impacts of light spill on krill distribution. Given the suite of pressures on the blue whale population including the declining krill abundance as a result of krill fisheries in the southern feeding grounds (identified in the CMP), the draft EIS does not discuss in sufficient detail the possibility that transitory feeding grounds such as that at Scott Reef will be increasingly important to sustaining a growing population.		
	Turtles	***Marine turtles*** **Context**: Scott Reef and Browse Island are considered 'Major' important nesting areas for green turtles. The 'Recovery Plan for Marine Turtles in Australia 2017-2027' (Commonwealth of Australia, 2017) establishes the following recovery actions: • Manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to the survival as per section 3.3 Table 6. (Action area A1)	WEL should provide clearer, logical and robust impact and risk evaluation that acknowledges the importance of Scott Reef to marine turtles. The EIA should demonstrate the impacts and the risks of the activity both in isolation and cumulatively (across multiple impact pathways).	Further light modelling and analysis of the potential impact of light emissions on the Scott Reef-Browse Island green turtle genetic stock (G-ScBr) has been carried out taking into consideration additional information made available since publication of the draft EIS/ERD. This analysis has taken into consideration project activities both in isolation and cumulatively.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
	• Manage anthropogenic activities in Biologically Important Areas to ensure that biologically important behaviour can continue. (Action area A1) Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats. The recovery plan also estimates the Scott Reef green turtle population to be between 1,000 and 5,000 individuals (nesting on Sandy Islet) with an average re-migration interval of 3-5years. Average internesting interval is 10 days based on satellite tracking (EIS p139). There is limited data available on hatching success and hatchling success / emergence. The relevant threats to Scott Reef green turtle stock according to the recovery plan include: • Climate change and variability • Chemical and terrestrial discharge • Habitat modification - infrastructure / coastal development. The evaluation of impacts to marine turtles presented in the EIS / ERD does not adequately recognise the absence of alternative nesting habitat for the Scott Reef green turtle stock and the relative significant of Sandy Islet for the survival of this stock.	The EIA and objectives will need to be reviewed to demonstrate consistency with the requirements of the Recovery plan, including that: • marine turtles are not displaced from identified habitat critical to the survival; and • that biologically important behaviour can continue. WEL will need to demonstrate through the impact analysis that the proposed action is not inconsistent with the recovery plan including those points outlined above. In order to respond to the issues identified to date, WEL could consider committing to further studies and monitoring. This could include ongoing monitoring of population viability / trends (e.g. nesting success, hatching success, and emergence success) which may require additional collection of baseline data and will require rigorous scientific design.	Since the original light modelling studies were undertaken, and submission of the draft EIS/ERD, there has been additional context regarding potential impacts to turtles from light emissions—in particular the release of the final National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth of Australia, 2020) in January 2020. A desktop lighting assessment, taking into account the final National Light Pollution Guidelines for Wildlife, has been undertaken and is provided in **Appendix A.1**. This includes an assessment of the relevant importance of Sandy Islet to the G-ScBr stock, a further literature review describing potential impacts of offshore sources of artificial light on all life stages of marine turtles and a gaps analysis of the assessment completed to date (against the National Light Pollution Guidelines for Wildlife, 2020). In addition, after further consultation with DAWE on the desktop lighting assessment, modelling of the artificial light emissions from the proposed offshore facilities has been undertaken to support the outcomes of the assessment of light emissions on marine turtles for the proposed Browse Project. The scope, methodology and results of the modelling study are incorporated in a Turtle Management Plan (TMP) (**Appendix C.3**). The key conclusions of this updated light modelling study and light impact assessment are summarised in **Section 4.3.3.4.**

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
	Issues identified from adequacy check and initial preliminary review There appears to be a high degree of uncertainty in the predictions of impacts to the Browse Island turtle nesting stock and Scott reef foraging populations and the implications of these impacts for population maintenance and recovery. Some of the matters that lead to uncertainty and present challenges in demonstrating that the project is able to be managed in a manner that is not inconsistent with the recovery plan are outlined below. **Aspect: light** Light modelling used to inform the light emission predictions for the draft EIS was the Jacobs Report 2014 prepared for Browse FLNG and ERM 2010 report prepared for Browse Upstream LNG Development. Modelling was undertaken to determine illuminance values measured in lux at pre-determined distances from an FLNG facility and proposed TRE drill centre. Since these modelling studies were undertaken, there is additional important context relevant for informing the acceptability of impacts on marine turtle populations, in particular the Recovery Plan for Marine Turtles in Australia 2017-2027 and National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds (2020). These documents set out specific considerations that are applicable to evaluating potential impacts to marine turtles from artificial light attributed to the Browse project.		The further evaluation provides confirmation that the residual impact rating provided in the draft EIS/ERD is appropriate. The impact assessment summary with adopted and additional controls and further environmental objectives are presented in **Section 4.3.** Woodside has conducted further evaluation of the proposed Browse Project against the Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth of Australia, 2017a) as made under the EPBC Act to demonstrate that the proposed Browse Project is not inconsistent with this recovery plan, in accordance with the EPBC Act. Please refer to **Section 4.5.3** for further details. The proposed Browse Project has already committed to updating existing green turtle (G-ScBr stock) data by a targeted monitoring program to verify impact predictions and inform adaptive management approaches at relevant times throughout the proposed Browse Project (**Section 9.4** of the draft EIS/ERD). A monitoring program will be conducted post FID to verify and update baseline data through on-going data acquisition at relevant times throughout the proposed Browse Project on the distribution, abundance, seasonality and behaviour of green turtles at Scott Reef and within habitat critical to survival for the G-ScBr stock (refer to **Section 4.4**).

Topic	Issue	Advice on key considerations for Woodside	Proponent’s Response
	There are a number of limitations of the light modelling studies that affect the reliability of modelling results for informing the environmental impact assessment presented in section 6 (chapter 1). In addition, there are inadequacies in the evaluation of light impacts that collectively lead to uncertainty as to whether the project can demonstrate that impacts will not be inconsistent with the Marine Turtle Recovery Plan. Examples include: • Modelling studies have not predicted the light attenuation / received levels from flaring associated with the Torosa FPSO. On the basis that flaring will be required during start-up / commissioning until steady state (FPSO) and given the uncertainty on the duration and intensity of flaring during commissioning, the absence of modelling to predict received levels at Sandy Islet and surrounding waters is considered an important omission of the EIA. • The draft EIS / ERD does not appear to include an assessment of light glow impacts on both nesting turtles and emerging hatchlings. While light glow is largely variable and is complex to predict, compounded by scattering of light by airborne particles, it is an important impact pathway that needs to be evaluated in order to understand the potential for, and severity of, impacts to the nesting population and hatchlings. According the National Light Pollution Guidelines the recommended 20 km buffer for evaluating impacts on important turtle habitat is based on		

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
	sky glow approximately 15 km from a nesting beach affecting flatback hatchling behaviour and light from an aluminium refinery disrupting turtle orientation 18 km away which is important in the context of predicting the effects of light glow on hatchlings. • The Torosa FPSO is located within a habitat critical to survival for green and hawksbill turtles. The EIA states that most of north Scott Reef would experience sea level of brightness in the order of 0.005 to 0.035 lux. However, the evaluation does not appear to predict the received levels of light at Sandy Islet in biologically relevant wavelengths (i.e. those from UV-yellow) and discuss the potential implications for marine turtles exposed to these levels of light using relevant scientific literature. • Within 12km of the FPSO there is potential for light to be received at levels that may impact in-water life stages of marine turtles for a 40 year duration. This represents the potential behavioural disturbance footprint (approx. 450km² of habitat critical at Scott Reef from the FPSO alone). The magnitude of this potential impact and the potential consequences for hatchlings and foraging marine turtles does not appear to be evaluated in the context of demonstrating that biologically important behaviour can continue across the area of potential impact. • The EIA provided does not predict the received levels of light at Sandy Islet (in biologically relevant wavelengths and intensities) from		

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response
		cumulative light sources related to the proposed action (including the construction phase) and compare these levels to biologically relevant impact thresholds document in published literature. • There is limited information on the light mitigation / management measures that are proposed to apply to the drilling, construction and operational phases of the project. There are limited commitments to the application of mitigation hierarchy including the adoption of specific light management measures and it is unclear what best practice lighting design features (outlined in the National Light Pollution Guidelines for Wildlife) are proposed to be adopted to minimise artificial light impacts. • There is limited information on the impact verification and monitoring studies that will be implemented to verify that the project has been able to meet environmental objective(s) for marine turtles and that artificial light has not resulted in impacts inconsistent with the recovery plan.		

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response
		Aspect: Noise Noise modelling indicates that there is potential for marine turtles to be injured within 250m of the pile driving activities and experience TTS within a 5km radius from the source with behavioural disturbance thresholds reached beyond 5km (Tables 58 and 59 Chapter 10 D.3). In addition, there is potential for TTS thresholds to be exceeded during drilling activities and during operational activities of the FPSO should DP be utilised. The marine turtle recovery plan requires the management of anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to their survival. However, the EIS / ERD does not make a robust case for how noise generating activities of the project will be managed such that turtles are not displaced from habitat critical to survival. This is particularly the case for pile driving activities which have potential to displace turtles over a substantial area of habitat critical (i.e. the Torosa FPSO anchor piling location). While it is acknowledged that ANIMAT modelling has been undertaken to estimate the number of turtles exposed to noise during various stages of the project, the reliability and plausibility of ANIMAT modelling outputs is largely contingent on understanding animal distribution, abundance and behaviour. The data for Scott Reef green turtle nesting and resident / foraging populations is limited, generating uncertainty for impact assessment and for drawing conclusions relative to recovery plan requirements.		

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		Aspect: Subsidence The draft EIS / ERD predicts that production activities through the extraction of naturally high-pressured reservoir fluids, will cause a reduction in the reservoir's pressure, which has the potential to result in the compaction of the geological layers overlying the reservoir leading to potential gradual subsidence (sinking) of the seabed within the field location. It is estimated for the proposed Browse to NWS Project that the vertical seafloor movement predicted to be in a range between 2.6 – 8.9 cm) over 40 years based on modelling. The EIS / ERD states that the subsidence assessment is *'based on the peer reviewed modelling results described above with a maximum subsidence of less than 10 cm over field life'*. According to the Recovery Plan for Marine Turtles, the Scott Reef green turtle stock is considered to be restricted in its capacity to expand into other nesting areas in the event that nesting beaches are lost or sand temperatures increase as a result of climate change. The draft EIS/ ERD has not made a robust case for why the potential reduction in the height of Sandy Islet by ~10 cm will not modify habitat critical to survival, or that resulting impacts for marine turtles are not inconsistent with the recovery plan. This evaluation needs to take into account the following factors:		

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response
		• The genetically isolated / distinct nesting stock with limited / no alternative nesting habitat should modification result in reduction or removal of suitable nesting habitat • The areal extent of reduced suitable habitat for nesting turtles and the implications for nesting success / re-productive success noting that there is a high density of nesting already taking place (Guinea, 2009). • Why a reduction in any habitat that is classified as 'habitat critical to survival' is not inconsistent with the recovery plan when the recovery plan requires: ◦ Minimise anthropogenic threats to allow for the conservation status of marine turtles to **improve** so that they can be removed from the EPBC Act threatened species list. In addition, the draft EIS / ERD does not provide an adaptive management framework that is able to demonstrate that action can be taken to remedy impacts in the event that any subsidence-related effects are greater than anticipated resulting in significant modifications and the loss of habitat critical to the survival of the Scott Reef green turtle population. ***Cumulative impacts*** The project represents a large scale, multiple activity project, parts of which are located in areas identified as habitat critical to survival for marine turtles.		

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response
		While table 9-11 (ch9) provides a discussion on cumulative impacts to marine turtles, the statement *'impacts from these aspects on marine turtles are not predicted to be significant and it is considered that they can be managed to an acceptable level through the implementation of mitigation measures'* is not substantiated because: • It does not appear that the precautionary principle has been adequately applied taking into account the duration of the project, its location in habitat critical, relative significance of Scott Reef for green turtles and the levels of uncertainty in the predictions of impacts from light, subsidence and underwater noise impacts. • It is not yet clear that there will be relevant biological and impact monitoring programs in place that are able to detect changes attributed to the project and inform management response. • The EIS / ERD does not make firm commitments to specific adaptive management measures that can be implemented in the event that measured impacts are confirmed to be unacceptable/ inconsistent with the marine turtle recovery plan. • The majority of effective mitigation measures, including consideration of avoidance and lighting design measures, need to take place at the early design / engineering phases of the project.		

Topic		Issue	Advice on key considerations for Woodside	Proponent's Response
	Sea birds	**Context:** Migratory Seabirds – **Section 6.3.3.4** p. 341 acknowledges the potential for light to disrupt the magnetic compass of migrating birds and offshore facilities to disrupt migration by attracting birds either directly as a result of light emissions or indirectly as a result of light attracting other sources of prey. ***<u>Issues identified from adequacy check and initial preliminary review</u>*** The impact assessment provides an overview of the East Asian Australasian flyway overlap with the Browse project area. It concludes that there is unlikely to be an impact as there is no significant nesting or roosting areas nearby. This assessment is disjointed and appears to overlook the potential impact of the project infrastructure on migrating seabirds/shorebirds utilising the East Asian Australasian flyway and the potential for disruption to migration. It is acknowledged that the red wavelength of light is most likely to disrupt the magnetic compass and the wavelengths of light from MODU fall below this. However it is also stated that the blue green wavelengths of light are important for magnetic compass orientation and this is not considered in enough detail. This information is important in the context of Australia's obligations under the JAMBA and CAMBA.	WEL should consider providing further information on proposed mitigation and management measures, including demonstrating how proposed controls will ensure an acceptable level of impact to seabird populations.	A desktop lighting assessment, taking into account the final National Light Pollution Guidelines for Wildlife, has been undertaken and is provided in **Appendix A.1**. This includes a further literature review describing potential impacts of offshore sources of artificial light on seabirds, a gaps analysis of the assessment completed to date (against the National Light Pollution Guidelines for Wildlife, 2020), and an updated impact assessment. The key conclusions of this updated lighting impact assessment with respect to seabirds are summarised in **Section 5.31** (MF-9).

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
3. Environmental quality of the Commonwealth marine area and Scott Reef	**Aspect: FPSO wastewater discharges, including Produced water (PW)** Impacts to water quality are predicted from the discharge of produced formation water and cooling water from the FPSO facilities during the operations. According to the EIS / ERD operational discharges at the FPSO facilities will be managed to meet 99% species protection or no effect concentrations at the edge of the mixing zone and at the State waters 3 nm boundary 95% of the time (informed by based on dispersion modelling results). Based on the assessment provided in the EIS / ERD. Is it concluded that there will be no impacts from operational discharges to water quality within the Scott Reef shallow water benthic habitats (<75 m). ***Issues identified from adequacy check and initial preliminary review*** It is unclear how WEL's commitment to achieve 99% species protection at the state waters boundary around Scott Reef would ensure WA's environmental quality objectives and expectation that a maximum level of protection be afforded to state waters at Scott Reef will also be able to be achieved.	WEL should provide further information and clarification in Supplementary Report to demonstrate, with a high level of confidence, that the environmental objectives for PW and environmental quality objectives for the Commonwealth marine area, including Scott Reef can be achieved.	The State ERD (**Appendix B; Section 8.2.6** of the draft EIS/ERD) provides a description of the proposed levels of ecological protection (LEP) relevant to construction and operation activities within the State Proposal Area. In general, this affords a maximum LEP to all of the State Proposal area (including the entire extent of the Scott Reef shallow water benthic communities and habitats (<75 m bathymetry), except where an area is designated a high, moderate or low LEP due to proposed marine discharges. Subsequent to the finalisation of the draft EIS/ERD for public comment, Woodside has prepared an EQMP that is expected to be updated from time to time following conclusion of the State environmental impact assessment process. This EQMP is provided in **Appendix C.2**. As part of the development of the EQMP the proposed LEP presented in the State ERD have been reviewed and refined. This refinement has been undertaken in response to consultation with EPA Services and in consideration of the levels of environmental quality that are predicted to be maintained as per the EPA's Technical Guidance for Protecting the Quality of Western Australia's Marine Environment (EPA, 2016).

Topic	Issue	Advice on key considerations for Woodside	Proponent’s Response
	Given uncertainties associated with wastewater discharges from the FPSO, the EIS / ERD needs to assess the impacts to the environmental quality of the area that may be affected by planned discharges and evaluate why impacts are acceptable in the context of the values of the Commonwealth marine area (rather than seeking an assessment and approval of a ‘mixing zone’. This approach requires clearer presentation and discussion of the impacts and levels of protection being proposed and what this means in terms of protecting the water quality values defined under the National Water Quality Management strategy and guidelines.		Chapter 6 of the draft EIS/ERD document presents a detailed assessment of the potential impacts from marine discharges (including PW) based on conservatively applied maximum discharge rates, which are likely to occur later in the field life. This assessment, which was based on the outcomes of extensive modelling, demonstrates the extent and fate of the key marine discharge contaminants based on established literature and ecotoxicological studies. The results of the PW dispersion modelling demonstrate that while there will be a reduction in water quality, the change will be limited to approximately 1,200 m from the discharge point for steady state operations (i.e. excluding start-up and shut downs etc.) and restricted to Commonwealth waters, based on the 99% species protection for oil in water using Torosa condensate ecotoxicity. The results demonstrate that the 99% species protection will be met at the State water 3 nm boundary, ensuring that the designated LEP are achieved. The draft EIS/ERD also outlines a range of mitigation measures (e.g. containment and reprocessing of PW) that can be adopted if required. Furthermore, the impact assessment has considered the potential impacts of the operational discharges on the relevant environmental receptors, including sediments, marine fauna and benthic habitats, with a determination made on the acceptability of the impact for each receptor.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
			The reference in the draft EIS/ERD to a 'mixing zone' has been made in a descriptive context to define the boundary where the relevant threshold for 99% species protection (or lowest NOEC as relevant) has been achieved, as well as showing the number of dilutions as contours from the point of discharge to the defined boundary. The assessment of impacts has been undertaken for receptors within and outside of this mixing zone (e.g. benthic habitats at Scott Reef). The assessment of impacts has been undertaken considering the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018), including the application of ecotoxicological testing for key chemical constituents of concern, resulting in the derived threshold values that were applied to the modelling. The extent of the modelling, including the discharge parameters, ecological thresholds used and determination of the fate of chemical constituents, is presented within the draft EIS/ERD Chapter 10 D4 (RPS Marine Discharge Modelling Report). As described in the draft EIS/ERD a comprehensive environmental management framework will be in place for all marine discharges applicable to proposed Browse Project. This framework will be described in and implemented via the activities specific Environment Plans to be prepared under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. The framework will apply to both the both the Torosa and Calliance/Brecknock FPSOs. An overview of this framework including the environmental quality values and environmental quality outcomes is presented in **Section 5.15**.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
4. Risk to Scott Reef - Oil spill	***Context:*** The oil spill modelling described in the draft EIS was characterised by a number of issues which provide some indication that the modelling results were not providing sufficient inputs into an appropriate description of the environment, risk assessment, and response planning. Examples of issues identified in the preliminary adequacy-for-publication review of the draft included: • emulsification thresholds for asphaltenes, • minimum exposure threshold concentrations for surface, dissolved, entrained, and shoreline concentrations • modelling of oil fate and behaviour in shallow-water areas. While some improvements were made in the published Draft EIS issues remain with these points. ***Issues identified from adequacy check and initial preliminary review*** The EIA does not fully describe and provide a detailed evaluation of the expected fate, behaviour and ecological consequences of oil in shallow water habitats of Scott Reef.	In the supplementary report WEL should consider: • providing further information evaluating the consequence of an oil spill for ecological integrity of Scott Reef taking into account time to contact severity and irreversibility of impacts. • updating oil spill modelling based on current scientific literature including NOPSEMA guidance on oil spill exposure threshold concentrations (incl. MDO) and ITOPF guidance on emulsification thresholds. • adopting engineering controls to further reduce the likelihood FPSO grounding on Scott Reef and the subsequent release of condensate.	Woodside has presented modelling and impact assessment of worst-case credible spill scenarios on a range of receptors (including Scott Reef) within **Section 6.3.21** of the draft EIS/ERD. Quantitative spill modelling presented in the draft EIS/ERD predicted that Scott Reef shallow reef and lagoon habitats could be contacted in Scenarios 1 to 4 (refer to **Section 6.3.21** of the draft EIS/ERD). The minimum time to contact of 39 hours (Scenario 2: cargo tank rapture) would limit the ability to respond and reduce contact / exposure of the reef to hydrocarbons. The draft EIS/ERD acknowledges that Scott Reef would be impacted in the highly unlikely event of a major unplanned hydrocarbon release (e.g. Scenario 1: well loss of containment). Depending on its severity (i.e. volume, hydrocarbon type and location), a hydrocarbon release resulting from the proposed Browse Project would have the potential to impact water and sediment quality and alter habitats. This could subsequently alter fauna behaviour, cause fauna injury or mortality, impact the aesthetic value of Scott Reef and alter the function, interests and activities of other users such as recreational fishers. Should a hydrocarbon release occur at the time of coral spawning (at potentially affected coral locations), there is the potential for a significant reduction in successful fertilisation and coral larval survival due to the sensitivity of early life stages of corals to hydrocarbon exposure (Negri and Heyward, 2000). These impacts would likely be severe and potentially irreversible, which is reflected in the risk assessment presented in the draft EIS/ERD which assessed the consequence of such an event as 'catastrophic' in accordance with Woodside's impact and risk assessment guidelines.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
	While the scenario of the FPSO vessel grounded on the reef has been identified in the EIS / ERD (p452), there does not appear to be consideration to further reducing the likelihood of a condensate release through adoption of engineering controls. Consideration should be given to engineering controls or evaluation of feasible alternatives such as double bottom / hull or other engineering measures that would further limit the likelihood and potential scale of a condensate spill resulting from a vessel grounding scenario. Addressing these issues is important to support a case for the inherent acceptability of spill risks for the project taking into account the proximity of the Torosa FPSO to Scott Reef, and the potential for a spill of this nature to impact on the values of the Scott Reef complex, key ecological features and habitats for threatened and migratory species within hours of a large scale condensate spill occurring.		As noted in the **Section 6.3.21** of the draft EIS/ERD, however, such an event is considered highly unlikely to occur. Further, the extent of impacts would depend on exposure concentration, duration and the degree of weathering of the hydrocarbons. In undertaking the risk assessment of a potential major hydrocarbon release, the spill likelihood was evaluated using blowout and well release frequencies based on the SINTEF offshore blowout database 2012 (Scandpower, 2013). This uses data from 1991-2010 to determine the likelihood for well blowouts and releases. For a gas well, the SINTEF calculated probability of blowout during drilling and completion is 2.93 x 10-4. The SINTEF data supports a likelihood of 'highly unlikely' for a well blowout with the potential to result in the worst-case credible spill. Furthermore, since the Gulf of Mexico Macondo event, significant improvements in engineering and management controls have been adopted by the industry, further reducing the likelihood of such an event occurring. Prevention and response measures in relation to potential unplanned release of hydrocarbons are detailed in **Section 6.3.21.7** of the draft EIS/ERD. In addition, in response to a request from EPA Services Unit, Woodside has prepared a supplementary document, that outlines the approach Woodside will apply on the proposed Browse Project to reduce the likelihood and consequence on Scott Reef from a hydrocarbon release, focussing on well loss of containment event but being applicable to other hydrocarbon loss of containment events. The Hydrocarbon Spill Risk Management Approach is provided in **Appendix C.4**. A summary of each chapter of the document is provided in **Section 5.16**.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
			Oil spill modelling – exposure thresholds Exposure thresholds used in the assessment of unplanned hydrocarbon releases are discussed in **Table 6-155** of the draft EIS/ERD. The adopted thresholds are consistent with NOPSEMA guidance and are considered conservative (as described in **Section 6.3.21.3** of the draft EIS/ERD). ***Oil spill modelling - emulsification thresholds.*** Chapter 10, Technical Study D.5 of the draft EIS/ERD provides the Browse Project Quantitative Spill Risk Assessment Report, which concludes that the Torosa condensate has low asphaltene content (0.66%). This indicates a low propensity for the mixtures to take up water to form a water-in-oil emulsion over the weathering cycle. It is noted that International Tanker Owners Pollution Federation Ltd (ITOPF) lists 0.5% asphaltene content as an emulsification threshold, but this value is not referenced to any source and is not supported by the peer-reviewed literature. Fingas and Fieldhouse (2014) tested the emulsion-forming behaviour, as well as the stability of any emulsion formed, for over 400 oil types; characterising the oils by a range of chemical and rheological properties. Asphaltene content was identified by Fingas and Fieldhouse (2014) (and other researchers) as a major determinant, but not the only determinant, of the water-in-oil type that forms. Highly viscous oils will not form "stable" or "meso-stable" emulsions. Oils of low viscosity, or without significant amounts of asphaltenes and resins, will not form any water-in-oil types and will retain less than 6% water (during significant agitation) which will be rapidly lost. Most of the oils found to form stable emulsions had an asphaltene content > 5%.

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			Starting oil properties that were concluded by Fingas and Fieldhouse (2014) to be indicative of "unstable" water-in-oil type are: • Density < 0.85 or > 1.0 kg/l • Viscosity < 100 or > 800,000 cP • Asphaltene or resin content < 1.5%. Therefore, based on the characteristics of stabilised Torosa condensate and unstabilised Torosa condensate, these oils should not form a stable emulsion, noting the asphaltene content of 0.66%. ***<u>FPSO loss of station scenario:</u>*** The key controls for managing unplanned hydrocarbon releases have been provided in **Section 6.3.21.1**7 of the draft EIS/ERD. As the FPSOs are permanently moored, the only credible scenario for FPSO loss of station with subsequent impact on Scott Reef during operations is due to an extreme weather event which causes the turret mooring system to fail. In this instance the key control mitigating this risk is the design of the mooring system, and this control is listed in the draft EIS/ERD: "FPSO facilities are assessed against one in 10,000-year return period weather conditions to mitigate risk of extreme weather conditions." A double bottom hull was evaluated for the FPSOs. However, this control was not selected as: • In an extreme weather event, whereby the mooring system fails and the FPSO is grounded, the pounding action of waves would likely penetrate either a single or double bottom hull, releasing hydrocarbons.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
			• The inclusion of a double bottom hull increases potential for safety incidents, as between approximately 0.25 - 1.0 worker-years per year more confined space entry time would be required to undertake tank inspection, maintenance and repair in a double bottom hull. As a double bottom hull is unlikely to provide material risk reduction for a scenario which is already considered to be remote and represents an increase in occupational health and safety exposure, it has not been included in the design. **Section 6.3.21.3** of the draft EIS/ERD provides details on why the FPSO loss of station scenario was not selected for modelling.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
5. Decommissioning	Draft EIS does not provide adequate commitment in relation to the process that will be applied to the project for progressive removal of property from the title areas as it becomes disused.	WEL should consider clear commitments to progressively removing property from title areas as it becomes disused at the end of activity stages.	Decommissioning will occur once infrastructure has reached the end of its economic life and may occur in stages. The process to determine timing for decommissioning of unused infrastructure will be detailed in operations Environmental Plans (EPs) towards (but prior to) the end of field life. All infrastructure installed above the seabed will be designed to allow removal. The base decommissioning case is for the removal of infrastructure, however, given the possible improvements in technology that may occur between now and the time of decommissioning, it is not possible to fully scope the decommissioning strategy that will be employed at that time. The strategy (which may also include an assessment of alternatives to the complete removal of subsea infrastructure) will be demonstrated through activity-specific EPs developed closer to the time.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
6. Greenhouse Gas Emissions	The Draft EIS considers avoidance, mitigation and management of Greenhouse Gas at a high level, however, the document lacks detail including: • how GHG emissions have been avoided, • how effective the proposed measures are, • whether the measures are mitigating emissions to the greatest extent possible, • whether the measures proposed are best practice • what other options there are that might be considered to achieve better outcomes over the life of the project including but not limited to investigation of emerging technologies, research into better methods etc.	WEL should consider providing further evidence to demonstrate that GHG emissions have been avoided, mitigated and managed to the fullest extent possible within the scope of the project. This should include consideration of emerging technologies and their applicability to the project and options to look at research to develop better mitigation technology over the life of the project.	The proposed Browse Project has been designed with consideration of the avoidance of GHG emissions and a list of the key emissions reduction measures has been provided in **Section 7.7.1** of the draft EIS/ERD. Accompanying this list is an estimate of how effective the controls will be in terms of the anticipated emissions reduction that has been provided. The design of the proposed Browse Project, including the proposed emissions reduction measures, represents best practice as: • **Figure 7-4** of the draft EIS/ERD demonstrates that the design is highly energy efficient upstream relative to other facilities with similar properties (i.e. reservoir CO_2 and tieback length). • The proposed emissions reduction measures include emerging technologies, such as the active heating flowline system and batteries, the former is currently being qualified to meet the proposed Browse Project conditions, and the latter has only been implemented once in offshore oil and gas facilities (at Goodwin Alpha, another Woodside operated facility).

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
			As outlined in **Section 7.7.3** of the draft EIS/ERD and **Section 5.10** of this Supplement Report to the draft EIS/ERD, geo-sequestration is presently a high risk, high cost mitigation option for Browse reservoir CO_2, and is not proposed in the draft EIS/ERD or this Supplement Report to the draft EIS/ERD. Opportunities nevertheless continue to be monitored and assessed as technology improves. As such, the BJV is continuing to assess the feasibility of carbon capture and storage opportunities, but these do not form part of the referred proposed action. Should an opportunity be considered feasible in future from a technical, commercial and regulatory perspective and be able to be progressed by the BJV in relation to the Browse titles, this will be separately referred by Woodside as Operator for and on behalf of the BJV. The generation and use of Australian Carbon Credit Units (ACCUs) through approved and validated carbon farming methodologies is a significantly lower risk and more cost-effective option that achieves an equivalent climate outcome. Australian generated ACCUs also offer potential co-benefits resulting from the additional ecosystem services provided when carbon is bio-sequestered, as well as social, economic and environmental benefits (e.g. improvements to air quality, employment opportunities in remote communities or provision of additional habitat for fauna). Woodside, as Operator of the proposed Browse project, will work with the BJV participants to continue to work to reduce (net) emissions intensity through improvements in energy efficiency, investments in bio-sequestration projects and innovation in production processes.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
			A GHG Management Plan (GHGMP), which describes how the proposed Browse Project will continuously review mechanisms to mitigate and manage GHG emissions, has been developed consistent with and in support of the draft EIS/ERD. This plan is appended in **Appendix C.1**. Further information on measures to avoid reduce and offset GHG emissions relating to the proposed Browse Project are detailed in **Section 5.4**.
7. Offsets	Offsets are required to compensate for residual significant impacts, and are not used to make unacceptable impacts acceptable. No discussion of offsets is provided in the draft EIS. Where a residual significant impact occurs that is determined to be acceptable, offsets will be required to compensate for the residual impacts. The Department expects that an offset package will be developed for this project which may include Green Turtles, Pygmy Blue Whales, Greenhouse Gas Emissions and the environment of Scott Reef.	WEL to commit to developing an offset plan for whales, turtles, GHG and Scott Reef and should provide information in the supplement on proposed offset options. As stated within the EIS guidelines, any offsets proposed must consider the principles in the *Environment Protection and Biodiversity Conservation Act* 1999 Environmental Offsets Policy (2012) (among other considerations in 3.10.4 of the EIS guidelines.	***GHG*** Woodside is committed to its obligations under the National Greenhouse and Energy Reporting (Safeguard Mechanism) (NGER/SGM). Based on the National Greenhouse and Energy Reporting Act 2007 (NGER Act) SGM emissions baseline requirements, it is anticipated that emissions from the proposed Browse Project will exceed any anticipated facility baseline. This would likely result in SGM offset obligations, which at this stage are required to be met in the form of ACCUs. This mechanism will ensure proposed Browse Project emissions stay within agreed limits, which are set to ensure Australia meets its commitments under the Paris Agreement. Since the draft EIS/ERD was published on 18 December 2019, the National Greenhouse and Energy Reporting (Safeguard Mechanism) Amendment (Prescribed Production Variables) Rule 2020 has been promulgated. These amendments introduce production variables and some default emissions intensity values into Schedule 2 and 3 of the Rules, but other Schedules and emissions intensities remain to be clarified. Woodside will continue to monitor legislative changes and comply with the applicable legislative obligations in force throughout the life of field.

Topic	Issue	Advice on key considerations for Woodside	Proponent's Response
			The SGM is intended to be periodically adjusted (Australian Government, 2019). This flexibility is designed to allow for an adjustment of the SGM baseline over time to reflect future changes to the Nationally Determined Contributions (NDC) under the Paris Agreement and other changes, such as technological advances. ***Marine*** Woodside is committed to minimising any adverse impacts on green turtles, pygmy blue whales and the Scott Reef environment from the proposed Browse Project. The EPBC Act Environmental Offsets Policy states that environmental offsets provide environmental benefits to counterbalance any significant 'residual impacts' that remain after avoidance and mitigation measures. As outlined **Section 4.2 and 4.3**, the residual impacts on green turtles, pygmy blue whales and the Scott Reef environment are not significant (as defined under the Significant Impact Guidelines available at www.environment.gov.au/epbc/guidelines-policies.html). The proposed Browse Project has committed to updating existing green turtle and pygmy blue whale data by targeted monitoring programs to verify impact predictions and inform adaptive management approaches at relevant times throughout the proposed Browse Project (**Section 9.4** of the draft EIS/ERD).

3.2 Department of Agriculture, Water and the Environment – Marine Parks Branch

Table 3-2 DAWE Marine Parks Branch comments and Proponent's response

	Marine Parks Branch Comments	Proponent's response
1	We previously advised that the draft EIS/ERD does not include adequate information on Australian Marine Park values. This is still the case as we have identified the below missing values in **Table 5-29** for Kimberley, Argo-Rowley Terrace and Mermaid Reef marine parks. These Australian Marine Parks are managed under the North-west Marine Parks Network Management Plan 2018 (the Management Plan), which includes further details on the values. a. **Kimberley Marine Park** i. The draft EIS/ERD references an overall IUCN Category of IV (Habitat Protection) and not VI (Multiple Use). The zone category needs to be corrected (refer to Table S2.1 on page 91 of the Management Plan). ii. The Biologically Important Area - foraging habitat for seabirds is missing as a Natural Value. iii. There is no reference to Historic Shipwrecks under Heritage Values. iv. Identified sea country is missing under Cultural Values. b. **Argo-Rowley Terrace Marine Park** v. There is no reference to Historic Shipwrecks under Heritage Values. vi. Identified sea country is missing under Cultural Values. c. **Mermaid Reef Marine Park** vii. There is no reference to ecosystems associated with emergent reef flat, deep reef flat, lagoon and submerged sand habitat under Natural Values. viii. There is no reference to tourism and recreational activities under Social and Economic Values.	**Kimberley Marine Park** It is acknowledged that **Table 5-29** (column 2) of the draft EIS/ERD incorrectly states the IUCN Category as IV – Habitats/Species management area. The correct IUCN category is VI (Multiple Use). It should be noted that the remainder of the draft EIS/ERD refers to the correct IUCN category. Woodside confirms that the impact assessment has been undertaken based on the correct category. **Table 5-29**, dot point 3 of the draft EIS/ERD should read "breeding and foraging' habitat for seabirds (**Section 5.3.2.2** and **Section 5.3.2.4**). Foraging was left off in error. As per **Table 5-20** of the draft EIS/ERD, potential seabird foraging BIAs have been considered in the impact assessment including those in the Kimberley Marine Park. It is acknowledged that **Table 5-29** of the draft EIS/ERD does not refer to the more than 40 known shipwrecks listed under the **Historic Shipwrecks Act** 1976, noting that none of these historic shipwrecks are present along the proposed BTL route. It is noted that as described in **Section 5.4.3.2** of the draft EIS/ERD, a suspected sunken Indonesian fishing boat was identified during the survey of the BTL route. It is acknowledged that identified sea country should be included in Table 5.29 of the draft EIS/ERD. Sea country has now been included in the revised Table 5.29 (**Appendix B.1**). **Argo-Rowley Terrace Marine Park** Refer to the above responses. **Mermaid Reef Marine Park** It is acknowledged that reference to ecosystems associated with emergent reef flat, deep reef flat, lagoon and submerged sand habitat has been inadvertently not included under Natural Values. Note that the ecosystems of Mermaid Reef are described in detail in **Section 5.3** and in **Table 5-29** of the draft EIS/ERD which states the AMP is of national and international significance due to its pristine character, coral formations, geomorphic features and diverse marine life. It is a key area for over 200 species of hard corals and 12 classes of soft corals with coral formations in pristine condition. The missing reference to tourism and recreation activities is also acknowledged and has been corrected in the revised Table 5.29 (**Appendix B.1**). **Updated Table 5-29 of draft EIS/ERD** An updated Table-5-29 (Australian Marine Parks (AMPs) within the vicinity of the Project Area) has been provided in **Appendix B.1.**

	Marine Parks Branch Comments	Proponent's response
2	There is no evidence of consultation with Bardi Jawi, Mayala, Nyul Nyul, Dambimangari and Wunambal Gaambera groups who have sea country interests in/adjacent to the Kimberley Marine Park. There is reference to consultation with Dampier Peninsula communities, however, there is no list of those consulted and it would be useful to at least have a list at the organisation level.	Engagement has been undertaken with the Kimberley Land Council (KLC) which is the nominated point of contact for Bardi Jawi, Mayala, Nyul Nyul, Dambimangari and Wunambal Gaambera groups. Specific engagement has included: • A meeting to provide an overview of the proposed Browse Project was held in December 2018 with a range of stakeholder including KLC. • On 18 December 2019, KLC was notified of the commencement of the public comment period. The link to the draft EIS/ERD was provided as was an invitation to meet. • On 15 January 2020 a notification of Woodside's 'public info events' was issued to KLC, and Woodside offered the opportunity for a personal briefing. • Engagement has also been held with Dampier Peninsula communities regarding the draft EIS/ERD throughout 2019 and January 2020; including Lombadina Aboriginal Corporation (includes Bardi Jawi), Djarindjin Aboriginal Corporation, Waardi, One Arm Point and Ardyaloon, Beagle Bay (includes Nyul Nyul and Jabbir Jabbir) and Kullari Regional Communities Incorporated (KRCI). • Browse Project update provided to KLC on 27 March and 4 April 2020.
3	The draft EIS/ERD could provide clearer and robust reasons given for the proposed location of the Browse Trunkline (BTL) route relative to the Mermaid Reef Marine Park, which underpin a case in the draft EIS/ERD for how impacts to Australian Marine Parks associated with the BTL installation and operation are acceptable and reduced to as low as reasonably practical. The case presented should also further support why there would be no other reasonably practicable and feasible options.	A BTL alternatives assessment is presented in **Section 3.8.3.2** of the draft EIS/ERD. This assessment focused on the BTL route from a broader perspective including an assessment of whether the route could avoid incursion into AMPs and whether it was possible to increase the separation between the BTL and the Mermaid Marine Park National Park Zone and Rowley Shoals State Marine Park. As discussed in **Section 3.8.3.2** of the draft EIS/ERD, an alternative route that runs south of the Argo-Rowley Terrace Marine Park Multiple Use Zone was assessed and found not to be preferable due to the shallower water and significant sand waves present. Installation of the BTL in this alternative area would require substantial seabed intervention to prepare the seabed for placement of the BTL. The intervention required would likely be via means such as mass flow excavation, trenching, ploughing or the placement of rock berms. The significantly shallower water would require significant secondary stabilisation after the pipe was laid to ensure pipeline integrity. Both extensive seabed preparation and secondary stabilisation would result in additional impact to receptors (e.g. localised turbidity and removal of benthic habitat) as well as additional cost. It should also be noted that this alternative BTL route would be longer and subsequently have increased impacts via seabed disturbance compared with the proposed BTL route, as well as additional steel requirements and GHG emissions from vessels during installation.

	Marine Parks Branch Comments	Proponent's response
		Given the above, it was determined that the additional potential environmental impact, cost and technical complexity of adopting alternative routes that avoid the Argo-Rowley Terrace Marine Park would significantly impact the proposed Browse Project, while potentially increasing the environmental impact. As such, it is considered that the proposed BTL route represents the only reasonably practicable and feasible option. With respect to the benthic habitat along the proposed BTL route, a benthic survey was undertaken in March and April 2019 to confirm the environmental characteristics of the seabed. Analysis of the benthic imagery acquired during an environmental survey of the BTL route found that the seabed along the BTL route within the AMPs was predominantly composed of unconsolidated soft sand, largely devoid of epibenthic communities, with occasional solitary non-coral benthic invertebrates (Advisian, 2019). Subsequent to the release of the draft EIS/ERD for public comment, high-quality seabed imagery of the BTL route within the marine parks acquired by an automatous underwater vehicle (AUV) has become available. A review of the AUV imagery demonstrated that the seabed along the selected sections of the BTL route within the Argo-Rowley Terrace Marine Park showed the seabed along this section of the BTL was characterised by unconsolidated soft sand forming shallow sand waves, largely devoid of epibenthic communities, with occasional solitary non-coral benthic invertebrates (e.g. crinoids, seapens, starfish and anemones), crustacea and demersal fish observed. A representative image of the seabed along the BTL route within the Argo-Rowley Terrace Marine Park is shown in **Figure 3-1**. Given the homogeneous nature and confirmation of no habitat or seabed features indicating areas of increased marine biodiversity along the proposed BTL route, impacts resulting from seabed disturbance are not predicted to be significant. Given this, there is a high level of confidence that the installation and operation of the BTL will not result in a reduction in the conservation values of the AMPs and it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018).
4	The draft EIS/ERD needs clarification of the final BTL route and whether it will go closer or inside the Mermaid Reef Marine Park and inside the Mermaid Reef and Commonwealth water surrounding Rowley Shoals Key Ecological Feature (KEF).	As shown in **Figure 1-2**, the BTL route is subject to refinement, particularly near the Rowley Shoals and the tie-in point near NRC. The hatched area shown in **Figure 1-2** represents the area in which the final route will lie. Woodside confirms that: • With reference to the proposed BTL route, the final BTL route will lie within the hatched area shown in **Figure 1-2** and the at this hatched area will not be moved closer to Mermaid Reef Marine Park. The BTL route will not enter the Mermaid Reef Marine Park.

	Marine Parks Branch Comments	Proponent's response
		• As described in Chapter 6 of the draft EIS/ERD, the final BTL route may lie inside the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals Key Ecological Feature (KEF). The impact assessment has, therefore, been undertaken on the basis that the BTL enters this KEF. ***BTL route refinement*** As detailed in Chapter 3 of the draft EIS/ERD, a BTL route corridor has been proposed, with the final route to lie within the defined corridor (**Figure 1-2**). Since release of the draft EIS/ERD for public comment, Woodside has continued to assess options with respect to the BTL route within the nominated route corridor. This included a review of the metocean conditions, geotechnical input data, assessment of the seabed intervention alternative equipment, and a preliminary assessment of the BTL route alignment options in the vicinity of Mermaid Reef Marine Park. The review was undertaken in consideration of a region of high seabed currents with significant sand waves identified during the BTL route geophysical survey. If not mitigated, the sand waves would create pipeline free spans (where the pipeline spans between highpoints). The preliminary assessment of the BTL placement within the defined corridor aimed to minimise the overall environmental impacts and risks, through consideration of the following: • minimising integrity risks to the BTL (and associated hydrocarbon inventory) through limiting span risk and management requirements • minimising overall seabed disturbance, including consideration of the uniform regional characteristics of the benthic habitat • minimising risks to the Mermaid Marine Park National Park Zone and Rowley Shoals State Marine Park associated with the installation activities (i.e. hydrocarbon inventory of the vessels etc). It should be noted that a final decision has not been made and route selection will be further assessed as part of Front-End Engineering and Design (FEED). It should also be noted that the BTL corridor is quite narrow where it passes outside of the Mermaid Reef Marine Park and then widens as it passes the other reefs of the Rowley Shoals. Key drivers in the ongoing route refinement process include: **Health and safety:** Routes within the proposed BTL corridor closer to Rowley Shoals and the Mermaid Marine Park are shorter and less complex to construct, inspect and maintain. Routes further from these features within the proposed BTL corridor would require increased seabed intervention during construction and increased inspection and maintenance frequency. This would result in increased exposure hours (i.e. increased health and safety risk).

	Marine Parks Branch Comments	Proponent's response
		Environment: At its closest point, the proposed BTL route corridor is greater than 2 km from Mermaid Reef Marine Park and greater than 3 km from the Rowley Shoals State Marine Park. This means that irrespective of the final route selection there are no predicted impacts from planned activities to the Rowley Shoals. Further, routes outside of the KEF and those further away from Mermaid Reef Marine Park will require significantly more seabed intervention (e.g. mass flow excavation, trenching, ploughing) and pipeline stabilisation activities. Environmental impacts from such activities (e.g. seabed habitat removal, turbidity generation) would be higher compared to areas where limited seabed preparation is required. It should be noted that subsequent to the release of the draft EIS/ERD for public comment, high-quality seabed imagery of the BTL route acquired by an AUV has become available. This seabed imagery builds on the available information regarding the seabed along the BTL route acquired from the environmental survey as described above. A review of a representative portion of the AUV imagery demonstrated that the seabed along the BTL route near Rowley Shoals and Mermaid Reef Marine Park is predominately unconsolidated soft sand, with only occasional solitary non-coral benthic invertebrates and demersal fish observed. No seabed features or areas of topographic complexity indicative of higher benthic community biodiversity were observed and there did not appear to be any association between the presence or abundance of benthic biota and the designated AMP seabed areas based on the images reviewed. It should also be noted that routes further to the south east are longer and would result in additional steel requirements and GHG emissions from vessels during installation. **Technical viability:** Within the BTL route corridor preliminary assessments suggests that the technical complexity is higher for routes outside of the KEF and further away from Mermaid Reef Marine Park and will require significantly more seabed intervention and pipeline stabilisation activities. In areas where seabed sand waves of over 5 m exist this would significantly impact the proposed Browse Project. **Cost:** Total cost (capital expenditure and operating cost) increases for routes placed outside of the KEF and further from Mermaid Reef Marine Park due to the requirement for significantly more seabed intervention (e.g. mass flow excavation, trenching, ploughing) and pipeline stabilisation activities. The nature of the benthic habitats in the area, the lack of predicted impacts to the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF and Mermaid Reef Marine Park; and the existing authorisation by the Director of National Parks via the North-west Marine Parks Network Class Approval – Mining Operations and Greenhouse Gas Activities, provide a high level of confidence that the installation and operation of the BTL will not result in a reduction in the conservation values of these features. As such, it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management Plan (Director of National Parks, 2018).

	Marine Parks Branch Comments	Proponent's response
5	**Table 1-14** AMP Features assessment' (page 18) categorises the Australian Marine Parks 'Receptor sensitivity' as 'Medium value (multiple use zones)'. We are not convinced by this reasoning as Mermaid Reef Marine Park is a National Park Zone (IUCN II) and the 'Assessment and Conclusion' does not reference Mermaid Reef Marine Park, only Kimberley Marine Park and Argo-Rowley Terrace Marine Park. Whereas in '**Table 1-15** State marine parks and nature reserves assessment' the 'Receptor sensitivity' is 'High value'.	As described in Chapter 6 of the draft EIS/ERD, the Mermaid Reef Marine Park lies outside of the Project Area and due to the minimum 2 km separation of the marine park boundary to the BTL route, no impact to the marine park is expected to occur as a result of the proposed action. As such, the Mermaid Reef Marine Park was not referenced in the conclusions, with the focus placed on the AMPs which may be impacted on by the proposed Browse Project. It is note that the Mermaid Reef Marine Park is referenced in the impact assessment of each relevant aspect within Chapter 6 of the draft EIS/ERD. Given this, it is considered appropriate to apply the medium value (multiple use zones) in accordance with Woodside's impact and risk assessment guidance. Woodside does agree that a 'high value' would be applied to the Mermaid Reef Marine Park (National Park Zone) in the assessment as per Woodside's impact and risk assessment guidance. It should be noted however that applying the same approach to Mermaid Reef Marine Park with a 'high value' for receptor sensitivity, would result in an impact significance level of "no impact predicted'. That is, the results of the impact assessment and conclusions with respect to acceptability would not change from that presented in the draft EIS/ERD.
6	'**Table 1-18** Tourism and Recreation/Scientific studies assessment' (page 20) refers to tourism operations in state waters and Scott Reef, but does not mention tourism at Mermaid Reef.	Acknowledged. This was not considered relevant due to the distance of the BTL route from the boundary of the Mermaid Reef Marine Park (~2 km) and subsequent lack of predicted impacts.
7	Authorisation by the Director of National Parks for oil and gas activities (construction of the Browse trunkline) in these Australian Marine Parks is covered by the North-west Marine Parks Network Class Approval – Mining Operations and Greenhouse Gas Activities (the Class Approval). Under the Class Approval, the activities must be conducted in accordance with an Environmental Plan accepted under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS Regs) and meet conditions of the Class Approval.	Acknowledged. Installation, operation (including IMMR) and decommissioning activities will be subject to an accepted EP.
8	The DNP is a 'relevant person' under the OPGGS Regs where oil and gas activities occur in, or potentially impact on, Australian Marine Parks. This means the DNP must be consulted on an Environment Plan required for the construction, installation, operation, maintenance and eventual decommissioning of this pipeline. It is our expectation that through the Environment Plan assessment process that the potential impacts and risks of the activity on marine park values will be acceptable and avoided or reduced to as low as reasonably practicable.	Noted.

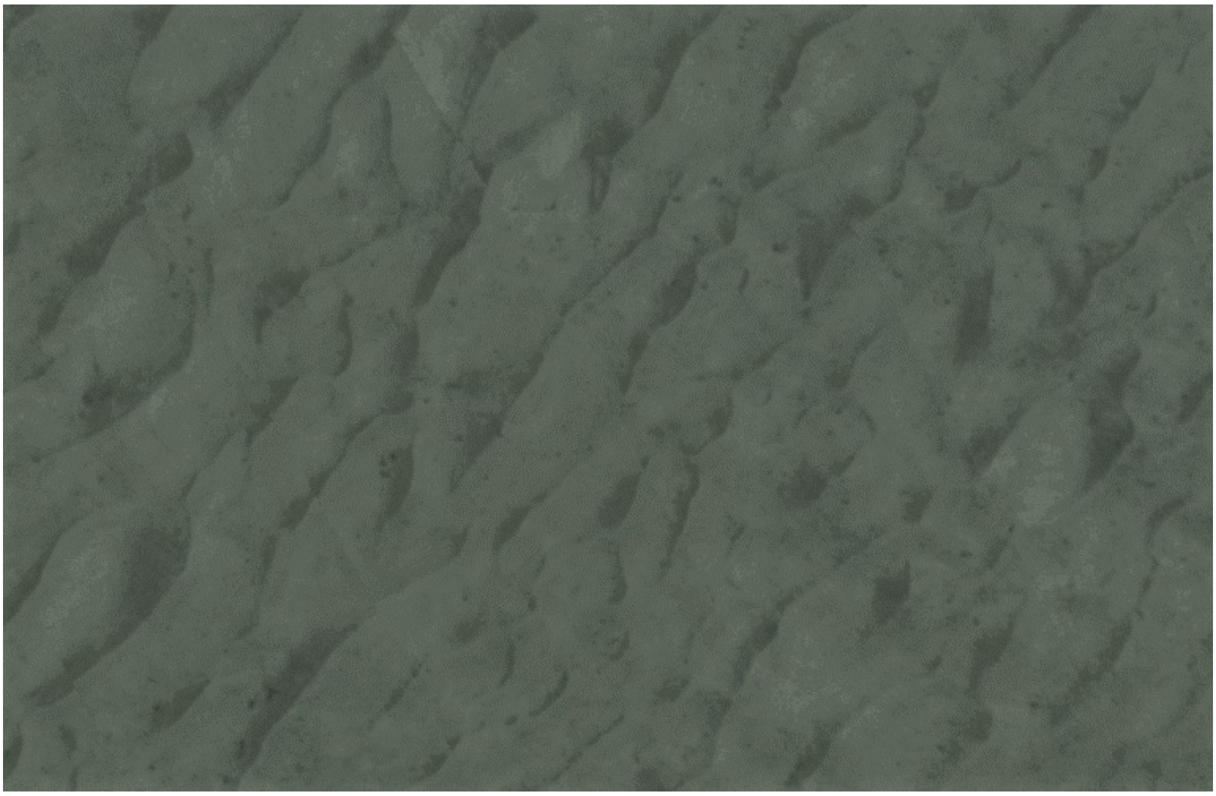

Figure 3-1 Representative image of seabed along the BTL route within the Argo-Rowley Terrace Marine Park

4. SUPPORTING INFORMATION

4.1 Modelling conservatism

Marine discharge and hydrocarbon spill modelling

Modelling is a predictive tool for the purposes of impact and risk assessment and as such there are assumptions and inherent uncertainties within the process which are addressed through the application of conservatism and sensitivity testing. The modelling presented in Chapter 10, **Appendix D.4** of the draft EIS/ERD is considered conservative given the selection of inputs and the overall modelling approach. Model inputs are based on the current basis of design, and typically represent the maximum design specifications (e.g. discharge rates, discharge orientation) providing the worst-case scenario. For example, for PW the maximum discharge rate was used, however rates will vary over the life of the proposed Browse Project, with increasing volumes of PW generated later in field life. While refinements to the design may occur as part of the FEED process, the outcomes will be demonstrated to remain within the defined impact envelope described in the draft EIS/ERD to ensure that predicted impacts are not greater than approved.

The far-field modelling is considered conservative in its approach. A stochastic modelling procedure is followed, where the characteristics of a single spill or discharge are simulated many times under randomly-selected samples of environmental conditions that are drawn from long term hindcast records representing the current and wind conditions that have occurred in the study area. The stochastic process is designed to capture the largest possible range of environmental forcing conditions that could occur during spill or discharge events, accounting for wide variations in the transport and weathering of marine pollutants, in order to map the potential spatial distribution of contaminants if an event was to occur. Within each simulation, random variations in wind and current forcing are applied to each discrete sub-portion of the overall spill/discharge volume to capture additional variability in potential transport patterns.

Current data are sourced from a ten-year hindcast data set of combined large-scale ocean (BRAN) and tidal currents to capture variations over time scales ranging from hourly to interannual, inclusive of major oceanographic trends (such as the ENSO index). Spill/discharge times within the ten-year span are identified by random selection which ensures that the sequences of environmental conditions imposed on the simulations are representative of the frequency at which particular environmental forcing conditions occur in the vicinity of the potential spill/discharge sites. This methodology ensures that the calculated movement and fate of pollutants is based on realistic environmental conditions applied within each simulation, and that the collective sample of simulations is representative of the range and frequency that particular environmental conditions occur. The environment that may be affected (EMBA) envelope, and contours indicating higher probabilities of contact within this envelope, are analysed from the collection of replicate simulations. This process is conservative because it ensures that simulations resulting in unusually long or wide migrations of pollutants have a larger effect on the EMBA than those with more common conditions.

The stochastic contours of hydrocarbon spill scenarios are analysed from all replicate simulations to show statistics for locations that might be contacted at greater than 1% probability (i.e. 1% of any possible spill/discharge times) at conservative concentrations, with the thresholds considering concentrations that might result in water quality or socio-economic effects. An allocation of 1% probability of contact to any location follows a conservative approach, a location will be marked as having at least this probability of contact if the threshold concentration is reached at any model time-step during any spill simulation. For a location to be included within the EMBA, such an outcome needs only to be calculated for any single 60-minute time-step during any single multi-week spill simulation. Allowing for ‘hits’ to be triggered by transient (acute) exposure times is additionally conservative in terms of ecological impact, because the toxicity thresholds that are applied have been calculated as protective levels with an assumption of more sustained (chronic) exposure times (24+ hours). Further conservatism is built into calculations for in-water concentrations (dissolved and entrained hydrocarbons) by analysing for the maximum concentration at any depth level (and, again, at any time-step during any simulation). This includes very shallow depths immediately below the surface. Separate assemblages of stochastic replicates are simulated and analysed to quantify risks associated with a spill commencing during each season. The seasonal EMBA contours are then overlain to represent the annualised EMBA envelope. This process is conservative because it ensures that all locations predicted to be contacted are included, and that any elevation of risk that might occur within a particular season is not obscured by averaging out probability calculations over multiple seasons.

For the continuous marine discharge simulations, very fine spatial resolution (40 m or less) and time-step (60 seconds) have been applied as a conservative approach that avoids artificial dilution of in-water concentrations. While plumes generated by marine discharges will vary in concentration in a patchy manner over time and in three-dimensional space, the presented results quantify the highest patch concentrations (lowest dilutions) calculated over time in each model cell. Calculations will therefore be more conservative than if the average concentration in each cell were taken. The results are summarised for the 95th percentile occurrence, which illustrate the distribution of concentrations expected to occur up to 95% of the time. Given the approach to deriving maximum contaminant concentration/ minimum dilutions within the model (e.g. exceedance within an individual grid cell in a modelled 60 second time step), the application of thresholds based on both acute (hours) and chronic toxicity (days) to derive areas of potential impact also has inherent conservatism. This is because the duration of sustained exposure required to cause impact is not necessarily being reached at all locations particularly in the far field, given the varying hydrodynamics and mixing characteristics of a discharge.

Underwater noise modelling

The underwater noise modelling presented in Chapter 10, **Appendix D.3** of the draft EIS/ERD has also incorporated various layers of conservatism.

With the exception of impulsive sound sources, the adopted acoustic source parameters incorporated into underwater propagation modelling represent hypothetical source values that represent the upper limit or maximum source values reported during sound source characterisation monitoring. Source level values are typically presented as values @ 1 m, which provides for a standardised and comparative approach, however this assumes the sound is radiating from a single point source in space. In reality sound radiates from a much wider area relative to the nature of the source type. Accordingly, the simplification of adopting source values referenced to @ 1 m has the tendency to commonly misrepresent the near field received levels of sound sources.

The sound speed profile incorporated within acoustic propagation models is well known to influence on propagation distance. In the draft EIS/ERD, June was selected as the most conservative sound speed profile month, which is expected to be more favourable for longer range propagation compared to other months; despite peak temporal sensitivity for most species occurring outside this period (pygmy blue whales and green turtles).

Acoustic propagation modelling broadly estimates the propagated sound field in three dimensions (x, y and z). However, for the purposes of simplifying how ranges to defined thresholds are presented and reported, the water column or depth component (z) is simplified and presented as the maximum value predicted across the water column depths modelled (typically seabed to surface). Although this doesn't significantly influence nearfield results (<1 km), for longer propagation ranges, in particular where sound can refract into deeper and relatively narrow slices within the water column, the simplification of maximum over depth can conservatively influence estimated predictions, which is confounded when assessing cumulative sound exposure levels over 24 hour periods (SEL_{24h}), as described further below. A more detailed overview of the propagation modelling methodology is outlined within Chapter 10, **Appendix D.3** (Sub Appendices E and F) of the draft EIS/ERD.

The assessment of impacts from underwater noise within the draft EIS/ERD is primarily based upon adoption of the conservative maximum range (R_{max}) results. The presented maximum range (R_{max}) value represents the distance to the farthest occurrence of the threshold level, whereas the 95th percentile range ($R_{95\%}$) encompasses 95% of the sound at levels above threshold (both R_{max} and $R_{95\%}$ values incorporate maximum over depth as described above). Using $R_{95\%}$ values reduces the sensitivity to extreme outling values (the farthest 5% of impact ranges). The assessment of impacts from underwater noise within the draft EIS/ERD are considered conservative as they are primarily based upon adoption of the R_{max} results. For example, within the draft EIS/ERD, the modelled marine mammal behavioural response R_{max} range for impact piling with an IHC S-600 hammer is up to 150% larger than the quoted 95th percentile behavioural response range.

The sound exposure level (SEL_{24h}) thresholds adopted for injury (PTS) and auditory fatigue (TTS) are based upon a time accumulated dosage of sound exposure (up to 24 hours). Accordingly, any elements of conservatism incorporated into the acoustic propagation model described above are compounded due to the cumulative nature of SEL exposure estimates. SEL_{24h} values are inherently conservative by nature as they assume an animal is required to be within the defined impact range for a period of up to 24 hours. Whilst this may be possible for larger PTS or TTS ranges, in environments where animals are known to be resident, it is not credible for sources that have much smaller impact radii. To provide more representative SEL_{24h} values, the incorporation of animal movement and behaviour (ANIMAT) into the propagation model is a useful tool to demonstrate the probability of exposure within these ranges and therefore a more representative estimation of potential impacts.

4.2 Pygmy blue whales

4.2.1 Introduction

In this section Woodside has provided more information and further evaluation in the form of additional analysis on the key impacts and risks specific to the pygmy blue whale species, as presented in the draft EIS/ERD. Additional project definition is now available that has allowed verification at a higher level of granularity. The key information presented is as follows:

- Woodside's conservative approach to impact and risk assessment for the pygmy blue whale (EPBC Act listed threatened and migratory species)
- updates to the information on cumulative impacts assessment for the pygmy blue whale
- Woodside's commitment to further management controls to mitigate and minimise potential impacts to this species
- updates to the environmental objectives specific to this species
- the further evaluation of the proposed Browse Project against the Conservation Management Plan for the Blue Whale 2015-2025 (Blue whale CMP) (Commonwealth of Australia, 2015a).

4.2.2 East Indian Ocean pygmy blue whale population

The proposed Browse Project Area overlaps with two BIAs for the East Indian Ocean pygmy blue whale population, namely, the migratory BIA and the possible foraging area BIA at Scott Reef (**Figure 4-1**). The possible foraging area is a large offshore, open water area that encompasses:

- North and South Scott Reef and the deep water channel between the reefs
- nearly all of State waters surrounding Scott Reef (the State Proposal Area)
- all of the drill centres in the Torosa field
- the Torosa FPSO location.

Woodside has collected multiple datasets over multiple years to understand pygmy blue whale dynamics (abundance, seasonality, migration) in the Browse Development Area (refer to **Table 5-24** and **Section 5.3.2.5**.2 of the draft EIS/ERD) and this underpins the proposed Browse Project's impact assessment (Chapter 6 of draft EIS/ERD). The studies include the following:

- Satellite tagging of eleven pygmy blue whales and their north bound migratory movements tracked from Perth Canyon into Indonesian waters (Double et al., 2014).
- Passive Acoustic Logger programs deployed in and surrounding Scott Reef, North West Cape and west of the Montebello Islands which detected singing pygmy blue whale calls plus other baleen whales (low frequency calling whales) and confirmed seasonality in the north and south bound migrations (McCauley, 2011; McCauley and Jenner, 2010).
- Physical and biological oceanographic characteristics of Scott Reef. AIMS undertook inter-seasonal cruises and collected data from water quality loggers between 2008 and 2010 in the south Scott Reef lagoon and deep water channel between North and South Scott Reef (Brinkman et al., 2010).
- Vessel and aerial based surveys undertaken over multiple years to establish a baseline understanding on the distribution, relative density and abundance of marine megafauna off the Dampier Peninsula, Kimberley and extending out to Scott Reef (RPS Environment and Planning, 2010a, 2010b; RPS Environment and Planning Pty Ltd, 2012, 2011). Vessel based surveys undertaken in the Browse Basin during the winter and spring (2008) and reported in the (Sutton et al., 2019) description of habitat association of cetaceans and seabirds in the tropical eastern Indian Ocean.

For a large marine mammal that migrates and feeds in offshore waters, undertaking studies to better understand population numbers, inter-seasonal variability and foraging dynamics is logistically and scientifically difficult. As the Conservation Management Plan for the Blue Whale - A Recovery Plan under the *Environment Protection and Biodiversity Conservation Act* 1999 Commonwealth of Australia 2015-2025 (Blue Whale CMP) outlines, the status of this population is complex, as it is unknown what proportion of the total population that estimates encompass, there is known inter-annual variability in the use of foraging areas, foraging habitat connectivity and site fidelity of individuals to different foraging areas is unknown and there is little knowledge of the pre-exploitation abundance of the pygmy blue whale (Commonwealth of Australia, 2015a).

Woodside has a good understanding of seasonality of pygmy blue whale visitation in the Scott Reef region (Table 41). However, as with other possible foraging areas, knowledge on the potential importance of the foraging areas, residence times and actual seasonal numbers is limited. In order to address this uncertainty in the underwater noise impact assessment for pygmy blue whales, a conservative approach to density estimate inputs to the ANIMAT modelling (refer to **Section 6.3.8.21** of the draft EIS/ERD) was adopted. Density estimates accounted for a precautionary and low vocalisation rate (8%) that acknowledged the fact that not all whales are singing and therefore detected. Furthermore, the density estimate applied (0.069 animals per km^2) took into account the following: (i) maximum recorded daily detection of three pygmy blues during the peak southern migration at the North West Cape (McCauley and Jenner, 2010); (ii) application of the population growth rate of 4.3% per year (McCauley et al., 2018) and (iii) a revised estimate of 5.64 whales per day, which translated into the conservative density estimate of 0.069 pygmy blue whales per km^2. Furthermore, a conservative 60 km listening range was applied compared to the 120 km used by McCauley and Jenner (2010).

Table 4-1 shows the migration periods of the East Indian Ocean pygmy blue whale population based on the available data on timing of northbound and southbound migrations detected and reflect the extended periods of migration and the migration periods for the North West Cape and Scott Reef.

Table 4-1: Seasonality of the East Indian Ocean pygmy blue whale population from the North West Cape to Scott Reef, Western Australia. Sources: (Double et al., 2014; McCauley, 2011; McCauley et al., 2018)

Pygmy Blue Whale	J	F	M	A	M	J	J	A	S	O	N	D
Northbound migration												
Southbound migration												
Key												
Shoulder period												
Peak period												

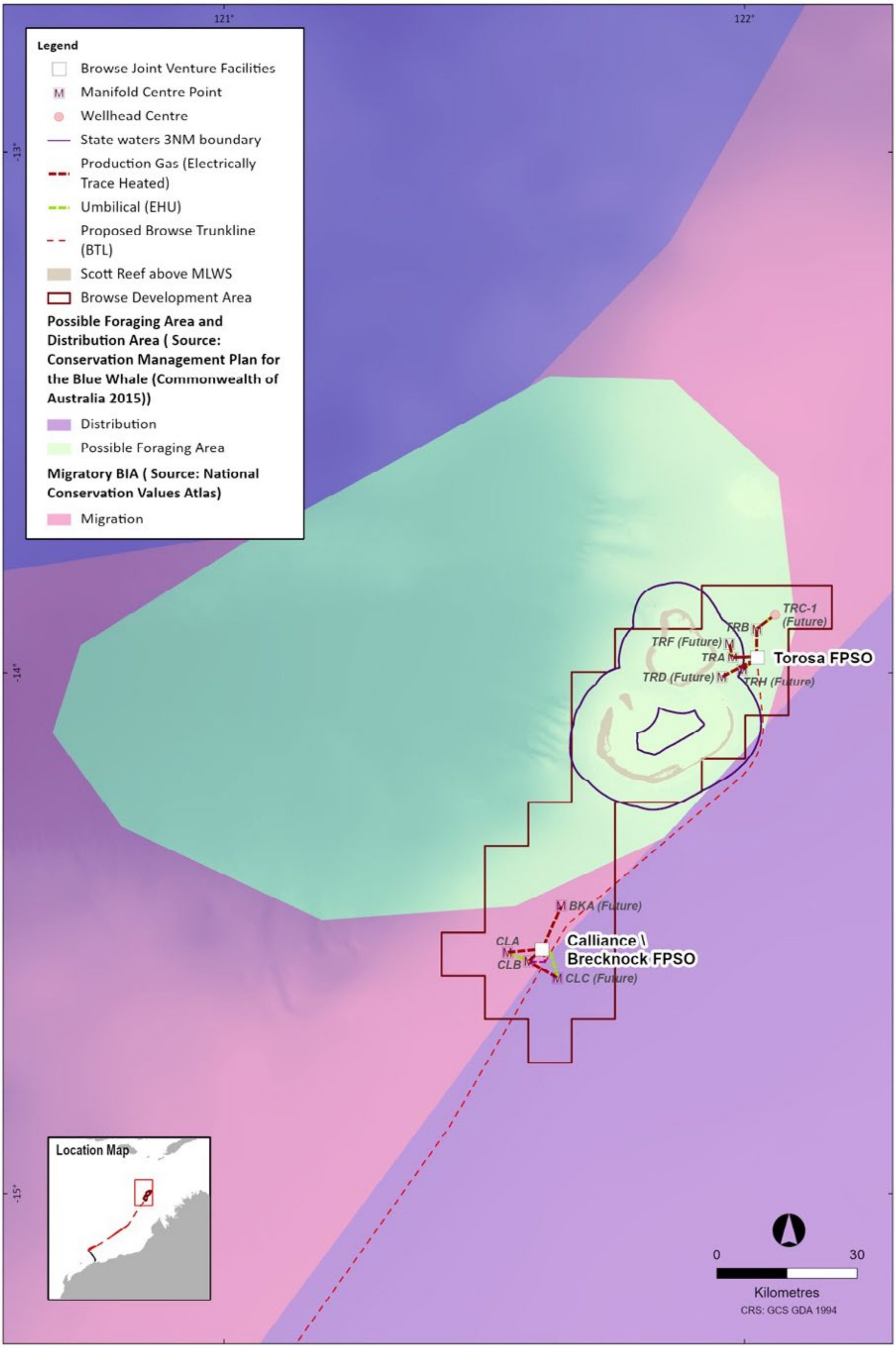

Figure 4-1: Scott Reef, the proposed Browse Development Area and the possible foraging area and migratory BIA for pygmy blue whales

4.2.4 Impact assessment and risk: underwater noise emissions

Section 6.3.8 of the draft EIS/ERD presented the outcomes of an evaluation of the potential impacts from underwater noise emissions associated with the proposed Browse Project. The impact assessment predicts the following maximum percentage overlap of ensonified zones with the pygmy blue whale possible foraging area, based on the application of the 120 dB re 1 µPa·(SPL) marine mammal behavioural response threshold for non-impulsive (continuous) noise, and the 160 dB re 1 µPa·(SPL) marine mammal behavioural thresholds for impulsive noise, both of which are derived from National Marine Fisheries Service (2018) and NOAA (US) (2019) (previously quoted in the draft EIS/ERD as National Marine Fisheries Service (2014)).

A detailed revision included updated modelling results for multiple scenarios has been completed in support of this EIS Supplement and documented within a Pygmy Blue Whale Management Plan (PBWMP) (**Appendix C.5**).

4.2.4.1 Proposed Browse Project development phase activities

The draft EIS/ERD acknowledged that the impact and risk assessment undertaken in relation to underwater noise was based on a level of activity definition that was still in development, additional definition is now available that has allowed analysis at a higher level of granularity. The spatial and temporal aspects of the proposed Browse Project are described to support the further analysis and sense check of the cumulative assessment for underwater noise emissions to low frequency cetaceans and the pygmy blue whale possible foraging area. This higher level of detail of the underwater noise emissions impact assessment (as presented in the draft EIS/ERD) for the Phase 1 (ready for start-up (RFSU)) development activities with indicative timeframes (subject to further engineering and in-field operational constraints) are as follows:

- drilling and completions (based on a reference case of 12 wells drilled for Phase 1 RFSU[4], up to approximately 18 months at Torosa, and 18 months between Calliance and Brecknock) – ranges to marine mammal behavioural response thresholds are predicted out to 10.5 km, representing an overlap of approximately 0.8 km² of the pygmy blue whale possible foraging area (dependent on the well location).
- SURF installation and commissioning –– it is estimated that approximately 14.7 km² of the possible foraging area will exceed the marine mammal behavioural response threshold
- installation of the inter-field spur line and BTL (approximately five days within possible foraging area) – it is estimated approximately 107km² of the possible foraging area will exceed the marine mammal behavioural response threshold
- driven piling for MODU (if required) and FPSO (if required) – See the PBWMP as this activity is subject to strict spatial and temporal restrictions.
- hook up and commissioning (HUC) of the FPSOs (anticipated to be nine months per FPSO) - it is estimated that up to 18.7 km² of the possible foraging area will exceed the marine mammal behavioural response threshold.

It should be noted that the activities above are subject to spatial or temporal controls as well as other management mitigations, as outlined in the PBWMP (See **Appendix C.5**).

4.2.4.2 Operations

The draft EIS/ERD acknowledged that the impact and risk assessment undertaken in relation to underwater noise was based on a level of activity definition that was still in development. Additional definition is now available that has allowed verification at a higher level of granularity. The spatial and temporal aspects of the proposed Browse Project have been further defined to support the further analysis of the impact assessment for underwater noise emissions to low frequency cetaceans, with particular focus on the pygmy blue whale possible foraging area. This higher level of detail of the underwater noise emissions for the impact assessment (as presented in the draft EIS/ERD) for the operation activities are as follows:

- Torosa FPSO during normal operations (continuous) – it is estimated that approximately 1 km² of the possible foraging area will exceed the marine mammal behavioural response threshold.
- Torosa FPSO using thrusters[5] - it is estimated that approximately 9.1 km² of the possible foraging area will exceed the marine mammal behavioural response threshold.

4 The draft EIS/ERD notes that additional wells above the 12 may be required for Phase 1 RFSU. In this eventuality, drilling and completions activity time may increase.

5 The Torosa FPSO is expected to use 5 MW of thrust (as modelled and presented in the draft EIS/ERD) infrequently, based on metocean conditions and operational requirements. Lower levels of thrust may be used more often.

- Torosa FPSO facility during offtake activities (FPSO using thrusters and OSV under DP) (every 2-4 weeks for approximately 24 hours plus mooring and unmooring operations) - it is estimated that approximately 22.4 km^2 of the possible foraging area will exceed the marine mammal behavioural response threshold.
- Wellhead noise (continuous) for subsea choke valve noise propagation estimated a range up to 500 m for Low Frequency marine mammal behavioural response. It is noted that the choke noise modelling adopted representative transects that attempt to present the maximum ensonified range above behavioural response thresholds within the channel using two different noise propagation methods, the influence of a sloping deeper bathymetry from the wellhead manifold location and using an omnidirectional source. Furthermore, predicted behavioural response threshold was estimated up to 500 m which did not reach beyond the maximum width of the transect or reef boundary, therefore this is considered a representative scenario to extrapolate in other directions.
- Support vessel offloading (supply runs anticipated five-six times per month per FPSO, with offloading expected to take approximately 12 hours) – it is estimated that approximately 19.6 km^2 of the possible foraging area will exceed the marine mammal behavioural response threshold.

Detailed assessment of individual activities is included in **Section 6** of the PBWMP (**Appendix C.5**)

4.2.4.3 Cumulative assessment

The draft EIS/ERD acknowledged that the impact and risk assessment undertaken in relation to underwater noise was based on a level of activity definition that was still in development. Additional definition is now available that has allowed analysis at a higher level of granularity. A detailed assessment of potential cumulative impacts is included in **Section 6** of the Pygmy Blue Whale Management Plan (**Appendix C.5**).

On this basis, the overall residual impact magnitude and significance level for underwater noise impacts on marine mammals, as presented in the draft EIS/ERD the impact significance level of - Slight and Minor (D) (draft EIS/ERD **Table 6-73**), does not change based on the further analysis of the cumulative noise scenarios.

4.2.4.4 Management and mitigation of underwater noise emissions for pygmy blue whales

As previously stated, scientific knowledge to support ongoing management for pygmy blue whales is limited throughout their geographic range because of logistical and scientific methodology constraints. The studies for the proposed Browse Project have used a range of techniques to improve our understanding of pygmy blue whale occurrence, seasonality and use of the project area through vessel and aerial based surveys, biological oceanography studies and passive acoustic loggers (see **Section 5.3.2.5.2** of the draft EIS/ERD). Many of these studies have been undertaken over multiple years. To address the residual scientific uncertainty on habitat usage of the Project Area by pygmy blue whales, Woodside has been conservative in the number of pygmy blue whales utilising the possible foraging area (refer **Section 4.2.2**) and assumed the possible foraging BIA is an actual foraging area. In addition, Woodside plans to implement additional management controls to minimise or eliminate impacts to pygmy blue whales, refer to **Table 4-2**.

The impact assessment outcomes evaluated in isolation and cumulatively have not changed the residual impact magnitude and significance level for underwater noise impacts on marine mammals as presented in **Table 6-73** of the draft EIS/ERD– Slight and Minor (D); and as such there are no significant impacts to pygmy blue whales predicted as defined by the significant impact criteria for endangered threatened species (**Table 6-5** of the draft EIS/ERD).

Table 4-2: Impact assessment summary for underwater noise emissions, adopted and additional controls, and environmental objectives for pygmy blue whales

Receptor (Sensitivity)	Potential Impacts	Environmental Objectives	Draft EIS/ERD Controls	Additional Controls	Magnitude	Impact Significance Level

Marine mammals (high value species)	• Change in fauna behaviour and injury or mortality to fauna	• Undertake the proposed Browse Project in a manner that will not disrupt migration and feeding of the East Indian Ocean pygmy blue whale population.
		• Undertake the proposed Browse Project in a manner that will not displace the East Indian Ocean pygmy blue whale population from the possible foraging area at Scott Reef.
			Project vessel operations:
			• Vessels will operate in accordance with EPBC Regulations 2000 – Part 8 Division 8.1 and Australian National Guidelines for Whale and Dolphin Watching whereby:
			  • Vessels will not knowingly travel greater than six knots within 300 m of a whale or 100 m of a dolphin
			  • Vessels will not knowingly approach closer than 100 m to a whale or 50m to a dolphin (except if bow riding)
			  • Vessels will not knowingly restrict the path of cetaceans.
			• Interactions between support vessels and whale sharks will be not inconsistent with the Whale Shark Code of Conduct.
				All project phases:
				• All vessels (including the Fast Crew Transfer Vessel (FCTV)) will not travel at speeds greater than12 knots within the pygmy blue whale possible foraging area that overlaps Scott Reef in peak migration periods (May, June and November), unless required for SOLAS[6].
				• Interactions between vessels and marine fauna will not be inconsistent the EPBC Regulations 2000 – Part 8 Division 8.1, and in the Australian National Guidelines for Whale and Dolphin Watching and the Whale Shark Code of Conduct, whereby unless in a permitted emergency situation, vessels will not travel at speeds greater than the speed restrictions prescribed for marine fauna encounters.
					Slight	Minor (D)

6 *i.e. in situations where the vessel master considers that complying with the requirement would adversely affect the safety or security of the vessel or its passengers or crew, or in situations where the vessel master is bound to provide assistance (under SOLAS Chapter V) upon receiving a distress signal from any source that persons are in distress at sea.*

Receptor (Sensitivity)	Potential Impacts	Environmental Objectives	Draft EIS/ERD Controls	Additional Controls	Magnitude	Impact Significance Level

			Operations:
			• Vertical Seismic Profiling (VSP) operations will have trained vessel crew as a marine fauna observer[7] and will be subject to pre-start up visual observations, operational, and shut-down procedures, as follows:
			  • 500 m shut down zone for whales
			  • 500 m shut down zone for marine turtles.
			• Impact pile driving activities will have trained vessel crew as a marine fauna observer and will be subject to pre-start up visual observations, soft start, operational, and shut-down procedures, as follows:
			  • 2 km shut down zone for whales
			  • 500 m shut down zone for marine turtles.
			• During impact piling, thermal imaging will be used during night time / times of low visibility to assist in detecting whales within the shutdown zones.
			• Underwater noise monitoring of an operational well will be undertaken to inform an adaptive management approach for noise management for the TRD wells if required.
				See **Section 8** of the (PBWMP) (**Appendix C.5**) for additional management controls that have been identified.		

7 *Marine fauna observer – a dedicated and suitably trained person who must not have any other duties that impede their ability to engage in visual observations for whale and marine turtles*

4.2.5 Impact assessment and risk: unplanned vessel interaction with fauna

Section 6.3.18.2 of the draft EIS/ERD presented the outcomes of an evaluation of the risk of vessel strike causing injury or mortality to marine fauna due to the physical presence and movements of vessels during all phases of the proposed Browse Project. This risk evaluation is based largely on the types and numbers of vessels in the Project Area and general description relating to the project phases. Relevant EPBC Act listed threatened species with particular attention to pygmy blue whales and green turtles and Western Australia threatened species status (Biodiversity Conservation Act 2016) were considered as well as the National Strategy for Reducing Vessel Strike on Cetaceans and other Marine Megafauna (Commonwealth of Australia, 2017b) for both the risk evaluation and identified mitigation measures.

The main receptors of concern with regards to unplanned vessel strikes from the proposed Browse Project activities are the pygmy blue whale as well as marine turtles, other marine mammals (dugongs and humpback whales), and whale sharks. **Section 6.3.18.4** of the draft EIS/ERD summarises the identified sensitive areas and seasonality including:

- a possible foraging area and migratory BIAs for pygmy blue whales (refer to **Figure 4-1**)
- habitat critical to the survival of green turtles (Scott Reef-Browse Island genetic stock – G-ScBr), as identified in Recovery Plan for Marine Turtles in Australia, Commonwealth of Australia 2017 (Commonwealth of Australia, 2017a) (refer **Figure 4-2**)
- an internesting BIA for green and hawksbill turtles around Sandy Islet
- a foraging BIA green turtles
- a migratory BIA for humpback whales
- a foraging BIA for dugongs.

4.2.5.1 Proposed Browse Project development phase activities

The draft EIS/ERD acknowledged that the environmental risk assessment undertaken in relation to unplanned vessel interaction was based on a level of activity definition that was still in development. Additional definition is now available that has allowed verification at a higher level of granularity. The spatial and temporal aspects of the proposed Browse Project were used to provide further evaluation of the risk of unplanned vessel interactions with fauna. The description includes the Phase 1 (RFSU) development activities (as listed below) for the associated project vessel requirements and movements:

- drilling and completions
- SURF installation and commissioning
- installation of the inter-field spur line and BTL
- HUC of the FPSOs.

Vessel presence is expected to be greatest for these relatively short-term development project activities and involve platform support vessels (PSVs) supporting development operations with supply runs to and from supply and logistic bases; and a range of construction and pipelay vessel types for SURF installation, installation of the inter-field spur line and BTL; and HUC of FPSO facilities.

Potential unplanned vessel interactions in the Torosa field were identified primarily with respect to:

- pygmy blue whales during northbound and southbound migrations through the Scott Reef possible foraging area including the Scott Reef channel
- green turtle nesting season at Sandy Islet, Scott Reef.

Potential unplanned vessel interactions relating vessel transfers to and from supply and logistic bases (such as Broome) were identified primarily with respect to:

- humpback whale northbound and southbound migrations to and from the breeding and calving BIA at Camden Sound
- the dugong and green turtle foraging areas adjacent to the Kimberley coast.

4.2.5.2 Operations

As described in **Section 3.5** of the draft EIS/ERD, the two FPSO facilities (located at the Calliance/Brecknock field and the Torosa field) are moored (and they freely weathervane on a moored turrent mooring system) and are expected to have a maximum producing life of an anticipated 44-years. Throughout the operating life of the FPSO facilities at Calliance/Brecknock and Torosa a number of activities involving other vessels are anticipated to support routine marine operations including IMMR.

The same sensitive receptors and BIAs were identified for operations as for the development project activity related vessel presence and movements described above.

Cumulative Assessment

As described in **Section 6.3.18.5** of the draft EIS/ERD, vessel movements will occur throughout all phases of the proposed Browse Project as well as general shipping and vessel movements during operations at existing offshore facilities such as Shell's Prelude FLNG and the Ichthys Venturer FPSO over 140 km distance from the nearest proposed facility within the Browse Development Area. Increased supply vessel movements from local ports, such as Broome, will also occur.

During the Phase 1 RFSU, there will be periods of simultaneous development project activities within the Calliance and Torosa fields. Review of the original cumulative risk assessment has concluded the assessment has not changed the residual risk consequence, likelihood and risk rating for unplanned vessel interactions with fauna as presented in the draft EIS/ERD (**Table 6-141**) – Moderate, unlikely to highly unlikely and Low (C1) to Moderate (C2).

4.2.5.3 Fast Crew Transfer Vessel (FCTV)

During the HUC of the FPSO facilities, personnel may be transferred from the supply and logistics base to the FPSO facilities by helicopter or FCTV. Additionally, during operations transfer of personnel to and from the FPSO facilities may be undertaken using the FCTV. It is anticipated FCTV personnel transfers may be required approximately once or twice per week to the FPSO facilities from Broome.

As described in **Section 6.2.22** of the draft EIS/ERD, a management approach to reduce the risk of impacts occurring to marine fauna from vessel interactions, including with the FCTV, will be implemented. This management approach includes:

- FCTV will operate under a FCTV management strategy, which will describe the appropriate additional control measures to manage vessel strike risk for the FCTV. This will include trained vessel crew acting as a marine fauna observer
- the possible design for the FCTV will intrinsically reduce the risk of vessel strikes, including a shallow vessel draught (i.e. approximately 1 m or less) and no propeller (i.e. jet-propelled vessel)
- travelling at 30 knots, in the event of sighting a whale at the edge of the caution zone, the FCTV can reach dead stop before being within the 100 m no approach zone. Subject to the potential for technological innovation and additional engineering controls, FCTVs will not travel at speeds greater than 30 knots in sensitive areas at sensitive times (as defined in **Table 6-139** of the draft EIS/ERD). The maximum allowable speed within the defined sensitive areas may be increased if incorporated engineering controls are able to achieve an equal or greater effectiveness as the speed restriction
- all project vessels, including the FCTV, will not travel at speeds greater than 12 knots with the State Proposal Area, or 6 knots in the Scott Reef channel, further reducing the risk of accidental collisions with marine fauna
- the proposed FCTV route will avoid habitat critical for flatback turtles around the Lacepede Islands during sensitive times and habitat critical for green turtles around Sandy Islet.

4.2.5.4 Management and mitigation of unplanned vessel interactions for pygmy blue whales

To address the residual scientific uncertainty on habitat usage of the project area by pygmy blue whales, Woodside has been conservative in the number of pygmy blue whales utilising the possible foraging area (refer **Section 4.1**) and assumed the possible foraging BIA is an actual foraging area. In addition, Woodside plans to implement additional management controls to minimise or eliminate risks to pygmy blue whales (refer to **Table 4-3**).

Based on further evaluation of the project activities and potential risks in isolation and cumulatively, the adopted controls including no vessel movements through the Scott Reef channel other than specific project activities and SOLAS requirements, and a vessel speed restriction of six knots within the Scott Reef channel, were deemed to be appropriate. Furthermore, two additional controls were identified to minimise the likelihood of unplanned vessel interactions with pygmy blue whales:

- all project vessels will have a maximum speed 12 knots in the pygmy blue whale possible foraging area that overlaps Scott Reef during peak migration periods (May, June and November)
- The FCTV will minimise time within the pygmy blue whale possible foraging area that overlaps Scott Reef by following a defined route to Torosa FPSO in peak migration periods (May, June and November).

The impact assessment summary with adopted and additional controls (applicable to all baleen whale species) and a revised environmental objective are presented in **Table 4-3**. The environmental objective has been developed to specifically report on the management of the potential risk of unplanned vessel interaction (including the FCTV) with marine fauna.

The risk assessment outcomes further evaluated in isolation and cumulatively have not changed the residual risk consequence, likelihood and risk rating for unplanned vessel interactions with fauna as presented in the draft EIS/ERD (**Table 6-141**) – Moderate, unlikely to highly unlikely and Low (C1) to Moderate (C2). As such there are no significant impacts to pygmy blue whales anticipated as defined by the significant impact criteria for endangered threatened species (**Table 6-5** of the draft EIS/ERD).

Table 4-3: Risk assessment summary for unplanned vessel interaction with marine fauna, adopted and additional controls, and environmental objective for marine fauna

Receptor (Sensitivity)	Risk Event	Environmental Objectives	Draft EIS/ERD Controls	Additional Controls	Consequence	Likelihood	Risk Rating
Marine turtles (high value) Marine mammals (high value)	Injury or mortality to fauna	• Undertake the Browse Project in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks, dugongs).	***Project vessel operations*** • Project vessels will only enter the channel between north and south Scott Reef during construction/ installation, IMMR, contingent activities, decommissioning and emergency situations. • Project vessels will not travel at speeds greater than 12 knots within the State Proposal Area, or 6 knots in the Scott Reef channel unless required for SOLAS. • FCTV will operate under a FCTV Management strategy (to be detailed in subsequent EPs as required) which will describe the appropriate additional control measures to manage vessel strike risk for the FCTV. Subject to the potential for technological innovation and additional engineering controls, FCTVs will not travel at speeds greater than 30 knots in sensitive areas at sensitive times (**Table 6-139** of the draft EIS/ERD).	***Project vessel operations*** All vessels (including the FCTV) will not travel at speeds greater than 12 knots within the pygmy blue whale possible foraging area that overlaps Scott Reef in peak migration periods (May, June and November), unless required for SOLAS[8]. The FCTV will minimise time within the pygmy blue whale possible foraging area that overlaps Scott Reef by following a defined route to Torosa FPSO in peak migration periods (May, June and November). Interactions between vessels and marine fauna will not be inconsistent the EPBC Regulations 2000 – Part 8 Division 8.1, and in the Australian National Guidelines for Whale and Dolphin Watching and the Whale Shark Code of Conduct, whereby unless in a permitted emergency situation, vessels will not travel at speeds greater than the speed restrictions prescribed for marine fauna encounters.	Moderate	Unlikely to highly unlikely	Low (C1) to Moderate (C2)

8 *i.e. in situations where the vessel master considers that complying with the requirement would adversely affect the safety or security of the vessel or its passengers or crew, or in situations where the vessel master is bound to provide assistance (under SOLAS Chapter V) upon receiving a distress signal from any source that persons are in distress at sea.*

Receptor (Sensitivity)	Risk Event	Environmental Objectives	Draft EIS/ERD Controls	Additional Controls	Consequence	Likelihood	Risk Rating

			• Interactions between vessels and whale sharks will be not be inconsistent with the Whale Shark Code of Conduct (DPaW, 2013), whereby unless in an emergency situation, vessels will not knowingly travel at speeds greater than eight knots within 250 m of a whale shark and not intentionally approach closer than 30 m of a whale shark.
			• Vessels will operate in accordance with EPBC Regulations 2000 – Part 8 Division 8.1 and Australian National Guidelines for Whale and Dolphin Watching whereby:
			  • Vessels will not knowingly travel greater than six knots within 300 m of a whale or 100 m of a dolphin.
			  • Vessels will not knowingly approach closer than 100 m to a whale or 50 m to a dolphin (except if bow riding).
			  • Vessels will not knowingly restrict the path of cetaceans.
			  • Vessels will take direct routes where practicable, whilst avoiding significant areas for marine fauna where possible.				

Receptor (Sensitivity)	Risk Event	Environmental Objectives	Draft EIS/ERD Controls	Additional Controls	Consequence	Likelihood	Risk Rating
			• The possible FCTVs design will intrinsically reduce the risk of vessel strikes, including a shallow vessel draught (i.e. approximately 1 m or less) and no propeller. • The possible FCTV will have trained vessel crew as a marine fauna observer.				

4.3 Green Turtles

4.3.1 Introduction

To support the further evaluation of the potential impacts risks to green turtles as presented in the draft EIS/ERD, Woodside has undertaken further desktop lighting assessment, a comprehensive literature review on the impacts of artificial light on marine turtle hatchlings (undertaken by specialists at Pendoley Environmental (Pendoley Environmental, 2021a), and a light modelling study modelling of the artificial light emissions from the proposed offshore facilities. Woodside has prepared a Turtle Management Plan (TMP) that provides the outcomes of the additional desktop study, literature review and light modelling. This TMP is presented in **Appendix C.3**. The results of the desktop lighting study are presented in **Appendix A.1** and the results of the light modelling study are presented in **Appendix C.3**.

In this section, Woodside has provided an overview of the key findings of the additional information and further evaluation including an updated assessment of the key impacts and risks specific to green turtles.

The key information presented is as follows:

- Information in relation to the green turtle Scott Reef-Browse Island genetic stock (herein after referred to as 'G-ScBr')
- A review of the sensitivity of marine turtles to artificial light
- Woodside's conservative approach to impact assessment for the green turtle (threatened and migratory species)
- updates to the information on cumulative impacts assessment for the green turtle
- Woodside's commitment to further management controls to mitigate and minimise potential impacts to this species
- updates to the environmental objectives specific to this species
- the further evaluation of the proposed Browse Project against the Recovery Plan for Marine Turtles in Australia 2017-2027 (Marine Turtle RP) (Commonwealth of Australia, 2017a).

4.3.2 Scott Reef-Browse Island Green Turtle Genetic Stock

The green turtle is distributed widely across northern Australia with a total of nine genetic stocks identified to date for this species (Commonwealth of Australia, 2017a). There are three genetic stocks within the NWMR; the North West Shelf, Ashmore Reef, and Scott Reef-Browse Island genetic stocks. Dispersal of these genetic stocks occurs over a large area in waters north and east of the northern WA coastline (Department of the Environment and Energy, 2017). The North West Shelf genetic stock comprises multiple nesting rookeries within close proximity, whilst the Ashmore Reef and Scott Reef-Browse Island genetic stocks are comparatively genetically isolated with fewer nesting rookeries. The G-ScBr stock is a discrete unit known to nest at only two locations within the north-east Indian Ocean—Sandy Islet and Browse Island (Commonwealth of Australia, 2017a). Only Sandy Islet falls within the Browse Development Area.

As identified in the Marine Turtle RP (Commonwealth of Australia, 2017a) there is a lack of data regarding the status of the G-ScBr stock, and the current population trend is unknown. This stock is considered likely to be restricted in its capacity to expand into other nesting areas in the event that availability or quality of nesting habitat is reduced. The G-ScBr stock is vulnerable to a range of threats to all life stages, and its resilience to cope with increasing pressures is likely to be limited by its restricted population gene pool and low number of nesting locations.

Woodside has collected multiple datasets over multiple years to understand green turtle dynamics (migration, internesting, nesting, hatchlings) in the Browse Development Area (refer to **Section 5.3.2.6** of the draft EIS/ERD) and underpins the project's impact assessment (Chapter 6 of Draft EIS/ERD), including:

- nesting assessment
- hatchling assessment
- satellite tagging
- manta tows.

From these multiple datasets the key metrics and understanding are described in the sub-sections below.

4.3.2.1 Habitat Critical to the Survival of a Species

In accordance with the *EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* (Commonwealth of Australia, 2013)), an action is deemed to have a significant impact if there is a real chance or possibility that it will adversely affect 'habitat critical to the survival of a species' (herein after referred to as 'habitat critical'). Habitat critical refers to areas that are necessary:

- "for activities such as foraging, breeding or dispersal
- for the long-term maintenance of the species (including the maintenance of species essential to the survival of the species)
- to maintain genetic diversity and long-term evolutionary development
- for the reintroduction of populations or recovery of the species."

Nesting and internesting habitat is defined as habitat critical, and these areas have been identified for each genetic stock of marine turtle in the Marine Turtle RP. One of the key criteria for identification of these areas is that "*Nesting habitat critical to the survival of green, loggerhead, flatback and hawksbill turtles includes at least 70 per cent of nesting for the stock*".

Designated habitat critical for the G-ScBr stock are the nesting locations of Sandy Islet and Browse Island, and an internesting buffer of 20 km radius around these rookeries, for the period November to March (refer Table 6 of the Marine Turtle RP). The habitat critical at Scott Reef (nesting location of Sandy Islet, and 20 km radius internesting buffer) is shown in **Figure 4-2**.

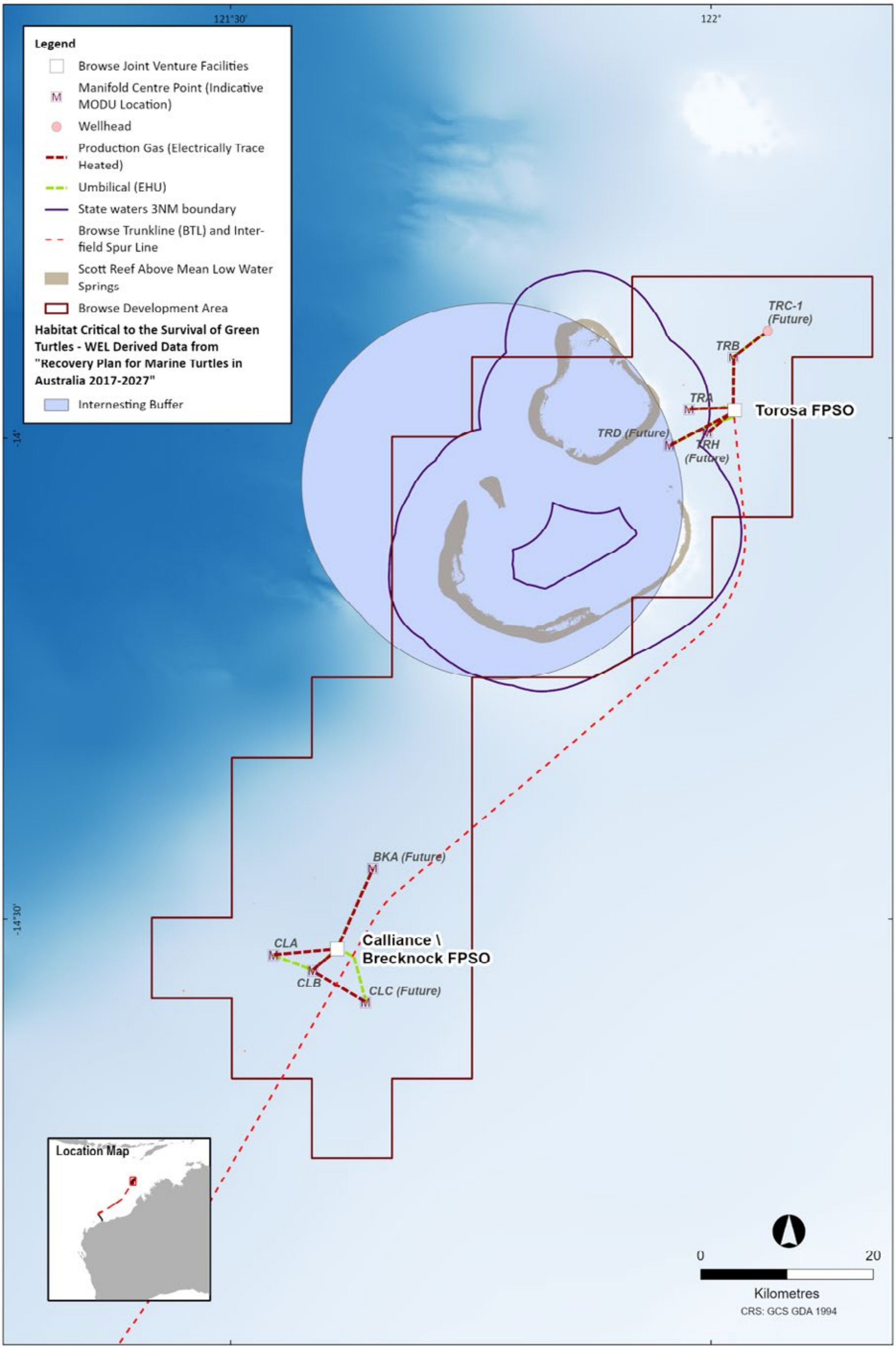

Figure 4-2: Habitat critical to the survival of green turtles at Scott Reef

4.3.2.2 Biologically Important Areas

While not defined under the EPBC Act, biologically important areas (BIAs) are spatially delineated area where aggregations of individuals of a species are known to display biologically important behaviours such as breeding, foraging, resting or migration (Department of the Environment and Energy, 2019a). BIAs were developed simultaneously with the Marine Bioregional Plans to inform regulatory and management decisions and are not enforced by legislation (Department of the Environment and Energy, 2019a).

Within the Browse Development Area, Sandy Islet (a part of Scott Reef) and the surrounding waters around Scott Reef is a designated internesting BIA for green turtles (specifically the G-ScBr stock). There are a number of other nesting, internesting and foraging BIAs for green turtles within vicinity of the Project Area, including at Ashmore Reef, Cartier Island, Cassini Island and the Lacepede Islands (Commonwealth of Australia, 2017a).

4.3.2.3 Life cycle and seasonality

Nesting activity reaches a peak in January and February with a peak in hatchling emergence approximately seven weeks later in March and April (Guinea, 2013) (**Table 4-4**). Also, on the reef during the breeding season and throughout the year are the non-breeding sub-adult and adult turtles that forage and reside in the area. Genetic studies (Dethmers et al., 2006) revealed that these belong to other green turtle stocks in Western Australia and the Indian Ocean.

Table 4-4 Seasonality for green turtle nesting activities at Sandy Islet

Activity	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
Nesting / internesting																
Hatchling emergence																
Key																
Shoulder period																
Peak period																

As described by Guinea (2013), within the generalised life cycle there are at least two cycles that involve breeding females using the reefs, lagoons and beaches (Sandy Islet) at Scott Reef:

- the female nesting cycle – every two to eight years when female green turtles migrate from their foraging grounds to Scott Reef to breed (re-migration interval)
- the internesting cycle – females spend two to three months within the vicinity of the nesting island moving only short distances of some tens of kilometres or less and nesting from three to six times during the nesting season, every eight to 16 days.

4.3.2.4 Population size and inter-seasonal fluctuations

Estimates of green turtle nester abundance was calculated based on recapture history of tagged turtles on eight survey (recapture) nights in the 2008/2009 season (Guinea, 2009). Estimates of abundance varied between survey nights providing a mean (±SE) abundance of 779 ± 383 (i.e. a maximum of 1162 individuals) (Guinea, 2009). Mean (±SE) female nester abundance for 2009/10 was estimated at 79 ± 25 over eight survey nights using similar methodology (Guinea, 2010). In both seasons, the individual standard error of each estimate exceeded 50% and consequently, abundance estimates should be considered indicative only, especially given the assumptions associated with the methodology are unverified (Guinea, 2010, 2009) .

The Marine Turtle RP appears to take the effective population size estimate from (Dethmers et al., 2010) as the median for an estimated 1001-5000 females nesting per year for the Scott Reef-Browse Island stock (refer **Figure 3** in the marine turtle RP). However, the proportion of this estimated 1001-5000 females utilising Sandy Islet versus Browse Island during any season is not known, as there are no estimates are available for the size of the Browse Island nesting population. Olsen et al. (2017) provide a summary of green turtle sightings around Browse Island during the 2016 and 2017 seasons, with an indication that there was a much higher level of nesting activity occurring in October compared with April. No estimates of overall population size are provided. However, Scott Reef (Sandy Islet) could be an important component (in term of total numbers of nesters) to the overall Scott Reef-Browse Island stock.

To account for the scientific uncertainty in the total number of nesters at Sandy Islet and the inter-annual variability a conservative maximum of 1162 females was applied to a modified internesting area (reef environment shallower than 50 m) to calculate a density estimate of 1.79 turtles/km² for Scott Reef, which was used for the ANIMAT modelling presented in the draft EIS/ERD.

4.3.2.5 Relative importance of Sandy Islet to the G-ScBr stock

Both Sandy Islet and Browse Island have been identified in the marine turtle RP as 'Major' nesting areas for the G-ScBr stock. However, given the need for further data on population size and trends in nesting abundance at both locations (despite the Sandy Islet focused studies undertaken to date), it is not possible to determine the relative importance of the two rookeries at a stock level. The availability of suitable nesting habitat at Browse Island each season could influence the numbers of females that utilise the alternative nesting location for this stock at Sandy Islet. As described in the Marine Turtle RP, the G-ScBr stock "is considered likely to be restricted in its capacity to expand into other nesting areas in the event that nesting beaches are lost or sand temperatures increase as a result of climate change". This is presumed to mean expansion to other nesting areas outside the two known rookeries for the stock.

4.3.3 Impact assessment and risk: light emissions

Section 6.3.3 of the draft EIS/ERD presented the outcomes of an evaluation of the potential impacts from light emissions associated with the physical presence of offshore facilities, MODU and vessels during all phases of the proposed Browse Project. This evaluation is based largely on light modelling studies conducted as part of the approved draft EIS for the Browse FLNG Development, which at the time of preparation of the draft EIS/ERD, included proposed drilling activities at the TRE drill centre, the closest to Sandy Islet. It is noted that since completion of the draft EIS/ERD, the TRE drill centre no longer forms part of the proposal.

Since completion of the draft EIS/ERD, additional studies have been undertaken including a desktop lighting assessment (**Appendix A.1**), taking into account the final National Light Pollution Guidelines for Wildlife (2020), a further literature review in relation to the sensitivity of marine turtles to artificial light; and modelling of the artificial light emissions from the proposed Browse Project.

The main receptors of concern with regards to light emissions from the proposed Browse Project activities are marine turtles, seabirds and migratory shorebirds. The draft EIS/ERD identifies that the Project Area overlaps areas designated as:

- habitat critical to the survival of green turtles (Scott Reef-Browse Island genetic stock – G-ScBr), as identified in Recovery Plan for Marine Turtles 2017-2027 (Commonwealth of Australia, 2017a) (refer **Figure 4-2**)
- a BIA for internesting green and hawksbill turtles around Sandy Islet
- a BIA (known resting area) for little terns.

4.3.3.1 Proposed Browse Project development phase activities

The draft EIS/ERD acknowledged that the impact and risk assessment undertaken in relation to light emissions was based on a level of activity definition that was still in development. Additional definition is now available that has allowed verification at a higher level of granularity. The spatial and temporal aspects of the proposed Browse Project are shown to support the further analysis of the impact assessment for light emissions. The description includes the Phase 1 (RFSU) development activities (as listed below) and FPSO operations, including movements of project vessels (OSVs, offtake tankers and FCTV):

- drilling and completions
- SURF installation and commissioning
- installation of the inter-field spur line and BTL
- HUC of the FPSOs.

4.3.3.2 Operations

As described in **Section 3.5** of the draft EIS/ERD, the two FPSO facilities (located at the Calliance/Brecknock field and the Torosa field) are expected to have a maximum producing life of an anticipated 44-years. Throughout the operating life of the FPSO facilities at Calliance/Brecknock and Torosa a number of activities involving other vessels are anticipated to support routine marine operations. All of these activities will produce light emissions (e.g. from navigational and operational lighting on vessels and the FPSO, and from intermittent flaring as described in the draft EIS/ERD (Chapter 3).

4.3.3.3 Cumulative assessment

The potential impacts from light emissions on marine turtles, seabirds and migratory shorebirds have been evaluated for both development and operations activities both in isolation and cumulatively. The potential cumulative impact from light emissions has been further evaluated using additional detail about project activities that is now available (see above), and there are no activity interactions that have not already been considered. However, additional consideration of potential impacts from sky glow has now been incorporated (refer **Section 4.2.3.4**).

4.3.3.4 Artificial light impacts on nesting turtles and emergent hatchlings

Little is known about the impact of artificial light on adult and juvenile turtles when they are offshore. Most studies around light impacts on adult and juvenile turtles at sea have stemmed from interactions of turtles with fishing gear (Pendoley, 2020). During internesting, turtles rest on the seabed, physically removing them from surface lighting sources, such as vessels, MODUs, FPSOs (Whittock et al., 2014). Since marine turtles do not feed during the breeding season (Limpus et al., 2013), attraction of internesting turtles to light sources as a secondary response to effects of light on prey distribution is not expected.

Internesting, breeding, foraging and migrating marine turtles do not use light cues to guide these behaviours. Further, there is no evidence, published or anecdotal, to suggest that internesting turtles are impacted by light from offshore vessels or installations. As such, light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages (Pendoley, 2020).

Turtle hatchlings typically emerge from their nests at night (Mrosovsky and Shettleworth, 1968) and must crawl rapidly to reach the ocean in order to avoid predation (Salmon, 2003). They find the ocean using a combination of topographic and brightness cues, orienting towards the lower, brighter oceanic horizon, and away from elevated darkened silhouettes of dunes and/or vegetation behind the point of their emergence on the beach (Limpus and Kamrowski, 2013; Lohmann et al., 1997; Pendoley and Kamrowski, 2015; Salmon et al., 1992)at preselected beach release sites, and within a walled wooden arena under various conditions in the field, are presented. We conclude that hatchlings orient as follows: (1. Artificial light at night can interfere with these cues, influencing their sea-finding behaviour (Kamrowski et al., 2014; Pendoley and Kamrowski, 2015; Witherington and Martin, 2003). As a result, hatchlings may become disorientated, where they crawl in circuitous paths; or mis-orientated, where they move in the wrong direction, resulting in an increased mortality rate due to exhaustion, dehydration, or increased exposure to predation (Withington & Martin, 2003; Lohmann et al., 1997; Salmon 2003).

It is generally accepted amongst the scientific community that there is insufficient information to derive defensible thresholds/limits of light intensity or its visibility on marine turtles and specifically in relation to hatchling behaviour. This conclusion was determined following a comprehensive literature review on the impacts of artificial light on marine turtle hatchlings by specialists at Pendoley Environmental (Pendoley, 2021b).

A range of experimental studies and in-situ research have been undertaken to determine the sensitivity of turtle hatchlings to artificial light emissions. A selection of these studies is discussed in **Section 2** of the TMP (**Appendix C.3**). Despite the numerous in situ and experimental studies that indicated light of a certain intensity and/or wavelength influenced hatchling sea-finding behaviour, no studies were able to account for the numerous inter-related variables that influence the intensity and visibility of artificial light to a hatchling turtle at a landscape scale. Hence, there are no generally accepted levels of artificial light that can be used as thresholds or limits for the purposes of this assessment.

4.3.3.5 Desktop lighting impact assessment

Since the original light modelling studies were undertaken, and submission of the draft EIS/ERD, there has been additional context regarding potential impacts to turtles from light emissions—in particular the release of the final National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth of Australia, 2020) in January 2020. These guidelines are intended to be read in conjunction with the other guidance, including the EPBC Significant Impact Guidelines and species recovery and conservation management plans.

A desktop lighting assessment, taking into account the final National Light Pollution Guidelines for Wildlife (2020) has been undertaken and is provided in **Appendix A.1**.This includes an assessment of the relevant importance of the turtle nesting beach located in the Browse Development Area (Sandy Islet) to the G-ScBr stock, a further literature review describing potential impacts of offshore sources of artificial light on all life stages of marine turtles and seabirds and migratory shorebirds, a gaps analysis of the assessment completed to date (against the National Light Pollution Guidelines for Wildlife, 2020), and an updated impact assessment which was conservatively based on the assumption that light emissions (in the form of either direct light or sky glow) from operational lighting may be visible at intensities resulting in behavioural impacts to marine turtles at 20 km from the source. For flaring, additional conservatism was made based on results of line of sight modelling, with behavioural impacts potentially occurring within 52 km the MODU and FPSO locations.

4.3.3.6 Light modelling study

After further consultation with DAWE, modelling of the artificial light emissions from the proposed offshore facilities was undertaken to support the outcomes of the assessment of light emissions on marine turtles for the proposed Browse Project. The scope, methodology and results of the modelling study (Pendoley Environmental, 2021b) are provided in the TMP (**Appendix C.3**).

Table 4-5: Risk assessment summary for light emissions, adopted and additional controls, and environmental objectives for green turtles

Receptor (Sensitivity)	Potential Impacts	Environmental Objectives	Draft EIS/ERD Controls	Additional Controls	Magnitude	Impact Significance Level
Marine turtles (high value species)	• Change in fauna behaviour • Fauna injury or mortality	• Undertake the Browse Project in a manner that will not disrupt migration, breeding, nesting, internesting and hatchling dispersal of the green turtle population at Scott Reef • Undertake the Browse Project in a manner that will not displace the green turtle population from habitat critical to the survival of the species at Scott Reef	• The design of the FPSO facilities will consider the Principles for Best Lighting Design. This includes the minimisation of light spill, selective use of long wavelength light sources and lighting in each operational area will be kept to the minimum required for safe passage when personnel are not required to be working in the area. • Navigation beacons and lighting will be designed in line with the safety requirements of the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and the Navigation Act 2012 (Cth). • The FPSO facilities will be designed such that continuous flaring will be limited to pilot gas and compressor seal gas. • Light monitoring will occur during drilling and completion of a well at TRA drill centre to verify modelling predictions.	• Woodside has prepared a TMP (**Appendix C.3**) which presents a management approach that will be implemented in relation to potential impacts and risks from light emissions and seabed subsidence on marine turtles as a result of the proposed Browse Project.	Slight	Minor (D)

4.4 Monitoring and research

4.4.1 Monitoring: proposed Browse Project verifying science programs

The proposed Browse Project has committed to updating existing pygmy blue whale and green turtle data by targeted monitoring programs to verify impact predictions and inform adaptive management approaches at relevant times throughout the proposed Browse Project (**Section 9.4** of the draft EIS/ERD).

4.4.2 Pygmy blue whale (East Indian Ocean population) verifying science program

A scientific monitoring program is planned to confirm and update baseline data on the distribution, abundance, seasonality and behaviour of pygmy blue whales within the possible foraging area at Scott Reef (refer to **Section 9** of the PBWMP (**Appendix C.5**)). On-going data acquisition at relevant times throughout the proposed Browse Project will be a key component of the scientific monitoring program to continue monitoring pygmy blue whales and confirm sound source levels of project activities.

The key objectives of the pygmy blue whale scientific monitoring program are as follows:

- to verify and further understand the seasonality, residency time, behaviours and percentage of the EIO pygmy blue whale population utilising the possible foraging area at Scott Reef
- provide for real-time detection of pygmy blue whales
- to identify any need for change to management actions, that will be made in response to triggers or action outcomes.

Further information is outlined in the PBWMP (**Appendix C.5**).

4.4.3 Green Turtle (G-ScBr genetic stock) verifying science program

Four distinct monitoring programs are proposed in relation green turtles within the project area, including:

- a green turtle monitoring program at Sandy Islet and surrounds to update baseline information on green turtle demographics at Scott Reef
- an anthropogenic light monitoring program to verify predicted light emissions from construction and operational activities
- a seabed subsidence monitoring to verify predicted subsidence levels which may be used to better understand causes of and changes to Sandy Islet morphology
- a Sandy Islet size and morphology monitoring program to monitor the size and morphology of Sandy Islet for comparison with historic minimum available nesting habitats.

Green turtle monitoring program

A green turtle monitoring program will be implemented as a core component of the proposed Browse Project. The purpose of this program will be to verify and update baseline data through on-going data acquisition at relevant times throughout the proposed Browse Project on the distribution, abundance, seasonality and behaviour of green turtles at Scott Reef and within habitat critical to survival for the G-ScBr stock.

The green turtle monitoring program will be designed on the advice of a suitably experienced, independent marine turtle expert. The design of the program will cover key demographic parameters, specific monitoring techniques, frequency and timing of monitoring, data analysis techniques, corrective action triggers, and reporting requirements. The baseline monitoring program will be designed within six months of final investment decision on the project and implemented such as to collect a minimum of four (target five) years of data prior to commencement of gas processing at the Torosa FPSO.

The monitoring program will be continued to implemented during operational phase. However, the design of the operational monitoring program will need to be informed by outcomes of the baseline monitoring program, and as such specific details are not yet available. The operational phase of the monitoring program will also be designed on the advice of a suitably experienced, independent marine turtle expert. Details of the program are incorporated into the TMP (**Appendix C.3**).

The key objectives of the green turtle monitoring program are as follows:

- To investigate nesting turtle behaviour and habitat usage within Scott Reef and to establish a baseline data set for nesting turtles.
- To understand the key breeding parameters (e.g. nest abundance, incubation success, hatchling sea finding behaviour and post hatching dispersal) for green turtles at Scott Reef.

- To understand the relative importance of Sandy Islet as a nesting site for the G-ScBr green turtle stock.

The monitoring information will provide baseline data which can be used to verify the potential impacts and risks that the proposed Browse Project may have on green turtles, to determine compliance against the proposed performance standards and to inform adaptive management if necessary.

The green turtle monitoring program will be comprised of three key components:

- Satellite tracking of adult nesting individuals to determine internesting, foraging and migration behaviour.
- Counts and tagging of adult nesting individuals to facilitate abundance estimates, long-term life history traits, and proportion of neophytes present each season.
- Hatchling and nest counts and observations to determine nesting abundance and density, nesting success and hatchling sea-finding behaviour.
- Hatchling in-water dispersal behaviour in area immediately surrounding Sandy Islet.

Anthropogenic Light Monitoring

The primary objective of the light monitoring program will be to verify the modelling predictions for the drilling (MODU)) and FPSO operations. Specifically, the light monitoring program at Sandy Islet will be comprised of two key components:

- establishing a baseline of ambient light conditions (prior to any project activities) across the lunar cycle during nesting season
- determining light intensity (i.e. direct light and sky glow) at Sandy Islet during nesting season during MODU and FPSO operations to verify modelling predictions and determine compliance with performance standards.

The monitoring program will be implemented at Sandy Islet and will employ specialised light monitoring equipment to detect direct light and sky glow visible from the monitoring location across the full 360o horizon. Specific details on the monitoring program (i.e. monitoring locations, techniques, frequency, timing, performance standard threshold criteria, data analysis techniques and reporting requirements) will be described in a specific monitoring program to be developed post FID on the advice of a suitably experienced, independent marine turtle expert.

Light monitoring will also be used to validate modelling predictions, which will be re-run once MODU/FPSO activities commence and MODU details are known.

Specific details on the monitoring program (i.e. specific monitoring parameters, techniques, frequency, timing, performance standard threshold criteria, data analysis techniques and reporting requirements) will be determined in consultation with DAWE and DWER and included in the TMP.

Seabed Subsidence Monitoring

Currently, the most practical method of measuring seabed subsidence of potentially millimetres per year over kilometre scale would involve the use a combination of natural and artificial physical targets (e.g. retroreflector / corner targets) installed near Sandy Islet combined with regular InSAR (see below) data acquisition to establish a baseline of seabed subsidence, to monitor changes in seabed subsidence rates over time.

Radar satellite interferometry (InSAR) is a non-invasive surveying technique able to measure the millimetric motion of terrain structures over wide areas. This technique is based on the exploitation of synthetic aperture radar images (SAR) acquired from satellite sensors. Techniques such as InSAR are used regularly for purposes such as monitoring building subsidence and is well suited to understand naturally occurring or hydrocarbon extraction related subsidence. Together with regular capture of satellite imagery, it will be possible to establish a comprehensive program to monitor changes in available nesting habitat, elevation and slope at Sandy Islet and attribute this to natural or man-made causes.

Further details of this monitoring program such as target locations and monitoring frequency and analysis/ interpretation techniques will be described in a specific monitoring program to be developed post FID. It is anticipated monitoring will commence post project FID to allow for establishment of a multi-year natural baseline before the first hydrocarbons are extracted from the Torosa reservoir.

Sandy Islet Morphology Monitoring

Since records are available (1974) the size of Sandy Islet has naturally varied between 1.8 ha and 2.3 ha, a variation of approximately 20%.

High resolution satellite imagery will be reviewed at least two times per year to monitor the areal extent of available nesting habitat (e.g. land above LAT). These will be compared to historic estimates of available nesting habitat in determining whether corrective actions are required.

4.5 Recovery plans acceptability

4.5.1 Introduction

Further evaluation of the proposed Browse Project against the following recovery plans has been made under the EPBC Act:

- Conservation Management Plan for the Blue Whale - A Recovery Plan under the *Environment Protection and Biodiversity Conservation Act 1999* Commonwealth of Australia 2015-2025 (Commonwealth of Australia, 2015a)
- Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth of Australia, 2017a).

This analysis is required to demonstrate that the proposed Browse Project is not inconsistent with these recovery plans. The recovery plan regime is designed to protect, conserve and manage a listed threatened species, with the ultimate objective to stop any decline and support recovery of the species so that its chances of long-term survival are maximised. Given the length of time anticipated to achieve that objective, interim recovery objectives and targets are set for the life of the plan, along with actions to support recovery.

A range of management actions are identified in recovery plans which, when taken collectively, seek to further the overall objective. However, no individual action alone is determinative of status of achievement of the overarching interim and long-term objectives. Recovery plans are also intended to have some flexibility in the implementation of actions—for example, and where relevant, through adoption of principles of adaptive management or consideration of new information that becomes available during the life of the plan.

Therefore, to evaluate whether the proposed Browse Project may be inconsistent with a recovery plan, it is necessary to consider that plan and its objectives holistically and with reference to the overall results it aims to achieve.

Woodside has undertaken a further evaluation on that basis, which has concluded that the proposed Browse Project is not inconsistent with the Blue Whale CMP or the Marine Turtle RP. To the contrary, implementation of the proposed Browse Project provides a unique opportunity to contribute to the further understanding of the pygmy blue whale and green turtle species. The proposed Browse Project has made commitments to undertake further studies and monitoring to verify and further update the existing data for pygmy blue whales and green turtles. Targeted monitoring programs will verify impact predictions and inform adaptive management regimes at relevant times throughout the proposed Browse Project life cycle.

- In summary, Woodside considers the proposed manner of implementation of the proposed Browse Project aligns with the interim and long-term objectives of the Blue Whale CMP and Marine Turtle RP as follows:
- The proposed Browse Project is not an anthropogenic threat that presents a material risk to the conservation status of either the pygmy blue whale sub-species or the green turtle (G-ScBr) genetic stock.
- Robust scientific information has been generated and considered by Woodside to support assessment of the proposed Browse Project and will continue to be used in decision making during implementation. In addition, conservative assumptions regarding, and interpretation of, available scientific data have been made and a conservative approach has been taken to mitigation and management measures for the proposed Browse Project where uncertainties have been identified (see **Section 4.2** and **Section 4.3**).
- Monitoring and management of potential impact to the East Indian Ocean pygmy blue whale population and the green turtle (G-ScBr) genetic stock will be undertaken in implementing the proposed Browse Project.
- The potential for anthropogenic threats to populations of pygmy blue whale or green turtles specifically associated with implementation of the proposed Browse Project has been mitigated such that those threats are demonstrably minimised and will be subject to an adaptive management regime (where appropriate).

4.5.2 Conservation Management Plan for the Blue Whale

4.5.2.1 Overview of the Plan

The ultimate goal of the Blue Whale CMP is to improve the species' conservation status so that they can be removed from the EPBC Act threatened species list.

The following four interim recovery objectives are identified in the Blue Whale CMP, with each one being assessed in accordance with associated recovery targets:

1. Assessing the conservation status of the blue whale using efficient and robust methodology.
2. The spatial and temporal distribution, identification of biologically important areas, and population structure of blue whales in Australian waters is described.
3. Current levels of legal and management protection for blue whales are maintained or improved and an appropriate adaptive management regime is in place.
4. Anthropogenic threats are demonstrably minimised.

A number of relevant actions are identified in the Blue Whale CMP which are expected to be progressed or be completed over a ten year period (the lifetime of the plan). Each of the actions address the threats which have been assessed as being the most significant to the blue whale population; or are for the purposes of understanding and measuring population recovery and identification of important habitat.

Two categories of actions are identified within the Blue Whale CMP:

1. Assessing and addressing threats.
2. Enabling and measuring recovery.

The actions identified under each category are directed at the interim recovery objectives and recovery targets, as well as key threats to the blue whale population.

4.5.2.2 Evaluation summary

A.2: Anthropogenic noise

In relation to this action area, a Pygmy Blue Whale Management Plan (PBWMP) has been developed (**Appendix C.5**). The primary purpose of the PBWMP is to outline how any underwater anthropogenic noise associated will be managed such that it will not be inconsistent with the Blue Whale CMP, specifically the requirements of Action A.2.3.

Action Area A.2, Action 3 of the Blue Whale CMP that states that:

> *"anthropogenic noise in biologically important areas (BIAs) will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area".*

Guidance on the key terms of the Blue Whale CMP and FAQs (DAWE, 2021 and NOPSEMA 2021) have been applied to the development of the PBWMP.

Woodside considers that the management approach outlined in PBWMP plan demonstrates, with a high level of confidence, that unacceptable impacts to pygmy blue whales will be avoided, by minimising the risk of injury to pygmy blue whales or displacement of pygmy blue whales from the Scott Reef possible foraging BIA, as a result of underwater noise emissions associated with the proposed Browse Project.

A detailed overview of each objective of the PBWMP is provided in **Section 3** of the plan and a summary of outcomes is provided in **Section 1-2** of the plan.

Management of Injury from Impulsive noise

The spatial and temporal controls presented in the PBWMP ensure that all activities generating impulsive noise will either be eliminated during the detailed design phase and if they are required, will only occur outside of times/places where pygmy blue whales are likely to be present. A scientific monitoring program will be put in place prior to these activities occurring, to provide a thorough understanding of times and places pygmy blue whales are likely to be present in and around the project area. A requirement to monitor for whales will apply to these activities, which can be immediately ceased if a whale is sighted, on a precautionary basis.

Management of Injury from Vessel noise

Modelling indicated that the greatest distance at which injury may be caused (after 24 hours of continuous exposure) to a whale was 1.5 km, which was associated with installation of the inter-field spurline, which would only affect the possible foraging area for a short duration. For vessels that are present for longer periods, (i.e. MODUs and Torosa FPSO), these were modelled as potentially causing injury (after 24 hours of exposure) at distances of less than 650 m from the noise source. Considering behavioural disturbance (e.g. avoidance) may occur at 120 dB re 1 μPa, and migratory pygmy blue whales typically travel 10s or 100s of kilometres a day, the risk of exposure of a PBW to TTS or PTS from vessel activities is considered highly unlikely.

To further understand injury risk, ANIMAT modelling was conducted to account for whale behaviour and sound exposure (**Appendix B**). ANIMAT modelling outcomes demonstrated that for the vessel activity with highest risk of injury (BTL installation), 95% of simulation results required a pygmy blue whale to come within 50 m of a vessel's propulsion system to be exposed to noise related injury (PTS). The probability of a PBW coming to such close proximity of a vessel was considered highly unlikely.

For the FPSO and MODU, ANIMAT modelling resulted in no simulated whales being exposed to PTS/TTS.

Disruption of foraging behaviour

It is recognised that the proposed Browse Project may result in the generation of underwater noise in excess of the recognised behavioural response threshold, which has the potential to disrupt pygmy blue whale foraging behaviour.

Accordingly, the PBWMP has considered:

- the time of year the activity will be undertaken and the likelihood of pygmy blue whale foraging in the area of potential overlap of the proposed Browse Project and the Scott Reef possible foraging area (BIA)
- the extent, intensity, and duration of sound exposure within the Scott Reef possible foraging area, including residual and cumulative impacts after the application of controls
- the implementation of any appropriate controls to prevent unacceptable impacts.

Best practice management measures in accordance with a precautionary approach have been established within the PBWMP and successful implementation will ensure that, with a high degree of certainty, the anthropogenic noise from the proposed Browse Project will be managed such that any blue whale will be able to continue to utilise the BIA without injury, and no blue whale will be displaced from a foraging area. In this way, the proposed Browse Project will not be inconsistent with the CMP.

Existing Knowledge of Pygmy Blue Whale Activity at Scott Reef

The PBWMP outlines key management principles used to determine activity specific controls that will be applied to the proposed Browse Project. Spatio-temporal management is a core element of this management approach, underpinned by a comprehensive review of existing knowledge of pygmy blue whale activity at Scott Reef and adaptive management to respond to uncertainty or possible future changes in understanding of pygmy blue whale activity in the region.

Pygmy blue whales are known to migrate on an annual basis through the Scott Reef possible foraging on their way to and from breeding and feeding grounds within the Banda Sea, Indonesia. The migratory seasons are defined by shoulder and peak periods and exact timings can vary inter-annually.

Evidence collected to date from a variety of techniques including sampling of zooplankton, pygmy blue whale vocalisation data from passive acoustic monitoring (noise loggers), survey observations (vessel-based and aerial) and satellite tracking suggests that Scott Reef is likely to be of less importance for the East Indian Ocean (EIO) pygmy blue whale population than other defined foraging areas. However, the relative importance of Scott Reef as a foraging area for migrating pygmy blue whales remains unclear and as such the possible foraging area will be managed as a known foraging area and BIA for the purposes of the proposed Browse Project.

In known foraging BIAs such as the Perth Canyon, pygmy blue whales can be observed in predictable annual higher abundance, exhibiting foraging behaviours and have extended residence times albeit in large areas of coastal or offshore waters. These observations, behaviours and residence times are not replicated at or in the vicinity of the Scott Reef possible foraging area, despite dedicated, multi-year studies over an extended period, using multiple survey and sampling techniques. Across the Scott Reef possible foraging area from west to east, based the understanding of pygmy blue whale foraging areas and habitat suitability, there is a higher likelihood of prey (krill) availability over the upper slope (with canyon features) habitat to the west of Scott Reef as compared to the featureless, homogeneous seabed habitat of the eastern extent of the BIA. This forms the basis of concluding that the likelihood of foraging by pygmy blue whales while migrating through the BIA is higher for (i) the upper slope habitat in the western extent of the BIA and (ii) potentially the Scott Reef channel as based on the findings reported by Sutton et al. (2019). Survey results for one season (in 2008), have been used to infer a predictable spring period of higher productivity leading to krill swarms that are a predictable food source for southbound migrating pygmy blue whales within the Scott Reef channel. Based on the likelihood of prey availability within suitable foraging habitat and foraging pygmy blue whale activity, a higher relative importance of the Scott Reef channel as a foraging habitat within the Scott Reef possible foraging has been adopted. It is recognised that there are knowledge gaps and scientific uncertainty about the predator-prey dynamics (pygmy blue whale and krill availability) and the potential temporal-spatial importance of the channel. The higher likelihood of foraging pygmy blue whales within the Scott Reef Channel (as presently accepted) underpins the approach to the management of noise and potential impacts to pygmy blue whales within the PBWMP.

Underwater Noise Characterisation & Assessment

Noise (sound power level) estimates for major activities or vessels, including continuous or impulsive noise are presented in the PBWMP, based on suitable analogues or indicative design data. Sound propagation modelling has then been performed to estimate the distance (R_{max}) from each activity at which certain noise levels will be received, corresponding to potential injury or behavioural disturbance effect thresholds.

Continuous noise sources range from 161.5 dB re 1 μPa.m for well head choke valve noise (at well centres with up to 7 wells) to 191 dB re 1 μPa.m for the rigid pipelay vessel. These activities were estimated to cause potential behavioural responses from pygmy blue whales at onset ranges from <500 m to 9.9 km, respectively.

After the application of elimination, substitution and reduction controls, and a cumulative ensonified area assessment is provided and demonstrates:

- There are no planned activities that will occur during peak periods of the pygmy blue whale migratory seasons, that generate noise above 120 dB re 1 μPa within the Scott Reef channel.
- Underwater noise is anticipated to peak during the initial subsea construction phase, during intermittent, short term activities (ie BTL installation concurrent with the MODU activities) that may ensonify (>120 dB re 1 μPa) an area of up to ~123 km² (0.95% of Management Zone B). These activities are targeted to occur outside of peak periods of the pygmy blue whale migratory seasons and BTL activities will only impact the BIA for a period of weeks.
- After this initial construction period, the total areal extent of the Scott Reef possible foraging ensonified above 120 dB re 1 μPa during peak pygmy blue whale migratory periods is reduced to ~1 km² at the surface (<0.01% of Management Zone B) during normal operations (with mitigations applied, i.e., turning off vessel propulsion or FPSO thrusters if a whale is sighted) and ~22 km² at the surface (0.17%) during intermittent (<1 day per fortnight) offtake operations (where vessel propulsion cannot be halted if a whale is sighted, due to offtake spill risks).
- Noise from well-heads during operations may ensonify up to ~4.7 km² of the Scott reef possible foraging area, however this noise propagation would not ensonify waters in the top 50 m of the water column, where whales would typically be when transiting to foraging areas or migrating. This value does not account for the predicted marked reductions in noise emissions expected to result from designing well head choke valves to minimise noise.
- Activities outside of the Scott Reef possible foraging area will also be managed, to minimise the risk of disturbance to opportunistic foraging and scientific monitoring will occur in this region to understand the likelihood of pygmy blue whale presence and foraging behaviour occurring.

Management Approach

The management approach within the PBWMP aligned with industry best practice and involves:

- reduction of potential impacts through the application of the hierarchy of controls
- spatio-temporal management principles
- an extensive scientific monitoring program
- an adaptive management program to respond to new scientific or technical information
- decision-making within the adaptive management framework based on scientific data and input from an expert review panel.

Management of underwater noise for the proposed Browse Project is governed by the application of hierarchy of controls with key principles applied summarised below:

- Avoid generating noise at times and/or in places where pygmy blue whales are likely to be present.
- Substitute high noise generating activities with quieter alternatives.
- Engineering will be used to reduce the sound source levels associated with equipment being designed for use on the Project.
- Where an activity cannot be eliminated, substituted or reduced such that noise generated is below behavioural response thresholds, operational mitigations will apply.

Spatio-temporal management principles will be applied to manage noise at certain areas and at certain times. Two management zones will be applied and managed for the Torosa development and operational activities:

- Management Zone A: Scott Reef channel.
- Management Zone B: the wider Scott Reef possible foraging area (BIA).

Spatio-Temporal Management Principles

Spatio-temporal management principles will be applied to manage noise within certain areas and at certain times. Two management zones will be applied and managed for the Torosa development and operational activities:

- Management Zone A: Scott Reef channel
- Management Zone B: the wider Scott Reef possible foraging area.

The spatio-temporal management approach proposed will apply a suite of key principles for managing underwater noise within each zone with the aim of eliminating noise propagating within and into the Scott Reef channel (Management Zone A) and minimising noise propagation within the wider Scott Reef possible foraging area (Management Zone B). These key principles are as follows:

Within management zone A during peak and shoulder pygmy blue whale migratory seasons include:

- There shall be no generation of noise capable of causing 'injury' to a pygmy blue whale from any source.

- There shall be no generation of noise from vessels (including FPSOs or MODUs) at levels above which may cause disruption to a foraging pygmy blue whale.

Additionally, there shall be no propagation of noise into this zone, from unmitigable long term noise sources above levels which may cause disruption to a foraging pygmy blue whale.

Within management zone B during peak periods of the pygmy blue whale migratory seasons include:

- There shall be no impulsive noise from impact piling or seismic activities including vertical seismic profiling.
- There shall be no vessel activity from which 'injury' (e.g. PTS/TTS) from noise exposure could occur (24 hour exposure) at 750 m or more from the source.
- There shall be no unmitigable or continuous long-term noise above levels which may cause a behavioural response beyond a 1 km radius from the source.
- Any mitigable surface activity generating noise at levels which may cause injury or a behavioural response must operate in accordance with an activity specific Whale Management Procedure.

The approach, as set out above ensures that underwater noise emissions will be eliminated, avoided or reduced such that injury to and displacement from foraging by a pygmy blue whale has been minimised to the greatest extent possible and the residual risk is negligible.

Key Management Actions

Design features and activity specific management measures applicable to anthropogenic noise with as incorporated by the hierarchy of controls and spatio-temporal management principles are presented in and include:

During Design:

- Thrusters on the FPSO **will be** designed to minimise noise generation, with the radius to the pygmy blue whale behavioural response threshold being reduced from ~2.8 km to 570 m if noise reduction from 183 re 1 µPa.m to 178dB re 1 µPa.m (50% thruster utilisation) is achieved.
- Subsea choke valves on well heads at Torosa **will be** designed to minimise noise generation, with initial investigations indicating noise can be reduced by approximately 16.5 dB, meaning the radius at which pygmy blue whale behavioural response threshold is experience would be significantly below the predicted ~500 m horizontal radius. The outcome of this exercise is uncertain, as it has not been possible to identify a vendor that has had to incorporate noise mitigations into well head design before. This design mitigation is a best in class approach to noise mitigation.

During subsea construction and installation:

- At Torosa and Brecknock, MODUs will not use DP systems to hold station while drilling during peak periods of the pygmy blue whale migratory seasons, but instead will be moored.
- Vessels operating in the Scott Reef possible foraging area will be required to implement operational restrictions and observe for pygmy blue whales, with triggers to delay or stop certain activities if whales are sighted within nominated management zones.
- No activities will occur within the Scott Reef Channel.

In relation to impulsive noise from subsea construction and installation activities:

- Non-impulsive noise generating alternatives to impact piling (e.g. suction piling) will be used at all times, where technically feasible.
- Impact piling will not occur in the Scott Reef channel (Management Zone A) at any time or within Management Zone B during peak or shoulder pygmy blue whale migratory periods.
- VSP activities will not occur in the Scott Reef channel (Management Zone A) at any time or within the Zone B during peak pygmy blue whale migration periods.
- A Whale Management Procedure (WMP) will be in place during all impact piling and VSP activities, to observe for whales and respond appropriately in the event that whales are detected within monitoring zones.

During operations (that coincide with peak periods of the pygmy blue whale migratory seasons):

- There will be no unmitigable vessel noise (including from FPSO or MODUs) above the behavioural response threshold within the Scott Reef channel
  - The Torosa FPSO is located in the swell shadow of the Scott Reef system, meaning the thrust required to control heading will be rarely utilised and will be substantially less than other offshore facilities, i.e., Calliance FPSO, significantly minimising long term noise generation from either continuous (weather-vaning FPSO) or intermittent (condensate offloading) activities.

- Concurrent activities at the Torosa FPSO will be restricted to reduce cumulative noise (i.e., supply vessels cannot conduct goods transfers while condensate offtakes are occurring).
- Mitigable noise, including from supply vessels and during condensate offtakes, will not occur unless a Whale Management Procedure is in place to establish exclusion zones where the activity cannot commence if a whale is present and once the activity has commenced, monitoring will continue, and applicable mitigations applied if a whale is observed.

During future tie-back phases:

- Subsea construction or installation activity (e.g., drilling or flowline installation) related to subsequent tiebacks from within the Torosa field will only occur outside of peak periods of the pygmy blue whale migratory seasons.
- Drilling and completions of any Torosa or Brecknock well as part of future (post Torosa RFSU) tieback phases will be required to be completed by a moored MODU when operating during peak periods of the pygmy blue whale season, unless the noise from the DP system would be the equivalent or less than noise generated were it to be moored.

Scientific Monitoring

Scientific monitoring programs will be designed to obtain a contemporary baseline data on the relative abundance, seasonality and, movement and behaviour of pygmy blue whales within the possible foraging area at Scott Reef prior to the commencement of operations.

On-going data acquisition is planned to occur throughout the life of the proposed Browse Project, which will be important to monitor any changes the movement and behaviour of pygmy blue whales and confirm sound source levels of project activities.

The key objectives of the pygmy blue whale scientific (baseline) monitoring program are as follows:

- To verify and further understand the seasonality, residency time, behaviours and relative abundance of the EIO pygmy blue whale population utilising the Scott Reef possible foraging area to ensure spatio-temporal management areas are appropriately defined.
- Identify the habitats within the Scott Reef possible foraging area that are likely to support predictable aggregations of prey (krill) to ensure spatial management areas are appropriately defined.

Additionally, the following monitoring activities will be put in place in support implementation of the PBWMP:

- Measurement of underwater noise from key activities to verify impact predictions and revise management procedures, if required.
- A technology maturation program to investigate and demonstrate feasibility for technologies to enable real-time detection of pygmy blue whales such as underwater listening stations and/or infra-red detection techniques.

An expert panel will be established to input to the scope and design of the scientific monitoring programs, review findings and decisions leading to changes in the management regime to minimise underwater noise emissions and potential impacts to pygmy blue whales.

Adaptive Management

An important element of applying a spatio-temporal management principles will be the application of an adaptive management process to verify and modify the management plan principles and triggers when new scientific or technical knowledge becomes available. The application of defined management zones and timing of seasonal controls is presently based on current knowledge regarding the presence and foraging behaviour within the Scott Reef possible foraging area. Findings from the baseline and ongoing (operational phase) scientific monitoring programs will be used to adaptively manage the applied spatio-temporal management regime and activity specific whale management procedures.

Adaptive management will ensure operational measures are aligned to possible changing knowledge or circumstances in space and time. Adaptative management actions and response trigger criteria are outlined in. The majority of actions are focussed on the pre-operational phase of the proposed Browse Project, to provide sufficient time to ensure operational plans can be adapted in response to any trigger criteria being met.

The primary objectives of the adaptive management are:

- Maintain a spatio-temporal management regime that minimises underwater noise emission impacts to pygmy blue whales and ensures the management objectives of the proposed Browse Project are met.
- To identify and execute any need for change to management actions, that will be made in response to triggers or action outcomes and scientific knowledge.

Aims of each key element of the Adaptative Management Plan are outlined below under two key categories – design modifications and spatio-temporal controls.

Design modifications:

- Predict noise levels from the Torosa FPSO thruster and Torosa well head choke valves based on detailed design information to ensure management objectives will be achieved or modifications to management actions are required.
- Validate predicted noise levels from well head choke valves at Calliance to inform if design changes are required for Torosa (applicable to post phase 1 activities).
- Validate predicted noise levels from the Torosa FPSO thruster and well head choke valves to ensure management objectives will be achieved or modifications to management actions are required.

Spatio-temporal controls:

- Ensure boundaries of management zones are appropriately defined and aligned to the most up to date understanding of pygmy blue whale movement and foraging behaviour.
- Ensure temporal restrictions based on seasonal peak and shoulder periods of the pygmy blue whale migration seasons accurately reflect actual pygmy blue whale presence and migratory periods including possible changes over time. Activity scheduling is to then be modified, where required, to meet temporal controls.
- Verify monitoring zone definitions and observation distances applied to relevant activities and designated within WMPs, are valid and accurate for each activity.

A.3: Understanding impacts of climate variability and change

The Blue Whale CMP identifies that this action is not primarily targeted at non-government entities. Rather, this action is primarily concerned with continuing to meet Australia's international commitments to reduce GHG emissions, and the associated effects on the blue whale population, which is largely a matter for Commonwealth policy and legislation.

As outlined in the Blue Whale CMP, climate change is expected to cause changes in migratory timing and destinations, population range, breeding schedule, reproductive success and survival of baleen whales, including the pygmy blue whale. It is predicted that cetaceans limited to warmer areas, such as pygmy blue whales, will experience a southward shift in distribution as ocean temperature increases. There is evidence of these changes already occurring in other marine mammal species, but such changes are difficult to detect for whales due to the complexity of ecological systems and the lack of detailed long-term records.

Woodside considers that the impacts of climate variability and change have been identified and considered in Chapter 7 of the draft EIS/ERD. Further relevant information is included within the **Section 5** and the Greenhouse Gas Management Plan (GHGMP) which details the measures proposed to manage the GHG emissions from the proposed Browse Project (**Appendix C.1**). In Woodside's view this approach is strongly aligned with interim recovery objectives 2, 3 and 4, and associated recovery targets 2-1, 3-1, 4-1, 4-2.

A.4: Minimising vessel collisions

Woodside is committed to reducing the risk of vessel strike as far as is reasonably practicable and complying with current legislative requirements in relation to this risk. This includes through the implementation of procedures and systems which seek to minimise and avoid vessel strike incidents.

The risk evaluation of unplanned vessel interactions with fauna is presented in **Section 6.3.14.4** of the draft EIS/ERD and further evaluated in **Section 4.2.5**, which has confirmed the governing risk rating of Low (C1). To mitigate any potential risk of unplanned vessel collisions to marine fauna including to pygmy blue whales from the proposed Browse Project, a number of key adopted controls (as set out in **Section 6.3.18.6** of the draft EIS/ERD) and additional controls (as presented in **Table 4-6**) and the systems and reporting requirements as outlined in Chapter 8 of the draft EIS/ERD will be implemented.

Woodside considers that the management approach outlined above demonstrably minimises the risk of vessel collisions and has strong alignment with interim recovery objectives 2, 3 and 4, and associated recovery targets 2-1, 3-1, 4-1 and 4-2.

Table 4-6: Alignment with Action Area A.4: minimising vessel collisions

Action Area	Draft EIS/ERD Controls	Additional Controls	Consequence	Likelihood	Risk Rating
A.4: Minimising vessel collisions	***Project vessel operations*** • Project vessels will only enter the channel between north and south Scott Reef during construction/installation, IMMR, contingent activities, decommissioning and emergency situations. • Project vessels will not travel at speeds greater than 12 knots within the State Proposal Area, or 6 knots in the Scott Reef channel. • FCTV will operate under a FCTV Management strategy (to be detailed in subsequent EPs as required) which will describe the appropriate additional control measures to manage vessel strike risk for the FCTV. Subject to the potential for technological innovation and additional engineering controls, FCTVs will not travel at speeds greater than 30 knots in sensitive areas at sensitive times. • Interactions between vessels and whale sharks will be not be inconsistent with the Whale Shark Code of Conduct (DPAW, 2013), whereby unless in an emergency situation, vessels will not knowingly travel at speeds greater than eight knots within 250 m of a whale shark and not intentionally approach closer than 30 m of a whale shark. • Vessels will operate in accordance with EPBC Regulations 2000 – Part 8 Division 8.1 and Australian National Guidelines for Whale and Dolphin Watching whereby:	***Project vessel operations*** • All vessels (including the FCTV) will not travel at speeds greater than 12 knots within the pygmy blue whale possible foraging area that overlaps Scott Reef in peak migration periods (May, June and November), unless required for SOLAS. • The FCTV will minimise time within the pygmy blue whale possible foraging area that overlaps Scott Reef by following defined route to Torosa FPSO in peak migration periods (May, June and November). • Interactions between vessels and marine fauna will not be inconsistent the EPBC Regulations 2000 – Part 8 Division 8.1, and in the Australian National Guidelines for Whale and Dolphin Watching and the Whale Shark Code of Conduct, whereby unless in a permitted emergency situation, vessels will not travel at speeds greater than the speed restrictions prescribed for marine fauna encounters.	Moderate	Unlikely	Moderate (C2)

Action Area	Draft EIS/ERD Controls	Additional Controls	Consequence	Likelihood	Risk Rating
	• Vessels will not knowingly travel greater than six knots within 300 m of a whale or 100 m of a dolphin. • Vessels will not knowingly approach closer than 100 m to a whale or 50 m to a dolphin (except if bow riding). • Vessels will not knowingly restrict the path of cetaceans. • Vessels will take direct routes where practicable, whilst avoiding significant areas for marine fauna where possible. • The possible FCTVs design will intrinsically reduce the risk of vessel strikes, including a shallow vessel draught (i.e. approximately 1 m or less) and no propeller. • The possible FCTV will have trained vessel crew as a marine fauna observer.				

4.5.2.3 Actions related to enabling and measuring recovery

B.1: Measuring and monitoring population recovery

As part of the design and impact assessment of the proposed Browse Project, robust scientific information has been collected, applied, and considered regarding pygmy blue whales (refer to **Section 4.2.2**). In addition, the project has committed to address any uncertainty through the implementation of a dedicated monitoring program to verify impact predictions of the proposed Browse Project (as set out in **Section 4.4**, and **Section 5.3.2.5**.2 and **Section 9.4** of the draft EIS/ERD).

Woodside considers that implementation of the proposed Browse Project provides a unique opportunity for ongoing measuring and monitoring of the East Indian Ocean pygmy blue whale population and has strong alignment with interim recovery objectives 1 and 2.

B.2: Investigating population structure and

B.3: Describing spatial and temporal distribution and defining biologically important areas.

As above, robust scientific information has been collected, applied and considered regarding pygmy blue whales during the course of assessment of the proposed Browse Project. This specifically included outcomes from research projects on pygmy blue whale migration and seasonality with particular focus on whale residence times and localised plankton dynamics in the Browse Development Area (refer to **Section 4.2.2**).

Data has also been collected on population structure, distribution and behavioural patterns of pygmy blue whales in the East Indian Ocean. The proposed monitoring program to verify impact predictions of the proposed Browse Project will allow for effective monitoring of the potential anthropogenic threats to the behaviour of pygmy blue whales specifically associated with the implementation of the proposed Browse Project. To the extent that any further threats are identified, an adaptive management regime will implement controls (where appropriate) to ensure that those threats are demonstrably minimised.

Woodside anticipates that the data it generates during implementation of the proposed Browse Project may assist to refine current understandings of BIAs and migratory pathways between breeding and possible foraging areas for the East Indian Ocean pygmy blue whale population and has strong alignment with interim recovery objectives 1 and 2.

4.5.3 Marine Turtle Recovery Plan

Similar to the Blue Whale CMP, the ultimate goal of the Marine Turtle RP is to improve the species' conservation status so that these species can be removed from the EPBC Act threatened species list.

The following four interim recovery objectives are identified in the Marine Turtle RP, with each one being assessed in accordance with associated recovery targets:

1. Current levels of legal and management protection for marine turtles are maintained or improved both domestically and throughout the migratory range of Australia's marine turtles.
2. The management of marine turtles is supported.
3. Anthropogenic threats are demonstrably minimised.
4. Trends at index beaches, and population demographics at important foraging grounds, are described.

A number of relevant actions are identified in the Marine Turtle RP that are expected to be progressed or be completed over the ten year life of the plan. Each of the actions address the threats which have been assessed as being the most significant to marine turtle populations; or are for the purpose of understanding and measuring population recovery.

The same two categories of actions as under the Blue Whale CMP are identified:

1. Assessing and addressing threats.
2. Enabling and measuring recovery.

The actions identified under each category are directed at the interim objectives and recovery targets, as well as key threats to marine turtle populations. For the purposes of the proposed Browse Project, only one species (green turtles) is relevant. The objectives in the context of actions relevant to green turtles are discussed below.

4.5.3.1 Evaluation

Woodside has conducted an evaluation of the proposed Browse Project against the Marine Turtle RP. This evaluation involved:

- consideration of the information pertaining to Scott Reef–Browse Island green turtle genetic stock (G-ScBr) as presented in the Marine Turtle RP

- proposed Browse Project funded surveys and satellite tracking studies at Scott Reef
- key published literature on the G-ScBr population with respect to distribution, BIAs (habitat critical to the survival of the species, foraging grounds and migratory routes); and seasonal occupancy (including peak periods for nesting and hatchling emergence) through the proposed Browse Development Area (refer to **Section 5.3.2.6.1** of the draft EIS/ERD).

Regard was also given to the following measures that will be undertaken by Woodside in implementing the proposed Browse Project:

- all reasonably practicable options to minimise anthropogenic threats during construction and operation
- opportunities for further development of the science in respect of the G-ScBr stock that arise from the proposed Browse Project including research and monitoring/verifying science to update the green turtle data and verify impacts of the proposed Browse project.

Woodside's analysis has concluded that the proposed action is not inconsistent with the Marine Turtle RP on the basis that:

1. The potential for impacts from the proposed Browse Project to the conservation status of the G-ScBr stock have been assessed using an efficient and robust methodology.
2. The spatial and temporal distribution, biologically important areas and population structure of the G-ScBr stock at Scott Reef, have been considered in this assessment.
3. Implementation of the proposed Browse Project will occur within the existing legal regime and protection of green turtles will be maintained, including through the application of principles of adaptive management (where relevant).
4. Anthropogenic threats associated with the proposed Browse Project are demonstrably minimised. In particular, artificial light within or adjacent to habitat which is critical to the survival of green turtles will be managed such that the green turtle population is not displaced from these habitats (refer **Section 4.3**).

The sections that follow set out further details of the evaluation of the proposed Browse Project against each of the categories of actions identified as relevant for G-ScBr stock in the Marine Turtle RP.

4.5.3.2 Actions related to assessing and addressing threats

A1: Maintain and improve efficacy of legal and management protection

Although the Marine Turtle RP identifies that this action is not primarily targeted at non-government entities, Woodside has conducted a detailed evaluation of the proposed action against the existing legislative instruments for the purposes of the assessment of the proposed Browse Project.

Woodside's analysis concludes that the proposed Browse Project is capable of being implemented and operated within the existing legal regime and is not inconsistent with any current or proposed laws or regulatory requirements. This is consistent with Woodside's approach to each of its projects, and it has implemented management measures to ensure that it continues to remain abreast of any proposed legislative or regulatory updates during the lifetime of the action.

Section 8.8 of the draft EIS/ERD provides further information in relation to the compliance history of Woodside, and **Section 2.11** of the draft EIS/ERD provides a summary of the legal framework relevant to the proposed Browse Project.

Woodside's assessment has concluded that no existing protections for green turtles more broadly will be impacted by implementation of the proposed Browse Project. Further, Chapter 6 of the draft EIS/ERD describes the action specific controls, systems, reporting requirements and checks which will be applied to ensure that the implementation occurs in a manner that embeds protections for green turtles.

Woodside considers that these measures are aligned with interim recovery objectives 1 and 2, and recovery targets 1.1, 1.2 and 2.1 in the Marine Turtle RP.

A2: Adaptively manage turtle stocks to reduce risk and build resilience to climate change and variability

This action identified in the Marine Turtle RP is multi-dimensional. Insofar as this action relates to climate change, the Recovery Plan identifies that it is not primarily targeted at non-government entities. Rather, it is concerned with continuing to meet Australia's international commitments to reduce GHG emissions, and the associated effects on marine turtle populations, which Woodside considers is largely a matter for Commonwealth policy and legislation.

As outlined in the Marine Turtle RP, climate change is of particular concern to marine turtles because it is likely to have impacts across their entire range and at all life stages. Climate change is expected to cause changes in dispersal patterns, food webs, species range, primary sex ratios, habitat availability, reproductive success and survivorship. Impacts will differ based on the ability of a stock to adapt to changes in suitable nesting beaches and food availability.

While some impacts have been observed, such as changes in breeding phenology, altered distribution, and evolution of thermal thresholds, there still is uncertainty with regard to how marine turtles will respond to climate change impacts.

Woodside considers that the impacts of climate variability and change have been identified and considered in Chapter 7 of the draft EIS/ERD. Further relevant information is included within the **Section 5** and in the Greenhouse Gas Management Plan (GHGMP) (which details the measures proposed to manage the GHG emissions from the proposed Browse Project and is attached in **Appendix C.1**). In Woodside's view, this approach is strongly aligned with interim recovery objectives 1 and 3, and recovery targets 1.1, 3.1 and 3.2 in the Marine Turtle RP.

A3: Reduce the impacts from marine debris

Similarly, the Marine Turtle RP identifies that this action is not primarily targeted at entities such as Woodside. However, Woodside is committed to reducing its impact on Australian waters, and more specifically, its potential to impact on green turtle populations so far as reasonably practicable. This includes, among other things, potential impact from marine debris.

As set out above, Woodside is committed to constructing and operating the proposed Browse Project in accordance with all current legislative and regulatory requirements. In addition to the measures set out above, this includes the implementation of measures specifically intended to minimise the marine debris caused by the proposed project. Implementation of these measures will ensure that, if marine debris occurs, it is addressed and risk to green turtle populations are reduced so far as practicable.

Section 6.3.14 of the draft EIS/ERD describes the adopted controls that are specific to reducing the impacts from hazardous and nonhazardous inorganic waste (including marine debris) from the proposed Browse Project. The Threat Abatement Plan for the Impacts of Marine Debris on Vertebrate Wildlife of Australia's Coasts and Oceans (Commonwealth of Australia, 2018a) identifies marine turtles as being adversely impacted by marine debris, and **Section 6.3.14** of the draft EIS/ERD also provides an assessment of the alignment of proposed management measures with the objectives and actions of this plan.

Woodside considers that the management approach outlined above demonstrably minimises the risk to green turtles caused by marine debris and has a strong alignment with interim recovery objectives 1, 2 and 3, and recovery targets 1.1, 1.2, 2.1, 2.2, 3.1 and 3.2.

A4: Minimise chemical and terrestrial discharge

Woodside is committed to ensuring that it avoids and minimises the potential to cause any chemical discharge or spills during the construction or operation of the proposed Browse Project. As part of the development and assessment of the proposed Browse Project, Woodside has undertaken analysis concerning the impact of marine discharges to waters adjacent to Scott Reef, and the predicted effect on the green turtle population.

Sections 6.3.10, 6.3.12, 6.3.13, 6.3.15, 6.3.16 and 6.3.17 of the draft EIS/ERD describe the adopted controls specific to minimising discharges from the proposed Browse Project. The conclusion of the impact assessment was that, with the implementation of these controls, routine marine discharges from the proposed Browse Project would not have any significant residual impacts on marine turtles.

The adopted controls are supported by the implementation of procedures and systems which seek to avoid discharges and/or spills. In the event that unintended discharges and/or spills do occur, Woodside has implemented measures to:

- ensure that they are detected early
- ensure that appropriate steps are taken to ensure that any impact or risk to green turtle populations is reduced as far as practicable.

Woodside considers that the rigorous approach outlined above demonstrably minimises the potential risks of chemical discharge to the green turtle population at Scott Reef and has strong alignment with interim recovery objectives 1, 2 and 3, and associated recovery targets 1.1, 1.2, 2.2 and 3.1.

A5: Address international take within and outside Australia's jurisdiction

This action identified in the Marine Turtle RP is not targeted at entities such as Woodside. Although Woodside has no direct power to highlight and reduce the illegal trade in marine turtle products, Woodside is committed to working collaboratively to increase education and communication of marine turtle conservation.

Woodside considers that the above measures broadly support interim recovery objectives 1 and 3, and associated recovery targets 1.1, 1.2 and 3.1.

A6: Reduce impacts from terrestrial predation

This action identified in the Marine Turtle RP is not targeted at entities such as Woodside or actions akin to the proposed Browse Project. However, based on the assessment which has been undertaken, Woodside does not consider that the proposed action will have an impact on the terrestrial predation of green turtles at Scott Reef.

Accordingly, Woodside considers there is no inconsistency with Action Area A6.

A7: Reduce international and domestic fisheries bycatch

Similarly, this action is not identified in the Marine Turtle RP as being targeted to entities such as Woodside or actions akin to the proposed Browse Project. Given the proposed project does not contemplate any proposed increase on fishing pressures, it is not predicted that the proposed Browse Project will have an impact on domestic fisheries.

Accordingly, Woodside considers there is no inconsistency with Action Area A7.

A8: Minimise light pollution

Woodside has assessed that the primary potential impact to green turtle populations as a result of the proposed Browse Project is artificial light within or adjacent to green turtle habitat at Scott Reef.

Section 6.3.3 of the draft EIS/ERD sets out the outcomes of an evaluation of the potential impacts to green turtles from light emissions associated with the physical presence of offshore facilities, MODU and vessels during all phases of the proposed Browse Project. As described in **Section 4.3.3**, an additional desktop lighting assessment, literature review and light modelling study has been conducted. This includes an assessment of the relative importance of the turtle nesting beach located in the proposed Browse Development Area (Sandy Islet) to the G-ScBr stock, a further literature review describing potential impacts of offshore sources of artificial light on all life stages of marine turtles, a gaps analysis of the assessment completed to date (against the National Light Pollution Guidelines for Wildlife, 2020), and an updated impact assessment based on six modelling scenarios.

This impact assessment was conservatively based on the assumption that light emissions (in the form of either direct light or sky glow) from operational lighting may be visible at intensities resulting in behavioural impacts to marine turtles at 20 km from the source. For flaring, additional conservatism was made based on results of line of sight modelling, with behavioural impacts potentially occurring within 52 km of the drill centre and FPSO locations. Key outcomes of the impact assessment are summarised in **Section 4.3.3**.

Woodside acknowledges the risk associated with light and proposes to manage this risk by implementing a Turtle Management Plan (**Appendix C.3**) which includes adopted controls (as identified in **Section 6.3.3.7** of the draft EIS/ERD) and additional controls described as result of the further evaluation. Woodside considers that the management approach outlined in the Turtle Management Plan demonstrably minimises light pollution at Scott Reef associated with the proposed Browse Project, and has strong alignment with interim recovery objectives 1, 2 and 3, and associated recovery targets 1.1, 1.2, 2.1, 2.2, 3.1 and 3.2.

A9: Address the impacts of coastal development/infrastructure and dredging and trawling

As part of the development and environmental impact assessment of the proposed Browse Project, robust scientific information has been generated and considered regarding the impact of the proposed action on the population of green turtles at Scott Reef. The proposed Browse Project will not require dredging or trawling. Based on Woodside's assessment, it considers that the primary potential impact to green turtle populations as a result of the proposed Browse Project is artificial light within or adjacent to green turtle habitat at Scott Reef.

The Marine Turtle RP identifies habitat modification (physical modification of habitat that has the potential to displace individuals or modify behaviour) as a threat to marine turtles. **Section 6.3.20** of the draft EIS/ERD presented the outcomes of an evaluation of the potential impacts of production-induced subsidence during the operations phase of the proposed Browse Project, which included change or loss of nesting habitat at Sandy Islet. This evaluation is based on peer-reviewed modelling of the magnitude of potential subsidence and associated horizontal movements for the Browse reservoirs. The conclusion of the modelling was that any production related subsidence at Scott Reef will be less than 10 cm over field life.

As described in **Section 6.3.20.4** of the draft EIS/ERD, the assessment of potential impacts of production-induced subsidence are largely based on a study by AIMS (2012) to assess the potential impacts on Scott Reef's coral habitats and Sandy Islet in the context of climate change. The study concluded that for the worst-case scenario, given the highly variable nature of sea level rise, cyclone occurrence and sediment dynamics, it is not possible to reliably predict the timing or just how much earlier any major changes to Sandy Islet might occur. The AIMS study concluded that impacts to Sandy Islet from the intermediate and best-case scenarios would be negligible. Given this, no significant change is predicted in terms of available turtle nesting locations or nesting success at Sandy Islet as a result of seabed subsidence. The AIMS (2012) study is provided in **Appendix A.2**.

SUPPORTING INFORMATION

The proposed Browse Project's impact on climate change has been assessed in Chapter 7 of the draft EIS/ERD.

The Turtle Management Plan (**Appendix C.3**) describes the adopted and additional controls to minimise light pollution. Woodside considers that the management approach outlined above demonstrably minimises threats to the green turtle population at Scott Reef associated with light pollution and has strong alignment with interim recovery objectives 1, 2 and 3, and associated recovery targets 1.1, 1.2, 2.1, 2.2, 3.1 and 3.2 of the Marine Turtle RP.

A10: Maintain and improve sustainable Indigenous management of marine turtles

This action identified in the Marine Turtle RP is not targeted at entities such as Woodside or for actions akin to the proposed Browse Project. Accordingly, the proposed Browse Project will have no impact on sustainable Indigenous management of marine turtles and is not inconsistent with Action Area A10.

4.5.3.3 Actions related to enabling and measuring recovery

B1: Determine trends at index beaches

Robust scientific information has been generated and considered regarding the G-ScBr stock during the course of Woodside's assessment of the proposed Browse Project. This specifically included long-term monitoring of nesting, internesting movements, hatchling emergence and hatchling dispersal at Sandy Islet (refer to **Section 4.3.2**).

As outlined in **Section 4.4**, Woodside considers that the implementation of the proposed Browse Project provides a unique opportunity for ongoing measuring and monitoring of the G-ScBr stock.

Woodside anticipates that data it generates during the implementation of the proposed Browse Project may assist to refine current understandings of trends in stock demographic parameters arising from monitoring of nesting and hatchling production, and has strong alignment with interim recovery objectives 1, 2 3 and 4 and associated recovery targets 1.1, 1.2, 2.1, 2.2, 3.2, 4.1 and 4.2.

B2: Understand population demographics at key foraging grounds

No BIAs for foraging green turtles are located within the Project Area, and therefore the proposed Browse Project will not impact on green turtles at key foraging grounds.

Accordingly, Woodside considers there is no inconsistency with Action Area B2.

B3: Address information gaps to better facilitate the recovery of marine turtle stocks

As above, robust scientific information has been generated and considered regarding the G-ScBr stock during the course of the assessment of the proposed Browse Project. This information has already supplemented the existing body of knowledge concerning the G-ScBr stock (refer **Section 4.3.2**).

Among other things, Woodside also proposes a monitoring program which will further supplement existing bodies of information in relation to population numbers, trends and life-cycle for the G-ScBr stock (refer **Section 4.4**).

Woodside's view is that the implementation of the proposed Browse Project provides a unique opportunity for ongoing measures and monitoring of the G-ScBr stock at Scott Reef and this is strongly aligned to interim recovery objectives 1, 2 3 and 4, and associated recovery targets 1.2, 2.1, 2.2, 3.2, 4.1 and 4.2.

5. RESPONSES TO COMMON SUBMISSIONS

5.1 Overview

The following sections provide responses to common submissions received during the public comment period. That is, where multiple submissions raise concerns or objections relating to the same aspect, receptor or topic, a common response has been prepared. The public submissions received via uploaded documents have been collated in **Appendix D.** Responses to common submissions have been prepared for:

- GHG-1: Response to objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)
- GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**)
- GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**)
- GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**)
- GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**)
- GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**)
- GHG-7: Lower and zero carbon energy (**Section 5.8**)
- GHG-8: The role of gas in the future energy mix (**Section 5.9**)
- GHG-9: Carbon capture and storage (CCS) of Browse gas (**Section 5.10**)
- GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**)
- ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**)
- AQ-1: Impact of air emission on public health (**Section 5.13**)
- BCH-1: Potential impacts to Scott Reef (**Section 5.14**)
- MEQ-1: Environmental Quality Management Framework (**Section 5.15**)
- MEQ-2: Unplanned hydrocarbon release (**Section 5.16**)
- MEQ-3: Australian marine parks and State marine parks (**Section 5.17**)
- MEQ-4: Produced water (**Section 5.18**)
- MEQ-5: Use of non-water -based fluids (NWBFs) during drilling (**Section 5.19**)
- MEQ-6: Management of drilling and completion discharges (**Section 5.20**)
- MEQ-7: Decommissioning (**Section 5.21**)
- MEQ-8: Potential impacts to Wetlands (**Section 5.22**)
- MF-1: Potential impacts to marine fauna (general). (**Section 5.23**)
- MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**
- MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**)
- MF-4: Vessel - fauna interaction (**Section 5.26**)
- MF-5: Potential impacts to marine turtles (**Section 5.27**)
- MF-6: Presences and abundance of blue whales in Project Area (**Section 5.28**)
- MF-7: Potential impacts to cetaceans (**Section 5.29**)
- MF-8: Potential impacts to sea snakes (**Section 5.30**)
- MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**)
- MF-10: New species of siphonophores (**Section 5.32**)
- MF-11: Potential impacts to fish (**Section 5.33**)

- SE-1: Displacement of Aboriginal people as a result of project infrastructure (**Section 5.34**)
- SE-2: Socio-economic benefits of the proposed Browse Project (**Section 5.35**).

5.2 GHG-1: Objections to the proposed Browse Project due to GHG emissions

A number of submissions objected to the proposed Browse Project on the basis of GHG emissions and contribution to climate change.

As described in **Section 7.4.5.2** of the draft EIS/ERD, the scientific consensus on climate change, and the commitment of global governments to reduce emissions is clear. There is also a need to both improve local air quality in countries that are currently reliant on higher emitting fossil fuels such as coal (which emit higher amounts of pollutants such as particulate matter) and increase access to modern energy sources. Access to clean, affordable and reliable energy improves living standards dramatically and the world's growing population is driving increased energy demand. Woodside supports the United Nations Development Programme's (UNDP) Sustainable Development Goal (Goal 7: Affordable and Clean Energy) to ensure universal access to affordable, reliable and modern energy services by 2030 (UNDP, 2016).

Access to energy

To achieve the 7th UNDP Sustainable Development goal while reducing GHG emissions in line with the Paris Agreement, the world needs more energy, delivered in cleaner ways. Renewables and emerging technologies such as hydrogen have a growing role to play. Experts agree however that natural gas has a role to play in a lower carbon world:

- The 2014 report of the Intergovernmental Panel on Climate Change (IPCC) said that "GHG emissions from energy supply can be reduced significantly" by switching to gas (Intergovernmental Panel on Climate Change (IPCC), 2014). When combusted in a power plant, natural gas typically emits around half the amount of CO_2 per unit of power generated, compared to coal (IEA, 2019).
- The IPCC's 2022 report on "Mitigation of Climate Change" confirms that "fuel switching from coal to gas" had contributed to a lower carbon intensity of energy over the period 2010-19 (paragraph B2.4). The report further projects the continued use of natural gas in modelled pathways that limit warming to 1.5°C, at median levels in 2050 45% below 2019 levels (i.e. remaining at 55% of 2019 levels). In modelled pathways that limit warming to 2°C, the equivalent levels are 15% below 2019 levels (i.e. remaining at 85% of 2019 levels) (paragraph C.3.2)9. The Browse Joint Venture proposes to target this ongoing demand.
- Australian Chief Scientist Alan Finkel has observed that "natural gas is already making it possible for nations to transition to a reliable, and relatively low emissions, electricity supply" (Australian Government, 2020). (https://www.chiefscientist.gov.au/news-and-media/national-press-club-address-orderly-transition-electric-planet)
- The IEA reports that "coal-to-gas fuel switching for power generation avoided 100 Mt of CO_2 in advanced economies" in 2019, helping avoid an increase in global energy-related CO_2 emissions (IEA, 2020). (https://www.iea.org/articles/global-CO_2-emissions-in-2019). Further, in its March 2022 "Global Energy Review: CO_2 Emissions in 2021", the IEA found the reverse was also true, and that in 2021 "Spiking natural gas prices resulted in gas-to-coal switching, increasing emissions by 250 Mt[10]."
- Under the IEA sustainable development scenario, which suggests a pathway that could see global temperature rises limited to well below 2°C this century in line with the Paris Agreement, demand for natural gas in the Asian markets that Woodside supplies is modelled to increase by 70% from 2018 to 2040 (from 519 million tonne of energy (mtoe) to 884 mtoe).
- Existing gas fields are in decline. New gas fields will need to be developed to continue to provide the natural gas that, along with renewables, can advance the global energy transition. Project's like the proposed Browse Project help get the global energy mix shifting in the right direction.

A partner to renewables

It should also be noted that the growth of renewables may also be constrained by the need to ensure grid stability; that is, grids need to be maintained at the correct frequency during fluctuations in demand. This can be readily done with readily dispatchable energy sources such as gas but more difficult with renewable sources such as solar and wind. This intermittency issue cannot currently be resolved via the use of large-scale battery storage as the technology is not currently available at sufficient scale. For example, the battery storage system built in South Australia by TESLA in 2017 (the largest of its type at the time) is capable of powering around 30,000 homes for just over an hour. Whilst

9 *IPCC (2022). Summary for Policymakers. In: Climate Change 2022, Mitigation of Climate Change, the Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.*

10 *IEA (2022), Global Energy Review: CO_2 Emissions in 2021, IEA, Paris https://www.iea.org/reports/global-energy-review-CO_2-emissions-in-2021-2*

this is hugely beneficial during peak demand, given the costs currently involved with battery storage, this is clearly not sufficient to solve intermittency issues on the scale required. This constraint can be supported by the use of gas partnering to address intermittency and enable deeper penetration of renewables into grid mixes. To have reliable energy and lower emissions, natural gas is the optimal complementary fuel. As a readily dispatchable power source, gas-fired power is an ideal partner with renewables to provide the necessary system stability.

Contribution to climate change impacts

It is important to acknowledge that anthropogenic climate change impacts cannot be directly attributed to any one project, as they are instead the result of global GHG emissions, minus GHG sinks, that have accumulated in the atmosphere since the industrial revolution started.

The more relevant consideration is the contribution that a project makes to net emissions, as it is the overall global atmospheric concentration of emissions that causes climate change. Browse gas processing and consumption results in GHG emissions, but these emissions have the potential to displace emissions from other sources. Where the use of Browse gas displaces energy from more emissions-intensive fuels, then there will be a net reduction in global GHG emissions.

ERM undertook a life cycle assessment (LCA) of the proposed Browse Project and Scarborough Development. ERM's independent expert analysis, critically reviewed by CSIRO, shows Woodside's Browse and Scarborough projects could avoid 650 Mt of CO_2 equivalent (CO_2-e) emissions (392 Mt for the proposed Browse Project) between 2026 and 2040 by replacing higher emission fuels in countries that need our energy (note that this includes anticipated minimum CO_2-e offsets (estimated at the time of the draft EIS/ERD publication), in the form of Australian Carbon Credit Units (ACCUs) estimated to be required for the proposed Browse Project for above baseline emissions pursuant to the Safeguard Mechanism (SGM)). This means for every tonne of GHG emitted in Australia from these proposed Woodside operated projects, this equates to about 4 tonnes in emissions reduced globally (ERM, 2020).

The LCA (**Appendix A.3**) describes in detail the methodology and assumptions used to assess the modelled impact the proposed Browse Project would have on global emissions over the 2024-2040 time period. The LCA compares the estimated emissions from power generation using gas from the Proposed Browse Project with the modelled grid mixes estimated emissions resulting from other fossil fuels in the context of different energy demand scenarios. These scenarios include the IEAs Current Policy Scenario (CPS), Stated Energy Policy Scenario (STEPS) and Sustainable Development Scenario (SDS).

IEA STEPS represents a case where countries implement their public policies and targets - even if there is not yet a clear path for them to do so. IEA SDS is a goal driven scenario that is essentially 'reverse engineered' to meet a predetermined sustainable future which achieves the Paris Agreement's climate change goals, eradicates energy poverty by 2030 and reducing the health impacts of poor air quality (ERM 2020).

In both these scenarios, gas, and LNG in particular, makes a growing contribution to the world's energy mix and, in the absence of LNG, other fossil fuels present a likely substitution fuel.

Figure 6-6 of the LCA (**Appendix A.3**), shows that if Browse gas is used to generate power in the target markets, it will release between 591 Mt CO_2e and 595 Mt CO_2e over the 2026-2040 period. If other fossil fuels are used to generate electricity under the IEA STEPS during the same period, then emissions would be 936 Mt CO_2e over the 2026-2040 period. As such, if Browse gas is used to generate electricity, avoided emissions are 936-594 = 342 Mt CO_2e, even when excluding any offsets required under the SGM. If the same calculations are conducted for the IEA SDS, avoided emissions would be 181 Mt CO_2e for the Browse Project (excluding any offsets under the SGM).

While the LCA presents the modelled avoided emissions from 2024-2040, Woodside also expects the potential for emission avoidance through the use of Browse gas to extend beyond this period and for the life of the Browse Project (31 years expected field life). **Section 5.9** describes the role of gas in the future energy mix in more detail.

A 650 Mt CO_2 reduction is equivalent to:

- cancelling out all emissions from WA for over eight years, or
- cancelling out the energy emissions of more than 5 million households over the 15-year period covered by the LCA.

ERM's LCA report (ERM, 2020) is attached as **Appendix A.3**.

Comparison with the Adani Project

A number of submissions noted a claim that Woodside's Burrup Hub will have four times the emissions of the Adani Project. These claims don't take into account the full life cycle of natural gas or the alternatives to it. The potential lifecycle contribution of natural gas in pathways consistent with limiting global warming has been addressed in the section above.

Socio-economic considerations

Given the above, Woodside considers that the proposed Browse Project presents an opportunity to realise significant local and international economic and social benefits while contributing to the reduction of net global GHG emissions as the world transitions to a lower carbon future. According to economic modelling by ACIL Allen in 2019, the proposed Browse and North West Shelf Extension projects are estimated to boost Australia's GDP by $289 billion between 2019-2063, of which 99% will be in Western Australia. It is also expected to generate direct taxation and royalty payments to the Commonwealth and State Governments of $63 billion, indirect taxation payments of $30 billion and are estimated to create an average of more than 2,700 jobs per annum (direct and indirect) nationally between 2019-2063 (ACIL Allen Consulting, 2019). ACIL Allen released a series of public brochures that outline the results of their assessment and are available on ACIL Allen's website. The brochures relevant to Browse and the Burrup Hub are attached as **Appendix A.4**.

Assessment process

Woodside has progressed the environmental referral and impact assessment of the proposed Browse Project in accordance with the relevant State and Commonwealth legislation. Woodside continues to progress the environmental impact assessment by providing responses to submission and further information as requested by the decision making authorities. This includes the development of a GHGMP (**Appendix C.1**).

In accordance with the EISG/ESD, Woodside has provided the proposed Browse project's predicted GHG emissions, considered local, Australian and global emissions and their potential for cumulative impact; and has actively sought to manage and mitigate these emissions by increasing energy efficiency and applying emissions reductions measures. Woodside has also estimated minimum reductions anticipated through offsets under the SGM for above baseline emissions, noting that these are likely to continue to change with ongoing regulatory reforms (refer to **Section 7.7** of the draft EIS/ERD). This includes measures outlined in the response GHG-3 below (**Section 5.4**). It should also be noted that mitigation and management measures associated with anticipated processing emissions (which will potentially include processing of Browse feed gas subject to regulatory and joint venture approvals and commercial agreements) for the NWS Project Extension are described in the NWSJVs 'North West Shelf Project Extension Environmental Review Document' and ''North West Shelf Project Extension Environmental Review Document – Response to Submissions' (EPA 2186, EPBC 2018/8335).

Overall, even without consideration of the potential net global GHG emissions avoidance described in the LCA, it is considered that in the context of Australia's international commitments and local legislation and policy, given the proposed mitigation of emissions, safeguard mechanism obligations and the importance of gas as a cleaner and reliable source of energy in the current and future energy mix, GHG emissions from the proposed Browse Project are acceptable. The LCA, while supplementary to the response to the specific issues raised in the public responses, further supports this position. Woodside will continue to assist the State and Commonwealth decision making authorities with respect to determining the acceptability of all aspects of the proposed Browse Project.

5.3 GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments

A number of submissions raised concerns with regards to the proposed Browse Project GHG emissions consistency with Australia meeting the Paris Agreement signed in 2015 and the WA State Greenhouse Gas Emissions Policy for Major Projects (State GHG Policy). Respondents expressed the view that the proposed Browse Project does not contribute to meeting net zero emissions targets (net zero by 2050). Within this theme, some submissions included claims that "*the Burrup Hub would be the most polluting project ever to be developed in Australia, with estimated total emissions of over 6 billion tonnes (gigatons) of carbon pollution across its lifetime, the proposal has profound implications for the global climate across generations and will inhibit efforts to address climate change*". These submissions refer to the various and separate proposed Burrup Hub projects and total emissions, rather than the proposed Browse Project specifically (see also GHG-6).

Woodside as Operator for and on behalf of the BJV acknowledges that the Australian Government has signed the Paris Agreement and notes their aspiration of global carbon neutrality by 2050, that is implicit in the Paris Agreement. We also acknowledge the State Government's aspiration of net zero emissions by 2050. It should be noted that net zero emissions by 2050 does not prohibit emissions from industrial activities; rather, it means a reduction and balancing levels of CO_2 emissions with carbon removal beyond natural processes, through carbon offsetting, or removing or sequestering CO_2 from the atmosphere to make up for emissions elsewhere.

In 2020, Woodside announced targets for near- and medium-term emissions reduction below the gross annual average equity Scope 1 and 2 greenhouse gas emissions over 2016-2020. These targets are to reduce net equity Scope 1 and 2 greenhouse gas emissions by:

- 15% by 2025
- 30% by 2030
- Towards an aspiration of net zero by 2050 or sooner[11]

Woodside notes the Australian Government's and Western Australian Government's aspiration of net zero emissions by 2050.

See **Section 5.4** GHG-3 for further information regarding Woodside's corporate initiatives.

Further to the information outlined above regarding Woodside's approach in the context of local and international climate change commitments, please note that each of the BJV Participants detail their respective corporate approach, initiatives and memberships on their websites.

Paris Agreement

In October 2021, Australia updated its Nationally Determined Contribution to include (i) a target of net zero emissions by 2050; (ii) seven low emissions technology stretch goals; and (iii) reaffirm its economy wide target (26-28% reduction below 2005 levels by 2030), which it expects to exceed by up to 9%[12].

On 16 June 2022, Australia again updated its NDC to note a target to reduce greenhouse gas emissions by 43% below 2005 levels by 2030. As part of this update, it was indicated that the Government would introduce legislation to enshrine this target in law.

As noted above, global carbon neutrality by 2050, that is implicit in the Paris Agreement, does not prohibit emissions from industrial activities; rather, it means a reduction and balancing levels of CO_2 emissions with carbon removal beyond natural processes, through carbon offsetting, or removing or sequestering CO_2 from the atmosphere to make up for emissions elsewhere.

Proposed Browse Project contribution to achieving Paris Agreement aspirations

As a cleaner and reliable energy source (described in **Section 7.7.1** of the draft EIS/ERD), gas is expected to play a key role in the future energy mix with the potential to contribute to a reduction in global GHG emissions by displacing higher carbon intensive power generation (e.g. oil and coal burning). Independent expert analysis by ERM, and critically reviewed by CSIRO, shows Woodside's Browse and Scarborough projects could avoid 650 Mt of CO_2 equivalent (CO_2-e) emissions (392 Mt for the proposed Browse Project) between 2026 and 2040 by replacing higher emission fuels in countries that need our energy (refer to **Section 5.2** for further details on how the potential emission avoidance has been calculated). Given this, by focusing on the challenge of providing clean, affordable and reliable energy, Woodside can contribute to achieving the aspirations of the Paris Agreement.

ERM's LCA report (ERM, 2020) is attached as **Appendix A.3.**

In preparing the draft EIS/ERD, Woodside has ensured the proposed controls and impact and risk levels have had regard to national and international standards, law and policies including Australia's implementation of the Paris Agreement on climate change through domestic legislation. Woodside will actively manage and mitigate Scope 1 GHG emissions associated with the Browse Project, in accordance with relevant legislation. Examples of how this may be achieved are provided in **Section 7.7** of the draft EIS/ERD and discussed in **Section 5.4**. Mitigation and management measures associated with anticipated processing emissions for the NWS Project Extension are described in the NWS JV's 'North West Shelf Project Extension Environmental Review Document' and 'North West Shelf Project Extension Environmental Review Document – Response to Submissions' (EPA 2186, EPBC 2018/8335). Mitigation will include offsetting of CO_2 emissions in accordance with the SGM requirements. This mechanism will ensure proposed Browse Project emissions meet regulatory requirements, including as implemented to achieve Australia's international aspirations and commitments.

GHG emissions arising from third party consumption of the proposed Browse Project gas along with other feed sources are to be managed and mitigated through relevant domestic and international emissions control frameworks.

For many countries, greater use of natural gas (both as a lower carbon fossil fuel, and as dispatchable power source to partner with renewables) is likely to be an important option. The IPCC's 2022 report on "Mitigation of Climate Change" confirms that "fuel switching from coal to gas" had contributed to a lower carbon intensity of energy over the period 2010-19 (paragraph B2.4). The report further projects the continued use of natural gas in modelled pathways that limit warming to 1.5°C, at median levels in 2050 45% below 2019 levels (i.e. remaining at 55% of 2019 levels). In modelled pathways that limit warming to 2°C, the equivalent levels are 15% below 2019 levels (i.e. remaining at 85% of 2019 levels) (paragraph C.3.2)[13].

11 Target is for net equity Scope 1 and 2 greenhouse gas emissions, relative to a starting base of the gross annual average equity Scope 1 and 2 greenhouse gas emissions over 2016-2020 and may be adjusted (up or down) for potential equity changes in producing or sanctioned assets with an FID prior to 2021.

12 Nationally Determined Contributions Registry | UNFCCC (See Australia)

13 IPCC (2022). Summary for Policymakers. In: Climate Change 2022, Mitigation of Climate Change, the Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

Moreover in the IEA's World Energy Outlook 2021, the Sustainable Development Scenario (which the IEA describes as a "gateway to achieving the outcomes targeted by the Paris Agreement") natural gas demand in the Asia Pacific region is modelled to increase to 37% above 2020 levels by 2030, and to remain higher than 2020 levels in 2040.

The Browse Joint Venture proposes to target this ongoing demand.

Under the Paris Agreement and global GHG accounting conventions, each signatory party (country) is responsible for accounting for, reporting and reducing emissions that physically occur in its jurisdiction. This means that the Paris Agreement is the current international framework, under which countries manage Scope 3 emissions associated with customer consumption of Browse gas. The Paris Agreement requires parties to publish NDCs, reflecting their commitment towards agreed global goals. The countries where likely major users of the proposed Browse Project gas are located, have made the following commitments as part of their current NDCs, which are designed to be successively tightened over time through future periodic NDC updates. In accordance with the Paris Agreement, these countries are required to update their NDCs, to "reflect its highest possible ambition", by 2025. These measures constitute examples of how third-party emissions targets associated with the combustion of proposed Browse Project gas will be managed and mitigated in customer nations, as described further below.

Japan[14]:

Japan updated its First Nationally Determined Contribution on 22 October 2021. It states: "Japan aims to reduce its greenhouse gas emissions by 46 percent in fiscal year 2030 from its fiscal year 2013 levels, setting an ambitious target which is aligned with the long-term goal of achieving net zero by 2050. Furthermore, Japan will continue strenuous efforts in its challenge to meet the lofty goal of cutting its emission by 50 percent." (Page 1).

Japan also published an "Outline of Strategic Energy Plan" in October 2021[15]. This plan assumes that LNG, while reducing from 37% in 2019, still makes up 20% of Japan's electricity generation mix in 2030. Renewables double from 18% to 36-38% and nuclear power increases from 6% to 20-22% (page 12). Outside the electricity sector it says in respect of heating "We will pursue the shift to natural gas on demand side and decarbonization of gas through methanation and other means, which play a significant role in decarbonizing heat demand. We will also work to further strengthen the resilience of gas." (Page 11).

China[16]:

The People's Republic of China updated its First Nationally Determined Contribution on 28 October 2021. It states: "On September 22, 2020, President Xi Jinping declared, at the General Debate of the 75th Session of the United Nations General Assembly, that China would scale up its Nationally Determined Contributions (NDCs) by adopting more vigorous policies and measures, and aims to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060." (Page 5).

"China will stringently curb coal-powered projects, set strict limitation on the increase in coal consumption over the 14th FYP period and to phase it down in the 15th FYP period. The large scale development of wind and solar power will be accelerated, hydro power in accordance with local condition will be developed, nuclear power will be advanced in an ordered manner with the premise of ensured safety, and peaking power including energy storage and gas-powered electricity will be stepped up rapidly." (Page 34).

"China will push forward technological breakthroughs in various fields to support the green and low-carbon transition, such as renewable energy, hydrogen energy, smart grid and energy storage, CCUS, circular economy, low-carbon transportation and smart cities, climate change impact and risk assessment." (Page 48).

Republic of Korea[17]:

The Republic of Korea updated its First Nationally Determined Contribution on 23 December 2021. It states: "The Republic of Korea declared to move towards the goal of carbon neutrality by 2050 in December 2020 and has finalized its 2050 carbon-neutrality scenarios as a follow-up measure." (Page 1) "The Republic of Korea is seeking to dramatically phase down coal-fired power generation while ramping up renewable power. Aged coal power plants will be shut down or shift their fuels from coal to Liquefied Natural Gas (LNG). The uptake of solar and wind power will be scaled up as well." (Page 2).

"The Republic of Korea has markedly raised its 2030 target on the deployment of zero-emission vehicles such as the ones powered by electricity and hydrogen." (Page 3).

Western Australian Government's GHG Emissions Policy for Major Projects

14 Nationally Determined Contributions Registry | UNFCCC (See Japan)
15 Government of Japan, Agency for Natural Resources and Energy (METI) 2021. "Sixth Strategic Energy Plan."
16 Nationally Determined Contributions Registry | UNFCCC (See China)
17 Nationally Determined Contributions Registry | UNFCCC (See Republic of Korea)

GHG emissions associated with the proposed Browse Project in the State Proposal Area will arise from activities in the Torosa field. Installation and construction are expected to form a minor component of the overall emissions associated with the proposed Browse Project. Total installation emissions across the life of the proposed Browse Project within the State Proposal Area are estimated to be ~0.4Mt CO_2-e over the life of the Project. Due to the position of the FPSOs outside of the State Proposal Area, operational emissions in the State jurisdiction will be limited to IMMR activities on subsea infrastructure and contingent drilling and completions activities on installed wells.

The Western Australian Government's GHG Emissions Policy for Major Projects includes an aspirational target of net zero GHG emissions by 2050 (**Section 7.3.3** of the draft EIS/ERD). It should be noted that the WA aspirational target of net zero emissions by 2050 does not prohibit emissions from industrial activities; rather, the target refers to net zero emissions State-wide, via means of reduction and balancing levels of CO_2 emissions with carbon removal beyond natural processes, through renewables, technology innovation, carbon offsetting, or removing or sequestering CO_2 from the atmosphere to make up for emissions elsewhere.

LNG is not incompatible with achieving an economy-wide net zero emissions target by 2050. Indeed, while the primary product from the proposed Browse Project will be LNG, under the Western Australia's recently updated domestic gas reservation policy, the proposed Browse Project will be expected to make gas equivalent to 15 percent of exports available for WA consumers in accordance with the policy. The emissions intensity of gas relative to the aggregate of WA electricity generators can be determined using data published by the Clean Energy Regulator (CER, 2019). This includes all 'designated generation facilities' that report under NGER. **Table 5-1** shows that gas-generated electricity in WA is approximately 15% less emissions intensive than the average electricity generated in the 2018 financial year. If the availability of proposed Browse Project domestic gas results in an increase in the proportion of electricity generated using gas, the average emissions intensity of WA power generation could be reduced.

Table 5-1 Western Australian electricity emissions intensity (Source: CER (2019))

Primary fuel	Total Generation (million MWh)	Scope 1 and 2 emissions (Mt CO_2-e)	Emissions intensity (tCO_2e/MWh)
Natural gas	13.1	7.4	0.57
Black coal	9.7	8.9	0.9
Oil	0.06	0.04	0.7
Solar, wind, landfill gas and hydro	2	0.01	0.007
Total	**25**	**16.3**	**(Average) 0.65**

5.4 GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions

A number of submissions raised concerns with respect to mitigation and offsetting of GHG emissions. The submissions generally related to the various proposed Burrup Hub projects, rather than the proposed Browse Project specifically. The following response addresses Woodside's company-wide approach to limiting GHG emissions, which it applies as Operator through the Woodside Management System, and the proposed Browse Project-specific GHG emissions mitigation and offsetting measures. Mitigation and management measures associated with anticipated processing emissions for the NWS Project Extension are described in the NWSJ V's 'North West Shelf Project Extension Environmental Review Document' and ''North West Shelf Project Extension Environmental Review Document – Response to Submissions'(EPA 2186, EPBC 2018/8335).

Woodside

Woodside's climate strategy is to reduce our net equity greenhouse gas emissions, while investing in the products and services that our customers need as they reduce their emissions.

We have a portfolio of quality oil and gas assets, and are developing new energy products and lower-carbon services.

We have set near- and medium-term targets to reduce net equity Scope 1 and 2 greenhouse gas emissions[18]. We have three ways to achieve these targets: avoiding emissions through design; reducing them through efficient operations; and offsetting the remainder. Avoiding and reducing emissions are our first priority. Offsets, that are scientifically verified and accurately accounted for, also have an important role.

18 https://www.woodside.com.au/docs/default-source/investor-documents/major-reports-(static-pdfs)/2021-climate-report/climate-report-2021.pdf

We are a signatory to the Methane Guiding Principles and are actively pursuing methane emissions reduction and measurement opportunities.

We have announced a Scope 3 emissions plan, containing three elements: investing in new energy products and lower-carbon services; supporting our customers and suppliers to reduce their net emissions; and promoting global measurement and reporting.

Management and mitigation measures relating to direct GHG emissions from the proposed Browse Project

Management and mitigation of GHG emissions from the proposed Browse Project are detailed in **Section 7.7** of the draft EIS/ERD. A GHGMP, which has been prepared for the proposed Browse Project in accordance with the WA Greenhouse Gas Emissions Policy for Major Projects, is proposed to continuously identify and review measures to mitigate and manage GHG emissions and accommodate NGER/SGM reporting and baseline requirements. The draft GHG Management Plan is provided in **Appendix C.1**. Further details with regards to management and mitigation of GHG emissions are provided below.

Avoid

Complete avoidance of GHG emissions for the proposed Browse Project is not feasible. GHG emissions will result from all phases of the project and from transport, distribution and consumption of Browse products. Energy efficiency measures have been incorporated into the design of the facilities; these are listed below with an estimate of the annual emissions saving:

- waste heat recovery units on gas turbines, avoiding the combustion of additional gas for heating purposes (0.70 Mt CO_2-e/annum saving)
- active heating system used to prevent hydrate formation in flowlines avoiding the requirement for an energy intensive Monoethylene Glycol (MEG) regeneration plant (0.20 Mt CO_2-e/annum saving)
- batteries for spinning reserve, avoiding an additional turbine from providing the spinning reserve (0.10 Mt CO_2-e/annum saving)
- efficient aero derivative gas turbines (0.02 Mt CO_2-e/annum saving)
- use of nitrogen to purge the flare stack rather than hydrocarbon gas (expected less than <0.1 Mt CO_2-e/annum saving).

By saving approximately up to 1 Mt of CO_2-e on average per year, this has reduced the expected average annual net Scope 1 Project emissions from up to 5.8 Mt CO_2-e to 4.8 Mt CO_2-e per year and saved 31 Mt CO_2-e of Scope 1 emissions over the expected life of the proposed Browse Project. It should also be noted that atmospheric emissions from the proposed Browse Project as a whole are less than or similar to the two former development concepts, as described in **Section 3.8** of the draft EIS/ERD.

Further, **Figure 7-4** of the draft EIS/ERD provides benchmarking between the processing emissions for the proposed Browse FPSOs and identified comparable facilities in Australia, to demonstrate the effectiveness of the upstream design in consuming energy to process the gas stream and pressurise it for export.

Reduce

- Implementation of Woodside's energy management requirements for the proposed Browse Project, requiring a facility specific:
  - energy management plan which will be developed prior to the operational phase
  - fuel and flare analysis, baselining and forecasting throughout operational life
  - annual setting of energy efficiency improvement and flare reduction targets throughout operational life
  - ongoing optimisation of energy efficiency through periodic opportunity identification workshops/studies, evaluation and implementation.
- Emissions from onshore processing of Browse gas will also be regulated by relevant legislation and approval requirements for the onshore LNG plant. These include:
  - As part of the North West Shelf Project Extension approvals process (under assessment) a Greenhouse Gas Management Plan is expected to include key provisions such as adoption of practicable and efficient technologies to reduce GHG emissions and managing emissions on a trajectory to net zero by 2050.
  - GHG emissions; annual fuel and flare targets; routine emissions monitoring and reporting; compliance with NGERS and the SGM, and implementation of a facility specific energy management plan.

- Adoption of the Methane Guiding Principles, including minimising any methane emissions in Woodside operations and the value chain. Operationally, this results in the implementation of a leak detection and repair program and implementing suitable methane emissions reduction projects over the project lifecycle.

Offsets

As detailed in Chapter 7 of the draft EIS/ERD, the BJV is committed to its obligations under the NGER/SGM. Based on current regulatory NGER Act SGM emissions baseline requirements, it is anticipated that emissions from the proposed Browse Project will exceed any anticipated facility baseline. This would likely result in SGM offset obligations, which at this stage are required to be met in the form of ACCUs. This mechanism will ensure proposed Browse Project emissions stay within agreed limits, which are set to ensure Australia meets its commitments under the Paris Agreement.

Since the draft EIS/ERD was published on 18 December 2019, the National Greenhouse and Energy Reporting (Safeguard Mechanism) Amendment (Prescribed Production Variables) Rule 2020 has been promulgated. These amendments introduce production variables and some default emissions intensity values into Schedule 2 and 3 of the Rules, but other Schedules and emissions intensities remain to be clarified. Woodside will continue to monitor legislative changes and the proposed Browse Project will comply with the applicable legislative obligations in force throughout the life of field.

The SGM is intended to be periodically adjusted (Australian Government, 2019). This flexibility is designed to allow for an adjustment of the SGM baseline over time to reflect future changes to the NDCs under the Paris Agreement and other changes, such as technological advances.

It is noted that a number of submissions dispute the effectiveness of the SGM. Woodside notes that the proposed Browse Project will be required to comply with regulatory requirements in Australia. If offsets are required under a regulatory scheme, such as the SGM or taxes are levied, Woodside as Operator for and on behalf of the BJV, or the joint venture (JV) participants as required by law, will meet obligations through the required mechanism.

As articulated in **Section 5.3**, gas from the proposed Browse Project is expected to contribute to lower net atmospheric concentrations of GHGs. However, climate change, and the policy response to it, has evolved rapidly and is expected to continue to do so. Therefore, Woodside proposes to adopt a range of management and mitigation measures to mitigate and manage GHG emissions.

5.5 GHG-4: Proposed Browse Project GHG emissions estimates

A number of submissions questioned GHG emissions estimates for the proposed Browse Project suggesting that the calculations have been undertaken using inadequate and old data; these include suggestions that there has been an underestimate of air emissions and GHGs, including methane, the contribution of fugitive emissions and the significance of methane in terms of contribution to climate change. Lack of accounting for Scope 3 emissions was also raised.

Estimating proposed Browse Project GHG emissions

Section 7.4.4 of the draft EIS/ERD provides the carbon emissions estimate for the proposed Browse Project and describes the approach taken to estimate the forecast GHG emissions for the proposed Browse Project, based on the GHG Protocol emissions classification scheme. In estimating expected GHG emissions, Woodside has utilised accepted emissions estimation methods including NGERs methods. This approach is in accordance with the approved EISG/ESD for the proposed Browse Project. The estimate was based on the current level of concept definition and assumptions regarding commercial arrangements, facility and activity scope, the feed gas composition and the scale, efficiency, interaction and complexity of the extraction, processing, anticipated production and compression of the product stream.

Methane emissions estimate as part of CO_2-e

While CO_2 accounts for the majority of GHG emissions associated with the proposed Browse Project, other related emissions will also occur across the full scope of proposed project activities, including methane and nitrous oxide. All estimates for CO_2-e (all emissions calculated for their CO_2 equivalent contribution to climate change) include both methane and nitrous oxide. The Global Warming Potential (GWP) adopted to determine the amount of CO_2-e contributed from both methane and nitrous oxide aligns to the National Greenhouse and Energy Reporting Regulations 2008, which at time of writing reflected the IPCC's Fourth Assessment Report. A breakdown of the relative contribution of these emissions on a gas-by-gas basis to forecast FPSO GHG emissions by CO_2-e equivalent is presented in **Table 7-6** of the draft EIS/ERD[19].

19 Subsequent to the finalisation of the draft EIS/ERD, the NGER Regulations and National Greenhouse and Energy Reporting (Measurement) Determination 2008 were amended to update emission factors based on updated Global Warming Potentials that convert non-carbon dioxide gases into carbon dioxide equivalent values in order to align NGERs with the Australian Government's implementation of the Paris Agreement. These changes are applicable from 01 July 2020 onwards and will be reflected in NGERs facility reports submitted for the 2020-2021 financial reporting year (due 31 October 2021). The impact on the total emissions forecast as well as the relative gas-by-gas contribution is minimal.

Fugitive emissions estimates

The expected fugitive emissions have been estimated based on the production rate of the FPSO facilities. An emissions factor has been taken from NGERs Method 1.

The IPCC (2014) report qualified the role of gas by pointing to the need to manage fugitive emissions of methane. Woodside is taking action to manage fugitive emissions of methane. Woodside has signed up to the Guiding Principles on "reducing methane emissions across the natural gas value chain" that were developed by a coalition of industry, international institutions, NGOs and academics. Under the principle of transparency (Principle 5), Woodside specifically included methane when reporting our GHG emissions in the 2018 and 2019 Sustainable Development Reports, which reported methane emissions are 4% of our total emissions on a CO_2-e basis across Woodside's operating facilities. This is predominantly driven by existing older facilities and that it is expected to be significantly lower for new facilities and once implementation of new technologies are implemented. As detailed in **Table 7-5** of the draft EIS/ERD, fugitive emissions for the proposed Browse Project are expected to be less than 0.3% of the total facility emissions. As detailed in **Table 7-6** of the draft EIS/ERD, methane emissions are expected to account for 1% for Scope 1 CO_2-e emissions.

Scope 3 emission estimates

Estimated Scope 3 emissions are presented in **Section 7.4.4.3** of the draft EIS/ERD. Estimated Scope 3 emissions for LNG exports have been calculated using an emissions factor sourced from the Ecoinvent v3.5 database. This emissions factor considers the transport, regasification, distribution and final combustion of LNG. Estimated Scope 3 emissions for Domgas, LPG and condensate have been calculated using emissions factors sourced from Schedule 1 of the National Greenhouse Energy Reporting (Measurement) Determination 2008.

5.6 GHG-5: LNG as a transition fuel and the displacement of coal

A number of submissions disputed the role of LNG as a transition fuel, claiming that LNG is not a valid transition pathway and that the role of LNG has been overestimated when comparing it as cleaner than coal.

As stated in **Section 7.4.5.2** of the draft EIS/ERD numerous independent energy and climate bodies agree that natural gas has a significant role to play in achieving both a reduction in net global emissions and an increased access to a reliable modern energy supply that supports a progressive transition to renewable energy sources. The 2014 report of the IPCC said that "GHG emissions from energy supply can be reduced significantly" by switching to gas (IPCC, 2014). When combusted in a power plant, natural gas typically emits around half the amount of CO_2 per unit of power generated, compared to coal (IEA, 2019).

According to the IEA (2019), "coal-to-gas fuel switching for power generation avoided 100 Mt of CO_2 in advanced economies" in 2019, helping avoid an increase in global energy-related CO_2 emissions. Under the IEA's sustainable development scenario, which suggests a pathway that could see global temperature rises limited to well below 2°C this century in line with the Paris Agreement, demand for natural gas in the Asian markets that Woodside supplies is modelled to increase by 70% from 2018 to 2040 (from 519 mtoe to 884 mtoe).

It should also be noted that the growth of renewables may also be constrained by the need to ensure grid stability; that is, grids need to be maintained at the correct frequency during fluctuations in demand. This can be readily done with controllable energy sources such as gas but is more difficult with renewable sources such as solar and wind. This intermittency issue cannot currently be resolved via the use of large-scale battery storage as the technology does not currently exist at sufficient scale. For example, the battery storage system built in South Australia by TESLA in 2017 (the largest of its type at the time) is capable of powering around 30,000 homes for just over an hour. Whilst this is hugely beneficial during peak demand, given the costs currently involved with battery storage, this is clearly not sufficient to solve intermittency issues on the scale required. This constraint can be supported by the use of gas partnering to address intermittency and enable deeper penetration of renewables into grid mixes.

Further, ERM's life-cycle analysis of LNG production and utilisation from the proposed Browse and Scarborough projects (ERM 2020), and critically reviewed by CSIRO, indicated that gas sourced from the proposed Browse Project can help facilitate and accelerate the energy transition, even under transformative decarbonisation scenarios.

Gas can help the energy transition given its flexibility as a fuel and the proximity of the proposed Browse Project to markets that are expected to grow rapidly and are at a relatively early stage of the transition to lower carbon energy. These markets are generally characterized as 'high carbon' featuring a large share of coal in the overall energy mix. Adding Browse gas to the power mix would be expected to lead to a decline in CO_2e emissions in each market under consideration until at least 2040 – as further described in the LCA (**Appendix A.3**). The IEA's 2020 report "The oil and gas industry in energy transitions" stated that "long-distance gas trade, largely in the form of LNG, remains part of the picture in the Sustainable Development Scenario... The optionality and flexibility of LNG gives it the edge over pipeline supply. The carbon-intensive developing economies, mostly in Asia, in which gas can play a role in energy transitions, are also short of abundant domestic gas resources. For this reason, even as they ramp up deployment of renewables at breakneck speed, they also increase imports of gas[20]."

Woodside considers a variety of internal and external scenarios including the IEA STEPS, APS (announced pledges scenario), SDS and NZE. Woodside considers a variety of internal and external scenarios including the IEA STEPS, APS (announced pledges scenario), SDS and NZE. **Section 5.9** describes the role of gas in the future energy mix in more detail.

ERM's LCA report (ERM, 2020) is attached as **Appendix A.3**.

5.7 GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula

A number of submissions noted that the Woodside operated existing and proposed developments related to the Burrup Peninsula comprise a number of separate projects and that each are subject to separate assessment and approvals processes, and asserted that cumulative GHG emissions from the Burrup Hub Projects may not have been considered.

Proposed projects for which Woodside Energy Ltd is Operator and which are part of the Woodside Burrup Hub vision (proposed Browse Project, NWS Project Extension, Scarborough) are proceeding through separate approvals processes noting separate joint ventures, regulatory requirements and jurisdictional differences. While Woodside is the Operator of each of these proposed projects, each is operated on behalf of different JVs and each is subject to different actual and proposed commercial arrangements (BJV, NWS JV and Scarborough JV). Assessment processes have been coordinated by the State and Commonwealth regulators in accordance with State and Commonwealth legislation. As the proposed Browse Project draft EIS/ERD and the proposed NWS Project Extension ERD have been submitted concurrently, the relevant State and Commonwealth regulator will have oversight of them simultaneously. The individual assessment documents, plus the regulatory assessments, consider the net contribution of the proposed projects in a Australian and global GHG emissions context within modelled scenarios.

It should be noted that the estimated total Scope 1 and 2 emissions from current and future assets operated by Woodside and which form part of the Burrup Hub vision (including the proposed Browse Project) were published on Woodside's website in parallel to the release of the draft EIS/ERD. These estimates can be viewed at https://www.woodside.com.au/our-business/burrup-hub/burrup-hub-environmental-topics-and-approvals/greenhouse-gas-emissions. It should also be noted that each of the proposed Woodside operated projects related to the Burrup Hub vision will operate in accordance with the relevant State and Commonwealth legislative framework (as described for the proposed Browse Project in Chapter 7 of the draft EIS/ERD). This includes ministerial conditions applicable to both Pluto LNG and NWS facilities requiring net zero emissions by 2050.

While the other proposed developments (i.e. non proposed Browse Project) are not within the scope of the draft EIS/ERD, it is noted that as per the above website link, forecast Scope 1 and 2 emissions from current and proposed Woodside-operated projects associated with the Burrup Hub vision are estimated to be on average 15.9 MTPA CO_2-e, increasing from the current 9.6 MTPA from the existing Woodside operated facilities on the Burrup (i.e. existing NWS Project and Pluto LNG (Train 1)). As per **Table 7-5** of the draft EIS/ERD, an average of 4.0 MTPA of these emissions will arise as a result of the upstream activities associated with the proposed Browse Project. The balance of emissions are from Pluto LNG (Train 2) or other offshore facilities (not associated with the proposed Browse Project).

As GHG emissions accumulate globally in the atmosphere (as opposed to regionally), the impact assessment of sources does not take into account proximity – unlike noise impacts for example, which can have magnified cumulative local impacts. As stated above the proposed Browse Project and the NWS Project Extension are being progressed in parallel (including the public comment period and the response to comment period). This allows the relevant regulators to assess potential impacts of the proposed actions/proposals in State and Australian contexts having regard to scenarios forecasting, the impacts of the global accumulation of GHG emissions in the atmosphere where relevant. In the context of GHG emissions, the potential net contribution of each proposed Project to Australian and global GHG emissions within modelled global scenarios has been provided. Finally, the draft EIS/ERD GHG emissions estimates take into consideration third-party downstream processing of GHG emissions (these have been apportioned based on the estimated proportion of NWS plant capacity that processing Browse gas may utilise, subject to commercial arrangements, relative to the GHG emissions footprint currently approved for the NWS facility).

5.8 GHG-7: Lower and zero carbon energy sources

A number of submissions referred to renewables and other low/no carbon energy sources with a preference to develop these sources as opposed to the development of LNG projects.

20 *IEA (2020). The Oil and Gas Industry in Energy Transitions.*

When comparing gas consumption to other sources of electricity generation it is important to consider the role that gas plays in the electricity mix. Gas is transportable, dispatchable and available at scale today, and competes with other fuel sources with similar characteristics. It is however more expensive than some other sources of electricity, such as renewables, that are often quoted as the cheapest source of electricity in many of the world's energy markets (for example, Hayward and Graham, 2017). Renewables are growing rapidly and experience policy support from governments wishing to decarbonise their electricity system. Where installed, renewable electricity often dispatches at zero marginal cost. Natural gas is primarily expected to compete with other dispatchable energy sources in the portion of the grid not satisfied by renewables.

There are however limits to the growth of renewables (described in response GHG-1 (**Section 5.2**)). Where growth of renewables is constrained, gas is expected to be a particularly important component of efforts to decarbonise energy supply. The growth of renewables may also be constrained by the need to ensure grid stability, but the response to this constraint can be supported by the use of gas partnering to address their intermittency and enable deeper penetration of renewables into grid mixes.

The role of gas will increasingly be to supplement domestically produced renewables. In doing so, it will compete with other transportable, dispatchable fossil fuels such as oil and coal, which along with competing sources of natural gas are therefore the appropriate comparators when considering alternative energy sources to gas from the proposed Browse Project.

Other solutions such as intercontinental high voltage direct current transmission and transportable hydrogen may also play a role in the decarbonising global energy mix, however current forecasts suggest that these contributions will remain negligible in comparison to other sources, even under the sustainable development scenario.

Woodside expects increasing demand for new energy products such as hydrogen and ammonia, and lower-carbon services such as CCUS. These can reduce the emissions arising when our customers consume energy compared to unabated use of fossil fuels.

Our intention is to add these new products and services to our portfolio to support our customers' chosen decarbonisation pathways, taking care to match the pace and scale of our investment to support and meet global demand.

In December 2021, Woodside announced a US$5 billion investment target by 2030 for these products and services. We recently announced several projects in support of our strategy, summarised in our Climate Report 2021 on pages 28-29.

These projects are supported by research and development, including partnerships for hydrogen refuelling infrastructure in Korea, and substitution of coal by ammonia in Japan.

5.9 GHG-8: The role of gas in the future energy mix

A number of submissions questioned the role of gas in the future pointing to the IPCC Special Report on Global Warming of 1.5°C and the revised World Energy Outlook Report (IEA,2019) projections. This included concerns with respect to the proposed Browse Projects resilience to declining natural gas demand (for example, fears that the proposed Browse Project would become a stranded asset).

Some relevant attributes of natural gas when considering the energy transition are:

- When used to generate electricity, natural gas emits around half the life cycle emissions of coal[21];
- The International Energy Agency (IEA) advises that while renewable, nuclear and other low carbon power sources are expected to meet most additional power demand, gas and coal are expected to compete to fill the gap[22];
- More than half of the world's natural gas supply is used in sectors other than power generation, such as in industrial applications and fertiliser manufacturing, some of which have lower emissions intensity than power generation[23,24];
- In the form of LNG, natural gas is transportable and flexible between destinations, which is an advantage during an uncertain and potentially volatile energy transition[25];
- While energy storage technologies (such as batteries) continue to improve, natural gas enables cost-effective and reliable conversion of power grids to renewable electricity because of its ability to 'firm up' intermittent generation (that is, support intermittent renewable generation by quickly ramping up or down to ensure stable electricity supply)[26];

21 *IEA 2019. "The role of gas in today's energy transitions", page 4.*
22 *IEA 2021. "Coal 2021 - analysis and forecast to 2024", pages 11, 14 and 27.*
23 *IEA 2021. "World Energy Outlook 2021", page 185.*
24 *Perdaman Urea Project 2019. "Greenhouse Gas Assessment – Final Report", pages 7-8.*
25 *IEA 2020. Website accessed 2022. https://www.iea.org/commentaries/record-year-for-gas-liquefaction-investment-lights-a-path-towards-market-flexibility.*
26 *Wood, T. and Ha, J. (2021). "Go for net zero". Grattan Institute. Page 30.*

- Natural gas is also used for hydrogen manufacture by steam methane reforming. This process, including carbon capture and storage (CCS), is predicted by the IEA to represent almost half of hydrogen production in 2030 in their Net Zero Emissions by 2050 Scenario (NZE)[27].
- These attributes contribute to explaining why the IPCC's 2022 report on "Mitigation of Climate Change" confirms that "fuel switching from coal to gas" had contributed to a lower carbon intensity of energy over the period 2010-19 (paragraph B2.4). The report further projects the continued use of natural gas in modelled pathways that limit warming to 1.5°C, at median levels in 2050 45% below 2019 levels (i.e. remaining at 55% of 2019 levels). In modelled pathways that limit warming to 2°C, the equivalent levels are 15% below 2019 levels (i.e. remaining at 85% of 2019 levels) (paragraph C.3.2)[28].

Moreover in the IEA's World Energy Outlook 2021, the Sustainable Development Scenario (which the IEA describes as a "gateway to achieving the outcomes targeted by the Paris Agreement") natural gas demand in the Asia Pacific region is modelled to increase to 37% above 2020 levels by 2030, and to remain higher than 2020 levels in 2040.

Furthermore, the IEA's World Energy Outlook 2021 also describes the impact of natural production decline in the absence of investment in upstream supply (**Figure 6.18**), which creates a supply gap which the Browse JV proposes to target.

5.10 GHG-9: Carbon capture and storage (CCS) of Browse gas

A number of submissions raised the potential use of carbon capture and storage (CCS) as a potential mechanism to mitigate GHG emissions from the proposed Browse Project.

CCS is one of many options considered for Browse. However, geo-sequestration was assessed as presently being a high risk, high cost mitigation option for Browse reservoir CO_2. CCS for an offshore floating facility remains technically challenging, however with time, CCS technology will improve. As such, the BJV is continuing to assess the feasibility of carbon capture and storage opportunities, but these do not form part of the referred proposed action. Should an opportunity be considered feasible in future from a technical, commercial and regulatory perspective and be able to be progressed by the BJV in relation to the Browse titles, this will be separately referred by Woodside as Operator for and on behalf of the BJV. The current concept provides space on board the FPSOs to install facilities to reinject reservoir GHG emissions at a future date. As described in Chapter 7 of the draft EIS/ERD, the generation and use of ACCUs through approved and validated carbon farming methodologies (bio-sequestration), is a significantly lower risk and more cost-effective option where required to meet SGM baseline requirements. Offsets can also deliver environmental and social co-benefits, such as biodiversity and regional employment opportunities. More specifically, Australian generated ACCUs can offer potential co-benefits resulting from the additional ecosystem services provided when carbon is bio-sequestered, as well as social, economic and environmental benefits (e.g. improvements to air quality, employment opportunities in remote communities or provision of additional habitat for fauna).

Woodside, as Operator of the proposed Browse Project, will continue to work to reduce net emissions intensity through improvements in energy efficiency, investments in bio-sequestration projects and innovation in production processes.

5.11 GHG-10: Climate change impacts on human health and environmental and social receptors

A number of submissions raised concerns with respect to the impacts of climate change on sensitive receptors including human health. Receptors and receptor sensitivity to global GHG emissions are detailed in **Section 7.5** of the draft EIS/ERD. In addition, a recent IPCC Report (Hoegh-Guldberg et al., 2018) summarised the potential impact of human-induced climate change (at 1.5 and 2oC) on a range of climatic variables (e.g. temperature, precipitation, drought, extreme events) and the likely consequence to different ecosystems and ecosystem services, at a range of spatial scales.

In the global context, the use of Browse gas is expected to result in an overall reduction in net global GHG emissions by displacing emissions associated with higher carbon intensity energy sources which are required to complement the development of renewable energy (refer to **Section 5.2** and **Section 5.8** for further details). It is therefore not feasible to link GHG emissions from the proposed Browse Project to a measurable increase in global temperature or other climate change impacts to human health and environmental and social receptors.

27 *IEA 2021. "Net Zero 2050 – A Roadmap for the Global Energy Sector", page 76.*

28 *IPCC (2022). Summary for Policymakers. In: Climate Change 2022, Mitigation of Climate Change, the Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.*

5.12 ESD-1: Principles of Ecologically Sustainable Development (ESD)

A number of submissions questioned whether the proposed Browse Project (and specifically associated GHG emissions) represented Ecologically Sustainable Development (ESD).

The principles of ESD - in relation to the proposed Browse Project - are addressed in **Section 9.5**, Chapter 6 (as part of the acceptability assessment for each aspect) and Chapter 7 (the acceptability assessment with respect to GHG emissions). Further information with respect to the principles of ESD is presented below.

Precautionary Principle

The Precautionary Principle states "where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation".

Woodside's position is that approval of the proposed Browse Project will not postpone, but rather provides a credible measure to prevent, environmental degradation resulting from the use of other credible alternative energy sources (other fossils fuels) in the absence of further LNG production.

As described in **Section 5.2** and **Section 5.3**, experts such as the IPCC, the Australian Chief Scientist and the IEA agree that as a cleaner and reliable energy source, gas is expected to play a key role in the future energy mix with the potential to contribute to a reduction in global GHG emissions by displacing higher carbon intensive power generation (e.g. oil and coal burning). Independent expert analysis by ERM, and critically reviewed by CSIRO, shows the Browse and Scarborough projects could avoid 650 Mt of CO_2 equivalent (CO_2-e) emissions (392 Mt for the proposed Browse Project) between 2026 and 2040 by replacing higher emission fuels in countries that need our energy (refer to **Section 4.2**). The proposed Browse Project therefore has the potential to reduce net global GHG emissions.

It is considered that there is sufficient scientific certainty with respect to the estimated GHG emissions from the proposed Browse project. Woodside has forecast GHG emissions, based on the GHG Protocol emissions classification scheme. This scheme has been adapted and deployed by national and local regulators and represents a globally accepted subdivision of GHG emissions for evaluation and reporting purposes. In estimating expected GHG emissions, Woodside has utilised accepted emissions estimation methods including NGERs methods.

The impact of global GHG emissions on the environment is also acknowledged and a detailed assessment has been made of the likely impacts of global GHG emissions and climate change on the Australian environment and in the vicinity of the proposed Browse project. This threat has been assessed together with potential impacts of the proposed Browse Project which may operate in combination with climate change impacts.

Woodside has ensured the proposed controls and impact and risk levels take into account national and international standards, law and policies including Australia's implementation of the Paris Agreement on climate change through domestic legislation. Woodside will actively manage and mitigate Scope 1 GHG emissions associated with the proposed Browse Project, in accordance with relevant legislation.

The role of NGER/SGM is to implement Australia's co-ordinated response to the threats posed by climate change. Woodside is committed to complying with NGER/SGM and meeting any requirement for offsets, likely in the form of ACCUs, required in relation to the anticipated excess emissions over a future facility baseline. Woodside has also detailed its corporate initiatives (**Section 5.4**) and GHG Management Plan (**Appendix C.1**) commitments in relation to ongoing GHG management and mitigation.

Intergenerational Equity Principle

The Intergenerational Equity Principle states "that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations".

Woodside acknowledges the impacts caused by climate change and the need to reduce these, so as to not prejudice the health, diversity and productivity of the environment, and is actively taking steps to reduce emissions both from the proposed Browse Project and by de-carbonising its overall portfolio (refer to **Section 5.3**). These measures are part of a program which fulfils Woodside's aspiration to transition to carbon neutrality by 2050 (Scope 1) in support of State and international policy.

As described in response GHG-1 (**Section 5.2**), access to clean, affordable and reliable energy improves living standards dramatically and the world's growing population is driving increased energy demand. To achieve the UNDP target while reducing GHG emissions in line the Paris Agreement, the world needs more energy, delivered in cleaner ways. Renewables and emerging technologies, such as hydrogen, have a growing role to play, but are not a complete solution today. However, as described in GHG-8 (**Section 5.9**) numerous independent energy and climate bodies agree that natural gas has a significant role to play in achieving both a reduction in net global emissions and increased access to a reliable modern energy supply that supports a progressive transition to renewable energy sources. Gas can help mitigate the intermittency associated with some renewable energy sources while more carbon-intensive fuel sources are phased out, thus providing increased energy security to future generations.

The mitigation measures and emissions reductions proposed will reduce the risk of potential impacts from the proposed Browse Project to acceptable levels and help maintain the environment and the services it provides for future generations.

As such, Woodside considers that the proposed Browse Project presents an opportunity to realise significant local and international economic and social benefits, while contributing to the reduction of global GHG emissions as the world transitions into a lower carbon world. In displacing more emissions intensive fuels, the proposed Browse Project takes into account the Intergenerational Equity Principle embedded within the EP Act 1986 and the EPBC Act 1999.

Conservation of Biological Diversity and Ecological Integrity Principle

The Conservation of Biological Diversity and Ecological Integrity Principle states *"that conservation of biological diversity and ecological integrity should be a fundamental consideration in environmental planning and decision-making processes. Biodiversity refers to the variety of all life. Environmental and species impact statements are one way that this principle is enacted"*. The proposed Browse Project draft EIS/ERD, Supplement report to the draft EIS/ERD and Response to Submissions on State ERD represent a comprehensive environmental impact assessment enabling this principle to be enacted upon.

As described in Chapter 7 of the draft EIS/ERD, no direct impacts to biological diversity or ecological integrity are predicted to occur as a result of GHG emissions from the proposed Browse Project.

It is not considered credible that as a stand-alone project, GHG emissions from the proposed Browse Project will significantly impact biological diversity or ecological integrity. Global GHG emissions will continue to have an effect on trends in receptor condition and there is potential for significant impacts to environmental receptors to occur as a result of climate change. As a stand-alone project however, taking into account all planned emissions reduction and offsetting measures (**Section 7.7** of the draft EIS/ERD), it is estimated that Scope 1 and 3 emissions from the proposed Browse to NWS Project will contribute in the range of 0.06% to 0.15% of global GHG emissions depending on the NDC scenario considered (**Table 7-13** of the draft EIS/ERD) and will not significantly impact biological diversity or ecological integrity.

Further, as discussed in **Section 5.2** above, gas has the potential to contribute significantly to the reduction in global GHG emissions by displacing higher carbon intensive power generation (e.g. coal-gas energy switch). If this occurs, the Browse Project may potentially have a positive impact by reducing impacts of climate change on biological integrity and ecological diversity.

The impacts of global GHG emissions and climate change on the Australian environment, in combination with the potential or actual impacts of the proposed Browse project, have also been assessed. For the environment in the vicinity of the proposed Browse Project, mitigation and management measures have been proposed (refer to **Section 5.4**) to meet the objectives of this principle in addition to ACCUs proposed to meet the likely requirements of NGER/SGM.

In this way, the proposed Browse Project takes into account the Conservation of Biological Diversity and Ecological Integrity Principle embedded within the EP Act 1986 and the EPBC Act 1999.

Polluter Pays Principle

The Polluter Pays Principle states "*those who generate pollution and waste should bear the cost of containment, avoidance or abatement*".

As detailed in **Section 5.4**, the BJV is committed to its obligations under the NGER/SGM. Based on current regulatory NGER Act SGM emissions baseline requirements, it is anticipated that emissions from the proposed Browse Project will exceed any anticipated facility baseline. This would likely result in SGM offset obligations, which at this stage are required likely to be met in the form of ACCUs. This mechanism will ensure proposed Browse Project emissions stay within agreed limits, which are set to ensure Australia meets its commitments under the Paris Agreement.

In this way, the proposed Browse Project addresses the Polluter Pays Principle embedded within the EP Act 1986 and the EPBC Act 1999.

Acceptability of impacts

Given the comprehensive environmental impact assessment undertaken in the draft EIS/ERD, Supplement Report to the draft EIS/ERD and Response to Submissions on State ERD together with the planned emissions management, mitigation and offsetting to reduce net GHG emissions, it is considered that the predicted GHG emissions from proposed Browse Project are acceptable. The proposed Browse Project has also taken into account the Principles of ESD embedded within the EP Act 1986 and the EPBC Act 1999.

5.13 AQ-1: Impact of air emissions on public health

A number of submissions raised concerns with respect to impacts on human health as a result of air emissions. It should be noted that these submissions related to all the Burrup Hub projects and were not specific to the proposed Browse Project. Air emissions associated with the onshore processing of the Browse gas by the NWS JV, is addressed within the ERD and Response to Public Submission associated with the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335).

Air emissions from the offshore activities of the proposed Browse Project are addressed in **Section 6.3.5.1** of the draft EIS/ERD. These emissions have the potential to result in a localised reduction in air quality in the immediate vicinity of the release point. While a slight reduction in air quality on a local scale will occur for the duration of the activities, given the low emissions levels and very low background levels of contaminants it is not anticipated that emissions from the proposed Browse Project will result in lasting effect on air quality locally or regionally. Further, other than the proposed Browse Project activities, there is no permanent human presence in the vicinity of the emissions sources. As such, no impact to human health from offshore air emissions is predicted.

5.14 BCH-1: Potential impacts to Scott Reef

A number of submissions raised concerns with respect to the proximity of the proposed project infrastructure to Scott Reef and potential impacts and risks to the reef (including impacts on coral larval production and recruitment) and the ecosystem surrounding it that may occur as a result of the proposed Browse Project.

For the purpose of the environmental impact and risk assessment presented in the draft EIS/ERD, Scott Reef, which encompasses the reef system including all coral habitats and communities, is considered as the area *"above the 75 m bathymetric contour within the 3 nm State waters boundary and the Scott Reef and Surrounds - Commonwealth Area which comprises the Commonwealth Marine Area wholly within the WA coastal waters surrounding North and South Scott Reef"*.

The importance of the marine environment within the Project Area is acknowledged within the draft EIS/ERD. In particular, the draft EIS/ERD acknowledges the proximity of the proposed project infrastructure to the Scott Reef system and provides a detailed description of the dynamics of the Scott Reef system (Chapter 5.3.1 of the draft EIS/ERD). The design of the proposed Browse Project has considered the proximity and includes various commitments and techniques to avoid impacts to the reef system including a commitment to not place any infrastructure on Scott Reef shallow water benthic communities and habitats (<75 m bathymetry), the use of laterally deviated wells which allow access to the reservoir below the reef without drilling wells on the reef itself; and the location of the Torosa FPSO facility ~8 km from Scott Reef.

A detailed assessment of potential impacts from planned activities and risks posed by unplanned events or incidents has been undertaken, which included detailed modelling and assessment of aspects such as light emissions, noise emissions, PW discharge, cooling water discharge, hydrotest fluid discharge and drilling and completions discharges. The assessment of these aspects concludes that with the planned controls and mitigation measures, no impacts to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) from planned activities are predicted. Furthermore, studies on the dispersion of coral larvae at Scott Reef (Done et al., 2015; Foster and Gilmour, 2018)"properties" (Done et al., 2015; Foster and Gilmour, 2018 demonstrates that while there is significant movement of larvae within the reef system itself (particularly for spawning corals), there is no evidence to suggest the coral larvae travel outside the reef system (i.e. off the reef) before re-settling on the reef. Therefore, given no impacts are predicted within the Scott Reef shallow water benthic communities and habitats (<75 m bathymetry), potential interaction with coral larvae (away from the reef) are not likely to impact the recruitment of corals within the Scott Reef system, as any affected coral larvae would not have been available to resettle on the reef regardless of whether the impact had occurred or not.

The assessment also concluded that while production-related seabed subsidence at Scott Reef may occur, this would be in the order of less than 10 cm over field life and would not result in a reduction in biological diversity or ecological integrity within of Scott Reef.

The occurrence of unplanned events or incidents that could potentially impact the reef (for example, unplanned hydrocarbon release or the unplanned introduction of IMS) is considered highly unlikely to remote given the controls and mitigation measures proposed.

In response to feedback from DAWE, Woodside has reviewed and revised the environmental objectives presented in the draft EIS/ERD to be more specific and measurable. These revised environmental objectives are provided in **Section 6**. Woodside is committed to achieving these environmental objectives including those relating to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) including:

- Undertake the Browse Project in a manner which avoids direct (i.e. physical footprint as a result of infrastructure placement) disturbance to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).
- Undertake the Browse Project in a manner that prevents changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).
- Manage the Browse Project in a manner that limits permanent benthic communities and habitat loss within the Scott Reef local assessment units (LAU) as shown in **Figure 6-1**, to the extent specified in **Table 6-2**.
- Implement the "Management approach – Torosa wells in the State Proposal Area" so that a maximum Level of Ecological Protection (as defined in the EQMP) is maintained within Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).

To achieve these environmental objectives, Woodside has made the following management and monitoring commitments:

- Key outcomes:
  - No infrastructure will be placed on Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).
  - A Maximum Level of Ecological Protection is proposed for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).
  - PW and cooling water discharges from the FPSO will be managed in Commonwealth waters to ensure the defined threshold values (e.g. 99% species protection or no effect concentrations) are met at the State waters 3 nm boundary, 95% of the time based on dispersion modelling results.
  - Drilling discharges (in particular, bottom-hole well section discharges) at drill centre locations in the State Proposal Area (i.e. TRA, TRD and TRF) will be managed using industry proven techniques to avoid potential impacts to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).
- Key management strategies:
  - FPSO PW will be treated prior to being discharged overboard using a tertiary treatment system, such as a Macro Porous Polymer Extraction (MPPE) system which is considered industry best practice.
  - Project vessels and MODUs will be subject to a risk assessment process to assess the likelihood of introducing IMS when transiting to the Project Area. Based on the outcomes of risk assessment, management measures commensurate with the risk (such as the treatment of internal systems, IMS inspections or cleaning) will be implemented.
  - Internationally sourced project vessels and MODUs required within 3 nm of Scott Reef (State Proposal Area) for longer than 48 hours will be inspected by an experienced IMS expert/marine scientist for IMS; and cleaned where required[29].
- Assurance:
  - Periodic and 'for cause' toxicity testing and characterisation of the physical and chemical composition of the FPSO PW stream prior to discharge will be undertaken.
  - During steady state FPSO operations, PW modelling and infield verification will be completed to verify the modelling predictions.
  - Baseline and periodic water and sediment quality monitoring at a gradient away from the FPSO facility in the receiving environment will be undertaken to detect changes as a result of FPSO PW discharge.
  - During steady state FPSO operations, cooling water modelling and infield verification will be completed to verify the modelling predictions.
  - Verification monitoring for seabed subsidence will be outlined within the relevant EP and will be undertaken.
  - IMS surveillance program will be undertaken at Scott Reef, consisting of a baseline survey prior to the commencement of activities in the State Proposal Area, and periodic surveys over the life of the proposed Browse Project.
- Verifying science:
  - The Scott Reef long term monitoring program will continue to monitor the status of the reef system, throughout the full lifecycle of the proposed Browse Project.

29 Subject to confirmation, vessel/rig may be permitted re-entry within Scott Reef State waters (3 nm) without re-inspection provided its movements outside Scott Reef State waters at stationary or at slow speeds (less than three knots) in waters less than 50 metres deep do not exceed a period totalling greater than seven accumulative days prior to returning to Scott Reef State waters (3 nm).

It should be noted that further environmental review and the implementation of controls will be undertaken in subsequent phases of the proposed Browse Project, such as during the preparation of activity specific EPs. While the overarching environmental objectives will be carried through to the EPs, controls and corresponding performance criteria will be detailed in the EPs and implemented to reduce risks to As Low As Reasonably Practicable (ALARP).

5.15 MEQ-1: Environmental Quality and Management Framework (EQMF)

5.15.1 Environmental Quality Management Plan (EQMP) for State Waters

A number of submissions requested that the proposed Environmental Quality Management Plan (EQMP) be provided as part of the supplementary documentation.

The EISG/ESD required Woodside to *"Outline a commitment to develop and implement a Marine Environmental Quality Management Plan (EQMP) for the State waters which identifies the Environmental Values to be protected and spatially defines the Environmental Quality Objectives and levels of ecological protection that Woodside aims to achieve in State waters".*

This requirement was fulfilled in the State ERD appended to the draft EIS/ERD which included the purpose and objectives of the EQMP and proposed Levels of Ecological Protection (LEP) within State waters around Scott Reef for both construction and operations of the proposed Browse Project. Given the development stage of the project (pre-FEED) the draft EIS/ERD has focused on presenting acceptable environmental outcomes and demonstrating that feasible and effective management options exist to achieve them. Management detail will be provided in the subsequent approval process under petroleum legislation (i.e. EPs). However, subsequent to the finalisation of the draft EIS/ERD for public comment, Woodside has prepared an EQMP that is expected to be matured and finalised beyond this assessment process. The EQMP is provided in **Appendix C.2**.

As part of the development of the EQMP the proposed LEP have been reviewed and refined. This refinement has been undertaken in response to consultation with EPA Services and in consideration of the levels of environmental quality that are predicted to be achieved as per the EPA's Technical Guidance for Protecting the Quality of Western Australia's Marine Environment (EPA, 2016).

The relevant elements of the Environmental Quality Management Plan proposed for State waters at Scott Reef will be applied within the Commonwealth Marine Area. These will be described in and implemented via the activities specific Environment Plans to be prepared under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. Relevant elements include mitigation, management and monitoring associated with:

- Drilling and completions discharges
- Browse Trunkline hydrotest discharge
- SURF hydrotest discharge
- FPSO Cooling water discharge
- FPSO Produced water discharge.

5.15.2 Environmental Management Framework for Marine Discharges in Commonwealth Waters

As described in the draft EIS/ERD a comprehensive environmental management framework will be in place for all marine discharges applicable to proposed Browse Project. This framework will be described in and implemented via the activities specific Environment Plans to be prepared under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. The framework will apply to both the both the Torosa and Calliance/Brecknock FPSOs. An overview of this framework is provided below.

i. Environmental Quality Values

The framework will be in place to avoid, mitigate and manage impacts to community values identified in the National Water Quality Management Strategy (NWQMS). The specific community values identified in the NWQMS that are applicable to the Browse Development Area and surrounds are:

- Aquatic ecosystems – i.e. the marine ecosystem health within the Commonwealth marine area
- Primary industries – i.e. commercial, traditional and recreational fishing
- Cultural and spiritual values – i.e. Traditional Indonesian fishers in the MOU 74 area
- Recreation and aesthetics.

ii. Environmental Quality Outcomes

Environmental outcomes for each of the relevant community values have been identified as follows. These have been selected to be consistent with the outcomes targeted in the Environmental Quality Management Plan (EQMP) prepared for State Waters in accordance with the WA EPA's Technical Guidance for Protecting the Quality of Western Australia's Marine Environment.

- Aquatic ecosystems – 'Maintain ecosystem integrity'
- Primary industries – 'Seafood is of a quality safe for eating'
- Cultural and spiritual values – 'Seafood is of a quality safe for eating' and 'Cultural and spiritual values of the marine environment are protected'
- Recreation and aesthetics. – 'Water quality is safe for activities in the water' and 'Aesthetic values of the marine environment are protected.

The proposed Browse Project has identified a series of Environmental Objectives. The Environmental Objectives relevant to the above values and outcomes for the Commonwealth Marine Environment include the following. Achieving these objectives will result in the identified outcomes being achieved.

- Manage the Browse Project marine discharges in a manner that prevents a change in sediment quality (as informed by baseline surveys and periodic monitoring) in areas outside of predicted impact areas defined in the draft EIS/ERD, to an extent which may otherwise result in an adverse effect on biodiversity, ecological integrity or human health.
- Manage the Browse Project marine discharges in a manner that prevents a change in water quality (as informed by baseline surveys and periodic monitoring) in areas outside of predicted impact areas defined in the draft EIS/ERD, to an extent which may otherwise result in an adverse effect on biodiversity, ecological integrity or human health.
- Manage the Browse Project FPSO produced water and cooling water discharges in a manner that ensures the defined threshold values[30] (e.g. 99% species protection or no effect concentrations) are met at the State waters 3 nm boundary, 95% of the time based on dispersion modelling results.

iii. Spatial Definition

The spatial definition of the Levels of Ecological Protection within WA State Waters is defined within the State Waters EQMP. Levels of protection to be applied to Commonwealth Waters are outlined below. Terminology for Levels of Protection is as per Table 1 of the EPA's Technical Guidance – Protecting the Quality of Western Australia's Marine Environment. Consistency between LEPs should be applied. While not in State Waters, LEPs are consistent with those applied in the State Waters EQMP.

For PW discharges, there will be a water column mixing zone that extends 1,200 m from the discharge point, at the boundary of which a High LEP (99% species protection) will apply. A moderate level of protection will apply within 500 m of the discharge point. Conformance to this limit will be applied to the results of whole effluent toxicity of PW discharges.

Mercury treatment equipment considered in the Browse FPSO design is expected to reduce mercury to below 0.005 mg/L for >95% of operating conditions and mercury in discharges will never exceed 0.03 mg/L. In abnormal conditions (e.g. unexpected upset to treatment equipment) it is possible that mercury in PW may exceed 0.005 mg/L. During circumstances where it has been identified where mercury discharge may exceed the 0.005 mg/L limit (i.e. if PW tertiary treatment is not available and the 0.005 mg/L discharge spec may not be met without it), the FPSOs are designed with sufficient water storage capacity to route water in-board. Once the system returns to normal, the in-boarded water can then be routed through the normal treatment system or supplementary/temporary treatment system if required.

The Level of Ecological Protection that will apply to PW in the water column are as follows:

- Low (80% species protection) – at entry to receiving environment for bioaccumulating constituents excluding elemental or inorganic mercury[31]
- Low (80% species protection) – within 20 m of discharge entry to receiving environment for elemental or inorganic mercury
- Low (80% species protection) – within 0 to 50 m of the discharge point for non-bioaccumulating constituents
- Moderate (90% species protection) – Beyond 50 m but within 500 m of the discharge point.
- High (99% species protection) – Beyond 500 m but within 1,200 m of the discharge point.
- Maximum (no detectable change from background associated with the Proposal) – beyond 1,200 m of the discharge point.

30 The level at which if exceeded, unacceptable impacts may occur. Threshold values applied to the proposed Browse Project are described in the draft EIS/ERD

31 Including methyl mercury species

The Level of Ecological Protection that will apply to PW (including mercury) in sediment are as follows:

- High (99% species protection) – within 1,200 of the discharge point.
- Maximum (no detectable change from background associated with the Proposal) – beyond 1,200m of the discharge point.

At "end of pipe" (the point at which discharges meet the receiving environment), the 80% species protection level for all bioaccumulating substances is to be achieved, with the exception of mercury. The 80% species protection level for mercury will be achieved within 20 m of the discharge point. This is a deviation from the default guidelines recommended by the National Water Quality Strategy but as further outlined below remains acceptable as Environment Values will continue to be protected. That is, there are no specific values that would be impacted by a slight elevated in mercury in the zone between the discharge point and 20 m from this point.

In terms of acute toxicity risks, any mercury would be diluted to 80% species protection levels typically within less than 20 m of the FPSO but always within 50 m. The maximum level of ecological protection would always be achieved within 1,200 m of the discharge point aligned to the EQMF that will be applied to the Browse FPSOs and as further described below.

In terms of bioaccumulation risks, modelling was conducted simulating mercury discharge from the Torosa FPSO at the maximum expected rates for the maximum expected duration of the project life (44 years). This showed that due to the low initial concentration of mercury, slow settling velocities and large spread of the mercury particles, any mercury accumulating on in sediments would never exceed a 'limit of reporting' 0.01 mg/kg for all operational periods assessed. For example, after 30 years of operations, the maximum mercury concentration was 0.0006 mg/kg, which is 16.7 times below the LOR, 250 times lower than the DGV and 1,670 times below the GV-high threshold.

The modelling report supporting this analysis is included as **Appendix A.5**.

iv. Key Criteria

The following environmental quality criteria will apply to produced water discharges and will be used to interpret environmental monitoring data or trigger management actions. These EQC are aligned to the levels of ecological protection described above under iii. Spatial Definition. The related environment quality criteria and sampling requirements are outlined at a high level below.

PW Environmental Quality Guidelines

- Chemical characterisation analysis of the produced water at end of pipe will be undertaken at least annually. Results must demonstrate that the specified species protection guideline values will be achieved at the specified distances based on modelled dilution rates.
- WET Testing of the produced water at end of pipe undertaken annually. Results must demonstrate that the specified species protection guideline values will be achieved at the specified distances based on modelled dilution rates.
- The bioavailable fraction of the metal or metalloid concentrations in sediments measured at 1,200 m from the discharge point will not exceed the recommended toxicant default guideline values for sediment quality (DGVs; ANZG, 2018).

Environment Quality Standards

Should the Environmental Quality Guidelines not be achieved, this would trigger investigation into the following Environmental Quality Standards:

Water quality

- If the EQC exceedance relates to water quality: Whole effluent toxicity (WET) testing of water quality samples taken at boundary of the 1,200 m mixing zone (in the direction of the PW plume occurrence during the sampling period), shows that no toxicity above background is detected.
- If the EQC exceedance relates to water quality: Beyond 500 m of the discharge point, no detectable change in natural variation (including abundance, diversity and composition) of epibenthos cover attributable to the Browse Project PW discharge.
- If the EQC exceedance relates to water quality and a contaminant that can bioaccumulate: Beyond 500 m of the discharge point, the median tissue concentration of chemicals that can adversely bioaccumulate or biomagnify should not exceed the 80th percentile of tissue concentrations of a filter feeder from a suitable reference site.

Sediment quality

- If the EQC exceedance relates to sediment quality: Within 1,200 m of the discharge point, sediment toxicity tests should not result in a statistically significant effect ($P < 0.05$) on lethal acute endpoints, or of greater than 50% on sublethal chronic endpoints for any species, compared to a matched reference sediment. Beyond 1,200 m of the discharge point, sediment toxicity tests should not result in a statistically significant effect ($P < 0.05$) on sublethal chronic or lethal acute endpoints for any species, compared to a matched reference sediment.

- If the EQC exceedance relates to sediment quality: No detectable change in natural variation (including abundance, diversity and composition) of epibenthos cover attributable to the Browse Project PW discharge.
- If the EQC exceedance relates to water quality and a contaminant that can bioaccumulate: At the same location as the EQC exceedance, the median tissue concentration of chemicals that can adversely bioaccumulate or biomagnify should not exceed the 80th percentile of tissue concentrations of a deposit feeder from a suitable reference site.

Environmental Monitoring – Water Quality and Sediment Quality

- Water & sediment quality monitoring at a gradient away from the FPSO facility in the receiving environment will be undertaken to confirm EQC are being achieved. This will occur at the following frequencies; baseline (pre-impact), initial and periodically (every 5 years) and at any time for cause (e.g. due to exceedance of a relevant EQC).
- In the first year of operations, a PW modelling verification field program will be completed to verify the modelling predictions. This study aims to verify the modelling predictions and in particular the dilutions achieved, which determines the point at which the defined thresholds levels are reached.

The statistical design on the monitoring program will follow a Before After Control Impact (BACI) approach. A priori statistical power analysis will be conducted to determine the required number of samples to detect a difference or change with a specified level of statistical confidence and power. Confidence and power relate to probabilities of committing Type I (false positive) and Type II errors (false negative) when performing hypothesis tests. These parameters will be set to 0.05 (95% confidence, or 5% chance of obtaining a false positive result) and 0.8 (20% chance of obtaining a false negative). Sufficient samples will be taken to ensure a sufficient 'effect size' can be determined.

The sampling design will be based on the following:

- A gradient design (as described in Holdway and Heggie, 2000).
- Increased sampling effort will occur in the direction of the prevailing current (distances to include 250 m, 750 m, 1 km and 2 km). Sampling will also occur at the LEP boundaries and the State Waters Boundary (for Torosa FPSO only).
- Samples will be collected, stored and handled using appropriate techniques consistent with guidance provided in AS 5667.1:1998 Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples (Standards Australia, 1998) and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018).

All analyses will be undertaken by NATA-accredited laboratories.

Environmental Monitoring – Benthos

Ecological surveys of epibenthos cover will be conducted prior to operations and in the event a relevant EQC is exceeded. Surveys will be conducted using high definition cameras (video and/or stills) with adequate lighting mounted to either a ROV, AUV, or suitable alternative/s methods. The camera system will have ultra-short baseline (USBL) positioning system to rectify the actual position on the seabed..

Video surveys will be conducted at similar locations to where the EQC exceedance was recorded and at control sites. At each location, five transects of 30 - 50 m lengths will be videoed and will be assessed for abundance, diversity and composition.

v. Environmental Investigations

Should the Environmental Quality Guidelines outlined in IV above not be achieved, this would trigger investigation into the stated Environmental Quality Standards.

Any exceedance of the EQG/EQS will be reported within five working days of determining that this has occurred. The significance of the exceedance and any required investigation/action will be determined following communication with the Regulator.

vi. Management implementation framework

In the event the discharge results in an exceedance of the EQS, an adaptive management strategy will be implemented which will be included in the Environment Plan governing the Torosa FPSO. This adaptive management strategy will include actions such as reducing the discharge rate, which increases dilutions in the nearfield or reduces an individual chemical concentration through additional treatment or commingling prior to discharge or the addition of new/ additional treatment stages or equipment.

vii. Remediation

Given the water depths at the FPSO locations, low levels of mercury being discharged combined with ongoing and frequent monitoring at the point of discharge and in the receiving environment, it is not considered credible that the management framework and actions would be so ineffective as to lead to a state where remediation is required. Sediment quality monitoring would be effective at detecting the presence of mercury in sediments at levels well below that which may cause environmental impact, which were they to occur, would occur gradually over an extended period of time allowing management actions to be implemented prevented sediments reaching a level where remediation is required.

5.16 MEQ-2: Unplanned hydrocarbon release

Potential impacts of an unplanned hydrocarbon release

A number of submissions raised concerns with respect to the potential impacts of an unplanned hydrocarbon release on local and regional ecosystems including benthic habitats and communities, marine environmental quality, marine fauna and wetlands.

It is acknowledged within the draft EIS/ERD that the Project Area and environment that may be affected (EMBA) by a major unplanned hydrocarbon release (i.e. Scenario 1 - well blow out) overlaps a number of sensitive environmental, social and economic receptors, including protected and culturally significant areas.

Depending on its severity (i.e. volume, hydrocarbon type and location), a hydrocarbon release resulting from the proposed Browse Project would have the potential to impact water and sediment quality and alter habitats. This could subsequently alter fauna behaviour, cause fauna injury or mortality, impact the aesthetic value of an area and alter the function, interests and activities of other users. This would potentially include impacts to the Scott Reef-Browse Island genetic green turtle population, vulnerable marine mammals (including humpback whales and pygmy blue whales) and whale sharks. Potential risks to marine fauna as a result of an unplanned hydrocarbon release is described in **Section 6.3.21** of the draft EIS/ERD.

Scott Reef as the closest coral habitat to the wells, subsea infrastructure and FPSO facilities is one of the most vulnerable sensitive receptors with respect to an unplanned hydrocarbon release. Quantitative spill modelling undertaken for the proposed Browse Project predicted that a number of shallower reef and lagoon habitats could be contacted in Scenarios 1 to 4 (refer to **Section 6.3.21** of the draft EIS/ERD).

It should be noted however that the occurrence of unplanned hydrocarbon release is considered highly unlikely. Further, the extent of impacts would depend on exposure concentration, duration and degree of weathering of the hydrocarbons. In undertaking this risk assessment of a potential major hydrocarbon release, the spill likelihood was evaluated using blowout and well release frequencies based on SINTEF offshore blowout database 2012 (Scandpower, 2013). This uses data from 1991-2010 to determine likelihood for well blowouts and releases. For a gas well, the SINTEF calculated probability of blowout during drilling and completion is 2.93×10^{-4}. The SINTEF data supports a likelihood of 'highly unlikely' for a well blowout with potential to result in the worst-case credible spill. Furthermore, since the Gulf of Mexico Macondo event, significant improvements in engineering and management controls have been adopted by the industry, further reducing the likelihood of such an event occurring. Prevention and response measures in relation to potential unplanned release of hydrocarbons are detailed in **Section 6.3.21.7** of the draft EIS/ERD.

With respect to the hydrocarbon spill modelling, feedback during the public comment period queried the rationale for the location of the modelled release in Scenario 1 (well blowout from the TRA-C well within the State Proposal Area), given the TRA-C well is not the closest proposed well to Scott Reef. The TRA-C well was selected for the modelling as it is one of the wells located closest to Scott Reef and is expected to have a higher release rate (and therefore total volume over a fixed period of time) compared to the other wells. As such, the TRA-C well was considered to represent the worst-case credible scenario (i.e. the governing scenario that represents the largest potential environmental impact) and as such is the appropriate location for use in the hydrocarbon spill modelling. It is noted that since the release of the draft EIS/ERD, the TRE drill centre is no longer proposed to be developed which further confirms TRA-C well as the worst-case credible scenario.

Measures to reduce the likelihood and consequence of an unplanned hydrocarbon release

In response to comments regarding this activity, a Hydrocarbon Spill Risk Management Approach (HSRMA) document has been prepared to outline the approach that will be applied on the proposed Browse Project to reduce the likelihood and consequence of unplanned hydrocarbon release events (**Appendix C.4**). This document has been prepared to provide a high-level overview of the key actions that will be implemented in order to reduce the likelihood and consequence of the worst case credible event associated with the Browse Project, a well loss of containment event. It should be noted that measures pertaining to oil spill response are applicable to other hydrocarbon loss of containment events that were identified as credible within the draft EIS/ERD.

Woodside follows an industry leading process in the development of its oil spill prevention, preparedness and response position for its projects and activities. The objective of the process is to mitigate and manage the risks and impacts from an unplanned hydrocarbon release, and the associated response operations, so that they are controlled to ALARP and acceptable levels.

The outcomes of the process will be presented in an Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA) which, together with the following 'secondary approval' documents, meet the requirements of the relevant regulatory regime governing hydrocarbon spill arrangements that is applicable to the Browse Project, namely the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and the State Petroleum (Submerged Lands) (Environment) Regulations 2012:

- Activity specific environment plans required under the Commonwealth and State regulations
- Oil Pollution Emergency Arrangements (OPEA)
- Activity specific Oil Pollution Emergency Plans (OPEP) including:
  - First Strike Plans (FSP)
  - relevant Operations Plans
  - relevant Tactical Response Plans (TRPs)
  - relevant supporting plans.

These plans are typically during the detailed design and planning phase of a project lifecycle, which the Browse to NWS project has not yet commenced. These 'secondary approvals documents' that will be prepared in accordance with all applicable regulations, are not yet able to be prepared as many of the critical details required to prepare these documents has not yet occurred.

Noting that these detailed documents have not yet been prepared, in order to provide stakeholders a more detailed understanding of the measures that will be in place on the Browse Project to reduce the likelihood and consequence of hydrocarbon releases, the HSRMA outlines the:

- measures that will be applied to minimise the likelihood of a well loss of containment event
- source control techniques to be applied and maximum response timeframes to be achieved to reduce the consequence (e.g. release duration) of a well loss of containment event
- hydrocarbon spill response (remediation) techniques to be applied to reduce the consequence (spill response) of any hydrocarbon release event
- process that will be followed as part of secondary approvals to ensure risks from hydrocarbon spills are acceptable and risks are ALARP including relevant approvals that must be obtained
- the Operational and Scientific Monitoring frameworks to be applied to inform response activities and monitor the effects of any spill.

A summary of key sections of the HSRMA is provided below.

Reducing the likelihood of well loss of containment events.

A well loss of containment event is classified as any release of hydrocarbon (regardless of size or duration) from primary and secondary well control barriers. For a gas well, the probability of blowout during drilling and completion is 0.000293%, based on international benchmark data (SINTEF 2017). The most important step in managing such a release is minimising the likelihood of the event occurring. At Woodside, this process is managed through the Drilling and Completions (D&C) Management System. The D&C Management System Framework is based on international standards, codes and best practices. Woodside regularly conducts activities in Australia and internationally in accordance with this Framework. A description of this framework is provided in Section of the document. In addition, Woodside has provided an overview of the measures that, at a minimum, will be implemented to minimise the likelihood of loss of well containment events from the proposed Browse Project.

These measures are the minimum that will be applied and have been identified very early in the lifecycle of the Browse Project, as part of the environmental impact assessment. As project design and planning develops, and as part of the secondary approvals required under the Commonwealth and State regulations, further measures will be identified and assessed to ensure the risk of a significant unplanned hydrocarbon release is reduced to ALARP in accordance with the regulations. **Appendix C.4** describes the process that will be undertaken as part of the development of the activity specific EPs that will be prepared in accordance with the regulations for acceptance by the Commonwealth and State regulators.

Source control techniques to be applied on the Browse to NWS Project to reduce the consequence of a well loss of containment event.

In the highly unlikely event of a well loss of containment event, source control techniques will be applied to stop the flow of hydrocarbons to the environment from the well.

At all times when drilling is occurring, the capacity and capability to implement the following source control techniques, in the specified timeframes, will be maintained.

- A ROV capable of manually operating the Blow Out Preventor (BOP) (in the event of automatic systems failing) will be available in field for immediate response when determined safe to do so.
- A subsea first response tool kit to remove debris and facilitate installation of a capping stack will be available for will be available for deployment at the well loss of containment event site within 11 days of any event.
- Access to a suitable capping stack (either through ownership or membership to a response organisation) will be maintained. The capping stack (on a suitable vessel for deployment) will be mobilised to site and the capping stack will be available for deployment at the well loss of containment event site within 11[32]-16[33] days of event, with a target of 13 days.
- Relief well capability will be monitored and at all times during the proposed Browse to NWS Project D&C activities, a suitable MODU capable of commencing relief well activities will be able to be mobilised and arrive in the field within 16 days of any well loss of containment event.

The HSRMA outlines the presents a level of minimum capability and commitment in relation to source control activities, including maximum response times to enacting particular response techniques. The provision of such detailed commitments at such an early stage in the project development lifecycle demonstrates the commitment to ensuring global best practice to minimising the risk to Scott Reef and surrounding environment. The techniques to be applied and response timeframes are considered to be in alignment with industry best practice.

These measures were identified in the context of the environmental impact assessment and primary approval process for the proposed Browse Project. As project design and planning matures, and as part of the secondary environmental plans required under the Commonwealth and State regulations, further measures will be identified and assessed to ensure the risk of a significant unplanned hydrocarbon release is reduced to ALARP in accordance with the regulations.

5.17 MEQ-3: Australian marine parks and State marine parks

A number of submissions noted the proximity of the proposed Browse Project to Australian marine parks (AMPs) and State marine parks.

Australian marine parks

It is acknowledged that the BTL route traverses the Argo-Rowley Terrace and Kimberley Marine Parks. However, as detailed in Chapter 9, **Table 9-13** of the draft EIS/ERD, the proposed activities are not predicted to result in impacts to the values of these AMPs and the proposed activities are consistent with the approved uses of the Multiple Use Zones (IV). Furthermore, activities will be progressed in accordance with applicable petroleum pipeline requirements, EPs and requirements in relation to North-West Marine Parks Networks which are currently the subject of a Class Approval from the Director of National Parks (Class Approval – Mining Operations and Greenhouse Gas Activities) dated 26/06/2018).

Assessment of alternatives

The potential to avoid these receptors has been evaluated in **Section 3.8.3.2** of the draft EIS/ERD. The assessment concluded that:

- Avoiding incursion into the Kimberley Marine Park (Multi Use Zone) by locating the BTL north of the marine park. While potentially technically viable, this alternative would result in significant increased complexity due to water depths greater than 600 m and associated risk due to the large changes in water depth that would occur along the route. The increased route length would also result in increased habitat modification as a result of seabed disturbance and a greater requirement for steel (due to the longer pipeline), with associated indirect impacts.
- An alternative route that runs south of the Argo-Rowley Terrace Marine Park Multi Use Zone was assessed and found not to be preferable due to the shallower water and significant sand waves present; installation of the BTL in this alternative area would require substantial seabed intervention to prepare the seabed for placement of the BTL. The intervention required would likely be via means such as mass flow excavation, trenching, ploughing or the

32 11 days is the mobilisation timeframe for the Singapore-based Wild Well Control Inc. capping stack to Port Hedland as calculated in the Australian oil and gas industry response time model (OSRL-APPEA, June 2021). This timeframe assumes the availability of a suitable vessel in Singapore within 24 hours.

33 16 days is the estimated mobilisation timeframe based on the OSRL-APPEA response time model (11 days) plus transit time to the spill location and contingency if a suitable vessel is not available within 24 hours.

placement of rock berms. The significantly shallower water would require significant secondary stabilisation after the pipe was laid to ensure pipeline integrity. Both extensive seabed preparation and secondary stabilisation would result in additional impact to receptors (e.g. localised turbidity and removal of benthic habitat) as well as additional cost. It should also be noted that this alternative BTL route would be longer and subsequently have increased impacts via seabed disturbance compared with the proposed BTL route.

Given the above, it was determined that the additional potential environmental impact, cost and technical complexity of adopting alternative routes that avoid the Kimberley Marine Park and/or the Argo-Rowley Terrace Marine Park would significantly impact the proposed Browse Project, while actually increasing the environmental impact. As such, it is considered that the proposed BTL route represents the only reasonably practicable and feasible option.

Characterisation of the seabed along the BTL route within the AMPs

Analysis of the benthic imagery acquired during and environmental survey of the BTL route found that the seabed along the BTL route within the AMPs was predominantly composed of unconsolidated soft sand, largely devoid of epibenthic communities, with occasional solitary non-coral benthic invertebrates (Advisian, 2019).

Subsequent to the release of the draft EIS/ERD for public comment, high-quality seabed imagery of the BTL route within the marine parks acquired by an automatous underwater vehicle (AUV) has become available. A review of the AUV imagery demonstrated that the seabed along the selected sections of the BTL route within the AMPs found:

- Kimberley Marine Park: the seabed along this section of the BTL was predominately unconsolidated flat soft sands with some areas demonstrating shallow sand waves and bioturbation. The seabed was almost entirely devoid of epibenthic communities, with only occasional solitary benthic invertebrates (e.g. crinoids, seapens, starfish and anemones), crustacea and demersal fish observed. A representative image of the seabed along the BTL route within the Kimberley Marine Park is shown in **Figure 5-1**.
- Argo-Rowley Terrace Marine Park: the seabed along this section of the BTL was characterised by unconsolidated soft sand forming shallow sand waves, largely devoid of epibenthic communities, with occasional solitary non-coral benthic invertebrates (e.g. crinoids, seapens, starfish and anemones), crustacea and demersal fish observed. A representative image of the seabed along the BTL route within the Argo-Rowley Terrace Marine Park is shown in **Figure 5-2**.

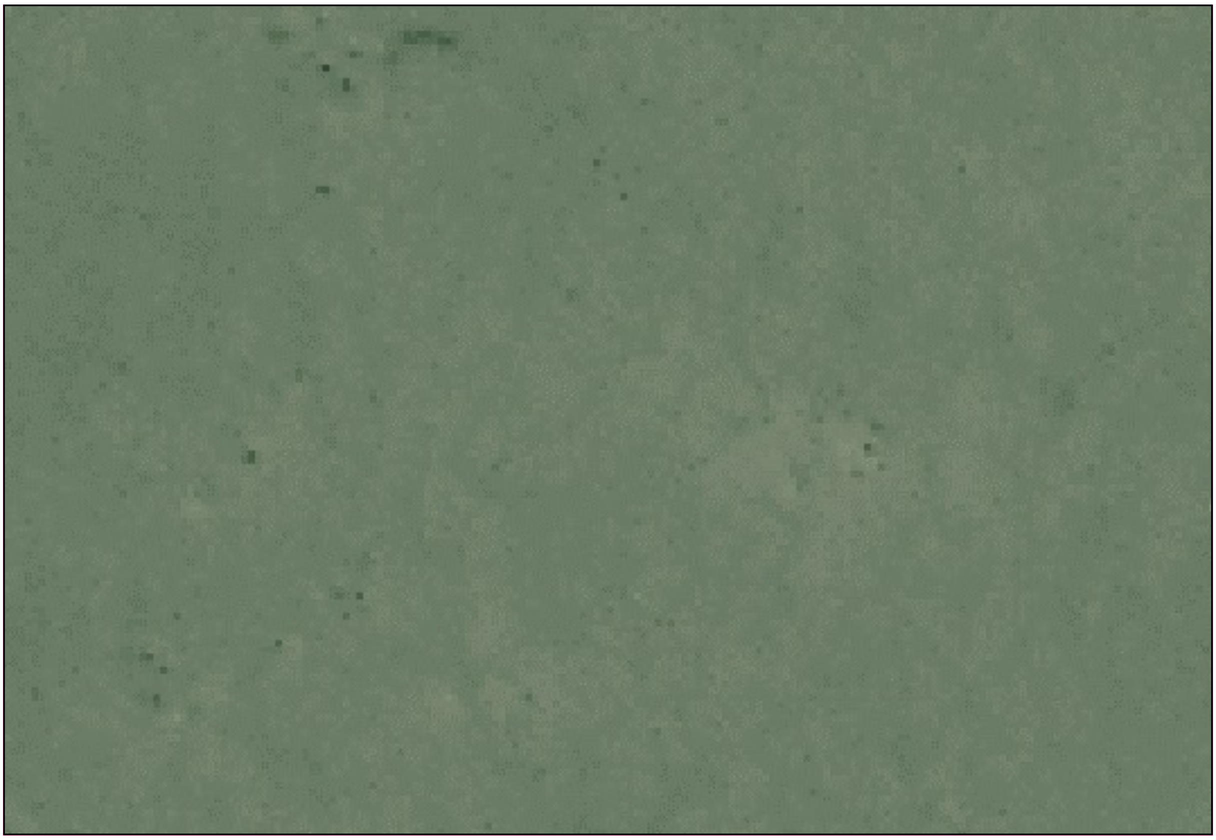

Figure 5-1 Representative image of seabed along the BTL route within the Kimberley Marine Park

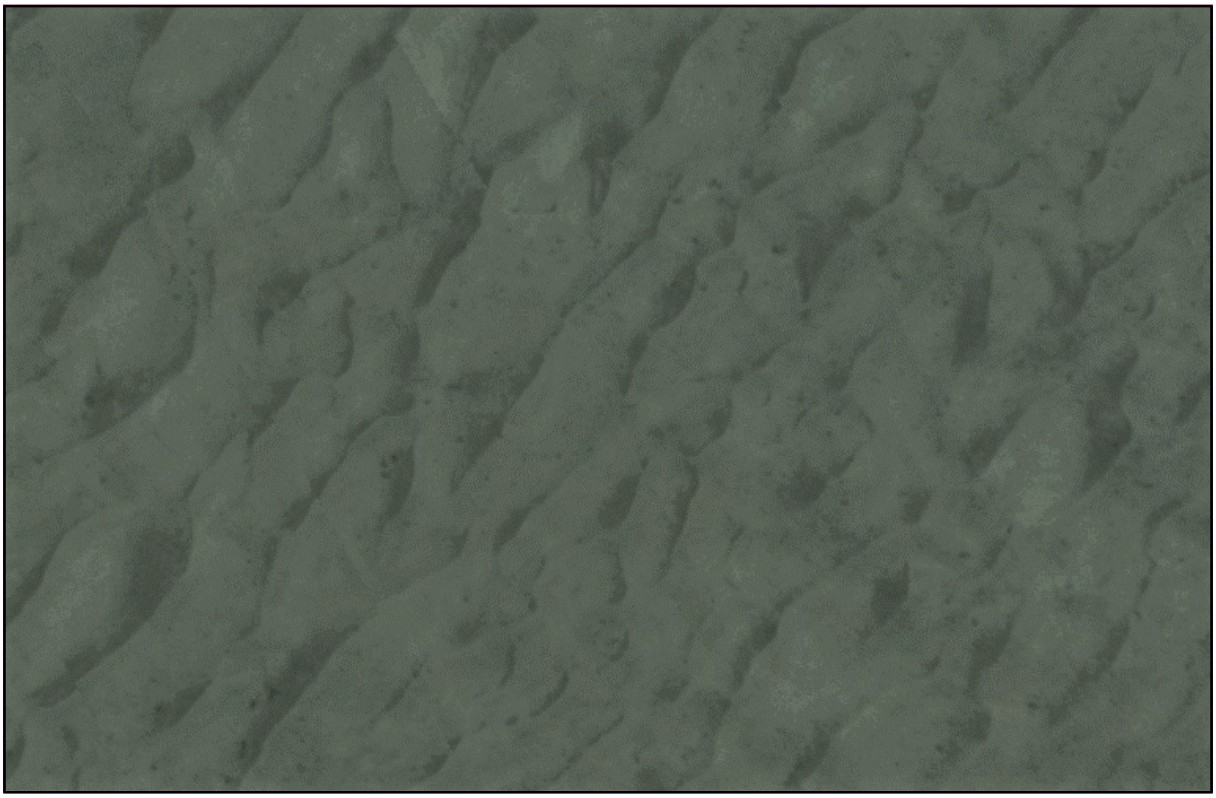

Figure 5-2 Representative image of seabed along the BTL route within the Argo-Rowley Terrace Marine Park

Given the lack of significant habitat or seabed features along the proposed BTL route, impacts resulting from seabed disturbance are not predicted to be significant. Given this, there is a high level of confidence that the installation and operation of the BTL will not result in a reduction in the conservation values of the AMPs and it is considered that the proposed activities are not inconsistent with the requirements of the North-west Marine Parks Network Management (Director of National Parks, 2018)

State marine parks

With respect to State marine parks, given the distance of the proposed activities from State marine parks (the Rowley Shoals Marine Park is located approximately 2 km from the proposed BTL route at its closest point), no impacts to State marine parks as a result of the proposed activities are predicted.

Unplanned hydrocarbon release

It is acknowledged that a major unplanned hydrocarbon release resulting from the proposed Browse Project would have the potential to impact the environmental values of AMPs and State marine parks. However, the occurrence of such a spill event is considered highly unlikely (refer to response MEQ-2 for further discussion of the unplanned hydrocarbon releases).

5.18 MEQ-4: FPSO marine discharges (produced water and cooling water)

A number of submissions raised concerns with respect to potential impacts on marine environmental quality from the discharge of PW from the FPSO facilities in Commonwealth waters. This included concerns with respect to the uncertainty of the PW ecotoxicity, the approach used to assess the potential area impacted by the PW discharge and the PW constituents. Further information was also requested with respect to the monitoring and management of PW and cooling water discharges.

PW Ecotoxicity

As described in **Section 6.2.16.2** of the draft EIS/ERD, whole of effluent toxicity data is not currently available for PW as insufficient well fluid samples are available to conduct this level of testing prior to start-up. This is unavoidable as PW is predominantly associated with later field life once the gas reserves are depleted and aquifer intrusion occurs. This is typical of both new developments and of operated assets, where there is uncertainty in how PW characteristics may change over time. Given this information is not currently available, the results of toxicity testing of Torosa condensate (the likely key contaminant for PW) have been identified as the most representative to determine PW toxicity. The draft EIS/ERD acknowledges this uncertainty and presents an adaptive management process based on FPSO PW discharge monitoring, periodic and 'for cause' toxicity testing and characterisation of the physical and chemical composition of the PW stream prior to discharge. This approach is broadly consistent with the management of PW uncertainty at existing operating assets.

PW potential area of impact

A detailed assessment of the PW discharge from the FPSO facilities has been provided in **Section 6.2.16** of the draft EIS/ERD. This assessment was based on robust modelling study taking into consideration the physical discharge parameters, chemical constituents and ecotoxicity. The modelling presented addresses two key scenarios:

- Scenario 1: Maximum processing capacity of the FPSO facilities, which is not expected until late field life. This corresponds to 5,723 m^3/day.
- Scenario 2: Flowrate of the FPSO facility shortly after start-up or on facility restart when MEG is typically expected to be discharged.

The results of the assessment determined that a reduction in water quality will occur in the vicinity of the PW discharge point due to the residual hydrocarbons and chemicals within the PW discharge. However, the point at which the 99% species protection level is met for oil in water (333 dilutions) is a maximum distance of 1,200 m from the Torosa FPSO discharge point (as defined in the modelling as described in **Section 6.3.12.3** of the draft EIS/ERD). The Torosa FPSO is located ~2.5 km from the 3 nm State water boundary and ~8 km from Scott Reef and as such there are no predicted impacts to Scott Reef or within the State water boundary (3 nm).

As the PW treatment system and discharge characteristics for the Calliance/Brecknock FPSO are the same as for the Torosa FPSO; and the receiving environment at the FPSO locations are similar, the modelling undertaken at the Torosa FPSO location has been used as a surrogate for the Calliance/Brecknock FPSO facility. The mixing zone extent therefore is anticipated to be similar for the Torosa FPSO as for the Calliance/Brecknock FPSO at approximately 1,200 m.

It should be noted that PW is generally expected to increase over time and be highest towards the end of the reservoir life. This is because as hydrocarbons are extracted over time, formation water is drawn towards the well and it is produced. As such, these scenarios are considered the most conservative scenarios, noting there will be sufficient time to monitor and adapt management measures to ensure impacts are within the limits presented in the draft EIS/ERD.

PW constituents – fate, transport and management of mercury

Submissions raised concerns with respect to the impact assessment of mercury as a constituent of PW, including with regards to mercury content in the PW stream, whether there is a requirement for mercury recovery units (MRUs) for the PW stream and bioaccumulation in the receiving environment.

The draft EIS/ERD identifies that some mercury in PW streams is expected to occur in the relatively low toxicity form (Hg (0)), with some potential for production of HgII (e.g. mercury chloride and mercury sulphide). Methyl-mercury (MeHg) is not expected to be produced.

As described in the previous subsection, the proposed Browse Project draft EIS/ERD assesses the potential impact of PW discharge on water quality. Consistent with the approach for other oil and gas facilities, the draft EIS/ERD specifies a mixing zone for potential impacts from PW discharge, which is based on oil in water as the selected governing constituent. In the draft EIS/ERD a discharge limit of 0.03 mg/L for mercury is specified, as this represent the discharge limit whereby the 99% species protection level[34] (0.1 µg/L) will be met at the edge of this defined mixing zone.

This approach is inherently conservative as it does not account for the ready volatilisation of elemental mercury (Hg (0)) from surface waters into the atmosphere (Neff, 2002). As described in **Section 6.2.16.4** of the draft EIS/ERD studies have found that surface waters of the marine environment typically emit mercury and this exchange of mercury at the interface between the ocean surface and the atmosphere unfolds relatively quickly (Gworek et al., 2016). It is therefore anticipated that the majority of the discharged elemental mercury will be volatilised to the atmosphere and hence is expected to remain in surface water for much less time than oil-in-water, leading to a smaller mixing zone than is proposed for oil-in-water. It is also recognised that there is potential for deposition of a small component of the mercury into sediment, particularly if Hg(0) is oxidised to Hg(II) (e.g. mercury chloride and mercury sulphide).

Further, the design of the Browse FPSOs have selected a PW discharge depth of 14 m below mean sea level, which facilitates dispersion and results in turbulent mixing of the buoyant plume close to the discharge point. As a result, while the 99% species protection limit is conservatively predicted to be met at the edge of the defined mixing zone (e.g. 1,200 m), based on the modelled dilution contours the 95% species protection limit (0.4 µg/L) is predicted to be reached within 200 m and the 80% species protection limit (1.4 µg/L) within 0 m of the discharge point for non-bioaccumulating constituents (noting that bioaccumulating constituents will be managed at to ensure 80% species protection at the discharge point, with the exception of elemental or inorganic mercury which will be managed to achieve 80% species protection within 20 m of discharge entry to receiving environment) (**Appendix D.4** of the draft EIS/ERD).

Meeting these ANZECC default guidelines at very short distance from the FPSO discharge point supports the environmental impact assessment for PW (**Section 6.3.12.4** of the draft EIS/ERD), which identified that:

- A change in water quality may occur in the vicinity of the PW discharge point (localised and limited to within 1,200 m mixing zone).
- The change in water quality as a result of PW discharges has the potential to result in the injury or death of plankton species within the water column through toxicity effects. Any potential for acute toxicity impacts to plankton would be expected to be limited to within the modelled mixing zone confined to a small portion of the water column (i.e. surface layer).
- Transient marine fauna (i.e. potentially exposed to toxicity for short periods) within the receiving environment adjacent to the discharge location are unlikely to be exposed to sufficient concentrations or durations of the discharge constituents to result in a toxicological impact. This is further substantiated as the threshold concentrations and the subsequent mixing zone have been determined through the application of chronic exposure thresholds based on ecotoxicological tests on larval marine fauna (i.e. during their most sensitive life stage) rather than transient adults.

34 *The mercury threshold specified in* **Section 6.3.12.2** *of the draft EIS/ERD is based on the ANZECC default guideline value for chronic exposure at the 99% species protection level for inorganic mercury in marine water. Chronic data used to derive the default guideline value was available for six taxonomic groups covering 43 data points (consisting of fish, crustaceans, echinoderm, molluscs, annelids and algae) (ANZG, 2018).*

Beyond the localised impact of mercury discharge in PW on localized water quality, the environmental impact assessment for the discharge of mercury in PW also considers the risk of mercury bioaccumulation. Of the different mercury forms, methyl-mercury (MeHg) is of most concern because it is readily bioavailable and can be responsible for toxicological effects at very low doses – in particular ANZECC technical guidance identifies that diet-derived methyl mercury is the primary concern with regards to bioaccumulation, due to the lipid-solubility of organic mercury (ANZG, 2018). As described in **Section 6.2.16.4** of the draft EIS/ERD, MeHg is not expected to be produced from the Browse reservoirs.

The predominant mechanism for methylation of mercury (by which an inorganic form of mercury is made organic) in the marine environment is biochemical transformation by microorganisms in anaerobic conditions (Gworek et al. 2016). Conversion of other mercury forms to MeHg does not occur in well-oxygenated marine waters (Neff, 2002) such as those of the Browse Development Area, and during a study into factors influencing the oxidation, reduction, methylation and demethylation of mercury species in coastal waters, no measurable methylation occurred in seawater samples during the incubation period of the study (Whalin et al., 2007). MeHg which has formed through methylation typically represents less than 1.5 % of the total quantity of deposited mercury in sediments (Gworek et al., 2016). Thus, the risk for bio-accumulation to occur due to trace amounts of mercury in PW discharge is remote. In addition, methylation of mercury after being ingested by marine fauna was not identified as a key process in a review of the scientific literature (e.g. Gworek et al., 2016).

As previously mentioned, the whole of effluent toxicity of the PW stream has the potential to fluctuate over the life of the field due to varying reservoir characteristics and associated rates of formation water. In the event that the mixing zone is larger than anticipated (i.e. because the whole of effluent toxicity of the PW stream is significantly higher than anticipated (refer to periodic and 'for cause' toxicity testing described above)), posing a significant increase in impact than that described in the draft EIS/ERD then corrective actions will be implemented onboard the FPSOs to reduce the risk, such as storing PW on board the FPSOs (i.e. temporarily halting discharge), additional treatment, and/or additional engineering to produce a change in discharge characteristics. In the specific case of mercury, where chemical characterization results demonstrate inorganic mercury in PW discharge exceeded the specified limit of 0.03mg/L, which has led to an increase in associated whole of effluent toxicity and a resultant mixing zone which is larger than anticipated, then corrective actions may include temporarily halting discharge until additional treatment and/or engineering produced a change in discharge characteristics.

Further, as described in **Section 3.7.6.2** of the draft EIS/ERD, onboard the FPSOs, the feed stream will be separated into a gas stream and a liquid stream. The liquid stream will then be separated into a condensate stream and PW stream. In Woodside's general experience operating oil and gas facilities, mercury from the reservoir typically partitions to preferentially follow the gas stream, then the condensate stream, with only a remnant being discharged within PW. Mercury Removal Units (MRUs) will be in place in the gas and condensate streams. This is consistent with observations throughout the oil and gas industry, and is supported by a recent article (Crafts and Williams, 2020).

The ability to store PW on board the FPSO as part of the management approach, is a key advantage of the FPSO concept when compared to fixed platforms. Given this and given the statements above regarding expected partitioning of mercury it is not considered that the use of an MRU to remove mercury from the PW stream is warranted as part of the base case design for the Browse FPSOs.

Environmental quality and management framework

As detailed in **Section 6.3.12** of the draft EIS/ERD, Woodside has made a number of management and monitoring commitments in relation to PW. These will be implemented to achieve the environmental objectives to:

Manage the Browse Project marine discharges in a manner that prevents a change in sediment quality (as informed by baseline surveys and periodic and post-operations monitoring) in areas outside of predicted impact areas defined in the draft EIS/ERD, to an extent which may otherwise result in an adverse effect[35] on biodiversity, ecological integrity or human health.

- Manage the Browse Project marine discharges in a manner that prevents a change in water quality (as informed by baseline surveys and periodic monitoring) in areas outside of predicted impact areas defined in the draft EIS/ERD, to an extent which may otherwise result in an adverse effect[36] on biodiversity, ecological integrity or human health.

35 The area where a detectable change in sediment quality may occur, as determined by marine discharge modelling and described within the draft EIS/ERD
36 The area where a detectable change in water quality may occur, as determined by marine discharge modelling and described within the draft EIS/ERD

- Manage the Browse Project FPSO PW and cooling water discharges in in a manner that ensures the defined threshold values[37] (e.g. 99% species protection or no effect concentrations) are met at the State waters 3 nm boundary, 95% of the time based on dispersion modelling results.
- Manage the Browse Project marine discharges in a manner such that the Levels of Ecological Protection in the State Proposal Area as defined in the Environmental Quality Management Plan are maintained.

Management measures to be implemented include:

- where practicable, design of the proposed Browse Project infrastructure will take into consideration opportunities to reduce the need for chemical additives (e.g. the use of active heating for hydrate management).
- Chemicals that may be operationally released or discharged to the marine environment will be subject to Woodside's chemical selection and assessment process and approved prior to use.
- FPSO PW will be treated prior to being discharged overboard using a tertiary treatment system, such as a MPPE system that meets Woodside and accepted industry standards.
- PW discharge from the FPSO facilities will be conducted below the water surface to promote dispersion and mixing.
- Hydrocarbon content in the FPSO PW discharge will be no greater than an average of 30 mg/L over any period of 24 hours during steady state operations (excluding start-up, shut-downs etc.) as demonstrated by monitoring.
- For the FPSO PW discharge, the defined threshold values (i.e. 99% species protection or no effect concentrations) will be met at the edge of the mixing zone and the State waters 3 nm boundary, 95% of the time based on dispersion modelling results.

To verify that the impacts associated with PW discharge are within the impact envelop presented in **Section 6.2.16** of the draft EIS/ERD, the following assurance activities will be undertaken:

- *During steady state FPSO operations, PW modelling and infield verification will be completed to verify the modelling predictions.* This study aims to verify the modelling predictions and in particular the dilutions achieved, which determines the point at which the defined thresholds levels are reached.
- *Periodic and 'for cause' toxicity testing and characterisation of the physical and chemical composition of the FPSO PW stream prior to discharge will be undertaken.* This provides an assessment of the individual constituent chemical concentration and the whole of effluent toxicity at end of pipe.
- *Baseline and periodic water and sediment quality monitoring at a gradient away from the FPSO facility in the receiving environment will be undertaken to detect changes as a result of FPSO PW discharge.* This monitoring aims to determine no changes in the receiving environment water and sediment quality outside of the defined mixing zone as a result of the FPSO PW discharges.
- *In the event the PW discharge does not meet the defined thresholds in the range predicted for any constituent concentrations, an adaptive management strategy will be implemented which will be included during the EP process.* This adaptive management strategy may include actions such as reducing the discharge rate, which increases dilutions in the nearfield or reduces an individual chemical concentration through commingling prior to discharge. It should also be noted that PW will come on slowly so there will be opportunity to sample and adapt before the full rates modelled are experienced.

The process of how these commitments will be operationalised, verified and monitored will be further outlined in activity specific EPs.

PW re-injection

A number of submissions questioned why re-injection to a reservoir is not being considered as a disposal option for PW, citing lack of discussion in the draft EIS/ERD on PW disposal options. A PW disposal options assessment is presented in **Section 3.8.3.3** of the draft EIS/ERD. The options assessment concluded that given the detailed environmental impact and risk assessment of PW (**Section 6.3.12** of the draft EIS/ERD) concluded that no significant environmental impacts are predicted and that the discharge of PW is acceptable; the increased health and safety risks, GHG emissions, technical complexity and capital and operating costs associated with PW re-injection into a reservoir is grossly disproportionate to the environmental benefit likely to be gained from this approach.

37 The level at which if exceeded, unacceptable impacts may occur. Threshold values applied to the proposed Browse Project are described in the draft EIS/ERD

5.19 MEQ-5: Use of non-water based fluids (NWBFs) during drilling

A number of submissions raised concerns with respect to the use of non-water based fluids (NWBFs) during drilling. In particular respondents questioned the use of synthetic oil-based NWBFs and if Woodside would implement toxicity parameters and concentration guidelines for offshore discharge of NWBF in line with OSPAR recommendations.

The proposed Browse Project will use water-based drilling fluids (WBFs) as the default option; however, NWBF may be required to manage well stability to safe levels based on the offset (comparative wells) history, geohazards assessment and borehole stability studies.

As detailed in **Section 6.3.15** of the draft EIS/ERD, WBFs consist mainly of fresh water or seawater with the addition of chemical and mineral additives to aid in its function. These additives are either inert in the marine environment, naturally occurring benign materials, or readily biodegradable organic polymers with a very fast rate of biodegradation in the marine environment.

As detailed in **Section 6.3.15** of the draft EIS/ERD, NWBF refers to drill fluids that are synthetic hydrocarbon based rather than water based. NWBF may contain a range of synthetic hydrocarbons, such as paraffins and olefins; however, such additives are designed to be low in toxicity and biodegradable, as well as not being readily bioavailable or likely to bioaccumulate amongst the deepwater benthic biota that live within the seabed (infauna) or on the seabed (epifauna). The Nedwed et al. (2006)supported by ocean currents measured during the drilling process and laboratory measurements of cuttings settling velocities. Sediment traps placed near the drill site accumulated a maximum thickness of 0.5 cm of solids, in good agreement with model predictions. Cuttings from sediment traps had significantly lower concentrations of nonaqueous base fluid than did the discharged cuttings suggesting that loss of base fluid during settling to the seabed through 950 m of water may act to significantly reduce potential chemical effects from discharges. In addition, low (up to a few tens of ppm study concluded that NWBF discharged in deep water caused very limited environmental impacts (from analysis of differences in benthic fauna between pre- and post-drilling samples).

Woodside notes that the use of NWBFs is not 'effectively banned' as stated in some submissions. Rather, the residual base oil on discharged drill cuttings is controlled and limited (in some regions, prescribed lower than 6.9%). While there is no prescriptive limit for oil-on-cuttings (OOC) in Australia, to date, accepted EPs typically commit to a maximum of 6.9% (wet) OOC.

As detailed in the draft EIS/ERD, Woodside has committed to monitoring NWBF drill cuttings discharges to confirm that the average OOC for the entire well (sections using NWBF) will not exceed 6.9% by wet weight. It should be noted however that this is a worst-case upper limit and setting this limit involves considering the proportionality of costs and benefits of the following hierarchy of available technology and practices to ensure the lowest feasible discharges. These considerations include:

- Elimination – can the discharge of NWBF retained on cuttings be eliminated? This includes consideration of options to capture and transport NWBF cuttings to shore for treatment and disposal. Associated challenges include transport emissions (~800 km return trip to Broome), vessel marine biosecurity (e.g. potential invasive marine species risk increase for Scott Reef), availability of suitable treatment and disposal facilities (e.g. in Broome) and terrestrial impacts of disposal (e.g. Kimberley-based land-fill, or long-distance transport to non-Kimberley location/s).
  Note that there will be no bulk discharge of NWBFs.
- Substitution – can NWBF be substituted for another fluid (e.g. use only WBF)? WBF is the default fluid. Proposed use of NWBF is internally challenged and is only used if it can be demonstrated that the proposed NWBF hole-sections have intolerable technical risk without the properties provided by NWBF.
- Limitation – can the use of NWBF be limited? Considerations include limiting NWBF use to certain hole-sections, limiting discharge of higher-OOC discharge streams (e.g. from centrifuges), or capturing higher-OOC streams for onshore treatment and disposal or collection and disposal at an alternative offshore location.
- Engineering controls – can the NWBF cuttings be treated prior to discharge? Typical controls routinely employed include high-performance shale shakers, cuttings dryers and centrifuges to minimise OOC. Other considerations include use of thermal desorption, chemical or microwave technologies. Challenges associated with these technologies include technical feasibility, operability, energy requirements, reduced throughput (which may increase drilling duration at the location and/or cause down-hole problems) and health and safety risks.
- Administrative controls – can administrative controls limit/manage NWBF cuttings discharges? Typical controls routinely employed include maintenance regimes, and accuracy of testing and reporting.

This process is consistent with the OSPAR concept of best available techniques/best environmental practice; and is based on the principle of ALARP prescribed in the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and the State Petroleum (Submerged Lands) (Environment) Regulations 2012. It should be noted that there will be no bulk discharge of NWBF and that NWBF that cannot be re-used (i.e. do not meet required drilling fluid properties or are mixed in excess of required volumes) are recovered from the mud pits and returned to the shore base for onshore processing for recycling and/or disposal. Further description for management of drilling discharges is provided in MEQ-6 and **Appendix A** of the Browse Project EQMP (**Appendix C.2**).

5.20 MEQ-6: Management of drilling and completion discharges

A number of submissions raised concerns with respect to the impacts of the discharge of drilling and completions discharges (including drill cuttings), particularly with respect to potential impacts on Scott Reef. **Section 6.3.15** of the draft EIS/ERD outlines the potential impacts and risks from the discharge of drilling or completions discharges associated with drilling activities.

As described in **Section 6.3.15.2** of the draft EIS/ERD, drilling discharges predominantly occur at two locations, at seabed and near surface. Drill cuttings and unrecoverable WBFs are discharged at the seabed at each well site for the top-hole sections, which are drilled riser-less (i.e. no closed loop with the MODU). This results in a localised area of sediment deposition (known as a cuttings pile) around and in proximity to the well site influenced by prevailing seabed currents.

Once the top-hole sections are complete, installation of the riser and blow out preventer provides a conduit back to the MODU, forming a closed circulating system. The bottom hole sections will be drilled with a marine riser in place that enables cuttings and drilling fluids to be circulated back to the MODU, where the cuttings are separated from the drilling fluids by the solids control equipment (SCE) and typically re-used in the closed loop system between the well bore and the MODU. The cuttings (with adhered residual fluids) are, in typical circumstances, discharged below the water line, with their fate and dispersion determined by cuttings particle size and the density of the unrecoverable fluids. In contrast the fluids are recirculated into the fluid system where there are a number of mud pits (tanks) on the MODU that provide a capacity to mix, maintain and store fluids required for drilling activities. The mud pits form part of the drilling fluid circulating system and may be discharged during the drilling of the well where particular criteria is met.

Cement discharge

Once each of the top hole sections are drilled, casing will be inserted into the wellbore and secured in place by pumping cement into the annular space. This may involve a discharge of excess cement at the seabed (~80 m^3/well). Overspill of cement will permanently alter physical sediment properties immediately adjacent to the well (within <50 m). The potential disturbance area is 0.008 km^2 per well. This will result in the permanent loss of the benthic communities and habitats in the disturbance area. This loss will be restricted to sparse, deepwater benthic habitat, with no impact on Scott Reef shallow water benthic communities and habitat (<75 m bathymetry) predicted.

Seabed discharge

Modelling of the proposed seabed discharge of drill cuttings was presented in **Section 6.3.15** of the draft EIS/ERD. The modelling indicated that the seabed discharge of drill cuttings (with unrecoverable fluids) from top-hole well sections may result in sediment plumes in the lower water column above seabed and associated deposition of sediment to the surrounding seabed. Such plumes are predicted to be confined to the bottom layers of the water column with no contact with deeper water or shallow water coral habitats at Scott Reef (<75 m bathymetry). There is some evidence of localised intrusions of cooler water around the western and eastern entrances to the channel between North and South Scott Reef during spring tides but no evidence of persistent upwelling or downwelling currents around Scott Reef (Green et al., 2019) and consequently drive variations in heat stress and bleaching severity. The Scott Reef atoll system was one of many reefs affected by the 2015–2016 mass coral bleaching event across tropical Australia, and specifically experienced sea surface temperature anomalies of 2 °C that caused severe mass bleaching (> 60% and therefore, no transport mechanisms to mobilise drill cuttings from deep waters to the shallower waters of the reef system. As such, given the location of the drill centres in deep water (>350 m), which experience strong surface and subsurface currents, drill cuttings and fluid discharge disposal at seabed would be expected to dilute rapidly. Therefore, any reduction in water quality due to elevated total suspended solids (TSS) is expected to occur in a localised area around the drill centre and will be temporary in nature.

Potential impacts are expected to be confined to sessile biota such as sediment burrowing infauna and epifauna where present in or on the seabed in immediate proximity to the well location. Ecological impacts to such biota are predicted when sediment deposition is equal to or greater than 6.5 mm in thickness (IOGP, 2016). Modelling (**Section 6.3.15.3** of the draft EIS/ERD) indicated that such deposition would potentially occur out from the well location to approximately 200 m (following the direction of the prevailing current). This deposition may result in the reversible loss in the order of 0.13 km^2 of deepwater benthic habitat per well based on an assumption of an expected spread radius of 150 m from each well (in addition to the irreversible loss of 50 m radius associated with cement – described above). Recovery of affected benthic infauna, epifauna and demersal communities is expected to occur relatively quickly, given the short duration of sediment deposition and the widely represented benthic and demersal community composition.

Surface discharge

In relation to the proposed discharge of bottom-hole drilling discharges at drill centres within the State Proposal Area when the riser is in place (i.e. conduit back to the MODU), previous modelling indicated that the surface release of drilling discharges generated at the previously proposed TRE and TRD drill centre locations would potentially result in incursions of sediment plumes and associated increased sedimentation to portions of North and South Scott Reef including within the lagoons. This has been further investigated in **Appendix A** of the Browse Project EQMP (**Appendix C.2**) (Management Approach for Torosa wells in State Proposal Area), which details the discrete surface discharges (e.g. drill cuttings with residual fluids and WBF mud pit bulk discharges) to assess individual risk to the Scott Reef shallow water benthic communities and habitats (<75 m bathymetry), where a maximum LEP has been proposed.

Additional management controls are proposed for the management of Torosa wells drilling discharges in the State Proposal Area to demonstrate that the maximum LEP for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) can be achieved. It is note that the TRE drill centre is no longer proposed so any TRE specific management measures previously proposed are no longer relevant.

For TRA, TRD, and TRF wells on the eastern side of Scott Reef, within the State Proposal Area, drilling discharges at the surface/near surface when drilling with riser are only being considered for bottom hole cuttings (with residual film of fluids) from the shakers (or equivalents) for WBF, and from the cuttings dryers (or equivalents) for NWBF,, due to their inherently lower adhered WBF/NWBF content, and the rapid settling velocity of the larger particle size of the cuttings (primary discharge source) and associated dispersion characteristics, and as such there is no anticipated credible risk to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry Noting that the WBF mud pit bulk discharges, which have larger volumes and finer particle distribution and hence wider dispersion, are proposed to be managed and either discharged at depth (>200 m), at the seabed, or retained for offshore disposal in Commonwealth waters in accordance with a sea dumping permit.

Note, one of the key mitigative options for the management of drilling discharges from Torosa wells in the State Proposal Area involves the collection and transportation of specific discharges to a location outside of State waters (in Commonwealth waters) for disposal (e.g. skip and ship). This option involves modifications to the MODU, which may differ depending on the discharge type and rig selection to allow the storage, potential treatment (e.g. slurrification) and transfer/disposal of the discharge. For drilling fluids, these may be recovered from the mud pits, transferred to storage tanks on the MODU or pumped into storage tanks on a barge/vessel for subsequent disposal. For drill cuttings, this activity may consist of the collection of the cuttings from the MODU into specially designed skips, via a steerable chute. The filled skips are then offloaded via a crane onto a dedicated collection vessel (e.g. barge) or to a standard platform supply vessel (PSV) for disposal. Alternatively, cuttings may be slurrified on the MODU and cuttings and/or fluids pumped to the barge/vessel for subsequent disposal. The disposal of such discharges within Commonwealth waters will be subject to further assessment and approval through the Environment Protection (Sea Dumping) Act 1981 as required.

The management approach for Torosa wells in the State Proposal Area (i.e. TRA, TRD and TRF) are outlined in **Appendix A** of the Browse Project EQMP (**Appendix C.2**). The approach will also be further described and regulated in future EPs submitted for approval under petroleum legislation.

Drilling discharges management

The following controls have been adopted as per **Section 6.3.15.7** of the draft EIS/ERD in relation to this discharge:

- The number of wells will be optimised to meet hydrocarbon recovery objectives and operational requirements and thereby reduce unnecessary use of drilling fluids and generation of drill cuttings. It is noted that the number of wells has been reduced from up to 54 in the draft EIS/ERD to up to 50.
- For technical, operational and environmental reasons NWBFs will be selected in accordance with Woodside's chemical selection and assessment processes.
- Risers will be used to ensure that NWBF and associated cuttings are recirculated to the MODU, where cuttings will be treated prior to discharge.
- There will be no planned discharge of unused NWBF at sea during drilling and completion operations.
- Drill cuttings will be tested to confirm that the average oil on cuttings for the entire well (but limited to sections using NWBF) will not exceed 6.9% by wet weight.
- Woodside has committed to a drilling or completions discharges management approach, which involves managing the drilling or completions discharges (in particular, bottom hole discharges) at drill centre locations in the State Proposal Area (i.e. TRA, TRD and TRF) in such a manner to avoid impacts to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).

As previously described, additional controls have been adopted to demonstrate that the maximum LEP for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) can be achieved. These management controls and associated context are described in detail in **Appendix A** of the Browse Project EQMP (Management Approach for Torosa wells in State Proposal Area).

Wireline logging activities

Wireline logging activities or Formation Evaluation while Drilling may be used for the Browse Project development wells. If radioactive sources are selected for the activity, then any radioactive materials used during the activity would be brought back to the MODU as part of the planned activity. The radioactive sources would not be discharged into the marine environment as part of this planned activity.

5.21 MEQ-7: Decommissioning

A number of submissions raised concerns with respect to decommissioning including what would occur in the event global gas demand decreased to a point where the proposed Browse Project was not financially viable. Woodside confirms that the facilities will be decommissioned in accordance with good oilfield practice and relevant legislation and practice at the time.

Decommissioning will occur once infrastructure has reached the end of its economic life and may occur in stages. The process to determine timing for decommissioning of unused infrastructure will be detailed in operations EPs towards (but prior to) the end of field life. All infrastructure installed above the seabed will be designed to allow removal.

The base decommissioning case is for the removal of infrastructure, however, given the possible improvements in technology that may occur between now and the time of decommissioning, it is not possible to fully scope the decommissioning strategy that will be employed at that time. The strategy (which may also include an assessment of alternatives to the complete removal of subsea infrastructure) will be demonstrated through activity-specific EPs developed closer to the time.

For further details, **Section 3.7.8** of the draft EIS/ERD outlines the proposed decommissioning activities in relation to the project.

5.22 MEQ-8: Potential impacts to wetlands

A number of submissions raised concerns with respect to potential impacts to wetlands including Ramsar wetlands. As described in **Section 5.3.3** of the draft EIS/ERD, no Ramsar wetlands occur within the Project Area and wetlands of international importance (Ramsar wetlands) was not identified as a controlling provision in relation to the Commonwealth environmental impact assessment process for the proposed Browse Project. The closest Ramsar wetland to the Project Area is Ashmore Reef Marine Park (formerly Ashmore Reef National Nature Reserve) located approximately 200 km north-east of Browse Development Area. Another Ramsar wetland is located in Roebuck Bay in close proximity to the Port of Broome which is a potential supply chain and logistics location for the proposed Browse Project. Mermaid Reef is a wetland of national importance which lies within the Mermaid Reef Marine Park. The BTL route is located >2 km from the marine park boundary (distance depending on final BTL route selection).

The impact assessment presented in Chapter 6 of the draft EIS/ERD determined that there will be no planned impacts to any wetlands of international or national importance as a result of the proposed Browse Project activities. It is acknowledged that a major hydrocarbon release resulting from the proposed Browse Project would have the potential to impact significant marine and coastal areas. However, it should be noted that, the occurrence of such a major spill event is considered highly unlikely, particularly given the stringent controls in place (refer to response MEQ-2 for further discussion of unplanned hydrocarbon releases).

5.23 MF-1: Potential impacts to marine fauna (general)

A number of submissions raised concerns with respect to potential impacts to marine fauna from the proposed Browse Project activities.

It is acknowledged that a variety of EPBC listed and non-listed marine fauna may occur in the Project Area with pygmy blue whales and green turtles of particular note. Potential impacts on marine fauna associated with the proposed project activities have been considered and assessed within Chapter 6 of the draft EIS/ERD. The assessment concludes that no significant impacts on marine fauna species are predicted to occur as a result of the proposed Browse Project activities.

Table 6-7 of the draft EIS/ERD identifies the environmental objectives, context and relevant aspects for all marine fauna that may interact with the proposed Browse Project activities. A further evaluation has been conducted for those aspects that have the potential to result in significant impacts and risks to the green turtle population at Scott Reef and the East Indian Ocean pygmy blue whale population visiting the possible foraging area at Scott Reef, both in isolation and cumulatively. Refer to **Section 4.2** for further details.

The outcomes of this further evaluation are summarised in **Section 4.3.3** (light emissions), **Section 4.2.4** (underwater noise emissions) and **Section 4.2.5** (unplanned vessel interactions). Additional controls (over and above the adopted controls identified in the draft EIS/ERD) to eliminate or minimise these impacts and risks to pygmy blue whales and marine turtles are described. This further evaluation has demonstrated the draft EIS/ERD impact and risk conclusions remain appropriate.

In response to feedback from DAWE (refer **Section 3.1**), Woodside has reviewed and revised the environmental objectives presented in the draft EIS/ERD to be more specific and measurable. These revised environmental objectives are provided in **Section 6**. Woodside is committed to achieving these environmental objectives including those relating to marine fauna.

Further details with respect to potential impacts to protected marine fauna and their management are provided in:

- MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**)
- MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**)
- MF-4: Vessel - fauna interaction (**Section 5.26**)
- MF-5: Potential impacts to marine turtles (**Section 5.27**)
- MF-6: Presences and abundance of blue whales in Project Area (**Section 5.28**)
- MF-7: Potential impacts to cetaceans (**Section 5.29**)
- MF-8: Potential impacts to sea snakes (**Section 5.30**)
- MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**)
- MF-10: New species of siphonophores (**Section 5.32**)
- MF-11: Potential impacts to fish (**Section 5.33**).

5.24 MF-2: Potential impacts to marine fauna as a result of light emissions

A number of submissions raised concerns with respect to light emissions from the proposed Browse Project infrastructure and resultant potential impacts to marine fauna and in particular marine turtles.

The main receptors of concern with regards to light emission from the proposed Browse Project activities are marine turtles, seabirds and migratory shorebirds. The draft EIS/ERD identifies that the Project Area overlaps areas identified as:

- habitat critical to the survival of green turtles (Scott Reef-Browse Island genetic stock) (as identified in Recovery Plan for Marine Turtles 2017-2027 (Commonwealth of Australia, 2017a)
- a BIA for internesting green turtles around Sandy Islet
- a BIA (known resting area) for little terns.

Section 4.2.5.3 describes a further evaluation of the project activities and potential impacts in isolation and cumulatively, and the outcomes of a desktop lighting impact assessment. Based on the findings of this further evaluation and updated impact assessment there is no change to the Magnitude and Impact Significanc e Level for light emissions as presented in the draft EIS/ERD – i.e. the level of residual impact remains as Minor (D).

The impact assessment summary, with adopted and additional controls (applicable to all marine turtle species), and revised environmental objectives are presented in Table 45.

Section 5.31 (MF-9: Potential impacts to seabirds and migratory shorebirds) provides a summary of the key findings of the desktop lighting assessment with regards to potential impacts from light emissions from the proposed Browse Project on seabirds and migratory shorebirds.

In response to feedback from DAWE (refer **Section 3.1**), Woodside has reviewed and revised the environmental objectives presented in the draft EIS/ERD to be more specific and measurable. Establishment of revised environmental objectives for the proposed Browse Project that are specific to green turtles is addressed and these revised environmental objectives are provided in **Section 6**.

5.25 MF-3: Potential impacts to marine fauna as a result of noise emissions

A number of submissions raised concerns with respect to noise emissions from the proposed Browse Project infrastructure and resultant potential impacts to marine fauna and in particular pygmy blue whales and marine turtles.

The main receptors of concern with regards to underwater noise emissions from the proposed Browse Project activities are marine mammals, marine turtles and fish.

The draft EIS/ERD presented the findings of a robust underwater noise impact assessment supported by modelling predictions for impulsive and continuous sources, and the application of acoustic effects thresholds for identified receptors. The impact assessment summary (**Table 6-73** of the draft EIS/ERD) presented the potential impacts and risks, environmental objectives, adopted controls and impact significance level / residual risk rating for all assessed receptors. The impact assessment summary indicated that there would be minimal impact to fish and marine turtles, impact significance levels of Slight (E) and Minor (D), respectively. Of particular note for the impact assessment of underwater noise emissions to pygmy blue whale and the outcomes of further evaluation are summarised in **Section 4.2.4** (underwater noise emissions). The analysis confirmed no change in the residual impact significance level of minor (D). Furthermore, additional controls (over and above the adopted controls identified in the draft EIS/ERD) to eliminate or minimise the impact were identified and are presented in **Table 4-2**.

Based on the East Indian Ocean pygmy blue whale population seasonal presence within the possible foraging area at Scott Reef, the evaluation of potential impacts as a result of underwater noise emissions is considered applicable to, and accounts for other species of cetacean that may occur within the Project Area.

The impact thresholds (behavioural response, TTS and PTS) used in the assessments were derived from National Marine Fisheries Service (2018) and NOAA (US) (2019). Within these publications, cetaceans are grouped into low-frequency (LF), mid-frequency (MF) and high-frequency (HF) cetaceans based on hearing sensitivity. LF cetaceans - incorporate all of the mysticetes, (baleen whales), for example, pygmy blue and humpback whales that may occur in the Project Area, MF cetaceans (odontocetes (toothed whales)) includes beaked whales, sperm whales and oceanic dolphins and HF cetaceans (odontocetes (toothed whales)) includes true porpoises and river dolphins. The behavioural response threshold is the same for all cetacean hearing groups (LF, MF and HF) and the ranges for TTS and PTS thresholds are the same for all LF cetaceans. The TTS and PTS results for MF cetaceans are considered negligible due to the modelled predicted small radii for these thresholds and the fact animals would be required to remain within these ranges for the cumulative exposure durations (per pile for impulsive noise or 24 hours for vessel continuous noise). The HF cetacean distribution does not overlap with the Project Area. Accordingly, the assessment placed more focus on the most sensitive cetacean group (LF cetaceans), which represents the worst-case potential impact to a cetacean species exposed to underwater noise emissions.

Further, as described in **Section 5.3.2.5.3** of the draft EIS/ERD, the spinner dolphins (the most abundant of the odontocetes species recorded within the Project Area) may be present in the vicinity of Scott Reef throughout the year, however, it is unlikely that they are reliant on the reef habitats given their population range and distribution. Given the above, pygmy blue whales are considered to be the most potentially sensitive cetacean with respect to underwater noise impacts from the proposed Browse Project, and the conservative approach to the impact assessment is considered applicable to other cetacean species that may occur in the Project Area.In response to feedback from DAWE (refer **Section 3.1**), Woodside has reviewed and revised the environmental objectives presented in the draft EIS/ERD to be more specific and measurable. Establishment of revised environmental objectives for the proposed Browse Project that are specific to pygmy blue whales has been addressed and these revised environmental objectives are provided in **Section 6**.

In order to provide further information in regard to how anthropogenic noise from the proposed Browse Project will be managed, a Pygmy Blue Whale Management Plan (PBWMP) has been prepared (**Appendix C.5**). The primary purpose of this plan is to outline how any underwater anthropogenic noise associated with the proposed Browse Project will be managed such that it will not be inconsistent with the Blue Whale CMP, specifically the requirements of Action A.2.3.

5.26 MF-4: Vessel - fauna interaction

A number of submissions noted the potential for interaction between project vessels (including Fast Crew Transfer Vessels (FCTVs)) and marine fauna.

Section 6.3.18.2 of the draft EIS/ERD presented the outcomes of an evaluation of the risk of vessel strike causing injury or mortality to marine fauna due to the physical presence and movements of vessels during all phases of the proposed Browse Project. This risk evaluation is based largely on the types and numbers of vessels in the Project Area, a general description relating to the project phases, and consideration of relevant EPBC Act listed threatened species are considered, with particular attention to pygmy blue whales, humpback whales and marine turtles.

The potential impacts and risks, environmental objectives, adopted controls and impact significance level / residual risk rating for marine fauna from unplanned vessel interactions are presented in **Table 6-141** of the draft EIS/ERD. The outcomes of further evaluation are summarised in **Section 4.2.5** (unplanned vessel interactions). Additional controls (over and above the adopted controls identified in the draft EIS/ERD) to eliminate or minimise these impacts and risks to marine fauna with particular focus on pygmy blue whales are described in Table 43.

In response to feedback from DAWE (refer **Section 3.1**), Woodside has reviewed and revised the environmental objectives presented in the draft EIS/ERD to be more specific and measurable. These revised environmental objectives are provided in **Section 6**. Woodside is committed to achieving these environmental objectives including the prevention of physical injury to marine fauna.

5.27 MF-5: Potential impacts to marine turtles

A number of submissions raised concerns with respect to marine turtle and potential impacts from planned activities and risks presented by unplanned events and incidents associated with the proposed Browse Project.

Table 6-7 of the draft EIS/ERD identifies the environmental objectives, context and relevant aspects for marine turtles for the proposed Browse Project activities. The importance of Sandy Islet for the G-ScBr stock has been acknowledged within the document and the impact assessment has been undertaken in consideration of the isolation and importance of this nesting area. **Section 4.3.2** provides a summary of the key metrics and understanding of nesting parameters for the Scott Reef component of the G-ScBr stock.

A further evaluation has been conducted for those aspects that have the potential to result in significant impacts and risks to the green turtle population at Scott Reef, both in isolation and cumulatively:

- light emissions
- underwater noise emissions
- unplanned vessel interactions
- seabed subsidence.

The potential impacts and risks, environmental objectives, adopted controls and impact significance level / residual risk rating for marine turtles from these four aspects are presented in **Table 6-25** (light), **Table 6-73** (underwater noise), **Table 6-141** (vessel interactions) and **Table 6-150** (subsidence) of the draft EIS/ERD. The outcomes of further evaluation are summarised in **Section 4.3.3** (light emissions), **Section 4.2.4** (underwater noise emissions) and **Section 4.2.5** (unplanned vessel interactions). Additional controls (over and above the adopted controls identified in the draft EIS/ERD) to eliminate or minimise these impacts and risks to marine turtles are described in the relevant sections above.

Seabed Subsidence

Predicted impacts on Sandy Islet turtle nesting habitat of reef subsidence, sea level rise and increased cyclone intensity

Potential impacts of reservoir-related seabed subsidence on the fate and dynamics of Sandy Islet (and as such the turtle nesting habitat) needs to be assessed against a backdrop of long-term global sea level rise and increasing cyclone intensity. In the last century sea levels have risen around the globe in response to a changing climate. From 1900 to 2010, the predicted rate of global sea-level was 1.4 - 1.9 mm/yr (Hay et al., 2015; Rhein et al., 2013). Satellite altimeters estimate the recent global rate of rise to be 3.2 ± 0.4 mm/yr (Masters et al., 2012). Ongoing climate change is predicted to continue to increase, and potentially accelerate sea level rise in coming decades. While the frequency of cyclones is predicted to remain constant, they may become more intense (Seneviratne et al., 2012).

In the last decade, many studies have focused on understanding the long-time fate of reef islands as sea level rises and cyclone intensity increases. The construction and maintenance of reef islands is a complex interaction between hydrodynamic processes such as waves and currents, and the reef structure that entrain, transport and deposit sediments at nodal locations on reef surfaces. Reef platform development and available sediments are essential components of island formation and maintenance (Gourlay, 1988; Kench, 2013; Stoddart and Steers, 1977). Traditional paradigms of reef island erosion and loss have been based on the belief that reef islands are static landforms, which will simply drown as the sea level rises (Quataert et al., 2015; Storlazzi et al., 2015). However, there is growing evidence that islands are geologically dynamic features that will adjust to changing sea level and climatic conditions, such as cyclone intensity.

There are a range of potential positive and negative impacts on the mass, area, height and morphology of reef islands in response to rising sea levels and increasing storm or cyclone intensity. Rising sea levels can facilitate the increased growth of reef invertebrates with calcareous skeletons, and increase subsequent sediment generation (Smithers et al., 2007). Furthermore, rising sea levels can allow a greater transfer of wave energy across reef and enhance sediment transport to the reef island. This process can increase island size and height (Kench et al., 2018)forcing human migration. Here we present analysis of shoreline change in all 101 islands in the Pacific atoll nation of Tuvalu. Using remotely sensed data, change is analysed over the past four decades, a period when local sea level has risen at twice the global average (~3.90 ± 0.4 mm.yr−1. However, larger waves reaching a reef island also have the potential to erode and modify island morphology. Evidence also shows extreme events, such as cyclones, can rapidly change reef island morphology, and in some cases either increase or decrease island size (Bayliss-Smith, 1988; Masselink et al., 2020). How these complex processes will occur and how they interact is difficult to predict.

Two approaches have been undertaken to understand potential reef island response to a changing climate. Firstly, a range of physical and numerical modelling studies have been undertaken to assess long-term changes of reef islands to changing hydrodynamics and sea level conditions (Masselink et al., 2020; Tuck et al., 2019). These studies have shown reef islands are likely to respond by accreting sediments, growing in size and retreating in a lagoonward direction. Secondly, studies have compared historical and recent aerial and satellite imagery to quantify reef island changes over decadal time frames in the Pacific and Indian Oceans. For example, Kench et al. (2018) analysed historical shoreline change in all 101 reef islands in the Pacific atoll nation of Tuvalu. Change was analysed over the past four decades, a period when local sea level has risen at twice the global average (~3.90 ± 0.4 mm/yr). Results highlight a net increase in land area in Tuvalu of 73.5 ha (2.9%), despite sea-level rise, and land area increase in eight of nine atolls. Island change has lacked uniformity, with 74% increasing and 27% decreasing in size. Most reef islands had not only grown but in most instances had migrated away from the direction of the prevailing wave fronts

Other studies, many with different rates of sea level rise have shown similar results (Aslam and Kench, 2017; Duvat, 2019; Duvat and Pillet, 2017; Kench et al., 2018; Mann and Westphal, 2016; McLean and Kench, 2015; Webb and Kench, 2010)Republic of Maldives are quantified in the context of global environmental change and anthropogenic impacts. Aggregated at the atoll scale, results show that, over the past four decades, total land area increased by 59ha (2.4%. Sea level rise across these studies was highly variable ranging from 2.2 to 3.5 mm/yr, and consequently sea level rise seems a poor predictor of long-term island erosion or accretion. A recent review of long-term changes of 709 islands over decadal timescales by (Duvat, 2019) found 88.6% of islands were either stable or increased in area, while only 11.4% contracted and no islands has disappeared below the highwater mark. In summary, physical and numerical models predict reef islands may get bigger in response to sea level rise (rather than shrink), which is supported by historical data, with most reef islands having grown larger in recent decades.

Reef subsidence at Sandy Islet

Woodside modelled the predicted seafloor subsidence from reservoir depletion in 2012 (Woodside, 2012), which was peer-reviewed by subject matter experts commissioned by Woodside (Hughes, 2012) in 2012 and the Commonwealth regulator in 2013 (CGSS, 2012). Vertical seafloor movement due to subsidence is not expected to be uniform and can be thought of as occurring in the shape of a bowl – with the location of greatest vertical seafloor movement (i.e. centre of the bowl) corresponding to the areas of greatest reservoir depletion. It is predicted that seabed subsidence will range from 8.9 cm at the centre of the bowl to 2.6 cm at the edge over 40 years; this is equivalent to 0.22 - 0.06 cm/yr. Simulation modelling indicates the centre of the subsidence bowl is likely to be 20 to 30 km to the northeast of Sandy Islet, in an area to the east of North Reef. Consequently, the seafloor directly beneath Sandy Islet is expected be on the edge to the subsidence bowl or outside it, with predicted subsidence to be less than 2.6 cm over the 40 years of hydrocarbon extraction (or 0.06 cm/yr).

Future estimates of sea level rise for the Scott Reef region is predicted to increase, with an average of 5.1 (3.2 – 7.1) mm/yr up to 2070 given an immediate climate change scenario (RCP4.5), and cyclones are predicted to became more intense but maintain the same frequency (Church et al., 2017). As stated previously, subsidence is predicted to be less than 0.65 mm/yr over the 40 years of hydrocarbon extraction beneath Sandy Islet. While analysis of historical cores of Scott Reef has indicated that vertical reef growth was between 1.4 to 3.5 mm/yr during previous reef growth phases (Collins et al., 2009). Subsidence and sea level rise may cause the depth over the reef flat adjacent to Sandy Islet to increase by approximately 7.75 mm/yr (worst case scenario for both sea level rise (7.1 mm/yr) and subsidence (0.65 mm/yr)) with potential reef subsidence contributing less than 10% of this overall rise. However, this is likely to be offset by increased growth of the reef flat towards the sea surface via increased growth of coralline algae, corals and other benthic invertebrates.

The long-term fate of the Sandy Islet at Scott Reef under rising sea levels, increased cyclone intensity and minor subsidence remains to a degree uncertain, however historical evidence ranging from decades to millennia, coupled with modelling and case studies elsewhere, indicate that it is unlikely to become completely submerged in the future. Sand has accumulated at the current location of Sandy Islet for millennia. In 1974, two 30 m long cores where drilled into Sandy Islet, both above the high water mark (King, 1975). These cores revealed the presence of a sand type, equivalent to the sand on the current Islet down to a depth of approximately 25 m in both cores. Collins et al (2011) dated these reef depths (~25 m) at Scott Reef between 7000 to 8500 years before present. During the last 8500 years, sea level rise, reef subsidence and ongoing reef growth has been dynamic, with sea levels rising rapidly at times (up to 10 mm/

yr), South Scott Reef naturally subsiding at rates of approximately of 0.45 mm/yr and the reef growing at 1-4 mm / yr towards the sea surface (Collins et al., 2011). The 1974 coring suggest that accumulation of sand has continued throughout these changing reef conditions.

More recently, sea level has been rising in response to a changing climate for over a century in the Scott Reef region. Between 1993 and 2009, it is estimated that sea levels have risen 4.5 ± 1.3 mm/yr−1 in northwest Australia, or 2.7 ± 0.6 mm/yr after the signal directly correlated with ENSO is removed (White et al., 2014). Consequently, sea level has been rising significantly at Sandy Islet for decades with little evidence of large-scale, long-term net erosion of the island. A comparison of Sandy Islet size and morphology at four intervals between 1975 and 2019 has shown the Islet has dramatically changed morphology and position but has maintained a similar spatial area of between 1.8 ha and 2.4 ha above the high water mark over the last 45 years (see **Figure 5-3**). As predicted by modelling and case studies undertaken elsewhere, Sandy Islet has migrated away from the direction of the prevailing wave fronts and has change morphology becoming narrower and longer. Sandy Islet is also resilient to extreme episodic events. In March 2004, Cyclone Fay, a Category 5 cyclone which passed directly over Scott Reef, caused extreme wave and storm surges that eroded the island, reducing its size by approximately one-third (Gilmour et al., 2013). In proceeding months and potentially years the island recovered its former size above the high-water mark. These long-term assessments of Sandy Islet response to long-term sea-level rise and extreme events highlight its dynamic nature and long-term resilience.

Historical datasets (cores, remote sensing and observations) and case studies elsewhere indicate that Sandy Islet is unlikely to disappear below the highwater mark. Moreover, Sandy Islet is a dynamic structure that will respond to changing hydrodynamics, biological processes and extreme events. It is likely, based on scientific literature and assessment of historical datasets, to continue to change overall morphology and increase island height in response to greater wave energy reaching the island. Net erosion of Sandy Islet in the future, while not likely in the long-term, cannot be completely ruled out. However, reservoir induced subsidence is unlikely play a meaningful role in the long-term fate of Sandy Islet given its minor contribution to water level adjacent to Sandy Islet compared to role of future sea level rise 0.65 mm/ yr vs 5.1 mm/yr). In addition, case studies elsewhere highlight that long-term dynamics of reef islands is complex with the rate of local sea level rise (and consequently reef flat height) being a poor predictor of long-term island accretion or erosion.

Turtle nesting is unlikely to be influenced by any island morphology changes related to sea level rise, which are likely to operate over timeframes of months to years except during extreme cyclone events. Given the green turtle nesting to hatchling period is approximately 60 days, "normal" island morphology change is highly unlikely to impact on turtle nest success via erosion. However, during future intense cyclones, like Cyclone Fay in 2004, major island erosion and morphology changes, coupled with overtopping by waves and storm surge is likely to substantially increase mortality rates of eggs incubating on the island. Furthermore, evidence suggests that nesting space is likely to reduce following these events but accretion of sediments in subsequent months is anticipated to return the island to its former size.

In conclusion, Sandy Islet is unlikely to disappear below the highwater mark over the 40 years of hydrocarbon production, and scientific evidence suggest it is unlikely to become completely submerged in coming decades but will continue to change morphology. Future island morphology changes will be at timescales that will not directly affect turtle nests and hatchlings. However, future cyclonic impacts to turtle nesting at Sandy Islet may become more damaging as cyclone intensity increases. The impact of reservoir subsidence, given its minor contribution to future sea height (on the reef flats surrounding Sandy Islet) is not expected to meaningfully influence the long-term fate of Sandy Islet and the turtles that use it as nesting habitat.

To verify this conclusion, verification monitoring for seabed subsidence will be undertaken including monitoring of the size and morphology of Sandy Islet. Should hydrocarbon production be determined to be causing a reduction in the availability of nesting habitat below historical minimum extents and/or changes to the morphology of Sandy Islet (slope and elevation), this would trigger additional management measures to be advised by expert opinion. Such additional measures could include artificial beach nourishment of Sandy Islet or modification of production rates from relevant wells to reduce subsidence to rates consistent with achieving of the Performance Standard relating to available nesting habitat and Sandy Islet morphology. The TMP (**Appendix C.3**) outlines the planned seabed subsidence and Sandy Islet size and morphology monitoring and the adaptive management that will be implemented should hydrocarbon production be determined to be causing a reduction in the availability of nesting habitat below historical minimum extents and/or changes to the morphology of Sandy Islet (slope and elevation).

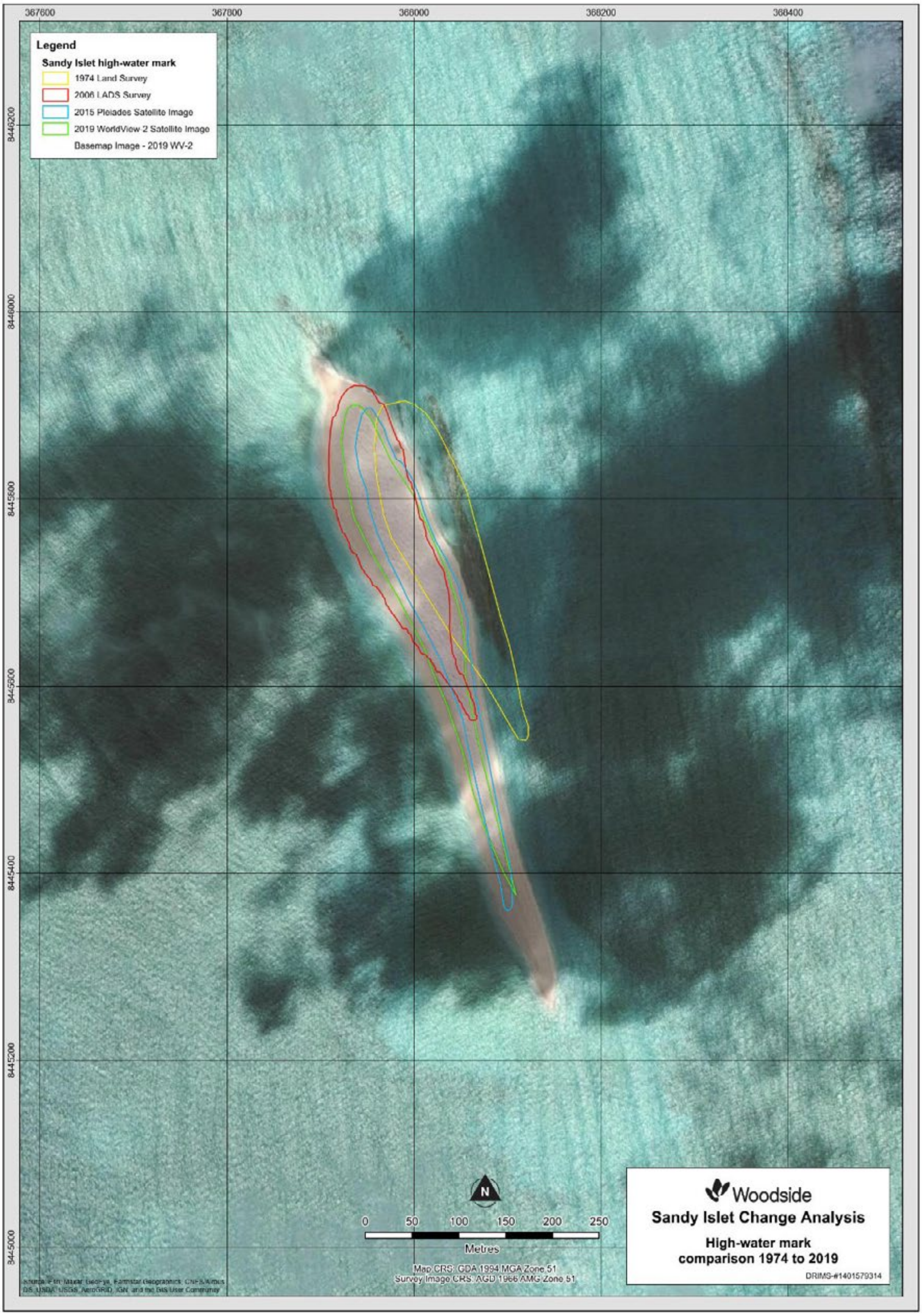

Figure 5-3 Comparison of Sandy Islet size and shape about the high-water mark at four intervals between November 1974 and May 2019 (1974, 2006, 2015 and 2019). The 1974 survey was mapped by a surveyor (King 1975), 2016 is a LADS survey, 2016 is a Pleiades satellite image and 2019 is a Worldview-2 satellite image. High-water mark was digitised and the area calculated; 1974 – 2.3 ha, 2006 – 2.2 ha, 2015 – 1.8 ha and 2019 - 2.0 ha. The baseline image is the 2019 Worldview-2 satellite image

Conclusion

Based on the additional impact assessment there is no change to the Magnitude / Consequence and Impact Significance Level or Risk Level for these four aspects (light emissions; underwater noise emissions; vessel interactions; seabed subsidence) in relation to potential impacts and risks to marine turtles.

The additional impact modelling and updated assessment has resulted in the establishment of revised environmental objectives for the proposed Browse Project that are specific to green turtles (refer **Section 6**).

5.28 MF-6: Presence and abundance of blue whales in Project Area

The draft EIS/ERD documented the presence of pygmy blue whales within the Project Area and described the scientific knowledge available that Woodside has supported. Multiple datasets over multiple years have been collected to understand pygmy blue whale dynamics (abundance, seasonality, migration) in the Browse Development Area (refer to **Table 5-24** and **Section 5.3.2.5**.2 of the draft EIS/ERD) and underpins the proposed Browse Project's environmental impact assessment (Chapter 6 of draft EIS/ERD). Woodside has been conservative in the number of pygmy blue whales utilising the possible foraging area (refer to **Section 4.2.2**, above) and assumed the possible foraging area BIA is an actual foraging area.

A Pygmy Blue Whale Management Plan (PBWMP) has been prepared in order to provide further detail as to how the presence and abundance of blue whales in the Project area will be considered. The PBWMP is provided in **Appendix C.5**. The primary purpose of the PBWMP is to outline how any underwater anthropogenic noise associated with the proposed Browse Project will be managed such that it will not be inconsistent with the Blue Whale CMP, specifically the requirements of Action A.2.3.

Action Area A.2, Action 3 of the CMP that states that:

> *"anthropogenic noise in biologically important areas (BIAs) will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area".*

Guidance on the key terms of the Blue Whale CMP and FAQs (DAWE, 2021 and NOPSEMA 2021) have been applied to the development of the PBWMP.

Best practice management measures in accordance with a precautionary approach have been established within the PBWMP plan and the approach demonstrates underwater noise emissions will be eliminated, avoided or reduced such that injury to and displacement from foraging by a pygmy blue whale has been minimised to the greatest extent possible and the residual risk is negligible. A detailed overview of each objective of the PBWMP is provided in **Section 4.5.2**.

5.29 MF-7: Potential impacts to cetaceans

A number of submissions raised concerns with respect to cetaceans (and in particular pygmy blue whales) and potential impacts from planned activities and risks presented by unplanned events and incidents associated with the proposed Browse Project.

Twenty-seven cetacean species have been identified as potentially occurring within the Project Area. Of these, there are a number of baleen whales (Mysticeti), such as the pygmy blue whale, humpback whale, fin whale, Bryde's whale and sei whale that are considered likely to occur within the Project Area, with the Project Area overlapping a possible foraging area and migration BIA for the pygmy blue whale, and the likely route between the onshore logistics locations and the Project Area traversing a humpback whale migration BIA (see Chapter 5 of the draft EIS/ERD).

Table 6-7 of the draft EIS/ERD identifies the environmental objectives, context and relevant aspects for all marine fauna that may interact with the proposed Browse Project activities. A further evaluation of the proposed Browse Project has been conducted for those aspects that have the potential to result in significant impacts and risks to the East Indian Ocean pygmy blue whale population visiting the possible foraging area at Scott Reef, both in isolation and cumulatively for the project activities, refer to **Section 4.2.2**.

The outcomes of this further evaluation are summarised in **Section 4.2.4** (underwater noise emissions) and **Section 4.2.5** (unplanned vessel interactions). Additional controls (over and above the adopted controls identified in the draft EIS/ERD) to eliminate or minimise these impacts and risks to pygmy blue whales (and applicable to other baleen whale species) are described.

Risk assessments to identify and evaluate the worst-case credible hydrocarbon spill scenarios of the proposed Browse Project were described in **Section 6.3.21**, draft EIS/ERD. As described in 6.3.21.5 of the draft EIS/ERD, migratory whales such as the pygmy blue whale have the potential to be impacted if an unplanned hydrocarbon spill occurred during their annual migration periods or if a spill is severe enough to result in significant long-term impacts to their prey. Direct contact via ingestion has the potential to cause sublethal and lethal toxic effects relating to fresh hydrocarbons but once weathered there would be less risk of toxic induced impacts. Physical contact with hydrocarbons is likely to have biological consequences to individual whales present in the area but is unlikely to impact entire populations. The risk rating was identified as high due to the catastrophic consequence of such a highly unlikely event. As such, the risk of unplanned hydrocarbon release will be subject to comprehensive engineering design and management measures to reduce the risk of an event occurring, and extensive hydrocarbon spill response planning.

In response to feedback from DAWE, Woodside has reviewed and revised the environmental objectives presented i n the draft EIS/ERD to be more specific and measurable. These revised environmental objectives are provided in **Section 6**. Woodside is committed to achieving these environmental objectives including those relating to marine fauna.

Support activities and infrastructure are described in **Section 3.7.9** of the draft EIS/ERD. Additional activities may be undertaken away from supply chain and logistics bases for short periods in order to support the construction phase. These may include activities such as heavy lift vessel unloading. For safety and logistical reasons, such activities require sheltered waters. The location of these activities is yet to be determined, however Powerful Island and Boonock Bay, as well as Cockatoo and Koolan islands are sheltered with deep water and have been identified as potential logistic activity locations for the FPSO and subsea installation scopes. Coastal locations between Broome and Dampier may also be required to support BTL installation.

It is noted that the potential locations of such activities may overlap with BIAs for humpback whales (breeding and calving known to occur, known aggregation areas). To manage potential noise emissions impacts on these important humpback whale lifecycle activities, no heavy lift activities (which typically requires use of large dynamically positioned vessels) will occur in the humpback whale breeding/calving BIA during the breeding/calving season for humpback whales (August to October to include the peak of the season) thereby making residual vessel movements consistent with general shipping activities in the region. Further, measures to mitigate the risk of unplanned vessel interactions with fauna will be applied as described in **Section 6.3.18** of the draft EIS/ ERD and **Section 4.2.5** (unplanned vessel interactions).

5.30 MF-8: Potential impacts to sea snakes

A number of submissions raised concerns with respect to sea snakes and potential impacts from planned activities and risks presented by unplanned events and incidents associated with the proposed Browse Project.

There are 25 species of sea snake recorded in WA waters and four of these species are endemic to the NWMR; the short-nosed sea snake (EPBC Act and WA Biodiversity Conservation Act: Critically Endangered), leaf-scaled sea snake (EPBC Act and WA Biodiversity Conservation Act: Critically Endangered), dusky sea snake (listed Marine) and large-headed sea snake (listed Marine), refer to **Section 5.3.2.7**, draft EIS/ERD). Sea snake distribution is widespread throughout tropical waters of Australia and typically associated with coral reef or inter-reef soft sediment habitats. The short-nosed sea snake (*Aipysurus apraefrontalis*) distribution, based on probability of occurrence (Udyawer et al., 2016), overlaps with the Browse Development Area (including the Torosa field overlap with Scott Reef). This reef habitat associated species has not been recorded at Scott Reef (URS, 2007; URS Australia Pty Ltd, 2006) and not recorded from Ashmore and Hibernia Reefs (primary habitat locations) since 1998 (Department of the Environment and Energy, 2019b). Six sea snake species are recorded for Scott Reef and sea snake abundance is most common in the more complex reef habitat (URS, 2007; URS Australia Pty Ltd, 2006.

Aspects of the proposed Browse Project that may potentially impact sea snakes include marine discharges and underwater noise emissions. As described in Chapter 6 of the draft EIS/ERD, impacts to water quality (for example: **Section 6.3.9**) are not expected to be significant (impact significance level determined to be Slight (E) for marine fauna and benthic communities and habitats). Impacts to sea snakes from noise emissions are expected to be limited to slight behavioural/avoidance behaviour. It should be noted that there is limited information available on hearing in sea snakes and it is likely that sea snakes rely more heavily on vision and olfaction than on hearing (Hibbard, 1975). However, a conservative approach with regards to potential impacts of underwater noise on sea snakes has been adopted (using fish noise impact thresholds as a surrogate) and the assumption that sea snakes will respond in a similar way as other marine reptiles (e.g. marine turtles), such as exhibiting likely avoidance behaviour to acute or chronic sound sources from project activities away from the reef habitat.

Risk assessments to identify and evaluate the worst-case credible hydrocarbon spill scenarios of the proposed Browse Project were described in **Section 6.3.21** of the draft EIS/ERD. Sea snakes may be impacted directly and indirectly due to hydrocarbon contact to Scott Reef and other remote oceanic reefs systems. Similar to marine turtles, these air breathing reptiles are susceptible to exposure to surface hydrocarbons on external body parts (particularly the eyes, and nasal and mouth cavities) and ingestion of hydrocarbons from contaminated food sources and other toxicity pathways. In addition, indirect consequences to sea snakes may occur due to the loss of coral habitat and the subsequent recovery of affected reef systems. The risk rating was identified as high due to the catastrophic consequence of such a highly unlikely event. As such, the risk of unplanned hydrocarbon release will be subject to comprehensive engineering design and management measures to reduce the risk of an event occurring, and extensive hydrocarbon spill response planning (as described in **Section 5.16**).

5.31 MF-9: Potential impacts to seabirds and migratory shorebirds

A number of submissions raised concerns with respect to potential impacts to seabird and migratory shorebirds within the Project Area.

The draft EIS/ERD identifies that the Project Area overlaps areas designated as a BIA (known resting area) for little terns at Scott Reef.

As described in the draft EIS/ERD, Scott Reef is the only emergent land mass within the immediate vicinity of the Browse Development Area which may serve to provide nesting and/or roosting for seabirds. Seabirds around Scott Reef are predominately associated with Sandy Islet, a part of South Scott Reef, and occur in small numbers in comparison to other breeding and roosting sites in the region. The islands of the Rowley Shoals, which the proposed BTL route passes at a distance of a few kilometres, are known to support a wide range of seabird species, including WA's second largest breeding colony of red-tailed tropicbird. The Rowley Shoals have also been identified as BIAs for the white-tailed tropicbird.

The Draft Wildlife Conservation Plan for Seabirds (Commonwealth of Australia, 2019) and the Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia, 2015b) identify a number of threats to seabirds and migratory shorebirds, including: habitat loss, habitat modification, anthropogenic disturbance, pollution (including light pollution); and climate variability and change. The Draft Wildlife Conservation Plan for Seabirds (Commonwealth of Australia, 2019) identifies resource extraction as a threat to seabirds, specifically in relation to night lighting, flaring and other visual cues resulting in aggregations of seabirds around oil and gas platforms.

Each of the identified threats are assessed in the two conservation plans using a risk matrix approach, and the risk assessment evaluated the likelihood of a threat occurring and the consequences of that threat.

Table 6-7 of the draft EIS/ERD identifies the environmental objectives, context and relevant aspects for seabirds and migratory shorebirds for the proposed Browse Project activities. Aspects of the proposed Browse Project that may potentially impact seabird and migratory shorebird include light emissions and noise emissions.

Light emissions

In the context of transitory seabirds or migratory shorebirds, the draft EIS/ERD acknowledges the potential for impacts due to light emissions from the offshore facilities. However, considering the breadth of the East Asian Australasian Flyway in the context of the highly localised extent of the potential light emissions, impacts to migratory seabirds and shorebirds were predicted in the draft EIS/ERD to be limited with no significant impacts on species at a population level.

Section 6.3.3.3 of the draft EIS/ERD presented the outcomes of light modelling studies conducted as part of the approved EIS for the Browse FLNG Development (for which drilling activities closest to Sandy Islet are the same). It is noted that since these light modelling studies were undertaken, and since the submission of the draft EIS/ERD, there has been additional context regarding potential impacts to seabirds and migratory shorebirds—in particular the publication of the Wildlife Conservation Plan for Migratory Shorebirds, the Draft Wildlife Conservation Plan for Seabirds, and the release of the final National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (Commonwealth of Australia, 2020) in January 2020. These guidelines are intended to be read in conjunction with the other guidance, including the EPBC Significant Impact Guidelines and species recovery and conservation management plans.

A desktop lighting assessment, taking into account the final National Light Pollution Guidelines for Wildlife (Commonwealth of Australia, 2020) has been undertaken and is provided in **Appendix A.1**. This includes a further literature review describing potential impacts of offshore sources of artificial light on seabirds and migratory shorebirds, a gaps analysis of the light modelling studies and assessment done to date (against the National Light Pollution Guidelines for Wildlife), and an updated impact assessment.

In respect of seabirds and migratory shorebirds, the key findings of the updated impact assessment were as follows:

- Seabird species with a nocturnal component of their life history, such as procellariforms (albatrosses, petrels, shearwaters and storm petrels), are at greater risk of negative impacts from artificial light emissions.
- Procellariforms have been shown to be attracted to artificial lights on land, and anecdotally to vessels and oil and gas facilities. This, in addition to undertaking nocturnal foraging on bioluminescent prey, potentially makes them susceptible to attraction to light sources in the Browse Development Area and any negative impacts that could

result. However, the absence of breeding colonies or known foraging areas at, and around, Scott Reef for these species indicates that impacts would be limited to individuals rather than populations.

- Presence of artificial light sources in the Browse Development Area may attract diurnal seabird species (e.g. terns, noddies and boobies) as they take advantage of increased prey availability and extended foraging activities. Although such attraction increases the risk of collision with facilities, incidents of collision of these species, or similar taxonomic groups, are few. Changes in foraging behaviour are unlikely to cause significant impacts at the individual or species level.
- Light sources associated with the Browse Project may negatively impact migration and nocturnal nest site selection of migratory shorebirds flying over Scott Reef or using Sandy Islet as a staging ground. Improved foraging success may occur, though this is would likely be limited to areas of intertidal foraging habitat experiencing direct light spill from the activities. Based on the information available, Scott Reef has not been identified as important habitat for migratory shorebirds, as defined by the EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Commonwealth of Australia, 2017c). Therefore, any impacts from light emission to migratory shorebirds are likely to be limited to effects at an individual level rather than at a population level.

Atmospheric noise emissions

Respondents raised concerns with respect to impacts to bird species as a result of helicopters transiting between Broome and the Browse Development Area. **Section 6.3.7** of the draft EIS/ERD discusses these potential impacts and in particular, bird species present around Roebuck Bay and Cable Beach (<1 km from the Broome Heliport). Given the high visibility and noise levels associated with helicopter movements, bird species are expected to actively avoid interaction. Any disturbance from helicopters in transit will be of limited duration as they pass by and impacts to bird species in the area surrounding Broome are expected to be negligible as helicopters passing by bird aggregation areas will be at significant altitude.

Impacts to bird species at Scott Reef are also expected to be negligible given the area does not represent a significant aggregation, nesting or roosting area for seabirds or migratory shorebirds; and flight paths will actively avoid roosting areas (Sandy Islet).

Bird species along the remainder of the flight path are expected to occur in low numbers. Given the altitude the helicopters will be flying at, impacts are not considered credible.

5.32 MF-10: New species of siphonophores

A number of submissions noted that a new species of Siphonophores has recently been discovered in the Kimberley Marine Park, noting that the species has not been included in the draft EIS/ERD, which means there are no specific management measures proposed and uncertainty regarding impacts.

AIMS (2020) identified fields of benthic siphonophores within the Ancient coastline at 125 m depth contour KEF in the Kimberley Australian Marine Park (AMP). The siphonophores were described as rare, free floating aggregations above the seabed.

The potential impact of seabed disturbance associated with the temporary or permanent installation, placement and decommissioning of facilities, infrastructure and equipment including the BTL was assessed and presented in **Section 6.3.1** of the draft EIS/ERD.

The proposed BTL route will overlap with the Kimberley AMP, Multiple Use Zone for approximately 68 km but the route is in deep water and does not overlap with the Ancient coastline at 125 m depth contour KEF. The installation of the BTL on the seabed is estimated to result in permanent seabed disturbance (the physical footprint of the BTL) of approximately 27 km^2 (refer to **Table 6-9** of the draft EIS/ERD). The pipelay process will likely result in very low levels of localised and temporary resuspension and deposition of natural sediments. Installation of the BTL will not result in lasting effects to deep water benthic communities outside the direct footprint area. Given the siphonophores are free living and from the limited information available may be present, it is possible that there may be some limited disturbance. However, it is noted that these aggregations were not identified in the drop camera footage acquired during the environment survey of the BTL route undertaken to support the draft EIS/ERD. Further, a review of a representative portion of high-quality seabed imagery of the BTL route acquired by an AUV survey (which has become available post draft EIS/ERD finalisation) has been undertaken. The review of imagery found that the seabed along the Ancient coastline at 125 m depth contour KEF, was predominately unconsolidated soft sand, with only occasional solitary non-coral benthic invertebrates and demersal fish observed.

Given the above and given the area to be disturbed is widespread and well represented in the region, the small area of disturbance is not predicted to significantly impact benthic biota including benthic siphonophores. Proposed management measures to minimise impacts to benthic habitats as presented in **Section 6.3.1** of the draft EIS/ERD are expected to mitigate potential impacts to benthic siphonophores. These include:

- secondary stabilisation of subsea infrastructure will be limited to the level necessary to ensure pipeline integrity.
- activities will be conducted in a manner not inconsistent with the objectives, values and principles of the multiple use zones of the AMPs which are traversed by the BTL route.

5.33 MF-11: Potential impacts to fish

A number of submissions noted that a number of threatened and migratory fish species and seahorses may occur in the Project Area and may be impacted by light emissions, noise emissions and vessel interaction (particularly in relation to whale sharks).

Potential impacts to fish have been evaluated in the draft EIS/ERD with a summary provided in **Section 9.2.2** of the draft EIS/ERD. This evaluation concluded that no lasting effect is predicted to occur to fish species as a result of planned activities. Potential risk posed to whale sharks from vessel interaction are assessed in 6.3.18 of the draft EIS/ERD. Whale sharks may occur within the Project Area, typically solitary individuals transiting on wider migrations to and from the seasonal aggregation site for whale sharks off the Ningaloo coast (Meekan and Radford, 2010; Wilson et al., 2006). Given this, the proposed vessel speed restrictions and compliance with the Whale Shark Code of Conduct for all vessels at the Browse Development Area, it is considered highly unlikely that a vessel strike on a whale shark will occur. Refer to response MF-4: Vessel – fauna interaction (**Section 5.26**) for further details with respect to the assessment of unplanned vessel-fauna interactions and proposed mitigation measures.

5.34 SE-1: Displacement of Aboriginal people as a result of project infrastructure

A number of submissions raised concerns with respect to potential disruption to Aboriginal peoples access to culturally significant sites.

As described in Chapter 5 of the draft EIS/ERD, no known sites of Aboriginal Heritage significance are located within the Browse Development Area according to the Western Australia Department of Aboriginal Affairs' Aboriginal Sites Inquiry System. No displacement of Aboriginal people as a result of the proposed Browse Project is expected.

5.35 SE-2: Socio-economic benefits of the proposed Browse Project

A number of submissions questioned the socio-economic benefits of the proposed Browse Project.

As described in **Section 6.4** of the draft EIS/ERD the findings of the ACIL Allen Economic Impact Assessment suggests that the proposed Browse Project is projected to provide direct economic benefit into the Western Australian economy, as well as indirect benefits through utilisation of service and support industries. This represents a significant opportunity to contribute to the economic development of Broome and the Kimberley more broadly. ACIL Allen released a series of public brochures that outline the results of their assessment and are available on ACIL Allen's website. The brochures relevant to Browse and the Burrup Hub are attached as **Appendix A.4**.

The submission of a large number of letters of support for the proposed Browse Project from individuals, businesses, business groups and local councils further support the potential socio-economic benefits of the proposed Browse Project.

6. ENVIRONMENTAL OBJECTIVES

In preparing response to the regulatory and public submission on draft EIS/ERD and the State ERD, Woodside has reviewed and where appropriate revised the environmental objectives for the proposed Browse Project. The full list of environmental objectives is presented in **Table 6-1**.

Table 6-1 Proposed Browse Project environmental objectives

No.	Environmental objective	Relevant jurisdiction	
		State	Cwlth
Air Quality (including GHG emissions)			
1	Undertake the Browse Project in a manner that will not result in a reduction in local or regional air quality that may otherwise result in an adverse effect[38] on biodiversity, ecological integrity, social amenity or human health.	✓	✓
2	Optimise efficiencies in air emissions and reduce direct GHG emissions to as low as practicable and acceptable levels.	✓	✓
3	Actively support the global transition to a lower carbon future by net displacement of higher carbon intensity energy sources.	✓	✓
Benthic communities and habitats			
4	Undertake the Browse Project in a manner which avoids direct (i.e. physical footprint as a result of infrastructure placement) disturbance to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).	✓	✓
5	Undertake the Browse Project in a manner that prevents changes beyond natural variation in ecosystem processes, biodiversity, abundance and biomass of marine life or in the quality of water, sediment and biota that form part of the Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).	✓	✓
6	Manage the Browse Project in a manner that limits permanent benthic communities and habitat loss within the Scott Reef local assessment units (LAU) as shown in **Figure 6-1**, to the extent specified in **Table 6-2**.	✓	
7	Undertake the Browse Project in a manner which prevents unplanned seabed disturbance.	✓	✓

38 An undesirable negative change beyond natural variation

No.	Environmental objective	Relevant jurisdiction	
		State	Cwlth
8	Implement the "Management approach – Torosa wells in the State Proposal Area" so that a maximum Level of Ecological Protection is maintained within Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).	✓	
9	Undertake the Browse Project infrastructure installation within the Continental slope demersal fish communities KEF in a manner that limits seabed disturbance to less than 0.05% of the total KEF area.		✓
10	Undertake the Browse Project infrastructure installation within the Seringapatam Reef and Commonwealth waters in the Scott Reef Complex KEF in a manner that limits seabed disturbance to less than 0.3% of the total KEF area.		✓
11	Undertake the Browse Project infrastructure installation within the Mermaid Reef and Commonwealth waters surrounding Rowley Shoals KEF in a manner that limits seabed disturbance to less than 0.09% of the total KEF area.		✓
12	Undertake the Browse Project infrastructure installation within the Ancient coastline at 125 m depth contour KEF in a manner that limits seabed disturbance to less than 0.03% of the total KEF area.		✓
13	Undertake the Browse Trunkline installation, operation and IMMR activities within the Kimberley Marine Park (multiple use zone) in a manner that will not be inconsistent with the objectives of the multiple use zone.		✓
14	Undertake the Browse Trunkline installation, operation and IMMR activities within the Argo Rowley Terrace Marine Park (multiple use zone) in a manner that will not be inconsistent with the objectives of the multiple use zone.		✓
15	Undertake the Browse Trunkline installation within the Kimberley Marine Park in a manner that limits seabed disturbance to less than 0.003% of the total park area.		✓
16	Undertake the Browse Trunkline installation within the Argo Rowley Terrace Marine Park in a manner that limits seabed disturbance to less 0.004% of the total park area.		✓
17	Undertake the Browse Project in a manner that prevents any activities[39] occurring within the Mermaid Reef Marine Park, State marine parks or State nature reserves.	✓	✓
18	Undertake the Browse Project in a manner which prevents a known or potential pest species (IMS) becoming established in the Scott Reef system.	✓	✓

39 With the exception of:

- *environmental monitoring or emergency/spill response activities associated with the proposed Browse Project which will be undertaken subject to obtaining any necessary approvals.*
- *SOLAS situations (i.e. in situations where the vessel master considers that complying with the requirement would adversely affect the safety or security of the vessel or its passengers or crew, or in situations where the vessel master is bound to provide assistance (under SOLAS Chapter V) upon receiving a distress signal from any source that persons are in distress at sea).and emergency and spill response exempt.*

No.	Environmental objective	Relevant jurisdiction	
		State	Cwlth
Marine Environmental Quality			
19	Manage the Browse Project marine discharges in a manner that prevents a change in sediment quality (as informed by baseline surveys and periodic monitoring) in areas outside of predicted impact areas[40] defined in the draft EIS/ERD, to an extent which may otherwise result in an adverse effect39 on biodiversity, ecological integrity or human health.		✓
20	Manage the Browse Project marine discharges in a manner that prevents a change in water quality (as informed by baseline surveys and periodic monitoring) in areas outside of predicted impact areas[41] defined in the draft EIS/ERD, to an extent which may otherwise result in an adverse effect39 on biodiversity, ecological integrity or human health.		✓
21	Manage the Browse Project FPSO produced water and cooling water discharges in a manner that ensures the defined threshold values[42] (e.g. 99% species protection or no effect concentrations) are met at the State waters 3 nm boundary, 95% of the time based on dispersion modelling results.	✓	✓
22	Manage the Browse Project marine discharges in a manner such that the Levels of Ecological Protection in the State Proposal Area as defined in the Environmental Quality Management Plan are maintained.	✓	
23	Undertake the Browse Project in a manner that will prevent an unplanned release of hydrocarbons to the marine environment that would result in an adverse effect39 on biodiversity, ecological integrity or human health.	✓	✓
24	Undertake the Browse Project in a manner that will prevent an unplanned release of chemicals to the marine environment that would result in a change in water quality leading to an adverse effect39 on biodiversity, ecological integrity or human health.	✓	✓
25	Undertake the Browse Project in a manner that will prevent an unplanned release of solid waste to the marine environment that would result in an adverse effect39 on biodiversity, ecological integrity or human health.	✓	✓
Marine Fauna			
26	Undertake the Browse Project in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks, dugongs, seabirds and migratory shorebirds).	✓	✓
27	Undertake the Browse Project in a manner that will not disrupt the migration and feeding of the East Indian Ocean pygmy blue whale population.	✓	✓
28	Undertake the Browse Project in a manner that will not displace the East Indian Ocean pygmy blue whale population from the possible foraging area at Scott Reef.	✓	✓
29	Undertake the Browse Project in a manner that will not disrupt migration, breeding, nesting, internesting and hatchling dispersal of the green turtle population at Scott Reef.	✓	✓
30	Undertake the Browse Project in a manner that will not displace the green turtle population from habitat critical to the survival of the species at Scott Reef.	✓	✓

40 The area where a detectable change in sediment quality may occur, as determined by marine discharge modelling and described within the draft EIS/ERD
41 The area where a detectable change in water quality may occur, as determined by marine discharge modelling and described within the draft EIS/ERD
42 The level at which if exceeded, unacceptable impacts may occur. Threshold values applied to the proposed Browse Project are described in the draft EIS/ERD

No.	Environmental objective	Relevant jurisdiction	
		State	Cwlth
Socio-Economic			
30	Undertake the Browse Project in a manner that prevents an adverse effect[39] on heritage values, consistent with the approach described in the draft EIS/ERD.	✓	✓
31	Undertake the Browse Project in a manner that does not to interfere with other marine users to a greater extent than is described in the draft EIS/ERD.	✓	✓
32	Undertake the Browse Project in a manner that does not result in significant harm to social surrounds, consistent with the approach described in the draft EIS/ERD.	✓	✓
33	Undertake the Browse Project in a manner that prevents an adverse effect[39] on commercially important species beyond natural variation (as informed by baseline water quality surveys and periodic water quality monitoring) such that the sustainability of commercial fishing is impacted.	✓	✓
34	Undertake the Browse Project in a manner that avoids any change in spawning biomass of a commercially important species and does not lead to changes in recruitment that may be discernible from normal natural variation (as informed by baseline water quality surveys and periodic water quality monitoring).	✓	✓

Table 6-2 Cumulative permanent benthic communities and habitat loss assessment for State waters around Scott Reef proposed LAUs

Benthic communities and habitat type	Original spatial extent (pre-European habitation)	Historic and approved losses	Current % remaining	Proposed extent of permanent loss from proposal[43]	Spatial extend of cumulative loss	% remaining after proposal
Scott Reef south lagoon deepwater coral habitats	213.47 km^2	0 km^2	100%	0 km^2	0 ha	100%
Scott Reef north deepwater sediment habitat	311.26 km^2	0 km^2	100%	0.24 km^2	0.24 km^2	99.99%
Scott Reef south deepwater sediment habitat	379.16 km^2	0 km^2	100%	0 km^2	0 km^2	100%
Scott Reef north shallow water benthic communities and habitats	179.51 km^2	0 km^2	100%	0 km^2	0 km^2	100%
Scott Reef south shallow water benthic communities and habitats	147.14 km^2	0 km^2	100%	0 km^2	0 km^2	100%

43 Proposed extent reduced from ERD as a result of removal of TRE drill centre and associated flowlines.

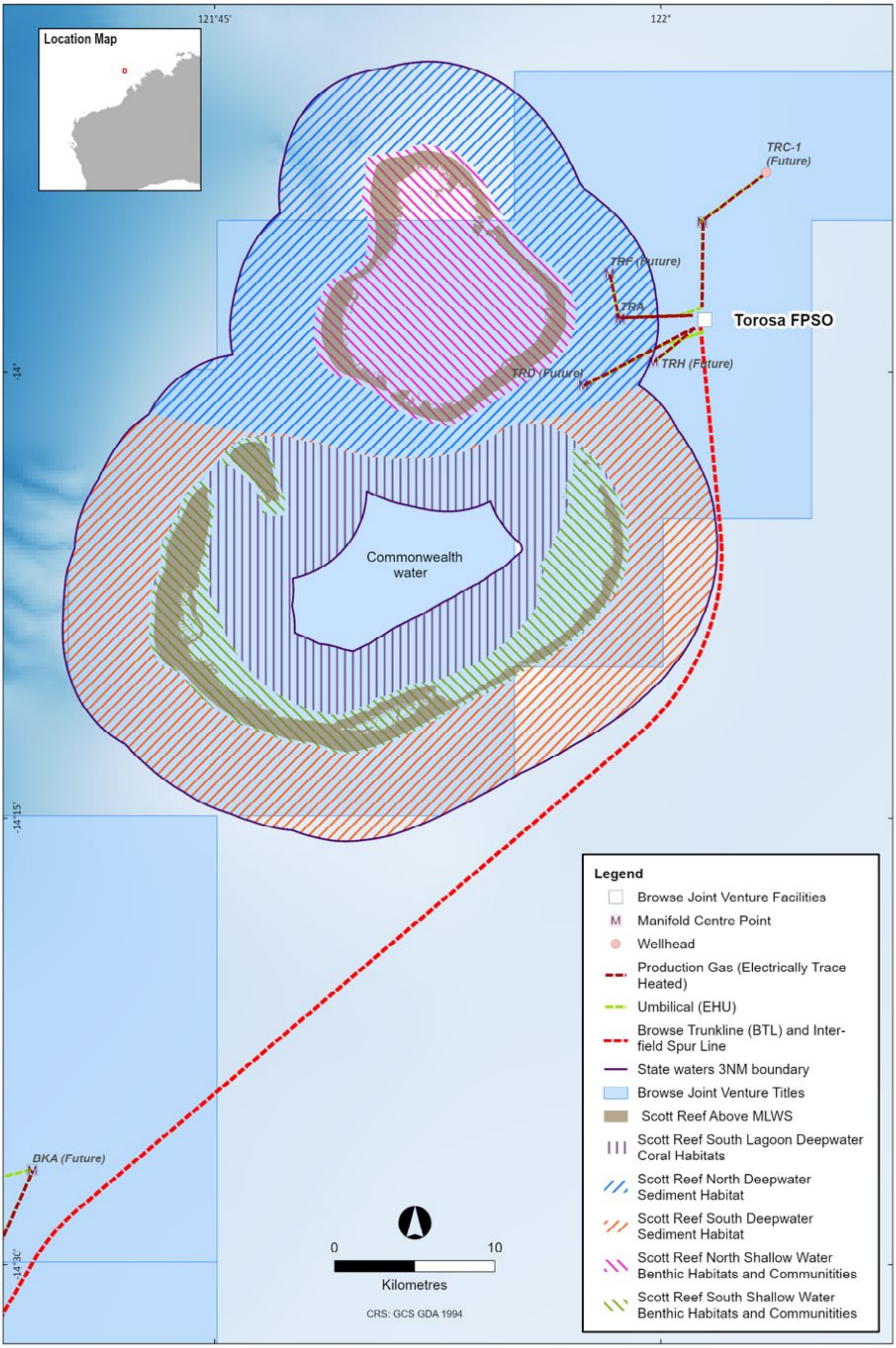

Figure 6-1 State Proposal Area - proposed Local Assessment Units (LAUs)

7. PUBLIC SUBMISSIONS ON DRAFT EIS/ERD

7.1 Support and no objection letters

Submissions confirming support for and/or no objection to the proposed Browse Project were received from 59 respondents either in the form of a bespoke submission or letter of support submitted via the EPA consultation hub. Three bespoke submissions were received, and these are included in **Table 7-1**. A total of 56 support / no objection letters were received and these are appended in **Appendix D.1**. Woodside, on behalf for the BJV thanks all submitters of letters of support and no objection, for their interest in the proposed Browse Project.

7.2 Public submissions and responses

Table 7-1 presents the public submissions received with respect to the draft EIS/ERD for the proposed Browse Project.

NOTE: Text from submissions has been included in full in italicised text in the left column of the table below, as per the submissions received, with the exception of submissions that extend over many pages. In order to include these submissions, key issues / items raised have been summarised. Text has only been redacted, where individual names, profanities or physical threats have been used.

Table 7-1 Public submissions and Proponent's response

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-1	ANON-57NR-WV58-6	*The environment impact of this proposal is unconscionable, and this project must not proceed. Australia is already failing to meet it's emission reduction targets and this will only worsen the situation. Please do the right thing by the vast majority of Australians who will not benefit from this, not to mention the environment at large.* *Please do the right thing.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** In relation to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-2	ANON-57NR-WV57-5	*"IN chapter two on page 108 in the SR1.5 IPCC report that came out last year it says that if we are to have a 67% chance of limiting the global temperature rise to below 1.5C, we had on January 1st 2018, 420 gigatonnes of CO2 left to emit in that budget. And, of course, that number is much lower today, as we emit about 42 gigatonnes of CO_2 per year, including land use. With today's emissions levels that remaining budget will be gone within about eight years." Greta Thunberg addressing the COP 25 Conference on December 12, 2019.* *What legislation will be pursued by our WA Labor Party state government to reduce WA's greenhouse gas emissions to zero in eight years?* *Why is Woodside being allowed to release 200 million tonnes of carbon dioxide for the next thirty years from its Browse Basin project as this will likely blow Australia's Paris climate targets out of the water?* *Is your government breaching its duty of care?* *Are governments, including yours, legally liable because they are now being hazardously negligent i.e. ignoring their own IPCC and allowing greenhouse gases in the atmosphere to increase?*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** In relation to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**).

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-3	ANON-57NR-WV5U-3	*To Whom it May Concern* *I would like to raise concerns regarding Woodside's planned extension / expansion of the Burrup Hub. How could a site that is being considered for world heritage status be in line for further industrial activity? Historically Woodside has shown a significant disregard for the heritage values of the Burrup which signals an organisational disregard for external stakeholders.* *I would also like to raise concerns regarding the fugitive, operational and downstream emissions associated with the expansion of the gas fields. Whilst other countries are declaring climate emergencies Australia seems content to bury it's head in the sand and continue opening up resources that threaten so much. Even if we take a elitist view that we deserve the spoils of providing the market with products that result in significant greenhouse gas pollution, have the risks to the Australian people listed below been considered:* *- International litigation associated with climate change related damages* *- Stranded assets of oil and gas companies that become liabilities for the tax payers (untapped wells, sites that have not be remediated etc)* *- Geopolitical risks associated with climate change. Has Australia considered that the most heavily populated areas of low-lying ground susceptible to sea level rises and extreme weather are on our doorstep?* *- Internal risks associated with climate change such as bushfire, drought, flood etc* *The decision to support further greenhouse gas pollution seems to have medium term economic justification. Even putting small probabilities on the potential financial outcomes to Australia would never justify the short term gains.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised within this submission relating to compatibility of the proposed extension of the Burrup Hub with the World Heritage listing nomination of the Murujuga Cultural Landscape, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**). ***GHG emissions*** With respect to the specific concerns raised in relation to GHG emissions Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • MEQ-7: Decommissioning (**Section 5.21**).

No.	Submitter	Submission and/or issue	Response to comment
		This reminds me of Nuclear Power. Forget the human cost, let's just look at the economics of the whole Nuclear industry. At the time of the Chernobyl disaster the whole history of nuclear generation globally amounted to 11,565 TWh. Chernobyl is still costing society, and total costs are estimated at USD 800 Billion. So that's an additional cost of 6c/kWh for every unit of electricity generated for all nuclear reactors globally up to the point of the Chernobyl disaster. If you fast forward to Fukushima and do the maths it's better but now much. Total global Nuclear generation to 2011 was 66,675 TWh and the total cleanup cost for Fukushima and Chernobyl comes in at USD 1.5 Trillion or 1.77c/kWh. That's a +20% increase in the cost of every unit of energy ever generated by Nuclear. This excludes any other nuclear externalities. What will be the external costs of our fossil fuel energy? They will pale in significance compared to Nuclear. If one adds a modest 20% to the energy cost of fossil fuels they immediately become completely uneconomic compared to renewable sources of energy now. Time to move on, get on board with the low carbon economy and make money in that new market rather than trying to grab a bigger piece of a rapidly shrinking pie. *I am not "anti" nuclear or anti fossil fuels. I am "pro" intelligent decisions based on robust evidence. Looking at the real cost of competing options is a helpful indicator of net benefits to society. I believe in a market economy where the best value products win. Right now we are backing poor value products in Australia by blindly supporting fossil fuel companies. Australia will suffer as a result. Please start making robust decisions.* *Kind regards* *[Redacted name]* *Sources of Info:* *https://www.world-nuclear.org/information-library/current-and-future-generation/nuclear-power-in-the-world-today.aspx* *https://globalhealth.usc.edu/2016/05/24/the-financial-costs-of-the-chernobyl-nuclear-power-plant-disaster-a-review-of-the-literature/* *https://cleantechnica.com/2019/04/16/fukushimas-final-costs-will-approach-one-trillion-dollars-just-for-nuclear-disaster/*	

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-4	ANON-57NR-WV55-3	*I have already made a submission in relation to the proposed extension of gas extraction on the North-West Shelf, expressing my deep concern that we must stop this development just as we must stop the Galilee Basin proposal. The catastrophic bushfires, the bleaching of our reefs, and other extreme weather events and environmental catastrophes demonstrate that no new fossil fuel extraction can occur.* *I therefore urge the EPA to respond to the three proposals before it as follows:* *1. Recommend renewing the licence for the present facility for just a decade. This should be sufficient time to either demonstrate that renewable energy is a superior energy source, economically as wealth as environmentally and for health reasons, or that the there is no hope of saving the planet.* *2. Recommend that consideration of tapping up to 24 gas wells in the offshore Browse gas field in WA state waters, and a further possible 30 wells in Commonwealth waters, along with the destructive infrastructure is delayed for a decade, again to either demonstrate that we have shifted to renewable energy or that the there is no hope.* *I am concerned that the overall impact of the three proposals linked to the North West Shelf (NWS) / Burrup Hub are not being assessed together which they should be. These are massive and disruptive developments which require a careful and overall analysis of all offshore pollution from venting, pollution from transporting gas hundreds of kilometres via pipelines, onshore pollution from processing, and emissions from burning gas overseas.* *This submission also makes a plea for mitigation. Three major conditions should be imposed on these massively profitable companies whose income is built on resources which belong to the people of Australia, including Indigenous Australians, and whose extraction will limit the futures of everyone on the planet.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***NWS Project extension*** With respect to the recommendation regarding the extension of the NWS license renewal, please refer to the response GHG-11 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**). ***GHG emissions*** With respect to the recommendations made in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**). ***National heritage values*** With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-RA-30 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).

No.	Submitter	Submission and/or issue	Response to comment
		1. Offset emissions: The Barnett govenrment's commitment to offsets must be imposed on our State's major polluters overseen by an independent regulatory body to ensure that offsets are effective. *2. In anticipation of WA's climate policy, the proponents must submit plans showing how they will "reasonably and practicably avoid, reduce and offset emissions to contribute to the state's aspiration of net-zero emissions by 2050."* *3. Requirement that the companies reduce the emissions of their operations to near net zero in order to protect the Murujuga rock art site. The WA government recognises its value in supporting World Heritage listing. In order to protect this site from further damage and guarantee a base for a growing tourism industry, the government must insist on zero nitrogen and acid forming emissions from commercial activities on the Peninsula. All it would take Woodside, according to a Macquarie think tank, is 1.5% of one year's annual profits to install the appropriate available technology to reduce their emissions to near zero. It is unlikely our State government will have the fortitude to halt this development and the Commonwealth government will be positively supportive, despite their professed commitment to emissions reduction. I therefore urge every possible mechanism that can delay expansion and limit the destruction caused by the present facility and any future facility. Every month brings more certainty that fossil fuel extraction is costing us more than it is worth, not just in the deaths of humans and animals but also in economic terms.*	

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-5	ANON-57NR-WV5J-R	*I am very concerned about Woodside's Expansion Plans because of their possible increase of Greenhouse Gas Emissions and all the concomitant damaging effects this would have. Specifically, I am worried that the mix of sulphur and nitrogen dioxide emissions will form strong acids which may dissolve the rock surface patina and thus contribute to the destruction of the Burrup Peninsula petroglyphs. Economic considerations may become less important as the cost of renewable sources of energy decreases and the price of burning gas increases.* *I strongly believe that we have a duty to preserve and protect ancient, irreplaceable artworks for future generations. and therefore I urge you to reject Woodside's application.* *[Redacted name]*	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to GHG-27 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**). ***GHG emissions*** • With respect to the concerns raised in relation to GHG emissions, please refer to the following responses in Section 5: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PS-RES-6	ANON-57NR-WV5E-K	*Dear [redacted name] EPA Chair,* *Why We Reject Browse to Northwest Shelf Project in Commonwealth Waters* *Allowing the extraction of vast amounts of natural gas from the Browse Basin is like igniting a firestorm that will sweep across all the fire-prone areas of the world. It is in our view an immoral action. The time has come to keep remaining fossil fuels in the ground.* *The ongoing catastrophic fires in Eastern Australia are clearly linked to climate change, which in turn is clearly linked to increasing levels of CO2e, which is itself clearly linked to increasing use of fossil fuels and related actions of human beings.* *Since the Browse Project will emit 200 million tons of CO2e over its lifetime (and that does not include the even higher amounts from the burning of that gas in other parts of the world) it will emit pollution equivalent to 2.7% increase over Australia's 2005 baseline. This will jeopardize Australia's goal of the 2015 Paris Climate Agreement and put at risk any chance of holding global temperatures below 1.5C on 2005 levels.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to the concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**). ***National heritage values*** With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**).

No.	Submitter	Submission and/or issue	Response to comment
		And as if these reasons were not enough to stop the Browse Project, there is the destruction of the priceless world heritage treasures of the Burrup Peninsula which will be impacted by the expansion of the gas processing facilities there as well as related industries. We have seen for ourselves the Murujuga Petroglyphs, the oldest in the world, recording the oldest human face and the oldest and longest record (about 50,000 years) of human life on this planet. But the gas plant emissions threaten these rock carvings and the visual pollution of the gas plant towers and gas flare destroys the heritage amenity and cultural identity of the Burrup Peninsula. *There is an alternative site set aside for industrial development that is off the Burrup Penisnsula: that is where the current processing plants need to moved to, and any new facility constructed.*	
PS-RES-7	ANON-57NR-WV5S-1	*Dear EPA,* *We are at the beginning of a climate emergency that is projected to accelerate.* *It is going to be driven by ongoing and increasing greenhouse gas emissions.* *Western Australia, Australia, the World, cannot continue to increase the emission of greenhouse gases.* *It is not an exaggeration to say that, over this century, civilisation as we know it is at stake.* *LNG activities on the NorthWest shelf must not be expanded.* *Yours sincerely,* *[Redacted name]*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** In relation to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-8	ANON-57NR-WV5C-	*Proposed Browse to North West Shelf Project: Commonwealth Submission* *[Redacted name]* *I understand that there are three proposals regarding this development:* *1. to extend the NWS plant's original approvals for onshore processing at Karratha's NWS gas plant, and to allow it to operate until 2070* *2.to tap up to 24 gas wells in the offshore Browse gas field in WA state waters, and a floating facility (under EPA jurisdiction)* *3.to tap up to 30 wells of the Browse field in Commonwealth waters, using a second floating facility, an 85-kilometre pipeline between, and a 900-kilometre pipeline connecting to the onshore NWS gas plant at Karratha (the federal government will assess the full impact of both offshore components)* *I consider that they are totally interdependent, for the Commonwealth's part my concerns are largely re National heritage values of a National Heritage Place.* *My major concern relates to the excessive destructive emissions from the Burrup industrial hub, and the consequent harm to the ancient, unique, and irreplaceable petroglyphs of the Burrup peninsula (Murujuga). This harm is irreversible.* *There is now plenty of evidence of the actual deterioration and the ongoing damage to the rock patina, from the emissions. I have read the findings of scientist Dr John Black.* *The existing emission level is excessive. The increased emissions that would result from more gas collection and processing at the Burrup Hub would cancel out the gains made by industry and individual Australians who have reduced their carbon emissions.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, including the advanced technology to reduce emissions and the World Heritage listing nomination, please refer to the response to SS-RA-31 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**). ***GHG emissions*** • With respect to the concerns raised in relation to GHG and other air emissions, please refer to the following responses in Section 5: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • AQ-1: Impact of air emissions on public health (**Section 5.13**).

No.	Submitter	Submission and/or issue	Response to comment
		Expansion of Woodside facilities on this world heritage site would be irresponsible vandalism. I cannot understand why Woodside would develop a 900km Trunkline to facilitate that vandalism. I believe processing should be done offshore or at an onshore site nearer to the gas field and well away from the petroglyphs. *Advanced technology now exists to cut acidic emissions to near zero. Woodside could do it at a tiny hit to their profit, I believe it is 0.25%.* *Unique heritage should be respected. Industry is necessary. But it is not necessary that they are co-located. There are strong conservation issues and also the aesthetic of industry and rock art gallery so closely co-located is unacceptable.* *The Australian government has just nominated the Burrup for World Heritage status; expansion of industry would be totally contradictory to that decision.* *In 2016 Colin Barnett said, re the proposed visitor centre, that it should not be located at Hearson Cove because of negative health impacts of emissions on visitors. Emissions have increased since then. I would not live in Karratha* *I understand also that the area is a biodiversity hotspot, home to turtle nesting grounds, whale migration pathways and vulnerable coral reef systems.* *I URGE THE GOVERNMENT TO DENY ANY FURTHER DEVELOPMENT ON THE BURRUP PENINSULA. The government should insist on a short term plan to bring emissions to near zero, with meaningful PENALTIES and a strict and specific MONITORING regime by an independent body, with public REPORTING at regular and frequent intervals. This should be a condition of any approval, and must apply to existing processing as well as any expansion.* *Thank you for the opportunity to comment.* *[Redacted name]*	***Marine environment*** With respect to the concerns raised in relation to potential impact to the marine environment including marine fauna and Scott Reef, please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • MF-11: Potential impacts to fish (**Section 5.33**). ***Browse development concept*** With respect to the assertion that the Browse resource "processing should be done offshore or at an onshore site nearer to the gas field", as described in **Section 2.8** of the draft EIS/ERD, significant screening work was done when assessing a development proposal for the Browse resources. This included offshore processing and alternate onshore processing locations. After extensively assessing a range of alternative developments, the proposed Browse Project as described in the draft EIS/ERD was considered the most likely commercially viable option to develop the resources, while meeting selection criteria related to the environmental, social and economic evaluation.

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-9	ANON-57NR-WV54-2 / DWERDT247368 CMS17489 (name redacted)	*Note the following was also issued as a document (DWERDT247368 CMS17489 (Redacted name)). The submitted document is provided in* **Appendix D.21**. *Browse EIS Comments (February 2020)* ***Browse GHG Emissions*** *The Browse proponent has forecast GHG emissions of 11.4 Mtpa CO_2-e and 200 – 271 Mt life of project (base case and extended case) and there are no explicitly stated commitments to manage or offset these emissions. Offsets of around 25% of emissions is discussed as partial mitigation for reservoir CO_2 but the only real commitment made is compliance with the Safeguard Mechanism which works by establishing a baseline and has no requirements to offset reservoir CO_2 emissions or abate any emissions at all – it's an ineffective mechanism for managing emission reductions.* *In the context of Australia's Emissions Projections 2019 released by the Australian Government Department of Environment and Energy offers context for the forecast 11.4 Mtpa CO_2-e GHG emissions from Browse:* • *It is equivalent to the emissions from electricity generation for the entire state of WA* • *If Australia's domestic aviation were to cease, avoiding 9 Mtpa emissions would not offset Browse.* • *If every passenger vehicle in Australia was converted to electric, would reduce forecast emission in 2030 by 9.7 Mtpa – insufficient to offset Browse.* • *Browse is equal to 40% of Australia's Direct Combustion emissions in the Energy Sector.* • *Would be the highest point source of emissions anywhere in Australia* • *Is contrary to Australia's target of 26-28% reduction in emissions from 2005 levels by 2030 and zero emissions by 2050.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) GHG-9: Carbon capture and storage (CCS) of Browse gas (**Section 5.10**). With respect to the establishment of a Pilbara Carbon Capture and Storage Hub, there is currently no proposal for such a facility. As such, it cannot be considered as part of the assessment of the proposed Browse Project. Note that the quoted figure of "11.4 Mtpa CO_2-e GHG emissions from Browse" represents Scope 1 (BJV and NWSJV) emission estimates from a peak production year, before SGM carbon credit requirements are applied. As detailed in Table 7.5 of the draft EIS/ERD, average Scope 1 (BJV and NWSJV) GHG emissions are estimated to be 6.4 Mtpa CO_2-e prior to the application of SGM carbon credit requirements.

No.	Submitter	Submission and/or issue	Response to comment
		Given public statements made by Woodside, BP and Shell, this proposal to emit such huge volumes of GHG is astonishing and hypocritical. The opportunity, if fully abated, Browse could contribute 20% of the shortfall towards meeting Australia's target of 26% reduction in 2005 levels by 2030.* *The Browse development needs to have conditions to abate / offset its forecast GHG emissions, at a minimum, all reservoir CO_2 per recent precedent projects (Pluto, Gorgon).* ***Browse Economics*** *Extracting data from Woodside's Investor Briefing Day 19 November 2019* • *Project Revenue $133.8B* • *Gas/LNG: reported reserves 13.9 Tcf and price 12% of $65 oil price = $108.4 B.* • *Condensate: 390 million barrels at $65 per barrel = $25.4B* • *Capital Cost: $20.5B initial plus $6.8B future phases, total capital $27.3B* • *Operating Cost: $3.60 per barrel equivalent (b.eq) for LNG. To calculate total b.eq, use Woodside 30.6% equity reserves 866 million b.eq grosses up to 2.83 B barrels x $3.60 = $10.2B* • *Net cash (before taxes). $133.8 - $27.3 - $10.2 = $96.3B (avg $3.1 B/y for 31 years)* • *100% emissions abatement (200 Mt) at stated $40/t = $8 B (avg $0.26 B/y for 31 years).* • *Net Cash after 100% abatement (pre-tax): $88.3 Billion* *Conclusion: Browse project can comfortably afford abating 100% of its GHG emissions.* **2005 emissions 611 Mt CO_2-e, 2030 forecast 511 Mt CO_2-e and 26% reduction of 2005 levels of 452 Mtpa CO_2-e, a shortfall of 59 Mt of which Browse could contribute 11.4 Mt if fully abated, assuming the Browse forecast is included in the 2030 forecast.*	***Produced water and Scott Reef*** With respect to the concerns raised in relation to produced water and potential impact to Scott Reef, please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-4: Produced water (**Section 5.18**).

No.	Submitter	Submission and/or issue	Response to comment
		<u>Woodside Shareholder Impact</u> *Thinking about ethical investments by shareholders, the impact of 100% GHG abatement on Woodside shareholder returns using Woodside published data:* • *Average emissions: 200Mt for 31 years = 6.45Mtpa* • *Woodside carbon cost: $40/t less 30% tax deduction = $28/t* • *Woodside 30.6% equity share results in $55 mill/yr NPAT impact.* • *Woodside has 921,168,018 shares at end 2018.* • *Calculates out at less than 6 cents per share from annual dividend of $1.50 - $2.35 / share (Policy of 50% NPAT and up to 80% of NPAT returned to shareholders).* *I put it to Woodside that its shareholders would not be opposed to 6c/share for a 'green' Browse development. Ethical investors would be attracted to a carbon neutral Browse development, driving up the share price and offset the cost. Similarly, domestic and international customers would be attracted to 'green LNG' and potentially willing to pay a premium for green energy, offsetting the cost and improving shareholder returns.* ***<u>Proposed Solution for GHG Abatement</u>*** *The report "National Carbon Mapping and Infrastructure Plan – Australia", 2009, (NCMIP) published by the Carbon Storage Taskforce under the then Department of Resources, Energy and Tourism, Canberra recommended Carbon Capture & Storage (CCS) Hubs for Australia, including the Pilbara. The development concept for Browse proposed by the proponent is to backfill the NWS as those fields deplete. Depleted gas reservoirs provide ideal sites for CCS as proven gas traps for hundreds of millions of years.* *CCS into depleted NWS fields is the obvious solution for Browse and needs a full assessment by the proponents to include CCS as the reference case:*	

No.	Submitter	Submission and/or issue	Response to comment
		1. There are currently 62 CCS projects globally – the feasibility and technology is proven. *2. There is precedent in Australia with the Gorgon LNG, with the world's largest CCS project injecting 3.5 – 4 Mt CO_2-e/y (note Shell is a common partner)* *3. Store the GHG in depleted NWS fields with proven traps for long term storage of CO_2 – i.e. put it back from where it came.* *4. Would maintain WA at the forefront of this important CCS technology, critical for global emissions abatement to meet the Paris targets.* *5. The USA National Petroleum Council released a very comprehensive report in December 2019 "NPC roadmap to at-scale deployment of Carbon Capture, Use and Storage (CCUS)" which recommends large scale commercial deployment of CCUS into the U.S. energy and industrial marketplace. Achieving this objective will "promote economic growth, create domestic jobs, protect the environment and enhance energy security".* *Browse could be the anchor tenant for a Pilbara CCS hub as recommended in the NCMIP report, abate its GHG emissions and capture / inject emissions from the onshore NWS plant that it will use, including existing turbine exhausts (4.3 Mtpa CO_2-e) and onshore reservoir emissions (0.9 Mtpa CO_2-e). This could be expanded to the full Burrup Hub (15.9 Mt/y) as well as other industries such as the Yara ammonia plant and possibly the mining industry with costs shared by all users of the CCS hub.*	

No.	Submitter	Submission and/or issue	Response to comment
		The proponent discussed injecting its reservoir CO_2 separated on the proposed offshore FPSOs into the Calliance field it will produce from and likely too risky. Alternatively, collecting the offshore emissions and sending dense phase CO_2 900km to NWS might also be infeasible. A compromise might be to allow Browse to emit the 6.2 Mt/y CO_2-e offshore to atmosphere on the condition a Pilbara CCS hub is established, and the forecast 5.2 Mt/y CO_2-e onshore reservoir and processing emissions are sequestered. This would set a condition to offset the total 4.9 Mt/y CO_2-e reservoir emissions, consistent with recent precedents of Pluto and Gorgon LNG. Once Calliance or another field in the Browse basin (such as Prelude, Icthys fields) is depleted, offshore CCS should be considered as a future condition to support the Australian and WA target of carbon neutral by 2050. *Adding the Pluto emissions of approximately 4 Mt/y CO_2-e would create a 9.2 Mt/y CO_2-e CCS hub. Once established, this CCUS hub would provide the solution for future developments in the Pilbara region and a feedstock for any future users of CO_2. For example:* • *Would support blue hydrogen from natural gas.* • *Methanol production is optimum with 15-22% CO_2 in the feedstock* • *Aquaculture uses CO_2 for producing fish food and being deployed near Exmouth.* *The alternative of lower cost offsets such as tree-planting is better than emitting but not preferred given this could use up all the low-cost abatements and prejudice other industries, retarding development and jobs. Tree planting could complement a CCS hub for further abatement, but the oil and gas industry need to deal with its own emissions.* *Woodside's 2018 annual shareholder report talks of its' carbon team and specifically mentions CCS. What has this team been doing?*	

No.	Submitter	Submission and/or issue	Response to comment
		Produced Water Discharge *The proponent proposes disposing peak rates of over 5.7 million litres a day of produced water containing trace amounts of marine toxins including hydrocarbons, heavy metals (mercury), ammonia, Mono-ethyl-glycol (MEG) and radioactive particles into the ocean, in close proximity to Scott Reef. The reliance is on dilution to avoid poisoning Scott Reef marine flora and fauna with much of the work focusing on plume modeling and number of dilutions before it reaches Scott Reef.* *Best practice is avoidance by reinjection of produced water to avoid any toxins entering the marine environment. The proponent stated this is feasible but rejected the option due to complexity and cost. I put it to the proponent that the cost and complexity of water treating is not material compared with the gas and condensate (which can explode) processing on the FPSOs.* *The proponent advises of uncertainty in the amount of toxins in the produced water given a lack of sampling from the exploration and appraisal wells yet concludes that the discharges will be "acceptable". The proponent needs to demonstrate acceptability with facts, not assumptions!* *Particularly concerning is the risk of mercury and heavy metals in the discharge water which accumulate in the marine system and food chain. The environment has no way of managing these highly toxic poisons which continue to accumulate. The proponent states that there is uncertainty in the amount of Mercury that will be produced. Facilities have been included in the design to remove mercury from the gas and condensate streams going to its customers, but not the produced water being discharged directly into the marine environment!! …….. arguing it is expected (not demonstrated) that mercury will partition to the gas and condensate. The proponent needs to prove there will be no mercury or heavy metals in the discharge water by installing mercury removal processing for the water stream or better still, follow industry best practice and reinject the produced water.*	

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-10	ANON-57NR-WV5D-J	*I realise that this submission relates to Commonwealth waters and the extremely lengthy pipeline and floating facility envisaged for the Browse project, but there is more than the risk of ecological damage to the marine environment because these proposed facilities are linked to an extension of LNG extraction for decades ahead.* *I believe that allowing LNG extraction to continue on a large scale until 2070 would be environmentally irresponsible because of the greenhouse gas emissions involved when the gas is burned and leakages when the LNG is processed.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** In relation to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PS-RES-11	ANON-57NR-WV5M-U	*Dear EPA,* *I write this submission in support of Woodside's Browse to North West Shelf Project.* *I believe it is important that policy and regulations recognise the role of natural gas in achieving a cleaner energy future. To have reliable energy and lower emissions, natural gas is essential as renewables currently cannot meet the baseload energy requirements of our economy.* *Developing Browse and processing Browse gas as third-party gas at the KGP is an efficient and effective use of existing infrastructure and more sustainable than a green-fields development, and also saves on the potential disruption to towns that could be caused by constructing a new processing facility.* *Both the Browse to NWS Project and NWS Project Extension incorporate a range of options to manage CO_2 and minimise emissions, and their potential impacts. This includes the NWS's commitment to a 40% reduction in NOx, while Browse has included efficient aero-derivative gas turbines, active heating in flowlines and batteries for peak power supply into its design.*	Woodside, on behalf for the BJV thanks submitters of letters of support and no objection, for their interest in the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
		My understanding from the Browse to NWS Project Environmental Impact Statement / Environment Review Document that the proposed Browse to NWS Project is expected to deliver significant benefits to the local community, the State of WA and the broader Australian economy during its approximate 40+ year operations. *I also understand from the NWS Project Extension Environmental Review Document, that the NWS Project Extension has the potential to provide continued, long term employment opportunities and associated economic benefits to the City of Karratha and broader community for several decades to come, with over 690 people employed during normal NWS operations and 60% of these people living locally and contributing to the local economy.* *Regards* *[Redacted name]*	
PS-RES-12	ANON-57NR-WV5Z-8	*Dear EPA,* *I wish to make a submission in support of Woodside's proposed Browse to North West Shelf project in Commonwealth waters.* *I believe it is important that policy and regulations recognise the role of natural gas in achieving a cleaner energy future. To have reliable energy and lower emissions, natural gas is essential as renewables currently cannot meet the baseload energy requirements of our economy.* *Developing Browse and processing Browse gas as third-party gas at the KGP is an efficient and effective use of existing infrastructure and more sustainable than a green-fields development, and also saves on the potential disruption to towns that could be caused by constructing a new processing facility.*	Woodside, on behalf for the BJV thanks all submitters of letters of support and no objection, for their interest in the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
		Both the Browse to NWS Project and NWS Project Extension incorporate a range of options to manage CO_2 and minimise emissions, and their potential impacts. This includes the NWS's commitment to a 40% reduction in NOx, while Browse has included efficient aero-derivative gas turbines, active heating in flowlines and batteries for peak power supply into its design. *My understanding from the Browse to NWS Project Environmental Impact Statement / Environment Review Document that the proposed Browse to NWS Project is expected to deliver significant benefits to the local community, the State of WA and the broader Australian economy during its approximate 40+ year operations.* *I also understand from the NWS Project Extension Environmental Review Document, that the NWS Project Extension has the potential to provide continued, long term employment opportunities and associated economic benefits to the City of Karratha and broader community for several decades to come, with over 690 people employed during normal NWS operations and 60% of these people living locally and contributing to the local economy.*	
PS-RES-13	ANON-57NR-WV5A-F	*I am responding to highlight my concerns about the plans for the three projects Woodside has lodged for the expansion of the Browse Basin and North West Shelf expansion.* *Overall these projects are for "short term' economic gains at the expense of long-term destructive impacts at a time when new technology (renewables) is becoming a reality.* *I am concerned:* • *about the substantial, long term, cumulative environmental impact of these projects (viz emissions)* • *that there is no single overarching authority that will assess the impact of these.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***<u>GHG emissions</u>*** With respect to the concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**)

No.	Submitter	Submission and/or issue	Response to comment
		• *that the EPA has only just released draft guidelines to assess major polluting projects such as these so it would be good to see how Woodside's plans address how they will "reasonably and practically avoid, reduce and offset emissions to contribute to the state's aspiration of net -zero emissions by 2050".* • *that the extension of operation for onshore processing at Karratha's NWS plant until 2070 is well beyond the mooted WA policy goal of net zero emissions by 2050.* • *about the impact on the Rock Art* *Although LNG is mooted as "clean" fuel, this is semantic as LNG is a fossil fuel (that is predominately methane, a much more potent greenhouse gas than carbon dioxide).* *There needs to be cumulative accounting of the total emissions for such projects alongside all existing ones, including the fugitive emissions released at all stages in a project's life.* *These projects will be one of the largest fossil fuel developments globally and increase the challenge for Australia to meet its international obligations for reduction of greenhouse gas emissions.* *LNG might be seen as a transition fuel as the world moves to greater reliance on renewable energy and greatly reduces its dependence on fossil fuels, so it is inappropriate to be considering new polluting developments at this stage with their long-term polluting effects. Will this lead to the new development being "stranded assets"?* *As a member of Friends of Australian Rock Art (FARA), I am also concerned about the increased impact these extra projects will have on the petroglyphs. Already the pH of the rock surfaces near the existing Woodside gas plant have changed markedly (from near neutral conditions pH7) to more acid (to pH 3.81). This results in the outer patina dissolving so destroying the Aboriginal Rock Art and Australia's unique cultural heritage. The impact of emissions from these proposed projects on rock art located on the islands along the shipping and pipeline route out of Dampier Port also needs to be considered.*	• GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**). ***NWS Project extension*** With respect to the specific issues raised in relation to the NWS Project Extension, please refer to the response GHG-13 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**). ***National heritage values*** With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-RA-30 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-14	ANON-57NR-WV5X-6	Note that the following submission was accompanied by a figure showing vessel traffic flow data. This figure is provided in **Appendix D.2**. *Submission from the Australian Maritime Safety Authority (AMSA)* *Thank you for the opportunity to review and provide comment on the proposed Browse to North West Shelf (NWS) Project and NWS Project Extension.* *Due to the proximity of the proposed pipeline to the north-west Shipping Fairways, (see attached), we would like to bring the following to your attention:* *Maritime Safety Information – please ensure that timely and relevant Maritime Safety Information (MSI) is promulgated specific to the area and nature of operations. To promulgate MSI, you should:* *1. contact the Australian Hydrographic Office at datacentre@hydro.gov.au no less than four working weeks before operations, with the details related to the pipe laying operations. The AHO will promulgate the information in appropriate Notice to Mariners (NTM); these are issued fortnightly, can be downloaded from the AHO website (http://hydro.gov.au/n2m/notices.htm) and will ensure vessels are informed of your activities.* *2. Ships engaged in pipe laying activity should also notify AMSA's Joint Rescue Coordination Centre (JRCC) through rccaus@amsa.gov.au (Phone: 1800 641 792 or +61 2 6230 6811) for promulgation of radio-navigation warnings, 24-48 hours before operations commence. AMSA's JRCC will require information on the pipelaying acitivity such as the vessel's details (including name, callsign and Maritime Mobile Service Identity (MMSI)), satellite communications details (including INMARSAT-C and satellite telephone numbers), area of operation, requested clearance from other vessels and times when the operations start and end.* *3. You should plan to provide updates to both the Australian Hydrographic Office and JRCC Australia on progress and importantly, any changes to intended operations*	We acknowledge the comments made and will consider each of these recommendations. Woodside will continue to work closely with AMSA to ensure the safe execution of our marine operations in relation to existing and future facilities.

No.	Submitter	Submission and/or issue	Response to comment
		VHF communications –The Master should consider the use of an all ships 'Securite' message at regular intervals on VHF radio, especially when crossing any shipping fairways, in order to warn other mariners of their intentions. *Exhibit appropriate lights and shapes to reflect the nature of operations - in conformance with the International Rules for Preventing Collisions at Sea (IRPCS), it is recommended that you consider the use of appropriate lights and shapes to reflect the nature of your operations (e.g. restricted in the ability to manoeuvre) in accordance with the IRPCS. You should also ensure your AIS navigation status is set to warn mariners of the nature of your operations.* *Monitor and warn traffic –It is advised that you should take measures to identify approaching vessels early, using all available means, and implement procedures to ensure they are warned in good time, of the nature of work of your vessel and the extent of outlying dangers.* *Contact shipping companies – AMSA, or a commercial AIS service provider, may be able to provide you information regarding ships that frequently operate in and around the NW shipping fairways. You may wish to take steps to contact the shipping companies directly to inform them of your work. Should you wish to request more analysis of data for the purposes of contacting shipping companies, you will need to submit a request for spatial information through AMSA's Spatial Portal. The form is quick and easy to complete and can be found here: https://www.operations.amsa.gov.au/Spatial/DataServices/AssistedRequest* *Escort vessels – Woodside should consider the use of chase boat(s), and/or guard vessel(s) to assist in de-conflicting encounters with other ships. You should deem what is appropriate based on the risks you identify.* *Harbour masters – It is recommended that Woodside liaise with local harbour masters through Western Australia's Department of Transport to ensure harbour masters and local maritime industry operators are aware of the operation and associated hazards.*	

No.	Submitter	Submission and/or issue	Response to comment
		The above advice is provided to assist in enhancing the safety of operations and protecting the marine environment. AMSA considers that it is the responsibility of the Owner and Master to ensure an appropriate risk assessment is conducted, and that the associated risks are appropriately addressed. Should you wish to discuss this further, please contact us via amsaconnect@amsa.gov.au.	
PS-RES-15	ANON-57NR-WVNG-E	*I am a resident of [Redacted name] I made a visit to Burrup and Karratha in 2018.* *I support the nomination of the Burrup rock art site for World Heritage listing.* *I cannot understand how industrial development of the scale already underway, let alone what is now proposed, can be regarded as compatible with the world heritage status of this area.* *Toxic airborne emissions definitely threaten the physical survival and of these remarkable ancient art works; underground vibrations pose a potentially greater threat. 'Monitoring' this impact as outlined in the development proposal is necessary but insufficient. Planning for mitigation / prevention of damage is what's required, yet this is largely absent from the documentation.* *Once again corporate interests will prevail over environmental and cultural heritage - shareholders will benefit but the citizens and communities will lose. Please listen to the voices of those who value, not destroy, the eternal values of art and culture.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised within this submission relating to compatibility of the proposed extension of the Burrup Hub with the World Heritage listing nomination of the Murujuga Cultural Landscape, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**).
PS-RES-16	ANON-57NR-WVN5-V	*Dear Environmental Protection Authority chair [redacted name],* *I am writing to you today to lodge a submission as I am deeply passionate about keeping global temperatures below 1.5 degree increase. I work in climate change policy and I am acutely aware of the scientist's projections and the climate change impacts that will increase in severity every year with rising greenhouse gas emissions.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to the concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**:

No.	Submitter	Submission and/or issue	Response to comment
		No approval should be given to any new fossil fuel project, as any new fossil fuel development is incompatible with the goal of the 2015 Paris Climate Agreement. Therefore this project is incompatible with the Paris Agreement, and Australia's commitment to that agreement. Global emissions are required to peak as soon as possible, and then reduce drastically before 2050. *The Browse project, if approved, will be the most emissions intensive development in Australia, adding an additional 7 million tonnes of CO_2e just through venting and pumping the gas 900 km and about another 7.6 million tonnes CO_2e from processing at the North West Shelf LNG facility. This project alone will emit pollution equivalent to 2.7% increase over Australia's total 2005 baseline.* *Approving this project, would be irresponsible.* *I understand that:* *This project will tap up to 30 gas wells in the Browse basin in Commonwealth waters by use of a floating facility and an 85-km pipeline between wells.* *The project will also see the construction of a 900km pipeline between the gas wells and floating facility to the onshore NWS gas plant at Karratha.* *Though the EPA is collecting submissions for the assessments in Commonwealth waters, the submissions will be assessed by the Commonwealth.* *The Commonwealth is assessing the project on four matters of national environmental significance, as identified by the Commonwealth Environment Protection and Biodiversity Conservation Act 1999: National heritage values of a National Heritage Place; Listed threatened species and communities; Listed migratory species; and The Commonwealth marine area. I believe that other matters, including World heritage properties, and Wetlands of international importance must also be included in the assessment, as well as the overall impact of greenhouse gas emissions.*	• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**). ***National heritage values*** With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**). ***Wetlands*** With respect to the concerns raised in relation to potential impacts to wetlands, please refer to the following responses in **Section 5**: • MEQ-8: Potential impacts to wetlands (**Section 5.22**). ***Marine environment*** With respect to the concerns raised in relation to potential impacts to the marine environment, please refer to the following responses in **Section 5**: • MEQ-2: Unplanned hydrocarbon release (**Section 5.16**) • MEQ-3: Australian marine parks and State marine parks (**Section 5.17**) • MEQ-4: Produced water (**Section 5.18**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • MF-11: Potential impacts to fish (**Section 5.33**).

No.	Submitter	Submission and/or issue	Response to comment
		In terms of heritage (both World Heritage properties and National heritage values): *The NWS venture presents a significant threat to the tangible cultural history of Western Australia's First People.* *The Burrup Peninsula is home to one of the largest, densest and most diverse collections of rock art, or petroglyphs, in the world -- the Murujuga Petroglyphs* *It is estimated to contain more than one million petroglyphs. These provide an archaeological record of traditional use of the area over thousands of years. The rock art has deep meaning for the Traditional Owners. It provides a link to stories, customs and knowledge of their land and connects them to the events and people of the past and their beliefs today.* *A world heritage nomination is currently being prepared for the Murujuga Petroglyphs to have its unique cultural, spiritual and archaeological values internationally recognised at the highest level - Given sites of similar age, such as the Lascaux Caves of France, have achieved international recognition and protection via UNESCO, it is reasonable to expect future recognition to a similar degree* *Recent surges in industrial activity at the Burrup Peninsula has already led to irreparable physical damage (from construction) and chemical damage from a universal, lax approach to emissions and pollution.* *In terms of wetlands: The NWS proposal will jeopardize several Ramsar wetlands and contradict Australia's long-standing and international commitment to the preservation of wetlands of international importance under The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat.* *The proposal has the potential to wreak havoc on both Marine & Coastal Zone wetlands, and Inland wetlands.*	

No.	Submitter	Submission and/or issue	Response to comment
		Noting that the consultation sought is relating to the offshore components of the project, a rudimentary understanding of ocean ecology highlights the threat posed by an increased, extractive industry presence within the vicinity of Ramsar wetlands. *Sites including Roebuck Bay, Eightymile Beach, Ord river floodplain/estuary and Ashmore Reef Nature Reserves stand to be affected by potential ecological disasters such as oil spills and facility structure damage. While sites around Christmas Island, and the Cocos/Keeling Islands may also be impacted by way of the South Equatorial Current.* *Additionally, ecological disturbances offshore in our north could pose further threats to the mangrove forests of Northern WA, and the Northern Territory (home to 39% of all coastal mangroves in Australia) through increased industrial pollutants, trace nutrients, sediment and pH fluctuations.* *In terms of listed threatened species and ecological communities: The waters around WA, including around the proposed site of the works, are home to myriad mammal, reptile, fish and invertebrate species .* *The Department of Parks & Wildlife list the three WA species of sea snake as 'critically endangered', three species of whale listed as 'endangered', 2 three species of endangered turtles in WA; and it lists several more aquatic mammals -- such as the Australian Sea Lion – as 'vulnerable', alongside fish, invertebrate, and bird species.* *The warmer currents surrounding the area in question, play host to cetacean who migrate along the west coast to give birth and nurse their young* *- https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/fauna_notice.pdf* *While a series of bottle-necks between Australia, Timor-Leste, Papua New Guinea and Indonesia have created a channel for migratory aquatic organisms to travel directly through the site of the proposed offshore structures*	

No.	Submitter	Submission and/or issue	Response to comment
		This proposal will not only directly interrupting the migratory path of cetaceans, marine teleosts, and their predators; any local, small-scale dependants on these natural movements are at risk. *This proposal rewards few yet risks the total collapse of our marine ecology – not just locally but across an international area.* *In terms of Commonwealth Marine area:* *This proposal sits adjacent to several Commonwealth Marine Reserves and the NWS threatens the ecological resilience of those marine reserves.* *As it is impossible to "contain" the potential impacts from the commission and operation of two Floating Production Storage and Offloading facilities (connected to existing NWS infrastructure via a 900-kilometre trunk line), the impact on surrounding commonwealth reserves and state reserve must also be considered.* *Commonwealths obligations to protect the intricate ecology of Benthic sediments and the Euphotic zones within Its jurisdiction, which serve to further discredit this proposal on severe ecological grounds.* *Other considerations:* *The Browse Basin and the NWS extension project will emit 2.7% of Australia's total emissions.* *The offshore components will emit at least 112 million tonnes to 2050 (the minimum expected field life).* *The Browse basin gas has an emissions intensity of above the average for Australian LNG exports.* *Thank you for your consideration of my submission. I hope you consider these points when making your assessment and determine that this project should not be allowed to go ahead.*	

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-17	ANON-57NR-WVN3-T	*I strongly disagree with the proposal to extend the North West Shelf project. Climate change has to be the underpinning consideration for all projects relating to the extraction, processing and burning of fossil fuels, as these have had a great impact on the human-induced climate emergency we are now dealing with.* *Current Scientific evidence calls for at least a 50% cut in global emissions to 2030, to avoid catastrphic and irreersible climate change impacts. THis means that all gas projects should not only be denied, but also that existing gas extraction, processing and burning should also be cut by 50%, not extended.* *This is much more than us as people, than company profit or than shareholders. We absolutely must make all decisions for the future of our planet and all of our safety and comfort. Renewable, clean energy sources represent the cheapest and best way forward - it is those we should be promoting, not dirty gas projects. Australia is now a top 3 global climate change promoter through the mining and export of fossil fuels - that HAS to stop if we are to get serious about our role in the current climate emergency.* *Sincerely*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** • In relation to concerns raised in relation to GHG emissions, please refer to the following responses in Section 5: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PS-RES-18	ANON-57NR-WVNE-C	*I am concerned that, while the Australian Government has weak short-term and no long term emissions reduction targets or strategies, Australia is still a signatory to, and a responsible global partner in the commitment to limit global warming to 2 degrees centigrade – 1.5 degrees aspirational – below pre-industrial levels.* *The existing levels of LNG production in WA's North West, together with domestic consumption and exports, is causing Australia to fail to meet its international obligations and the proposed expansion of LNG production will lead to greater failure, while committing Australia to destructive emissions for decades, or the prospect of stranded assets in the face of declining global demand for fossil fuels.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to the concerns raise in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**)

No.	Submitter	Submission and/or issue	Response to comment
		I strongly request that the environmental impacts of the proposals be examined, beyond those represented by the proponents, because I understand that devious means are being employed to conceal the cumulative environmental impacts of the proposed expansion, and some significant elements, such as the venting of substantial volumes of CO_2 in international waters are being omitted from their declarations. The ecological damage to endangered species at the extraction site MUST be seriously considered and effective measures put in place to protect them or to deny the project. *I understand the Government wants to be seen to protect the economy, but the claimed benefits in jobs, royalties and tax payments are ephemeral while the profits flowing to overseas interests are massive.* *If these projects are to proceed, there MUST be adequate emissions reduction or offsets set and policed. The simplest way to ensure this is to put a price on the emissive content of the resources at the point of extraction.* *I expect the EPA to prepare well founded and truthful recommendations regardless of any opposition or blow-back. Our futures depend on it.*	• GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**). Woodside notes that the proposed Browse Project does not include venting of CO_2 in international waters. ***Endangered species*** With respect to the concerns raised in relation to ecological damage to endangered species, please refer to the following responses in **Section 5**: • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-6: Presences and abundance of blue whales in Project Area (**Section 5.28**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**).
PS-RES-19	ANON-57NR-WVNY-Z	*To whom it may concern:* *This is in regard to the Browse development including:* • *Proposal 1: Up to 24 offshore gas wells and a floating facility in the offshore Browse gas field in state waters, under Western Australian EPA jurisdiction (Browse to NWS Project – State waters).* • *Proposal 2: Up to 30 offshore gas wells of the Browse field in Commonwealth waters, using a second floating facility, an 85-kilometre pipeline between, and a 900-kilometre pipeline connecting the lot to the onshore North West Shelf gas plant at Karratha (Browse to NSW Project – Commonwealth waters)* • *Proposal 3: Gas processing onshore at Karratha's existing North West Shelf gas plant - by extending the plant's original approvals to allow it to operate until 2070*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**)

No.	Submitter	Submission and/or issue	Response to comment
		We are concerned with the greenhouse gas emissions of this development. *The proposals assert that gas is a 'clean' fuel. All evidence indicates otherwise. Gas is still a fossil fuel and is a major driver of global greenhouse gases from end use, flaring and fugitive emissions.* • *The Browse proposals argue that the greenhouse gas emissions from the development are acceptable based on the International Energy Agency (IEA) 2018 World Energy Outlook (WEO) "Sustainable Development Scenario" forecast for gas. The IEA has recently released the 2019 WEO and this substantially revises gas demand and supply estimates under the Sustainable Development Scenario. The IEA state that this scenario is aligned with achieving Paris Climate Agreement objectives.* • *The project documentation states that gas demand will increase to 2040, including increasing in the Asian market by 130%, and also that LNG exports can reduce emissions through coal-to-gas switching. Now, the 2019 WEO Sustainable Development Scenario indicates gas demand would peak sooner (global peak by late 2020s and Asia peak in late 2030s), that there would be much lower Asian growth overall (31% not 130%), coal-to-gas switching is less feasible economically, and LNG faces uncertainty in terms of scale of imports, their durability and price competitiveness. Currently, there is still an over-supply of LNG and several new projects and expansion projects are planned, including development of Woodside's Scarborough field. Why then, should Browse also be developed, when it fails to deliver 'clean' energy, supply may not be warranted, it will contribute more total emissions than most countries?* • *Current 2019 Australian Government projections indicate that Australia will not meet its Paris Climate Agreement emissions reduction commitment without the use of Kyoto carry-over credits. The Browse proposals are presently unaccounted for in Australia's emissions projections, yet they will add around 3% to Australia's annual emissions. How will this be accommodated for Australia to meet its Paris commitments?*	• GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**) • ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**). ***NWS Project extension*** With respect to the specific issues raised in relation to the NWS Project Extension, please refer to the response GHG-46 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).

No.	Submitter	Submission and/or issue	Response to comment
		• *No one authority will assess the entire impact of the development on account of the approvals documentation being split into three parts.* • *There is no cumulative impacts assessment for greenhouse gas emissions. This is concerning because it fails to place the Browse development in the context of the broader Burrup hub and northern Australia developments (which already produce significant emissions). A cumulative impact assessment would quantify the emissions from multiple, proposed fossil fuel projects and how these would affect Australia's ability to meet its Paris Climate Agreement commitments.* • *The documentation does not adequately or convincingly demonstrate how these major polluting proposals will contribute to Western Australia's aspiration of net zero by 2050. At best the Browse to NWS Project Draft EIS/ERD commits to offsetting around 25% of direct emissions in an 'average' operating year and the NWS Project Extension commitment is <1%. How is this acceptable for a major polluting activity that seeks to operate to 2070?* *For the reasons above, the Browse development is not consistent with ecologically sustainable development, it does not support intergenerational equity for our kids, and the emissions from this project are not 'acceptable' as claimed.*	
PS-RES-20	ANON-57NR-WV88-9	*The appropriate conclusion of the environmental impact assessment of this proposal is clear. Essentially, the Minister can allow new emissions and make the task of abatement more difficult and expensive for other sectors of the economy and taxpayers, or prevent additional emissions from adding to the already exceeded carbon budget. It seems fairly common sense as to which of these would be consistent with a safe climate and the expectations of the community, and which is not.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** In relation to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-21	ANON-57NR-WV87-8	*I am concerned about the impacts of drilling on the turbidity levels of Scott Reef, as the South Reef lagoon floor hosts extensive coral communities living at depths of up to 70 m at the limit of tolerable low nutrient and light conditions. As outlined by the Australian Institute of Marine Science (https://www.aims.gov.au/publications/discovering-scott-reef), these corals receive little from the plankton rich water column and hence rely on light as their primary source of energy. Therefore reduced sediment quality could have adverse consequences for corals that haven't been explored. Furthermore, due to the warming temperatures resulting from climate change, corals may not be able to recover from mass bleaching events (such as the April 2016 event) if they are overcome by the additional stressors of industrial pollution and potential spills. Hence, it would seem reckless to attempt such a project without a more detailed analysis and reassessment of the effects of potentially increased turbidity on the coral's light-harvesting abilities.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***Scott Reef*** With respect to concerns raised in regard to potential impacts to Scott Reef, please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Marine Environmental Quality and Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon release (**Section 5.16**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**).
PS-RES-22	ANON-TCUY-7GQY-D / ANON - 57NR-WVNH-F (NGARLUMA Aboriginal Corporation)	*This submission was provided as an uploaded document. The majority of the submission provide background with respect to native title and social impact of the NWS Project on the Ngarluma People. The submission provides specific recommendations in relation to both the proposed Northwest Shelf Project Life Extension Project and the proposed Browse Project.* *The following replicates the NAC recommendations specific to the proposed Browse Project which were also submitted separately (ANON-TCUY-7GQY-D). The full submission (ANON - 57NR-WVNH-F) is provided in* **Appendix D.14.** **NAC recommendation specific to the proposed Browse Project:** *While LNG is championed as providing lower emissions than other fossil fuels, there are still significant carbon emissions predicted from the Browse to NWS Project. Furthermore, despite using a third-party toiling plant for processing, the project footprint is significantly higher than the baseline of other LNG projects, which is understood to be due to higher reservoir carbon dioxide content and the considerable distance that the gas will be piped requiring significant energy input.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***NAC recommendations – NWS Project Extension*** With respect to the specific recommendations raised in relation to the NWS Project Extension, please refer to following responses provided in the NWS Project Extension ERD Response to Submissions: • AQ-17 (**Section 3.1.3**, **Table 3-3**) • GHG-48 (**Section 3.2.3**, **Table 3-7**) • SS-3 (**Section 3.3.3**, **Table 3-10**) • SS-4 (**Section 3.3.3**, **Table 3-10**) • SS-5 (**Section 3.3.3**, **Table 3-10**) • SS-RA-10 (**Section 3.3.3**, **Table 3-10**) • SS-RA-11 (**Section 3.3.3**, **Table 3-10**) • SS-RA-12 (**Section 3.3.3**, **Table 3-10**).

No.	Submitter	Submission and/or issue	Response to comment
		Woodside has committed to offsetting emissions for the increased carbon footprint of the project above baseline; however, no further commitment has been made to offset emissions within the baseline. *The resources are being extracted within Australian waters; therefore, some commitments to further offsetting emissions to facilitate meeting the Commonwealth Government's reduction targets of 26-28% on 2005 levels by 2030 should be made. Since Woodside has researched and invested in offset programs and understands the benefits, a plan to contribute further offsetting of emissions that cannot be avoided should be expected, with key milestones and detail on how accountability is going to be maintained.* *Recent public criticism of the Browse to NWS project has included the perception that the project carbon dioxide emissions have been split up in order to be less than transparent. Is Woodside able to provide a simplified flow diagram showing where each part of the total C02 emissions is to be released from the proposed extraction and processing of the Browse gas fields?*	***NAC recommendations – Browse Project Commonwealth Waters*** In response to the NAC recommendation specific to the proposed Browse Project please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**).
PS-RES-23	ANON - 57NR-WV52-Z (Transition Kwoorabup Denmark)	This submission was provided as an uploaded document. The submission relates to: • potential impacts to Commonwealth Marine Parks • potential impacts to wetlands • risk associated with an unplanned hydrocarbon release • potential impacts to marine fauna • pollution from increased activity on the Burrup Peninsula • potential impacts to Aboriginal rock art on the Burrup Peninsula • GHG emissions. The full submission can be found in **Appendix D.3**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***Commonwealth Marine Parks*** With respect to concerns raised in relation to potential impact to Commonwealth Marine Parks, please refer to the following responses in **Section 5**: • MEQ-3: Australian marine parks and State marine parks (**Section 5.17**). ***Wetlands*** With respect to the concerns raised in relation to potential impacts to wetlands, please refer to the following responses in **Section 5**: • MEQ-8: Potential impacts to wetlands (**Section 5.22**).

No.	Submitter	Submission and/or issue	Response to comment
			Unplanned hydrocarbon release With respect to the concerns raised in relation to the potential for unplanned hydrocarbon releases, please refer to the following responses in **Section 5**: • MEQ-2: Unplanned hydrocarbon release (**Section 5.16**). ***Marine fauna*** With respect to concerns raised in relation to potential impacts to marine fauna please refer to the following responses in **Section 5**: • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-10: New species of siphonophores (**Section 5.32**) • MF-11: Potential impacts to fish (**Section 5.33**). ***National heritage values*** With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**). ***GHG emissions*** In relation to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PS-RES-24	ANON - 57NR-WV5H-P (Western Australian Fishing Industry Council (WAFIC)	This submission was provided as an uploaded document. The full submission can be found in **Appendix D.4.**	We acknowledge the comments made and provide the following information in response to the matters raised.

No.	Submitter	Submission and/or issue	Response to comment
		Physical Presence: Disturbance to Other Users *Woodside noted that the long—term 500 metre safety exclusion zone around the FPSO is a relatively small area overlapping commercial fisheries therefore displacement activities is not expected to impact commercial fishing activities.* *WAFIC requests Woodside reassess this point. The impact is not based on the area of the 500 metre (permanent) exclusion zone over any one commercial fishery, it is a 500 metre (permanent) exclusion zone impact on the fishable areas / fished areas of a fishery.*	It is acknowledged that the 500 m exclusion zone represents a permanent (for the lifetime of the project) exclusion around each of the two FPSO facilities. The context of the statement within the draft EIS/ERD in relation to the impact, is that the exclusion from these two areas will have a very limited operational or economic impact on the commercial fisheries which overlap the Project Area. It is considered that this statement is accurate, given that the Project Area is not an area of high commercial fishing activity.
		Note snagging risk to commercial fishers, especially to trawl fisheries (North West Slope Trawl and Pilbara Trawl). Woodside's "Adopted Controls" of "ongoing consultation with commercial fishers etc that operate in the Project Area will be undertaken". *What does this mean? What are your targeted outcomes of this ongoing consultation? How will you remediate any potential impact to the commercial fishers who may be operating in this area?*	The rationale for ongoing consultation with commercial fishers is to keep them informed on the current status and extent of any offshore operations within the fishery areas in order to avoid unplanned interactions with project vessels or facilities.
		Woodside notes the low fishing effort expected in the area of the project and that wells etc are marked on navigational charts and that wells are in water depths greater than 350 metres with no known subsea features of significance and fish populations, it is not considered that the loss of access within the petroleum safety zones (representing a fraction of the area of the fisheries) will affect current fishing levels. *- North West Slope Trawl fish between 200 and 750 metres water depth, the key indicator species is the mud dwelling scampi. Commercial fishers may potentially fish these areas.* *- Woodside is expecting commercial fishers to "give up" access rights for the 100% exclusive use of Woodside. Please note. the Woodside safety exclusion zones are not the only safety exclusion zones in the northwest shelf. How many other safety exclusion zones are overlapping these fisheries — you cannot assess the Woodside zones in isolated context. Cumulative impacts across a range of issues are significant.*	The North West Slope Trawl Fishery encompasses an extensive Commonwealth marine area along the north-west coast approximately between the 200 m isobath and the outer limit of the Australian Fishing Zone (AFZ), including the MoU 74 Box. Fisheries data demonstrates that since 2008-09 season the fishery has stabilised to between one to two vessels per year. While the proposed project infrastructure (i.e. subsea wells, flowlines and trunklines) will pose a potential snagging impact for these fishers, the extent of the Project Area in the context of the total fishery is minimal and is not likely to have any operational or commercial impacts. The requirement for a safety 'exclusion' zone around operating offshore facilities is a Commonwealth legislative requirement managed through Part 6.6 of the Offshore Petroleum and Greenhouse Gas Storage Act 2006 (OPGGS Act). This zone, typically 500 m, is designated to ensure the safety of the facility, crew and other marine users, given the potentially hazardous nature of the operating facilities.

No.	Submitter	Submission and/or issue	Response to comment
		- It may be a lower fishing effort but. every bit adds up — if the commercial fishing industry lost "all" low fishing effort areas, over time this will come at a significant cost to our industry.	
		Physical Presence: Light and Underwater Noise *Woodside notes that light emissions and underwater noise impacts will be negligible with no expected significant subsequent impact to fisheries - Woodside confirms there will be underwater noise monitoring of an operational well be undertaken to inform an adaptive management approach for noise management for the TRD and TRE wells if required,* *Will there be ongoing noise and light monitoring of the FPSO'?*	There is no current plan for ongoing operational monitoring of light or underwater noise during steady state operations. Please refer to the following responses in **Section 5**: • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**).
		Marine Discharges: Drilling and Completions Discharges *Note this will be "managed in such a manner to avoid impacts to Scott Reef shallow water benthic communities and habitats" - How will this be managed and will there be ongoing monitoring?* *- Are any other shallow water areas located within this project boundaries and if so, how does Woodside plan to mediate this?* *- There is a difference between "avoid" and not occurring at all. What happens if Woodside cannot "avoid" negative marine discharges? Considering this is a long life project, does Woodside plan to review and monitor to ensure that the original avoidance strategy actually occurs over the life of the project without any negative or cumulative impacts, especially to the commercial fishing resource?*	No, other than Scott Reef, no other shallow water benthic communities and habitats (<75m bathymetry) exist within the Project Area. Management and mitigation of potential impacts to Scott Reef including monitoring and assurance are detailed in response "BCH-1: Potential impacts to Scott Reef" in **Section 5.14**.
		Unplanned Hydrocarbon Releases *Woodside notes that "in general, fisheries have the potential to be impacted by an unplanned hydrocarbon release through direct impacts to target populations or prey species and fishing gear and from the exclusion of users from a fishing area, potentially resulting in lost revenue".* *It is not a" potential" loss — depending on the size of the unplanned hydrocarbon spill there will be a loss.*	Woodside does not agree with the assertion that an unplanned large hydrocarbon release is a probable event and maintains its position that such an event is highly unlikely to occur. Refer to response "MEQ-2: Unplanned hydrocarbon release" in **Section 5.16** for further discussion on unplanned hydrocarbon releases.

No.	Submitter	Submission and/or issue	Response to comment
		This loss is not restricted to impacts on target key indicator species (eg tainted fish) and gear and restriction or loss of access to an area, it also will impact the fish spawn and could potentially wipe out an entire years' spawning cycle and therefore ongoing longer cumulative repercussions and significant reduction of the sustainable viability of a commercial fishery. *Reputation damage could potentially be significant resulting in long term lack of demand and or lower market price.* *Woodside notes that the risk of unplanned large spill is highly unlikely, this may be so from a desk analysist perspective, We didn't expect the Deepwater Horizon incident therefore we must look at this as a probable outcome.* *There is no mention at all in the information sent to WAFIC of any form of compensation to loss and or damages to commercial fishers. On behalf of commercial fishers WAFIC seeks further information on Woodside's planned process should commercial fishers / a commercial fishery suffer financial ongoing and cumulative loss.*	The petroleum activity will be carried out in a manner that does not interfere with fishing to a greater extent than is necessary for the reasonable exercise of the BJVs rights and performance of duties. Woodside would consider the implications in the unlikely event of a hydrocarbon spill on a case by case basis. Further **Section 6.3.21.7** of the draft EIS/ERD provides information on Woodside's oil spill scientific monitoring program (SMP) which in the event of a Level 2 or 3 unplanned hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors is activated. The objectives of the SMP are: Assess the extent, severity and persistence of the environmental impacts from the spill event; and Monitor subsequent recovery of impacted key species, habitats and ecosystems. The SMP comprises ten targeted environmental monitoring programs which assess and monitor the status of a range of physical-chemical (water and sediment) and biological (species and habitats) receptors including EPBC Act listed species, environmental and socio-economic values associated with protected areas.
PS-RES-25	ANON - 57NR-WV5N-V (Patrons of the UWA Rock Art Conservation Project)	This submission was provided as an uploaded document. The submission relates to: • the ancient indigenous rock art (petroglyphs) located on the Peninsula and surrounds • increasing WA's greenhouse gas emissions (CO_2, methane, nitrous oxide) which affects Australia and the world by increasing the impacts of climate change. The full submission can be found in **Appendix D.5**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***<u>National heritage values</u>*** With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-RA-9 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).

No.	Submitter	Submission and/or issue	Response to comment
			GHG emissions With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**).
PS-RES-26	ANON - 57NR-WV5Y-7	*I strongly oppose the development of the Browse basin fields, and attach my submission for your use.* This submission was provided as an uploaded document. The submission relates to: the ancient indigenous rock art (petroglyphs) located on the Peninsula and surrounds greenhouse gas emissions health concerns relating to air emissions. The full submission can be found in **Appendix D.6**. It should be noted that the majority of the submission relates to the NWS Project Extension ERD. Where the submission relates to the NWS Project Extension ERD, the submission has been addressed within the NWS Project Extension ERD Response to Submissions.	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-28 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**). ***Emissions on the Burrup Peninsula*** With respect to concerns raised in relation to emissions monitoring and public health impacts from emissions from the Burrup Hub on the Burrup Peninsula, please refer to the response to AQ-10 of the NWS Project Extension ERD Response to Submissions (**Section 3.1.3**, **Table 3-3**).

No.	Submitter	Submission and/or issue	Response to comment
			GHG emissions With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**). ***Health concerns*** With respect to concerns raised in relation to public health impacts from emissions from the Burrup Hub on the Burrup Peninsula, please refer to the response to AQ-2 and AQ-3 in the NWS Project Extension ERD Response to Submissions (**Section 3.1.3**, **Table 3-3**). With respect to public health impacts from emission resulting from the proposed Browse Project, please refer to the following responses in **Section 5**: • AQ-1: Impact of air emissions on public health (**Section 5.13**).

No.	Submitter	Submission and/or issue	Response to comment

PS-RES-27	ANON - 57NR-WV7B-J	*This submission was provided as an uploaded document. The submission relates to:*
		• *Principles of Ecologically Sustainable Development in relation to potential impacts to rock art*
		• *North-west Shelf Project Expansion and in particular:*
		  ◦ GHG emissions
		• *GHG emissions resulting from the propose Browse Project and particular:*
		  ◦ cumulative emissions from extraction, onshore processing and customer use of the gas
		  ◦ Western Australia Climate Policy.
		The full submission can be found in **Appendix D.7**.
			We acknowledge the comments made and provide the following information in response to the matters raised.
			Principles of Ecologically Sustainable Development
			The submission raised concerns relating to Principles of Ecologically Sustainable Development which were specific to the NWS Project Extension. A response to these concerns is provided in the response to GHG-KIR-5 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.2**, **Table 3-5**).
			With respect to the Principles of Ecologically Sustainable Development in relation to the proposed Browse Project, please refer to the following responses in **Section 5**:
			• ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**).
			NWS Project extension
			With respect to the specific issues raised in relation to the NWS Project Extension, please refer to the response GHG-41 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
			GHG emissions
			With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**:
			• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)
			• GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**)
			• GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**)
			• GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**).

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-28	ANON - 57NR-WV7V-6 (Australian Parents for Climate Action)	• *This submission was provided as an uploaded document. The submission relates to:* • GHG emissions and in particular: • the need to reduced global GHG emissions • the assertion that the Proposal is not Ecologically Sustainable Development • global gas supply and demand and in particular the revised 2019 WEO Sustainable Development Scenario • gas as a transition fuel and coal to gas switching • Burrup Hub cumulative emissions • Australia's obligations under the Paris Agreement • offsets and mitigation • Western Australia GHG policy. *The full submission can be found in* **Appendix D.8**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to concerns raised in relation to GHG emissions please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**) • ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**).
PS-RES-29	ANON - 57NR-WV8T-5	*This submission was provided as an uploaded document. The submission relates to:* • *GHG emissions including how they relate to the EPBC Act* • *the impact of climate change on the Commonwealth Marine Environment* • *potential impacts to wetlands* • *potential impacts to Burrup Peninsula rock art.* *The full submission can be found in* **Appendix D.9**.	We acknowledge the comments made and provide the following information in response to the matters raised. Woodside notes the comments within the submission with respect to the appropriateness of the EPBC Act in relation to GHG emissions and climate change. Commonwealth legislation and policy exists with respect to GHG emissions (as described in **Section 7.3** of the draft EIS/ERD). Woodside comply with these requirements.

No.	Submitter	Submission and/or issue	Response to comment
			GHG emissions With respect to concerns raised in relation to GHG emissions, including the impacts of climate change on the Commonwealth Marine Environment, please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**). ***Wetlands*** With respect to the concerns raised in relation to potential impacts to wetlands, please refer to the following responses in **Section 5**: MEQ-8: Potential impacts to wetlands (**Section 5.22**). ***National heritage values*** With respect to the concerns raised relating to potential impacts of emissions to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to AQ-KIR-1 and SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.1.2**, **Table 3-2** and **Section 3.3.2**, **Table 3-9** respectively).
PS-RES-30	ANON-57NR-WV53-1	*This submission was provided as an uploaded document. The submission relates to:* *atmospheric emission on the Burrup Peninsula and potential resultant impacts to rock art.* *GHG emissions in the context of Australia's obligations under the Paris Agreement and Western Australia's GHG policy* *cumulative atmospheric emissions resulting from the Burrup Hub projects.* *The full submission can be found in* **Appendix D.10**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to AQ-KIR-1 and AQ-18 in the NWS Project Extension ERD Response to Submissions (**Section 3.1.3**, **Table 3-3**).

No.	Submitter	Submission and/or issue	Response to comment
			GHG emissions With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • AQ-1: Impact of air emissions on public health (**Section 5.13**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**).
PS-RES-31	ANON - 57NR-WV75-5	*This submission was provided as an uploaded document. The submission relates to:* *Burrup Hub air emissions and potential impacts to rock art.* *potential impacts to wetlands* *potential impacts resulting from an unplanned hydrocarbon release* *potential impacts to marine fauna* *potential impacts to Commonwealth marine parks and State marine park* *discovery of a new species of siphonophore* *impacts to traditional fishers utilising MOU 74* *economic benefits / impacts of the proposed Browse Project* *GHG emissions.* *The full submission can be found in* **Appendix D.11**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**). With respect to the reference to dredging in relation to a new pipeline and potential related impacts to submerged artefacts, Woodside confirms that there no planned pipeline installation (or related dredging) at the Burrup Peninsula associated with the proposed Browse Project. The proposed Browse Trunkline is planned to tie into the existing second trunkline near the NRC complex which is located a significant distance from shore.

No.	Submitter	Submission and/or issue	Response to comment
			Wetlands With respect to the concerns raised in relation to potential impacts to wetlands, please refer to the following responses in **Section 5**: • MEQ-8: Potential impacts to wetlands (**Section 5.22**). ***Unplanned hydrocarbon release*** With respect to the concerns raised in relation to the potential for unplanned hydrocarbon releases and subsequent impacts to Scott Reef, please refer to the following responses in **Section 5**: • MEQ-2: Unplanned hydrocarbon release (**Section 5.16**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**). ***Marine fauna*** With respect to concerns raised with respect to potential impacts to marine fauna, please refer to the following responses in **Section 5**: • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • MF-11: Potential impacts to fish (**Section 5.33**). ***Commonwealth Marine Parks*** With respect to concerns raised in relation to potential impact to Commonwealth Marine Parks including the new species of siphonophore that has been identified, please refer to the following responses in **Section 5**: • MEQ-3: Australian marine parks and State marine parks (**Section 5.17**) • MF-10: New species of siphonophores (**Section 5.32**).

No.	Submitter	Submission and/or issue	Response to comment
			Socio-economic considerations With respect to socio-economic consideration raised in the submission, please refer to the following responses in **Section 5**: SE-2: Socio-economic benefits of the proposed Browse Project (**Section 5.35**). ***GHG emissions*** With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

PS-RES-32	ANON - 57NR-WV79-9	*This submission was provided as an uploaded document.*
		The submission relates to GHG emissions and in particular:
		• *projected emissions*
		• *Australia's performance against Paris Climate Agreement global gas supply and demand and in particular the revised 2019 WEO Sustainable Development Scenario*
		• *coal to gas switching*
		• *challenges to the assertion that gas is a "Clean, Affordable, Reliable Energy"*
		• *the GHG emission contribution of the proposed Browse Project and potential resultant socio-economic and cumulative impacts*
		• *mitigation*
		• *the acceptability of the proposed Project, particularly in relation to:*
		  • the Paris Agreement
		  • the role of gas
		  • Principles of Ecologically Sustainable Development.
		The full submission can be found in **Appendix D.12**.
			We acknowledge the comments made and provide the following information in response to the matters raised.
			GHG emissions
			With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**:
			• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)
			• GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**)
			• GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**)
			• GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**)
			• GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**)
			• GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**)
			• GHG-7: Lower and zero carbon energy sources (**Section 5.8**)
			• GHG-8: The role of gas in the future energy mix (**Section 5.9**)

No.	Submitter	Submission and/or issue	Response to comment
			• GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**).
PS-RES-33	ANON - 57NR-WVNF-D	*This submission was provided as an uploaded document. The submission relates to:* • *Burrup Hub air emissions and potential impacts to rock art.* • *potential impacts to human health as a result of air emissions* • *potential impacts to wetlands* • *potential impacts to marine fauna* • *potential impacts to Commonwealth marine parks* • *discovery of a new species of siphonophore* • *potential impacts resulting from an unplanned hydrocarbon release* • *GHG emissions.* *The full submission can be found in* **Appendix D.13**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**). ***Health concerns*** With respect to concerns raised in relation to public health impacts from emissions from the Burrup Hub on the Burrup Peninsula, please refer to the response to AQ-2 and AQ-3 in the NWS Project Extension ERD Response to Submissions (**Section 3.1.3**, **Table 3-3**). With respect to public health impacts from emission resulting from the proposed Browse Project, please refer to the following responses in **Section 5**: • AQ-1: Impact of air emissions on public health (**Section 5.13**). ***Wetlands*** With respect to the concerns raised in relation to potential impacts to wetlands, please refer to the following responses in **Section 5**: • MEQ-8: Potential impacts to wetlands (**Section 5.22**). ***Marine fauna*** With respect to the concerns raised in relation to potential impacts to listed threatened species and ecological communities, and migratory species, as well as the newly identified species of siphonophores, please refer to the following responses in **Section 5**:

No.	Submitter	Submission and/or issue	Response to comment
			• MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • MF-10: New species of Siphonophores (**Section 5.32**) • MF-11: Potential impacts to fish (**Section 5.33**). ***Commonwealth Marine Parks*** With respect to concerns raised in relation to potential impact to Commonwealth Marine Parks including potential impacts from an unplanned hydrocarbon spill, please refer to the following responses in **Section 5**: • MEQ-2: Unplanned hydrocarbon release (**Section 5.16**) • MEQ-3: Australian marine parks and State marine parks (**Section 5.17**). ***GHG emissions*** With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**).

No.	Submitter	Submission and/or issue	Response to comment
			Woodside notes that the claim that venting of reservoir CO_2 has not been included in Woodside's calculations of total emissions is incorrect. GHG emissions estimate are provided in **Section 7.4.4.2** of the draft EIS/ERD.
PS-RES-34	ANON - 57NR-WVNK-J (The Beeliar Group)	*Submission relates atmospheric emissions (including GHG emissions) includes 50 submission grouped into the following 20 topics.* • *suggested outcomes from the State and Commonwealth assessments* • *Woodside and the joint venture partners have failed to mitigate their companies' exposure to climate risk* • *decision—makers must consider the Paris Agreement mitigation objectives* • *the proposals are not ecologically sustainable development* • *the two proposals are inextricably linked, and the separate assessments obscure the overall carbon footprint* • *decision—makers must consider cumulative emissions* • *decision-makers must recognise that all greenhouse gas emissions contribute to climate change* • *for the Commonwealth assessment. the relevant events or circumstances for the Scope 1 and Scope 3 emissions are the physical effects associated with climate change* • *decision-makers should not apply a simple mechanistic notion of causation in assessing impacts and should consider Australia's partial responsibility for climate change* • *a basis for evaluating the significance of a project's emissions* • *decision-makers should not accept Woodside's claims of emissions reductions if LNG displaces coal in import countries and should instead accept Woodside's admission that the correct proposition is that gas has benefits over coal in generating electricity* • *failure to consider the IPCC Special Report on Global Warming of 1.5 OC* • *IEA perspectives on LNG & IEA scenarios* • *emission intensities for LNG derived from the Browse reservoirs*	We acknowledge the comments made and provide the following information in response to the matters raised. ***<u>GHG emissions</u>*** With respect to the concerns raised, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**) • GHG-9: Carbon capture and storage (CCS) of Browse gas (**Section 5.10**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**).

No.	Submitter	Submission and/or issue	Response to comment
		• *inadequacy of measures to avoid and reduce greenhouse gas emissions, need for carbon capture and storage, inadequacy of offsets for residual greenhouse gas emissions* • *Woodside uses an internal carbon price to guide its decision-making and is well positioned to accommodate offset costs for all residual emissions* • *the offsetting of all residual emissions is practicable* • *methane emissions & Methane Guiding Principles* • *LNG is a driver of a rise in greenhouse gas emissions in Australia and WA* • *the current Commonwealth framework does not adequately constrain greenhouse gas emissions and is best seen as setting a floor for the regulation of large facilities.* *The submission also expresses support for FARA submission and notes Australian Government recently lodged a submission for the Murujuga cultural landscape on Western Australia's Burrup Peninsula to be included on* *Australia's world heritage tentative list* *The full submission can be found in* **Appendix D.15**.	***National heritage values*** With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**). With respect to the FARA submission, please refer to the response provided in item 40 of this table.
PS-RES-35	ANON - 57NR-WVNP-Q	*This submission was provided as an uploaded document. The submission relates to:* • *GHG emissions, particularly with respect to whether gas should be considered a transition fuel and Australia obligations under the Paris Agreement* • *Burrup Hub air emissions and potential impacts to rock art* • *potential impacts to wetlands* • *potential impacts to marine fauna, particularly in relation to potential underwater noise impacts* • *potential impacts to Commonwealth marine parks* • *potential impacts to Scott Reef* • *potential impacts to marine environmental quality around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to concerns raised in relation to GHG emission, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**)

No.	Submitter	Submission and/or issue	Response to comment
		The full submission can be found in **Appendix D.16**.	• GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**). ***National heritage values*** With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**). ***Wetlands*** With respect to the concerns raised in relation to potential impacts to wetlands, please refer to the following responses in **Section 5**: • MEQ-8: Potential impacts to wetlands (**Section 5.22**). ***Marine environment*** With respect to concerns raised in relation to potential impact to Australian Marine Parks, Scott Reef and listed threatened species and ecological communities, please refer to the following responses in **Section 5**: • MEQ-3: Australian marine parks and State marine parks (**Section 5.17**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-4: Vessel - fauna interaction (**Section 5.26**) • MF-5: Potential impacts to marine turtles (**Section 5.27**)

No.	Submitter	Submission and/or issue	Response to comment
			• MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • MF-11: Potential impacts to fish (**Section 5.33**).
PS-RES-36	Australian Marine Conservation Society (AMCS) submission to North West Shelf assessments 2191 and 2186	*This submission was provided as an uploaded document. The submission relates to:* • *GHG emissions and in particular, the need to reduce carbon emissions, Australia's obligations under the Paris Agreement and Western Australia's GHG policy.* • *potential cumulative impacts Scott Reef and the ability to understand these potential impacts adequately enough to be able to assess them.* • *potential impacts to marine fauna and critical habitat for endangered species, including marine turtles and cetaceans.* *Note that the submission refers to and supports other submissions from the conservation section including the Conservation Council of Western Australia (CCWA) rather than providing detailed comments. The submission registers opposition for the proposal due to concerns with respect to carbon pollution and impacts on marine life.* *The full submission can be found in* **Appendix D.17**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***CCWA submission*** The AMCS submission expresses support for the CCWA submission. Woodside's response to the CCWA submission is provided in response PS-RES-38 of this table. ***GHG emissions*** With respect to concerns raised in relation to GHG emission, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**).

No.	Submitter	Submission and/or issue	Response to comment
			Potential impacts to Scott Reef With respect to concerns raised in regard to potential impacts to Scott Reef including corals communities, please refer to the following responses in **Section 5**: • BCH-1: Potential Impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**). ***Potential impacts to marine fauna and critical habitat*** With respect to concerns raised in regard to potential impacts to marine fauna and critical habitat at Scott Reef, please refer to the following responses in **Section 5**: BCH-1: Potential Impacts to Scott Reef (**Section 5.14**) MEQ-1: Environmental Quality Management Framework MEQ-1: Environmental Quality Management Framework (**Section 5.15**) MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) MF-4: Vessel - fauna interaction (**Section 5.26**) MF-5: Potential impacts to marine turtles (**Section 5.27**) MF-7: Potential impacts to cetaceans (**Section 5.29**).
PS-RES-37	CCWA / Clean State	*This submission was provided as uploaded documents. The submission includes two parts:* • *Browse Burrup Hub Report - a detailed report on carbon emissions from the proposed Burrup Hub project, as well as environmental and heritage impacts.* • *A submission that summaries the outcomes of the Browse Burrup Hub Report and provide further specific comment on the proposed Browse Project GHG emissions.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**:

No.	Submitter	Submission and/or issue	Response to comment

		The submissions specifically relate to:
		• *GHG emissions and climate change particularly in relation to:*
		  ◦ the magnitude of emission from the proposed Burrup Hub Proposals
		  ◦ the carbon intensity of Browse gas including methane content and global warming potential
		  ◦ global gas demand projections
		  ◦ cumulative GHG emission from the Burrup Hub Proposals
		  ◦ latest climate science, carbon budgets and global analysis of climate change trends and impacts
		  ◦ Australia's obligations under the Paris Agreement and Western Australia's GHG policy
		  ◦ coal to gas switching the role of gas in the future energy mix
		  ◦ Woodsides efforts to avoid and reduce carbon emissions from the proposed Browse Project
		  ◦ mitigation efforts for the NWS LNG facility
		  ◦ offsetting and the SGM
		• *impacts on cultural heritage - Murujuga rock art*
		• *risks to the health of people and communities from atmospheric emissions on the Burrup Peninsula*
		• *potential impacts to marine life including endangered marine and migratory species from subsea drilling, seismic testing, industrial noise, light pollution, and heavy shipping operations*
		• *risks from fracking to supply gas to Burrup Hub*
		• *socio-economic impacts*
		• *risk to investors and shareholders.*
		Note that the submission makes reference to the NWS Project Extension ERD. Where the submission relates to the NWS ERD and not the proposed Browse Project, this part of the submission has been addressed in the NWS Project Extension ERD Response to Submissions. The full submission (both documents) can be found in **Appendix D.18**.
			• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)
			• GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**)
			• GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**)
			• GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**)
			• GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**)
			• GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**)
			• GHG-7: Lower and zero carbon energy sources (**Section 5.8**)
			• GHG-8: The role of gas in the future energy mix (**Section 5.9**)
			• GHG-9: Carbon capture and storage (CCS) of Browse gas (**Section 5.10**)
			• GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
			National heritage values
			With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the following responses in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).
			• GHG-51 (**Table 3-7**, **Section 3.2.3**)
			• SS-RA-46 (**Section 3.3**.3, **Table 3-10**).
			Health concerns
			With respect to concerns raised in relation to public health impacts from emissions from the Burrup Hub on the Burrup Peninsula, please refer to the response to SS-RA-18 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-3**).

No.	Submitter	Submission and/or issue	Response to comment
			Marine environment With respect to concerns raised in regard to potential impacts to Scott Reef and endangered marine and migratory species, please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-5: Use of non-water -based fluids (NWBFs) during drilling (**Section 5.19**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-4: Vessel - fauna interaction (**Section 5.26**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**). ***Fracking*** Woodside confirms that there is no fracking associated with the proposed Browse Project. ***Socio-economic considerations*** With respect to concerns raised in relation to socio-economic considerations, please refer to the following responses in **Section 5**: • SE-2: Socio-economic benefits of the proposed Browse Project (**Section 5.35**).

No.	Submitter	Submission and/or issue	Response to comment
			Risk to investors and shareholders. In regard to the project and corporate risk raised, Woodside continues to assess and mitigate project and corporate risks. The draft EIS/ERD and associated documents have been prepared to enable to assessment of the environmental acceptability of the proposed Browse Project with respect to the relevant legislation. The risks raised in the submission are not the subject of the assessment.

PS-RES-38	Conservation Council of WA (CCWA)	*This submission was provided as an uploaded document. The full submission can be found in* **Appendix D.19**. *Note that the Browse Burrup Hub Report prepared by Clean State and referenced above was also submitted by CCWA. This report can be found in* **Appendix D.18**. *The submission relates to:*
		Consultation and other submissions
		• *concerns with the environmental impact assessment process, particularly in relation to meeting the objectives of the EP Act*
		• *concerns relating to the duration and timing of public consultation*
		• *CCWA's intention to provide supplementary comments*
		• *additional information requested from the proponent including:*
		    • Greenhouse Gas Management Plan
		    • other management plans
		    • data to enable assessment of health impacts
		    • marine monitoring and other data to enable assessment of impacts on the marine environment
		    • the conclusion and results of independent studies regarding the impacts of acid gas emissions from LNG processing on Murujuga rock art
		GHG emissions and climate change
		The submission raised concerns in relation to:
			We acknowledge the comments made and provide the following information in response to the matters raised.
			EIA process
			Woodside has complied with the requirements of the EP Act and EPBC Act in preparing the draft EIS/ERD. The draft EIS/ERD was prepared in accordance with the Commonwealth EIS Guidelines (EISG) and the Environmental Scoping Documents (ESD).
			Duration and timing of public consultation
			It is correct that the projects related to the Burrup Hub (proposed Browse Project, NWS Life Extension, Scarborough) are proceeding through separate approvals processes given jurisdictional differences. Further, while Woodside is the Operator of each of these projects, we operate them on behalf of different Joint Ventures (JVs) (Browse JV, NWS JV and Scarborough JV). Given these factors, Woodside has agreed assessment processes with the State and Commonwealth regulators in accordance with State and Commonwealth legislation.
			Woodside notes the public review period is set by the Minister. The original six-week period was extended by two weeks as the public comment period ran over the Christmas period.
			Supplementary comments
			Woodside understands that the public review period is now closed.

No.	Submitter	Submission and/or issue	Response to comment

		• *the magnitude of emission from the proposed Burrup Hub Proposals and its acceptability*
		• *the impact of climate change on environmental receptors*
		• *cumulative GHG emission from the Burrup Hub Proposals*
		• *Woodsides efforts to avoid and reduce carbon emissions from the proposed Browse Project*
		• *Australia's obligations under the Paris Agreement and Western Australia's GHG policy*
		• *coal to gas switching the role of gas in the future energy mix*
		• *latest climate science, carbon budgets and global analysis of climate change trends and impacts*
		• *mitigation efforts for the NWS LNG facility*
		• *offsetting and the SGM*
		• *coal to gas switching the role of gas in the future energy mix*
		• *the Principles of Ecologically Sustainable Development including:*
		  ◦ Precautionary principle
		  ◦ Principle of intergenerational equity
		  ◦ Principle of biological diversity and ecological integrity
		  ◦ Improved valuation, pricing and incentive mechanisms
		• *acceptability under the EPBC Act including:*
		  ◦ Emission reduction measures - CCWA assert that the emissions reduction and offset measures proposed by the Proponent in the
		  ◦ draft EIS/ERD are grossly inadequate to manage or mitigate the impacts from the Proposal's GHGe on MNES including listed threatened migratory species, threatened ecological communities, the Commonwealth Marine Area or the environment.
			Additional information requests
			Woodside has provided a GHG MP within this Supplement Report to the draft EIS/ERD (**Appendix C.1**). An EQMP has been provided in (**Appendix C.2**). Information on marine studies is provided in Chapter 5 of the draft EIS/ERD. With respect to studies relating to impacts on Murujuga rock art please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**).
			
			With respect to the request for marine monitoring and other data, Woodside has commissioned approximately 60 studies within the Project Area, Scott Reef and the broader region that span approximately two decades. Studies have included baseline and annual programs for humpback whale, turtle, other marine megafauna and fish species in the region, as well as long-term monitoring of coral and fish communities at Scott Reef. The results of these studies are summarised in Chapter 5 of the draft EIS/ERD and the relevant technical report are also attached or referenced in the draft EIS/ERD. Further, summaries and detailed technical reports relating to proposed marine discharges, unplanned hydrocarbon releases, noise emissions and drilling discharges are provided in the draft EIS/ERD. A further desktop lighting study has been undertaken as part of preparation of the responses to public submissions and is provided in **Appendix A.1**.
			
			GHG emissions
			With respect to concerns raised in relation to GHG emissions, please refer to the following responses **Section 5**:
			• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)
			• GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**)
			• GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**)

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		• We strongly oppose the Proponent's reliance on the lack of direct link between GHGe from Proposal and impacts on environment and the difficulties associated with predicting and measuring these impacts to argue that the impacts from the Proposal's GHGe on MNES are acceptable. The EPBC Act refers to significant impacts on MNES. Section 527E provides that an event or circumstance is an impact of an action if it is a direct or indirect consequence of the action (provided the action is a substantial cause of the event or circumstance). Accordingly, there is no requirement for impacts to be directly caused by the Proposal's GHGe, the emissions just need to be a substantial cause of the impacts. Relevantly, the EPBC Policy Statement on Indirect Impacts confirms that relevant indirect consequences or impacts can include 'downstream impacts'.
		• The mitigation and offsetting measures and GHG Abatement Plan proposed by the Proponent in the draft EIS/ERD are grossly inadequate. In particular, they only reduce a small amount of the Proposal's GHGe and offset emissions the Proponent is legally obliged to offset under the Safeguard Mechanism as a result of exceeding its baseline. This means they will not effectively manage or mitigate the significant impacts of the Proposal's GHGe on listed threatened migratory species, threatened ecological communities, the Commonwealth Marine Area or the environment in accordance with the MNES Significant Impact Guidelines, meaning the Proposal cannot be considered acceptable under the EPBC Act. Accordingly, DoEE must recommend against implementation of the Proposal.
		• The market substitution claim should not be accepted unless the Proponent can demonstrate the actual reductions they claim in the form of verified carbon credits or other verified accounting mechanism.
		• In CCWA's view, the impacts of the Proposal's substantial GHGe are not consistent with, or acceptable under, the environmental principles of the EPBC Act
			• GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**)
			• GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**)
			• GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**)
			• GHG-8: The role of gas in the future energy mix (**Section 5.9**)
			• GHG-9: Carbon capture and storage (CCS) of Browse gas (**Section 5.10**)
			• GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
			• ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**).
			Note that as described in **Section 5.4**, Woodside has prepared a GHG Management Plan for the proposed Browse Project and has attached the plan as **Appendix C.1**.
			With respect to comments made in relation to GHG emissions related to the NWS Project Extension, please refer to response GHG-RES-52 (**Section 3.2.3**, **Table 3-7**).
			With respect to acceptability under the EPBC Act:
			• Emission reduction measures – please refer to the following responses in Section 5:
			  • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (Section 5.4)
			  • GHG-10: Climate change impacts on human health and environmental and social receptors (Section 5.11).

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		• *acceptability under other aspect or receptor requirements including State, Federal and International standards, laws, policies and guidelines including:* ◦ In relation to the acceptability of the Proposal under the Paris Agreement, the Proponent merely states that the Proposal has the potential to contribute to the reduction in global GHGe by displacing higher carbon intensive power generation (e.g. coal burning). As addressed above, these claims of market substitution are not sufficiently substantiated or proven by credible evidence. Accordingly, allowing the Proposal to proceed, without mitigation or offsetting measures that can effectively ensure that its substantial GHGe are reduced or achieve a net benefit outcome, is inconsistent with the objectives of the Paris Agreement. ◦ The draft EIS/ERD acknowledges that the emissions reduction task to achieve Australia's NDC is currently 328 MT CO_2-e. Despite the Proposal having the potential to increase Australia's emissions, the Proponent states in the draft EIS/ERD that it is not expected to prevent Australia meeting its NDC commitments.40 In our view, this argument is completely false and unfounded. By causing substantial GHGe, the Proposal will increase Australia's GHGe and further jeopardise our ability to achieve our insufficient NDC. Accordingly, the Proposal is not consistent with Australia's NDC commitments under the Paris Agreement. ◦ In our view, allowing the Proposal to proceed with a maximum lifetime of 44 years and substantial additional GHGe cannot be considered consistent with the target of net zero GHGe by 2050. Given WA's GHGe continue to increase, achieving net zero emissions implies a decrease, rather than increase, in emissions. ***Air quality*** *The submission raises concerns with respect to:*	• Market substitution – as detailed in GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) ERM undertook a life cycle assessment (LCA) of the proposed Browse Project and Scarborough Development. ERM's independent expert analysis, critically reviewed by CSIRO, shows Woodside's Browse and Scarborough projects could avoid 650 Mt of CO_2 equivalent (CO_2-e) emissions (392 Mt for the proposed Browse Project) between 2026 and 2040 by replacing higher emission fuels in countries that need our energy. • Environment principles of the EPBC Act – please refer to ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**). With respect to acceptability under other aspect or receptor requirements including State, Federal and International standards, laws, policies and guidelines, please refer to: • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**). ***Air quality*** Woodside notes that the approach taken of directing the reader to the NWS Extension ERD with respect to potential impacts in relation to third party processing of Browse gas is consistent with the approved EIS Guidelines for the assessment under the EPBC Act. With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-47 in the NWS Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**). With respect to concerns raised in relation to public health impacts from emissions from the Burrup Hub on the Burrup Peninsula, please refer to the response to AQ-21 in the NWS Project Extension ERD Response to Submissions (**Section 3.1.3**, **Table 3-3**).

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		• *onshore processing of the Browse gas by the NWS JV, being addressed within the ERD for the NWS Project Extension Proposal (EPA 2186, EPBC 2018/8335)*
		• *lack of consideration of indirect and cumulative impacts of emissions on rock art*
		• *potential impacts on human health.*
		
		Environmental values of Scott Reef
		The submission raised concerns in relation to potential impacts to Scott Reef as a result of:
		• *drilling (location, seabed disturbance, drilling fluids)*
		• *subsidence*
		• *seabed preparation*
		• *marine discharges (including produced water)*
		• *unplanned hydrocarbon releases and adequacy of hydrocarbon spill modelling*
		• *cumulative impacts to environmental quality*
		• *acceptability under the EPBC Act. Note that the submission states that "Impacts are on MNES affected by the project which are dealt with under the above section and in other sections of this document. Further analysis is required to identify specific impacts on MNES within the state waters component of the project on Scott Reef. CCWA wishes to provide further information on these aspects at a later date". Given this, Woodside has responded to the information in the submission under the EP Act acceptability header including:*
		  • as a designated nature reserve and a place of extremely high conservation value, the pristine marine environment of Scott reef warrants the maximum level of ecological protection
		  • assertion that if the EIS/ERD conclusions are to be accepted by the EPA, the proponent must provide further information on the omissions from the draft EIS/ERD including:
			Environmental values of Scott Reef
			Woodside notes that a management approach has been proposed based on a commitment to meet the maximum level of ecological protection for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) as presented in the EQMP.
			
			With respect to concerns raised in relation to potential impact to Scott Reef, please refer to the following responses **Section 5**:
			• BCH-1: Potential impacts to Scott Reef (**Section 5.14**)
			• MEQ-1: Environmental Quality Management Framework MEQ-1: Environmental Quality Management Framework (**Section 5.15**)
			• MEQ-2: Unplanned hydrocarbon release (**Section 5.16**)
			• MEQ-4: Produced water (**Section 5.18**)
			• MEQ-5: Use of non-water -based fluids (NWBFs) during drilling (**Section 5.19**)
			• MEQ-6: Management of drilling and completion discharges (**Section 5.20**).
			• With respect to the statements made in relation to acceptability under the EPBC Act:
			• Within the draft EIS/ERD and the EQMP (Appendix C.2), Woodside has provided a Maximum Level of Ecological Protection (LEP) for the majority of the State Proposal Area including all of Scott Reef (< 75 m bathymetry)
			• Wireline logging activities or Formation Evaluation while drilling may be used for the proposed Browse Project development wells. If radioactive sources are selected for the activity, then any radioactive materials used during the activity would be brought back to the MODU as part of the planned activity. The radioactive sources would not be discharged into the marine environment as part of this planned activity.

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		• insufficient detail in the EIS/ERD about the discharge of radioactive materials from wireline logging activities and the produced water by-products • reliance on dilution of produced water discharges • uncertainty about the amount of toxins in the water • avoidance of produced water discharge by reinjection due to complexity and cost • the unreasonable proximity of the proposed drilling activities to the sensitive marine environment of Scott reef • Woodside's reliance on previous modelling to ensure that it won't cause major issues through subsidence and compaction of rock strata. • insufficient detail in the draft EIS/ERD about the composition of the drilling fluid that will be discharged into the marine environment • insufficient detail in the EIS/ERD about the composition of the wellbore content which Woodside plans to flow back to the MODU and discharge if a well is underperforming • inadequate methodology for the unplanned hydrocarbon release modelling • lack of detailed cumulative impact assessment. ***Marine fauna*** *The submission raised concerns with respect to:* • *potential impacts to green turtles at Scott Reef from light emissions, noise emissions, chemical discharge, unplanned hydrocarbon releases and seabed subsidence.* • *potential impacts to cetaceans from noise emissions.*	• The use of dilutions to assess potential impacts from industrial discharges is consistent with common industry practice. The EPA's technical guidance refers to the use of dilutions in determining predicted impacts. • The options assessment concluded that given the detailed environmental impact and risk assessment of PW (**Section 6.3.12** of the draft EIS/ERD) concluded that no significant environmental impacts are predicted (and no impact on State Waters) and that the discharge of PW is acceptable; the increased health and safety risks, GHG emissions, technical complexity and capital and operating costs associated with PW re-injection into a reservoir is grossly disproportionate to the environmental benefit likely to be gained from this approach. • Location of drilling – Please refer to MEQ-6: Management of drilling and completion discharges (**Section 5.20**). Woodside has prepared an EQMP which includes a 'Management Approach for Torosa wells in State Proposal Area' which details how the proposed LEPs (including the Max LEP for Scott Reef) will be achieved. • Subsidence – the modelling used in relation to subsidence within the draft EIS/ERD has been peer reviewed by Baker Hughes GMI Geomechanics Services (Hughes, 2012) who concluded that the method and supplied data was appropriate. The DoEE sought further independent review by CO_2 Geological Storage Solutions Pty Ltd (CGSS) (CGSS, 2012) who found that the report conclusions were reasonable. Woodside therefore has a high level of confidence with respect to the modelling results. • Composition of the drilling fluid – please refer to MEQ-5: Use of non-water -based fluids (NWBFs) during drilling (**Section 5.19**) • Composition of the wellbore content – Woodside confirms that: • should there be wellbore fluids contaminated with hydrocarbons or NWBFs, they will be captured and stored on the MODU for discharge if oil concentration is <1% by volume, or returned to shore if discharge requirements cannot be met.

No.	Submitter	Submission and/or issue	Response to comment
		• *the submission states that "as described below, the proposal contains several activities which would heavily impact on the Sandy Islet nesting and internesting area, including light interference, drilling activities and marine discharges. These activities have several implications for the species. There is a real chance that they will reduce the area of occupancy, adversely affect habitat critical to the survival, disrupt the breeding cycle and fragment this important sub-population of green turtles". Woodside notes that there is no further information in relation to impacts to marine fauna below this statement and has such assume the submission intended to refer to the information presented above the statement under the acceptability under the EP Act section. This information included the assertion that if the EIS/ERD conclusions are to be accepted, the proponent must provide further information on the errors and omissions from the draft EIS/ERD including:* ◦ misleading statements in evaluating the impacts of underwater noise emissions on the risk of potential impacts to green turtles. In the EIS, Woodside justifies its assessment of the risk as 'minor', based on the argument that the noise emissions affect a 'very small portion of offshore waters' (i.e. the ocean), and will only occur within several hundred metres of the source. This justification deliberately ignores the fact that the TRE drill centres is located adjacent to habitat critical to the survival of the Scott reef-Browse stock of green turtles. ◦ Prejudicial methodology was used for the light density modelling, which informs the evaluation and assessment of light pollution impacts of green turtles. Woodside reuses its light density modelling from previously proposed FLNG facilities at Torosa. The major source of light emissions, the flare of the pilot flame, was not included in this assessment. It is completely unsatisfactory that the most impactful source (flaring) was excluded from the lighting modelling.	◦ should there be wellbore solids contaminated with hydrocarbons, they will be treated as hazardous waste as per draft EIS/ERD Section 6.3.14. • Hydrocarbon release modelling - The TRA-C well was selected as it is one of the wells located closest to Scott Reef and is expected to have a higher release rate (and therefore total volume over a fixed period of time) compared to the other wells. As such, the TRA-C well is considered to represent the worst-case credible scenario (i.e. the governing scenario that represents the largest potential environmental impact) and as such is the appropriate location for use in the hydrocarbon spill modelling. • Cumulative impact assessment – aspect based cumulative impacts are assessed in Chapter 6 of the draft EIS/ERD. This assessment has shown that aspect-based cumulative impacts resulting from the proposed Browse to NWS Project are unlikely to result in significant impacts. The majority of emissions and discharges will be within the Browse Development Area, which is in a remote, offshore location and unlikely to result in significant interactions with other activities/developments. • Receptor based cumulative impacts assessment in Chapter 9 of the draft EIS/ERD. The cumulative impact assessment focusses on predicted impacts from planned routine and non-routine activities and evaluates the nature of any aspect interaction (e.g. whether one aspect exacerbates the impact of another) and the scale of the cumulative impact as a result. No significant cumulative impacts were identified. ***Marine fauna*** Woodside notes the TRE drill centre is no longer proposed (refer to **Section 2**). With respect to concerns raised in relation to potential impact to marine fauna, please refer to the following responses **Section 5**:

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		• It downplays the impact that the potential seabed subsidence risk could have on habitat critical to the survival of the green turtle. While the EIS/ERD acknowledges that ‘slight impacts’ are predicted to occur from drilling (i.e. sinking of the seabed), it concludes that ‘reef growth rates are expected to match or exceed any sea level reduction’ and considers the impact ‘acceptable’. This evaluation is unfounded and discounts the vulnerability of the Sandy Islet habitat to sea evel rise, cyclones and industrial threats. Loss of habitat will significantly impact on the ecological functioning and process of the green turtle stock.
		• It assesses the impacts on pygmy blue whales as ‘acceptable’, but fails to demonstrate any meaningful mitigation or amendments to the proposal to reduce these impacts. The EIS/ERD states that ‘it is acknowledged that pygmy blue whales have been recorded in the channel between North and South Scott reef’. However, Woodside has proposed to build its TRE drilling unit and up to five production wells in this channel. The EIS/ERD contains no trace of feasible mitigation or proposals to change the location of the TRE well to reduce the intolerable impact of the drilling noise on the pygmy blue whales.
		• The EIS/ERD does little to offer protections for this vulnerable population other than to follow EPA lighting guidelines if practicable and to monitor the population. As with other major WA oil and gas operations, monitoring the demise or decline of a sea turtle population does not equate to a mitigation or protection.
			• MEQ-1: Environmental Quality Management Framework (**Section 5.15**)
			• MEQ-2: Unplanned hydrocarbon release (**Section 5.16**)
			• MF-1: Potential impacts to marine fauna (general) (**Section 5.23**)
			• MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**)
			• MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**)
			• MF-4: Vessel - fauna interaction (**Section 5.26**)
			• MF-5: Potential impacts to marine turtles (**Section 5.27**)
			• MF-6: Presences and abundance of blue whales in Project Area (**Section 5.28**)
			• MF-7: Potential impacts to cetaceans (**Section 5.29**).
			The submission questions the assertion in the draft EIS/ERD that “of the two southern subspecies, only the pygmy blue whale has been observed in the region around Scott Reef”. As described in **Section 5.3.2.5.2** of the draft EIS/ERD, the subspecies Antarctic blue whale (true blue whale) is considered to be uncommon north of 60oS and that given the known distribution of the subspecies it is not considered that the Antarctic Blue Whale will occur within the Project Area.
			With respect to the statements made in relation to acceptability under the EPBC Act:
			• Underwater noise impacts – please refer to:
			  ◦ MF-3: Potential impacts to marine fauna as a result of noise emissions (Section 5.25)
			  ◦ MF-5: Potential impacts to marine turtles (Section 5.27).

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			• Light modelling in relation to flaring – A desktop lighting assessment, taking into account the final National Light Pollution Guidelines for Wildlife (2020) has been undertaken and is provided in Appendix A.1. Flaring at the Torsosa FPSO was accounted for in this assessment. Please refer to MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) for further details. Seabed subsidence – Please refer to MF-5: Potential impacts to marine turtles (**Section 5.27**) Pygmy blue whales - Please refer to: MF-6: Presences and abundance of blue whales in Project Area (**Section 5.28**) MF-7: Potential impacts to cetaceans (**Section 5.29**).
PS-RES-39	CCWA / Climate Analytics	*This submission was provided as two uploaded documents:* • *A 1.5°C Compatible Carbon Budget for Western Australia* • *impact of Burrup Hub for Western Australia's Paris Agreement Carbon Budget.* *These submissions analyse the impact of the Burrup Hub LNG projects for Western Australia's carbon budget under the Paris Agreement and its net zero emissions 2050 goal, building on a study published earlier on Western Australia's carbon budget under the Paris Agreement.* *Both of these submissions can be found in* **Appendix D.20**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** Woodside notes that key to the reports provided by Climate Analytics is the assumption on page 2 of "A 1.5°C Compatible Carbon Budget for Western Australia" which states *"To develop a carbon budget for Western Australia, we draw upon the modelling framework that gives these global results and apply it within the West Australian context so that the CO_2 emissions budget as well as the energy system transformation dynamics are consistent with the global results."* Woodside disagrees with this key assumption and therefore all conclusions following this. Climate change is a global issue – it should be dealt with internationally, or by national governments acting upon international agreements. Unilateral provincial action undermines this effort. With respect to the concerns raised in relation to GHG emissions, please refer to the following responses **Section 5**:

No.	Submitter	Submission and/or issue	Response to comment
			• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**) • GHG-9: Carbon capture and storage (CCS) of Browse gas (**Section 5.10**).
PS-RES-40	Friends of Australian Rock Art Inc (FARA)	*This submission was provided as an uploaded document. The submission relates to:* • *GHG emissions and in particular the cumulative emissions from the Burrup Hub projects, impacts to receptors from climate change and planned mitigation and offsetting measures* • *The Principles of Ecological Sustainable Development* • *potential impacts to Murujuga Rock Art* • *potential impacts to human health resulting from air emissions.* *The full submission can be found in* **Appendix D.22**. *It should be noted that the majority of the submission related to the NWS Project Extension ERD. Where the submission relates to the NWS Project Extension ERD, the submission has been addressed within the NWS Project Extension ERD Response to Submissions.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to the concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**)

No.	Submitter	Submission and/or issue	Response to comment
			• GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**). ***National heritage values*** With respect to the concerns raised relating to potential impacts to the Murujuga rock art site, please refer to the following responses in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**): • SS-RA-36 (**Section 3.3.3, Table 3-10**) • SS-RA-37 (**Section 3.3.3, Table 3-10**) • SS-RA-38 (**Section 3.3.3, Table 3-10**) • SS-RA-39 (**Section 3.3.3, Table 3-10**) • SS-RA-40 (**Section 3.3.3, Table 3-10**) • SS-RA-41 (**Section 3.3.3, Table 3-10**). ***Health concerns*** With respect to concerns raised in relation to public health impacts from emissions from the Burrup Hub on the Burrup Peninsula, please refer to the response to AQ-22 of the NWS Project Extension ERD Response to Submissions (**Section 3.1.3**, **Table 3-3**). With respect to public health impacts from emission resulting from the proposed Browse Project, please refer to the following responses in **Section 5**: • AQ-1: Impact of air emissions on public health (**Section 5.13**).

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-41	Submission on Browse-Burrup Hub_Redacted	*This submission was provided as an uploaded document. The submission relates to:* • *socio-economic considerations of the proposed Browse Project* • *GHG emissions and potential impacts on Australia's heritage and environmental receptors.* *The full submission can be found in* **Appendix D.23**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***Socio-economic considerations*** With respect to socio-economic consideration raised in the submission, please refer to the following responses in **Section 5**: • SE-2: Socio-economic benefits of the proposed Browse Project (**Section 5.35**). ***GHG emissions*** In relation to the concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PS-RES-42	Wilderness Society of WA	*This submission was provided as an uploaded document. The submission relates to:* • *impact on marine fauna including seabird and migratory shorebirds, marine mammals, marine reptiles and fish* • *impacts on marine water quality and in particular the use of Non-water based drilling fluids (NWBF)* • *GHG emissions.* *The full submission can be found in* **Appendix D.24**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***Marine fauna*** With respect to concerns raised with respect to potential impacts to marine fauna, please refer to the following responses in **Section 5**: • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-4: Vessel - fauna interaction (**Section 5.26**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-6: Presences and abundance of blue whales in Project Area (**Section 5.28**)

No.	Submitter	Submission and/or issue	Response to comment
			• MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • MF-11: Potential impacts to fish (**Section 5.33**). ***Marine water quality*** With respect to concerns raised with respect to marine water quality, please refer to the following responses in **Section 5**: • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-5: Use of non-water -based fluids (NWBFs) during drilling (**Section 5.19**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**). ***GHG emissions*** With respect to GHG emissions, the submission states that the Wilderness Society of WA agrees with the findings and recommendations contained in Sustainable Energy Now's assessment submission to the EPA regarding Woodside's Browse Project. No submission by Sustainable Energy Now was made via the Commonwealth approvals process. As such, please refer to Woodsides response within the proposed Browse Project Response to Submissions on State ERD (**Section 6.3**, **Table 6-2**, GHG-RES-34).

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-43	ANON-57NR-WVNR-S (Denmark Environment Centre Inc)	*This submission was provided as an uploaded document. The submission relates to:* • *heritage (both World Heritage properties and National heritage values) in relation to Murujuga Petroglyphs on the Burrup Peninsula* • *potential impacts to wetlands including from impacts of unplanned hydrocarbon releases* • *potential impacts to marine fauna from noise emissions, light emissions and marine discharges* • *potential impacts to the Commonwealth marine environment around Scott Reef and Rowley Shoals* • *potential impacts to Scott Reef including from drilling discharges* • *GHG emissions.* *The full submission can be found in* **Appendix D.25**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-RA-13 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**). ***Wetlands*** With respect to the concerns raised in relation to potential impacts to wetlands, please refer to the following responses in **Section 5**: • MEQ-8: Potential impacts to wetlands (**Section 5.22**). • MEQ-2: Unplanned hydrocarbon release (**Section 5.16**) ***Marine fauna*** With respect to concerns raised in relation to potential impacts to marine fauna please refer to the following responses in **Section 5**: • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-4: Vessel - fauna interaction (**Section 5.26**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-6: Presences and abundance of blue whales in Project Area (**Section 5.28**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**)

No.	Submitter	Submission and/or issue	Response to comment
			• MF-10: New species of Siphonophores (**Section 5.32**) • MF-11: Potential impacts to fish (**Section 5.33**). ***Commonwealth Marine Area*** With respect to concerns raised in relation to potential impacts to the Commonwealth Marine Environment please refer to the following responses in **Section 5**: • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-3: Australian marine parks and State marine parks (**Section 5.17**) • MEQ-4: Produced water (**Section 5.18**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**). Woodside notes that the marine environmental around Scott Reef and Rowley shoals is described in detail in Chapter 5 of the draft EIS/ERD. Potential impacts to these marine areas are described in detail in Chapter 6 of the draft EIS/ERD. ***Drilling discharges*** With respect to concerns raised in relation to development drilling discharges at Scott Reef potential impacts to the Commonwealth Marine Environment please refer to the following responses in **Section 5**: • MEQ-5: Use of non-water -based fluids (NWBFs) during drilling (**Section 5.19**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**). ***GHG emissions*** With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**:

No.	Submitter	Submission and/or issue	Response to comment
			• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**).
PS-RES-44	Redacted-1	*This submission was provided as an uploaded document. The submission relates to:* • *potential impacts to rock art on the Burrup Peninsula* • *GHG emissions* • *potential impacts to human health resulting from air emissions.* *The full submission can be found in* **Appendix D.26**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to GHG-56 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**). ***GHG emissions*** With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**). ***Health concerns*** With respect to concerns raised in relation to public health impacts from emissions from the Burrup Hub on the Burrup Peninsula and Karratha region, please refer to the response to AQ-3 in the NWS Project Extension ERD Response to Submissions (**Section 3.1.3**, **Table 3-3**).

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-45	Redacted-2	*This submission was provided as an uploaded document. The submission relates only to the proposed North West Shelf Project Extension ERD and raises concerns with respect to potential impacts to rock art on the Burrup Peninsula.* *The full submission can be found in* **Appendix D.27**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***National heritage values*** With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-RA-43 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).
PS-RES-46	ANON - 57NR-WV7F-P (Doctors Reform Society of Western Australia)	*This submission was provided as an uploaded document. The submission relates to GHG emissions and in particular the impacts of climate change on human health.* *The full submission can be found in* **Appendix D.28**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** In relation to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment

PS-RES-47	ANON - 57NR-WV7K-U	*This submission was provided as an uploaded document. The submission relates to:*
		• *GHG emissions, and in particular:*
		  • the magnitude of GHG emissions
		  • Australia's obligation under the Paris Agreement
		  • renewable energy
		• *potential impacts to wetlands*
		• *potential impacts to rock art on the Burrup Peninsula*
		• *a newly identified species of siphonophores*
		• *potential impacts to listed threatened species and ecological communities*
		• *potential impacts to Australian Marine Parks and State marine reserves.*
		The full submission can be found in **Appendix D.29**.
			We acknowledge the comments made and provide the following information in response to the matters raised.
			GHG emissions
			With respect to concerns raised in relation to GHG emission, please refer to the following responses in **Section 5**:
			• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)
			• GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**)
			• GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
			Wetlands
			With respect to the concerns raised in relation to potential impacts to wetlands, please refer to the following responses in **Section 5**:
			• MEQ-8: Potential impacts to wetlands (**Section 5.22**).
			National heritage values
			With respect to the concerns raised relating to potential impacts of emissions to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-20 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).
			Marine fauna
			With respect to concerns raised in relation to potential impacts to marine fauna, including the recently identified species of siphonophore, please refer to the following responses in **Section 5**:
			• MF-1: Potential impacts to marine fauna (general) (**Section 5.23**)
			• MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**)

No.	Submitter	Submission and/or issue	Response to comment
			• MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-4: Vessel - fauna interaction (**Section 5.26**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • MF-10: New species of Siphonophores (**Section 5.32**) • MF-11: Potential impacts to fish (**Section 5.33**). ***Australian Marine Parks and State Marine Parks*** With respect to concerns raised in relation to potential impact to Commonwealth Marine Parks including potential impacts from an unplanned hydrocarbon spill, please refer to the following responses in **Section 5**: • MEQ-3: Australian marine parks and State marine parks (**Section 5.17**).
PS-RES-48	ANON - 57NR-WV7Y-9	*This submission was provided as an uploaded document. The submission relates to:* ***GHG emissions, particularly:*** • GHG emission estimates including fugitive emissions • Australia's obligations under the Paris Agreement • Australia's GHG emissions • Coal to gas switching • potential damage to infrastructure (and resultant impacts to the marine environment) as a result of the increased intensity of tropical storms as a result of climate change. *The full submission can be found in* **Appendix D.30**.	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** • In relation to concerns raised in relation to GHG emission, please refer to the following responses in Section 5: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**)

No.	Submitter	Submission and/or issue	Response to comment
			• GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**). In relation to the increase in the intensity of tropical storms, Woodside has been operating in harsh environments for decades, including operational areas prone to cyclones. Woodside's design standards ensure that current and future assets are designed appropriately for a range of variables including extreme weather events and sea conditions. We review the input data every 5 years to ensure that it's still appropriate and conduct risk assessments when our understanding of future weather extremes change.
PS-RES-49	ANON-57NR-WV71-1	*My name is [Redacted name], I migrated to Australia 33 years ago from the - I came to the "lucky country"* *Yet over that 33 years I have witnessed our ever growing greed, at the expense of the natural world. As a recreational scuba diver, I have literally watched marine life and reef disappear.* *It has been under stress for 30 years. Perhaps we were somewhat ignorant back then, but not now, we know the effects of carbon emissions, disturbance and death of our ecosystems. Hence the concept of this complex and risky development to extract more gas seems untenable* *I understand this project will span some 900 kms, tapping into numerous gas fields across multiple basins, with scores of wells, and hundreds of Kms of pipeline. crisscrossing state and commonwealth waters and multiple Environmental regulators, complex web of overlapping or underlapping responsibilities across this complex multifaceted project.* *I must assume that neither State or commonwealth EPA 's could entertain this project, as it intends to extract and process gas for up to 50 years – taking us to 2070 (yet we seek to cut emissions to net zero by 2050) this intention is a total mismatch and would be misleading to citizens.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** In relation to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**). ***Fracking*** Woodside confirms that there is no fracking associated with the proposed Browse Project and a total of three reservoirs in one basin are being targeted for development.

No.	Submitter	Submission and/or issue	Response to comment
		As a layman it is not my role to report to you all the facts and risks – I must trust that you have these in hand from experts internal, external and neutral in scrutiny. There has been much work to inform the public of risks, and I have been well read and informed of these. Hence, it is clear even as a layman that there are many and varied risks, to countless ecosystems. We also know that Potential fracking is dangerous to already compromised drinking water sources. *There is no logic or benefits to this project from an environmental or climate security point of view. Adding to emissions and extending any fossil fuel project into 2070 is unethical, and unnecessary. The environmental risks are of a colossal scale, for no gain to humanity or our earth as we have the capacity to generate energy for the future in other viable and low impact ways.* *If you approve this project (any part of this project) – it is contradictory your responsibilities as Protectors of the Environment, destabilising climate further, and locking in horrendous consequences already happening throughout our country.* *I entrust in your role to actively Protect our natural Environment, essential ecosystems, and future of our children, what will they say – when the planet is unliveable because we simply "wanted more gas".*	
PS-RES-50	ANON-57NR-WVN9-Z (Albany Community Environment Centre (ACEC)	*Woodside proposes to create three new projects to expand Liquified Natural Gas (LNG) production in WA. The ACEC object to these proposals due to Greenhouse Gas emissions, marine environment and impact on cultural heritage.* *Greenhouse Gas Emissions* *According to Woodside:* *"We propose to create a regional LNG hub on the Burrup Peninsula, where we have been safely and reliably operating for more than 30 years. Our vision for the Burrup Hub involves the proposed development of some 20 to 25 trillion cubic feet of gross dry gas resources from Scarborough, Browse and Pluto, relying on our proven LNG facilities – Pluto LNG and the Karratha Gas Plant."*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to concerns raised in relation to GHG emission, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**)

No.	Submitter	Submission and/or issue	Response to comment
		"The Burrup Hub could process more gas than the entire volume extracted from the north west shelf since startup in 1984." *https://www.woodside.com.au/our-business/burrup-hub* *Woodside - YouTube* *In page 17 of the Executive review of the proponent states that:* *"The Proposal will contribute up to 0.03% of global greenhouse gas emissions and this contribution is assessed as contributing to a slight impact (i.e. increase) to global emissions."* *How was the figure of 0.03% of global greenhouse gas emissions arrived at? Does it include the emissions of the gas being burned by consumers, or only the emissions produced by mining and processing? What is the actual amount? Please provide more detail.* *"It was not possible to quantitatively assess the impact of the Proposal to any regional, state or global climate changes."* *Why is a quantitative assessment of impacts on climate change not possible? Surely if a percentage is known, it is possible to access local global, Australia, and statewide climate modeling (as has been done regionally on page 40 of the document) and note that known impacts of climate change the project will be contributing to?* *"While the Proposal will contribute directly to a slight increase in global greenhouse gas emissions, natural gas has the potential to contribute significantly to the reduction in global greenhouse gas emissions by displacing higher carbon intensive power generation (e.g. coal-gas energy switch). As such, the Proposal may result in a net reduction in global emissions."* *What specific trade agreement ensures that LNG from these projects will actually be displacing any other high carbon energy sources, and to a significant enough level to meet Australia's commitments to the Paris Agreement of "limiting global temperature increase to well below 2 degrees Celsius, while pursuing efforts to limit the increase to 1.5 degrees"?*	• GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**). With respect to the quantitative assessment of impacts on climate change, the statement quoted in the submission refers to the NWS Project Extension ERD (not the proposed Browse Project draft EIS/ERD). As stated in the proposed Browse Project EIS/ERD, "it is estimated that Scope 1 and 3 emissions from the proposed Browse to NWS Project will contribute in the range of 0.06% to 0.15% of global GHG emissions depending on the NDC scenario considered". Further, the draft EIS/ERD discusses potential impacts of global climate change on receptors. ***National heritage values*** With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-18 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**). ***Marine fauna*** With respect to concerns raised in regard to potential impacts to marine fauna, please refer to the following responses in **Section 5**: MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) MF-4: Vessel - fauna interaction (**Section 5.26**) MF-5: Potential impacts to marine turtles (**Section 5.27**) MF-7: Potential impacts to cetaceans (**Section 5.29**) MF-8: Potential impacts to sea snakes (**Section 5.30**).

No.	Submitter	Submission and/or issue	Response to comment
		With growing global population and energy demands, is it not likely that natural gas will be used as well as other high carbon energy sources? Will not this set of proposals result in LNG producing nearly half of W.A.'s Greenhouse Gas emissions? Might this be worth mentioning in the Environmental Revision Document? *Liquified Natural Gas (LNG) is methane (APPEA – What is LNG?), a greenhouse gas with a radiative forcing of at least 84 times CO_2 within twenty years (Myhre et al Pg. 74). The Australian Petroleum Production & Exploration Association (APPEA) states "Electricity produced from gas produces 50-70% less greenhouse gas emissions than current coal-fired power generation facilities." (APPEA – How Natural Gas can Minimise Greenhouse Emissions) however, when considering full life-cycle assessment and including fugitive emissions LNG can have higher emissions than coal (Jamarillo et al), and the APPEA's and Woodside's statements are thus worth examining in light of possible bias and comprehensiveness. Additionally, gas is not even mentioned as a viable Energy System Transition in the IPCC's Special Report 'IPCC, 2018: Global Warming of 1.5°C…' (pg.s 324-327) and again an industry bias in advertising it as such is worth critiquing.* *Cultural Heritage* *Additionally, due to emissions on a local scale, will not the projects' release of nitrogen dioxide and sulphur dioxide increase acidification leading to the degradation of Murujuga/Burrup Peninsula rock art? (Are not acidity levels on the surface of rocks adjacent to the Woodside LNG facility now 1000 times higher than before industry was established there in the 1980s?) The projects are not consistent with maintaining priceless, irreplaceable rock art.* *Marine Life* *The waters around the proposed site of the works are home to many species that are listed as critically endangered, endangered or vulnerable including turtles and sea snakes and interrupts the migratory path of multiple species of cetaceans.*	

No.	Submitter	Submission and/or issue	Response to comment
		Of the following marine mammals who migrate through the area,the first is listed as Vulnerable under the EBPC: Humpback whale (Megaptera novaeangliae), Indo-Pacific humpback dolphin (Sousa chinensis), Indian Ocean bottlenose dolphin (Tursiops aduncus),and Dugong (Dugong dugon). As well as a Critically Endangered Short-nosed Sea snake (Aipysurus apraefrontalis) *The fregion hosts several migratory turtles, the first two Endangered and the last three Vulnerable under the EBPC: Leatherback Turtle, Leathery Turtle, Luth (Dermochelys coriacea),* *Loggerhead Turtle (Caretta caretta), Green Turtle (Chelonia mydas), Hawksbill Turtle (Eretmochelys coriacea) and the Flatback Turtle (Natator depressus).* *Woodside's Environmental Revision Document shows Biologically Important Areas (BIAs) for Humpback Whales (as well as for Flatback, Green, and Hawksbill turtles) within the development envelope. In the case of Humback Whales, what is being down to ensure that there will be no impact from the project on the whale's as they migrate? What is being down to ensure that there will be no impact from the project on the other marine mammals and reptiles?* *We urge rejection of the project, as it is inconsistent with decreasing greenhouse gas emissions, as well as impacting cultural heritage and marine life.* *References* *North West Shelf Project Extension – Environmental Revision Document - Revision 1 – December, EPA Assessment No. 2186, EPBC 2018/8335 2019 - Woodside* *https://www.woodside.com.au/our-business/burrup-hub*	

No.	Submitter	Submission and/or issue	Response to comment
		Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forc¬ing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. *https://www.appea.com.au/oil-gas-explained/oil-and-gas/what-is-liquefied-natural-gas-lng/* *https://www.appea.com.au/industry-in-depth/policy/greenhouse/how-natural-gas-can-minimise-greenhouse-emissions/* *Australian Petroleum Production & Exploration Association (APPEA)* *Comparative Life-Cycle Air Emissions of Coal, Domestic Natural Gas, LNG, and SNG for Electricity Generation* *Jamarillo et al* *Environ. Sci. Technol. 2007, 41, 6290-6296* *Australia 1.46% of global emissions 541 924 Gg CO_2-e 2013 (exluding land use...)* *United Nations Framework Convention on Climate Change (UNFCCC) Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015* *X`IPCC, 2018: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the co ntext of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.*	

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-51	ANON-57NR-WVN1-R	*The City of Karratha supports the proposed Browse to NWS Project.* *The City of Karratha supports the rationale for selecting the "piping Browse gas to the Burrup Peninsula for processing onshore" option, being that it provides the opportunity to minimise environmental impact by developing the Browse hydrocarbon resources using an existing onshore facility. The City also notes that this is a proven, low risk option.* *The City is excited about the increased employment and population that this project will bring. The City's preference is that Karratha-based operational workers and their families live in the City of Karratha. The City has the infrastructure and amenities that can support and sustain this growth. Many partners, including Woodside, the NWS Joint Venture and the State Government, have contributed to creating this strong foundation to building the Capital of the North West.* *The City wants to assist Woodside wherever it can to provide support services and infrastructure locally to develop the most sustainable operational model possible.* *The Browse to NWS Project will make a substantial contribution to the State and National economy over the life of the project. The impacts on the environment and social surroundings will be most noticeably felt on the Burrup Peninsula and in the communities of the City. It is important that the public financial benefits generated from the proposed Browse to NWS Project contribute to improving visitors' access to, appreciation of and caring for the exceptional environmental values of the area, and to enhancing the physical and social infrastructure required to accommodate this project while improving liveability.* *The City of Karratha supports Woodside in its efforts and initiatives to reduce carbon emissions from its operations. Based on Woodside's excellent track record, the City expects that Woodside will continue to obtain all necessary approvals, comply with relevant statutory requirements and strive for best practice in operating the Browse to NWS Project.*	We acknowledge the comments made. Woodside, on behalf for the BJV thanks all submitters of letters of support and no objection, for their interest in the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
PS-RES-52	ANON-57NR-WV8G-R	*WA is the only Australian state with increasing greenhouse gas emissions (GHGe). Australia's emissions also continue to increase, with it not being on track to achieve its Nationally Determined Contribution/target under the Paris Agreement. This target has been considered as insufficient to achieve the objectives of the Paris Agreement and limiting global warming to 1.5'C, meaning that our ability to reach this insufficient target is even more shocking. The recent report by the IPCC confirms the importance of limiting warming to 1.5'C in order to avoid adverse impacts to the environment and people. Scientific experts have revealed that climate change has already had demonstrated adverse impacts on WA and has significant predicted impacts. To avoid these impacts, scientific evidence reinforces that global warming must be limited to 1.5'C, which requires rapid reductions in GHGe. This is supported by the EPA's proposed new environmental objective for the Environmental Factor Guideline for Greenhouse Gas Emissions, which is to reduce net GHGe and in order to minimise the risk of environmental harm associated with climate change.* *First and foremost, the separation of the Woodside's "Burrup Hub" project into separate proposals, is inappropriate. It is clear from Woodside's website and diagrams that the proposals are all connected to each other. Assessing each proposal individually has prevented the total, cumulative and aggregated impact of GHGe from the total project from being considered. These must be considered by the EPA and DoEE in assessing the Browse Proposal.* *The total (scope 1 and 3) GHGe of the proposed Browse to NWS Development (Browse Proposal) are estimated to be 36.8 $MtCO_2$-e per annum. This means that the Browse Proposal will contribute 0.09-0.15% of global GHG emissions in 1.5°C and 2°C NDC pathways respectively. This will increase WA, Australian and global GHGe, and therefore is not consistent with limiting warming to 1.5'C, or reducing Australia or WA's GHGe, or the EPA's environmental objective of reducing net emissions.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**).

No.	Submitter	Submission and/or issue	Response to comment
		The mitigation and offsetting measures proposed by Woodside in the EIS/ERD only propose to avoid, reduce or offset a very small proportion of the Browse Proposal's total GHGe. In particular, Woodside only proposes to offset GHGe that it is already legally required to offset under the Safeguard Mechanism, as a result of exceeding the baseline. The Safeguard Mechanism has been heavily criticised for being ineffective in reducing emissions, so the fact that the Browse Proposal exceeds its baseline under this Mechanism demonstrates that it is clearly unacceptable. If the Browse Proposal is allowed to proceed, it must at the very least be required to achieve a net reduction outcome and net zero emissions by 2050. *While Woodside relies on market substitution claims (that LNG will replace coal and reduce global GHGe), it fails to sufficiently substantiate these claims. Accordingly, these claims cannot be accepted by the EPA or DoEE.* *The Browse Proposal is also clearly inconsistent with the environmental/ESD principles in the EP Act and the EPBC Act, Australia's international obligations and NDC under the Paris Agreement and the WA Government's net zero emissions target announced late last year.* *Given the above and adverse impacts the substantial GHGe from the Browse Proposal will have on species, ecosystems and and social, economic and cultural impacts, it cannot be considered acceptable or allowed to proceed. The EPA and DoEE must therefore recommend against approval of the Browse Proposal.*	
PS-RES-53	Clean State	This submission was provided as an uploaded document. The submission is a paper petition submission and has been signed by multiple signatories. The submission states: *I reject the proposed Browse Basin and North West Shelf gas projects* *Dear Dr Tom Hatton (Chairperson EPA WA)* *Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable technologies. We must rapidly move away from all types of fossil fuels, including LNG.*	We acknowledge the comments made and provide the following information in response to the matters raised. ***GHG emissions*** With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**)

No.	Submitter	Submission and/or issue	Response to comment
		We cannot allow the Burrup Hub to become the most polluting fossil fuel project in Australia. Every year until 2070, these projects will emit 95mtpa of carbon pollution which is equivalent to 24 of the largest, dirtiest coal fired power station in WA. This will have devastating impacts on our climate for generations. *I strongly urge you to reject Woodside's proposal as we should be pursuing the cheap and abundant renewable resources we have available right here in WA.* *The full submission can be found in* **Appendix D.31**.	• GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

PS-RES-54	ANON-TCUY-7GH9-4	This submission was provided as an uploaded document. The submission relates to:
		
		• GHG emissions, particularly:
		  ◦ Australia's obligations under the Paris Agreement
		  ◦ Climate Analytics carbon emission estimates and carbon budget for Western Australia
		  ◦ Browse and Burrup hub carbon emission intensities
		  ◦ gas as a transition gas and the displacement of coal
		  ◦ future gas demand outlook
		  ◦ Western Australia's carbon policy
		  ◦ issues with Woodsides GHG accounting and methodology
		  ◦ failure to provide detail of investment plans, inadequate CO_2 abatement from offsets.
		
		The full submission can be found in **Appendix D.32**.
			We acknowledge the comments made and provide the following information in response to the matters raised.
			
			GHG emissions
			
			The submission is largely based on a report prepared by Climate Analytics with respect to the impact of the proposed Browse Project on Western Australia 'carbon budget'. Please refer to GHG-RES-39 of this table for Woodside response to the Climate Analytics report.
			
			Woodside notes that key to the report provided by Climate Analytics is the assumption on page 2 of "A 1.5°C Compatible Carbon Budget for Western Australia" which states
			
			"To develop a carbon budget for Western Australia, we draw upon the modelling framework that gives these global results and apply it within the West Australian context so that the CO_2 emissions budget as well as the energy system transformation dynamics are consistent with the global results."
			
			Woodside disagrees with this key assumption and therefore all conclusions following this. Climate change is a global issue – it should be dealt with internationally, or by national governments acting upon international agreements. Unilateral provincial action undermines this effort.
			
			With respect to concerns raised in relation to GHG emissions, please refer to the following responses in **Section 5**:

No.	Submitter	Submission and/or issue	Response to comment
			GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) GHG-8: The role of gas in the future energy mix (**Section 5.9**) GHG-9: Carbon capture and storage (CCS) of Browse gas (**Section 5.10**).

Proforma submissions

The following submissions represent ‘proforma submissions’ where a template of a submission has been prepared by an organisation, enabling members of the public to provide a submission. An option is also often provided to provide additional comments to the submission. Proforma submissions and additional text, as well as the Proponents response are provided below.

The following proforma submissions have been grouped as follows:

Group 1 – Submissions primarily related to air emissions including GHG emissions

Group 2 – Submissions primarily related to potential impacts to the marine environment

Group 3 – Submissions primarily related to the Burrup Hub and onshore development.

No.	Submitter	Submission and/or issue	Response to comment
Group 1 – Submissions primarily related to air emissions including GHG emissions			
PRO-G1-RES-1	Proforma submission	*Header: Don't approve the proposed Browse Basin and North West Shelf LNG projects* *Dear [redacted name] Chairperson EPA WA,* *I am writing regarding the proposed Browse Basin and North West Shelf projects. If these projects were to proceed, the Burrup Hub would become one of the largest and most polluting fossil fuel projects in the world. If Western Australia is to meet its policy goal of net-zero emissions by 2050, we cannot afford to expand our LNG industry.* *Gas is not a 'transition' fuel. We have the resources and technology for a rapid transition to renewable energy. We should be embracing the potential for job opportunities and regional development in carbon farming and the renewables sector. Gas is not part of the solution for climate change, or the solution to sustainably power Western Australia into the future. A large scale LNG project with a lifespan of over 50 years cannot go ahead.* *Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable technologies. We must rapidly move away from all types of fossil fuels, including LNG. I strongly urge you to reject Woodside's proposal as we should be pursuing the cheap and abundant renewable resources we have available right here in WA.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**) • GHG-9: Carbon capture and storage (CCS) of Browse gas (**Section 5.10**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-2	Proforma submission	*Header: Reject the proposed Browse Basin and North West Shelf LNG projects* *Dear [redacted name] Chairperson EPA WA,* *I am writing in response to the current consultations on the Browse Basin and North West Shelf extension projects. If the proposed Burrup Hub extension projects proceed, the Burrup Hub will be Australia's largest and most polluting fossil fuel project, and one of the largest fossil fuel developments anywhere in the world.* *The extent of the emissions that would result from gas collection and processing at the Burrup Hub would cancel out the gains made by both individual Australians and industry seeking sustainable ways to reduce their carbon emissions.* *Allowing for both the creation of new, and the extension of existing, large-scale carbon pollution sources such as the proposed Burrup Hub, will breach our international carbon reduction obligations, and push our national reduction goals out of reach. The carbon pollution created by this project makes it fundamentally incompatible with Western Australia's policy goal of net zero emissions by 2050.* *The claims made by Woodside that gas is a 'clean' fuel contributing to reduced emissions are unsubstantiated and misleading. In 2019, LNG overtook coal as the most significant driver of pollution increases across the globe. LNG is a fossil fuel with pollution at every stage of its development and use and cannot be considered a solution to address climate change.* *The carbon emissions from the Burrup Hub will have a significant detrimental impact for decades to come. At a time where Western Australia needs to be taking contribution to global carbon emissions seriously, approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible.* *The life-time emissions of these projects must be considered. It is for these reasons that I strongly urge you to reject Woodside's proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**) • GHG-9: Carbon capture and storage (CCS) of Browse gas (**Section 5.10**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-3	Proforma submission	*To Chairperson Environmental Protection Authority WA and Secretary Department of Environment and Energy,* *I am writing in response to the current consultations on the proposed Browse Basin and North West Shelf (NWS) expansion projects and the catastrophic effect these would have on the ancient petroglyphs of the Burrup Peninsula.* *The proposed increase in emissions of sulphur and nitrogen dioxides, mixed with moisture, will form additional strong acids which have been proven to dissolve the rock surface patina and thus the rock carving images which form a vital part of Aboriginal Australia's cultural heritage.* *The impacts of this increase in total cumulative emissions on the Burrup Peninsula must be calculated, considered, regulated and monitored. Only then can the actual emissions from the Browse-NWS expansion projects be calculated to estimate the extra harm they will do to the environment and the ancient rock art.* *Approvals for the Burrup Hub should not go ahead until the State's government's Rock Art Strategy Stakeholder Committee has activated the promised monitoring program.* *"I am totally against it: I don't want any more industry to be built in this area. I've been out here my entire life and there's rock art that I 've noticed which is actually starting to fade away. I mean why would UNESCO want to approve World Heritage Listing in a place where they're going to continue to develop more industry... I want to see the rock art given first priority, and I really want to see World Heritage Listing, because it brings protection with it.'* *Clinton Walker, Ngarluma/Yindjibarndi man and director of award-winning Ngurrangga Tours.* *Quotation from 2019 ABC RN Singing the Stones Radio Documentary* *https://aus01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.abc.net.au%2Fradionational%2Fprograms%2Fearshot%2Fsinging-the-stones%2F11261158&data=02%7C01%7Cinfo.epa%40dwer.wa.gov.*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-49 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).

No.	Submitter	Submission and/or issue	Response to comment
		'The destruction of our country is now out of control with Woodside preparing, with the active assistance of the WA State government, for the wholesale destruction of these ancient carvings that link us spiritually with our ancestors.' *[Redacted name] elder and custodian of the Burrup Peninsula. I urge you and the EPA to consider the longevity and well being of the ancient Murujuga petroglyphs against the short-term profits of the gas industry.*	
PRO-G1-RES-4	Proforma submission (additional text)	*I am alarmed that these projects are being considered as, the Burrup Hub would become one of the largest and most polluting fossil fuel* *Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable technologies. There are towns in Western Australia already successfully making use of wind to supply almost half of their town's power needs. We have the technology and the expertise to build more wind farms.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-5	Proforma submission (additional text)	*As Australia burns, I write to you regarding the proposed Browse Basin and North West Shelf projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-6	Proforma submission (additional text)	*WA must tackle its emissions through the creation of jobs and investment in renewable technologies, including large-scale solar in the Pilbara and Kimberley which would permit the export of clean, renewable power to our neighbours in Indonesia, Singapore and Timor. We must rapidly move away from all types of fossil fuels, including LNG.* *I thank you in advance for your proactive, enlightened stance on this crucial issue.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-7	Proforma submission (additional text)	*If Western Australia is to meet its policy goal of net-zero emissions by 2050, we cannot afford to expand the LNG industry.* *I strongly urge you to reject Woodside's proposal as we should be pursuing the cheap and abundant renewable resources available in WA.* *Please advise me of your decision and the reasons for it, by email.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-8	Proforma submission (additional text)	*You have a duty of care to the people and our environment and wildlife. It is reprehensible that you even entertain the idea of these gas mines. It would be an absolute dereliction of duties to approve this. Our country is on fire. I cry every day because 1.25 billion animals have burned alive holding their babies in their arms. Our irreplaceable forests are burned beyond recognition like an atomic bomb has been dropped on us, and most of our country was already in severe drought. Arsonists started the fires, and climate change is the reason the fires became so big and spread so far. You have no business approving any gas mine that will pump huge amounts of pollution into the air. Our emissions need to go down, it is our commitment in the Paris Agreement and approving these mines would be in failing to live up to our commitment. It would in fact make you culpable in the destruction that will follow and creating the poisonous air we will be breathing. You need to protect life in WA, not a gas mine.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-9	Proforma submission (additional text)	*If these projects were to proceed, it would result in one of the largest and most polluting fossil fuel. WA has the resources and technology for a rapid transition to renewable energy. We should be embracing job opportunities and regional development in carbon farming and the renewables sector. Gas is not part of the solution. A large scale LNG project cannot go ahead. We need clean jobs and renewable technologies. We must rapidly move away from all types of fossil fuels, including LNG. I strongly urge you to reject Woodside's proposal.[redacted name]*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-10	Proforma submission (additional text)	*If the proposed Browse Basin and North West Shelf projects were to proceed, Western Australia would not meet its policy goal of net-zero emissions by 2050. Fossil fuel is dying and to propose such projects harms Australia's more profitable tourism, agricultural and housing industries. WA has the resources and technology to lead the world in a rapid transition to renewable energy, geographically we are in a perfect spot for solar and wind projects. We should be embracing the potential for job opportunities and regional development in the renewables sector.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-11	Proforma submission (additional text)	*Gas is not part of the solution for climate change, it only emits more carbon into the air, to disastrous effects such as this summer's fatal bushfires. Australia is one of the countries to be hit the hardest by climate change, and so it would likely be destroyed itself by bushfires, storms, cyclones and the rising sea levels set to hit Australia regardless. It is unsustainable and a drain on our natural resources.* *I strongly urge you to reject Woodside's proposal as we should be pursuing the cheap and abundant renewable resources we have available right here in WA, before it is too late to even try.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-12	Proforma submission (additional text)	*Why do I even have to write this?* *Why in God's name is it even being considered?* *Just grow a set & do the right thing, instead of the expedient thing! Please!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**).
PRO-G1-RES-13	Proforma submission (additional text)	*And any further damage and disruption to Burrup is petroglyphs can not be condoned. This is a World Heritage listed site of national and global significance, containing the oldest known portrait of a human being on the planet. It is a place of extreme cultural value and definitely not the location for a gas plant* *Also had is not a 'transition' fuel. We have the resources and technology for a rapid transition to renewable energy. We should be embracing the potential for job opportunities and regionally.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**). With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to GHG-68 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-14	Proforma submission (additional text)	*PLEASE think carefully before considering approval of this project. The science tells us we should be very wary of gas. Is it really necessary... do the benefits really outweigh the costs to the whole world. Think globally.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-15	Proforma submission (additional text)	*There is no doubt in my mind that our devastated Australia has been driven by climate change.* *Hotter temperatures and drier conditions in Australia are contributing to a longer fire season. Australia has now burnt through more than 10 million hectares, and killed more than a billion Australian fauna. The incredible toll this heating up crisis is taking on us, our environment, wildlife and air quality is immeasurable. The costs of all the words of politicians, but no real action, has crippled our country* *I am very concerned that the govt's 'business as usual' stance will destroy Australia, unless the government actually acts on the obvious climate change through powerful new legislation, and urgently reduce our emissions. Bear with me a moment - think about it, Australia is already a hot place, what happens when it suddenly gets hotter by a few degrees, remember this is not Greenland where it gets warmer and the ice melts and they can now go outdoors some more. While that happens in Greenland - we're getting cooked!* *I urge the EPA not to allow this massive carbon producing demon to destroy us!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-16	Proforma submission (additional text)	*I know it is difficult for some people to believe, but the proposed Browse Basin and North West Shelf projects will be a planetary nightmare, just like the bushfires that are ravaging our country.* *If we don"t meet that goal, we're toast; burnt toast, at that.* *Development in carbon farming and the renewables sector. Gas is neither part of the solution for climate change, nor the solution to sustainably power Western Australia into the future. A large scale LNG project with a lifespan of over 50 years should not even be considered.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**). • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
		Western Australia must reduce its emissions through the creation of clean jobs and investment in renewable technologies. We must rapidly move away from all types of fossil fuels, including LNG. *I strongly urge you to reject Woodside's proposal, and instead pursue the cheap and abundant renewable resources we have here in WA.*	
PRO-G1-RES-17	Proforma submission (additional text)	*We have already seen, Australia-wide, the devastating effects of climate change, with only a 1 degree rise in world temperatures. We cannot afford to add any more carbon-dixide to the atmosphere.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-18	Proforma submission (additional text)	*For australia's sake STOP.* *The only people to benefit from this project in the long term are the backers and the profiteers. Make a choice for the people, not the magnates!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-19	Proforma submission (additional text)	*We MUST get our Energy Policy into THIS century with Clean Renewables - NOT more polluting Fossil Fuels!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-20	Proforma submission (additional text)	*Please note I ask this despite the fact that the decision would be financially detrimental to me personally as a Woodside shareholder.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-21	Proforma submission (additional text)	*We are 5 years away from enough RENEWABLE energy for the whole planet. Why are we doing this?* *Isn't the bush-fires raging across the width and breadth of this country a big enough hint to what is happening to the planet?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-22	Proforma submission (additional text)	*First, it is disheartening as a citizen to see the strength of influence that the major energy companies have over our state public bodies such as the EPA, paid for by taxation to monitor and mediate international corporate influences not necessarily acting in our best interest. The degree of trust in politicians and their government agencies depends on their performance. The capitulation of the EPA to Woodside in a context of low transparency deserves an erosion of confidence from the public. OK, so big deal that can be ignored. But only in the short term as the banking sector (rock bottom in public trust) found out.* *I'm objecting to the expansion (without apparent limit or control by government) of the Burrup gas projects. It again reflects the hegemony that international companies have over our government in relation to development of our resources. And we get little for it except higher carbon emissions, temporary employment and persistently high local gas prices.* *I want you to show some courage and reinstate forceful controls over these companies and PUBLICLY explain your position -especially if you renege on the independence of your own advice. That, or resign.* *In summary, I am writing about your involvement in the current consultations on the proposed Browse Basin and North West Shelf projects, and about your approach to it with the knowledge that emissions will negate the gains made by real efforts (often coming at a personal cost) from caring people and industries with an interest in this country beyond a financial one.* *You have the scientific facts at hand. Use them. Carbon emissions from the Burrup Hub will have a negative effect on the environment's carbon levels for lifetime magnitudes.* *The global impacts of these projects must be considered in a scientific and humanitarian view, not a monetary viewpoint. The very rich in these companies can avoid global warming consequences - away from rising sea levels, away from violent weather events, away from increases in disease, away from the flood of desperate people moving to first world arenas. Those most negatively affected by climate change are the least able to deal with its impacts. It is for these reasons that I strongly urge you to reject Woodside's proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-23	Proforma submission (additional text)	*Please please think of the climate disaster we are leaving our children and grandchildren.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-24	Proforma submission (additional text)	*We need to stop supplying easy gas- it's delaying transition to cleaner more renewable forms of power.* *We need to be 50% cut in emissions by 2030- for a 50% of living on a habitable planet/ not real good odds for my children.opening these projects will seal the dark fate of future generations*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-25	Proforma submission (additional text)	*As my address below shows, I am not one of your constituents however, the emissions emitted from this proposed project will not recogise the various boundary lines we have imposed on the landscape; they will impact across all sectors of our shared world. If we are to have any chance of limiting global warming to 1.5°, we cannot afford to grant Woodside the approvals required to commence this project*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-26	Proforma submission (additional text)	*My name is [redacted name], and I am from [redacted]. I write to you regarding the proposed Browse Basin and North West Shelf projects, and to formally request that these projects are NOT to be approved. Should these projects were to proceed, the Burrup Hub would become one of the largest and most polluting fossil fuel projects in the world. If Western Australia is to meet its policy goal of net-zero emissions by 2050, we truly cannot afford to expand our LNG industry.* *We already have the resources and technology for a rapid transition to renewable energy. Instead of starting up more gas projects, we should instead be embracing the potential for job opportunities and regional* *WA has already suffered through catastrophic bushfires this season. We cannot go on embarking on heavy carbon emitting projects; it is non-viable for the environment and all living beings, instead, WA needs to look at reducing emissions through the creation of clean jobs and investment in renewable technologies. We must rapidly move away from all types of fossil fuels.* *Once again, I strongly urge you to reject Woodside's proposal. The risk/cost benefit analysis does not weigh up.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-27	Proforma submission (additional text)	*Having just spent the last month out fighting fires NSW that scientists link directly to climate change, I implore you on the strongest possible terms to reject the proposal which will undoubtedly exacerbate our current drought, fire and extreme weather problems.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-28	Proforma submission (additional text)	*As a final note, my postcode should not negate my high concern. Being a now quite mature Australian, and citizen of this Planet. We will all suffer through ill-advised environmental destruction for short term gain.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-29	Proforma submission (additional text)	*This is not the time to be investing in high emissions projects. We must drastically reduce our emissions in line with the science of climate change.* *Our futures, that of your children and grandchildren are in your hands.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-30	Proforma submission (additional text)	*We know that CO_2 emissions from fossil fuels are exceeding what the planet can cope with. If the proposed Burrup Hub projects proceed, the Burrup Hub will be* *The carbon pollution created by this project makes it fundamentally incompatible with Western Australia's policy goal of net zero emissions by 2050.* *Considering approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).
PRO-G1-RES-31	Proforma submission (additional text)	*WE SHOULD BE DEVELOPING AND USING EXISTING RENEWABLE OPTIONS RATHER THAN SUPPORTING AND CONTINIUNG AN INDUSTRY THAT THAT BENEFITS FEW BUT NEGATIVELY AFFECTS EVERYONE.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-32	Proforma submission (additional text)	*Please take the environment into consideration and the longer term effects - not just on ourselves but future generations.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-33	Proforma submission (additional text)	*Come to Melbourne and breath the most dangerous polluted air in the World if you're happy that is the future.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

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PRO-G1-RES-34	Proforma submission (additional text)	*If you have not noticed the country is burning!!! When the whole world is burning will you stop !!!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-35	Proforma submission (additional text)	*You have the public duty & personal ability to do your job, Save the environment and protect Australia's future, let's we how deep the corruption in WA runs.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-36	Proforma submission (additional text)	*I strongly urge you to reject Woodside's proposal as the state should be pursuing the cheap and abundant renewable resources we have available right here in WA.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-37	Proforma submission (additional text)	*Now more than ever before it imperative that everything possible is done to protect every aspect of the environment.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-38	Proforma submission (additional text)	*HOW DARE YOU!* *The life-time emissions of these projects must be considered. It is for these reasons that I strongly INSIST you to reject Woodside's proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-39	Proforma submission (additional text)	*If one day, there's a Royal Commission into what corporations were allowed to spew into our atmosphere, knowing what we now know about Climate Change, will you feel comfortable with what the EPA is allowing to go through?* *I, for one, don't want the Burrup Hub to become the most polluting fossil fuel project in Australia! Do you?* *Hence If these projects were to proceed, the Burrup Hub would become one of the largest most polluting fossil fuel projects not just here, but IN THE WORLD. If Western Australia is to meet its policy goal of net-zero emissions by 2050, how can we expand this industry?* *Please don't allow pressure from politicians to influence your ability to do your job and make the right, independent decisions.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).
PRO-G1-RES-40	Proforma submission (additional text)	*The last thing we need is a large project that will increase our carbon emissions. We should be 100% focused only on wind, solar and hydro power and lowering fossil fuel exploration and use.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-41	Proforma submission (additional text)	*Australia's largest and most polluting ofossil fuel project, and one of the largest fossil fuel developments anywhere in the world.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-42	Proforma submission (additional text)	*I write in sadness today because our country is facing a long road to recovery after a summer of catastrophic bushfires. These fires have occurred after many warnings, first from science and then from the broader community, that climate change is real and presents an immense threat to the Australian continent.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
		Scientists tell us that as a global community we must reduce the emission of greenhouse gases by 45% by 2030. That leaves us ten short years to undertake the most challenging restructure of our economy, society and way of life we have ever attempted. I would argue that as a wealthy nation, and as a fossil fuel exporter, Australia and Western Australia should be a leader in this struggle, by refusing to allow any further expansion of fossil fuel extraction. *We simply cannot afford for these Woodside projects to proceed. They would make the Burrup Hub one of the largest and most polluting fossil fuel* *It will leave the workers in that industry vulnerable, as those facilities become stranded assets in the near future.* *I strongly urge you to reject Woodside's proposal as the state should be pursuing the cheap and abundant renewable resources we have available right here in WA. Please, do the right thing for us all.*	
PRO-G1-RES-43	Proforma submission (additional text)	*I write as a lay person who on reading the public material available find it incredible that WA is even considering allowing a project that will cause such high levels of pollution.* *I'm sure you will receive many fully documented responses but mine is simply from the heart. Do we really need the mantle of having one of the largest and most polluting fossil fuel developments anywhere in the world on our doorstep.* *Please reject this on the grounds of common sense and protecting our environment for my 10 grandkids.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-44	Proforma submission (additional text)	*Every 16 tonne of natural gas combustion provides 44 tonne of CO_2 - more than some coals!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-45	Proforma submission (additional text)	*The devastating climate change related fires of the Eastern Seaboard is a wake up call to every single Australian. We must free ourselves from coal and gas ASAP. Fossil fuel is not the future. You and your committee have the ability to signal change by denying this project.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-46	Proforma submission (additional text)	*This month my family & I narrowly escaped losing our home to bushfires. These fires were exacerbated by climate change , fuelled by our mining & export of fossil fuels.* *It is time to stop any new projects, forgo any extensions & bring to a timely close all ongoing projects, for the sake of our planet.* *It could only be considered by someone who has already given up on the future of our planet.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-47	Proforma submission (additional text)	*STOP FOSSIL FUEL PRODUCTION AND INVEST IN RENEWABLES*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-48	Proforma submission (additional text)	*I fully support the following points and I want to make this one first: the current bushfire emergency is a foretaste if what is to come if we do not URGENTLY act to limit greenhouse gas emissions. We cannot afford the proposed extension by Woodside. We cannot afford any expansion of oil, gas and coal - we need to start phasing them out NOW.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-49	Proforma submission (additional text)	*As a deeply concerned mother of 5 children, I am very well aware of the impacts of climate change and in particular, the role of fossil fuels in our environment's demise. I am therefore writing with regard to the current consultations on the Browse Basin and North West Shelf extension projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-50	Proforma submission (additional text)	*Even though I obviously do not live in the area, I am concerned for Australia and the planet and so should you be.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-51	Proforma submission (additional text)	*The life-time emissions of these projects and their contributions to global emissions of CO_2 and methane must be considered. It is for these reasons that I strongly urge you to reject Woodside's proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-52	Proforma submission (additional text)	*Even though I do not live in WA, this issue is a global issue, concerning all who live on this planet. The one we call home. The one that is unique. The one we must look after. The one we have been destroying. The one that will be subjected to disaster after disaster, because we have not listened, we have been totally out of balance. To restore some balance and avoid total apocalypse, we must act on this without delay. And is a radical way. Climate action demands that we transition to renewable energy and sustainable practices. That we stop new fossil fuel projects. Now.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-53	Proforma submission (additional text)	*I object to it taking so long to get this project up and going! What's wrong with you people, why the hell can't you approve this wonderful project faster?* *God speed,*	We acknowledge the comments made and thank you for your interest in the proposed Browse Project.
PRO-G1-RES-54	Proforma submission (additional text)	*WE ONLY HAVE ONE PLANET AND IT BELONGS TO ALL LIFE _ PLEASE STOP DESTROYING IT*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-55	Proforma submission (additional text)	*If the proposed Burrup Hub extension projects proceed, the Burrup Hub will be Australia's largest and most polluting fossil fuel project, and one of the largest fossil fuel developments in the world.* *The extent of emissions that would result from gas collection and processing at the Burrup Hub would cancel out the gains made by both individual Australians and industry seeking sustainable ways to reduce their carbon emissions.* *The science is telling us that the earth has passed a series of critical systems tipping points. (1) We can no longer afford to extract fossil fuels. Doing so is suicide.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-56	Proforma submission (additional text)	*The life-time emissions of these projects must be considered. We have a responsibility to include all ultimate emissions of any fossil fuels we export. All add to global heating and its disastrous consequences.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-57	Proforma submission (additional text)	*Tom, for my children, your grandchildren, all the wild and wonderful creatures of this world - we cannot allow this proposal to go ahead. Greed can not be the driving factor here. You can not allow the profits into the pockets of Woodside and the political cowardice and fear of the Government blindside all the evidence that you and I know screams this is a terrible project to approve. My stomach churns at the thought of it - especially given the time we are in with my friends on the east coast rebuilding their family properties ravaged by fire.* *If this project goes ahead we are responsible for future climate damage. How will we look our children and grandchildren in the eyes and tell them we did all we can? The future needs courage and leaders. We are relying on the EPA to lead the way.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-58	Proforma submission (additional text)	*See the facts below. You cannot let these projects go ahead. Australia will become uninhabitable, or a dangerous place to live (it already is if you look at the fires, one yesterday less than a kilometre from our house) due to climate change. We cannot afford any more warming caused directly by fossil fuels. I feel betrayed by [Premier of Western Australia] , signing off on no fossil fuels by 2050 and now pushing for this. I do believe our governments are corrupt and in the pockets of Woodside, Chevron, Whitehaven etc because these projects are not in the public interest, let alone the natural environment. They don't care about Koalas who can't move fast enough to escape bushfires.* *Please for once, protect our environment. Our children are only 11 years old, I want them to have a world for their life that isn't miserable.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).

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PRO-G1-RES-59	Proforma submission (additional text)	*I am writing in response to the current consultations on the Browse Basin and North West Shelf extension projects. And I write in the light of the fires now engulfing Australia. It would be an extremely irresponsible action to approve such fossil fuel projects when the emphasis must now be for Australia, and all countries, to leave fossil fuels in the ground and support renewables and transition projects for people and communities. Surely these fires are a wake up call for all.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-60	Proforma submission (additional text)	*We have seen from the current state of our country that climate change has brought catastrophic consequences to our environment, our food industry, air quality, water supply and therefore peoples lives. This is just the beginning if we don't make drastic changes now. You are there for the people to protect us from this happening.* *Please step up and enforce these changes to enable a brighter future than we are looking at now.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-61	Proforma submission (additional text)	*I am living with bushfires and global warming is already here. Please do not exacerbate the situation. Look to renewables not fossil fuels that will heat the planet even more.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-62	Proforma submission (additional text)	*Morally this development is wrong and not complying with the community or international expectations.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-63	Proforma submission (additional text)	*Allowing for both the creation of new, and the extension of existing, large-scale carbon pollution sources such as the proposed Burrup Hub, and proposed supporting infrastructure like the Subsea 7 pipeline bundle project for Heron Point will breach our international carbon reduction obligations, and push our national* *At a time when we are seeing the devastating results of climate change caused by rising emissions resulting in horrendous bushfires throughout Australia, it would be sheer madness to allow this expansion to go ahead.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-64	Proforma submission (additional text)	*Although not a resident of WA, our current bushfire crises confirm that we can't afford to be parochial about issues facing the planet, therefore*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-65	Proforma submission (additional text)	*While I live on the east coast of Australia, right now we are experiencing the predicted impact of a warming and drying climate due to climate change. The bushfires are horrendous. We must reverse the levels of carbon pollution we are pumping into our atmosphere or, like a billion animals on the east coast this summer, face extinction.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-66	Proforma submission (additional text)	*An ecological conversion is overdue!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-67	Proforma submission (additional text)	*It's insane to consider signing any new contracts, any extension or supporting any proposal. Fossil fuel extraction must end.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-68	Proforma submission (additional text)	*I can only change how I impact the planet, I'm calling on you to prevent the impact of others, please.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-69	Proforma submission (additional text)	*As bushfires rage throughout many parts of Australia we are brought face to face with the necessity of taking positive action to curb climate change. We desperately need to take positive steps to reduce fossil fuel use. Maybe you could invest in solar power*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-70	Proforma submission (additional text)	*What we are currently living through in the worst bush fire season in our history is telling a strong message that we simply must heed. We need to stop polluting our earth we don't have another.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-71	Proforma submission (additional text)	*As a original western Australian I am horrified you would look at granting any extension to this project. Our country is on fire and the mining and gas fracking have so much to answer for. It is clear that donations (or as we call it bribes) get many of these approved.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G1-RES-72	Proforma submission (additional text)	*LNG is a fossil fuel with pollution at every stage of its development and use, and cannot be considered a solution to address climate change.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

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PRO-G1-RES-73	Proforma submission (additional text)	*We need energy - but it must be renewable energy.* *Your company's rapacious greed for profit won't be impressive when the planet is dead.* *Do you really want to go down in history alongside Mr Morrison? Shame on both of you.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-74	Proforma submission (additional text)	*The CO_2 and other emissions already in the atmosphere have created the bushfires in eastern Australia this summer. These have resulted in 30 deaths, an enormous number of hospital admissions, the loss of livelihoods for countless small businesses, over 1 billion animal deaths, and loss of over 10 million hectares of farmland and natural habitat. The proposed project would lock in even more severe summers in the future.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-75	Proforma submission (additional text)	*But of course you pollys won't listen to any of the above, as I see it you are determined to ensure all life on Earth is exterminated in the pursuit of some so-called "economy" for the already privileged. [The President of the United States of America] , and the [Prime Minister of Australia] are living proof, Do; please prove me wrong?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-76	Proforma submission (additional text)	*At some time people who have the ability must put a stop to our continuing dependence on fossil fuels and drive the development of new and sustainable technologies. This is the time. You are one of those people, Tom.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-77	Proforma submission (additional text)	*When will stop this mindless idea of endless economic and population growth. We are doing to much damage to our planet I have seen it for years a s a farmer.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-78	Proforma submission (additional text)	*We must start using our intelligence and act as a planet, for we are all in great peril!.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-79	Proforma submission (additional text)	*As a previous resident of WA, I am appalled at the thought that there would be approval for fossil fuel projects in the northwest. As the ongoing drought and fires show, the country is heading on a slippery slope ride to a tipping point in destroying our way of life along with the uniquely Australian environment and wildlife.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-80	Proforma submission (additional text)	*The Burrup Hub project proposals are sheer lunacy. Neither Australia nor the world can afford the environmental and human cost. Surely the EPA cannot endorse such an enormous additional contribution to atmospheric pollution, at the very time when the need to drive emissions down is more urgent than ever.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-81	Proforma submission (additional text)	*I am astounded that the political party for which I voted would even consider the proposed development of the 'Burrup Hub'.* *This 'Burrup Hub' would be one of the largest fossil fuel developments in the world. And this at a time of our Global Heating Crisis!* *The narrow and dying interests of Woodside are desperate to exploit our resources. They are pushing this proposed development where they know there is weak governance.* *The world is now faced with a moral imperative*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-82	Proforma submission (additional text)	*PLEASE for the sake of my grandchildren and yours, do the right thing and reject Woodside's LNG projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-83	Proforma submission (additional text)	*The emissions that would result from gas collection and processing at the Burrup Hub would cancel out the gains made by both individual Australians and industry seeking sustainable ways to reduce their carbon emissions.* *The carbon emissions from the Burrup Hub will have a serious detrimental impact for decades to come.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-84	Proforma submission (additional text)	*Please find a more Natural and Sustaining method.* *The Future of the Ecosystem that supports our Race, and all other Living species are at stake.* *Seek out your Competition and Band Together.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-85	Proforma submission (additional text)	*It is time to look and preserve the sustainability of our once wonderful planet. Foe each and every creature and all flora and fauna on earth.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-86	Proforma submission (additional text)	*As a resident of [redacted name] for nearly 10 years* *North West Shelf gas extraction is the single greatest source of air pollution in our state, dwarfing road vehicle emissions.* *In particular, uncontrolled emissions of methane during the extraction process pose a particularly dangerous threat, as they have at least 25 times as great a greenhouse effect as carbon dioxide. Natural gas companies have shown quite a lax approach to stemming such emissions.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).

No.	Submitter	Submission and/or issue	Response to comment
		Allowing for both the creation of new, and the extension of existing, large-scale carbon pollution sources such as the proposed Burrup Hub would breach our international carbon reduction obligations and push our national reduction goals out of reach. The carbon pollution created by this project makes it fundamentally incompatible with Western Australia's policy goal of net zero emissions by 2050. *I thank you in advance for your enlightened, forward-thinking stance on this crucial issue.*	
PRO-G1-RES-87	Proforma submission (additional text)	*The carbon emissions from the Burrup Hub will have a significant detrimental impact for decades to come. At a time when Western Australia needs to be taking our contribution to global carbon emissions very seriously, and in light of the recent fires, approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-88	Proforma submission (additional text)	*Do you know [EPA Chair] that the temperature of the earth, land, oceans and atmosphere, has increased by 1% since the industrial revolution? This seems like a minuscule temperature increase, but the earth has not been this warm for over 50 000 000 years. Life on earth can therefore not adapt to such a sudden increase in temperature, which is what 100 years is in physical adaptation terms.* *Life on earth cannot survive the heating of the surface and the atmosphere of the planet because of the shortage of water on land the heating causes. Hence the doughts all over Australia and other parts of the world as well. The heating of the planet is caused by the burning of fossil fuels such as LNG that loads the atmosphere with CO_2. If all the forests, plants, especially the trees had not been bulldozed then perhaps the CO_2 may have been absorbed, but there are not enough trees and other plants left, to stop the planet heating.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
		The oceans have been absorbing heat as well, but that absorption process has slowed down. If you would like to learn more about how the burning of fossil fuels is killing life on earth, you may like to listen to Professor Will Steffen, he's an expert on the effects of temperature increase or climate change if you will. An innocuous term that the IPCC has decided to keep on using, even though they know it is an emergency, but stupidly they do not want people to get anxious. You can ask Professor Mark Howden who is also a climate change expert and on the IPCC. *The extent of the emissions that would result from gas collection and processing at the Burrup Hub would cancel out the gains made by both individual Australians and industry seeking sustainable ways to reduce their carbon emissions. The claims made by Woodside that gas is a 'clean' fuel contributing to reduced emissions are a lie, unsubstantiated and misleading.* *The carbon emissions from the Burrup Hub will have a significant detrimental impact and cause death and destruction for decades to come. At a time where Western Australia needs to be taking contribution to global carbon*	
PRO-G1-RES-89	Proforma submission (additional text)	*As a grandmother and carer of this 1 planet that we live on, I am totally sick and appalled each day, i hear of more and more fossil fuels being spewed into the atmosphere.! Where IS the care and commonsense in the world , seeming run by TOO large company's you included...that put $ before health. SHAME , shame. sad and sick! writing in response to the current consultations on the proposed Browse Basin and North West Shelf projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-90	Proforma submission (additional text)	*As a grandparent I am deeply concerned about the life-time emissions of these project. As a concerned citizen that I strongly urge you to reject Woodside's proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-91	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects & existing exploitation of Gorgon gas field. Evidence to date indicates that the sequestration of CO_2 is both a technical and practical failure and open reporting of progress needs to be openly reported and audited. Further, if more projects were to proceed, the Burrup Hub would become one of the largest and most polluting fossil fuel …*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-92	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects. These projects are entirely unacceptable and irresponsible from a global and climate-change perspective!* *… development in carbon farming and the renewables sector. Gas is not part of the solution for climate-change, or the solution to sustainably power Western Australia into the future.* *Please understand, it is your climate-responsibility and global-responsibility to reject these projects, and any that are not totally and environmentally-sustainable for now and into the future (which includes all coal, oil and gas projects). Our children's lives depend on you making the moral choice for the planet. You are the Environmental PROTECTION Agency…the title of your organisation says it all. Please do not allow political or industry pressures to divert your attention from where your true and ONLY responsibility lies… protection of our environment.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-93	Proforma submission (additional text)	*Allowing for both the creation of new, and the extension of existing, large-scale carbon pollution sources such as the proposed Burrup Hub, would breach our international carbon reduction obligations, and push our national reduction goals out of reach. The carbon pollution created by this project would make it fundamentally incompatible with Western Australia's policy goal of net zero emissions by 2050.* *The carbon emissions from the Burrup Hub, if allowed to go ahead would have a significant detrimental impact for decades to come. At a time where Western Australia needs to be taking it's contribution to global carbon emissions seriously, approving new LNG projects that would continue to pollute at a large scale for the next 50 years is indefensible.* *The life-time emissions of such projects must be considered. It is for these reasons that I strongly urge you to reject Woodside's proposal*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-94	Proforma submission (additional text)	*I'd like to add that this is completely contrary to caring for the health and well being of all Australians and our natural environment as demonstrated by the catastrophic events of this summer.* *Furthermore it is incompatible with concerns for closing the gap and the health of my Kimberley patients who are already marginalised and stand to suffer disproportionately from the effects of climate change.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-95	Proforma submission (additional text)	*We are supposed to be limiting pollution not drastically adding to it. Trying to slip in poisonous projects like this before the door finally slams on them worldwide ensures that the future for our children, grandchildren, etc., will be all the more dangerous.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-96	Proforma submission (additional text)	*I am writing in response to the current consultations on the proposed Browse Basin and North West Shelf projects. Decisions of this nature, made now, will overwhelmingly influence the well being of future generations. We therefore have a huge responsibility to ensure that what we decide now does not negatively impact the world we leave to our kids & theirs. The impact of fossil fuel mining on our atmosphere & climate has never been clearer then now, at this shocking time of climate emergency. Any new projects particularly as large as the proposed Burrup Hub projects, will have devastating impacts on our climate.* *I am bound by my responsibility to the world & future generations to ask you not to allow this climate destroying program to get started. Your responsibility to inter-generational equity & your duty of care to us all as Chairperson of EPA WA, is to ensure it is not allowed.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**).
PRO-G1-RES-97	Proforma submission (additional text)	*We must leave a healthy, living, complete planet to our children. To that end I strongly urge you to reject Woodside's proposal. We should be pursuing the cheap and abundant renewable resources we have available right here in WA. I am, of course, writing regarding the proposed Browse Basin and North West Shelf projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-98	Proforma submission (additional text)	*The extent of the emissions that would result from gas collection and processing at the Burrup Hub would cancel out the gains any made by both individual Australians and industry seeking sustainable ways to reduce their carbon emissions.* *LNG is a fossil fuel with pollution at every stage of its development and use and cannot be considered a solution to address climate change or be considered as an acceptable Transition Fuel.* *The carbon emissions from the Burrup Hub will have a significantly detrimental impact on emissions for decades to come. At a time where Western Australia needs to be taking serious action to reduce their contribution to global carbon emissions. Approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**).
PRO-G1-RES-99	Proforma submission (additional text)	*Look, I don't expect this small contribution to get anywhere BUT!! I love my country and all country for that fact. Please stop hurting this land ??* *If not for us but our next generations ??*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-100	Proforma submission (additional text)	*With the devestating impact across Australia of the recent intense bushfires caused by climate change - it is clear that we cannot continue with business as usual. Australia must meet its international carbon reduction obligations. This project is incompatible with these objectives and to allow it to proceed would be negligent in the extreme. I therefore strongly urge you to reject Woodside's proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-101	Proforma submission (additional text)	*If Western Australia is to meet its policy goal of net-zero emissions by 2050, we cannot afford to expand the LNG industry.* *Gas is no longer a viable 'transition' fuel. We have the resources and technology for a rapid transition to renewable energy.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-102	Proforma submission (additional text)	*I'm a Nurse,Mother, and Grandmother.* *What good is it for any of us ordinary exceptional Australians to recycle, reduce plastic, plant trees and consume less if projects like this blow any of our attempts to be responsible stewards to a healthy country and planet out of the water..literally. The Central bank is talking about stepping in to curb Australias current leaderships disregard for real action on carbon emissions reduction and climate change action. Insurance agencies are now demanding leadership on real climate action as its not good for business..I see that you have a real opportunity to redirect private enterprise by signaling that your department won't allow for climate polluting ventures to go ahead on your watch..of course after you've concidered the Science and are prepared to act on it. Below is the intelligently worded letter that you will be receiving in abundance by now. Every one sent is from a concerned citizen. What you do affects not just your state or even Australia it affects the world.* *Please show the country you're serious about handing on to my kids ..the next generation.. not a scortched Earth but a healthy future.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-103	Proforma submission (additional text)	*I believe you have the opportunity to be remembered as someone who made the right choice and rejected further fossil fuel development in favour of renewables.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-104	Proforma submission (additional text)	*Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable technologies. Australia must rapidly move away from all types of fossil fuels, including LNG. I strongly urge you to reject Woodside's proposal as Australians should be pursuing the cheap and abundant renewable resources we have.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-105	Proforma submission (additional text)	*I visited the Burrup Peninsula 2 years ago and was in awe of the Aboriginal petroglyphs. Having previously visited the much smaller but still wonderful and celebrated collection in Namibia I was astounded and horrified that the wonderful archeological treasure was at risk from and hidden almost fossil fuel infrastructure. These treasures belong to the world and need to be celebrated and protected.* *The proposed Browse Basin and North West Shelf projects would further damage these treasures which belong to our First Nation people and make the Burrup Hub become one of the largest and most polluting fossil fuel …*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-61 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).
PRO-G1-RES-106	Proforma submission (additional text)	*All governments need to be extremely careful about signing contracts without clauses to get out! Locking us into the project from get go is irresponsible given the state of our environment but signing it to 2070 is negligent. Likewise not charging fossil fuel companies taxes, environmental fees or donations is again negligent!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-107	Proforma submission (additional text)	*I would like to shorten and personalise this email to persuade you of my sincerity and genuine concern. But I cannot delete any of the following comments. They are all so exactly what I want to say. I can only add that today in Victoria we are recovering from, in less than three weeks, catastrophic bushfires, furious windy days, days when we had the worst air quality in the world thanks to distant fires, drenching rains and now rain full of precious top soil, now damaging our rivers. The unexpected damage to both us and our economy are just the beginning if we do not take every drastic action we can to leave fossil fuels in the ground.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-108	Proforma submission (additional text)	*Please take your obligations to the environment seriously and don't condemn us and future generations to the consequences of more CO_2 in the atmosphere.* *How will you look your children in the eye knowing you could have stopped these emissions and didn't.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-109	Proforma submission (additional text)	*We are the highest emitters per person on this planet of greenhouse gases. By approving this project you would be increasing our emissions and contributing to the climate change and destruction of this country and the planet*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-110	Proforma submission (additional text)	*As an Australian citizen I am deeply concerned by the proposed Browse Basin and North West Shelf projects.* *If these Burrup Hub projects proceed, they will become the largest and most polluting fossil fuel projects in Australia, and one of the largest fossil fuel developments anywhere in the world.* *Climate change has had a devastating impact on the east coast of Australia and the atmosphere has no boundaries. Individuals and industry are working hard to decrease their carbon emissions and the only way we can hope to live in a world that can sustain humans is to keep all fossil fuels in the ground. The evidence suggests that there is a risk of fugitive gas emissions each step of the way in the production of LNG; including extraction, gas collection and processing.* *The creatiion of new carbon emission sources and the extension of existing large scale ones, will be a breach of our international obligations, and an abrogation of your responsibility to the Australian people. The carbon emissions this project would produce means that the Burrup Hub is fundamentally ncompatible with Western Australia's policy goal of net zero emissions by 2050.* *Woodside claims that gas a 'clean' fuel and makes a contribution to the goal of reducing emissions. The scientific evidence unequivocally refutes these claims, which are deliberately designed to mislead.* *LNG has become the most significant driver of climate change in the world; overtaking coal in 2019. As stated previously, there is pollution at every stage of its development and use and there is no basis on which it could be considered a solution to address climate change.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
		All of Australia, at every level, needs to take their contribution to carbon emissions seriously. There is no Planet B. The Burrup Hub would have a significant and long lasting impact on global warming, and a detrimental effect on our very existence. Western Australia has relied on the fossil fuel industry for economic prosperity, but it is well placed to pursue renewable enery projects which will provide a safe, more sustainable future. I have travelled extensively though WA and have witnessed innovation and renewable energy sources being employed successfully from Marble Bar to Albany. Knowing that the technology exists and is currently being deployed makes even the contemplation approving any new LNG projects indefensible and a dereliction of your role to consider environmental impacts. *With my whole heart, on behalf of all Australians, I ask you to reject Woodside's proposal. I want my children and grandchildren to have a chance at growing up in a world of opportunity and hope. The lifetime emissions of this project will directly contribute to global warming and make a huge impact on future generations. It is in your hands but I hope you have the strength and courage to think beyond the short- term economic benefits to a few, and consider the long-term prosperity of us all.*	
PRO-G1-RES-111	Proforma submission (additional text)	*THE TRANSITION TO A FOSSIL FUEL FUTURE IS IN YOUR HANDS.* *I IMPLORE YOU TO OPEN YOUR MIND AND BE PART OF THE EVOLUTIONARY PROCESS.* *BE A LEADER - NOT A FOLLOWER - AND SEND WOODSIDE PACKING!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**).
PRO-G1-RES-112	Proforma submission (additional text)	*Every day I am signing petitions and writing to ministers or CEOs about some or other environmentally disastrous decision Incredible that despite recent events we are continuing on this path to a dead planet.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-113	Proforma submission (additional text)	*The carbon pollution created by the proposed Burrup Hub projects makes it fundamentally incompatible with Western Australia's policy goal of net zero emissions by 2050. Approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible.* *The claims made by Woodside that gas is a 'clean' fuel contributing to reduced emissions are unsubstantiated and misleading. LNG is a fossil fuel and its use cannot be considered a solution to address climate change.* *The life-time emissions of these polluting projects must be considered. It is for these reasons that I strongly urge you to reject Woodside's proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**).
PRO-G1-RES-114	Proforma submission (additional text)	*The carbon emissions from the Burrup Hub will have a significant detrimental impact for decades to come. At a time where Western Australia needs to be taking seriously its contribution to global carbon emission, approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-115	Proforma submission (additional text)	*I know the EPA isn't allowed to consider greenhouse emissions in your environmental impact assessments. Which is truly the dumbest thing I have EVER heard of, and I've heard some dumb things before now.* *So… putting aside the most obvious reason why this project should be canned, consider VERY carefully the impact on turtle breeding areas.* *Turtles are some of my favourite animals, and we are so lucky to have them in WA. They are very significantly under threat, in large part because of our warming climate. Because the sex of baby turtles is determined by the temperature of the eggs as they mature, rising temperatures are leading to greater chances of sex imbalances and more challenges for turtles to breed.* *So please give this very high importance in your assessment.* *I also agree with the other points in the Conservation Council form letter, below.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-116	Proforma submission (additional text)	*I worked as a Chemical Engineer for Woodside in the 1980's. I worked on the Burrup and in Japan on the design team of the first LNG plant. I understand the science.* *What was known then, but very much hidden, that is the impact of fossil fuel plants like this proposal on our climate, is now very much a living reality. I now live in the Blue Mountains surrounded by bushfires that are still burning, watching ecosystems and animals and the land I love destroyed. It is heartbreaking. Our whole community and many others around Australia are in shock and trauma with our evacuation bags still packed at the front door-for weeks.* *Climate change is here. There is no more time to continue business as usual.* *So, with my engineering background that I have long left, my understanding of climate science and where we are heading if we continue to develop new fossil fuel projects and burn more CO_2, and my strong request that this project be declined in the face of gathering climate change and very close tipping points, I endorse the following letter. I too urge you to decline Woodside's proposal. Thank you.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-117	Proforma submission (additional text)	*NO NO NO WOODSIDE* *As the Climate Change Created Drought,* *Rips the guts out of our precious soils here at our Quairading Farm...* *It deeply saddens me to report that our meager twenty five year efforts here in demonstrating drought proofing in "Revisioning the Drylands W.A. Project" appears insufficient to avoid considerable present to long term species loss...*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-118	Proforma submission (additional text)	*I beseech you all at the EPA our "Protection" judge, to do something REAL with your children in heart. Regrettably Western Australia is a very very dirty player in global emissions. If you doubt me its not surprising, as our press here is pathetic in truth news. Our big business ~ mostly low tax paying multi nations, governments and you as our "mouse" EPA Environmental Protection Authority, or more honestly… "Environmental Destruction Agency" are not helping to move to the Zero Carbon Economy. Mother Nature has simply had enough! What was once called pollution, is now softly labeled as carbon tonnes… yes tonnes of massive costly problems. We All have no choice but to act now, to slow down her wrath. Dim witted delusionary politics, complacency and illusions of distraction, will not stop the horrors of slow Australian heat death, as we steer reluctantly with "Too Little Too Late" towards a "Zero Carbon Circular Unividual Society". One of our biggest exports is dust or top soils, jeopardising our feeding capacity. Global Heating is No Joke, limiting food and clean water, currently leading to poverty wars and desperate anarchy. Surely we must change immediately to Clean Fuels… There are immediate fast track solutions. So We Beseech you to not allow these dirty enterprises to compromise all of our futures.If you promote this foolish project you are simply in bed with the dinosaurs and are traitors to your esteemed occupation. If you value a safer, cleaner, W.A. and this World, please use your full powers, to stop this destructive, dirty, vain multinational Woodside with their partners, with their ludicrous gas proposals.Respectfully as a very outraged citizen*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-119	Proforma submission (additional text)	*Woodside could be investing in renewables rather than being so focused on creating more emissions. It is likely that within 5 years there will be international pressure and embargoes on Australia for it's role in excessive global emissions. Let's not learn this lesson the hard way. I strongly urge you to reject Woodside's proposal as we should be pursuing the cheap and abundant renewable resources available in WA.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-120	Proforma submission (additional text)	*I trust you are aware that Australia is burning.* *Show me your level of understanding between fossil fuels and the rising temperatures around the globe.* *Your position as a Decision Maker is most important today because it is will impact our future in either a positive or a very negative way.* *You have a challenge and an opportunity here. But your time is limited. Are you strong enough to see the crisis we are facing? The resources and technology for a rapid transition to renewable energy already exist.* *Show me what you value.* *Prove you love Australia and are willing to fight for a safe, sustainable future.* *Please reject Woodside's proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-121	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects. If Western Australia is to meet its policy goal of net-zero emissions by 2050, we cannot afford to expand our LNG industry. Even this goal fails to meet scientific standards which would require net zero emissions by 2030 if we are to avoid catastrophic climate change.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).
PRO-G1-RES-122	Proforma submission (additional text)	*I write in response to the the proposed Browse Basin and North West Shelf projects. , the Burrup Hub will be It will also further degrade on of the most significant human collections of art in the world.* *I've visited the Burrup peninsula as a younger man when working as an engineer in the Pilbara for Hammersly Iron. friend and I made a week long rock climbing trip to Dolphin Island. We were absolutely astounded when I stumbled (literally) on the art. The extent of it is just unbelievable. I researched it afterwards and it become even more incredible to me. It transcends ices ages, climate change and tells an incredible story on anthropology. I really think it should be a world heritage site and there's more appropriate locations to build an enormous industrial hub.*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised within this submission relating to compatibility of the proposed extension of the Burrup Hub with the World Heritage listing nomination of the Murujuga Cultural Landscape, please refer to the response to GHG-177 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-123	Proforma submission (additional text)	*I have grandchildren, do you? I would dearly love for them and their children to experience Australian flora and fauna as we have.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-124	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects, together, potentially, the largest and most polluting fossil fuel projects in the world.* *Western Australia will not be able to meet its 'policy' goal of net-zero emissions by 2050 if there is expansion of the LNG industry. Australia will also be in breech of our Paris Treaty Agreement carbon emissions.* *Gas is not a 'transition' fuel. It is similar to coal when all emissions from extraction, process, transport and use are taken into account.* *Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable energy technologies and manufacturing using clean energy.* *We must rapidly move away from all types of fossil fuels, including LNG. I strongly urge you to reject Woodside's proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-125	Proforma submission (additional text)	*I am writing in response to the current consultations on the proposed Burrup Hub and associated gas fields.* *I have no doubt that you are already aware of the following, but I believe that it will give important context to enrich my argument.* *If current trends in GHG emissions continue, the world is on track to 3-5 degrees of warming (WMO, 2019), the consequences of which will seriously impact the lives of every single Western Australian. The GHG emissions driving climate change accumulate from the emissions of many, both big and small. Australia, as the highest emitter per capita of green house gases in the world, has a major role to play in what is in all honestly a struggle to preserve the livability of our planet.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).

No.	Submitter	Submission and/or issue	Response to comment
		*To do our part in keeping emissions under 2*C, Australia must cut its emissions by 30% by 2025 (Climate Change Authority, 2015).* *In your opinion EPA Chair, how is Woodside's proposed Burrup Hub and Browse Basin and NWS extensions consistent with the urgent need to reduce this State's emissions, especially those in scope 3?* *How can the EPA justify letting these projects go ahead when Woodside willingly admits the Burrup Hub will produce more gas then has ever been extracted from the North West Shelf, when, once burnt, this carbon will contribute to the worsening of bush fires and droughts that put the lives and livelihoods of so many ordinary Australians at risk?* *Under the Environmental Protection Act 1986, the objective of the EPA is to: protect the environment. Where the environment is defined as "living things, their physical, biological and social surroundings.." My question to you, sir, is don't the humans of Australia fit into the Act's definition of the environment?* *Does the EPA therefore not have a responsibility to protect all Australians who will, now and in the future, be affected by climate change?*	
PRO-G1-RES-126	Proforma submission (additional text)	*The only moral response to Woodside's proposal is rejection. Rejection because the emissions these projects will produce, across all 3 scopes, are not consistent with the EPA's obligation to protect Australia's environment and Australia's people.* *Any social benefit derived from these projects is short term and insignificant when compared to the steps backwards they would produce from the necessary meeting our emissions reductions goals.* *Sir, I do not mean to sound patronising but rejecting Woodside's proposal will take courage. I sincerely hope that you find the courage to do what is right and necessary in the face of those who seek to profit from continuing our destructive addiction to fossil fuels. If you do find the courage to make the right decision, and I know you will, then you will have played a not insignificant role in the fight to change climate change.* *Please do not let Woodside's Burrup Hub and Browse Basin go ahead.* *[redacted name]*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-127	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects.* *Currently Australia is experiencing extreme temperatures, long lasting drought, overall drying of the environment including the water table and surface water.* *All of these conditions are a result of too much carbon in the atmosphere which is largely a result of ignorant fossil fuel companies and governments throughout the world putting economic growth and extreme wealth for a few over the general population health and well-being. As you are well aware a balanced healthy environment is the essence of good health for animals and humans.* *It is time for you to stand up to the government and not let the short sighted policy's of getting re-elected take precedence over the survival of human beings. This is a turning point, please put us first and do what is right for the future.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-128	Proforma submission (additional text)	*The implications for this area are therefore highly damaging and toxic.This adds to our current climate crisis.* *This area is of significant indigenous heritage. Desecration through development displays enormous disrespect and wilful oversight.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**). With respect to the concerns raised within this submission relating to compatibility of the proposed extension of the Burrup Hub with the World Heritage listing nomination of the Murujuga Cultural Landscape, please refer to the response to GHG-183 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-129	Proforma submission (additional text)	*WA is crying out for leadership on climate. We need the EPA to take the strongest possible actions to prevent new fossil fuel developments, while we work with all other available processes to stop the current burning of fossil fuels and protect and restore native forests and other carbon dense ecosystems.* *Please reject the Browse Basin and NW Shelf LNG projects and help get us on track to dealing responsibly with climate change.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-130	Proforma submission (additional text)	*Please spend your money on renewable projects. They will make more money in the long term. You don't want to be left with a stranded asset.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-131	Proforma submission (additional text)	*Additionally the priceless and sacred rock art at Murujuga National Park - the world's most significant concentration of ancient petroglyphs - will suffer even more disruption and threat than it already endures should this project proceed. This rock art is an international treasure whose protection has already been mismanaged by the Western Australian government over several decades. I am lucky to regularly introduce international visitors to the Pilbara's national parks through my work in the region, and I feel intense shame to call myself Western Australian when explaining to our international guests that a gas plant has been permitted to be installed in the heart of one of the world's most significant archeological sites. Every visitor I have hosted at the Burrup has been baffled as to why this has been allowed, especially given that our State's scale and climate present obvious alternatives for the production of sustainable fuel and power. The world is watching our State and our country at the moment, and relying on us to show leadership in regard to addressing climate change. Please do not fail them, or your constituents by supporting these repugnant, greed-driven projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**). With respect to the concerns raised within this submission relating to compatibility of the proposed extension of the Burrup Hub with the World Heritage listing nomination of the Murujuga Cultural Landscape, please refer to the response to SS-RA-50 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).
PRO-G1-RES-132	Proforma submission (additional text)	*Enough is enough. We must recognise the damage that carbon intense industries pose and respond appropriately to safeguard our future for us and our ancestors.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-133	Proforma submission (additional text)	*At this time when many of us mourn devastating climate changed fires, we need to pull back from such projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-134	Proforma submission (additional text)	*In relation to the proposed Browse Basin and North West Shelf projects, I urge the EPA to oppose their approval and encourage our WA government to invest in renewable energy.* *An article titled 'Bushfires Reap What Australia's Carbon Exports Have Sown' by David Fickling in Bloomburg Opinion on 7 January sums up the issue for us as a responsible global citizen.* *[Prime Minister of Australia's] focus on Australia's 1.3 per cent share of global emissions takes no account of our contribution via the export of coal and LNG. Adding exports to our total makes Australia the sixth largest global emitter, after China, USA, Russia, India and Saudi Arabia.* *WA's contributions through exports of LNG from the Browse Basin are already significant. If the proposed projects proceed, the Burrup Hub will become one of the largest and most polluting fossil fuel projects in the world and WA would not be able to meet its policy goal of net zero emissions by 2050.* *The scientific evidence is clear that LNG is not a transition fuel, creating about the same amount of emissions as coal does.* *Those who believe Australia should go on supplying the 'drug' of fossil fuels to the world argue that someone else will do it if we don't. This means we must do more than stop the supply; we must help the 'addicts' recover. In so doing, we can swap our fossil fuel exports for renewable energy.* *We can work with our major customers in Japan, South Korea, China, Taiwan, and India, and stop 'pushing' coal fired power stations in places like Vietnam. Instead we can export solar panels to remote Indian villages; wave energy to South Korea; liquid hydrogen to Japan; and solar and wind energy by subsea cables to Indonesia. These projects are within our reach, particularly with government investment in their development.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-135	Proforma submission (additional text)	*Greenhouse gas emissions are a highly significant environmental factor in your consideration of environmental significance of major projects such as this. This is the case in your consideration of the proposed Browse Basin and North West Shelf projects.* *Indeed I submit that we need to reach the goal of net zero emissions much sooner - by 2030. In this we need to shift to 100% renewable energy for WA as an emergency - by 2025.* *In addition, the threat of air emissions of NOx and SOx by Woodside's LNG mining and others on the world class Burrup Aboriginal Rock Art must be removed. This is another compelling reason to reject the proposed Browse Basin and North West Shelf LNG as totally environmentally unacceptable.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**). With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-RA-51 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).
PRO-G1-RES-136	Proforma submission (additional text)	*Tell the Premier what you think of his relationship with the big polluters! Or do you support this?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-137	Proforma submission (additional text)	*I am a medical doctor currently working in Perth, WA.* *We are at an 'tipping point'. Australia, as we know it, is changing. Our climate is changing - and the negative social, environmental, and health impacts of the abyss into which we stare, should not be underestimated.* *We must - Manage the Avoidable, and Avoid the Unmanageable. For without swift and decisive action - we will soon run out of options - and it will be 'unmanageable'. Just as these fires have been.* *With this in mind projects in the world.* *We have to take heed of the warnings at this time. The health impacts of the changing climate - and the impact on our vulnerable WA population will result in a Health Crisis. Heat waves, extreme weather, fire events - and the physiological and psychological damage done by this.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).
		If Western Australia is to meet its policy goal of net-zero emissions by 2050, we cannot afford to expand our LNG industry.	

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-138	Proforma submission (additional text)	*I do hope the the Australian bush fires will prompt you to be a much better environmental advocate than industry advocate. We should stop subsidising fosil fuels and subsidise things that support improvement in our environment, not the converse.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-139	Proforma submission (additional text)	*IT WOULD BE A MISTAKE OF MASSIVE PROPORTION SHOULD WOODSIDE BE GIVEN APPROVAL TO EXPAND LNG PRODUCTION IN THE NW SHELF. WE ARE EXPERIENCING THE DEPRESSINGLY NEGATIVE EFFECTS OF TOO MUCH CO_2 IN THE ATMOSPHERE AT THIS RELATIVELY EARLY STAGE OF CLIMATE HEATING. TO 'ADD FUEL TO THE FIRE' WILL BE SEEN BY FUTURE GENERATIONS AS AN ACT OF INSANITY, THE APPROVAL OF WHICH WILL MOSTLY BENEFIT A COMPANY THAT PAID NO TAX LAST FINANCIAL YEAR AND ITS SHAREHOLDERS, THE MAJORITY NON AUSTRALIAN.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-140	Proforma submission (additional text)	*The planet can no longer afford unsustainable projects like this and we need to innovate and think differently rather than committing to long term destruction.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-141	Proforma submission (additional text)	*The proposed Browse Basin and North West Shelf projects must not go ahead. Australia is already in the spotlight for our government's failure to respond to climate change, and this proposal clearly demonstrates that lack of vision. These projects would become one of the largest and most polluting fossil fuel projects in the world. How can Western Australia fulfil its goal of net-zero emissions by 2050 if we continue to expand our LNG industry?* *We have the resources and technology for a rapid transition to renewable energy, and we should be taking advantage of job opportunities and regional development these offer in carbon farming and renewables. Gas is not part of the solution for climate change or a solution for WA's power needs. A large-scale LNG project with a lifespan of over 50 years is completely irresponsible.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
		At this critical time we should be investing in renewable technologies that create clean energy and rapidly divesting from all fossil fuels, including LNG. Please reject Woodside's proposal. We need to be developing the cheap and abundant renewable resources that are available right here in WA.	
PRO-G1-RES-142	Proforma submission (additional text)	*Please take these submissions seriously. It used to seem like a far-off thing to say "no jobs on a dead planet" etc, but it's all ramping up now, the consequences of what we've done previously.* *Projects like this no longer have legitimacy. We have to protect the future and the present and look for alternative ways to create energy, and to live well without destroying what's around us and what literally provides our requirements for life.* *And so, Australia's largest and most polluting fossil fuel project, and one of the largest fossil fuel developments anywhere in the world - this is unacceptable.* *The extent of the emissions that would result from gas collection and processing at the Burrup Hub would cancel out the gains made by both individual Australians and industry seeking sustainable ways to reduce their carbon emissions - this is unacceptable and infuriating.* *obligations, and push our national reduction goals out of reach - why agree to goals if we are going to break them?* *The carbon pollution created by this project makes it fundamentally incompatible with Western Australia's policy goal of net zero emissions by 2050 which in itself is already too little too late.* *You must begin rejecting projects like this, or we will be in greater and greater strife in the coming years, and there are people directly responsible for this - don't be in this category any longer.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-143	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects.* *The bushfires, the rapid and accelerating melting of glaciers all over the world and increases in temperature show that we must transition to renewable energy fast before there is a climate catastrophe with food shortages, displacement of millions of people and increased possibilities of war. Too long Australians have done nothing or too little.* *Yet, Australia has the best conditions for going 100% renewable. Stupidly Australia hasn't realised any of these business potential.* *We cannot continue like this. We cannot afford paying more and more in relief yet causing more and more damage to our climate. Stop the madness.* *Going renewable creates many new jobs.* *All of this is a no brainer. Not knowing why there is this enormous resistance to doing what makes sense and is morally and economically sound, leaves only few possibilities: governments are bought or corrupt and really are not governing for the people.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-144	Proforma submission (additional text)	*4 Tidal power stations can provide most of australia's power needs.* *Please evaluate closely that option and suggest it to the state government.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-145	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects. I could not believe the size of the project.* *IT BEGGARS BELIEF THAT SUCH DESTRUCTIVE PROJECTS ARE STILL BEING CONSIDERED NOW THAT WE KNOW THE DEVASTATION THEY CAUSE.* *Gas is not a 'transition' fuel. We have the resources and technology for a rapid transition to renewable energy. WA should be LEADING initiatives for job opportunities and regional* *I want our industries to be part of the solution NOT part of the problem.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-146	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects.* *projects in the world, which quite clearly to me is an appalling thought.* *If Western Australia is to meet its policy goal of net-zero emissions by 2050, we cannot afford to expand our LNG industry.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).
PRO-G1-RES-147	Proforma submission (additional text)	*If Western Australia is to meet its policy goal of net-zero emissions by 2050, we cannot allow our LNG industry to further expand..* *Gas is being hailed by its supporters as a 'transition' fuel. It is not when that transition period covers decades of production.. We have the resources and technology for a rapid transition (less than one decade) to renewable energy generation and storage.* *We should be embracing the potential for job opportunities and regional development in carbon farming and the renewables sector.* *Gas is not part of the solution for climate change, or the solution to sustainably power Western Australia into the future. A large scale LNG project with a lifespan of over 50 years cannot be allowed to proceed.* *Western Australia can tackle its emissions through investment in renewable technologies which will create skilled jobs into the future. As we do this we can rapidly move away from all types of fossil fuels, including LNG.* *I strongly urge you to reject Woodside's proposal when we can be pursuing the cheap and abundant renewable resources we have available right here in WA.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-148	Proforma submission (additional text)	*The life-time emissions of these projects must be considered in light of the ongoing impacts upon the quality of life for future generations.* *It is for these reasons that I strongly urge you to reject Woodside's proposal.* *I am writing regarding the proposed Browse Basin and North West Shelf projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
		On behalf of myself, my children, the future generations to come and the earths biosphere, I object to this project in the strongest possible terms. *1 Fugitive emissions; Australia is at a point where we need to be reducing our greenhouse gas emissions, yet at this point our emissions are rising.* *The fugitive gas emissions from the extraction of Gas, particularly involving fracking and the release of Methane, will result in significantly adding to Australia's emissions.*	
PRO-G1-RES-149	Proforma submission (additional text)	*It is ironic that Australia's reserves of Oil, Gas and Uranium, thought to be an asset, are actually an achilles heel that, due to the pressure for revenue if stifling what really needs to happen, a national energy policy, and innovation away from exporting a product which will become toxic stranded assets in the foreseeable future.* *Environmental and Indigenous; There is a big groundswell of opposition towards Fracking the the expansion of the Gas industry in general. The indigenous groups are lining themselves up for a battle and they have the backing of a board spectrum of the wider Australian public, who, due to recent events, are awakening from their lethargy in regards to the wider threat of climate change and the fossil energy business as usual scenario. Add to that the more frequent droughts and the prospect of the contamination of ground water supplies, and the entire expansion of the gas industry just does not make sense.* *Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable technologies. You must rapidly move away from all types of fossil fuels, including LNG. I strongly urge you to reject Woodside's proposal as the State should be pursuing the cheap and abundant renewable resources we have available right here in WA, to enable an orderly transition that must and will occur anyway.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G1-RES-150	Proforma submission (additional text)	*We really have to turn our abundant energies entirely towards renewables.* *Alternatively, read James Lovelock's 2009 "The Vanishing Face of Gaia". He has convinced me nuclear is the way to go.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-151	Proforma submission (additional text)	*Surely the drought and tragic bushfires are evidence enough that we need to stop approving fossil fuel projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-152	Proforma submission (additional text)	*I am a geologist writing regarding the proposed Browse Basin and North West Shelf projects.* *Fossil fuels are not the future!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-153	Proforma submission (additional text)	*The time for change is now and you, the EPA, have the ability to make this happen. We need you to protect our environment. For now and future generations.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-154	Proforma submission (additional text)	*Recent and ongoing bushfires have increased the danger the ongoing use of fossil fuel will make the planet uninhabitable not just for man but for all mammalian species.* *Governments of Australia must come to the realisation that the wealth created by the income from fossil fuels production is at the expense of the survival of all of us and of all creatures great and small. The duty owed is to the people.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-155	Proforma submission (additional text)	*Dear reader, Please stand in full responsibility for the actions you act out on this earth in your life time. You will feel sorry after seeing what happened to this world and knowing you could have change the outcome. It is okay for you to take a moment and think this through, think about all aspects of this action. Think about all levels of life involved, think about your own feelings and how you would feel if your comfort space would be taken over for reasons unknown to you. Just imagine. Please take some time in silence and reflect your life\'s choices. What karma are you putting on yourself? Why would you put the idea of financial gain over the knowledge of natural (and perfect as it is) wildlife. I ask you to please feel in your body what the best action is in this situation. Feel what your body is telling you, you know somewhere in your body when something is off, and I hope you listen to this signal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-156	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects. If Western Australia is to meet its policy goal of net-zero emissions by 2050, we cannot afford not to expand our LNG industry.CSIRO regards gas is a 'transition' fuel. CleanState and other environmental activists who have no clue claim it isn't. We have the resources and technology for a rapid transition to renewable energy. We should be embracing the potential for job opportunities and regional development in gas as the solution for climate change, and the solution to sustainably power Western Australia into the future. A large scale LNG project with a lifespan of over 50 years should obviously go ahead.Western Australia must tackle its emissions through the creation of clean jobs and investment in transition fuels and renewable technologies. I strongly urge you to accept Woodside's proposal as we should be pursuing the cheap and abundant resources we have available right here in WA.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-157	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects. I would like to urge both the State Government and Federal Government to reject these projects. The science could not be more clear - to have a hope of keeping warming within a safe range, we need to be peaking carbon emissions as soon as possible and reducing emissions rapidly. The scale of the Burrup Hub would mean that this project would become one of the largest and most polluting fossil fuel projects in the world. If Western Australia is to have any hope of meeting its policy goal of net-zero emissions by 2050, we cannot allow the LNG industry to expand. The reality of climate change requires us to leave fossil fuels in the ground. Despite attempts to brand LNG as a 'transition' fuel, it is still a fossil fuel, emitting large amounts of carbon emissions. In Western Australia, we have the resources and technology to enable a rapid transition to renewable energy. To be part of the 21st century, in this State and across Australia we need to embrace the potential for job opportunities and regional development in carbon farming and the renewables sector. LNG is not part of the solution for climate change. LNG does not have a future in a world that is genuinely transitioning to a low carbon future. At this point in history, it seems incredible that we could even be considering approving a large scale LNG project with a lifespan of over 50 years. Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable technologies.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-158	Proforma submission (additional text)	*The proposed Woodside Browse Basin and Burrup Hub gas mega-projects would produce carbon pollution equivalent to 32 coal-fired power stations every year for 45 years, making it Australia's largest and dirtiest new fossil fuel project. The carbon emissions are four times those of the proposed Adani Carmichael mine in Queensland.The science is clear, and Australia has signed on to the Paris Agreement to keep global warming to below 1.5C. We can't do this if we continue to open massive fossil fuel basins.I am calling on the EPA to reject Woodside's dangerous new gas project, which would make the climate emergency much worse. We know from international reports that we have only 12 years to reduce our emissions to a level commensurate with global targets. This would be impossible to achieve, if your government will support and invest in this project. We are in a climate emergency, and*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • commitments (**Section 5.3**)

No.	Submitter	Submission and/or issue	Response to comment
		we urgently need serious climate action across the world and here in WA. Climate scientist have produced global evidence gas is simply another fossil fuel that, when burnt, inexorably will add to the green-house gas burden of our planet and add to the serious health risks of climate change. The use of gas in power generation has been promoted because it has a significantly lower carbon footprint than coal but when fugitive emissions from well- heads and transit and distribution of gas are measured, the carbon footprint may be little better than coal.There are viable options for economic development and transitioning from these types of invasive and destructive developments particularly because there is extensive supply of renewable energy in the northwest. I urge our government to uphold their fiduciary duty to protect the citizens of our state and invest in our human right to live in a clean environment as a matter of Climate Justice. Respect and Goodwill	• GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-159	Proforma submission (additional text)	*[redacted name]*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-160	Proforma submission (additional text)	*This is my personal submission in opposition to the proposed Browse Basin and North West Shelf projects which would make the Burrup Hub one of the largest and most polluting fossil fuel projects in the world. If approved, the Western Australia Government would fail to meet its policy goal of net-zero emissions by 2050. Gas is not a 'transition' fuel. We have the resources and technology for a rapid transition to renewable energy. Western Australia should embrace the potential for job opportunities and regional development in carbon farming and the renewables sector. It is time to move beyond all types of fossil fuels, including LNG. Woodside's proposal should be rejected so our government can progress to renewable resources that we have in abundance in WA, without further delay. Yours*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change • commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-161	Proforma submission (additional text)	*The extent of the emissions that would result from gas collection and processing at the Burrup Hub would cancel out the agains made by both individual Australians and industry seeking sustainable ways to reduce their carbon emissions.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**:

No.	Submitter	Submission and/or issue	Response to comment
			• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-162	Proforma submission (additional text)	*And wherever we live - the repercussions will effect the whole planet. Now is the time to be developing well known and proven sources of clean energy not introducing new production programmes for the old polluting processes. Time is running out to make -what are now urgent - changes to protect the planet on which we all depend.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-163	Proforma submission (additional text)	*I'm sure you will receive many submissions drowning in detail and facts & figures.I simply believe that the environment cannot afford the emissions that this project will release.I do not believe that gas is the answer to "clean" fuel nor that WA can afford this extra pollution and how this will allow us to meet ur so called "net-zero" emissions in the future. . Why on earth with our natural sun, wind & tides would we want to pollute more? Can't WA lead the way in renewable energy. Surely there would be job opportunities for both local, regional and interstate employment for more than 50 years. I strongly urge you to reject Woodside's proposal as we should be pursuing the cheap and abundant renewable resources we have available right here in WA.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-164	Proforma submission (additional text)	*I beg you to dig deep and really think about the future of Australians and our planet. If you had a sore tooth and went to the dentist and he told you, you've got to have it pulled out, you're very likely to trust him. Same with a podiatrist or cardiac specialist. Why are we not listening to the advice and dire warnings from scientists who literally dedicate their lives (like other professionals) to their line of work. WHY do your profits come before our livelihoods and the livelihoods of native Australian animals? There is literally no need for exploration. Scientists have the answers so please listen to them.* *Gas is a fossil fuel, and if we continue to burn these, the world gets hotter and weather events worsen. This is literally what all environmental, atmospheric, conservation, (etc) scientists learn in their first year of study. Please, for the love of my life, listen to them. Of course, these trace gases are naturally present in our atmosphere but humans pumping it into an atmosphere that's already warming and suffering is so irresponsible. This is scary.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-165	Proforma submission (additional text)	*I would like to make a submission to you in response to the proposed Browse Basin and North West Shelf projects. At a time when scientists are telling us in the strongest terms that we cannot afford extract and burn any more fossil fuels if we are to have any hope of keeping global temperature rise to under 1.5 degrees, we simply cannot allow this project to get the green light. I thank you for the opportunity to provide this submission and strongly urge you to reject this proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-166	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects. I am a mother of two young children and deeply concerned about the climate crisis which has been driven by fossil fuels, and the industry itself has known how it is heating the planet to dangerous levels for decades - 1. I am shocked to learn that you are considering approving one of the largest and most polluting fossil fuel projects in the world. No amount of money or jobs make this a reasonable decision. Gas is not a 'transition' fuel. We have the resources and technology for a rapid transition to renewable energy.* *I live in South Australia and find myself moved to write to you about this - your decision has long-lasting and serious ramifications for all Australians and beyond. The decision you are making is appalling economically and ethically and the risks are KNOWN - 2. Look to how South Australia is leading in renewables. You can reap the benefits of moving in this direction too. I strongly urge you to reject Woodside's proposal. Think of the future. Be wise. Show true leadership and stand up against fossil fuels.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-167	Proforma submission (additional text)	*I was recently explaining the concept of a dystopian society to my 14 year old and he asked if we lived in a dystopian society. I said we didn't, but he thought the push of governments to continue to do things that wreck the planet that will make it uninhabitable for future generations sounded pretty dystopian. I guess really, he's right!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-168	Proforma submission (additional text)	*A large scale LNG project with a lifespan of over 50 years cannot go ahead.I am not a citizen of WA, but I believe this is a national issue - as a nation we must tackle its emissions through the creation of clean jobs and investment in renewable technologies. We must rapidly move away from all types of fossil fuels, including LNG. And WA has a chance to lead the country. I strongly urge you to reject Woodside's proposal as we should be pursuing the cheap and abundant renewable resources available in WA.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-169	Proforma submission (additional text)	*Please get your Energy Policy into THIS century!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-170	Proforma submission (additional text)	*Gas is not part of the solution for climate change, or the solution to sustainable power Western Australia into the future.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-171	Proforma submission (additional text)	*Furthermore, the price for alternative energy projects has significantly reduced and is no a viable alternative.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-172	Proforma submission (additional text)	*I am writing to you from New South Wales to object to the proposed Browse Basin and North West Shelf projects. I may not live in Western Australia anymore (though I spent my first 28 years there), but the emissions from these projects will have a global impact and are contrary to numerous scientific recommendations that the world needs to decarbonise rapidly to have any chance of retaining a safe climate.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-173	Proforma submission (additional text)	*The extent of the emissions that would result from gas collection and processing at the Burrup Hub would cancel out the gains made by both individual Auastralians and industry seeking sustainable ways to reduce their carbon emissions.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-174	Proforma submission (additional text)	*I am deeply concerned and writing in response to the current consultations on the proposed Browse Basin and North West Shelf (NWS) expansion projects and the catastrophic effect these would have on the ancient petroglyphs of the Burrup Peninsula.I teach Australian art history at university level and with a particular focus on ancient aboriginal art in Western Australia. I urge you and the EPA to consider the longevity and well being of the ancient Murujuga petroglyphs against the short-term profits of the gas industry.*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to GHG-226 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-175	Proforma submission (additional text)	*I am adding my own concerns to the formatted letter below, because if we can't turn to, & rely on, our Environment PROTECTION Authority, who on earth can we turn to? WA has the WORST carbon emission in Australia BECAUSE of gas.....* *Australia is already bottom of the carbon emissions reduction pile of countries who pledged to reduce their CO_2's......* *This is shameful. Countries with far less natural resources, like SUNSHINE... are doing better than us......Climate change is happening NOW. In Australia fires, destruction, death, like never before.* *Floods, droughts, & golf ball hail stones that hit Canberra just as the smoke cleared.....Other parts of the world are experiencing extremes like never before too...* *THIS WILL CONTINUE TO GET WORSE -* *UNLESS OUR ACTION GETS BETTER.........This IS crisis time. The iceberg has tipped.....And it is releasing the deadly methane gas as it melts......This is suicide. or is it genocide.....? as people do know, but don't do enough to prevent it.So the idea that Woodside want to add to our already worst polluting State...is preposterous!* *Some 'body' in an official capacity needs to use their GOOD power to STOP IT.Read below how the GOOD IS OUTWEIGHED BY THE BAD.Think of your children. Your grandchildren. Thanking you IN HOPE.......*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-176	Proforma submission (additional text)	*The Zero emissions target for 2050 or any other rapid deescalation of fossil fuel use is esseyfor the health of humans and the environment. More gas with high methane levels is not where Australia needs to be heading. How about a solar PV powered cable from the Kimberley to SE Asia?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-177	Proforma submission (additional text)	*I would also like to add that as a very proud Australian and concerned parent, this is not the legacy I would like to pass onto my son and grandchildren.* *Australia was once the 'lucky' country where mateship and concern for our community was our driving force. Now there is no concern for community or our 1st Nation indigenous history or culture.I would like to think that these concerns as well as those affecting the environment would also be important when making the decision about this proposal. We have a voice and would like to be heard, we do not want this for our country or our state, when there are so many other environment and community friendly ways to produce the energy needed.* *We should be leading the way in reducing emissions not adding to them.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-178	Proforma submission (additional text)	*I consider it truly appalling that Australia is still embarking on projects that are absolutely polluting the Earth's environment. All this is done so that some very large businesses and some extremely wealthy people can continue to make their enormous profits (and often do not pay tax on those profits) at the expense of the environment. It is, indeed, a very short term outlook.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-179	Proforma submission (additional text)	*Dear Dr Tom, I am almost 80. I was not born here. I am now an Australian, a West Australian at that!* *I have worked in Advertising/Marketing in London, Sydney and Perth. However in the 80's decided It was a young persons game!* *I did something I always wanted to do...three years at the well respected Claremont School of Art. On graduating knew full time endeavour was not for me, but I made a damn good administrator working for the WA Government, Crafts Council, City of Perth etc. and during that time fell in love with art of the First People of this country as a close friend took a job working with an Aboriginal organisation in the Kimberley. He took me out with his friends to Crocodile Hole. Amazing. Quiet. An experience etched in my mind. Forever. It then really struck home I had been with people who had lived on this land for 50,000 years at least. Wow. And from there I collected, visited, advised a number of communities in the Kimberley and Pilbara, plus Hopevale Arts Centre in FNQ.* *Of course, I visited the Burrup Peninsula...what can I say. I am not going to talk re. CCWA, they do great positive work, and you know full well what they are on about!* *I just want to remind you of what touched me so very deeply. We live with a community of people who have lived here, in broken, for over 50,000 years. What they have to say is etched over many years on those Burrup Stones.* *It is their legacy, it is our legacy. Please respect the Elders, their Elders, and their Elders.*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to GHG-232 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-180	Proforma submission (additional text)	*In my role as Convenor of the Cockburn Community Wildlife Corridor Our community group of some 80 members and over 300 supporters works locally to help protect and restore TECs in our local.urban bushland. These communities are under continual attack by developers and Main Roads. We feel strongly that it's time to draw the line on the continued destruction of our natural heritage in the name of jobs and growth.Our work and efforts (and the efforts of many other ordinary Australians and forward-looking sustainable industries who care for the environment) will be cancelled out by the extent of the emissions that would result from gas collection and processing at the Burrup Hub. These polluting projects need to be stopped. The life-time emissions of these projects must be considered. The future*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
		lies in the development of renewable energies. Australia could lead the way. It is for these reasons that I and the CCWC strongly urge you to reject Woodside's proposal.	
PRO-G1-RES-181	Proforma submission (additional text)	*Dear EPA Chair and Secretary Department of Environment and Energy I am writing to you from the NSW Southern Highlands,in response to the current consultations on the proposed Browse Basin and North West Shelf projects. Firstly please read and consider this short personal account of life in bushfire affected NSW. This is the first opportunity I have had in weeks to communicate to you my deep concern about the proposed Woodside LNG hub. For myself, and thousands of others, the first weeks of 2020 were an endless round of fire preparation; packing cars and leaving for safer locations, returning and monitoring for flareups and embers, being awakened during the night with alerts when fires flared again, constantly monitoring nearby fires and keeping in contact with neighbours. Since early November 2019, the region I live in has been impacted by the Currawon Fires (1 and 2), the Green Wattle Creek Fire and finally the Morton Fire which destroyed homes, property, endangered the lives of residents and firefighters, killed stock and innumerable wildlife in our bush and National Parks. Tragically, four firefighters in our immediate area died. For myself and neighbours, we are lucky, experiencing only minor property damage and returning to habitable houses only thanks to the availability and skill of firefighters. Why is this relevant? It is because Australia's coal and gas industry is one of the factors which can be managed and changed. These fires were finally declared 'Out' only in the past few days after rainfall of between 200 and 600mls or more in the past week. Yes, drought and lightning strikes were contributing factors to these bushfires, but are only partial explanations. Arson has been discounted as a significant factor. All reports are that the scale and intensity of these fires is unprecedented. Increasingly fact and science based information points to human induced climate change as a significant factor in creating the conditions which contributed to these bushfires. None of this information is new. All has previously been made known to government, at all levels, and decisionmakers, such as yourselves. . I am one of the increasing number of voting citizens who are fed up with inaction on the part of our elected*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
		representatives and those who provide advice to them. Unfavourable global attention has rightly been drawn to Australia's lack of effective policy and action in relation to our fossil fuel industries and exports. In writing this to you I have carefully considered the following points, endorse them fully and recommend the following for your urgent consideration in relation to the proposed Browse to North West Shelf Project.	
PRO-G1-RES-182	Proforma submission (additional text)	*I am writing to oppose the Browse Basin and North West Shelf projects. My primary reason is the contribution that will be made to worsen climate change.I include in my concerns not just the gas produced and then burnt or otherwise processed, but critically the methane and other greenhouse gas leakage and other production contributions to climate change. These impacts of both the gas sold and the production impacts are massive - significant on an international, national and state scale. Plus there are the negative local impacts on rock art, traditional owners and other people's wellbeing.I am concerned that any public money supporting these projects will effectively be used to prop up a dying industry, stranded assets. It may take 10 or 20 years but the future harm that these projects will contribute to will devalue these projects significantly. No public money should in anyway support or subsidise these. Nor should any legal precedent be created which creates a financial obligation on the sate to directly support these projects. Just paying for the harm they will cause will impact people globally. Supporting these/this project will result in a transferral of wealth to Woodside and partners, and wide-scale environmental harms plus social harms most affecting those marginalised. There is clear literature about the impacts of climate change on marginalised people. Supporting this project will increase those impacts direly.The life-time environmental and social (including cultural heritage) impacts of these projects must be considered. Given our political context, the donations by fossil fuel companies to major political parties, it seems inevitable this project will go ahead. If it does, I request you attach conditions of environmental remediation that includes fully offsetting the atmospheric greenhouse gas impacts with some form of greenhouse gas removal e.g.widescale tree plantations, and landscape remediation. Further, that these actions are a condition of ongoing operation with review schedules included in the licence conditions spaced at 2-4 years checkpoints, such that where the license is contingent on ongoing net zero greenhouse/carbon gas production.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**) With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-RA-52 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-183	Proforma submission (additional text)	*As a past [redacted name]. I am well aware of the value of the Burrup. The Burrup peninsula is probably the most significant cultural site in Australia and the location should not be further disrupted by industrial development. woodside's own documentation states that there are more than 9000 significant rock carvings. These carvings are some of the oldest in the world.* *If you allow the degradation of this important site you will be responsible for an egregious act against humanity. This is akin to mining the Vatican or crushing Borobudur.* *The site has the potential to be a major tourist attraction akin to Uluru. It would provide sustainable employment forever.*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised within this submission relating to potential impacts of emissions to the Murujuga rock art site, please refer to the response to SS-RA-60 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-184	Proforma submission (additional text)	*I am writing regarding the proposed Browse Basin and North West Shelf projects. Given the terrifying prospects the world faces as a consequence of greenhouse gas emissions, we would be completely PROFLIGATE to allow a 17.2MtCO_2-e per annum impact, expansion of our LNG industry. With an impact of 7.MtCO_2-e per annum for the Browse project from venting and pumping this will be the most polluting LNG project in Australia. Furthermore, It is still worse, as this LNG is exported and impacts much more on the environment as further GHG emisions and abundant, wasteful and harmful, cheap plastic production. I understand these impacts are not part of your assessment, which I do not agree with. As this represents an EVEN bigger impact on Australia.I am not aware of any meaningful GHG controls apliying to this project, previous GHG controls (eg Gorgon) have been ineffective and not enforced. This speaks to the failing of a social licence for this industry to operate. Gas is not a 'transition' fuel. We have the resources and technology for a rapid transition to renewable energy. We should be embracing the potential for job opportunities and regional development in carbon farming and the re-newables sector.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-4: Proposed Browse Project GHG emissions estimates (**Section 5.5**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-185	Proforma submission (additional text)	*I have a fundamental problem with #fossilfuels extraction adding to global warming, additional C02, Metgane & other greenhouse gases. The size of this proposed operation will not contain Australia\'s emission targets. However the immediate damage to Scotts Reef is a real and present danger to sea life as mentioned above. As indicated in my concern above, the Woodside's proposed Browse Basin and Burrup hub proposal is Australia's most polluting fossil fuel mega-development which will contribute around four times the pollution of the proposed Adani coal mine.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**).
PRO-G1-RES-186	Proforma submission (additional text)	*At this point in history the future of the fossil fuel industry is looking more and more tenuous and also need to preserve the remaining natural habitat is critical. I agree we cannot close the coal gas and oil industry overnight but we must avoid the temptation of starting new projects for short term gain. We must swing our efforts toward preserving what is left and changing to a carbon neutral or carbon negative world as soon as is humanly possible.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**)
PRO-G1-RES-187	Proforma submission (additional text)	*I am writing in regards to the proposed Woodside Petroleum drilling project. The recent, terrible Australian fire season was greatly exacerbated by carbon pollution induced global warming. In light of this and the many other climate change induced natural disasters occurring around the world at present, any proposal to extract more fossil fuels is ludicrous, and adds greatly to the threat currently facing the world we live in. The fact that the proposed site is an untouched wilderness, a last haven for all kinds of endangered sea life, makes the threat to Australia\'s diverse natural heritage all the more severe. Were any mishaps to occur, the damage not just to the local ecosystem but the entire Australian coast would be devastating, but any industrial activity would have irreversible effects and may well spell the end for many of the species that call Scott Reef their home. Futhermore, as the rest of the world rapidly transitions away from fossil fuel, the project also makes no economic sense. I urge you to protect Australia\'s natural heritage, and to approve projects that help provide a just transition to a fossil free economy for Australian workers, rather than approving last ditch attempts by fossil fuel barons to line their pockets at the expense of the Australian public\'s beautiful places and natural heritage.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**). • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-188	Proforma submission (additional text)	*I have offgrid power and it works well. There is no reason to keep overcharging us for something that we can do ourselves without your interference. Why keep stuffing everything up when we have the technology to deal with everything ourselves. We do not live in a democracy when you keep pork barrelling every project you touch. Over paid politicians combined with over paid Public Service who contribute nothing but financial loss to our lives. You are all overpaid have no experience in the real world yet insist on telling us what to do.* *You represent the biggest loss to our middle class, the environment and to our way of life as you all leach on us, guide us into wars in past etc. You continually lie to us but now reality strikes and you all do not know what to do and keep coming up with hair brain schemes put forward by your so called "experts". Here is an idea! If you take all the taxes, duties off of Offgrid power it will encourage people to invest in it and the need for grid power will shrivel in demand drastically. Why won't you do it?* *But that will cut down the wages and conditions of your mates eh? [Premier of Western Australia] and his mates will lose the next election as we are sick of you acting like your doing something and producing nothing. Refusing to listen to our people shall be a big mistake as you have lost our respect. Gas and coal usage along with the suggestion of nuclear power generation is not welcome or wanted. Are you getting the message?* *The sun that produces light is our saviour to produce clean power. Stop importing people stabilize our population and guess what ? And all your problems go away in the most important thing we have faced. That is saving our planet! Are you listening? Tell all your idiot experts to come and have a look at our system of 10 KW. It works well and we live by it!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-189	Proforma submission (additional text)	*A global climate emergency is in place. We must stop destructive and polluting fossil fuel projects like this! Please do not release these proposed immense carbon emissions.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-190	Proforma submission (additional text)	*I am writing regarding the current consultations on the proposed Browse Basin and North West Shelf projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-191	Proforma submission (additional text)	*Western Australia is the biggest contributor to greenhouse gas pollution. More than any other state. Let that sink in for a moment. Also, remember the last mining boom. The most mishandled resource sector boom ever? Why are you selling off the country, bit by bit, with no pay back for us? Are we a country, or a corporation. And to be honest, WA Labor, we see you. We SEE you, and with an election coming up, people are not impressed. You can ban puppy mills, but not your mates money mills. Which side of history are you going to be on? We need money to rebuild our power grid, for example, but instead of raising that through mining, you let companies take the spoils, while we get left with the heavy lifting.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-192	Proforma submission (additional text)	*I am not a resident of WA, but I have visited WA and I love WA's natural environment. WA's beautiful natural environment is already at risk from climate change. New fossil fuel developments like these will further push the world towards catastrophic climate change, and risk irreparably harming WA's magnificent and unique natural beauty. It will also have impacts across Australia and the world. Western Australia and the world needs to urgently transition to 100% clean energy. You must uncategorically reject these gas projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-193	Proforma submission (additional text)	*With the current bushfire disaster (caused by years of drought, due mostly to the usage of fossil fuels), and the destruction of so much wildlife habitat on land already, but also the pollution of nearly all waterways and the oceans with toxic chemicals and garbage caused by the severe flooding... With the eyes of the world on the government, now even more than before, this government and the industry cannot afford anymore environmental disasters and the making of decisions in favour of the fossil fuel industry!!! Environmental disasters that you cannot guarantee will never happen, and negative effects on the wildlife in our precious waters, you can also not guarantee that will never happen!!! Discharges of wastewater and pollution*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**)

No.	Submitter	Submission and/or issue	Response to comment
		from oil spills will contaminate marine ecosystems with toxic heavy metals and other chemicals. I urge you also to not propose these developments anywhere else, and start investing and earning your money with renewable energy sources. This, as it is the future and is what not only Australia, but also the rest of the world wants and has to happen!	• MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**).
PRO-G1-RES-194	Proforma submission (additional text)	*" There is not one reason in the known universe to justify degrading our planet, Mother Earth. "" Thought before profit. "" Think, Woodside, think! "*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-195	Proforma submission (additional text)	*I write as a health professional. Climate change is recognised as one of the most serious threats to global health of our century. Climate change has and will increasingly have enormous impacts on human health, both directly and indirectly.It is vital that Australia, and all nations, collaborate to reduce the pollution that drives climate change.Most existing fossil fuels need to stay in the ground in order to maintain a reasonably safe climate for future generations. It is dangerous to develop new gas resources.I understand that, if the proposed Browse Basin and North West Shelf projects proceed, the Burrup Hub would become one of the largest and most polluting fossil fuel projects in the world. If Western Australia is to meet its policy goal of net-zero emissions by 2050, we cannot afford to expand our LNG industry. Gas is not an appropriate 'transition' fuel. It is less polluting than coal at the point of combustion, but its primary constituent, methane, is a highly potent greenhouse gas when leaked. Instead of gas, we should be developing resources and technology for a rapid transition to renewable energy. We should be embracing the potential for job opportunities and regional development in carbon farming and the renewables sector.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-196	Proforma submission (additional text)	*Take a look around you and see that the world is literally dying because of this sort of crap.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-197	Proforma submission (additional text)	*In 2019, LNG overtook coal as the most significant driver of CO_2 pollution increases across the globe. LNG is a transition fuel and should be seen as necessary in the journey to decarbonisation - however in line with the EPAs own recommendations all new developments should be carbon neutral. UNLESS Woodside commits to ensuring that the project is carbon neutral (and this is enforced). Woodside has the resources to ensure carbon-neutrality, but this will come at a cost and therefore it won't implement this voluntarily.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-3: Reduction, mitigation and offsetting of proposed Browse Project GHG emissions (**Section 5.4**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**).
PRO-G1-RES-198	Proforma submission (additional text)	*By implementing carbon neutrality Western Australia will become a world leader in large scale carbon-mitigation technology, and set an example of how to balance the requirements for energy and climate change control.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).
PRO-G1-RES-199	Proforma submission (additional text)	*Dear [redacted name] Chairperson Environmental Protection Authority WA, [redacted name] Secretary Department of Environment and Energy, and [redacted name] DWER: After reading Woodside's documents RE: their proposed Browse Basin - North West Shelf (NWS) extension project, and the two associated offshore components (wells and bringing the gas to the Burrup Peninsula for processing), I am extremely concerned about the devastating effect these would have on the Murujuga rock engravings. The rock art is internationally significant and part of Australia's cultural heritage. It should not be degraded or destroyed in the interest of profits and at the greater expense of increased global emissions of greenhouse gases. Importantly, the emissions from these proposed projects contain substantial amounts of sulfur and nitrogen dioxides which form sulfuric and nitric acids when the emissions mix with atmospheric moisture. These acids break down the patina on the rock surface which of course destroys the rock carvings. In order to truly evaluate the environmental impact of these industrial emissions, it is imperative that the total cumulative emissions from*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-53 in the NWS Project Extension ERD Response to Submissions (**Table 3-10** respectively).

No.	Submitter	Submission and/or issue	Response to comment
		industries on the Burrup Peninsula must be calculated, considered, regulated and monitored. Furthermore, the Burrup Hub proposals should not be approved until the promised monitoring program has been initiated by the WA government's Rock Art Strategy Stakeholder Committee, and they have real data to comment on the consequences of an increased pollutant load. The emissions from processing, transporting, and burning the LNG are a huge source of carbon dioxide and methane which Australia must curtail. I am also very concerned about the health impacts of industrial emissions on local workers and residents of the Burrup Peninsula and Karratha region, given the high levels of air pollution that are consistently visible on BOM images. Much of this could be reduced if Woodside and other industries were forced to have the highest possible level of scrubber and other technology to reduce emissions -- some of their huge profits could be reduce harm to the petroglyphs, human health and well being. EPA has a responsibility to Aboriginal Australia, as well as the entire population, to protect the irreplaceable cultural heritage contained in the Murujuga petroglyphs rather than facilitate the short-term profits of the gas industry.	
PRO-G1-RES-200	Proforma submission (additional text)	*As a Science and Agricultural Sc teacher with over 40 yrs experience, I am well aware of the impact this project will have. I have 6 grandchildren and I would hope that they would be able to experience this wonderful world as I have done.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-201	Proforma submission (additional text)	*I am very concerned about the proposed Browse Basin and North West Shelf projects. If these projects were to proceed, the Burrup Hub would become one of the largest and most polluting fossil fuel projects in the world. If Western Australia is to meet its policy goal of net-zero emissions by 2050, as part of the 2015 Paris agreement we cannot afford to expand our LNG industry. Gas is not a 'transition' fuel. A large scale LNG project with a lifespan of over 50 years is going to be a considerable contributor to global warming and this is something we cannot accept. Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable technologies. . Our children need a safe, clean future. Any development in the fossil fuel industry is more than a backwards step. It seals our fate for the future.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-202	Proforma submission (additional text)	*More fossil fuels? You are proposing to kill even more sea life. When will the killings stop? When the last sea creature has died? And the seaweed has turned to stinking slime? It's just not worth it ; SO STOP THE KILLING BEFORE YOU KILL THE WHOLE PLANET!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G1-RES-203	Proforma submission (additional text)	*Spend 10% of the amount proposed for this ecologically damaging & insensitive project, on refining renewable energy alternatives. In the long term, so much lore will be obtained.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-204	Proforma submission (additional text)	*Also, we do not need gas! Other parts of the world are easily moving beyond gas by banning natural gas in new developments like Berkley (induction cooktops and electric heat pumps!) and banning ICE vehicles (yes, even Boris Johnson likes EVs)*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**).
PRO-G1-RES-205	Proforma submission (additional text)	*It would appear to me as a result of taking an active interest in the wider debate connected with human activities and the environment, that not only scientists, but also the business world , economists and the general public are becoming increasingly aware that there are better alternatives to fuel energy needs.Why then would oil companies want to waste their resources by drilling for oil that may not be required in the future.? Would it not be better to encourage money to be invested in more acceptable alternative technologies which would prepare them for inevitable changes ahead and avoid further damage to a vulnerable ecosystem?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-206	Proforma submission (additional text)	*Please sirs, listen and see what is happening to the climate on Earth. Temperatures are rising. Australia has seen and is seeing catastrophic droughts and fires. Human-driven pollutants in the air have contributed to rising temperatures.I'm concerned about the proposed Browse Basin and Nor-West Shelf projects. These are fossil fuel projects, polluting projects. Because WA has plans for net-zero emissions by 2050, the State needs to reduce LNG projects rather than starting up new projects. The State has already made moves towards renewable energy. I urge you to encourage further development of technology and investment in renewable energy. Jobs will be created and there will be benefits for the State.Reduce emissions rather than creating more. Our world cannot afford further rising in temperature.Please reject Woodside's proposals for these projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-207	Proforma submission (additional text)	*Oil and gas operations should surely be a thing of the past given the cost to life and the economy of this summer of fire. Will next summer be the same as this one? More fires, more devastation. Cancel the overseas contract for gas and let us use the gas we have in WA within Australia. No more drilling, no more frackinge*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental. Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G1-RES-208	Proforma submission (additional text)	*The time is now to act in response to the clear threat to our environment of continued preferencing of mining for carbon producing products over sustainable eco systems. Please exercise your influence to contain this out-dated pattern.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-209	Proforma submission (additional text)	*I am a retired academic geologist. Given the effects of global warming, bushfires, and coral bleaching we must stop using fossil fuels as soon as possible, and that means NO NEW DRILLING.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-210	Proforma submission (additional text)	*I implore you to insist on better protection of the ancient Murujuga petroglyphs in the face of expanded development. I am sure there are technological solutions that our Government could require of the companies involved. The site is of global significance and we Western Australians are its custodians.*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to GHG-260 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-211	Proforma submission (additional text)	*Our destruction of our environment ,and décimation of our wildlife by unprecedented climate change weather events ,means we cannot add any more destruction to our important ecosystems ,which are under great threat.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-212	Proforma submission (additional text)	*At a time where Western Australia needs to be taking its contribution to global carbon emissions seriously, approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).
PRO-G1-RES-213	Proforma submission (additional text)	*It is time for all governments to act responsibly and do what the people want, and not just what the gas, oil and mining industries want. Sustainable, green energy will create more jobs for everyone in the long run.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**:

No.	Submitter	Submission and/or issue	Response to comment
			• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-214	Proforma submission (additional text)	*In the midst of our climate crisis, knowing only that the world's climate will become hotter and more unpredictable with time, this development is the last thing that this country needs.It is time for regulators and governments to take a stand and protect our environment, and place it above the exploitation and ruthless desire to make money that has seen so many marine and other environments destroyed or severely degraded.My understanding is that I am told that Make a decision for the children of this world and their children, together with all our wonderful wildlife - rather than a decision to line the pockets of a multinational company and those that are already rich and well-off.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-215	Proforma submission (additional text)	*Hi. I know form letters aren't the greatest way of communicating with politicians at times, but in this case I think the information below is worth repeating. I'm just a South Aussie who has loved the Northwest on my visits so far, and can't wait to get back up there. We are currently fighting Oil & Gas expansion along my pristine home coast as well, so I just wanted to add my voice to those urging you to do what you can to block more of it up there. The science is clear that we can not globally afford more fossil fuel development, and I reckon we are one of the countries best placed economically/technologically to ramp up the transition to 'green' options. All we need is the political will & bravery to draw a line in the sand and begin. So please be part of that process.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-216	Proforma submission (additional text)	*Since oil and gas are dying industries it is wastefully destructive to drill in this fabulous environment.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-217	Proforma submission (additional text)	*Australia has just had massive, widespread fires due to climate change, brought on in significant part due to fossil fuels. We need to stop this reliance on fossil fuel energy and we need to stop destroying the world in the name of money.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-218	Proforma submission (additional text)	*What are these people\'s problem? The world is at a tipping point MOSTLY because of fossil fuels and here they are wanting to put the final nail in our collective coffins!Extreme weather events EVERYWHERE in the world. Bushfires in the Arctic for christ\'s sake! Billions of native Australian animals wiped out over the last six months! And many more to die because they no longer have a habitat all due to the burning of fossil fuels.Are you the Environment PROTECTION Authority or not?Stop it!Do you want to have the death of our planet on your conscience for the rest of your life???*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-219	Proforma submission (additional text)	*I know there is an economic cost to not going ahead with this project, but .. when are we actually going to start looking after our environment. At every opportunity, we are pounding our beleaguered environment, and there are signs that it is now really struggling with the weight of human consumerism. Please, do not go ahead with this project. I would like to see the world change its direction in favour of living sustainably with our environment.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-220	Proforma submission (additional text)	*Western Australia is to meet its policy goal of net-zero emissions by 2050, we cannot afford to expand our LNG industry. Gas is not a 'transition' fuel, that opportunity was lost 20 years ago.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-221	Proforma submission (additional text)	*Tom* *As a WA constituent, I am seriously concerned that the Burrup Hub development will lead to a major new fracking industry in WA, with devastating consequences for groundwater, communities and the natural environment. Woodside's own documents reveal that significant additional gas volumes will be required beyond the offshore Scarborough and Browse proposals identified The carbon pollution created by this project alone makes it *fundamentally incompatible* with Western Australia's policy goal of net zero emissions by 2050 and national and global efforts to maintain temperatures at safe levels. Given the unacceptable risks of gas fracking AND the carbon pollution and environmental impacts of the Burrup hub development, I urge you *in the strongest terms* to REJECT Woodside's proposed Burrup hub developments. The future is not in fossil fuels of any kind!* *We MUST put every effort into persuading our energy suppliers to re-tool for a zero emissions future as soon as possible.* *The machinery of government has many ways to make that move palatable to the big polluters.* *It is your responsibility to look after ALL Western Australians, not just the big end of town. What future do you want for your grand-children?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G1-RES-222	Proforma submission (additional text)	*We are already experiencing the negative impacts of a changing climate so to even consider opening up what could be one of the most polluting new projects on earth surprises me. I oppose the proposal for the Burrup Hub, Browse Basin and North West Shelf LNG projects and links to the project to the spread of onshore gasfields across farming regions of WA.Thank you for the opportunity to have my say on the proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-223	Proforma submission (additional text)	*I can hardly believe that this is even on the table! The environmental and human health risks of fracking are widely documented and recognised, and even if fracking was totally safe, the end result is MORE FOSSIL FUELS BEING BURNED. Our planet is facing a climate crisis as a direct consequence of our use of fossil fuels as a power source; why on earth are you considering adding to the problem? Australia is blessed with abundance of renewable energy sources (sun, wind, wave power); we need to transition to renewable*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**)

No.	Submitter	Submission and/or issue	Response to comment
		energy NOW, and leave all remaining fossil fuels in the ground! We are all in this together, and there is no Planet B! What sort of planet do you want YOUR great-grandchildren to be born onto?	• GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-224	Proforma submission (additional text)	*This is important. Please read to the end. Instead please put your attention to growing kelp forests that can be used as biofuels, cleans the water, takes* CO_2 *out of the atmosphere and creates marine sanctuaries to help grow the fish population. See Tim Flannery, Tasmanian University and his TED talk about the research about seaweed.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-225	Proforma submission (additional text)	*None of this adds up in the long term as environmental impacts will exceed all possible benefits. Reject this project or you will have blood on your hands - including that of your own kids and grandkids.What else really needs to be said?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-226	Proforma submission (additional text)	*I am DISGUSTED that in 2020 we humans STILL think we have a Right to DESTROY this PLANET. We are in a CLIMATE EMERGENCY and yet we get big corporations that think they can go out and DESTROY this PLANET for GREED, at the rate that us humans are PUTTING PRESSURE on PLANET EARTH. We All won\'t have a Planet to call Home. We are LITERALLY wiping OURSELVES of this PLANET, unless we STOP this STUPIDITY from Woodside proposal. SAY NO TO WOODSIDE.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-227	Proforma submission (additional text)	*We are at a unique time in the worlds history with the centuries old technology\'s of oil and coal threatening our worlds climate and environment and the new technology on the very cusp of evolving to replace them imminently. Our children deserve the right to enjoy the natural world that we have taken for granted and exploited as a young country finding it\'s position amoung the nation\'s of the world. We have developed and should now lead as a nation at this critical time in our worlds history for all our children\'s sake . This oil and gas resource will not disappear if it is mined in the short term and in the longer term we may develop safe ways to mine it if needs be, but give our children a chance to have a future rich in natural resources.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-228	Proforma submission (additional text)	*The destruction of our country is now out of control with Woodside preparing, with the active assistance of the WA State government, for the wholesale destruction of these ancient carvings that link us spiritually with our ancestors.'* *[redacted name].I urge you and the EPA to consider the longevity and well being of the ancient Murujuga petroglyphs against the short-term profits of the gas industry.*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-49 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).
PRO-G1-RES-229	Proforma submission (additional text)	*It's just not right. Everything that I do each day is about me thinking about whether I can reduce my carbon footprint. I'm doing the work. For my children and my future grandchildren (I hope). I expect the WA govt and big business to have the same line of thinking. We should not be undertaking any business enterprises that increase our carbon emissions. Why don't you build an electric car plant and make money from that eg.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)
PRO-G1-RES-230	Proforma submission (additional text)	*I am also concerned that atmospheric greenhouse gases are already too high for any new fossil fuel project to recover it\'s establishment costs before being shut down due toloss of commercial viability, in which case the proponent may not be able to fund cleanup and restoration works.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)
PRO-G1-RES-231	Proforma submission (additional text)	*I am really worried about the future of life on earth. For over 30 years we have been warned about climate change but little has been effectively achieved. I believe that we are in the tipping point as David Attenborough and others have warned.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-232	Proforma submission (additional text)	*Enough is enough, human greed is ruining our beautiful planet and it needs to stop now. We need to look to new ways to do things without destroying the planet and it's inhabitants.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-233	Proforma submission (additional text)	*What could be more important than the safety and conservation of our planet? If you say profits then you're the number one problem wrong with the human race.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-234	Proforma submission (additional text)	*The carbon emissions from the Burrup Hub will have a significant detrimental impact for decades*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-235	Proforma submission (additional text)	*Dear EPA Chair,Enough! When does culture become more important to than profit? Today you have the power to show the world, our First Nations people & general Australian community that culture is more important than profit. Woodside owes this country a duty to protect Aboriginal art & our environment. Destruction or preservation? What will be your legacy?*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to GHG-284 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-236	Proforma submission (additional text)	*We must learn quickly that this type of development is both dangerous to the environment and will increase Climate Change. As a Victorian who has watched in dismay the damage that has occurred over this summer, first with terrible fires and now with floods, we must stop raping the earth and turn quickly to renewable energy.* *Change to renewables now and your company will flourish with the new technology and will help relieve the dangers that will come with your proposed development.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-237	Proforma submission (additional text)	*This proposed project is daft, environmentally irresponsible and plainly economically stupid.* *Politicians who allow or champion projects of this type can take warning: you will pay a heavy price at the ballot box for putting the narrow interests of big business before the broad and urgent challenges of the environment.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-238	Proforma submission (additional text)	*Please don't let only economic gains be the point of your decision, allow the ecological stability and natural beauty hold weight . The future of humanity needs decisions on relationshop between energy and nature to be innovative design , not old outmoded and polluting fuels.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-239	Proforma submission (additional text)	*seriously, approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-240	Proforma submission (additional text)	*seriously, approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible. The life-time emissions of these projects must be considered. It is for these reasons that I strongly urge (and trust) you to reject Woodside's*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-6: Estimated GHG emissions from Woodside operated projects related to the Burrup Peninsula (**Section 5.7**).
PRO-G1-RES-241	Proforma submission (additional text)	*I'm just adding a brief note to this pre-generated email - I'm not an expert and so haven't memorised the relevant scientific information provided below. I do want to have my say as a West Australian, and to let you know that the preservation of the local and global ecosystems, including this incredibly precious rock art, is infinitely more important to me than any financial benefit related to the fossil fuel industry. We should be positioning ourselves as global leaders in the rapid transition to renewable energy sources, instead of sacrificing irreplaceable cultural sites to a dirty, dying fuel. The climate crisis will exacerbate the existing chasm between the quality of life of the most wealthy and the most impoverished in Australia and around the world - governments' duty ought to be with elevating the disadvantaged, not pandering to the already wealthy. Anyway, the rest of the pre-generated email text follows.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-242	Proforma submission (additional text)	*I have visited the Burrup with my family and was speechless when viewing the incredible wealth of petroglyphs there. I was also speechless to see the inappropriate development in the area. Industries producing sulfur and nitrogen dioxide emissions are the worst kind of neighbours for the petroglyphs. The state and federal governments should be reducing the impacts in this special area to protect the heritage values. Please consider a World Heritage recommendation so this treasure can be preserved into the future. Industrial developments should be located in more suitable areas. I concur strongly with the information below:*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to GHG-291 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-243	Proforma submission (additional text)	*I am writing to you even though I live on the east coast: this issue affects all Australians. Gas is not a transition fuel - that time is long past. Our planetary atmosphere needs immediate stabilising and gas is a major contributor to green house gases. I also live in a region that was nearly fracked, and I know the dangers that it presents to water, soil and air quality. As desertification spreads across the planet, arable farming land needs to be regenerated and protected from inappropriate development. For these reasons, plus those mentioned below, I want to show my support for the people in Western Australia who oppose this project, and to also voice my objections.I'm alarmed about the industry reports that this proposed gas hub could also be connected farmers across WA to fracking gas fields is well known to the Government. It is totally inappropriate for the Government to be considering this gas hub proposal without fully*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G1-RES-244	Proforma submission (additional text)	*I am amazed that I and many others need to write to you regarding the proposed Browse Basin and North West Shelf projects. How can it even be considered as viable in our current awareness?If these projects were to proceed, the Burrup Hub would become one of the largest and most polluting fossil fuel Gas is no longer a 'transition' fuel. We have the resources and technology for a rapid transition to completely renewable energy. This aim is what we need to be embracing with the potential for job opportunities and regional For Western Australia to sustainably prosper, tackling its emissions through the creation of clean jobs and investment in renewable technologies it an imperative. We can and need to rapidly move away from all types of fossil fuels, including LNG. I therefore strongly urge you to reject Woodside's proposal as we should be pursuing the cheap and abundant renewable resources we have available right here in WA.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-245	Proforma submission (additional text)	*I cannot believe that in 2020, in the middle of the sixth mass extinction of life on earth, I have to write to the EPA & the Sec of Environment & energy (well there's the problem writ large - you cannot serve the environment while also enabling fossil fuel extraction and use) in relation to the consultation on Woodside's Browse Basin development. The EPA knows that Australia cannot afford any new Oil and Gas projects if we are to keep warming to below 1.5 degrees - current forecasts have us heading for 3 degrees with our existing behaviour! That is not a life-enhancing prospect. It will be a dangerously unstable environment to try to live in as we can see the effects of just 1 degree of warming right now. You could save a heap of money and time by just rejecting outright any new fossil fuel projects or extensions. It is insanity to have to consider them and reckless for profit-driven companies to suggest them. I am livid that Woodside's proposed activities threaten the sensitive marine .world Woodside's proposed Browse Basin and Burrup hub proposal is Australia's MOST POLLUTING fossil fuel mega-development which will contribute around FOUR TIMES the pollution of the proposed ADANI coal mine. Scott Reef has already suffered the impacts of bleaching events from climate change and this would sign its death warrant. I urge you to take a stand for our children. They will have no chance of living on a safe planet if we carry on destroying the earth's ecosystem. Please reject the criminally negligent, ecocidal proposal to undertake oil and gas development on or around Scott Reef. From fellow human,*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**).
PRO-G1-RES-246	Proforma submission (additional text)	*The professional letter follows however in simplest terms we need to transition from carbon based and all fossil fuel sources for energy. It need s to be left in the ground. We need you and all who have the capacity to support significant change for the benefit of all living beings on earth so recognise this HAS TO HAPPEN NOW. Why corrupt and pollute a relatively pristine environment which will be a key area to rehabilitate and maintain ocean diversity to benefit a very small number of shareholders.Please amend your thoughts. Make decisions that benefit all species on earth.You have been tasked with a great moral and ethical decision not a corporate or financial one.Please err for the benefit of the greater good.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-247	Proforma submission (additional text)	*It breaks my heart that we the people are constantly having to protect each and every piece of land from the greedy corporations seeking to take take take in the name of money and power instead of moving forward with technology that respects our home and nurtured her to renewal.It is exhausting and enfuriating.It is causing anxiety in much of the population that we are seemingly powerless and must stand by and watch as our future is destroyed and anything of significance culturally especially silly takes a back seat to lining the pockets of the already super elite.These companies are a disgrace to mankind and the earth in which they depend upon to live. Shame on you for continuing to allow this destruction. May you stand before the children of the future and explain yourselves.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-248	Proforma submission (additional text)	*Having visited the Pilbara 18months ago as a guest artist for Red Earth Arts Festival 2018 I was incredibly moved by the history and deep richness of this area. In addition, I was graciously exposed to Rock Art and national treasure by Clinton and his family. The rest of this letter is pre- drafted as I cannot express any better my deep distress that this ancient historical world class site is not being valued or managed with best practice measures in mind or action.*	With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-55 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-249	Proforma submission (additional text)	*If we must burn gas for power then burn it here in WA and export the electricity via high voltage DC current. This will result in far fewer ghg emissions and require far less gas than would be required to liquefy the gas and export it via ships. Of course these companies want to use their ships but that is not something the EPA should be worried about.Don't forget that there are fugitive emissions from these projects. These emissions are far more potent greenhouse gases than carbon dioxide so although smaller in quantity they still would make a huge contribution to our greenhouse gas budget.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-250	Proforma submission (additional text)	*To [redacted name] Chairperson Environmental Protection Authority WA and [redacted name] Secretary Department of Environment and EnergyGentlemen, we rely on you and the Department Heads in the Public Service to take control of the "Climate Change" situation because our politicians are completely "out of their depth" and don't know what to do.I believe the scientist as I hope you would and their advice is we don't need more gas and we don't need more coal. For the sake of future generations, please say no to any increase is exploration and development of gas and coal resources.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-251	Proforma submission (additional text)	*As an international citizen who is informed and concerned about environmental issues and who is aghast at the destruction of Australia's unique species and ecosystems by the recent fires, I write regarding the proposed Browse Basin and North West Shelf projects*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-252	Proforma submission (additional text)	*To knowingly allow activities that threaten this rock art is a cultural crime, Any actions will be recorded, remembered and judged by future generations, please don't let our generation be seen to have been party to, or to have facilitated this.*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-56 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-253	Proforma submission (additional text)	*Surely it is time to concentrate on totally renewable energy sources and cease the continued distruction of our wonderful marine creatures.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-254	Proforma submission (additional text)	*No matter where we live, there is a strong need to take care of our world.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-255	Proforma submission (additional text)	*I am deeply concerned that yet again the Murujuga National Park and Rock Art is threatened by further industrial development. An Internationally recognised Petroglyph site, of World Heritage value, must struggle with the destructive outfall from fossil fuel industrial waste, despite the scientific evidence that such pollution can destroy these ancient artifacts. This is part of Australia's(and the world's) significantly ancient human story, that should be preserved and respected. And just as the destruction upon the Australian continent for "mining resources" has wreaked havoc upon the unique environment, so too to enter the water off shore for gas extraction places at*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
		risk the unique coastal water environments that provide a base for the tourist and fishing industries. This is a "balancing act" fraught with terrible consequences. To top it all off, rather than reducing global carbon-based emissions to reduce the impact of global warming, this would increase emissions and have a greater impact on global warming, creating a more expensive situation to then address global warming problems. A short term profit for the companies involved and a long term problem for the people of the world and a very, large recovery/adaptation bill for the government(aka the taxes of the Australian people, money that could be better spent elswhere).At this stage in the history of the planet, what actions are taken to control fossil fuel emissions are the important matters of the day. Adding newer and bigger amounts of fossil fuel wastes into the atmosphere is criminal, given all the scientific evidence on the impact this will have worldwide.The recent fires on the East Coast already a significant warning of what some are calling the "new normal", adding further fuel to this "normality" is an unconscionable act of greed before humanity and the planet. Every effort must be made to reduce emissions and stabilise global warming, this is what the science has been asking governments to do. Rated 57 out of 57 on our "current" efforts to address the global emissions problem, the Woodside proposal is anathema to all that needs to be done to honour our global agreements to reduce emissions. The scientific reality of future temperatures and weather conditions and their impacts upon the whole planet are only just beginning to come home to roost. That we are struggling to responsibly contain emissions now and would add greater emissions to the equation beggars belief. The only responsible action to be taken with regard to the Burrup Hub Proposal by Woodside is to stop the process immediately. The WORLD cannot afford the additional pollution and inaction this project would involve. We cannot keep adding more fuel to the global warming fire and expect it to "get better", it can only exacerbate the problem in much worse ways. The definition of Insanity is repeating the same thing and expecting different results, adding more fossil fuel emissions to the atmosphere/environment will not resolve global warming. If the science can recognised in every other sphere of human usage, it is time it was recognised when it comes to Climate Change/Action. No Woodside Hub at Burrup!	With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-57 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-256	Proforma submission (additional text)	*In the measure of its true task, the EPA must be more than what its currently lessened regulatory power enables it to do - to safeguard the stability, ecological integrity, and beauty of this land and water for many generations to come If this proposal is accepted, then this sets the tone for even further regulatory weakening and 'capture' by corporate interests that we have seen in developing in other nations - most notably the rollback of environmental protection in the USA, right at the time of the critical juncture between now and meaningful action addressing catastrophic climate change to come.* *Please do not fail us.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-257	Proforma submission (additional text)	*The proposed Browse Basin and North West Shelf projects will significantly increase global carbon emissions. We have already passed the point where we need to be reducing our emissions towards zero, as soon as possible.* *Emissions from these projects will accelerate global heating and ensure that Western Australia and many more vulnerable countries will experience increasingly severe weather events. The southern half of WA will continue to heat up and dry out and make the current water stress in Denmark and other southern Shires significantly worse.* *These emissions combined with those from other parts of Australia and the world will render more areas of WA uninhabitable to humans and will extinguish many species, especially in our prized biodiversity hotspots. These will just get hotter.* *Expansion of gas extraction when the science is clear that phasing out is essential to the survival of so many species and habitats is unconscionable.* *Please use all your powers to reject these proposals*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-258	Proforma submission (additional text)	*Please reject Woodside's proposal for the Burrup Hub project. It must be stopped. We are all trying to reduce our environmental impact personally yet, big companies like Woodside get away with emitting more damaging emissions than anyone and all for their own profit and at the detriment of our world. Please see below information which I haven't written but I have read and researched and could not have articulated myself better so am using. Please do not consider this is a lack of interest on my behalf rather sensibly using a response that is more succinct than I can write personally. I am writing in response to the current consultations on the proposed Browse Basin and North West Shelf projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-259	Proforma submission (additional text)	*My son is 9. We are hoping next year to have 3 months travelling and camping in WA. I can't wait to show him the amazing environment you have. But I am so worried about our environment. Having lived through the bushfires over East, I know we have to take action now if we want to have anything resembling the environment I was privileged to grow up in. My son's favourite animal is turtles. Please don't jeopardise their future.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-260	Proforma submission (additional text)	*Every developer is squeezing every dollar they can wring out of this weary country and it's the silent dwindling natural environment that always suffers. Everyone holds the environment very dear to their hearts. Everyone except the developers and politicians who allow them to risk ruining the land or sea*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-261	Proforma submission (additional text)	*I am writing in response to the current consultations on the proposed Browse Basin and North West Shelf projects. The risk to irreplaceable marine environments and Indigenous world-class heritage worthy sites is too great. When the rest of the country is already burning, or coral reefs dying because of human long term behaviour, it is necessary to preserve those places that we have left. It might be too late to remove existing projects in these areas, but it is irresponsible to permit expansion of them.WA has the chance to take a significant position in saying enough is enough - our land and sea that sustain life on this planet, has to come first - WA and Australia can still become a world leader in saving this planet from irreversible damage. Show the world that Australia's politicians, through government policy, that they can (despite their track record so far) do the brave thing for once, and finally say no to big business. Protect the natural environments we have left and refuse the approval of these projects, please.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**). With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to GHG-309 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-262	Proforma submission (additional text)	*please show some leadership and reject woodside's lng as this season's bushfires have highlighted, climate change is here and now and we need to halt all fossil fuel projects immediately and instead invest in renewables. on behalf of our children and our planet, i urge you to see sense. thank you!!!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-263	Proforma submission (additional text)	*It is extremely important that such proposals offer carbon capture, or abatement. In the absence of a capture plan to harness 95mtpa of carbon & other greenhouse gases this proposal must not be approved.The extent of the emissions that would result from gas We have seen the effects of Bushfires this past 5 - 6 months that global warming has had on the Eastern sea-board of Australia, Queensland, South Australia, including Kangaroo Island and in Western Australia. Devastating fires of the like never before seen by professional firefighters with many decades experience.Our country should not be subjected to proposals that will increase our carbon & methane emissions, that is directly attributable to increased severe weather events.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-9: Carbon capture and storage (CCS) of Browse gas (**Section 5.10**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-264	Proforma submission (additional text)	*I am personally appalled at the lack of respect for the environment on which we and all life depend, being shown by greedy, profit-motivated resource companies. They don't appear to care about the damage they do, and the fact that governments just let them do what they like, is an unconscionable disgrace. No wonder there is so much anxiety amongst the young people !The life-time emissions of these projects must be considered. It is for these reasons that I strongly urge you to reject Woodside's*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-265	Proforma submission (additional text)	*PLEASE ACQUAINT YOURSELVES WITH THE SCIENTIFIC ASSESSMENTS OF THE CONSEQUENCES OF CONTINUING CARBON EMISSIONS. THE REQUIRED RATE OF REDUCTION OF EMISSIONS TO PROVIDE SOME POSSIBILITYOF AVOIDING CATASTROPHIC CLIMATE CHANGE NECESSITATES AN END TO ALL NEW FOSSIL FUEL DEVELOPMENTS AND THE CURTAILMENT AS RAPIDLY AS POSSIBLE OF EXISTING MINES AND GAS EXTRACTION. I AM 76 YEARS OLD AND FEAR FOR MY GRANDCHILDRENS' FUTURE, AND EVERYONE ELSE'S FOR THAT MATTER.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-266	Proforma submission (additional text)	*The extent of the emissions that would result from gas collection and processing at the Burrup Hub would cancel out the gains made by both individual residents and industry seeking sustainable ways to reduce their ecological impact. Allowing for both the creation of new, and the extension of existing, large-scale carbon pollution sources such as the proposed Burrup Hub, will breach your international carbon reduction obligations, and push the national reduction goals of Australia out of reach. The carbon pollution created by this project makes it fundamentally incompatible with Western Australia's policy goal of net zero emissions by 2050. pollution increases across the globe. LNG is a fossil fuel with pollution at every stage of its development and use and cannot be considered a solution to address climate change and ecological destruction. The carbon seriously, approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible. More importantly, the construction of the facilities themselves will involve the destruction of local ecosystems. I lived in Australia from 1970 to 1992. Since I did not wish to be part of a country in which the large-scale destruction of natural habitats, logging of forests and extermination of native animals continue to take place and which is the result of genocide against indigenous peoples, I returned to my country of origin, Croatia, and encourage others to do the same. I also avoid products from such countries. I am campaigning against an LNG terminal that is planned in Croatia that could involve the import of gas from Australia or North America. All the ecological impacts for the life-time of these projects must be considered. It is for these reasons that I strongly urge you to reject Woodside's*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • Lower and zero carbon energy sources (**Section 5.8**). With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to GHG-314 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-267	Proforma submission (additional text)	*I am writing in response to the current consultations on the proposed Browse Basin and North West Shelf projects. I have written many letters to many politicians and decision-making entities for twenty years regarding the environment. I have yet to see any of them really listen or respond in a meaningful way. I humbly ask you to consider, really consider, this letter, and the concern I share about this project and others like it with thousands around the country. If the proposed Burrup Hub projects proceed, the Burrup Hub will be I have sent too many letters of this kind, and I am weary. It's time for us to move on to new energy sources, and stop emissions from sources that will inevitably run out anyway.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-268	Proforma submission (additional text)	*I am writing in response to the current consultations on the proposed Browse Basin and North West Shelf projects. I understand that if the proposed Burrup Hub projects proceed, the Burrup Hub will be .With all the knowledge we have today, the implications of this project amount to ecocide. There is a moral and human rights case against further industrial development of this nature. We cannot afford to add to the destruction of nature, animals and life support systems. People around the world are already suffering from the devastating impact of the fossil fuel industry.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-269	Proforma submission (additional text)	*The Burrup Hub project should not go ahead as it will not only breach our international carbon reduction obligations, but also risk the health of the Australian coastline since more earthquakes are expected in this region and more severe tropical cyclones are becomingthe norm, which would risk damaging the structures put at sea.* *Please consider the impact this project would have both in the short term and the long term on the environment and tourism industry.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-270	Proforma submission (additional text)	*When will ever care enough for the future of our children, the planet and the wildlife?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-271	Proforma submission (additional text)	*We have just one chance to survive on our Earth.* *Projects like the one proposed here are greatly diminishing our chances at success, and are likely robbing our children and grandchildren of a joyful secure future.* *People around the world will not tolerate the blatant destruction of our Habitat in a missguided folly like this one.* *The zombies that are perpetuating these acts of mindless self sabotage will be judged harshly in the very near future, by themselves as well as the rest of us.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
		We all MUST change our daily rigmaroles and directions, to a long-term sustainable path. *There are NO second chances in outer space !* *And that is exactly where we all are.*	
PRO-G1-RES-273	Proforma submission (additional text)	*Please do not proceed with this plan. There is still time to move in a different direction and save yourself.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-274	Proforma submission (additional text)	*In addition, the rock art on the Burrup peninsular is extremely vulnerable to current industry already. Further development would cause more damage to one of the most significant sites of human culture.*	We acknowledge the comments made and provide the following information in response to the matters raised With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-RA-58 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.3**, **Table 3-10**).
PRO-G1-RES-275	Proforma submission (additional text)	*As an Australian citizen who is very concerned about the climate emergency and the state of our environment,. At this time in human history, this project is a really bad idea. It is obvious that gas is a fossil fuel, and arguments that it is less polluting than coal belie the fact that we need to be focusing our development of renewable energy, not extracting more fossil fuels! The extent of the emissions that would result from gas Please consider the responsibility that current generations have in ensuring a liveable world for those to come. Australia is already experiencing a climate emergency and releasing more gas can only make matters worse, as well as setting a very poor example to the rest of the world.Yours extremely [redacted name]*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-276	Proforma submission (additional text)	*How much have they greased your pockets with you spineless cretins? I studied political science in 2002 and 2003 and dropped out because I saw how the Iraq war played out despite massive public outcry against a war for oil. Millions in the streets and millions of petitions were overturned because the corporate power runs the government and not the government for the people. In the years since my initial disillusionment I have seen both spineless sides of 'government' be bought out by the interests of the oil*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
		and mining lobby well in advance of any elections and I grew so sick of it that I can't think about the problems facing this country as being directly caused by this pathetic excuse for democracy. For [redacted] sakes do the right thing and stop approving billion dollar demolitions of our fragile environment and start making these arrogant companies change their direction in favour of sustainable development.	
PRO-G1-RES-277	Proforma submission (additional text)	*Seriously the planet is in enough trouble without more destructive practices such as this,.world Leave something for the future. Our greedy era must stop*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-278	Proforma submission (additional text)	*I am writing in response to the current consultations on the proposed Browse Basin and North West Shelf projects.At a time when we are globally supposed to be divesting away from fossil fuels, it is inconceivable to me that the governments of Australia would approve, and invest in, coal projects like this to see us into the future.Other, smarter, governments, are shutting down coal plants and investing in renewable energy and Australia should be doing the same. Most importantly, Australia should not be digging up reserves to pass onto irresponsible countries to burn at their discretion.Indeed if we have any hope of keeping global warming below 1.5-2 degrees Celsius, Australia is in a particularly important position as we have the power to stop flooding the global market with cheap fossil fuels.The proposed Burrup Hub, if approved, will be collection and processing at the Burrup Hub would cancel out the gains made by both individual Australians and industry seeking sustainable ways to reduce their carbon footprint. The carbon pollution created by this project makes it fundamentally incompatible with Western Australia's policy goal of net zero emissions by 2050. The claims made by Woodside that gas is a 'clean' fuel contributing to reduced emissions are unsubstantiated and misleading. There is no such thing as clean fossil fuels. Please don't play us, the public and people of Australia, for fools.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).
PRO-G1-RES-279	Proforma submission (additional text)	*Given that it is no longer plausible in this country to deny climate change and given what the scientific consensus tells us about our carbon emissions it is either suicidal or idiotic to proceed with new massive fossil fuel projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-280	Proforma submission (additional text)	*So bloody tired of governments head up it's bum attitude to OUR environment. Wake up and listen to the people!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-281	Proforma submission (additional text)	*Re: the current consultations on the proposed Browse Basin and North West Shelf projects. It's time to step into a new era!If the proposed Burrup Hub projects proceed, the Burrup Hub will be .NOT what the world needs now. The extent of the emissions that would result from gas both the creation of new, and the extension of existing, large-scale projects such as the proposed Burrup Hub, will breach our international carbon reduction obligations.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).
PRO-G1-RES-282	Proforma submission (additional text)	*STOP THIS CRIMINAL INSANITY! !!.world*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-283	Proforma submission (additional text)	*Although I live in NSW, I think this matter concerns all Australians. I am aware that the federal government is on a pro-gas agenda. I am also aware that major international monetary funds are divesting from fossil fuels on the basis of economic decision making. I am also aware that our fossil fuel industry is heavily subsidised by our taxes. These three things, plus the fact that climate change has arrived in Australia, is caused by increased warming gases in the atmosphere and and that fossil fuel is a direct contributor to this effect, means that I have a stake in this. Not only this, I am a diver and recreational enjoyer of the ocean, and a lover of marine life. My body has*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**).

No.	Submitter	Submission and/or issue	Response to comment
		as much water in it as the earth. I owe my life to it. So do you. Onward to the following points: I am concerned that Woodside's proposed activities threaten the sensitive marine .world (And, as is seen by the great garbage islands in the Pacific, and modelling on the currents from the Great Australian Bight, the ocean moves and takes things from here to there.) And in case you didn't notice, our entire country, every state, including WA, is burning. That's climate change.	
PRO-G1-RES-284	Proforma submission (additional text)	*This is insanity on steroids! It is also a criminal offence according to the UN Human Rights charter. Look it up.* *The Dutch have already created a precedent and won their case in The Hague. All Australian citizens have to do is follow suit.* *How anybody can even contemplate an action like this, so against everything that needs to be done to reverse climate change and protect rapidly declining wild life and flora is absolutely dumbfounding.* *Are you people aware that Australia is on fire; that we've already lost lives, flora and fauna that can never be replaced, businesses, properties, communities have been utterly devastated, that nature, indigenous trees and bush and re-greening of the planet is our only way to survive and mitigate climate change, and yet Australia's conservative local and federal governments appear to be doing everything they can to tip is over into the abyss? Didn't know you were a conservative, [Premier of Western Australia]! There are no words to express the grief, rage and frustration of the majority of the population over the criminal actions of conservative climate deniers. But things are turning around, and you people should be very afraid. The precedent has been set in The Hague. Ecological vandals will no longer have free rein; they will be brought to account.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-285	Proforma submission (additional text)	*Thank you for accepting my email with regard to the North West Shelf Project. Surely with current climate change statistics across Australia this summer Australia needs to be focussing upon expanding renewable energy and all the innovations such as are currently occurring in institutions such as La Trobe University at 4 sites and Monash University passive housing. Surely, at the same time we must reduce Australians reliance on energy across the nation, such as improving energy efficiency in buildings. I refer you here to housing developments such as the Cape in Victoria requiring ER7 plus.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**)

No.	Submitter	Submission and/or issue	Response to comment
		The NCC has written new codes for Volume One 2019, and is also writing new codes for Volume Two 2022 for better thermal performance therefore greatly reducing a buildings reliance on energy for heating and cooling. The Department of energy and the environment is developing energy efficiency requirements for existing homes to be released 2020 to improve energy efficiency of older homes and businesses. For years the government sponsored EneryCut organisation has been helping industry reduce their reliance on energy sources. However, with all this in mind I am specifically writing in relation to the current consultations on Woodside's Browse Basin development. Please note that this is a stranded asset industry and apart from the environmental issues discussed below, can be a huge waste of money In particular I am concerned that Woodside's proposed activities threaten the sensitive marine world the proposed Adani coal mine. Scott Reef has already suffered the impacts of climate change through bleaching events and this proposal would significantly add to this problem. Innovation in energy performance of buildings can be the growth industry of the future offering new products, new businesses and jobs by the thousands for the millions of buildings which demand upgrades.	• MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**).
PRO-G1-RES-286	Proforma submission (additional text)	*LNG is a fossil fuel with pollution at every stage of its development and use and cannot be considered a solution to address climate change.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-287	Proforma submission (additional text)	*Following is the "proper" letter with the intellectual reasons, but first I want to express the emotional reasons for sending this.Are you crazy????Coal & oil are reaching their use-by dates. Are you so afraid of the idea of change that you wi commit this country to both the dishonor & the rusting & stranded assets that this will produce, not to mention the environmental destruction along the way!!For goodness sake, if you're not up to the job, then as Bob said "If you can't lend a handThen get out of the way,For the times they are achangin'."*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-288	Proforma submission (additional text)	*I'm just going to add a quick note to this otherwise pre-generated email. Expanding fossil fuel production in WA is unethical, a direct attack on the futures of all vulnerable people without sufficient money to insulate themselves from the worst effects of climate change. We need to reduce carbon emissions as drastically and quickly as possible, not increase them. Other governments have already faced legal action for failing to act on climate change, there is no reason to suppose this won't also happen in Australia. Please, don't allow these projects to proceed. We could be a world leader in renewable energy, if we could just put science and human rights ahead of ideology and the shortsighted interests of the fossil fuel industry.I am writing in response to the current consultations on the proposed Browse Basin and North West Shelf projects.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-289	Proforma submission (additional text)	*Incidents of failure occur and at rare times damage beyond compression like the Sidoarjo mud flow or Lapindo mud which may keep discharging for 25 years. Fossil fuels including gas are in them selves dangerous for life.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-290	Proforma submission (additional text)	*I doubt you will though as I suspect you're both [redacted]*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-291	Proforma submission (additional text)	*Furthermore I consider, these proposal to be tantamount to criminal actions and those responsible should, at some time in the future, be held responsible in an international court of law!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-292	Proforma submission (additional text)	*We want renewable energy (solar thermal and wind) not any new coal or gas.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**)

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-293	Proforma submission (additional text)	*I am also deeply concerned for the Aboriginal artefacts at Burrup Peninsula and for the possible damage to areas with deep significance to Aboriginal people.*	We acknowledge the comments made and provide the following information in response to the matters raised With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**).
PRO-G1-RES-294	Proforma submission (additional text)	*Start living and planning in this century and for the future.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-295	Proforma submission (additional text)	*I wish to express my deep concern over the proposal for the Burrup Hub and the Browse Basin development. I am alarmed about the industry reports that this hub could also be connected to several new major onshore gas projects in the farming region aro The Waitsia and West Erregulla projects are still going through assessment and exploration processes, yet it seems as if the Burrup Hub project is already talking up access to vast amounts of The strong opposition from regional communities and farmers across WA to fracking gasfields is well known to the Government. The environmental assessment of the Burrup hub project must consider the impacts of all these future gas developments, and Woodside must disclose all gas supplies and their environmental impacts. It is also regressive when we are already experiencing the negative impacts of a changing climate to even consider opening up what could be one of the most polluting new projects on earth. WA needs to do better--to stop increasing the flow of polluting gas and get serious about economic opportunities from clean renewable energy and renewable energy exports. WA's vast potential to be an exporter of clean, renewable wind and solar power to neighbouring nations like Indonesia and East Timor must be explored and exploited, not polluting gas. Huge expanses of land in northern WA could be devoted to such facilities with NO harm to terrain, water or atmosphere. In conclusion, I fervently oppose the proposal for the Burrup Hub, Browse Basin and North West Shelf LNG I thank you for this opportunity to express my opinion on this crucial issue*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**). With respect to the concerns raised relating to onshore development including fracking, please refer to the response to O-21 in the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-296	Proforma submission (additional text)	*I lived in Geraldton for years and people don't want mining & gas like the Pilbara. They want clean energy & jobs. The mid-west could become a hub for renewables. They have plenty of wind & sun*	We acknowledge the comments made and provide the following information in response to the matters raised With respect to the concerns raised relating to potential impacts to the Murujuga rock art site and the World Heritage listing nomination, please refer to the response to GHG-340 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-297	Proforma submission (additional text)	*I am writing to you because I am deeply concerned by the proposal for the Burrup Hub and the Browse Basin development. I'm alarmed that this hub could also be connected to several new major onshore gas projects in the farming region aro The serious opposition from regional communities and farmers across WA to fracking gasfields is well known to the Government. Hence It also reflects poorly, given that we are already experiencing the negative impacts of a changing climate, to even consider opening up what could be one of the most polluting new projects on earth.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**). With respect to the concerns raised relating to onshore development including fracking, please refer to the response to GHG-341 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).
PRO-G1-RES-298	Proforma submission (additional text)	*In addition, Woodside's proposed Browse Basin and Burrup hub proposal is Australia's most polluting fossil fuel mega-development which will contribute around four times the pollution of Thank you for your urgent consideration of all this.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-299	Proforma submission (additional text)	*I urge you and the EPA to consider the longevity and well-being of the ancient Murujuga petroglyphs against the short-term profits of the gas industry. Yours [redacted name]*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised relating to onshore development including fracking, please refer to the response to GHG-344 in the NWS Project Extension ERD Response to Submissions (**Section 3.2.3**, **Table 3-7**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-300	Proforma submission (additional text)	*I don't understand why we have to keep on fighting this. Surely by now you have realised that this isn't the way forward only the way backwards. We need to think for ourselves and not follow in the world's footsteps, instead lead the way forward in a new positive direction towards renewable energy sources. It is just upsetting that these emails and protests have to continue to be written over and over again. The funny thing we all put this much effort without monetary gain. Yet, the people that we appoint/get appointed won't make the hard decisions we the appointees put them there to do. So the only thing I can see going on is that there is some extra monetary gain for those appointed other then what we the people are aware of! Are you not tired hearing "this is just the world we live in and there's nothing we can do about it". Well there are people who can do something about it and those are the ones in power that need to grow a set and stand up for what needs to happen.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)
PRO-G1-RES-301	Proforma submission (additional text)	*At a time when hydrocarbon energy sources are becoming 'the bad thing of the past', we should channel future energy developments toward renewable. For the future of our species.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-302	Proforma submission (additional text)	*Think about the future of our planet as we need clean environment for us to live healthy lives ...WA is only interested in the DOLLAR...THEY DON\'T CARE ABOUT THE ENVIRONMENT COAST LINE OR THE AIR...STOP NOW SELL YOUR SHARES*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-303	Proforma submission (additional text)	*A large scale fossil fuel LNG project with a lifespan of over 50 years simply cannot be allowed while we're already experiencing the effects of climate change in Australia. Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable technologies. We must rapidly move away from all types of fossil fuels, including LNG. I strongly urge you to reject Woodside's proposal as we should be pursuing the cheap and abundant renewable resources we have available right here in WA*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-304	Proforma submission (additional text)	*In addition, it is patently obvious that continued use of fossil fuels is increasing the risk of further Climate Change as witnessed by the WORST bushfires Australia has ever experienced. The dubious benefits of your proposals would be more than offset by the losses of homes, lives and the killing of huge numbers of animals and denude the land of tree cover as the next wave of fires continue to destroy Australia.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-305	Proforma submission (additional text)	*OMG! I cannot believe that you are even considering this!!!* *[redacted name]*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-306	Proforma submission (additional text)	*I am appalled by the shear arrogance and disrespect for our environment and* *[redacted]*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-307	Proforma submission (additional text)	*Planet before profit ...Do you really care about your kids/grandkids ?????????* *?????????????????????????????????*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-308	Proforma submission (additional text)	*The following sets out the scientific arguments, but basically my response is: how dare you. How dare you consider another attempt at genocide? This proposal should be rejected out of hand with a message that the future of life on our planet requires an approach sympathetic to all life forms, and our species survival relies on the survival of all of them.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-309	Proforma submission (additional text)	*Are you mad???*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-310	Proforma submission (additional text)	*Climate change is the existential threat to our planet and our human species. Now is the time to ACT not when the damage has been done and it cannot be reversed.* *Woodside has taken enough wealth out of Western Australia. It's time to stop the exploitation and greed and to focus on protecting our planet.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-311	Proforma submission (additional text)	*I recently returned from Germany with a copy of Die Zeit weekly. This is one of the world\'s few remaining deeply researched and highly regarded newspapers. This included a world map in 80 years, by the year 3000 - that is, within the lifetime of our/your grandchildren, when most of Australia, all of South America, most of the US, all of Europe below the latitude of the German city of Bonn, all of Africa, will be uninhabitable due to drought and/or catastrophic weather. This will be our world if we continue as Australia (badly) and most countries in failing to meet the 2015 Paris Climate Agreement limits on carbon emissions. Australia, with the devastating and widespread bushfires, and now with towns evacuated earlier because of fires, now being evacuated due to floods, represents the world\'s canary in the mine, en plein air, that is, in full sight of the world, for the massive destruction of habitat and of over a billion animals. Miners and gas explorers need to change their business model: there will be NO world to exploit within decades! Shame, shame, shame! Greta Thunberg is one of the few speaking up for what is clearly right (read and reflect on \"The Emperor\'s New Clothes\" story?): \"How dare you take away our future?\"*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-312	Proforma submission (additional text)	*I acknowledge this is a \" form\" letter and in public consultation processes such as these receive a discount.* *However the letter fully represents my views and I request that it receive the same weight as any individual letter.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-313	Proforma submission (additional text)	*Please DO NOT allow the Brows basin Development.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-314	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. This is appalling betrayal on the people of Australia.* *We have had enough of mining companies ravaging our lands and pushing us into drought. Coal mines consume enormous amounts of our precious water, and drain our land of moisture and nourishment. Coal emissions are rising and any new coal mines would push Australia's emissions even higher.* *Woodside's proposed activities threaten the sensitive and irreplaceable marine* *After 1.25 billion animals have been burned alive you need to take their lives seriously, and ours. Every day we suffer another trauma from the continued push of coal. It is killing us and our land and our oceans. Enough. This is not what the people want and you need to reject this disgusting proposal. Land or water our wildlife must be protected and any new coal mines will simply kill us all.* *After a summer of watching our forests and animals burn alive this proposal is an attack on the Australian people and our precious home.* *Woodside might not care if we burn alive and have no water, but we do!!* *And to suggest ravaging our precious Reef, and a major tourist attraction, is again another attack on us. Clearly Woodside has no respect for us and sees our country as its quarry. We are not.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G1-RES-315	Proforma submission (additional text)	*This matter is very important.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-316	Proforma submission (additional text)	*In addition to this, the continuing approval of such applications demonstrates that Australia still has no credible policy on reducing carbon emissions to zero (including those of other countries to whom we sell or who are allowed to exploit our resources) and transitioning our economy completely from dependence on fossil fuels, which we need to do as quickly as possible in order to limit the effects of climate change. There is now overwhelming public support for much stronger and more rapid action in this country, which is incompatible with the continued approval of such projects. Either we start acting responsibly on climate change, or we continue to destroy the planet and render ourselves extinct, but approving Woodside, after Adani, after Equinor, after other new projects, is not the way to respond to climate change and preserve what can still be preserved. Such approval would be undemocratic and morally unconscionable.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-317	Proforma submission (additional text)	*Please do not approve this proposal. It is heartbreaking to have seen first-hand the terrible damage to our Australian habitat during these last fires and any future development that risks damaging any other natural environment should not be allowed. It is obvious these developments benefit few yet risk so much.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-318	Proforma submission (additional text)	*I can no longer sleep at night!! what will it take ?????????????????????????????????????*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-319	Proforma submission (additional text)	*Save what is special about Australia please.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-320	Proforma submission (additional text)	*Please help save our planet*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-321	Proforma submission (additional text)	*Please say \"No way\" to Woodside!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-322	Proforma submission (additional text)	*There is an urgency now to transition from oil and gas to more sustainable energy sources in order to reduce the impact of climate change. Right now climate change is placing increasing pressure on the survival of marine ecosystems. Therefore, the EPA must implement the Precautionary Principle in this matter as a priority. Scott Reef is also an area used for scientific research, and has beneficial uses for tourism and social purposes.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**).
PRO-G1-RES-323	Proforma submission (additional text)	*Climate change is socialism in disguise*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-324	Proforma submission (additional text)	*In a time of Climate Emergency the world needs to be moving right away from new oil and gas as well as Coal. These are all fossil fuels whose carbon has been sequestered eons ago. We have used them profligately for the last 50 years and now must move away from them. The bushfires of 2019-2020 have only added to CO_2 levels in the atmosphere and so will aggravate Global heating. Even if the mining of this gas or oil were not adding to the climate problem the granting of license to Woodside Petroleum to drill in the Scott Reef area should not be granted for the reasons which follow.* *I am concerned that Woodside's proposed activities threaten the sensitive marine*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G1-RES-325	Proforma submission (additional text)	*WON\'T you ever learn .... I am appaled that we the citizens, still have to write against projects of the sort.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-326	Proforma submission (additional text)	*In short put the environment and our future first and gas and coal and oil in the ground where it belongs*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-327	Proforma submission (additional text)	*EMISSIONS AFFECT EVERYONE AND EVERYTHING. Obligations, and push our national reduction goals out of reach. The carbon pollution created by this project makes it fundamentally incompatible with Western Australia's policy goal of net zero*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-328	Proforma submission (additional text)	*Oil and gas are fossil fuels which contribute to climate change (and coral bleaching), and as active contributors to this environmental crisis need to be scaled back and not increased through new extraction approvals such as what Woodside is proposing.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-329	Proforma submission (additional text)	*I am a father and grandfather deeply frightened and concerned for the futures of my grandchildren and children and our environments in a world exposed to the consequences of fossil fuels pollution in global heating. We are living the climate crisis already. I want ecological protection and thrival to be our no 1 priority in all assessments we do on any project. Do No Harm! Next, the health and well-being of our communities. Only once these are guaranteed, ought investors be permitted any activities in our environments and only on the precautionary principle of DO NO HARM*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • ESD-1: Principles of Ecologically Sustainable Development (ESD) (**Section 5.12**).
PRO-G1-RES-330	Proforma submission (additional text)	*Fossil fuels are killing the planet. But the most frustrating thing is, if fossil fuel companies spent half as much effort on switching to renewables as they do on starting new fossil fuel projects, they would make as much, if not more, money and do the planet and everyone on it a favour.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-331	Proforma submission (additional text)	*Woodside's proposed Browse Basin and Burrup hub proposal is Australia's most polluting fossil fuel mega-development which will contribute around four times the pollution of* *PLEASE REJECT THIS PROPOSAL FOR THE SAKE OF OUR PLANET, hUMANS & WILDLIFE.* *PLEASE REPLY TO THIS.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-332	Proforma submission (additional text)	*\'HOW DARE YOU!\"*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-333	Proforma submission (additional text)	*Another horrible report last week about our global omnicide threat has not been widely circulated in mainstream media but we really should be concerned as islands go underwater, the seas acidify and desperate climate refugees take to the boats. Please reject the anachronistic proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G1-RES-334	Proforma submission (additional text)	*YES THE BELOW IS A STANDARD LETTER - BUT PLEASE PLEASE PLEASE - BE AWARE THAT THIS BEING A POINT IN TIME OF SUCH SIGNIFICANCE AFFECTING FUTURE GENERATIONS WHO WILL JUDGE US, EVERY \'DIRTY\' PROJECT IS AN INSULT. WHAT WILL BE YOUR LEGACY?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-335	Proforma submission (additional text)	*Fugitive emissions will directly threaten the viability of this important habitat.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-336	Proforma submission (additional text)	*I am sending this because the climate science says that unless we (people of earth) stop using fossil fuels we might as well kiss Mother Earth as we know it goodbye. I grieve for what has been lost already and for my grandchildren.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-337	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. Enough is enough. As a nation we have lost so many native animals to fires. The wanton destruction of our animals and habitats must stop. We are close to nothing left.* *You have a responsibility to the people of Australia and our future.* *We need our wildlife and natural beauty-habitats more than more oil and gas fields. How much will go off shore?* *We are not stupid and your days of telling us that \'worlds best practices are in place\' are over.* *Stop this oil and gas madness now.* *Stop being a mouth piece for the fossil fuel companies and do your job in support of Australia today and tomorrow.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-338	Proforma submission (additional text)	*The world cannot afford to pump more greenhouse gas emissions into the atmosphere. Extracting of fossil fuels must end now if we are to have a viable climate for future generations.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-339	Proforma submission (additional text)	*I think its time our government showed real inspired leadership & made our environment top priority before its too late. Its time to make a transition from 20th C technology to 21st C technology & create jobs in the new domains that emerge as we create a sustainable (not growing but sustainable) environment for all life in this country & for that matter the planet.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-340	Proforma submission (additional text)	*In fact gas is just another fossil fuel and must not take the place of coal in environmental destruction.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-341	Proforma submission (additional text)	*"It is difficult to understand why any company would be looking at this development when so much evidence points to the detriment of the environment, our unique wildlife and the future health of the citizens of Australia.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G1-RES-342	Proforma submission (additional text)	*What a disgrace this is even being considered!* *We are losing our children to suicide due to hopelessness and why the hell would any of us participate anymore? What is the point of toeing the line when it just doesn\'t matter? If this goes ahead don\'t be surprised at the backlash..a breaking point is imminent if not surpassed already.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-343	Proforma submission (additional text)	*I write regarding the current consultations on Woodside's Browse Basin development. In the light of everything we know about Climate Change, and the imperative to REDUCE emissions from Fossil Fuels, it is foolhardy to allow further drilling for gas and oil to go ahead at all, let alone in such a sensitive marine habitat.* *Woodside's proposed activities threaten the sensitive marine environment of Scott Reef and will likely disturb, injure or kill marine fauna and irreversibly degrade critical habitat for endangered marine life.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**) • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G1-RES-344	Proforma submission (additional text)	*PS: Stop listening to the overwhelming energy lobby, that has a choke grip on all government elected representatives and on public servants advising on all technical and economic details.* *PPS New hydrocarbon source exporation must stop all over the world*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G1-RES-345	Proforma submission (additional text)	*I used to live in WA and cannot believe the WA government is even considering this proposal. Have we not done enough damage to Australia with mining already, invest in solar/wind. WA certainly gets an abundance of both. I now live in the ACT and we have been in the middle of the fire devastation happening all around us in NSW and now here as well and have had some of the most toxic air in the world over the last 2 months, can we not learn something from what is happening to Australia, everything we do to our environment has some impact on it which we never consider until its too late. Please listen to the community & Australians like myself and not the money hungry, greedy few who own the mining companies.* *I know you probably wont even read this but on the off chance someone does*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G1-RES-346	Proforma submission (additional text)	*If it s a joke it s a bad one. If not how ashamed is this! What will you tell your children and grand children , great grand children destroying their precious Heritage. It is priceless. Is money the only motivation? You have no pride, you have no value, you have no integrity, you are a monster. I hope it s a joke and you're not all this*	We acknowledge the comments made and provide the following information in response to the matters raised. With respect to the concerns raised within this submission relating to compatibility of the proposed extension of the Burrup Hub with the World Heritage listing nomination of the Murujuga Cultural Landscape, please refer to the response to SS-KIR-1 in the NWS Project Extension ERD Response to Submissions (**Section 3.3.2**, **Table 3-9**).
PRO-G1-RES-347	Proforma submission (additional text)	*If the project is rejected, there will be a cost which can be calculated in dollars, based on lost jobs, royalties, taxes, and so on. Very persuasive.* *If the project goes ahead, there will be a cost which cannot be calculated in dollars - based on damage to us, the people affected by future damage to the air, oceans and land; and to plant, microbe, animal, insect, bird - all life forms. This cost will be huge, incalculable. But already we feel and see real consequences of poor decisions in the past - decisions that ignored, were blind to, or criminally negligent of the consequences that were forecast - now increasingly real.* *How lucky we are to experience uncontrollable wildfires in non-flammable rainforest!* *How lucky to see red sky, or black sky, by day or night, in our holiday destinations, our suburbs, our towns and cities.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
		Or choking smoke, or animals with their feet burnt off, or extinguished as a species - or families, businesses, buildings, budgets… *How lucky to learn so much about how fire works, how people band together to protect and support each other in times of lethal crisis.* *You've heard a lot of arguments?* *You may be dead before the real effects of your decision.* *What brings you to make the best decision for those people who live IN the effects of your decision?* *- The largest and most polluting fossil fuel projects in the world?* *- Net-zero emissions by 2050?* *- Expand our LNG industry?* *- Repair and regeneration of damaged environment and lives?* *Please reject the Woodside proposal.*	
PRO-G1-RES-348	Proforma submission (additional text)	*We are all aware of how drastic the global environmental crisis is and more and more of us are taking steps in our own day-to-day lives to reduce our energy footprint and live more sustainably. We look to our leaders and decision makers such as yourselves to absolutely set an example that we can trust. Please, inspire us through wisdom and decisions made taking in the long-term view, respecting the environment we call home! I am writing in response to the current consultations on the proposed Browse Basin and North West Shelf projects. If the proposed Burrup Hub projects proceed, the Burrup Hub will be Australia's largest and most polluting fossil fuel project, and one of the largest fossil fuel developments anywhere in the world. The extent of the emissions that would result from gas collection and processing at the Burrup Hub would cancel out the gains made by both individual Australians and industry seeking sustainable ways to reduce their carbon emissions. Allowing for both the creation of new, and the extension of existing, large-scale carbon pollution sources such as the proposed Burrup Hub, will breach our international carbon reduction obligations, and push our national reduction goals out of reach. The carbon pollution created by this project makes it fundamentally incompatible with Western Australia's policy goal of net zero emissions by 2050. The claims made by Woodside that gas is a 'clean' fuel contributing to reduced emissions are*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**). • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

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		unsubstantiated and misleading. In 2019, LNG overtook coal as the most significant driver of pollution increases across the globe. LNG is a fossil fuel with pollution at every stage of its development and use and cannot be considered a solution to address climate change. The carbon emissions from the Burrup Hub will have a significant detrimental impact for decades to come. At a time where Western Australia needs to be taking contribution to global carbon emissions seriously, approving new LNG projects that will continue to pollute at a large scale for the next 50 years is indefensible. The life-time emissions of these projects must be considered. It is for these reasons that I strongly urge you to reject Woodside's proposal.	
PRO-G1-RES-349	Proforma submission (additional text)	*My prime concern is the severe lack of regard for the unrelenting consumption of Fossil fuel. The year is now 2020, has any regard been shown for the year 2420, 2620, 3020, 3820, 4800. Or are we going to finally have consumed the last mammal on our planet and all that will be left is cardboard and cockroaches. The pursuit of a computer screen with a profit of trillions of zeros on it, will be of little consequence to the generations of people left alive. With nothing left to Eat, but cardboard and cockroaches. Left with a ever increasing population , with no food, and no way of leaving, dead Oceans and parched poisoned soil. With no resources left will the CEOs of the past be there to stop the Cannibals from bringing Hell to life. year 5000ad. We are generating our worst Nightmare, slowly heating the pot of water up and explaining to our grandchildren," Why is that frog Dead Grandpa ?" Only pure arrogance gives the Executive order to keep going.I challenge [redacted]. For every LNG tonne of compressed gas exported from Australia, one Tonne of gas / one glass of Mercury. Because some Bastard, gave Chevron permission to sell $$, Pure liquid - Mercury to be placed, in Amalgam fillings to be used in dental fillings in Australia. How in God's name is that possible Two words, Corporate Genocide.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G1-RES-350	Proforma submission (additional text)	*Subject: Woodside's Browse Basin development. Scientists confirm that we face a climate crisis, caused by emissions from burning fossil fuels including gas. Gas extraction projects such as the proposed above development also pose enormous environmental risks. Those risks include destruction and/ or pollution of precious marine habitat and unchecked and unrecorded gas leakage. But most of all, the inevitable increase to Australia\'s Ce*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**)

No.	Submitter	Submission and/or issue	Response to comment
		emissions due to this development and other similar ones proposed for WA and NT would most certainly kill off any prospect of Australia meeting the commitments it made under the 2015 Paris Agreement to play its part in keeping global average temperatures to less than 2.0 C.In 2010, the EPA itself noted that light pollution from activities such as subsea oil and gas drilling can disrupt the nesting and behavior of hatchling and adult turtles and other endangered marine life. In 2010, Woodside's own risk models predicted that a mixed gas and oil spill would last 77 days, spreading across the reef, and as far as 800 km from the site, at concentrations lethal to marine life. Can the EPA, in good faith accept such a risk?The absurdity is that we have cleaner, safer and in the long run more economically beneficial alternatives. We can develop our vast renewable energy resources and promote the establishment of a hydrogen from renewables export industry. In the public interest, the EPA must exercise its authority to reject such a dangerous, out of date and out of touch proposal and open the way for clean, safe and forward looking alternatives. I urge you to reject Wooside\'s Browse Basin application.	• GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-5: LNG as a transition fuel and the displacement of coal (**Section 5.6**) • GHG-8: The role of gas in the future energy mix (**Section 5.9**). • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**). • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-5: Potential impacts to marine turtles (**Section 5.27**).
PRO-G1-RES-351	Proforma submission (additional text)	*The carbon pollution created by this project makes it fundamentally incompatible with Western Australia's policy goal of net zero*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**).
Group 2 – Submissions primarily related to potential impacts to the marine environment			
PRO-G2-RES-1	Proforma submission	*Header: Assessment # 2191/2186: Proposed Browse to North West Shelf Project (Commonwealth and State Waters)* *To (Chairperson Environmental Protection Authority WA) and Secretary Department of Environment and Energy,* *I am writing in relation to the current consultations on Woodside's Browse Basin development. In particular I am concerned that Woodside's proposed*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**)

No.	Submitter	Submission and/or issue	Response to comment
		activities threaten the sensitive marine environment of Scott Reef and will disturb, injure or kill marine fauna and irreversibly degrade critical habitat for endangered marine life. *Scott Reef supports a huge array of sea life from across the Indian Ocean and Timor Sea. This includes critical nesting habitat for one of the most endangered species of marine turtle in the world, the green sea turtle. Five species of whales visit the area, including Humpback whales and Blue Pygmy whale and at least 10 species of dolphins are found at Scott Reef in pods numbering hundreds of individuals.* *In 2010, the EPA noted that light pollution from activities such as subsea oil and gas drilling can disrupt the nesting and behavior of hatchling and adult turtles and other endangered marine life. Additionally, persistent low frequency noise from gas extraction is known to affect feeding, migration, and breeding behavior in sea turtles, and impact the migratory patterns of whales. Discharges of wastewater and pollution from oil spills can contaminate marine ecosystems with toxic heavy metals and other chemicals. Woodside's own risk models predict that a mixed gas and oil spill would last 77 days, spreading across the reef, and as far as 800 km from the site, at concentrations lethal to marine life.* *In addition, the Woodside's proposed Browse Basin and Burrup hub proposal is Australia's most polluting fossil fuel mega-development which will contribute around four times the pollution of the proposed Adani coal mine. Scott Reef has already suffered the impacts of climate change through bleaching events and this proposal would significantly add to the problem.* *Oil and gas operations such as the Browse Basin development are not compatible with a sensitive marine environment like the Scott Reef and are totally inconsistent with maintaining the safe climate conditions that Scott Reef and other marine environments rely on.* *Protection of this sensitive, nationally significant marine environment is a paramount conservation priority which is fundamentally threatened by the Browse Basin proposal.* *I urge you to reject the proposal to undertake oil and gas development on or around Scott Reef.*	• MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-4: Vessel - fauna interaction (**Section 5.26**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**)

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-2	Proforma submission (addition text)	*I have signed this letter to show my total opposition to projects such as this that threaten such important pristine areas. It is time for everyone stand up and say enough is enough. We cannot continue to treat our planet with such disdain. Time for greedy mining companies to be held accountable for the destruction of our planet before its too late.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-3	Proforma submission (additional text)	*Our waters are home to the most incredible wildlife, please don't put these ecosystems in danger and help preserve our natural habitats for my children and their future children.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-4	Proforma submission (additional text)	*Furthermore, as a fairly regular visitor to the Kimberley and to the Ningaloo Reef area, I personally plead with you to not spoil these amazing areas off our magical coastline.* *Swimming with whale sharks, fishing way off the coast - absolutely amazing.* *Our Great Barrier Reef is failing - we need to preserve what we have.* *Tourist dollars will pay more in the long term than mining for LNG.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-5	Proforma submission (additional text)	*I ask that you truly consider what a sanctuary is, why it was set up and what most Australians expect of it. Oil and gas exploration and development do not fit at all.* *As a concerned citizen, I expect you to honour protection of this sanctuary which is fundamentally threatened by the Browse Basin proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-6	Proforma submission (additional text)	*Additionally, the region has a huge and as yet not fully classified range of marine life from algae to corals, fish species and crustaceans as well as the larger mammalian marine creatures. All of these contribute to and maintain the health of the marine and coastal environs. Gas drilling will not contribute in any way to this. Its only contribution is $$$ but the cost to the future health of the region and to the future is beyond pricing.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-7	Proforma submission (additional text)	*You have so many people giving you good reasons not to allow this project to proceed. I won't repeat what they all say.* *Instead, I ask you to please consider putting the environment first. We can't breathe money. We can't drink it. We can't eat it. It is but a fleeting affair.* *If recent events have shown us anything, it is that we must revegetate and create arks of those ecosystems that remain.* *Please, we are one species among thousands who all have equal rights to life, yet no say in what happens to their homes.* *I implore you.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-8	Proforma submission (additional text)	*Variations in proformas: The following text is also present in some proformas.* *In particular I am concerned that Woodside's proposed activities threaten the sensitive marine environment of Scott Reef and will harm marine fauna and irreversibly degrade critical marine habitats and the marine life that is dependent on those habitats.* *Scott Reef supports a diverse range of marine life from across the Indian Ocean and Timor Sea. This includes critical nesting habitat for one of the most endangered species of marine turtle, the green sea turtle. Five species of whales visit the area, including Humpback and Blue Pygmy whales and at least 10 species of dolphins are found at Scott Reef in pods numbering hundreds of individuals.* *In 2010, the EPA noted that light pollution from activities such as subsea oil and gas drilling can disrupt the nesting and behaviour of hatchling and adult turtles and other endangered marine life. Additionally, persistent low frequency noise from gas extraction is known to affect feeding, migration, and breeding behaviour in sea turtles, and impact the migratory patterns of whales.* *Scott Reef has already suffered the impacts of climate change through bleaching events and this proposal would add to the problem significantly.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-4: Vessel - fauna interaction (**Section 5.26**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-9	Proforma submission (additional text)	*To EPA Chair and Secretary Department of Environment and Energy Please do not permit Woodside to proceed with its Browse Basin drilling project. Marine environments like Scott Reef are far more valuable assets to the community in the long term than whatever short term benefits to the economy might be achieved by drilling for fossil fuels. Reefs are the safe breeding grounds for the fish we need into the future. Scott Reef also is the home for many important sea creatures such as endangered green sea turtles, dolphins and whales. No matter what Woodside might claim, the scientific fact is that drilling creates pollution that will destroy these habitats. Then there are also the risks of big oil spills and widespread damage to ocean beds and coastline. Climate change is already causing catastrophic bushires and flooding this summer, with more to come. Australia needs to get out of fossil fuels, not to permit more to be extracted. The time has come to change how we manage our natural resources, and that means leaving oil and gas in the ground.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-4: Vessel - fauna interaction (**Section 5.26**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-10	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine Scott Reef supports a huge array of sea life from across the Indian Ocean and Timor Sea. This includes critical nesting habitat for one of the most endangered species of marine turtle in the world, the green sea turtle. For the sake of all of us (you included) and our future generations (including your\'s) I urge you to make a stand and reject the proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-11	Proforma submission (additional text)	*I am writing in relation to the Woodside's Browse Basin development which will threaten the sensitive marine environment of Scott Reef.Scott Reef supports a huge array of endangered sea life in the Indian Ocean and the Timor Sea. it provides critical nesting habitat for one of the most endangered species of marine turtle in the world, the green sea turtle. Five species of whales visit the area, including Humpback whales and Blue Pygmy whales, and at least 10 species of dolphins are found at Scott Reef in pods numbering hundreds of individuals. Scott Reef has already suffered the impacts of climate change through bleaching events and this proposal would greatly add to the problem. Oil and gas operations such as the Browse Basin development are not compatible with a sensitive marine environment like the Scott Reef. Protection of this sensitive, nationally significant marine environment is a paramount conservation priority.I urge you to reject the Woodside proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**).
PRO-G2-RES-12	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. In particular, I am concerned that Woodside's proposed activities threaten the sensitive marine Scott Reef supports a huge array of sea life from across the Indian Ocean and the Timor Sea. This includes critical nesting habitat for one of the most endangered species of marine turtle in the world, the green sea turtle. In 2010, the EPA noted that light pollution from activities such as subsea oil and gas drilling can disrupt the nesting and behaviour of hatchling and adult turtles and other endangered marine life. Additionally, persistent low-frequency noise from gas extraction is known to affect feeding, migration, and breeding behaviour in sea turtles, and impact the migratory patterns of whales.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-5: Potential impacts to marine turtles (**Section 5.27**).
PRO-G2-RES-13	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. In particular I am beyond concerned that Woodside's proposed activities threaten the obviously sensitive marine environment of Scott Reef and will disturb, injure and kill marine fauna and irreversibly degrade critical habitat for endangered marine life. As Australia is already burnt, on fire and trying to recover in every way-you can see how adding to this already horrific situation is irrevocably damaging and horrendously stupid for every soul included.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**)

No.	Submitter	Submission and/or issue	Response to comment
			• MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-14	Proforma submission (additional text)	*My personal view is this is NOT NECESSARY for humans… only for faceless multi-nats.. It is obscene to prostitute the Wilderness for profit. It is a LOSER.. in the long run.Bad NEWS indeed.I am writing in relation to the current consultations on Woodside's Browse Basin development.I do not believe we can breathe or eat profits that COULD be generated, especially as it seems.. these big companies PAY NO TAX.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-15	Proforma submission (additional text)	*" There is not one reason in the known universe to justify degrading our planet, Mother Earth. "" Thought before profit. "" Think, Woodside, think! "*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-16	Proforma submission (additional text)	*I am most concerned that Woodside's proposed oil drilling activities will threaten the sensitive marine You would be aware that The EPA noted, in 2010, that light pollution from activities such as subsea oil and gas drilling can disrupt the nesting of hatchling and adult turtles and other endangered marine life.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-5: Potential impacts to marine turtles (**Section 5.27**).
PRO-G2-RES-17	Proforma submission (additional text)	*I write about Woodside's proposed Browse Basin development. This is madness. Drilling for oil and gas near a reef! It beggars belief. Scott Reef is home to an amazing quantity of sea life and includes critical nesting habitat for the green sea turtle. Five species of whales visit the area, and at least 10 species of dolphins. Noise pollution, discharged chemical pollutants and general disturbance will naturally play havoc with all the creatures that*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**)

No.	Submitter	Submission and/or issue	Response to comment
		call Scott Reef home. Feeding, migration, and breeding are all drastically affected. Woodside's own risk models predict that a mixed gas and oil spill would last 77 days - that\'s over two months! - spreading up to 800 km from the site, at concentrations lethal to marine life. Furthermore, Woodside's proposed Browse Basin and Burrup hub proposal is a mega-development which will contribute around four times the pollution of the proposed Adani coal mine. It\'s unthinkable. Please REJECT any proposal to drill for oil and gas on or around Scott Reef.	• MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**).
PRO-G2-RES-18	Proforma submission (additional text)	*How awe inspiring and absolutely precious are our natural environments - our oceans, our flora and fauna - this is what makes us proud to be Australia. With so much of our heritage under threat, I am therefore writing in relation to the current consultations on Woodside's Browse Basin development. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-19	Proforma submission (additional text)	*I am currently working in Western Australia and want to express my strongest objection to gas and oil exploration such as that proposed by Woodside's Browse Basin development. There is no doubt that we have extraordinary wildlife and it must be protected. We have seen how our ecosystems are depleted, and they face ever-growing risk. I am concerned that Woodside's proposed activities threaten the sensitive marine environment.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-20	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. I am concerned that Woodside's proposed activities threaten the sensitive marine environment of Scott Reef and will irreversibly destroy critical habitat for marine life. Scott Reef supports a huge array of sea life from across the Indian Ocean and Timor Sea:- Critical nesting habitat for one of the most endangered species in the world, the green sea turtle. - Five species of whales visit the area, including Humpback whales and Blue Pygmy whale.- At least 10 species of dolphins are found at Scott Reef in pods numbering hundreds of individuals. Drilling activities for oil and gas will impact on marine life:– Pollution can disrupt the nesting and behavior of hatchling and adult turtles. - Persistent low frequency noise from gas extraction is known to affect feeding, migration, and breeding behavior*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**)

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		in sea turtles, and impact the migratory patterns of whales. – Woodside's OWN RISKS MODEL predict that a mixed gas and oil spill would last 77 DAYS, spreading across the reef, and as far as 800 km from the site, at concentrations LETHAL TO MARINE LIFE.In addition, the Woodside's Browse Basin and Burrup hub proposal is Australia's most polluting fossil fuel mega-development which will contribute about FOUR TIMES the pollution of the proposed Adani coal mine. Protection of this sensitive, nationally significant marine environment is a paramount conservation priority. We need our oceans to stay healthy in order to sustain not just marine life but human life as well. We need to preserve what we can so that we can have a positive future.	• MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-4: Vessel - fauna interaction (**Section 5.26**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-21	Proforma submission (additional text)	*Where I live oil riggs are most like going to be approved in the Great Australian Bight, more madness for no economic gain or purpose.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-22	Proforma submission (additional text)	*Why is this development even being considered???? The reef in one of a decrease number of places on earth that are relatively pristine and allow for numerous creatures to breed and raise their off spring. Woodside, even if it had a stainless record should not gain approval for this development. The cost is too high in terms of loss.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-23	Proforma submission (additional text)	*It has come to my notice that your company may be about to wreak ecological damage on Scott Reef. In these fragile times, such a move is unconscionable. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine environment of the reef and will disturb, injure or kill marine fauna and irreversibly degrade critical habitat for endangered marine life.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-24	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. I strongly oppose the proposed Woodside development and any such similar development. Unfortunately, humans are so aggresively and irresponsibly dealing with the natural environment that they can be easily classified as VERMIN. They are also multiplying like vermin. Human behaviour MUST dramatically change if we want our children and grandchildren to enjoy normal life and not seriously degraded environment, which will not be able to provide reliable economy and food, but only struggle and misery. We are well on the way to this point.In particular I am concerned that Woodside's proposed activities threaten the sensitive marine I urge you to reject the proposal to undertake oil and gas development on or around Scott Reef as well as similar future applications for such developments.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-25	Proforma submission (additional text)	*It's time to wake up and use the sun, spread the wealth into alternative power sources. I want my grandchildren to have a beautiful safe planet not a poisoned earth , that's the way it's going, please say no to more pollutants. We cannot do without our beautiful oceans they cannot absorb any more pollution.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-26	Proforma submission (additional text)	*Another example of environmental destruction to the ecosystems in Australia. This follows a pattern to the decay of these systems during the last 30 years. Shame on you!!!!!!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-27	Proforma submission (additional text)	*This risk is unacceptable! I urge you to reject the proposal to undertake oil and gas development on or around Scott Reef and place a higher priority on developing the huge economic opportunities found with renewable sources of energy.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-28	Proforma submission (additional text)	*Regarding the proposed Woodside Browse Basin development. Woodside's proposed activities are BOTH a direct threat to sensitive marine environment s, and ALSO are contrary to any rational investment in future energy requirements. The research alone will disturb, injure or kill marine species and permanently damage critical habitat for endangered marine life. The world\'s reefs are already struggling against the damage caused by fossil fuel emissions !! Is this proposal anything more than continuing stupid greed of a small sector while destroying the habitats and life-expectancy of all species, including humans ?I urge you to reject the proposal to undertake oil and gas development on or around Scott Reef, and all such proposal for new fossil fuel developments.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-29	Proforma submission (additional text)	*Please consider the needs of our precious wildlife and put them above profit before our already stressed environment is totally destroyed. Time to think of the Big Picture...money is useless if there\'s nobody left on the planet to spend it.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-30	Proforma submission (additional text)	*As a deeply concerned mother of two Wiradjuri First Nations person, I strongly urge you to reject the proposal to undertake oil and gas development on or around Scott Reef. For the sake of our children, let\'s make them proud of us & our future generations, please listen. Its is critical.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-31	Proforma submission (additional text)	*It is a matter of fact that the marine habitat where Woodside are proposing to drill for gas and oil is a sensitive and vulnerable environment and home to threatened marine species. How can any economic benefit compare to the long term negative externalities of these types of projects?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-32	Proforma submission (additional text)	*As a World citizen I am appalled! Protection of this sensitive, globally significant marine environment is a paramount conservation priority which is fundamentally threatened by the Browse Basin proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-33	Proforma submission (additional text)	*Scott Reef is a magical, wild place - we must protect it. Teeming with unique and endangered marine life off the remote Kimberley coast, the remote reefs and lagoons of Scott Reef are a haven for sea turtles, whales, huge pods of dolphins, dugong and many other species of endangered marine life. We cannot let a once pristine ecosystem be overwhelmed by the industrial noise, pollution and heavy shipping that comes with dirty marine fossil fuel extraction. Woodside's own models predict a mixed gas and oil spill would last 77 days, and spread for up to 800km - far outstripping the ability of the reef to cope or the wildlife to flee. What's more, if this immense destructive development went ahead its direct and indirect carbon emissions would make it one of the most polluting fossil fuel projects in the world! It would cancel out global efforts to control global heating, accelerating the destruction of critical habitats and the wildlife that depend on them. Now, more than ever, we must protect the Australian wildlife we love so much.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-34	Proforma submission (additional text)	*Woodside's Browse Basin development would threaten the sensitive and extraordinary marine environment of Scott Reef. Marine fauna would be altered and overtime, negate habitat for endangered marine life. Moreover, the Woodside's proposed Browse Basin and Burrup hub proposal is Australia's most polluting fossil fuel mega-development which will contribute around four times the pollution of the proposed Adani coal mine. This is the time to preserve not not develop for infustry. Consultation must protect this nationally significant marine environment which is fundamentally threatened by the Browse Basin proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-35	Proforma submission (additional text)	*I have the honour of addressing you in relation to the current consultations on Woodside's Browse Basin development. I must express deep concern. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine . I cannot believe Australia\'s disdain for our sea life: whales and dolphins and the threatened species; the green sea turtle, which Scott Reef supports.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**)

No.	Submitter	Submission and/or issue	Response to comment
			• MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**).
PRO-G2-RES-36	Proforma submission (additional text)	*As I tourist, I would not be interested in coming to the west Australian coast if it has numerous mining as industrial areas. I will go elsewhere.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-37	Proforma submission (additional text)	*This is not acceptable given Australia\'s current environmental challenges. Scott Reef has already suffered the impacts of climate change through bleaching events and this proposal would significantly add to the problem. The reef must be given time to recover.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-38	Proforma submission (additional text)	*I have actually spent three days in a small boat exploring the waters around Scott and Seringapatam Reefs in the mid 1980s, including the enfringing coral reefs and walking on the islands themselves.* *It is one of the most remote, unspoilt wilderness areas I have visited. The life, both marine and on land, was wonderfully abundant.* *Three years later I heard that the reef had largely been destroyed by a warming of the seawater. This warming was almost certainly an example of what global warming has in store for coral reefs world-wide.* *I believe that Scott has largely, if slowly, recovered. But as warming events become more common and more extreme, such recovery will be less and less likely.* *And it is the developed world\'s endlessly increasing use of fossil fuels that is a major cause of this warming.* *And now Woodside are planning to build a large number of oil-wells in this once, and possibly still, pristine wilderness.* *I say a thousand times no!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**)

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-39	Proforma submission (additional text)	*I'm really just asking that you do your job thoroughly and respect the rights of our environment to not be destroyed through human greed. After all that the world has been through with our earth suffering from the consequences of mans impact. It must stop and this is where it stops, you must do your job - the one that EPA stands for and not be swayed or influenced to downgrade the impacts you know these types of operations cause.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-40	Proforma submission (additional text)	*I also urge you to reflect on the state of Labor nationwide and how their credibility regarding the environment and sticking with promises to NOT increase damage and emissions is at an all time low with voters. Reefs and breeding grounds globally are under threat to the point one cannot say this small area if damaged will not be significant. We need to ensure we are not destroying entire species for a corrupt few who have been hiding the truth about their companies destructive footprints for decades. Labor has a chance to shine once more and be the global citizens we need or it can follow the Coalition into extinction as the full extent of climate change strikes harder and we turn on those who irresponsibly managed and sacrificed what we hold precious for these corporate parasites.* *Tourism also relies on pristine environments NOT oil and gas wells and accompanying sludge!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-41	Proforma submission (additional text)	*I urge you to reject the proposal to undertake oil and gas development on or around Scott Reef. I holiday in that area and if you haven't seen the beauty of the area yourself, I suggest you do before you make a decision.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-42	Proforma submission (additional text)	*DRILLING IN BEAUTIFUL PLACES FULL OF ANIMALS THAT WE CANNOT BE KILLING IS SO UNECESSARY. IT NEEDS TO STOP. FIND SOME OTHER WAY TO GET OIL OR USE SOMETHING DIFFERENT. JUST STOP. OUR PLANET CANNOT TAKE ANYMORE.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-43	Proforma submission (additional text)	*I want to express my concern about the Woodside Browse Basin development. Surely it is clear by now that human interference with the Earths ecosystems that have developed over millions of year is unsustainable and can no longer be countenanced. The specifics are below but the bottom line must be a rejection of this proposal on the grounds of unacceptable risk to the environment that supports an entire interdependent ecosystem - one which is necessary for the survival of so many, including we humans. Surely the bushfires have taught us this much. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine .Scott Reef supports a huge array of sea life from across the Indian Ocean and Timor Sea. This includes critical nnesting habitat for one of the most endangered species of marine turtle in the world*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**).
PRO-G2-RES-44	Proforma submission (additional text)	*I write about Woodside's proposed Browse Basin development. This is madness. Drilling for oil and gas near a reef! It beggars belief. Scott Reef is home to an amazing quantity of sea life and includes critical nesting habitat for the green sea turtle. Five species of whales visit the area, and at least 10 species of dolphins. Noise pollution, discharged chemicall pollutants and general disturbance will naturally play havoc with all the creatures that call Scott Reef home. Feeding, migration, and breeding are all drastically affected. Woodside's own risk models predict that a mixed gas and oil spill would last 77 days - that\'s over two months! - spreading up to 800 km from the site, at concentrations lethal to marine life. Furthermore, Woodside's proposed Browse Basin and Burrup hub proposal is a mega-development which will contribute around four times the pollution of the proposed Adani coal mine. It\'s unthinkable. Please REJECT any proposal to drill for oil and gas on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-45	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. I am extremely concerned that Woodside's proposed activities threaten the sensitive marine I strongly urge you to reject the proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-46	Proforma submission (additional text)	*Below is a very long email urging you to protect the environment at Scott Reef. This email has come to me from the Australian Marine Conservation Society, an organisation I support financially. I am endorsing the form email below and add that I am simultaneously disappointed and outraged that the West Australian government is open to new oil and gas exploration that can only lead to greater threats to global climate change. Please do all you can to prevent any new fossil fuel development in Western Australia Thank you*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G2-RES-47	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development.* *Fundamentally it is more and more clear additional fossil fuels to those already being \"harvested\" are not necessary to see us through the transition to renewables worldwide, and they would be much better being left in the ground as sequestered carbon.* *On top of that are the obvious environmental effects as described by AMCS below.* *\" In particular I am concerned that Woodside's proposed activities threaten the sensitive marine .I urge you to reject the proposal to undertake oil and gas development on or around Scott Reef.\"* *Together it seems a no- brainer to prevent this project*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G2-RES-48	Proforma submission (additional text)	*Be careful with our marine life. Marine permaculture has a portentously to draw down Caron, provide food and a healthy habitat for our marine life so please stop mucking around with nature!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-49	Proforma submission (additional text)	*It is long past the time when Australian governments could get away with the destruction of our wildlife and their ecosystems. We should be responsible and protect them. More and more Australians are recognising this.The environmental Protecion Authority should do that instead of paving the way for these industries which are destroying out environment.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-50	Proforma submission (additional text)	*For goodness sake read what is written below and think about what it is saying. Where is a line going to be drawn? Stop putting our precious irreplaceable natural ecosystems and and animals at risk. We hate the lies and the fake environmental impact statements that you pay for to claim these projects are not harming the environment. Do what is right and look after the depleting natural environment that we have. This is in relation to the sensitive marine environment of Scott Reef and the proposed project that will disturb, injure or kill marine fauna and irreversibly degrade critical habitat for endangered marine life.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-51	Proforma submission (additional text)	*Fighting to protect precious marine life and habitat from oil and gas is a worldwide issue!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-52	Proforma submission (additional text)	*Here in America we fight for NO offshore drilling anywhere off any coast Atlantic, Pacific, Gulf or Alaska! NO seismic blasting or other oil gas exploration! Our oceans and marine life worldwide must be protected from oil and gas destruction by the U.S. or Australia or anywhere on the planet! Australia has the added responsibility of protecting the greatest areas of the world's reef systems.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-53	Proforma submission (additional text)	*The life in our sea is decreasing. We need more marine sanctuary zones, to protect and increase numbers and breeding, not more ways to destroy our oceans and sea life!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-54	Proforma submission (additional text)	*I believe that we need to keep the reefs of our world as pristine as possible and so*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-55	Proforma submission (additional text)	*Additionally, Woodside's proposed Browse Basin and Burrup hub proposal is Australia's most polluting fossil fuel mega-development and will contribute around four times the pollution of, I urge you to take a stand for the environment, for the generations of Australians to come, and for the sake of the ocean, the reef, and the many animals and plants: reject the proposal to undertake oil and gas development on or around Scott Reef - PLEASE!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G2-RES-56	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-57	Proforma submission (additional text)	*Please think of our future generations & protect our reefs*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-58	Proforma submission (additional text)	*I think we can no longer ignore environmental harm and I believe that as well as altering irrecoverably Scott reef by drilling in it (hard to believe)!!! That it is also no longer possible to keep putting money into an antiquated energy supply source such as gas and oil.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-59	Proforma submission (additional text)	*I am writing in response to the current consultation on Woodside's Browse Basin development. I have worked in environmental regulation for many years in NSW. I am very concerned that Woodside's proposed activities threaten the important marine environment of Scott Reef. The potential for both short and long term damage to kill marine fauna is high.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-60	Proforma submission (additional text)	*I write in relation to the current consultations on Woodside's Browse Basin development. In particular I am deeply concerned that Woodside's proposed activities threaten the sensitive marine.* *Protection of this highly sensitive, nationally significant marine environment is a paramount conservation priority which is fundamentally threatened by the Browse Basin proposal. [Redacted name]*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-61	Proforma submission (additional text)	*In 2010, the EPA noted that light pollution from activities such as subsea oil and gas drilling can disrupt the nesting and behaviour of hatchling and adult turtles and other endangered marine life. Additionally, persistent low frequency noise from gas extraction is known to affect feeding, migration, and breeding behaviour in sea turtles, and impact the migratory patterns of whales.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**).
PRO-G2-RES-62	Proforma submission (additional text)	*Would it be possible for the WA Environmental Authority to actually protect, with some useful certainty, the very significant ecological values it has in its charge? To this end*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-63	Proforma submission (additional text)	*I urge you to reject the proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-64	Proforma submission (additional text)	*We need our reefs.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-65	Proforma submission (additional text)	*We\'ve got to do better than this.* *We have to do better than this. It\'s our children\'s future.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-66	Proforma submission (additional text)	*I am HORRIFIED ABOUT the current consultations on Woodside's Browse Basin development. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-67	Proforma submission (additional text)	*I am writing to ask that consider Woodside's proposal and reject it. We must leave some of the natural environment intact for future genera day this incessant development threatens these pristine areas and all of the marine life contained therein.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-68	Proforma submission (additional text)	*It's a critical nesting habitat for one of the most endangered species of marine turtle in the* *I urge you emphatically o reject the proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MF-5: Potential impacts to marine turtles (**Section 5.27**).
PRO-G2-RES-69	Proforma submission (additional text)	*I am bewildered how this is even a topic for conversation with the devastation we are seeing around the world to our environment. Australia should be leading the world in habitat preservation.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-70	Proforma submission (additional text)	*Do we really need to disturb the marine environment around Scott Reef? Yes, you must get sick of people that are concerned about the planet banging on about \'protecting\' it for future generations, but we need to be mindful of the impact we are having on the planet.* *Please reject the proposal for oil and gas development on or around Scott Reef.* *Please think about the future you are creating...yes, we need oil and gas but not at this price.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-71	Proforma submission (additional text)	*Additionally, persistent low frequency noise from gas extraction is known to affect feeding, migration, and breeding behaviour in sea turtles. Discharges of wastewater and pollution from oil spills can contaminate marine ecosystems with toxic heavy metals and other chemicals.* *If there was a spill accident, Woodside's own risk models predict a mixed gas and This is just unacceptable.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-72	Proforma submission (additional text)	*There comes a time in the history of the human race where we (YOU) have to stop prioritising money over habitat.....our habitat and that of all creatures. The lure of an easy buck is strong but the will of the people WILL win the day (and it might not be pretty for the money men.....be warned).*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-73	Proforma submission (additional text)	*We have recently seen so much destruction of natural habitat across Australia with drought, fires and floods. I know we need to protect what is left and to stop and reflect on any plans for any activities or explorations in any sensitive areas.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-74	Proforma submission (additional text)	*I understand that a proposal for Woodside Petroleum to drill on Scott Reef in the Kimberley region is under consideration.* *I have visited the Kimberley region, inland and along the coast, and the Broome area on several occasions. I was asked recently what my favourite area of Australia is. It's a very difficult question of course but my answer was 'The Kimberley'. The land, coastal and marine environments are all incredibly beautiful and ecologically significant. They contain many threatened species of animals and plants. The culture and history of the region, particularly the Indigenous culture and history, are unique and precious.* *The environments and ecologies of the world, Australia and the Kimberley are threatened in so many ways: for instance climate change, pollution, loss of habitat, and loss of biodiversity. It is highly regrettable that we would allow the natural environment to be destroyed in these ways but it is almost unbelievable that we would do it also knowing that we are in the process destroying the conditions that make life possible for humans on planet earth.* *It is easy to think that each bad decision such as allowing oil and gas*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
		drilling in the Kimberley is just a small decision affecting a small corner of the world but we know that all such small decisions over the last 200 years are adding up to make the world an unstable, unhealthy and threatening place. We must stop making decisions that provide short term gains for a small number of people and yet threaten the very survival of humanity. I find it incredible and incredibly disappointing that in 2020 Australia might still be prepared to drill for oil and gas in the Kimberley. It is even more incredible (and irresponsible) when one takes climate change into account. The evidence is clear that to keep global warming to under 1.5C we cannot burn all the fossil fuels that we currently have access to. We do not need any additional sources of fossil fuels. *I very much hope that you will reject this proposal outright because of the damage it will do to the Kimberley and because it is entirely inappropriate to site such drilling in a largely untouched area.* *Should you proceed with considering the proposal, I trust that you will ensure that comprehensive environmental and health impact assessments are conducted by independent, appropriately skilled organisations/individuals before any decision is made. I am confident that should such assessments be conducted, the only reasonable decision will be to reject the proposal.* *I fully support the submission made to you by the Australian Marine Conservation Society of which my wife and I are strong financial and practical supporters.* *I would be grateful if you could acknowledge receipt of this submission and keep me informed of progress with decisions about the proposal.* *I have no objection to my submission being made public.* *In summary, I urge you to reject completely the proposal to undertake oil and gas development on or around Scott Reef.*	
PRO-G2-RES-75	Proforma submission (additional text)	*It is time we started protecting our coastal systems because without them where are we?! It is up to you people to stop this development and start the process of protection not destruction. Say a big NO!!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-76	Proforma submission (additional text)	*Just because very few people have been privileged to see dugongs and sea turtles in their natural environment does not mean that you can take them for granted or destroy their home. The public at large recognises that such animals are indicative of a healthy environment, and that even if we never see them the protection of their environment is essential. It is not possible to isolate one section of the sea, or to contain damage. Ordinary members of tge p ublic can see that an action on one part of the planet has repercussions globally. I hope your clever engineers haven\'t forgotten this.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-77	Proforma submission (additional text)	*I travel to WA regularly for work and holiday reasons... and you should be doing the utmost to protect such a wonderful environment and place to visit. That said decisions like this impact all of Australia - clearly from the denigration of environment and climate we need to do far more to look after our fragile scenario.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-78	Proforma submission (additional text)	*As someone who has lived and travelled in WA, and is a keen sailor in more remote areas,*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-79	Proforma submission (additional text)	*[Redacted name] and I are writing in relation to the current consultations on Woodside's Browse Basin development. In particular we are very concerned that Woodside's proposed activities threaten the sensitive marine* *We urge you in the strongest possible terms to reject the proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-80	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. In particular I am very concerned that Woodside's proposed activities threaten the sensitive marine Considering the terrible devastation on marine life from plastic pollution, the threats to our reef, and the incomprehensible toll on wildlife from bushfires, further threats to natural ecosystems and wildlife should not be pursued.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-81	Proforma submission (additional text)	*Re: Woodside's Browse Basin development.* *In an era when we should be walking away from fossil fuels altogether, it is sheer LUNACY to contemplate operating any extraction sites that DO go ahead, anywhere near biodiversity hotspots such as Scott Reef.* *In particular I am concerned that Woodside's proposed activities threaten the sensitive marine*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-82	Proforma submission (additional text)	*Though not a WA resident, I cannot fathom how your government can enter into consultations re Woodside\'s Browse Basin proposal to drill in a pristine ecosystem across the Indian Ocean and Timor Sea. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine The Australian Marine Conservation Society\'s analysis (of the impact on marine life that such drilling and extraction) is compelling.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-83	Proforma submission (additional text)	*You know the idiom 'evolve or die'? We need your help to urge the evolution of both thought and practice regarding energy production. Evolve what is permitted, what our standards must be so that we progress as a nation, as a ripple, as a planet. Or we die.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-84	Proforma submission (additional text)	*This MUST be a joke, right? That Woodside thinks it\'s OK to drill for Gas and oil HERE. I say NO, and I plead that you also say NO, don\'t allow it, ts completely unnecessary, there is much to be done, use alternatives, follow that, not this old and failed way of finding oil and gas. WE DONT NEED IT!!!!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-85	Proforma submission (additional text)	*The proposed oil and gas developments are totally against marine's conservation recommendations.* *They are also totally against the wishes of more than 50% of the voting public.* *I join with the thousands of others who are vehemently against the proposed developments*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-86	Proforma submission (additional text)	*I am writing as someone who lived and worked in the Kimberley for over 10 years. During that time I visited many beautiful places along the coastline of Western Australia, from north to south.* *What I saw and experienced during that wonderful time is the reason I am signing this protest petition against allowing Woodside Petroleum- or any other company - to drill along the coastline for their Browse Basin development.* *In particular I am concerned that Woodside's proposed activities threaten the sensitive marine*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-87	Proforma submission (additional text)	*Australia has a global responsibility to protect all endangered species and natural habitats, which we have not done ad are still not doing. There should be a blanket prohibition on all such drilling and exploitation in any such environment, without exception. We have also seen in numerous examples both in Australia and around the world that companies like Woodside do not take adequate precautions to protect the environment or aquifers or anything else, even when they promise to do so, they do not undertake the remediation they are expected or required to do in the event of spills and other damage, they do not provide full financial compensation for damage they cause, we cannot bring back species once they have become extinct, and Australia has some of the most toothless and incompetent regulation of these activities of any country imaginable. Neither the companies nor government can be trusted. It is in this government\'s interest to approve this application, not to oppose it. That does not mean that it is in the interests of either the environment or a majority of the Australian public*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-88	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development.* *This is a ridiculous proposal for a ecologically rare and special place full of endemic species, both in the sediments and in the water column. The research and monitoring I did of this region uncovered many rare and endemic benthic species, some were previously unknown to science (An investigation of benthic sediments and macrofauna within pearl farms of Western Australia in Aquaculture 319(3):466-478 · October 2011).* *I am very concerned that Woodside's proposed activities threaten the sensitive marine environment of Scott Reef which supports a huge array of*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**)

No.	Submitter	Submission and/or issue	Response to comment
		sea life from across the Indian Ocean and Timor Sea. This includes critical nesting habitat for one of the most endangered species of marine turtle.	• MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**)
PRO-G2-RES-89	Proforma submission (additional text)	*I vehemently oppose drilling for gas and oil on the Scott Reef. I have dived there as a tourist in WA, and besides the economic loss to tourism (especially when the Great Barrier Reef is essentially dying), it's an extremely irresponsible thing to do. The drilling process and the risks of mining the Reef are far too great for a short term economic gain.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**).
PRO-G2-RES-90	Proforma submission (additional text)	*There is no Planet B!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-91	Proforma submission (additional text)	*The Bjelke-Petersen government in QLD rightly decided against oil and gas mining the Great Barrier Reef 50 years ago.* *Nothing has changed since - in such irreplaceable areas these proposals can never justify the risk.* *It seems our pollies these days are asking more and more for tourists to visit. The damage in the last 12 months has been monumental. What are they going to see? - signs saying this is where things used to be?* *In particular you need to look at this in context of a changing ocean environment which is less and less friendly to coral reefs. Any impact from mining will be magnified by what is already occurring.* *Another alternative is to take the view that the reefs are stuffed so we might as well trash them anyway. A lot of people seem to be taking this approach these days - not sure why they keep dropping their kids off at school of a morning however.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-92	Proforma submission (additional text)	*We've done enough damage, as a Nation and worldwide, as ignorant humans to our environment here, so unique yet vulnerable* *On planetary terms meaning survival of us as a species Don't Do Any More Damage!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-93	Proforma submission (additional text)	*[Redacted name]I am a biologist with 40 years of professional experience with environmental issues.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-94	Proforma submission (additional text)	*Finally, I draw your attention to the limitations and prohibitions of the Federal Government\'s Environmental Protection and Biodeversity Conservation Act which affords you the authority to terminate Woodside\'s plans in total. Of anywhere, Scott Reef qualifies under the Act\'s definition of \"critically endangered ecological community.\" The Act and the Guidelines are specific about the inclusion of marine environments (See p.14 of the Guideline).* *The Guideline states specifically \"The proposed action should be considered at its broadest possible scope. This includes all stages and components of the action, all related activities, and all related infrastructure...\"* *Specifically commenting on Marine Environments it says that an action shall not \"modify, destroy, fragment, isolate or disturb an important or substantial area of habitat such that an adverse impact on marine ecosystem functioning or integrity in a Commonwealth marine area results [or] ...have a substantial adverse effect on a population of a marine species or cetacean including its life cycle (for example, breeding, feeding, migration behaviour, life expectancy) and spatial distribution* *Petroleum mining cannot proceed without spill risk. The ONLY effective way to remove that risk is to not permit the action to take place at all. Mitigation after the event is a shoddy second alternative, and it completely flies in the face of the EPA\'s Federal directives.* *You know and I know this is a last \'hurrah\' for petrochemicals. Do what you can to stop it. No last hurrah\'s for Woodside.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**).
PRO-G2-RES-95	Proforma submission (additional text)	*No, no, no. Instead, think of the future.....* *Save the environment, marine life and the future welfare of all on this planet. Environmental Protection Authority WA) and [redacted], Secretary Department of Environment and Energy,*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-96	Proforma submission (additional text)	*I am adding my personal plea to you to help protect us from further degradation of our planet and to encourage work that is sustainable for the only environment we have to live in. We have to live with the consequences of our decisions.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-97	Proforma submission (additional text)	*This reef is too valuable as a natural treasure to risk damage to it from the extraction of fossil fuels, which in itself is an activity harmful to our atmosphere.* *Thank you for acting to protect this valuable part of our natural heritage.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G2-RES-98	Proforma submission (additional text)	*We are already moving away from gas and oil and need to do more to protect the ocean and habitats.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-99	Proforma submission (additional text)	*Earth is not only our home, we are all a part of this ecosystem and ripple effects will reach all of us.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-100	Proforma submission (additional text)	*Would it be possible for the WA Environmental Authority to actually protect, with some useful certainty, the very significant ecological values it has in its charge? To this end*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-101	Proforma submission (additional text)	*Survival of our environment should be the overriding aim of any State or Federal Government. That includes both land and water.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-102	Proforma submission (additional text)	*I have read the letter prepared by the Australian Marine Conservation Society in opposition to the proposal and adopt its contents. In addition, I add that I have been a frequent visitor to this part of Western Australia. This sort of development will jeopardise tourism by degrading the environment.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-103	Proforma submission (additional text)	*Even more disastrously, Woodside's proposed Browse Basin and Burrup hub proposal is Australia's most polluting fossil fuel mega-development. It will contribute around four times the pollution of the proposed Adani coal mine and also impact severely on Scott Reef which has previously suffered the impacts of climate change through bleaching events* *Oil and gas operations such as the Browse Basin development are incompatible with the sensitive marine environment of the Scott Reef and its survival as we know it. Protection of this sensitive, nationally significant marine environment is of paramount conservation importance. The Browse Basin proposal forces a choice between fossil fuel extraction and the associated greenhouse emissions, and the degradation of a unique Australian environment. I urge you to reject the proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: BCH-1: Potential impacts to Scott Reef (**Section 5.14**) MEQ-1: Environmental Quality Management Framework (**Section 5.15**) GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-104	Proforma submission (additional text)	*Even more disastrously, Woodside's proposed Browse Basin and Burrup hub proposal is Australia's most polluting fossil fuel mega-development. It will contribute around four times the pollution of the proposed Adani coal mine and also impact severely on Scott Reef which has previously suffered the impacts of climate change through bleaching events* *Oil and gas operations such as the Browse Basin development are incompatible with the sensitive marine environment of the Scott Reef and its survival as we know it. Protection of this sensitive, nationally significant marine environment is of paramount conservation importance. The Browse Basin proposal forces a choice between fossil fuel extraction and the associated greenhouse emissions, and the degradation of a unique Australian environment. I urge you to reject the proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: BCH-1: Potential impacts to Scott Reef (**Section 5.14**) MEQ-1: Environmental Quality Management Framework (**Section 5.15**) GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-105	Proforma submission (additional text)	*I am writing in hopes of influencing and preventing a dire decision in the current consultations on Woodside's Browse Basin development.* *The entire project should be denied, for obvious reasons of fossil hydrocarbons having a biologically dangerous effect on the Entire earth and the climatic stability now being destroyed.* *In particular I am concerned that Woodside's proposed activities threaten the sensitive marine* *Because completely protected oceanic areas are essential for recovering fish*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**)

No.	Submitter	Submission and/or issue	Response to comment
		and other aquatic organisms, and the toxicity of undersea drilling for fossil fuels is proven and repeated constantly since the inception of the practice, Scott Reef is FAR more valuable than any direct or private exploitation can be. *Governments exist to protect the future from such destruction*	• GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-106	Proforma submission (additional text)	********Look at this fact: ************ *---Did you know that Woodside's proposed Browse Basin and Burrup hub will contribute around four times the pollution as that of the proposed Adani coal mine!! 4 Times!* *--And Australian know ALL about the Adani controversy!* *!!! OMG not again. Please stop this proposed development from proceeding.* *--Oil drilling is hugely disruptive. To wildlife, the oceans, and ultimately our world as a whole is affected. We are all linked to what happens in WA.* *It will disturb, injure or kill marine fauna and irreversibly degrade critical habitat for endangered marine life.* *Really!* ***** *Scott Reef has already suffered the impacts of climate change through bleaching events and this proposal would significantly add to the problem.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-107	Proforma submission (additional text)	*Please read this email to the end. I am signing because I cannot believe drilling would be allowed in such a significant area of our coast endangering our marine animals.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**). • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**).
PRO-G2-RES-108	Proforma submission (additional text)	*I also would urge that this company has no 'social license' to do anything in Australian waters. This company has been involved in trying to rip off one of the most impoverished countries in the world - Timor L'Este; and not satisfied with that also doing everything to ensure they pay little or no tax in Australia.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-109	Proforma submission (additional text)	*What will your children and grandchildren think of you if you approve The Woodside's Browse Basin development? Will they be proud that your decision approved Woodside's proposed activities that will threaten the sensitive marine environment of Scott Reef and will disturb, injure or kill marine fauna and irreversibly degrade critical habitat for endangered marine life? I know my children, and in time their children, would not be proud of me if I approved the destruction of such habitats particularly in pursuit of fossil fuels.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**).
PRO-G2-RES-110	Proforma submission (additional text)	*No, no, no!!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-111	Proforma submission (additional text)	*Soon we will not have any marine areas of any quality left and of course the world\'s oceans are like a large bowl of soup that is getting degraded beyond rehabilitation. This effects the quality of life of all life on earth.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-112	Proforma submission (additional text)	*ALL FOR MONEY AND U CANNOT EVEN TAKE IT WITH YOU..ONE FOOT IN THE BANK ANOTHER IN THE GRAVE..MAY GOD HAVE MERCY ON YOU IN ETERNITY WHEN THE TIME COMES AND HE SAYS \"ENOUGH\" AND YOU HAVE DONE THIS AND DESTROYED OUR PLANET*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-113	Proforma submission (additional text)	*I am writing as a doctor concerned about the current consultations on Woodside's Browse Basin development. In particular I am worried that Woodside's proposed activities threaten the sensitive marine*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-114	Proforma submission (additional text)	*Please, please don\'t allow oil and gas development (drilling) on Scott Reef. It\'s imperative that we, as stewards of the planet, protect habitat to allow the Earth\'s creatures to thrive.* *[redacted]*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-115	Proforma submission (additional text)	*What an amazing natural wonderland!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-116	Proforma submission (additional text)	*I have worked in the oil & gas industry most of my working life & have worked for Woodside on the Angel project. Times are changing & it is time to review how resources are exploited. We should not be risking this valuable place adding more carbon emissions.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-117	Proforma submission (additional text)	*Around thirty years ago, my family from SA took a camping holiday around WA, and one of the most impressive things we observed was a HUGE turtle laying her eggs in the sand just after twilight on a remote beach near Exmouth. We watched in awe as she laboriously dug her hole in the sand with her flippers, then laid her eggs, then covered them carefully with the sand she had displaced. We were transfixed by the whole process, and it was an experience my husband and I, and our two children (now adults with children of their own) will never forget.* *So I am writing to you now in relation to the current consultations on Woodside's Browse Basin development. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine* *For these reasons, I am urging you to reject the proposal to undertake oil and gas development on or around Scott Reef, and take steps to preserve your beautiful, unique marine environment and its amazing creatures, so that generations to come may be able to enjoy and experience the awe and wonder that we did on that Spring evening so long ago.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-118	Proforma submission (additional text)	*Australia is becoming re-known for destroying natural habitats and killing off wildlife to the point of species extinction.. Do you want to be known as one who has sent more animals to extinction?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-119	Proforma submission (additional text)	*I cannot believe at this critical state Australia is in that ANY GOVERNMENT in their right mind would even consider this abomination …\"Have the recent disasters taught you nothing?\" This government continues to not do the right thing…and will not listen to the voting public…..WE SHARE THIS PLANET WITH ALL OF GODS CREATURES NOT OWN IT AND ALL THAT\'S ON IT ….* *These areas DO NOT belong to any government..but to all Australians and future generations… How dare you think you can do \'willy nilly\' whatever you like without giving a damn about the natural marine life and the future health of this planet…. Enough is enough…no amount of Money would ever be enough to qualify the rape and destruction of these habitats…* *Please stop this lunacy and do the right thing…*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-120	Proforma submission (additional text)	*I am extremely concerned that Woodside's proposed Browse activities threaten the sensitive marine environment, particularly Scott Reef and will negatively impact marine fauna and irreversibly degrade critical habitat for endangered marine life.* *Scott Reef is a WA state treasure and should be protected.* *Scott Reef has already suffered the impacts of climate change through bleaching events and this proposal would significantly add to the problem.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**)
PRO-G2-RES-121	Proforma submission (additional text)	*I am so over wrecking our environments when it is unsafe for all creatures to co-exist with the effects of our human needs, (gas and oil). There has to be a better, friendlier way please try to find one?* *Selling my shares, can't keep supporting the impacts of this any longer.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-122	Proforma submission (additional text)	*This area is between very valuable marine protected areas, so any pollution, whether accidental via oil spillage, or incidental from wastewater or other means, must affect those valuable adjacent areas. As for drilling on a coral reef, I thought Australia had abandoned any suggestion of that since the 1960\'s!* *This area is being studied by a number of international, as well as Australian universities (University of Sydney's Australian Centre for Field Robotics, the University of Rhode Island (URI) Graduate School of Oceanography, the Woods Hole Oceanographic Institution (WHOI), the Massachusetts Institute of Technology (MIT) School of Aerospace, the University of Hawaii, Australian Marine Ecology (AME) and Evologics Gmbh) showing how important it is.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**).
PRO-G2-RES-123	Proforma submission (additional text)	*Just think about all the money made from people going to see the wild life, which will grow and go on for ever,while after the oil and gas companies are finished destroying it all they will just move on to their next path of destruction. There will be no wild life to see and no one paying.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-124	Proforma submission (additional text)	*I understand you are filling your own pockets to facilitate Woodsides permission to drill in these areas however I take offence when those in charge of protecting our fragile environment are making decisions not reflective of what the community wants or needs, if you okay this process then shame on you.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-125	Proforma submission (additional text)	*The conservation of the ecosystem matters, but reducing the supply of fossil fuels matters even more*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-126	Proforma submission (additional text)	*As a marine biologist, WA-loving tourist and parent,*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-127	Proforma submission (additional text)	*IF NOPSEMA FINDS CONSTANT FAULT WITH WOODSIDE, HOW CAN YOU IGNORE IT?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-128	Proforma submission (additional text)	*I am a citizen resident in Queensland who feels that the coastline and waters surrounding Australia belongs to all Australians and not just the interests of a the few.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-129	Proforma submission (additional text)	*Firstly and above all I find it a little bit disconcerting that the general public needs to be on our toes ready to defend fragile environments or endangered species, be they flora or fauna. This job is supposed to work the other way around. The Woodside proposal to drill in the vicinity of Scott Reef for the environment is a no-brainer. It bothers me personally that such places even have an exploration lease over them. I believe the EPA should have already cordoned off such areas and it should be the exploration and mining companies that seek to do the risky work to put it by the general public before any proposal is even looked at by the EPA. I am with everyone else against this proposal in relation to the current consultations on Woodside's Browse Basin development. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-130	Proforma submission (additional text)	*Your decisions will affect the planet forever. Now is the time to stand up for what\'s left of our wildlife. The ethical question here is: What ought one to do? It\'s a no brainer.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-131	Proforma submission (additional text)	*Below are words written by the Australian Marine Conservation Society that I wholeheartedly agree with. I would also add that should any oil spills or damage be done to such an environmentally sensitive area, it will be known by future generations that YOU allowed such a monumental error to happen. Too many places around our planet are being destroyed in the pursuit of more and more profit, it is a madness that is undeniably destroying the only planet we humans can exist on. You are in a unique position to protect the environment as you title suggests so Please do NOT allow drilling in this area because if it is damaged it cannot be replaced and going by how these petroleum companies work in their mad pursuit of more and more profit, they will take short cuts or use inferior materials,have no doubt, short cuts that increase their profit also increase the very real possibility of irreparable damage to our magnificent coastline. In Australia we are blessed with a relatively clean environment in which to live in, please let us not go down the path of other countries who have allowed theirs to be destroyed by international companies that have no respect to the laws of that country to which we all abide nor the magnificent beauty of the Earth. It was once thought that life was abundant throughout the universe, now with technology astronomers and scientists have now come to believe that a planet like the Earth with such an abundance and diversity of life is not as common as they once thought. It is rare and unique and an absolute gem that should be treasured and looked after not trashed and destroyed.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**).
PRO-G2-RES-132	Proforma submission (additional text)	*Finally, Australia is not getting anything from drilling but a terrible environment for All to live in.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-133	Proforma submission (additional text)	*PLEASE DON\'T FOLLOW The President of the United States of America's [redacted] MODAL OF NOT CARING FOR OUR ENVIRONMENT AND THE REST OF THE ORGANISMS WHO ALSO LIVE ON THIS PLANET! SHORT TERM OIL AND GAS EXPLORATION WILL LEAVE OUR FUTURE GENERATIONS A WORLD THAT IS BARREN AND NO LONGER TEEMING WITH LIFE . . . .*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-134	Proforma submission (additional text)	*Hasn\'t Australia and its wildlife seen enough disasters for one decade? Why encourage more?* *I cannot urge you strongly enough to reject the proposal to undertake oil and gas development on or around Scott Reef.* *Fossil Fuel exploration is from the past, to whatever extent in transitioning to other power sources we continue to allow it, it must not be in our more critical ecology regions. Please give Woodside a firm NO along with and don\'t ask again …*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-135	Proforma submission (additional text)	*Is Scott Reef to support a huge array of sea life from across the Indian Ocean and Timor Sea or is it just for mining Such remote regions are physically isolated which enables critical nesting habitat for one of the most endangered species of marine turtle in the* *It does not exist nor should it as simply a mining site as it is far too important for that. Yet, we have good reason to fear the political influence of this multinational giant, which relies for its operations on political compliance locally and nationally. It is its political influence over the environmental decisions that is at the heart of its political networking.* *Woodside's Browse Basin and Burrup hub proposal is one of Australia's major polluting fossil fuel mega-development. Scott Reef has already suffered the impacts of climate change through bleaching events and this proposal would significantly add to the problem.* *Oil and gas operations such as the Browse Basin development are incompatible with a sensitive marine environment like the Scott Reef and are totally inconsistent with maintaining the safe climate conditions that Scott Reef and other marine environments* *I strongly urge you to reject the proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-136	Proforma submission (additional text)	*I SAY NO, NO, NO TO WOODSIDE EXPLORATION AT SCOTT REEF!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-137	Proforma submission (additional text)	*If there is a 100% guarantee that there will be no spills or pollution at all then I would not object to this proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**).
PRO-G2-RES-138	Proforma submission (additional text)	*There is a need for vision and protection of the environment for our children and grandchildren. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-139	Proforma submission (additional text)	*Don\'t drill Scott Reef. Build renewables and leave the wildlife alone.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-7: Lower and zero carbon energy sources (**Section 5.8**).
PRO-G2-RES-140	Proforma submission (additional text)	*We urge you to reject the proposal to undertake oil and gas development on or around Scott Reef. "*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-141	Proforma submission (additional text)	*PLEASE DON'T RUSSIAN ROULETTE TO BE PLAYED WITH OUR REEF!!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-142	Proforma submission (additional text)	*I am deeply concerned that you are considering the possibility of endorsing Woodside's Browse Basin development. I am 70 years old and have watched my beautiful planet raped and pillaged by oil companies and have watched* *as our precious environment has been decimated to a point at which in many instances there is now no return. You yourself are probably too young to remember the abundant beauty and diversity with which I was fortunate enough to experience in my earlier life. I am begging you not to endanger the remaining diversity by allowing money to override the future of our planet and wildlife. We now know there are other less harmful ways to create the energy we think we need to survive … please put your energies into finding alternate solutions and place ecosystems above profit before it is too late.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-143	Proforma submission (additional text)	*I urge you to please reject the proposal to undertake oil and gas development on or around Scott Reef, for the sake of our children. We can\'t be seen as the generation who ignored the science and destroyed the natural environment for corporate greed.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-144	Proforma submission (additional text)	*"I am a petroleum geologist. I went for an interview with woodside in the 90s came 2nd.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-145	Proforma submission (additional text)	*Despite this, based on what I know, which is little re the environment if scott reef I would say that just like GtBarrier Teef it should be excluded from oil and gas exploration. It is a unique habitat with great wildlife and needs to be protected on that basis."*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-146	Proforma submission (additional text)	*I WANT YOU TO KNOW I THINK BEING AT A MOMENT WHERE WELL BE JUDGED, THIS IS YOUR CHANCE TO DO THE RIGHT THING BY THOSE TO COME. Environmental Protection Authority WA) and [redacted] Secretary Department of Environment and Energy*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-147	Proforma submission (additional text)	*STOP PUTTING SHORT TERM PROFITS OVER LONG TERM ENVIRONMENTAL HEALTH!!! DO YOU HAVE A FAMILY? GRANDCHILDREN? WHY POLITICIANS ARE SO SHORT SIGHTED MY CHILDREN ARE INHABITING A DYING WORLD! MONEY WON'T FIX EVERYTHING!*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-148	Proforma submission (additional text)	*It is time to actively and publicly start protecting our fauna on land and in the sea. Fossil fuels are polluting and slowly destroying this world. Let's conserve our world and let go of fossil fuel use.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-149	Proforma submission (additional text)	*Some places must NEVER be \"developed\" and this is one of those.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-150	Proforma submission (additional text)	*We cannot continue to destroy the ecosystem and the world with the polluting fossil fuels. Think of your children and grandchildren\'s world in the future.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-151	Proforma submission (additional text)	*Scott Reef supports a huge array of sea life from across the Indian Ocean and Timor Sea. The \"impregnable\" oceans are in serious trouble for a number of reasons. Fossil is a deathly, dead end. Why this risk? Once, years ago now, the prestigious Australian Academy of Science and CSIRO, and BOM, warned that the risk of continued fossil use was too, too far to take, it bound all. Without the guidance of a \"think tank\" we are flying blind, entailing an incredible risk. Those bodies\' position should have been and be the governing factor. However, in the ensuing period of inaction, the supreme bodies, in the field have seen the change, over many years - that is seen it, \"face-to-face\". They are the US National Oceanic and Atmospheric Administration and David Attenborough. The only difference between the modelling and what they are seeing is that the change is faster. I worked very closely with the leading representatives of energy companies in the 1980s, of the ExxonMobil warning bulletin, and 1990s, of the Shell bulletin. It was assumed that people would heed the warning. It is inexplicable this has not been the case. So I have been put in the box seat to see what was covered, then play out, in the last incomprehensible 30 years. I urge you to reject the proposal to undertake oil and gas development on or around Scott Reef, on the basis of the reef\'s welfare, alone and the wider madness of continued fossil use.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-152	Proforma submission (additional text)	*In light of the recent devastation to the environment caused in part, if not all, by the actions of entities from the resources sector...only an idiot would suggest that any project that threatens the environment, is acceptable.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-153	Proforma submission (additional text)	*Earth is not only our home, we are all a part of this ecosystem and ripple effects will reach all of us.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-154	Proforma submission (additional text)	*As a marine scientist with more than 40 years\' exprience diving on corals reefs, including Scott Reef, I am writing in relation to the current consultations on Woodside's Browse Basin development. In particular I am concerned with information provided by AMCS that Woodside's proposed activities threaten the sensitive marine* *I can attest from personal experience that It also acts as an important \'stepping stone\' in connecting populations of marine species along the WA coast and Timor Sea more generally.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-155	Proforma submission (additional text)	*Woodside's Browse Basin development is being discussed at the moment, and I'm very worried About the effect Woodside's proposed activities will have on the fragile marine environment of Scott Reef. My understanding is that it could disturb, injure or kill marine fauna and irreversibly degrade critical habitat for endangered marine life.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**)
PRO-G2-RES-156	Proforma submission (additional text)	*I respectfully strongly urge you to reject the proposal to undertake oil and gas development on or around Scott Reef.* *Thank you for listening to me, even though I am not an Australian.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-157	Proforma submission (additional text)	*Our beautiful reefs are one of the biggest reasons people visit WA and Australia in general. We are so lucky to live in a country with so much diversity in wildlife and marine life that we should work hard to keep it that way.* *In a time where most Australians are fearing for the future of our country and precious wildlife and marine life, you have the opportunity to step up and be a leader in this space. Be a leader that we can remember, one that puts our pristine, precious marine environments first rather than one that destroys it. Reject the proposal and keep Australia beautiful!* *Thank you and kind regards*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-158	Proforma submission (additional text)	*In 2010, the EPA noted that light pollution from activities such as subsea oil and gas drilling can disrupt the nesting and behaviour of hatchling and adult turtles and other endangered marine life. Additionally, persistent low frequency noise from gas extraction is known to affect feeding, migration, and breeding behaviour in sea turtles, and impact the migratory patterns of whales.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**).
PRO-G2-RES-159	Proforma submission (additional text)	*You have the details of previous studies showing the dangers to the environment.* *Australia is already a heavy polluter on a per capita measure. Please don\'t be responsible for enabling further fossil fuel development* *Scott Reef already shows impacts of climate change through bleaching events and this proposal would significantly add to the problem.* *I might live in the eastern part of Australia but I regard myself as a responsible Australian citizen. My grandchildren deserve to be able to see the wonders of this area and I hope they can through your wise decision making.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-160	Proforma submission (additional text)	*I am a qualified marine Biologist,and teach Biology and Ecosystems to adults intending to go to University. The amount of data showing the damage done by exploratory drilling and echo-sounding alone is extensive, and well-documented. And as a scuba diver , with multiple dives on the West Australian coast, i am aware of the delicacy of the narrow reef systems there.* *The value of the Reef to the tourist economy long term far outweighs the return from oil, which will have a limited life, and cause permanent damage and possible destruction of the ecosystem.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-161	Proforma submission (additional text)	*As an international citizen who understands the importance to the world of Australia's unique marine species and ecosystems and the terrible pressures they are under, I write in relation to the current consultations on Woodside's Browse Basin development. In particular I am concerned that Woodside's proposed activities threaten the sensitive marine.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-162	Proforma submission (additional text)	*I was horrified to learn that Woodside Petroleum is seeking approval for no less than 54 oil and gas wells in Browse Basin.* *Not only would creating and excavating these significantly threaten the sensitive marine environment of Scott Reef, but burning any fossil fuels extracted from them would inevitably exacerbate global warming - thereby ensuring that all of Australia\'s bushfire seasons for the foreseeable future will be even worse than the current one.* *world, the green sea turtle. Five species of whales also visit the area, including Humpback whales and Blue Pygmy whales, and at least 10 species of dolphins are found there in pods that each contain hundreds of individuals. The proposed activities would seriously disturb, injure or kill all or most of the local marine fauna and irreversibly degrade critical habitat for surviving creatures. In 2010, the EPA noted that sunlight pollution from activities such as subsea oil and gas drilling can disrupt the nesting and behavior of hatchling and adult turtles and other endangered marine life. Additionally, persistent low frequency noise from gas extraction is known to affect feeding, migration,* *and breeding behavior in sea turtles, and adversely impact the migratory patterns of whales. oil spill would last 77 days, spreading across the reef and as far as 800 km from the site - at concentrations lethal to marine life.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**)MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**) • MF-8: Potential impacts to sea snakes (**Section 5.30**) • MF-9: Potential impacts to seabirds and migratory shorebirds (**Section 5.31**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-163	Proforma submission (additional text)	*For the sake of future generations, please reject the proposal to undertake oil and gas development on or around Scott Reef.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-164	Proforma submission (additional text)	*There are ALWAYS disastrous spills and leaks where oil is dripped, plus toxic pollution released into the water.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**).
PRO-G2-RES-165	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. In particular I am greatly concerned that Woodside's proposed activities seriously threaten the very fragile and sensitive marine Considering your role, you are surely fully aware that Scott Reef supports a huge array of sea life from across the Indian Ocean and Timor Sea. Please remember that this includes highly critical nesting habitat for one of the most endangered species of marine turtle in the world, the green sea turtle.* *You will also know, that five species of whales visit the area, including Humpback whales and Blue Pygmy whale and that at least 10 species of dolphins are found at Scott Reef in pods numbering hundreds of individuals. Please recall that in 2010, the EPA noted that even so called \"light pollution\" from activities such as subsea oil and gas drilling are likely to disrupt the nesting and behavior of hatchling and adult turtles and other endangered marine life. Clearly, this poses an unacceptable risk to the marine life.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**) • MEQ-6: Management of drilling and completion discharges (**Section 5.20**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-2: Potential impacts to marine fauna as a result of light emissions (**Section 5.24**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**)

No.	Submitter	Submission and/or issue	Response to comment
		Additionally, it is well known that persistent low frequency noise from gas extraction will affect feeding, migration, and breeding behavior in sea turtles, and impact the migratory patterns of whales. *Also of unacceptable impact is the discharges of wastewater and pollution from oil spills that will contaminate marine ecosystems with toxic heavy metals and other chemicals.* *Please take note that Woodside's own risk models predict that a mixed gas and* *Considering all the irreversible consequences to the marine life, I very strongly urge you to fully reject the proposal to undertake oil and gas development on or around Scott Reef.* *Assuming that you too love Australia and all its natural environment, I trust that you will do everything in your power to provide the ongoing protection it requires.* *Thank you*	• MF-5: Potential impacts to marine turtles (**Section 5.27**) • MF-7: Potential impacts to cetaceans (**Section 5.29**)
PRO-G2-RES-165	Proforma submission (additional text)	*I am someone who loves Australia and its environment and am appalled to think that this project could be approved. We travel the W.A. coast regularly and love spending time there - and our money! But, if this proceeds, we will be thinking twice.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above
PRO-G2-RES-166	Proforma submission (additional text)	*I include the generic email below. In my own words, this drilling mustn\'t be allowed to proceed. Time and again profit is being out before sensible action.* *We can\'t have more fossil fuels dug up and there are many alternatives .* *Enough is enough* *As an Australian citizen I am asking you not to approve this drilling project.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-167	Proforma submission (additional text)	*Yes, this is a \'form letter\'. It is sent with the hope that you and the Authority will do all within your powers to halt Woodside Petroleum in its attempts to drill in the Scott Reef. Surely, with all the different Anthropocene impacts currently assailing our Planet, it is time to be very cautious when considering any activity which further impacts the natural environment. . . . . isn\'t it?*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-168	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development.* *1.0 Subsea drilling proposed* *In particular I am concerned that Woodside's proposed activities threaten the sensitive marine* *2.0 Reduce Australia\'s Carbon footprint* *Our current carbon footprint per person is at the top of the world footprint per person table. This is because of the huge exports of huge quantities of LNG, and coal in its various forms.* *Australia must reduce its carbon foot print to help reduce the human effect on climate change that is so well documented in the 2015 Paris Agreements. These must be signed immediately by Australia.* *Please take these 2 factors to heart when deciding on the Woodside proposal.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-2: Proposed Browse Project in the context of meeting local and international climate change commitments (**Section 5.3**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).
PRO-G2-RES-169	Proforma submission (additional text)	*I am writing from Brisbane. Although I am a long way from the Browse Bay site matters such as Woodside's proposed activities are of concern to all Australians as it is imperative we maintain sensitive marine environments of such as Scott Reef which is a critical habitat for endangered marine life.* *Oil and gas operations such as the Browse Basin development are totally inconsistent with maintaining the safe climate conditions that Scott Reef and other marine environments*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-5: Potential impacts to marine turtles (**Section 5.27**) • GHG-1: Objections to the proposed Browse Project due to GHG emissions (**Section 5.2**) • GHG-10: Climate change impacts on human health and environmental and social receptors (**Section 5.11**).

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-170	Proforma submission (additional text)	*Will disturb, injure or kill marine fauna and irreversibly degrade critical habitat for endangered marine life.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MF-1: Potential impacts to marine fauna (general) (**Section 5.23**) • MF-3: Potential impacts to marine fauna as a result of noise emissions (**Section 5.25**) • MF-5: Potential impacts to marine turtles (**Section 5.27**).
PRO-G2-RES-171	Proforma submission (additional text)	*I would not object if Woodside Petroleum would absolutely guarantee 100% that they would not cause any pollution and that if they did so they would pay a fine of 500 times the total clean-up bill*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • MEQ-1: Environmental Quality Management Framework (**Section 5.15**) • MEQ-2: Unplanned hydrocarbon spills (**Section 5.16**).
PRO-G2-RES-172	Proforma submission (additional text)	*Please put right b before profit.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-173	Proforma submission (additional text)	*I have worked in the oil and gas industry and it\’s not as safe and clean as you think. Every time we have a spill it’s always reported as 19.9 litres, not the 199 litres that was lost.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-174	Proforma submission (additional text)	*Protection of WA’s environment and development of its economy should not be nothing more than a numbers game. Proforma submissions as provided by the Conservation Council of WA in opposition to exploration for oil and gas as per above should be dismissed as lacking substance and hence not be considered by the EPA when assessing the project.* *I therefore urge you to assess the merits or otherwise of any project on the substance of the development proposal and on the basis of evidence put forward by submitters.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-175	Proforma submission (additional text)	*world Protection of this sensitive, nationally significant marine environment is a paramount conservation priority*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the following responses in **Section 5**: • BCH-1: Potential impacts to Scott Reef (**Section 5.14**) • MEQ-1: Environmental Quality Management Framework (**Section 5.15**).
PRO-G2-RES-176	Proforma submission (additional text)	*The proposed oil and gas developments are totally against marine's conservation recommendations.* *They are also totally against the wishes of more than 50% of the voting public.* *I join with the thousands of others who are vehemently against the proposed developments*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-177	Proforma submission (additional text)	*Australia is lucky to have such a beautiful asset as the Scott Reef. We MUST NOT let Woodside or any others drill in such a delicate ocean system.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.
PRO-G2-RES-178	Proforma submission (additional text)	*I am writing in relation to the current consultations on Woodside's Browse Basin development. Are you both crazy? The money we get from tourism and the jobs generated by tourism far outweighs any money or jobs from this proposal. Remove the subsidies you give the oil industry and it would be uneconomic.* *Apart from the financial side, Woodside's proposed activities threaten the sensitive marine* *Oil and gas operations such as the Browse Basin development are not compatible with a marine environment like the Scott Reef and are totally inconsistent with maintaining the safe* *Protection of this nationally significant marine environment is a paramount conservation priority which is fundamentally threatened by the Browse Basin proposal.* *It makes sound economic and environmental sense to reject the proposal to undertake oil and gas development on or around Scott Reef. As an Australian I request you reject it.*	We acknowledge the comments made and provide the following information in response to the matters raised. Please refer to the response to PRO-G2-RES-1 above.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G2-RES-179	Proforma submission (additional text)	*Protection of WA's environment and development of its economy should not be nothing more than a numbers game. Proforma submissions as provided by the Conservation Council of WA in opposition to exploration for oil and gas as per above should be dismissed as lacking substance and hence not be considered by the EPA when assessing the project. I therefore urge you to assess the merits or otherwise of any project on the substance of the development proposal and on the basis of evidence put forward by submitters.*	We acknowledge the comments made. As the comment does not raise any specific concerns in relation to the proposed Browse Project, no response is provided.
Group 3 – Submissions primarily related to the Burrup Hub and onshore development			
PRO-G3-RES-1	Proforma submission	*Header - Assessment # 2186: Proposed North West Shelf Project Extension* *Dear (Chairperson Environmental Protection Authority WA) and Minister (Minister for Regional Development; Agriculture and Food; Ports),* *I am writing to express my deep concern with the proposal for the Burrup Hub and the Browse Basin development. I'm alarmed about the industry reports that this hub could also be connected to several new major onshore gas projects in the farming region around Dongara.* *The Waitsia and West Erregulla projects are still going through assessment and exploration processes, yet it seems like the Burrup Hub project is already talking up access to vast amounts of gas around the Mid West, claiming "new exploration technologies and deeper drilling" will give them access to gas "previously out of reach".* *The serious opposition from regional communities and farmers across WA to fracking gasfields is well known to the Government.* *It is totally inappropriate for the Government to be considering this gas hub proposal without fully considering the risks to farming, groundwater, pollution and negative health impacts of massive onshore gas expansion.* *The environmental assessment of the Burrup hub project must consider the impacts of all these future gas developments and Woodside must disclose all gas supplies and their environmental impacts.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such the reader is referred to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
		It is also out of line when we are already experiencing the negative impacts of a changing climate to even consider opening up what could be one of the most polluting new projects on earth. WA needs to do better, stop growing the flow of polluting gas and get serious about economic opportunities from clean renewable energy and renewable energy exports. *I strongly oppose the proposal for the Burrup Hub, Browse Basin and North West Shelf LNG projects and links to the project to the spread of onshore gasfields across farming regions of WA.* *Thank you for the opportunity to have my say on this project.*	
PRO-G3-RES-2	Proforma submission (additional text)	*Please do some research. Fracking poisons the land and the water. It is a toxic and brutal process to unleash on any landscape.* *See what happened at Condomine river near Warragamba. Flaming water. Any where that has been fracked in America. Totally toxic. They must be offering you a lot of money to look the other way.* *Your children and grandchildren will hate you for the shortsighted decision to allow this. $ is worthless if your land and water is poisoned.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-3	Proforma submission (additional text)	*I regularly holiday in WA visiting broome, cape leveque, james price point and all the way down to exmouth and coral bay. Do NOT put anymore abominations like that on the burrup peninsula. It is foul*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G3-RES-4	Proforma submission (additional text)	*Please Please* *LEAVE BURRUP ALONE - Our Planet Earth belongs to LIFE, not money!* *Please Please Please Please PleasePlease Please*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-5	Proforma submission (additional text)	*I am appalled by this application from Woodside. Having recently traveled to this area in 2019 I was blown away by the beauty of the area. The biodiversity and untouched wilderness is an important asset for all the people of our state and it is your responsibility to ensure this is protected for generations to come.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-6	Proforma submission (additional text)	*Please start looking at our long term future - tourism would go though the roof of the Kimberley was looked after. It's starting to look like Hedland in Broome you fools. Look at the age of thise moving now families don't want to be here it's a methamphetamine riddled bogs hole. The family holiday destination with indigenous connection and promotion is dying with this sort of policy of profiteering at all cost.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G3-RES-7	Proforma submission (additional text)	*These companies have no respect for Western Australia; they agree to whatever license conditions are needed to get approval and then blatantly ignore them once the plant is operational, knowing full well that no Government or Department has the fortitude to impose meaningful penalties or to shut them down. All sorts of commitments and snake oil solutions are promised, but inevitably come to nothing, and they just keep on polluting and our Government is complicit by allowing them to do it. It must stop.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-8	Proforma submission (additional text)	*It is ironic that Australia's reserves of Oil, Gas and Uranium, thought to be an asset, are actually an achilles heel that, due to the pressure for revenue if stifling what really needs to happen, a national energy policy, and innovation away from exporting a product which will become toxic stranded assets in the foreseeable future.* *Environmental and Indigenous; There is a big groundswell of opposition towards Fracking the the expansion of the Gas industry in general. The indigenous groups are lining themselves up for a battle and they have the backing of a board spectrum of the wider Australian public, who, due to recent events, are awakening from their lethargy in regards to the wider threat of climate change and the fossil energy business as usual scenario. Add to that the more frequent droughts and the prospect of the contamination of ground water supplies, and the entire expansion of the gas industry just does not make sense.* *Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable technologies. You must rapidly move away from all types of fossil fuels, including LNG. I strongly urge you to reject Woodside's proposal as the State should be pursuing the cheap and abundant renewable resources we have available right here in WA, to enable an orderly transition that must and will occur anyway.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G3-RES-9	Proforma submission (additional text)	*The Government needs to fully consider the risks to farming, groundwater, pollution and negative health impacts of massive onshore gas expansion.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-10	Proforma submission (additional text)	*to do anything less than stop this project is a betrayal to every living creature in this country.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-11	Proforma submission (additional text)	*Being a farmer in Carnarvon I know the importance of a good water supply to the growing of food. Any risk of pollution to our ground water in totally wrong! Drilling through aquifers and pumping gas through them, relying on bore casings that a percentage are know to fail should not be allowed.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G3-RES-12	Proforma submission (additional text)	*Additionally there has been an economic cost to the massive fracking operations in the US in that prices have dropped for the product*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-13	Proforma submission (additional text)	*Fracking projects overseas have proven to be disastrous to the environment, giving irreparable damage to rivers, soil and the atmosphere, its a costly, inefficient, dirty and terrible way to produce energy.. solar, wind and tidal energy have been proven to be cheaper and far healthier to us and the environment, the only reason fracking can happen is if corruption and dodgy deals are in place, STOP IT NOW!!!!!!!!!! EVERYONE'S HEALTH DEPEND ON IT!!!! INCLUDING YOURS*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-14	Proforma submission (additional text)	*Proposal for the Burrup Hub and the Browse Basin development. Think globally and act locally. Food security and climate safety are more important than corporate profit. Fracking irreparably pollutes both ground- and surface-water, and the inevitable methane leaks add to climate warming. To trade one of the best parts of the WA wheatbelt for gas that would be exported along with most of the profit, as well as adding to global warming, simply does not make sense.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G3-RES-15	Proforma submission (additional text)	*Gas seam mining is a highly risky business and I do not believe the affects of fracking can be contained or will be contained by profit driven companies. Our most precious resource is clean water.* *Fracking for gas risks contaminating our clean ground water destroying our agricultural industry and their production of clean food and all life that depends on uncontaminated water.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-16	Proforma submission (additional text)	*Please consider our environmental guys.* *Easy to frack our future away for a few dollars but please put the things into perspective with what we have been blessed with, water fresh water, fruit vege etc area to develope something that is natural without risk or doubt.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-17	Proforma submission (additional text)	*It is totally inappropriate that the Government consider this gas hub proposal without fully considering the risks to farming, groundwater, pollution and negative health impacts of massive onshore gas expansion.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G3-RES-18	Proforma submission (additional text)	*The environmental assessment of the Burrup hub project must consider the impacts of all these future gas developments, Especially Where It Concerns FRACKING and Woodside must disclose all gas supplies and their environmental impacts.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-19	Proforma submission (additional text)	*Now is the time to be changing our lifestyles and exploring different ways of living in order to protect and be able to continue to experience the beauty we have inherited, instead of squandering resources that took millions of years to be created. Regards*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**).
PRO-G3-RES-20	Proforma submission (additional text)	*Dear EPA Chair and Minister MacTiernan* *You will be aware that the Waitsia and West Erregulla projects are still undergoing assessment and exploration processes, while the Burrup Hub project is anthropogenic claiming "new exploration technologies and deeper drilling" are giving them access to gas "previously out of reach".* *Strong opposition from regional communities and farmers across WA to fracking gasfields is well known to the government.* *It is difficult to understand how the government can consider this gas hub proposal without fully considering the risks to farming, groundwater, pollution and negative health impacts of massive onshore gas expansion? Apart from massive wads of money to vested interests that is.* *We are already experiencing the negative impacts of anthropogenic climate disruption and to even consider opening up what could be one of the most polluting new projects on earth is C … R … A … Z … Y. Renewable energy and renewable energy exports are the future. .*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G3-RES-21	Proforma submission (additional text)	*I am writing on behalf of myself, but also farmers I work with in the Mid West, to express my deep concern with the proposal for the Burrup Hub. I'm alarmed about the industry reports that these could be connected to two new major onshore gas projects in our farming region around Dongara. The Waitsia and West Erregulla projects are still going through exploration and assessment processes, yet it seems like this massive project is already talking up access to vast amounts of gas in our Mid West, claiming "new exploration technologies and deeper drilling" will give them access to gas "previously out of reach". The serious opposition from regional communities and farmers across WA to fracking gasfields is well known to the Government, and we know there's tight gas that the companies are keen to co-develop through fracking in the Mid West. It is totally inappropriate for the Government to be considering the Burrup gas hub proposal without fully and get serious about economic opportunities from clean renewable energy and renewable energy exports. I strongly oppose the proposal for the Browse Basin and North West Shelf LNG projects as part of the Burrup Hub and links to the project to the spread of onshore gasfields across farming regions of WA.Thank you for the opportunity to have my say on this project.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-22	Proforma submission (additional text)	*It is uttey inappropriate for the Government to be considering this gas hub proposal without fully considering the risks to farming, groundwater, pollution and negative health impacts of massive onshore gas expansion.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G3-RES-23	Proforma submission (additional text)	*I find it alarming that the Government ignores the environmental destruction and the poisoning of our water and still propose fracking.* *In fact all steam ahead. I think this is madness considering the experience in the USA and the poisoning of clean water and the hazard of gas leaks. That's just saying 2 simple hazards and there's more if you care to do your research.* *The people who are opposing this are people that vote.* *The risks to farming, groundwater, pollution and negative health impacts of massive onshore gas expansion.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-24	Proforma submission (additional text)	*I am disappointed in the WA Government's feeble approach to fracking: there should be a total ban and that should be the end of it. In the name of basic human dignity, there must be limits to GREED.*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-25	Proforma submission (additional text)	*I am contacting you in response to the current consultations on the proposed Browse Basin and North West Shelf LNG projects as part of the Burrup Hub. My key concern is that the Burrup Hub development will lead to a major new fracking industry in WA, with devastating*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

No.	Submitter	Submission and/or issue	Response to comment
PRO-G3-RES-26	Proforma submission (additional text)	*Why are we proposing to sacrifice our country for the benefit of other countries?* *FRACKING IS A RECKLESS PROCESS THAT DOES NOTHING BUT DESTROY OUR ENVIRONMENT WHILE WASTING AND POLLUTING OUR WATER. WATER IS THE SINGLE MOST IMPORTANT ITEM FOR ANY HUMAN BEING, ANIMAL OR PLANT*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.
PRO-G3-RES-27	Proforma submission (additional text)	*West Shelf LNG projects as part of the Burrup Hub. As a Driller myself, I am particularly concerned that the Burrup Hub development will lead to a major new fracking industry in WA, with devastating Yours [redacted]*	We acknowledge the comments made and provide the following information in response to the matters raised. This proforma, while provided to the Browse Project as a public submission, relates to the North West Shelf Project Extension Proposal (EPA 2186, EPBC 2018/8335). As such, please refer to response O-21 of the NWS Project Extension ERD Response to Submissions (**Section 3.5.3**, **Table 3-15**). Woodside confirms that there is no fracking associated with the proposed Browse Project.

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APPENDIX A TECHNICAL STUDIES

APPENDIX A.1 BROWSE PROJECT DESKTOP LIGHTING ASSESSMENT

JACOBS

PROPOSED BROWSE PROJECT DESKTOP LIGHTING ASSESSMENT

Prepared by

Pendoley Environmental Pty Ltd

For

Jacobs

27 May 2020

PENDOLEY ENVIRONMENTAL

MARINE CONSERVATION ENVIRONMENTAL SERVICES

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EXECUTIVE SUMMARY

Woodside Energy Limited (Woodside), as operator for and on behalf of the Browse Joint Venture, is proposing to develop the Browse hydrocarbon resource located in the Brecknock, Calliance, and Torosa reservoirs. To support environmental approvals prepared for the proposed Browse Project, a desktop lighting assessment was conducted. The assessment included a review of existing artificial light modelling and a site-specific impact assessment.

The Browse Project Area includes two FPSO locations and 11 drill centres. Associated light sources include:

- Operational and navigational lighting of MODUs and FPSO facilities.
- Operational and navigation lighting of project vessels, including support/supply vessels, survey vessels and installation vessels.
- Flaring from MODUs and FPSOs.

The Browse Project Area is located adjacent to Scott Reef which includes Sandy Islet, a known green turtle (*Chelonia mydas*) rookery. The behavioural response of marine turtles to artificial light is well documented in the scientific literature. However, the vulnerability of individuals to behavioural impacts is influenced by a number of factors including, but not limited to, the properties of the artificial light (including intensity and wavelength), duration of exposure, visibility (e.g. shielding from topography) and the life stage or behaviour being undertaken. Green turtles are most sensitive to short wavelength blue light and show preference for wavelengths <600 nm.

The impact assessment was conservatively based on the assumption that light emissions (in the form of either direct light or sky glow) from operational lighting may be visible at intensities resulting in behavioural impacts to marine turtles at 20 km from the source. For flaring, additional conservatism was made based on results of line of sight (LOS) modelling, with behavioural impacts potentially occurring within 52 km the MODU and FPSO locations. Outcomes of the impact assessment are summarised as follows:

- Operational lighting, if rich in short wavelengths, may present a greater risk of behavioural impact compared to flaring, which has a higher proportion of wavelengths >650 nm. However, if intensity of the flare is great enough behavioural impacts may still occur, especially during periods of the new moon, particularly when considering the absence of competing artificial light sources in the area.
- Light, in the form of directly visible point source light and/or sky glow, may be visible at Sandy islet from eight drill centres and the Torosa FPSO. The lack of topographic features at Sandy Islet inhibits natural shielding from light, meaning that all nesting habitat on Sandy Islet may be exposed to artificial light.
- Operational lighting may be visible at Sandy Islet during drilling activities at drill centre TRE. Drilling activities at this location may span two consecutive breeding seasons in two drilling phases.

- Flaring from the MODU may occur intermittently for up to 1-2 days per well. However, since eight different drill centres (7 – 45 km distance), plus the Torosa FPSO (29 km distance), occur within 52 km of Sandy Islet, flaring may visible at Sandy Islet for multiple consecutive breeding seasons. However, it is expected that the intensity of light received at Sandy Islet will decrease with distance.
- The duration and frequency of flaring at the Torosa FPSO during the operational phase is unknown but could span an entire breeding season in an unplanned situation.
- Key findings for different life history stages / behaviours of green turtles at Scott Reef are summarised in Table 1 below.
- Potential impacts of artificial light to seabirds and migratory shorebirds at Scott Reef are expected to be limited to local attraction, however, species present are not at high risk of collision with structures. Negative impacts to migration and nocturnal nest site selection of shorebirds may occur, however, as Scott Reef has not been identified as an important habitat for these species, any impacts are likely to be limited to individuals rather than populations.

Table 1: Key findings of the artificial light impact assessment for green turtles

Vessel / facility	Light source / distance from Sandy Islet	Life history stage / behaviour and impact pathway			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat.
MODU and associated project vessels	**Operational lighting** Continuous over two consecutive breeding seasons, in two phases. TRE - ~7 km	Operational lighting at TRE presents greater risk compared to flaring at all drill centres due to light characteristics (i.e. spectral output) and duration of exposure.			**No impact predicted**
	Flaring Intermittent within breeding seasons throughout development drilling phase. TRA - ~24 km TRB - ~31 km TRC – ~36 km TRD - ~20 km TRE - ~7 km TRF - ~24 km TRH - ~25 km BKA - ~45 km	• Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely • Postulated that neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Negative impacts to post-nesting sea finding behaviour considered unlikely, particularly as females are never more than ~30 m from the ocean • Behavioural responses will decrease in consequence as light intensity decreases with distance from source. Therefore, drilling activities at TRE pose greatest risk to nesting females.	• Absence of dunes and other topographic features may reduce the ability of the hatchlings to discriminate between the artificial light horizon and the ocean horizon (i.e. absence of dark horizon cue). • Hatchlings may orient towards artificial light source rather than ocean horizon. • Behavioural response may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m. • Not all hatchlings are expected to display a behavioural response depending upon the orientation of light sources to the clutch, prevalence of disrupted sea finding behaviour in published studies and lunar phase at emergence. • The consequence of the behavioural response is not expected to result in reduced survival at the population level.	• Potential for dispersal of a proportion of hatchlings to be affected by presence of MODU and support vessels at TRE. • Extent of this impact will depend on current speed and direction and lunar phase at emergence. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume. • Potential for hatchling dispersal behaviour to be affected decreases with distance to shore. • Apart from TRE, all other drill centres are >20 km from Sandy Islet. At these ranges the density of dispersing hatchlings will have decreased, meaning fewer will be at risk of attraction.	• Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations • Large aggregations of foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages

Vessel / facility	Light source / distance from Sandy Islet	Life history stage / behaviour and impact pathway			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat.
Torosa FPSO	**Operational lighting** Continuous throughout 44-year project life ~29 km	**No impact predicted.**	**No impact predicted.**	• Potential for hatchling dispersal behaviour to be affected decreases with distance to shore. • Torosa FPSO located ~29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be low and few individuals will be at risk of attraction • Therefore, it is unlikely that large numbers of hatchlings will be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations • Large aggregations of foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages
	Flaring Continuous over one breeding season. Intermittent throughout 44-year project life. ~29 km	• Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Flaring could be intermittent or continuous over a breeding season. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Risk of negative impacts to post-nesting sea finding behaviour considered low, particularly as females are never more than ~30 m from the ocean • Spectral output of flares outside peak sensitivity for green turtles, potential reducing potential for behavioural impacts, depending upon the intensity.	• In absence of dunes/topographic features, hatchlings may orient towards artificial light source rather than ocean horizon. • Behavioural response may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m. • Only a proportion of the annual number of hatchlings could be affected by intermittent flaring. • A prolonged flaring event at the Torosa FPSO could result in all clutches within a given season being exposed to artificial light • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output of flaring, orientation of light sources, and lunar phase at emergence. • The consequence of the behavioural response is not expected to result in reduced survival at the population level.		

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Acronyms

BIA	Biologically Important Areas
CCT	Correlated Colour Temperature
CIE	Commission International de l'Eclairage
EAAF	East Asian Australasian Flyway
EIS	Environmental Impact Statement
ERD	Environmental Review Document
FLNG	Floating Liquefied Natural Gas
FPSO	Floating Production Storage Offloading
G-ScBr	Green turtle Scott Reef- Browse Island genetic stock
HPS	High Pressure Sodium
LED	Light Emitting Diode
LOS	Line of sight
m/s	Meters per second
MODU	Mobile Offshore Drilling Unit
NWS	North West Shelf
WA	Western Australia

1 INTRODUCTION

1.1 Project Background

Woodside Energy Limited (Woodside), as operator for and on behalf of the Browse Joint Venture, is proposing to develop the Browse hydrocarbon resource located in the Brecknock, Calliance, and Torosa reservoirs.

The proposed Browse Project comprises two floating production storage offloading (FPSO) facilities and subsea infrastructure, to be located approximately 290 km north-west of mainland Australia and approximately 425 km north of Broome, Western Australia within the Browse Development Area (Figure 1). Hydrocarbon extraction will require up to 54 wells and associated subsea infrastructure including manifolds and flowlines. Indicative location of mobile offshore drilling units (MODUs) and FPSOs are shown in Figure 1.

Production drilling will be undertaken in phases at 11 drill centres; drilling may not occur at each drill centre during all phases, though a detailed schedule is unavailable at present. Within each drilling phase, MODUs are planned to be infield for up to approximately 18 months, though the timeframe could be extended as operational requirements or restraints dictate. FPSOs will be continually present during the 44-year operational phase.

1.2 Scope and Exclusions

Jacobs have engaged Pendoley Environmental on behalf of Woodside to conduct a desktop lighting impact assessment to:

- Describe the marine turtle species and relative importance of nesting beaches in the vicinity of the Browse Development Area.
- Describe the seabirds and migratory shorebirds species assemblage and habitat use within the Browse Development Area.
- A gap analysis of existing artificial light modelling applied in the light impact assessment provided in the Browse to NWS Project draft Environmental Impact Statement (EIS)/Environmental Review Document (ERD) (EIS/ERD).
- Describe the potential impacts of offshore sources of artificial light on all life stages of marine turtles.
- Describe the potential impacts of offshore sources of artificial light to seabirds and migratory shorebirds.
- Site-specific artificial light impact assessment.

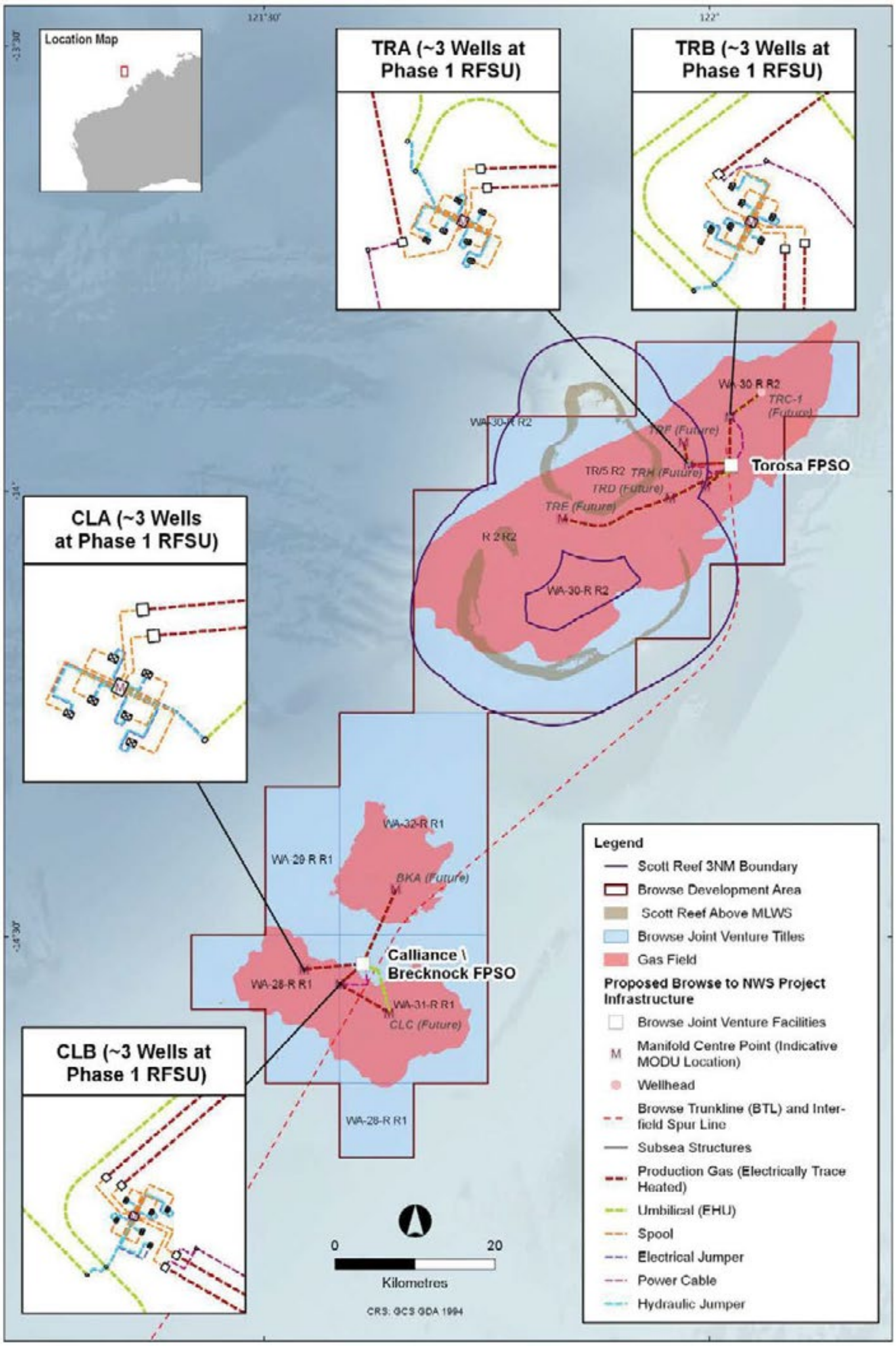

Figure 1: Proposed Browse Development Area and indicative location of FPSOs and MODUs. Source: Proposed Browse Project EIS/ERD (Woodside, 2019)

2 SPECIES LITERATURE REVIEW

2.1 Marine Turtles

Six species of marine turtle may occur in the vicinity of Scott Reef: leatherback (*Dermochelys coriacea*), flatback (*Natator depressus*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*), loggerhead (*Caretta caretta*) and green turtle (*Chelonia mydas*). With the exception of one hawksbill turtle that was tagged and recaptured at Scott Reef (Guinea, 2009), turtle nesting is restricted to green turtles. Accordingly, while some elements are applicable to marine turtle species in general, this report predominantly focuses on green turtles.

Green turtles nesting at Scott Reef are part of the discrete Scott Reef - Browse Island (G-ScBr) genetic stock. There is a lack of data regarding the status of this stock and the current population trend is unknown. This stock is considered likely to be restricted in its capacity to expand into other nesting areas in the event that availability or quality of nesting habitat is reduced (Commonwealth of Australia, 2017a). Although no index beaches, where long term monitoring is conducted, are identified, surveys have been conducted at Sandy Islet, a known green turtle nesting site for the G-ScBr genetic stock. The nesting habitat at Sandy Islet, and a 20 km internesting buffer, are designated as both habitat critical to the survival of a species ('habitat critical') and a biologically important area (BIA) (Commonwealth of Australia, 2017a).

Marine turtle surveys conducted at Scott Reef in 2006, 2008 and 2009 indicate that the summer months from late November to February are the preferred breeding season for green turtles at Sandy Islet (Guinea, 2009). While peak breeding occurred within this time frame, 24% of green turtles tagged at Sandy Islet were first encountered during winter/ spring surveys indicating that lower level nesting may occur year-round (Guinea, 2009), though to what extent is unknown.

Estimates of green turtle nester abundance was calculated based on recapture history of tagged turtles on eight survey (recapture) nights in the 2008/09 season (Guinea, 2009). Estimates of abundance varied between survey nights providing a mean (±SE) abundance of 779 ± 383 (Guinea, 2009). Mean (±SE) female nester abundance for 2009/10 was estimated at 79 ± 25 over eight survey nights using similar methodology (Guinea, 2010). In both seasons, the individual standard error of each estimate exceeded 50% and consequently, abundance estimates should be considered indictive only, especially given the assumptions associated with the methodology are unverified (Guinea, 2009; 2010). Using molecular methods, the effective population size of the Sandy Islet breeding population was estimated at 2,500, and the annual number of breeding females at 300 (Dethmers *et al.*, 2006).

Although the variation in annual abundance estimates outlined above are likely influenced by differences or limitations in the methodologies, interannual fluctuations in nester abundance is well documented in green turtles (e.g. Limpus *et al.*, 2005). As herbivores, green turtle fluctuations in annual nesting numbers are likely due to changes in the food supply (Broderick *et al.*, 2001). In northern and eastern Australia, fluctuations in green nesting numbers have been linked the Southern Oscillation Index (Limpus & Nicholls, 1994, Limpus & Nicholls, 1988) and sea surface temperatures (Solow *et al.*, 2002).

Green turtles were found to use all available habitat for nesting on Sandy Islet, though seasonal variation in the specific areas as well as in the shape of the sand habitat available for nesting at Sandy

Islet was recorded (Guinea, 2010, 2011). Excavation of clutches on Sandy Islet provided mean (±1 SD) hatch success and hatchling emergence success estimates of 80.2 ± 10.9% and 70.3 ± 17.4 respectively during the 2008/09 season (Guinea, 2009). In the 2009/10 season, hatching success varied from 39.6% to 100% and emergence success varied from 28.6% to 96.2% (Guinea, 2010). Since clutches were identified by signs of emergence (e.g. observation of hatchlings emerging or hatchling tracks) these estimates do not account for failed clutches and are likely to overestimate success. Accordingly, extrapolation of success rates to provide estimates of the total number of hatchlings emerging and reaching the ocean within a season, survey period or survey night is limited in accuracy, especially considering the limitations in estimating nester abundance described above.

In absence of systematic marking of clutches, information regarding the fate of clutches is largely anecdotal. Disturbance of nests by subsequent nesting attempts of other females was common in the 2006 and 2009 surveys and was considered a main contributor to nest failure (Guinea, 2009). Disturbance was not as prevalent in the 2009/2010 season due to a lower density of nesting females (Guinea, 2010). Preference for nesting below the spring high water mark was observed in 2008/09 (Guinea, 2009). These clutches are exposed to saltwater inundation which has been shown to increase mortality during incubation and potential result in complete failure of the clutch (Miller *et al.*, 2003).

Predation of hatchlings is thought to be high once they enter the water (Stancyk, 1982) so hatchlings adopt a dispersal phase which involves rapidly swimming away from dangerous coastal water habitats (Wyneken & Salmon, 1992). To date, no information regarding post hatchling predation or dispersal of green turtle hatchlings emerging from Scott Reef is available. Green turtle hatchlings have been tracked as they disperse through nearshore waters near Ningaloo and were found to move directly away from the shoreline at speeds of 0.49 m/s (Thums *et al.*, 2016). Ocean currents influenced the bearing of hatchling tracks when they reached speeds of approximately 0.3 m/s (Thums *et al.* 2016). In-water predation of green turtle hatchlings at a natural reef site on the east coast of Australia at Heron Island was on average 31 %, but ranged between 0 and 85 % (Gyuris, 1994).

Male green turtles often aggregate close to nesting sites (1.2 to 8 km away) during October and November each year (Limpus, 1993). Both juvenile and mature male green turtles were observed in the internesting habitat around Sandy Islet during the 2010 survey (Guinea, 2010), indicating habitat use by other life stages.

Satellite tagging of nesting females has been undertaken during three breeding seasons; 2002/03, 2003/04 (Pendoley, 2005) and 2009/10 (Guinea, 2010, 2011). Individuals tagged on all three occasions were not recorded farther than 14 km from Sandy Islet during the internesting period; most remained within 5 km of Sandy Islet in water depths of between 5 and 10 m. The average internesting interval was estimated from satellite tagged individuals at 10 days (Guinea, 2010, 2011) which is similar to the 10-14 day interval reported elsewhere (Carr *et al.*, 1974). These satellite tagged individuals provide an indication of the migratory routes and behaviour of green turtles leaving Scott Reef. Upon leaving Sandy Islet, tagged turtles swam through South Reef lagoon and over the shallow reef flat of the Reef. Once they had left Scott Reef they dispersed toward the Western Australian (WA) mainland via two distinct post-nesting migration pathways; travelling east and north toward the Bonaparte Archipelago and then north along the coast to the NT, or travelling south to Cape Leveque and then south along the coast to the De Grey River in the Pilbara region (Guinea, 2011). This eastern post-nesting migration route along the northern coast of Australia was also recorded by Pendoley (2005).

2.2 Seabirds and Migratory Shorebirds

The nearest emergent feature to Scott Reef is Browse Island at 170 km. Due to its isolation, Scott Reef, particularly Sandy Islet, may serve to provide nesting and/or roosting for seabirds and shorebirds. Few dedicated surveys have been undertaken; however, reports suggest that seabirds and shorebirds occur in relatively small numbers in comparison to other breeding and roosting sites in the region (e.g. Ashmore Reef (Clarke *et al.*, 2011).

Surveys conducted at Scott Reef in 2003 recorded little tern (500 individuals), brown booby (6), ruddy turnstone (50), Australian lesser noddy (200) and the common noddy (30) (Smith *et al.*, 2004). Earlier surveys reported 70 common noddy nests in 1986, and 50 nests in 1991 (Surman & Nicholson, 2011). Brown boobies have also been recorded breeding at this location (Johnstone & Storr, 1998).

Surveys observed increased numbers of seabird individuals, without differentiating between species, at Scott Reef during spring than winter (Jenner *et al.*, 2009). While not specified for Scott Reef, at Ashmore Reef, ~200 km to the north, the common noddy has been reported breeding between April and July, and again in October and November, whereas brown booby breeding was reported year round (Clarke *et al.*, 2011). Considering that the species present are typically diurnal, it is likely that individuals will roost on Sandy Islet at night and forage in nearby and offshore waters during the day.

In the water surrounding Scott Reef, pelagic species, which do not return to land to roost or rest, may also occur. A number of "unidentified shearwater species" were reported by Jenner *et al.* (2009). It can be presumed that this category could have included Hutton's shearwaters, wedge-tailed shearwaters (Surman & Nicholson, 2011), and streaked shearwaters. Whilst there are no confirmed records of breeding of these species at Scott Reef, the wedge-tailed shearwater is the most common shearwater species in the eastern Indian Ocean (Dunlop *et al.*, 2002) and are presumed to undertake a partial northward migration between May and September, wintering at or above the tropical convergence zone (Surman & Nicholson, 2011). Further, unpublished data from surveys conducted at sea between Broome and Ashmore Reef regularly recorded both Hutton's shearwater and the wedge-tailed shearwater (Surman & Nicholson, 2011).

Migratory shorebirds may also migrate through the area. On the WA mainland, Roebuck Bay and Eighty Mile Beach have been identified as two important areas in the East Asian Australasian Flyway (EAAF) for migratory shorebirds (Bamford *et al.*, 2008). Approximate migratory pathways presented in Bamford *et al.* (2008) and Minton *et al.* (2006) suggest that Scott Reef is located within proximity of the flight path from breeding sites in South East Asia to Roebuck Bay and Eighty Mile Beach. Indeed, migratory shorebirds, such as the ruddy turnstone mentioned above, have occasionally been observed at Scott Reef. Sandy Islet may be used as a staging ground during the migration between the Northern Hemisphere and Australia.

3 GAP ANALYSIS

A gap analysis was undertaken to assess information provided in the proposed Browse Project EIS/ERD regarding marine turtle species presence, distribution and behaviour in the vicinity of Scott Reef and the assessment of impacts arising from artificial light associated with the project. Specifically, the gap analysis aimed to:

- Review the methodology of two artificial light studies against the *National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds* (Commonwealth of Australia, 2020), with emphasis on the measuring biologically relevant light and modelling predicted light sections.
- Assess the scenarios of the artificial light studies against the current proposed Browse Project concept, as described in the EIS/ERD.
- Assess the degree to which the study findings can be applied to a project specific artificial light impact assessment, based on the scenarios and methodology of the studies detailed.
- Identify gaps or deficiencies in the artificial light impact assessment presented in the proposed Browse Project concept EIS/ERD in light of findings in the above points and in the context of information provided in Section 2.1 of this report.

The following documents were reviewed:

- ERM (2010). Browse Upstream LNG Development: Light Impact Assessment. Report produced for Woodside Energy Limited.
- Jacobs-SKM (2014). Light Modelling Study Final Report. Report prepared for Woodside Pty Ltd.
- Woodside (2019) Proposed Browse to NWS Project Draft EIS/ERD EPA Assessment No. 2191 EPBC 2018/8319

3.1 Species Description

The EIS/ERD provides a detailed summary of pertinent information regarding turtle nesting activity at Scott Reef. While information presented is based on the best available data regarding turtle nesting activity, surveys conducted were typically confined to short time frames across a limited number of breeding seasons. Given the interannual variation in breeding numbers observed in green turtles the population estimates derived during these surveys may not reflect peak nester abundance, as described in Section 2.1, and this limitation is not acknowledged.

While the green turtle nesting population at Scott Reef is acknowledged as belonging to the Scott Reef-Browse Island genetic stock, the significance of this, namely the lack of alternative nesting habitat at a regional scale, and the significance of Sandy Islet, is not identified.

3.2 Light Sources and Modelling

3.2.1 ERM (2010) Assessment

This report assesses light emissions from a MODU at the Torosa South-1 well location, and includes three components:

1. Line of sight (LOS) modelling

While LOS modelling provides an indication of the distances from the source at which direct light sources could be visible, it does not account for scattering of light into the atmosphere or for sky glow, which may be visible at distances greater than direct light, depending on the intensity of the source. LOS modelling does not incorporate parameters relating to the light properties (e.g. spectral power distribution), number or placement, and instead assumes a sum total of light emissions from the point source and then calculates the decrease in light intensity with distance using he inverse square law. Consequently, the results can be applied to other scenarios if the elevation of the light sources are similar.

2. Light density modelling

To predict light density (which is more appropriately referred to as light intensity), a field based light monitoring survey of a rig located on the Torosa South-1 rig site was conducted prior to 2010. The results of the monitoring were interpolated across a 2 x 2 km grid to produce a heatmap. However, a detailed description of the instrumental equipment and methodology used to conduct the field survey is lacking, preventing a thorough review and assessment of the data analysis methods, results, or of the assumptions and limitations of the interpolation process. Because the measurements are reported in lux, we are assuming a commercial lux meter was used. Lux meters, also known as light meters, are not an appropriate tool for measuring light over long distances (i.e. more than several hundred meters) as they are not sensitive enough to measure at the very low light levels characteristic of ambient sky brightness or artificial light sky glow. Furthermore, lux meters are photometric instruments which only quantify light within (and weighted to) the Commission International de l'Eclairage (CIE) curve. Unlike radiometric measurements that detect and quantify all wavelengths from the ultra-violet (UV) to infrared (IR), photometric measurements do not capture all light visible to wildlife (see Commonwealth of Australia, 2020 for review).

The ERM report did not provide any information regarding the number, type or placement of lights for the rig located on Torosa South-1 during the field survey and, therefore, the results from this assessment are not directly comparable to other rigs, without acknowledging the likely differences between them.

3. Light wavelength measurements

The report presents the spectral wavelength distribution along a 1 km long transect west of the drilling rig, however, the equipment and the sampling methodology used is not reported, e.g. instrument type, make, model, aiming function, detection limits etc. preventing further assessment. The reported spectral power distribution curve results are qualitative only and do not provide a quantitative output across the spectrum.

It is important to recognize that different light types produce different spectral curves, as shown in Figure 2, with different relative proportions of short and long wavelength light. Since the types of lights present on the monitored rig are not reported, and since there is no quantitative data available from the survey, it is not possible to apply these results to other rigs which may differ in lighting specifications.

Although not reported, the presented spectral power distribution curve suggests the rig lighting at the time it was monitored was dominated by fluorescent lights. However, the rapid changes in lighting technology over the past 10 - 15 years has seen suppliers discontinue old-style fluorescent lights, as well as high pressure sodium (HPS) and metal halide, and move to more economical and energy efficient light emitting diodes (LED). Consequently, the lighting design on a modern MODU is highly likely to have LED lights which will produce different light emission characteristics and intensities than the lights that were present when the pre 2010 survey was conducted.

3.2.1.1 Conclusion

The LOS modelling presented, while does not account for scattering and sky glow, can provide an accurate estimation of the distance from the proposed MODU that light may be directly visible before it drops below the horizon, assuming that the maximum elevation point of the proposed MODU is not significantly greater than the modelled rig (reported in Table 3.1 of ERM, 2010). However, it cannot be assumed that light, in the form of sky glow, is not visible at distances beyond those reported.

The Torosa South-1 rig light inventory at the time of monitoring is not reported in ERM (2010). Considering recent developments and implementation of LED technology, it is unlikely that the lighting design of current MODUs is consistent with the lighting design pre-2010 when the monitoring was undertaken. Without knowledge of the lighting design at the time of monitoring, it is not possible to compare the lighting design, and therefore the intensity of light emissions, of the Torosa South-1 MODU presented in ERM (2010) with the same MODU now, or any other MODU. Currently, there is no “standard MODU lighting design” that can be used to characterize a typical MODU that could be used as a representative analogue. Consequently, the light intensity modelling and wavelength measurement results are not directly comparable to other rigs, without acknowledging the likely differences between them.

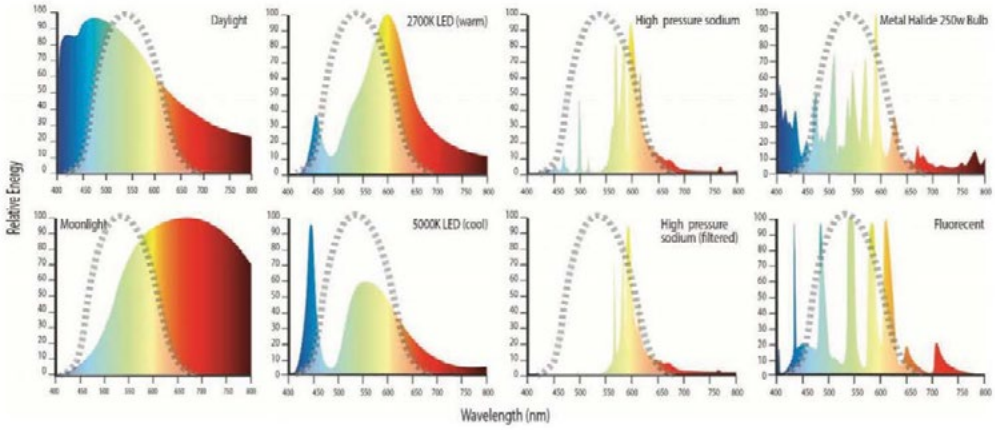

Figure 2: Spectral curves of different light sources, the CIE curve is shown by a dashed line. Source: Commonwealth of Australia (2020)

3.2.2 Jacobs-SKM (2014) Assessment

This report focused on a previous concept for the Browse field development comprising multiple floating liquefied natural gas (FLNG) locations. The modelling was undertaken in two stages:

1. Line of sight (LOS) modelling

All comments provided in Section 3.2.1 are also applicable here.

2. Light intensity modelling

A worst-case approach was taken by summing a total lumen output total lumen output (13.67 million lumens) based on required illumination levels of 200 lux, multiplied by the area of a FLNG vessel (~20,000 m^2). The model reports results in lux and consequently is likely this is a photometric model that does not account for the short wavelength light between 400 – 500nm or the longer wavelengths between 600 – 700 nm (see Section 3.2.1). In absence of specific light fixture details (number and type of lights) this approach is reasonable to quantify total output; however, the model does not account for the biologically important sky glow. As with LOS modelling, sky glow is very likely to be visible at distances greater than that of directly visible light.

That the model inputs are not based on specific light types, but rather on operational illuminance levels, allows the model to be applied where details of lighting types (e.g. spectral output and correlated colour temperature – CCT) design are unknown, or differ between facilities, assuming that this base case of operational illuminance is not exceeded.

An important factor to consider in future lighting design, monitoring and management is the current changes in lighting technology with old type gas discharge lights being replaced with modern LED lights. Because LED lamps require less energy to produce the equivalent amount of light output as other traditional light sources, such as HPS, replacing a 400W HPS with a 400W LED will produce a greater intensity of light. Therefore, it is important that the lighting design take this difference into account to avoid the risk of exceeding facility illumination requirements.

3.2.2.1 Conclusion

The LOS modelling presented for the FLNG operational lighting can be applied to the proposed FPSO, assuming that the maximum deck elevation point of the proposed FPSO is not significantly greater than the modelled FLNG (Figure 2-1 in Jacobs-SKM, 2014). However, it cannot be assumed that light, in the form of sky glow, will not be visible at distances beyond those reported for the LOS model.

The light intensity model clearly stated it was based on a worst-case scenario of a larger facility (where size of the vessel was a key input to the model), and consequently the results were considered conservative for the proposed FPSO. However, since the model does not include parameters specific to light types, the results of that modelling should only be applied with caution to the proposed FPSO.

It is important to recognize that the model did not consider sky glow, which can be visible at distances much greater than directly visible light (including over the horizon), and this limitation, along with the lack of information regarding spectral output, should be acknowledged in any impact assessment. A more sophisticated model that takes into account specific lighting designs, luminaire specifications including spectral characteristics, and site-specific environmental characteristics would more reliably predict illuminance and the visibility of sky glow on a landscape scale, which is important in applying model outputs for ecological impact assessments.

3.3 Impact Assessment

In general, the description of artificial light impacts to marine turtles across all life cycle stages is provided. The modelling results are presented as reported in ERM (2010) and Jacobs-SKM (2014), however, a discussion of the limitations, as described above, is lacking. Specifically, regarding the absence of sky glow in the models.

Flaring at the FPSO, although temporary, has the potential to impact marine turtles, which is not addressed. While the implications of MODU presence being temporary is acknowledged, the long term, continuous presence of the FPSO (located 28.6 km from Sandy Islet) is not.

Although the potential for behavioural impacts to occur in areas of light spill is acknowledged, the consequences of such an impact when considering the available nesting habitat of the green turtle Scott Reef- Browse Island (Gr-ScBr) genetic stock is not considered.

4 IMPACT ASSESSMENT

4.1 Light Sources

Light sources associated with the proposed Browse Project in the vicinity of Scott Reef include:

- Operational and navigational lighting of MODUs and FPSO facilities.
- Operational and navigation lighting of project vessels, including support/supply vessels, survey vessels and installation vessels.
- Flaring from MODUs and FPSOs.

4.1.1 Area of impact

Modelling of light sources associated with MODUs and FPSOs were undertaken and are discussed in Section 2.

The MODU LOS modelling (ERM, 2010), showed that the maximum distance that direct light may be visible extended up to:

- 16.6 km for main deck lights.
- 21 km for drill floor lights.
- 26.6 km for derrick lights.
- 45.2 km for a continuous 2 m high purge flare.
- 52.4 km for an intermittent emergency flare (indicative initial flame length of 50 m).

The FLNG LOS modelling (Jacobs-SKM, 2014), showed that the maximum distance that direct light may be visible extended up to:

- 18.5 km for deck lighting.
- 33.4 km for topside modules/cranes lighting.
- 47.9 km for the flare.

The LOS modelling provides an indication of the distance at which direct light may be visible, however it does not provide an indication of intensity or the areal extent (spread) of the light in the atmosphere. While the behavioural response of marine turtles to light is relatively well understood (see Witherington & Martin, 2003 for review), there is currently no agreed upon intensity limits for determining what the impact of a given light might be. For hatchlings, which are considered the most vulnerable life stage, a large range of factors influence the visibility and impact of light including light intensity, visibility (a function of lamp orientation and shielding), spectral power distribution (wavelength and colour), atmospheric scattering, cloud reflectance, spatial extent of sky glow, duration of exposure, horizon elevation, lunar phase, hatchling swimming speeds, tide and current speeds and flow direction. As such, the likelihood and severity of a behavioural impact occurring at a given location cannot be predicted. Any behavioural responses will be driven by a complex suite of confounding influences and will be highly site specific at a fine spatial scale (i.e. at the individual clutch level). As such, no study has yet been able to identify or recommend a quantitative threshold for the behavioural impacts of artificial light on marine turtles. However, based on extensive experience observing marine turtles and their response to both onshore and offshore construction light in field settings, Pendoley (pers. comm.) suggests that light intensity from an artificial source equivalent to a quarter moon is unlikely to result in behavioural response of marine turtle hatchlings.

Light intensity modelling of FLNG operational lighting, excluding flaring, was conducted and was considered applicable to the proposed FPSO (Section 2). Figures presented in Appendix B of Jacobs-SKM (2014) showed light intensity reduced to less than 0.025 lux (equivalent to a quarter moon) at distances between 9 km and 11 km, depending upon source location (Jacobs-SKM, 2014).

However, this intensity modelling does not account for sky glow, which will occur from the FPSO and MODUs. Sky glow is the diffuse glow caused by a light source that is screened from view but through reflection and refraction of the emitted light, creates a glow in the atmosphere. Scattering of light by dust, salt and other atmospheric aerosols increases the visibility of light as sky glow, while the presence of clouds reflecting light back to earth can substantially illuminate the landscape (Kyba *et al.*, 2011). White/blue light scatters more easily and further in the atmosphere compared to yellow-orange light (Kyba *et al.*, 2011). Since the light intensity modelling did not account for sky glow, intensity may be underestimated. Further, that model results were reported in lux, a unit weighted to the sensitivity to the human eye, light intensity across the entire spectrum (from 400 – 700 nm) is potentially underestimated.

Considering these limitations, the outputs of the Jacobs-SKM (2014) light intensity modelling cannot be directly applied as maximum distances at which behavioural impact may be observed. However, the results provide justification for the assumption that, for operational lighting of both the FPSO and MODU, light intensity will have decreased below a level which could result in behavioural impact to marine turtles at distance less than the maximum distance predicted by the LOS modelling. Accordingly, a distance of 20 km was selected as the distance from a source of operational lighting within which behavioural impacts to marine turtles may occur. This distance is based on recommendations of the National Light Pollution Guidelines for Wildlife (Commonwealth of Australia, 2020; and references therein) and is considered conservative based on the FLNG light intensity modelling.

Given the high intensity and elevation of flares, and that intensity modelling was not undertaken for flaring, it is assumed that light will be at an intensity that could result in behavioural impacts up to the maximum distance predicted by LOS modelling.

Therefore, impact radii for potential behavioural impacts to marine turtles are defined as:

- 20 km: Operational and navigational lighting associated with MODUs, vessels and FPSOs.
- 52 km: Flaring from the MODU.
- 52 km: Flaring from the FPSO.

Approximate distances from the light sources to Sandy Islet are provide in Table 2. MODU and project vessels operational lighting is only expected to result in behavioural impacts to marine turtles at Sandy

Islet when operating at drill centre TRE. Drill centres CLA, CLB, CLC and the Calliance/Brecknock FPSO are not expected to produce light emissions, from either operational light or flaring, that could result in behavioural impacts at Sandy Islet. Flaring, but not operational lighting, at all other drill centres and the Torosa FPSO may result in behavioural impacts (to vary extents, see Section 4.3) to marine turtles at Sandy Islet.

4.1.2 Duration of potential impact

Development drilling is planned to occur in phases. The duration of each phase may overlap up to two consecutive marine turtle breeding seasons, and phases may be separated by between two and four years. Up to four phases may occur at some drill centres, though at TRE, the closest drill centre to Sandy Islet and the only location where behavioural impacts may occur due to operational lighting, drilling is planned to be restricted to two phases, approximately four years apart. No continuous flaring is expected during development drilling, with flaring limited to 1-2 days per well. At each drill centre, the MODU will move location as different wells are completed. However, movements will not be so great that the overarching distance and bearing of the MODU to Sandy Islet is changed.

Following installation, FPSO presence will be permanent for the 44-year operational phase of the project. The duration and frequency of flaring at the FPSO is unknown. However, during unplanned events, flaring can be constant for weeks or months, potentially overlapping with an entire breeding season in the worst case.

In summary, the duration of potential impact varies depending upon the project phase and activity undertaken, as outlined in Table 2, and includes:

- Continuous operational lighting at drill centre TRE for up to two consecutive breeding seasons, in two drilling phases occurring four years apart.
- Intermittent flaring occurring at eight drill centres. Flaring is expected to last approximately 1-2 days per well, although there are multiple wells per drill centre. Due to the number of drill centres, intermittent light from flaring could occur within multiple consecutive breeding seasons throughout the development phase. While the flare may be visible at Sandy islet from eight drill centres, intensity of light is expected to decrease with distance. Although influenced by a number of site-specific and circumstantial factors, the consequence of impacts due to artificial light from flaring is expected to decrease with intensity. Hence, it is not expected that the degree of impact to marine turtles at Sandy Islet from MODU flaring would be constant between all drill centres.
- Intermittent flaring at the Torosa FPSO throughout the 44-year operational phase. The frequency and duration of flaring activities are not yet known.
- Continuous flaring at the Torosa FPSO throughout a breeding season due to a prolonged, unplanned flaring event.

4.2 Sandy Islet

As described in Section 2.1, Sandy Islet supports large numbers of nesting green turtles each year relative to the small area of Sandy Islet available for nesting. The islet is relatively flat and lacks topographic features such as cliffs or large dunes. Sandy Islet is approximately 700 m long in a north-south direction (with approximately 400 m remaining above water at extreme high tide) and approximately 60 m at its widest part (Guinea, 2009) (Figure 3). The northern and southern sand spits of Sandy Islet shift several metres over the reef flat with prevailing weather conditions (Guinea, 2009) and can be completely submerged during extreme weather events (Woodside, pers. comm.).

No permanent artificial light sources occur within proximity of Scott Reef, with current artificial light restricted to transient fishing and shipping vessels. The distance from Sandy Islet to light sources associated with the proposed Browse Project are provided in Table 2, outlining which sources of artificial light may be visible at intensities potentially resulting in behavioural impacts to marine turtles. Given the distance between Sandy Islet and light sources (6.9 km at the closest point), direct light spill onto the beach is not considered credible from any light source. However, since Sandy Islet lacks topographic features such as cliffs or large dunes which may provide natural shielding from light, light, in the form or directly visible point sources or as sky glow, may be visible across the whole of Sandy Islet, regardless of the orientation of the light sources from the islet. With the exception of the BKA drill centre, visible light sources are all located in a NE bearing from Sandy Islet (Figure 1). Even if activities occur concurrently, sky glow is not expected to illuminate the entire horizon.

Figure 3: Sandy Islet as viewed from the camera location (red cross) looking north. NB: not to scale.

Table 2: Distance from different light sources to Sandy Islet and potential for behavioural impacts

Light source		Distance to Sandy Islet (km)	Potential marine turtle behavioural impacts	Duration of potential impact
MODU and associated project vessels	TRA	23.7	Flaring only	Intermittent up to two consecutive breeding seasons
	TRB	31.0	Flaring only	Intermittent up to two consecutive breeding seasons
	TRC	35.9	Flaring only	Intermittent up to two consecutive breeding seasons
	TRD	20.1	Flaring only	Intermittent up to two consecutive breeding seasons
	TRE	6.9	Flaring	Intermittent up to two consecutive breeding seasons
			Operational lighting	Continuous for two consecutive seasons, for two drilling phases
	TRF	24.4	Flaring only	Intermittent up to two consecutive breeding seasons
	TRH	24.7	Flaring only	Intermittent up to two consecutive breeding seasons
	CLA	58.2	None	Not applicable
	CLB	57.9	None	Not applicable
	CLC	59.7	None	Not applicable
	BKA	44.8	Flaring only	Intermittent up to two consecutive breeding seasons
FPSOs	Torosa	28.6	Flaring only	Intermittent throughout 44-year operational phases and potentially continuous for one breeding season
	Calliance/ Brecknock	55.0	None	Not applicable

4.3 Marine Turtles

In general, artificial light most disruptive to marine turtles are those rich in short wavelength blue and green light (Fritsches, 2012; Pendoley, 2005; Witherington, 1992b). The attractiveness to light differs by species (Horch *et al.*, 2008; Pendoley, 2005; Wang *et al.*, 2007; Witherington & Bjorndal, 1991a, 1991b), however, green, flatback and loggerhead turtles all show increased sensitivity to wavelengths <600 nm (Fritsches, 2012; Pendoley, 2005; Levenson *et al.*, 2004). Further, green and flatback turtles show stronger preference for blue light <500 nm (Fritsches, 2012; Pendoley, 2005).

The spectral output measured from four different oil and gas flares across Australia, show that intensity peaks at between 650 - 700 nm (Pendoley Environmental, unpublished data). Spectral output measures of a tower flare and pit flare at Thevenard Island, Western Australia in 1995/96, found no significant spectral difference between the two flares, although the intensity of the light above the tower flare appeared to be higher than the pit for most wavelengths (Pendoley, 2000). Further, varying flow rates were not found to change the spectra of the light above either flare, or the amount of measured illumination (Pendoley, 2000).

Although longer wavelengths of light are less attractive than shorter wavelengths, long wavelength light can still disrupt sea-finding of hatchlings (Robertson *et al.*, 2016; Pendoley, 2005; Pendoley & Kamrowski, 2015), and if bright enough can elicit a similar response to shorter wavelength light (Mrosovsky, 1972; Mrosovsky & Shettleworth, 1968; Pendoley & Kamrowski, 2015; Cruz *et al.*, 2018). Hence, the disruptive effect of light on hatchlings is also strongly correlated with intensity. Red light must be almost 600 times more intense than blue light before green turtle hatchlings show an equal preference for the two colours (Mrosovsky, 1972).

In absence of competing light sources (Section 4.2), there is potential for artificial light resulting from the proposed Browse Project to result in behavioural impacts to marine turtles, should the intensity be great enough, even if spectral output of light sources are outside the peak sensitivity of green turtles (i.e. >600 nm).

4.3.1 Mating, Internesting, Foraging and Migration

Little is known about the impact of artificial light on adult and juvenile turtles when they are offshore. Most studies around light impacts on adult and juvenile turtles at sea have stemmed from interactions of turtles with fishing gear. Chemical light sticks are often used in longline fisheries to attract baitfish which then attract the larger, target fish such as tunas and swordfish (Witzell, 1999). Whether the turtles are attracted to the light source or prey that is attracted to the light source is unclear, however, adult turtles have been observed feeding on prey presumed to be attracted by lights of oil production platforms in the Gulf of Mexico (Kebodeaux, 1994). Further, illuminating fishing nets has been shown to reduce the bycatch of green turtles as they are thought to alert them to the presence of a net (Ortiz *et al.*, 2016) suggesting that they are not attracted to the light sources at sea.

During internesting, turtles rest on the seabed, physically removing them from the surface activity of the MODU, FPSO and vessels (Whittock *et al.* 2014). Since marine turtles do not feed during the breeding season (Limpus *et al.*, 2013), attraction of internesting turtles to light sources as a secondary response to effects of light on prey distribution is not expected. Indeed, to date, there is no evidence to suggest internesting turtles are attracted to light from offshore vessels.

Based on information presented in Section 2.1, internesting females, breeding males and migrating individuals are likely to occur within 20 km of several light sources identified in Section 4.1. While foraging of individuals, such as hawksbill turtles, may occur on the reef, foraging aggregations have not been identified at Scott Reef. Therefore, while internesting, breeding and migrating individuals may be exposed to temporary (i.e. vessels and MODU) and permanent (i.e. FPSO) light sources, marine turtles do not use light cues to guide these behaviours. Further, there is no evidence, published or anecdotal, to suggest that internesting turtles are impacted by light from offshore vessels or installations. As such, light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

4.3.2 Nesting

Adult female marine turtles return to land, predominantly at night, to nest on sandy beaches, relying on visual cues to select, and orient on, nesting beaches. That artificial lighting on or near beaches has been shown to disrupt nesting behaviour is relatively well documented (see Witherington & Martin, 2003 for review). Beaches with light spill, such as those located adjacent to urban developments, roadways and piers, often have lower densities of nesting females compared to beaches with less development (Salmon, 2003; Hu *et al*., 2018).

It has been postulated that neophytes (females breeding for the first time) are more vulnerable to nesting disruption by artificial light compared to experienced females that had nested at a given beach prior to the introduction of light sources (Limpus, pers. comm.). Anecdotal outcomes of long-term marine turtle monitoring programs across Australia suggest that (assumed) neophyte turtles favour nesting on dark beaches unaffected by onshore light pollution whereas experienced nesters continue to use light affected beaches. Over time this could result in changes in nesting distribution in response to artificial light.

Due to the size and shape of Sandy Islet there would unlikely be areas of nesting habitat that are shielded from light emissions (Section 4.2). Although an increase in vulnerability to disruption to nesting from artificial light in neophytes has not been reported in the scientific literature, if the anecdotal observations described above present a credible impact pathway, artificial light received at Sandy Islet could potentially prevent nesting of neophytes on the cay. In absence of alternate nesting habitat for this genetic stock, this could result in reduced recruitment of neophytes into the breeding population. This effect would be fundamentally hard to detect given the difficulties in tracking female turtles from hatching to sexual maturation (18 – 30 years in wild green turtle populations (Wyneken *et al.*, 2013)) and would only be detected by a decline in the annual number of nesting females in long-term monitoring programs. Further, even if a decline in adult nesters in a long-term dataset is detected, demonstrating that the decline can be attributed directly to artificial light would not be possible.

Green turtles have been found to use all available habitat for nesting on Sandy Islet though seasonal variations were recorded (Guinea, 2010, 2011). In seasons of high nesting activity, disturbance of incubating nests by subsequent nesting attempts of other females (i.e. nesters digging up existing incubating eggs while excavating a nest chamber) was common and considered a main contributor to nest failure (Guinea, 2009). Should artificial light alter nest site selection by nesters, for example selecting areas with lower light intensity (e.g. Witherington, 1992; Salmon 2003; Mazor et al. 2013; Weishampel et al. 2016; Price *et al.,* 2018), the distribution of nests across Sandy islet may be changed so that annual nesting is concentrated in smaller areas, increasing nest density and the potential for disturbance to incubating clutches, resulting in negative density dependence in incubation success.

In addition to potential impacts to nesting females prior to or during nesting, artificial light also has the potential to impact post-nesting behaviour. On completion of laying, nesting females are thought to use light cues in order to return to open ocean, orientating towards the brightest light (Witherington & Martin, 2003). However, observations of nesting females and emerging hatchlings at the same beach showed that females were disorientated much less frequently than hatchlings (Witherington, 1992) indicating that nesting females are less vulnerable to impacts of artificial light on sea-finding behaviour post nesting.

Nesting females are at risk from operational lighting associated with vessel and MODU presence at the TRE drill centre, and from flaring at drill centres TRA, TRB, TRC, TRD, TRF, TRH and BKA, and the Torosa FPSO (refer Table 2).

Nesting females may be vulnerable to behavioural impacts resulting from operational light of the MODU and project vessels at drill centre TRE, particularly if the spectral output of light sources is rich in short wavelength light. The MODU may be present at drill centre TRE for two consecutive breeding seasons within each drill phase. The remigration interval of nesting females is approximately two to six years (Summers *et al.* ,2018 and references therein), meaning that an individual nesting female is unlikely to be exposed to MODU operational lighting for more than one breeding season in each drilling phase at drill centre TRE. However, due to the topography of Sandy Islet preventing local scale shielding from light emissions (Section 4.2), there is potential for all females nesting during the drilling activity to be exposed to operational light emissions.

Flaring during drilling is expected to be limited to 1-2 days per well. However, since flaring may be visible from a number of drill centres, light emissions from MODU flares may be intermittently visible at Sandy Islet for multiple consecutive breeding seasons. The duration and frequency of flaring at the Torosa FPSO is unknown but is likely to occur intermittently throughout the 44-year operational phase, and in unplanned situations, could potentially span the duration of a breeding season.

Flaring from the MODU and Torosa FPSO is expected to result in light emissions with wavelengths that are less sensitive to green turtles. Although not quantified, the intensity of light received at Sandy Islet from the flares will decrease with distance. However, the intensity of light from flaring can be high, and if intensity is great enough could result in behavioural impacts, especially considering the absence of competing light sources in the area.

Although flaring from drilling may be visible for multiple consecutive breeding seasons, the restricted duration and intermittent frequency of flaring during drilling will limit the proportion of the annual number of nesters which may be impacted in any one season. Conversely, flaring from the Torosa FPSO and operational light from the MODU at drill centre TRE may span an entire breeding season, potentially impacting all nesting females in that season.

While there is a possibility that light sources could cause disruption to sea-finding behaviour post nesting, nesting females are not considered highly vulnerable to disorientation due to artificial light. Together with the small size of Sandy Islet, where a female is never more than half the maximum width of the islet (which, while variable, is typically ~60 m at the widest point) from the ocean, the risk of artificial light negatively impacting post-nesting sea-finding behaviour is considered unlikely.

Experienced nesting females are considered less vulnerable to the effects of light on nest site selection and it is unlikely that the project will result in permanent displacement of these individuals. The effects on neophytes is less well understood and there is potential that disruption to nesting of neophytes may occur during drilling at TRE or, to a lesser extent, flaring events elsewhere in the project area. These events may overlap with an entire breeding season or be intermittent over the 44-year operational life, however, it is unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. Should neophytes be displaced from Sandy Islet, the limited nesting sites for the G-ScBr genetic stock regionally may restrict nesting females in their capacity to expand into other nesting areas, and even low-level impacts may have consequences at the population level.

4.3.3 Emerging hatchlings

Hatchling turtles emerge from the nest, typically at night (Mrosovsky & Shettleworth, 1968), and must rapidly reach the ocean to avoid predation (Salmon, 2003). Hatchlings locate the ocean using a combination of topographic and brightness cues, orienting towards the lower, brighter oceanic horizon, and away from elevated darkened silhouettes of dunes and/or vegetation behind the beach (Pendoley & Kamrowski, 2015; Lohmann *et al.*, 1997; Limpus & Kamrowski, 2013).

Artificial lights interfere with natural light levels and silhouettes, which disrupts hatchling sea-finding behaviour (Withington & Martin, 2003; Pendoley & Kamrowski, 2015; Kamrowski *et al.*, 2014). Hatchlings may become disorientated - where hatchlings crawl on circuitous paths; or become misorientated - where they move in the wrong direction, possibly attracted to artificial lights (Withington & Martin, 2003; Lohmann *et al.*, 1997; Salmon, 2003). Hatchlings disoriented or misoriented by artificial lighting may take longer, or fail, to reach the sea. This may result in increased mortality through dehydration, predation or exhaustion (Salmon & Witherington, 1995). Studies of hatchling sea-finding behaviour found that, on Curtis Island in Queensland, 20% of hatchling fans within proximity to artificial light associated with an onshore LNG plant had an offset bearing of >90°, indicating severe sea-finding disruption (Kamrowski *et al.*, 2014). However, the number of individual hatchlings that traversed the beach at bearings that indicated misorientation or disorientation are not reported.

Hatchling orientation has been shown to be disrupted by light produced at distances of up to 18 km from the nesting beach (Hodge *et al.*, 2007, Kamrowski *et al.*, 2014), although the degree of impact will be influenced by a number of factors including light intensity, visibility (a function of lamp orientation and shielding), spectral power distribution (wavelength and colour), atmospheric scattering, cloud reflectance, spatial extent of sky glow, duration of exposure, horizon elevation and lunar phase. Disruption to orientation of emerging hatchlings has been found to occur most often during the new moon phase and least frequent during full moon phases (Salmon & Witherington, 1995). Experiments showed that background illumination from the moon (while in phases closer to full moon), restored normal sea-finding behaviour in hatchlings but did not result in attraction in the direction of the moon. It was concluded that background illumination from the moon reduced light intensity gradients of artificial light, reducing, but not eliminating, its effect on hatchling orientation (Salmon & Witherington, 1995).

As with nesting females, emerging hatchlings are at risk from operational lighting associated with vessel and MODU presence at the TRE drill centre, and from flaring at drill centres TRA, TRB, TRC, TRD, TRF and BKA, and the Torosa FPSO (refer Table 2).

As described in Section 4.3.2, the MODU may be continually present at drill centre TRE for two consecutive breeding seasons within each drill phase. Flaring during drilling is expected to be limited to 1-2 days per well. The duration and frequency of flaring at the Torosa FPSO is unknown but is likely to occur intermittently throughout the 44-year operational phase, and in unplanned situations could potentially span the duration of a breeding season. Although light emissions from the flare are expected to contain greater intensities at wavelengths >650 nm, to which green turtles are less sensitive, behavioural impacts could still occur if light intensity is sufficiently high, especially considering the absence of competing light sources in the area.

Due to the size and shape of Sandy Islet there would unlikely be areas of nesting habitat that are shielded from direct light or sky glow (Section 4.2). During drilling at drill centre TRE, or during a prolonged flaring event at the Torosa FPSO, this could result in all clutches within a given season being exposed to artificial light. Flaring from MODUs at the drill centres listed above, although intermittent, could occur during multiple consecutive seasons. This would result in a small proportion of the annual number of clutches potentially impacted by artificial light in consecutive seasons.

However, the orientation of the light sources to Sandy Islet will influence the consequence of hatchling attraction. For example, for clutches on the eastern side of the islet, the majority of light sources (Table 2) are located in an offshore direction. Conversely, for clutches on the western side of islet, light sources are in an onshore direction. The absence of dunes and other topographic features may reduce the ability of the hatchlings to discriminate between the artificial light horizon and the ocean horizon. Should hatchlings be attracted to these light sources, unlike at nesting beaches on coastlines of larger islands or the mainland where disorientation can decrease survival, hatchling movements would still be in a seaward direction given the narrow (~60 m) width of the cay (see Figure 3). Unless hatchlings are disorientated so that they move in circuitous paths for extended periods of time, which is considered unlikely given the size of Sandy Islet and that only a proportion of the horizon is expected to be illuminated, such a behavioural response would be limited to a negligible increases in energy expenditure, reducing the consequence of the behavioural impact. Since green turtle nesting occurs across the whole islet, albeit with interannual variation in distribution (see Section 2.1), it is not possible to predict the relative proportion of clutches that may be negatively impacted.

At drill centre TRE, all hatchlings emerging in up to four breeding seasons (two consecutive seasons in two drilling phases), may be exposed to operational lighting associated with the MODU and project vessels. However, changes in sea-finding behaviour may not occur in all instances for the following reasons:

- For a proportion of clutches, the light sources will be located directly offshore and therefore will unlikely be the cause of mis- or disorientation, as described above.
- The potential for impacts to occur is lower during the full moon, reducing the likelihood that disturbance to sea-finding would occur for clutches emerging during this time. However, it is not possible to estimate the proportion of the lunar cycle within which natural light reduces the effect of artificial light on hatchling orientation.
- Even if it is assumed that sea-finding is disrupted for all hatchlings in a given clutch, which is highly unlikely (Pendoley, pers. comm.) impacts may be observed in less than 20% of clutches in any one night (assuming a lower probability of impact compared to that reported in Kamrowski *et al.*, 2014.
- Individual hatchlings that are disorientated will still reach the water with negligible additional energy expenditure due to the size and topography of Sandy Islet.

- The additional energy expenditure at the individual level is not expected to reduce survival of the hatchling cohort to the extent that additive mortality rates are detectable above natural levels.

Potential impacts from flaring are expected to be lower than operational lighting given that, with the exception of an unplanned event at the Torosa FPSO, the short duration of flaring will reduce the proportion of the annual number of clutches emerging from Sandy Islet that are exposed to artificial light. Further, the intensity of light emissions is expected to decrease with distance meaning that not all flaring events will elicit the worst case behavioural impact of disruption to sea-finding behaviour, and for the proportion of clutches which do emerge during flaring activities, not all hatchlings will be negatively impacted for the reasons described above. The potential for negative impacts may be further reduced when considering the longer wavelength light associated with flaring.

4.3.4 Dispersing hatchlings

Once in nearshore waters, artificial lights on land can also interfere with the dispersal of hatchlings. Presence of artificial light can slow down their in-water dispersal (Witherington & Bjorndal, 1991; Wilson *et al.*, 2018) or increase their dispersion path, potentially depleting yolk reserves, or even attract hatchings back to shore (Truscott *et al.*, 2017). In addition to interfering with swimming, artificial light can influence predation rates, with increased predation of hatchlings in areas with significant sky glow (Gyuris, 1994; Pilcher *et al.*, 2000). Since the nearshore area tends to be predator-rich, hatchling survival may depend on them exiting this area rapidly (Gyuris, 1994). Should this be the case, aggregation of predatory fish occurring in artificially lit areas and under artificial structures (refer Wilson *et al.*, 2019) may further increase predation of hatchlings.

An internal compass set while crawling down the beach, together with wave cues, are used to reliably guide hatchlings offshore (Lohmann & Lohmann, 1992, Stapput & Wiltschko, 2005; Wilson *et al.*, submitted). In the absence of wave cues, however, swimming hatchlings have been shown to orientate towards light cues (Lorne & Salmon, 2007, Harewood & Horrocks, 2008) and in some cases, wave cues were overridden by light cues (Thums *et al.*, 2013, 2016; Wilson *et al.*, 2018).

The speed and direction of at-sea dispersal is substantially influenced by currents; the offshore trajectory of flatback hatchlings at Thevenard Island was displaced by tidal currents that ran parallel to the beach, an effect that increased as the hatchlings moved further offshore (Wilson *et al.*, 2018, 2019). However, when light was present this effect was diminished, showing that hatchlings actively swam against currents and towards the light source, which slowed their offshore dispersal from 0.5 m/s when no light was present, to 0.35 - 0.44 m/s, depending on the type of light (Wilson *et al.*, 2018). Wilson *et al.* (2018) demonstrated that when flatback hatchlings were within 150 m of the beach, they were able to swim against currents up to 0.3 m/s.

These results suggest that hatchlings can move in any direction when their swimming speed is greater than the speed of the nearshore current, although the speed at which currents can no longer be overcome by hatchlings will be species specific and related to swimming speeds. The mean swimming of green turtle hatchlings has been measured at 0.49 m/s (Thums *et al.*, 2016). Given the similarities in swim speeds between flatback and green turtles, it is possible that green turtles will have the ability to swim against similar strength currents as reported for flatback turtles (0.3 m/s) (Wilson *et al*., 2018).

Surface currents within the Scott Reef channel average approximately 0.3 m/s, with speeds up to and exceeding 1 m/s (Woodside, 2019). At these speeds, green turtles may be able to swim against the predominant currents for at least a proportion of the breeding season, should they be attracted to artificial light. If current speed allows, hatchlings may be able to swim against currents and maintain position in areas of light spill, potentially becoming entrapped. Wilson *et al.* (2018) observed flatback hatchlings becoming entrapped in the light spill from a small survey vessel for up to one hour. Other reports of the duration of time in which hatchlings may be entrapped in direct light spill varies widely; while Thums *et al.* (2016) found that light trapping was very temporary (minutes), anecdotal observations of hatchlings entrapped by light spill from a pipelay vessel off Barrow Island found hatchlings remained within the light spill in the lee of the barge all night until dawn (K. Pendoley, pers. obs., 2003). Although the ability of hatchlings to swim towards the MODU at the TRE drill centre will vary across the season, depending on currents, the presence of the MODU for the duration of a given breeding season increases the proportion of the total number of hatchlings emerging from Sandy Islet during that season are exposed to potential impacts of energy depletion (decreasing individual fitness) and increased predation risk.

Hatchlings may also be transported by currents in the direction of light sources other than the MODU at the TRE drill centre. While not tested empirically due to the logistical constraints of tracking large numbers of hatchlings concurrently, the density of hatchlings will decrease with distance from the nesting beach as individuals disperse in open ocean. Since the distance between Sandy Islet and light sources, excluding TRE drill centre, exceeds 20 km (Table 2), the number of hatchlings emerging from Sandy Islet occurring within close proximity of these light sources will be lower compared to the TRE drill centre.

While disruption to hatchling dispersal behaviour (e.g. attraction to or trapping by light) of an unknown proportion of the annual number of hatchlings emerging from Sandy Islet is credible, following sunrise, any effect of the light sources on hatchlings will be eliminated allowing dispersal behaviour to resume. Further, the potential for hatchling dispersal behaviour to be affected decreases with distance to shore. Excluding the TRE drill centre, light sources, including the permanently present FPSOs, are located more than 20 km from Sandy Islet. At these distances the density of dispersing hatchlings is expected to have decreased, meaning that fewer are at risk of attraction to these light sources.

4.4 Seabirds and Migratory Shorebirds

While LOS modelling for the MODU and FPSO may provide an indication of the distance at which direct light may be visible to a seabird or shorebird on land or resting on the water, it is not applicable to birds in flight. The distance at which light may be visible will be depend upon the altitude of a bird, which will vary greatly between species and individuals depending upon the behaviour being undertaken. Accordingly, the following impact assessment does not refer to distances from the light sources.

4.4.1 Seabirds

Artificial light can have a variety of effects on seabirds and shorebirds, depending upon the species and the life stage or behaviours being undertaken at the time. Negative responses of birds to artificial light may include collision, entrapment, stranding, grounding, disorientation or interference with navigation (being drawn off course from usual migration route), potentially resulting in reduced fitness, injury and/or death (see Commonwealth of Australia, 2020 for review).

Species with a nocturnal component of their life history, such as procellariforms, are at greater risk of negative impacts. The bulk of the literature concerning impacts of lighting upon procellariforms relate to the synchronised mass exodus of fledgling seabirds from their nesting sites (Deppe *et al.*, 2017; Raine *et al.*, 2007; Rodriguez *et al.*, 2015a; Rodriguez *et al.*, 2015b; Le Corre *et al.*, 2002; Reed *et al.*, 1985), with fewer investigating the impacts of light at sea. Reports of interaction between seabirds and artificial light at sea is generally anecdotal following significant interaction events (e.g. Black, 2005) or by unsystematic monitoring by oil and gas operators (e.g. Day *et al.*, 2015; Glass & Ryan, 2013; Weise *et al.*, 2001; Ronconi *et al.*, 2015)). Deck lights and spotlights on fishing vessels have been recorded attracting numerous seabirds at night, particularly on nights with little moon light or low visibility (Black, 2005; Merkel & Johansen, 2011; Montevecchi, 2006).

Nocturnal foraging at sea is known to occur across the procellariform order, with preferences for bioluminescent prey (Imber, 1975). This is likely linked to the vertical migration of prey in the water column; the greater abundance of prey closer to the sea surface under darkness enables more efficient foraging by birds compared to during daylight.

That procellariforms are shown to be attracted to artificial lights on land, and anecdotally to vessels and oil and gas facilities, in addition to undertaking nocturnal foraging on bioluminescent prey, makes them susceptible to attraction to light sources in the Browse Development Area and negative impacts that could result. However, the absence of breeding colonies or known foraging areas at, and around, Scott Reef for these species indicates that impacts would be limited to individuals rather than populations.

Diurnal seabird species, such as terns, noddies and boobies, in contrast to procellariforms, are less vulnerable to impacts resulting from nocturnal behaviours. However, the presence of facilities can alter foraging behaviours and provide artificial roosting sites. Although reports describing the interaction between species identified at Scott Reef and offshore facilities are lacking, Tasker *et al.* (1986) reported that a variety of seabird species recorded around oil platforms were observed feeding by the light of the gas flare at night, pecking at small unidentified items in the sea, a behaviour was noted less frequently during the day (Tasker *et al.*, 1986). Ortego (1978) reported that the only impact of artificial light associated with an oil rig in the Gulf of Mexico on the blue faced booby was increased foraging.

Presence of light sources in the Browse Development Area may attract diurnal seabird species as they take advantage of increased prey availability and extended foraging activities, potentially resulting in changes in abundance and distribution. Although such attraction increases the risk of collision with facilities, incidents of collision of these species, or similar taxonomic groups, are few (see Ronconi *et al.*, 2015 for review).

4.4.2 Migratory shorebirds

As with diurnal seabirds described above, artificial lighting has been shown to influence the foraging behaviour in shorebirds, with increased foraging success in areas illuminated by artificial light (Santos *et al.*, 2010). Although shorebirds may be attracted to foraging areas with increased illumination, artificial light near nocturnal roosting sites may displace shorebirds if they select darker roost areas where risk of predation is perceived to be lower (Rogers *et al.*, 2006).

Additionally, artificial light may attract migratory shorebirds in flight (Longcore *et al.*, 2013) influencing stop-over selection and impacting successful migration and decreased fitness (McLaren *et al.*, 2018). Sage (1979) (cited in Ronconi *et al.*, 2015) reports incidents of migrating waders colliding with offshore platforms, though whether this was due to attraction by artificial light is unknown. In addition to attraction to facilities, artificial light, specifically long wavelength red light, has been shown to impact migration of passerines via disruption of magnetic orientation in the laboratory (Wiltschko *et al.*, 1993) and in the field (Poot *et al.*, 2008). Studies indicate that some migratory shorebirds possess a magnetic compass and suggest that magnetic cues are of primary directional importance (e.g. sanderling: Gudmundsson & Sandberg, 2000).

Light sources associated with the proposed Browse Project may negatively impact migration and nocturnal nest site selection of migratory shorebirds flying over Scott Reef or using Sandy Islet as a staging ground. Improved foraging success may occur, though this is would likely be restricted to areas of intertidal foraging habitat experiencing direct light spill from the activities. Based on the information available, Scott Reef has not been identified as important habitat for migratory shorebirds, as defined by the *EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (Commonwealth of Australia, 2017b) and therefore, any impacts are likely to be limited to individuals rather than populations.

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Woodside Energy

APPENDIX A TECHNICAL STUDIES

APPENDIX A.2 EXPERT OPINION: SUBSIDENCE OF SCOTT REEF (AIMS, 2012)

JB0006RH10010001

Australian Government | Australian Institute of Marine Science

AIMS Expert Opinion on SEWPAC comment relating to Subsidence of Scott Reef

Comment from SEWPAC

While it is stated that climate change poses a larger threat to Sandy Islet and Scott Reef than subsidence alone, any subsidence would exacerbate the impacts of climate change, which could result in unacceptable impacts to Sandy Islet and the Green turtles that nest there. The 'negligible' risk rating applied in the draft EIS should be reconsidered in the Supplementary EIS. In addition, the three climate change/subsidence scenarios modelled take only the corresponding subsidence level into account (worst case sea level rise with worse case subsidence, intermediate case sea level rise with intermediate case subsidence, best case sea level rise with best case subsidence). What is unclear is how Sandy Islet and Scott Reef would be affected purely in relation to the sea level rise scenarios and with no subsidence. Similarly how would Sandy Islet and Scott Reef be affected by only subsidence and no sea level rise? And so on.

Required: An expert opinion on the above.

Inputs: Cooper et al. (2010) Ecological implications of sea level rise on Scott Reef;

Expert Opinion from AIMS:

Summary

If subsidence occurred on its own, with no climate change impacts, then the overall impact on both the reef coral communities and on Sandy Islet would be expected to be insignificant or temporarily positive. There may be an initial period of increased coral cover on the reef flat and possibly an increase in the size or height of the cay during the period of subsidence, after which the reef would regain its former height in relation to the sea surface and the coral communities and cay would be expected to return to a state similar to that observed prior to the subsidence.

If no subsidence occurred, but climate change caused an increase in sea level and cyclone activity, then it is predicted that, for all except the most optimistic scenarios, significant adverse changes to both the coral communities and Sandy Islet will occur over time.

There is an infinite combination of climate change and subsidence combinations and there is little benefit to be derived from detailed examination of several additional scenarios. One additional scenario has been included in which the relative contribution of subsidence has been set to maximum levels. In all cases which involve both subsidence and climate change, the main consequence of the addition of subsidence into the analysis is for impacts that would occur anyway to be brought forward in time. For Sandy Islet, the diversity of factors that influence cay stability and persistence, including the high dynamic rate of sea level rise, make it impractical to reliably predict just how much earlier these impacts might occur.

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Detailed Response

In responding to the comments from SEWPAC we address three specific questions relating to the impacts of subsidence and climate change on the Scott Reef system:

1. What are the relative contributions of climate change and subsidence under different scenarios?
2. How would the addition of subsidence to the impacts of climate change affect the reef and islet?
3. What would be the impact of subsidence in the absence of climate change impacts?
4. Is there a scenario where the addition of subsidence to climate change would tip impacts over a threshold to create an unacceptable impact?

What are the relative contributions of climate change and subsidence under different scenarios?

While the relative contributions of subsidence to sea level rise are fairly small in the scenarios originally presented in Cooper et al. (2010) (Table 1), there are an infinite number of combinations which could be considered and in some of these the relative contribution from subsidence is much higher. We have added an additional scenario "Worst case for development impact" where the sea level rise is at the lowest end of expected values and subsidence is at the highest end. In this scenario, the net change in water depth (11.5cm) is not as high as the worst case scenario (19.5cm), however the relative contribution due to subsidence is at its maximum (50%). In these scenarios the relative contributions are calculated over the life of the project only. While subsidence will cease at the end of the project, sea level rise would be expected to continue to occur well past this date.

Table 1. Modification of Table 5 from Cooper et al. (2010) (blue text) to show the net change in water depth for each scenario due to subsidence only or SLR only over a 40 year timeframe. The per cent contribution of subsidence to the net change is also shown in column (e).

Scenario*	(a) VAR (cm)	(b) Seafloor subsidence (cm)	(c) Net VAR (cm)	(d) SLR (cm)	(e) % of net change due to subsid.	Net change in water depth** (cm) (f)	(g)	(h)
						SLR & Subs.	Subs. only	SLR only
Best-case	14.0	2.1	14.0	7.2	23%	**-4.7***	-11.9*	-6.8*
Intermediate-case	9.8	4.4	7.8	11.2	28%	**7.8**	-3.4*	3.4
Worse-case	5.6	7.1	2.8	15.2	32%	**19.5**	4.3	12.4
Worst Development Impact	5.6	7.1	2.8	7.2	50%	11.5	4.3	4.4

*Negative values indicate that the potential for reef growth exceeds the rate of sea level rise or reef subsidence. Actual net change in all such cases on the reef flat would be zero since corals cannot grow above maximum sea level. (a) vertical accretion rates (VAR) (1.4 to 3.5 mm y-1, Collins et al. 2009), (b) average estimates of seafloor subsidence provided by Woodside, (c) Net VAR incorporating declines in coral growth of 0% for best-case, 20% for intermediate-case, and 50% for worse-case from Reynaud et al. (2003); Cooper et al. (2008); De'ath et al. (2009), (d) the lower to upper range of estimates for sea level rise (SLR) based on Scenario SRES B1 (1.8 to 3.8 mm y-1), and (e) the % of net change attributable to subsidence.

** Net change is calculated as follows: **(f)** = (b)+(d) - (c); **(g)** = (b) - (c) ; **(h)** = (d) - (c) .

What would be impacts of subsidence in the absence of climate change impacts?

In the various scenarios, climate change impacts have been included through reductions to the maximum rates of vertical reef growth (coral mortality due to cyclones and coral bleaching; reduced growth due to ocean acidification and temperatures exceeding those for optimum growth) and sea level rise. In the absence of these factors, subsidence on its own, is predicted to cause no more than a 4.3cm increase in water depth above the corals at Scott Reef over 40 years. It is likely that the impact of this change will be negligible (somewhat better than the Intermediate case scenario described in section 5.4.3 of Cooper et al. 2010). After 40 years, subsidence is assumed to halt and (in the absence of climate change impacts) corals would grow back to the surface over a period of 12 years or so.[1]

How would the addition of subsidence to the impacts of climate change affect the reef and islet?

The nature and mechanisms of the impact of subsidence on Scott Reef and Sandy Islet is identical to sea level rise. Both tend to increase the water level above the reef. Consequently the combined impacts of subsidence and sea level rise are purely additive rather than synergistic. In addition, since subsidence is predicted to occur for a maximum of 40 years, its primary impact will be to increase the rate at which the impact increases in severity over this time and to bring forward the time at which any theoretical impact threshold is reached. For all scenarios, except the best case, Sandy Islet would eventually (over 50-100 years) be washed away and the coral reef would be drowned and stop growing (over hundreds to thousands of years). The effect of subsidence would only be to make this happen a bit earlier.

Is there a scenario where the addition of subsidence to climate change impacts would tip impacts over a threshold to create an unacceptable impact?

Sandy Islet is clearly the most significant aspect of this assessment of impacts since it is more likely to change in response to small changes in water level and since it is a nesting site for Green turtles, which are an endangered species. The report by Cooper et al. (2010) did not specifically examine the risk to green turtles but it indirectly addressed this issue by assessing the impacts on the stability and persistence of Sandy Islet.

While this question of thresholds is highly relevant, it is not possible to address it in a quantitative manner for two reasons. First, there is no accepted threshold of acceptability for impacts on coral reefs or turtle nesting that can be used as a basis for comparison of impacts. Nor has any threshold been provided by SEWPAC. Second, it was beyond the scope of the Cooper et al. (2010) report commissioned by Woodside to quantitatively model the likely impacts of various scenarios on the ecology of Scott Reef or the stability and viability of Sandy Islet as a turtle nesting ground. The best that can be provided with the existing information is a qualitative expert opinion on the different types and severities of impacts that might occur.

[1] The time would be 12 years if the reef grows at a constant rate. Since growth will slow as the reef reaches the surface the total time taken will be longer than 12 years.

Cooper et al. have discussed the range of likely impacts for three levels of impact in which water depth over the reef does not change, or increases by 7.8 or 19.5 cm. Given the necessarily qualitative nature of their discussion of possible impacts, there would be no value in further refining these to predict specific impacts for intermediate water depths.

Under the Worst Development Impact, water depth would rise to 11.5 cm above the reef, a depth about half way between the intermediate and worst case scenarios. Under this scenario there might be a risk for the Islet to become less stable due to erosional processes associated with increased wave height, although the most important factor influencing the persistence of the Islet is the frequency of category 5 cyclones.

Under this impact scenario we estimate that there is a low, but non-negligible risk that Sandy Islet could be reduced significantly in size or lost for significant periods. However these impacts would still occur in the absence of subsidence albeit over a longer time period. Given the highly variable nature of sea level rise, cyclone occurrence and sediment dynamics it is not possible to reliably predict the timing of any major changes to Sandy Islet in either case.

Under the Worst Case scenario, water depth would rise by 12.4cm over a 40 year timeframe, even in the absence of subsidence, and so could cause non-negligible impacts. However the addition of subsidence to create a total increase in depth of 19.5cm would have the effect of bringing forward by several years impacts which would occur anyway due to sea level rise.

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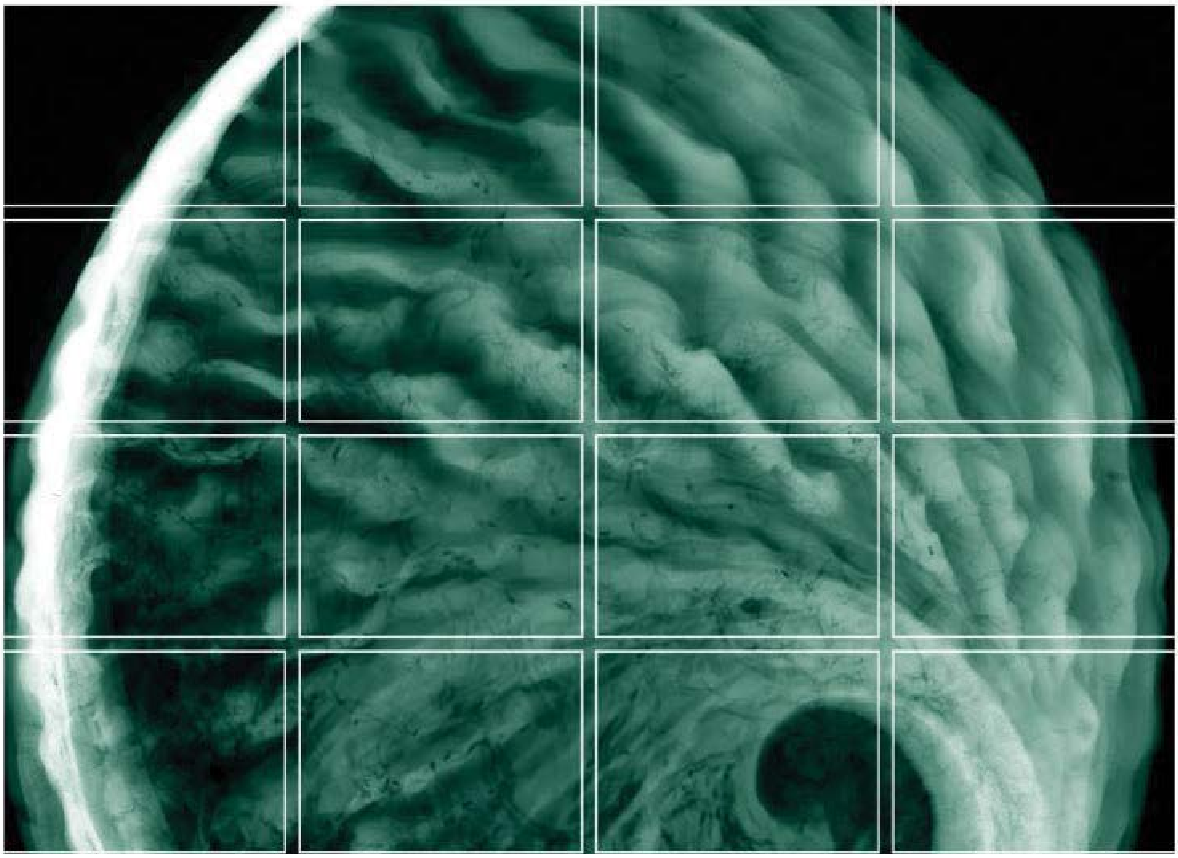
APPENDIX A TECHNICAL STUDIES

APPENDIX A.3 COMPARATIVE LIFE CYCLE ASSESSMENT



Comparative Life Cycle Assessment: Browse and Scarborough

Comparative Life Cycle Assessment

22 April 2020

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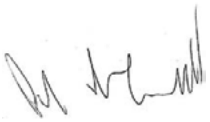
Comparative Life Cycle Assessment: Browse and Scarborough

Comparative Life Cycle Assessment



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ABBREVIATIONS AND GLOSSARY OF TERMS

Acidification – Potential impact category	Measured in Mol H^+ e This impact category looks at the emissions (SO_2, NO_x, NH_3, HCl, HF) by human activities that could affect the quality of all components of the environment (including air, soils and surface waters) not only in the vicinity of the sources, but also hundreds or even thousands of kilometres from their emitting sources. In the case of the systems under this study, the key acidification components are NO_x and SO_2.
ASEAN	The ASEAN region includes the following ten countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam
Average mix	Defined as the emissions intensity of a more diversified power market, for all fuels, including fossil, renewables and nuclear.
Climate change – Potential impact category	Measured in kg CO_2e The impact category, climate change, represents the carbon footprint of a product system adding up all greenhouse gas emissions (GHG) taking account of their respective global warming potentials (GWPs). GWPs represent the amount of heat trapped by the gas in the atmosphere over time. All gases are measured relative to carbon dioxide. The most relevant gases to this study are carbon dioxide, methane and nitrous oxide. This impact method does not include the extent to which these emissions cause a change in global temperature as this requires additional modelling of other global emissions and sinks.
Coal only mix	Defined as the emissions intensity of the coal-only section of the power market under study.
CPS	Current Policy Scenario.
Fossil fuel mix	Defined as the emissions intensity of the power market under study, which accounts only for fossil fuel power sources.
FPSO	Floating, Production, Storage and Offloading facilities.
FPU	Floating Production Unit.
IEA	International Energy Agency.
IPCC	Intergovernmental Panel on Climate Change.
ISO14044	International Organization for Standardization Standard 14044, Environmental Management Standard – Life Cycle Assessment, 2006.
KGP	Karratha Gas Plant.
LCA	Life Cycle Assessment.
LNG	Liquefied Natural Gas.
MWh	Megawatt hours.

Particulate matter – Potential impact category	Measured in g $PM_{2.5}e$. This impact category represents the human health impacts from exposure to particulate matter (PM_{10} and $PM_{2.5}$ principally) but also secondary particulates including SO_2 and NH_3. This is one of the highest non-behaviour related risks to human health as identified in the global burden of disease (Vos, Barber et al. 2015).
Photochemical smog – Potential impact category	Measured in g NMVOC e Photochemical smog, also known as photochemical oxidation creation potential, represents the potential of hydrocarbons and nitrogen oxides in the atmosphere to react under the catalytic action of sunlight to produce tropospheric (ground level) ozone, as well as some other chemicals, which has significant respiratory and other health effects. While all impact categories represent potential impacts, this is particularly the case with photochemical smog as the effect only occurs when the appropriate mix of gases are present in sunlight.
SDS	Sustainable Development Scenario.
STEPS	Stated Policy Scenario.
TPED	Total Primary Energy Demand.
WEO	World Energy Outlook.

GUIDE FOR READERS

This document presents a summary of a life-cycle assessment (LCA) for the two proposed Woodside Energy Limited (Woodside) operated gas reservoirs; Browse and Scarborough. The broader report discusses the context and rationale for Liquefied Natural Gas (LNG) in Asia Pacific under various future electricity generation scenarios. The report follows the outline of the structure provided below:

Chapter 1 provides background to the study.

Chapter 2 introduces the International Energy Agency (IEA) scenarios describing future market developments, including the emergence of a lower-carbon world.

Chapter 3 examines a case study for the role of gas in decarbonising the energy system in Europe, the United States and China.

Chapter 4 defines the goal and scope of the study.

Chapter 5 covers the inventory analysis.

Chapter 6 gives an overview of the results of the study relating to greenhouse gas emissions. Chapter 6 also includes comparisons to IEA scenarios, and describes the method used to conduct this analysis.

Chapter 7 provides an interpretation of the LCA results.

Chapter 8 provides a discussion and conclusion to the study.

This document is the second LCA commissioned by Woodside on the sources to end user (gas well to power generation) impacts of the proposed Browse and Scarborough LNG projects. Since the completion of the first study in 2019, a number of changes have occurred, which have warranted the revision of the first LCA study. These changes cover a range of refined and updated input data. As data continues to improve over time, e.g. to extend the data series, the increase in confidence in the conclusions may lead to further revisions.

Changes from the first study include (but are not limited to):

- More accurate quantification of LNG production quantity;
- Updated efficiency of the use of Scarborough and Browse gas over time;
- Correction of how shipping emission factors treat the return journey;
- Inclusion of Woodside's estimates of emissions required to meet the Australian Safeguard Mechanism, as stated in the December 2019 Draft Browse to NWS EIS/ERD and existing Western Australian conditions;
- Updated production and emissions forecasts, including changes due to an uplift in Scarborough reserve volumes of 52% from 7.3 trillion cubic feet (tcf) to 11.1 tcf;
- Updated LNG production efficiency, that has occurred as engineering design has progressed; and
- An update to the IEA scenario data to align with data from the World Energy Outlook published in November 2019.

The LCA is intended for public release and therefore constitutes a comparative assertion which may be disclosed to the public, invoking specific requirement from the ISO 14044 standard including 3rd party review and a data quality assessment. This public release document is the entire report, except for granular production and emissions data for Browse, Scarborough and shipping which has been removed from Appendix B since it is commercially sensitive.

EXECUTIVE SUMMARY

The purpose of this life cycle assessment (LCA) is to analyse the full life-cycle impacts of liquefied natural gas (LNG) production and utilisation from two proposed Woodside Energy Limited (Woodside) operated gas reservoirs; Browse and Scarborough. The main market for LNG from these reservoirs is Asia Pacific, and in particular China, Japan, Southeast Asia (ASEAN) and India.

This study covers LNG, which is the major product from Browse and Scarborough, but other products including domestic gas, condensate and liquid petroleum gases (LPGs) will all be produced. These other products are not in the scope of this report.

Natural gas is a fossil fuel like coal and oil. However, it can be used more efficiently than other fossil fuels and increasing natural gas contributes to lower greenhouse gas (GHG) emissions when it replaces the burning of coal and oil for power generation, as well as combustion for heat. In Europe, the USA and China, increasing consumption of natural gas has substantially contributed to lower GHG emissions than would have been the case. Gas from the Woodside operated Browse and Scarborough projects is expected to play this role in the four markets under consideration.

As the global energy system changes, driven principally by advancing technology and pressure to curb climate change, tracking an accurate path to the future has become ever more difficult. This report considers different scenarios to assess uncertainty, and to test the role for Browse and Scarborough gas under a range of market conditions, some of which look very different to those of today. For this study, the International Energy Agency (IEA) World Energy Outlook (WEO) scenarios provide an appropriate backdrop. IEA WEO scenarios are revised annually and are broadly considered by industry to be a benchmark of energy scenarios. The three scenarios that comprise the WEO cover a sufficient range of policy, technology and climate outcomes to 2040 (the end of the IEA modelled period), allowing a significant portion of the lifetime of the Browse and Scarborough assets to be considered.

The differences between the IEA WEO Sustainable Development Scenario (SDS), the Stated Policies Scenario (STEPS) and Current Policies Scenario (CPS), are a very important consideration in the analysis. As a goal-driven scenario, the SDS works backwards from a set of specific sustainability-related outcomes, including CO_2e emissions, and builds an energy system of the future, consistent with these goals. By contrast, the STEPS and CPS are more akin to forecasts, projecting forward growth in energy demand and sources from today's market conditions.

The study compares the environmental impacts of electricity generated in the four target markets, using Browse and Scarborough LNG as fuel, to the environmental impact of specific electricity grid mixes in the same markets under each future development scenario. This analysis demonstrates how Browse and Scarborough-sourced gas would compare, either on a grid-average basis (which includes nuclear and renewables), directly against coal-fired generation, or against a portfolio of fossil fuel power sources.

A portfolio of fossil fuel power sources is considered the most appropriate comparison for Browse and Scarborough-sourced gas, for several reasons. Direct competition against coal offers the greatest reduction in emissions, but as the world, and specifically Asia Pacific markets, move to decarbonise, the proportion of coal in the energy mix will inevitably decline. Therefore, the assumption that gas will only ever compete with and offset coal should be treated with caution. So too should the assumption that gas will compete directly with renewables.

Renewable power generation is growing at a fast pace, supported by maturing technology and falling capital investment costs. Renewables have a near zero short run marginal cost, so power is delivered to grids whenever the sun shines or the wind blows. Applicable to all of the markets (apart from China) under consideration, and beyond, is that limits to growth of renewables are more likely to be dictated by physical capacity constraints than economics. All of this indicates that renewables will take their place in power markets, leaving the various fossil sources to compete for the remaining market share.

Table 0-1 shows the LCA potential environmental impact assessment indicator results of climate change, particulate matter, photochemical smog potential and acidification potential. These are presented in the form of equivalents as (CO_2e), ($PM_{2.5}$ e), (NMVOC e) and (H^+e) respectively for electricity produced from LNG sourced from Browse and Scarborough for all four regions, under three different policy scenarios, averaged over the 2026-2040 timeframe.

These results present the default case for Browse and Scarborough LNG for these markets, and do not include any sensitivity assessments. **Table 0-1** results indicate that electricity from LNG has significant benefits in reducing photochemical (ground-level) ozone formation, acidification, and particulate matter in all modelled regions, for both the CPS and STEPS. The benefit of LNG sourced electricity for these non-carbon indicators is much smaller when compared to the SDS. This is to be expected for an energy scenario featuring a large and increasing proportion of renewable sources. Note: annual values of the indicators shown in the table change significantly to 2040, particularly in the case of the SDS.

With regard to the LCA potential environmental impact indicator of climate change (represented by CO_2e), the picture is more nuanced, but still positive. From a power sector emissions intensity perspective, Asia Pacific markets are generally characterised as 'high carbon', featuring a large share of coal in the overall mix. Adding gas from Browse or Scarborough to the power mix is expected to lead to a decline in CO_2e emissions intensity in each market under consideration, to at least 2040.

Table 0-1 LCA Environmental Impact Indicator Results for 1 MWh Electricity Generated from Browse and Scarborough LNG Compared to Fossil Grid Scenarios in China, Japan, ASEAN and India

Region	Scenario	Climate Change t CO_2e	Particulate Matter g $PM_{2.5}$e	Photochemical Smog kg NMVOC e	Acidification mol H^+ e
China	CPS	1.00	1146	3.15	5.67
China	STEPS	1.03	1189	3.25	5.87
China	SDS	1.03	1149	3.18	5.70
China	LNG Browse	0.56	36	0.56	0.42
China	LNG Scarborough	0.49	36	0.46	0.40
Japan	CPS	0.70	222	1.68	4.03
Japan	STEPS	0.69	213	1.63	3.82
Japan	SDS	0.57	135	1.12	2.23
Japan	LNG Browse	0.50	24	0.51	0.37
Japan	LNG Scarborough	0.44	23	0.41	0.36
ASEAN	CPS	0.79	669	1.68	4.32
ASEAN	STEPS	0.77	631	1.62	4.10
ASEAN	SDS	0.64	394	1.18	2.71
ASEAN	LNG Browse	0.57	100	0.58	0.44
ASEAN	LNG Scarborough	0.49	100	0.47	0.42
India	CPS	0.96	715	2.65	4.90
India	STEPS	0.99	754	2.77	5.15
India	SDS	0.76	473	1.93	3.42
India	LNG Browse	0.57	37	0.67	0.52
India	LNG Scarborough	0.49	36	0.56	0.50

This study assumes distribution of Browse and Scarborough gas into the target markets of China (31%), Japan (24%), ASEAN (27%), India (19%). Browse and Scarborough gas is assumed to be displacing fossil-generated electricity under all three scenarios. **Table 0-2** shows that Browse and Scarborough gas, if used to generate power in the target markets, will release approximately 913 Mt CO_2e over the 2026 – 2040 period (circa. 595 Mt CO_2e from Browse and 318 Mt CO_2e from Scarborough). Differences in **Table 0-2** between the STEPS and CPS scenarios are due to slightly different implied emissions intensities. This in turn is a result of the different balance of power generation technologies utilised in each scenario.

By contrast, if the broad fossil fuel mix forecast by the IEA is used to generate electricity in the target markets, then emissions are much higher. Under the STEPS, the baseline total is 1514 Mt CO_2e (936 Mt CO_2e Browse, 577 Mt CO_2e Scarborough). Under the CPS, the fossil balance of the power grids in the target markets are more biased towards coal relative to the STEPS. Thus, the baseline total under this scenario is 1528 Mt CO_2e from 2026 – 2040 (945 Mt CO_2e Browse, 583 Mt CO_2e Scarborough).

This means that using Browse and Scarborough gas to generate power in the target markets, results in avoided emissions of 601 Mt CO_2e under the STEPS (i.e. 1514 less 913), and 620 Mt CO_2e under the CPS (i.e. 1528 less 908). Of the approximately 913 Mt CO_2e of life cycle emissions associated with Browse and Scarborough gas, around 159 Mt CO_2e is associated with the production of the LNG in Australia. The remainder of the life cycle emissions and all of the avoided emissions will occur in the jurisdiction where the LNG is consumed. The ratio of production emissions in Australia to avoided emissions across the life cycle is 159:601 (STEPS) or 159:620 (CPS), or 1:3.8 and 1:3.9 respectively. In other words for every 1 Mt CO_2e associated with the production of Browse and Scarborough LNG in Australia, approximately 4 Mt CO_2e of net emissions to the global atmosphere would be avoided.

Grids are envisaged to be significantly more progressed in their decarbonisation pathways in the SDS than in the other two scenarios. Therefore, avoided emissions – are 345 Mt CO_2e over the 2026 – 2040 period.

Table 0-2 also takes into account the use of CO_2e offsets for Browse and Scarborough, used to offset the volumes of CO_2 vented at the well. Use of offsets effectively lowers emissions by a further 50 Mt CO_2e for Browse, and 0.2 Mt CO_2e for Scarborough. Avoided emissions are therefore 651 Mt CO_2e compared to the fossil power baseline under the STEPS, and 670 Mt CO_2e compared to the fossil power baseline under the CPS. If the same displacement assumptions were made for the SDS, avoided emissions would be 395 Mt CO_2e over the 2026 – 2040 period.

Table 0-2 Mt CO_2e Emitted / Saved by Browse and Scarborough LNG from 2026 to 2040 Compared to Fossil Grids, under Three Policy Scenarios

Emissions Description	CPS Fossil	STEPS Fossil	SDS Fossil
Emissions from Browse-sourced power	592	595	591
Emissions of baseline scenario (fossil grid)	945	936	771
Browse CO_2e offsets	-50	-50	-50
Browse avoided emissions (no offsets)	***-354***	***-342***	***-181***
Browse avoided emissions (including offsets)	***-404***	***-392***	***-231***
Emissions from Scarborough-sourced power	316	318	316
Emissions of baseline scenario (fossil grid)	583	577	481
Scarborough CO_2e offsets	-0.2	-0.2	-0.2
Scarborough avoided emissions (no offsets)	***-267***	***-259***	***-165***
Scarborough avoided emissions (including offsets)	***-267***	***-259***	***-165***
Total Emissions from Browse and Scarborough-sourced power	**908**	**913**	**907**
Total Emissions of baseline scenario (fossil grid)	**1528**	**1514**	**1252**
Total avoided emissions (no offsets)	***-620***	***-601***	***-345***
Total avoided emissions (including offsets)	***-670***	***-651***	***-395***

The results from the LCA identify that LNG based electricity supply into Asia Pacific will improve air quality outcomes compared to the IEA's assumptions about the fossil grid under all scenarios. Particulate matter emissions are much higher than those from LNG under any of the scenarios assessed.

For climate change, LNG impacts vary through time, and are sensitive to factors such as the relative levels of coal, gas and renewables on power grids.

1. INTRODUCTION

1.1 Background

The twin challenges of decarbonisation and rapidly-maturing alternative technologies have upset the balance of energy commodity markets in recent years. Uncertainty over demand, price, and market landscape is a challenge for energy producers worldwide. Companies are now expected, by capital markets and regulators, to show how current and planned investments perform under a range of future market conditions, some of which are a radical departure from the conditions of today.

The purpose of this report is to assess the life-cycle impacts of LNG production and utilisation from Browse and Scarborough, two proposed gas developments held by different joint ventures where Woodside is the operator. The main market for LNG from these projects is Asia Pacific, and in particular China, Japan, Southeast Asia (ASEAN) and India. The study compares the life cycle CO_2e emissions of electricity generated in these markets from Browse and Scarborough LNG to the CO_2e emissions of specific electricity grid mixes in the same markets. This analysis demonstrates how Browse and Scarborough-sourced gas would compete in the power markets under consideration, either on a grid-average basis, directly against coal-fired generation, or against a portfolio of fossil fuel power sources.

A portfolio of fossil sources is considered the most appropriate comparator for Browse and Scarborough-sourced gas, for several reasons. Direct competition against coal offers the greatest emissions benefits, but as the world (and specific to this analysis, markets in Asia Pacific) move to decarbonise, the proportion of coal in the energy mix will inevitably decline. Therefore, the assumption that gas will only ever compete with coal should be treated with caution. So too should the assumption that gas will compete directly with renewables. The latter form of power generation is growing at a fast pace, supported by maturing technology, falling capital investment costs and, in many regions, a generous subsidy regime. Renewables have a near zero short-run marginal cost, so power is delivered to grids whenever the sun shines or the wind blows. Limits to growth are more likely to be dictated by physical capacity constraints, than economics relative to other energy sources. All of this indicates that renewables will take their place in power markets, leaving the various fossil sources to compete for the remaining market share.

Scenarios used in this assessment are drawn from the International Energy Agency World Energy Outlook (IEA WEO) 2019 and cover a business-as-usual outlook (Current Policies Scenario), a central case (Stated Policies Scenario) and a lower-carbon outlook (Sustainable Development Scenario). Note, these scenarios are not forecasts, but assessments of how global and regional energy markets could look under a range of policy environments.

The study has been undertaken following the requirements of the International Organization for Standardization (ISO) Standard 14044, Environmental Management Standard – Life Cycle Assessment, 2006 (International Organization for Standardization 2006).

1.2 Audience

The primary audience for the study is Woodside Energy Limited (Woodside), with the potential to extend it to licensing and regulation bodies and the public. As released to the public, the study would constitute a public comparative assertion according to ISO 14044.

1.3 Life Cycle Assessment

Life Cycle Assessment (LCA) is a method for assessing the full ‘cradle-to-grave’ environmental impacts and benefits of products and processes by assessing environmental flows (i.e. impacts) at each stage of the life cycle. LCA aims to include all important environmental impacts for the product system being studied. In doing so, LCA seeks to avoid shifting impacts from one life cycle stage to another, or from one environmental impact to another. The method and guidance for undertaking life cycle assessment follows the international standards ISO 14040:2006 and ISO14044:2006

(International Organization for Standardization 2006). The general structure of the LCA framework is shown in **Figure 1-1**. Each stage of the LCA interacts with other stages.

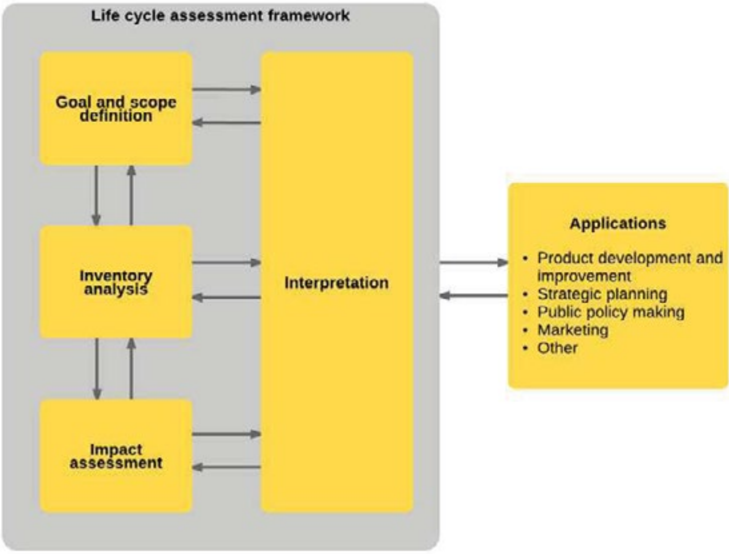


Figure 1-1 Framework for LCA from ISO 14040

The first stage in the LCA framework (goal and scope definition) describes the reasons for the LCA, the scenarios, boundaries and indicators used. The second stage (inventory analysis) builds a model of the production systems involved in each scenario and describes how each stage of the production process interacts with the environment. The third stage (impact assessment) assesses the inventory data against key indicators to produce an environmental profile of each scenario. The final stage (interpretation) analyses the results and undertakes systematic checks of the assumptions and data to ensure robust results.

2. IEA SCENARIOS: ILLUSTRATING A PATH TO DECARBONISATION

As the global energy system changes, driven by advancing technology and pressure to curb climate and other environmental impacts, tracking an accurate path to the future has become ever more difficult. Scenarios are a useful tool to assess uncertainty. They may describe differing economic or demographic or technological futures, but what is critical is that the chosen views of the future illustrate a range of outcomes under which the investments under consideration may be expected to function.

This section provides an overview of the scenarios contained in the 2019 edition of the IEA WEO. These scenarios have been used in this report to test the proposed Browse and Scarborough developments against a range of future market conditions.

For this study, the IEA WEO scenarios provide an appropriate backdrop. IEA WEO scenarios are revised annually, and are broadly considered to be the benchmark of energy scenarios. The three scenarios that comprise the WEO (details below) cover a sufficient range of policy, technology and climate outcomes over the years to 2040, allowing a significant portion of the lifetime of the Browse and Scarborough assets to be considered.

The study uses an energy mix directly drawn from IEA data, and power generation efficiencies calculated from IEA data but not published by them.

2.1 Current Policies Scenario

The Current Policies Scenario (CPS) is the IEA's business as usual outlook. This scenario assumes no change (i.e. no additional) policy from that of today. Energy demand continues to grow through to 2040, and much of this demand growth is met by fossil fuels. Meeting energy demand at lowest cost is a priority, especially in emerging markets, and environmental concerns are secondary. Global CO_2e emissions exceed 40 billion tonnes per year by 2040, and the world is on track for significant global warming.

2.2 Stated Policies Scenario

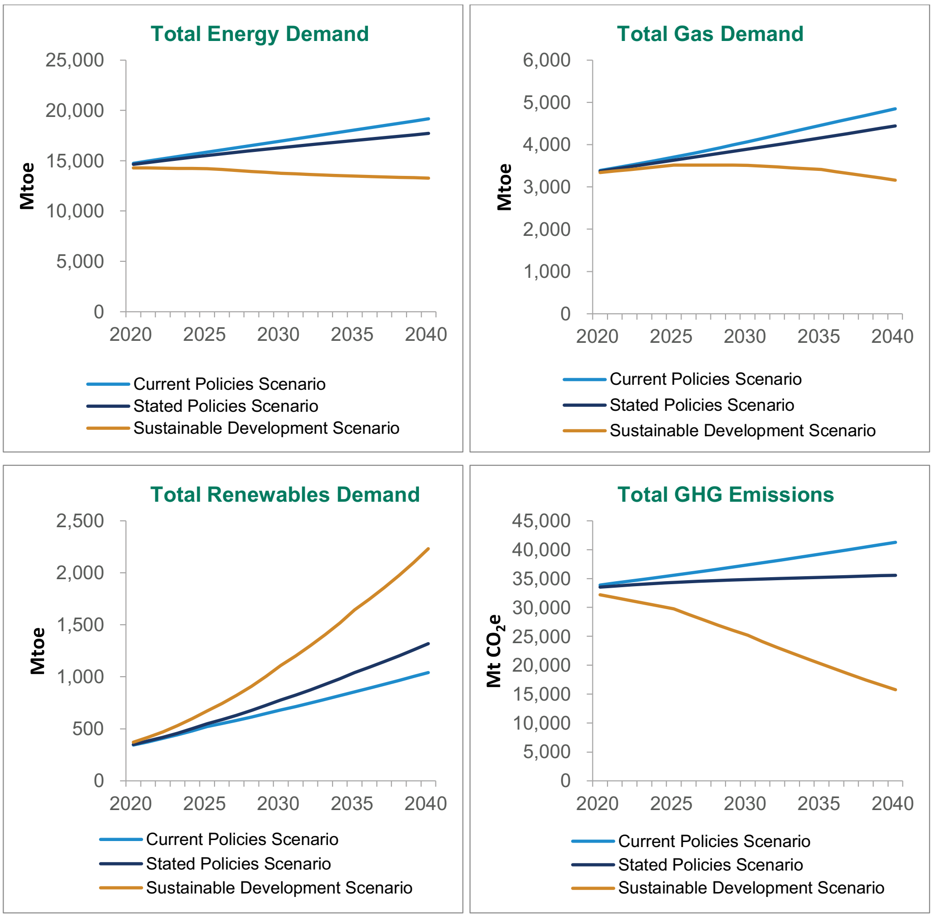
The Stated Policies Scenario (STEPS) is the IEA's central case. The STEPS accounts for policies and measures announced even if they have not yet been enacted by governments. The STEPS delivers a world which is broadly consistent with the aggregated Nationally Determined Contributions (NDCs) under the Paris Agreement. However, these NDCs are not yet strict enough to reverse emissions growth or keep global warming below 2^{o}C. Nevertheless, the STEPS does see additional decarbonisation relative to the CPS, including a shift to greater use of gas and renewables.

2.3 Sustainable Development Scenario

The Sustainable Development Scenario (SDS) envisages a radical change in the supply and consumption of energy, such that global CO_2e emissions peak in 2020 and decline sharply thereafter. The SDS is consistent with the ultimate goals of the Paris Agreement, to keep global warming below 2^{o}C, alleviate energy poverty and improve air quality in line with the UN Sustainable Development Goals. Unlike the CPS and STEPS, the SDS works backwards from these goals, to map a path to that future from the present day.

To achieve this lower-carbon future, the world shifts wholesale to lower carbon energy. The SDS is therefore often a challenging future for fossil fuel demand. This includes gas, demand for which plateaus between 2025 and 2030 before falling into decline. However, markets in Asia Pacific are expected to see demand growth to 2035 even under this lower-carbon scenario. This in turn is expected to be supportive of LNG demand.

Key metrics from the three scenarios are shown in **Figure 2-1.** Energy demand, defined as Total Primary Energy Demand (TPED), is shown in million tonnes of oil equivalent (Mtoe) and GHG emissions are presented in million tonnes (Mt CO_2e).



Source: IEA WEO 2019

Figure 2-1 Global Energy, Gas and Renewables Demand; Global CO_2e Emissions, IEA Scenarios 2020 – 2040

3. CASE STUDY: NATURAL GAS AS A DECARBONISATION FUEL IN EUROPE, THE USA, AND CHINA

Natural gas has the lowest carbon content of the fossil fuels. When combusted in a power plant, natural gas typically emits around half the amount of carbon dioxide (CO_2) per unit of power generated, compared to coal.[1] When combusted, natural gas also emits around 98% less carbon monoxide (CO), sulphur dioxide (SO_2), nitrous oxide (N_2O), and particulate matter than coal. Increasing natural gas use tends to contribute to lower GHG emissions, as it can replace the burning of coal and oil for power generation. Natural gas is also increasingly used as a substitute for petroleum fuels in petrochemicals.

When considering the role gas from Browse and Scarborough may play in the energy systems of the markets where it will be consumed, it is useful to examine case studies of markets where increasing consumption of gas has contributed to lowering emissions growth. This has occurred in Europe, the USA and China, but at different times, and for different reasons.

In Europe, the USA, and China, gas demand has been increasing steadily since the early 1980s, as shown in **Figure 3-1**. In Europe, gas demand steadily increased from around 1970 to 2008, but it has wavered slightly since then, in part due to the relative low pricing of coal following the near collapse of the EU Emissions Trading Scheme. The USA has always been a large consumer of natural gas (for domestic and industrial use), although demand increased again from around 2006, following the emergence of unconventional gas as a supply source. In China, gas demand has been increasing since the early 2000s, supported by a growing economy, and more recently a drive to improve local air quality.

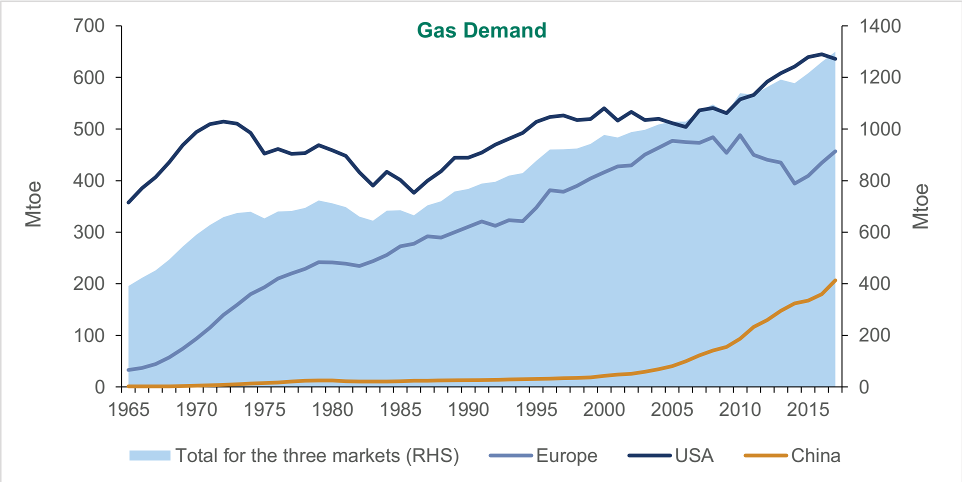


Figure 3-1 Natural Gas Demand in Europe, the USA, and China, 1965 to 2017

(Source: BP Statistical Review of World Energy, 2018)

3.1 Europe

While European gas demand had grown during the 1970s, it was not until the beginning of the 1990s that demand for gas began to be widespread across the continent. Simultaneously, key consumers, including the UK, began a ‘dash for gas’ which almost doubled demand for the fuel in the space of ten years.

[1] In 2017, gas: 0.506 Mt CO_2/TWh; coal: 0.996 Mt CO_2/TWh. Source: IEA World Energy Outlook 2018

The transition of the UK from coal to gas clearly illustrates the effect of increasing gas consumption on GHG emissions. Gas consumption in the UK started to grow from the early 1970s, much in line with the European trend. The initial increase was due to natural gas substitution into homes for both cooking and heating, as well as increasing industrial use.

A second period of increasing consumption occurred from 1990. This ‘dash for gas’ occurred due to several key changes in the UK energy market:

- The UK electricity industry was privatised in 1990, and this led to changing regulation which permitted the use of natural gas as a fuel in power generation;
- Natural gas power stations were smaller and quicker to build than coal and nuclear plants which made them more attractive financially due to the high interest rates at the time;
- Developments in generation technology meant combined cycle gas turbines (CCGTs) were economically attractive due to their higher efficiency and lower capital costs; and
- Wholesale natural gas prices were falling as supply increased, predominantly from the North Sea.

At this point therefore, it was not a climate change policy which encouraged the use of natural gas. Growth in the 1990s was market-led, driven by the electricity sector, this is shown in **Figure 3-2** below. Lines (read from the LH axis) show power generation by fuel, while the shaded area (read from the RH axis) shows sectoral CO_2e emissions.

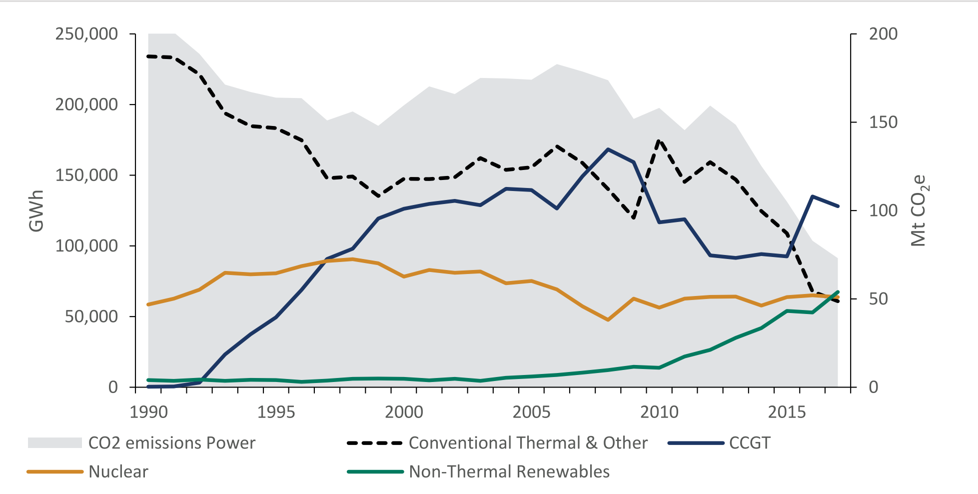


Figure 3-2 UK Power Gen. by Fuel and Sectoral CO_2e Emissions (RHS), 1990 – 2017

(*Source: UK Department for Business, Energy and Industrial Strategy)*

Figure 3-2 also shows the inverse relationship between natural gas (marked on the chart as CCGT) and coal power generation (included on the chart in Conventional Thermal and Other). Natural gas generation increased throughout the 1990s, rising from 1.6% in 1990 to just under 40% of total generation by 2000. This led to a decrease in coal generation of 42% from 1990 to 2000. As **Figure 3-2** shows, power generation from natural gas and coal have largely been in equilibrium since 2000; as one has increased, the other has decreased, often in equal volumes. This change has been mostly driven by profit margin differences between natural gas and coal power generation, known as ‘spark spreads’ and ‘dark spreads’[2], respectively.

Before carbon pricing, coal to natural gas switching was driven by wholesale price differences. Since 2005 however, when the EU Emissions Trading Scheme (ETS) began, power generators have also had to factor in the costs of purchasing carbon allowances under the scheme. This is known as the ‘clean spark spread’ and the ‘clean dark spread’ for natural gas and coal, respectively. The carbon cost is proportional to the efficiency of the generation type, meaning natural gas is cheaper in terms of carbon allowances.

The difference between the clean spark spread and the clean dark spread is known as the ‘climate spread’. After the global financial crisis issues with the EU ETS (allowances far in excess of demand) meant that carbon prices were not high enough to stimulate coal to natural gas generation switching. Fluctuations in the wholesale costs of natural gas and coal also meant that there have been instances since 2005 when the volume of coal generation has moved back above natural gas. This was most noticeable in the period around 2012 when high natural gas prices favoured coal generation. This often led to a subsequent increase in emissions, which can also be seen in **Figure 3-2**. It is clear, therefore, that since 2000 in the UK, natural gas has played a key role in halting the volume of emissions from coal generation.

Today, gas is playing a new role. Since the oil price crash of 2014, wholesale natural gas prices have been low enough to stimulate lasting coal to natural gas switching. However, a new dynamic is at play: generation from renewables. This has been accelerated by climate change policies and regulatory changes which have facilitated the build out of renewables at massive scale.

Renewables now occupy a 28% share of the UK electricity market, up from less than 5% in 2000. Natural gas is holding on to its 40% share by virtue of providing balancing generation for intermittent renewable generation, such as onshore wind power. Natural gas has excellent suitability for this role because gas generation can be ramped up and down much more easily than coal or nuclear generation. The long-term viability of this is dependent on the type of plant used to generate power from natural gas. But nevertheless, natural gas generation in the UK looks set to become a facilitator for the next wave of emissions reduction which will see coal all but leave the generation mix, replaced by onshore and offshore wind, and photovoltaic solar.

3.2 USA

In the USA, the recent growth of natural gas consumption is a story all about supply. The development of unconventional onshore oil and gas resources since around 2006 has led to a 46% increase in natural gas production to 2017, as shown in **Figure 3-3.** This has had extensive knock-on effects for the domestic energy market.

[2] The ‘spark spread’ is the gross margin of a gas fired power plant selling one unit of power. The ‘dark spread’ is the same margin for a coal fired power plant. ‘Clean spark’ and ‘clean dark’ spreads are similar margins for the two fuels, but also accounting for costs of carbon allowances.

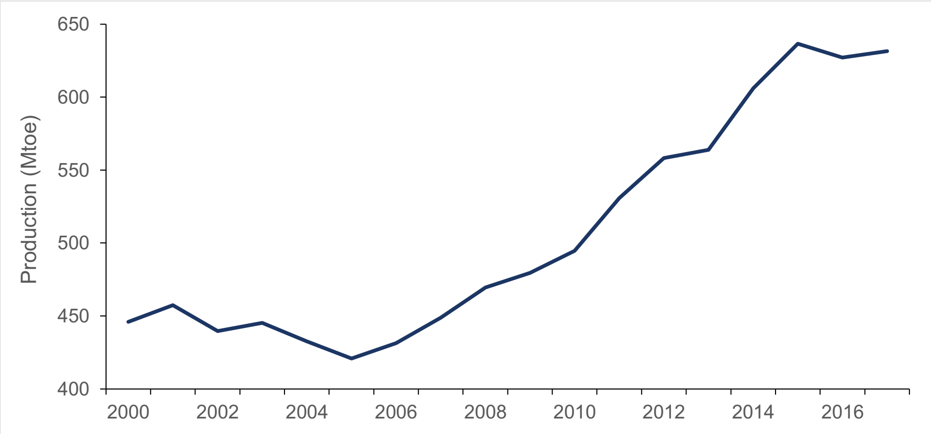


Figure 3-3 Natural Gas Production in the USA from 2000 to 2017

(Source: BP Statistical Review of World Energy, 2018)

Prior to the large-scale development of unconventional resources, the US energy sector had been anticipating an upcoming shortage of natural gas supply. This had led several companies to begin developing LNG regasification plants for import. Cheniere, for example, had begun development of import facilities at Sabine Pass and Corpus Christi on the Gulf Coast. Once the scale of the unconventional natural gas opportunity was realised however, these projects were reconfigured for LNG liquefaction and export.

The availability of natural gas in these volumes meant that prices fell dramatically. This stimulated power generators, faced with a period of relatively high coal costs and impending climate change-related regulations, to begin investing in natural gas. **Figure 3-4** shows the increase in natural gas generation, which, similarly to Europe, has reduced the market share of coal by around 38% since 2007, as well as contributing to power sector GHG emissions which are nearly 30% lower.

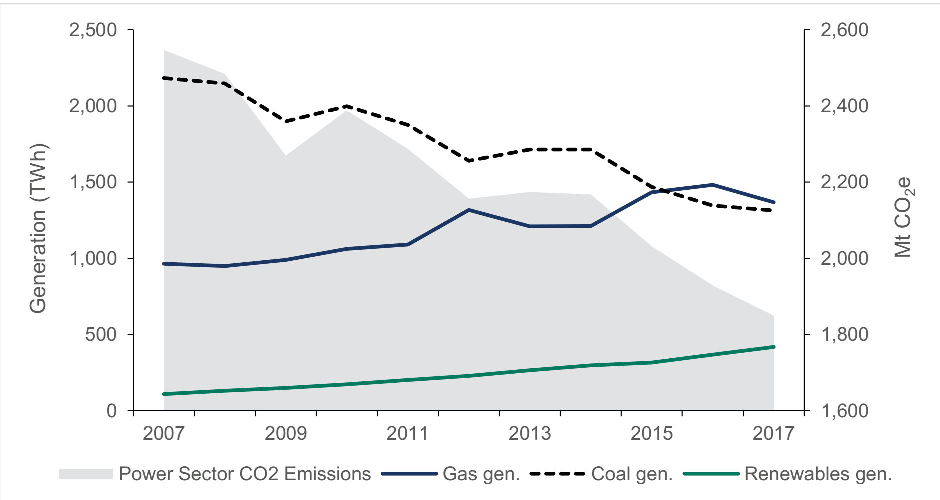


Figure 3-4 USA Power Generation and National Emissions (RHS) from 2007 – 2017

(Source: Generation from BP Statistical Review, 2018; Power sector emissions from the IEA)

Therefore, coal to natural gas switching in the US power sector is mostly a result of commodity prices, although in some state jurisdictions, for example California, there are carbon pricing mechanisms which also play a role. The reduced market share of coal generation has caught the headlines in recent times; with so much cheap natural gas available, the market has struggled to respond to the drive for coal on purely economic terms.

While there are considerable differences at the state level, the US power sector is in much the same situation as the UK was around 2006. The prominence of renewables is growing, spurred on by nearing cost parity with other generation sources. It’s likely that natural gas will continue to take market share from coal, before having a longer term role as backup generation for renewables.

3.3 China

China has only ever had relatively limited natural gas resources. In 2017, China produced 60% of the natural gas it consumed, but natural gas was only 7% of total primary energy consumption, and 3% of power generation. This means that if natural gas consumption is to continue to increase, it is likely that much more natural gas will have to be imported either via pipeline, or in the form of LNG.

A national carbon pricing scheme will come into force in China in 2020. Despite this, the primary reason for China’s domestic action on emissions is because of urban air pollution. Policy and regulation have primarily been developed to target this, as opposed to being exclusively climate change related. Nevertheless, the result is the same – a reduction in emissions of GHGs and particulates.

China’s urban air pollution problem mainly comes from the dominance of coal in the energy and industrial sectors, although low emissions standards for vehicles is also a contributing factor. In 2017, coal met 60% of China’s primary energy needs. However, this is reduced from over 70% a decade ago. Moreover, part of the reason for that decline is due to the growing consumption of natural gas, as well as the mass development of nuclear and hydro power, and, more recently, renewables.

The sheer scale of economic growth that has occurred in China over the last two to three decades has meant China pulling all levers available to meet energy demand. Due to large natural reserves, coal was developed first. Now, China is in a situation where economic growth has slowed, and efforts can be made to address air pollution and climate change goals.

Natural gas consumption in China is not just driven by the power sector; industry and manufacturing will also play a large role. Already, natural gas consumption has increased by more than 870% since 2000, albeit from a low starting point. This trend looks set to continue as natural gas will gradually be favoured over coal for generating not just power, but also heat. **Figure 3-5** shows the ever-increasing role of natural gas, hydro, and renewables in contributing to lowering the emissions intensity of the Chinese economy. The changing balance of the Chinese economy from industry to services is a factor in falling intensity, but the most recent decline (since 2007), coincides with a retrenchment in coal’s share of the total energy mix, as other fuels gain in importance.

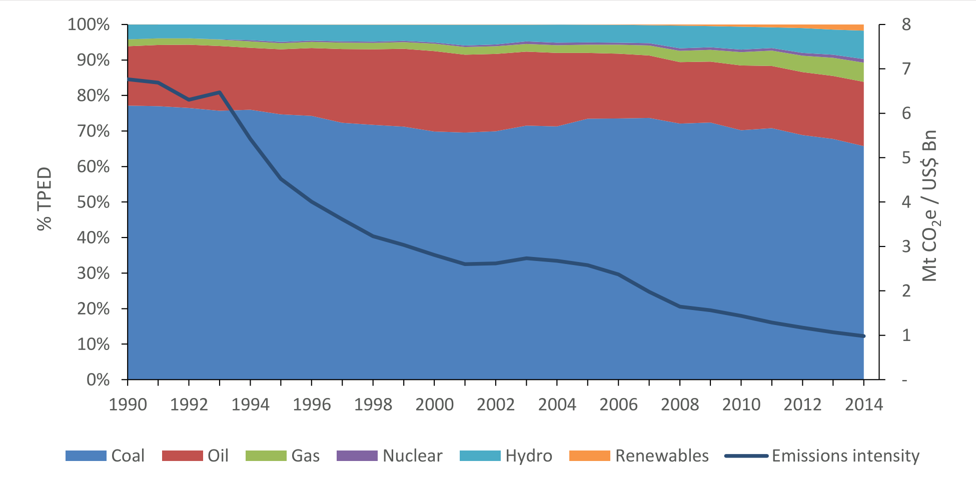


Figure 3-5 Share of Total Primary Energy Demand (TPED) and GHG Emissions Intensity in China, 1990 – 2014

(Source: Generation from BP Statistical Review, 2018; Emissions intensity from the World Bank)

Nevertheless, in 2014, China's economy was still around six times more carbon intensive than Europe's. This means that China still has a considerable carbon burden it needs to shift in order to achieve its climate change goals. Therefore, it is likely that the natural gas story in China has a considerable way yet to run. Upcoming national carbon pricing will also provide a boost to natural gas demand. As China lacks the domestic supply of the USA, this will support demand for imported natural gas.

3.4 Conclusion

Natural gas has played a varying role in the three markets considered, but in all of them it has substantially contributed to decarbonisation as a point of empirical fact. In Europe, natural gas began to displace coal generation from 1990 onwards, driven by changing regulation, growing supply availability, commodity prices, and later climate change policy; all leading to a decline in GHG emissions. Natural gas will now play a role in facilitating the development of renewable generation, further supporting the effort to decarbonise.

In the USA, natural gas demand has grown since the mid-2000s and the advent of readily available, low cost supply from unconventional domestic gas resources. Despite a changing regulatory environment, the USA has followed a similar trend to Europe, with natural gas power generation outcompeting coal on cost, lowering GHG emissions.

China will follow a slightly different pathway, in part due to limited natural resource availability and the timing of its climate change action. Essentially, China has 'early access' to renewable generation, which Europe and the USA were lacking when initial efforts to decarbonise were made. But China is also, by far, the largest energy market in the world, and even at relatively slow rates of annual growth will continue to build phenomenal demand in absolute terms. China's path to decarbonisation must therefore make use of all tools. Coal to gas switching is an essential strategic goal, as the examples of Europe and the USA make clear, and will complement China's ability to build out renewables at scale seen nowhere else in the world. Ultimately, it is the scale of China's emissions problem that will boost demand for natural gas.

4. GOAL AND SCOPE OF THE LCA

4.1 Goal

The goal of this report, as described in Section 1, is to assess the life cycle impacts of LNG production and utilisation from two proposed gas developments; Browse and Scarborough. The main market for LNG from these developments is Asia Pacific, and in particular China, Japan, Southeast Asia (ASEAN) and India. The main use of LNG in these markets is electricity generation, and is the focus of the LCA study. The LCA follows the ISO 14044 requirements, although the structure of the report has been arranged to aid understanding by a non-LCA audience.

The LCA was commissioned by Woodside, undertaken by ERM and Lifecycles and has been critically reviewed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The LCA is intended for public release and therefore constitutes a comparative assertion which may be disclosed to the public, invoking specific requirement from the ISO 14044 standard including 3rd party review and a data quality assessment. This public release document is the entire report, except for granular production and emissions data for Browse, Scarborough and shipping which has been removed from Appendix B since it is commercially sensitive.

4.2 Functional Unit

The international standard on LCA describes the functional unit as defining what is being studied, and states that all analysis should be relative to the functional unit. The definition of the functional unit needs to clearly articulate the functionality or service that is under investigation. In this study, the functionality is the supply of electricity in different Asia Pacific markets over the period 2026 -2040.

The functional unit used for this assessment is:

“the supply of 1 MWh of electricity entering the grid from generators in the World, Chinese, Japanese, the ASEAN[3] and Indian markets between 2026 and 2040.”

The scenarios to be assessed are:

- Average, fossil fuel and coal only grid mixes under the IEA Current Policies Scenario (CPS);
- Average, fossil fuel and coal only grid mixes under the IEA Stated Policies Scenario (STEPS);
- Average, fossil fuel and coal only grid mixes under the IEA Sustainable Development Scenario (SDS);
- Electricity supplied from LNG sourced from Scarborough; and
- Electricity supplied from LNG sourced from Browse.
- For analytical purposes a reference unit of 1 gigajoule of delivered gas to market is also used to compare the results from Scarborough and Browse in **Figure 6-8** and **Figure 6-9**.

4.3 System Boundary

The system boundary describes the life cycles, stages and processes included in the LCA; **Figure 4-1** shows the boundary of the system representing the production of LNG from Scarborough used for electricity generation. Note there is one coproduction stream with the production of condensate at the onshore LNG plant. **Figure 4-2** shows the boundary of the system representing electricity produced from LNG sourced at Browse gas field, which has three co-product streams – one offshore being condensate, and two onshore – the first being, propane and butane, with the second co-production between domestic gas and gas used for LNG production and export. **Figure 4-3** represents a generic system diagram for the other electricity sources, both thermal and renewable, used for the comparative scenarios. The analysis uses the same general boundary where applicable for all scenarios, including infrastructure production, fuel extraction, processing and power plant operation.

[3] The IEA state that ASEAN region includes the following ten countries - Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam

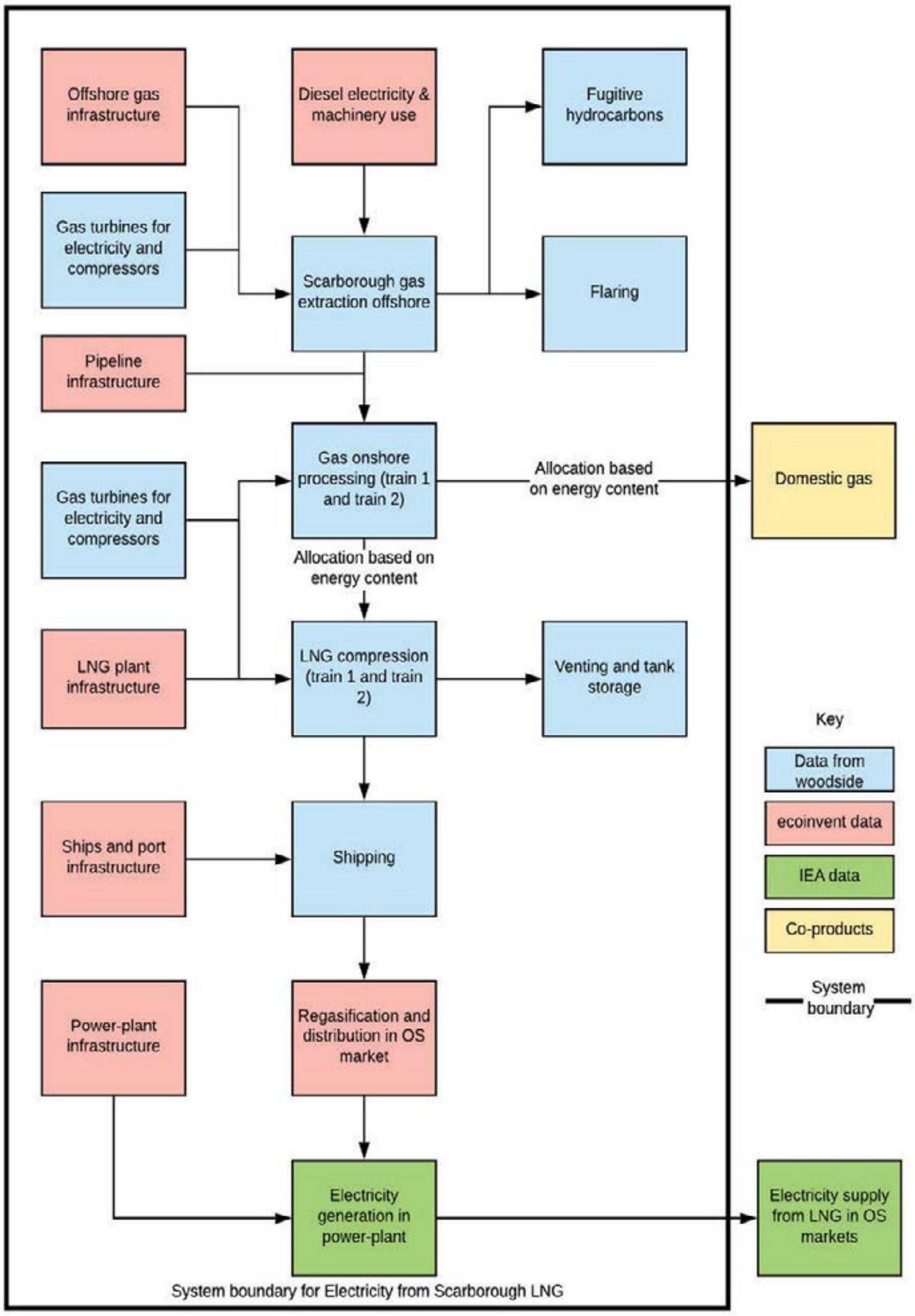


Figure 4-1 System Boundary for the Electricity Production from LNG Sourced from Scarborough Gas Field

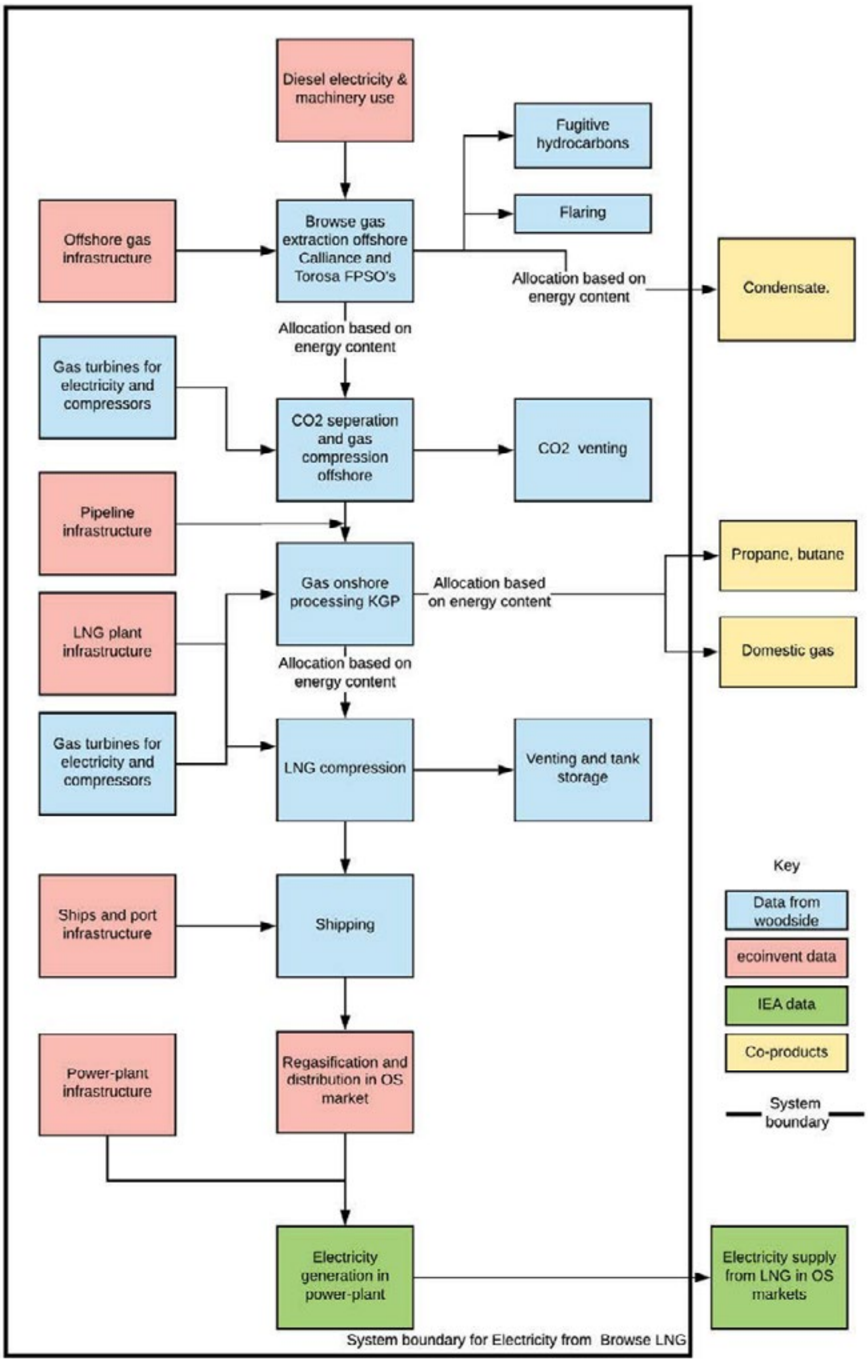


Figure 4-2 System Boundary for the Electricity Production from LNG Sourced from Browse Gas Field

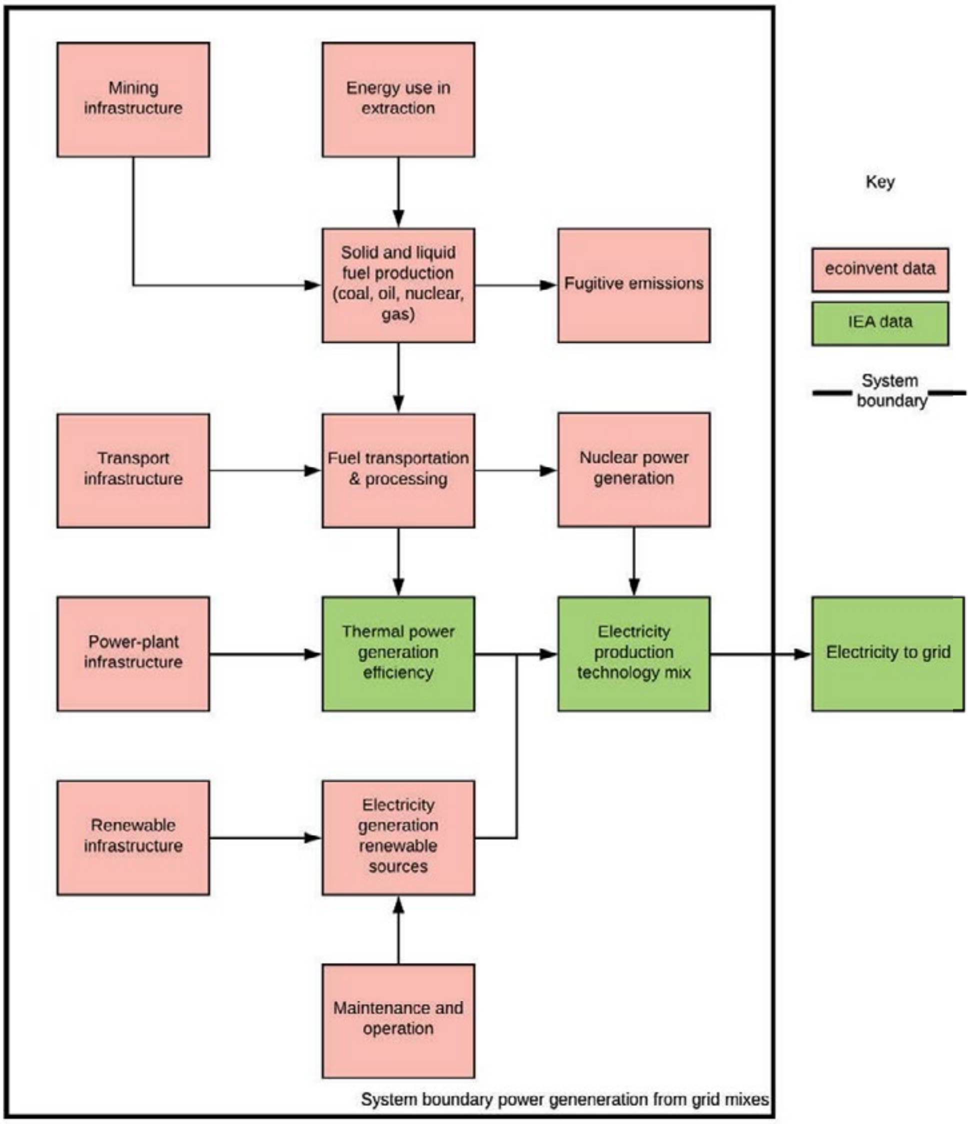


Figure 4-3 System Boundary for the Electricity Production from Other Sources

4.3.2 Included Processes

The assessment included raw gas production from offshore wells, gas treatment (e.g. separation of liquids), and reservoir CO_2 removal where relevant, all extraction processes for natural gas, its transport to shore, further processing in the onshore gas plant and LNG production and storage, LNG shipping to the relevant market, regasification into the local grid and combustion in the power station. Infrastructure elements are included such as drilling rigs, pipes, ships and processing equipment. For electricity supply from other sources, see **Figure 4-3**, the boundary includes fuel extraction, transport and combustion as well as capital equipment.

4.3.3 Cut-off Criteria

ISO standard for LCA allows for the exclusion from the inventory of any flows expected to be less than 1% of any impact category. Small flows such as activated Methyl Diethanol Amine (aMDEA) solvent used in the CO_2 separation, propane refrigerants, machine lubricants, and solid and liquid waste treatment, were not investigated as these were estimated to be well below the 1% mass or impact threshold. Exploration emissions for natural gas, oil and coal as well as research and development of other energy technologies is not included. The climate change impacts of gas exploration in Australia account for 0.26% of total life cycle of gas combustion.

4.4 LCA Methodology and types of Impacts

The choice of environmental indicators has been based on impacts which are strongly linked to power generation. **Table 4-1** describes each of the impact indicators chosen for the LCA and the source of the characterisation factors. Note that LCA impact categories represent **potential** environmental impacts as the different contributions are summed over time and from across the world based on total emission loads. This is different from regulatory reporting of pollutants which is usually concerned with specific locations, timing and concentration of emissions.

Climate change is included due to its high policy relevance, and the links between power generation and greenhouse gas emissions. Photochemical ozone creation potential also known as photochemical smog, is included to incorporate impacts from Non-Methane Volatile Organic Compound (NMVOC) emission from gas processing, as well as the emissions from other power generation technologies especially coal and oil which contribute nitrogen oxides to the atmosphere. Particulate matter is an important indicator to power generation from coal, oil and biomass combustion especially in China where over one million premature deaths per year have been attributed to particulate matter(Lin, Liu et al. 2016). Acidification has been included because of the high contribution of thermal electricity generation technologies and the prevalence of acidification in Asia in particular China (Zhu, De Vries et al. 2016).

We have chosen to exclude abiotic depletion for fossil fuels as fossil fuel depletion is strongly correlated with climate change, with the emerging issue being the ability to deal with the emissions from the combustion of fossil fuels rather than of scarcity of fuel resources. Mineral depletion is important in the renewable energy sector but not in the LNG production, however the models have significant uncertainty so have not been included.

Human and eco toxicity have been excluded due to high uncertainties of these emissions and likely strong correlation to climate change impact linked to coal fired power generation. Ionizing radiation has been excluded as Browse and Scarborough gas is considered most likely to compete against a portfolio of fossil fuel power sources rather than nuclear power generation where this might be significant.

Table 4-1 Impact Assessment Categories and Characterisation Models used in this LCA.

Impact Category	Description	Characterisation Model
Climate change	Measured in kg CO_2e The potential impact category, climate change, represents the carbon footprint of a product system adding up all greenhouse gas emissions taking account of their respective global warming potentials (GWPs). GWPs represent the amount of heat trapped by the gas in the atmosphere over time. All gases are measured relative to carbon dioxide. The most relevant gases to this study are carbon dioxide, methane and nitrous oxide. This impact method does not include the extent to which these emissions cause a change in global temperature as this requires additional modelling of other global emissions and sinks.	IPCC model provided in the fourth assessment report based on the cumulative effect over 100-year timeframe. (IPCC 2007) While updated factors are available from the IPCCs fifth assessment report (IPCC 2013) the report uses the 2007 values which are used by the Australian government and industry for current GHG reporting.
Photochemical smog	Measured in g NMVOC e Photochemical smog, also known as photochemical oxidation creation potential, represents the potential of hydrocarbons and nitrogen oxides in the atmosphere to react under the catalytic action of sunlight to produce tropospheric (ground level) ozone, as well as some other chemicals, which has significant respiratory and other health effects. While all impact categories represent potential impacts, this is particularly the case with photochemical smog as the effect only occurs when the appropriate mix of gases are present in sunlight.	Characterisation factors based on van Zelm et al. (2008) as listed in ILCD method (European Commission JRC IES 2011) documented in SimaPro. Factors are calculated for Europe but are considered applicable to other industrialised regions.
Particulate matter	Measured in g $PM_{2.5}$e This potential impact category represents the human health impacts from exposure to particulate matter (PM_{10} and $PM_{2.5}$ principally) but also secondary particulates including SO_2 and NH_3. This is one of the highest non-behaviour related risks to human health as identified in the global burden of disease (Vos, Barber et al. 2015).	Characterization factors based on Rabl, A. and J. Spadaro (2004) as listed in ILCD method (European Commission JRC IES 2011) documented in SimaPro.
Acidification`	Measured in Mol H^+ e This potential impact category looks at the acid pollutants (SO_2, NO_x, NH_3, HCl, HF) emitted by human activities that could affect the quality of all components of the environment (including air, soils and surface waters) not only in the vicinity of the sources, but also hundreds or even thousands of kilometres from their emitting sources. In the case of the systems under this study, the key acidification components are NO_x and SO_2.	Based on model by Seppälä, Posch et al. (2006) and Posch, Seppälä et al. (2008) as listed in ILCD method (European Commission JRC IES 2011) documented in SimaPro.

4.5 Data Quality Requirements

For a prospective study of future impacts for the extraction and utilisation of LNG for energy in five different regions sourcing data is a challenge. The preference for the study would be to find data projects to future production system in terms of fuel extraction and, electricity generation efficiency.

The key data quality criteria for the study were:

- Data quality
- Time related coverage
- Geographical coverage
- Technology coverage
- Representativeness.

The data quality is assessed using the data quality assessment framework included in **Table 4-2**.

Table 4-2 Data Quality Assessment Framework used in this LCA.

	Poor	Fair	Good	Very good
Reliability	Unqualified estimate	Estimate based on expert judgement	Estimates based on prior measurements	Measured value
Time related coverage	From past production >5 years old	From current production data <5 years old	From future production - singe or unspecified time period	From future production averages from time-period 2026-2040
Geographical coverage	From distinctly dissimilar region	From similar region	From global average	From region of interest
Technology coverage	From old or dissimilar technology	Generic technology average	From technology specific to region	From actual technology used
Representativeness	Unknown coverage	Sample from small part of target region	Sample covers >50% of target region	Representative of entire target region.

4.6 Multi-functionality

Multi-functionality occurs when a single process or group of processes produces more than one usable output, or ‘co-product’. ISO defines a co-product as ‘any of two or more products coming from the same unit process or product system’. A product is any good or service, so by definition it has some value for the user. This is distinct from a ‘waste’, which ISO defines as ‘substances or objects which the holder intends or is required to dispose of’, and therefore has no value to the user.

As LCA identifies the impacts associated with a discrete product or system, it is necessary to separate the impact of co-products arising from multifunction processes. While there are several coproducts produced in LNG production, almost all products are different forms of fuel, destined for energy markets. The ISO 14044 LCA standard provides a four-step hierarchy for solving the issue of multi-functionality:

1a **Avoid allocation by subdividing systems** – wherever possible, allocation should be avoided by dividing the unit process into sub-processes.

1b **Avoid allocation by system expansion** – expanding the product system to include the additional functions related to the co-products.

2 **Allocation by underlying physical relationships** – the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them.

3 **Allocation between co-products** – the inputs should be allocated between the products and functions in a way that reflects other relationships between them. For example, data may be allocated between co-products in proportion to the economic value of the products.

(adapted from text in International Organization for Standardization 2006).

Table 4-3 describes the allocations in the foreground system of this LCA and how they have been handled. The background system of the LCA has used ecoinvent 3.5 which applies economic allocation throughout the database.

Table 4-3 Co-production in the LCA Foreground and Allocation Used

Process	Determining Product	Co-Product	Allocation Approach Used
Gas extraction at well, Browse	Natural gas for pipeline to shore	Condensate	Energy allocation uses as both products represent raw input to energy supply chains.
Natural gas processing at KGP	Natural gas	Propane and Butane	Energy allocation uses as both products represent raw input to energy supply chains.
Natural gas processing at KGP	Liquefied natural gas	Domestic gas	Energy allocation used allocation between LNG and domestic gas
Natural gas processing at Pluto	Liquefied natural gas	Domestic gas	Energy allocation uses as both products represent raw input to energy supply chains.

The background database from ecoinvent contain multi-functionality and by default this is dealt with through economic allocation and in some instances physical allocation. For example, refineries include mostly allocation on energy production in the ecoinvent database. Given the dominance of the foreground results in this study (emissions from power generation technologies) the allocation choices for background databases have insignificant effect on the final results.

5. INVENTORY ANALYSIS

Figure 5-1 shows the different types of flows included in the life cycle inventory. These include flows to and from the environment as well as flows to and from other technical processes (the technosphere). A Life Cycle Assessment model is made up of linked unit processes which deliver the ultimate functional unit.

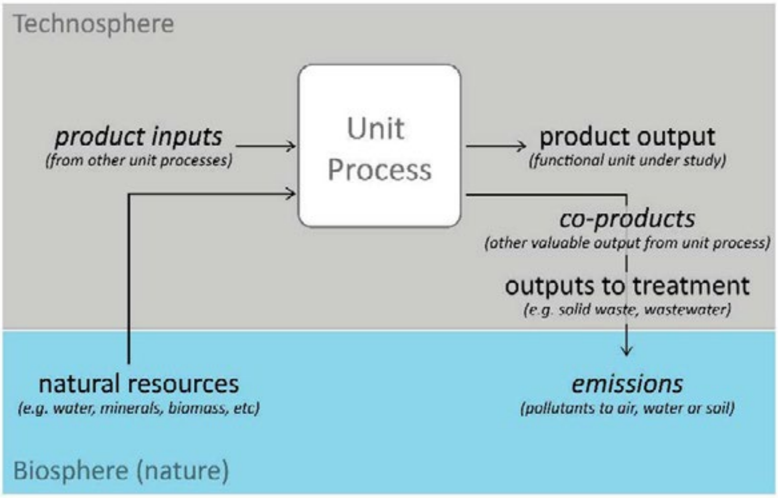


Figure 5-1 Inputs and Outputs of a Unit Process in LCA

The model representing the delivery of the functional unit is broken up into a series of unit processes. Unit processes can be categorised into foreground unit processes and background unit processes:

- Foreground processes are those for which specific data are collected for the study. They may include primary data collected from facilities; however, they can also include secondary data from published papers and modified background processes from LCA databases.
- Background processes are those for which data are typically sourced from pre-existing databases. Background data are either less important to the study outcomes or are already well-characterised in existing data sets and therefore do not warrant specific modelling. In some instances, background unit processes may be modified to better reflect the conditions of the study.

5.1 Foreground Data

The data for Woodside operations have been sourced from a mix of predictive internal technoeconomic models. This applies to extraction impacts, flares and fugitive emissions at the two new fields; historic operational data for LNG processing at Pluto and KGP (the existing processing plants which will be used for the new fields) and for shipping operations. All this data are projections for future production – with the existing facility operations being adjusted to align with the specific feedstocks from Browse and Scarborough. There is no technology adjustment into the future to account for improvements in LNG production technology. For Browse, there is a small ramp up at the start of the 2026 to 2040 period, while Scarborough has the same annual production throughout the 15 years of the analysis period.

5.1.1 Browse

The Browse development includes two Floating, Production, Storage and Offloading (FPSO) facilities (Calliance and Torosa), connected to the Browse reservoir subsea production wells via the Browse subsea raw gas gathering manifolds, flowlines and risers.

The FPSOs will process the raw well fluids into:

- condensate that will be stored on each facility and exported from there, and
- treated (dry) gas, which, for the two FPSOs following partial removal of reservoir CO_2, will be compressed and exported via a common for the two FPSOs subsea pipeline to the Karratha Gas Plant (KGP), located on the Burrup Peninsula.

Part of the raw gas, following treatment, will be used at the FPSOs as fuel for the export compressor gas turbines and the gas turbine generators, used for electricity generation.

Following arrival at the KGP, Browse gas will be split into two main streams:

- feedstock for domestic gas, and
- feedstock for the LNG Trains 4 and 5.

The LNG feedstock stream is additionally treated to remove residual reservoir CO_2 (acid gas), mercury and water and further processed to produce:

- liquefied natural gas (LNG),
- liquefied petroleum gas (LPG) and fuel gas for the LNG compressor gas turbines and gas turbine electricity generators.
- Acid gas, dominated by reservoir CO_2, but also containing residual quantities of CH_4, BTEX and H_2S is either vented or combusted into the KGP Thermal Oxidiser (TO).

Small quantities of processed gas from various parts of the processing plants, both offshore and onshore, are periodically flared following process upset events or preparation for maintenance through the FPSOs' and the KGP's flares.

A high-level Browse gas processing and energy flow diagram relevant to this study is summarised in **Figure 5-2**. The boxes on the left of the page represent the offshore FPSOs, whilst the box on the right represents the KGP.

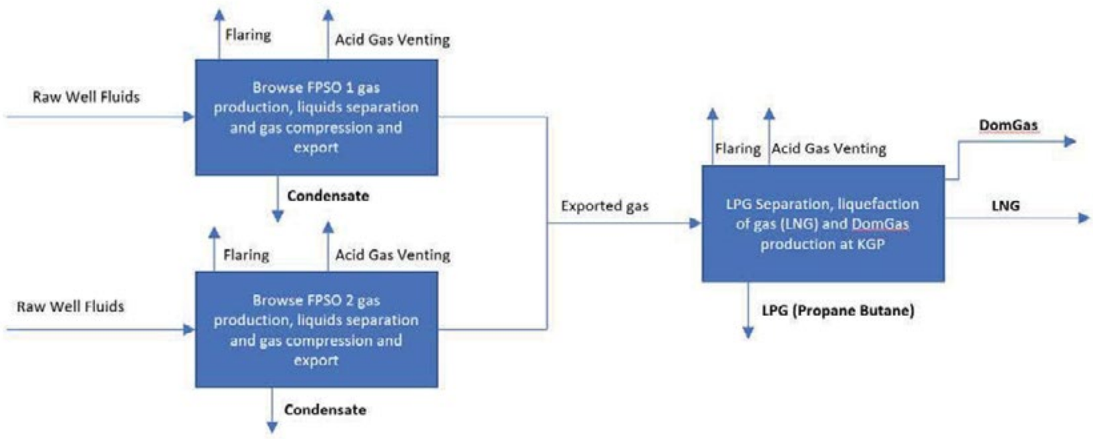


Figure 5-2 Structure of Browse LNG Production Process

The inputs and emission for production of gas at the Browse FPSOs gas field and processing at KGP are provided in Appendix B.

5.1.2 Scarborough

The Scarborough development will involve subsea, high-rate gas wells, tied back to a semi-submersible floating production unit (FPU). The raw gas, containing very small quantities of hydrocarbon liquids, will be treated to separate those liquids and produced water at the FPU and then compressed and transported along an approximately 430 km long pipeline to the Pluto LNG Plant on the Burrup Peninsula.

The production capacity of the Pluto LNG Plant, currently representing a single 5 Mtpa LNG train, will be expanded with a future 5 Mtpa LNG train, dedicated primarily to processing the exported gas stream from the Scarborough FPU. A gas equivalent of 1.65 Mtpa LNG will be processed through the existing Train 1 of the Pluto LNG Plant, whilst a gas equivalent of 4.85 Mtpa LNG will be processed through the future Train 2.

Scarborough gas will also be used to produce the equivalent of 1 Mtpa domestic gas (domgas), which will be processed to achieve the required export specification for the Dampier to Bunbury Natural Gas Pipeline.

Figure 5-3 presents a high-level gas processing and energy flow diagram for the Scarborough gas, showing the offshore FPU facility to the left and the two Pluto LNG Trains to the right. Pluto Train 1 and Train 2 are shown as two separate processing facilities due to their different emissions intensities / energy efficiencies.

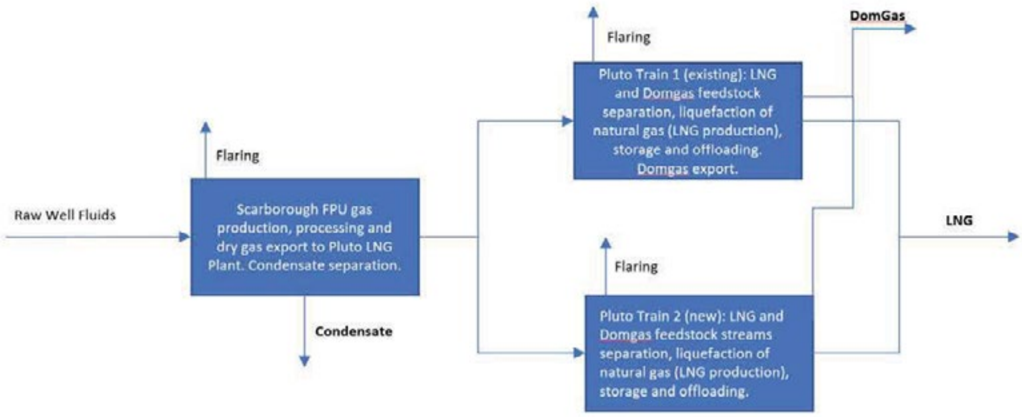


Figure 5-3 Structure of Scarborough LNG Production Process

The inputs and emissions for production of gas at the Scarborough gas field and processing at Pluto gas processing plant are provided in Appendix B.

5.1.3 Gas Compression and Gas Turbine Electricity Generation

The majority of energy inputs to processing gas offshore and onshore is through the use of the available natural gas being combusted in gas turbines to drive both gas compressors and electricity generation.

Specific facility data have been used for Nitrogen oxides, Sulphur oxides, Non-methanic volatile organic compounds (NMVOC) and particulate matter are all sourced from equipment specifications provided by Woodside.

The CO_2 emissions are based on emission factors specific to Browse and Scarborough gas based on gas composition. Methane and nitrous oxide emissions are default values from the National Greenhouse Accounts Factors (2019). The emissions associated with the materials and manufacture of the equipment are based on ecoinvent data[4]. The emissions from compressors and electricity generation for onshore and offshore processes are detailed Appendix B.

5.1.4 LNG shipping

LNG shipping is operated by third party from Woodside. A complete fuel and emissions data set has been provided which has been used to calculate the impacts of shipping. The shipping data is converted into freight task unit: “tonne kilometer” and then multiplied by the distance of the trip and the mass of LNG being transported. The detailed emissions data for shipping are listed in Appendix B

5.1.5 Regasification

Regasification is the process of converting liquefied natural gas into gaseous form in the distribution network of the importing country. The regasification data have been sourced from ecoinvent global databases 3.5 (Weidema, Bauer et al. 2018) and is based on data for regasification in Japan. This has been used for all regions, as no other data are available for the other regions being assessed. Appendix B lists the specific inputs and emissions data for regasification

5.1.6 Gas Transmission

Gas Transmission is assumed to be high pressure transport of gas, and not include lower pressure distribution networks.

The data have been sourced from ecoinvent global databases 3.5 (Weidema, Bauer et al. 2018) and data from Japan have been used for all regions as specific data for other regions assessed is not available.

5.1.7 Electricity Generation

Electricity generation technologies are well represented in LCA database having been studied for many years and often representing the majority of impact in any LCA study. For this study we stop at the generation point for all fuels and don’t include transmission and distribution of electricity to end users.

The majority of background data was sourced from ecoinvent 3.5. This source includes datasets for natural gas and electricity in each of the following regions - Japan, China, India as well as for global supply of electricity. For ASEAN region, not all countries are represented so Indonesian processes were used as a proxy for ASEAN region after adjusting the thermal efficiency of each technology to figures published by IEA. The only exception was for hard coal in ASEAN region where the process was based on the ecoinvent process for electricity from Malaysian hard coal, adjusting the thermal efficiency to match the IEA data for ASEAN region. **Table 5-1** lists the ecoinvent inventory processes used for thermal electricity generation processes. Appendix C lists all generation processes used in the grid mixes for each country / region.

The data for electricity generation from LNG are the same as the data used for other natural gas because once LNG is regasified into the local transmission networks, there is no discernible difference between LNG sources natural gas and other sources. For countries where the energy generation data are broken down into regions (China and India) each generation technology was assessed across all regions for climate change impact, and the median region was selected.

[4] Electricity, medium voltage [DE}| natural gas, burned in gas turbine, for compressor station | APOS, U

For the global model a generation process was selected for coal oil and gas, based on the median climate change impact of all available generation processes in ecoinvent. Note that this may be a poor representation of average technology for the non-greenhouse gas emissions, but was considered acceptable considering that the global model used in calculating the overall benefits of LNG exports.

Table 5-1 Ecoinvent Inventories Selected for Fossil Fuel Power Generation for each Country/Region

Region	Fuel	Unit Process Name in Simapro Ecoinvent APOS Library
ASEAN	Hard coal	Electricity, high voltage [MY}| electricity production, hard coal | APOS, U
China	Hard coal	Electricity, high voltage {CN-GZ}| electricity production, hard coal | APOS, U
Global	Hard coal	Electricity, high voltage [CN-GS}| electricity production, hard coal | APOS, U
India	Hard coal	Electricity, high voltage [IN-MP}| electricity production, hard coal | APOS, U
Japan	Hard coal	Electricity, high voltage [JP}| electricity production, hard coal | APOS, U
ASEAN	Natural gas	Electricity, high voltage [ID}| electricity production, natural gas, combined cycle power plant | APOS, U
China	Natural gas	Electricity, high voltage [CN-GX}| electricity production, natural gas, combined cycle power plant | APOS, U
Global	Natural gas	Electricity, high voltage [IN-GJ}| electricity production, natural gas, combined cycle power plant | APOS, U
India	Natural gas	Electricity, high voltage [IN-KL}| electricity production, natural gas, conventional power plant | APOS, U
Japan	Natural gas	Electricity, high voltage [JP}| electricity production, natural gas, combined cycle power plant | APOS, U
ASEAN	Oil	Electricity, high voltage [ID}| electricity production, oil | APOS, U
China	Oil	Electricity, high voltage [CN-GZ}| electricity production, oil | APOS, U
Global	Oil	Electricity, high voltage [CA-QC}| electricity production, oil | APOS, U - GLO
India	Oil	Electricity, high voltage [IN-TN}| electricity production, oil | APOS, U
Japan	Oil	Electricity, high voltage [JP}| electricity production, oil | APOS, U

5.1.8 Generation Efficiencies

The thermal efficiency of power generation from natural gas was adjusted to reflect the energy efficiency values derived from IEA data for each year and each region. For natural gas, this efficiency value was representative of all natural gas power generation which would include a mix of gas turbines and combine cycle gas turbine power plants. Therefore, the inventory represented a mix of natural gas electricity generation technologies defined by the overall thermal efficiency. This efficiency changed over the study period (2026-2040), and this change was included in the calculation of the year by year impacts of power generation. A similar, technology-specific change in efficiency over time was also used for coal and oil-based electricity generation in each region.

Table 5-2 shows the original efficiency of the selected inventories and the efficiency range used in the LCA study. Some of the inventories, such as Chinese natural gas, have lower efficiencies than the range quoted by IEA. This may be because of the difference of approximately 10 years from when the inventory data were collected and the start of the study period. There is a similar discrepancy with coal-based electricity in India which currently is listed to have a very low efficiency compared with the IEA range. This may reflect an expected investment in more efficient power plants and India over the coming 20 years.

The IEA quoted efficiency for electricity from oil is very low, however the amount of electricity from oil in China in these years is insignificant and this does not materially affect the results.

Power generation from LNG is based on the natural gas power generation inventories adjusted to account for slight differences in energy content of gas from LNG compared to the gas reported in the ecoinvent inventory.

Emission control from power generation processes was not modified beyond the changes to overall efficiency of the power plant. Unfortunately the IEA datasets do not project emission control equipment and the effects of that equipment into the future.

The remaining energy technologies such as renewables and nuclear were based on current production with no change in efficiency with time. The overall impact of these technologies are influenced more by the impacts from capital equipment and typically have much lower impacts per kWh than fossil-based power generation systems.

Table 5-2 Original Thermal Efficiency, Efficiency Range in Study and Energy Content of Selected Fossil Fuel Power Generation Inventories

Region	Fuel	Original Efficiency	Efficiency Range in Study Based on IEA Data	Energy Content LHV[1]
ASEAN	Hard Coal	31.50%	36%-38%	22.8
China	Hard Coal	33.00%	35%-38%	22.8
Global	Hard Coal	33.00%	35%-38%	22.8
India	Hard Coal	23.70%	38%-40%	19.3
Japan	Hard Coal	39.80%	37%-44%	24.1
ASEAN	Natural Gas	42.70%	46%-52%	39
China	Natural Gas	33.00%	42%-51%	39
Global	Natural Gas	46.50%	44%-48%	33.1
India	Natural Gas	33.00%	47%-55%	33.1
Japan	Natural Gas	56.40%	52%-59%	39
ASEAN	Oil	28.40%	28%-34%	38.5
China	Oil	33.00%	1%-10%	38.5
Global	Oil	32.30%	27%-33%	38.5
India	Oil	25.80%	26%-28%	31.3
Japan	Oil	40.10%	43%-47%	31.7

1 Energy content is in MJ/m^3 for natural gas, and MJ/kg for oil and hard coal and all are source from ecoinvent database version 3.5 (Weidema, Bauer et al. 2018) documentation.

5.1.9 IPCC Emission Factors compared with Ecoinvent

Developed from broad studies of available scientific literature, the Intergovernmental Panel on Climate Change (IPCC) assessments of emission intensities for different energy sources remain a reliable open-source benchmark. In 2014, the IPCC updated its findings as part of the Working Group III contribution to the IPCC Fifth Assessment Report, published the same year. While IPCC is a respected source, its published numbers are not sufficiently disaggregated to model electricity generation in each country with all the nuances of fuel type, supply chains for fuel import and processes and technology types.

For the purposes of this study, using ecoinvent emission intensities provides for more accurate analysis. Ecoinvent uses the same emission factors, or more likely the same underpinning sources as the IPCC, but does it on a per MJ fuel basis, rather than per kWh of electricity generated. This enables the modelling approach to account for efficiency differences, etc. Comparing the underlying factors in ecoinvent for direct emissions from coal, they are very close to the IPCC values. The ecoinvent number is a weighted average of a selection of countries and technologies which may affect particularly the non-CO_2 emissions. **Table 5-3** shows the comparison of ecoinvent and IPCC coal emission factors, and demonstrates a high level of consistency between the two sources. A similar consistency across other fuel emission factors can be observed between ecoinvent and IPCC factors.

Table 5-3 Comparison of Ecoinvent and IPCC Coal Emission Factors

	Ecoinvent	IPCC
CO_2	95.5 kg/ GJ	95.8 kg/ GJ
CH_4	0.902 g/ GJ	0.73 g/ GJ
N_2O	1.1 g/GJ	1.32 g/ GJ
Total	95.9 kg CO_2e	96.2 kg CO_2e

5.1.10 Electricity Grids

Each electricity grid modelled for the different scenarios is based on data from the IEA policy scenarios (International Energy Agency 2018). The ecoinvent database version 3.5 was also used to model each individual technology which make up the average country grid. For each region, ecoinvent supplies data for the most common electricity production processes such as coal, oil and gas. However, there is not a dataset for every energy generation type for every region. In this case, proxies have been used when a country was not covered in ecoinvent.

Technology mixes in renewable energy systems (for example between small- and large-scale wind power) were maintained in current ratios to each other. The IEA forecast grid data were disaggregated by region/country and by year, between 2026-2040. Each annual grid mix was calculated and matched to the efficiency values mentioned in the last section. The results from each set of annual data were summed to produce average results across the 15-year timeframe from 2026-2040.

5.2 Background Data

5.2.1 Infrastructure

Infrastructure is required at every point of the gas production process. The infrastructure included material impacts, transport of materials to site, installation, maintenance and eventual disposal. The infrastructure has a long lifetime, is sometimes reused from prior operations and may be used after the project timeframe for future operations. Because of this, infrastructure inputs have not been developed from the Browse or Scarborough project proposals but have used background models on oil and gas infrastructure models supplied with the ecoinvent database (ecoinvent 3.5, allocation at the point of substitution version).

The three processes used include:

- Natural gas processing plant production (Pluto, KGP, Regasification plant);
- Offshore platform production, natural gas (Browse, Scarborough);

- Pipeline construction, natural gas, long distance, high capacity, offshore (Pipelines from Browse to KGP and Scarborough to Pluto).

Table 5-4 shows the characteristics of the infrastructure models from ecoinvent. The plant data are apportioned to Woodside processes on a per GJ of gas production equivalent to the scale of the original processes. For the pipeline process based on the length of the pipeline so this is modelled directly to the required pipeline distance used and then annualised by dividing the pipeline length but the assumed life of the pipeline which is 45 years.

Table 5-4 Infrastructure Models used from Ecoinvent Data

Process	Assumed Life	Size of Facility	Origin
Natural gas processing plant	60	4.23 billion Nm^3 per year	Gas treatment plants in Norway
Pipeline construction, natural gas, long distance, high capacity, offshore	45	1.6 Mio. Nm^3 gas per hour, 1000 metre diameter, steel 25mm, concrete 100mm.	Average Norwegian North Sea pipeline
Offshore platform production, natural gas	11	27.7 Mrd. Nm^3 natural gas per year	Platform Odin, which belonged to Esso Norway.

6. STUDY RESULTS AND ANALYSIS: CLIMATE CHANGE

6.1 Climate Change Results

6.1.1 Comparison against IEA Scenarios

The IEA scenarios consider energy used in all its forms, e.g. in power generation, heating (e.g. residential domestic gas supply), automotive power etc. This study examines the role of LNG as a competitor to other forms of energy in the power generation sector in the four target markets.

From a power sector emissions intensity perspective, Asia Pacific markets are generally ‘high carbon’, featuring a large share of coal in the overall fuel mix. Under the IEA STEPS outlook, adding gas from Browse or Scarborough to the power mix is expected to lead to a decline in CO_2e emissions intensity in each market under consideration, to at least 2040.

Under very low carbon scenarios (IEA’s SDS), Browse and Scarborough gas may play a significant role in the target markets, supporting the shift away from coal, and the build-out of intermittent renewable generation. Under the SDS, total gas demand in the target markets grows by over 60% between 2020 and 2040, while the emissions intensity of total primary energy demand (TPED) falls by more than half over the same period. Therefore, the success of achieving a lower-carbon outcome as described by the SDS is in fact predicated on the increased use of gas in the target markets. The proximity of Browse and Scarborough to these markets represents a competitive advantage versus LNG from, for example, the Middle East or the US Gulf Coast.

6.1.2 Comparative Emissions under Specific Grid Mixes

To demonstrate how Browse and Scarborough-sourced gas would compare to other sources of generation in the power markets under consideration, it is necessary to show climate change impacts under three specific grid mixes:

- **Fossil fuel mix.** Defined as the emissions intensity of the power market under study, which accounts only for fossil fuel power sources. This comparator is considered the baseline for this study, and has been applied for all three IEA scenarios, reflecting most realistically how gas will compete in the target markets. Gas-on-renewables competition is considered to be limited, due to policy support and falling costs for renewables under the STEPS and especially the SDS, and the limited presence of renewables under the CPS. Imported fossil energy remains essential to satisfy growing demand; gas-on-gas competition is implicit in this comparison.
- **Average mix.** This is defined as the average emissions intensity of a more diversified power market, which includes all fuels, including fossil, renewables and nuclear. This comparator demonstrates the impact of the changing balance of power generating sources through time, which will tend to reduce overall grid intensity as lower-carbon power grows in market share.
- **Coal only mix.** The emissions intensity of the coal-only section of the power market under study. This comparator is included to represent direct gas-to-coal competition. New gas fired generation has competed directly with coal in Europe and the USA, and switching from coal to gas is one of the most robust methods to reduce the emissions intensity of power generation.

6.1.3 Regional Trends over Time

The trends in climate change impacts over time are shown in **Figure 6-1** for electricity produced from LNG sourced from Browse and Scarborough and delivered to China, as well as the results for average, fossil fuel, and coal only grid mixes in China, as described by the IEA policy scenarios between 2025 and 2040. These results are shown**,** Japan in **Figure 6-2**, the ASEAN region in **Figure 6-3,** for India in **Figure 6-4** and globally in **Figure 6-5.**

6.1.3.1 China

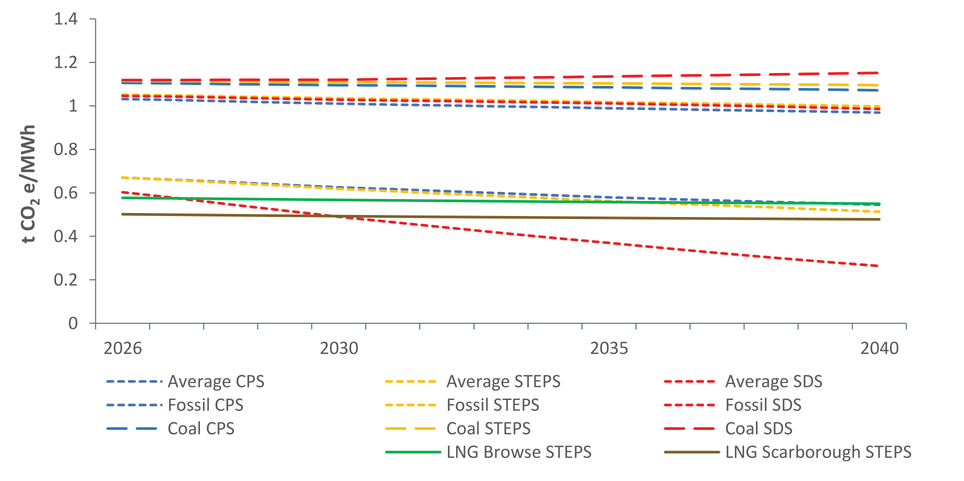


Figure 6-1 Climate Change Comparison of Electricity from LNG and IEA Energy Scenarios in China[5]

The data illustrates the as-yet relatively undifferentiated nature of the Chinese power market. Unsurprisingly, coal only emissions intensity is highest, and trends down only marginally through time as plants become more efficient.

China's fossil fuel emissions intensity is marginally lower than the coal only trend. This shows that diversification within the fossil component of the power fleet is at an early stage – gas generation has a lot of upside and opportunity to take market share from coal. China's fossil power emissions intensity is also approximately double that of gas from Browse or Scarborough indicating LNG from the two developments will provide an emissions intensity benefit when competing with coal, or China's fossil mix, under any scenario.

The average grid mix tells a different story. Here, China's build-out of nuclear, hydro, gas and renewable power is evident in pulling down the emissions intensity of the grid to below 0.7 tCO_2e / MWh by 2026 under the CPS and STEPS scenarios. By this time, a rapid push for clean energy has pushed the SDS average grid emissions intensity to below 0.6 t CO_2e / MWh. Browse and Scarborough-derived power nevertheless undercuts China's average emissions intensity until the mid-2030s, under the CPS and STEPS scenarios. Beyond this point, while the emissions intensity of gas is above the average, it continues to have displacement potential for higher emissions intensity fuels still present in the mix. In the SDS, a goal-driven scenario, which is consistent with a <2°C climate outcome, gas necessarily occupies a significant portion of the energy mix in order to minimise the overall power grid emissions intensity.

[5] For LNG from Browse and Scarborough only the STEPS scenario is shown as the changes under different scenarios are very small for LNG electricity making it not practical to represent them on these graphs. Results were calculated under CPS and SDS scenarios which we use for calculating the overall avoided emissions for each policy scenario.

6.1.3.2 Japan

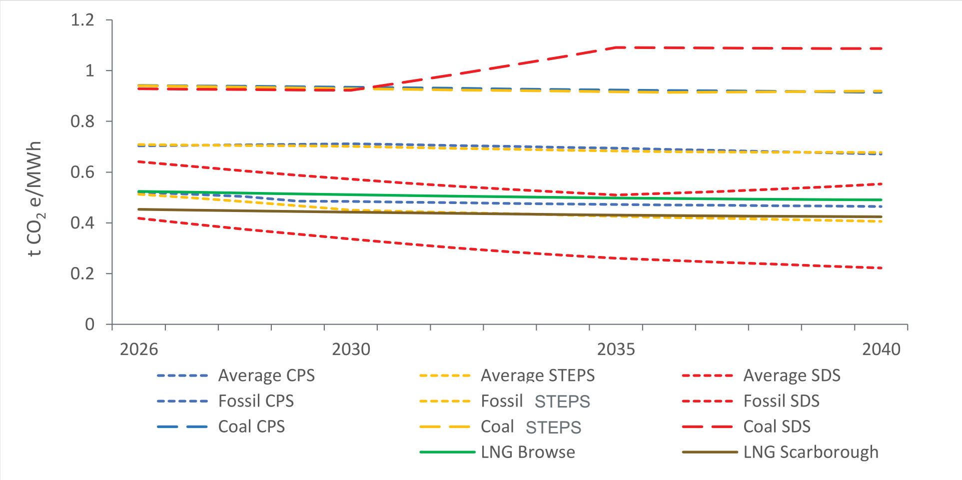


Figure 6-2 Climate Change Comparison of Electricity from LNG and IEA Energy Scenarios in Japan

Results for Japan **Figure 6-2** show again the split between intensities for coal only and fossil fuel generation. The kink in the SDS coal line is an artefact of IEA data inconsistencies[6].

Under the SDS, coal-fired generation is at its lowest across all scenarios in 2040 in absolute terms, but its share of the fossil mix does increase between 2035 and 2040, from 7% to 13%. This explains the differing trajectories of the SDS and STEPS/CPS fossil fuel intensities, and the rebound shown in the chart between 2035 and 2040 for the SDS line. As coal increases its relative share in the fossil mix under the SDS, the emissions intensity of that mix also increases.

Market peculiarities aside, the chart illustrates that Browse and Scarborough gas compete favourably on emissions intensity on a coal only or fossil fuel basis. At first glance, the existence of oil in the power mix may suggest headroom for gas which no longer exists in other developed power markets. But Japan is a low-growth market overall, and any new market entrants will almost certainly be competing directly against existing gas.

By the mid-2020s some of Japan's nuclear fleet will have come back on line post Fukushima. This, and along with significant growth in renewable energy, is stark under the SDS, where gas-fired power drops by half in the years to 2040.

[6] In the Sustainable Development Scenario for Japan, CO_2 emissions for coal-fired power drop off much more sharply than the fall in coal-fired power output. In the case of Japan, emissions fall from 66 million tonnes to 2 million tonnes over 5 years, while power output drops from 17 to 4 TWh. This pulls down the CO_2 emissions intensity of combustion. But the data represented in the charts for Japan and China also include emissions from extraction, processing, shipping, etc. As coal demand falls, this 'upstream' share of the emissions burden becomes proportionally much larger than the combustion share (the reverse is true under normal circumstances). This then acts to drive up coal's emissions intensity, in this scenario only.

6.1.3.3 ASEAN

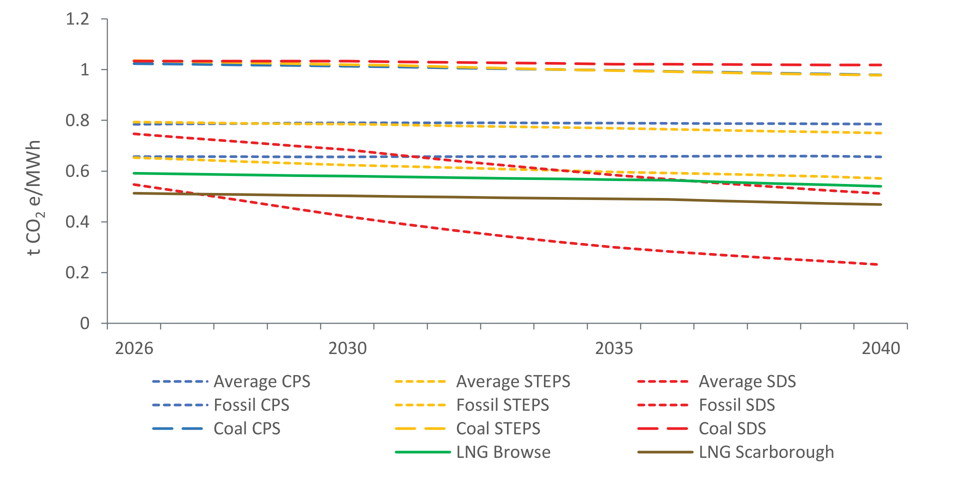


Figure 6-3 Climate Change Comparison of Electricity from LNG and IEA Energy Scenarios in ASEAN Region

Collectively, the ASEAN markets[7] **Figure 6-3** follow a path very similar to that illustrated by India (**Figure 6-4**). Coal to gas switching is dramatic under the SDS, with a commensurate effect on the emissions intensity of the power sector. In fact, this is a sufficient switch from coal to gas to push the emissions intensity of the SDS fossil grid below that of Browse LNG before 2040.

Coal emissions intensity is high and stable throughout all three scenarios. From a fossil fuel mix perspective, differences between the CPS and STEPS scenarios are relatively small. Coal and gas demand grow from 2026 to 2040, and, as in India, the final share of the fuels in the power mix is broadly similar across the two scenarios.

Under the SDS, power sector coal demand is less than one tenth of 2040 demand under the CPS, and gas demand is at approximate parity across the scenarios, in absolute terms. Again, as in India, fossil fuel emissions intensity falls dramatically in this scenario, dropping even below the average emissions intensity under the STEPS and CPS scenarios.

6.1.3.4 India

As in other markets, coal emissions intensity in India is high throughout all three scenarios, **Figure 6-4**. From a fossil fuel mix perspective, differences between the CPS and STEPS scenarios are relatively small. Coal demand grows from 2026 to 2040, as does gas, but the final share of the fuels in the power mix is approximately the same across the two scenarios, explaining the close parallel emissions intensity trajectories.

Under the SDS, 2040 coal demand in India's power sector is pushed down to approximately one tenth of CPS demand. Meanwhile, 2040 SDS gas demand is approximately double the CPS, in absolute terms. As a result, fossil fuel emissions intensity falls dramatically under the SDS, dropping even below the grid average emissions intensity under the CPS.

[7] The ASEAN region includes the following ten countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam

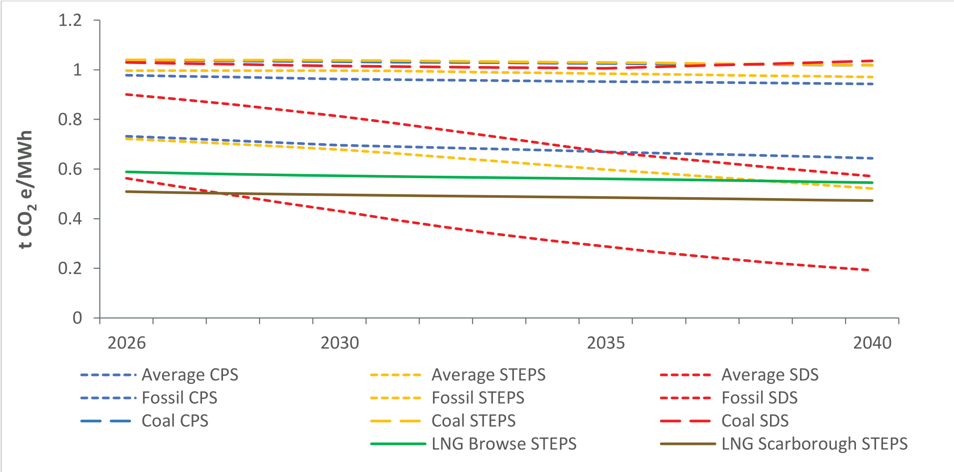


Figure 6-4 Climate Change Comparison of Electricity from LNG and IEA Energy Scenarios in India

On an average grid basis, this opportunity remains clear, under the CPS and STEPS scenarios at least: Browse and Scarborough gas will help to reduce emissions through to 2040. It is only under the SDS – where the sharp drop in coal is accompanied by a booming renewables market – that average emissions intensity falls below that of gas-fired power before 2030. But given that Browse and Scarborough-sourced power is likely to compete against the broad fossil mix, or directly with coal, there is a compelling case for its place in India's electricity mix.

6.1.3.5 Global

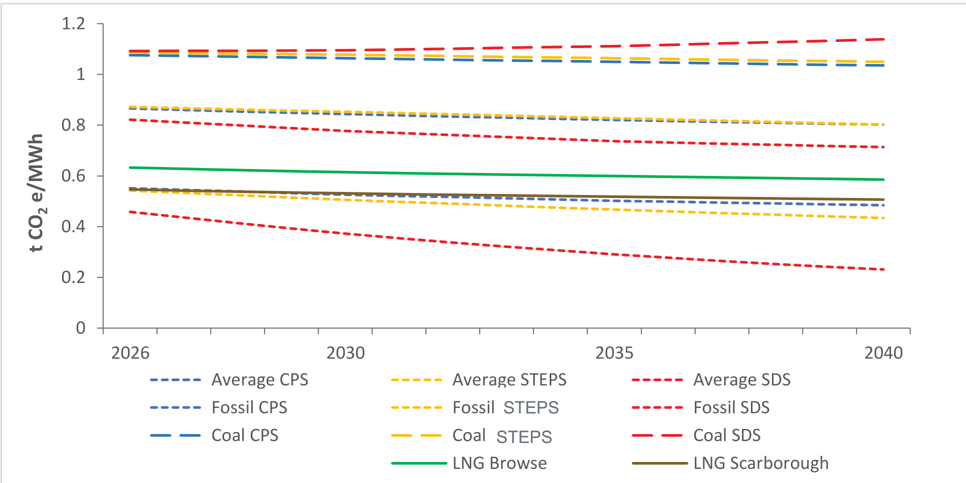


Figure 6-5 Climate Change Comparison of Electricity from LNG and IEA Global Energy Scenarios

Clearly, the idea of a 'global' market is somewhat misleading in terms of where Browse and Scarborough-sourced power will compete. However, the analysis **Figure 6-5** allows consideration of where the various Asia Pacific markets place in terms of the global average, and by implication describes some features of the European and American power markets.

On a coal only basis, emissions intensity is unsurprisingly high. In fact, the trajectories of the coal only lines are very similar to those seen in China, as a result of the predominance of that country in the global coal-fired power fleet.

The fossil fuel mix demonstrates the importance of gas in reducing the burden of emissions from coal. Compared to all other Asia Pacific markets except China, the emissions intensity of the global fossil mix in 2040 is within a close range, indicating a likely global convergence in terms of coal / gas balance in power markets towards the end of the outlook period.

For the grid average, however, global emission intensities are lower than all Asia Pacific markets, except Japan. This would suggest a higher penetration of renewables in the European and American power systems. Grid emission intensities in these markets are likely to be among the lowest in the world.

6.1.3.6 Long-term Average Emission Intensities

Comparison of Long-term Average Emission Intensities is shown in **Table 6-1** and describes the emission intensities of electricity produced from Browse and Scarborough LNG in each region compared to the grid-average, fossil fuel and coal only grids under the three different IEA scenarios. The data show that power sourced from fossil fuels – the baseline comparator – has a greater emissions intensity than power derived from Browse and Scarborough LNG, for all scenarios in all regions. Power sourced from coal still has a greater emissions intensity.

Compared to average grids, which factor in lower-carbon power sources including renewables and nuclear as well as gas, power derived from Browse and Scarborough LNG retains its emissions advantage over the 15 year average in China, Japan, ASEAN and India for the CPS and STEPS scenarios. The average grid under the SDS shows a lower emissions intensity (and therefore emissions output) than power sourced from Browse or Scarborough LNG.

Table 6-1 Emission Intensities in t CO_2e/MWh Averaged from 2026 to 2040 for Different Markets and under Three Policy Scenarios

	CPS Av.	STEPS Av.	SDS Av.	CPS Fossil	STEPS Fossil	SDS Fossil	CPS Coal	STEPS Coal	SDS Coal	Browse	Scarb.
China	0.60	0.59	0.42	1.00	1.03	1.03	1.09	1.11	1.13	0.56	0.49
Japan	0.48	0.44	0.30	0.70	0.69	0.57	0.93	0.92	1.01	0.50	0.44
ASEAN	0.66	0.61	0.36	0.79	0.77	0.64	1.00	1.01	1.03	0.57	0.49
India	0.68	0.63	0.35	0.96	0.99	0.76	1.03	1.03	1.02	0.57	0.49
Global	0.51	0.48	0.33	0.83	0.84	0.77	1.06	1.07	1.11	0.61	0.52

6.1.4 Avoided Emissions – 2026 to 2040

It is possible to assess the potential impact Browse and Scarborough gas would have on the global total emissions burden over the 2026 to 2040 time period, should the gas be used to generate electricity in the target markets. The following assumptions are factored into this assessment:

- Gas volumes from both Woodside developments are delivered to China (31% of total), Japan (24%), ASEAN (27%) and India (19%), from 2026 to 2040. This distribution of trade is based on IEA net import projections for the target markets in 2040, taken from the 2019 WEO, since it is uncertain where the gas will actually be sold. This export split is not an indication of where the gas will be sold, or of the contracting strategy of Woodside or its Joint Venture Partners.

- Delivered gas volumes account for energy lost in the value chain between reservoir and power plant.
- Emission intensities account for non-combustion fossil CO_2 emissions e.g. from venting reservoir CO_2 and fugitive emissions during the LNG production process.
- Gas is used to generate electricity, with plant efficiency identical to the gas fleet average for the relevant market under each scenario.
- Each MWh of gas sourced from Browse or Scarborough displaces 1 MWh of fossil fuel-generated power from the markets under consideration.
- This fossil fuel-generated MWh is regarded as the baseline, with substitution benefits measured against this.
- The IEA's STEPS is regarded as the central case.

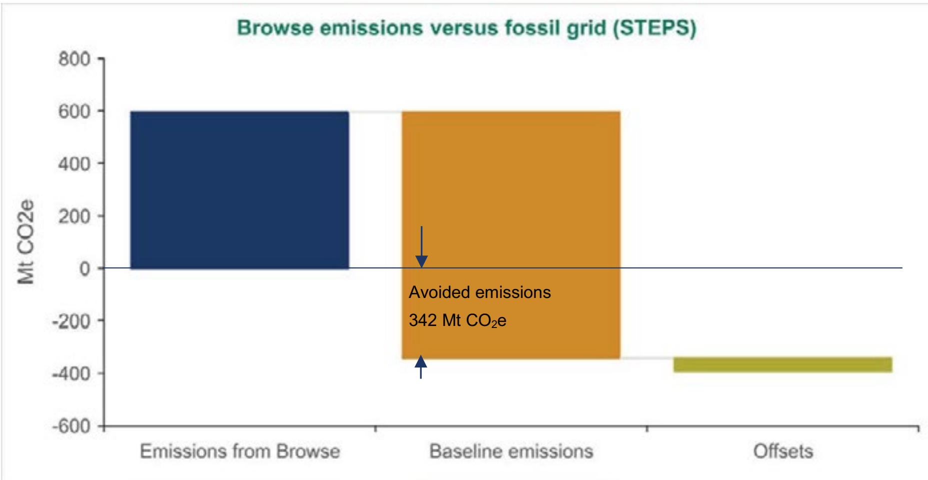
Figure 6-6 shows that Browse gas, if it is used to generate power in the target markets, will release between 591 Mt CO_2e and 595 Mt CO_2e over the 2026 – 2040 period, depending on the IEA power generation scenario.

If fossil fuels are used to generate power under STEPS, then emissions are much higher: 936 Mt CO_2e over the 2026 – 2040 period. Therefore, if Browse gas is used to generate power, then avoided emissions are 936 – 594 = 342 Mt CO_2e.

Under the CPS, the fossil balance of the power grids in the target markets is more biased towards coal relative to the STEPS. This is reflected in the emissions total: 945 Mt CO_2e from 2026 – 2040. If Browse sourced power displaces fossil power under the CPS, then avoided emissions are 354 Mt CO_2e.

The SDS shows a fossil grid with less coal than either of the other two scenarios. The SDS is a goal-driven scenario, meaning that the idea of gas 'competing' is not strictly valid, as gas is required to deliver emissions savings from coal and other high-emitting fuels. Nevertheless, should the same analysis be conducted as for the STEPS and CPS above, avoided emissions under the SDS are approximately 181 Mt CO_2e.

Figure 6-6 also takes into account the use of CO_2e offsets for Browse, which is Woodside's expectation of Browse's compliance obligations under the Australian Safeguard Mechanism Rules, as stated in the December 2019 Draft Browse to NWS EIS/ERD. Use of offsets effectively reduces emissions versus the baseline by a further 50 Mt CO_2e. Avoided emissions are therefore 392 Mt CO_2e under the STEPS, and 404 Mt CO_2e under the CPS. Should the same analysis be conducted for the SDS, avoided emissions would be 231 Mt CO_2e.



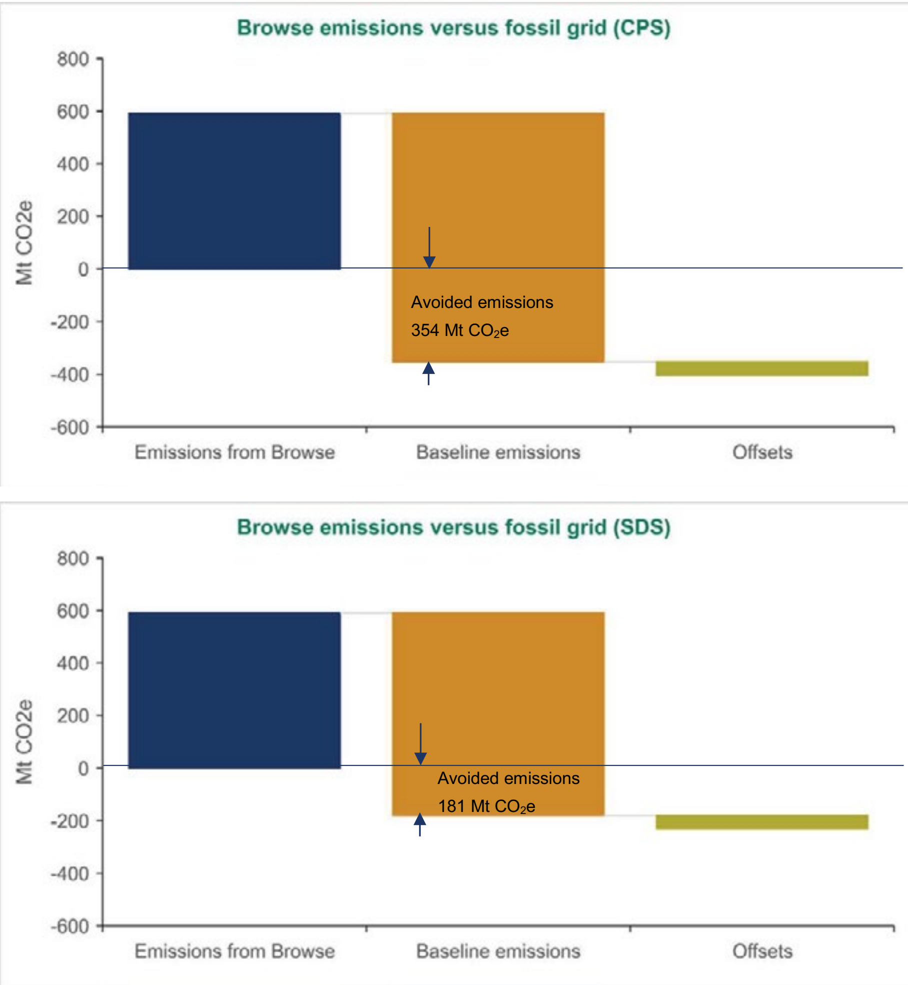
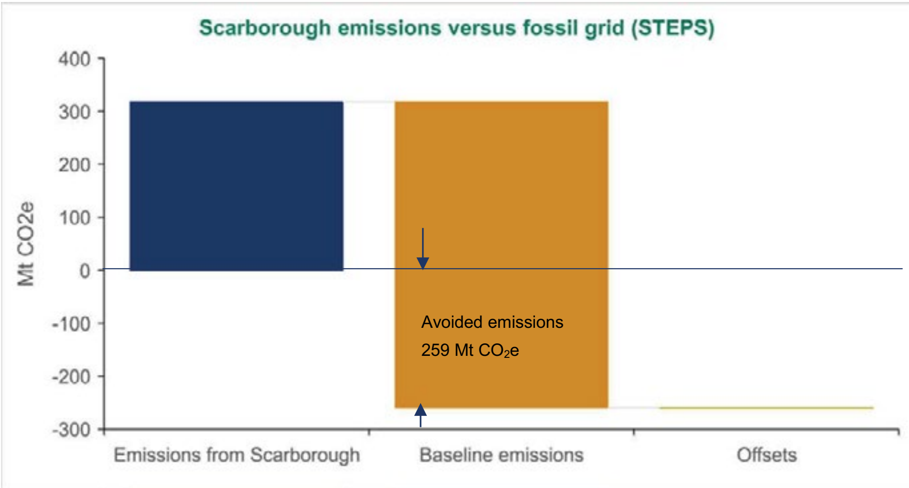
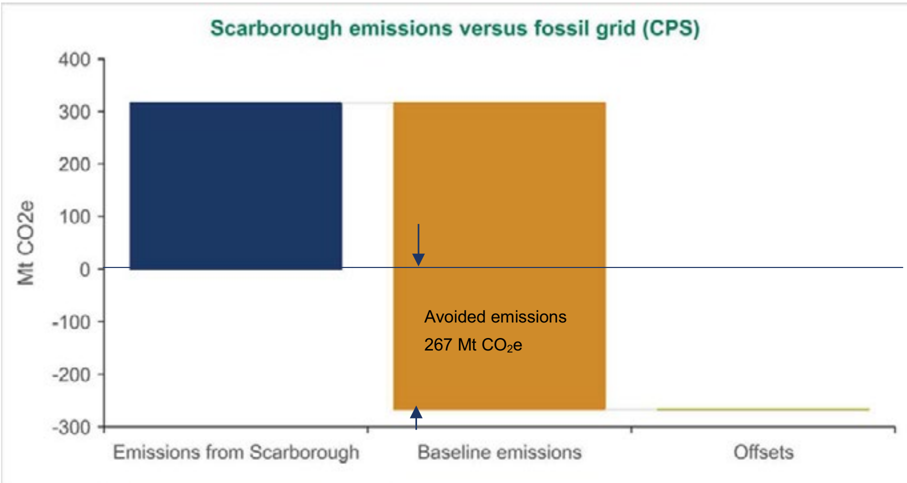


Figure 6-6 Emissions of Browse-Sourced Power versus Fossil Grid under IEA Scenarios

Figure 6-7 covers the impact of Scarborough-sourced power under the various scenarios. Due to the lower average emissions intensity of Scarborough gas versus Browse, and the lower delivered volumes from the project, emissions total between 316 Mt CO_2e and 318 Mt CO_2e over the 2026 – 2040 period. When displacing fossil-sourced power, avoided emissions are 259 Mt CO_2e under the STEPS, 267 Mt CO_2e under the CPS, and 165 Mt CO_2e under the SDS.

Figure 6-7 also takes into account the use of CO_2e offsets for Scarborough, to compensate for CO_2 vented at the field, as required by Pluto's environmental license condition. Use of offsets effectively reduces emissions versus the baseline by a further 0.2 Mt CO_2e under each scenario.


Scarborough emissions versus fossil grid (STEPS)
Mt CO2e
400
300
200
100
0
-100
-200
-300
Avoided emissions
259 Mt CO_2e
Emissions from Scarborough
Baseline emissions
Offsets


Scarborough emissions versus fossil grid (CPS)
Mt CO2e
400
300
200
100
0
-100
-200
-300
Avoided emissions
267 Mt CO_2e
Emissions from Scarborough
Baseline emissions
Offsets

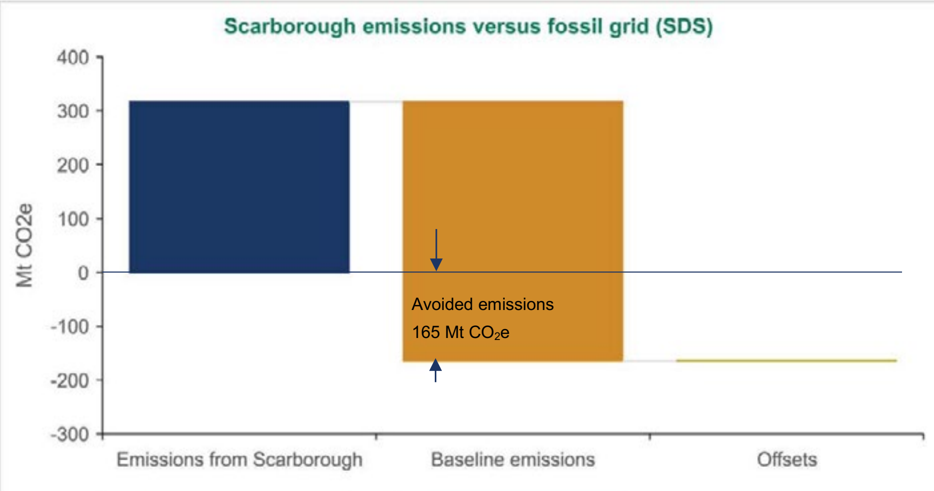


Figure 6-7 Emissions of Scarborough-Sourced Power versus Fossil Grid under IEA Scenarios

6.1.5 Emissions Intensity Results: Browse Versus Scarborough

Figure 6-8 show that the climate change impacts for producing 1 GJ of natural gas are higher for Browse (19.65 kg CO_2e) than for Scarborough (10.5 kg CO_2e) mainly due to the associated CO_2 venting at field and higher impacts from offshore gas processing. This compares reasonably with factors for domestic gas production in different states in Australia, which vary from 3.9 to 13.6 kg CO_2e (Department of Energy and Environment (2019)

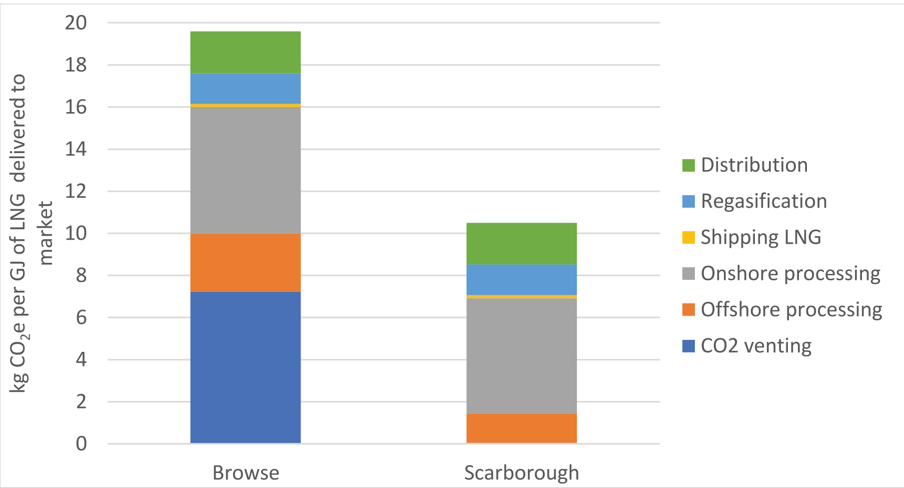


Figure 6-8 Climate Change Results for 1 GJ from Gas Distributed in China

Table 6-2 and **Figure 6-9** shows the impact of the same 1 GJ of gas but also includes its combustion in China. The upstream gas production processes account for 26% and 16% of the electricity climate change results for Browse and Scarborough respectively.

Table 6-2 Climate Change Results for 1 GJ of LNG from Browse and Scarborough Combusted in China

	Combustion	Distribution	Regasification	Shipping LNG	Onshore Processing	Offshore Processing	CO_2 Venting	Total
Browse kg CO_2e	56.10	1.99	1.46	0.15	6.02	2.74	7.24	75.70
Browse % of process	74%	2.6%	1.9%	0.2%	8.0%	3.6%	9.6%	
Scarborough kg CO_2e	56.10	1.98	1.46	0.15	5.47	1.39	0.05	66.60
Scarborough. % of process	84%	3.0%	2.2%	0.2%	8.2%	2.1%	0.1%	

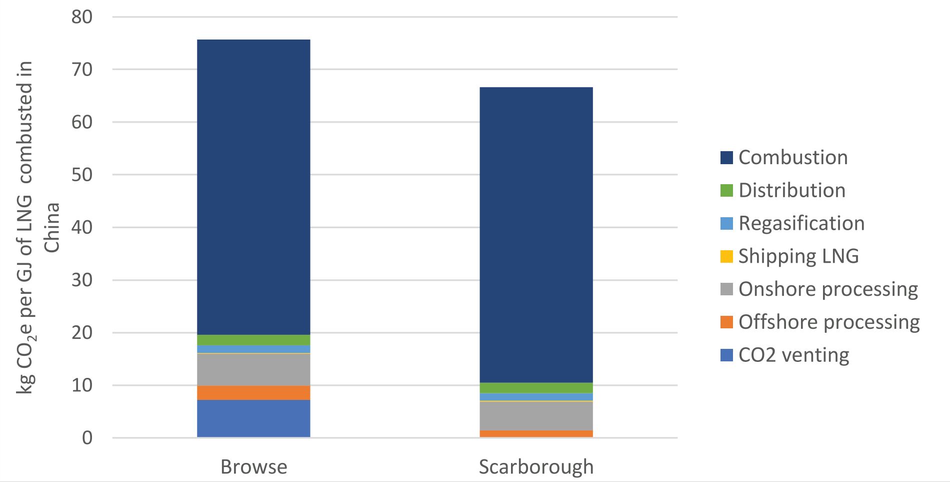


Figure 6-9 Climate Change Results for 1 GJ of LNG from Browse and Scarborough Combusted in China

6.2 Results: Other Impact Categories

Table 6-3 shows the results for electricity produced from fossil fuel portion of the grid and LNG sourced from Browse and Scarborough for all four regions, under the three different policy scenarios, averaged over the timeframe 2026-2040. **Table 6-4** and **Table 6-5** show the same results for a coal-based grid supply and an average grid supply from each region.

For particulate matter most results are an order of magnitude lower for LNG than competing grid mixes. Under the average grid comparisons, the difference is less in Japan and ASEAN regions where the advantage of LNG electricity is a factor four (four times lower) and factor two (half as much) respectively.

For photochemical smog, the results are mostly half that of the best performing grid mixes with only the average grid under SDS scenario in Japan and ASEAN region getting close to being equivalent of LNG.

For acidification LNG results are between half and a quarter of the impacts of average grid supplies in each region. When compared to fossil or coal grids mixes LNG is typically an order of magnitude lower.

Table 6-3 Results for 1 MWh Electricity from Browse and Scarborough LNG Compared to Fossil Grid Scenarios in China, Japan, ASEAN and India

Region	Unit	Climate Change t CO_2e	Particulate Matter g $PM_{2.5}e$	Photochemical Smog kg NMVOC e	Acidification mol H^+ e
China	CPS	1.00	1146	3.15	5.67
China	STEPS	1.03	1189	3.25	5.87
China	SDS	1.03	1149	3.18	5.70
China	LNG Browse	0.56	36	0.56	0.42
China	LNG Scarborough	0.49	36	0.46	0.40
Japan	CPS	0.70	222	1.68	4.03
Japan	STEPS	0.69	213	1.63	3.82
Japan	SDS	0.57	135	1.12	2.23
Japan	LNG Browse	0.50	24	0.51	0.37
Japan	LNG Scarborough	0.44	23	0.41	0.36
ASEAN	CPS	0.79	669	1.68	4.32
ASEAN	STEPS	0.77	631	1.62	4.10
ASEAN	SDS	0.64	394	1.18	2.71
ASEAN	LNG Browse	0.57	100	0.58	0.44
ASEAN	LNG Scarborough	0.49	100	0.47	0.42
India	CPS	0.96	715	2.65	4.90
India	STEPS	0.99	754	2.77	5.15
India	SDS	0.76	473	1.93	3.42
India	LNG Browse	0.57	37	0.67	0.52
India	LNG Scarborough	0.49	36	0.56	0.50

Table 6-4 Results for 1 MWh Electricity from Browse and Scarborough LNG Compared to Coal Grid Scenarios in China, Japan, ASEAN and India

Region	Unit	Climate Change t CO_2e	Particulate Matter g $PM_{2.5}e$	Photochemical Smog kg NMVOC e	Acidification mol H^+ e
China	CPS	1.09	1331	3.59	6.52
China	STEPS	1.11	1352	3.64	6.63
China	SDS	1.13	1383	3.73	6.78
China	LNG Browse	0.56	36	0.56	0.42
China	LNG Scarborough	0.49	36	0.46	0.40
Japan	CPS	0.93	353	2.58	6.89
Japan	STEPS	0.92	351	2.57	6.86
Japan	SDS	1.01	382	2.79	7.47
Japan	LNG Browse	0.50	24	0.51	0.37
Japan	LNG Scarborough	0.44	23	0.41	0.36
ASEAN	CPS	1.00	1082	2.40	6.67
ASEAN	STEPS	1.01	1085	2.41	6.69
ASEAN	SDS	1.03	1107	2.46	6.83
ASEAN	LNG Browse	0.57	100	0.58	0.44
ASEAN	LNG Scarborough	0.49	100	0.47	0.42
India	CPS	1.03	796	2.87	5.35
India	STEPS	1.03	798	2.88	5.37
India	SDS	1.02	788	2.84	5.30
India	LNG Browse	0.57	37	0.67	0.52
India	LNG Scarborough	0.49	36	0.56	0.50

Table 6-5 Results for 1 MWh Electricity from Browse and Scarborough LNG Compared to Average Grid Scenarios in China, Japan, ASEAN and India

Region	Unit	Climate Change t CO_2e	Particulate Matter g $PM_{2.5}e$	Photochemical Smog kg NMVOC e	Acidification mol H^+ e
China	CPS	0.60	687	1.92	3.44
China	STEPS	0.59	678	1.89	3.39
China	SDS	0.42	473	1.36	2.41
China	LNG Browse	0.56	36	0.56	0.42
China	LNG Scarborough	0.49	36	0.46	0.40
Japan	CPS	0.48	169	1.09	2.56
Japan	STEPS	0.44	156	0.97	2.21
Japan	SDS	0.30	102	0.55	1.07
Japan	LNG Browse	0.50	24	0.51	0.37
Japan	LNG Scarborough	0.44	23	0.41	0.36
ASEAN	CPS	0.66	540	1.35	3.82
ASEAN	STEPS	0.61	477	1.22	3.47
ASEAN	SDS	0.36	206	0.60	1.97
ASEAN	LNG Browse	0.57	100	0.58	0.44
ASEAN	LNG Scarborough	0.49	100	0.47	0.42
India	CPS	0.68	520	1.94	3.56
India	STEPS	0.63	491	1.82	3.35
India	SDS	0.35	243	1.00	1.74
India	LNG Browse	0.57	37	0.67	0.52
India	LNG Scarborough	0.49	36	0.56	0.50

7. INTERPRETATION

7.1 Sensitivity Analysis Climate Change

The study covered a very broad range of options assessing the effects of the use of LNG from Browse and Scarborough. This includes:

- Assessment of four regions where LNG may be sold;
- Assessment of three policy scenarios for grid mixes in the future; and
- Assessment of average, fossil and coal grid mixes as displaced electricity mixes.

An additional sensitivity is included below to test the impact of higher than anticipated methane fugitive emissions across the supply chain.

7.1.1 Fugitive Methane Emissions across the LNG Processing Supply Chain

The fugitive emission of methane (CH_4) is a potential concern given the global warming potential of methane is 25 times that of CO_2. Methane is emitted from a variety of points along the LNG supply chain and whilst the data for Woodside operations are robust, only generic data from ecoinvent have been available for other parts of the supply chain. Not all emissions are fugitive, as some are residual methane after combustion, and some are methane contained in venting emissions. **Table 7-1** shows the current emissions of methane across the supply chain for LNG from both Browse and Scarborough. Browse has total methane emissions equivalent to 0.125% of gas delivered while Scarborough is 0.107%. For this sensitivity we compared the current result with the median and highest results from the ecoinvent data.

Table 7-1 Methane Emissions from the LNG Supply Chain for Scarborough and Browse, as percentage of GJ of Gas Delivered

	Browse	Scarborough
Offshore AGRU	0.010%	Not Applicable
Offshore fugitive	0.000010%	0.00014%
Offshore flare	0.000007%	0.00022%
Onshore fugitive	0.011%	0.005%
Onshore flare	0.002%	0.003%
Shipping	0.0001%	0.0001%
Transmission	0.032%	0.032%
Other individual upstream processes <0.0001%	0.070%	0.067%
Total	0.125%	0.107%

An analysis of 29 different region high pressure gas supply inventories from ecoinvent LCA database has methane values ranging from as low as 0.096% of gas supplied, up as high as 1.85% with a median value of 0.78% (shown in Appendix A). The difference between the ecoinvent results compared to the Browse and Scarborough results can be explained in part because ecoinvent is based historical data and Browse and Scarborough are based predominantly on current and/or new technology and equipment. Nevertheless, it is valuable to examine the sensitivity of the results to potentially higher methane fugitive emissions.

Table 7-2 show the results of a sensitivity when varying the total methane fugitive emissions between the current value (0.125% for Browse and 0.107% for Scarborough), to both 0.78% and 1.85% respectively for Browse and Scarborough in all regions. These two values have been used for demonstration purposes and does not infer that these are likely scenarios

At 0.78% fugitive emissions the electricity production climate change result increases by 4% for Browse and 5% for Scarborough which flows on to reduce the overall emission offset by 7%. At 1.85% fugitive emissions the electricity production climate change result increases by 12% for Browse and 14% for Scarborough which flows on to reduce the overall emission offset by 19%.

Table 7-2 GWP (tCO_2e/MWh of electricity) Results Variation with Different Methane Emission Levels (China Scenario) and Total Project Emission Offsets

	Current	0.78% Fugitive	1.85% Fugitive
Browse tCO_2e per MWh	0.561	0.585	0.624
% change to result for 1 GJ of gas		4%	11%
Scarborough tCO_2e per MWh	0.487	0.512	0.551
% change		5%	13%
Avoided emissions for STEPS scenario based on fossil grid.	601	558	489
% change in avoided emissions for STEPS scenario based on fossil grid.		-7%	-19%

7.2 Contribution Analysis: Particulate Matter

Table 7-3 shows the process contribution to particulate matter results for Chinese average grid, electricity from Browse and Scarborough LNG in China. The electricity from coal production is main contributor with onsite power generation at the mine being the most significant source. For LNG the emissions are small, with the largest component being from use of grid electricity for regasification in the destination country.

Table 7-3 Particulate Matter Process Contributions for Average Chinese Grid Electricity and Electricity from LNG in China (kg $PM_{2.5}$ e /MWh)

	Average Grid China	Electricity from Browse LNG	Electricity from Scarborough LNG
Electricity production, hard coal	0.134	<0.001	<0.001
Electricity, co-generation, wood chips	0.007	<0.001	<0.001
Electricity production, hard coal, at coal mine	0.512	0.013	0.013
Electricity production, LNG	<0.001	0.003	0.003
Excavation, skid-steer loader (pipeline infrastructure)	<0.001	0.001	0.001
Natural gas processing plant	<0.001	0.001	0.001
All remaining processes	0.034	0.018	0.018
Total	0.687	0.036	0.036

7.3 Contribution Analysis: Photochemical Smog

Table 7-4 shows the process contribution to photochemical smog for Chinese average grid, electricity from Browse and Scarborough LNG in China. The majority of the emissions are from coal fired power, with the main contributor being nitrogen oxide emissions. The most significant contributions for electricity from LNG are from the use of onshore LNG compressors. The remaining processes contribute a lot of very small amounts from across the supply chain.

Table 7-4 Photochemical Smog Process Contributions for Average Chinese Grid Electricity and Electricity from LNG in China (kg NMVOCe /MWh)

	Average Grid	Electricity from Browse LNG	Electricity from Scarborough LNG
Electricity production, LNG	<0.01	0.20	0.20
Excavation, skid-steer loader (pipeline infrastructure)	<0.01	<0.01	0.02
Natural gas, burned in gas compressors, onshore	<0.01	0.14	0.04
Natural gas, burned in gas compressors, offshore	<0.01	0.04	0.04
Natural gas, GT, electricity generation, onshore	<0.01	<0.01	0.03
Electricity production, hard coal	1.50	<0.01	<0.01
Electricity production, at coal mine from coal	0.08	<0.01	<0.01
Hard coal mine operation	0.05	<0.01	<0.01
All remaining processes	0.29	0.17	0.13
Total	1.92	0.56	0.46

7.4 Contribution Analysis: Acidification

Table 7-5 shows the process contribution acidification results for Chinese average grid, electricity from Browse and Scarborough LNG in China. Coal-fired power generation is the largest contributor to acidification from the Chinese average grid. This is caused mostly by sulphur oxides and nitrogen oxide emissions. The largest acidification contribution from electricity from LNG is from nitrogen oxide emissions from natural gas combustion in the electricity power plant.

Table 7-5 Acidification Process Contributions for Average Chinese Grid Electricity and Electricity from LNG in China (mol H^+e /MWh)

	Average Grid China	Electricity from Browse LNG	Electricity from Scarborough LNG
Electricity production, LNG	<0.01	0.14	0.14
Gas compressors at onshore	<0.01	0.04	0.02
Gas compressors at offshore	<0.01	0.03	0.03
GT, electricity generation, Pluto	<0.01	<0.01	0.02
Natural gas processing plant	<0.01	<0.01	<0.01
Electricity production, hard coal	2.72	<0.01	<0.01
Electricity, co-generation, wood chips	0.05	<0.01	<0.01
Electricity production, hard coal, at coal mine	0.29	<0.01	<0.01
All remaining processes	0.38	0.21	0.19
Total	3.43	0.42	0.40

7.5 Data Quality Assessment

Table 7-6 shows the data quality assessment for the LCA. As Woodside own and operate LNG infrastructure the access to data is excellent, with the main uncertainties being the need to extrapolate to the future. For power generation technologies, ecoinvent has high quality data as this area has been studied extensively in LCA over many years due to its high impact in most LCAs. The ecoinvent 3.5 release updated much of the data on electricity production and expanded coverage globally. The data on grid mixes and energy efficiency is good at the macro level for countries, with the main difficulties being the inherent uncertainties of modelling into the future and the limitation of collecting data from many nation states.

Table 7-6 Data Quality Assessment for LCA

Process	Reliability	Time Period	Geography	Technology	Representativeness	Comment
Offshore extraction and processing	Good	Good	V.Good	V.Good	V.Good	The data are sourced directly from the teams designing gas extraction and processing. Data are extrapolated from current practice across the next 15 years of extraction.
Onshore gas processing	Good	Good	V.Good	V.Good	V.Good	The data are sourced directly from the existing gas processing facilities. Data are extrapolated from current to future processing
Shipping LNG	V.Good	Good	V.Good	V.Good	Good	The data are sourced directly from the existing shipping operations.
Regasification	Good	Fair	Good	Good	Fair	Data are source from ecoinvent for Japan for evaporation of LNG into the distribution system. Data were extrapolated to other geographies with adaption of the grid mix.
Distribution	Good	Fair	Good	Good	Fair	Data are sourced from ecoinvent for distribution in Japan. Data were extrapolated to other geographies with adaption of the grid mix.
Power generation natural gas, coal and oil	Good	Good	Good	Good	Good	All power generation data with the exception of efficiencies are taken directly from ecoinvent 3.5 which has updated power generation technologies for many countries. Where are large range of power generation regions were included the median region based on climate change impacts was chosen as representative median of the country. Generation efficiency interpreted from IEA published fuel use and power generation projections for each of the regions examined and averaged between 2026 and 2040

Process	Reliability	Time Period	Geography	Technology	Representativeness	Comment
Power generation renewables	Good	Fair	Good	Fair	Fair	All power generation data with the exception of efficiencies are taken directly from ecoinvent 3.5 which has updated power generation technologies for many countries. Where are large range of power generation regions were included the median region based on climate change impacts was chosen as representative of the country. Technology does not change through timeframe.
Power generation nuclear	Good	Good	Good	Fair	Fair	All power generation data with the exception of efficiencies are taken directly from ecoinvent 3.5 which has updated power generation technologies for many countries. Where are large range of power generation regions were included the median region based on climate change impacts was chosen as representative of the country. Technology does not change through timeframe.
Grid mixes	Fair	Good	V.Good	Good	V Good	Based on IEA published grid scenario for the future for each of the regions examined and averaged between 2026 and 2040

8. DISCUSSION AND CONCLUSIONS

8.1 Discussion

This study indicates that gas, sourced via LNG from the Browse and Scarborough developments can help facilitate the energy transition to lower-carbon electricity generation in Asia Pacific markets, even under transformative decarbonisation scenarios. The key is the flexibility of gas as a fuel, and the proximity of Browse and Scarborough to markets which are simultaneously high-growth, and at a relatively early stage of the transition to lower-carbon energy.

Gas, combusted as either a power generation fuel or for heating, industry or cooking, is a cleaner fuel than coal. The analysis indicates that electricity generated from Browse or Scarborough-sourced LNG has significant benefits in reducing photochemical (ground-level) ozone formation, acidification, and particulate matter generation in all modelled regions, for both the IEA's STEPS and CPS scenarios. The benefit of LNG sourced electricity are sustained in the SDS, which demands a wholesale shift away from coal towards lower-carbon fuels (renewables and nuclear) and also gas. Critically, the impact of gas remains a beneficial one across all scenarios, in comparison to the fossil mix in the grid.

With regard to climate change, the picture is more nuanced, but still positive. From a power sector emissions intensity perspective, Asia Pacific markets are generally characterised as 'high carbon', featuring a large share of coal in the overall mix. Adding gas from Browse or Scarborough to the power mix is expected to lead to a decline in CO_2e emissions intensity in comparison to the fossil mix in the grid in each market under consideration, to at least 2040.

8.2 Limitations of the Study

The forecast of future production always comes with a degree of uncertainty. In particular the emission profiles predicted for Browse and Scarborough are based on current design and estimates of operational parameters.

The policy scenarios developed by the IEA are not forecasts, but rather highly specific views of what the future could look like under certain conditions. Nevertheless, they represent a reasonable boundary for the lower and upper range of technology development and implementation.

When analysing the net benefits or impacts gas might have in the electricity generation in each target market, the likely long-run marginal fuel (what type of electricity generation will be constructed, if additional or replacement generating capacity is required) should be considered. This will depend on several factors, but is likely to be fossil-based, rather than renewables or nuclear. Therefore comparing Browse and Scarborough gas to the fossil mix in the grid gives a fair assessment of its relative benefits.

In this study, grid mixes are predicted for the future, but current technology is used for each individual generation type. It can be expected that future generation could improve efficiencies, especially for renewable electricity generation.

The IEA scenarios take no account of carbon capture and storage, which could become a requirement for fossil fuelled electricity generation within the study period.

8.3 Conclusion

For climate change, LNG impacts vary through time, but are net negative (i.e. the CO_2e emissions burden is lower) on the basis of electricity derived from Browse and Scarborough LNG competing with average fossil fuelled electricity generation, in the markets under consideration, under all scenarios.

Increasing LNG electricity generation in Asia Pacific will improve air quality outcomes compared to all grid mixes projected by the IEA. For the fossil grid mix, the photochemical impact is almost twice as high as LNG, and the acidification impact four times higher. Only when the SDS is fully implemented in Japan do the photochemical and acidification impacts trend close to those from LNG electricity.

For particulate matter impacts Browse and Scarborough LNG electricity is eight times lower than the fossil based electricity mix under the SDS scenario. For all other scenarios and regions, the impacts of average fossil grids are more than 10 times that of LNG electricity in that region.

Understanding how electricity sourced from Browse and Scarborough LNG performs against electricity from other fossil fuels is critical, as this reflects most closely how gas will compete in the target markets. Gas-on-renewables competition is considered to be limited, due to policy support and falling costs for renewables under the STEPS and especially the SDS scenarios, and the limited presence of renewables under the CPS. Furthermore, physical constraints on the development of renewables are likely in three of the four target markets[8], meaning imported fossil energy will remain essential to satisfy growing demand.

Even under very ambitious scenarios such as the SDS, gas can play a role in delivering the lower-carbon energy transition. In fact, the success of achieving a lower-carbon outcome as described by the SDS is predicated on the increased use of gas in the target markets, especially in the years to 2030.

[8] Electricity generation technology cost projections 2017 – 2050, CSIRO 2017

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APPENDIX A ASSUMPTIONS AND LIMITATIONS.

Assumptions and Limitations

Assumptions

HC and VOC emissions – assumed to be 98% methane, 2% non-methane VOC
Emissions intensity for projects has been determined based on the time that they are operating at full output. This data has been applied to the full time scale – including a short period before Browse has even been constructed.

Limitations

- This report was performed by ERM Australia Pty Ltd (ERM) for Woodside Energy Ltd (the Client). The Scope of Work was governed by a contract between ERM and the Client (4610001822).
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  b. must not be relied upon or used by any other party outside of the intended use (8a) ;

  c. does not purport to provide, nor should be construed as, legal advice.

- Methane emissions from high pressure gas supply to different regions in ecoinvent LCA database. **Figure A-9-1** shows the results for methane emission for different regions included in ecoinvent LCA database (version 3.5, Allocation at Point of Substitution version) using the market processes. The regions are identified by ISO two letter country codes with two value for Canada (CA-QC for Quebec) and CA-AB Alberta) and row is the default value for rest of world and GLO stands for global average. Note that none of these are specifically for LNG supply chain but each country includes a mix of gas supply.

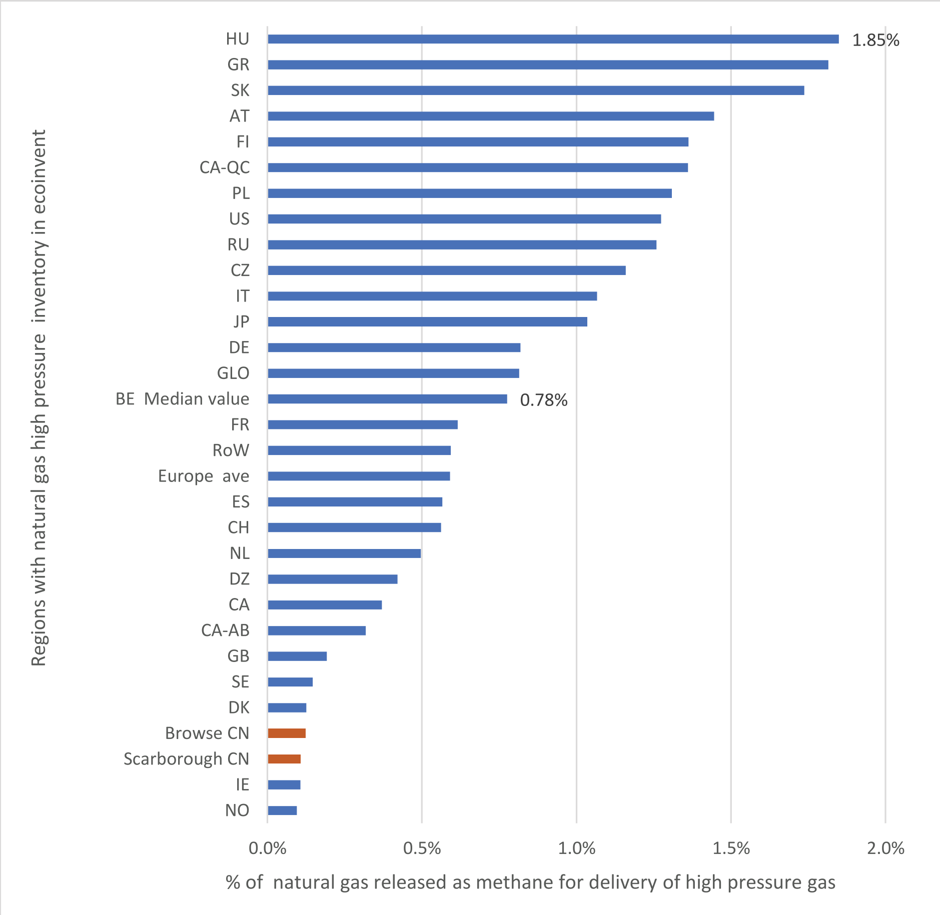

Figure A-9-1 Methane Emission Results as % of Natural Gas for Different Regions Included in Ecoinvent LCA Database

APPENDIX B LIFE CYCLE INVENTORY FOR LNG PRODUCTION.

B – Foreground LCA data from Woodside

Please note: granular production and emissions data for Browse, Scarborough and shipping has been removed from Appendix B of this public report since it is commercially sensitive.

Regasification

Data from ecoinvent is used for both the electricity use and infrastructure for regasification of gas into the regions distribution network, however the electricity is localised to each regional market. Table B-9-1 shows the process flows for regasification of gas.

Table B-9-1 Process Flows for Regasification of 1m^3 Gas in Destination Market

Process	Unit	Flow
Process output		
Gas evaporated into gas network at overseas market	m^3	1
Process inputs		
Electricity, medium voltage (local grid)	kWh	0.051
Natural gas processing plant,	Plants	7.89E-13
LNG	MJ	38.6[1]

[1] Note this energy content is the value used in the ecoinvent and is therefore used to scale the regasification inputs in this inventory.

Gas Transmission

The data have been sourced from ecoinvent global databases 3.5 (Weidema, Bauer et al. 2018) and data from Japan have been used for all regions as specific data for other regions assessed is not available.

The data from ecoinvent is used for both the electricity use and infrastructure but the electricity is localised to each regional market. **Table B-9-2** shows the process flows for gas transmission.

Table B-9-2 Process Flows for Natural Gas Transmission in Destination Market

Process	Unit	Flow
Process output		
Natural gas, at powerplant	GJ	1
Distribution fugitives	kg	0.0057
Inputs		
LNG, regasified into local transmission network	GJ	1.0131
Heat, from natural gas	GJ	0.0014
Electricity, medium voltage (local grid)	kWh	0.063
Pipeline, natural gas, high pressure distribution network	km	2.253E-05

1 Note that the gas loss of 0.013 GJ is not all lost to fugitives in the original ecoinvent inventory.

APPENDIX C LIST OF ECOINVENT ELECTRICITY INVENTORIES USED IN REGIONAL GRIDS

Appendix C List of Ecoinvent Electricity Inventories Used in Regional Grids

Electricity Processes Included in Chinese Grid

The coal, oil and gas grids were selected based on the median climate change impact grid. Photovoltaic electricity was taken from Japan as Chinese data were too complex. Geothermal was taken from Japanese process as one was not available for China

- Electricity, high voltage [CN-GZ}| electricity production, hard coal | APOS, U
- Electricity, high voltage [CN}| electricity production, hydro, reservoir, non-alpine region | APOS, U
- Electricity, high voltage [CN}| electricity production, hydro, run-of-river | APOS, U
- Electricity, high voltage [CN}| electricity production, natural gas, existing | APOS, U
- Electricity, high voltage [CN}| electricity production, nuclear, pressure water reactor | APOS, U
- Electricity, high voltage [CN-GZ}| electricity production, oil | APOS, U
- Electricity, high voltage [CN}| electricity production, wind, <1MW turbine, onshore | APOS, U
- Electricity, high voltage [CN}| electricity production, wind, >3MW turbine, onshore | APOS, U
- Electricity, high voltage [CN}| electricity production, wind, 1-3MW turbine, offshore | APOS, U
- Electricity, high voltage [CN}| electricity production, wind, 1-3MW turbine, onshore | APOS, U
- Electricity, high voltage [CN}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | APOS, U
- Electricity, high voltage [JP}| electricity production, deep geothermal | APOS, U
- Electricity, low voltage [JP}| electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted | APOS, U
- Electricity, low voltage [JP}| electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted | APOS, U
- Electricity, high voltage [CN-CQ}| electricity production, wind, 1-3MW turbine, onshore | APOS, U
- Electricity, high voltage [CN}| electricity production, LNG | APOS, U

Electricity Processes Included in Indian Grid

The coal, oil and gas grids were selected based on the median climate change impact grid. Photovoltaic electricity was taken from Japan as Chinese data were too complex. Solar thermal was taken from rest of world inventory as a local one was not available.

- Electricity, high voltage [IN}| electricity production, hard coal | APOS, U
- Electricity, high voltage [IN-Hydro}| electricity, high voltage, production mix | APOS, U
- Electricity, high voltage [IN-KL}| electricity production, natural gas India conventional power plant | APOS, U
- Electricity, high voltage [IN-TN}| electricity production, oil | APOS, U
- Electricity, high voltage [IN- Nuclear}| electricity, high voltage, production mix | APOS, U
- Electricity, high voltage [IN-Wind}| electricity, high voltage, production mix | APOS, U
- Electricity, high voltage [CN}| heat and power co-generation, wood chips, 6667 kW, state-of-the-art 2014 | APOS, U
- Electricity, high voltage [ID}| electricity production, deep geothermal | APOS, U
- Electricity, high voltage [JP}, solar, average
- Electricity, high voltage [RoW}| electricity production, solar thermal parabolic trough, 50 MW | APOS, U
- Electricity, high voltage [CN-CQ}| electricity production, wind, 1-3MW turbine, onshore | APOS, U
- Electricity, high voltage [IN-KL}| electricity production, LNG India conventional power plant | APOS, U

Electricity Processes Included in Japanese Grid

Japan did not have sub grids so national generation inventories were used.

- Electricity, high voltage [JP}| electricity production, hard coal | APOS, U
- Electricity, high voltage [JP}| electricity production, oil | APOS, U
- Electricity, high voltage [JP}| electricity production, natural gas, combined cycle power plant | APOS, U
- Electricity, high voltage [JP}| electricity production, nuclear, boiling water reactor | APOS, U
- Electricity, high voltage [JP}| electricity production, nuclear, pressure water reactor, heavy water moderated | APOS, U
- Electricity, high voltage [JP}| electricity production, hydro, run-of-river | APOS, U
- Electricity, high voltage [JP}| electricity production, hydro, pumped storage | APOS, U
- Electricity, high voltage [JP}| electricity production, hydro, reservoir, alpine region | APOS, U
- Electricity, high voltage [RoW}| ethanol production from sweet sorghum | APOS, U
- Electricity, high voltage [RoW}| ethanol production from wood | APOS, U
- Electricity, high voltage [JP}| electricity production, wind, <1MW turbine, onshore | APOS, U
- Electricity, high voltage [JP}| electricity production, wind, >3MW turbine, onshore | APOS, U
- Electricity, high voltage [JP}| electricity production, wind, 1-3MW turbine, offshore | APOS, U
- Electricity, high voltage [JP}| electricity production, wind, 1-3MW turbine, onshore | APOS, U
- Electricity, high voltage [JP}| electricity production, deep geothermal | APOS, U
- Electricity, low voltage [JP}| electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted | APOS, U
- Electricity, low voltage [JP}| electricity production, photovoltaic, 3kWp slanted-roof installation, single-Si, panel, mounted | APOS, U
- Electricity, high voltage [RoW}| electricity production, solar thermal parabolic trough, 50 MW | APOS, U
- Electricity, high voltage [JP}, wind, average
- Electricity, high voltage [JP}| electricity production, LNG, combined cycle power plant | APOS, U

Electricity Processes Included in ASEAN Grid

Mostly Indonesian processes were used with the exception of hard coal which was taken from Malaysia as a hard coal inventory was not available in ecoinvent.

- Electricity, high voltage [ID}| electricity production, deep geothermal | APOS, U
- Electricity, high voltage [ID}| electricity production, hydro, reservoir, tropical region | APOS, U
- Electricity, high voltage [MY}| electricity production, hard coal | APOS, U
- Electricity, high voltage [ID}| electricity production, natural gas combined cycle power plant | APOS, U
- Electricity, high voltage [ID}| electricity production, oil | APOS, U
- Electricity, high voltage [ID}| heat and power co-generation, biogas, gas engine | APOS, U
- Electricity, high voltage [JP}| electricity production, nuclear, boiling water reactor | APOS, U
- Electricity, high voltage [ID}| electricity production, wind, <1MW turbine, onshore | APOS, U
- Electricity, high voltage [JP}, wind, average
- Electricity, high voltage [RoW}| electricity production, solar thermal parabolic trough, 50 MW | APOS, U
- Electricity, high voltage [ID}| electricity production, LNG, combined cycle power plant | APOS, U

Electricity Processes Included in Global Grid

Thermal generation processes were selected based on median climate change impact from full range of each technology type. Average of all hydro power inventories in the ecoinvent global grid mix was used but represent too many processes to display.

- Electricity, high voltage [RoW}| electricity production, geothermal | APOS, S
- Global hydro average
- Electricity, high voltage [GLO}| electricity production, natural gas, combined cycle power plant | APOS, U
- Electricity, high voltage [CN-GS}| electricity production, hard coal | APOS, U
- Electricity, high voltage [CA-QC}| electricity production, oil | APOS, U - GLO
- Electricity, high voltage [ID}| heat and power co-generation, biogas, gas engine | APOS, U
- Electricity, high voltage [ZA}| electricity production, nuclear, pressure water reactor | APOS, S
- Electricity, high voltage [WECC, US only}| electricity production, wind, >3MW turbine, onshore | APOS, S
- Electricity, low voltage [CN-SH}| electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted | APOS, S
- Electricity, high voltage [RoW}| electricity production, solar thermal parabolic trough, 50 MW | APOS, U
- Electricity, high voltage [GLO}| electricity production, LNG, combined cycle power plant | APOS, U
- Electricity, high voltage, label-certified [CH}| electricity production, hydro, run-of-river, label-certified | APOS, U
- Electricity, high voltage, label-certified [CH}| electricity production, hydro, reservoir, alpine region, label-certified | APOS, U
- Global hydro average –

APPENDIX D PEER REVIEW DECLARATION

CSIRO

Critical Review Statement

Critical Review of the Study "Comparative Life Cycle Assessment: Browse and Scarborough. Version 22 April 2020. Project No 0541307" by Paul McConnell, Tim Grant.

Commissioned by: Woodside

Critical Review Panel: Maartje Sevenster, Jenny Hayward, Nawshad Haque (CSIRO)

Draft Date: 15 March 2020

Reference: ISO 14044:2006 Environmental Management–Life Cycle Assessment–Requirements and Guidelines

The review panel assessed that:

- the methods used to carry out the comparative LCA are consistent with ISO 14044:2006
- the methods used to carry out the LCA are scientifically and technically valid,
- the data used are appropriate and reasonable in relation to the goal of the study,
- the interpretations reflect the limitations identified and the goal of the study,
- the reporting is transparent and consistent, and meets the criteria specified by ISO 14044:2006 for studies that support comparative assertions intended to be disclosed to the public,
- the energy scenarios used for LCA-based comparisons are appropriate and relevant.

Analysis and validation of the inputs and outputs for the LNG production processes was outside the scope of this review.

Process. The review panel provided comments on the final draft of the technical report. These were discussed with the authors and informed the final report. The reviewers also evaluated the underlying life cycle inventory modelling. The process was constructive and comprehensive.

Conclusion. The study has been carried out in compliance with ISO 14044:2006. The critical review panel deems the overall quality of the study and methods to be high, and the used data appropriate and reasonable. The LCA reporting is sufficiently transparent and consistent, and meets the criteria specified by ISO 14044:2006.

Reviewer	Signature	Reviewer	Signature
Dr M. Sevenster	MSevenster	Dr N. Haque	NHaque
Dr J. Hayward	J Hayward		

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APPENDIX A TECHNICAL STUDIES

APPENDIX A.4 BURRUP HUB ECONOMIC IMPACT ASSESSMENT

Browse and North West Shelf Extension

ECONOMIC IMPACT ASSESSMENT
JUNE 2019


Image courtesy of Woodside

DEVELOPMENT MAP

Burrup Hub			
Browse and NWS Extension		Scarborough	
Browse Fields	NWS Project Extension	Pluto Train 2	Scarborough Field
NWS Project	Pluto-NWS Interconnector	Pluto LNG	

PROJECT OVERVIEW

Browse to North West Shelf

Woodside Energy Ltd (Woodside) as Operator on behalf of the Browse Joint Venture is proposing to develop the Brecknock, Calliance and Torosa fields located approximately 425 km north of Broome in the offshore Browse Basin. Hydrocarbon resources in these fields are predominantly gas and estimated to contain 13.9 trillion cubic feet of dry gas and 390 million barrels of condensate (100%, 2C). The proposed Browse to North West Shelf development concept includes two floating production storage and offloading (FPSO) facilities that will deliver gas through an approximately 900 km pipeline to a proposed expansion of the existing North West Shelf infrastructure, with condensate expected to be exported at the FPSO facilities.

North West Shelf Project Extension

Woodside Energy Ltd (Woodside) as Operator on behalf of the North West Shelf Joint Venture, proposes the ongoing operation of the North West Shelf Project to enable the long-term processing of third-party gas and fluids and North West Shelf Joint Venture field resources through the North West Shelf Project facilities until around 2070.

This summary report has been independently prepared by ACIL Allen Consulting for Woodside to provide a high level overview of the estimated direct and indirect economic impacts of Browse and North West Shelf Extension on the Australian and Western Australian economies, and the regional economies of the City of Karratha and the Shire of Broome, over the life of the projects. The results include the economic impacts related to the combined projects which include developing the Browse fields and processing via North West Shelf Project infrastructure and the North West Shelf Project Extension.

ESTIMATED PROJECT PRODUCTION

LNG: 2,021 MMBOE

Domestic gas: 300 MMBOE

Condensate: 390 MMBOE

LPG: 62 MMBOE

Average annual LNG production is equivalent to over 20% of WA's projected LNG exports

Average annual domestic gas production is enough to generate electricity to power over 800,000 WA homes each year from the proposed Project

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Direct contribution

The proposed Browse and North West Shelf Extension are expected to result in a significant **direct** contribution to the Australian economy through capital and operational spending, employment, taxation and royalty payments, and exports. The majority of these direct impacts will be realised in Western Australia including in the Pilbara and the Kimberley regions. A summary of the **direct** impacts of the proposed projects are set out below.

Capital expenditure of **$36 billion** in Western Australia between **2019-2063**

…including **$27.3 billion** on the proposed Browse project and **$8.6 billion** on the NWS Extension

…including over **$1 billion** in Karratha and Broome

Peak construction workforce of over **1,800 jobs** in 2024

…or on average **700 jobs** per annum between 2019 and 2063

Proposed capital expenditure from the proposed Browse and NWS Extension is equivalent to the construction costs of 23 Optus Stadiums

x23

Around **720 operations jobs** will be created or sustained on average during operations

…including up to **320 jobs** in the Karratha region during operations

Businesses in **Karratha** will on average benefit from over **$50 million per annum** of direct localised spending required to operate the proposed Browse and NWS Extension

$493 million of annual average operational expenditure in Western Australia

…including **$15 million** of spend per annum for **Broome** logistics support activities

The annual average operational spend of the proposed development is equivalent to the average annual retail spending of 38,000 Western Australian residents each year

38,000

Almost **$63 billion** of total taxation and royalty payments estimated to be directly paid as a result of the proposed Project

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Economic impacts

The proposed Browse and North West Shelf Extension are expected to deliver significant long term benefits across Australia over the life of the projects. The estimated economic impact of the projects are presented below in the form of the **direct and indirect** impacts to incomes, output, and full time equivalent (FTE) jobs at a regional, state and national level, as well as the estimated direct and indirect tax and royalty payments generated as a result of the projects. It is estimated the projects will…

Boost the Gross Domestic Product of Australia by
$289 billion
between 2019-2063

…of which **99% will be in Western Australia**

Larger than the total output produced by the Western Australian economy in 2017-18

Increase the real incomes of Australian residents by
$249 billion
between 2019-2063

…of which over **$15.6 billion** will be retained in Karratha, and a further **$3.3 billion** in Broome

The boost to national incomes is equivalent to 2 times the total incomes earned in Western Australia in 2017-18

Create an average of more than
2,700 jobs
per annum nationally between 2019-2063

…with almost **1,400** jobs created in Karratha and Broome

Equivalent to the employment created by more than 450 new small businesses each year

Generate direct taxation and royalty payments to the Commonwealth and State Governments of
$63 billion
between 2019-2063, and indirect taxation payments of
$30 billion

Average annual tax payments of $2.1 billion could construct over 140 km of national highway every year between 2019-2063

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Image courtesy of Woodside

Assumptions

The economic impact assessment has been undertaken on the assumption that joint venture and regulatory approvals are obtained and commercial agreements finalised.

The study period for the economic impact assessment is 2019-2063.

All results presented are for the total share of the development and therefore include the Woodside share as well as joint venture share. Only the Woodside operated assets are included in this report.

All values are reported in real Australian dollars (2018). Production values are reported in millions of barrels of oil equivalent (MMBOE).

All estimated construction and operation spending data for each proposed development has been supplied by Woodside and publicly available information. Capital expenditure includes initial construction costs, ongoing capital costs and end of life abandonment costs.

A flat $86.66 (USD$65) per barrel price for oil has been assumed, with prices for LNG, LPG and Condensate benchmarked to this.

Reported direct taxation and royalty payments paid by Woodside and its joint venture participants include all Company Taxation, Petroleum Resources Rent Taxation (PRRT), Payroll Taxation, development specific royalty payments, Condensate Excise, and carbon payments.

Methodology

Economic impacts have been estimated using ACIL Allen's proprietary computable general equilibrium model *Tasman Global*.

Economic impacts include the direct and indirect (or flow on) impacts of each proposed development / project by Woodside and its relevant joint venture participants. The indirect impact is a result of changes in demand in other industries from the initial impact created from the construction and operation of the developments. Economic impacts are reported in terms of:

Gross product or real economic output
A measure of the size of an economy or the output generated by an economy over a period of time.

Real income
A measure of the welfare of residents in an economy through their ability to purchase goods and services and to accumulate wealth.

Real employment (jobs)
The number of net full time equivalent job years created as a result of a project. Real employment creation is the direct and indirect (flow on) employment as a result of a project. Real employment is measured in full time equivalent (FTE) job years which is equivalent to the employment of one person on a full time basis for one year.

Total taxation
The direct taxation paid by the development as well as the indirect taxation created as a result of additional economic activity resulting from the development.

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Burrup Hub

ECONOMIC IMPACT ASSESSMENT
JUNE 2019


Image courtesy of Woodside

DEVELOPMENT MAP

Burrup Hub			
Browse and NWS Extension		Scarborough	
Browse Fields	NWS Project Extension	Pluto Train 2	Scarborough Field
NWS Project	Pluto-NWS Interconnector	Pluto LNG	

BURRUP HUB OVERVIEW

The Burrup Hub involves the proposed development of an additional 20 to 25 trillion cubic feet of gas resources from the Scarborough and Browse fields off the north west coast of Western Australia. The Burrup Hub builds on the existing Pluto LNG and North West Shelf projects, linking two of the State's largest pieces of economic infrastructure to create a regional LNG production centre on the Burrup Peninsula.

The Burrup Hub has the potential to enable the long term processing of gas resources to supply both domestic and international markets and create significant employment and regional development opportunities, including logistics support through Broome to service the proposed Browse to North West Shelf development concept .

The vision for the Burrup Hub also includes initiatives not modelled as part of this report, such as additional fields that could tie in to the Hub, as well as new initiatives designed to abate and offset emissions from operations and to improve energy efficiency. Woodside is pursuing options for integrating solar with gas fired power generation to run facilities.

This summary report has been independently prepared by ACIL Allen Consulting for Woodside to provide a high level overview of the estimated direct and indirect economic impacts on the Australian and Western Australian economies, and the regional economies of Karratha and Broome, over the life of the projects that make up the Burrup Hub. The results represent the incremental economic impacts over and above current production levels from the North West Shelf and Pluto LNG projects.

ESTIMATED DEVELOPMENT PRODUCTION

LNG: 3,026 MMBOE

Domestic gas: 450 MMBOE

Condensate: 390 MMBOE

LPG: 62 MMBOE

Average annual LNG production is equivalent to over 30% of WA's projected LNG exports

Average annual domestic gas production is enough to generate electricity to power over 1.2 million WA homes each year from the Burrup Hub

ACIL ALLEN CONSULTING

Direct contribution

The Burrup Hub is expected to result in a significant **direct** contribution to the Australian economy through capital and operational spending, employment, taxation and royalty payments, and exports. The majority of these direct impacts will be realised in Western Australia including in the Pilbara and the Kimberley regions. A summary of the **direct** impacts of the proposed development are set out below.

Capital expenditure of **$52 billion** in Western Australia between **2019-2063**

...including over **$1.3 billion** in Karratha and Broome

Peak construction workforce of over **4,600 jobs** in 2023

...or on average **950 jobs** per annum between 2019 and 2063

Proposed capital expenditure from the development of the Burrup Hub is equivalent to the construction costs of 33 Optus Stadiums

x33

Almost **1,100 operations jobs** will be created or sustained on average during operations

...including up to **460 jobs** in the Karratha region during operations

Businesses in **Karratha** will on average benefit from over **$86 million per annum** of direct localised spending required to operate the Burrup Hub

$703 million of annual average operational expenditure in Western Australia

...including **$15 million** of spend per annum for **Broome** logistics support activities

Over **$82 billion** of total taxation and royalty payments estimated to be directly paid as a result of the Burrup Hub

The annual average operational spend of the Burrup Hub is equivalent to the average annual retail spending of 54,000 Western Australian residents each year

54,000

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Economic impacts

The Burrup Hub is expected to deliver significant long term benefits across Australia over the life of the project. The estimated economic impact of the development is presented below in the form of the **direct and indirect** impacts to incomes, output, and full time equivalent (FTE) jobs at a regional, state and national level, as well as the estimated direct and indirect tax and royalty payments generated as a result of the development. It is estimated the Burrup Hub will…

Boost the Gross Domestic Product of Australia by
$414 billion
between 2019-2063

…of which **99% will be in Western Australia**

Equivalent to 23% of Australia's GDP in 2017-18

Increase the real incomes of Australian residents by
$370 billion
between 2019-2063

…of which over **$22 billion** will be retained in Karratha, and a further nearly **$4.8 billion** in Broome

The boost to national income is over 3 times the total incomes earned by WA residents in 2017-18

Create an average of more than
4,000 jobs
per annum nationally between 2019-2063

…with over **1,900 jobs** located in Karratha and Broome

Equivalent to the employment created by more than 650 new small businesses each year

Generate direct taxation and royalty payments to the Commonwealth and State Governments of
$82 billion
between 2019-2063, and indirect taxation payments of
$44 billion

Average annual tax payments of $2.8 billion could construct over 180 km of national highway every year between 2019-2063

ACIL ALLEN CONSULTING


Image courtesy of Woodside

Assumptions

The economic impact assessment has been undertaken on the assumption that joint venture and regulatory approvals are obtained and commercial agreements finalised.

The study period for the economic impact assessment is 2019-2063.

All results presented are for the total share of the development and therefore include the Woodside share as well as joint venture share. Only the Woodside operated assets are included in this report.

All values are reported in real Australian dollars (2018). Production values are reported in millions of barrels of oil equivalent (MMBOE).

All estimated construction and operation spending data for each proposed development has been supplied by Woodside and publicly available information. Capital expenditure includes initial construction costs, ongoing capital costs and end of life abandonment costs.

A flat $86.66 (USD$65) per barrel price for oil has been assumed, with prices for LNG, LPG and Condensate benchmarked to this.

Reported direct taxation and royalty payments paid by Woodside and its joint venture participants include all Company Taxation, Petroleum Resources Rent Taxation (PRRT), Payroll Taxation, development specific royalty payments, Condensate Excise, and carbon payments.

Methodology

Economic impacts have been estimated using ACIL Allen's proprietary computable general equilibrium model *Tasman Global*.

Economic impacts include the direct and indirect (or flow on) impacts of each proposed development by Woodside and its relevant joint venture participants. The indirect impact is a result of changes in demand in other industries from the initial impact created from the construction and operation of the developments. Economic impacts are reported in terms of:

Gross product or real economic output
A measure of the size of an economy or the output generated by an economy over a period of time.

Real income
A measure of the welfare of residents in an economy through their ability to purchase goods and services and to accumulate wealth.

Real employment (jobs)
The number of net full time equivalent job years created as a result of a project. Real employment creation is the direct and indirect (flow on) employment as a result of a project. Real employment is measured in full time equivalent (FTE) job years which is equivalent to the employment of one person on a full time basis for one year.

Total taxation
The direct taxation paid by the development as well as the indirect taxation created as a result of additional economic activity resulting from the development.

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Appendix B Updated Information

Appendix B.1 Updated draft EIS/ERD Table 5-29 (Australian Marine Parks (AMPs) within the vicinity of the Project Area)

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
Kimberley Marine Park (74,469 km^2)	VI (Multiple Use).	The Kimberley Marine Park provides protection for the habitats and ecological communities in waters offshore of the Kimberley coastline, ranging in water depth from less than 15 to 800 m. **Natural values** – natural values of the Kimberley Marine Park include: • ecosystems representative of the northwest shelf province, northwest shelf transition and Timor province (**Section 5.2.1**) • the KEFs 'Ancient coastline at the 125 m depth contour' and 'Continental slope demersal fish communities' intersect this AMP (see **Section 5.3.3.1**) • breeding and foraging habitat for seabirds (**Section 5.3.2.1.1** and **Section 5.3.2.3**) • internesting and nesting habitat for marine turtles (**Section 5.3.2.1.1**, **Section 5.3.2.2** and **Section 5.3.2.5**) • breeding, calving and foraging habitat for inshore dolphins (**Section 5.3.2.4.3**) • calving, migratory pathway and nursing habitat for humpback whales (**Section 5.3.2.1.1** and **Section 5.3.2.4.1**) • migratory pathway for pygmy blue whales (**Section 5.3.2.1.1** and **Section 5.3.2.4.2**) • foraging habitat for dugongs (**Section 5.3.2.4.3**) • foraging habitat for whale sharks (**Section 5.3.2.1.1** and **Section 5.3.2.7**). Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	~ 40 km from the Browse Development Area. The proposed BTL route runs through the Multiple Use Zone (IUCN VI) of the Kimberley Marine Park for approximately 68 km.

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
		Cultural values – Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. The Wunambal Gaambera, Dambimangari, Mayala, Bardi Jawi and the Nyul Nyul people's sea country extends into the Kimberley Marine Park. The Wunambal Gaambera people's country includes daagu (deep waters), with about 3400 km^2 of their sea country located in the Marine Park. The Wunambal Gaambera, Dambimangari, Mayala, Bardi Jawi and the Nyul Nyul people have an unbroken connection to their sea country, having deep spiritual connection through Wunggurr (creator snakes) that still live in the sea. Staple foods of living cultural value include saltwater fish, turtles, dugong, crabs and oysters. Access to sea country by families is important for cultural traditions, livelihoods and future socio-economic development opportunities. Key cultural values that extend into the Kimberley Marine Park and that are recognised by the national heritage listing for the West Kimberley are: • Wanjina Wunggurr Cultural Tradition • log-raft maritime tradition • interactions with Makassan traders • pearl resources. The Wunambal Gaambera, Dambimangari and Bardi Jawi people consider that these values extend into the Kimberley Marine Park. The Wanjina Wunggurr is law of the Wunambal Gaambera and Dambimangari people and it is recognised that all of the sea country, land, plants and animals were put there by Wanjina Wunggurr. Under Wanjina Wunggurr law, the Wunambal Gaambera and Dambimangari people have a responsibility to manage country, to maintain the health of the country and all living things. The Wunambal Gaambera, Bardi Jawi, Mayala and the Nyul Nyul people have had native title determined over parts of their sea country included in this Park. The native title holders for these people are represented by the Wunambal Gaambera Aboriginal Corporation, Bardi and Jawi Niimidiman Aboriginal Corporation and the Kimberley Land Council. These representative bodies are the points of contact for their respective areas of sea country for the Marine Park.	

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
		Due to the nature and coastal location of these values, they are not anticipated to be significantly impacted by project activities and have not been described further.	
		Heritage values – there are no international, Commonwealth or National heritage listings relevant to the Kimberley Marine Park. The Marine Park contains more than 40 known shipwrecks listed under the *Historic Shipwrecks Act* 1976	
		Social and economic values – socio-economic values of this marine park include tourism, recreation, mining and traditional use. Relevant values are described further in **Section 5.4.**	
Argo-Rowley Terrace Marine Park (146,003 km^2)	VI – Protected area with sustainable use of natural resources	This AMP provides protection for the ecological communities and habitats of the deeper offshore waters of the region, in water depths ranging from 220 to 6,000 m. This includes protection for many bathymetric features, including aprons and fans, canyons, continental rise, knolls/abyssal hills and the terrace and continental slope. This AMP provides connectivity between the Mermaid Reef Marine Park / WA Rowley Shoals Marine Park and the deeper waters of the NWMR.	~ 125 km from the Browse Development Area. The proposed BTL route runs through the Multiple Use Zone (IUCN VI) of the Argo-Rowley Terrace Marine Park for approximately 97 km.
		Natural values – natural values of the Argo-Rowley Terrace Marine Park include: • ecosystems representative of the northwest transition and Timor province (**Section 5.2.1**) • the KEFs 'Canyons linking the Argo Abyssal Plain and Scott Plateau' and 'Mermaid Reef and Commonwealth waters surrounding the Rowley Shoals' intersect this AMP (**see Section 5.3.3.**1) • species listed as Threatened, Migratory, Marine or Cetacean under the EPBC Act (**Section 5.3.2**) • ecosystems of the Marine Park are associated with emergent reef flat, deep reef flat, lagoon, and submerged sand habitats (**Section 5.3**) • BIAs, including resting and breeding habitat for seabirds and a migratory pathway for the pygmy blue whale (**Section 5.3.2.1.1**). Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
		Cultural values – as noted in the 'North-west Marine Park Management Plan' (Director of National Parks, 2018), limited information regarding the cultural significance of this marine park is currently available. Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. There is limited information about the cultural significance of this Marine Park.	
		Heritage values – there are no international, Commonwealth or National heritage listings relevant to the Argo-Rowley Terrace Marine Park. The Marine Park contains two known shipwrecks listed under the *Historic Shipwrecks Act* 1976: Alfred (wrecked in 1908) and Pelsart (wrecked in 1908).	
		Social and economic values – socio-economic values of this MP include fishing and mining. Relevant values to the proposed Browse to NWS Project are described further in **Section 5.4.**	
Ashmore Reef Marine Park (583 km²)	Ia – Strict nature reserve	Ashmore Reef (see **Section 5.3.3.4**) is an emergent oceanic shoal with vegetated islands protected by this AMP. The reef and broader Marine Park is a stepping stone connecting reef systems along the WA coast by facilitating the transport of biological material. This AMP it is a biodiversity hotspot that features high endemism in demersal fish communities. The AMP supports some of the most important seabird breeding colonies on the NWS, and features BIAs for marine turtles, pygmy blue whales and dugongs. Ashmore Reef is also internationally recognised for its high diversity of sea snakes.	~ 230 km north-west of the Browse Development Area.
		Natural values – natural values of the Ashmore Reef Marine Park include: • ecosystems representative of the northwest shelf province, northwest shelf transition and Timor province (**Section 5.2.1**) • the KEFs 'Ashmore Reef and Cartier Island and surrounding Commonwealth waters' and 'Continental slope demersal fish communities' (see **Section 5.3.3.1**) • habitats associated with two extensive lagoons, sand flats, shifting sand cays, extensive reef flat and seagrass (**Table 5-36**) • species listed as Threatened, Migratory or Marine or Cetacean under the EPBC Act (**Section 5.3.2.1**)	

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
		• BIAs, including those for seabirds, migratory shorebirds, marine turtles and the pygmy blue whale (**Section 5.3.2.1.1**) • features the Ashmore Reef Ramsar Site (**Section 5.3.3.4**). Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	
		Cultural values – as noted in the 'North-west Marine Park Management Plan' (Director of National Parks, 2018), limited information regarding the cultural significance of this marine park for Indigenous Australians is currently available. The MP does, however, contain Indonesian artefacts and grave sites and the reef is still visited by Indonesian fishers (see **Section 5.4.2.3).**	
		Heritage values – there are no international or National heritage listings relevant to the Ashmore Reef MP. Ashmore Reef was Commonwealth Heritage listed in 2004.	
		Social and economic values – socio-economic values of this marine park include tourism, recreation and scientific research. Relevant values are described further in **Section 5.4**.	
Cartier Island Marine Park (172 km^2)	Ia – Strict nature reserve	This AMP encompasses a diversity of habitats, including Cartier Island (an unvegetated sand island described in **Table 5-38),** a mature reef flat, Wave Governor Bank (a submerged pinnacle), and two shallow pools. Cartier Island and the broader AMP is a stepping stone connecting reef systems along the WA coast by facilitating the transport of biological material.	~ 230 km north-west of the Browse Development Area.
		Natural values – natural values of the Ashmore Reef Marine Park include: • ecosystems representative of the Timor province (**Section 5.2.1**) • the KEFs 'Ashmore Reef and Cartier Island and surrounding Commonwealth waters' and 'Continental slope demersal fish communities' (see **Section 5.3.3.1**) • high diversity and abundance of hard and soft corals, gorgonians, sponges and encrusting organisms • species listed as Threatened, Migratory or Marine or Cetacean under the EPBC Act (**Section 5.3.2.1**) • BIAs, including those for seabirds, marine turtles and the whale shark (**Section 5.3.2.1.1**).	

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
		Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	
		Cultural values – as noted in the 'North-west Marine Park Management Plan' (Director of National Parks, 2018), limited information regarding the cultural significance of this marine park for Indigenous Australians is currently available.	
		Heritage values – there are no international, Commonwealth or National heritage listings relevant to the Cartier Island Marine Park. The Ann Millicent shipwreck is located within this AMP.	
		Social and economic values – socio-economic values of this MP include scientific research. Relevant values are described further in **Section 5.4.**	
Mermaid Reef Marine Park (540 km²)	II – National park	The Mermaid Reef Marine Park features water depths between 15 and 500 m. Mermaid Reef is one of three reefs forming the Rowley Shoals (**Section 5.2.3.3**); the best geological example of shelf atolls in Australia. The AMP is of national and international significance due to its pristine character, coral formations, geomorphic features and diverse marine life. It is a key area for over 200 species of hard corals and 12 classes of soft corals with coral formations in pristine condition.	~ 325 km south-west of the Browse Development Area. ~ 2 km from the proposed BTL route at its closest point.
		Natural values – natural values of the Ashmore Reef Marine Park include: • ecosystems representative of the northwest transition (**Section 5.2.1**) • the KEF 'Mermaid Reef and Commonwealth waters surrounding Rowley Shoals' (see **Section 5.3.3.1**) • species listed as Threatened, Migratory or Marine or Cetacean under the EPBC Act (**Section 5.3.2.1**) • BIAs, including those for seabirds and the pygmy blue whale (**Section 5.3.2.1.1**) Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	
		Cultural values – as noted in the 'North-west Marine Park Management Plan' (Director of National Parks, 2018), limited information regarding the cultural significance of this marine park for Indigenous Australians is currently available.	

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
		Heritage values – there are no international or National heritage listings relevant to the Mermaid Reef MP. Mermaid Reef was Commonwealth Heritage listed in 2004 and the 'Lively' shipwreck is located within this MP (**Section 5.4.3**)	
		Social and economic values – Tourism, recreation, and scientific research are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation. Relevant values are described further in **Section 5.4**.	
Dampier Marine Park (1,252 km^2)	VI – Protected area with sustainable use of natural resources	The Dampier Marine Park is a shallow marine park ranging in water depths from 15 to 70 m. It encompasses several submerged reefs and shoals. The reserve provides a high level of protection for offshore shelf habitats adjacent to the Dampier Archipelago.	~ 800 km south-west of the Browse Development Area. ~ 105 km south-east of proposed BTL route at its closest point.
		Natural values – natural values of the Ashmore Reef Marine Park include: • ecosystems representative of the northwest shelf province (**Section 5.2.1**) • species listed as Threatened, Migratory or Marine or Cetacean under the EPBC Act (**Section 5.3.2.1**) • BIAs, including those for seabirds, marine turtles and the humpback whale (**Section 5.3.2.1.1).** Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	
		Cultural values – no specific Indigenous Australian cultural values were noted in the 'North-west Marine Park Management Plan' (Director of National Parks, 2018), although the Ngarluma, Yindjibarndi, Yaburara and Mardudhunera people were identified as having responsibility for sea country within the marine park.	
		Heritage values – there are no international, Commonwealth or National heritage listings relevant to the Dampier Marine Park.	
		Social and economic values – socio-economic values of this MP include port activities commercial fishing and recreation. Relevant values are described further in **Section 5.4**.	
Montebello Marine Park	VI – Protected area with sustainable	The Montebello Marine Park is located offshore of Barrow Island in water depths of 15 to 150 m. The MP provides connectivity between the nearby Barrow Island and Montebello Islands MPs (**Section 5.3.5.20**) and deeper shelf and slope waters.	~ 860 km south-west of the Browse

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
(3,413 km^2)	use of natural resources	**Natural values** – natural values of the Ashmore Reef Marine Park include: • ecosystems representative of the northwest shelf province (**Section 5.2.1**) • the KEF 'Ancient coastline at the 125m depth contour' (see **Section 5.3.3.1**) • species listed as Threatened, Migratory or Marine or Cetacean under the EPBC Act (**Section 5.3.2.1**) • BIAs, including those for seabirds, marine turtles, foraging habitat for the whale shark and a migratory pathway for the humpback whale (**Section 5.3.2.1.1**). Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	Development Area. ~ 62 km south-east of proposed BTL route at its closest point.
		Cultural values – no specific Indigenous Australian cultural values were noted in the 'North-west Marine Park Management Plan' (Director of National Parks, 2018).	
		Heritage values – there are no international, Commonwealth or National heritage listings relevant to the Montebello MP.	
		Social and economic values – socio-economic values of this marine park include tourism, commercial fishing, mining and recreation. Relevant values are described further in **Section 5.4**.	

APPENDIX A TECHNICAL STUDIES

APPENDIX A.5 PRODUCED WATER MERCURY DISCHARGE MODELLING

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
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Contents

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EXECUTIVE SUMMARY

Background

The Browse hydrocarbon resource is located in the Brecknock, Calliance and Torosa reservoirs, approximately 425 km north of Broome and 290 km off the Kimberley coastline of Western Australia. Woodside Energy Ltd (Woodside) is the operator for and behalf of the Browse Joint Venture (BJV).

Woodside had commissioned a dispersion modelling study, which examined the potential concentrations on the seabed from mercury in particulate form adsorbed to sediments within the produced water (PW) stream. Modelling was carried out for a PW flow rate of 296 m^3/d, and a steady state mercury concentration of 5 µg/L for 95% of the time then 30 µg/L for the remaining 5% of the discharge period. Based on the proposed PW treatment system, the modelled particle size distribution (PSD) is based on an analogous Woodside facility with particle sizes up to 10 µm (assuming 99% removal efficiency of larger particles) and 1% based on 20 µm.

The principal aim of the study was to compare the modelling results of the predicted mercury concentrations on the seabed associated with the PW stream discharge to the limit of reporting (LOR) of 0.01 mg/kg, as well as the Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) sediment quality guidelines (ANZECC, 2000), default guideline value (DGV) and 'upper' guideline value (GV-high) of 0.15 mg/kg and 1.00 mg/kg, respectively, for 5, 10, 30 and 44 years of operations.

Methodology

The study was carried out in stages. Firstly, the current data and discharge characteristics were input into a three-dimensional dispersion model, MUDMAP, to predict the movement and initial settlement of the mercury absorbed to the PW sediments. Fifty discharge simulations were each run for a continuous discharge period of 30 days, with an initial mercury concentration of 5 µg/L for 28.5 days and 30 µg/L for the remaining 1.5 days. Each simulation had the same information but different start times, so that a wide range of current speeds and directions were sampled. Lastly, the results for all 50 simulations were collectively assessed (i.e. 1,500 days of discharge modelling with no temporal overlapping) and scaled up accordingly to evaluate the potential exceedances of the laboratory LOR, DGV (0.15 mg/kg) and GV-high (1.00 mg/kg) thresholds for 5, 10, 30 and 44 years of operations.

Key Findings

The key findings are:

- Due to the slow settling velocities of the mercury particles, it was predicted that particles will remain in suspension for extended periods of time (days) and spread under the influence of the prevailing currents. The directionality and intensity of the prevailing currents dictated the transportation and ultimately the settlement.
- Due to the low initial concentration of mercury, slow settling velocities and large spread of the mercury particles, the concentrations on the seabed were well below the LOR of 0.01 mg/kg for all operational periods assessed. For example, after 30 years of operations, the maximum mercury concentration was 0.0006 mg/kg, which is 16.7 times below the LOR, 250 times lower than the DGV and 1,670 times below the GV-high threshold.

1 INTRODUCTION

1.1 Background

The Browse hydrocarbon resource is located in the Brecknock, Calliance and Torosa reservoirs located 425 km north of Broome and approximately 290 km off the Kimberley coastline of Western Australia. Woodside Energy Ltd (Woodside) is the operator for and behalf of the Browse Joint Venture (BJV).

Hydrocarbon resources contained in these reservoirs are predominately gas, with contingent resources (2C, 100%) of 13.9 trillion cubic feet of dry gas, and approximately 390 million barrels of condensate (Woodside estimate). The BJV propose to develop the Browse resource using two Floating Production Storage and Offloading (FPSO) facilities with up to 1,100 million standard cubic feet per day export capacity (annual daily average). The FPSOs will be supplied by a subsea production system and will export gas to the existing North West Shelf (NWS) Project infrastructure via a ~85 km spur line and a ~900 km Browse Trunkline, which will tie in near the North Rankin Complex. Construction is expected to commence approximately 2021-2022, with operations expected for up to 44 years.

Woodside had commissioned a dispersion modelling study, which examined the potential concentrations on the seabed from mercury in particulate form adsorbed to sediments within the produced water (PW) stream. Modelling was carried out for a PW flow rate of 296 m^3/d, and a steady state mercury concentration of 5 µg/L for 95% of the time then 30 µg/L for the remaining 5% of the discharge period. Based on the proposed PW treatment system, the modelled particle size distribution (PSD) is based on an analogous Woodside facility with particle sizes up to 10 µm (assuming 99% removal efficiency of larger particles) and 1% based on 20 µm.

The release location is shown in Table 1.1 and Figure 1.1.

The principal aim of this study was to compare the modelling results of the predicted mercury concentrations on the seabed associated with the PW stream discharge to the to the limit of reporting (LOR) of 0.01 mg/kg, as well as Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) sediment quality (ANZECC, 2000) default guideline value (DGV) and ‘upper’ guideline value (GV-high) of 0.15 mg/kg and 1.00 mg/kg, respectively, for 5, 10, 30 and 44 years of operations.

Table 1.1 Torosa FPSO PW dispersion modelling release location.

Release Site	Latitude (S)	Longitude (E)	Water depth (m)
Torosa FPSO	13° 58' 15.06"	122° 01' 28.53"	481

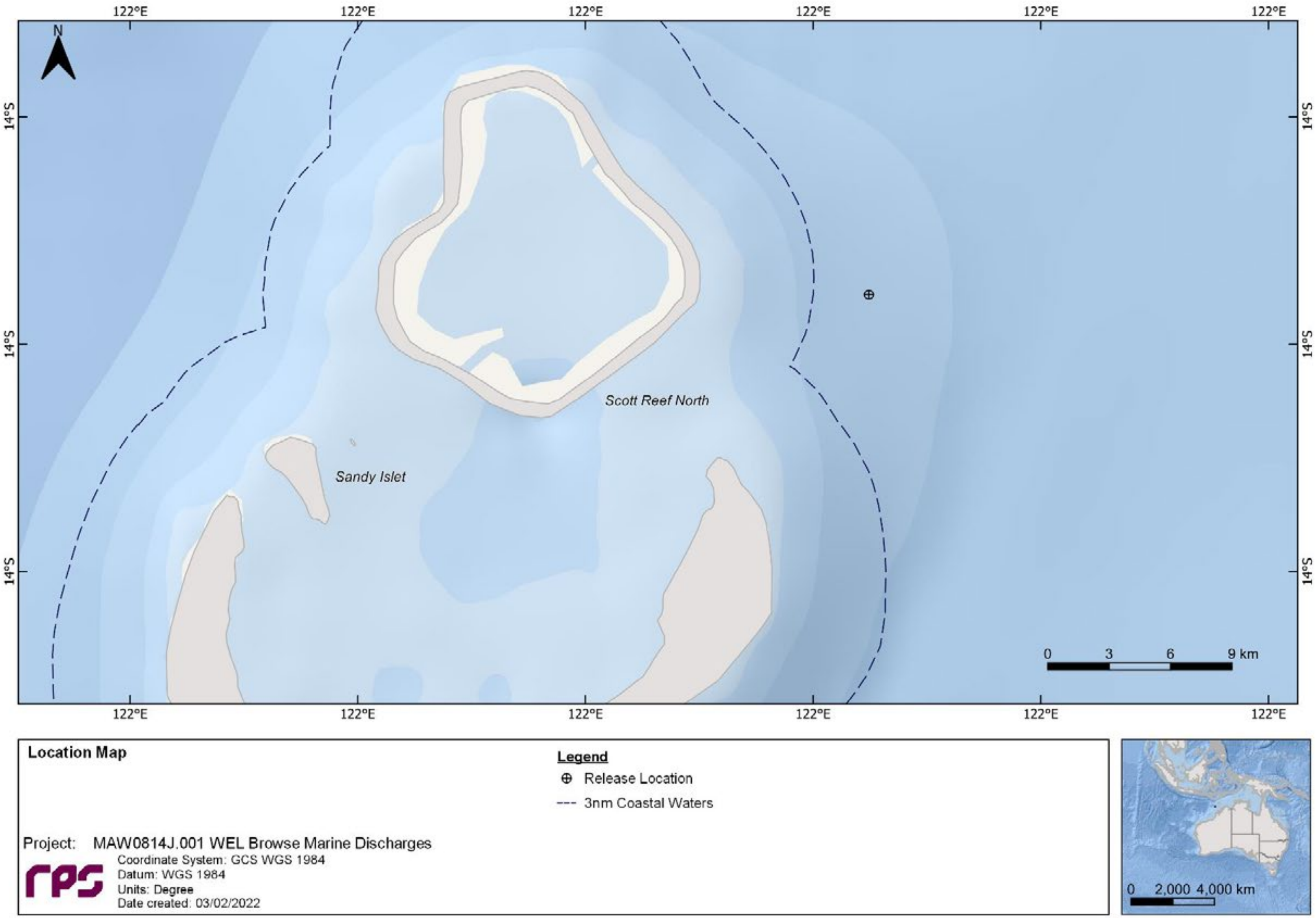

Figure 1.1 Torosa FPSO, in proximity to Scott Reef, off the Kimberley Coast of Western Australia

1.2 Modelling Scope

The scope of the modelling included the following components:

- Retrieval of a 10-year dataset (2006-2015) of three-dimensional spatially-varying currents surrounding the Torosa FPSO. The current data set included the combined influence of ocean drift and tidal currents and was suitably long to be indicative of interannual variability in ocean currents. The current dataset was validated against metocean data collected in the Browse project area;
- Input the current data and PW discharge specifics into the three-dimensional dispersion model (MUDMAP) to predict the movement and initial settlement of the mercury absorbed to the sediments;
- Fifty discharge simulations were run for a continuous discharge period of 30 days, with an initial mercury concentration of 5 µg/L for 28.5 days and 30 µg/L for the remaining 1.5 days of simulated discharge. Each simulation had the same information but different start times, in order to sample a range of current speeds and directions;
- Finally, the results for all 50 simulations were collectively assessed (i.e. 1,500 days of discharge modelling with no temporal overlapping) and scaled up accordingly to assess the potential exceedances of the LOR, DGV (0.15 mg/kg) and GV-high (1.00 mg/kg) for 5, 10, 30 and 44 years of operations.

2 REGIONAL CURRENTS

The area of interest for this study is located within the influence of the Indonesian Throughflow, a large-scale current system characterised as a series of migrating gyres and connecting jets that are steered by the continental shelf (Godfrey, 1996). While the mass flow is generally towards the south-west, year-round, the internal gyres generate local currents in all directions. As these gyres migrate through the area, large spatial variations in the speed and direction of currents will occur at a given location over time. Further south of the project area, the Leeuwin Current becomes the dominant large-scale current system, flowing poleward down the pressure gradient along the Western Australian coastline and past Cape Leeuwin (Condie & Andrewartha, 2008).

The current-induced transport of plumes can be variably affected by combinations of tidal, wind-induced and density-induced drift currents. Depending on their local influence, it is critical to consider all these potential advective mechanisms to rigorously understand patterns of potential transport from a given discharge location.

To appropriately allow for temporal and spatial variation in the current field, dispersion modelling requires the current speed and direction over a spatial grid covering the potential migration. A composite modelled ocean current data product was derived by combining predictions of BRAN global ocean circulation currents, with predictions of tidal currents generated by the RPS HYDROMAP model. A more detailed presentation of the hybrid current data can be found in RPS (2019).

2.1 Mesoscale Circulation Model

Data describing the flow of ocean currents was obtained from the global ocean circulation model BRAN (Bluelink ReANalysis; Oke et al., 2008, 2009; Schiller et al., 2008), which is sponsored by the Australian Government through the Commonwealth Bureau of Meteorology (BoM), Royal Australian Navy, and Commonwealth Scientific and Industrial Research Organisation (CSIRO). BRAN is a data-assimilative, three-dimensional ocean model that has been run as a hindcast for many periods and is now used for ocean forecasting (Schiller et al., 2008). BRAN routinely assimilates sea level anomaly data, tide gauge data, sea surface temperature and in situ temperature and salinity measurements (Oke et al., 2009). Comparisons of BRAN hindcast outputs to satellite and independent in situ observations found that BRAN was reliably representing the broad-scale ocean circulation, the mesoscale surface eddy field, and shelf circulation around Australia (Oke et al., 2008; Schiller et al., 2008). Additionally, reanalysis of past periods using the BRAN model has been shown to realistically represent upwelling events, in particular along the Bonney Coast of South Australia, a region of frequent wind-driven upwellings (Oke et al., 2009).

The BRAN predictions for drift currents are produced at a horizontal spatial resolution of approximately 0.1° over the region, at a frequency of once per day, averaged over the 24-hour period. Hence, the BRAN model data provides estimates of mesoscale circulation with horizontal resolution suitable to resolve eddies of a few tens of kilometres' diameter, as well as connecting stream currents of similar spatial scale. Drift currents that are represented over the inner shelf waters in the BRAN data are principally attributable to wind induced drift.

2.2 Tidal Circulation Model

As the BRAN model does not include tidal forcing, and because the data is only available at a daily frequency, a tidal model was developed for the study region using RPS' three-dimensional hydrodynamic model, HYDROMAP.

The model formulations and output (current speed, direction and sea level) of this model have been validated through field measurements around the world for more than 30 years (Isaji & Spaulding, 1984, 1986; Isaji et al., 2001; Zigic et al., 2003). HYDROMAP current data has also been widely used as input to forecasts and hindcasts of oil spill migrations in Australian waters. This modelling system forms part of the National Marine Oil Spill Contingency Plan for the Australian Maritime Safety Authority (AMSA, 2002).

HYDROMAP simulates the flow of ocean currents within a model region due to forcing by astronomical tides, wind stress and bottom friction. The model employs a sophisticated dynamically nested-gridding strategy, supporting up to six levels of spatial resolution within a single domain. This allows for higher resolution of currents within areas of greater bathymetric and coastline complexity, or of particular interest to a study.

The numerical solution methodology of HYDROMAP follows that of Davies (1977a, 1977b) with further developments for model efficiency by Owen (1980) and Gordon (1982). A more detailed presentation of the model can be found in Isaji & Spaulding (1984).

3 WATER TEMPERATURE AND SALINITY

The average annual water temperature and salinity throughout the water column adjacent to the release location is presented in Table 3.1. Data was obtained from the World Ocean Atlas 2013 database produced by the National Oceanographic Data Centre (National Oceanic and Atmospheric Administration) and its co-located World Data Centre for Oceanography (see Levitus et al., 2013; NODC, 2013).

Table 3.1 Average annual water temperature and salinity through the water column adjacent to the release location.

Water depth (m)	Temperature (°C)	Salinity (psu)
0	28.6	34.4
10	28.5	34.4
25	28.2	34.4
50	27.4	34.4
75	26.2	34.5
100	24.9	34.5
125	23.2	34.5
150	21.1	34.6
200	16.8	34.6
300	11.5	34.6
400	9.4	34.4

4 THREE-DIMENSIONAL DISPERSION MODEL: MUDMAP

The movement and initial settlement was predicted using the three-dimensional dispersion model, MUDMAP.

The far-field calculation (passive dispersion stage) employs a particle-based, random walk procedure. Any chemicals/constituents within the discharge stream are represented by a sample of Lagrangian particles. These particles are moved in three dimensions over each subsequent time step according to the prevailing local current data as well as horizontal and vertical mixing coefficients.

MUDMAP treats the Lagrangian particles as conservative tracers (i.e. they are not removed over time to account for chemical interactions, decay or precipitation). Predicted concentrations will therefore be conservative overestimates where these processes actually do occur. Each particle represents a proportion of the discharge, by mass, and particles are released at a given rate to represent the rate of the discharge (mass per unit time).

Settling under currents is selective for particle size, with the larger sizes tending to settle quickly and closer to the discharge location. Smaller particles will remain suspended for longer periods and will therefore be dispersed more widely by the ambient currents. Dispersion of the finer discharged material will tend to be greater with increased current speeds and water depth.

The system has been extensively validated and applied for discharge operations in Australian waters (e.g. Burns et al., 1999; King & McAllister, 1997, 1998).

4.1 Model Set-up

Table 4.1 presents a summary of the discharge modelling assumptions.

Woodside indicated that the study should be based on the average PW rate of 296 m^3/day via a horizontal discharge pipe 14 m below sea level. The average PW is estimated for the Torosa facility based on the expected reservoir outcome. The discharge depth is based on the FPSO facility design. In addition, it was assumed that 100% of the mercury would adsorb onto the sediments within the PW stream, which is highly conservative.

Based on the proposed PW system design filtering solids 10 µm and smaller, the contribution was based on a representative facility with a PSD less than 10 µm (Figure 4 1). The fall velocities for the various sizes were derived from empirical data provided by Dyer (1986).

Simulations were run for an additional 3 days after the discharge to allow finer sediments to settle out of suspension or to disperse.

Table 4.1 Summary of discharge modelling inputs and assumptions.

Parameter	Description/Value(s)		
Average produced water flow rate (m^3/day)	296		
Depth of discharge (m) BMSL	14		
Assumed state of mercury	100% (aggregated/particulate form)		
Mercury concentrations (µg/L)	Initial mercury concentration of 5 µg/L for 95% of the PW discharge period then, 30 µg/L for the remaining 5% of the PW discharge period		
Particle size distribution of mercury absorbed to the suspended solids within the PW stream and corresponding setting velocities	**Particle Size (µm)**	**Settling velocity (cm/s)**	**Contribution (%)**
	20	0.045	1.0
	10	0.010	8.9
	7.1	0.006	9.9
	5.6	0.004	13.7
	4.5	0.003	24.2
	3.2	0.001	42.3
Simulated discharge type	Continuous		
Years modelled	2006-2015		
Number of simulations	50 with different start dates		
Discharge duration (days)	30		
Model simulation length (days)	33		
Reporting thresholds (mg/kg)	0.01 Laboratory Limit of reporting (LOR) 0.15 (ANZECC & ARCANZ default guideline value (DGV) concentration) 1.00 (ANZECC & ARCANZ 'upper' guideline value (GV-high) concentration)		

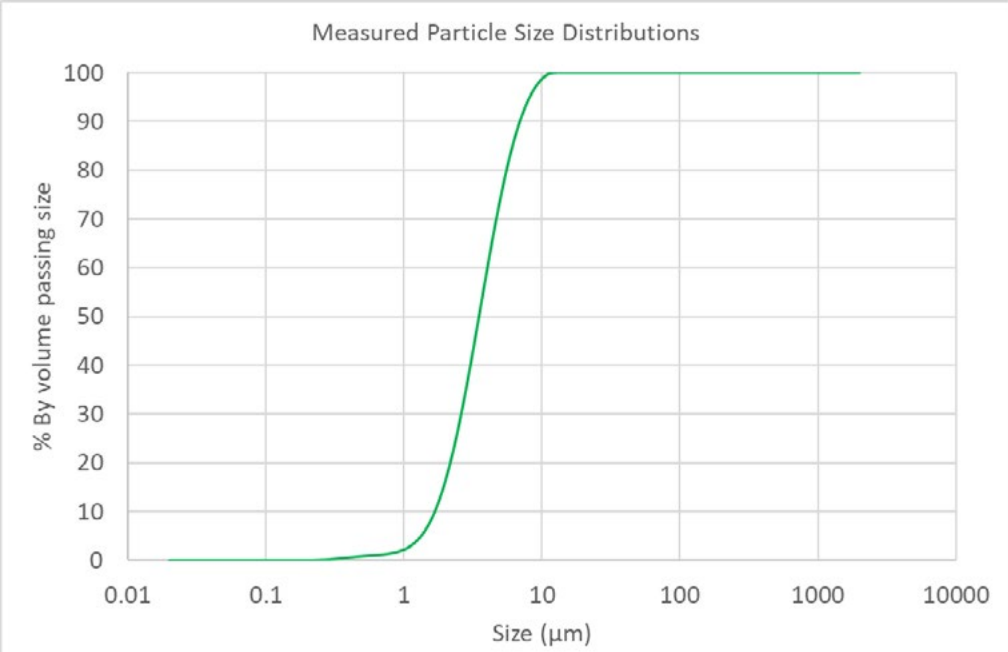

Figure 4.1 Estimated cumulative particle size distribution curves based on an analogous Woodside facility.

4.1.1 Mixing Parameters

The horizontal and vertical dispersion coefficients represent the mixing and diffusion caused by turbulence, both of which are sub-grid-scale processes. Both coefficients are expressed in units of rate of area change per second (m^2/s). Increasing the horizontal dispersion coefficient will increase the horizontal spread of the discharge plume and decrease the centreline concentrations faster. Increasing the vertical dispersion coefficient spreads the discharge across the vertical layers (or depths) faster.

Spatially constant, conservative dispersion coefficients of 0.25 m^2/s and 0.00001 m^2/s were used to control the spreading of the PW discharge in the horizontal and vertical directions, respectively. Each of the mixing parameters was selected following extensive sensitivity testing to recreate the plume characteristics predicted by the near-field modelling. It would be expected that the in-situ mixing dynamics would be greater under average and high energy conditions by a factor of 10 (King & McAllister, 1997, 1998) and thus the far-field model results are designed to produce a worst-case result for concentration extents.

4.1.2 Grid Configuration

MUDMAP uses a three-dimensional grid to represent the geographic region under study (water depth and bathymetric profiles). Due to the rapid mixing and small-scale effect of the effluent discharge, it was necessary to use a fine grid with a resolution of 20 m x 20 m to track the movement and fate of the discharge plume. The extent of the grid region measured approximately 20 km (longitude or x-axis) by 20 km (latitude or y-axis), which was subdivided horizontally into 1,000 x 1,000 cells.

5 REPORTING THRESHOLDS AND CALCULATIONS

As previously mentioned, the mercury concentrations on the seabed were compared to the LOR of 0.01 mg/kg, as well as ANZECC (2000) DGV and GV-high thresholds of 0.15 mg/kg and 1.00 mg/kg, respectively, to operational periods of 5, 10, 30 and 44 years.

The ambient baseline mercury concentrations were considered negligible as previous sampling show it was below detectible limits (Gardeline 2009).

The mass of mercury was calculated by multiplying the mercury deposition concentrations by the density of mercury (13,534 kg/m^3) and area of each grid cell (which is 20 m x 20m). Therefore, based on a model predicted maximum deposition value of 0.0000043 g/m^2 following a 30 day continuous discharge (see Section 6), this equates to a mass of 1.72 mg.

The results for all 50 simulations were collectively assessed, hence, the 1,500 days of discharge modelling with no temporal overlapping was scaled accordingly to evaluate the potential exceedances of the LOR, DGV (0.15 mg/kg) and GV-high (1.00 mg/kg) for 5, 10, 30 and 44 years of operations.

To estimate the mass of the existing baseline sediment layer within the depth horizon was a step wise approach:

- Based on previous sampling operations to assess the environmental impacts of sediment contamination a 2.8 cm core thickness was used to determine the concentration of mercury to sediments;
- Sediment sample data collected by Woodside (Gardeline 2009) showed that the PSD consistently on average 65% fines (i.e. 0.063 mm or smaller) and based on a paper by Mohr et al. (2018) this would be characterised by a density of 1,890 kg/m^3; and
- Therefore, based on a density, depth horizon of 2.8 cm and the area of each grid cell, the mass of sediment was estimated at 21,168 kg.

In conclusion, to calculate the mercury concentrations, the mass of mercury within the grid cell was divided by the mass of sediment within the depth horizon.

Lastly, a study by Glen (1997) had found that the maximum natural sedimentation rate for Northwest Australia is 223.21 cm/ka (0.02 cm/year). Based on the sedimentation rate over the expected life of the facility (30 years), the natural sedimentation would add only 0.6 cm, hence, the application of the ANZECC & ARMCANZ (2000) sediment quality threshold had only considered the existing baseline sediment layer.

6 MODELLING RESULTS

In general, due to the slow settling velocities the mercury remained in suspension for extended periods of time (days) under the influence of the prevailing currents, which dictated the transportation and ultimately the settlement area.

Figure 5 1 illustrates the predicted mercury deposition for the maximum triggered grid cell at the end of the 30 day discharge period for each simulation. It should be noted that all other model cells are below this value and therefore, the results assessed are highly conservative.

The results show that for 16 simulations recorded deposition values below 0.000001 g/m^2, which equates to 0.4 mg, which, would be mostly likely due to mercury drifting northeast from the release location into deeper waters.

Using the methodology described in Section 5, the results for all 50 simulations were collectively assessed and the mercury concentrations for the maximum triggered grid cells scaled up accordingly to represent 5, 10, 30 and 44 years of operations (see Table 6.1).

After 30 years of operations, the maximum concentration was 0.0006 mg/kg, which is 16.7 times below the LOR, 250 times lower than the DGV of 0.15 mg/kg and 1,670 times below the GV-high threshold of 1.00 mg/kg.

Table 6.1 Summary of the mercury concentrations for the maximum triggered grid cell based on 5, 10, 30 and 44 years of operations.

Mercury concentration (mg/kg)			
5 years	10 years	30 years	44 years
0.0001	0.0002	0.0006	0.0009

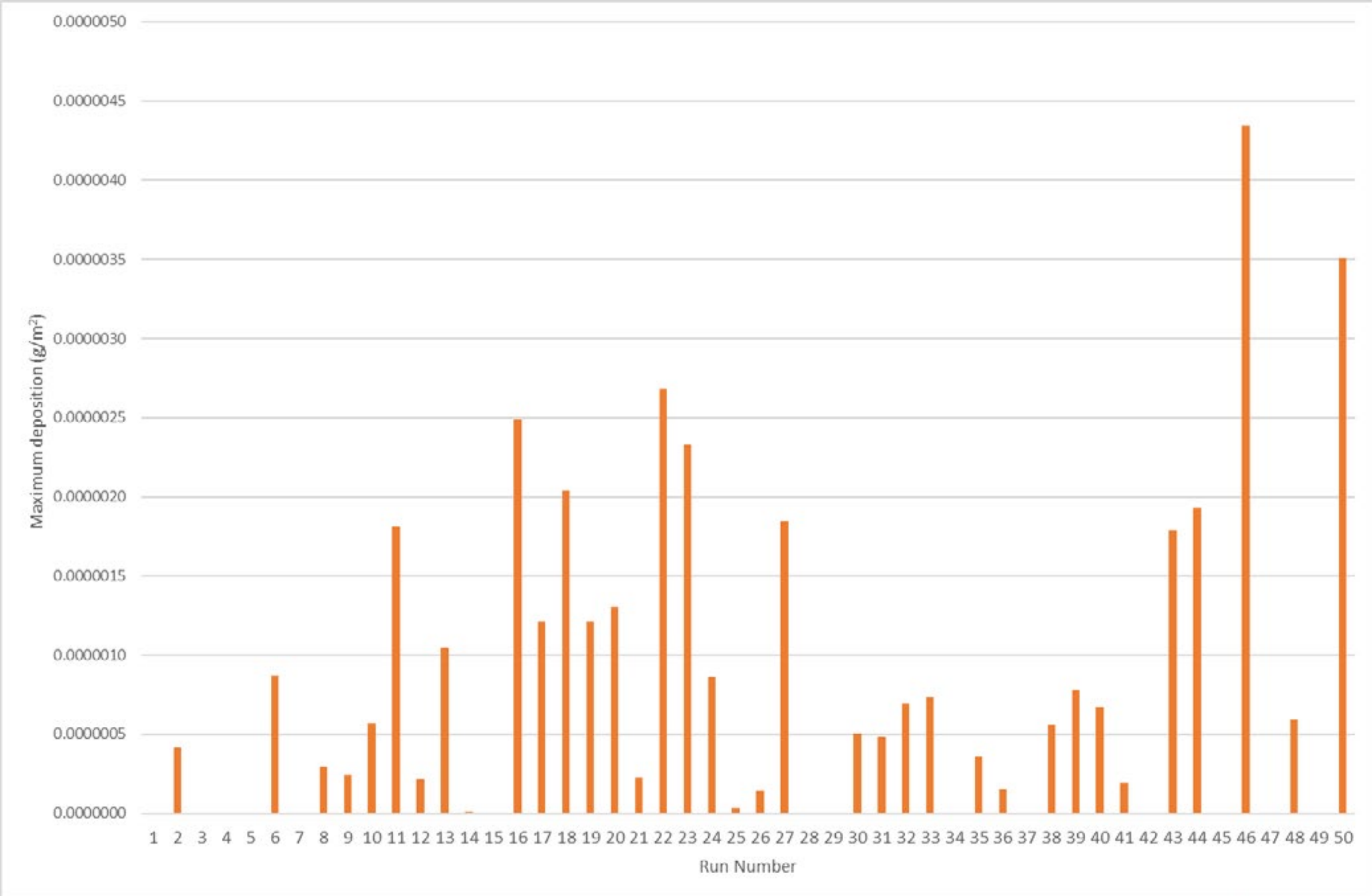

Figure 6.1 Predicted mercury deposition within the maximum triggered grid cell at the end of the 30 day discharge period for each simulation.

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APPENDIX B

APPENDIX B.1 UPDATED INFORMATION

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
Kimberley Marine Park (74,469 km^2)	VI (Multiple Use).	The Kimberley Marine Park provides protection for the habitats and ecological communities in waters offshore of the Kimberley coastline, ranging in water depth from less than 15 to 800 m. **Natural values** – natural values of the Kimberley Marine Park include: + ecosystems representative of the northwest shelf province, northwest shelf transition and Timor province (**Section 5.2.1**) + the KEFs 'Ancient coastline at the 125 m depth contour' and 'Continental slope demersal fish communities' intersect this AMP (see **Section 5.3.3.1**) + breeding and foraging habitat for seabirds (**Section 5.3.2.1.1** and **Section 5.3.2.3**) + internesting and nesting habitat for marine turtles (S**ection 5.3.2.1.1**, **Section 5.3.2.2** and **Section 5.3.2.5**) + breeding, calving and foraging habitat for inshore dolphins (**Section 5.3.2.4.3**) + calving, migratory pathway and nursing habitat for humpback whales (**Section 5.3.2.1.1** and **Section 5.3.2.4.1**) + migratory pathway for pygmy blue whales (**Section 5.3.2.1.1** and **Section 5.3.2.4.2**) + foraging habitat for dugongs (**Section 5.3.2.4.3**) + foraging habitat for whale sharks (**Section 5.3.2.1.1** and **Section 5.3.2.7**). Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	~ 40 km from the Browse Development Area. The proposed BTL route runs through the Multiple Use Zone (IUCN VI) of the Kimberley Marine Park for approximately 68 km.

Marine Park	Category[1]		
		Cultural values – Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. The Wunambal Gaambera, Dambimangari, Mayala, Bardi Jawi and the Nyul Nyul people's sea country extends into the Kimberley Marine Park. The Wunambal Gaambera people's country includes daagu (deep waters), with about 3400 km2 of their sea country located in the Marine Park. The Wunambal Gaambera, Dambimangari, Mayala, Bardi Jawi and the Nyul Nyul people have an unbroken connection to their sea country, having deep spiritual connection through Wunggurr (creator snakes) that still live in the sea. Staple foods of living cultural value include saltwater fish, turtles, dugong, crabs and oysters. Access to sea country by families is important for cultural traditions, livelihoods and future socio-economic development opportunities. Key cultural values that extend into the Kimberley Marine Park and that are recognised by the national heritage listing for the West Kimberley are: + Wanjina Wunggurr Cultural Tradition + log-raft maritime tradition + interactions with Makassan traders + pearl resources. The Wunambal Gaambera, Dambimangari and Bardi Jawi people consider that these values extend into the Kimberley Marine Park. The Wanjina Wunggurr is law of the Wunambal Gaambera and Dambimangari people and it is recognised that all of the sea country, land, plants and animals were put there by Wanjina Wunggurr. Under Wanjina Wunggurr law, the Wunambal Gaambera and Dambimangari people have a responsibility to manage country, to maintain the health of the country and all living things. The Wunambal Gaambera, Bardi Jawi, Mayala and the Nyul Nyul people have had native title determined over parts of their sea country included in this Park. The native title holders for these people are represented by the Wunambal Gaambera Aboriginal Corporation, Bardi and Jawi Niimidiman Aboriginal Corporation and the Kimberley Land Council. These representative bodies are the points of contact for their respective areas of sea country for the Marine Park. Due to the nature and coastal location of these values, they are not anticipated to be significantly impacted by project activities and have not been described further.	
		Heritage values – there are no international, Commonwealth or National heritage listings relevant to the Kimberley Marine Park. The Marine Park contains more than 40 known shipwrecks listed under the Historic Shipwrecks Act 1976	
		Social and economic values – socio-economic values of this marine park include tourism, recreation, mining and traditional use. Relevant values are described further in **Section 5.4**.	

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
Argo-Rowley Terrace Marine Park (146,003 km^2)	VI – Protected area with sustainable use of natural resources	This AMP provides protection for the ecological communities and habitats of the deeper offshore waters of the region, in water depths ranging from 220 to 6,000 m. This includes protection for many bathymetric features, including aprons and fans, canyons, continental rise, knolls/abyssal hills and the terrace and continental slope. This AMP provides connectivity between the Mermaid Reef Marine Park / WA Rowley Shoals Marine Park and the deeper waters of the NWMR.	~ 125 km from the Browse Development Area. The proposed BTL route runs through the Multiple Use Zone (IUCN VI) of the Argo-Rowley Terrace Marine Park for approximately 97 km.
		Natural values – natural values of the Argo-Rowley Terrace Marine Park include: + ecosystems representative of the northwest transition and Timor province (**Section 5.2.1**) + the KEFs 'Canyons linking the Argo Abyssal Plain and Scott Plateau' and 'Mermaid Reef and Commonwealth waters surrounding the Rowley Shoals' intersect this AMP (see **Section 5.3.3.1**) + species listed as Threatened, Migratory, Marine or Cetacean under the EPBC Act (**Section 5.3.2**) + ecosystems of the Marine Park are associated with emergent reef flat, deep reef flat, lagoon, and submerged sand habitats (**Section 5.3**) + BIAs, including resting and breeding habitat for seabirds and a migratory pathway for the pygmy blue whale (**Section 5.3.2.1.1**). Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	
		Cultural values – as noted in the 'North-west Marine Park Management Plan' (Director of National Parks, 2018), limited information regarding the cultural significance of this marine park is currently available. Sea country is valued for Indigenous cultural identity, health and wellbeing. Across Australia, Indigenous people have been sustainably using and managing their sea country for tens of thousands of years. There is limited information about the cultural significance of this Marine Park.	
		Heritage values – there are no international, Commonwealth or National heritage listings relevant to the Argo-Rowley Terrace Marine Park. The Marine Park contains two known shipwrecks listed under the Historic Shipwrecks Act 1976: Alfred (wrecked in 1908) and Pelsart (wrecked in 1908).	
		Social and economic values – socio-economic values of this MP include fishing and mining. Relevant values to the proposed Browse to NWS Project are described further in Section 5.4.	

Marine Park	Category[1]		
Ashmore Reef Marine Park (583 km^2)	Ia – Strict nature reserve	Ashmore Reef (see **Section 5.3.3.4**) is an emergent oceanic shoal with vegetated islands protected by this AMP. The reef and broader Marine Park is a stepping stone connecting reef systems along the WA coast by facilitating the transport of biological material. This AMP it is a biodiversity hotspot that features high endemism in demersal fish communities. The AMP supports some of the most important seabird breeding colonies on the NWS, and features BIAs for marine turtles, pygmy blue whales and dugongs. Ashmore Reef is also internationally recognised for its high diversity of sea snakes.	~ 230 km north-west of the Browse Development Area.
		Natural values – natural values of the Ashmore Reef Marine Park include: + ecosystems representative of the northwest shelf province, northwest shelf transition and Timor province (**Section 5.2.1**) + the KEFs 'Ashmore Reef and Cartier Island and surrounding Commonwealth waters' and 'Continental slope demersal fish communities' (see **Section 5.3.3.1**) + habitats associated with two extensive lagoons, sand flats, shifting sand cays, extensive reef flat and seagrass (**Table 5-36**) + species listed as Threatened, Migratory or Marine or Cetacean under the EPBC Act (**Section 5.3.2.1**) + BIAs, including those for seabirds, migratory shorebirds, marine turtles and the pygmy blue whale (**Section 5.3.2.1.1**) + features the Ashmore Reef Ramsar Site (S**ection 5.3.3.4**). Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	
		Cultural values – as noted in the 'North-west Marine Park Management Plan' (Director of National Parks, 2018), limited information regarding the cultural significance of this marine park for Indigenous Australians is currently available. The MP does, however, contain Indonesian artefacts and grave sites and the reef is still visited by Indonesian fishers (see **Section 5.4.2.3**).	
		Heritage values – there are no international or National heritage listings relevant to the Ashmore Reef MP. Ashmore Reef was Commonwealth Heritage listed in 2004.	
		Social and economic values – socio-economic values of this marine park include tourism, recreation and scientific research. Relevant values are described further in Section 5.4.	

Australian Marine Park	IUCN Category[1]	Description and Values	Distance from Project Area
Cartier Island Marine Park (172 km²)	Ia – Strict nature reserve	This AMP encompasses a diversity of habitats, including Cartier Island (an unvegetated sand island described in Table 5-38), a mature reef flat, Wave Governor Bank (a submerged pinnacle), and two shallow pools. Cartier Island and the broader AMP is a stepping stone connecting reef systems along the WA coast by facilitating the transport of biological material.	~ 230 km north-west of the Browse Development Area.
		Natural values – natural values of the Ashmore Reef Marine Park include: + ecosystems representative of the Timor province (**Section 5.2.1**) + the KEFs 'Ashmore Reef and Cartier Island and surrounding Commonwealth waters' and 'Continental slope demersal fish communities' (see **Section 5.3.3.1**) + high diversity and abundance of hard and soft corals, gorgonians, sponges and encrusting organisms + species listed as Threatened, Migratory or Marine or Cetacean under the EPBC Act (**Section 5.3.2.1**) + BIAs, including those for seabirds, marine turtles and the whale shark (**Section 5.3.2.1.1**). Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	
		Cultural values – as noted in the 'North-west Marine Park Management Plan' (Director of National Parks, 2018), limited information regarding the cultural significance of this marine park for Indigenous Australians is currently available.	
		Heritage values – there are no international, Commonwealth or National heritage listings relevant to the Cartier Island Marine Park. The Ann Millicent shipwreck is located within this AMP.	
		Social and economic values – socio-economic values of this MP include scientific research. Relevant values are described further in Section 5.4.	

Marine Park	Category[1]		
Mermaid Reef Marine Park (540 km^2)	II – National park	The Mermaid Reef Marine Park features water depths between 15 and 500 m. Mermaid Reef is one of three reefs forming the Rowley Shoals (**Section 5.2.3.3**); the best geological example of shelf atolls in Australia. The AMP is of national and international significance due to its pristine character, coral formations, geomorphic features and diverse marine life. It is a key area for over 200 species of hard corals and 12 classes of soft corals with coral formations in pristine condition.	~ 325 km south-west of the Browse Development Area. ~ 2 km from the proposed BTL route at its closest point.
		Natural values – natural values of the Ashmore Reef Marine Park include: + ecosystems representative of the northwest transition (**Section 5.2.1**) + the KEF 'Mermaid Reef and Commonwealth waters surrounding Rowley Shoals' (see **Section 5.3.3.1**) + species listed as Threatened, Migratory or Marine or Cetacean under the EPBC Act (**Section 5.3.2.1**) + BIAs, including those for seabirds and the pygmy blue whale (**Section 5.3.2.1.1**) Of these natural values, those relevant to the project are discussed throughout this Chapter (as per the section references provided).	
		Cultural values – as noted in the 'North-west Marine Park Management Plan' (Director of National Parks, 2018), limited information regarding the cultural significance of this marine park for Indigenous Australians is currently available.	
		Heritage values – there are no international or National heritage listings relevant to the Mermaid Reef MP. Mermaid Reef was Commonwealth Heritage listed in 2004 and the 'Lively' shipwreck is located within this MP (**Section 5.4.3**)	
		Social and economic values – Tourism, recreation, and scientific research are important activities in the Marine Park. These activities contribute to the wellbeing of regional communities and the prosperity of the nation. Relevant values are described further in **Section 5.4**.	

APPENDIX C MANAGEMENT PLANS

APPENDIX C.1 GREENHOUSE GAS MANAGEMENT PLAN

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1. SUMMARY

Woodside Energy Ltd (Woodside) is Operator for and on behalf of the Browse Joint Venture (BJV) (Woodside Browse Pty Ltd, Shell Australia Pty Ltd (Shell), BP Developments Australia Pty Ltd (BP), Japan Australia LNG (MIMI Browse) Pty Ltd (MIMI), and PetroChina International Investment (Australia) Pty Ltd (PetroChina)), which proposes to develop the Brecknock, Calliance, and Torosa fields (collectively known as the Browse hydrocarbon resources) using two 1100 million standard cubic feet per day (MMscfd) (annual daily export average) Floating Production Storage and Offloading (FPSO) facilities.

The FPSO facilities will be supplied by a subsea production system and will transport gas to existing North West Shelf (NWS) Project infrastructure via a ~85 km spur line and a ~900 km proposed Browse Trunkline (BTL), which are proposed to be tied-in near the existing North Rankin Complex (NRC) in Commonwealth water (Note: The NRC is owned by the North West Shelf Joint Venture (NWSJV)).

The proposal is described in its entirety in the draft Environmental Impact Statement/Environmental Review Document (draft EIS/ERD) and is summarised in **Section 2.1** of this Greenhouse Gas Management Plan (GHGMP) for ease of reference.

The proposed Browse Project is subject to both State and Commonwealth assessment and approval; each having their own respective assessment requirements. The structure of this GHGMP reflects the jurisdictional breakdown of emissions sources and associated requirements.

This GHGMP details the measures proposed to manage the Greenhouse Gas (GHG) emissions from the proposed Browse Project. **Table 1-1** summarises the information contained in this GHGMP.

Table 1-1 GHGMP summary table

Title of Proposal	Proposed Browse Project
Proponent Name	Woodside Energy Ltd, as Operator for and on behalf of the Browse Joint Venture
Purpose of the GHGMP	This GHGMP has been developed to fulfil a commitment in the draft EIS/ERD in order to: • continuously review mechanisms to mitigate and manage GHG emissions • ensure compliance with the *National Greenhouse and Energy Reporting Act* 2007 (NGER Act)/Safeguard Mechanism (SGM) baseline requirements.
Key Provisions in the GHGMP (Management Actions – see Section 6)	Management of the contribution to global GHG concentrations through the implementation of the following key provisions: • fuel and flare targets are set annually to drive continuous improvement • continue to identify and adopt practicable mitigation and management measures to reduce Scope 1 GHG emissions • routine emissions monitoring and reporting is undertaken in accordance with the *National Greenhouse and Energy Reporting Act* 2007 • comply with SGM (or applicable legislation) to manage emissions within the facility baseline • adhere to the Methane Guiding Principles • undertake 5-yearly assessment of reasonable and practicable emission reduction equipment and technologies that could be implemented to reduce GHG emissions

2. INTRODUCTION

2.1 The Proposed Browse Project

The proposed Browse Project will comprise subsea infrastructure and two Floating Production Storage and Offloading (FPSO) facilities, connected to existing NWS Project infrastructure via the ~900 km Browse Trunkline (BTL).

The key characteristics of the proposed Browse Project are presented in Table 1-1 of the draft EIS/ERD and described below:

- hydrocarbon extraction will require up to 54 wells with associated subsea infrastructure, including manifolds and flowlines
- extracted hydrocarbons will be transferred via subsea infrastructure, including wellheads, manifolds and flowlines, up to the FPSO facilities, which are located in Commonwealth Water.
- condensate stabilisation and storage will occur on the FPSO facilities prior to offtake to condensate tankers for delivery to market
- gas processing will also occur on the FPSO facilities prior to export via the inter-field spur line and BTL to existing NWS Project infrastructure.

The BTL is proposed to tie into the existing second trunkline (2TL) near NRC. The NWSJV is pursuing approvals for the NWS Project Extension Proposal; the long-term processing of third-party gas and fluids and NWSJV field resources using NWS Project infrastructure until around 2070 (EPBC 2018/8335 and EPA 2186).

Subject to all regulatory and joint venture approvals being obtained and commercial agreements, transmission of the gas from the BTL tie in point through 2TL and onshore processing of the gas by the NWSJV would be undertaken using existing NWS Project infrastructure. Activities in State waters will comprise a limited subset of infrastructure and activities. This will include developing up to an estimated 24 wells and associated subsea infrastructure, targeting the State component of the hydrocarbon resources of the Torosa reservoir.

2.2 Scope of the GHGMP

This GHGMP has been developed to fulfil a commitment in the draft EIS/ERD in order to:

- continuously review mechanisms to mitigate and manage GHG emissions
- ensure compliance with the *National Greenhouse and Energy Reporting Act* 2007 (NGER Act)/SGM baseline requirements.

This GHGMP specifically addresses the management of BJV Scope 1 GHG emissions arising from the proposed Browse Project activities, as defined by the National Greenhouse and Energy Reporting Regulations 2008 (Cth). **Table 3-1** provides greater definition on project activities and emissions sources. This GHGMP specifically excludes emissions which are not classified as BJV Scope 1. The excluded emissions sources are summarised in **Table 2-1**.

Scope 3 emissions are not within the scope of this GHGMP. Scope 3 emissions for the proposed Browse Project would typically be Scope 1 emissions for other entities that that have operational control of the emission source and are subject to regulation at the point of emission. Those other entities include customers of the proposed Browse Project products, such as electricity generators, and contractors engaged in the development of the proposed Browse Project.

Accordingly, the Browse Scope 3 emissions are anticipated to be accounted for and managed by contractors and the customers of proposed Browse Project products under their Scope 1 emissions management and reporting and obligations. Some Scope 3 emission sources will be within Australia and the majority will be in international jurisdictions.

Table 2-1 Sources of GHG Emissions excluded from this GHGMP

Emissions Source/Process	Jurisdiction	Scope
Indirect GHG emissions from venting of reservoir CO2 extracted from the gas exported from the FPSO and vented from the downstream NWSJV AGRU. These are addressed in the NWS GHGMP ((NWS, 2019) as updated from time to time).	State	Scope 1 (NWS JV)
Indirect emissions from combustion of hydrocarbon-based fuels at the NWSJV facilities required for processing of hydrocarbon gas prior to export. These are addressed in the NWS GHGMP ((NWS, 2019) as updated from time to time).	State	Scope 1 (NWS JV)
Scope 2 upstream emissions sources (none have been identified for the proposed Browse Project).	N/A	Scope 2
Emissions associated with activities under the operational control of third parties to carry out or support operations, installation, construction, hook up and commissioning activities etc.	State, Commonwealth and International (depending on location)	Scope 3 (contractor)
Emissions associated with the transport, distribution and consumption of products from the proposed Browse Project.	State, Commonwealth and International (depending on location)	Scope 3 (consumer)

2.3 Rationale and Approach

This GHGMP outlines how GHG emissions from the proposed Browse Project will be managed to meet the environmental objectives of the proposed Browse Project. This approach acknowledges that planned, continuous and occasional emissions to air from the proposed Browse Project will occur and that the impacts from these can be reduced or mitigated by implementing the measures outlined in this GHGMP.

The content of this GHGMP has been developed considering both relevant Commonwealth and State climate change initiatives and policies[1], as well as Woodside's approach to GHG emissions.

Relevant Commonwealth and State climate change initiatives and policies are discussed in **Section 1**, with the GHGMP giving greater clarity on the jurisdictional breakdown of the emissions profile. This in particular describes the nature of GHG emissions arising within the State Proposal Area, and the applicability of the WA Environmental Protection Authorities' (EPA's) Greenhouse Gas Emissions Environmental Factor Guideline (EPA, 2020a).

Woodside's approach to GHG emissions is described in **Section 4**. A key component of the Framework is Woodside's Greenhouse Gas Reduction Philosophy (**Section 4.3**) which aims to limit our net emissions based on three key activities: Design Out, Operate Out and Offset.

- Design Out: The design of the proposed Browse Project is well progressed, with key Design Out mitigations presented in the Section 7.7 of the draft EIS/ERD and repeated in **Section 5.1** for context.

[1] https://www.environment.gov.au/climate-change/government

- Operate Out: Woodside's Management System processes facilitate continuous review of mechanisms to mitigate and manage GHG emissions, thereby optimising efficiencies in GHG emissions in the Operate Phase. These processes are described in **Section 5.2**.
- Offset: The offsetting of a component of residual GHG emissions arising from the Project, including ensuring compliance with the NGER Act/SGM baseline requirements are described in **Section 5.3**.

In order to clearly meet the commitments of this GHGMP as provided in the draft EIS/ERD and the environmental objectives of the proposed Browse Project, key management provisions have been developed and presented in **Section 6**. Noting the inherent constraints on the feasibility of measuring, monitoring and attributing direct site-specific effects on the environment from GHG emissions, the measures outlined in this GHGMP are necessarily management-based rather than outcome-based. Provisions in this GHGMP are therefore focussed on ensuring offshore facilities are optimised and continually evaluated to reduce emissions.

3. REGULATORY CONTEXT

3.1 Jurisdictional Breakdown of Scope 1 GHG emissions

Table 3-1 shows the breakdown of Scope 1 GHG emissions by jurisdiction for the proposed Browse Project.

Table 3-1 Browse Project Scope 1 GHG Emissions

Description	Jurisdiction	Emissions Source/Process	Scope	Emissions Estimate (Expected Field Life)
Processing and Reservoir CO_2 Emissions	State	Direct GHG emissions generated in the State Proposal Area from operational activities associated with upstream processing of Browse gas.	Scope 1 (BJV)	0.01 MT[1]
	Commonwealth	Direct GHG emissions from venting of reservoir CO_2 extracted from the production stream via the FPSOs AGRUs	Scope 1 (BJV)	70 (81) MT[2,3]
	Commonwealth	Direct emissions from combustion of hydrocarbon-based fuels required for processing, compression of hydrocarbon gas on the FPSO prior to pipeline export and other operational activities. Also includes flaring and fugitive emissions of natural gas.	Scope 1 (BJV)	40.6 MT

[1] Based on Scope 1 emissions which are limited to fugitive emissions (plus any vessel movements under Woodside's operational control) arising from subsea infrastructure in the State Proposal Area. Further detail on the breakdown of emissions in the State Proposal Area is described below. Fugitives are estimated in accordance with NGER (Measurement Determination 2008 section 3.76) Method 1 for natural gas transmission (fugitive emissions).

[2] Upstream reservoir emissions have been estimated based on the maximum expected case given a gas export specification target of 2.5mol% CO_2. Estimates of emission implications for a 1 mol% to 2.8 mol% CO_2 gas export specification are presented in Table 7-7 of the draft EIS/ERD. Note the gas export specification is dependent on the outcome of final commercial arrangements.

[3] Bracketed emissions refer to high reservoir CO_2 composition scenario.

Further quantification of emissions sources, including the methodology used to develop these estimates, is provided in Section 7.7 of the draft EIS/ERD. Quantification of emissions sources from the draft EIS/ERD has been appended to this document for the reader's convenience (**Appendix A**).

Commonwealth Waters

Direct (Scope 1) GHG emissions generated in Commonwealth Waters from operational activities associated with upstream processing of Browse gas, arise principally from two sources, both situated on the two FPSOs:

- the combustion of hydrocarbon-based fuel, necessary to process the gas and for power export compression as well as associated processing and utilities
- naturally occurring CO_2 in the hydrocarbon reservoir that must be removed prior to LNG liquefaction.

State Proposal Area

In order to provide further definition to the State Proposal Area emissions estimates provided in the draft EIS/ERD**, Table 3-2** presents the total GHG estimates anticipated from within the State

Proposal Area, including Scope 3 emissions. Please note that Scope 3 emissions estimates are provided for context only and are outside the scope of this GHGMP (refer **Section 2.2**).

Table 3-2 Proposed Browse Project State Proposal GHG emissions

GHG Emissions Source/Process	Scope	GHG Emissions (Expected field life – 31 years)	GHG Emissions (Annual average over Expected field life - 31 years)
Fugitive emissions from subsea infrastructure	Scope 1 (BJV)	0.008MT (7,500 t)	0.00024MT (240 t)*
Construction, installation and well unloading	Scope 3	0.30 MT (306,000 t)	0.012MT** (11,600 t)
Operations (Subsea Inspection, Maintenance, Monitoring and Repair)	Scope 3	0.03MT (30,000 t)	0.001MT (950 t)
Total	Scope 1 - 3	0.35MT (343,500 t)	0.013MT (12,900 t)

**Estimated in accordance with NGER (Measurement Determination 2008 section 3.76) Method 1 for natural gas transmission (fugitive emissions)*

***Construction/installation due to drilling sequence will occur progressively. It is expected that drilling may occur over approximately 10 years of the overall 31 year expected field life.*

Direct GHG emissions anticipated to be generated in the State Proposal Area from operational activities associated with upstream processing of Browse gas are limited to activities under Woodside's operational control. Typically, vessels and drilling rigs associated with both the construction and operation of proposed Browse facilities are not expected to be under Woodside's operational control, and therefore emissions from these sources are expected to be classified as Scope 3 emissions. Scope 3 emissions from installation in the State Proposal Area was estimated in the draft EIS/ERD to be less than 0.4 MT over the expect life of the proposal.

Scope 1 GHG emissions may also include any fugitive emissions associated with the subsea infrastructure (i.e. wellheads, jumper cables, manifolds and flowlines). Fugitive emissions have been estimated (in accordance with NGER (Measurement Determination 2008 section 3.76) to be <1kT per annum.

3.2 Commonwealth Regulatory Context

3.2.1 Relevant Matters of National Environmental Significance

Under the *Environment Protection and Biodiversity* Conservation Act 1999 (EPBC Act), a proposed action which may adversely affect Matters of National Environmental Significance (MNES) requires approval under the Act. The controlling provisions related to MNES relevant to the proposed Browse Project have been identified in the draft EIS/ERD.

GHG emissions from the proposed Browse Project will contribute to net global emissions. Natural gas from the proposed Browse Project has the potential to support an overall reduction in net global atmospheric concentration by displacing more emissions-intensive fuels such as coal and heavy oils. The potential environmental impact of GHG emissions from the proposed Browse Project has been assessed in Chapter 7 of the draft EIS/ERD.

Use of Browse products such as LNG and condensate by third party customers results in GHG emissions (Scope 3 emissions) which are beyond the control of Woodside as operator of the proposed Browse Project and the scope of this GHGMP. Note that the BJV participants may equity lift (i.e. individually sell) products produced through the NWS Joint Venture facilities under proposed commercial arrangements, and so the markets into which these products are sold are beyond the operational control of Woodside as operator. Emissions associated with the extraction of Browse feedgas, production of offshore condensate and transportation of feedgas to NWS Project infrastructure for processing will be within the control of the BJV and are the subject to the provisions of this GHGMP. The GHGMP considers and references applicable Commonwealth laws, policies and programs where relevant.

3.2.2 Environmental Values Potentially Affected by Global GHG Emissions

While it is not feasible to directly correlate the potential impact of the proposed Browse Project GHG emissions on receptors (be that impact negative or positive in the case of replacing higher carbon fuels), it is possible to predict the likely effects of climate change on the Australian environment. In a study by CSIRO (2015) into the 'Implications of Climate Change for Australia's Biodiversity', modelling indicated that temperatures will increase across Australia, rainfall patterns will change significantly and extreme events such as droughts, floods and wildfires will become more common. These changes are likely to impact on individual species, ecosystems and ecosystem services such as food and water availability. Within decades, environments across Australia may be substantially different. Biodiversity will be affected by climate change in a variety of ways and there will be much spatial variation in ecological change.

The International Energy Agency (IEA, 2019) has highlighted the role of natural gas in enabling the energy transition, reporting that "global energy-related CO_2 emissions flattened in 2019 following two years of increases. This resulted mainly from a sharp decline in CO_2 emissions from the power sector in advanced economies, thanks to the expanding role of renewable sources (mainly wind and solar PV), fuel switching from coal to natural gas, and higher nuclear power output". This demonstrates the contribution gas is making to lowering net global GHG emissions and net atmospheric concentrations by providing a dispatchable, transportable energy source to replace higher carbon-intensive fuels, such as coal, and supporting cheap renewables. As Australia's Chief Scientist has noted, "natural gas is already making it possible for nations to transition to a reliable, and relatively low emissions, electricity supply"[2].

It should also be noted that the growth of renewables may also be constrained by the need to ensure grid stability; that is, grids need to be maintained at the correct frequency during fluctuations in demand. This can be readily done with readily dispatchable energy sources such as gas but more difficult with renewable sources such as solar and wind. The role of gas will increasingly be to supplement domestically produced renewables. In doing so, it will compete with other transportable, dispatchable fossil fuels such as oil and coal, which along with competing sources of natural gas are therefore the appropriate comparators when considering alternative energy sources to gas from the proposed Browse Project.

LNG supplied into Asian markets, and the pipeline natural gas for WA, contributes to lower life cycle atmospheric contributions of GHG than would otherwise be the case. The Browse Joint Venture is committed to maximising this outcome by lowering the Browse Project's direct net Scope 1 emissions through plant design, efficient operations, and offsets.

3.3 State Regulatory Context

3.3.1 Key Environmental Factors

In the EPA's determination that the proposed Browse Project requires assessment under the *Environmental Protection Act 1986* (EP Act), the EPA identified air quality from the emissions of

[2] https://www.chiefscientist.gov.au/sites/default/files/2020-02/National%20Press%20Club%20address%202020%20web_0.pdf

gases during well drilling and construction in the State Proposal Area as a key preliminary environmental factor. In the recent update to the WA EPA's Statement of Environmental Principles, Factors and Objectives (Version 3.0) (EPA, 2020b), GHG Emissions has been covered as a separate factor.

This GHGMP considers the WA EPA's Greenhouse Gas Emissions Environmental Factor (EPA, 2020a), which has the following objective:

To reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change.

Net GHG emissions are defined by the WA EPA (EPA, 2020a) as the residual (net) direct GHG emissions arising from the proposal's activities (i.e. Scope 1 emissions). It should be noted that the Project has limited Scope 1 emissions arising within the State Proposal Area. This is further discussed in **Section 3.3.3**.

3.3.2 Western Australia State Government Policy

In August 2019 the WA Government released a Greenhouse Gas Policy for Major Projects (Government of Western Australia, 2019)[3]. The policy includes the statements outlined in **Table 3-3**, which align with the EPA's Environmental Factor Guideline on Greenhouse Gas Emissions (EPA, 2020a). Woodside's response to the policy is also outlined in **Table 3-3**.

Table 3-3 Response to WA State Greenhouse Gas Policy

State Greenhouse Gas Policy on Contents of the Plan (Government of Western Australia, 2019)	Woodside response
The policy supports the development of GHGMPs for proponents which: Outline strategies to avoid, reduce, mitigate and offset the project's direct (Scope 1) emissions contributing towards the State's aspiration of net zero by 2050	The proposed Browse Project is a significant opportunity for Western Australia that will enable the development of further natural gas resources and the potential use of established processing infrastructure for decades to come. This gas is subject to the WA Domestic Gas Policy and will contribute both to State energy security and to the State's 2050 net zero target by extending access to natural gas during the transition to renewable energy sources. Natural gas is both the lowest carbon fossil fuel and also enables greater use of renewables by matching their intermittent nature with dispatchable power. The Western Australian Government's Greenhouse Gas Emissions Policy for Major Projects includes an aspirational target of net zero GHG emissions by 2050 (Section 7.3.3 of the draft EIS/ERD). It should be noted that the WA aspirational target of net zero emissions by 2050 does not prohibit emissions from industrial activities; rather, the target refers to net zero emissions State-wide, via means of reduction and balancing levels of CO_2 emissions with carbon removal beyond natural processes, through carbon offsetting, or removing or sequestering CO_2 from the atmosphere to make up for emissions elsewhere. Strategies to avoid, reduce and offset Scope 1 emissions from the proposed Browse Project are outlined in **Section 1**. They include facility design features, improvement opportunities, and the setting of annual fuel and flare targets. The proposed Browse Project will export gas to existing NWS LNG liquefaction and export infrastructure, avoiding the need for the construction

[3] http://www.dmp.wa.gov.au/Petroleum/New-emissions-policy-25793.aspx

State Greenhouse Gas Policy on Contents of the Plan (Government of Western Australia, 2019)	Woodside response
	and operation of new LNG facilities and the associated environmental impacts and risks (i.e. disturbance footprint). Strategies to offset emissions are encompassed in the proposed Browse Project's compliance with the SGM. The supporting regulations and rules of the SGM establish the framework for allowable methodologies for valid offsets. Woodside anticipates that additional emissions reductions may be achieved via ongoing application of the optimisation reference plan (ORP) process (refer **Section 5.2.2**).
Are unique to a proposal's specific circumstances	The development concept of the proposed Browse Project is intended to optimise the use of existing infrastructure as far as practicable, that is, by tying in to existing offshore pipeline and onshore LNG liquefaction and export facilities, thus avoiding a significant amount of GHG emissions which might otherwise be associated with construction of new downstream facilities which were contemplated in previous development concepts. The proposed extension of life of the NWS facilities (refer NWSJV's 'North West Shelf Project Extension ERD' (EPA 2186, EPBC 2018/8335), potentially allows the supply of natural gas fuel, which has low GHG emissions relative to coal, into domestic and international markets, enabling partnering with renewables, as a dispatchable power source that can enable their greater use.
Allow proponents to take account of opportunities at either facility level or across national operations	Opportunities to design out GHG emissions have been incorporated in the design of the Browse upstream facilities. This is described in Section 7.7 of the draft EIS/ERD and summarised in **Section 5.1** of this GHGMP. Furthermore, Woodside as an experienced oil and gas operator at the national level has significant experience in the efficient operation of oil and gas facilities. Key Woodside processes relevant to Operating Out carbon emissions are described in **Section 5.2** of this GHGMP.
Allow proponents to propose their own timeframes and targets	The SGM sets the limits (baselines) allowable for industrial emitters in relation to facilities that are consistent with achieving the Nationally Determined Contribution (NDC) (to 2030) under the Paris Agreement. Woodside has nevertheless set corporate targets and regular review milestones, as outlined in **Section 8**.
Include requirements for periodic public reporting against their targets	Reporting for the proposed Browse Project will be undertaken in accordance with the NGER Act. In addition, Woodside publicly releases Sustainable Development reports which report against environmental performance.
Account for and align with Commonwealth requirements.	The current Commonwealth policy requirements are included in the Federal Government's Climate Solutions Package which sets out how Australia will meet its initial NDC, and with which Woodside complies. The Australia's emissions projections 2019 report provides an indicative summary of how Australia is tracking to achieve its Nationally Determined Contribution of 26 to 28 per cent below 2005 levels in 2030. Projected emissions to 2030 from the LNG sector (direct combustion and fugitive) are included in the methodology used to underpin these projections (please refer to Section 7.6 of the draft EIS/ERD for more information).
Consistent with the Government's focus on economic development and diversification, plans	Woodside will ensure benefits to local communities and local industry participation via the proposed Browse Project. More widely, Woodside is an active participant in multiple community projects and research initiatives aimed at reducing the global effects of climate change. These include

State Greenhouse Gas Policy on Contents of the Plan (Government of Western Australia, 2019)	Woodside response
that include undertakings to develop Western Australian expertise, carry out research, pilot new initiatives and technologies, and support local communities are encouraged.	carbon farming through the re-forestation of former agricultural land to produce high quality carbon offsets in WA, and the pioneering use of new technologies such as battery use on an offshore platform to reduce emissions associated with back-up power generation.

More detailed measures for supporting these policy goals are presented in **Section 4**.

3.3.3 Consideration of WA EPA GHG Emissions EF Guideline

In developing this GHGMP, Woodside has also considered the following from the Greenhouse Gas Emissions Environmental Factor Guideline (EPA, 2020a):

- application of the mitigation hierarchy to avoid, reduce and offset emissions
- the interim and long-term emissions reduction targets the proponent proposes to achieve
- the adoption of best practice design, technology and management appropriate to mitigate GHG emissions
- whether proposed mitigation is plausible, timely, achievable, verifiable and is all that is reasonable and practicable.

Woodside has also considered the following from the Guideline (EPA, 2020a):

The EPA will require proponents to develop a Greenhouse Gas Management Plan as part of the assessment process that demonstrates their contribution towards the aspiration of net zero emissions by 2050. The EPA notes that both the Paris Agreement and the IPCC's 1.5 report recommends net zero emissions by 2050.

The EPA Greenhouse Gas Emissions Factor Guideline notes that generally, GHG emissions from a proposal will be assessed where they exceed 100,000 tonnes of Scope 1 emissions each year measured in CO_2-e. This is currently the same as the threshold criteria for designation of a large facility under the Australian Government's Safeguard Mechanism.

At a minimum, a GHGMP should outline (EPA, 2020a):

- intended reductions in Scope 1 emissions over the life of the proposal
- regular interim and long-term targets that reflect an incremental reduction in Scope 1 emissions over the life of the proposal
- strategies which demonstrate that all reasonable and practicable measures have been applied to avoid, reduce and offset a proposal's Scope 1 emissions over the life of the proposal.

Direct (Scope 1) GHG emissions generated in the State Proposal Area from operational activities associated with upstream processing of Browse gas are limited to operational activities under Woodside's operational control. Typically, vessels and drilling rigs associated with both the construction and operation of Browse facilities are not expected to be under Woodside's operational control, and therefore emissions from these sources are expected to be classified as Scope 3 emissions. Scope 1 GHG emissions may also include any fugitive emissions associated with the subsea infrastructure (i.e. wellheads, jumper cables, manifolds and flowlines). It is therefore considered unlikely that the proposed Browse Project activities in State Jurisdiction will routinely exceed 100,000 tCO_2-e per annum of Scope 1 emissions within the State Proposal Area throughout the life of the field.

As the vast majority of the Scope 1 GHG emissions associated with the upstream proposed Browse Project occur on the two FPSOs (in Commonwealth Waters), GHG mitigation focusses on these emissions sources. For further information on the approach to these emissions sources, including incorporated mitigation opportunities, please refer to **Section 1**.

Given the estimated scale of the Scope 1 Project emissions (significantly less than 100,000t CO_2-e per annum) and the nature of Scope 1 GHG emissions in the State Proposal Area (ie limited to fugitive emissions from subsea infrastructure and any vessel movements under Woodside's operational control), the environmental impact assessment considerations as described in the EPA's Greenhouse Gas Emissions Environmental Factor Guideline (EPA, 2020a) are not considered relevant to Woodside's Scope 1 emissions in the State Proposal Area.

3.3.4 Regulatory Requirements

The proposed Browse Project is currently being assessed by the EPA and the Department of Agriculture, Water and the Environment (DAWE), therefore Ministerial Statements are yet to be issued.

Should the proposed Browse Project be approved for implementation, regulatory requirements relating to GHG management will be included in this section and updated from time to time.

4. WOODSIDE'S APPROACH TO GHG EMISSIONS

Woodside is the Operator for and on behalf of the BJV. Woodside and the BJV supports the global effort to reduce GHG emissions and accepts it has a responsibility to minimise the GHG impact of its own operations. Woodside's key priority is to reduce GHG emissions at source, either through energy efficiency improvements or technological solutions.

4.1 Woodside Management System

The Woodside Management System (WMS) defines how Woodside delivers business objectives and the boundaries within which all Woodside employees and contractors are expected to work. Environmental management is one of the components of the overall WMS. The overall direction for Environment is set through Woodside's Corporate Health Safety, Environment and Quality (HSEQ) Policy. The policy provides a public statement of Woodside's commitment to minimising adverse effects on the environment from its activities and to improving environmental performance. It sets out the principles for achieving the objectives for the environment and how these are to be applied. The policy is applied to all Woodside's activities, and employees, contractors and BJV partners engaging in activities under Woodside's operational control.

Woodside's Climate Change Policy outlines that Woodside recognises the scientific consensus on climate change and the challenge of providing safe, clean, affordable and reliable energy whilst reducing emissions. A key principle of this policy states that Woodside will set and publish targets to encourage innovation and drive reductions in Woodside's carbon footprint and energy use.

4.2 Environmental Performance

Environmental performance requirements are applicable to all Woodside developments and production assets with projected GHG emissions in excess of 25,000 tonnes of CO_2-e per annum. In general, environmental performance requirements consider:

- design and operation to minimise GHG emissions and energy intensity
- monitoring of GHG emission sources and estimating GHG emissions
- consideration of carbon price in development/production asset economics in the identification, assessment and implementation of opportunities to reduce GHG emissions and energy intensity.

Further information on key requirements of the WMS during the Operate Phase, and how these relate to the mitigation of Browse GHG emissions is discussed in **Section 5.2**.

4.3 Woodside's GHG Reduction Philosophy

Woodside aims to reduce Scope 1 GHG emissions from the proposed Browse Project in accordance with our GHG Reduction Philosophy. The GHG Reduction Philosophy applies three key steps to minimise GHG emissions: Design Out, Operate Out and Offset.

First during the Design phase, **Design Out** GHG emissions sources to reduce expected emissions to 'as low as reasonably practicable' (ALARP). This occurs through incorporating energy efficiency and emissions reductions measures into the design of the facility's processing and utility equipment.

Throughout the Operate phase, continuously identify opportunities to **Operate Out** GHG emissions through improving energy performance. This occurs through a structured approach in accordance with the requirements of the WMS.

Once emissions sources have been Designed and Operated Out, **Offset** a portion of the residual GHG emissions (i.e. those that cannot be Designed Out or Operated Out) to meet statutory requirements applicable to a specific facility and to meet Woodside's corporate-level voluntary targets as set and reviewed periodically across Woodside's equity portfolio.

The application of Woodside's GHG Reduction Philosophy to the proposed Browse Project is described in **Section 1**.

5. BROWSE PROJECT GHG MITIGATION

The three key steps of Woodside's GHG Reduction Philosophy are applicable to all emissions sources in the proposed Browse Project within scope of this GHGMP. In particular, the processes described under 'Operate Out' and the purchase of ACCUs under 'Offset' can be applied to emissions arising from activities in both the Commonwealth and State jurisdictions.

Given the jurisdictional breakdown of the proposed Browse Project's GHG emissions, the key Scope 1 emissions sources (i.e. fuel gas emissions) occur within Commonwealth Waters. As a result, it is expected that opportunities identified during Operate Out will focus on emissions occurring within Commonwealth Waters, commensurate with the jurisdictional breakdown. This is also reflected in 'Design Out', where the key mitigations incorporated in the design focus on the emissions sources in Commonwealth Waters.

5.1 Design Out

Section 7.7 of the draft EIS/ERD presents key information regarding the design of the Browse upstream facilities to mitigate GHG emissions. The below information is replicated from the draft EIS/ERD, to provide context in the GHGMP.

Energy efficiency measures have been incorporated into the design of the facilities; these are listed below with an estimate of the annual emissions saving:

- waste heat recovery units on gas turbines, avoiding the combustion of additional gas for heating purposes (0.70 MT CO_2-e/annum saving)
- active heating system used to prevent hydrate formation in flowlines avoiding the requirement for an energy intensive MEG regeneration plant (0.20 MT CO_2-e/annum saving)
- batteries for spinning reserve, avoiding an additional turbine from providing the spinning reserve (0.10 MT CO_2-e/annum saving)
- efficient aero derivative gas turbines (0.02 MT CO_2-e/annum saving)
- use of nitrogen to purge the flare stack rather than hydrocarbon gas (expected less than <0.1 MT CO_2-e/annum saving).

By saving approximately up to 1 MT of CO_2-e on average per year, this has reduced the expected average annual net Scope 1 Project emissions from up to 5.8 MT CO_2-e to 4.8 MT CO_2-e per year and saved 31 MT CO_2-e of Scope 1 emissions over the expected life of the proposed Browse Project. It should also be noted that atmospheric emissions from the proposed Browse Project as a whole are less than or similar to the two former development concepts, as described in Section 3.8 of the draft EIS/ERD.

Further, Figure 7-4 of the draft EIS/ERD provides benchmarking between the processing emissions for the proposed Browse FPSOs and identified comparable facilities in Australia, to demonstrate the effectiveness of the upstream design in consuming energy to process the gas stream and pressurise it for export.

5.2 Operate Out

Energy efficiency measures will be continually identified and implemented through the life of the proposed Browse Project through the means discussed below. The means of achieving these improvements include the Woodside Energy Management Framework and Procedure, and the Production Optimisation and Opportunity Management Procedure.

5.2.1 Energy Management Framework

Woodside's Energy Management Framework, applicable to all Woodside developments and production assets, aims to improve energy efficiency across Woodside's operations in order to:

- add significant value and maximise shareholder returns
- minimise environmental impacts through reduced GHG emissions which contribute to climate change
- enhance our reputation as a partner of choice.

The Energy Management Procedure defines the minimum mandatory requirements for energy management at Woodside assets to deliver continuous improvement in energy performance. The Energy Management Framework requires that an Energy Management Plan is established, implemented and maintained for each operating asset (including the proposed Browse Project) or group of assets which are required to measure, analyse and communicate energy performance. Opportunities to improve energy performance are to be identified and captured in accordance with the Production Optimisation and Opportunity Management Procedure (refer to **Section 5.2.2**), such that energy opportunities are considered alongside other opportunities and constraints.

5.2.2 Production Optimisation Process

In accordance with the Production Optimisation and Opportunity Management Procedure, the proposed Browse Project will prepare an Optimisation Reference Plan (ORP) which identifies and implements opportunities to improve production and energy efficiency whilst reducing emissions. The ORP recognises that any reduction in emissions is also identified as a production opportunity, as gas that can be diverted from fuel or flare streams can potentially be turned into a saleable product.

The ORP delivers a ranked list of opportunities used to justify further study/implementation of each opportunity listed. Results are then incorporated into relevant plans to ensure consideration for funding / resourcing. Consideration of opportunities is based on a number of economic and environmental factors:

- opportunities are prioritised based upon net present value (NPV), their contribution to Woodside corporate initiatives for GHG reduction, and the confidence of return (CoR) to ensure efficient capital allocation. The CoR is estimated based upon maturity, complexity, technology novelty and ease of implementation.
- production enhancing opportunities need to meet set criteria to be considered economic and reviewed for recommendation. Opportunities may not be recommended if economics are marginal and there is low probability of success, however opportunities that include significant environmental/strategic merit (e.g. emissions reduction benefit) may continue to be considered even where economic criteria have not been met.

5.2.3 Methane Guiding Principles

In 2018, Woodside became a signatory to the Methane Guiding Principles, an initiative to reduce methane emissions across the natural gas value chain . Woodside will continually look for ways to minimise methane emissions from the plant operations.

5.3 Emissions Offsets

5.3.1 Compliance Requirements (as at May 2020)

Australia's nationally determined contribution to global emissions reductions under the Paris Agreement sets a national emissions reduction target, of 26-28% emissions reductions from 2005 levels, by 2030. The Australian Government has introduced a number of initiatives in order to deliver national emissions reductions and these include the Emissions Reduction Fund and SGM.

- The Emissions Reduction Fund, enacted through the *Carbon Credits (Carbon Farming Initiative) Act* 2011 (CFI Act), is a voluntary scheme that aims to provide incentives for a range of organisations to adopt new practices and technologies to reduce their emissions.
- The SGM, enacted through the NGER Act, is designed to ensure that emission reductions implemented through the Emissions Reduction Fund are not offset or exceeded by increases in GHG emissions (above 'business-as-usual levels'). It achieves this by placing a legislated obligation on emitters to keep net emissions below their emissions limit (or baseline).

The Operator of a facility that has, or is likely to, exceed its baseline can reduce the facility's net emissions by purchasing and surrendering Australian carbon credit units (ACCUs) to offset its emissions.

5.3.2 Australian Carbon Credit Units

ACCUs are a type of 'carbon credit' which represents the removal of one tonne of carbon dioxide equivalent (tCO_2-e) from the atmosphere (via an activity which results in a reduction in emissions or increase in sequestration relative to a reference case). ACCUs are tradeable financial instruments issued by a certification body (the Clean Energy Regulator) which sets rules as to the types of activities which can be recognised as removing carbon dioxide from the atmosphere and how it can be calculated.

The ACCU certification scheme, enacted by the CFI Act, provides a four-step process for the approval of offset projects and generation of ACCUs.

- Firstly, methods are made by the Minister for Energy and Emissions Reduction. The methods set out the types of activities which can be recognised as removing carbon dioxide from the atmosphere and how it can be calculated. Methods can only be made if they satisfy prescribed offsets integrity standards in the CFI Act (these ensure that abatement is genuine) and are endorsed by the Emissions Reduction Assurance Committee (an independent statutory body) as having satisfied these standards.
- Secondly, projects are declared as an eligible offsets project. The declaration is made by the Clean Energy Regulator following an application from the offset-project developer. Projects must meet additionality requirements and the project activity must occur within Australia.
- Thirdly, periodic reporting must be done on the declared project's net amount of GHG emissions avoided or removed by the project, as calculated in accordance with the relevant method. Audits are required at prescribed intervals.
- Lastly, credits are issued by the Clean Energy Regulator on application by the offset-project developer. For emissions avoidance projects, the number of units issued equals the net abatement amount calculated in accordance with the method. By contrast, for sequestration projects, the unit entitlement is equal to the net abatement amount minus the 'risk of reversal buffer' (generally 5%). The issued credits are registered in the Australian National Registry of Emissions Units and can be traded or surrendered.

5.3.3 ACCU Markets & Sourcing

The primary source of demand for ACCUs comes from the Emissions Reduction Fund. The Emissions Reduction Fund has a purchasing scheme, whereby the Australian Government voluntarily purchases ACCUs from eligible offset projects. A secondary source of demand is the compliance market. The compliance market refers to the sale and purchase of ACCUs to meet a facility operator's legal obligation to keep net emissions below the emissions limit prescribed by the SGM.

The Climate Change Authority (an independent statutory agency, established to provide expert advice on climate change policy) is required by the CFI Act to undertake a review every three years to assess whether the Act is working to create incentives for people to carry on offset projects.

It is planned that the BJV will source ACCUs required for compliance and surrender when required. ACCUs can be sourced through various commercial arrangements including:

- the direct development or funding of new ACCU generating projects
- purchase of existing ACCUs issued by the Clean Energy Regulator from market traders or offset-project developers
- offtake arrangements for ACCUs to be generated from new or existing projects
- spot purchase and long term purchase agreements from market traders or project-developers.

5.4 Report

The NGER Act was introduced as the national framework for reporting and disseminating company information about GHG, energy production, energy consumption and other information specified under the NGER Act. The Act sets up the NGER Scheme, which aims to:

- inform government policy and the Australian public
- help meet Australia's international reporting obligations
- assist Commonwealth, State and Territory government programs and activities
- avoid duplicating reporting requirements in the states and territories.

The methods and criteria for calculating GHG emissions and energy data under the NGER Act are detailed in the National Greenhouse and Energy Reporting (Measurement) Determination 2008 , as updated from time to time. GHG emissions from the proposed Browse Project will be reported annually under the NGER Act. Woodside will conduct routine emissions monitoring and reporting of GHG emissions from facilities in accordance with the NGER Act.

6. GHG MANAGEMENT PLAN PROVISIONS

This section describes the provisions of this GHGMP in the context of the objectives. Woodside has incorporated a suite of contemporary best practice management and mitigation measures (each included as Management Actions) to ensure ongoing, long term reductions in GHG emissions will be achieved. **Table 6-1** lists the management-based provisions that will be implemented with the proposed Browse Project. These provisions are applicable to all GHG emissions in the scope (**Section 2.2**) of this GHGMP. These are based on the rationale and approach described in **Section 2.3**.

Given the jurisdictional breakdown of the proposed Browse Project's GHG emissions, the key emissions sources (i.e. vented reservoir CO_2 and fuel gas emissions) occur within Commonwealth Waters. As a result, it is expected that the management plan provisions, while applicable to all emissions sources, will focus on emissions sources occurring within Commonwealth Waters, commensurate with the jurisdictional breakdown.

Table 6-1 Management-Based Provisions

Management Actions (MA)	Targets	Monitoring	Reporting
MA-1: Fuel and flare targets are set annually to drive continuous improvement.	Targets will be set annually for the amount of gas to be flared and fuel to be consumed by the proposed Browse Project.	Performance against targets will be monitored. Potential sources or causes for exceedance will be explained.	Fuel and flare emissions presented in annual reporting (as described in the draft EIS/ERD).
MA-2: Continue to identify and adopt practicable mitigation and management measures to reduce Scope 1 GHG emissions.	Optimisation and opportunity management processes will be implemented to identify and prioritise enhancement opportunities including improving energy efficiency, reducing fuel use and intensity and minimising flaring.	Selected opportunities will be monitored in accordance with the Production Optimisation and Opportunity Management Procedure and ORP.	Reporting on the adopted practicable management and mitigation measures to reduce scope 1 GHG emissions.
MA-3: Routine emissions monitoring and reporting is undertaken in accordance with the *NGER Act.*	Direct GHG emissions (e.g. fuel, flare, fugitive and venting emissions) will be measured and reported in accordance with the NGER Act.	Scope 1 emissions will be measured in accordance with the requirements of the National Greenhouse and Energy Reporting Measurement Determination.	Estimation of emissions is performed in accordance with the NGER Act and presented in annual reporting (as described in the draft EIS/ERD).

Management Actions (MA)	Targets	Monitoring	Reporting
MA-4: Comply with Safeguard Mechanism (or applicable legislation) to manage emissions within the facility baseline	Emissions will be managed to ensure net emissions are below the SGM baseline Allowable offsets will be purchased and surrendered equivalent to the amount of emissions above the baseline level.	Monitoring of net emissions performed in accordance with MA 4 Monitoring of volume of offsets required, purchased and surrendered in accordance with SGM.	Summary of purchase and surrender of allowable offsets included in annual reporting (as described in the draft EIS/ERD) and published as part of annual SGM data tables by the Clean Energy Regulator.
MA-5: Adhere to the Methane Guiding Principles	Management of methane emissions performed in accordance with the Methane Guiding Principles.	Methane reduction initiatives monitored through the implementation of the ORP.	Performance against the Methane Guiding Principles will be presented in annual reporting (as described in the draft EIS/ERD).
MA-6: Undertake 5-yearly assessment of reasonable and practicable emission reduction equipment and technologies that could be implemented to reduce GHG emissions	Assessment will identify practicable and reasonable opportunities and their feasibility of implementation to improve GHG emissions performance.	Any relevant changes or modifications will be reviewed and impact on GHG emissions generation will be assessed.	Summary of assessment will be reviewed and reported 5 yearly.

7. STAKEHOLDER CONSULTATION

This GHGMP has been prepared to support the proposed Browse Project draft EIS/ERD and therefore is to be reviewed by the EPA, DAWE and key Decision-Making Authorities (DMAs). The GHGMP has factored in any comments received during the public comment period for the draft EIS/ERD. Further changes may be incorporated over time through inputs received via Woodside's ongoing stakeholder engagement processes.

8. ADAPTIVE MANAGEMENT AND REVIEW OF THE GHGMP

In line with the concept of adaptive management, the management actions presented in this GHGMP shall be monitored, reviewed, evaluated and updated, as required, considering:

- outcomes of any technical review of and evaluation of any routine emissions monitoring
- new and relevant data/information gained as a result of implementing this GHGMP, or from external sources
- effectiveness of internal processes and procedures to reduce and manage GHG emissions
- stakeholder input (see **Section 7**)
- changes in State or Commonwealth legislation or policy.

Relevant updates included in a revised GHGMP.

Overall technical review and evaluation of the management actions outlined in this GHGMP will be conducted every five years (if not initiated prior to that time) to ensure the management actions are adequately addressing the objectives of this GHGMP (please refer **Section 2.2**). If, as a result of any review, any significant changes are required to be made to the monitoring program or any other aspect of this GHGMP, a revised GHGMP will be provided to the regulator.

When the five-yearly review cycle is triggered, or if a significant change to either the facility, activity, or environmental impact or risk is identified, a revised GHGMP will be submitted to the regulator. When approved, the revised plan will be made publicly available.

9. REFERENCES

CSIRO, 2015. Implications of climate change for Australia's biodiversity [WWW Document]. URL https://www.csiro.au/en/Research/LWF/Areas/Ecosystems-biodiversity/Monitoring-biodiversity/Biodiversity-and-climate-change (accessed 6.4.19).

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EPA, 2020b. Statement of Environmental Principles, Factors and Objectives. Western Australia.

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IEA, 2019. World Energy Outlook.

NWS, 2019. North West Shelf Project Extension Greenhouse Gas Management Plan", EPA 2186, EPBC 2018/8335.

10. TERMS

Acronym	Definition
ACCU	Australian Carbon Credit Units
AGRU	Acid Gas Removal Unit
BJV	Browse Joint Venture
BTL	Browse Trunkline
CO_2	Carbon Dioxide
CoR	Confidence of Return
DAWE	Department of Agriculture, Water and the Environment
DMA	Decision Making Authorities
DoEE	Department of the Environment and Energy
Domgas	Domestic Gas
EIS	Environmental Impact Statement
ERD	Environmental Review Document
ERF	Emissions Reduction Fund
FPSO	Floating, Production, Storage and Offloading
GHG	Greenhouse Gas
GHGMP	Greenhouse Gas Management Plan
HSEQ	Health, Safety, Environment and Quality
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquified Natural Gas
MEG	Monoethylene Glycol
MT	Megatonnes (Million tonnes)
NGER	National Greenhouse and Energy Reporting Act (Cth) 2007
NPV	Net Present Value
NRC	North Rankin Complex
NWS JV	North West Shelf Joint Venture
ORP	Optimisation Reference Plan
SGM	Safeguard Mechanism
tCO_2-e	Tonnes of Carbon Dioxide Equivalent
WA EPA/EPA	West Australian Environmental Protection Authority
WMS	Woodside Management System

APPENDIX A: PROPOSED BROWSE PROJECT GHG EMISSIONS PROFILE

For convenience, proposed Browse Project upstream emissions estimates are provided in the draft EIS/ERD and are replicated in **Table A.1**. Emissions estimates were calculated based on the available level of concept definition and assumptions regarding future commercial arrangements, the feed gas (final composition) and the scale, efficiency, interaction and complexity of the extraction, processing, anticipated production and compression of the product stream. Methodologies from the NGER Act were used in calculating emissions. For further information on calculation methodology, including the emissions factors and other assumptions used, please refer to Chapter 7 of the draft EIS/ERD.

Table A.1 Draft EIS/ERD table - forecast Scope 1 (BJV) GHG emissions summary

CO_2-e MT	Average Year	Peak Production Year	Total Expected Field Life	Total Extended Field Life
Reservoir Emissions[1]	2.3 (2.6)[2]	4.0 (4.6)	70 (81)	93 (107)
Fuel Gas	1.2	2.1	38	50
Flaring	0.14	0.14	4	6
Fugitives	0.01	0.02	0.3	0.4
Upstream Total[1]	**3.6 (4.0)**	**6.2 (6.8)**	**112 (123)**	**149 (163)**

[1] Upstream reservoir emissions have been estimated based on the maximum expected case given a gas export specification target of 2.5mol% CO_2. Estimates of emission implications for a 1 mol% to 2.8 mol% CO_2 gas export specification are presented in Table 7-7 of the draft EIS/ERD. Note the gas export specification is dependent on the outcome of final commercial arrangements.
[2] Bracketed emissions refer to high reservoir CO_2 composition scenario.

APPENDIX C MANAGEMENT PLANS

APPENDIX C.2 ENVIRONMENTAL QUALITY MANAGEMENT PLAN

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1. SUMMARY

Woodside Energy Ltd (Woodside) is Operator for and on behalf of the Browse Joint Venture (BJV) (Woodside Browse Pty Ltd, Shell Australia Pty Ltd (Shell), BP Developments Australia Pty Ltd (BP), Japan Australia LNG (MIMI Browse) Pty Ltd (MIMI), and PetroChina International Investment (Australia) Pty Ltd (PetroChina)). The BJV proposes to develop the Brecknock, Calliance, and Torosa fields (collectively known as the Browse hydrocarbon resources) using two 1,100 million standard cubic feet per day (MMscfd) (annual daily export average) Floating Production Storage and Offloading (FPSO) facilities.

The FPSO facilities will be supplied by a subsea production system and will transport gas to existing North West Shelf (NWS) Project infrastructure via a ~85 km spur line and a ~900 km proposed Browse Trunkline (BTL), which will tie-in near the existing North Rankin Complex (NRC) in Commonwealth water (Note: The NRC is owned by the North West Shelf Joint Venture (NWSJV) and operated under separate approvals).

The proposed Browse Project is described in the draft Environmental Impact Statement / Environmental Referral Document (draft EIS/ERD). Note that while proposed Browse Project infrastructure and activities will be located in both State and Commonwealth waters, the scope of this Environmental Quality Management Plan (EQMP) is limited to activities that may impact marine environmental quality within the State Proposal Area only. As such, only these activities are described in this document (**Section 2.2**). Environment Plans (EPs) for activities in Commonwealth and State waters will also be prepared in accordance with the relevant Commonwealth legislation, and unless potentially affecting the State Proposal Area, are not discussed further in this plan.

This EQMP was prepared in accordance with the Environmental Protection Authority's (EPA) *Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans* (EPA, 2020) and the *Technical Guidance Protecting the Quality of Western Australia's Marine Environment* (EPA, 2016).

Table 1-1 presents the key definitions used within this EQMP based on EPA (2016).

Table 1-1: Key definitions

Term	Definition
Environmental quality management framework (EQMF)	The framework adopted by the EPA and described in this guidance for managing the quality for the marine environment to meet the EPA's objectives and the community and stakeholder's long-term desires. The main output of the EQMF is the Environmental Quality Plan and Environmental Quality Management Plan.
Environmental value (EV)	Particular value or use of the environment that is important for a healthy ecosystem or for public benefit, welfare, safety or health and that requires protection from the effects of pollution, waste discharges and deposits.
Environmental quality objective (EQO)	A specific management goal for a designated part of the environment that signals the level of environmental quality needed to protect the environmental value.
Environmental quality plan (EQP)	A plan that identifies the environmental values that apply to an area and spatially maps the zones where the environmental quality objectives (including levels of ecological protection) should be achieved.
Level of ecological protection (LEP)	A level of environmental quality desired by the community and stakeholders for the EQO maintenance of ecological integrity.
Environmental quality criteria (EQC)	Environmental quality guidelines and/or standards.
Environmental quality guideline (EQG)	A threshold numerical value or narrative statement which if met indicates there is a high degree of certainty that the associated environmental quality objective has been achieved.

Term	Definition
Environmental quality standard (EQS)	A threshold numerical value or narrative statement that indicates a level which if not met indicates there is a significant risk that the associated environmental quality objective has not been achieved and triggers a management response.

This EQMP details the measures that are required to manage the potential impacts to marine environmental quality within the State Proposal Area from the proposed Browse Project. **Table 1-2** summarises the information contained in this EQMP.

Table 1-2: EQMP summary table

Title of Proposal	Proposed Browse Project (State Proposal Area)
Proponent Name	Woodside Energy Ltd (Woodside), as Operator for and on behalf of BJV
Purpose of the EQMP	This Environmental Quality Management Plan (EQMP): • identifies the Environmental Values (EVs) to be protected • establishes the Environmental Quality Objectives (EQOs) to ensure the selected EVs are maintained • establishes Environmental Quality Criteria (EQC) for indicators relevant to the discharges • spatially defines areas of low, moderate, high and maximum Levels of Ecological Protection (LEP), which were developed based on the likely footprint from drilling discharges and changes in water quality from marine discharges including hydrotest fluids and FPSO cooling water discharges • presents an adaptive management program based on the Environmental Quality Management Framework (EQMF as defined in EPA (2016)) designed to ensure the EQOs continues to be achieved in the event of specified changes to the discharge or other factors • presents the proposed management approach for drilling discharges at Torosa drill centres within the State Proposal Area.
EPA's relevant key Environmental Factors and objectives	**Key Environmental Factor: Marine Environmental Quality** **EPA Objective:** To maintain the quality of water, sediment, and biota so that environmental values are protected (EPA, 2018).
Key Provisions in the EQMP	Management of marine discharges to the marine environment to maintain ecosystem integrity.

2. CONTEXT, SCOPE, AND RATIONALE

2.1 Introduction

This section provides an overview of the activities associated with the proposed Browse Project relevant to the State Proposal Area. A full description of the proposed Browse Project is provided in Chapter 3 of the draft EIS/ERD.

As described in Chapter 2 of the draft EIS/ERD, the overall Project Area (encompassing both State and Commonwealth components) comprises:

- the proposed Browse Development Area (in which the Brecknock, Calliance, and Torosa fields, the FPSO facilities and the subsea production systems, including wells, will be located) (Figure 2-1 of the draft EIS/ERD)
- the pipeline corridor within which the proposed BTL and inter-field spur line will be located (Figure 2-2 of the draft EIS/ERD).

The State Proposal Area, which is the subject of the assessment under the *Environmental Protection Act 1986* (WA) (EP Act) and this EQMP, is located within the Browse Development Area and comprises all areas above the low water line (based on mean low water springs (MLWS)) and all waters within 3 nm of the territorial sea baseline, as shown in **Figure 2-1**.

This EQMP will be implemented following receipt of approval under the EP Act and *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act) and subject to all necessary regulatory and joint venture approvals and commercial agreements being obtained. It should be noted that this EQMP is expected to be matured and finalised beyond the State Proposal assessment process as the design of the proposed Browse Project matures.

2.2 Proposal

Activities in the State Proposal Area (**Figure 2-1**) comprise a small subset of infrastructure and activities of the proposed Browse Project. Within the State Proposal Area, activities include the development of up to an estimated 21[1] wells and associated subsea infrastructure targeting the hydrocarbon resources within the Torosa reservoir. The remaining facilities and infrastructure will be located in Commonwealth waters. Extracted hydrocarbons will be transferred via subsea infrastructure, including Christmas trees, manifolds and flowlines, to the Torosa FPSO facility, located in Commonwealth waters.

Activities within the State Proposal Area are likely to be most intense during the drilling and completion period, installation period and future decommissioning phases. During this time, a mobile offshore drilling unit (MODU) and approximately ten vessels may be present simultaneously for a short duration. As all permanent infrastructure within the State Proposal Area is subsea, the operation of the wells will be controlled remotely via the Torosa FPSO facility that is located in Commonwealth waters. Outside of drilling and completion and installation periods, surface activities in the State Proposal Area will comprise periodic inspection, maintenance, monitoring and repair (IMMR) activities involving one or two vessels and later phase well construction and decommissioning (including well plug and abandonment).

It is noted that proposed Browse Project activities may potentially impact on State waters (e.g. marine discharges), and these are also addressed within this Plan.

[1] The maximum number of wells within State waters has been reduced from 24 to 20 since preparation of the ERD as a result of the removal of the TRE well centre and associated infrastructure from the Proposal.

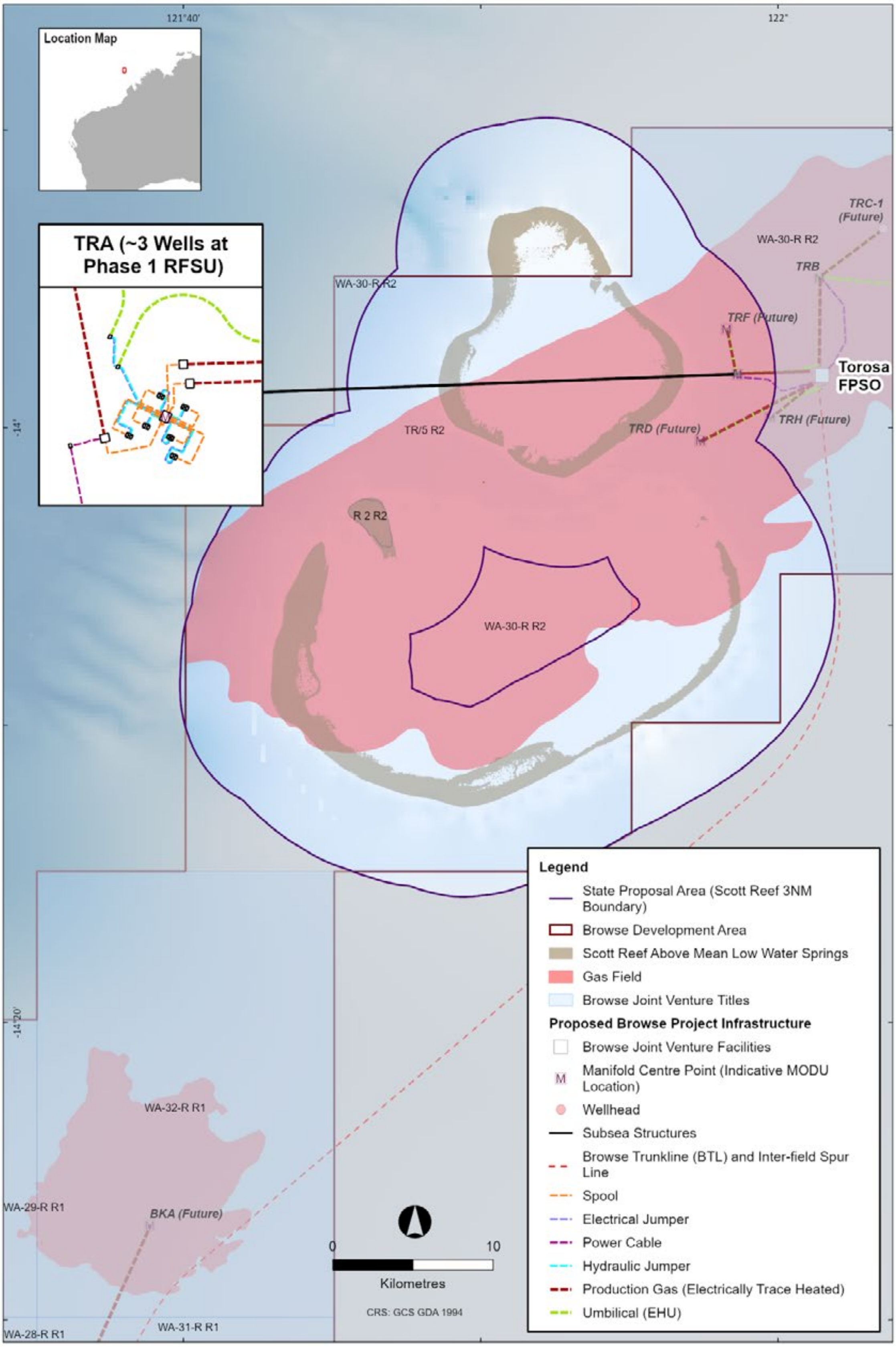

Figure 2-1 State Proposal Area

2.3 Purpose of management plan

This EQMP has been prepared in accordance with the *Technical Guidance Protecting the Quality of Western Australia's Marine Environment* (EPA, 2016). This document sets out an EQMF to achieve the objective of maintaining the EVs of the State Proposal Area. The approach to managing the proposed activities in a way that achieves this objective is based on a combination of impact assessment and early response indicators.

The impact pathways were assessed to determine if there is a risk of the proposed activities impacting the key relevant environmental factor, Marine Environmental Quality. Where the activity required management through design controls the risk was determined to be sufficiently managed.

This EQMP acknowledges that the nature of liquid discharges and the state of the receiving environment may change over the life of the proposed Browse Project. Therefore, this EQMP includes an adaptive management program (**Section 4**) to confirm that the management measures proposed continue to be appropriate and ensure protection of the environment value to be protected.

2.4 Scope of the EQMP

This EQMP specifically addresses the management of potential environmental impacts to the marine environment from planned discharges from the proposed Browse Project during the construction and operation phase in the State Proposal Area. Where discharges in Commonwealth waters may incur into the State Proposal Area, these have been considered within this EQMP. With the exception of produced water discharge from the Torosa FPSO, marine discharges from construction and operation activities that occur in Commonwealth waters that are not predicted to impact the State Proposal Area are outside of the scope of this EQMP. The impacts of all discharges in State and Commonwealth waters and the justification for their inclusion in this plan in terms of a management response is provided in **Section 3.3**.

2.5 EPA environmental factors

Key environmental factors are defined by the EPA as parts of the environment that may be impacted by an aspect of a proposal or scheme. They provide a specific approach to organizing environmental information for the purpose of environmental impact assessment and a structure for the assessment report (EPA, 2016). The key environmental factor addressed in this EQMP is summarised in **Table 2-1**.

Table 2-1 The EPA definition and objective for relevant Key Environmental Factors

Key Environmental Factor	EPA Definition	EPA Objective for Environmental Factor
Marine Environmental Quality	The term 'environmental quality' refers to the level of contaminants in water, sediments or biota or to changes in the physical or chemical properties of waters and sediments relative to a natural state. It does not include noise pollution, which is dealt with separately under the marine fauna factor (EPA, 2016).	To maintain the quality of water, sediment, and biota so that environmental values are protected (EPA, 2018).

2.6 Existing values of the State Proposal Area

A detailed description of the existing environment within the State Proposal Area is provided in Chapter 5 of the draft EIS/ERD. The values relating to the State Proposal Area include the following:

- benthic communities and habitats including:
  - Scott Reef, which encompasses the reef system including all coral habitats and communities (considered as the area above the 75 m bathymetric contour and within the 3 nm State waters boundary)

   - The deepwater benthic communities which are defined as those communities below the 75 m bathymetric contour within the State waters boundary
- plankton communities
- diverse fauna communities including EPBC Act and State *Biodiversity Conservation Act 2016* (BC Act) listed species
- habitat critical to the survival of a species for the green turtle Scott Reef-Browse Island genetic stock
- Biological Important Areas (BIAs) for species including the:
   - green turtle (nesting and internesting)
   - hawksbill turtle (nesting and internesting)
   - little tern (resting)
   - pygmy blue whale (migratory and possible foraging area)
- Key Ecological Features (KEFs) including:
   - Seringapatam Reef and Commonwealth waters in the Scott Reef Complex
   - Continental Slope Demersal Fish Communities KEFs
- socio-economic values including commercial, traditional and recreational fishers and scientific research.

2.7 Rationale and approach

The development of this EQMP follows the EPAs *Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans* (EPA, 2020) and *Technical Guidance – Protecting the Quality of Western Australia's Marine Environment* EPA (2016). EPA (2016) describes an outline of an EQMF. The framework of this EQMP is shown in **Figure 2-2**.

This EQMP:

- identifies the EV(s) relevant to the State Proposal Area and associated EQOs. Maintenance of the EQOs is designed to ensure that the associated EVs are protected (**Section 3.2**)
- where residual risk exists, establishes spatially defined LEP (**Section 3.4.1**)
- establishes EQC for each LEP (**Section 3.4.2**). EQC represent scientifically based limits of acceptable change to a measurable environmental quality indicator that is important for the protection of the associated EV (**Section 3.4.2**). The EQMF requires appropriate EQC to be established to ensure an appropriate framework is in place for measuring the extent to which the EQO is maintained and therefore demonstrating the EV is being protected. Two types of EQC are defined under the EQMF:
   - Environmental Quality Guidelines (EQGs): These are quantitative investigative triggers that, if achieved, indicate there is a low probability that the EQO is not being achieved.
   - Environmental Quality Standards (EQSs): These are management triggers based on multiple lines of evidence, which, if exceeded, signify that the EQO may not be being met and that a management response is required.
- details management provisions (**Section 3.4.3**) and monitoring (**Section 3.5**) with respect to the EQC
- outlines the EQMP adaptive management and review (**Section 4**).

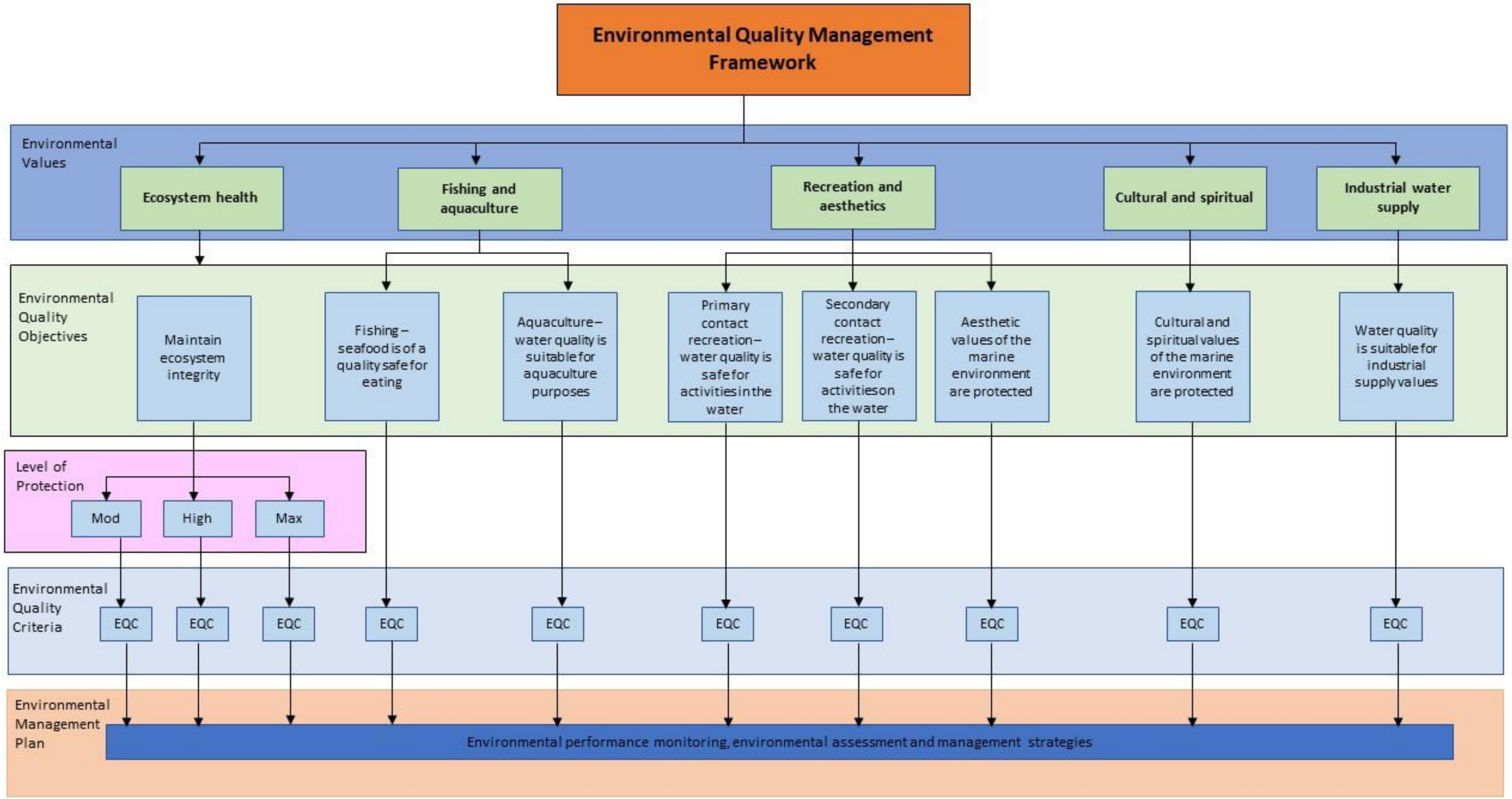

Figure 2-2 Environmental Quality Management Framework for Western Australia Marine Waters (EPA, 2016)

3. ENVIRONMENTAL QUALITY MANAGEMENT FRAMEWORK

3.1 Overview

A summary of the EQMF for the proposed Browse Project is provided in **Figure 3-1**. The following sections outline the rationale for the selection of the EVs, EQOs, relevant aspects, LEP and EQCs.

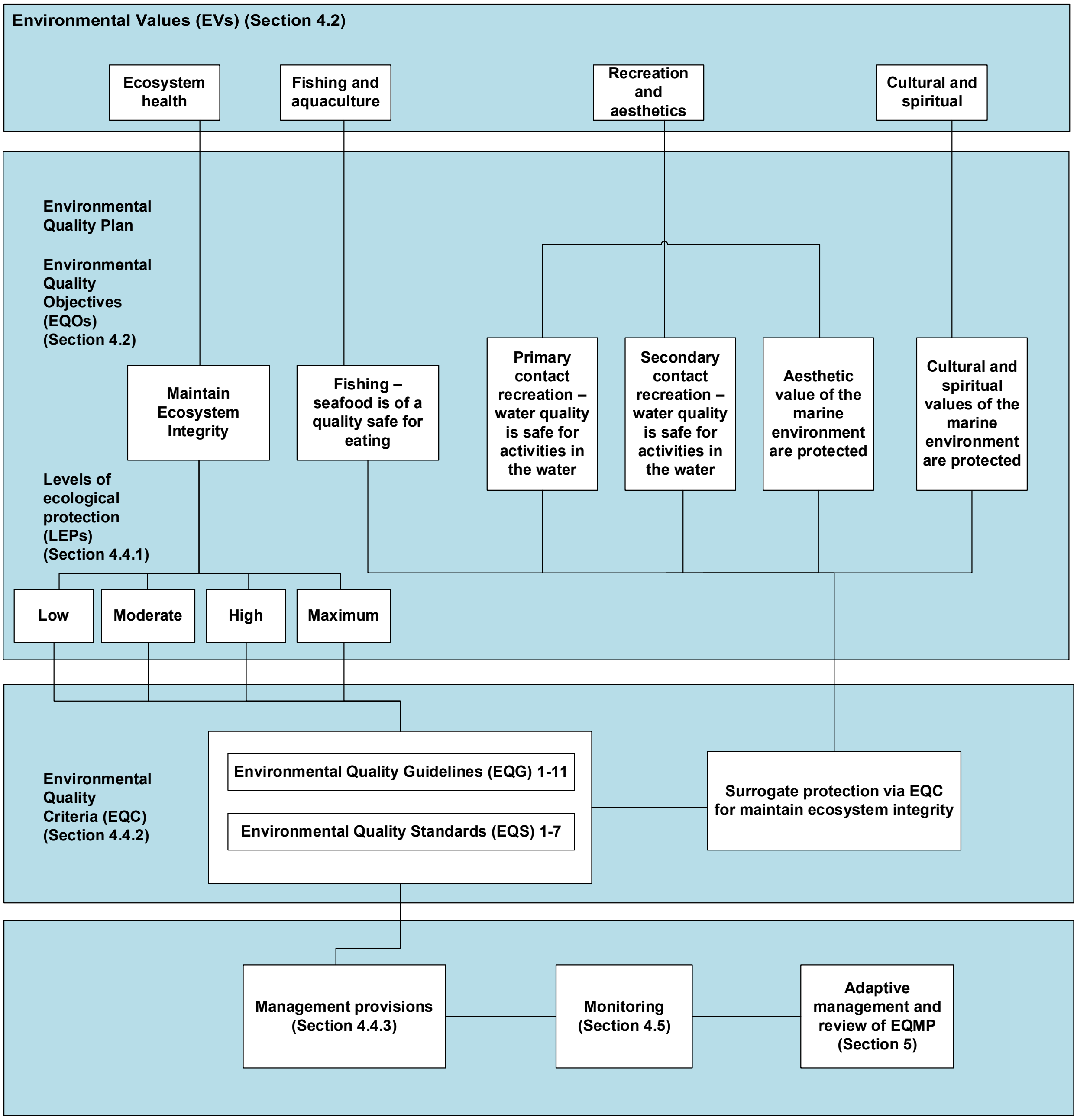

Figure 3-1: Environmental Quality Management Framework for proposed Browse Project

3.2 Establishing State Proposal Area EV and EQO relevant to this EQMP

The first step in the development of the EQMF was to undertake an assessment of the relevance of each EV and EQO identified in the EQMF for Western Australia Marine Waters (EPA, 2016). This assessment is presented in **Table 3-1**.

Table 3-1 EVs and EQOs and their relevant relevance to the proposed Browse Project

EV	Relevance of EV to proposed Browse Project	EQO	Relevance of EQO to proposed Browse Project
Ecosystem health	**Relevant**	Maintain ecosystem integrity	**Relevant**
Fishing and aquaculture	**Relevant**	Fishing – seafood is of a quality safe for eating	**Relevant**
		Aquaculture – water culture is suitable for aquaculture purposes	Not relevant – no aquaculture activities in State Proposal Area.
Recreation and aesthetics	**Relevant**	Primary contact recreation – water quality is safe for activities in the water	**Relevant**
		Secondary contact recreation – water quality is safe for activities in the water	**Relevant**
		Aesthetic value of the marine environment are protected	**Relevant**
Industrial water supply	Not relevant – No industrial water uses within the State Proposal Area	N/A – EV not relevant	N/A – EV not relevant
Cultural and spiritual	**Relevant**	Cultural and spiritual values of the marine environment are protected	**Relevant**

3.3 Assessment of activities potentially impacting identified State Proposal Area EVs

3.3.1 Overview

The second step in the development of the EQMF is to assess the planned discharges in the context of impacts to the EVs of the State Proposal Area (i.e. is there a residual risk for the aspect that potentially compromises the EQOs).

While the impacts of the planned discharges in State and Commonwealth waters have been comprehensively assessed in the draft EIS/ERD, the following provides a high-level summary of the potential impacts within the State Proposal Area and identifies where residual impacts potentially compromising EQOs exist.

3.3.2 Mobilisation of sediments as a result of seabed disturbance

Table 3-2 outlines the assessment of the impact of the mobilisation of sediment as a result of seabed disturbance with respect to achieving the EQOs.

Table 3-2 Assessment of mobilisation of sediments as a result of seabed disturbance in relation to achieving EQO

Discharge	Mobilisation of sediments as a result of seabed disturbance
Description	Seabed disturbance within the State Proposal Area will occur as a result of the installation of subsea infrastructure (including pre-lay activities, placement and post lay rectification of infrastructure), wet storage (which involves temporarily placing equipment on the seabed), anchoring of the MODU and IMMR activities. Within the State Proposal Area, seabed disturbance is planned to occur in deep water (>350 m), with direct seabed disturbance of approximately 0.26 km^2 and indirect disturbance (which is considered reversible) approximately 3.25 km^2
Draft EIS/ERD reference	• Draft EIS/ERD Section 6.3.1 • State ERD Section 8.2.4.2
Project stage(s)	Construction and operations
Receptors	The following receptors within the State Proposal Area have been identified as potentially being impacted by mobilisation of sediments associated with seabed disturbance: • sediment quality • water quality • biota.
Potential impacts	Seabed disturbance is likely to result in temporary (ranging in the order of minutes to a few hours) and localised displacement of naturally occurring sediments for the duration of the activity (ranging in the order of minutes to a few hours) and limited to the immediate disturbance area. Seabed disturbance in the State Proposal Area is likely to result in increases in turbidity levels at the seabed in deep water that will quickly disperse in the oceanic marine environment due to prevailing hydrodynamic conditions. As such, any reduction in water quality will be temporary and will be limited to the water column immediately surrounding the disturbance area. The majority of the sediments that may be displaced are naturally occurring and, do not contain any contaminants of concern (Section 5.2.10 of the draft EIS/ERD). It should be noted that drill cuttings discharged during drilling activities may be displaced as a result of seabed disturbance. These drill cuttings may contain contaminants of concern as described in **Section 3.3.7**. It is considered that the potential effects of temporary remobilisation of these sediments are covered in the assessment of drilling discharges. The impact assessment presented in Section 8.2.4.2 of the State ERD found that turbidity and associated sedimentation generated by seabed disturbance are not expected to result in any lasting change to the physical or chemical properties of water or sediments or have any lasting adverse effects on biota. Further, turbidity and associated sedimentation generated by seabed disturbances is expected to be limited to the deep-water benthic communities and habitats (>75m bathymetry). Also given the temporary and localised nature of the displacement of sediments, it is not considered credible that seabed disturbance relating to activities in Commonwealth waters will affect the EVs of the State Proposal Area. As such these are not considered further in this plan.
Mitigation and management	The following controls have been adopted in relation to this discharge as per Section 6.3.1 of the draft EIS/ERD: • No infrastructure will be placed on Scott Reef shallow water benthic communities and habitat (<75 m bathymetry). • No moorings for the MODUs will be installed in the Scott Reef shallow water benthic communities and habitat (<75 m bathymetry). • No moorings will be installed within the lagoon at North and South Scott Reef.

Discharge	Mobilisation of sediments as a result of seabed disturbance		
	• For subsea infrastructure, in particular flowlines, seabed preparation and secondary stabilisation requirements will be limited to the level necessary to ensure pipeline integrity.		
Assessment of residual risk to EQO			
EV	**EQO**	**Assessment**	**Residual risk to EQO exists?**
Ecosystem health	Maintain ecosystem integrity	Localised temporary turbidity not predicted to affect ecosystem integrity.	No
Fishing and aquaculture	Fishing – seafood is of a quality safe for eating	Localised temporary turbidity not predicted to affect seafood quality.	No
Recreation and aesthetics	Primary contact recreation – water quality is safe for activities in the water	Localised temporary turbidity not predicted to affect recreational use.	No
	Secondary contact recreation – water quality is safe for activities in the water	Localised temporary turbidity not predicted to affect recreational use.	No
	Aesthetic values of the marine environment are protected	Localised temporary turbidity will not affect aesthetic value of marine environment.	No
Cultural and spiritual	Cultural and spiritual values of the marine environment are protected	As per (EPA, 2016), in the absence of any specific environmental quality requirements for protection of 'Cultural and Spiritual' values, it is assumed that if water quality is managed to protect ecosystem integrity, primary contact recreation, seafood quality safe for eating, and aesthetic values, then this may go some way towards maintaining cultural values.	No

3.3.3 Sewage and sullage discharge

Table 3-3 outlines the assessment of the impact sewage and sullage discharge with respect to achieving the EQOs.

Table 3-3 Assessment of sewage and sullage discharge in relation to achieving EQO

Discharge	Sewage and sullage discharge
Description	There are no planned discharges of untreated sewage or sullage within the State Proposal Area, however, discharges of treated sewage and sullage from project vessels, installation vessels and the MODU within the State Proposal Area will occur. Under normal operating conditions, drilling and vessel activity (and associated marine discharges) will be limited to the deep waters in proximity to the location of the proposed development wells and subsea infrastructure. Drilling activities are expected to take two to three months per well, with up to 21 wells in the State Proposal Area. It must be noted that drilling and completions will occur in phases (e.g. Phase 1 RFSU includes three wells at TRA) and therefore not all 21 wells will be drilled in a continuous sequence.

Discharge	Sewage and sullage discharge
	A review of current petroleum activities shows that vessels and MODUs typically generate around 5 to 15 m³ of waste water (consisting of sewage and sullage) per day (National Energy Resources Australia (NERA), 2017). Using a rate of 0.375 m³/person/day as a guide (NERA, 2017), installation vessels may discharge approximately 22.5 m³/day, based on 60 persons aboard.
Draft EIS/ERD reference	• Draft EIS/ERD Section 6.3.9 • State ERD Section 8.2.4.4
Project stage (s)	Construction and operations
Receptors	The following receptors within the State Proposal Area have been identified as potentially being impacted by this planned discharge: • water quality • biota.
Potential impacts	The discharge of treated sewage and sullage has the potential to result in the temporary (ranging in the order of minutes to a few hours) and localised (tens of metres) reduction in water quality via eutrophication as a result of increased nutrient levels (e.g. ammonia, nitrite, nitrate and orthophosphate). Sewage and sullage may also include some particulate matter which can cause an increase in the turbidity of the receiving waters close to the point of discharge. The impact assessment presented in Section 8.2.4.4 of the State ERD found that: • Discharges will disperse and dilute rapidly, with concentrations of wastes significantly dropping with distance from the discharge point. • Monitoring of sewage and sullage discharge during the drilling campaign for the Torosa-6 well in 2008 determined discharges were rapidly diluted in the upper (less than 10 m) water layer to 1% of their original concentration within 50 m, with no elevations above background in nutrients or metals recorded at any sampling station (ERM and SKM, 2008). • Changes to the physical and chemical properties of the marine water as a result of sewage and sullage discharge will be temporary and highly localised. • No change to the physical or chemical properties of sediments are expected due to the bathymetric depth of the water where treated sewage and sullage would be discharged. • Although organic materials from the discharges will likely exert biological oxygen demand on the receiving waters, this is unlikely to reach levels below background ambient dissolved oxygen concentrations. • Similarly, while the nutrient inputs from discharged effluent will rapidly be taken up by phytoplankton, pronounced increases in productivity as evidenced by increased chlorophyll a concentration are not expected. This is largely due to the assimilative capacity of the open ocean, with any additive nutrients not expected to accumulate in the vicinity of the discharge location. • Given the relatively small volume of treated sewage and sullage to be discharged, the distance from the discharge to Scott Reef and the expected rapid dilution of the discharge, the temporary and highly localised changes to water quality are not expected to have any impacts to biota. The impact assessment as described in Section 6.3.9 of the draft EIS/ERD found that sewage and sullage discharges in Commonwealth waters are not predicted to affect the EVs of the State Proposal Area. As such these are not considered further in this plan.
Mitigation and management	The following controls have been adopted in relation to this discharge: • Project vessels will comply with MARPOL 73/78 Annex IV: Sewage – (as applied in Australia under Commonwealth Protection of the Sea (Prevention of Pollution

Discharge	Sewage and sullage discharge
	from Ships) Act 1983 and Marine Order 96 (Marine pollution prevention—sewage)). • Discharge of sewage will occur in accordance with the WA Department of Transport sewage strategy within State waters. • There will be no discharge of untreated sewage within 3 nm of Scott Reef. • Chemicals that may be operationally released or discharged to the marine environment must be subject to Woodside's chemical selection and assessment process and approved prior to use.

Assessment of residual risk to EQO

EV	EQO	Assessment	Residual risk to EQO exists?
Ecosystem health	Maintain ecosystem integrity	Compliance with MARPOL 73/78 Annex IV: Sewage – (as applied in Australia under Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983) and (Marine pollution prevention—sewage), and WA Department of Transport sewage strategy within the State Proposal Area will ensure EQOs are not compromised.	No
Fishing and aquaculture	Fishing – seafood is of a quality safe for eating		No
Recreation and aesthetics	Primary contact recreation – water quality is safe for activities in the water		No
	Secondary contact recreation – water quality is safe for activities in the water		No
	Aesthetic values of the marine environment are protected		No
Cultural and spiritual	Cultural and spiritual values of the marine environment are protected	As per (EPA, 2016), in the absence of any specific environmental quality requirements for protection of 'Cultural and Spiritual' values, it is assumed that if water quality is managed to protect ecosystem integrity, primary contact recreation, seafood quality safe for eating, and aesthetic values, then this may go some way towards maintaining cultural values.	No

3.3.4 Treated utility water, chemical and deck drainage discharge

Table 3-4 outlines the assessment of the impact treated utility water, chemical and deck drainage discharge with respect to achieving the EQOs.

Table 3-4 Assessment of treated utility water, chemical and deck drainage discharge in relation to achieving EQO

Discharge	Treated utility water, chemical and deck drainage discharge
Description	Within the State Proposal Area, treated utility water, chemical and deck drainage will be limited to deck drainage, treated bilge water and desalination brine from project vessels, installation vessels and the MODU. Potentially contaminated deck drainage discharges would occur from the MODU during periods of heavy rain, with potentially

Discharge	Treated utility water, chemical and deck drainage discharge
	contaminated drainage routed to slops tanks for treatment prior to discharge. Bilge water from within machinery spaces will be captured separately in a bilge tank for treatment. An oil-in-water separator will be available onboard the MODU and vessels (as applicable to vessel class), which will be maintained and operated so that bilge water is treated to reduce hydrocarbon concentrations below 15 ppm in accordance with MARPOL 73/78 Annex. Under normal operating conditions, drilling and vessel activity (and associated marine discharges) will be limited to the deep waters in proximity to the location of the proposed development wells and subsea infrastructure.
Draft EIS/ERD reference	• Draft EIS/ERD Section 6.3.10 • State ERD Section 8.2.4.5
Project stage(s)	Construction and operations
Receptors	The following receptors within the State Proposal Area have been identified as potentially being impacted by this planned discharge: • water quality • biota.
Potential impacts	As described in Section 8.2.4.5 of the State ERD, considering the composition of the drain discharges (i.e. small quantities of hydrocarbons and detergents) and assimilative capacity of the receiving environment, it is expected that drain discharges will rapidly dilute within the surrounding waters. As such, these discharges will result in temporary (lasting a few minutes) change to water quality in the immediate vicinity of the discharge. Given the water depth (>300 m) and distance to Scott Reef from where these discharges would occur, this change to water quality is not expected to have any impacts to the EVs of the State Proposal Area. As described in Section 8.2.4.5 of the State ERD, elevated salinity levels (above ambient) as a result of desalination brine discharge from MODU or vessel will be highly localised (within meters) at the discharge point and unlikely to have a perceptible effect on ambient salinity concentrations in the water column. The impact assessment described in Section 6.3.10 of the draft EIS/ERD found that treated utility water, chemical and deck drainage discharges in Commonwealth waters are not predicted to affect the EVs of the State Proposal Area. As such, these are not considered further in this plan.
Mitigation and management	The following controls related to the State Proposal Area have been adopted in relation to this discharge as described in Section 6.3.10 of the draft EIS/ERD: • Areas of potential contamination such as machinery and bulk liquid storage areas will be bunded to capture any spilled chemicals or oil residues. Drainage from these areas will be directed to holding tanks for treatment prior to discharge, subject to overflow arrangements. • An oil-in-water separator will be available onboard the MODU and vessels (as applicable to vessel class), which will be maintained and operated so that bilge water is treated to reduce hydrocarbon concentrations below 15 ppm in accordance with MARPOL 73/78 Annex I, as applied in Australia under the Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Part II Prevention of pollution from oil); Marine Orders 91 (Marine pollution prevention – Oil) as applicable to vessel class; and the WA Pollution of Waters by Oil and Noxious Substances Act 1987. • Chemicals that may be operationally released or discharged to the marine environment must be subject to Woodside's chemical selection and assessment process and approved prior to use.

Discharge	Treated utility water, chemical and deck drainage discharge		
Assessment of residual risk to EQO			
EV	**EQO**	**Assessment**	**Residual risk to EQO exists?**
Ecosystem health	Maintain ecosystem integrity	Compliance with MARPOL 73/78 Annex I, as applied in Australia under the Commonwealth Protection of the Sea (Prevention of Pollution from Ships) Act 1983 (Part II Prevention of pollution from oil); Marine Orders 91 (Marine pollution prevention – Oil) as applicable to vessel class; and the WA Pollution of Waters by Oil and Noxious Substances Act 1987 will ensure EQOs are not compromised.	No
Fishing and aquaculture	Fishing – seafood is of a quality safe for eating		No
Recreation and aesthetics	Primary contact recreation – water quality is safe for activities in the water		No
	Secondary contact recreation – water quality is safe for activities in the water		No
	Aesthetic values of the marine environment are protected		No
Cultural and spiritual	Cultural and spiritual values of the marine environment are protected	As per (EPA, 2016), in the absence of any specific environmental quality requirements for protection of 'Cultural and Spiritual' values, it is assumed that if water quality is managed to protect ecosystem integrity, primary contact recreation, seafood quality safe for eating, and aesthetic values, then this may go some way towards maintaining cultural values.	No

3.3.5 Produced water discharge

Table 3-5 outlines the assessment of the impact of the produced water discharge with respect to achieving the EQOs.

Table 3-5 Assessment of produced water discharge in relation to achieving EQO

Discharge	Produced water discharge
Description	When hydrocarbons are recovered from the reservoir a by-product is produced water (PW), which is separated out from the hydrocarbons during the production process and discharged. This PW may consist of a combination of formation water (water that occurs naturally within the hydrocarbon-bearing geological formations that is drawn into the well during hydrocarbon recovery), and condensed water (water vapour contained in the gaseous phase of the reservoir fluids that condenses out of the gas as the pressure and temperature is reduced when the reservoir fluids are brought up to the surface). For the proposed Browse Project, the primary source of PW discharges will occur from the FPSO facilities in Commonwealth waters, with low levels also discharged from the MODU. PW will be produced during operations where it will be treated, using a tertiary treatment system on board the FPSO facilities prior to discharge to the marine environment in Commonwealth waters. The FPSO PW treatment circuit will be

Discharge	Produced water discharge
	designed for a maximum processing capacity of 5,723 m^3/day on each FPSO. At Phase 1 RFSU, actual PW rates are expected to be significantly less than the design, with formation water (and therefore PW) generally expected to increase over time and be highest towards the end of the reservoir life. Low levels of PW may also be discharged from the MODU at the drill centre locations, during well unloading. The estimate of total unloading is anticipated to take 1-2 days per well (i.e. the amount of time that the well is flowing), with PW generally limited to small volumes of condensed water. PW discharged to the marine environment may include: • trace amounts of hydrocarbon compounds • trace amounts of metals • monoethylene glycol (MEG) • naturally occurring radioactive materials (NORMs) • nutrients such as ammonia.
Draft EIS/ERD reference	• Draft EIS/ERD Section 6.3.12 • State ERD Section 8.2.4.6
Project stage(s)	Construction and operations
Receptors	The following receptors within the State Proposal Area have been identified as potentially being impacted by this planned discharge**:** • water quality • sediment quality • biota.
Potential impacts	*MODU* Low levels of PW may be discharged from the MODU at the well locations, including within deep water areas of the State Proposal Area during well unloading. This PW would be condensed water generated in the hydrocarbon gas stream during well unloading and would be discharged as part of the discharge of well clean up fluids, which would include drilling fluids. The PW component of the discharge will constitute a very small proportion of the discharge stream, with the discharge dominated by suspension fluids and associated PW generally limited to small volumes of condensed water. As such, MODU PW discharge is considered to be part of drilling discharges (addressed in **Section 3.3.7**) and is not considered a separate discharge for the purpose of this plan. *Torosa FPSO* Discharge of PW from the Torosa FPSO (in Commonwealth waters) may change water quality due to thermal impacts (increased water temperature) and toxicity impacts relating to the residual hydrocarbons and chemical concentration within the PW discharge. Modelling of the FPSO PW discharge (Section 6.3.12.3 of the draft EIS/ERD) indicates: • Within the immediate area of influence of the discharge (in Commonwealth waters), water temperatures will be elevated temporarily impacting water quality. However, as outlined within the modelling results, the temperature differential between the discharge and the ambient water is predicted to achieve the threshold level (3^{o}C above ambient temperature) within the near-field area. Subsequently, such thermal impacts are not predicted to occur outside of a maximum distance of 44 m from the discharge location and are not expected to affect the State Proposal Area.

<table>
<tr><th>Discharge</th><th>Produced water discharge</th></tr>
<tr><td></td><td>A change in water quality due to the residual hydrocarbons and chemical concentration of the PW discharge will occur in the vicinity of the PW discharge location. The point at which the 99% species protection level is met for oil in water (333 dilutions) is at a maximum distance of 1,200 m from the Torosa FPSO discharge point, as defined in the modelling as described in Section 6.3.12.3 of the draft EIS/ERD. This modelling indicates that there will be no detectable change to water quality within the State Proposal Area from Torosa FPSO PW discharge.
Given the above, no change to the EVs of the State Proposal Area are predicted as a result of PW discharge.</td></tr>
<tr><td>Mitigation and management</td><td>The following controls and adaptive management approach have been adopted in relation to the discharge of PW as described in Section 6.3.12 of the draft EIS/ERD. Note that as the FPSO PW discharges originate in Commonwealth waters, they will be managed under an accepted FPSO EP to be prepared under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS (E) Regulations).
Where practicable, design of the proposed Browse Project infrastructure will take into consideration opportunities to reduce the need for chemical additives (e.g. the use of active heating for hydrate management).
FPSO PW will be treated prior to being discharged overboard using a tertiary treatment system, such as a Macro Porous Polymer Extraction (MPPE) system that meets Woodside and accepted industry standards.
PW discharge from the FPSO facilities will be conducted below the water surface to promote dispersion and mixing.
For the FPSO PW discharge, the defined threshold values (i.e. 99% species protection or no effect concentrations) will be met at the edge of the mixing zone and the State waters 3 nm boundary, 95% of the time based on dispersion modelling results.
Hydrocarbon content in the FPSO PW discharge will be no greater than an average of 30 mg/L over any period of 24 hours during steady state operations (excluding start-up, shut-downs etc.) as demonstrated by monitoring.
Chemicals that may be operationally released or discharged to the marine environment will be subject to Woodside's chemical selection and assessment process and approved prior to use.
In the event the FPSO PW discharge does not meet the defined thresholds in the range predicted for any constituent concentrations, an adaptive management strategy will be implemented (and described in subsequent EPs) to mitigate potential risk to the State Proposal Area, and in particular Scott Reef shallow water benthic communities and habitats (<75 m depth) where a maximum LEP is proposed. The strategy is premised on the commitment to meet the 99% species protection or no effect concentrations at the edge of the mixing zone and the State waters 3 nm boundary, 95% of the time based on dispersion modelling results, which will be verified through monitoring.
This adaptive management strategy may include actions such as reducing the discharge rate, which increases dilutions in the nearfield or reduces an individual chemical concentration through commingling prior to discharge. It should also be noted that PW will come on slowly so there will be opportunity to sample and adapt before the full rates modelled are experienced.
Monitoring to support this adaptive management strategy will include:
During steady state FPSO operations, PW modelling and infield verification will be completed to verify the modelling predictions. This study aims to verify the modelling predictions and in particular the dilutions achieved, which determines the point at which the defined thresholds levels are reached.</td></tr>
</table>

Discharge	Produced water discharge
	• *Periodic and 'for cause' toxicity testing and characterisation of the physical and chemical composition of the FPSO PW stream prior to discharge will be undertaken.* This provides an assessment of the individual constituent chemical concentration and the whole of effluent toxicity at end of pipe. • *Baseline and periodic water and sediment quality monitoring at a gradient away from the FPSO facility in the receiving environment will be undertaken to detect changes as a result of FPSO PW discharge. This gradient will extend to the point at which environmental quality meets the guidelines and standards required for the designated LEP in the State Proposal Area are achieved.* This monitoring aims to demonstrate no changes in the receiving environment water and sediment quality outside of the defined mixing zone as a result of the FPSO PW discharges.

Assessment of residual risk to EQO

EV	EQO	Assessment	Residual risk to EQO exists?
Ecosystem health	Maintain ecosystem integrity	No impacts to ecosystem integrity are predicted.	**No** – note however, that PW monitoring and environmental quality criteria are proposed within the EQMP to address any potential uncertainty in the PW modelling predictions.
Fishing and aquaculture	Fishing – seafood is of a quality safe for eating	No impact to seafood quality predicted.	No
Recreation and aesthetics	Primary contact recreation – water quality is safe for activities in the water	No change in water quality is predicted.	No
	Secondary contact recreation – water quality is safe for activities in the water	No change in water quality is predicted.	No
	Aesthetic values of the marine environment are protected	No change in water quality is predicted.	No
Cultural and spiritual	Cultural and spiritual values of the marine environment are protected	As per (EPA, 2016), in the absence of any specific environmental quality requirements for protection of 'Cultural and Spiritual' values, it is assumed that if water quality is managed to protect ecosystem integrity, primary contact recreation, seafood quality safe for eating, and aesthetic values, then this may go some way towards maintaining cultural values.	No

3.3.6 Cooling water discharge

Table 3-6 outlines the assessment of the impact of the cooling water discharge with respect to achieving the EQOs.

Table 3-6 Assessment of cooling water discharge in relation to achieving EQO

Discharge	Cooling water discharge
Description	Seawater is used as a cooling media for heat exchangers to remove excess heat from the production processes on the FPSO facilities as well as from machinery systems on: • project vessels • FPSO facilities (in Commonwealth waters) • MODUs. Seawater cooling systems draw seawater from the ocean which is then pumped through heat exchangers where it absorbs heat. It is then discharged at a higher temperature than source. Cooling water is often treated with additives including scale inhibitors and biocide (such as chlorine) to avoid biofouling of pipework. These chemicals are usually added at low dosages, and are typically consumed in the inhibition process, so there is little residual chemical concentration remaining upon discharge. For the proposed Browse Project, the primary source of cooling water discharges will occur from the FPSO facilities in Commonwealth waters. The FPSOs are proposed to have a cooling water system where seawater is pumped up to the facility, treated with hypochlorite and passed through heat exchangers prior to discharge. The cooling water system consists of both a Process Seawater System and an Essential Seawater System. In addition to passing through heat exchangers, the Process Seawater System will also cool the inlet gas stream although will not cool any process streams with liquid hydrocarbons. It is estimated that the Process Seawater System demand will be in the order of 720,000 m^3/day per FPSO facility, which will be routinely discharged overboard below the water line, at a design temperature of approximately 50^{o}C. The Essential Seawater System demand is significantly smaller (expected to be <5% of the Process Seawater System). Cooling water discharges will also occur from the MODUs and vessels operating in both Commonwealth and State waters. However, the discharge volumes are anticipated to be significantly less that than FPSO facilities in the order of approximately 50 m^3/day, depending on vessel size. MODU and vessel related cooling water impacts will be primarily limited to the construction phase of the project, with the exception of operations support vessels and IMR activities.
Draft EIS/ERD reference	• Draft EIS/ERD Section 6.3.13 • State ERD Section 8.2.4.7
Project stage(s)	Construction and operations
Receptors	The following receptors within the State Proposal Area have been identified as potentially being impacted by this planned discharge: • water quality • biota.
Potential impacts	*Vessels and MODU* Cooling water discharge from project vessels and the MODU at the well locations may impact marine environmental quality due to thermal impacts (increased water temperature) and toxicity impacts relating to the residual chlorine concentration within the cooling water discharge Relatively low levels of cooling water will be discharged from project vessels and the MODU operating in the State Proposal Area (approximately 50 m^3/day depending on

Discharge	Cooling water discharge
	vessel size). Under normal operating conditions, drilling and vessel activity (and associated marine discharges) will be limited to the deep waters near the location of the proposed development wells and subsea infrastructure. These cooling water discharges are expected to rapidly disperse and dilute (within tens of metres) with impacts expected to be a highly localised change in water quality. The reduction in water quality as a result of these discharges is not expected to have any impacts to the EVs of the State Proposal Area. *Torosa FPSO* Modelling of the FPSO cooling water discharge (Section 6.3.13.3 of the draft EIS/ERD predicted that the chlorine threshold for continuous discharges of 2 ppb (0.002 mg/L), which represents the predicted no effect concentration for chronic exposure at the 99% species protection level (Chariton and Stauber, 2008), would be achieved by the 3 nm State waters boundary based on the annualised 95th percentile predictions for a conservative maximum discharge rate of 720,000 m^3. Temperature thresholds are expected to be reached within 120 m of the discharge location. As such the modelling indicates that sufficient dilutions to achieve 99% species protection will occur at the boundary of the State Proposal Area. Modelling of the FPSO cooling water discharge also indicates that the discharge plume may enter the State Proposal Area but at concentrations not exceeding the 99% species protection level (based on the 95th percentile). The maximum extent of this incursion is approximately 2 km and remains 2.4 km away from Scot Reef shallow water benthic communities and habitat (<75 m bathymetry). Given the above, a detectable change in water quality may occur within the State Proposal Area as a result of the Torosa FPSO cooling water discharges in Commonwealth waters, however no impacts to biota are predicted. It should be noted that the modelling took a conservative approach and assumed that no processes other than dilution would reduce the source concentrations over time. The modelling assumed no natural degradation or decay of the chlorine would occur and further reduce the mixing zone. It also did not take account of all mixing processes due to wave action in the upper water column which will likely serve to increase the magnitude of dilution acting on the cooling water plume. This is likely to result in an underestimation of mixing and dilution and overestimation of cooling water concentrations in modelling predictions.
Mitigation and management	As described in Section 6.3.13 of the draft EIS/ERD, the following controls and adaptive management process have been adopted in relation to the discharge of cooling water from the FPSO. Note that as the FPSO cooling water discharges originate in Commonwealth waters, they will be managed under an accepted FPSO operations EP to be prepared under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (OPGGS (E) Regulations). • Cooling water discharge from the FPSO facilities will be conducted below the water surface to increase dispersion and mixing. • Hypochlorite will be used to control fouling in sea water systems in line with best practice, due to its solubility in water and rapid biodegradability. • The FPSO facilities' cooling water systems have been designed to be segregated from process hydrocarbon streams to prevent potential contamination of the cooling water. • For Torosa FPSO cooling water discharges, the defined threshold value (i.e. 99% species protection; 3°C above ambient) will be met at the edge of the mixing zone and the State waters 3 nm boundary, 95% of the time based on dispersion modelling results. • During steady state operations, FPSO cooling water modelling and infield verification will be completed to verify the modelling predictions.

Discharge	Cooling water discharge		
	Note infield verification using a range of monitoring techniques will be completed during steady state operations to verify the model predictions and confirm that the mixing zone, including at the 3 nm State waters boundary is met. In the event that the mixing zone is larger than anticipated, posing a significant increase in impact than that described in the draft EIS/ERD then corrective actions will be implemented onboard the FPSOs to reduce the impact. Corrective actions include additional engineering to produce a change in discharge characteristics.		
Assessment of residual risk to EQO			
EV	**EQO**	**Assessment**	**Residual risk to EQO exists?**
Ecosystem health	Maintain ecosystem integrity	Detectable changes in water quality (below threshold levels) may be detected within the State Proposal Area as a result of the Torosa FPSO cooling water discharge in Commonwealth waters. No impact to EVs is predicted as the discharge will be diluted to below 99% species protection (95th percentile) prior to it reaching the boundary of the State Proposal Area. No impacts to ecosystem integrity from discharges within the State Proposal Area (vessels and MODU) are predicted due to the extremely small volumes and short discharge durations.	**Yes** (as a result of Torosa FPSO cooling water discharge in Commonwealth waters)
Fishing and aquaculture	Fishing – seafood is of a quality safe for eating	Highly localised and temporary change to water quality below threshold levels are not predicted to impact to seafood quality predicted.	No
Recreation and aesthetics	Primary contact recreation – water quality is safe for activities in the water	Highly localised and temporary change to water quality below threshold levels are not predicted to impact recreational use.	No
	Secondary contact recreation – water quality is safe for activities in the water	Highly localised and temporary change to water quality below threshold levels are not predicted to impact recreational use.	No
	Aesthetic values of the marine environment is protected	Highly localised and temporary change to water quality below threshold levels are not predicted to impact aesthetic value of marine environment.	No
Cultural and spiritual	Cultural and spiritual values of the marine environment are protected	As per (EPA, 2016), in the absence of any specific environmental quality requirements for protection of 'Cultural and Spiritual' values, it is assumed that if water quality is managed to protect ecosystem integrity, primary contact recreation, seafood quality safe for eating, and	No

Discharge	Cooling water discharge		
		aesthetic values, then this may go some way towards maintaining cultural values. Incursion of cooling water discharge (below threshold levels) not predicted to impact this EQO.	

3.3.7 Drilling or completions discharges

Table 3-7 outlines the assessment of the impact of the drilling or completions discharges with respect to achieving the EQOs.

Table 3-7 Assessment of drilling or completions discharges in relation to achieving EQO

Discharge	Drilling or completions discharges
Description	Development drilling activities within the State Proposal Area involve the drilling and completion of up to an estimated 21 wells. Drilling of production wells will generate drill cuttings, require cementing of the casing; and require the use of a range of fluids, that may be discharged to the marine environment, typically at the seabed and at or near the sea surface depending on the hole section and if riser in place. During the life of the proposed Browse Project, well components will require maintenance, repair or replacement. This will require well intervention activities which generally occur within the wellbore and may include but not limited to well logging activities (slickline, wireline, coil tubing), well testing and flowback; and well workovers. In addition, well abandonment activities can result in discharges to the marine environment including but not limited to installation and pressure testing of the blow out preventer (BOP), cutting/perforation of casing or production tubing; and installation of permanent reservoir and surface barrier (cementing). The discharges relevant to drilling and completion activities include the following which are described in Section 6.3.15 of the draft EIS/ERD and 8.2.4.8 of the State ERD: • drill cuttings • drilling fluids – water-based fluids (WBF) and non-water based fluids (NWBF) • cement • subsea control fluids • completion fluids • reservoir fluids • well annular fluids.
Draft EIS/ERD reference	• Draft EIS/ERD Section 6.3.15 • State ERD Section 8.2.4.8 • State ERD Section 8.3.4.9
Project stage(s)	Construction
Receptors	The following receptors within the State Proposal Area have been identified as potentially being impacted by this planned discharge: • water quality • sediment quality • biota.
Potential impacts	*Drill cuttings and fluids discharge*

Discharge	Drilling or completions discharges
	Modelling of the proposed seabed discharge of drill cuttings was presented in Section 6.3.15 of the draft EIS/ERD. The modelling indicated that the seabed discharge of drill cuttings from top-hole well sections may result in sediment plumes in the lower water column above seabed and associated deposition of sediment to the surrounding seabed. Such plumes are predicted to be confined to the bottom layers of the water column with no contact with deeper water or shallow water coral habitats at Scott Reef (<75 m bathymetry). There is some evidence of localised intrusions of cooler water around the western and eastern entrances to the channel between North and South Scott Reef during spring tides but no evidence of persistent upwelling or downwelling currents around Scott Reef (Green et al., 2019b) and therefore, no transport mechanisms to mobilise drill cuttings from deep waters to the shallower waters of the reef system. As such, given the location of the drill centres in deep water (>350 m), which experience strong surface and subsurface currents, drill cuttings and fluid discharge disposal at seabed would be expected to dilute rapidly. Therefore, any reduction in water quality due to elevated TSS is expected to occur in a localised area around the drill centre and will be temporary in nature. In relation to the proposed discharge of bottom-hole drilling discharges at drill centres within the State Proposal Area when the riser is in place (i.e. conduit back to the MODU), previous modelling indicated that the surface release of drilling discharges generated at the previously proposed TRE and TRD drill centre locations would potentially result in incursions of sediment plumes and associated increased sedimentation to portions of North and South Scott Reef including within the lagoons. This has been further investigated in **Appendix A** (Management Approach for Torosa wells in State Proposal Area), which details the discrete surface discharges (e.g. drill cuttings with residual fluids and WBF mud pit bulk discharges) to assess individual risk to the Scott Reef shallow water benthic communities and habitats (<75 m bathymetry), where a maximum LEP protection has been proposed. Additional management controls are proposed for the management of Torosa wells drilling discharges in the State Proposal Area to demonstrate that the maximum LEP for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) can be achieved For TRA, TRD, and TRF wells on the eastern side of Scott Reef, within the State Proposal Area, drilling discharges at the surface/near surface when drilling with riser, are only being considered for bottom hole cuttings (with residual film of fluids) from the shakers (or equivalents) for WBF, and from the cuttings dryers (or equivalents) for NWBF, due to their inherently lower adhered WBF/NWBF content and the rapid settling velocity of the larger particle size of the cuttings (primary discharge source) and associated dispersion characteristics, and as such there is no anticipated credible risk to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry). Noting that the WBF mud pit bulk discharges, which have larger volumes and finer particle distribution and hence wider dispersion, are proposed to be managed and either discharged at depth (>200m), at the seabed, or retained for offshore disposal in Commonwealth waters in accordance with a sea dumping permit. Further details are provided in **Appendix A** (Management Approach for Torosa wells in State Proposal Area) *Change in water quality* The modelling (Section 6.3.15.3 of the draft EIS/ERD) indicates that both seabed and surface drilling discharges would result in impacts to water quality as a result of elevations in TSS and the introduction of low toxicity contaminants. This reduction in water quality will be temporary (i.e. limited to the duration of the activity, restricted to deep water (for Torosa drill centres in the State Proposal Area) and subject to rapid dispersion and dilution by prevailing currents, due to the open oceanic waters of the State Proposal Area. A description of the potential effect of drilling cuttings and fluids discharge in the State Proposal Area on water quality is provided in Section 8.2.4.8 of the State ERD which

Discharge	Drilling or completions discharges
	concluded that given the predicted rapid dispersion of suspended sediments within the open ocean environment of the State Proposal Area, the short period of intermittent discharge and the generally low concentration of total suspended solids (TSS) within the plume, any change in water quality associated with drill cutting discharge are expected to be temporary with a slight effect and with no long-term reduction in the environmental values of the State Proposal Area. *Cement discharge* Once each of the top hole sections are drilled, casing will be inserted into the wellbore and secured in place by pumping cement into the annular space. This may involve a discharge of excess cement at the seabed (~80 m^3/well). Overspill of cement will permanently alter physical sediment properties immediately adjacent to the well (within <50 m). The potential disturbance area is 0.008 km^2 per well; giving a total potential irreversible disturbance footprint of 0.17 km^2 within the State Proposal Area. This will result in the permanent loss of the benthic communities and habitats in the disturbance area and is reflected in the assessment against the EQOs below. *Sediment deposition* Following the discharge of drill cuttings and fluids, the coarser fractions (sand and gravel-sized particles), will rapidly settle to the seabed. Where cuttings are discharged to the seabed, a cuttings pile of deposited sediment particles will develop around and in close proximity to the well site. The nature and size of the pile will depend on a number of factors including particle size of the cuttings and tidal and current forces at the seabed. Discharge of cuttings at the surface will result in rapid dispersion and settlement of cuttings through the water column to the seabed with fines forming a sediment plume that will disperse and settle on the seabed less rapidly. Final deposition of cuttings will be dependent on the particle size distribution of cuttings, bathymetry, as well as the prevailing wind, tidal influence and current velocity and directions. Potential impacts are expected to be confined to sessile benthic biota such as sediment burrowing infauna and epifauna where present in or on the seabed offset up to several hundred metres from the immediate proximity to the well site and top hole cuttings pile. Ecological impacts to such biota are conservatively predicted when sediment deposition is equal to or greater than 6.5 mm in thickness (IOGP, 2016). Modelling (Section 6.3.15.3 of the draft EIS/ERD) indicated that such deposition would potentially occur out from the well location to approximately 200 m (following the direction of the prevailing current). This deposition may result in the reversible loss in the order of 0.13 km^2 of deepwater benthic habitat per well based on an assumption of an expected spread radius of 150 m from each well (in addition to the irreversible loss of 50 m associated with cement – described above). Recovery of affected benthic infauna, epifauna and demersal communities is expected to occur, given the short duration of sediment deposition and the widely represented benthic and demersal community composition. This effect on the EVs of the State Proposal Area is reflected in the assessment against the EQOs below.
Mitigation and management	The following controls have been adopted as per Section 6.3.15.7 of the draft EIS/ERD in relation to this discharge: • The number of wells will be optimised to meet hydrocarbon recovery objectives and operational requirements and thereby reduce unnecessary use of drilling fluids and generation of drill cuttings. • For technical, operational and environmental reasons NWBFs will be selected in accordance with Woodside's chemical selection and assessment processes. • Risers will be used to ensure that NWBF and associated cuttings are recirculated to the MODU, where cuttings will be treated prior to discharge. • There will be no planned discharge of unused NWBF at sea during drilling and completion operations.

Discharge	Drilling or completions discharges		
	• Drill cuttings will be tested to confirm that the average oil on cuttings for the entire well (but limited to sections using NWBF) will not exceed 6.9% by wet weight. • Drilling or completions discharges (in particular, bottom hole discharges) at drill centre locations in the State Proposal Area (i.e. TRA, TRD and TRF) will be managed in such a manner to avoid impacts to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) (see Management approach - Torosa wells in the State Proposal Area). As previously described, the management approach for drill centre locations in the State Proposal Area (i.e. TRA, TRD and TRF) described in Section 6.3.15.3 of the draft EIS/ERD has been further reviewed and developed, in consideration of the discrete drilling discharges, and has resulted in the inclusion of additional proposed management controls to demonstrate that the maximum LEP can be achieved for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry). Refer to **Appendix A** (Management Approach for Torosa wells in State Proposal Area) for details.		
Assessment of residual risk to EQO			
EV	**EQO**	**Assessment**	**Residual risk to EQO exists?**
Ecosystem health	Maintain ecosystem integrity	Activity is predicted to result in sediment deposition above ecological thresholds (6.5 mm in thickness, (IOGP, 2016)) for a radius in the order of 200 m from each well, and the discharge of cement for a radius of approximately 50 m from each well. In addition, modelling indicates TSS levels will be temporarily increased above natural variability as a result of drilling discharges. No impacts to ecosystem integrity are predicted outside of these areas is predicted.	**Yes**
Fishing and aquaculture	Fishing – seafood is of a quality safe for eating	Localised and temporary change to water quality not predicted to impact seafood quality.	No
Recreation and aesthetics	Primary contact recreation – water quality is safe for activities in the water	Localised and temporary change to water quality below threshold levels are not predicted to impact recreational use.	No
	Secondary contact recreation – water quality is safe for activities in the water	Localised and temporary change to water quality below threshold levels are not predicted to impact recreational use.	No
	Aesthetic values of the marine environment are protected	Localised and temporary change to water quality below threshold levels are not predicted to impact aesthetic value of marine environment	No
Cultural and spiritual	Cultural and spiritual values of the marine	As per (EPA, 2016), in the absence of any specific environmental quality requirements for protection of	No

Discharge	Drilling or completions discharges		
	environment are protected	‘Cultural and Spiritual’ values, it is assumed that if water quality is managed to protect ecosystem integrity, primary contact recreation, seafood quality safe for eating, and aesthetic values, then this may go some way towards maintaining cultural values. Sediment and cement deposition on seabed in deepwater not predicted to impact this EQO.	

3.3.8 Subsea control fluids

Table 3-8 outlines the assessment of the discharge of subsea control fluids with respect to achieving the EQOs.

Table 3-8 Assessment of the discharge of subsea control fluids in relation to achieving EQO

Discharge	Subsea control fluids
Description	Subsea control fluids will be used to control subsea valves remotely and are present on subsea equipment utilised during construction and installation (e.g.. ROVs and BOPs) and on the operational subsea infrastructure. The subsea hydraulic control system will have high pressure (HP) and low pressure (LP) circuits. The HP system will operate the downhole safety valve and the LP system will operate all other subsea valves. An open loop subsea control system will be adopted for the HP control systems, whereby the control fluid is pressurised on the FPSO facilities by the hydraulic accumulators and delivered to subsea valves via umbilicals. For the LP control system, a hybrid solution will be used. The open loop HP hydraulic system will discharge a small amount (0.1 L) at the Christmas tree when testing or operating the downhole safety valve. The release will be at the wellhead subsea control module, typically at 350 m water depth or greater. The hybrid LP hydraulic system will utilise a contingency injection line in the umbilical in order to achieve a closed loop configuration. This hybrid system has no planned discharges and will only release hydraulic fluid if the system leaks or the contingency injection line is required due to failure of the primary injection line. During drilling activities, control fluids will be discharged during function and pressure testing of the BOP control system. The maximum volume of control fluid that will be released to the marine environment per manifold is 1,900 L per year of water-based fluid containing ~3% active ingredient (40–68 L of control fluid additive).
Draft EIS/ERD reference	• Draft EIS/ERD Section 6.3.16 • State ERD Section 8.2.4.9
Project stage(s)	Construction and operations
Receptors	The following receptors within the State Proposal Area have been identified as potentially being impacted by this planned discharge: • sediment quality • water quality • biota.
Potential impacts	Control fluids are sourced from proprietary suppliers and are composed of low toxicity, water-based fluids. The specific control fluid has not yet been selected; however, such fluids are typically water based with additives such as MEG (usually about 40% of the total volume), lubricants, corrosion inhibitors, biocides and surfactants.

Discharge	Subsea control fluids
	Given the small volumes and solubility of the proposed water-based discharges, it is anticipated that the fluids would be rapidly diluted in the prevailing currents adjacent to the discharge location on the seabed. Hence, the intermittent discharge of small volumes of subsea control fluid may result in a minor, localised and temporary change in water quality that will be temporary (limited to the duration of the activity), restricted to deep water (>350 m); and subject to rapid dispersion and dilution by prevailing currents due to the open oceanic waters of the State Proposal Area. Due to the expected rapid dispersion and dilution by prevailing currents, and the fact that discharged subsea fluid is not predicted to accumulate in sediments, no lasting change to sediment quality is predicted. Therefore, the discharge of subsea control fluids is not predicted to impact the EVs of the State Proposal Area.
Mitigation and management	The following controls have been adopted in relation to this discharge: • Chemicals that may be operationally released or discharged to the marine environment will be subject to Woodside's chemical selection and assessment process and approved prior to use. • For the subsea LP control system, a hybrid solution in closed loop configuration will be used which returns fluids to the FPSOs and minimises discharges. The system will revert to an open loop system if the return lines to the FPSOs are no longer available to support the LP hydraulic system.

Assessment of residual risk to EQO

EV	EQO	Assessment	Residual risk to EQO exists?
Ecosystem health	Maintain ecosystem integrity	Localised and temporary change to water quality not predicted to impact ecosystem integrity.	No
Fishing and aquaculture	Fishing – seafood is of a quality safe for eating	Localised and temporary change to water quality not predicted to impact seafood quality.	No
Recreation and aesthetics	Primary contact recreation – water quality is safe for activities in the water	Localised and temporary change to water quality in >350 m deep water not predicted to impact recreational use.	No
	Secondary contact recreation – water quality is safe for activities in the water	Localised and temporary change to water quality in >350 m deep water not predicted to impact recreational use.	No
	Aesthetic values of the marine environment are protected	Localised and temporary change to water quality in >350 m deep water not predicted to impact aesthetic value of the marine environment.	No
Cultural and spiritual	Cultural and spiritual values of the marine environment are protected	As per (EPA, 2016), in the absence of any specific environmental quality requirements for protection of 'Cultural and Spiritual' values, it is assumed that if water quality is managed to protect ecosystem integrity, primary contact recreation, seafood quality safe for eating, and aesthetic values, then this may go some way towards maintaining	No

Discharge	Subsea control fluids		
		cultural values. Sediment and cement deposition on seabed in deepwater not predicted to impact this EQO.	

3.3.9 Hydrotest fluid discharge

Table 3-9 outlines the assessment of the discharge of hydrotest fluid with respect to achieving the EQOs.

Table 3-9 Assessment of the discharge of hydrotest fluid in relation to achieving EQO

Discharge	Hydrotest fluid discharge
Description	Hydrotest fluids are used for two distinct purposes; testing of the integrity of the pipeline and flowlines and for preservation of the pipelines and flowlines prior to the introduction of reservoir fluids. Hydrotest fluids may consist of a combination of seawater, biocides, corrosion inhibitors, oxygen scavenger, MEG and fluorescent dye. The period of time the hydrotest fluid is left within the infrastructure as a preservation fluid will depend on the type of fluid selected and the Browse Project schedule for construction and installation activities. If treated water is selected as the hydrotest fluid, it may only be suitable to be left in-situ for a period of approximately 12 to 24 months, after which it is typically discharged at sea and the flowline refilled, if required. If MEG is selected, it is likely that it could be left in-situ for longer, therefore reducing the frequency of discharge to sea. Discharge of hydrotest fluids into the State Proposal Area is associated with the subsea umbilicals, risers and flowlines (SURF) infrastructure and MODU. BTL discharge (in Commonwealth waters) may extend into the State Proposal Area depending on the chosen discharge locations as described below.
Draft EIS/ERD reference	• Draft EIS/ERD Section 6.3.17 • State ERD Section 8.2.4.10
Project stage(s)	Construction and operations
Receptors	The following receptors within the State Proposal Area have been identified as potentially being impacted by this planned discharge: • sediment quality • water quality • biota.
Potential impacts	*Hydrotest fluid toxicity* Due to the proposed chemical additives with the hydrotest fluid (i.e. biocides, corrosion inhibitors, oxygen scavenger, fluorescent dyes and MEG), the discharges have the potential to impact sensitive receptors within the discharge area of influence, primarily through toxicological effects ranging from the inhibition of key biological processes (e.g. reproduction) to mortality. In considering the potential impacts to receptors it should be noted that the activity is planned during commissioning, with no ongoing discharge of hydrotest fluids during the normal operations. For the purpose of the BTL hydrotest impact assessment, the hydrotest chemical treatment is assumed to be Hydrosure 0-3670R as a conservative analogue for other chemical treatments. Hydrosure 0-3670R is a proprietary chemical mixture designed for the treatment of water (neutralising bacteria and dissolved oxygen). To identify the potential toxicity of the hydrotest fluids following discharge to the marine environment, Chevron Australia Pty Ltd (2015) conducted whole effluent toxicity (WET) testing on

Discharge	Hydrotest fluid discharge
	Hydrosure 0-3670R (Champion Chemicals Pty Ltd), diluted in seawater. WET testing was undertaken on five locally relevant species from four different taxonomic groups based on ANZECC & ARMCANZ (2000). Since Hydrosure 0-3670R is a mixture containing both the biocide and oxygen scavenger for chemical treatment, only one assay in each test species was necessary to evaluate the toxicity of the product. The results from this study established a 99% species protection value of 0.06 mg/L, which was applied in the modelling over a 48-hr rolling median (Chevron Australia Pty Ltd, 2015). In addition, MEG, which may be used in the hydrotest fluid, is commonly used as a hydrate inhibitor within oil and gas developments. The chemical itself is clear and colourless, with a low volatility and miscible with water; however, no hydrolysis of the compound is expected in surface waters (WHO, 2000). MEG is listed as 'E' category fluids under the Offshore Chemical Notification Scheme (OCNS) and are listed on the Oslo Paris Commission (OSPAR) PLONOR ('pose little or no risk to the environment') list. In addition, the compound has little or no capacity to bind to particulates and will be mobile in soil (WHO, 2000). Rapid degradation has been reported in surface waters, with a generally low toxicity to aquatic organisms. Direct toxicity testing of neat MEG, on eight, mainly tropical species, representing seven taxonomic groups, established the lowest no observable effect concentration (NOEC) for sea urchin fertilisation of 130 mg/L (Jacobs, 2019). *Commonwealth waters discharges (BTL)* As noted in Section 6.3.17 of the draft EIS/ERD, Woodside will continue to pursue dry commissioning of the BTL and inter-field spur line. If deemed technically feasible and acceptable, this is the preferred method for preparing the BTL and inter-field spur line for the introduction of export product. Acceptance of dry commissioning of the BTL and associated inter-field spur line is subject to stakeholder endorsement (most notably relevant regulator(s) and the Classification Society) that the as-installed BTL and associated inter-field spur line complies with relevant engineering standards to provide alternative means to verify its safety and integrity, replacing the traditional hydrostatic system test and associated flood, clean, gauge and dewater. Therefore, final stakeholder endorsement of the dry commissioning approach will only occur after the BTL and associated inter-field spur line has been installed. If dry commissioning of the BTL and inter-field spur line is not deemed technically feasible and acceptable, three discharge options are being assessed for the discharge of hydrotest fluid during dewatering of the BTL and inter-field spur line. Note the actual hydrotest dewatering scenario may be combination of Scenarios 1 to 3 described, with potential postponement in discrete discharges where required. The chosen scenario will however remain within the bounds of impact and risk assessment completed in the draft EIS/ERD. These include the following, which all originate in Commonwealth waters: • Base case - scenario 1 (NRC PLET): 736,000 m^3 hydrotest fluid (BTL and inter-field spur line) is discharged at the NRC PLET location, followed by 110,000 m^3 hydrotest fluid (2TL) at least 6 months later. • Alternative scenario 2 (Torosa PLET): 846,000 m^3 hydrotest fluid (BTL, inter-field spur line and NWS Project's 2TL) is discharged at the Torosa PLET. • Alternative scenario 3a / 3b (Brecknock/ Calliance PLET and Torosa PLET): BTL and NWS Project's 2TL hydrotest fluid (790,000 m^3) is discharged at the Calliance/ Brecknock PLET, while the hydrotest fluid from the inter-field spur line (56,000 m^3) is discharged at the Torosa PLET. Modelling of Scenario 2 and 3b (as presented in Section 6.3.17 of the draft EIS/ERD), indicated that the hydrotest discharge plume would likely extend into the State Proposal Area resulting in a temporary and localised decline in water and sediment quality as a result of the presence of chemical additives in discharged hydrotest fluids. The modelling also indicates that sufficient dilutions to achieve 99% species

protection may not be achieved by the time the plume reaches the State Proposal Area boundary, meaning potential impacts to deepwater benthic biota may occur.

Based on the modelling, the hydrotest discharge above threshold levels is predicted to extend into the State Proposal Area for a distance of approximately 800 m for both Scenario 2 and Scenario 3b. The hydrotest plume is predicted to extend into the State Proposal Area a total distance of approximately 1.5 km for Scenario 2 and 1.8 km for Scenario 3b.

No contact with Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) is predicted due to the depth of the discharge (461 m), with the plume staying in deep water, following the contours at the base of the reef and the prevailing bed currents. The modelling predicts the plume will reach no closer than approximately 3.8 km and approximately 3.3 km from the Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) for Scenario 2 and Scenario 3b respectively.

It should be noted that there is no evidence of persistent upwelling or downwelling currents at Scott Reef, but seawater temperature monitoring has recorded some evidence of localised intrusions of cooler water around the western and eastern entrances to the channel between North and South Scott Reef during spring tides (Brinkman et al., 2010; Green et al., 2019). Such cool water intrusions are primarily semi-diurnal in timing, driven by the strong semi- diurnal periodicity in the prevailing internal wave and tide regime in the channel, combined with horizontal shear due to the strong tidal currents that can entrain water from below the sill depth of the channel up into the lagoon. Logger data suggests that the cool water entering the lagoon originates within the thermocline from depths shallower than 160 m, with no evidence of deeper waters entering the lagoon system (Brinkman et al., 2010). Hence, no influence on the hydrotest discharges at depth (>460 m).

State waters SURF

For the SURF infrastructure, the flowline and riser hydrotest fluid will most likely be returned to the FPSO facility and then discharged to sea in Commonwealth waters. However, discharge may occur in deep water at the manifolds or riser base flowline end terminals (FLETS) for rigid flowlines.

For flowlines where the manifold is in the State Proposal Area, discharge will occur at the FPSO location (either from the FPSO or from the riser base FLETS) in order to maximise distance of the discharge from Scott Reef. However, for flowlines which are terminated at both ends within the State Proposal Area (specifically for TRE and TRF manifolds only), discharge of flowline hydrotest fluid in the State Proposal Area may be unavoidable.

Hydrotest fluid volumes being discharged to the marine environment will vary depending on the flowline section to be tested. Volumes are estimated to be up to approximately 950 m^3 of hydrotest fluid for the TRE flowline and up to approximately 250 m^3 for TRF flowline. A subsea flowline hydrotest discharge is likely to take less than a day to complete. These discharges will occur for each piece of infrastructure during pre-commissioning.

The size of the mixing zone associated with a hydrotest discharge from flowlines is dependent on the discharge characteristics (e.g. rate, volume, density etc.) and prevailing hydrodynamics. Woodside has previously performed hydrotest modelling for a range of discharge rates (4.8 m^3/min, 3.7 m^3/min, 1.85 m^3/min and 1.5 m^3/min), in water depths ranging from 130 m to 830 m on the North West Shelf, which is considered appropriate to support this plan. The far-field dispersion modelling indicated that based on an in-pipe chemical concentration of 600 ppm, the plume would achieve 600 dilutions to dilute to below 1 ppm (based on LC50 over 96 hours) in proximity to the discharge location, ranging at a distance from 50 m (130 m water depth; 1.5 m^3/min; summer; 95th percentile) to 300 m (844 m water depth; 4.8 m^3/min; summer; 95th percentile) downstream of the discharge point.

For the SURF dewatering discharges, the plume is expected to travel in proximity to the seabed which means the temporary change in water quality will be restricted to

Discharge	Hydrotest fluid discharge		
	deep waters. The discharge would be subject to rapid dispersion and dilution by prevailing currents, due to the open oceanic waters of the Project Area. In addition, the low toxicity hydrotest fluids will degrade and decay once released. As such no lasting effect on water quality is predicted. *MODU* The temporary production system on the MODU will be hydrotested for well unloading activities. This will be conducted using hydrotest fluids, whereby the temporary production system on the MODU flowlines will be pressurised with fluids and the pressure will be monitored to detect leaks, prior to discharge of the hydrotest fluids. Discharges of small volumes of hydrotest fluid would be subject to rapid dispersion and dilution by prevailing currents with no lasting impact on water quality predicted.		
Mitigation and management	The following controls have been adopted in relation to this discharge: • The subsea infrastructure installation schedule will be optimised to minimise the requirement for discharge and refill of hydrotest fluid. • Chemicals that may be operationally released or discharged to the marine environment will be subject to Woodside's chemical selection and assessment process and approved prior to use. • For flowlines connected to those production manifolds that are located within 3nm of Scott Reef, the discharge of flowline hydrotest fluid will occur from the end of the flowline furthest from Scott Reef, where technically feasible. • Future engineering will consider the viability of alternatives to flowline hydrotest fluid discharge in the State Proposal Area, which will be described in a future EP.		
Assessment of residual risk to EQO			
EV	**EQO**	**Assessment**	**Residual risk to EQO exists?**
Ecosystem health	Maintain ecosystem integrity	Detectable levels of contaminants (above threshold levels) may occur within the State Proposal Area as a result of the BTL hydrotest discharge (depending on chosen discharge location). Detectable levels of contaminants (above threshold levels) may occur within the State Proposal Area as a result of the SURF infrastructure hydrotest discharge.	**Yes**
Fishing and aquaculture	Fishing – seafood is of a quality safe for eating	Localised and temporary change to water quality in >350 m deep water not predicted to impact seafood quality	No
Recreation and aesthetics	Primary contact recreation – water quality is safe for activities in the water	Localised and temporary change to water quality in >350 m deep water not predicted to impact recreational use	No
	Secondary contact recreation – water quality is safe for activities in the water	Localised and temporary change to water quality in >350m deep water not predicted to impact recreational use	No

Discharge	Hydrotest fluid discharge		
	Aesthetic values of the marine environment are protected	Localised and temporary change to water quality in >350m deep water not predicted to impact aesthetic value of the marine environment	No
Cultural and spiritual	Cultural and spiritual values of the marine environment are protected	As per (EPA, 2016), in the absence of any specific environmental quality requirements for protection of 'Cultural and Spiritual' values, it is assumed that if water quality is managed to protect ecosystem integrity, primary contact recreation, seafood quality safe for eating, and aesthetic values, then this may go some way towards maintaining cultural values. Sediment and cement deposition on seabed in deepwater not predicted to impact this EQO.	No

3.3.10 Summary

Table 3-10 presents a summary of the discharges the are considered to have the potential to pose a residual risk to EQOs.

Table 3-10 Summary of the discharges the are considered to have the potential to pose a residual risk to EQOs

Activity	EV	EQO	Assessment
Drilling or completions discharges	Ecosystem health	Maintain ecosystem integrity	Activity is predicted to result in sediment deposition above ecological thresholds (6.5 mm in thickness (IOGP, 2016) for a radius in the order of 200 m from each well, and the discharge of cement for a radius of approximately 50 m from each well. In addition, modelling indicates TSS levels will be temporarily increased above natural variability as a result of drilling discharges.
Hydrotest fluid discharge	Ecosystem health	Maintain ecosystem integrity	Detectable levels of contaminants (above threshold levels) may occur within the State Proposal Area as a result of the BTL hydrotest discharge (depending on chosen discharge location). Detectable levels of contaminants (above threshold levels) may occur within the State Proposal Area as a result of the SURF infrastructure hydrotest discharge.
Torosa FPSO cooling water discharge in Commonwealth waters	Ecosystem health	Maintain ecosystem integrity	Detectable levels of contaminants (below threshold levels) may be detected within the State Proposal Area as a result of the Torosa FPSO cooling water discharge in Commonwealth waters. No impact to biota is predicted as the discharge will be diluted to below achieve 99% species protection prior to it

Activity	EV	EQO	Assessment
			reaching the boundary of the State Proposal Area.

3.4 Management framework

3.4.1 Environment Quality Plan

This EQMP was developed to manage those aspects of the proposed Browse Project activities that have the potential to affect the relevant EV (ecosystem health) or that may vary from the associated EQO of maintaining ecosystem integrity. A key component of this is the development of an EQP which is defined by the EPA as "a plan that identifies the environmental values that apply to an area and spatially maps the zones where the environmental quality objectives (including levels of ecological protection) should be achieved" (EPA, 2016).

The objective of this EQP is to maintain a healthy and diverse ecosystem and there are potentially four (low, moderate, high or maximum) LEP that may be applied, each corresponding to a different target environmental quality condition. This method is seen as a practicable and auditable way of setting an objective for maintenance of ecosystem integrity while allowing for some discharge of waste to the marine environment in certain areas and under strictly controlled conditions.

The definitions of allowable change beyond natural variation under each LEP are outlined in **Table 3-11**. The limits of acceptable change for each environmental element with regard to the four LEP are detailed in **Table 3-12**.

Table 3-11 Definition of allowable changes to natural background under Levels of Ecological Protection (LEP) (EPA 2016)

LEP	Definition
Low	Allows large changes in abundance and biomass of marine life, biodiversity, and rates of ecosystem processes, but only within a confined area.
Moderate	Applied to relatively small areas within inner ports and adjacent to heavy industrial premises where pollution from current and/or historical activities may have compromised a high LEP.
High	Allows for small measurable changes in the quality of water, sediment, and biota, but not to a level that changes ecosystem processes, biodiversity, or abundance and biomass of marine life beyond the limits of natural variation.
Maximum	Activities to be managed so that there were no changes beyond natural variation in ecosystem processes, biodiversity, abundance, and biomass of marine life or in the quality of water, sediment, and biota.

Table 3-12 Limits of acceptable change to State Proposal Area marine environmental quality

Key elements	Limits of acceptable change	Maximum LEP	High LEP	Moderate LEP	Low LEP
Ecosystem processes (e.g. primary production, nutrients cycles, food chains)	Ecosystem processes are maintained within the limits of natural variation (no detectable change)	✓	✓		
	Small changes in rates, but not types of ecosystem processes			✓	
	Large changes in rates, but not types of ecosystem processes				✓
Biodiversity (e.g. variety and types	Biodiversity as measured on both local and regional scales remains	✓	✓	✓	

Key elements	Limits of acceptable change	Maximum LEP	High LEP	Moderate LEP	Low LEP
of naturally occurring marine life)	at natural levels (no detectable change)				
	Biodiversity measured on a regional scale remains at natural levels although possible change in variety of biota at a local scale				✓
Abundance and biomass of marine life (e.g. number or density of individual animals, the total weight of plants)	Abundances and biomasses of marine life vary within natural limits (no detectable change)	✓	✓		
	Small changes in abundances and/or biomasses of marine life			✓	
	Large changes in abundances and/or biomasses of marine life				✓
The quality of water, biota and sediment (e.g. types and levels of contaminants such as heavy metals, dissolved oxygen content, water clarity)	Levels of contaminants and other measures of quality remain within limits of natural variation (no detectable changes)	✓			
	Small detectable changes beyond limits of natural variation but no resultant effect on biota		✓		
	Moderate changes beyond limits of natural variation but not to exceed specified criteria			✓	
	Substantial changes beyond limits of natural variation				✓

The LEP for the State Proposal Area have been identified based on the assessment of the activities presented in the **Section 3.3**. When determining the proposed LEP, consideration has been given to potential impacts to marine environmental quality during construction and operations. This includes the planned staged development of the proposed Browse Project, where construction and commissioning activities such as drilling and completions of future drill centres may occur simultaneously with operations. As such, separate LEP have been proposed for construction activities (including pre-commissioning) and for operations. The proposed LEP are presented in **Table 3-13** and are shown in **Figure 3-2** and **Figure 3-3**.

Table 3-13 Proposed Limits of Ecological Protection (LEP) for the State Proposal Area

Activity	Predicted extent and magnitude of impact	Predicted limit of ecological change	Applicable LEP achieved
Construction activities			
Drilling or completions discharges	Activity is predicted to result in sediment deposition above ecological thresholds (6.5 mm in thickness, (IOGP, 2016)) for a radius in the order of 200 m from each well, and the discharge of cement for a radius of approximately 50 m from each well. This may lead to the alteration of the physio-chemical composition of sediments, the burial and potential smothering of sessile benthic biota, and potential contamination and toxicity effects to benthic biota from drilling fluids. In addition, modelling indicates TSS levels will be temporarily increased above natural variability as a result of drilling discharges.	**Ecosystem processes (e.g. primary production, nutrients cycles, food chains)** Given the localised area potentially affected by the drilling or completions discharges in the context of deepwater habitats that are well represented both in the State Proposal Area and regionally, ecosystem processes are expected to be maintained within natural variation (i.e. no detectable change).	***Drilling cuttings and cement discharge – Low LEP*** Based on predicted changes to the abundance and biomass of marine life and the quality of water, biota and sediment, a **low** LEP is proposed within a 200 m radius of each well. ***Drilling cuttings discharge – Moderate LEP*** A **moderate** LEP is proposed from 200m from each well, extending to a 1,000 m radius from each drill centre. Note that based on this 1,000 m radius, sediment deposition resulting from drilling wells radiating from TRH drill centre (in Commonwealth waters), may extend into the State Proposal Area. A corresponding **moderate** LEP has been proposed. It should be noted that given the exact location of each well within the well centre is currently unknown, the exact locations of these low LEPs are also unknown and not currently depicted on **Figure 3-2** or **Figure 3-3.** Once the decisions on the location of these well is known, the EQMP will be updated to reflect this.
		Biodiversity (e.g. variety and types of naturally occurring marine life) Given the localised area potentially affected by the drilling or completion discharges in the context of deepwater habitats that are well represented both in the State Proposal Area and regionally, biodiversity as measured on both local and regional scales remains at natural levels (no detectable change).	
		Abundance and biomass of marine life (e.g. number or density of individual animals, the total weight of plants) The localised smothering of biota associated with deepwater habitats within the State Proposal Area resulting from discharge of drill cuttings and cement is expected to lead to small changes in the abundance and/or biomasses of marine life within approximately 1,000 m radius of each drill centre, depending on individual well locations.	

Activity	Predicted extent and magnitude of impact	Predicted limit of ecological change	Applicable LEP achieved
		The quality of water, biota and sediment (e.g. types and levels of contaminants such as heavy metals, dissolved oxygen content, water clarity) The deposition of drill cuttings (with residual fluids) may result in the contamination of sediments within approximately 1,000 m radius of each drill centre, depending on individual well locations. The generation of localised and temporary elevated turbidity may result in a small detectable change in water quality beyond limits of natural variation but no resultant effect on biota is predicted.	The 1,000 m radius around each drill centre for the **moderate** LEP is proposed to allow flexibility in the final location of the wells. Note that the estimated extent of deposition impacts within the moderate and low LEPs (0.16 km^2 irreversible due to the discharge of cement and 2.36 km^2 of reversible loss due to cuttings deposition) still applies within these LEPs. Therefore, while the total area of low and moderate LEP as a result of drilling discharges is 10.67 km^2, a total of 2.52 km^2 only is predicted to be impacted. ***Drilling discharges – High LEP*** Based on the modelling results presented in Section 6.3.15 of the draft EIS/ERD, TSS levels will be temporarily increased above natural variability, with no impact on biota as a result of drilling or completions discharges expected outside of the moderate LEP. The modelling has been used to define an area of high LEP where a temporary change in water quality (above natural variability) may occur at a point of time during construction as a result of drilling discharges. In defining this LEP, a TSS threshold of 20 mg/L has been adopted based on review of near seabed TSS measurements (as detailed in Section 5.2.9 of the draft EIS/ERD).
	Discharge of hydrotest fluid from the flowlines and the temporary	**Ecosystem processes (e.g. primary production, nutrients cycles, food chains)**	

Activity	Predicted extent and magnitude of impact	Predicted limit of ecological change	Applicable LEP achieved
Hydrotest discharge – flowlines and MODU	production system in the MODU located in the State Proposal Area may result in a temporary and localised decline in water and sediment quality as a result of the presence of chemical additives in discharged hydrotest fluids. Representative modelling indicates that such discharge would dilute to achieve 90% species protection levels within 300 m.	Given any impacts to water quality will be localised and temporary, ecosystem processes are expected to be maintained within natural variation (i.e. no detectable change). **Biodiversity (e.g. variety and types of naturally occurring marine life)** Given any impacts to water quality will be localised and temporary, biodiversity as measured on both local and regional scales remains at natural levels (no detectable change). **Abundance and biomass of marine life (e.g. number or density of individual animals, the total weight of plants)** Given any impacts to water quality will be localised and temporary, abundances and biomasses of marine life is not expected to be vary outside of natural limits (no detectable change). **The quality of water, biota and sediment (e.g. types and levels of contaminants such as heavy metals, dissolved oxygen content, water clarity)** The discharge of hydrotest fluid may result in moderate changes in water quality beyond limits of natural variation but not to exceed specified criteria.	Based on predicted changes to the quality of water, biota and sediment, a **moderate** LEP is proposed. This hydrotest discharge would occur within (and be incorporated within) the areas proposed as a **moderate** LEP around the drill centres and subsea infrastructure described above for the drilling or completions discharges.
Hydrotest discharge – BTL	Discharge of hydrotest fluid from the BTL in Commonwealth waters may result in a temporary decline in water and sediment quality as a	**Ecosystem processes (e.g. primary production, nutrients cycles, food chains)** Given any impacts to water and sediment quality will be localised and temporary, ecosystem	Based on predicted changes to the abundance and biomass of marine life and the quality of water, biota and sediment, a **moderate** LEP is proposed in the area

Activity	Predicted extent and magnitude of impact	Predicted limit of ecological change	Applicable LEP achieved
	result of the presence of chemical additives in the discharge. Modelling of such a release at the Torosa PLET (not preferred option) which represents the worst-case option in proximity to the State Proposal Area indicates the discharge plume may enter the State Proposal Area. The modelling also indicates that sufficient dilutions to achieve 99% species protection may not be achieved by the time the plume reaches the boundary of the State Proposal Area.	processes are expected to be maintained within natural variation (i.e. no detectable change). **Biodiversity (e.g. variety and types of naturally occurring marine life)** Given any impacts to water and sediment quality will be localised and temporary, biodiversity as measured on both local and regional scales remains at natural levels (no detectable change). **Abundance and biomass of marine life (e.g. number or density of individual animals, the total weight of plants)** As the plume may not be diluted to a level that achieves 99% species protection at the 3nm State waters boundary, small changes in the abundance and/or biomass of marine life may occur. Once the plume is diluted to a 99% species protection level, no change to the abundance and biomasses of marine life is predicted. **The quality of water, biota and sediment (e.g. types and levels of contaminants such as heavy metals, dissolved oxygen content, water clarity)** As the plume may not be diluted to a level that achieves 99% species protection at the 3nm State waters boundary, changes in water quality at a moderate level and beyond the limits of natural variation may occur. Once the plume is diluted to a 99% species protection level, small detectable changes beyond limits of natural variation may occur but with no resultant effect on biota.	where modelling indicates that there are insufficient dilutions to achieve the defined thresholds based on 99% species protection level. Based on the modelling, this area of moderate LEP extends into the State Proposal Area for a distance of approximately 800 m for both Scenario 2 and Scenario 3b (refer to **Section 3.3.9**). A **high** LEP is proposed for the area where modelling indicates sufficient dilutions will have occurred to achieve 99% species protection levels, however insufficient dilutions to reach background levels. Based on the modelling, this area of **high** LEP extends into the State Proposal Area for a distance of 1.5 km for Scenario 2 and 1.8 km for Scenario 3b.

Activity	Predicted extent and magnitude of impact	Predicted limit of ecological change	Applicable LEP achieved
All other areas	A **Maximum LEP** (no detectable change beyond natural variation) is proposed for all other areas within the State Proposal Area. This includes all Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).		
Operations			
Subsea infrastructure - wells	The predicted irreversible loss (approximately 50 m radius of each well) of benthic habitat resulting from the discharge of cement that will occur during construction of the wells will remain throughout the operations phase. Note any reversible loss has not been considered in the operations phase LEP.	**Ecosystem processes (e.g. primary production, nutrients cycles, food chains)** Given the small localised area potentially affected in the context of deepwater habitats that are well represented both in the State Proposal Area and regionally, ecosystem processes are expected to be maintained within natural variation (i.e. no detectable change). **Biodiversity (e.g. variety and types of naturally occurring marine life)** Given the small localised area potentially affected in the context of deepwater habitats that are well represented both in the State Proposal Area and regionally, biodiversity as measured on both local and regional scales remains at natural levels (i.e. no detectable change). **Abundance and biomass of marine life (e.g. number or density of individual animals, the total weight of plants)** The localised smothering of biota associated with the deepwater habitats within the State Proposal Area are expected to lead to small changes in abundances and/or biomasses of marine life within 50 m radius of each drill centre.	Based on predicted changes to the abundance and biomass of marine life a **moderate** LEP is proposed. It should be noted that only a portion of the proposed **moderate** LEP area around the drill centres will be impacted. However, at the time of writing, the location of each individual well around each drill centre has not been confirmed and will be further refined through detailed engineering and design. A 1,000 m radius around each drill centre is proposed to allow flexibility in the final location of the wells. Note that the estimated extent of cement discharge within the moderate LEPs (0.16 km^2 irreversible due to the discharge of cement) still applies within the **moderate** LEP. Therefore, while the total area of **moderate** LEP proposed is 10.67 km^2, only 0.16 km^2 is predicted to be impacted irreversibly.

Activity	Predicted extent and magnitude of impact	Predicted limit of ecological change	Applicable LEP achieved
		The quality of water, biota and sediment (e.g. types and levels of contaminants such as heavy metals, dissolved oxygen content, water clarity) No detectable change to water quality during operations is predicted as cement discharge will only occur during construction.	
FPSO cooling water	Discharge of cooling water from the Torosa FPSO (in Commonwealth waters) may result in a temporary and localised decline in water quality as a result of the presence of chemical additives in discharged cooling waters. Modelling of the FPSO cooling water discharge (**Section 6.3.13.3** of the draft EIS/ERD) indicates that the discharge plume may enter the State Proposal Area but at concentrations not exceeding the 99% species protection level (95Th percentile). The maximum extent of this incursion is approximately 2 km.	**Ecosystem processes (e.g. primary production, nutrients cycles, food chains)** Given any impacts to water quality will be localised and temporary, ecosystem processes are expected to be maintained within natural variation (i.e. no detectable change). **Biodiversity (e.g. variety and types of naturally occurring marine life)** Given any impacts to water quality will be localised and temporary, biodiversity as measured on both local and regional scales remains at natural levels (i.e. no detectable change). **Abundance and biomass of marine life (e.g. number or density of individual animals, the total weight of plants)** Given any impacts to water quality will be localised and temporary (with 99% species protection levels achieved) no change to the abundance and biomasses of marine life is predicted. **The quality of water, biota and sediment (e.g. types and levels of contaminants such as**	A **high** LEP is proposed for the area where modelling indicates the cooling water plume discharged from the Torosa FPSO in the Commonwealth waters may enter into the State Proposal Area (at sufficient dilutions to achieve 99% species protection levels)

Activity	Predicted extent and magnitude of impact	Predicted limit of ecological change	Applicable LEP achieved
		heavy metals, dissolved oxygen content, water clarity) Given any impacts to water quality will be localised and temporary (with 99% species protection levels achieved), small detectable changes beyond limits of natural variation may occur but with no resultant effect on biota.	
All other areas	A **Maximum LEP** (no detectable change beyond natural variation) is proposed for all other areas within the State Proposal Area. This includes all Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).		

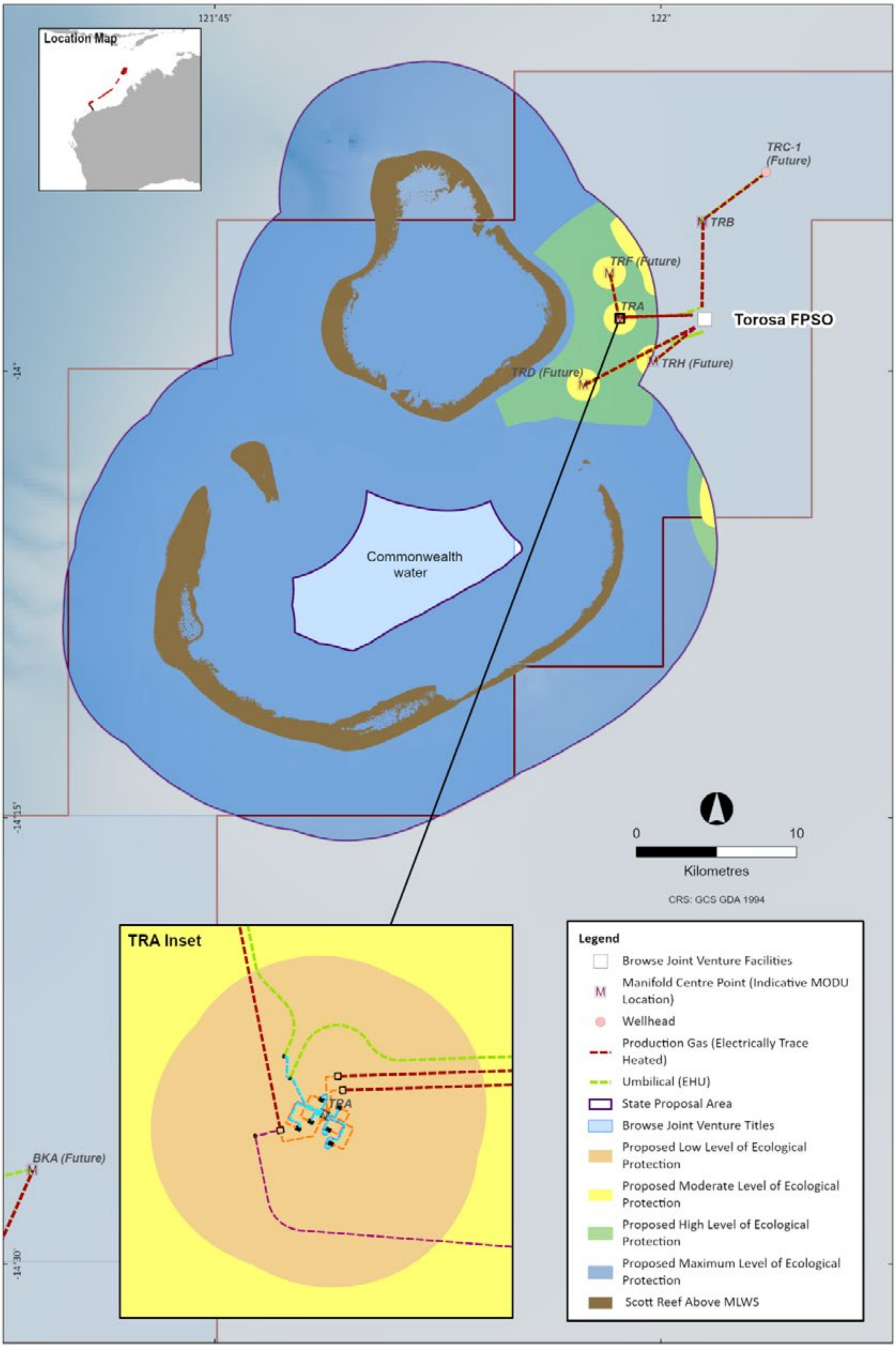

Figure 3-2 Proposed State Proposal Area LEP – Construction

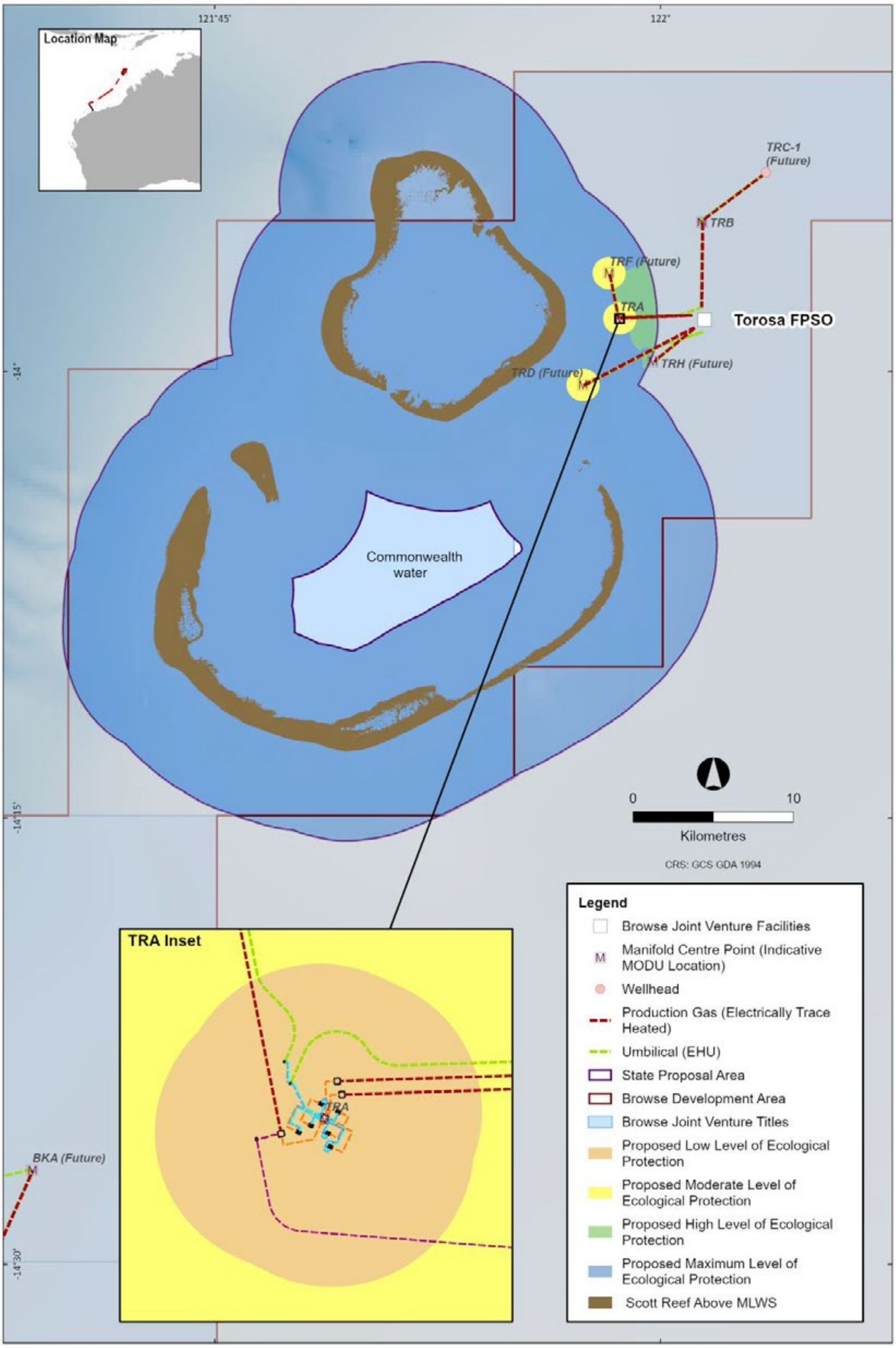

Figure 3-3 Proposed State Proposal Area LEP – Operations

3.4.2 Environmental Quality Criteria

Environmental quality criteria (EQC) represent scientifically based limits of acceptable change to a measurable environmental quality indicator that is important for the protection of the associated environmental value (EPA, 2016).

The EQC provide the benchmarks against which environmental quality is measured. The EQC define the limits of acceptable change to the measured environmental quality indicators. The key to successful marine environmental performance under the EQMF is to maintain environmental quality within the bounds of the EQC. If the EQC are met, then it is assumed that the EQOs are met and EVs are protected

There are two levels of EQC:

- Environmental Quality Guidelines (EQGs): These are relatively simple and easy-to-measure triggers that, if met, indicate a high degree of certainty that the associated EQO was achieved. If the EQG is not met, there is uncertainty as to whether the associated EQO was achieved and a more detailed assessment against the EQS is required.
- Environmental Quality Standards (EQSs): These are numerical values or narrative statements that, if not met, indicate a significant risk that the associated EQO has not been achieved and a management response is required. The management response focuses on identifying the cause (or source) of the exceedance and identifying the cause of the exceedance and initiating a response to rectify.

As per EPA guidance (EPA, 2016) in the absence of any specific environmental quality requirements for protection of 'Cultural and Spiritual' values, it is assumed that if water quality is managed to protect ecosystem integrity, primary contact recreation, seafood quality safe for eating, and aesthetic values, then this may go some way towards maintaining cultural values. As such no EQCs are identified specifically for protecting cultural and spiritual values.

EQC and associated management provisions are outlined in **Table 3-14**.

3.4.3 Management provisions

For each environmental indicator monitored, the relevant EQC serve as a benchmark against which the monitoring data can be compared to determine whether the EQO has been achieved. If an EQG is exceeded, assessment against the EQS will commence. If an EQS is exceeded, a management response is required to ensure the EQO continues to be achieved. These responses are specific to maintaining the relevant EQO that is at risk of not being met. The response after triggering EQG/EQS typically requires reporting to the relevant agency (WA Department of Water and Environmental Regulation (DWER)). Responses include further investigations to determine the extent and source of the environmental impact and/or applying management options to reduce the impact. Outcomes-based management provisions for the proposed Browse Project are outlined in **Table 3-14**. Note that all monitoring data associated with the monitoring described in **Table 3-14** will be provided along with the Annual Report to the Compliance Branch at DWER.

Table 3-14 Outcomes-based management provisions for the Browse Project

Environmental Quality Objective	Monitoring Target	Monitoring	Environmental Quality Guidelines	Management Response / Reporting	Environmental Quality Standards	Management Response / Reporting
Drilling or completions discharges						
Maintenance of ecosystem integrity	Sediment quality	Sediment quality sampling conducted at locations based on a gradient design, radiating out from the well. Monitoring will be undertaken at completion of the first batch of drilling at each well centre as well as on completion of the last well at each well centre.	**EQG 1** The bioavailable fraction of the metal or metalloid concentrations measured at the Low LEP / Moderate LEP and Moderate LEP / High LEP boundaries will not exceed the recommended toxicant default guideline values for sediment quality (DGVs; ANZG, 2018) and as specified in **Section 3.5.1.2**. **EQG 2** Hydrocarbon concentrations measured at the Low LEP / Moderate LEP and Moderate LEP / High LEP boundaries will not exceed the guideline values (DGVs) for sediment quality (ANZG, 2018) and as specified in **Section 3.5.1.2**. *For this EQG to be triggered, concentrations must be above background levels measured prior to the activity or a suitable reference location and be attributable to the Browse Project activities*	Report any exceedance to DWER in the Annual Environment Report. An investigation against EQS 1 will then be conducted.	**EQS 1** Whole sediment toxicity tests (at least 3 tests) from sediment at the Low LEP / Moderate LEP boundary should not result in a statistically significant effect (P < 0.05) on lethal acute endpoints, or of greater than 50% on sublethal chronic endpoints for any species, compared to a matched reference sediment. **EQS 10** Whole sediment toxicity tests (at least 3 tests) from sediment at the Low LEP/Moderate LEP boundary should not result in a statistically significant effect (P < 0.05) on lethal acute endpoints, or of greater than 50% on sublethal chronic endpoints for any species, compared to a matched reference sediment.	Any exceedance of the EQS will be reported to the DWER within five working days of confirmation that the exceedance has occurred. The significance of the exceedance and any required investigation/action will be determined following communication with the DWER.
Maintenance of ecosystem integrity	Epibenthos cover	Benthic cover surveys involving transects radiating out from a well conducted. Benthic cover surveys will be undertaken at completion of the first batch of drilling at each well centre as well as on completion of the last well at each well centre.	**EQG 3** No net detectable change in epibenthos diversity or composition outside 200 m radius from the well (or zone of impact based on revised modelling if further) within the defined Moderate LEP boundary attributable to the Browse Project activities.	Report any exceedance to DWER in the Annual Environment Report. An investigation against EQS 2 and EQS 3 will then be conducted.	**EQS 2** At the Low LEP / Moderate LEP boundary, no change to epibenthos species diversity and composition attributable to the Browse Project. **EQS 3** At the Moderate LEP / High LEP boundary, no detectable change in natural variation (including abundance, diversity and composition) of epibenthos cover attributable to the Browse Project activities.	Any exceedance of the EQS will be reported to the DWER within five working days of confirmation that the exceedance has occurred. The significance of the exceedance and any required investigation/action will be determined following communication with the DWER.

Environmental Quality Objective	Monitoring Target	Monitoring	Environmental Quality Guidelines	Management Response / Reporting	Environmental Quality Standards	Management Response / Reporting
Maintenance of ecosystem integrity	Water quality at Scott Reef (considered as the area above the 75 m bathymetric contour and within the 3 nm State waters boundary).	Particle size distribution of surface discharges monitored.	**EQG 4** Particle size distribution of the drilling fluids considered for surface discharge a show that 99% of particles are greater than 63 µm in size.	Report any exceedance to DWER in the Annual Environment Report. An investigation against EQS 4 will then be conducted.	**EQS 4** Water quality monitoring in the direction of the cuttings discharge plume shows no detectable change from natural variation of total suspended solids or contaminants in waters at Scott Reef (considered as the area above the 75 m bathymetric contour and within the 3 nm State waters boundary).	Any exceedance of the EQS will be reported to the DWER within five working days of confirmation that the exceedance has occurred. The significance of the exceedance and any required investigation/action will be determined following communication with the DWER. Response measures will include the reduction or cessation of the surface discharge of drill cuttings and fluids at times and locations where resultant plumes are likely to reach Scott Reef.

Environmental Quality Objective	Monitoring Target	Monitoring	Environmental Quality Guidelines	Management Response / Reporting	Environmental Quality Standards	Management Response / Reporting
BTL hydrotest discharge						
Maintenance of ecosystem integrity	Water quality	Water quality monitoring conducted at the boundaries of the State waters / Moderate LEP, State waters / High LEP, Moderate LEP / High LEP and High LEP / Moderate LEP during hydrotest discharge and in the hydrotest discharge plume.	**EQG 5** For BTL hydrotest discharge, concentration at the State waters boundary / Moderate LEP for hydrotest discharge components indicate sufficient dilution to achieve 95% species protection levels has been achieved. **EQG 6** For BTL hydrotest discharge, concentration at the moderate/high LEP for hydrotest discharge components indicate sufficient dilution to achieve 99% species protection levels has been achieved.	Report any exceedance to DWER in the Annual Environment Report. An investigation against EQS 5 and EQS 6 will then be conducted.	**EQS 5** At the State waters / Moderate LEP boundary, no change to epibenthos species diversity or composition attributable to the Browse Project. **EQS 6** At the Moderate LEP / High LEP boundary, no detectable change in natural variation (including abundance, diversity and composition of epibenthos cover attributable to the Browse Project activities.	Any exceedance of the EQS will be reported to the DWER within five working days of confirmation that the exceedance has occurred. The significance of the exceedance and any required investigation/action will be determined following communication with the DWER. Given the low likelihood of even EQG exceedance, EQS exceedance will trigger Woodside to develop an internal learning bulletin to prevent future occurrences.
SURF hydrotest discharge						
Maintenance of ecosystem integrity	Water quality	Water quality monitoring associated with the SURF hydrotest discharge is not proposed. The Moderate LEP associated the SURF hydrotest discharge is encompassed by the low LEP associated with the drilling and completions discharges. Further, SURF hydrotest discharge will take less than a day to complete. It is not considered that water sampling in >400 m water due to discharge of a known toxicity is warranted from a scientific, safety or logistics/cost perspective given the area to be monitored will already be designated either a low or moderate LEP due to the drilling and completions discharges.	**EQG 7** For SURF discharges, modelling indicates the concentration of chemicals in the discharge would achieve 90% species protection levels at the Low LEP / Moderate LEP boundary.	Modify activity (e.g. reduced flow rates) until modelling shows EQG likely to be met. An investigation against EQS 7 and EQS 8 will then be conducted.	**EQS 11** At the Low LEP / Moderate LEP boundary, no change to epibenthos species diversity and composition attributable to the Browse Project. **EQS 7** At the Moderate LEP / High LEP boundary, no detectable change in natural variation (including abundance, diversity and composition) of epibenthos cover attributable to the Browse Project activities.	Any exceedance of the EQS will be reported to the DWER within five working days of confirmation that the exceedance has occurred. The significance of the exceedance and any required investigation will be determined following communication with the DWER.

Environmental Quality Objective	Monitoring Target	Monitoring	Environmental Quality Guidelines	Management Response / Reporting	Environmental Quality Standards	Management Response / Reporting
FPSO cooling water						
Maintenance of ecosystem integrity	Water quality	During steady state FPSO operations, cooling water modelling and infield verification will be completed to verify the modelling predictions. This study aims to verify the modelling predictions and in particular the dilutions achieved, which determines the point at which the defined thresholds levels are reached. In field water sampling will be carried out to establish a baseline and annually during the first three years of steady safe FPSO operations. After this time, periodic (every five years) and for cause (e.g. due to EQG 8 exceedance) water quality monitoring at a gradient away from the FPSO facility in the receiving environment will be undertaken to measure compliance with EQC 9 and EQC 10. This monitoring aims to determine no changes in the receiving environment water outside of the defined mixing zone as a result of the FPSO cooling water discharges.	**EQG 8** For FPSO cooling water discharges, residual chlorine will be monitored at the end of pipe so that the defined threshold value (i.e. 99% species protection) will be met at the edge of the mixing zone and the State waters 3 nm boundary, 95% of the time based on dispersion modelling results. **EQG 9** For cooling water, within the High LEP, water quality in the relation to the contaminants of concern meets ANZG (2018) 99% species protection guideline values. **EQG 10** For cooling water, within the Maximum LEP, no detectable change from background concentrations in water quality in the relation to the contaminants of concern.	Report the exceedance to DWER in the Annual Environment Report. An investigation against EQS 9 will then be conducted.	**EQS 8** Whole effluent toxicity (WET) testing of water quality samples taken in the High LEP show that no toxicity is detected (no significant difference from controls).	Any exceedance of the EQS will be reported to the DWER within five working days of determining that this has occurred. The significance of the exceedance and any required investigation/action will be determined following communication with the DWER. In the event the cooling water discharge results in an exceedance of the EQS an adaptive management strategy will be implemented which will be included in the EP governing the Torosa FPSO. Actions may include reducing discharge rates, changing discharge location, decreasing chemical dosing or changing the chemical dosing regime. The primary management response will be a review and adjustment of the chlorine dosage rate and regime so that residual chlorine is minimised. Residual chlorine levels will be monitored and routinely maintained at <0.2 parts per million (ppm) at the point of discharge. The frequency of monitoring of end of pipe chlorine concentrations and toxicity will be increased until such time that it can be shown that the risk of exceedances of the EQGs and EQS is removed.
FPSO Produced water						
Maintenance of ecosystem integrity	Water quality	In the first year of operations, a PW modelling verification field program will be completed to verify the modelling predictions. This study aims to verify the modelling predictions and in particular the dilutions achieved, which determines the point at which the defined thresholds levels are reached In situ water sampling (to verify EQG 12) will be undertaken to establish baseline and then annually during the first three years of steady state FPSO	**EQG 11** Chemical characterisation analysis of the produced water at end of pipe undertaken annually. Results demonstrate the ANZG (2018) 99% species protection guideline values will be achieved for each contaminant at the State Waters boundary, based on modelled dilution rates. **EQG12** At the entry to the State Waters boundary, water quality samples indicate no detectable change in water quality from background concentrations in the relation to the contaminants of concern.	Report the exceedance to DWER in the Annual Environment Report. An investigation against EQS 10 will then be conducted.	**EQS 9** Whole effluent toxicity (WET) testing of water quality samples taken at the entry to the State Waters (in the direction of the PW plume occurrence during the sampling period), shows that no toxicity above background is detected.	Any exceedance of the EQS will be reported to the DWER within five working days of determining that this has occurred. The significance of the exceedance and any required investigation/action will be determined following communication with the DWER. In the event the PW discharge results in an exceedance of the EQS, an adaptive management strategy will be implemented which will be included in the Environment Plan governing the Torosa FPSO. This adaptive management strategy will include actions such as reducing the discharge rate, which increases dilutions in the nearfield or reduces

Environmental Quality Objective	Monitoring Target	Monitoring	Environmental Quality Guidelines	Management Response / Reporting	Environmental Quality Standards	Management Response / Reporting
		operations and every five years thereafter. This monitoring aims to determine no changes in the receiving environment water outside of the defined mixing zone as a result of the FPSO produced discharges.	**EQG 13** WET Testing of the produced water at end of pipe undertaken annually. Results demonstrate the 99% species protection guideline values will be achieved at the State Waters boundary, based on modelled dilution rates.			an individual chemical concentration through additional treatment or commingling prior to discharge or the addition of new/additional treatment stages or equipment.

3.5 Monitoring

3.5.1 Drilling and completions discharges - Deepwater sediment quality

3.5.1.1 Environmental Quality Criteria

The EQGs and EQSs for sediment quality in relation to drilling and completions discharges area shown in Table **3-15**. Only contaminants of concern as relevant to drilling discharges are subject to the EQC.

Table 3-15 Environmental Quality Criteria (EQC) for contaminants in sediment (drilling and completions discharges)

Environmental Quality Guideline (EQG)	Environmental Quality Standard (EQS)
EQG 1 The bioavailable fraction of the metal or metalloid concentrations measured at the Low LEP / Moderate LEP and Moderate LEP / High LEP boundaries will not exceed the recommended toxicant default guideline values for sediment quality (DGVs; ANZG, 2018) and as specified in **Section 3.5.1.2**. **EQG 2** Hydrocarbon concentrations measured at the Low LEP / Moderate LEP and Moderate LEP / High LEP boundaries will not exceed the guideline values (DGVs) for sediment quality (ANZG, 2018) and as specified in **Section 3.5.1.2**. *For this EQG to be triggered, concentrations must be above naturally occurring background levels measured prior to the activity or a suitable reference location and be attributable to the Browse Project activities.*	**EQS 1** Whole sediment toxicity tests (at least 3 tests) from sediment at the Low LEP / Moderate LEP boundary should not result in a statistically significant effect (P < 0.05) on lethal acute endpoints, or of greater than 50% on sublethal chronic endpoints for any species, compared to a matched reference sediment. **EQS 10** Whole sediment toxicity tests (at least 3 tests) from sediment at the Moderate LEP / High LEP boundary should not result in a statistically significant effect ($P < 0.05$) on sublethal chronic or lethal acute endpoints for any species, compared to a matched reference sediment.

3.5.1.2 Assessment against Environmental Quality Guidelines 1 and 2

The following assessment procedure will be followed:

- Sediment toxicant concentrations at sites at the Low LEP / Moderate LEP and Moderate LEP / High LEP boundaries will be compared directly to the default guideline values (GVs) listed in ANZG (2018) (presented in **Table 3-16**). The concentrations of organics and metals will be normalised to 1% total organic carbon (TOC) before comparison with the guidelines, with the exception of Total Petroleum Hydrocarbons (TPH). For TOC contents of <0.2% or >10%, multiplication factors of 5 and 0.1 will be used for normalisation, respectively.
- EQG 1 - Results of the bioavailable fraction of the metal or metalloid concentration at sites at the Low LEP / Moderate LEP and Moderate LEP / High LEP boundaries will be compared to the ANZG (2018) DGVs as specified in **Table 3-16**.
- EQG 2 - Results of the sediment hydrocarbon concentrations at sites at the Low LEP / Moderate LEP and Moderate LEP / High LEP boundaries will be compared to the ANZG (2018) DGVs as specified in **Table 3-16**.
- For results that exceed the DGVs specified in ANZG (2018) , an assessment against background levels measured prior to the activity or a suitable reference location will be undertaken prior to triggering assessment against the EQS.

Table 3-16 Recommended toxicant default guidelines values (GV) for sediment quality (ANZG 2018)

Toxicant	Units	Default Guideline Value	GV - High
Metal and Metalloids			
Aluminium	mg/kg dry weight	NA	NA
Antimony	mg/kg dry weight	2.0	25
Arsenic	mg/kg dry weight	20	70
Barium	mg/kg dry weight	NA	NA
Cadmium	mg/kg dry weight	1.5	10.0
Chromium	mg/kg dry weight	80	370
Copper	mg/kg dry weight	65	270
Iron	mg/kg dry weight	NA	NA
Lead	mg/kg dry weight	50	220
Manganese	mg/kg dry weight	NA	NA
Mercury	mg/kg dry weight	0.15	1.0
Molybdenum	mg/kg dry weight	NA	NA
Nickel	mg/kg dry weight	21	52
Silver	mg/kg dry weight	1.0	4.0
Vanadium	mg/kg dry weight	NA	NA
Zinc	mg/kg dry weight	200	410
Organics			
TPH (C6 to C36)	mg/kg dry weight	280	550
PAH (total)*	µg/kg dry weight	10,000	50,000

*Normalised to 1% total organic carbon

3.5.1.2.1 Sampling protocol

Remote operated vehicles (ROV) fitted with sampling devices, or suitable alternative/s (with demonstrated limited fines loss) will be used to sample sediments, and provide a visual indication (post drilling) of the prevailing direction of deposited drill cuttings. In accordance with the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018), quality control samples (e.g. splits, duplicates and/or triplicates) will be taken at a subset of sampling locations to account for variability.

Sediment quality sampling will be conducted at locations corresponding to EQG requirements (e.g. LEP boundaries.

The statistical design on the monitoring program will follow a Before After Control Impact (BACI) approach. A priori statistical power analysis will be conducted to determine the required number of samples to detect a difference or change with a specified level of statistical confidence and power. Confidence and power relate to probabilities of committing Type I (false positive) and Type II errors (false negative) when performing hypothesis tests. These parameters will be set to 0.05 (95% confidence, or 5% chance of obtaining a false positive result) and 0.8 (20% chance of obtaining a false negative). Sufficient samples will be taken to ensure a sufficient 'effect size' can be determined.

The sampling design will be based on the following:

- Sampling to occur at the specified LEP boundaries and supplement by sampling along gradient (as described in Holdway and Heggie, 2000) radiating out from the drilling disturbance centre to approximately 2 km
- Increased sampling effort will occur in the direction of the prevailing current. Where technically feasible within the constraints of existing subsea infrastructure, distances will be targeted to include the low LEP / Moderate LEP boundary, 250 m, 500 m, 750 m, 1 km, 2 km and at the Moderate LEP / High LEP boundary. Sampling will also occur at parallel locations down current of the well within the moderate LEP where required to increase the statistical power.
- No monitoring will be undertaken within a 200 m radius of the drilling disturbance as a low LEP is proposed in this area (due to sediment deposition and cement discharge).
- Consideration of the local hydrodynamics where dispersion is likely the greatest
- Sediment quality and ecological (epifauna) sampling locations will be co-located where possible to maximise comparisons and multiple lines of evidence assessments.

Samples will be collected, stored and handled using appropriate techniques consistent with guidance provided in *AS 5667.1:1998 Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples* (Standards Australia, 1998) and the *Australian and New Zealand Guidelines for Fresh and Marine* Water Quality (ANZG, 2018).

All analyses will be undertaken by NATA-accredited laboratories and to a limit of detection that is below the ANZG 2018 guidelines.

3.5.1.2.2 Timing

Monitoring will be undertaken as soon as practicable but no more than 3 months after completion of the first batch of wells at each well centre as well as within three months of completion of the last well at each well centre.

The monitoring locations will be based on those wells located closest to the to the Moderate LEP / High LEP boundary in the direction of the prevailing current. For the TRE well centre, where tidal movement runs in an east- west direction, monitoring will likely be at wells located in the eastern and western most parts of the Moderate LEP area. For the TRA, TRD and TRF wells, which are affected by the north-west/south-east tidal currents, wells will likely be located in the north-western and south-eastern parts of each Moderate LEP area. Monitoring will also be undertaken at an appropriate time pre-drilling.

3.5.1.3 Assessment against Environmental Quality Standards 1 and 10

In the event that EQG 1 or EQG 2 is exceeded (see **Table 3-15**), an investigation against EQS 1 and EQS 10 will be conducted at the same location as the exceedance, within one month of the EQG exceedance being determined to have occurred. The following assessment procedure will be followed:

- EQS 1 - Whole sediment toxicity tests (at least 3 tests) from sediment at the Low LEP / Moderate LEP boundary should not result in a statistically significant effect ($P < 0.05$) on lethal acute endpoints, or of greater than 50% on sublethal chronic endpoints for any species, compared to a matched reference sediment.
- EQS 10 - Whole sediment toxicity tests (at least 3 tests) from sediment at the Moderate LEP / High LEP boundary should not result in a statistically significant effect ($P < 0.05$) on sublethal chronic or lethal acute endpoints for any species, compared to a matched reference sediment.

3.5.1.3.1 Sampling protocol

Sediment sample collection will be conducted using the same methodology as per EQG1 and EQG 2 at the locations at which exceedances were observed.

3.5.1.3.2 Timing

Monitoring of EQS 1 and 10 will occur within one within one month of the EQG exceedance being determined to have occurred.

3.5.3 Drilling and completions discharges - Epibenthos cover

3.5.3.1 Environmental Quality Criteria

The EQG and EQS for epibenthos in relation to drilling and completions discharges are shown in **Table 3-17.**

Table 3-17 Environmental Quality Criteria for epibenthos cover (drilling and completions discharges)

Environmental Quality Guideline (EQG)	Environmental Quality Standard (EQS)
EQG 3 No net detectable change in epibenthos diversity or composition outside 200 m radius from the well within the defined Moderate LEP boundary attributable to the Browse Project activities.	**EQS 2** At the Low LEP / Moderate LEP boundary, no change to epibenthos species diversity and composition attributable to the Browse Project. **EQS 3** At the Moderate LEP / High LEP boundary, no detectable change in natural variation (including abundance, diversity and composition) of epibenthos cover attributable to the Browse Project activities.

3.5.3.2 Assessment against Environmental Quality Guideline 3 and Environmental Quality Standards 2 and 3

To assess against the EQG and EQS, density/abundance, diversity and composition will be assessed along 50 m transects based on both still and video images. Then the composition and diversity of epibenthic communities prior to and after drilling will be compared to assess potential for change as a result of drilling discharges. Assessment of the EQG and EQS are aligned, as due to the complexity and cost in obtaining this data, sufficient transects and data will be obtained for assessment of both the EQS and EQG, at the same time.

3.5.3.2.1 Sampling protocol

Ecological surveys of epibenthos cover are proposed to be conducted using high definition cameras (video and/or stills) with adequate lighting mounted to either a ROV, AUV, or suitable alternative/s methods. The camera system will have ultra-short baseline (USBL) positioning system to rectify the actual position on the seabed. In the post drilling survey, the selected method will be used to verify the prevailing direction of deposited drill cuttings and complete the survey transects.

Video surveys will be conducted at similar locations to sediment quality (for EQG 1 and 2) along the prevailing current axis. Surveys will be conducted prior to drilling at the same locations as the post drilling monitoring sites, and also at control sites. Post drilling surveys will only be undertaken where the EQG are exceeded and at control sites. At each location, five transects of 30 - 50 m lengths will be videoed. Control sites will also be surveyed before and after the drilling program. Control sites will be separate sites located in similar habitats to determine epibenthos in areas unimpacted by drill cuttings.

3.5.3.2.1 Timing

Monitoring of benthic (epibenthos) cover at a gradient away from the well will be undertaken at each well centre within the State Proposal Area, to verify that the EQC (as provided in **Table 3-17**) within the Moderate LEP has been achieved. Monitoring will be undertaken within three months of completion of the first batch of drilling at each well centre as well as on completion of the last well at each well centre.

The monitoring locations will be based on those wells located closest to the to the Moderate LEP / High LEP boundary. For the TRE well centre, where tidal movement runs in an east- west direction, monitoring will be at wells located in the eastern and western most parts of the Moderate LEP area. For the TRA, TRD and TRF wells, which are affected by the north-west/south-east tidal currents, wells sampled will be those located in the north-western and south-eastern parts of each Moderate LEP area.

Monitoring will be undertaken at an appropriate time pre-drilling and as soon as practicable post-drilling (within 3 months where practicable) in water depths deeper than 350m (actual depth will be dependent on which drill centre is chosen to assess).

3.5.5 Drilling and completions discharges – Scott Reef Water Quality

3.5.5.1 Environmental Quality Criteria

The EQG and EQSs for cutting discharge and water quality at Scott Reef is shown in **Table 3-18.**

Table 3-18 Environmental Quality Criteria for water quality (drilling and completions discharges)

Environmental Quality Guideline (EQG)	Environmental Quality Standard (EQS)
EQG 4 Particle size distribution of the drilling cuttings and fluids returned to the MODU via the riser, where the cuttings are separated from the fluids by SCE and fluids discharged at surface within State Waters show that 99% of particles are greater than 63 µm in size.	**EQS 4** Water quality monitoring in the direction of the cuttings discharge plume shows no detectable change from natural variation in concentrations of total suspended solids or contaminants in waters at Scott Reef (considered as the area above the 75 m bathymetric contour and within the 3 nm State waters boundary).

3.5.5.2 Assessment against Environmental Quality Guideline 4

Monitoring of the EQG (PSD size of the cutting and fluid to be discharged) will occur on board the MODU at sufficient frequency to provide confidence the EQG is being achieved. This will be compared against the criteria of 99% of particles are greater than 63 µm in size.

3.5.5.1 Assessment against Environmental Quality Standard 4

Water quality (total suspended solids) will be assessed against baseline levels and suitable reference locations to confirm suspended solid levels do not vary from natural background levels.

3.5.5.1.1 Timing

Water quality monitoring will be undertaken at proactively in accordance with the below sampling protocol, during a single representative well for the TRA, TRD, TRF drill centres.

Water quality monitoring will be reactively undertaken if exceedance of the EQG occurs, noting Woodside has committed to not discharging particles of the size indicated in EQG 4.

3.5.5.1.2 Sampling protocol

The statistical design on the monitoring program will follow a Before After Control Impact (BACI) approach. A priori statistical power analysis will be conducted to determine the required number of samples to detect a difference or change with a specified level of statistical confidence and power. Confidence and power relate to probabilities of committing Type I (false positive) and Type II errors (false negative) when performing hypothesis tests. These parameters will be set to 0.05 (95% confidence, or 5% chance of obtaining a false positive result) and 0.8 (20% chance of obtaining a false negative). Sufficient samples will be taken to ensure a sufficient ‘effect size’ can be determined.

The sampling design will be based on the following:

- Turbidity (NTU) will be used as a measure of TSS to allow real time measurements to be taken in the field to facilitate adaptive management.
- A gradient design (as described in Holdway and Heggie, 2000).
- Include sampling in the prevailing current from the point of discharge.
- Increased sampling effort will occur in the direction of the prevailing current. Where technically feasible within the constraints of existing subsea infrastructure, distances will be targeted to include the low LEP / Moderate LEP boundary, 250 m, 500 m, 750 m, 1 km, 2 km and at the

Moderate LEP / High LEP boundary. Sampling will also occur at parallel locations down current of the well within the moderate LEP where required to increase the statistical power. Monitoring should also occur at suitable reference sites, before and after the wells are drilled.

- Consideration of the local hydrodynamics where dispersion is likely the greatest.

3.5.7 BTL hydrotest discharges - Water Quality

3.5.7.1 Environmental Quality Criteria

The EQG for water quality in relation to the BTL hydrotest discharge is shown in **Table 3-19**.

Table 3-19 Environmental Quality Criteria for water quality (hydrotest discharge)

Environmental Quality Guideline (EQG)	Environmental Quality Standard (EQS)
EQG 5 For BTL hydrotest discharge, concentration at the State waters boundary / Moderate LEP for hydrotest discharge components indicate sufficient dilution to achieve 95% species protection levels has been achieved. **EQG 6** For BTL hydrotest discharge, concentration at the moderate/high LEP for hydrotest discharge components indicate sufficient dilution to achieve 99% species protection levels has been achieved.	**EQS 5** At the State waters / Moderate LEP boundary, no change to epibenthos species diversity or composition attributable to the Browse Project. **EQS 6** At the Moderate LEP / High LEP boundary, no detectable change in natural variation (including abundance, diversity and composition of epibenthos cover attributable to the Browse Project activities.

3.5.7.2 Assessment against Environmental Quality Guideline 5 and 6

Water samples taken in accordance with the sampling protocol will be analysed for the concentration of hydrotest discharge chemicals in the receiving environment. Results will be compared to toxicity data for the hydrotest fluids, to ensure that either 95% (within the Moderate LEP) or 99% species protection levels (within the High LEP) are achieved. The distance of the LEP boundaries from the discharge point, water depth and predicted dilutions at LEP boundaries means that it highly unlikely to be able to detect hydrotest fluids in-situ at LEP boundaries so samples will be supplemented by water samples collected in-situ closer to the discharge point where the plume is expected to be visible. These water sampling results (measuring for the concentration of hydrotest fluids) will be compared with discharge modelling results to determine EQG conformance even if there is no detection at sampled LEP boundaries.

3.5.7.2.1 Timing

Water quality monitoring (sampling) close to the plume will be undertaken within five days of hydrotest discharge activities from the BTL commencing.

3.5.7.2.2 Sampling protocol

Water samples will be collected via ROV with suitable water collection devices fitted (within the visible plume) or via vessel using a grab/niskin bottle sampler for samples at LEP boundaries. Triplicate samplings will be taken at LEP boundaries and at samples at least 5 locations will be collected within the visible plume, at increasing distances from the plume discharge point.

Water quality samples will be collected, stored and handled using appropriate techniques consistent with guidance provided in AS 5667.1:1998 Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples (Standards Australia, 1998) and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018).

All analyses will be undertaken by NATA-accredited laboratories.

3.5.7.3 Assessment against Environmental Quality Standards 5 and 6

To assess against the EQS, density/abundance, diversity and composition will be assessed along 50 m transects based on both still and video images. Then the composition and diversity of epibenthic communities prior to and after BTL hydrotest discharge will be compared to assess potential for change.

3.5.7.3.1 Timing

Monitoring of epibenthos at the State waters / Moderate LEP boundary, State waters / High LEP boundary, Moderate LEP / High LEP boundary and High LEP / Max LEP boundary associated with the BTL hydrotest discharges will be undertaken at a representative location before hydrotest discharges occur to establish a baseline of epibenthos cover. As modelling predicts that the hydrotest fluids may enter State waters at two different locations (depending on the current direction), the sampling will assess the ecological boundaries at both these locations. A repeat survey will be undertaken within and outside of the Moderate LEP if the EQGs are exceeded.

3.5.7.3.2 Sampling protocol

Ecological surveys of epibenthos cover are proposed to be conducted using high definition cameras (video and/or stills) with adequate lighting mounted to either a ROV, AUV, or suitable alternative/s methods. The camera system will have ultra-short baseline (USBL) positioning system to rectify the actual position on the seabed. In the post discharge survey, the selected method will be used to verify the prevailing direction of deposited drill cuttings and complete the survey transects. Video surveys will be conducted at similar locations to sediment quality sampling, along the prevailing current axis. At each location, five transects of 30 - 50 m lengths will be videoed. Control sites will also be surveyed in similar habitats.

3.5.8 SURF hydrotest discharges – Epibenthos Cover

3.5.8.1 Environmental Quality Criteria

The EQCs for epibenthos cover in relation to SURF hydrotest discharge area shown in **Table 3-20**.

Table 3-20 Environmental Quality Criteria for epibenthos cover (SURF hydrotest discharge)

Environmental Quality Guideline (EQG)	Environmental Quality Standard (EQS)
EQG 7 For SURF discharges, modelling indicates the concentration of chemicals in the discharge would achieve 90% species protection levels at the Low LEP / Moderate LEP boundary.	**EQS 7** At the Moderate LEP / High LEP boundary, no detectable change in natural variation (including abundance, diversity and composition) of epibenthos cover attributable to the Browse Project activities. **EQS 11** At the Low LEP / Moderate LEP boundary, no change to epibenthos species diversity and composition attributable to the Browse Project.

3.5.8.2 Assessment against Environmental Quality Guideline 7

To assess against the EQC, representative modelling of the proposed discharge will be undertaken to confirm that the discharge will achieve 90% species protection levels at the Low LEP / Moderate LEP boundary. This will be done prior to the discharge occurring and the chemical dosing regime will be performed to ensure the EQG is achieved.

3.5.8.3 Assessment against Environmental Quality Standard 7 and 11

To assess against the EQS, density/abundance, diversity and composition will be assessed along 50 m transects based on both still and video images. Then the composition and diversity of epibenthic communities at control sites will be compared to LEP boundary sites, to assess potential for change.

3.5.8.3.1 Timing

Monitoring to the requirement of EQS 7 and 11 will be undertaken within 30 days of any EQG exceedance.

3.5.8.3.2 Sampling protocol

Ecological surveys of epibenthos cover are proposed to be conducted using high definition cameras (video and/or stills) with adequate lighting mounted to either a ROV, AUV, or suitable alternative/s methods. The camera system will have ultra-short baseline (USBL) positioning system to rectify the actual position on the seabed. In the post discharge (if triggered) survey, the selected method will be used to verify the prevailing direction of the current and complete the survey transects. Video surveys will be conducted along the prevailing current axis. At each location, five transects of 30 - 50 m lengths will be videoed. Data will be compared to that of relevant control sites.

3.5.9 FPSO cooling water discharges (originating in Commonwealth waters)

3.5.9.1 Environmental Quality Criteria

The EQG for water quality in relation to the FPSO cooling water discharge is shown in **Table 3-21.**

Table 3-21 Environmental Quality Criteria for water quality (Cooling water)

Environmental Quality Guideline (EQG)	Environmental Quality Standard (EQS)
EQG 8 For FPSO cooling water discharges, residual chlorine will be monitored at the end of pipe so that the defined threshold value (i.e. 99% species protection) will be met at the edge of the mixing zone and the State waters boundary, 95% of the time based on dispersion modelling results. **EQG 9** For cooling water, within the High LEP, water quality in the relation to the contaminants of concern meets ANZECC 99% species protection guideline values. **EQG 10** For cooling water, within the Maximum LEP, there will be no detectable change from background concentrations in water quality in the relation to the parameters of concern (i.e. temperature and residual chlorine).	**EQS 8** Whole effluent toxicity (WET) testing of water quality samples taken in the High LEP show that no toxicity is detected (no significant difference from controls).

3.5.9.2 Assessment against Environmental Quality Guidelines 8, 9 and 10

Samples will be analysed for the parameters of concern (i.e. potential contaminants discharged as part of the cooling water and change in temperature). In field sample results will be compared to the ANZG (2018) 99% species protection levels (High LEP) and background levels (maximum LEP). Result from the end of pipe sampling will be compared against the ANZG (2018) 99% species protection guideline values at the edge of the mixing zone taking modelled dilutions into account

3.5.9.2.1 Timing

Within one year of steady state FPSO operations, cooling water modelling and infield verification will be completed to verify the modelling predictions underpinning EQG 8. This study aims to verify the modelling predictions and in particular the dilutions achieved, which determines the point at which the defined thresholds levels are reached.

In field water sampling will be carried out to establish a baseline and annually for the first three years of steady safe FPSO operations to verify compliance with EQC 9 and EQC 10.

After this time, periodic (every five years) and for cause (e.g. due to EQG 8 exceedance) water quality monitoring at a gradient away from the FPSO facility in the receiving environment will be undertaken to measure compliance with EQC 9 and EQC 10.

Monitoring will entail water quality monitoring along a gradient from the Torosa FPSO and will include water quality monitoring at the boundary of the State Proposal Area (which is also the boundary of the High LEP associated with the FPSO cooling water discharge) and the boundary of the High LEP (where High turns to Max LEP).

3.5.9.2.2 Sampling protocol

The statistical design on the monitoring program will follow a Before After Control Impact (BACI) approach. A priori statistical power analysis will be conducted to determine the required number of samples to detect a difference or change with a specified level of statistical confidence and power.

Confidence and power relate to probabilities of committing Type I (false positive) and Type II errors (false negative) when performing hypothesis tests. These parameters will be set to 0.05 (95% confidence, or 5% chance of obtaining a false positive result) and 0.8 (20% chance of obtaining a false negative). Sufficient samples will be taken to ensure a sufficient 'effect size' can be determined.

The sampling design will be based on the following:

- A gradient design (as described in Holdway and Heggie, 2000).
- Sampling for parameters associated with cooling water discharge (e.g. residual chlorine and elevated temperature).
- Increased sampling effort will occur in the direction of the prevailing current (distances to include 250 m, 500 m, 750 m, 1 km and 2 km). Sampling will also occur at the boundary of the State Proposal Area, within the High LEP and at the boundary of the High LEP in the direction of the prevailing current.

Water quality samples will be collected, stored and handled using appropriate techniques consistent with guidance provided in AS 5667.1:1998 Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples (Standards Australia, 1998) and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018).

All analyses will be undertaken by NATA-accredited laboratories.

3.5.9.3 Assessment Against Environmental Quality Standard 8

Should the EQG for the High or Maximum LEP be exceeded, EQS 8 will be monitored, namely whole effluent toxicity (WET) testing of water quality samples taken in the High LEP will be compared to local controls.

3.5.9.3.1 Timing

Assessment of EQS will occur within one month of the EQG exceedance being detected.

3.5.9.3.2 Sampling Protocol

To determine whole effluent toxicity, a minimum of eight mainly chronic toxicity tests are to be carried out with each water sample. The toxicity tests typically include a range of tropical and temperate Australian marine species, selected based on their ecological relevance, known sensitivity to contaminants, availability of robust test protocols and known reproducibility and sensitivity as test species for assessing impacts from discharges in marine environments. Current test suite for Woodside operated offshore assets include:

- Bacterial 5- and 15-min luminescence (*Vibrio fischeri*) (Microtox® acute, temperate)
- Microalgal 72-h growth rate inhibition using the tropical isolate of *Nitzschia closterium* (chronic, tropical)
- Copepod 48-h survival test using *Acartia sinjiensis* test (acute, tropical)
- Copepod 7-d early life stage development test with *Gladioferens imparipes* (chronic, temperate)
- Sea urchin 72-h larval development with *Echinometra mathaei* (chronic, tropical/subtropical)
- Sea urchin 1-h fertilisation test with *Heliocidaris tuberculata* (chronic, temperate)
- Oyster 48-h larval development test with *Saccostrea echinata* (chronic, tropical)
- Fish 96-h larval imbalance using *Lates calcarifer* (acute, tropical).

Other tests can be exchanged over time if tests are not available, or become obsolete, however, preference would be for tests that mimic the receiving environment as closely as possible (i.e. for most facilities this would be tropical, marine water tests) and for at least eight mainly chronic tests (Warne et al. 2015).

Upon completion of WET testing, the results of these tests are combined into safe dilution estimates for the protection of either 95% or 99% of species as relevant. These safe dilution estimates can be used as the PNEC in assessing environmental risk associated with each discharge. A statistical program (e.g. the Burrlioz (version 2.0, CSIRO), SSD Tools Shiny App or similar) is used to plot species sensitivity distributions and to derive species protection (e.g. PC99 or PC 95) concentrations (and safe dilutions). Acute toxicity results are converted to an equivalent chronic value by dividing the acute EC50 by 10 (the adjustment factor that was a substitute for the acute-to-chronic ratio). These data are then combined with chronic IC10 or EC10 values and plotted in a cumulative frequency plot. The Burr Type III curve is used to fit the species sensitivity distribution (SSD). PC values are converted to the equivalent safe dilutions by dividing 100 by the PCx value.

3.5.10 Produced Water (originating in Commonwealth waters)

There is no discharge of Produced Water within State Waters and in all modelled circumstances PW is predicted to be diluted sufficiently to achieve 99% species protection values at the entry to State Waters. For the majority of seasonal conditions, PW travels parallel to the State Waters boundary.

The following EQC are established only for State Waters but rely on monitoring within Commonwealth Waters to validate that environment objectives are being achieved.

3.5.10.1 Environmental Quality Criteria

The EQG for water quality in relation to the Produced Water discharge is shown in **Table 3-22Table 3-21.**

Table 3-22 Environmental Quality Criteria for water quality (Produced Water)

Environmental Quality Guideline (EQG)	Environmental Quality Standard (EQS)
EQG 11 Chemical characterisation analysis of the produced water at end of pipe undertaken annually. Results demonstrate the ANZG (2018) 99% species protection guideline values will be achieved for each contaminant at the State Waters boundary, based on modelled dilution rates. **EQG 12** At the entry to the State Waters boundary, water quality samples indicate no detectable change in water quality from background concentrations in the relation to the contaminants of concern from PW discharges. **EQG 13** WET Testing of the produced water at end of pipe undertaken annually. Results demonstrate the 99% species protection guideline values will be achieved at the State Waters boundary, based on modelled dilution rates.	**EQS 9** Whole effluent toxicity (WET) testing of water quality samples taken at the entry to State Waters (in the direction of the PW plume occurrence during the sampling period), shows that no toxicity above background is detected.

3.5.10.2 Assessment against Environmental Quality Guideline 11, 12 and 13

Assessment of EQG 11 and 13 involve collecting representative samples of PW at the discharge point and analysing either for chemical contaminants or conducting WET testing on the discharge. Assessment of EQG 12 involves collecting water samples at the specified location and analysing this water for the presence of contaminants of concern.

3.5.10.2.1 Timing

- Chemical characterisation analysis of the produced water at end of pipe undertaken annually.

- In situ water sampling (to verify EQG 12) will be undertaken to establish baseline and annually for the first three years of steady state FPSO operations and every five years thereafter.
- Toxicity testing of the physical and chemical composition of the undiluted FPSO PW stream will be undertaken annually.
- Water quality monitoring will occur in accordance with the sampling protocol below. This monitoring aims to determine no changes in the receiving environment water quality outside of the defined mixing zone, as a result of the FPSO PW discharges.

3.5.10.2.2 Sampling protocol

The statistical design on the monitoring program will follow a Before After Control Impact (BACI) approach. A priori statistical power analysis will be conducted to determine the required number of samples to detect a difference or change with a specified level of statistical confidence and power. Confidence and power relate to probabilities of committing Type I (false positive) and Type II errors (false negative) when performing hypothesis tests. These parameters will be set to 0.05 (95% confidence, or 5% chance of obtaining a false positive result) and 0.8 (20% chance of obtaining a false negative). Sufficient samples will be taken to ensure a sufficient 'effect size' can be determined.

The in-situ water quality sampling design will be based on the following:

- A gradient design (as described in Holdway and Heggie, 2000).
- Include in-field sampling for containment of concern, informed through chemical characterisation of the PW stream. WET testing will be performed on collected sea water in relation to EQG 13 using the sampling protocol outlined in 3.5.9.3.2.
- Include sampling in the prevailing current from the point of discharge.
- Increased sampling effort will occur in the direction of the prevailing current (distances to likely include 250 m, 500 m, 750 m, 1 km and 2 km). Sampling will also occur at the boundary of the State Proposal Area in the direction of the prevailing current.
- Include appropriate statistical design, which shall be considered in context of field survey duration and sample holding times
- It should be noted, in no circumstances is PW predicted to be present at the State Waters boundary, so it may be necessary to select a location for the collection of in-situ water samples based on prevailing currents and distance to the FPSO.

Water quality samples will be collected, stored and handled using appropriate techniques consistent with guidance provided in AS 5667.1:1998 Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples (Standards Australia, 1998) and the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018).

All analyses will be undertaken by NATA-accredited laboratories

3.5.10.3 Assessment against Environmental Quality Standard 9

In the event that EQG 11 or EQG 12 is exceeded an investigation against EQS 10 will be conducted at the same location as the exceedance.

3.5.10.3.1 Timing

Water samples required for EQS 10 will be conducted within one month of the exceedance of EQG 11 or EQG 12 being identified.

3.5.10.3.2 Sampling protocol

WET testing protocols will adhere to those outlined in Section 3.5.9.3.2.

4. ADAPTIVE MANAGEMENT AND REVIEW OF THE EQMP

Recognising that the nature of the drilling discharges; cooling water and hydrotest discharges; the receiving environment; and the science underpinning environmental impact assessment; is not static, adaptive management also allows monitoring programs to feed back into the management processes so that environmental management continues to be fit-for-purpose. The EQMF that underpins this EQMP is inherently an adaptive management framework.

In line with the concept of adaptive management, the management actions presented in this EQMP shall be monitored, reviewed, evaluated and updated as required, with consideration of:

- persistent exceedances, systematic changes to the discharge/environmental conditions and/or changes to the science underpinning the monitoring and management of marine discharges
- material updates to the scientific literature supporting the GVs or management framework underpinning this EQMP
- a comparison of monitoring data that shows unexpected results which vary significantly from previous and baseline results or predictions.

Relevant updates identified through this process will be included in a revised EQMP.

In addition, this EQMP may be reviewed against:

- relevant changes in State or Commonwealth legislation or policy.
- new or revised operating licence(s) issued under Part V of the Environmental Protection Act 1986 (WA) (where relevant)
- revisions to EPs under the Commonwealth and State EP petroleum activities regulations
- if a new process or activity is proposed to be introduced that has the potential to alter the discharges from the Proposal (and that is not in accordance with this EQMP).

Technical review and evaluation of the management actions outlined in this EQMP will be conducted every five years (if not initiated prior to that time) to ensure the management actions are adequately addressing the key risks and meeting EPA objectives. If, as a result of any review, any significant changes are required to be made to this EQMP, a revised EQMP will be provided to the regulator for approval.

When the five-yearly review cycle is triggered, or if a significant change to either the facility, activity, or risk is identified, a revised EQMP will be submitted to the regulator. When approved, the revised plan will be made publicly available.

5. STAKEHOLDER CONSULTATION

Given the detailed information provided in the draft EIS/ERD, including the presentation of draft LEPs, it is considered that consultation on the contents of this EQMP has been undertaken via the draft EIS/ERD public comment period and regulator engagements. It should be noted that this EQMP is a draft and is expected to be matured and finalised beyond the State Proposal assessment process. Further stakeholder engagement may be undertaken during this process.

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7. TERMS

Acronym	Meaning
BOP	blow out preventer
BJV	Browse Joint Venture
BTL	Browse Trunkline
draft EIS/ERD	draft Environmental Impact Statement / Environmental Referral Document
EP	Environmental Plan
EP Act	*Environmental Protection Act 1986* (WA)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth*
EPA	Environmental Protection Authority
EQCs	Environmental Quality Criteria
EQGs	Environmental Quality Guidelines
EQMF	Environmental Quality Management Framework
EQMP	Environmental Quality Management Plan
EQOs	Environmental Quality Objectives
EQP	Environmental Quality Plan
EQSs	Environmental Quality Standards
EVs	Environmental Values
FLETS	flowline end terminals
FPSO	Floating Production Storage and Offloading
GV	Guideline value
LEP	Levels of Ecological Protection
MEG	monoethylene glycol
MLWS	mean low water springs
MMscfd	1100 million standard cubic feet per day
MODU	Mobile offshore drilling unit
NOEC	no observable effect concentration
NWBFs	Non-water based fluids
NWQMS	National Water Quality Management Strategy
NRC	North Rankin Complex
NWSJV	North West Shelf Joint Venture
OCNS	Offshore Chemical Notification Scheme

Acronym	Meaning
OPGGS (E) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009
PLONAR	pose little or no risk to the environment’
SURF	subsea umbilicals, risers and flowlines
TOC	Total organic carbon
TPH	Total Petroleum Hydrocarbons
WBFs	Water based fluids

APPENDIX A: MANAGEMENT APPROACH – TOROSA WELLS IN STATE PROPOSAL AREA

Appendix A - Management Approach for Torosa wells in State Proposal Area

Proposed Browse Project

July 2022
Rev 3

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1. INTRODUCTION

1.1 Purpose and objective

The draft EIS/ERD provides a description of the proposed Browse Project drilling and completions program (in **Section 3.7.2**), and a detailed description of the assessment of the potential impacts and risks associated with the drilling discharges, including the high level management approach for Torosa wells in the State Proposal Area (in Section 6.3.15 of the draft EIS/ERD and Section 8.2.4.8 of the State ERD).

The purpose of this addendum is to review and provide further details on the proposed management approach for drilling discharges from Torosa wells in the State Proposal Area (see **Table 1-1**) in order to demonstrate that the maximum[1] level of ecological protection (LEP) can be achieved at Scott Reef shallow water benthic communities and habitats (<75 m bathymetry), as defined in Section 3.4.1 and Figure 3.2 of the Browse Project Environmental Quality Management Plan (EQMP).

The specific objective of the management approach is to manage drilling discharges (in particular, bottom-hole section discharges) at drill centres in the State Proposal Area (i.e. TRA, TRD and TRF)[2] using industry proven techniques to meet the maximum LEP at Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).

Table 1-1: Coordinates and water depths of drill centres in the State Proposal Area[2]

Field	Drill centre	Coordinates	Approx. water depth (m)	Distance to Scott Reef 75 m bathymetric contour	Jurisdiction
Torosa	TRA	389 521 E, 8 455 338 N	423 m	2.7 km	State
Torosa	TRD	387 315 E, 8 451 207 N	389 m	2.3 km	State
Torosa	TRF	388 865 E, 8 458 144 N	446 m	2.7 km	State

1.2 Background

1.2.1 Drilling and completions overview

The proposed Browse Project requires the drilling of up to 54 production wells (with up to 24 wells within the State Proposal Area). It is anticipated the drilling and completion activities will be completed in multiple phases. The first phase is planned to include drilling and completion of three wells at the TRA drill centre within the State Proposal Area to achieve Phase 1 RFSU, with subsequent phases of drilling and completion of additional wells undertaken over the life of the Proposal to optimise reservoir recovery.

It is anticipated that a MODU will be used to drill and complete the wells. The MODU may be either conventionally moored or dynamically positioned (DP). The MODU utilised during development drilling and completion will be fitted with typical solids control equipment (SCE) which may include, but will not be limited to, shale shakers, cuttings dryers and centrifuges to maximise separation of the drilling fluid from the cuttings and drill solids.

The drilling process will typically start with the drilling of the largest size hole and a smaller diameter conductor will be cemented inside this hole. Next, a smaller diameter hole section will be drilled, and a surface and intermediate casing will be run in and cemented (with some discharge to the seabed).

[1] Activities to be managed so that there were no changes beyond natural variation in ecosystem processes, biodiversity, abundance, and biomass of marine life or in the quality of water, sediment, and biota.

[2] TRE drill centre described in draft EIS/ERD no longer proposed

Casings provide structural support for the hole walls, isolate geological formations and allow pressure management that may be experienced during drilling. Additional casing/liner sizes may be required to manage drilling risk. Drilling will then be paused far above the hydrocarbon reservoir.

A blow-out preventer (BOP) and riser system will then be installed. With the BOP in place, a hole will then be drilled into the top of the reservoir and a liner cemented over this hole section. The final hole section will then be drilled through the reservoir as required based on reservoir targets. A schematic of this process is provided in **Figure 1-1**.

During this process, drilling fluids will be used to lubricate the drill string, resist any pressure from the well stream and return cuttings to the surface. They will be formulated according to the well design, the expected reservoir geological conditions and the surrounding formations.

Drilling fluids are comprised of a base fluid, weighting agents and chemical additives used to give the fluid the exact properties required to minimise environmental impact and make the drilling as efficient and safe as possible. In general, the top-hole sections of the well will be drilled using water based fluids (WBFs) such as seawater with bentonite and then bentonite and guar gum sweeps. The bottom-hole sections will be drilled with either WBF or non-water based fluids (NWBF). The selection of fluid types will not be finalised until the detailed design phase when well design is confirmed.

Once the well has been drilled it will be completed, which is the process for making the well ready for production. Completions activities may be conducted using a light well intervention vessel (LWIV), MODU or a combination of the two. This process will involve the installation of the lower completions (including well casings, liners), the installation of the christmas tree and the installation of the upper completions (including the production tubing). During this installation process the well will remain isolated, with two independent and verifiable barriers. Typically, the BOP is removed in this sequence and replaced with an alternative barrier. The subsea christmas tree may be installed by a construction vessel on wire.

The well will then be flowed to the MODU or a suitable vessel. This first production is known as unloading and typically lasts approximately 1-2 days per well. Once stable flow is achieved, the produced fluids will be sent to tanks for separation. The produced gas and condensate will be flared, while produced water, making up a small proportion of the drill cuttings and fluids discharge stream, will be treated prior to discharge overboard.

Once unloading activities are completed, the wells will then be isolated until they are connected up to the FPSO facilities. The option to unload wells directly to the FPSOs (once connected) may also be considered in future. It should be noted that the precise sequence of the drilling, completions and unloading activity is dependent on the type of christmas tree installed.

There are a number of drilling and completions unplanned contingencies that may be required if operational or technical issues occur. These contingencies do not represent significant additional risks or impacts but may generate additional volumes of discharges such as drilling cuttings and fluids. These contingencies may include well workover, side-tracks, well suspension and well intervention.

A full description of the drilling and completions activity, including all associated potential discharges (i.e. primary and minor discharges) are provided in **Section 3.7.2** and in Section 6.3.15 of the draft EIS/ERD and Section 8.2.4.8 of the State ERD. This addendum focuses on the primary discharges defined as drill cuttings and fluids generated during drilling only.

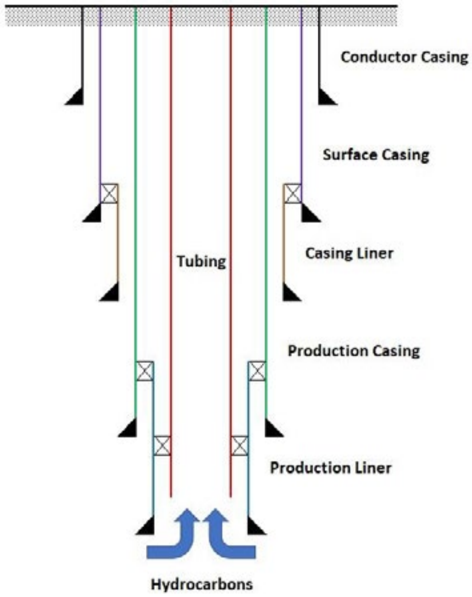

Figure 1-1: A schematic representation of a well (Domec and Thibodeaux, 2019)

1.2.2 Drill cuttings and fluids overview

Drilling of production wells will generate drill cuttings, require cementing of the casing, and require the use of a range of fluids, that may be discharged to the marine environment, typically at the seabed and at or near the sea surface depending on the hole section. The primary discharges used as the basis of the impact and risk assessment for the proposed Browse Project are as follows:

- Drill cuttings: drilling generates drill cuttings due to the breakup of solid material from within the borehole. The resultant drill cuttings are basically rock particles of various shapes, with sizes typically ranging from very fine to very coarse.
- Drilling fluids: serve many purposes including maintaining borehole stability and hydrostatic pressure, reducing friction and cleaning/ cooling of the drill bit, in addition to acting as a medium to carry cuttings from the well bore and return them to the surface at seabed or on the MODU. There are two main types of drilling fluids as follows:
  - Water based fluids (WBF) consists mainly of fresh water or seawater with the addition of chemical and mineral additives to aid in its function. Drilling additives typically used may include chlorides (e.g. sodium, potassium), bentonite (clay), cellulose polymers, guar gum, barite or calcium carbonate. These additives are either completely inert in the marine environment, naturally occurring benign materials, or readily biodegradable organic polymers with a very fast rate of biodegradation in the marine environment. Bentonite and guar gum are listed as 'E' category fluids under the OCNS and is included on the Oslo Paris (OSPAR) Commission PLONOR (chemicals that 'pose little or no risk to the environment') list (OSPAR Commission, 2019).
  - Non-water based fluids (NWBF) refers to drill fluids that are hydrocarbon rather than water based fluid. NWBF may contain a range of synthetic hydrocarbons, such as paraffins and olefins; however, such additives are designed to be low in toxicity and biodegradable, as well as not being readily bioavailable or likely to bioaccumulate, particularly in deeper water areas. It is noted that microbial biodegradation can result in oxygen reduction within sediments, however Nedwed et al (2006) found that depth is an important factor for residual concentrations of NWBF once they reach the seabed, suggesting that loss of base fluid during settling acted to significantly reduce chemical effects from discharges. It is also noted

that NWBF cuttings tend to clump and settle to the seabed rapidly adding to the cuttings pile in proximity to the well site.

Drill cuttings and unrecoverable WBFs are discharged at the seabed at each well site for the top-hole sections, which are drilled riser-less (i.e. no closed loop with the MODU). This results in a localised area of sediment deposition (known as a cuttings pile) around and in proximity to the well site influenced by prevailing seabed currents.

Once the top-hole sections are complete, installation of the riser and BOP provides a conduit back to the MODU, forming a closed circulating system. The bottom hole sections will be drilled with a marine riser in place that enables cuttings and drilling fluids to be circulated back to the MODU, where the cuttings are separated from the drilling fluids by the solids control equipment (SCE) and typically re-used in the closed loop system between the well bore and the MODU. The cuttings (with adhered residual fluids) are, in typical circumstances, discharged below the water line, with their fate and dispersion determined by cuttings particle size and the density of the unrecoverable fluids. In contrast the fluids are recirculated into the fluid system where there are a number of mud pits (tanks) on the MODU that provide a capacity to mix, maintain and store fluids required for drilling activities. The mud pits form part of the drilling fluid circulating system and may be discharged during the drilling of the well where particular criteria is met.

A schematic of a typical drilling process and associated discharges for reference is illustrated in **Figure 1-2**. Note this schematic represents an exploration activity rather than a production well sequence which is very similar, with the exception of the “after drilling” illustration which would include the christmas tree and flowlines.

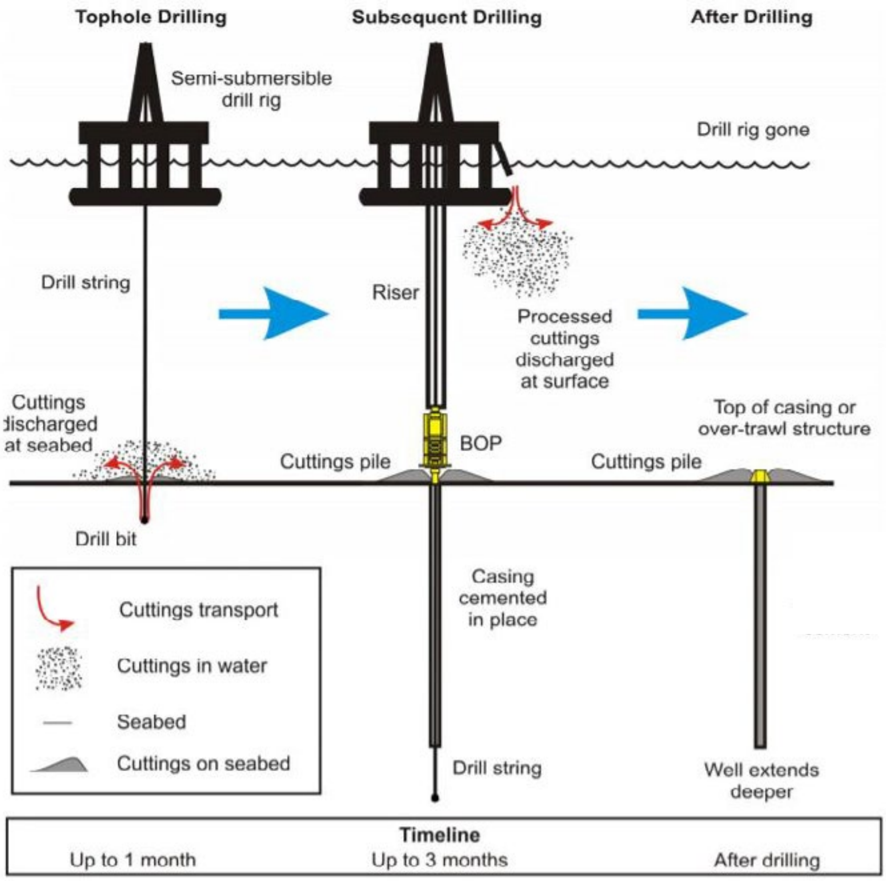

Figure 1-2 Primary drilling discharges during exploration drilling activity in deepwater (Cordes et al., 2016) representing a typical approach to drilling discharges

A summary of the drill cuttings and fluid volumes for a typical Browse well are presented in **Appendix A**, with further Project details provided in Section 3.7.2 of the draft EIS/ERD.

1.2.3 Drilling discharges process description

There are four primary types of drill cuttings and fluids discharges associated with drilling a production well. **Table 1-2** presents an overview of the types and their typical discharge/disposal management with the process (when drilling with a riser) also illustrated in **Figure 1-3** and **Figure 1-4** for WBF and NWBF respectively, for further context.

Table 1-2 Drill cuttings and fluids process description for typical Browse well

Aspects	Process description
Top hole cuttings (with unrecoverable WBF) *When drilling riserless*	• Drill cuttings and unrecoverable WBF are discharged at the seabed at each well site for the top-hole sections drilled riser-less (no closed loop with the MODU).
Bottom hole cuttings (with residual WBF/NWBF) *When drilling with riser and BOP in place (during routine operations)*	• Sections that are drilled with a marine riser in place that enables cuttings and drilling fluids to be circulated back to the MODU, where the cuttings are separated from the drilling fluids by the solids control equipment (SCE). • The SCE comprises equipment such as shale shakers, cuttings dryer(s) and centrifuges. **Drilling with WBF (Figure 1-3):** • The SCE uses shale shakers to remove coarse cuttings from the drilling fluid. Shakers are the primary solids control equipment comprising screens of selected mesh size that separate WBF and cuttings returning from the well into cuttings (discharged to the ocean with a residual film of WBF) and recovered WBF (which returns to the mud pits on the MODU). • From the shakers, cuttings with residual WBF are typically discharged via a chute below the waterline, while the fluids are recirculated into the fluid system (i.e. mud pits - see below) (**Figure 1-3**, discharge 1). • WBF in the mud pits may be circulated through de-weighting centrifuges[3], which are used to remove fine solids (i.e. 4.5 to 6 µm). Solids is a separate source of drilling discharge generated from the centrifuge process which removes fine cuttings (fine rock particles) or fine weighting agents from the drill fluids (fine weighting agents are added or removed to control a fluid's specific gravity) (**Figure 1-3**, discharge 3). • The volume of drilling fluid retained on cuttings is determined by the SCE (up to SCE technical limit; output varies based on input). Typically, treated WBF cuttings may retain 5 to 25% of the drilling fluid after passage through SCE (Neff, 2005). **Drilling with NWBF (Figure 1-4):** • The SCE uses shale shakers to remove coarse cuttings from the drilling fluid. When using NWBF, there is no direct discharge from the shakers (except for a short time in some emergency situations). • From the shakers, the cuttings with retained NWBF are diverted through a cuttings dryer[4]/s and associated SCE, to reduce the average oil on cuttings (OOC) to 6.9% wt/wt or less on wet cuttings, prior to discharge (**Figure 1-4**, discharge 1).

[3] De-weighting centrifuges are connected to the mud pit system on a MODU and used (when required) to remove fine solids from the WBF/NWBF to reduce the specific gravity of the fluid.

[4] Cuttings dryers are used to further reduce the volume of residual NWBF adhered to cuttings prior to discharge.

Aspects	Process description
	• Outputs from a dryer are separated into cleaned cuttings (which are typically discharged below the waterline with a residual film of NWBF) and recovered NWBF (which returns to the mud pits on the MODU via a dryer centrifuge). • The recovered NWBF fluids from the cuttings separated in the dryer may also be directed to dryer centrifuges[5] (**Figure 1-4**, discharge 2) and/or de-weighting centrifuges (Figure 1-4, discharge 3), which are used to remove fine solids (i.e. 4.5 to 6 µm). Solids is a separate source of drilling discharge generated from the centrifuge process which removes fine cuttings (fine rock particles) or fine weighting agents from the drill fluids (fine weighting agents are added or removed to control a fluid's specific gravity). • After passing through SCE the cuttings with residual NWBF from the dryers and/or centrifuges that meet the OOC requirements are usually discharged below the water line and the fluid is recirculated into the fluid system. • The volume of drilling fluid retained on cuttings is determined by the SCE (up to SCE technical limit; output varies based on input). Typically, treated cuttings when drilling with NWBF may retain 5 to 15% of the drilling fluid (Neff et al., 2000).
WBF discharges (pit dumps/bulk discharges) *Occurs at end of each well section or when switching between fluid types (riserless or with riser)*	• There are typically a number of mud pits (tanks) on the MODU that provide a capacity to mix, maintain and store fluids required for drilling activities. The mud pits form part of the drilling fluid circulating system. • If WBF cannot be re-used due to bacterial deterioration or does not meet required drilling fluid properties, it may be discharged to the marine environment using seawater flushing (**Figure 1-3**, discharge 2). WBF may not be able to be reused between drilling sections due to the drilling sequence, technical requirements of the fluid (i.e. no tolerance for deterioration of fluid during storage) and maintenance of productivity/ injectivity. • Unused or spent WBFs may be disposed of from the MODU as a bulk discharge (defined as a discrete discharge of large quantities) at the end of each well section (**Figure 1-3**, discharge 2). • Additional products such as barite and bentonite may be discharged in bulk/single discharge at the end of the activity if they cannot be reused or taken back to shore. Discharge may be in the form of dry bulk or as a slurry; however, discharges will not be contaminated with hydrocarbons.
NWBF discharges (pit dumps/bulk discharges) *No discharge of unused NWBF at sea during drilling and completion operations*	• The NWBF that cannot be re-used (i.e. do not meet required drilling fluid properties or are mixed in excess of required volumes) are recovered from the mud pits and returned to the shore base for onshore processing for recycling and/or disposal. • The mud pits and associated equipment/ infrastructure are cleaned when NWBF is no longer required, with wash water discharged with mud pit washings, or returned to shore for disposal if discharge criteria cannot be achieved. • The mud pits, any supply vessel storage tanks carrying WBF or NWBF, and associated equipment/ infrastructure are cleaned out during and at the end of drilling and completions operations. • Mud pit wash residue is operationally discharged from the MODU with less than 1% oil contamination by volume. Where the mud pit residue exceeds 1% by volume, the residue will be retained and disposed onshore.

[5] A dryer centrifuge is connected to the recovered NWBF output of a cuttings dryer to remove undesirable fine solids from the fluid before it returns to the mud pits, and to reduce the volume of residual NWBF adhered to the fines prior to discharge

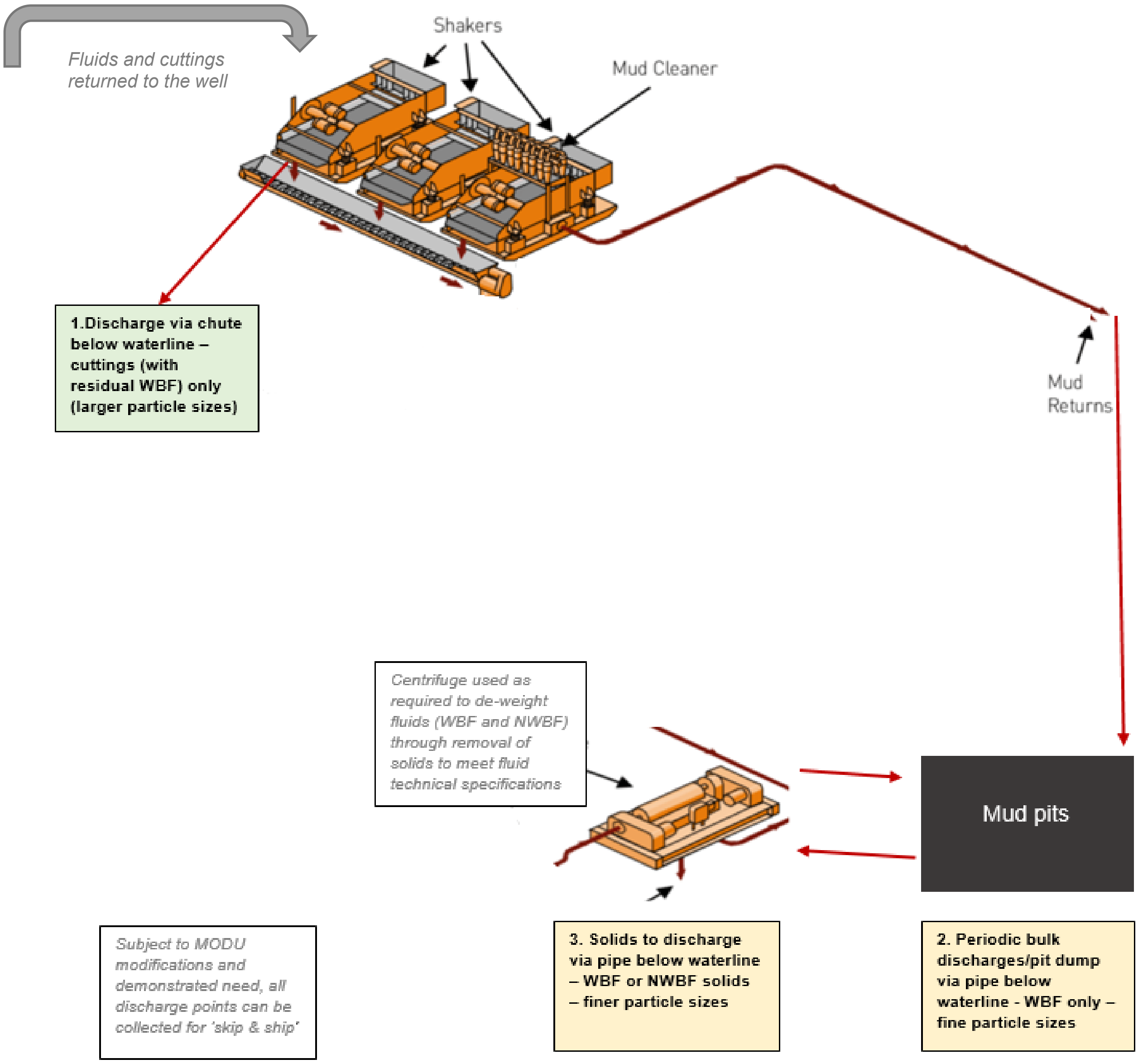

Figure 1-3: Example riser drilling discharges process diagram for WBF (adapted from IOGP (2016). Note green box discharge applies to all proposed Browse Project wells, while yellow box discharges are proposed to be managed for Torosa wells in the State Proposal Area.

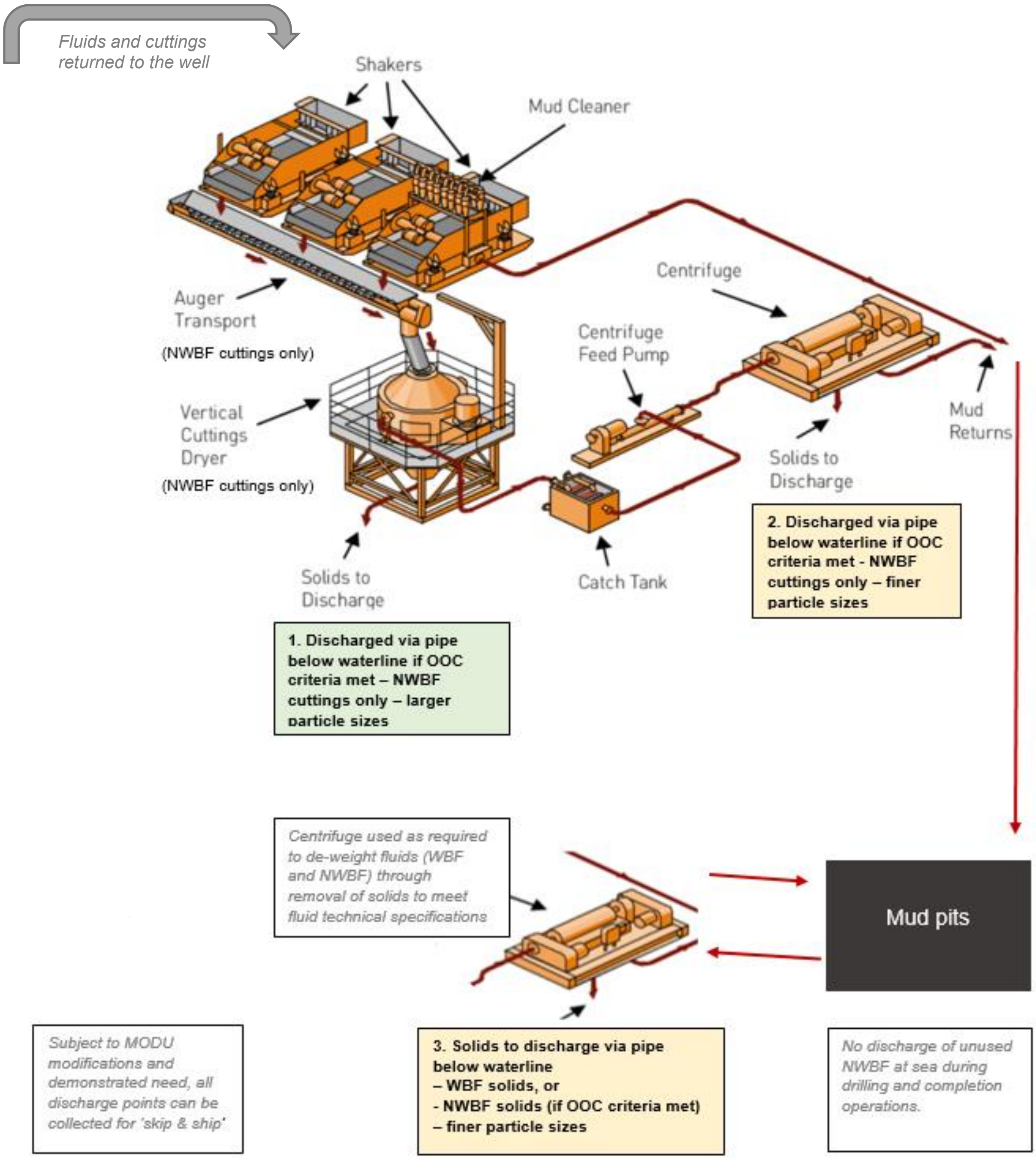

Figure 1-4: Example riser drilling discharges process diagram for NWBF (adapted from IOGP (2016). Note green box discharge applies to all proposed Browse Project wells while yellow box discharges are proposed to be managed for Torosa wells in the State Proposal Area.

1.2.4 Drill cuttings and fluids dispersion characteristics

The dispersion and fate of drilling discharges is dependent on a number of factors including the discharge rate, the discharge depth and associated water depth, the particle size distribution and density of the fluids and cuttings, the amount of fluid retained on the cuttings, and receiving environment hydrodynamics, including current speed and direction at different depths in the water column at the discharge site. The cuttings particle size and the density of the fluids are key parameters as they determine the settling velocity of the particle once it is passively dispersing in the marine environment.

Drill cuttings (and unrecoverable fluids) discharged at seabed (riserless drilling)

General description of base case for a typical Browse production well

For a typical Browse well, the total indicative volume of drill cuttings and associated fluids to be discharged to the seabed is predicted to be ~240 to 625 m^3 of cuttings with ~1,404 to 1,789 m^3 of adhered fluids (incl. ~56 to 106 m^3 of solids), depending on well sections drilled riserless (excluding mud pit discharge) (**Appendix A**).

Drill cuttings and unrecoverable fluids are discharged at the seabed at each well site for the top-hole sections drilled riser-less (i.e. no closed loop with the MODU). This results in a localised area of sediment deposition (known as a cuttings pile) in proximity to the well site. The larger cuttings particles will settle out of suspension and deposit in close proximity to the well site (tens of metres) with potential for localised spreading downstream. In contrast, the finer particles will remain in suspension and be transported away from the well site, rapidly diluting and eventually depositing over a slightly extended area (potentially up to several hundreds of metres) downstream of the well site. The spread of cuttings and associated unrecoverable WBF is expected to be around 50 to 200 m downstream from the discharge location based on a review of seven studies summarised by International Association of Oil and Gas Producers (IOGP, 2016).

Relevance to Torosa wells in the State Proposal Area

As described in Section 6.3.15 of the draft EIS/ERD, the seabed discharge of drill cuttings from top-hole well sections may result in sediment plumes in the lower water column above seabed and associated deposition of sediment to the surrounding seabed. Such plumes are predicted to be confined to the bottom layers of the water column with no contact with deeper water or shallow water coral habitats at Scott Reef (<75 m bathymetry). There is some evidence of localised intrusions of cooler water around the western and eastern entrances to the channel between North and South Scott Reef during spring tides but no evidence of persistent upwelling or downwelling currents around Scott Reef (Green et al., 2019b) and therefore, no transport mechanisms to mobilise drill cuttings from deep waters to the shallower waters of the reef system. As such, given the location of the drill centres in deep water (>350 m; **Table 1-1**), which experience strong surface and subsurface currents, drill cuttings and fluid discharge disposal at seabed would be expected to dilute rapidly. Therefore, any reduction in water quality due to elevated TSS is expected to occur in a localised area around the drill centre and will be temporary in nature.

Drill cuttings (and residual WBF/NWBF) discharged near surface (riser return to MODU)

General description of base case for a typical Browse production well

The bottom hole sections will be drilled with a marine riser in place that enables cuttings and drilling fluids to be circulated back to the MODU, where the cuttings are separated from the drilling fluids by the solids control equipment (SCE). The cuttings (with adhered residual fluids) under typical circumstances are usually discharged below the water line, with their fate and dispersion determined by cuttings particle size and the density of the residual fluids. For a typical Browse well, total indicative volumes of drill cuttings is predicted to be ~225 to 610 m^3 with adhered fluids of ~225 to

610 m^3 (incl. ~55 to 105 m^3 of solids in the fluids with the remainder being primarily brine for WBF). The values exclude mud pit discharges and includes an indicative range that is dependent on well sections drilled with a riser vs. riserless (**Appendix A**).

Drill cuttings with small amounts of residual WBF/NWBF dilute and disperse at different rates depending on particle size and density, with finer fractions more dependent on particle diameter (i.e. surface area) than density. For cuttings returned to the MODU, the particle size distribution of cuttings from the shale shakers[6] (WBF) or cuttings dryers[7] (NWBF), prior to discharge, typically consists of large particle sizes that are considered non-cohesive[8], with a minor proportion of finer particles and a density substantially denser than seawater (Jones et al., in prep). For example, particle size distribution for drilling cuttings from a northwest shelf development well showed 99.1% of cuttings were larger than 62 µm and 96.5% larger than 1 mm in **Table 1-3** (Jones et al., in prep). For the coarser particles the Stokes settling velocity for 1 mm sized sand is approximately 10 cm per second (Jones et al., in prep) and would settle to the seabed under very low flow conditions in approximately an hour based on 400 m water depth and sink below the 75 m water depth within less than 15 min.

Bottom-hole drill cuttings are typically discharged to the marine environment at a low velocity (i.e. nil to minimal dynamic plume) due to the near continuous discharge of a low volume of cuttings during the drilling of each well section. For a typical Browse well section (e.g. 16" well section) this is in the order of 0.8 m^3/hr of cuttings (with 0.1 m^3/hr of residual solids in fluids) (**Appendix A**). This discharge forms a plume in the water column, which often separates into an upper and a lower plume that dilutes rapidly as it drifts away from the discharge point driven by the prevailing currents.

The upper plume typically contains dissolved and fine particulate cuttings fractions. The dissolved components of the plume, including the salts and water soluble drilling fluid organic additives, dilute rapidly in the receiving environment. While the fine particulate fractions such as barite (grain size 6 to 75 µm; density 4.2 g/cm³) and clay (grain size < 2 µm; density 2.4 g/cm³), which typically form a minor component of the overall discharge, settle slowly and disperse over a wide area (IOGP, 2016). In contrast, the lower plume typically contains larger, denser cuttings particles including flocculated clay/barite particles and particle aggregates, which would settle rapidly and accumulate on the seabed nearer to the discharge point (IOGP, 2016). Note, most of the organic additives in WBF and the NWBF adsorb tightly to inorganic particles in the cuttings and disperse and settle with them through the water column.

After separation on the MODU, drill cuttings and residual fluids released below the waterline, in deeper waters, are generally deposited over an area extending up to approximately 500 m from the discharge site, with deposition patchy in nature and sharply decreasing with distance from the discharge point (Balcom et al., 2012). These discharges overlap and slightly extend the top hole cuttings pile, with the deeper the discharge point the smaller the associated deposition footprint.

Relevance to Torosa wells in the State Proposal Area

When assessing bottom hole drill cuttings with residual fluids alone (i.e. excluding mud pit discharges), there is no anticipated interaction of elevated total suspended solids (TSS) with Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) , due to their discharge characteristics (e.g. volumes and rates), their inherently lower adhered WBF/NWBF content, typically large particle size and associated dispersion characteristics, in addition to the location of the Torosa drill centres in the State Proposal Area (in the order of 2 km from the 75 m bathymetric contour).

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[6] Shakers are the primary solids control equipment that separate WBF and cuttings returning from the well into cuttings (discharged to the ocean with a residual film of WBF) and recovered WBF (which returns to the mud pits on the MODU).

[7] When using NWBF, there is no direct discharge from the shakers (except for a short time in some emergency situations). Instead, after cuttings have passed over the shakers, they are diverted to cuttings dryer/s. Cuttings dryers are used to further reduce the volume of residual NWBF adhered to cuttings prior to discharge. Outputs from a dryer are separated into cleaned cuttings (which are typically discharged to the ocean with a residual film of NWBF) and recovered NWBF (which returns to the mud pits on the MODU via a dryer centrifuge).

[8] Non-cohesive sediments are generally considered to have a mean particle size of >64 µm (sands) (Wolanski, 2007) .

Management outcome relevant to Torosa wells in the state Proposal Area

Based on no anticipated interaction with shallow waters of Scott Reef (<75 m bathymetry), drill cuttings (with residual WBF/NWBF) are planned to be discharged near surface for TRD, TRA and TRF wells. It is proposed however that fine solids[9] separated by dryer centrifuges[10] and de-weighting centrifuges[11] (or equivalents) will be managed. Refer to **Section 2** for further details.

Note, management of drill cuttings (and residual fluids) generated when drilling with a riser in place will also be further addressed and subject to appropriate performance outcomes in EPs required under petroleum legislation (refer to **Section 4**).

WBF discharges (pit dumps/bulk discharges) discharged near surface (from MODU)

General description of base case for a typical Browse production well

The dispersion and fate of WBF from mud pit discharges differs to drill cuttings given the considerable shift in particle size distribution to the finer fractions (for example 99.1% <7.8 µm; **Table 1-3**) and the significantly higher rate and volume of fluid discharge. For a typical Browse well, a total indicative volume of ~3,744 m^3 of mud pit fluids (incl. ~619 m^3 of solids) may be discharged at discrete times during the drilling campaign at a rate of ~200 m^3/hr (**Appendix A**). Particle size distribution measurements of drilling fluids in samples from the mud pits just prior to discharge consists of predominantly silts to clays, which are considered cohesive in nature.[12]

The dispersion of the discharge will depend, initially, on the geometry and hydrodynamics of the discharge itself, where the induced momentum and buoyancy effects dominate over background processes. The pit discharges occur at velocity over a short period (tens of minutes, depending on the amount discharged, typically at a rate of ~200 m^3/hr), and therefore the plume will initially be dominated by its own momentum. As the plume descends, the discharges mix with the ambient waters, the momentum and buoyancy signatures are lost, and the ambient processes become dominant. Once downward momentum is lost, the fate of the plume will depend upon discharge buoyancy as the dominating factor, which is expected to remain negatively buoyant (i.e. denser than the receiving environment). Noting that the Stokes sinking velocity for such fine particle fractions is considered to be very slow (Jones et al., in prep), and under low flow conditions the particles may take days to weeks to settle to the seabed under gravitational forces.

Relevance to Torosa wells in the State Proposal Area

Given the PSD, density, discharge characteristics, water depth and prevailing hydrodynamics at discharge location, it is anticipated that near surface discharge of unused/spent WBM fluids from the mud pits may disperse kilometres at low TSS concentrations from the discharge location and there may be a very minor risk that these could potentially reach Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) within the maximum LEP zone. Note any suspended solids that could reach Scott Reef are not anticipated to pose a risk to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry), due to the number of dilutions expected to occur over the intervening distances and hence the resultant TSS concentrations.

Management outcome relevant to Torosa wells in the state Proposal Area

Based on very minor risk of a low concentration of WBM fluids from mud pits reaching the shallow waters of Scott Reef (<75 bathymetry) (abet below biological/ ecological risk levels) – for TRD, TRA and TRF wells, WBF bulk discharges will be managed and occur either at depth (> 200 m), at the

[9] Solids in this context refers to fine rock particles (cuttings) that are removed from the well with fluids via SCE when returned to the MODU, and/or fine solid material intentionally added to or removed from a drill fluid to control its specific gravity

[10] A dryer centrifuge is connected to the recovered NWBF output of a cuttings dryer to remove undesirable fine solids from the fluid before it returns to the mud pits, and to reduce the volume of residual NWBF adhered to the fines prior to discharge.

[11] De-weighting centrifuges are connected to the mud pit system on a MODU and used (when required) to remove fine solids from the WBF/NWBF to reduce the specific gravity of the fluid.

[12] Muds are usually defined as having a mean particles size of <4 µm and are considered to be completely cohesive whereas silts are considered to be weakly cohesive (Wolanski, 2007).

seabed or retained for offshore disposal in Commonwealth waters under a sea dumping permit. Refer to **Section 2** for further details.

Table 1-3: - Drilling cuttings and drilling fluid particle size analysis. Mean particle size distribution (± 95% confidence intervals) and density of cuttings samples collected from the shale shakers at ~300 m intervals down the LPA1 well sampled between 340 to 2,176 m below sea level, and for the drilling fluids in samples from the mud pits just prior to discharge. PSD distribution was simplified to 5 and 9 sediment classes for the cuttings and discharge modelling. Extract from a North West Shelf well (Jones et al., in prep)

			Drill Cuttings			Drilling fluids				
Distribution	phi	µm	Sediment Class	mean	95% CI	Sediment Class	gel-mud	KCl mud	mean	95 CI
fine pebbles	-2	>4000	1	0.6	0.5		0.9	0.0	0.5	0.5
very fine pebbles	-1	>2000		62.4	12.2		0.0	0.0	0.0	0.0
very coarse sand	0	>1000	2	33.4	11.2		0.0	0.0	0.0	0.0
coarse sand	1	>500	3	1.8	0.4	1	0.0	1.2	0.6	0.6
medium sand	2	>250		0.6	0.2	2	0.0	1.4	0.7	0.7
fine sand	3	>125	4	0.2	0.1	3	0.0	8.1	4.1	4.1
very fine sand	4	>62.5		0.1	0.1	4	0.0	15.9	8.0	8.0
coarse silt	5	>31.3		0.1	0.1	5	0.0	18.4	9.2	9.2
medium silt	6	>15.6	5	0.2	0.2	6	0.0	15.5	7.8	7.8
fine silt	7	>7.81		0.2	0.2	7	3.1	13.4	8.3	5.2
very fine silt	8	>3.91		0.3	0.3	8	61.7	9.2	35.5	26.3
clay	9	>1.95		0.0	0.0	9	34.3	16.9	25.6	8.7
		phi		-0.78	0.16		6.39	4.91	5.65	0.74
		x̄ µm		1775	179		12	33	23	11
Wet bulk density (g/cm^3)				1.74	0.05		1.30	1.30	1.30	0.00
Grain density (g/cm^3)				2.30	0.03		-	-	-	-
TSS (g/L)				45	8		245	257	251	6

2. MANAGEMENT APPROACH

2.1 Proposed management approach

The management approach for drill centre locations in the State Proposal Area (i.e. TRA, TRD and TRF) described in Section 6.3.15.3 of the draft EIS/ERD has been further reviewed and developed, in consideration of the discrete drilling discharges, and has resulted in the inclusion of additional proposed management controls to demonstrate that the maximum LEP can be achieved for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry). Demonstration that the new controls demonstrably minimise the risk to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry) designated the maximum LEP, is provided in **Section 1.2**. Given the robustness of the additional controls, infield adaptive monitoring is not considered required.

The additional proposed management controls are provided in **Table 2-1**, with the revised approach illustrated in **Figure 2-1**, which shows an escalation in management relative to the potential risk to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry). This includes management controls to eliminate the risk for particular discrete discharges, including discharge at depth and the collection and transportation of specific discharges to a location outside of State waters (in Commonwealth waters) for disposal (e.g. skip and ship) in accordance with a sea dumping permit, which are further described in **Section 2.2**. Note, in developing the details of the management approach an external SME has been engaged to provide advice.

Table 2-1 Summary of adopted drilling discharges management controls for Torosa wells in the State Proposal Area to demonstrably minimise risk to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry)

Aspects	Draft EIS/ERD adopted controls (relevant to discharges)	Additional proposed controls to achieve maximum LEP for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry)
Top hole cuttings (with unrecoverable WBF) *When drilling riserless*	• Use and discharge of all chemicals will be performed in line with Woodside's chemical selection and assessment process and approved prior to use. • NWBF will not be used for top-hole section drilling (riserless).	• No additional control (all cuttings and associated fluids discharged at seabed) – no predicted impact or potential risk to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).
Bottom hole cuttings (with residual WBF) *When drilling with riser and BOP in place (during routine operations)*	• Use and discharge of all chemicals will be performed in line with Woodside's chemical selection and assessment process and approved prior to use. • Risers will be used to ensure that WBF and associated cuttings are recirculated to the MODU,	• At TRD, TRA and TRF wells, only bottom hole cuttings (with residual film of WBF) from the shakers[13] (or equivalents) will be discharged at surface due to rapid settling velocity of the larger particle size of the cuttings (primary discharge source) and the inherently lower adhered WBF content (after treatment). • At TRD, TRA and TRF wells, fine solids[14] separated from WBF by de-weighting centrifuges[15] (or equivalent) will be discharged

[13] Shakers are the primary solids control equipment that separate WBF and cuttings returning from the well into cuttings (discharged to the ocean with a residual film of WBF) and recovered WBF (which returns to the mud pits on the MODU).
[14] Solids in this context refers to fine rock particles (cuttings) that are removed from the well with fluids via SCE when returned to the MODU, and/or fine solid material intentionally added to or removed from a drill fluid to control its specific gravity.
[15] De-weighting centrifuges are connected to the mud pit system on a MODU and used (when required) to remove fine solids from the WBF to reduce the specific gravity of the fluid.

Aspects	Draft EIS/ERD adopted controls (relevant to discharges)	Additional proposed controls to achieve maximum LEP for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry)
	where cuttings will be treated prior to discharge. • The proposed Browse Project will use WBF as the preferred option.	at depth (>200 m), at the seabed, or retained for offshore disposal in Commonwealth waters in accordance with a sea dumping permit.
Bottom hole cuttings (with residual NWBF) *When drilling with riser and BOP in place (during routine operations)*	• Use and discharge of all chemicals will be performed in line with Woodside's chemical selection and assessment process and approved prior to use. • Risers will be used to ensure that NWBF and associated cuttings are recirculated to the MODU, where cuttings will be treated prior to discharge. • Drill cuttings will be tested to confirm that the average oil on cuttings for the entire well (sections using NWBF) will not exceed 6.9% by wet weight.	• At TRD, TRA and TRF wells, only bottom hole cuttings (with residual film NWBF) from the cuttings dryers[16] (or equivalents) will be discharged at surface due to rapid settling velocity of the larger particle size of the cuttings (primary discharge source) and the inherently lower adhered NWBF content (after treatment). • At TRD, TRA and TRF wells, fine solids[17] separated from NWBF by dryer centrifuges[18] and de-weighting centrifuges[19] (or equivalents) will be discharged at depth (>200 m), at the seabed, or retained for offshore disposal in Commonwealth waters in accordance with a sea dumping permit.
WBF discharges (pit dumps/bulk discharges) *Typically occurs at end of each well section or when switching between fluid types (riserless or with riser)*	• Use and discharge of all chemicals will be performed in line with Woodside's chemical selection and assessment process and approved prior to use.	• For TRD, TRA and TRF wells, WBF bulk discharges will occur either at depth (> 200 m), at the seabed or retained for offshore disposal in Commonwealth waters under a sea dumping permit.
NWBF discharges (pit dumps/bulk discharges) *No discharge of unused NWBF at sea during drilling and completion operations*	• There will be no discharge of unused NWBF at sea during drilling and completion operations. • Mud pit wash residue is operationally discharged from the MODU with less than 1% oil contamination	• No additional controls required, as discharge already managed.

[16] When using NWBF, there is no direct discharge from the shakers (except for a short time in some emergency situations). Instead, after cuttings have passed over the shakers, they are diverted to cuttings dryer/s. Cuttings dryers are used to further reduce the volume of residual NWBF adhered to cuttings prior to discharge. Outputs from a dryer are separated into cleaned cuttings (which are typically discharged to the ocean with a residual film of NWBF) and recovered NWBF (which returns to the mud pits on the MODU via a dryer centrifuge).
[17] Solids in this context refers to fine rock particles (cuttings) that are removed from the well with fluids via SCE when returned to the MODU, and/or fine solid material intentionally added to or removed from a drill fluid to control its specific gravity
[18] A dryer centrifuge is connected to the recovered NWBF output of a cuttings dryer to remove undesirable fine solids from the fluid before it returns to the mud pits, and to reduce the volume of residual NWBF adhered to the fines prior to discharge.
[19] De-weighting centrifuges are connected to the mud pit system on a MODU and used (when required) to remove fine solids from the NWBF to reduce the specific gravity of the fluid.

Aspects	Draft EIS/ERD adopted controls (relevant to discharges)	Additional proposed controls to achieve maximum LEP for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry)
	by volume. Where the mud pit residue exceeds 1% by volume, the residue will be retained and disposed onshore.	

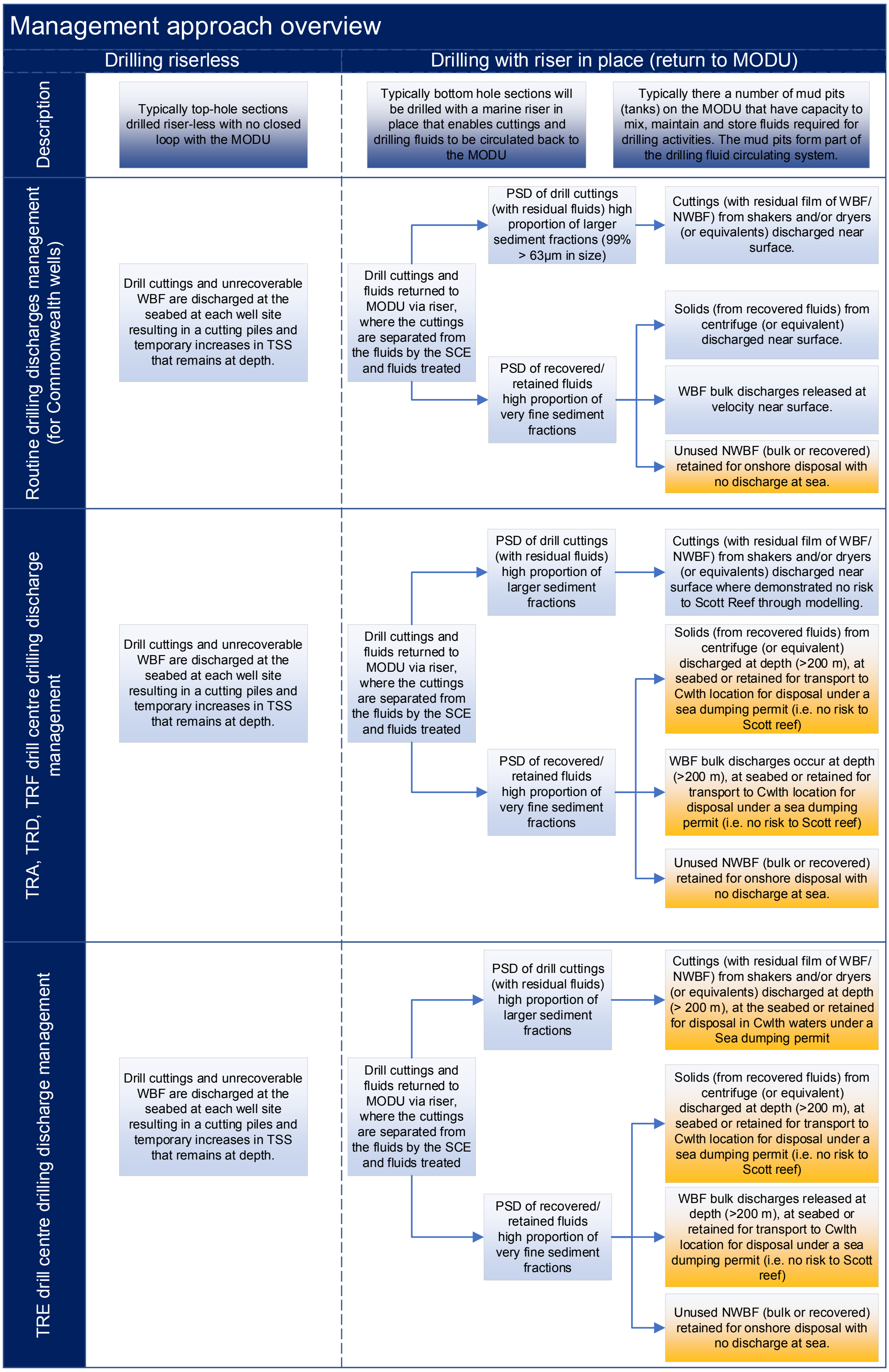

Figure 2-1: Process diagram with increasing levels of proposed management in context of potential risk to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry)

2.2 Management options and assessment

2.2.1 Discharge of drill cuttings and fluids at depth (>200 m)

At Scott Reef, the local water flow within the reef system is largely influenced by the macro tidal environment and its interaction with the topography of the reef structure. The spring tidal range is approximately 4.5 m with a semi-diurnal tidal cycle (Seafarer Tides, 2011). Depending on the cycle of the tide, the reef flat may be exposed or immersed and it is this cycle of exposure and inundation that has a major influence on the surface currents and thermodynamics of the reef (AIMS, 2006; Green et al., 2019a) . Oceanic currents and the seasonal monsoonal weather conditions impact the layering of the water column so that the surface mixed layer deepens during periods of persistent wind and thins during calm periods (Brinkman et al., 2010).

The Scott Reef system is largely subject to the seasonal and inter-annual variability in temperature and salinity structure exhibited by the regional oceanic waters, with greater variability within the South Scott Reef lagoon caused by local processes such as enhanced vertical mixing due to internal waves, modified horizontal advection, residence times and local evaporation (Brinkman et al., 2010). Circulation is controlled by a south-eastward tidal propagation, with tidal currents flooding from the north-west and receding in a south easterly direction. Tidal driven flood currents within the channel between North and South Scott Reef propagate towards the east with enhanced velocities. The circulation around and inside Scott Reef is determined by dynamic influences (winds and tides) as well as thermodynamic processes (Green et al., 2019a).

There is no evidence of persistent upwelling or downwelling currents at Scott Reef, but seawater temperature monitoring has recorded some evidence of localised intrusions of cooler water around the western and eastern entrances to the channel between North and South Scott Reef during spring tides (Green et al., 2019a). Such cool water intrusions are primarily semi-diurnal in timing, driven by the strong semidiurnal periodicity in the prevailing internal wave and tide regime in the channel, combined with horizontal shear due to the strong tidal currents that can entrain water from below the sill depth of the channel up into the lagoon. Logger data suggests that the cool water entering the lagoon originates within the thermocline from depths shallower than 160 m, with no evidence of deeper waters entering the lagoon system (Brinkman et al., 2010).

The discharge of drill cuttings and fluids in deeper water (>200 m or at the seabed) may result in sediment plumes and associated deposition of sediment to the surrounding seabed, however in consideration of prevailing hydrodynamics and modelling outcomes, this is predicted to be confined to the deeper layers of the water column with no contact with deeper water or shallow water coral habitats at Scott Reef.

As outlined, while there is some evidence of localised intrusions of cooler water around the western and eastern entrances to the channel between North and South Scott Reef during spring tides, there is no evidence of persistent upwelling or downwelling currents around Scott Reef (Green et al., 2019b) and therefore, no transport mechanisms to mobilise drill cuttings and fluids from deep waters to the shallower waters of the reef system. As such, given the location of the drill centres in deep water (>350 m), which experience strong surface and subsurface currents, drill cuttings and fluid discharge disposal at depth or the seabed would be expected to settle rapidly.

As such this option has been carried forward as a key mitigative management control for bottom-hole (drilling with riser) discharge parameters that may pose a risk to the Scott reef shallow water benthic communities and habitat (<75 m bathymetry).

2.2.2 Transportation to offshore disposal site in Commonwealth waters

One of the key mitigative options for the management of drilling discharges from Torosa wells in the State Proposal Area involves the collection and transportation of specific discharges to a location outside of State waters (in Commonwealth waters) for disposal (e.g. skip and ship). This option involves modifications to the MODU which may differ depending on the discharge type and rig selection to allow the storage, potential treatment (e.g. slurrification) and transfer/disposal of the discharge. For drilling fluids, these may be recovered from the mud pits, transferred to storage tanks on the MODU or pumped into storage tanks on a barge/vessel for subsequent disposal.

For drill cuttings, this activity may consist of the collection of the cuttings from the MODU into specially designed skips, via a steerable chute. The filled skips are then offloaded via a crane onto a dedicated collection vessel (e.g. barge) or to a standard platform supply vessel (PSV) for disposal.

Alternatively, cuttings may be slurrified on the MODU and cuttings and/or fluids pumped to the barge/vessel for subsequent disposal. This process typically involves:

1. Cuttings processed over rig shakers
2. Cuttings then travel to grinding pumps where they are broken down into a pumpable slurry
3. Slurrified cuttings then stored on MODU until a critical volume is achieved
4. Critical volume then pumped to vessel via a transfer pump
5. Vessel then moves off location to 'disposal site' and discharges slurrified cuttings.

Cuttings and drill fluids returned to the MODU may also be processed through centrifugal slurry pumps fitted with tungsten carbide impellors designed to break down the cuttings particle size and form a slurry by the addition of water and a viscosifier. The slurry may then go over a classification shaker to screen out larger particles that needed further processing through the slurry pumps. Once the criteria is met, the classified slurry then may pass to the slurry holding tank, ready for transfer to the mud pits for temporary storage prior to being transferred to the vessel for discharge.

The disposal of such discharges within Commonwealth waters will be subject to assessment and approval of a sea dumping permit through the *Environment Protection (Sea Dumping) Act* 1981, with potential disposal locations within the Browse Development Area identified in **Figure 2-2**. These locations have been nominated as feasible sites as they are located within the Browse Development Area where the existing environment has been described, impacts and risks assessed, and consideration has been given to the avoidance of Key Ecological Features and proposed infrastructure location.

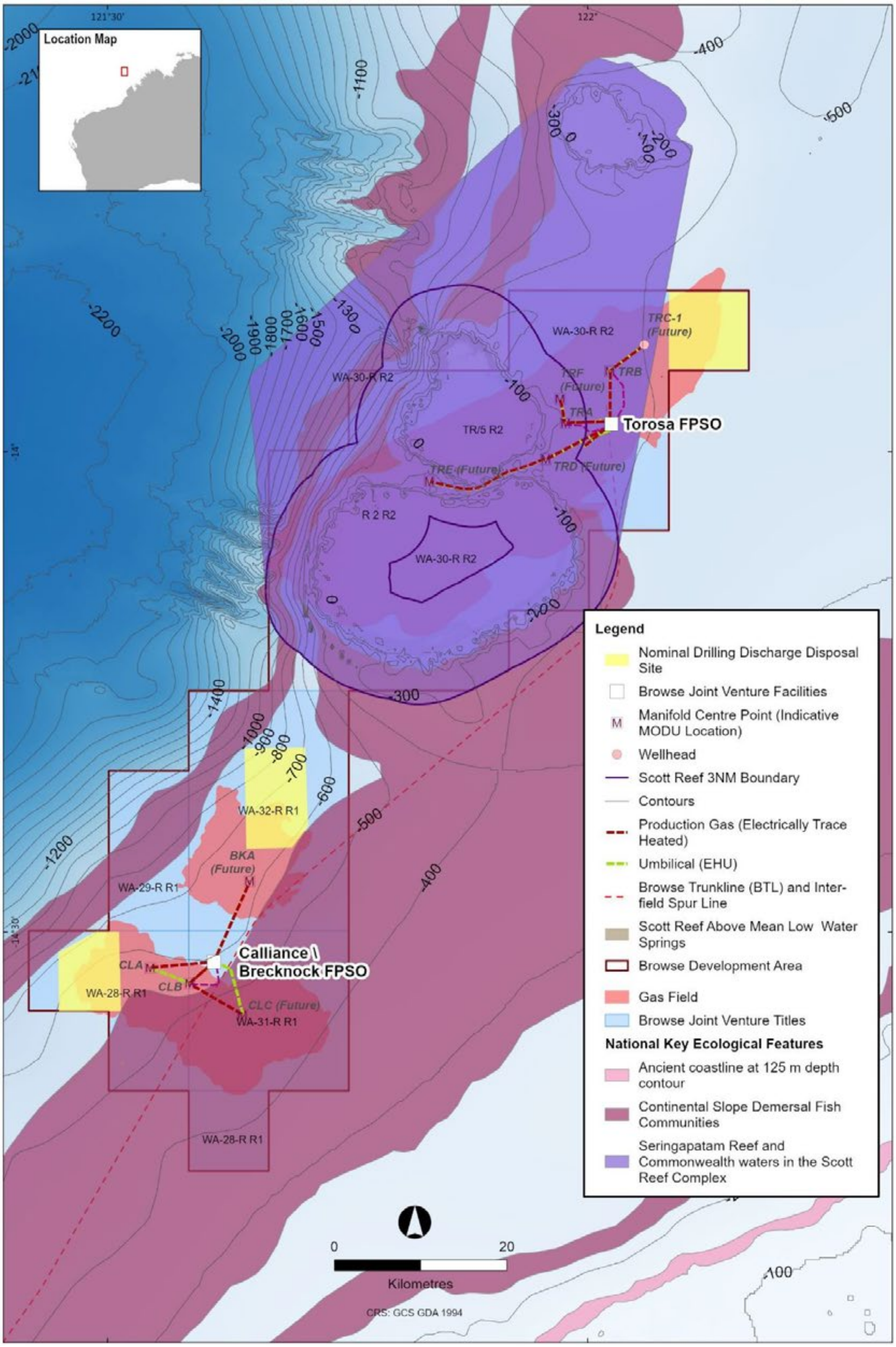

Figure 2-2: Nominal disposal location for retained drilling discharges* TRE shown but no longer proposed

3. MONITORING APPROACH

3.1 Hydrodynamic model validation (pre-drilling)

3.1.1 Background

Detailed site-specific information on current direction and flow speeds as well as water column stratification and Ekman layering is essential for modelling. As a part of previous concepts, detailed metocean and ecosystem processes studies have been completed in the Scott Reef region, which has been used as the basis for model validation. Since the completion of modelling, additional metocean studies, including current and wave data in the region have also been collected.

3.1.2 Purpose

A further hydrodynamic model validation study is proposed, which consists of the following:

1. Undertake a desktop assessment to understand the full extent of metocean data available in the Scott Reef region and assess adequacy for robust model calibration and validation with respect to fine-scale hydrodynamics in proximity to the Torosa drill centre locations in the State Proposal Area.
2. Where it is deemed that there is insufficient data in consultation with the modelling consultant, conduct a metocean study to collect site specific information in the vicinity of the Torosa drill centres in the State Proposal Area.
3. Undertake further calibration and validation of the fine scale hydrodynamics model/s that drive the dispersion of discharges within the model domain, based on available metocean data.

3.1.3 Methods

Desktop metocean assessment

The Scott Reef region has been studied by Woodside, its contractors and academics institutions for decades. This review will collate and review all data collected on behalf of Woodside and any other publicly available information, which has sufficient resolution for the purpose of fine-scale hydrodynamic model calibration and validation.

Metocean study

Where a site specific metocean study is deemed necessary, water column current profiles and waves measurements are proposed to be recorded at observational sites through the deployment of Acoustic Waves and Currents (AWAC) and Acoustic Doppler Current Profilers (ADCP) with wave capability. The current profilers are proposed to be mounted at selected sites and acoustically sampled current velocities vertically up through the water column. Observational sites for moored instrumentation will be chosen to provide good spatial coverage of the water column surrounding Scott Reef, in context of existing data, with a focus on the areas in proximity to the proposed drill centre locations within the State Proposal Area.

Hydrodynamic model validation

Further, calibration and validation of the 3-dimensional hydrodynamic model for Scott Reef and the surrounding area is proposed to be completed as the basis for drilling discharges modelling for inclusion in EPs required under petroleum legislation. This will likely involve calibration and validation of the model for a two week period (in order to capture the spring-neap cycle) in each of the four seasons (where relevant) with in-situ measurements, using in field measurements in and around the region surrounding Scott Reef at sites applicable to the Torosa drill centres in the State Proposal Area.

3.2 Drilling discharges volume validation (during drilling)

3.2.1 Background

A key modelling input is the volume of cuttings and fluids to be discharged to the marine environment. Infield quantification of the mud/solids discharges is completed routinely and is important information that can be collected from early phase wells to inform future phase modelling. Noting in the absence of suitable data, conservative (worst-case) scenarios become the default typically overstating the impact/risk.

3.2.2 Purpose

For early Phase 1 drilling activities, detailed records of the discharge characteristics that are routinely tracked will be reviewed. The purpose of this is twofold:

- Validation of the modelling inputs to demonstrate that the modelling was appropriately conservative and that the impact/risk was adequately defined, and where not corrective actions would be implemented.
- Provide better information (i.e. input data to the models) for future phase drilling activities that will allow more realistic discharge scenarios to be modelled and hence a more balanced understanding of risk.

3.2.3 Methods

The following records will be reviewed whether remotely or on the MODU:

- cuttings discharge volumes and mass and discharge rates
- fluids lost on cuttings and below the mudline
- total fluids/solids lost per well and well section
- daily fluids/solids loss budget showing what proportion are lost to the formation, below the mudline, via mud pit dumps and via the centrifuges.

3.3 Drilling discharges deepwater sediment and water quality monitoring (Post drilling)

Monitoring of deepwater sediment quality and epibenthos cover at a gradient away from the well will be undertaken for a representative well for TRA, TRD and TRF drill centres within the State Proposal Area, to verify that the environmental quality criteria (as provided in **Table 3-1**) at the Moderate LEP boundary have been achieved. Monitoring will be undertaken at an appropriate time pre-drilling and as soon as practicable post-drilling in water depths deeper than 350m (actual depth will be dependent on which drill centre is chosen to assess).

Water quality monitoring will be undertaken at Scott Reef (defined as the area above the 75 m bathymetric contour and within the 3 nm State waters boundary) during drilling of a single representative well for TRA, TRD, TRF drill centres, to verify that the environmental quality criteria (as provided in **Table 3-1**) at Scott Reef has been achieved.

Details of the drilling discharges sediment and water quality monitoring program is provided in Section 3.5.1 and Section 3.5.3 of the proposed Browse Project EQMP.

Table 3-1: EQGs and EQSs for the drilling discharges in the State Proposal Area

Potential Impact	Source of Impact	EQGs	EQSs
Drilling or completions discharges			
Contamination of sediments	Drilling cuttings and fluids discharges	**EQG 1** The bioavailable fraction of the metal or metalloid concentrations measured at the Low LEP / Moderate LEP and Moderate LEP / High LEP boundaries will not exceed the recommended toxicant default guideline values for sediment quality (DGVs; ANZG, 2018) and as specified in Section 3.5.1.2 of the EQMP. **EQG 2** Hydrocarbon concentrations measured at the Low LEP / Moderate LEP and Moderate LEP / High LEP boundaries, will not exceed the guideline values (DGVs) for sediment quality (ANZG, 2018) and as specified in Section 3.5.1.2 of the EQMP. *For this EQG to be triggered, concentrations must be above background levels measured prior to the activity or a suitable reference location and be attributable to the Browse Project activities*	**EQS 1** Whole sediment toxicity tests (at least 3 tests) from sediment at the Low LEP / Moderate LEP boundary should not result in a statistically significant effect (P < 0.05) on lethal acute endpoints, or of greater than 50% on sublethal chronic endpoints for any species, compared to a matched reference sediment. **EQS 10** Whole sediment toxicity tests (at least 3 tests) from sediment at the Low LEP/Moderate LEP boundary should not result in a statistically significant effect (P < 0.05) on lethal acute endpoints, or of greater than 50% on sublethal chronic endpoints for any species, compared to a matched reference sediment.

Potential Impact	Source of Impact	EQGs	EQSs
Sediment deposition causing burial or smothering of marine fauna	Drill cuttings discharged at the seabed	**EQG 3** No net detectable change in epibenthos cover outside 200 m radius from the well (or zone of impact based on revised modelling if further) within the defined Moderate LEP boundary attributable to the Browse Project activities.	**EQS 2** At the Low LEP / Moderate LEP boundary, no change to epibenthos species diversity and composition attributable to the Browse Project. **EQS 3** At the Moderate LEP / High LEP boundary, no detectable change in natural variation (including abundance, diversity and composition) of epibenthos cover attributable to the Browse Project activities.
Sediment plume reaching Scott Reef	Drilling or completions discharged at surface	**EQG 4** Particle size distribution of the drilling fluids considered for surface discharge a show that 99% of particles are greater than 63 µm in size.	**EQS 4** Water quality monitoring in the direction of the turbid plume shows no detectable change from natural variation of total suspended solids or contaminants in waters at Scott Reef (considered as the area above the 75 m bathymetric contour and within the 3 nm State waters boundary).

4. CONCLUSION

Table 2-1 provides a summary of draft EIS/ERD and additional management controls relevant to drilling discharges from Torosa wells within the State Proposal Area that have been proposed to demonstrate that the maximum LEP can be achieved for Scott Reef shallow water benthic communities and habitats (<75 m bathymetry).

For TRA, TRD, and TRF wells on the eastern side of Scott Reef, within the State Proposal Area, drilling discharges at the surface/near surface when drilling with riser, are only being considered for bottom hole cuttings (with residual film of fluids) from the shakers (or equivalents) for WBF, and from the cuttings dryers (or equivalents) for NWBF, due to their inherently lower adhered WBF/NWBF content, and the rapid settling velocity of the larger particle size of the cuttings (primary discharge source) and associated dispersion characteristics, and as such there is no anticipated credible risk to Scott Reef shallow water benthic communities and habitats (<75 m bathymetry). Noting that the WBF mud pit bulk discharges, which have a finer particle distribution and associated wider dispersion, are proposed to be managed and either discharged at depth (>200 m), at the seabed, or retained for offshore disposal in Commonwealth waters in accordance with a sea dumping permit.

To support this approach, site specific modelling for the worst-case well at each Torosa drill centre within the State Proposal Area is being proposed for inclusion and assessment within the associated EP following detailed engineering and design. This modelling will be supported by additional hydrodynamic model validation as described in **Section 3.1** and may include a range of sensitivity testing. This process flow is illustrated in **Figure 4-1**.

Note the impact and risk assessment for Torosa wells within the State Proposal Area will be further described in future EPs submitted and accepted under the Petroleum (Submerged Lands) Act 1982, which provides the regulatory framework for the exploration and production of petroleum resources adjacent to the WA coast. The Petroleum (Submerged Lands) (Environment) Regulations 2012 are based on the Commonwealth OPGGS (E) Regulations and have the objective of ensuring petroleum or geothermal energy activities are carried out in a manner consistent with the principles of ecologically sustainable development. The Regulations require an EP be in force for any petroleum activity undertaken in WA State waters.

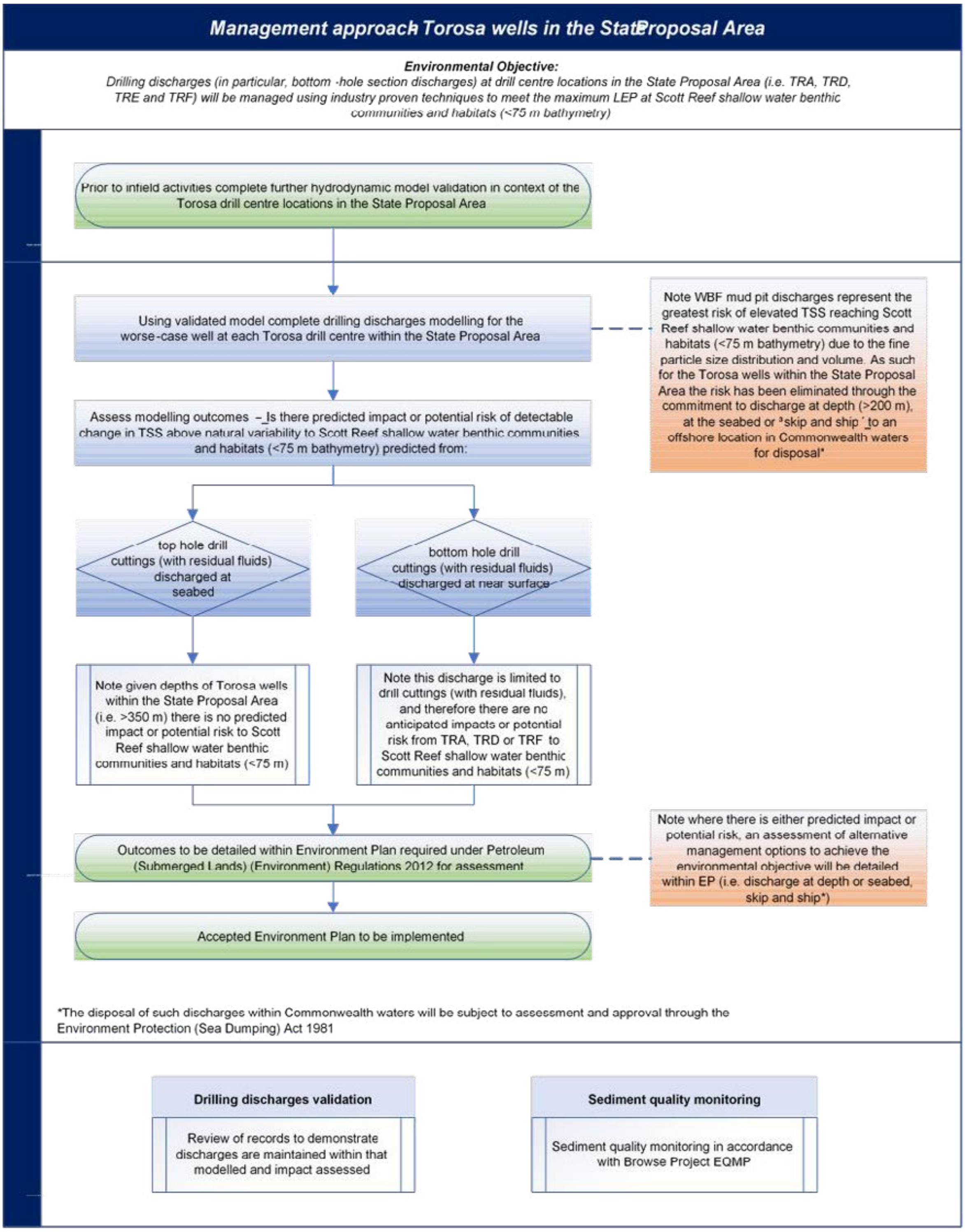

Figure 4-1: Approvals approach to demonstrate acceptable discharge of cuttings (with residual fluids) at surface/near surface at TRA, TRD and TRF drill centres.

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APPENDIX A: INDICATIVE CUTTINGS VOLUME AND FLUID TYPE FOR A TYPICAL BROWSE WELL

Table 5-1: Indicative cuttings volume and fluid type for a typical Browse well

Indicative well section diameter	Indicative drill length (m)	Indicative cuttings volume (m^3)	Indicative fluids volume (m^3)	Fluids adhered to cuttings (Indicative estimates for context purposes only)			Mud pit discharges (Indicative estimates for context purposes only)			Indicative fluid type	Indicative discharge location*
				Fluids volume (m^3)	Solids in fluids volume (m^3)	Discharge duration (days)**	Fluids volume (m^3)	Solids in fluids volume (m^3)	Discharge duration (days)		
42"	100	89	427	342	14	~0.25	85	3	0.02	Seawater with bentonite sweeps	Drilled riserless – seabed discharge
26"	440	151	1327	1062	42	2	265	11	0.06	Seawater with bentonite sweeps	Drilled riserless – seabed discharge
16"	2970	385	1892	385	50	~20	1507	196	0.31	WBF	Drilled riserless – seabed discharge or drilled with riser – near surface discharge
$12^{1/4}$	2799	213	1478	213	53	~15	1265	316	0.26	WBF, **OR**	Drilled with riser – near surface discharge
			702	120	30	~15	Not applicable – no discharge of NWBF, backloaded for onshore storage/disposal.			NWBF	
$9^{7/8}$	243	12	633	12	2	5	621	93	0.13	WBF, **OR**	Drilled with riser – near surface discharge
			545	7	2	5	Not applicable – no discharge of NWBF, backloaded for onshore storage/disposal.			NWBF	
Total per well	**6,552 m**	**850 m^3**	**5,757 m^3**								

*This is based on a typical Browse well, noting near-surface drilling discharges from Torosa wells in the State Proposal Area are proposed to be managed as detailed in **Section 2**.
**Note cuttings and residual fluids are generally only discharged when drilling new hole section of the well (including circulating hole clean).

APPENDIX C MANAGEMENT PLANS

APPENDIX C.3 TURTLE MANAGEMENT PLAN

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LIST OF ABBREVIATIONS & ACRONYMS

Acronym	Meaning
2C	Contingent resources
2TL	Second trunkline
ALMP	Artificial Lighting Management Plan
BC Act	Biodiversity Conservation Act.
BJV	Browse Joint Venture
BTL	Browse Trunkline
DAWE	Department of Agriculture, Water and Environment
EP	Environment Plan
EPA	Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
EP Act	*Western Australia Environmental Protection Act* 1986
EQMP	Environmental Quality Management Plan
FOV	Field of View
FPSO	Floating Production Storage and Offloading
FME	Full Moon Equivalent
G-AR	Ashmore Reef green turtle genetic stock
G-ScBr	Green turtle Scott Reef-Browse Island genetic stock
IMMR	Inspection, maintenance, monitoring and repair activities
LOS	Line of sight
MMscfd	Million standard cubic feet per day
MODU	Mobile offshore drilling units
NRC	North Rankin Complex
NWS	North West Shelf
NWSJV	NWS Joint Venture
NWMR	North-west Marine Region
SRTM	Shuttle Radar Topography Mission
SQM	Sky Quality Meter
SURF	Subsea umbilicals, risers and flowlines
TCF	Trillion cubic feet
TMP	Turtle Management Plan
WA	Western Australia

1. INTRODUCTION

1.1 Proposed Browse Project Background

The Browse hydrocarbon resource is located in the Brecknock, Calliance, and Torosa reservoirs, approximately 425 km north of Broome and approximately 290 km off the Kimberley coastline of Western Australia (WA). These three fields will be collectively referred to as the Browse hydrocarbon resources. Hydrocarbon resources contained in these fields are predominately gas, with contingent resources (2C, 100%) of 13.9 trillion cubic feet (tcf) of dry gas, and approximately 390 million barrels of condensate (Woodside resource estimate).

Woodside Energy Ltd (Woodside) is Operator for and on behalf of the Browse Joint Venture (BJV). The participants in the BJV are:

- Woodside Browse Pty Ltd
- Shell Australia Pty Ltd (Shell)
- BP Developments Australia Pty Ltd (BP)
- Japan Australia LNG (MIMI Browse) Pty Ltd (MIMI)
- PetroChina International Investment (Australia) Pty Ltd (PetroChina).

The BJV proposes to develop the Browse hydrocarbon resources using two 1100 million standard cubic feet per day (MMscfd) (annual daily export average) Floating Production Storage and Offloading (FPSO) facilities. The FPSO facilities will be supplied by a subsea production system and will transport gas to existing North West Shelf (NWS) Project infrastructure via a pipeline which will tie in near the existing North Rankin Complex (NRC) in Commonwealth waters (Note: The NRC is owned by the NWS Joint Venture (NWSJV)[1]).

Subject to market conditions, all necessary regulatory approvals, joint venture approvals and commercial agreements, execution of the proposed Browse Project would be targeted to commence mid-2020s with operations expected for up to 44 years.

1.2 Purpose of Plan

An environmental impact and risk assessment was undertaken for the proposed Browse Project in accordance with Woodside's Impact Assessment Procedure, Environment Impact Assessment Guideline and Risk Management Procedure. These documents set out the broad principles and high-level steps for assessing environmental impacts and risks across the lifecycle of Woodside's activities.

The assessment of impacts and risk was undertaken through a systematic process consistent with Woodside's Impact Assessment Procedure and Environment Impact Assessment Guideline. Each activity (either planned or unplanned) was considered with respect to its potential to affect an environmental receptor. The assessment was informed by a range of environmental studies that included the review of existing data and the modelling of discharges and emissions. Inherent controls, such as design features, legislative requirements, industry good practice and applicable Woodside corporate standards were considered when identifying the credible impact and risk scenarios.

[1] The NWSJV comprises six companies: Woodside Energy Ltd. (Operator), BHP Billiton Petroleum (North West Shelf) Pty Ltd, BP Developments Australia Ltd, Chevron Australia Pty Ltd, Japan Australia LNG (MIMI) Pty Ltd, and Shell Australia Pty Ltd. The NWS Joint Venture owns the infrastructure used as part of the North West Shelf Project.

As part of the impact and risk assessment process, management and mitigation measures have been identified and will be implemented to meet the requirements of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Western Australia *Environmental Protection Act* 1986 (EP Act) and other relevant legislation and regulations.

One of the key environmental receptors identified during the assessment of impacts and risk was marine turtles utilising Sandy Islet and the surrounding waters for nesting and inter-nesting. **Section 1** provides a description of the marine turtles and marine turtle habitat relevant to this Turtle Management Plan (TMP or 'Plan').

A number of planned and unplanned aspects (i.e. elements of the proposed Browse Project that can potentially interact with an environmental receptor) were identified as having the potential to result in impacts to marine turtles. Most of these aspects were determined to either present a negligible impact or risk to marine turtles or presented an impact or risk that could be predicted with a high level of certainty and mitigated and managed using industry standard practice. The management approach for these aspects will be detailed in various environmental management plans such as the Environmental Quality Management Plan (EQMP) which has been prepared to manage marine discharges in the State Waters portion of the Project Area, and activity specific Environment Plans (EPs) required under State and Commonwealth legislation.

However, two aspects (light emissions and seabed subsidence) were identified by the Department of Agriculture, Water and the Environment (DAWE) (now Department of Climate Change, Energy, the Environment and Water (DCCEEW)) and the WA Environmental Protection Authority (EPA) as presenting a higher level of uncertainty, both with respect to the magnitude of the aspect and the resultant impact on marine turtles. The uncertainties in relation to these aspects are presented in **Table 1-1**.

Table 1-1 Uncertainties in relation to potential impacts on marine turtles as a result of the proposed Browse Project

Aspect	Uncertainty

Light emissions	• The magnitude and nature of the light emissions (e.g., intensity, brightness) during construction as the specific mobile offshore drilling units (MODU) to be used have not been identified.
	• The magnitude and nature of the light emissions (e.g. intensity, brightness) during operations due to the early stage design of the FPSO facilities.
	• Light levels that will be received at Sandy Islet and surrounding waters given:
	  o The uncertainty in the magnitude and nature of the light emissions from the MODU and FPSO facilities.
	  o The cumulative effect of light emissions from the MODU and FPSO facilities.
	  o Inherent uncertainties in the light modelling undertaken as part of the impact and risk assessment.
	• The magnitude and nature of the potential impacts to marine turtles utilising Sandy Islet and surround waters as a result of light emissions, noting that responses are likely to be population, location, life-stage and seasonal dependent.

Seabed subsidence	• The available green turtle data is dated, noting the data was determined to be adequate for the purposes of impact assessment and management planning purposes based on the lack of significantly altered regional cumulative impacts since collection, ability to extrapolate population trends using existing literature, and conservative interpretation of available data where applied.

Aspect	Uncertainty
	• The magnitude of seabed subsidence at Sandy Islet given the inherent uncertainties in the subsidence modelling undertaken as part of the impact and risk assessment. • The effect of seabed subsidence on Sandy Islet given natural processes such as erosion and accretion. • The magnitude and nature of the potential impacts to marine turtles utilising Sandy Islet.

Furthermore, DAWE (August 2021) and the EPA (June 2021) formally requested further information on the light emission and seabed subsidence aspects of the assessment in relation to marine turtles, to support their assessment of the Proposed Browse to North West Shelf Development ERD/EIS. Hence, the purpose of this Plan is to present a management approach that will be implemented in relation to potential impacts and risks from light emissions and seabed subsidence on marine turtles as a result of the proposed Browse Project. This management approach is required to ensure that the aspects are managed so as not to result in an unacceptable impact to marine turtles.

1.3 Project Overview

1.3.1 Project Area

The overall Project Area for the proposed Browse Project comprises:

- the proposed Browse Development Area (in which the Brecknock, Calliance, and Torosa fields, the FPSO facilities and the subsea production systems, including wells, will be located) (**Figure 1-1**)
- the pipeline corridor within which the proposed Browse Trunkline (BTL) and inter-field spur line will be located (**Figure 1-2**).

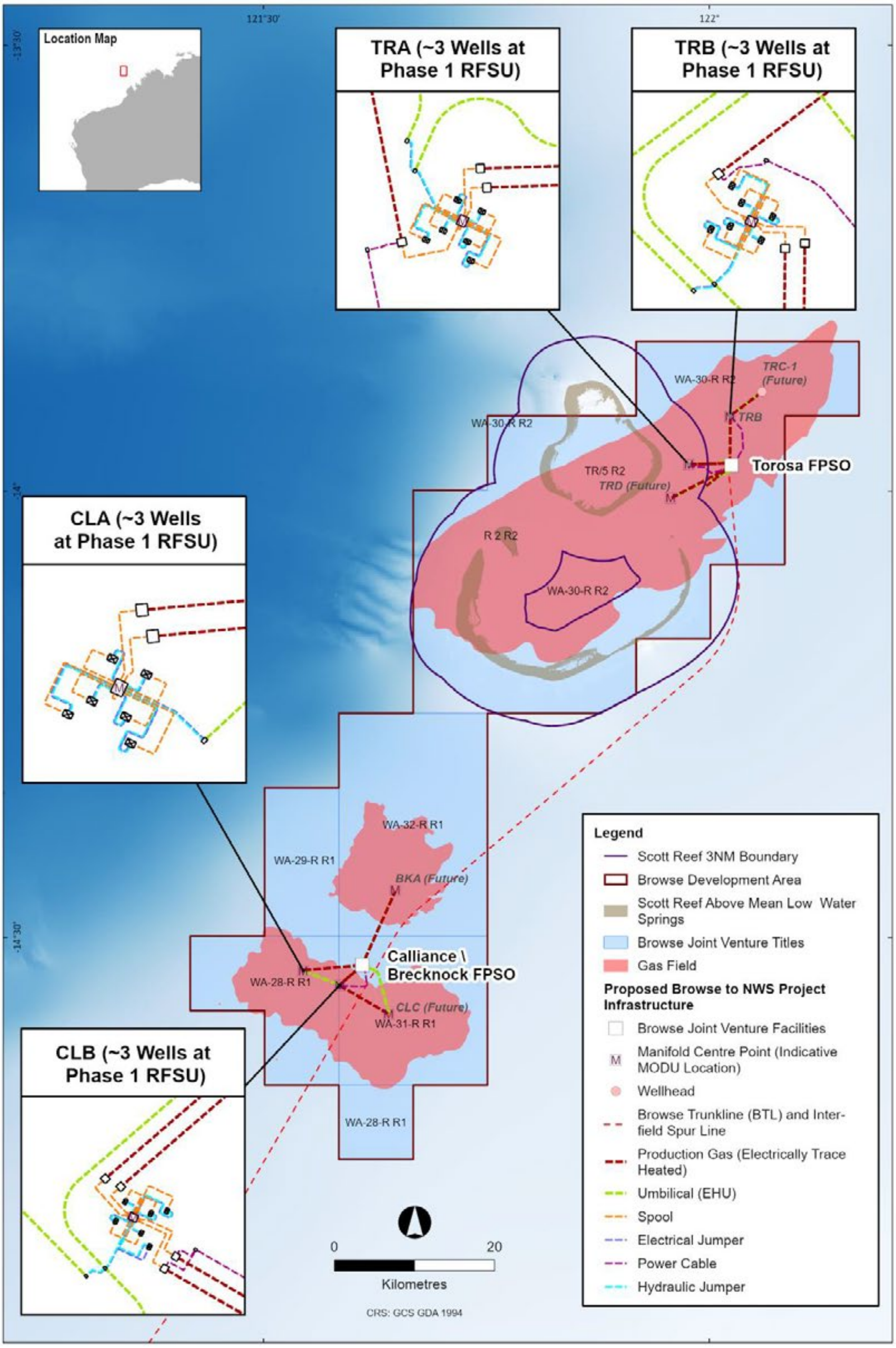

Figure 1-1 Proposed Browse Development Area and notional field layout

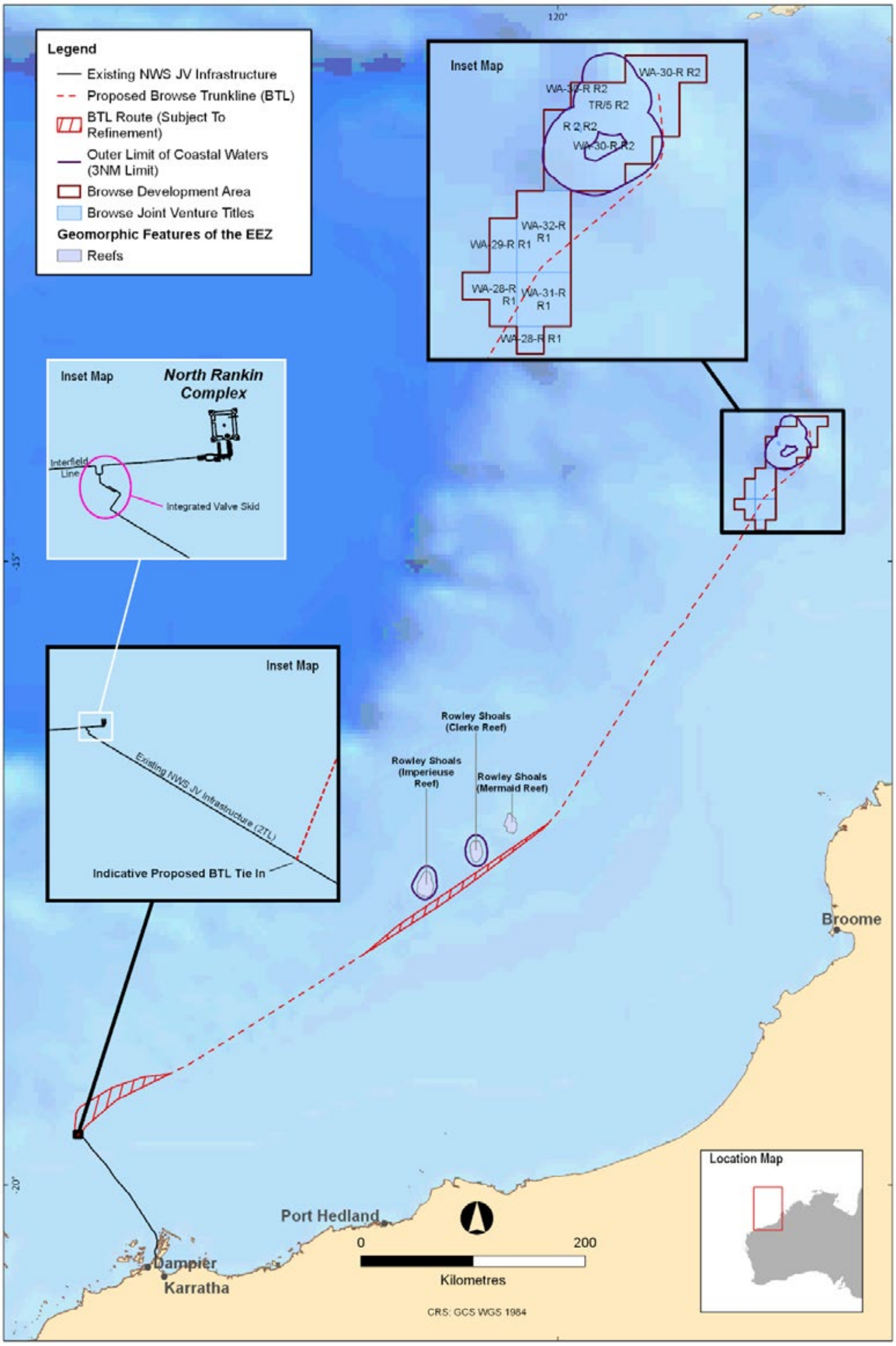

Figure 1-2 Proposed Browse Trunkline (BTL) route

1.3.2 Key Characteristics

The proposed Browse Project will comprise subsea infrastructure and two FPSO facilities, connected to existing NWS Project infrastructure via the ~900 km BTL.

The key characteristics of the proposed Browse Project are described below:

- hydrocarbon extraction will require up to 50 wells with associated subsea infrastructure, including manifolds and flowlines
- extracted hydrocarbons will be transferred via subsea infrastructure, including wellheads, manifolds and flowlines, up to the FPSO facilities, which are located in Commonwealth waters
- condensate stabilisation and storage will occur on the FPSO facilities prior to offtake to condensate tankers for delivery to market
- gas processing will also occur on the FPSO facilities prior to export via the inter-field spur line and BTL to existing NWS Project infrastructure.

The BTL will tie into the existing second trunkline (2TL) near NRC with transmission of the gas from the tie-in point and onshore processing of the gas to be undertaken using existing NWS Project infrastructure.

1.3.3 Project Activities

Activities associated with the proposed Browse Project include:

- piling for mooring the FPSO facilities, securing the export riser bases and potentially for mooring the MODUs. Suction piling is the most likely option for pile installation, however, depending on the seabed substrate, alternate piling methods such as drilling and cementing or impact piling may be selected
- development drilling and completions for the development of up to 50 production wells
- installation and commissioning of the subsea umbilicals, risers and flowlines (SURF)
- installation and commissioning of the BTL and inter-field spur line
- installation, hook up and commissioning of the FPSO facilities
- operations including hydrocarbon extraction, gas processing and export and condensate offloading
- inspection, maintenance, monitoring and repair activities (IMMR) to ensure the integrity of the infrastructure and identify any problems before they present a risk of loss of containment
- support activities including logistics support, project vessels and helicopters
- decommissioning in accordance with good oilfield practice and relevant legislation and practice at the time.

A detailed description of the activities associated with the proposed Browse Project is provided in **Section 3.7** of the draft EIS/ERD.

2. DESCRIPTION OF THE PROTECTED MATTER

Six species of marine turtle occur within Australian waters; the leatherback turtle (*Dermochelys coriacea*), loggerhead turtle (*Caretta caretta*), olive ridley turtle (*Lepidochelys olivacea*), green turtle (*Chelonia mydas)*, hawksbill turtle (*Eretmochelys imbricata*) and flatback turtle (*Natator depressus*). All six marine turtle species are known to occur within the North-west Marine Region (NWMR) and are protected under the EPBC Act and the Western Australian *Biodiversity Conservation Act 2016* (BC Act); however, given the identified uncertainties relating to impacts of light emissions and seabed subsidence outlined in **Section 1.2** this plan particularly focuses on green turtle that are known to nest on Sandy Islet and forage within the broader Browse Development Area.

2.1 Green Turtle

2.1.1 Stock Identification and Genetic Exchange

The green turtle is distributed widely across northern Australia with a total of nine genetic stocks identified to date for this species (Commonwealth of Australia, 2017). There are three genetic stocks within the NWMR; the North West Shelf, Ashmore Reef, and Scott Reef-Browse Island genetic stocks. Dispersal of these genetic stocks occurs over a large area in waters north and east of the northern WA coastline (Department of the Environment and Energy, 2017). The North West Shelf genetic stock comprises multiple nesting rookeries within close proximity, whilst the Ashmore Reef and Scott Reef-Browse Island genetic stocks are comparatively genetically isolated with fewer nesting rookeries. The green turtle Scott Reef-Browse Island genetic stock (herein after referred to as 'G-ScBr') is a discrete unit known to nest at only two locations within the north-east Indian Ocean—Sandy Islet and Browse Island (Commonwealth of Australia, 2017). Only Sandy Islet falls within the Browse Development Area.

Genetic mixing between rookeries is known to occur for green turtle stocks in WA, but the offshore rookeries in the Browse Basin (Ashmore Reef, Scott Reef and Browse Island) appear to form a discrete sub-group weakly isolated from coastal Kimberley rookeries despite their close proximity (Whiting *et al*., 2018). These offshore rookeries are, in turn, weakly differentiated from each other—SNP (single nucleotide polymorphisms) analyses show low but significant genetic differentiation between the Sandy Islet and Browse Island rookeries (Whiting *et al*., 2018), whereas mitochondrial DNA data group them together (Jensen, 2010). These rookeries are only ~190 km apart but it appears from the SNP data that there are some limits to gene flow between the two sites (although the sample size for Browse Island was low).

The findings of the Whiting *et al*. (2018) study confirmed previous findings that there is genetic exchange among green turtle rookeries along coastal parts of the Kimberley, but little exchange occurs among offshore atolls, or between offshore and coastal rookeries.

As identified in the Recovery Plan (Commonwealth of Australia, 2017) there is a lack of data regarding the status of the G-ScBr stock, and the current population trend is unknown. This stock is considered likely to be restricted in its capacity to expand into other nesting areas in the event that availability or quality of nesting habitat is reduced. The G-ScBr stock is vulnerable to a range of threats to all life stages, and its resilience to cope with increasing pressures is likely to be limited by its restricted population gene pool and low number of nesting locations.

2.1.2 Habitat Critical to the Survival of a Species

In accordance with the *EPBC Act Significant Impact Guidelines 1.1 – Matters of National Environmental Significance* (Commonwealth of Australia, 2013), an action is deemed to have a significant impact if there is a real chance or possibility that it will adversely affect 'habitat critical to the survival of a species' (herein after referred to as 'habitat critical'). Habitat critical refers to areas that are necessary:

- for activities such as foraging, breeding or dispersal
- for the long-term maintenance of the species (including the maintenance of species essential to the survival of the species)
- to maintain genetic diversity and long-term evolutionary development
- for the reintroduction of populations or recovery of the species.

Nesting and internesting habitat is defined as habitat critical, and these areas have been identified for each genetic stock of marine turtle in the Recovery Plan. One of the key criteria for identification of these areas is that "*Nesting habitat critical to the survival of green, loggerhead, flatback and hawksbill turtles includes at least 70 per cent of nesting for the stock*".

Designated habitat critical for the G-ScBr stock are the nesting locations of Sandy Islet and Browse Island, and an internesting buffer of 20 km radius around these rookeries, for the period November to March (refer Table 6 of the Recovery Plan). The habitat critical at Scott Reef (nesting location of Sandy Islet, and 20 km radius internesting buffer) is shown in **Figure 2-1**.

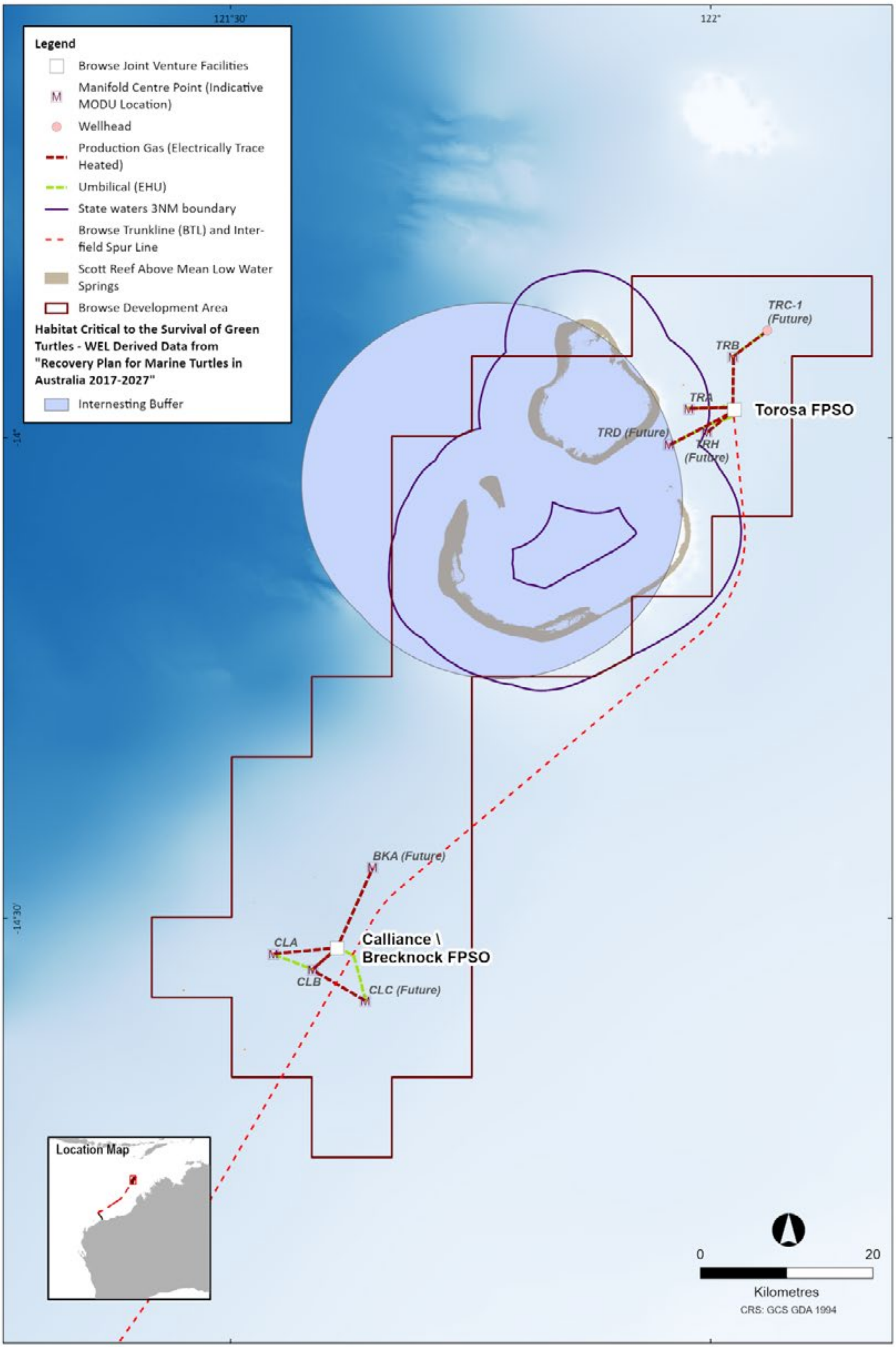

Figure 2-1 Habitat Critical to the Survival of green turtles at Scott Reef

2.1.3 Biologically Important Areas

While not defined under the EPBC Act, biologically important areas (BIAs) are spatially delineated area where aggregations of individuals of a species are known to display biologically important behaviours such as breeding, foraging, resting or migration (Department of the Environment and Energy, 2019b). BIAs were developed simultaneously with the Marine Bioregional Plans to inform regulatory and management decisions and are not enforced by legislation (Department of the Environment and Energy, 2019b).

Within the Browse Development Area, Sandy Islet (a part of Scott Reef) and the surrounding waters around Scott Reef is a designated internesting BIA for green turtles (specifically the G-ScBr stock). There are a number of other nesting, internesting and foraging BIAs for green turtles within vicinity of the Project Area, including at Ashmore Reef, Cartier Island, Cassini Island and the Lacepede Islands (Commonwealth of Australia, 2017).

2.1.4 Life Cycle and Seasonality

All marine turtle species have complex life cycles involving active dispersal and several stages and periods of migration. For green turtles the life cycle begins with hatchlings moving from the nest above the high water mark to the beach and beyond to oceanic and coastal habitats, before returning 30 to 50 years later to the region of their birth to breed (Guinea, 2013). In the case of green turtles in the G-ScBr and Ashmore Reef green turtle genetic stock (G-AR), this life cycle may involve feeding and moving between reefs in the tropical Indian Ocean and northern Australia. During the breeding season green turtles from the G-ScBr and G-AR stocks congregate in October at their respective reefs where they mate (Whiting & Guinea, 2005; Guinea, 2013).

Seven surveys conducted at Scott Reef in 2006, 2008 and 2009 indicate that the summer months from late November to February are the preferred breeding season for green turtles at Sandy Islet (Guinea, 2009)—refer **Table 3-1**. While peak breeding occurred within this timeframe, 24% of green turtles tagged at Sandy Islet were first encountered during winter/spring surveys indicating that lower level nesting may occur year-round (Guinea, 2009), though to what extent is unknown.

Nesting activity reaches a peak in January and February with a peak in hatchling emergence approximately seven weeks later in March and April (Guinea, 2013)—refer **Table 3-1**. Also on the reef during the breeding season and throughout the year are the non-breeding sub-adult and adult turtles that forage and reside in the area. Genetic studies (Dethmers *et al*., 2006) revealed that these belong to other green turtle stocks in Western Australia and the Indian Ocean.

Table 3-1 Seasonality for green turtle nesting activities at Sandy Islet

Activity	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
Nesting / internesting																
Hatchling emergence																
Shoulder period																
Peak period																

As described by Guinea (2013), within the generalised life cycle there are at least two cycles that involve breeding females using the reefs, lagoons and beaches (Sandy Islet) at Scott Reef:

- the female nesting cycle – every two to eight years when female green turtles migrate from their foraging grounds to Scott Reef to breed (re-migration interval)

- the internesting cycle – females spend two to three months within the vicinity of the nesting island moving only short distances of some tens of kilometres or less and nesting from three to six times during the nesting season, every eight to 16 days.

2.1.5 Internesting Movements and Habitats

As detailed in Section 5.3.2.6.1 of the draft EIS/ERD, based on the movements of 11 satellite tagged females in the 2010 study (Guinea, 2010, 2011), the internesting cycle at Scott Reef in that one season appeared to have a maximum of five nesting events (i.e. the 11 individuals returned between one and four times), with an average internesting interval of 10 days. The females occupy an internesting habitat after each nesting event, primarily to rest and to develop the next clutch of eggs.

For green turtles these internesting habitats appear to be defined by their function rather than by location. At Scott Reef, the Guinea (2010) study showed that the satellite tagged turtles remained within 3 km of Sandy Islet during the internesting period, except for one individual which travelled into the South Scott Reef lagoon, 12 km south of Sandy Islet. The results of the 2010 study were consistent with the previous Pendoley (2005) satellite tagging of nesting green turtles at Sandy Islet, which indicated that individuals were not recorded farther than 14 km from Sandy Islet during the internesting period and most stayed within 5 km of Sandy Islet and in water depths of between 5 and 10 m.

Preferred internesting habitat at Scott Reef has been identified, from both satellite tagging studies and visual census, as the southern region of Sandy Islet, in waters over shallow sand (from 7 to 17 m; refer to Area A in **Figure 2-2**) and two areas of subtidal sandy substrate located to the south-west of Sandy Islet (Areas B and C in **Figure 2-2**). Internesting and other adult turtles preferred habitat comprising sandy substrates amongst coral blocks (Guinea, 2010), in relatively shallow water depths (<20 m). This is consistent with the findings of other studies of the internesting movements and behaviour of green turtles. The maximum depth that tagged green turtles at Ascension Island in the South Atlantic routinely reached during resting dives in the internesting period was between 18 and 20 m, with resting dives deeper than 20 m being extremely rare (Hays *et al*., 2000).

Based on satellite tracking of eight green turtles at the Lacepede Islands, Waayers *et al*. (2011) found that that during internesting periods females generally remained within 10 km of their nesting beaches (average of ~7 km). The extent of these internesting movements away from nesting beaches are supported by data for green turtles tracked at island and mainland rookeries within the Ningaloo Marine Park and the Muiron Islands Marine Management Area. This study recorded longshore movements in the range 2-9 km (mean of 3.5 km) for island nesting beaches, a range of 4-13 km (mean of 7.0 km) for mainland beaches, and similar offshore movements (island mean = 1.3 km, range 1-3 km; mainland mean = 2.7 km, range 1-7 km) (Tucker *et al*., 2020).

Male green turtles often aggregate close to nesting sites (1.2 to 8 km away) during October and November each year (Limpus, 1993). Both juvenile and mature male green turtles were observed in the internesting habitat around Sandy Islet during the 2010 survey (Guinea, 2010), indicating habitat use by other life stages.

Pendoley (2005) has also previously undertaken satellite tagging of nesting green turtles at Sandy Islet; four nesting females were tagged during the 2002/2003 and 2003/2004 nesting seasons. In keeping with the Guinea 2010 survey (Guinea 2010, 2011), individuals were not recorded farther than 14 km from Sandy Islet during the internesting period and most stayed within 5 km of Sandy Islet and in water depths of between 5 and 10 m. Furthermore, no tagged turtles swam off Scott Reef into waters deeper than 50 m, or into the channel between North and South Scott Reef (Pendoley 2005).

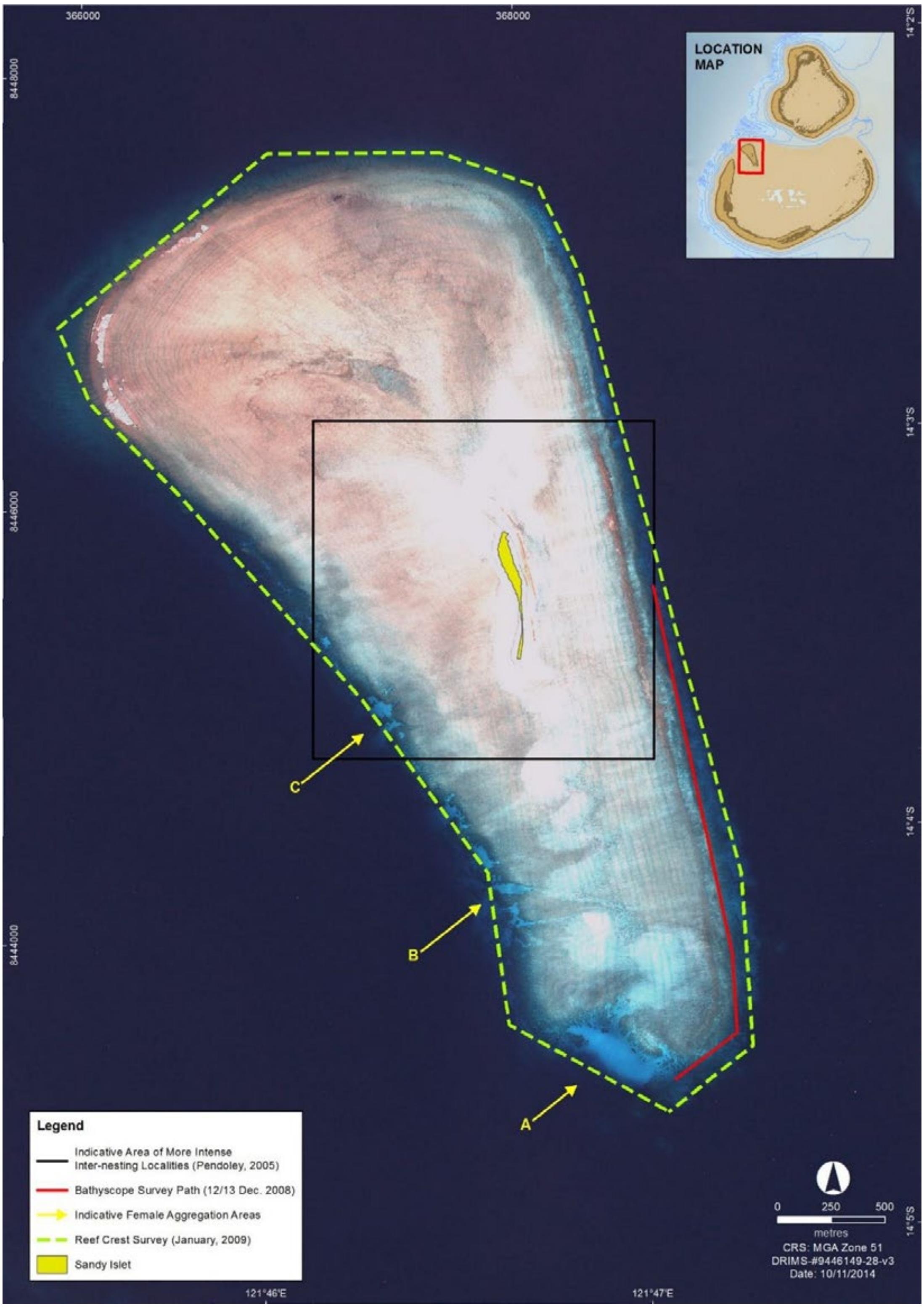

Figure 2-2 Areas of particular importance as known internesting areas for green turtles at Sandy Islet, as identified by Guinea (2009)

2.1.6 Resilience of Sandy Islet as a Nesting Habitat

It is apparent that Sandy Islet represents a spatially restricted nesting habitat—as described in Guinea (2010, 2011) green turtles were found to use the entire habitat of Sandy Islet for nesting, with seasonal variation recorded in the specific areas of the islet used for nesting, as well as in the shape of the sand habitat available for nesting. Disturbance of nests by subsequent nesting attempts of other females was common in the 2006 and 2009 surveys and was considered a main contributor to nest failure (Guinea, 2009). Disturbance was not as prevalent in the 2009/2010 season due to a lower density of nesting females (Guinea, 2010). Preference for nesting below the spring high water mark was observed in 2008/2009 (Guinea, 2009). These clutches are exposed to saltwater inundation which has been shown to increase mortality during incubation and potential result in complete failure of the clutch (Miller *et al.*, 2003).

The resilience of Sandy Islet as a rookery is potentially threatened by increasing sea temperatures and coral bleaching events, an increasing frequency of severe cyclone events, and the anticipated rise in sea level due to climate change.

2.1.7 Migratory Movements from Scott Reef

Satellite tagging studies (Pendoley, 2005; Guinea 2011) have provided an indication of the behaviour and migratory routes of adult green turtles leaving Scott Reef. Most animals appear to swim through South Reef lagoon and disperse toward the Western Australian mainland via two distinct post-nesting migration pathways (shown in Figure 5-38 of the draft EIS/ERD); travelling east and north toward the Bonaparte Archipelago and then north along the coast to foraging areas in Northern Territory waters, or travelling south to Cape Leveque and then south along the coast to the Turtle Islands off the mouth of the De Grey River in the Pilbara region.

Based on an analysis of satellite tracking data for 96 adult, female green turtles from 10 rookeries and two genetic stocks (Northwest Shelf stock and G-ScBr stock) Ferreira *et al.* (2021) broadly identified two migratory corridors, one used by the NWS stock-Pilbara and another used by the NWS stock-Kimberley and the G-ScBr stock with some overlap at the northern and southern extents respectively.

2.1.8 Knowledge Gaps for the G-ScBr Stock

There is a lack of data regarding the status of the G-ScBr stock, and existing data are not contemporary. The Recovery Plan lists the status of this stock as “Unknown”. Currently, there are several key knowledge gaps for this stock, as described below.

2.1.8.1 Population Size and Inter-seasonal Fluctuations

Estimates of green turtle nester abundance was calculated based on recapture history of tagged turtles on eight survey (recapture) nights in the 2008/2009 season (Guinea, 2009). Estimates of abundance varied between survey nights providing a mean (±SE) abundance of 779 ± 383 (i.e. a maximum of 1162 individuals) (Guinea, 2009). Mean (±SE) female nester abundance for 2009/10 was estimated at 79 ± 25 over eight survey nights using similar methodology (Guinea, 2010). In both seasons, the individual standard error of each estimate exceeded 50% and consequently, abundance estimates should be considered indicative only, especially given the assumptions associated with the methodology are unverified (Guinea, 2009; 2010).

The estimate of a maximum of 1162 females was applied to a modified internesting area (reef environment shallower than 50 m) to calculate a density estimate of 1.79 turtles/km^2 for Scott Reef, which was used for the ANIMAT modelling presented in the draft EIS/ERD.

Dethmers *et al.* (2006), using an analysis of genetic diversity, provides estimates of the annual number of breeding females as 300, and an effective population size of 2576 individuals. The

Recovery Plan appears to take the effective population size estimate from Dethmers et al. (2006) as the median for an estimated 1001-5000 females nesting per year for the Scott Reef-Browse Island stock (refer Figure 3 in the Recovery Plan). However, the proportion of this estimated 1001-5000 females utilising Sandy Islet versus Browse Island during any season is not known, as there are no estimates are available for the size of the Browse Island nesting population.

As reported in Guinea (2010) only 16 green turtles were tagged at Browse Island during the 2010 survey (compared to 56 at Scott Reef), and no manta tow surveys were conducted so no population estimates could be calculated. Olsen et al. (2017) provide a summary of green turtle sightings around Browse Island during the 2016 and 2017 seasons, with an indication that there was a much higher level of nesting activity occurring in October compared with April. No estimates of overall population size are provided.

As described in Section 5.3.2.6.1 of the draft EIS/ERD, based on the limited data available there appears to be considerable inter-seasonal fluctuation in the nesting population at Sandy Islet. As suggested by Guinea (2010), "*Possible reasons for the fluctuation in the Sandy Islet breeding population are likely to be linked to their trophic status and the fluctuations in food supply in the foraging grounds*". In northern and eastern Australia, fluctuations in green turtle nesting numbers have been linked the Southern Oscillation Index (Limpus & Nicholls, 1994, Limpus & Nicholls, 1988) and sea surface temperatures (Solow *et al*., 2002).

Additionally, inter-seasonal fluctuations in the numbers of females successfully nesting at Sandy Islet are likely to be linked to the availability of suitable areas of sand for nesting, which will change significantly year to year as a result of cyclonic events and other factors. In addition to monitoring to gain a better understanding of trends in nesting abundance, there is a clear need for long-term monitoring of the extent and quality of nesting habitat available each season at Sandy Islet.

2.1.8.2 Sandy Islet Hatchling Numbers

Information on the number of green turtle hatchlings successfully emerging from their nests on Sandy Islet and reaching the ocean during the peak nesting season is very limited and is complicated by the variation in the estimates of the size of the nesting green turtle population utilising this nesting location (refer above). As described in Section 5.3.2.6.1 of the draft EIS/ERD, hatchling numbers are likely to vary considerably from season to season, given that females can re-nest up to five times in one season, and the variability in the number of nests, hatching success and hatchling emergence success.

Excavation of clutches on Sandy Islet provided mean (±1 SD) hatch success and hatchling emergence success estimates of 80.2 ± 10.9% and 70.3 ± 17.4 respectively during the 2008/09 season (Guinea, 2009). In the 2009/2010 season, hatching success varied from 39.6% to 100% and emergence success varied from 28.6% to 96.2% (Guinea, 2010). Since clutches were identified by signs of emergence (e.g. observation of hatchlings emerging or hatchling tracks) these estimates do not account for failed clutches and are likely to overestimate success. Accordingly, extrapolation of success rates to provide estimates of the total number of hatchlings emerging and reaching the ocean within a season, survey period or survey night is limited in accuracy, especially considering the limitations in estimating nester abundance described above.

In absence of systematic marking of clutches, information regarding the fate of clutches is largely anecdotal (Pendoley Environmental, 2020). Predation of hatchlings is thought to be high once they enter the water (Stancyk, 1982) so hatchlings adopt a dispersal phase that involves rapidly swimming away from dangerous coastal water habitats (Wyneken & Salmon, 1992). To date, no information regarding post hatchling predation or dispersal of green turtle hatchlings emerging from Sandy Islet is available. Green turtle hatchlings have been tracked as they disperse through nearshore waters near Ningaloo Reef and were found to move directly away from the shoreline at speeds of 0.5 m/s

(Thums *et al*., 2016). Ocean currents influenced the bearing of hatchling tracks when they reached speeds of approximately 0.3 m/s (Thums *et al*., 2016).

2.1.8.3 Relative Importance of Sandy Islet to the G-ScBr Stock

Both Sandy Islet and Browse Island have been identified as 'Major' nesting areas for the stock, but given the lack of data on population size and trends in nesting abundance at both locations it is not possible to determine the relative importance of the two rookeries at a stock level. The availability of suitable nesting habitat at Browse Island each season could influence the numbers of females that utilise the alternative nesting location for this stock at Sandy Islet.

As described in the Recovery Plan, the G-ScBr stock is considered likely to be restricted in its capacity to expand into other nesting areas in the event that nesting beaches are lost or sand temperatures increase as a result of climate change.

2.1.8.4 Migratory Movements

Notwithstanding the previous satellite tagging studies (Pendoley, 2005; Guinea 2011), which provide an indication of the behaviour and migratory routes of adult green turtles leaving Scott Reef, there is a need for more information on the movements of hatchlings within the immediate vicinity of Sandy Islet and the broader Scott Reef-Seringapatam Reef area. Additionally, a better understanding is required of the movements and behaviour of adults migrating between Scott Reef and key foraging grounds for this species in Northern Territory waters and at the Cocos (Keeling) Islands, where individuals from the G-ScBr stock have been identified (Dethmers *et al*., 2010).

2.1.8.5 Extent of Illegal Harvest

As described in the Recovery Plan, there are anecdotal reports of illegal harvest of green turtle adults and eggs at Sandy Islet and Browse Island but the extent of this take is currently unknown. At present, there is a limited understanding of the current level of visitation by Indonesian fishers to Scott Reef; consequently, it is not possible to estimate the extent of this threat. Historically, the peak period for Indonesian fishing effort at Scott Reef was between July and October, due to more favourable wind conditions (i.e. outside of cyclone season, and the nesting season for green turtles). Monitoring of both levels of visitation by Indonesian fishers to Scott Reef, and their utilisation of Sandy Islet, is required to determine if any illegal harvest is occurring.

2.1.8.6 Key Threats and Priority Actions for the G-ScBr Stock

As identified in the Recovery Plan, there are three threats that are defined as having a High[2] level of risk for the G-ScBr stock:

- climate change and variability
- chemical and terrestrial discharge – acute and chronic
- habitat modification – infrastructure/coastal development.

Additionally, there are three other threats to this stock that are defined as having a Moderate[3] level of risk:

- light pollution
- vessel disturbance

[2] Additional mitigation action and an adaptive management plan required, the precautionary principle should be applied.

[3] Obtain additional information and, where multiple threats receive a moderate rating, develop additional mitigation action if required.

- noise interference – acute and chronic.

Priority actions specifically required to recover this stock are identified in the Recovery Plan as:

- manage anthropogenic activities to ensure marine turtles are not displaced from identified habitat critical to survival
- understand the implications of sea level rise for this stock
- establish a long-term monitoring program at index beaches to assess trends in nesting turtle abundance.

2.2 Sensitivity of Marine Turtles to Artificial Light

Little is known about the impact of artificial light on adult and juvenile turtles when they are offshore. Most studies around light impacts on adult and juvenile turtles at sea have stemmed from interactions of turtles with fishing gear (Pendoley Environmental, 2020). During internesting, turtles rest on the seabed, physically removing them from surface lighting sources, such as vessels, MODUs, FPSOs (Whittock et al. 2014). Since marine turtles do not feed during the breeding season (Limpus et al., 2013), attraction of internesting turtles to light sources as a secondary response to effects of light on prey distribution is not expected. Indeed, to date, there is no evidence to suggest internesting turtles are attracted to light from offshore vessels (Pendoley Environmental, 2020).

Internesting, breeding, foraging and migrating marine turtles do not use light cues to guide these behaviours. Further, there is no evidence, published or anecdotal, to suggest that internesting turtles are impacted by light from offshore vessels or installations. As such, light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages (Pendoley Environmental, 2020).

Turtle hatchlings typically emerge from their nests at night (Mrosovsky & Shettleworth, 1968) and must crawl rapidly to reach the ocean in order to avoid predation (Salmon, 2003). They find the ocean using a combination of topographic and brightness cues, orienting towards the lower, brighter oceanic horizon, and away from elevated darkened silhouettes of dunes and/or vegetation behind the point of their emergence on the beach (Pendoley & Kamrowski, 2015; Lohmann *et al*., 1997; Limpus & Kamrowski, 2013; Salmon *et al*., 1992). Artificial light at night can interfere with these cues, influencing their sea-finding behaviour (Withington & Martin, 2003; Pendoley & Kamrowski, 2015; Kamrowski *et al*., 2014). As a result, hatchlings may become disorientated, where they crawl in circuitous paths; or mis-orientated, where they move in the wrong direction, resulting in an increased mortality rate due to exhaustion, dehydration, or increased exposure to predation (Withington & Martin, 2003; Lohmann *et al*., 1997; Salmon 2003).

It is generally accepted amongst the scientific community that there is insufficient information to derive defensible thresholds/limits of light intensity or its visibility on marine turtles and specifically in relation to hatchling behaviour. This conclusion was determined following a comprehensive literature review on the impacts of artificial light on marine turtle hatchlings by specialists at Pendoley Environmental (Appendix A). Despite the conclusions of the review, valuable insights into the sensitivity of turtle hatchlings to artificial light were provided and are outlined in the section below.

2.2.1 Hatchling Orientation

A range of experimental studies have been undertaken to determine the sensitivity of turtle hatchlings to artificial light emissions. A selection of these studies is discussed below.

- Cruz *et al*. (2018) used an experimental design to measure the orientation of swimming olive ridley hatchlings exposed to lights with different wavelengths (red, 720 nm; yellow, 660 nm, and green, 520 nm) and intensities (0.1 – 3.3 lux, 10.3 – 45.9 lux, 47.5 – 84.2 lux, 91.3 – 140.8 lux, 150.1 – 623 lux), situated 2 m from a hatchling. The results indicated that hatchlings were attracted to green and yellow lights at low light intensities (0.1 – 45.9 lux) as well as red lights at high intensities (>39.3 lux). However, the experiment was undertaken under controlled experimental conditions with no variation in the distance of the light from the hatchling.

- Karnad *et al*. (2009) used controlled arena trial experiments to identify the influence of light wavelength (red, 580 – 800 nm; yellow, 475 – 600 nm; blue, 375 – 575 nm; violet, 300 – 450 nm), intensity (two intensities generated by an LED torch; four LED bulbs and eight LED bulbs of 15,000 mcd), and the influence of vegetation height on the orientation of olive ridley hatchlings. The study found that the wavelength and intensity of light interacted to influence hatchling orientation towards light. Hatchlings were found to orient towards high intensity light more than to low intensity light for all wavelengths except violet.
- Pendoley & Kamrowski (2015) used controlled field-based arena trial experiments involving flatback turtle hatchlings to measure their orientation when different types of light, placed at different orientations and elevations, were visible 150 m away. The type of lights included in the study were high pressure sodium vapour, metal halide, and fluorescent white light. The light's intensity was also varied, with low intensity considered 500 W, medium intensity as 1000 W, and high intensity as 1300 W for the metal halide and high-pressure sodium lights. At medium and high light intensities of all three light types, hatchlings were significantly less oriented towards the ocean when exposed to light at 2° elevation compared to 16° elevation; however, there was no indication of a limit or threshold at which hatchling sea-finding behaviour was influenced.

In addition to the experimental studies, *in situ* research into the effects of artificial light emissions has been undertaken and the results of relevant studies as summarised by Pendoley Environmental (2021) are presented below.

- Price *et al*. (2018) measured the intensity of visible light (320 – 700 nm) using a Sky Quality Meter (SQM) across various zones of a loggerhead turtle nesting beach in Florida. The study investigated the occurrence of hatchling turtle disorientation events recorded at the same beach and compared the orientation of hatchlings in each zone with the light intensity. The study found that luminance from artificial beachfront lighting may be related to increased incidences of hatchling disorientation but did not determine a luminance/intensity threshold at which more disorientations began to occur.
- Kamrowski *et al*. (2014) used both *in situ* nest fan measurements and results of controlled arena trial experiments to determine the influence of artificial light on the sea-finding of flatback turtle hatchlings at Peak and Curtis islands in Queensland. The study also involved the measurement of ambient light using a stellar photometer fitted with a V filter to ensure light at a wavelength of 480 – 660 nm was measured. The results indicated no disruption to hatchling sea-finding at Peak Island, whereas the sea-finding of hatchlings at Curtis Island was shown to be moderately disrupted. Due to constraints with the approach for measuring light, only comparisons of directional light and light between sights was provided.

Despite the numerous *in situ* and experimental studies that indicated light of a certain intensity and/or wavelength influenced hatchling sea-finding behaviour, no studies were able to account for the numerous inter-related variables that influence the intensity and visibility of artificial light to a hatchling turtle at a landscape scale. Hence, there are no generally accepted levels of artificial light that can be used as thresholds or limits for the purposes of this assessment.

3. ASPECTS RELEVANT TO THIS PLAN

3.1 Light Emissions

3.1.1 Source of Aspect

Lighting from the proposed project activities will be long-term, that is, over the life of the project. Artificial light emissions will be generated from the following sources:

- Navigational and operational lighting – these functional lighting sources are required on vessels, MODU and FPSO facilities at levels that provide a safe working environment for personnel and ensure maritime shipping safety. Standard lighting on marine vessels typically consists of bright white (i.e. metal halide, halogen, fluorescent) lights and is not dissimilar to lighting used for other offshore activities, including fishing and shipping.
- FPSO marine and operational lighting – Browse FPSO's use ”turtle friendly” versions of all light sources to minimise the potential for biological impacts. On average, illumination levels of approximately 200 Lux will be used in outdoor operational areas. Further details on which lighting types are considered appropriate for usage near turtle nesting habits (“turtle friendly”) is within Table 6 of the National Light Pollution Guidelines (Commonwealth of Australia, 2020).
- Flaring - during hydrocarbon processing or occasionally during drilling operations, flare stacks are used for burning off flammable gas released, to ensure it is not accidently ignited in an unsafe location. Light emissions are associated with intermittent flaring from the FPSOs and MODU. These will vary in duration and intensity. There will be no continuous flaring during normal operations, with the exception of pilot gas and compressor seal gas. Flaring most often takes place during start-ups and shutdowns or in emergency events.

Light sources and, therefore, light emissions within the Browse Development Area will vary depending on the phase of the proposed Browse Project. It is likely that the footprint from light emissions will be highest during the construction phase (i.e. drilling and installation) due to the presence of multiple vessels and MODUs. Light sources are likely to be reduced during routine operations as primary light sources will be from the FPSOs. Lighting from MODU operations will be transient at each drill centre (typically in the order of two to three months per well), with flaring associated with well unloading only in the order of 1-2 days per well.

Light emissions will also be generated as part of the proposed BTL and inter-field spur installation activities; however, the impact from these emissions are likely to be temporary and minor. This is because the pipelay vessels will move along the proposed BTL route and inter-field spur line route at a rate of up to approximately 5 km/day (depending on the pipelay vessel and operational conditions such as sea state) meaning light emissions in any one area will be short-term. Once the BTL and inter-field spur lines are operational, there will be no ongoing light emissions except occasional vessel lights during IMR activities.

Table 3-1 summaries the light emissions that will occur in associated with each project activity.

Table 3-1 Sources of light emissions

Activity	Source of light emissions
Piling	• Navigational and operational lighting on the piling vessel(s). • Navigational and operational lighting on support vessel(s).
Drilling and completions	• Navigational and operational lighting on the MODU(s) • Navigational and operational lighting on support vessel(s).

Activity	Source of light emissions
	• Intermittent (~48 hours per well) flaring from the MODU during well unloading and unplanned contingency activities. This would be expected to occur at rates of up to approximately 70MM scf/day.
SURF Installation	• Navigational and operational lighting on the installation vessel(s). • Navigational and operational lighting and support vessel(s).
BTL and inter-field spur line installation	• Navigational and operational lighting on the installation vessel(s). • Navigational and operational lighting on support vessel(s).
FPSO installation / commissioning	• Navigational and operational lighting on FPSOs. • Navigational and operational lighting on support vessel(s).
Operations	• Navigational and operational lighting on FPSOs. • Navigational and operational lighting on support vessel(s). • Flaring from the FPSOs including during commissioning, operations and upset scenarios.
IMR	• Navigational and operational lighting on IMR vessel(s). • Navigational and operational lighting on support vessel(s).
Decommissioning	• Navigational and operational lighting on decommissioning vessel(s). • Navigational and operational lighting on support vessel(s).
Support activities and infrastructure	• Navigational and operational lighting on support vessel(s).

3.1.2 Light Modelling

To support the outcomes of the assessment of light emissions on marine turtles for the proposed Browse Project, modelling of the artificial light emissions from the proposed offshore facilities was undertaken. The scope, methodology and results of the modelling study (Pendoley Environmental, 2021b) are summarised below and included as Appendix A to this Plan.

3.1.2.1 Methodology

Currently, there are no standard commercial models for landscape scale modelling of artificial light emissions (Commonwealth of Australia, 2020). The base model used for this study was the ILLUMINA model that has been developed at Sherbrooke University, Canada (Aubé *et al*., 2005). This well-documented, open-source model was selected for its ability to represent light across large areas and distances and equally across the entire visible spectrum, including biologically meaningful light from 350 nm – 700 nm. The model is three-dimensional and accounts for both line-of-sight light visibility in addition to the glow derived from atmospheric scattering of light. The model also addresses the attenuation/loss of light over landscape scale distances and, consequently, the areal extent of light glow across the sky can be modelled (Pendoley Environmental, 2021b).

The model input parameters include project specific details about light type and spectral distribution, including any shielding. The model also includes project location-specific inputs, such as surface reflectance and topographic values that are incorporated from aerial imagery (Pendoley Environmental, 2021b).

3.1.2.2 Description of Model Outputs

The results of the modelling were demonstrated as an 'all-sky' panorama image as viewed from the observer viewpoint. The modelled panorama images show the predicted brightness (including direct, reflected and refracted light) across the whole sky, including the horizon, for each of the seven scenarios (see **Figure 3-1** for an example). The predicted brightness is expressed in units of absolute radiance (W/m^2/sr), where W = watts, m^2=metres squared and sr = steradian. This value has then been converted to Full Moon Equivalents (FME – e.g. a relative unit of measure used to compare light received to that of a full moon) to give the radiance output some biological relevance and to aid interpretation in an environmental impact assessment context.

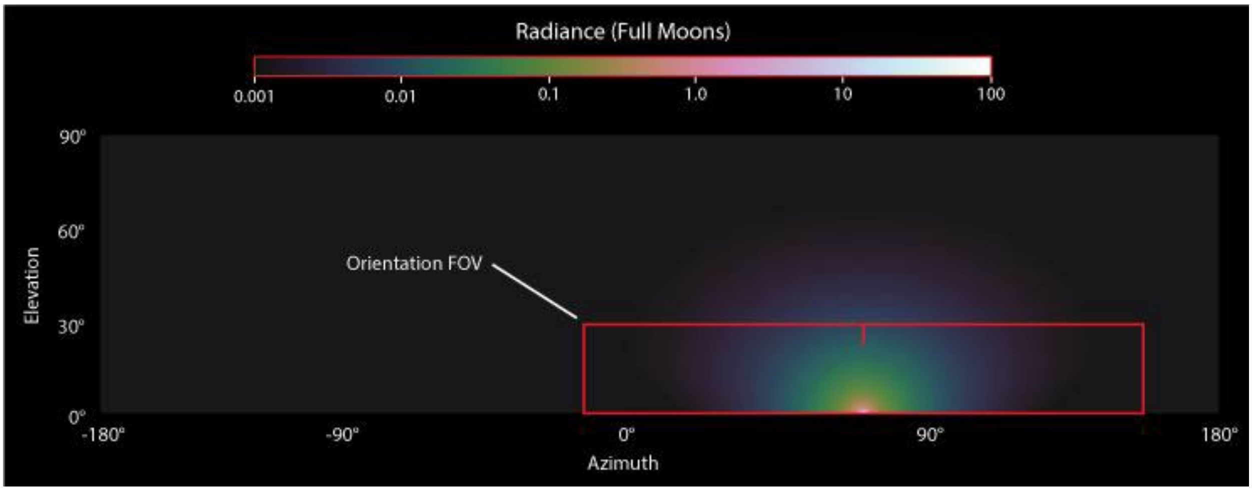

Figure 3-1 Example all-sky modelled image from an observer location showing predicted brightness

The sensitivity of a hatchling turtle to directional light can be described by a specific 'cone of acceptance', which indicates how much of the world a hatchling views and measures at any one instant, defined by Witherington (1992) as 180° horizontally and 30° vertically. To understand potential impacts on hatchling behaviour, all pixels in the 180° x 30° window centred over the brightest light source at the observer viewpoint are averaged (**Figure 3-1**), with the results presented as an orientation field of view in FME units.

3.1.2.3 Model Assumptions & Inputs

3.1.2.3.1 Operational Lighting Assumptions (FPSO and MODU)

As there was only high-level lighting detail available at this stage of the project, several assumptions had to be made to generate a lighting inventory for the Torosa FPSO and MODU as follows:

- When generating the lighting inventory, illumination levels were assumed to be 150% higher than required to provide a conservative estimate of light output.
- All operations lighting on the FPSO was assumed to have a colour temperature of 3000 K.
- All operations lighting on the MODU was assumed to have a colour temperature of 6500 K.
- All interior or enclosed lighting was assumed to be 100% shielded and therefore not represented within the model.

All scenarios included standard operational lighting levels. In relation to the Torosa FPSO, this is the normal level of external lighting expected to be required on the facility. The model has been informed through a review of the deck plan of the FPSO and safe working lighting levels required in each area. Operational Lighting has assumed to be installed in accordance with Best Practice guidelines, including appropriate wavelengths using mainly LED lighting, implementing light shielding where necessary.

3.1.2.3.2 Flaring Assumptions

Light from the Torosa FPSO flare tower is the only light source expected to be directly visible (based on height above the horizon at Sandy Islet for extended periods of time during the Proposal life).

As changes in flare activity are likely to have the greatest impact on light emissions visible from Sandy Islet, a total of five different flares scenarios were modelled, described in **Table 3-2**.

Table 3-2 Flaring scenarios used for light impact assessment modelling

Flaring descriptor	Typical cause	Rate (MM scf/day)	Predicted duration (maximum)	Duration as proportion of year
Background/typical flaring	Normal operational flaring rates	1	335 days per year	92%
Minor upset flaring	Flash gas compressor outage	25	Up to 15 days per year (but average of 8 days per year)	4.1%
Moderate upset flaring	Facility restart	125	240 hours[1] per year (total 10 days)	2.8%
Major upset flaring	Facility depressurisation post trip	250	96 hours[1] per year (total 4 days)	1%
Commissioning flaring				
Torosa FPSO Commissioning flaring (one off activity)	Flaring required to commission production equipment	250	Up to 8 weeks during a six month commissioning period	Up to 25% of a single year.

1 – Events of this nature typically last less than 24 consecutive hours

- **Background flaring:** The Browse FPSOs are designed to eliminate the need for flaring during steady state operations. The background (or baseline) flaring rate is aligned to flaring expected for >92% of the facility life. Flaring only occurs as a result of a pilot flame and compressor seal gas sent to flare. The predicted total flaring rate during these conditions is approximately 0.25 MMscf/day but modelling conservatively assumes a rate of 1 MMscf/day.
- **Minor upset flaring (e.g. flash gas compressor outage)**: In some circumstances, equipment required as part of the flaring elimination system may be temporarily offline, with the most obviously example being low pressure gas recovery compressors, which take gas that on typical facilities would be flared, and recovers it back to the production system. If this equipment is offline, there may be relatively small flaring that occurs for the duration of the outage. The flaring rate assumed in the model is conservatively assumed to be 25 MMscf/day. It is assumed to occur for no more than 15 days in any given year but no more than 40 days in any given five year period.
- **Moderate upset flaring (e.g. facility restart flaring):** This rate of flaring can occur for short durations (e.g. less than 48 hours) when the FPSO is re-starting after a trip/shutdown while gas is brought on specification, but is not expected to be sustained for extended durations. The flaring rate assumed in the model is conservatively assumed to be 125 MMscf/day. This flaring rate is assumed to occur for no more than 240 hours per year (total 10 days) per year based on facility reliability forecasts.
- **Major upset flaring (e.g. trips):** Major upset flaring where a significant rate of flaring is required due to a major equipment upset, most typically associated with a facility outage where gas cannot be processed so the facility is depressurised by diverting gas to the flare. The facility would not

typically be producing when flaring of this rate is occurring and therefore in normal operations, flaring of this rate would be limited to approximately 96 hours (total four days) per year. This flaring rate is based on the indicative maximum design capacity of the flare system that could be sustained for any significant period of time (i.e. more than 15 minutes) without potentially impacting the integrity of the flare itself.

- **Torosa FPSO commissioning flaring:** During a one-off commissioning activity, flaring at elevated levels may be required as gas must flow through the FPSO to commission equipment but it will not meet gas export specifications. Commissioning flaring is expected to occur for 4 – 6 weeks but is conservatively assumed to occur for up to 90 days during a six month commissioning period to account for unforeseen circumstances. The flaring rate assumed in the model is assumed the indicative maximum design capacity of the flaring system that can be sustained for any significant period of time (i.e. more than 1 hour) without potentially impacting the integrity of the flare itself.
- **Well clean up flaring:** Well unloading during the drilling and completions of the well requires the flaring of gas from the MODU as it cannot be sent to the FPSO for processing as it may have contain containments from the newly completed well. Gas that cannot be used is flared for safety reasons. The flaring rate assumed in the model is conservatively assumed to be 70 MMscf/day. Clean up flaring is only required for a maximum of 48 hours (total two days) at each well.

3.1.2.3.3 Cloud Cover

To inform the interpretation of modelling results, a review was undertaken of historic cloud coverage, which was obtained from the Broome Observatory (the closest to the project location) for a 5 year period (2017 – 2021) and the results are shown in **Table 3-4**. Cloud cover was examined for both the whole year and for turtle nesting season (November – April). The data showed that the sky was generally fine (very little cloud) for 86.5% of the year or 77.6% of turtle nesting season. The sky was at least partly cloudy (>3/8^{ths} sky covered) for 22% (34 days) of each nesting season historically and cloudy (>6/8ths sky covered) for only 11% of the nesting season. January and February were the months with highest frequency of overcast days.

Cloud cover was split into three categories of cover that align to modelling scenarios and the results are summarised in **Table** 3-3 and shown in **Table 3-4.**

Table 3-3 Summary of historic cloud cover data from the Broome region (2017 - 2021).

Cloud Descriptor	Cloud Level	# Days per Year	% Days Per Year	#Days per Nesting Season	%Days per Nesting Season
Fine	<25% (<2 oktas)	316	86.5%	118	77.6%
Partly cloudy	25-75%	22	6.1%	17	11.1%
Cloudy / overcast	>75% (>6 oktas)	27	7.3%	17	11.1%

Table 3-4 Typical cloud coverage in the Broome region (days as % of month) based on five years of historic observations.

Typical number of days (% of month)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fine	64	68	85	95	93	92	95	95	94	91	89	77
Partly cloudy	14	16	6	3	2	2	1	1	2	5	8	13

Cloudy / overcast	22	16	9	2	5	6	4	3	4	3	3	11

3.1.2.3.4 Relative frequency of occurrence of each lighting scenarios

As is relevant to modelling interpretation, the **Table 3-5** shows the number of days within any given year each of the expected levels of FPSO flaring would be expected to occur in different cloud conditions. The analysis is based on a multiplication of data within **Table 3-2** and **Table 3-3**.

Table 3-5 Number of days per year (italics) on which combination of flaring and cloud cover used in light modelling scenarios are expected to occur.

Calculation of flaring rates occurring during specified cloud conditions.			**Cloud coverage (typical % of year)**		
			Clear	**Partly cloudy**	**Mostly cloudy**
			77.6%	11.1%	11.1%
Flaring rate and expected occurrence (% of year)	**Background**	92.0%	*261*	*37*	*37*
	Minor	4.1%	*12*	*2*	*2*
	Moderate	2.8%	*8*	*1*	*1*
	Major	1.0%	*3*	*~1*	

3.1.2.4 Model Scenarios

Modelling of predicted light from the FPSO, MODU at the TRA drill centre and MODU at the TRD drill centre was undertaken using a single observer viewpoint on Sandy Islet for all scenarios.

Scenarios

The flaring scenarios were separated into three categories:

1. FPSO only: (Individual Scenarios; IS1 – IS6)
2. MODU only (Individual Scenarios; IS5 and IS6)
3. FPSO and MODU together (Cumulative Scenarios; CS1 – CS4)

These scenarios were also run in both clear (**A**) and mostly cloudy (**B**) sky conditions and are outlined in **Table 3-6**.

Table 3-6 Summary of the modelled scenarios, the vessel inventory and cloud parameters

Vessel	**Vessel Parameters**		**Scenario Code[4]**	**Cloud Parameters**		
	Inventory	**Period (days/yr)**		**Cover (%)**	**Height (km)**	**Period (d/yr)**
FPSO	Background Flaring	365	**IS1A**	0	0	118
			IS1B	80	3	17
	Minor Upset Flaring	15	**IS2A**	0	0	118
			IS2B	80	3	17
	Moderate (Unplanned) Upset Flaring	12	**IS3A**	0	0	118
			IS3B	80	3	17

[4] Where "A" Scenarios denote clear conditions and "B" Scenarios are in cloudy sky conditions. OFOV units are in Full Moon Equivalents

	Major Upset Flaring	12	**IS4A**	0	0	118
			IS4B	80	3	17
MODU	Operation Light at TRD	365	**IS5**	0	0	118
	Well Clean Up Flaring at TRA	8	**IS6**	0	0	118
FPSO + MODU	Background Flaring Operation Light at TRD	365	**CS1A**	0	0	17
			CS1B	80	10	17
	Minor Upset Flaring Well Clean Up Flaring at TRA	15 8	**CS2A**	0	0	118
			CS2B	80	10	17
	Moderate Upset Flaring Well Clean Up Flaring at TRA	12 8	**CS3A**	0	0	118
			CS3B	80	10	17
	Major Upset Flaring Well Clean Up Flaring at TRA	12 8	**CS4A**	0	0	118
			CS4B	80	10	17

3.1.2.5 Impact Criteria

As outlined in **Section 2.2.1**, there is insufficient information to derive thresholds or limits of light intensity or its visibility on marine turtles, specifically in relation to hatchling behaviour. In the absence of such thresholds, FME units were used and applied to the results of the modelling, with predicted impacts based on these results (**Table 3-7**). This approach is consistent with the process of expert elicitation and builds on available research findings in the absence of detailed empirical data (Burgman 2005; Burgman *et al*., 2011; Patterson *et al*., 2007).

Table 3-7 Proxy artificial light impact criteria for marine turtles, referred to as FME within this plan.

Impact Level	Radiance as Full Moon Equivalents (FME)	Impact potential to marine turtles
4	1 - 10	Light or light glow visible and impact likely, represents a very bright light equivalence to up to 10 times the radiance of one moon. This level of artificial light radiance will override the moderating influence of the ambient full moon at the time of exposure.
3	0.1 - 1	Light or light glow visible and behavioural impact possible, depending on ambient moon phase at the time of exposure, which will influence the visibility of the artificial light sources, equivalent to the light output. Artificial lights will be more visible to marine turtles under a first quarter moon than under a full moon.
2	0.01 - 0.1	Light or light glow visible but behavioural impact unlikely (i.e. not biologically relevant). Equivalent to the light output from the first quarter moon to new moon.
1	<0.01	Light or light glow is considered ambient, and no impact expected. Equivalent to a new moon

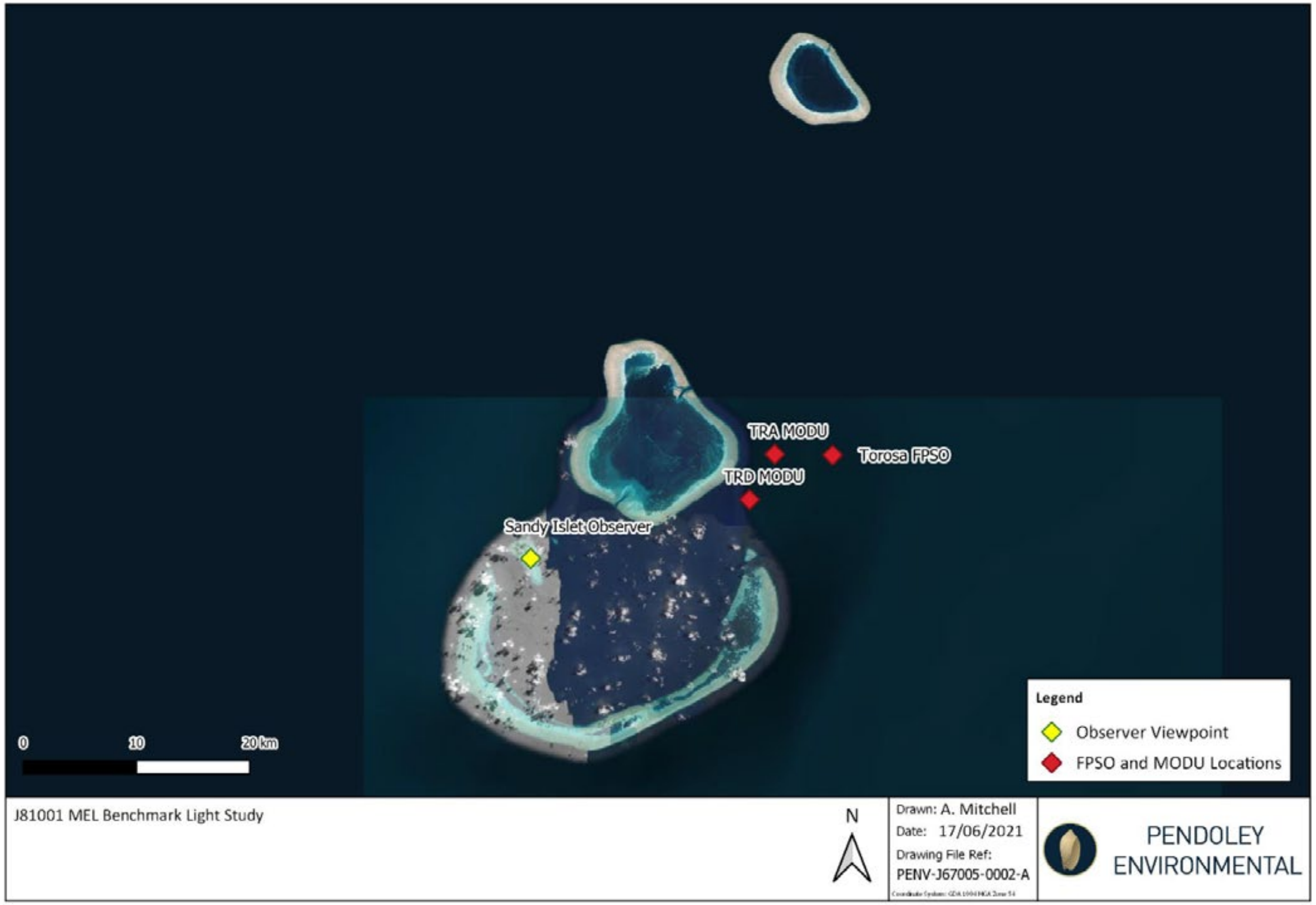

Figure 3-2 Location of the Sandy Islet observer viewpoint and facilities considered in the modelling (Torosa FPSO and the MODU at TRA and TRD drill centres) (Pendoley Environmental, 2021b)

3.1.3 Light Modelling Results

The modelling of 18 different scenarios was completed, with 10 Individual Scenarios (IS), and eight Cumulative Scenarios (CS), results are shown in **Table 3-8**.

Table 3-8 Orientation Field of View (FOV) values for each scenario (FME)

Vessel	Lighting Inventory	Scenario Name[5]	OFOV (FME)	Impact Level
FPSO	Background Flaring	IS1A IS1B	0.004 0.010*	1 2
	Minor Upset Flaring	IS2A IS2B	0.009 0.028	1 2
	Moderate (Unplanned) Upset Flaring	IS3A IS3B	0.031 0.116	2 3
	Major Upset Flaring	IS4A IS4B	0.041 0.156	2 3
MODU	Operational Lighting at TRD	IS5	0.001	1
	Well Clean Up Flaring at TRA	IS6	0.020	2
FPSO + MODU	Background Flaring & MODU (not flaring) at TRD	CS1A CS1B	0.006 0.012	1 2
	Minor Upset Flaring & MODU Flaring at TRA	CS2A CS2B	0.030 0.103	2 3
	Moderate Upset Flaring & MODU Flaring at TRA	CS3A CS3B	0.054 0.192	2 3
	Major Upset Flaring & MODU Flaring at TRA	CS4A CS4B	0.065 0.236	2 3

*30% cloud cover has an OFOV of 0.08 as per “additional scenarios” within Appendix A.

3.1.3.1 FPSO

In IS1A - 4A (clear sky conditions, various flaring scenarios) the FPSO is identifiable as a small point source of direct light on the horizon, predominantly due to the height of the flare (base height: 182 m above sea level). The areal extent of sky glow from the FPSO correlates strongly with flaring intensity ranging from minimal levels during background flaring and extending across the sky during minor major upset flaring scenarios.

Orientation FOV (OFOV) Full Moon Equivalent (FME) values correlate strongly with flaring intensity and the resulting changes in sky glow extent, with values decreasing with flaring rates, from 0.041 for major flaring to 0.009 for minor flaring rates and 0.004 from routine or background flaring rates.

The impact of clouds on sky glow is clearly demonstrated in IS1B - 4B by the order of magnitude increase in OFOV FME values, with the smallest increase occurring in IS1B (0.01; 239%) and increasing in IS2B (0.028; 293%), IS3B (0.116; 371%), and IS4B (0.156; 377%) (**Table 3-8**).

A summary of the OFOV and corresponding impact level is show in **Table 3-9**. A summary of the expected number of days at which impact level would occur is shown in **Table 3-10**.

[5] Where “A” Scenarios denote clear conditions and “B” Scenarios are in cloudy sky conditions. OFOV units are in Full Moon Equivalents

Table 3-9 Summary of modelling results showing OFOV (FME) and impact level (in brackets) for each operational scenario permutation.

Light Impact predictions		Cloud cover scenario		
		Clear	Partly cloudy	Mostly cloudy
Flaring assumption	Background	0.004 (1)	0.008 (1)	0.010 (2)
	Minor	0.009 (1)	0.018 (2)	0.028 (2)
	Moderate	0.031 (2)	0.062 (2)	0.116 (3)
	Major	0.041 (2)	0.08 (2)	0.156 (3)

1 – Interpolated (not modelled) using a ratio of clear:partly cloudy of 1:2 informed by 'background' flaring scenario outcomes.

Table 3-10 Estimated duration (days per year) at which each given impact level will occur during operation of the Torosa FPSO only.

Impact Level	Frequency of occurrence (applicable to years in which no drilling of commissioning occurs)
1	298 days
2	65.5 days
3	1.5 days
4	Not predicted to occur

3.1.3.2 MODU

Modelling demonstrates that in isolation from FPSO operation and in clear conditions, the modelled MODU when operating but not flaring at TRD shows almost no visible sky glow with only very low levels of light reflecting off the ocean below 2° elevation and an OFOV value of 0.001. TRD is the closest MODU to Sandy Islet located approximately 18 km away.

The model results show the impact of flaring from the MODU at the TRA site (IS6), where the extent of the sky glow increases substantially within the OFOV to 0.020, which is approximately 18 times brighter than the MODU without flaring at the TRD site (IS5).

A summary of either modelled or interpolated results for MODU OFOV is shown in **Table 3-11**. Only when the MODU was flaring was it expected to exceed OFOV corresponding to Impact Level 2. In any cloud conditions, the MODU would not exceed impact level 1.

Table 3-11 Summary of modelled and interpolated results showing OFOV (FME) and impact level (in brackets) for MODU operational scenarios during different cloud conditions.

Light Impact predictions		Cloud cover scenario		
		Clear	Partly cloudy	Mostly cloudy
Flaring assumption	MODU Not flaring (Modelled at TRD)	0.001 (1)	0.0021 (1)	0.0041 (1)
	MODU Flaring (Modelled at TRA)	0.02 (2)	0.04 (2)	0.08 (2)

1 – Interpolated (not modelled) using a OFOC (FME) ratio of clear:partly cloudy of 1:2 and clear:mostly cloudy of 1:4 derived conservatively from the modelling data set.

Table 3-12 Estimated duration (days per year) at which each given impact level will occur during operation of MODU within the Torosa field (prior to Torosa FPSO operations commencing).

Impact Level	Frequency of occurrence during MODU operations prior to FPSO operations commencing
1	365 days
2	Not predicted to occur
3	Not predicted to occur
4	Not predicted to occur

3.1.3.3 Commissioning flaring (Torosa FPSO)

A flaring rate representative of the maximum which may occur during commissioning ('major' flaring) was modelled, including in different cloud conditions. In cloudless conditions, commissioning flaring is expected to generate light at impact level 2. In higher cloud cover periods, the effect of this sky glow increases impacts to level 3.

Commissioning flaring is expected to occur for 6 – 12 weeks within a 6 month commissioning window. Given the magnitude but brief duration of the impact which cannot be avoided but the duration is highly uncertain, a commitment has been made to plan FPSO operations so that commissioning commences outside of peak turtle nesting season.

3.1.3.4 Construction & Support vessels

In addition to the modelling of the FPSO and MODU facilities, a review of the potential impacts on turtles associated with artificial lighting from offshore construction vessels (pipelay and a standard OSV) was undertaken. Light modelling undertaken for the proposed pipelay vessel (*Audacia*) for the Barossa Gas Export Pipeline demonstrated that light emissions from the vessel were reduced to ambient levels at approximately 11 km from the source, and at approximately 3.3 km from the vessel lighting emissions were predicted to be 0.1 FME (equivalent to the light output from the first quarter moon to new moon; **Table 3-7**). Therefore, whilst light will be visible, it is unlikely to result in any behavioural impacts on turtles. However, behavioural impacts may occur within approximately 3.3 km of the pipelay vessel (ConocoPhillips Australia, 2019). Modelling of the construction vessel demonstrated that light emissions were reduced to ambient levels approximately 1.6 km from the vessel. At approximately 0.5 km from the vessel, lighting emissions were predicted to be 0.1 FME and therefore, whilst light will be visible, it is unlikely to result in any behavioural impacts on turtles; however, behavioural impacts may occur within 0.5 km of the construction vessel (ConocoPhillips Australia, 2019).

3.1.3.5 Cumulative Scenarios

A range of cumulative scenarios considering FPSO flaring, MODU activity and cloud coverage stages were assessed. Only in two circumstances did the presence of the MODU result in an increase in impact levels from the non-cumulative equivalent. These were for the for FPSO minor flaring during clear conditions or background flaring during partly cloudy conditions.

A summary of the OFOV (FME) and expected impact level is shown in **Table 3-13** for each of the cumulative scenarios examined. As per **Table 3-14**, the cumulative impact of MODU activities with FPSO operations leads to an additional 49 days per year (assuming the MODU is active every day of the year). This scenario can only occur for a maximum of approximately 5 years, as once the FPSO arrives there is only a need to drill an additional 19 wells, with each well taking a maximum of 3 months each.

Table 3-13 Summary of modelling results showing OFOV (FME) and impact level (in brackets) for each operational scenario permutation. Scenarios which increased an impact level are underlined,

Light Impact predictions		Cloud cover scenario		
		Clear	Partly cloudy	Mostly cloudy
Flaring assumption + MODU lighting (as at TRD)	Background	0.005 (1)	<u>0.0101 (2)</u>	0.0141 (2)
	Minor	<u>0.01 (2)</u>	0.0201 (2)	0.0321 (2)
	Moderate	0.032 (2)	0.0641 (2)	0.1201 (3)
	Major	0.042 (2)	0.0821 (2)	0.1601 (3)

1 – Interpolated (not modelled) as being between modelled cloud cover levels and informed by modelling of background flaring rates during different conditions.

Table 3-14 Estimated duration (days per year) at which each given impact level will occur during operation of MODU within the Torosa field simultaneously with Torosa FPSO operations. Change to FPSO only (Table 3-10) is shown in brackets.

Impact Level	Frequency of occurrence during FPSO operations concurrent with MODU operations (assumes a full 12 months of MODU activity)
1	249 days (-49 days)
2	114 days (+49 days)
3	1.5 days (No change)
4	Not predicted

3.1.4 Impact Assessment

The light modelling study further assessed the likely impacts on the life history stages and behaviours of green turtles associated with each of the modelled scenarios. A summary of this assessment is provided in **Table 3-15** and detailed overview is provided in **Table 3-16** to **Table 3-19**.

Table 3-15 Summary key findings for potential impacts to green turtles at Scott Reef across life stages and lighting impact levels

Impact Level	Nesting	Hatchling sea finding	Hatchling dispersal	Mating / Internesting / Foraging / Migration
1	No impact predicted	No impact predicted	No impact predicted	No impact predicted
2	No impact predicted	Light and light glow highly visible, behavioural impact unlikely	Light and light glow highly visible, behavioural impact unlikely	No impact predicted
3	Minor impact possible	Light and light glow highly visible, behavioural impact unlikely	Light and light glow highly visible, behavioural impact unlikely	No impact predicted

4	Not assessed, as not predicted to occur

Table 3-16 Impact Level 1 – Continuous Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility **2. Scenario code** **3. Duration of impact** **4. Distance from Sandy Islet**	**Scenario code Orientation FOV (FME)** **Figure #**	**Life history stage / behaviour and impact pathway**			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1. FPSO 2. IS1A; CS1A 3. Continuous throughout 44-year project life 4. ~29 km 1. MODU (TRD) 2. IS5 3. 18 months at given TR site. 4. ~20 km	IS1A – 0.004 CS1A – 0.009 IS5 – 0.001 (Figures 4, 8 and 9 of Appendix A)	**No impact predicted** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a small area of dim glow low on the horizon, which will have no impact on nesting females. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts, depending upon the intensity.	**No impact predicted** • The modelled radiometric visibility of the light source(s) indicates the facilities will appear as a small area of dim glow within the orientation FOV, which is not likely to have any impact on hatchlings during sea-finding. • In the absence of dunes/topographic features, hatchlings may orient towards artificial light source rather than ocean horizon. • Behavioural response may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of light sources, and lunar phase at emergence.	**No impact predicted** • Potential for hatchling dispersal behaviour to be affected decreases with distance to shore. • Light sources located from ~20 - 29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be very low, and few individuals will be at risk of attraction • Surface currents at Scott Reef will carry hatchlings on, and in the direction, of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will either reach or be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impact to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

Table 3-17 Impact Level 1 – Intermittent Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility 2. Scenario code 3. Duration of impact 4. Distance from Sandy Islet	Scenario code Orientation FOV (FME) Figure #	Life history stage / behaviour and impact pathway			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1. FPSO 2. IS2A 3. Flaring Intermittently 4. ~29 km	IS2A – 0.009 (Figure 5 of Appendix A)	**No impact predicted** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a small area of dim glow low on the horizon, which will have no impact on nesting females. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts, depending upon the intensity. • Flaring may occur intermittently during 1 nesting season.	**No impact predicted** • The modelled radiometric visibility of the light source(s) indicates the facility will appear as a small area of dim glow within the orientation FOV, which is not likely to have any impact on hatchlings during sea-finding. • In the absence of dunes/topographic features, hatchlings may orient towards artificial light source rather than ocean horizon. • Behavioural response may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of light sources, and lunar phase at emergence. • Duration and rate of flaring is difficult to predict but it is likely to be limited to a small proportion of hatchlings emerging at any time, i.e. the increased brightness and extent of sky glow under different flaring conditions will not be a static long term stressor impacting all emerging hatchlings across an entire nesting season.	**No impact predicted** • Potential for hatchling dispersal behaviour to be affected decreases with distance to shore. • Light sources located from ~20- 29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be very low, and few individuals will be at risk of attraction • Surface currents at Scott Reef will carry hatchlings on, and in the direction, of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will either reach or be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

Table 3-18 Impact Level 2 – Intermittent Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility 2. Scenario code 3. Duration of impact 4. Distance from Sandy Islet	Scenario code Orientation FOV (FME) Figure #	Life history stage / behaviour and impact pathway			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1. FPSO 2. IS3A, IS4A, IS1B, IS2B 3. Flaring and overcast intermittently 4. ~29 km 1. MODU 2. IS6 3. Flaring intermittently 4. ~20 km 1. FPSO + MODU 2. CS1B, CS2A, CS3A, CS4A 3. Flaring intermittently 4. ~20-29 km	IS1B - 0.010 IS2B - 0.029 IS3A – 0.031 IS4A – 0.041 IS6 – 0.020 CS1B – 0.012 CS2A – 0.030 CS3A – 0.054 CS4A – 0.065 (Figures 4 – 12 of Appendix A)	**No impact predicted** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a small area of dim glow low on the horizon, which will have no impact on nesting females. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts, depending upon the intensity. • Flaring may occur intermittently during 1 nesting season.	**Light and light glow highly visible, behavioural impact unlikely** • In absence of dunes/topographic features, hatchlings may orient towards artificial light source and sky glow which might be along the islet rather than directly towards the ocean horizon and may result in disorientation behaviour where hatching crawl in circles while trying to orient themselves. • Behavioural misorientation and disorientation responses may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Maximum predicted continuous flaring could potentially result in all clutches within a season being exposed to artificial light (weeks). • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of light sources, and lunar phase at emergence. • Cloud cover and thickness is dynamic and will vary with time leading to a range of potential exposure conditions and impacts that are a function of the duration and rate of flaring and difficult to predict but are likely to be limited to a small proportion of hatchlings emerging at any time, i.e. the increased brightness and extent of sky glow under clouds will not be a static long term stressor impacting all emerging hatchlings across an entire nesting season.	**Light and light glow highly visible, behavioural impact unlikely** • Potential for hatchling dispersal behaviour to be affected decreases with distance from shore. • Light sources located ~20-29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be low, and few individuals will be at risk of attraction. • Surface currents at Scott Reef will carry hatchlings on and in the direction of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

Table 3-19 Impact Level 3 – Intermittent Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility 2. Scenario code 3. Duration of impact 4. Distance from Sandy Islet	Scenario code Orientation FOV (FME) Figure #	Life history stage / behaviour and impact pathway			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1. FPSO 2. IS3B, IS4B 3. Intermittent Flaring and intermittent cloud (< 20 days/yr for each) 4. ~29 km 1. FPSO + MODU 2. CS2B, CS3B, CS4B 3. Intermittent Flaring and intermittent cloud (< 20 days/yr for each) 4. ~20-29 km	IS3B – 0.116 IS4B – 0.156 CS2B – 0.103 CS3B – 0.192 CS4B – 0.236 (Figures 6-7 and 10-12 of Appendix A)	**Minor impact possible** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a broad area of sky glow encompassing the entire field of view of the turtles at right angles to the beach (seaward) and at the horizon. • Recovery Plan Action Area A8: It is unlikely an Impact Level 3 level of lighting will cause displacement of nesting females from Sandy Islet and any displacement is expected to be minor, limited to individuals potentially exposed to a very short window of high light levels under heavy cloud, and who are likely to move to Browse Island, which is part of the same genetic stock (G-ScBr) as Sandy Islet. • Flaring expected to be limited to 8 – 15 days per year and associated with unplanned upset flaring or well clean up flaring, worst case scenario this occurs during the 17 days of cloudy days reported for the area during the nesting season. Impact is intermittent and limited to one nesting season. • The intensity of the light is between 0.103 and 0.236 FME, so even under the worst-case scenario of Major Upset Flaring plus Well Clean Up Flaring at TRA (**CS4B**), the illumination will fall in the lower range of a full moon brightness, closer to a quarter moon than a half moon. The number of days in a moon cycle that this high level of sky brightness could exceed the illumination from a half to new moon is 14 days, further reducing the potential number of days turtles could be exposed to high light levels under full cloud during the nesting season. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely.	**Light and light glow highly visible, Minor behavioural impact possible** • The modelled radiometric visibility of the worst-case scenario of Major Upset Flaring plus Well Clean Up Flaring at TRA, with cloud cover at 80% and a ceiling height of 10 km (**CS4B**) shows a bright point source of light on the horizon, and the entire sky illuminated by light. The reflected light and glow extend well beyond the defined orientation FOV box and is almost 4 times brighter than the scenario with no cloud (**CS4A**). • In absence of dunes/topographic features, hatchlings may orient towards artificial light source and sky glow which might be along the islet rather than directly towards the ocean horizon and may result in disorientation behaviour where hatching crawl in circles while trying to orient themselves. • Behavioural misorientation and disorientation responses may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Flaring expected to be limited to 8 – 15 days per year, associated with unplanned upset flaring or well clean up flaring, worst case scenario this occurs during the 17 days of cloudy days reported for the area during the nesting season. Impact is intermittent and limited to one nesting season. • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of light sources, and lunar phase at emergence and differences in individual visual sensitivities. • Cloud cover and thickness is dynamic and will vary with time leading to a range of	**Light and light glow highly visible, No behavioural impact predicted** • Potential for hatchling dispersal behaviour to be affected by light decreases with distance from shore. • Light sources located ~20-29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be low, and few individuals will be at risk of attraction. • Surface currents at Scott Reef will carry hatchlings on and in the direction of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

		• Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Sandy Islet and Browse Island green turtles are the same genetic stock (G-ScBr), and so should a neophyte be displaced from Sandy Islet she could potentially move to Browse Island. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • The 5 – 8 year re-nesting interval for green turtles means that only small subset of breeding females could potentially be exposed to this level of brightness in a single season should it overlap with this level of flaring and cloud cover.	potential exposure conditions and impacts that are a function of the duration and rate of flaring and difficult to predict but are likely to be limited to a small proportion of hatchlings emerging at any time, i.e. the increased brightness and extent of sky glow under clouds will not be a static long term stressor impacting all emerging hatchlings across an entire nesting season. Nests will emerge over 8 – 12 weeks at the peak of the nesting season, a small subset of emerging nests could potentially be exposed to this level of brightness in a single season should it overlap with this level of flaring and cloud cover.		

3.2 Seabed Subsidence

3.2.1 Source of Aspect

Subsea subsidence may manifest as a result of production activities, through the extraction of hydrocarbons from the Torosa reservoir causing a reduction in the reservoir's pressure. Potential impacts of reservoir-related seabed subsidence on the fate and dynamics of Sandy Islet (and as such the turtle nesting habitat) have been assessed in the draft EIS/ERD and Supplement Report to the draft EIS/ERD, against a backdrop of long-term global sea level rise and increasing cyclone intensity.

The phenomenon of subsidence due to oil and gas production is considered rare and is mostly imperceptible. Only a few reported instances are known in the industry worldwide (Nagel, 2001). Instances where higher magnitude production-induced subsidence has been recorded are likely related to specific geologic conditions at these locations. These have included reservoirs located in the offshore North Sea region (44 cm/year at Ekofisk), onshore California (22 cm/year at Wilmington and up to 20 cm/year at South Belridge), offshore Malaysia (M3), offshore Indonesia (Arun) and offshore Oman (4.5 cm/year at Yibal) (Nagel, 2001).

3.2.2 Seabed Subsidence Modelling

Subsidence associated with oil and gas extraction is a physical response of the seabed due to pressure reduction inside the reservoir. Woodside has modelled the magnitude of potential subsidence and associated horizontal movements for the Browse reservoirs (Woodside, 2014). Analyses took into account a range of parameters, including the geological/fault structure of the reservoir, its spatial dimensions, the hydrocarbon reservoir thickness and its depth, reservoir temperature and pressure as well as pore compressibility in the reservoir. These analyses were supported by field measurements and laboratory tests on core samples obtained from exploration wells within the Browse reservoirs. The results of the model were subsequently peer-reviewed by subject matter experts commissioned by Woodside (Hughes, 2012) in 2012 and the Commonwealth regulator in 2013 (CGSS, 2012).

Vertical seafloor movement due to subsidence is not expected to be uniform and can be thought of as occurring in the shape of a bowl – with the location of greatest vertical seafloor movement (i.e. centre of the bowl) corresponding to the areas of greatest reservoir depletion. It is predicted that seabed subsidence will range from 8.9 cm at the centre of the bowl to 2.6 cm at the edge over 40 years; this is equivalent to 0.22 - 0.06 cm/yr. Simulation modelling indicates the centre of the subsidence bowl is likely to be 20 to 30 km to the northeast of Sandy Islet, in an area to the east of North Reef. Consequently, the seafloor directly beneath Sandy Islet is expected be on the edge to the subsidence bowl or outside it, with predicted subsidence to be less than 2.6 cm over the 40 years of hydrocarbon extraction (or 0.06 cm/yr).

Average subsidence was predicted to occur over a radius of about 10 km centred on a point in deep water on the eastern side of North Scott Reef. The magnitude of subsidence is predicted to diminish away from this point up to 18 km. Beyond 20 km, the magnitude of subsidence would be virtually nil (Woodside, 2012).

This analysis has been peer reviewed by Baker Hughes GMI Geomechanics Services (Hughes, 2012)[6] who concluded that the method and supplied data was appropriate. The DoEE sought further independent review by CO2 Geological Storage Solutions Pty Ltd (CGSS) (CGSS, 2012)[7] who found that the report conclusions were reasonable. Woodside therefore has a high level of confidence that any production related subsidence at Scott Reef will be less than 10 cm over field life.

[6] Hughes (2012) available at: https://www.woodside.com.au/our-business/burrup-hub/index-of-previous-browse-studies
[7] CGSS (2012) available at: https://www.woodside.com.au/our-business/burrup-hub/index-of-previous-browse-studies

3.2.3 Impact Assessment

The long-term fate of Sandy Islet at Scott Reef under rising sea levels, increased cyclone intensity and minor subsidence remains to a degree uncertain; however, historical evidence ranging from decades to millennia, coupled with modelling and case studies elsewhere, indicate that it is unlikely to become completely submerged in the future.

Sand has accumulated at the current location of Sandy Islet for millennia. In 1974, two 30 m long cores where drilled into Sandy Islet, both above the high water mark (King, 1975). These cores revealed the presence of a sand type, equivalent to the sand on the current islet down to a depth of approximately 25 m in both cores. Collins *et al*. (2011) dated these reef depths (~25 m) at Scott Reef between 7000 to 8500 years before present. During the last 8500 years, sea level rise, reef subsidence and ongoing reef growth has been dynamic, with sea levels rising rapidly at times (up to 10 mm/yr), South Scott Reef naturally subsiding at rates of approximately of 0.45 mm/yr and the reef growing at 1-4 mm /yr towards the sea surface (Collins *et al*., 2011). The 1974 coring suggest that accumulation of sand has continued throughout these changing reef conditions.

More recently, sea level has been rising in response to a changing climate for over a century in the Scott Reef region. Between 1993 and 2009, it is estimated that sea levels have risen 4.5 ± 1.3 mm/yr in north-west Australia, or 2.7 ± 0.6 mm/yr after the signal directly correlated with ENSO is removed (White *et al*., 2014). Consequently, sea level has been rising significantly at Sandy Islet for decades with little evidence of large-scale, long-term net erosion of the island. A comparison of Sandy Islet size and morphology at four intervals between 1975 and 2019 has shown the islet has dramatically changed morphology and position but has maintained a similar spatial area of between 1.8 ha and 2.4 ha above the high-water mark over the last 45 years (see **Figure 3-3**).

As predicted by modelling and case studies undertaken elsewhere, Sandy Islet has migrated away from the direction of the prevailing wave fronts and has change morphology becoming narrower and longer. Sandy Islet is also resilient to extreme episodic events. In March 2004, Cyclone Fay, a Category 5 cyclone that passed directly over Scott Reef, caused extreme wave and storm surges that eroded the island, reducing its size by approximately one-third (Gilmour *et al*., 2013). In proceeding months and potentially years the island recovered its former size above the high-water mark. These long-term assessments of Sandy Islet response to long-term sea-level rise and extreme events highlight its dynamic nature and long-term resilience.

Net erosion of Sandy Islet in the future, while not likely in the long-term, cannot be completely ruled out. However, reservoir induced subsidence is unlikely play a meaningful role in the long-term fate of Sandy Islet given its minor contribution to water level adjacent to Sandy Islet compared to role of future sea level rise (0.65 mm/yr subsidence vs 5.1 mm/yr sea level rise).

Turtle nesting is unlikely to be influenced by any island morphology changes related to sea level rise, which are likely to operate over timeframes of months to years except during extreme cyclone events. Given the green turtle nesting to hatchling period is approximately 60 days, “normal” island morphology change is highly unlikely to impact on turtle nest success via erosion. However, during future intense cyclones, like Cyclone Fay in 2004, major island erosion and morphology changes, coupled with overtopping by waves and storm surge is likely to substantially increase mortality rates of eggs incubating on the island. Furthermore, evidence suggests that nesting space is likely to reduce following these events but accretion of sediments in subsequent months is anticipated to return the island to its former size.

In conclusion, Sandy Islet is unlikely to disappear below the highwater mark over the 40 years of hydrocarbon production, and scientific evidence suggest it is unlikely to become completely submerged in coming decades but will continue to change morphology. Future island morphology changes will be at timescales that will not directly affect turtle nests and hatchlings. However, future cyclonic impacts to turtle nesting at Sandy Islet may become more damaging as cyclone intensity increases. The impact of reservoir subsidence, given its minor contribution to future sea height (on the reef flats surrounding Sandy Islet) is not expected to meaningfully influence the long-term fate of Sandy Islet and the turtles that use it as nesting habitat.

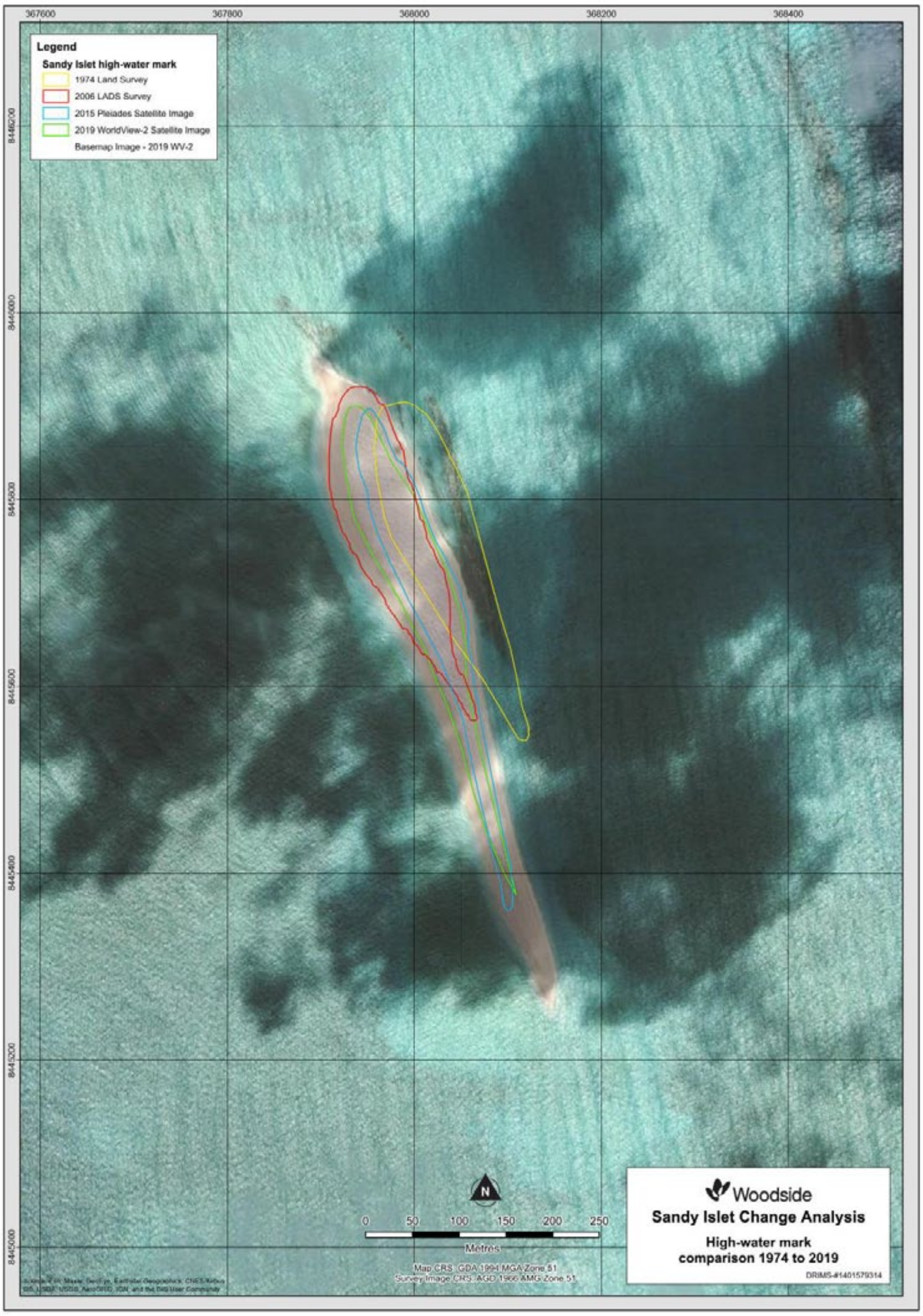

Figure 3-3 Comparison of Sandy Islet size and shape about the high-water mark at four intervals between November 1974 and May 2019 (1974, 2006, 2015 and 2019)

4. MANAGEMENT OBJECTIVES, APPROACH AND PERFORMANCE STANDARDS

4.1 Management Objectives

Receptor specific environmental objectives were identified for the proposed Browse Project in the draft EIS/ERD. In preparing responses to the regulatory and public submission on draft EIS/ERD and the State ERD, Woodside reviewed and where appropriate revised these environmental objectives.

The environmental objectives that are relevant to the marine turtles are:

- Objective 29 - Undertake the Browse Project in a manner that will not disrupt migration, breeding, nesting, internesting and hatchling dispersal of the green turtle population at Scott Reef.
- Objective 30 - Undertake the Browse Project in a manner that will not displace the green turtle population from habitat critical to the survival of the species at Scott Reef.

4.2 Management Approach

Management of the potential impacts to marine turtles from light emissions and seabed subsidence is required so that the above management objectives are achieved. The management approach incorporates:

- light emissions minimisation during design
- light emissions minimisation during execution
- impact avoidance during execution via:
  - application of seasonal based restrictions to activities where the achievement of the management objectives would be compromised should the activity occur at times when green turtles are nesting at Sandy Islet
  - application of marine fauna observers and shut down zones.
- implementation of a science verification monitoring program including:
  - biological monitoring to inform adaptive management
  - light emissions monitoring to verify predicted light emission levels, assess light emissions for comparison with performance standards (**Section 4.3**) and inform management response and adaptive management.
  - subsidence monitoring to verify predicted subsidence levels, assess subsidence for comparison with performance standards (**Section 4.3**) and inform management response and adaptive management.

Specific mitigation and management measures that will be applied are detailed in **Section 4.4.** The adaptive management approach is detailed in **Section 6**.

4.3 Performance Standards

Performance standards required in order to achieve the stated management objectives are outlined in **Table 4-1**.

Table 4-1 Performance standards

Management Objectives	Performance standards
• Undertake the Browse Project in a manner that will not disrupt migration, breeding, nesting, internesting and hatchling dispersal of the green turtle population at Scott Reef. • Undertake the Browse Project in a manner that will not displace the green turtle population from habitat critical to the survival of the species at Scott Reef.	1. Received levels of artificial light at Sandy Islet from proposed Browse Project activities do not exceed 0.1 FME (as defined in (**Table 3-7**) 2. Reservoir related subsidence attributable to the proposed Browse Project (e.g., not attributable to cyclonic events), when combined with natural variability, net erosion and sea level rise, does not result in: a. a reduction in available turtle nesting habitat at Sandy Islet to below historically recorded minimum extents (1.8 ha); or b. a change in the elevation and slope outside of natural variation demonstrated by historical analysis.

4.4 Mitigation and Management Measures

As part of the impact and risk assessment process undertaken for the proposed Browse Project, management and mitigation measures have been identified to reduce the level of impact and risk to an acceptable level and meet the environmental objectives and performance standards for each aspect. The following framework tools were applied, as appropriate, to assist with identifying appropriate management and mitigation measures:

- Good industry practice – identifies further engineering control standards and guidelines which may be applied by Woodside in addition to those required to meet the legislation, codes and standards.
- Professional judgement – uses relevant personnel with the knowledge and experience to identify alternative controls.

In accordance with Woodside's HSE risk management procedures, risk reduction measures should be prioritised and categorised in accordance with the hierarchy of controls, where risk reduction measures at the top of the hierarchy take precedence over risk reduction measures further down. The proposed management and mitigation measures have been developed using the following adaptive framework:

- eliminate the risk by removing the hazard
- substitute a hazard with a lesser one
- prevent a credible impact from occurring through the implementation of additional engineering control measures
- reduce the magnitude of a credible impact through the implementation of additional engineering control measures
- mitigate the credible impact on the environment through the reduction in extent, scale, duration of impact
- apply environmental offsets where justified
- carry out emergency response and contingency planning to facilitate recovery from the credible impact of an event.

The proposed mitigation and management measures pertaining to anthropogenic light including their timing and reporting requirements are presented in **Table 4-2 and Table 4-3**. For subsidence, these are shown in **Table 4-4**. Also presented within the table are the corrective action triggers and the corrective actions triggers to be implemented should the mitigation and management measures not be implemented correctly, or the performance standard not be met. These corrective actions include the implementation of the adaptive management approach which is presented in **Section 6**.

For the purposes of this plan and in order to contextualise the proposed mitigation and management measures in relation to anthropogenic light within the project area, the measures have been divided into three distinct project areas within which differing measures will be applied. The areas are described as follows.

- Proposed Browse Project construction and operational vessel (including MODU) activities within 18 km of Sandy Islet (See **Figure 4-1**)
- Proposed Browse Project construction and operational vessel (including MODU) activities beyond 18 km of Sandy Islet
- Proposed Browse Project FPSO operations.

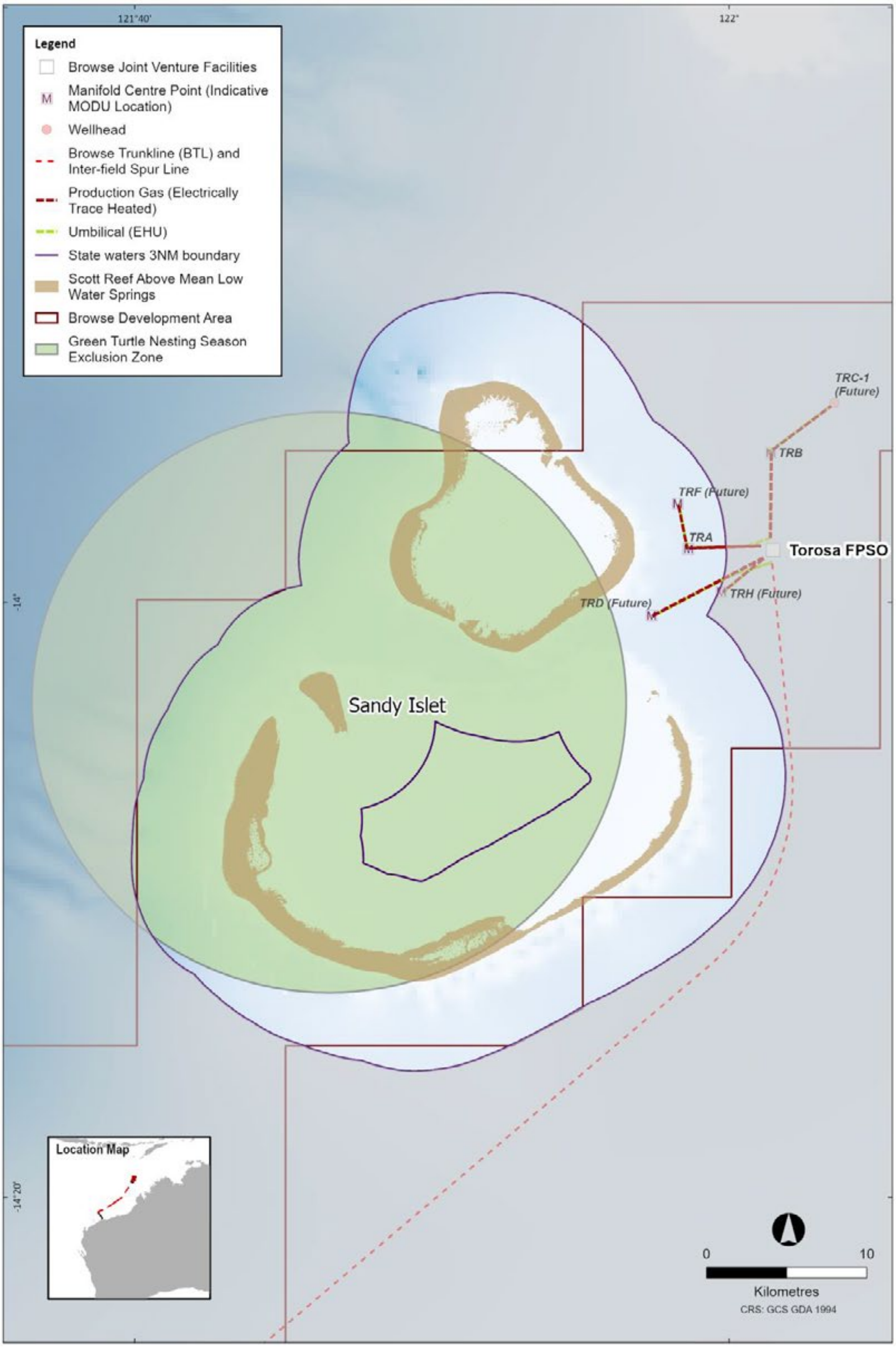

Figure 4-1 Sandy Islet Vessel Exclusion Zone.

Table 4-2 Mitigation and management measures applicable to anthropogenic light from proposed Browse Project vessel activities (including MODU and Construction Vessels)

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
Light emissions					
• Undertake the Browse Project in a manner that will not disrupt migration, breeding, nesting, internesting and hatchling dispersal of the green turtle population at Scott Reef. • Undertake the Browse Project in a manner that will not displace the green turtle population from habitat critical to the survival of the species at Scott Reef.	The following applies to all vessels operating more than 18 km from Sandy Islet, but where operational lighting is within line of sight of Sandy Islet or Scott Reef and the vessel will be present for more than 7 days. These vessels will develop an "artificial light management plan" in accordance with the guidelines in Section 4 of the National Light Pollution Guidelines. This plan will include consideration of light spill, selective use of long wavelength light sources, installation of light shades and blinds and the minimisation of lighting levels for external operational areas.	During activity planning.	• Records showing vessels light management plans developed and adhered to.	• ALMP not in place for specified vessels.	• Implement a review and update of procurement procedure.
	During the Sandy Islet green turtle nesting and hatchling emergence periods (peak and shoulder; November - April), planned flaring from MODU operations that are within line of site (LOS) of Sandy Islet will occur during daytime only (excluding flaring during unplanned or emergency events). Based on expected MODU specifications, well centres at which the MODU is expected to be within LOS of Sandy Islet include TRD, TRA, TRH. Any MODU selected to operate at Torosa will be assessed to determine if it is within LOS of Sandy Islet and if so, this measure will be applicable to that activity also.	During drilling and completions activities at relevant well centres.	• MODU operational records show activity location and flaring records. • MODU validation of line of site to Sandy Islet will occur once MODU selected and flaring rates known.	• Planned flaring occurs from a MODU within line of site of Sandy Islet occurs at night-time during green turtle peak nesting and hatchling emergence period (January- April) (excluding flaring for safety reasons).	• Immediately cease non-conforming flaring activities (where safe and practicable to do so). • Undertake an investigation into the cause of the non-compliance. • Undertake a risk assessment of to determine the potential impacts of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER.
	Monitoring of received light levels at Sandy Islet as a result of MODU operations at TRA will be undertaken to verify light modelling predictions shown in **Section 3.1.2**.	Light monitoring report.	• Light modelling verification report.	• Model validation identifies that the performance standard relating to received light levels (**Table 4-1**) may not be achieved or light model verification not completed.	• Revise light modelling. • Implement adaptive management (**Section 6.2**).

Table 4-3 Mitigation and management measures applicable to anthropogenic light from proposed Browse Project FPSO operations

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
Light emissions					
• Undertake the Browse Project in a manner that will not disrupt migration, breeding, nesting, internesting and hatchling dispersal of the green turtle population at Scott Reef. • Undertake the Browse Project in a manner that will not displace the green turtle population from habitat critical to the survival of the species at Scott Reef.	**Operational Lighting** The design of the FPSO facilities will incorporate the Principles of Best Practice Lighting Design, outlined in Appendix A of the National Light Pollution Guidelines for Wildlife (Commonwealth of Australia, 2020). The FPSO lighting design will minimise lighting impacts through measures where applicable, including but not limited to; • Use of adaptive light controls (e.g. motion sensors) • Lighting only the area intended • Using a lighting intensity appropriate for the task • Using lights with reduced or filtered out blue, violet and ultraviolet wavelengths • Incorporation of light shielding or shrouding to minimise light spill/glow.	During FPSO design.	• Design report showing that Principles for Best Practice Lighting Design incorporated into FPSO facility design.	• Design report showing that Principles for Best Practice Lighting Design have not been incorporated into FPSO facility design.	• Review and revise design to incorporate principles of Best Practice Lighting Design.
	Continuous Flaring The FPSO facilities will be designed such that continuous flaring will be limited to pilot gas and compressor seal gas and design continuous flaring rates will not exceed 1 MMscf/day.	During FPSO design.	• Design report showing FPSO facilities designed such that continuous flaring will be limited to pilot gas and compressor seal gas.	• FPSO continuous flaring rates designed to exceed 1MM scf/day.	• Revise impact assessment modelling of expected continuous flaring rates and confirm EPOs can still be achieved. • Review and revise design to ensure continuous flaring is minimised and facility can achieve EPOs.
	Commissioning flaring Infield commissioning of Calliance/Brecknock FPSO will be commenced prior to infield commissioning of Torosa FPSO in order to incorporate learnings into an adaptive management approach and minimise flaring associated with FPSO commissioning.	During FPSO commissioning.	• Project schedule and planning documentation. • FPSO commissioning records.	• Infield commissioning of Calliance/Brecknock FPSO not commenced prior to infield commissioning of Torosa FPSO.	• Undertake an investigation into the cause of the non-compliance. • Undertake a risk assessment of to determine the potential impacts of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER.
	Commissioning flaring Start-up Excellence/Construction and commissioning planning will be undertaken to optimize in-field FPSO commissioning durations, which will reduce flaring to ALARP. Torosa Commissioning flaring (at rates of up to 250 MMscf/day) will be targeted to not occur for more than 8 weeks during a six month commissioning period (commissioning period).	During FPSO commissioning.	• Report detailing results of start-up Excellence/Construction and commissioning planning and how in-field FPSO commissioning durations have been optimised.	• Start-up Excellence/Construction and commissioning planning not undertaken or did not include in-field FPSO commissioning optimisation. • Commissioning flaring occurs for > 6 months	• Undertake an investigation into the cause of the non-compliance. • Undertake a risk assessment of to determine the potential impacts of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER.

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
	Planned flaring Torosa FPSO will plan major shutdowns to avoid planned flaring during night-time during the Sandy Islet green turtle nesting and hatchling emergence periods (peak and shoulder; November-April). Torosa FPSO will also plan routine maintenance (i.e., annual inspections) to avoid planned flaring during night-time in the Sandy Islet green turtle nesting and hatchling emergence periods. Reactive / Corrective maintenance will occur as required.	During Torosa FPSO operations.	• Shut down / maintenance schedules and planning documentation. • Torosa FPSO shut down / maintenance records.	• Planned flaring occurs at night-time during Torosa FPSO major shutdowns or routine maintenance events during Sandy Islet green turtle peak nesting and hatchling emergence period (peak and shoulder; November-April) (excluding flaring for safety reasons).	• Immediately cease planned flaring at night from Torosa FPSO during major shutdowns and routine maintenance events (where safe and practicable to do so). • Undertake an investigation into the cause of the non-compliance. • Undertake a risk assessment of to determine the potential impacts of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER.
	Unplanned flaring (Minor) Torosa FPSO flaring events due to equipment failure will be rectified at the earliest practicable opportunity. Minor upset flaring (at rates of between 1 MM and 125 MMscf/day) from the Torosa FPSO will be targeted to occur on no more than 10 nights per year during the Sandy Islet green turtle nesting and hatchling emergence periods, beyond the first year of FPSO operations.	During Torosa steady state operation.	• FPSO operational records and monthly / annual flaring reports.	• Torosa FPSO flaring events due to equipment failure not rectified as earliest practicable opportunity. • Flaring rates exceed the stated rates / durations.	• Undertake an investigation into the cause of the non-compliance. • Undertake a risk assessment of to determine the potential impacts of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER.
	Unplanned flaring (Major) Major upset flaring (>125 and <250 MMscf/day) from the Torosa FPSO will be targeted to occur on no more than 4 nights per year during the Sandy Islet green turtle nesting and hatchling emergence periods, beyond the first year of FPSO operations.	During Torosa steady state operation.	• FPSO operational records and monthly / annual flaring reports.	• Flaring rates exceed the stated rates / durations.	• Undertake an investigation into the cause of the non-compliance. • Undertake a risk assessment of to determine the potential impacts of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER.
	Unplanned flaring (Major) Major upset flaring (>250 MMscf/day) will not occur for more than 60 minutes on any given night in the Sandy Islet green turtle nesting and hatchling emergence periods and will be targeted to not occur for more than one night during each annual Sandy Islet green turtle nesting and hatchling emergence period.	During Torosa steady state operation.	• FPSO operational records and monthly / annual flaring reports.	• Flaring rates exceed the stated rates / durations.	• Undertake an investigation into the cause of the non-compliance. • Undertake a risk assessment of to determine the potential impacts of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER.
	Monitoring of received light levels at Sandy Islet as a result of Torosa FPSO operations will be undertaken to verify light modelling predictions shown in **Section 3.1.2.**	Within 12 months of Torosa FPSO start up.	• Light monitoring not undertaken during Torosa FPSO operations.	• Model validation identifies that the performance standard relating to received light levels (**Table 4-1**) may not be achieved.	• Revise light modelling. • Implement adaptive management (**Section 6**).

Table 4-4 Mitigation and management measures relating to seabed subsidence

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
• Undertake the Browse Project in a manner that will not disrupt migration, breeding, nesting, internesting and hatchling dispersal of the green turtle population at Scott Reef. • Undertake the Browse Project in a manner that will not displace the green turtle population from habitat critical to the survival of the species at Scott Reef.	Regular updates to modelling of predicted subsidence rates will be conducted, based on known reservoir performance, during the operations phase.	At least every five years during Torosa field operation.	• Subsidence modelling reports.	Further modelling of likely subsidence based on known reservoir performance during operations not conducted with 5 years of Torosa production commencement.	• Undertake modelling as soon as practicable. • Undertake an investigation into the cause of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER.
				Further modelling based on known reservoir performance indicates that seabed subsidence attributable to the proposed Browse Project may occur at a rate such that the Performance Standard relating to available nesting habitat and Sandy Islet morphology (**Table 4-1**) may not be achieved.	• Implement adaptive management (**Section 6**.
	If revised modelling predicts higher subsidence rates than presented in the EIS/ERD are occurring, further investigation would be initiated into any potential short term and longer-term biological and ecological implications for Scott Reef and Sandy Islet. This would include engagement with appropriate scientific organisations to provide expert opinion and advice on potential impacts to the Scott Reef.	At least every five years during Torosa field operation.	• Scientific reports. • Records of engagements with appropriate scientific organisations. • Documented expert opinions.	Further investigation into potential short term and longer-term biological and ecological implications for Scott Reef and Sandy Islet, including engagement with appropriate scientific organisations not undertaken	• Undertake further investigation and engagement as soon as practicable. • Undertake an investigation into the cause of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER.
				Further investigation into potential short term and longer-term biological and ecological implications for Scott Reef and Sandy Islet, including engagement with appropriate scientific organisations indicate that potential impacts to green turtle nesting habitat at Sandy Islet beyond approved limits may occur as a result of seabed subsidence attributable to the proposed Browse Project.	Implement adaptive management (**Section 6**).
	Verification monitoring for seabed subsidence will be undertaken including monitoring of the size and morphology of Sandy Islet (**Section 5.3** and **Section 5.4**). *Reservoir extraction related subsidence attributable when combined with natural variability (excluding cyclonic events), will not result in a continuous, ongoing significant reduction in available turtle nesting habitat or loss of habitat to below historically recorded minimum extent (1.8 ha) at Sandy Islet.*	During operations.	• Verification monitoring reports.	Verification monitoring indicates that: a. actual seabed subsidence attributable to the proposed Browse Project is occurring at a rate greater than that predicted via modelling such that the Performance Standard relating to available nesting habitat and Sandy Islet morphology (**Table 4-1**) may not be achieved. b. Monitoring of Sandy Islet indicates a reduction trend in available nesting habitat at Sandy Islet, over a five year period attributional to the proposed Browse Project such that the Performance Standard relating to available nesting habitat and	Sandy Island Beach Nourishment Plan to be developed and implemented.

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
				Sandy Islet morphology (**Table 4-1**) may not be achieved. c. Monitoring of Sandy Islet indicates a change in morphology (slope and elevation) over a five year period attributional to the proposed Browse Project such that the Performance Standard relating to available nesting habitat and Sandy Islet morphology (**Table 4-1**) may not be achieved.	

5. SCIENTIFIC MONITORING

There is a need for four sperate scientific monitoring programs to be conducted as part of implementation of the TMP, focussing on both the aspects of the Browse project (e.g. lighting, seabed subsidence) and the impacts (e.g. changes to green turtle behaviour or change to morphology of sandy islet). For each monitoring program, there is a corresponding set of adaptive management actions (**Section 6**) that could be triggered depending on outcomes of the monitoring program.

Four distinct monitoring programs are proposed in relation green turtles within the project area, including:

- a green turtle monitoring program at Sandy Islet and surrounds (**Section 5.1**) to update baseline information on green turtle demographics at Scott Reef
- an anthropogenic light monitoring program (**Section 5.2**) to verify predicted light emissions from construction and operational activities
- a seabed subsidence monitoring (**Section 5.3**) to verify predicted subsidence levels which may be used to better understand causes of and changes to Sandy Islet morphology
- a Sandy Islet size and morphology monitoring program (**Section 5.4**) to monitor the size and morphology of Sandy Islet for comparison with historic minimum available nesting habitats.

5.1 Green Turtle Monitoring Program

A green turtle monitoring program will be implemented as a core component of the proposed Browse Project. The purpose of this program will be to verify and update baseline data through on-going data acquisition at relevant times throughout the proposed Browse Project on the distribution, abundance, seasonality and behaviour of green turtles at Scott Reef and within habitat critical to survival for the G-ScBr stock.

The green turtle monitoring program will be designed on the advice of a suitably experienced, independent marine turtle expert. The design of the program will cover key demographic parameters, specific monitoring techniques, frequency and timing of monitoring, data analysis techniques, corrective action triggers, and reporting requirements. The baseline monitoring program will be designed within six months of final investment decision on the project and implemented such as to collect a minimum of four (target five) years of data prior to commencement of gas processing at the Torosa FPSO.

The monitoring program will be continued to implemented during operational phase. However, the design of the operational monitoring program will need to be informed by outcomes of the baseline monitoring program, and as such specific details are not yet available. The operational phase of the monitoring program will also be designed on the advice of a suitably experienced, independent marine turtle expert.

5.1.1 Key Objectives

The key objectives of the baseline phase of the green turtle monitoring program are as follows:

- To investigate nesting turtle behaviour and habitat usage within Scott Reef and to establish a baseline data set for nesting turtles.
- To understand the key breeding parameters (e.g. nest abundance, incubation success, hatchling sea finding behaviour and post hatching dispersal) for green turtles at Scott Reef.
- To understand the relative importance of Sandy Islet as a nesting site for the G-ScBr green turtle stock.

The monitoring information will provide baseline data that can be used to verify the potential impacts and risks that the proposed Browse Project may have on green turtles, to determine compliance against the proposed performance standards and to inform adaptive management if necessary. Data will be reviewed in the context of regional, national and international trends.

5.1.2 Key Components

The green turtle monitoring program will be comprised of four key components.

- Satellite tracking of adult nesting individuals to determine internesting, foraging and migration behaviour.
- Counts and tagging of adult nesting individuals to facilitate abundance estimates, long-term life history traits, and proportion of neophytes present each season.
- Hatchling and nest counts and observations to determine nesting abundance and density, nesting success and hatchling sea-finding behaviour.
- Hatchling in-water dispersal behaviour in area immediately surrounding Sandy Islet.

5.2 Anthropogenic Light Monitoring

The primary objective of the light monitoring program will be to verify the modelling predictions for the drilling (MODU)) and FPSO operations as outlined in **Section 3.1.2**. Specifically, the light monitoring program at Sandy Islet will be comprised of two key components:

- Establishing a baseline of ambient light conditions (prior to any project activities) across the lunar cycle during nesting season.
- Determining light intensity (i.e. direct light and sky glow) at Sandy Islet during nesting season during MODU and FPSO operations to verify modelling predictions and determine compliance with performance standards.

The monitoring program will be implemented at Sandy Islet and will employ specialised light monitoring equipment to detect direct light and sky glow visible from the monitoring location across the full 360° horizon. Specific details on the monitoring program (i.e. monitoring locations, techniques, frequency, timing, performance standard threshold criteria, data analysis techniques and reporting requirements) will be described in a specific monitoring program to be developed post FID on the advice of a suitably experienced, independent marine turtle expert.

Light monitoring will also be used to validate modelling predictions, which will be re-run once MODU/FPSO activities commence and MODU details are known.

5.3 Seabed Subsidence Monitoring

Currently, the most practical method of measuring seabed subsidence of potentially millimetres per year over kilometre scale would involve the use a combination of natural and artificial physical targets (e.g. retroreflector / corner targets) installed near Sandy Islet combined with regular InSAR (see below) data acquisition to establish a baseline of seabed subsidence, to monitor changes in seabed subsidence rates over time.

Radar satellite interferometry (InSAR) is a non-invasive surveying technique able to measure the millimetric motion of terrain structures over wide areas. This technique is based on the exploitation of synthetic aperture radar images (SAR) acquired from satellite sensors. Techniques such as InSAR are used regularly for purposes such as monitoring building subsidence and is well suited to understand naturally occurring or hydrocarbon extraction related subsidence. Together with regular capture of satellite imagery, it will be possible to establish a comprehensive program to monitor changes in available nesting habitat, elevation and slope at Sandy Islet and attribute this to natural or man-made causes.

Further details of this monitoring program such as target locations and monitoring frequency and analysis/interpretation techniques will be described in a specific monitoring program to be developed post FID. It is anticipated monitoring will commence post project FID to allow for establishment of a multi-year natural baseline before the first hydrocarbons are extracted from the Torosa reservoir.

5.4 Sandy Islet Morphology Monitoring

Since records are available (1974) the size of Sandy Islet has naturally varied between 1.8 ha and 2.3 ha, a variation of approximately 20%.

High resolution satellite imagery will be reviewed at least two times per year to monitor the areal extent of available nesting habitat (e.g. land above LAT). These will be compared to historic estimates of available nesting habitat in determining whether corrective actions are required.

6. ADAPTIVE MANAGEMENT

To support adaptive management, four distinct monitoring programs have been proposed in relation green turtles (**Section 5**). These monitoring programs will support adaptive management responses based on:

- Changes in green turtle biologically important behaviours.
- Received light levels at Sandy Islet.
- Changes to availability of Sandy Islet turtle nesting habitat.

6.1 Management response - Changes in Green Turtle Biologically Important Behaviours

The following corrective action triggers are based those in the Gorgon Gas Development and Jansz Feed Gas Pipeline Long-term Marine Turtle Management Plan (Chevron 2018).

Corrective action triggers will be established based on statistical deviations from the baseline conditions for each demographic parameter. During design of the monitoring program, a power analysis will be conducted to determine the statistical power of various deviation bands to detect changes or impacts to demographic parameters related to population viability for the Scott Reef green turtle population.

Dependent on the outcome of the power analysis, each trigger will be represented as a trend towards, or change beyond, a ±1, ±2, or ±3 statistical deviation (standard deviation [SD], standard error [SE] or median absolute deviation from median [MAD]) from baseline conditions:

- Alert: A trend towards the ±1 statistical deviation limit for two consecutive years, or, a change beyond ±1 statistical deviation from baseline conditions.
- Review: A change beyond ±2 statistical deviation from baseline conditions.
- Action: A change beyond ±3 statistical deviation from baseline conditions.

Demographic data will be compared against the corrective action triggers annually. The aim of the initial response to activation of any trigger will be to determine whether the cause is attributable to the proposed Browse Project i.e. it cannot be confidently attributed to natural variations in green turtle population trends at genetic stock, regional and national levels. If deemed to be Project-attributable, the associated response actions will be initiated according to the level of trigger activated. The following action will be initiated in response to each trigger:

- Alert: Conduct an internal investigation of existing data and other relevant information into cause for activation of the management trigger.
- Review: As for Alert, but additionally, conduct risk assessment to identify any potential risk of significant adverse impacts and conduct further data analysis, monitoring or studies if necessary to confirm actual or potential risk of significant adverse impacts.
- Action: As for review, but additionally, conduct a review of existing management measures and, where necessary, propose and implement additional management measures. Actions to offset any significant impacts may be required.

The tiered approach outlined above does not preclude early management action if a trigger is determined to be attributable to a stressor from the proposed Browse Project and/or represents a significant threat to the viability of the Scott Reef green turtle population.

6.2 Management response – Received Light Measurements

There are no fixed thresholds at which light can be categorically predicted disrupt biologically important behaviour so instead the TMP has been structured to implement further corrective actions if light monitoring indicated that light was being received at Sandy Islet at an intensity significantly greater than that predicted through modelling this will trigger an investigation and implementation of any necessary corrective actions. A significant increased will be considered to have occurred if light received is either in a higher tier of the impact criteria (unless less than 10% different) predicted and described in **Table 3-7**.

Management responses will depend on the cause of the incident and source of the lighting but possible mitigative actions to be considered are as follows;

If the light is associated with a MODU:

- Retrofitting MODU lighting to incorporating best practice lighting design such as applying colour filters to existing lights or light shields to any lights causing excessive light spill.

If the light is associated with Torosa FPSO flaring:

- Improving facility reliability to reduce the occurrence of any unplanned flaring events.

If the light is associated with Torosa FPSO operational lighting:

- Implementing further changes to operational lighting design, such as increasing shrouding on operational lights to reduce sky glow.

6.3 Management Trigger – Sandy Islet Nesting Habitat

If required to maintain the availability of nesting habitat on Sandy Islet consistent with historic minimums, a beach nourishment plan will be developed and executed should the following triggers be exceeded:

a) *Where an ongoing annual decline (>3%) in available nesting habitat at Sandy Islet is observed for a continual period of five years, but where nesting habitat remains above 1.8 ha, the beach nourishment program shall be enacted.*

b) *Where an ongoing annual decline (>3%) in available nesting habitat at Sandy Islet is observed for a consecutive period of three years and where nesting habitat becomes less than 1.8 ha, the beach nourishment program shall be enacted.*

Where a single or even sequential year decline is observed or can be readily attributable to a natural event (e.g. cyclone) beach nourishment is not proposed. This program should be performed in accordance with a beach nourishment plan developed in consultation with relevant experts and regulatory agencies.

Intervention in natural processes through beach nourishment is not without risk, as with any artificial intervention in a natural system. Therefore, the need for beach nourishment should be limited to those circumstances where there is a clearly defined need, in order to not unnecessarily impact on available nesting habitat.

Key elements of beach nourishment campaign

Various studies have been undertaken (primarily in North America) with respect to the impacts of beach nourishment on turtle nesting success. For example, Crain et al. (1995) found that placement of dredged sand increases nesting habitat availability and total number of nests and turtle crawls often increase as a result of nourishment, and unless there are significant changes to the beach profile, there is unlikely to be any effect to the beach selection by female turtles. Fletemeyer (1983), compared three natural and three nourished beaches and found that nesting on natural beaches produced shallower nests, while Ryder (1991) noted nesting females on nourished beaches failed to sufficiently cover their nests compared to on natural beaches.

For nesting females, nourishment can result in decreased nesting success as a result of beach compaction, altered nest-chamber geometry and nest concealment (Crain et al., 1995). Given the low flat profile of Sandy islet and its distance offshore (and thus susceptibility of the nests to predators) altered nest-chamber geometry and nest concealment are unlikely to be an issue on Sandy Islet.

For eggs and hatchlings, beach nourishment can result in a decrease survival rate and egg development as a result of changed sand characteristics such as compaction, nutrient availability, thermal environment and gaseous environment.

Given this, one of the most important considerations for beach nourishment is the choice of fill material and the beach profile (elevation and slope) post nourishment. Important physical characteristics for marine turtles includes (Crain et al., 1995).

- sand-grain size
- grain shape
- silt-clay content
- sand colour
- beach compaction
- moisture content
- mineral content
- substrate water potential
- porosity/gas diffusion.

The other key issue is timing of nourishment activities to avoid covering nests and direct and indirect impacts to nesting turtles.

In the event that any of the corrective action triggers (**Table 4-4**) relating to seabed subsidence rates, available nesting habitat or Sandy Islet morphology are triggered, Woodside will prepare and implement a peer reviewed beach nourishment plan. Prior to undertaking beach nourishment activities, Woodside will seek regulatory approval for the beach nourishment activities in accordance with the prevailing regulations at the time.

Beach nourishment of Sandy Islet is expected to involve the following key elements:

- Selection of a sand source that closely matches the attributes of Sandy Islet, preferably from an area close to the islet.
- Use of hydraulic means to place the sand in the area to be nourished and the use of natural processes to shape the nourished areas as opposed to mechanical means which could result in compaction and other disturbances (including to resting birds).
- Limiting nourishment to a small portion of the islet in any one campaign, so that the majority of the islet retains its natural sediment characteristics.
- Avoidance of nourishment activities during turtle nesting season with timing targeted to occur closely after the end of a nesting season to allow time for the islet to return to a natural state prior to the following nesting season.
- Checks to ensure no nesting activity is occurring prior to commencing nourishment activities.
- Standard techniques to ensure indirect impacts to the marine environment and fauna (turbidity, light and noise emissions, interaction with birds as a result of opportunistic feeding during nourishment) are avoided or minimised as far as practicable.

- Monitoring (turtle nesting success, sediment compaction, sediment characteristics) of the nourished area during nesting seasons following nourishment.

7. REPORTING

The results of the monitoring programs will be routinely reported internally. External reporting will be undertaken in line with the subsequent approval decision and following any incident or non-compliance of performance standards as determined by the monitoring.

Reviews of the monitoring data and resultant recommendations will be undertaken by suitably qualified marine turtle experts.

A summary of the reporting requirements is provided below in **Table 7-1**.

Table 7-1 Summary of reporting

Report	Recipient	Details	Frequency
Monitoring Reports	• Woodside • DWER and DAWE	Results of monitoring programs with full data analysis, reporting and discussion on the separate monitoring scopes (i.e., Light, green turtles and seabed subsidence).	• Annually • As necessary if non-compliance of performance standards determined by monitoring.
Incident Reports	• Woodside • DWER and DAWE	Incident reporting.	As necessary

8. PLAN REVIEW

The plan will be reviewed on an annual basis to ensure the proposed measures and objectives continue to be met. In addition, a review process will be initiated following a non-compliance of the performance standards, in accordance with the adaptive management framework outlined in **Section 6.**

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Appendix A - Woodside Browse Light Modelling Report (Pendoley Environment 2022)

JACOBS

WOODSIDE BROWSE LIGHT MODELLING

Prepared by

Pendoley Environmental Pty Ltd

For

Jacobs

9th June 2022

DOCUMENT CONTROL INFORMATION

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EXECUTIVE SUMMARY

Woodside Energy Limited (Woodside), is proposing to develop the Browse hydrocarbon resource located in the Brecknock, Calliance, and Torosa reservoirs. The Torosa reservoir is located near Sandy Islet within the Scott Reef complex and is identified as sensitive turtle nesting habitat for green turtles, while the surrounding waters may also be used by leatherback (*Dermochelys coriacea*), flatback (*Natator depressus*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*) and loggerhead (*Caretta caretta*) turtles.

Pendoley Environmental (PENV) undertook artificial light modelling of the proposed Torosa Floating Production Storage and Offloading (FPSO) and Mobile Offshore Drilling Unit (MODU) facilities, that will be located within 30 km of Sandy Islet, to predict if there will be any impacts to hatchling marine turtles as a result of light emissions from the facilities. A total of 24 scenarios were modelled, covering five flaring types and five cloud/sky conditions. Eighteen of these 24 scenarios were then analysed as best and worst cases of Individual and Cumulative lighting scenarios.

Results from the Individual Scenarios (IS) modelled showed Orientation FOV (OFOV) Full Moon Equivalent (FME) light intensity values correlated strongly with flaring rates and the associated changes in sky glow extent, with the brightest values generated in IS4A (0.041 FME; Impact Level 2), and decreasing in IS3A (0.031 FME; Impact Level 2), IS2A (0.009 FME; Impact Level 1) and IS1A (0.004 FME; Impact Level 1). When these scenarios are influenced by cloud, these values increase substantially with IS1B increasing by 238% (0.010 FME; Impact Level 2), and IS4B increasing by 377% (0.156 FME; Impact Level 3).

In IS5 and IS6 the MODU is visible from Sandy Islet as a point source of direct light on the horizon, with the visibility of the TRD site (IS5) marginally greater than the TRA site (IS6) due to its shorter distance from Sandy Islet. As there is no flaring at the TRD site, there is very little sky glow (0.001 FME; Impact Level 1). Flaring from the MODU at the TRA site increases the extent of sky glow substantially to 0.020 FME (Impact Level 2), which is approximately 18 times brighter than the non-flaring MODU at the TRD site.

In the Cumulative Scenarios (CS) the combination of flaring from both the FPSO and MODU at TRA caused an increase in light received by the sensitive receptor at Sandy Islet. The brightest OFOV values were generated in CS4A (0.065 FME; Impact Level 2), and decreasing in CS3A (0.054 FME; Impact Level 2), CS2A (0.030 FME; Impact Level 2) and CS1A (0.006 FME; Impact Level 1). Similar to the Individual Scenarios, cloud coverage increased OFOV values by 202% in CS1B (0.012 FME; Impact Level 2) and moved CS2B (0.103 FME; 344%), CS3B (0.192 FME; 356%) and CS4B (0.246 FME; 364%) to Impact Level 3.

The predicted impacts of the modelled Scenarios with continuous impacts on marine turtles were assessed as 'no expected impact'. However, modelled Scenarios that may intermittently affect a given turtle nesting season ranged from "no expected impact" to "unlikely impact", and "possible impact".

In accordance with the approach outlined in the National Light Pollution Guidelines PENV recommend the following biological and light monitoring programs be implemented to confirm these predictions and to provide a basis for adaptive management as required:

- Ground-truth the modelled results by measuring light from the facilities (or equivalent).
- Monitor the biological response of hatchlings at Sandy Islet during commissioning, flaring and operations.
- Monitor the water around vessels and facilities during commissioning and operations to confirm if hatchlings are aggregating around the FPSO, MODUs or associated vessels.

Table 1: Impact Level 1 – Continuous Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility **2. Scenario code** **3. Duration of impact** **4. Distance from Sandy Islet**	**Scenario code** **Orientation FOV (FME)** **Figure #**	**Life history stage / behaviour and impact pathway**			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1) FPSO **2)** IS1A; CS1A **3)** Continuous throughout 44-year project life **4)** ~29 km **1)** MODU (TRD) **2)** IS5 **3)** 18 months at given TR site. **4)** ~20 km	IS1A – 0.004 FME **Figure 4a** CS1A – 0.009 FME **Figure 9a** IS5 – 0.001 FME **Figure 8a**	**No impact predicted** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a small area of dim glow low on the horizon, which will have no impact on nesting females. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts, depending upon the intensity.	**No impact predicted** • The modelled radiometric visibility of the light source(s) indicates the facilities will appear as a small area of dim glow within the orientation FOV, which is not likely to have any impact on hatchlings during sea-finding. • In the absence of dunes/topographic features, hatchlings may orient towards artificial light source rather than ocean horizon. • Behavioural response may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of light sources, and lunar phase at emergence.	**No impact predicted** • Potential for hatchling dispersal behaviour to be affected decreases with distance to shore. • Light sources located from ~20 - 29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be very low, and few individuals will be at risk of attraction • Surface currents at Scott Reef will carry hatchlings on, and in the direction, of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will either reach or be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

Table 2: Impact Level 1 – Intermittent Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility **2. Scenario code** **3. Duration of impact** **4. Distance from Sandy Islet**	**Scenario code** **Orientation FOV (FME)** **Figure #**	**Life history stage / behaviour and impact pathway**			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1) FPSO **2)** IS2A **3)** Flaring Intermittently **4)** ~29 km	IS2A – 0.009 FME **Figure 5a**	**No impact predicted** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a small area of dim glow low on the horizon, which will have no impact on nesting females. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts, depending upon the intensity. • Flaring may occur intermittently during one nesting season.	**No impact predicted** • The modelled radiometric visibility of the light source(s) indicates the facility will appear as a small area of dim glow within the orientation FOV, which is not likely to have any impact on hatchlings during sea-finding. • In the absence of dunes/topographic features, hatchlings may orient towards artificial light source rather than ocean horizon. • Behavioural response may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of light sources, and lunar phase at emergence. • Duration and rate of flaring is difficult to predict but it is likely to be limited to a small proportion of hatchlings emerging at any time, i.e. the increased brightness and extent of sky glow under different flaring conditions will not be a static long term stressor impacting all emerging hatchlings across an entire nesting season.	**No impact predicted** • Potential for hatchling dispersal behaviour to be affected decreases with distance to shore. • Light sources located from ~20-29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be very low, and few individuals will be at risk of attraction • Surface currents at Scott Reef will carry hatchlings on, and in the direction, of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will either reach or be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

Table 3: Impact Level 2 – Intermittent Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility **2. Scenario code** **3. Duration of impact** **4. Distance from Sandy Islet**	**Scenario code** **Orientation FOV (FME)** **Figure #**	**Life history stage / behaviour and impact pathway**			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1) FPSO **2)** IS3A, IS4A, IS1B, IS2B **3)** Flaring and overcast intermittently **4)** ~29 km **1)** MODU **2)** IS6 **3)** Flaring intermittently **4)** ~20 km **1)** FPSO + MODU **2)** CS1B, CS2A, CS3A, CS4A **3)** Flaring intermittently **4)** ~20-29 km	IS1B - 0.010 FME **Figure 4b** IS2B - 0.029 FME **Figure 5b** IS3A – 0.031 FME **Figure 6a** IS4A – 0.041 FME **Figure 7a** IS6 – 0.020 FME **Figure 8b** CS1B – 0.012 FME **Figure 9b** CS2A – 0.030 FME **Figure 10a** CS3A – 0.054 FME **Figure 11a** CS4A – 0.065 FME **Figure 12a**	**No impact predicted** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a small area of dim glow low on the horizon, which will have no impact on nesting females. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts, depending upon the intensity. • Flaring may occur intermittently during one nesting season.	**Light and light glow highly visible, behavioural impact unlikely** • In absence of dunes/topographic features, hatchlings may orient towards artificial light source and sky glow which might be along the islet rather than directly towards the ocean horizon and may result in disorientation behaviour where hatching crawl in circles while trying to orient themselves. • Behavioural misorientation and disorientation responses may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Maximum predicted continuous flaring could potentially result in all clutches within a season being exposed to artificial light (weeks). • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of	**Light and light glow highly visible, behavioural impact unlikely** • Potential for hatchling dispersal behaviour to be affected decreases with distance from shore. • Light sources located ~20-29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be low, and few individuals will be at risk of attraction. • Surface currents at Scott Reef will carry hatchlings on and in the direction of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

			light sources, and lunar phase at emergence. • Cloud cover and thickness is dynamic and will vary with time leading to a range of potential exposure conditions and impacts that are a function of the duration and rate of flaring and difficult to predict but are likely to be limited to a small proportion of hatchlings emerging at any time, i.e. the increased brightness and extent of sky glow under clouds will not be a static, long-term stressor impacting all emerging hatchlings across an entire nesting season.		

Table 4: Impact Level 3 – Intermittent Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility **2. Scenario code** **3. Duration of impact** **4. Distance from Sandy Islet**	**Scenario code** **Orientation FOV (FME)** **Figure #**	**Life history stage / behaviour and impact pathway**			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1) FPSO **2)** IS3B, IS4B **3)** Intermittent Flaring and intermittent cloud (< 20 days/yr for each) **4)** ~29 km **1)** FPSO + MODU **2)** CS2B, CS3B, CS4B **3)** Intermittent Flaring and intermittent cloud (< 20 days/yr for each) **4)** ~20-29 km	IS3B – 0.116 FME **Figure 6b** IS4B – 0.156 FME **Figure 7b** CS2B – 0.103 FME **Figure 10b** CS3B – 0.192 FME **Figure 11b** CS4B – 0.236 FME **Figure 12b**	**Minor impact possible** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a broad area of sky glow encompassing the entire field of view of the turtles at right angles to the beach (seaward) and at the horizon. • Recovery Plan Action Area A8: It is unlikely an Impact Level 3 level of lighting will cause significant displacement of nesting females from Sandy Islet. Any displacement is expected to be minor, limited to individuals potentially exposed to a very short window of high light levels under heavy cloud. Any females displaced from Sandy Islet are likely to move to nesting beaches on Browse Island, which is the only other known nesting location for the G-ScBr genetic stock. • Flaring expected to be limited to 8 – 15 days per year and associated with unplanned upset flaring or well clean up flaring, worst case scenario this occurs during the 17 days of cloudy days reported for the area during the nesting season. Impact is intermittent and limited to one nesting season.	**Light and light glow highly visible, Minor behavioural impact possible** • The modelled radiometric visibility of the worst-case scenario of Major Upset Flaring plus Well Clean Up Flaring at TRA, with cloud cover at 80% and a ceiling height of 10 km (**CS4B**) shows a bright point source of light on the horizon, and the entire sky illuminated by light. The reflected light and glow extend well beyond the defined orientation FOV box and is almost 4 times brighter than the scenario with no cloud (**CS4A**). • In absence of dunes/topographic features, hatchlings may orient towards artificial light source and sky glow which might be along the islet rather than directly towards the ocean horizon and may result in disorientation behaviour where hatching crawl in circles while trying to orient themselves. • Behavioural misorientation and disorientation responses may result in hatchlings taking a longer route to the ocean.	**Light and light glow highly visible, No behavioural impact predicted** • Potential for hatchling dispersal behaviour to be affected by light decreases with distance from shore. • Light sources located ~20-29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be low, and few individuals will be at risk of attraction. • Surface currents at Scott Reef will carry hatchlings on and in the direction of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

		• The intensity of the light is between 0.103 and 0.236 FME, so even under the worst-case scenario of Major Upset Flaring plus Well Clean Up Flaring at TRA (**CS4B**), the illumination will fall in the lower range of a full moon brightness, closer to a quarter moon than a half moon. The number of days in a moon cycle that this high level of sky brightness could exceed the illumination from a half to new moon is 14 days, further reducing the potential number of days turtles could be exposed to high light levels under full cloud during the nesting season. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Sandy Islet and Browse Island green turtles are from the same genetic stock (G-ScBr) and so should a neophyte be displaced she could potentially move to Browse Island nesting beaches. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • The 5 – 8 year renesting interval for green turtles means that only small subset of breeding females could potentially be exposed to this level of brightness in a single season should it overlap with this level of flaring and cloud cover.	• Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Flaring expected to be limited to 8 – 15 days per year, associated with unplanned upset flaring or well clean up flaring, worst case scenario this occurs during the 17 days of cloudy days reported for the area during the nesting season. Impact is intermittent and limited to one nesting season. • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of light sources, and lunar phase at emergence and differences in individual visual sensitivities. • Cloud cover and thickness is dynamic and will vary with time leading to a range of potential exposure conditions and impacts that are a function of the duration and rate of flaring and difficult to predict but are likely to be limited to a small proportion of hatchlings emerging at any time, i.e. the increased brightness and extent of sky glow under clouds will not be a static long term stressor impacting all emerging hatchlings across an entire nesting season. • Nests will emerge over 8 – 12 weeks at the peak of the nesting season, a small subset of emerging nests could potentially be exposed to this level of brightness in a single season should it overlap with this level of flaring and cloud cover.		

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1 INTRODUCTION

1.1 Background

Woodside Energy Limited (Woodside), as operator for and on behalf of the Browse Joint Venture, is proposing to develop the Browse hydrocarbon resource located in the Brecknock, Calliance, and Torosa reservoirs. The Torosa reservoir is located near Sandy Islet within the Scott Reef complex, identified as sensitive turtle nesting habitat for green turtles in the discrete Scott Reef - Browse Island (G-ScBr) genetic stock, while the surrounding waters may also be used by leatherback (*Dermochelys coriacea*), flatback (*Natator depressus*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*) and loggerhead (*Caretta caretta*) turtles.

A desktop lighting assessment of the Browse project (Pendoley 2020) found that the behavioural response of marine turtles to artificial light is well documented in the scientific literature. The vulnerability of individuals to behavioural impacts is influenced by a number of factors including the properties of the artificial light (including intensity and wavelength), duration of exposure, visibility (e.g., shielding from topography) and the life stage or behaviour being undertaken. Green turtle hatchlings are most sensitive to short wavelength blue light and show preference for wavelengths <600 nm.

Therefore, Woodside requested Pendoley Environmental (PENV) undertake artificial light modelling of their proposed Floating Production Storage and Offloading (FPSO) and Mobile Offshore Drilling Unit (MODU) facilities that will be located within 30 km of Sandy Islet (**Figure 1**) to determine if there will be any impacts to hatchling marine turtles as a result of light emissions from the facilities.

1.2 Scope of Work

Jacobs engaged PENV on behalf of Woodside to conduct artificial light modelling of the Torosa FPSO, and a MODU at the TRD and TRA sites, as viewed from Sandy Islet, under different conditions. Specifically, PENV modelled a total of 24 scenarios, covering five flaring types and five cloud/sky conditions. These scenarios are further divided into Individual Scenarios (IS; containing either the FPSO or MODU in isolation), or Cumulative Scenarios (CS; containing the FPSO and MODU together). Of the 24 scenarios completed, 18 are presented in this report representing best- and worst-case scenarios, with additional scenarios included as **Appendix D**.

PENV also undertook a review of current literature to identify any existing light intensity thresholds for impacts on hatchling marine turtles. (**Appendix C**)

2 METHODOLOGY

2.1 Artificial Light Modelling

Currently, there are no standard commercial models for landscape scale modelling of artificial light emissions (Commonwealth of Australia 2020). Recognising this gap and the growing need to respond to both local and national regulatory concerns over artificial light impacts on wildlife, PENV has invested in considerable research and development effort to develop a landscape-scale artificial light model. This has been recently applied for our Australian oil and gas clients, and for a large-scale development in Saudi Arabia (The Red Sea Development Project).

The base model used for this work was the ILLUMINA model (version 2) that has been developed by Physics Professor Dr Martin Aubé of Sherbrooke University, Canada (Aube et al. 2005). This well-documented, open-source model was selected for its ability to represent light across large areas and distances and equally across the entire visible spectrum, including biologically meaningful light from 350 nm – 700 nm.

Unlike commercially available engineering light models that are commonly used to design human centric lighting for the relatively small footprint of single or multiple buildings, parking lots, streetlighting etc., ILLUMINA is a three-dimensional model that accounts for both line-of-sight light visibility in addition to the glow derived from atmospheric scattering of light. The model also addresses the attenuation/loss of light over landscape scale distances and, consequently, the areal extent of light glow across the sky can be modelled. Additional details of the equations and model parameterisation can be found in Aube et al. (2005). The model input parameters include project specific details about light type and spectral distribution, including any shielding, which substantially increases the model precision and accuracy. The model also includes project location-specific inputs such as surface reflectance and topographic values that are incorporated from aerial imagery supplied by NASA.

2.1.1 Modelling Scenarios

Modelling of predicted light emissions visible from the FPSO, MODU at TRD and MODU at TRA was undertaken using a single observer viewpoint on Sandy Islet for all scenarios. All scenarios included standard operational lighting levels based on information provided by Woodside (see **Appendix A**). As changes in flare activity are likely to have the greatest impact on light emissions visible from Sandy Islet, a total of five different flares were modelled (**Table 5**).

Table 5: Summary of the flares used in the scenarios. The flare rate (in mmscfD), power of flare (in mega-lumens), and expected flare period in number of days per year.

Vessel	Flaring Type	Rate (mmscfD)	Power (Mlm)	Period (~d/yr)
FPSO	Background Flaring	1	5.44	365
FPSO	Minor Upset Flaring	25	17.12	15
FPSO	Unplanned Upset Flaring	125	77.48	12
FPSO	Major Upset Flaring	250	104.63	12
MODU	Well Clean Up Flaring	70	35.43	8

The flaring scenarios were separated into three categories:

1. FPSO only: (Individual Scenarios; IS1 – IS6)
2. MODU only (Individual Scenarios; IS5 and IS6)
3. FPSO and MODU together (Cumulative Scenarios; CS1 – CS4)

These scenarios were also run in both clear (**A**) and cloudy (**B**) sky conditions and are outlined in **Table 6**.

Table 6: Summary of the modelled scenarios, the vessel inventory and cloud parameters. Where "A" scenarios denote clear conditions and "B" scenarios are in cloudy sky conditions. Operations lighting has been assumed to be on for all scenarios.

Vessel	Vessel Parameters		Scenario Code	Cloud Parameters		
	Inventory	Period (days/yr)		Cover (%)	Height (km)	Period (d/yr)
FPSO	Background Flaring	365	**IS1A** **IS1B**	0 80	0 3	118 17
	Minor Upset Flaring	15	**IS2A** **IS2B**	0 80	0 3	118 17
	Unplanned Upset Flaring	12	**IS3A** **IS3B**	0 80	0 3	118 17
	Major Upset Flaring	12	**IS4A** **IS4B**	0 80	0 3	118 17
MODU	Operation Light at TRD	365	**IS5**	0	0	118
	Well Clean Up Flaring at TRA	8	**IS6**	0	0	118
FPSO + MODU	Background Flaring Operation Light at TRD	365	**CS1A** **CS1B**	0 80	0 10	17 17
	Minor Upset Flaring Well Clean Up Flaring at TRA	15 8	**CS2A** **CS2B**	0 80	0 10	118 17
	Unplanned Upset Flaring Well Clean Up Flaring at TRA	12 8	**CS3A** **CS3B**	0 80	0 10	118 17
	Major Upset Flaring Well Clean Up Flaring at TRA	12 8	**CS4A** **CS4B**	0 80	0 10	118 17

2.1.2 Model Inputs

The following general parameters were used as inputs into the model:

1. Topography and reflectance: NASA Shuttle Radar Topography Mission (SRTM) digital elevation data (1 arc-second resolution).
2. GPS coordinates for the observer viewpoint on Sandy Islet and the FPSO, MODU (TRA) and MODU (TRD) locations (**Table 7** and **Figure 1**).
3. Weather conditions: All scenarios have been run in clear sky conditions as well as a variety of cloudy sky conditions as listed below:
   - Cloud type: thick cirrus;
   - Cloud height: 3 km and 10 km;

- Cloud coverage: 0%, 30% (not presented) and 80%.

These parameters were selected based off historical average weather data from the closest weather station (Broome) and agreed to by Woodside. This data has been averaged over the assumed turtle nesting season of October to February.

4. A detailed lighting inventory (light types, positions, heights, intensity) for each modelled scenario based on information provided by Woodside. Refer to **Appendix A** for a more detailed methodology describing the generation of the lighting inventory.

Table 7: Location of Sandy Islet observer, FPSO and MODU sites considered in the modelling.

Locations	Scenario	Latitude	Longitude	Distance to Sandy Islet (km)
Sandy Islet Observer	All	-14.055552	121.777309	0
Torosa FPSO	1 – 5	-13.970850	122.024592	29
MODU at TRD site	6	-13.970140	121.977139	20
MODU at TRA site	7	-14.007399	121.956549	23

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Figure 1: Location of the Sandy Islet observer viewpoint and facilities considered in the modelling (Torosa FPSO and the MODU at TRA and TRD sites).

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Drawn: A. Mitchell
Date: 17/06/2021
Drawing File Ref:
PENV-J67005-0002-A

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2.1.3 Model Outputs

All-sky modelled image: An all-sky modelled panorama 'as viewed' from the observer viewpoint was produced and shows the predicted brightness (including direct, reflected and refracted light) across the whole sky, including the horizon, for each of the seven scenarios (see **Figure 2** for an example).

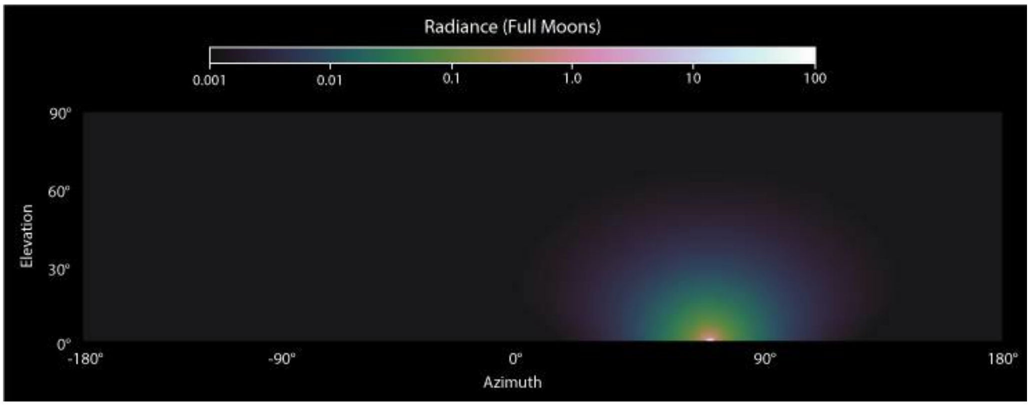

Figure 2: Example all-sky modelled image from an observer location showing predicted brightness.

The model outputs in units of absolute radiance; W/m^2/sr, where W = watts, m^2=metres squared and sr = steradian. In the absence of any published or generally accepted units of measurement, or scale, for measuring the impact of artificial light at night (ALAN) on marine turtles, moonlight has been selected as a proxy. The model output has been converted to Full Moon Equivalents (FME) to give the radiance output some biological relevance and to aid interpretation in an environmental impact assessment context. The rationale behind this approach is outlined in **Section 2.1.4**.

The sensitivity of a hatchling turtle to directional light can be described by a specific 'cone of acceptance' which indicates how much of the world a hatchling views and measures at any one instant, defined by Witherington (1992) as 180° horizontally and 30° vertically. To understand potential impacts on hatchling behaviour, all pixels in the 180° x 30° window centred over the brightest light source at the observer viewpoint are averaged (**Figure 2**), with the results presented as Orientation Field of View (OFOV) in FME units.

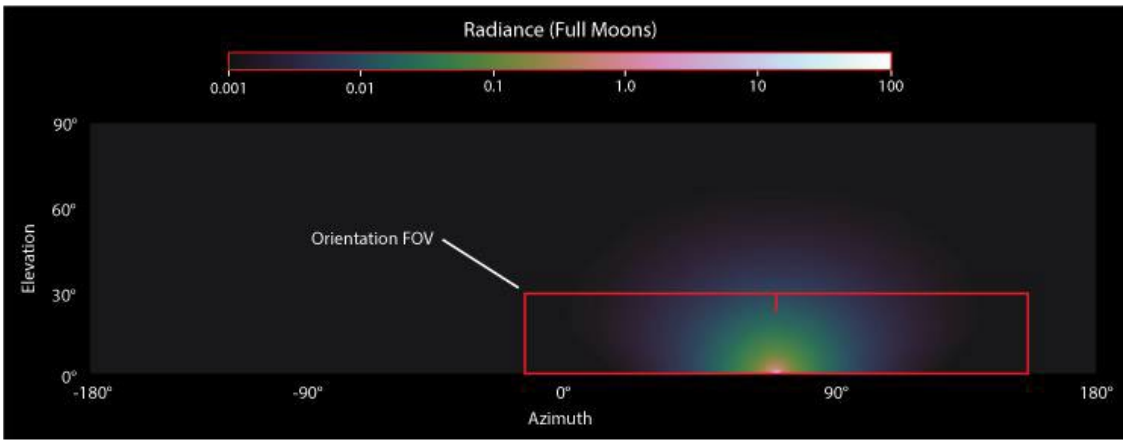

Figure 3: Cone of acceptance centred over the brightest light source. Pixels within this area are averaged and presented as Orientation Field Of View in FME.

2.1.4 Model Assumptions

As there was only high-level lighting detail available at this stage of the project, several assumptions had to be made to generate a lighting inventory for the FPSO and MODU. These are summarised below and outlined in more detail within **Appendix A**.

- When generating the lighting inventory, illumination levels were considered to be 150 % higher than required to meet lighting requirements specified in Woodside's engineering standards, to provide a conservative estimate of light output.
- All operations lighting on the FPSO is assumed to have a colour temperature of 3000 K. This assumes best practice lighting design measures are incorporated into the FPSO design.
- All operations lighting on the MODU is assumed to have a colour temperature of 6500 K.
- All interior or enclosed lighting is considered to be 100 % shielded and therefore not represented within the model.

2.1.5 Model Limitations

- As this model is still developmental, results have not yet been definitively ground-truthed for large-scale projects (Linareset al. 2018; Linares Arroyo et al. 2020). While the approach outlined within this report is considered sound at the time of writing, future model results may not be comparable due to updates in the science and methodology that underpin the current software.
- The precision of the model outputs is directly related to the level of input detail. At this stage of the project, only high-level detail was available and thus many assumptions were needed to generate a lighting inventory, potentially reducing the precision of the model outputs.
- The model considers light equally across the spectrum (radiometrically) at 100 % sensitivity to all wavelengths. Therefore, it is not representative of the vision of marine turtles which have a high sensitivity to short wavelengths and less sensitivity to longer wavelengths. While it is possible to weight model outputs to a spectral sensitivity curve for marine turtles, after discussion between PENV and Woodside it was agreed that outputs would be represented in the radiometric format as this provides a conservative "worst case" output where light is assumed to be received at a maximum level across all wavelengths.

2.1.6 Literature Review and Impact Criteria

Recognising the absence of any limits or thresholds as well as the many limitations associated with estimating a likelihood of impact from light to hatchling turtles, Woodside engaged PENV to undertake a literature review to determine if thresholds or limits have been defined in the literature that relate to the intensity, visibility, or direction of light from a nesting beach at which an impact to a hatchling turtle could occur. The objective of the literature review was to identify any threshold or limit that could be used to improve the interpretation of modelled outputs of light from the resource development and better inform the EIA outcomes.

The literature review found there were no conclusive thresholds/limits of light intensity, or its visibility, defined within reviewed literature that specified that when exceeded, would influence hatchling sea-finding behaviour (see full review in **Appendix B**). In the absence of these thresholds, PENV has used the FME units and tied these results to impact criteria based on our collective professional experience observing hatchling behaviour (**Table 8**). This approach is consistent with the process of expert elicitation, which builds on the available research findings in the absence of detailed empirical data (Burgman 2005; Burgman et al .2011; Patterson et al. 2007). The reasoning used includes:

1. The range of moon brightness across a whole lunar cycle is a realistic scale representative of the ambient light levels that turtle eyes are adapted to, at the lower end of the scale the radiant output is equivalent to no light in the sky while the upper limit is greater than the radiance from a single full moon and was selected to try to account for the reasonable increase in radiance levels that would occur if bright light was reflected from clouds.

2. While the behavioural response of marine turtles to light is relatively well understood (see Witherington and Martin (2003) for review), there is currently no agreed upon intensity limits for determining what the impact of a given light might be. A large range of factors influence the visibility and impact of light on hatchlings including light intensity, visibility (a function of lamp orientation and shielding), spectral power distribution (wavelength and colour), atmospheric scattering, cloud reflectance, spatial extent of sky glow, duration of exposure, horizon elevation, lunar phase, hatchling swimming speeds, species, tide and current speeds and flow direction etc. Using the scale of light radiance derived from the calculated decrease in light intensity with distance (proportion radiance of a full moon) and together with our extensive subject matter experience observing marine turtles and their response to both onshore and offshore construction light in field settings, we have proposed conservative, potential impact criteria for marine turtles based on radiance thresholds relative to moon radiance, as shown in **Table 8.**

3. The scale for the units “the proportion of radiance of one full moon” is derived from the logarithmic nature of light decay with distance (a function of the inverse square law), e.g. the scale of <0.01, 0.01 – 0.1, 0.1 – 1, 1 – 10 represents a range of radiant brightness from a minimum of <0.01 full moon (so essentially a new moon) to a maximum radiant brightness of the equivalent to 10 full moons.

Table 8: Potential artificial light impact criteria (marine turtles).

Impact Level	Radiance as Full Moon Equivalents (FME)	Impact potential to marine turtles
4	1 - 10	Light or light glow visible and impact likely, represents a very bright light equivalence to up to 10 times the radiance of one moon. This level of ALAN light radiance will override the moderating influence of the ambient full moon at the time of exposure.
3	0.1 - 1	Light or light glow visible and behavioural impact possible, depending on ambient moon phase at the time of exposure, which will influence the visibility of the artificial light sources, equivalent to the light output. Artificial lights will be more visible to marine turtles under a first quarter moon than under a full moon.
2	0.01 - 0.1	Light or light glow visible but behavioural impact unlikely (i.e. not biologically relevant). Equivalent to the light output from the first quarter moon to new moon.
1	<0.01	Light or light glow is considered ambient and no impact expected, equivalent to a new moon

4 RESULTS AND DISCUSSION

The modelling of 18 different scenarios was successfully completed, with 10 Individual Scenarios (IS), and 8 Cumulative Scenarios (CS), results are shown in **Table 9**. Results from these scenarios are outlined in further detail in **Sections 4.1 and 4.2.**

Table 9: Orientation FOV values for each scenario, and the corresponding impact levels. Where "A" Scenarios denote clear conditions and "B" Scenarios are in cloudy sky conditions. OFOV units are in Full Moon Equivalents (FME; refer to Section 2.1.3).

Vessel	Lighting Inventory	Scenario Name	OFOV (FME)	Impact Level
FPSO	Background Flaring	**IS1A**	0.004	**1**
		IS1B	0.010	**2**
	Minor Upset Flaring	**IS2A**	0.009	**1**
		IS2B	0.028	**2**
	Unplanned Upset Flaring	**IS3A**	0.031	**2**
		IS3B	0.116	**3**
	Major Upset Flaring	**IS4A**	0.041	**2**
		IS4B	0.156	**3**
MODU	Operation Light at TRD	**IS5**	0.001	**1**
	Well Clean Up Flaring at TRA	**IS6**	0.020	**2**
FPSO + MODU	Background Flaring Operation Light at TRD	**CS1A** **CS1B**	0.006 0.012	**1** **2**
	Minor Upset Flaring Well Clean Up Flaring at TRA	**CS2A** **CS2B**	0.030 0.103	**2** **3**
	Unplanned Upset Flaring Well Clean Up Flaring at TRA	**CS3A** **CS3B**	0.054 0.192	**2** **3**
	Major Upset Flaring Well Clean Up Flaring at TRA	**CS4A** **CS4B**	0.065 0.236	**2** **3**

4.1 Individual Scenarios

In IS1A - 4A (clear sky conditions) the FPSO is identifiable as a small point source of direct light on the horizon, predominantly due to the height of the flare (base height: 182 m above sea level). The areal extent of sky glow from the FPSO correlates strongly with flaring intensity ranging from minimal levels during background flaring (IS1A; **Figure 4a**) and extending across the sky during minor (IS2A; **Figure 5a**), unplanned (IS3A; **Figure 6a**), and major upset flaring (IS4A; **Figure 7a**). Orientation FOV (OFOV) Full Moon Equivalent (FME) values also correlate strongly with flaring intensity and the resulting changes in sky glow extent, with the brightest values generated in IS4A (0.041), and decreasing in IS3A (0.031), IS2A (0.009) and IS1A (0.004; see **Table 9**).

The impact of clouds on sky glow is clearly demonstrated in IS1B - 4B by the order of magnitude increase in OFOV FME values, with the smallest increase occurring in IS1B (0.01; 239%) and increasing in IS2B (0.028; 293%), IS3B (0.116; 371%), and IS4B (0.156; 377%; see **Table 9**). The impact of the low cloud ceiling on sky glow from the different FPSO flaring conditions is shown in **Figures 4b – 7b**.

In Scenarios IS5 and IS6 the MODU is also an identifiable point source of direct light on the horizon and the visibility of direct lighting at the TRD site (IS5; **Figure 8a**) is marginally higher than the TRA site (IS6;

Figure 8b) because of its shorter distance from Sandy Islet. As there is no flaring at the TRD site, there is almost no visible sky glow with only very low levels of light reflecting off the ocean below 2° elevation and an OFOV value of 0.001. The model results show the impact of flaring from the MODU at the TRA site (IS6), where the extent of the sky glow increases substantially within the OFOV to 0.020, which is approximately 18 times brighter than the MODU at the TRD site (IS5; **Table 9**).

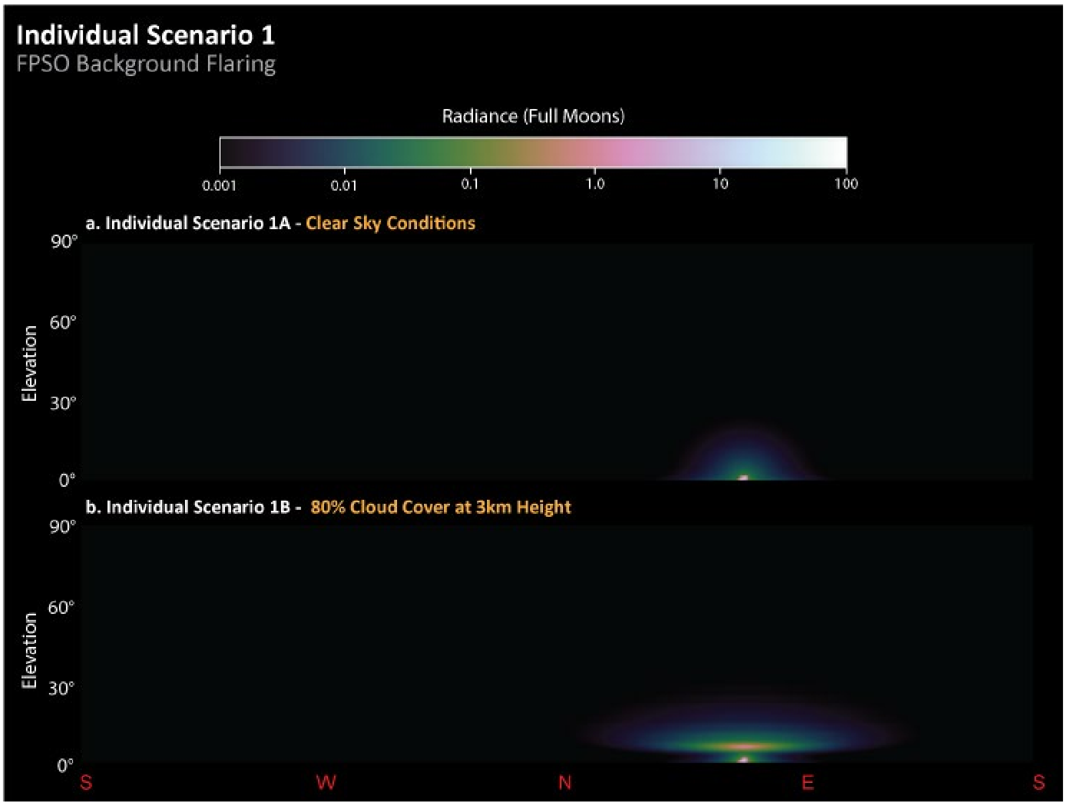

Figure 4: Model outputs for the FPSO – Individual Scenario 1: a. Clear sky conditions (IS1A); b.80% Cloud Cover at a height of 3km (IS1B).

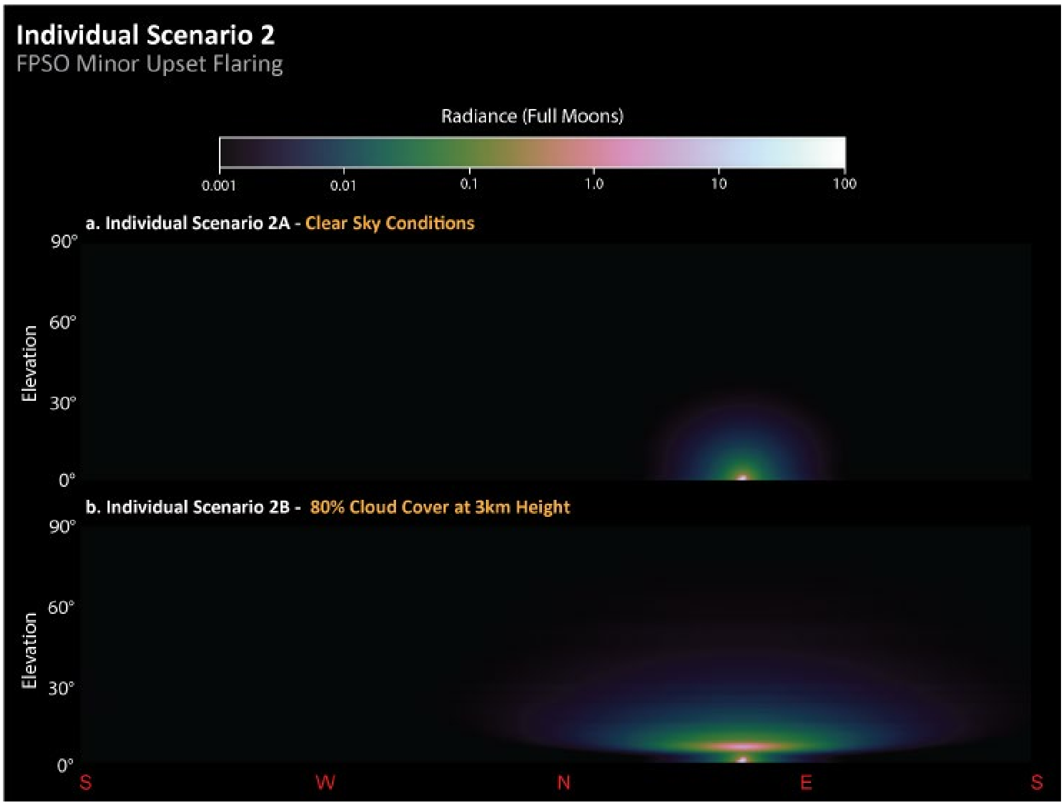

Figure 5: Model outputs for the FPSO – Individual Scenario 2: a. Clear sky conditions (IS2A); b.80% Cloud Cover at a height of 3km (IS2B).

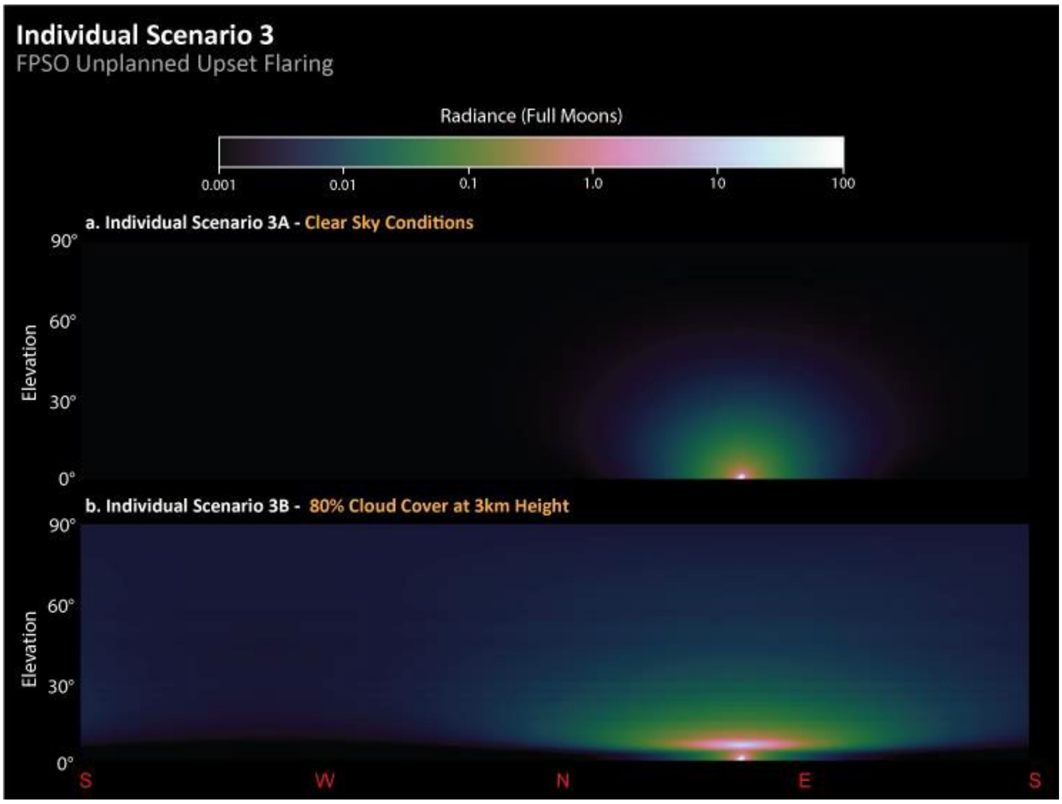

Figure 6: Model outputs for the FPSO – Individual Scenario 3: a. Clear sky conditions (IS3A); b.80% Cloud Cover at a height of 3km (IS3B).

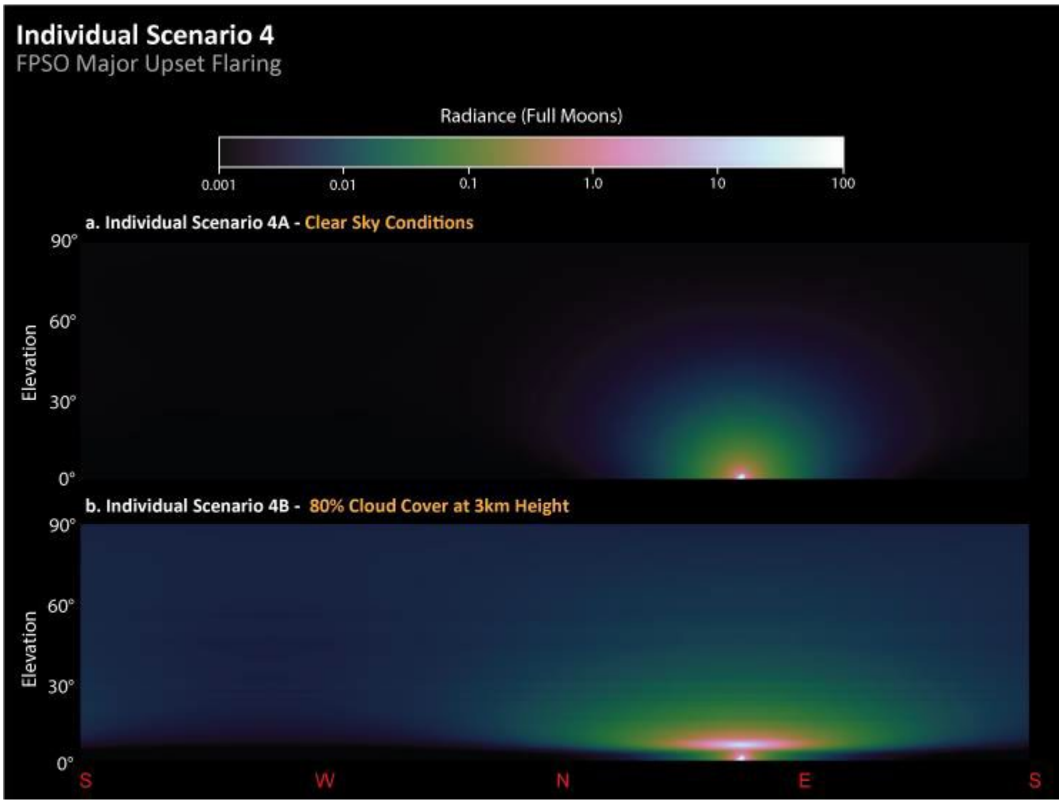

Figure 7: Model outputs for the FPSO – Individual Scenario 4: a. Clear sky conditions (IS4A); b.80% Cloud Cover at a height of 3km (IS4B).

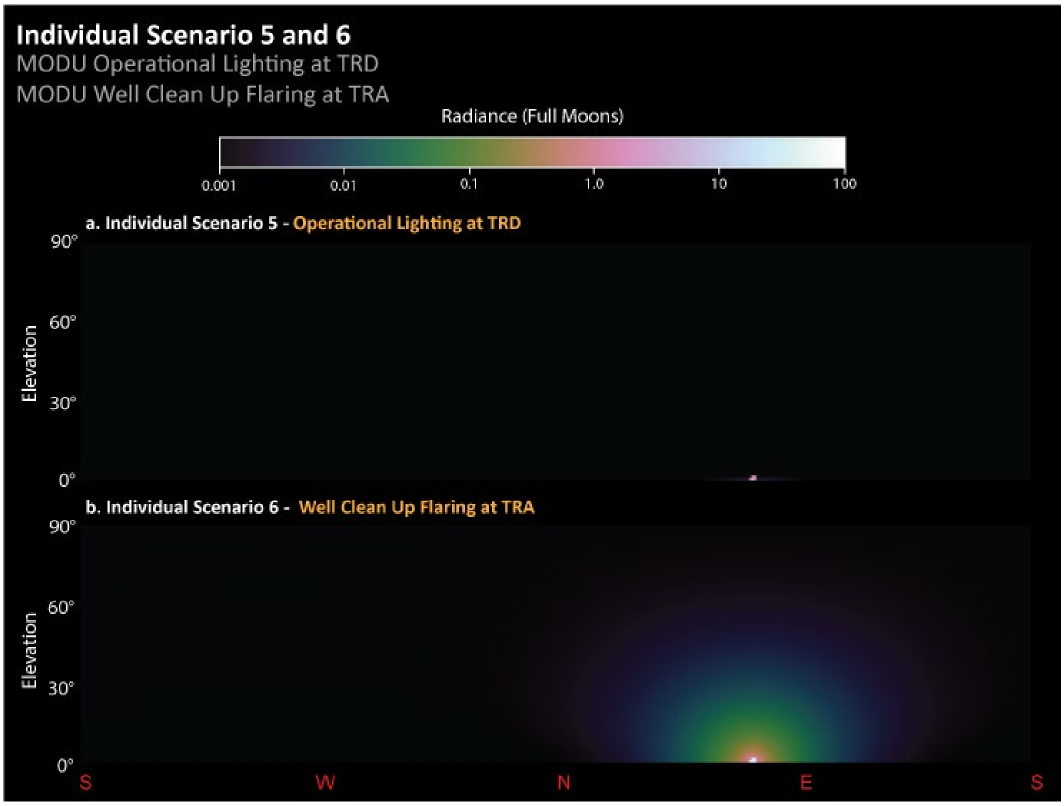

Figure 8: Model outputs for the MODU – Individual Scenario 5 and 6: a. MODU Operational Lighting at TRD (IS5); b. MODU Well Clean Up Flaring at TRA (IS6).

4.2 Cumulative Scenarios

Clear sky conditions were modelled for the cumulative inventories of the four FPSO flaring scenarios and the MODU Well Clean Up Flaring scenario in CS1A-4A. Both the FPSO and the MODU are identifiable as small point sources of direct light on the horizon. The areal extent of sky glow from the cumulative inventories correlates strongly with flaring intensity from the FPSO, ranging from minimal levels during background flaring (CS1A; **Figure 9a**) and extending across the sky during minor (CS2A; **Figure 10a**), unplanned (CS3A; **Figure 11a**), and major upset flaring (IS4A; **Figure 12a**). OFOV FME values also correlate strongly with flaring intensity and the resulting changes in sky glow extent, with the brightest values generated in CS4A (0.065), and decreasing in CS3A (0.054), CS2A (0.030) and CS1A (0.006; see **Table 9**).

The impact of cloud on sky glow is clearly demonstrated in CS1B - 4B by the order of magnitude increase in OFOV FME values (**Table 9**), with the smallest increase occurring in CS1B (0.012; 202%; **Figure 9b**) and increasing in CS2B (0.103; 345%; **Figure 10b**), CS3B (0.192; 356%; **Figure 11b**), and CS4B (0.236; 364%; **Figure 11b**).

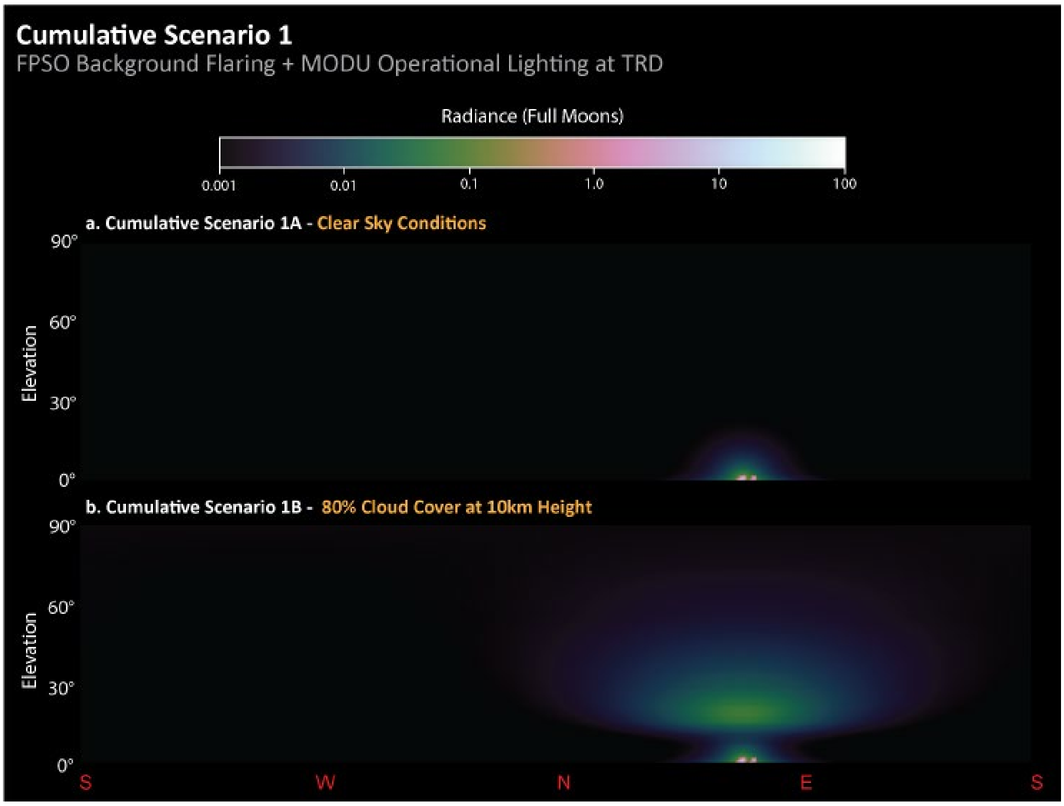

Figure 9: Model outputs for the FPSO and MODU – Cumulative Scenario 1: a. Clear sky conditions (CS1A); b.80% Cloud Cover at a height of 10km (CS1B).

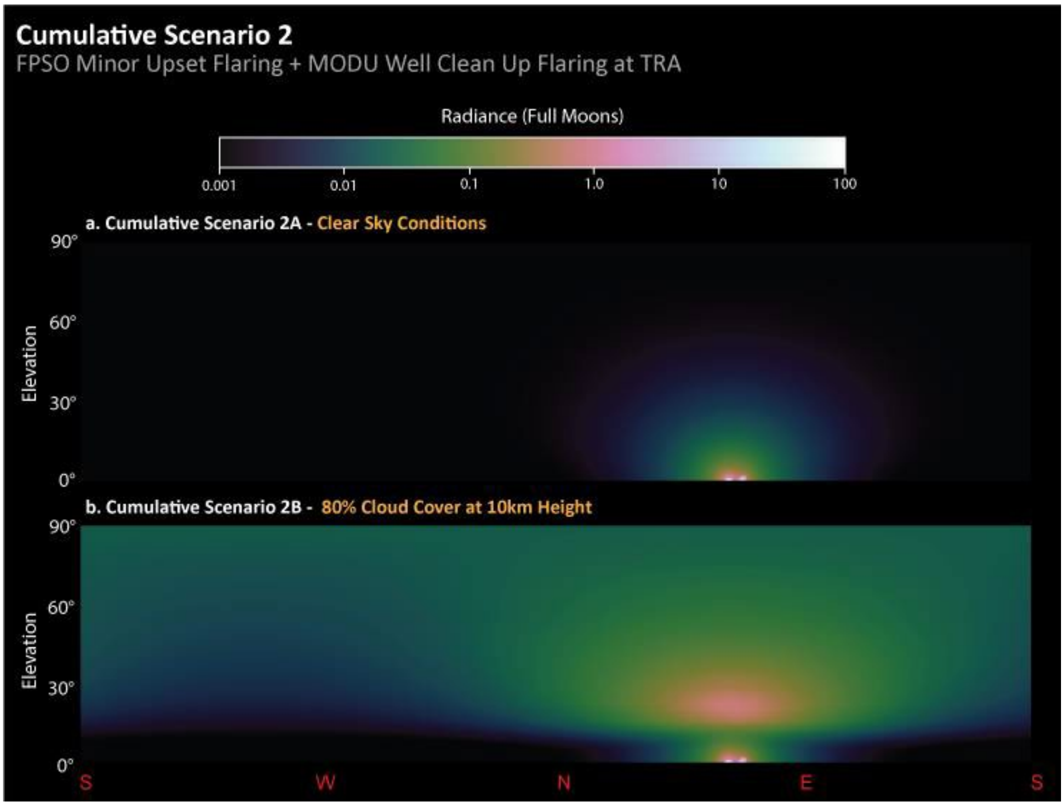

Figure 10: Model outputs for the FPSO and MODU – Cumulative Scenario 2: a. Clear sky conditions (CS2A); b.80% Cloud Cover at a height of 10km (CS2B).

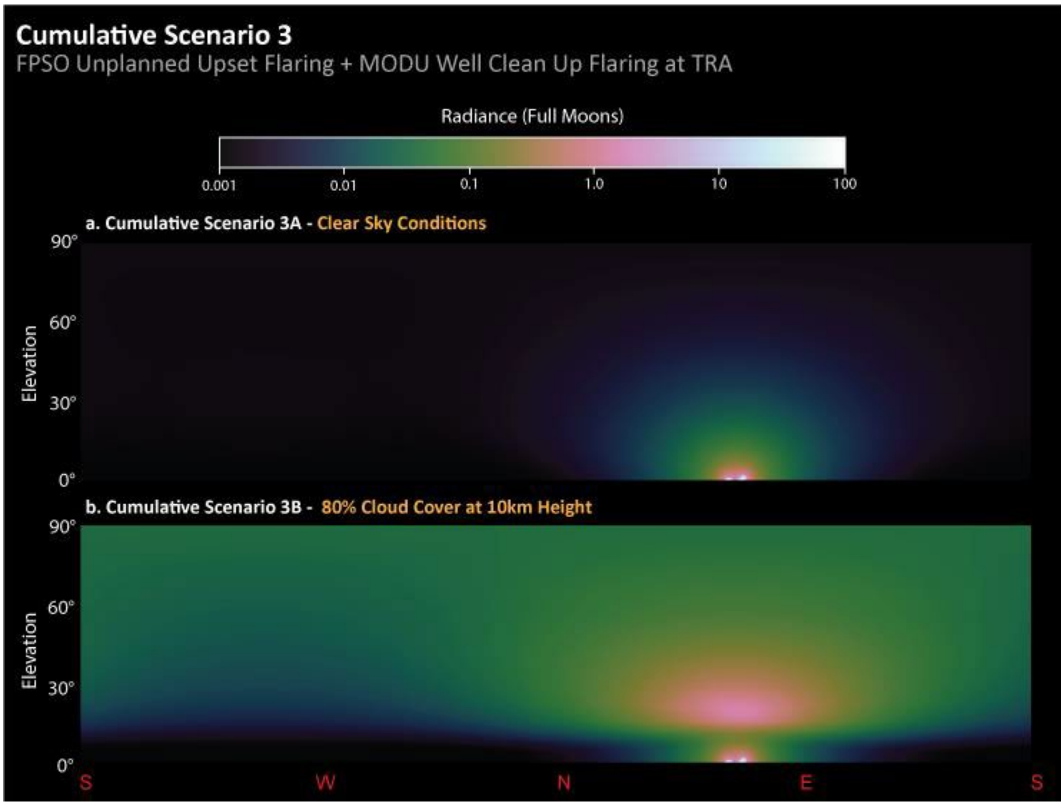

Figure 11: Model outputs for the FPSO and MODU – Cumulative Scenario 3: a. Clear sky conditions (CS3A); b.80% Cloud Cover at a height of 10km (CS3B)

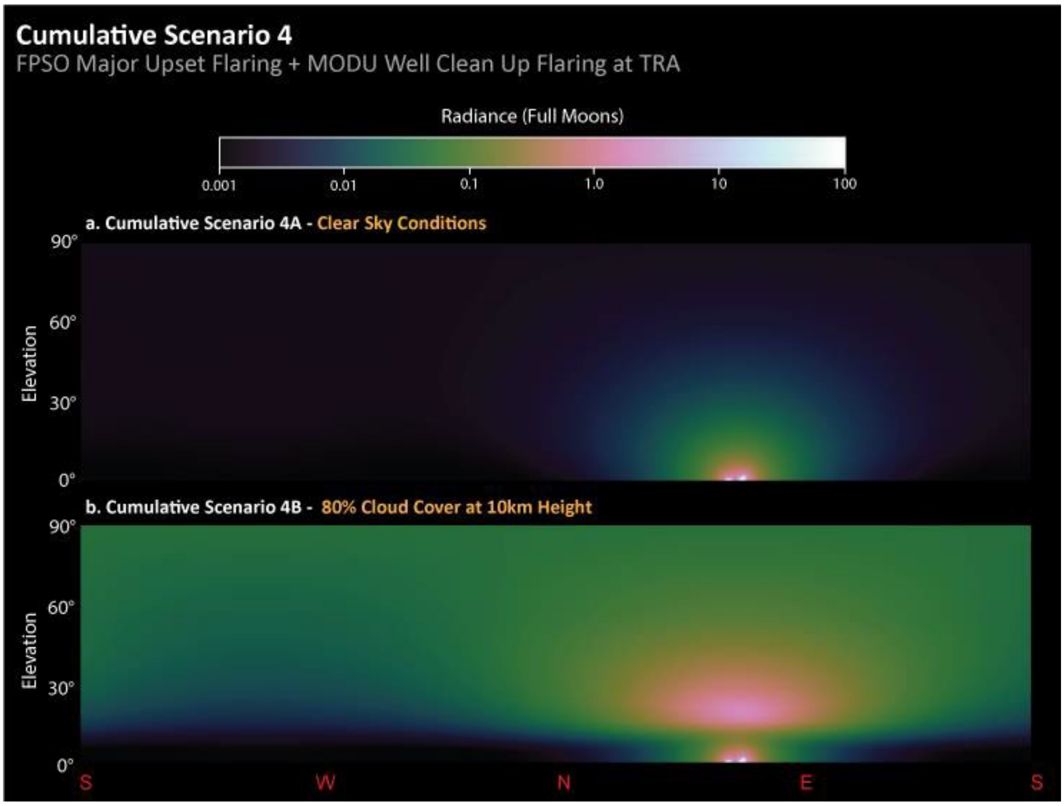

Figure 12: Model outputs for the FPSO and MODU – Cumulative Scenario 4: a. Clear sky conditions (CS4A); b.80% Cloud Cover at a height of 10km (CS4B).

4.3 Potential Impacts

For the purposes of the assessment the modelled Scenarios have been categorised based on:

- the expected duration of impact (intermittent or continuous) and;
- the modelled impact level (FME - **Table 8**).

Intermittent is a short-term potential impact which is defined as less than or equal to one nesting season, while continuous potential impacts are defined as the routine light impacts that will occur for the lifetime of the project, i.e. over multiple concurrent turtle seasons. The assessment considers the intermittent nature both of flaring and of cloud cover (height, percent and period; **Table 6**). Four impact tables have been generated based on the duration and level of impact (**Appendix C**).

The three categories of impact level generated by the 18 modelled scenarios considered in the assessment are summarised below.

4.3.1 Impact Level 1 (<0.01 FME)

Impact level 1 is described as "Light or light glow is considered ambient, and no impact expected, equivalent to a new moon". Scenarios falling into this category are predicted to have no impact on hatchling behaviours.

Scenarios which returned an Impact Level 1 result from the modelling included:

- **IS1A**: FPSO background flaring (no cloud, continuous),
- **IS2A**: FPSO minor upset flaring (no cloud, intermittent),
- **IS5**: MODU operation lighting at TRD (no cloud, continuous),
- **CS1**: FPSO background flaring and MODU operation lighting at TRD (no cloud, continuous).

4.3.2 Impact Level 2 (0.01 – 0.1 FME)

Impact level 2 (0.01 – 0.1 FME) is described as "Light or light glow visible but behavioural impact unlikely (i.e., not biologically relevant). Equivalent to the light output from the first quarter moon to new moon.". Consequently, while the source may be visible, no impacts are expected on hatchling sea finding behaviour from these light emissions.

Scenarios which returned an Impact Level 2 result from the modelling included:

- **IS1B**: FPSO background flaring (cloud, intermittent)
- **IS2B**: FPSO minor upset flaring (cloud, intermittent)
- **IS3A**: FPSO unplanned upset flaring (no cloud, intermittent)
- **IS4A**: FPSO major upset flaring (no cloud, intermittent)
- **IS6**: MODU well clean up flaring (no cloud, intermittent)
- **CS1B**: FPSO background flaring and MODU operations lighting at TRD (cloud, intermittent)

- **CS2A**: FPSO minor upset flaring and MODU well clean up flaring at TRA (no cloud, intermittent)
- **CS3A**: FPSO unplanned upset flaring and MODU well clean up flaring at TRA (no cloud, intermittent)
- **CS4A**: FPSO major upset flaring and MODU well clean up flaring at TRA (no cloud, intermittent)

Scenarios are considered intermittent due to either sporadic flaring (IS3A, IS4A, IS6, CS2A, CS3A, CS4A), cloud conditions (IS1B, CS1B), or a combination of both (IS2B).

4.3.3 Impact Level 3 (0.1 – 1 FME)

Impact level 3 (0.1 – 1 FME) is described as "Light or light glow visible and behavioural impact possible, depending on ambient moon phase at the time of exposure, which will influence the visibility of the artificial light sources, equivalent to the light output. Artificial lights will be more visible to marine turtles under a first quarter moon than under a full moon". Light sources falling into this category will be brighter than the moon for approximately half of its monthly cycle, and less detectable in the other half, meaning that the likely impact on receptors will change across the lunar cycle.

Scenarios which returned an Impact Level 3 result from the modelling included:

- **IS3B**: FPSO unplanned upset flaring (cloud, intermittent)
- **IS4B**: FPSO major upset flaring (cloud, intermittent)
- **CS2B**: FPSO minor upset flaring and MODU well clean up flaring at TRA (cloud, intermittent)
- **CS3B**: FPSO unplanned upset flaring and MODU well clean up flaring at TRA (cloud, intermittent)
- **CS4B**: FPSO major upset flaring and MODU well clean up flaring at TRA (cloud, intermittent)

In all of these Scenarios the modelled bright and widespread sky glow is caused by the presence of heavy cloud cover which strongly reflects and scatters light across the entire sky. While the potential to impact on hatchling behaviour is greatest at this impact level, the likelihood of this impact level being reached is mediated by the relatively low number of days (~17 days) during the nesting season that clouds are typically present at the project site (**Table 6**). Furthermore, the flaring is expected to be limited to 8 – 15 days per year, associated with unplanned upset flaring or well clean up flaring. Under worst-case conditions, to create enough light emissions to reach an impact level 3 threshold, the unplanned flaring would have to coincide with the 17 cloudy days reported for the area during the nesting season. The potential impact on nesting adults and hatchlings is therefore considered intermittent, limited to one nesting season and assessed as minor should it occur.

The Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017) Action Area A8 (Minimise light pollution) has the following action:

- Artificial light within or adjacent to habitat critical to the survival of marine turtles will be managed such that marine turtles are not displaced from these habitats.

It is unlikely an Impact Level 3 level of lighting will cause significant displacement of nesting females from Sandy Islet, and should it occur, any displacement is expected to be minor and limited to susceptible individuals potentially exposed to a very short window of high light levels under heavy cloud. Any females displaced from Sandy Islet are likely to move to nesting beaches on Browse Island (~190 km to the east), which is the only other known nesting location for the G-ScBr genetic stock. Experienced nesting females are not considered vulnerable to the effects of light on nest site selection and therefore permanent displacement of these individuals is unlikely.

4.4 Summary

A summary of the artificial light impact assessment for green turtles at Sandy Islet for all Scenarios incorporating the model results is shown in **Appendix C, Tables C1 – C4**

The predicted impacts of the modelled Scenarios with continuous impacts on marine turtles were assessed as 'no expected impact'. However, modelled Scenarios that may intermittently affect a given turtle nesting season ranged from "no expected impact" to "unlikely impact", and "possible impact".

The predicted impact under the worst-case scenario of unplanned flaring and heavy cloud cover are assessed as "minor impacts possible", however the risk of this impact is considered low given the limited number of days this flaring is expected to occur, the limited number of days of predicted heavy cloud cover, the small proportion of the nesting population that could be exposed in any one season and the limited number of emerging hatchlings that could be exposed during this level of light exposure.

In accordance with the approach outlined in the National Light Pollution Guidelines we recommend the following biological and light monitoring programs be implemented to confirm these predictions and to provide a basis for adaptive management as required:

- Ground-truth the modelled results by measuring the facilities (or equivalent).
- Monitor the biological response of hatchlings at Sandy Islet during commissioning, flaring and operations.
- Monitor the water around vessels and facilities during commissioning and operations to confirm if hatchlings are aggregating around the FPSO, MODUs or associated vessels.

5 REFERENCES

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Appendix A: Generation of Lighting Inventories

Appendix B: Literature Review

Appendix C: Impact Tables

1 GENERATION OF LIGHTING INVENTORIES

The lighting inventories used in each scenario for the FPSO and MODU were generated using information provided by Woodside. In the absence of detailed lighting design plans at this phase of the project, assumptions were made about the light types likely to be used for standard operations, illuminance levels of major areas within the FPSO and MODU, and the output of the flare. These assumptions can calculations are outlined in more detail in the following sections.

1.1 Operations Lighting

1.1.1 FPSO

Two light types were selected for input into operations lighting calculations (**Table A1**):

1. A "normal" 6900-lumen LED light (based off a fluorescent equivalent) with no light emitted above the horizontal plane) and a colour temperature of 3000 K.
2. A 25000-lumen floodlight with no light emitted above the horizontal plane and a colour temperature of 3000 K.

Table A1: Light types used for standard operations lighting in the FPSO.

Fixtures	Type	Colour Temperature	Shielding (%)	Power (Lumens)
Normal	LED	3000 K	50	6900
Floodlight	LED	3000 K	50	25,000

Required illumination levels of main areas in the FPSO were provided by Woodside and are outlined in **Table A2**.

Table A2: Illumination levels for different areas in the FPSO (note: levels are 150% of the minimum required).

Area type	Areas included	Illumination level (lux)
Operating areas	• Main Deck (MD) • Process modules • Turret module (levels 1 – 3)	225
Access ways	• Accommodation module • Turret module (levels 4 – 9)	37.5

To calculate the number of lights required to illuminate an area to the specified level, the following formula is used:

$$\Phi = E \times A$$

Where Φ is total power required measured in lumens, E is illumination measured in lux, and A is the area on which the light lands measured in metres squared. The assumptions made regarding lit operations areas on the FPSO and the resulting total lumen outputs are summarised in **Sections 1.1.1.1 – 1.1.1.5**.

1.1.1.1 Main Deck

- Dimensions of 66 x 300 metres with a total area of 19,800 m^2.
- Lights mounted at 2 m high.
- Required illumination levels of 75 lux.
- A ratio of approximately 90% normal to 10% floodlights was assumed
- The required lumens to light this area was calculated to be 1,485,000 lumens (122 normal lights and 26 floodlights).

1.1.1.2 Accommodation Module

- Dimensions of 25 x 50 m. The total area of each level is 1250 m^2, however the interior of the module is considered to be shielded and unlit. This leaves only the 2 m-wide access ways around the exterior which equate to an area of 284 m^2.
- Six levels at 4 m intervals, from MD + 10.5 m to MD + 30.5 m.
- Lights are mounted at 2 m high
- Required illumination levels of 37.5 lux.
- All normal lighting with no floodlights
- A total of 22 lights required for a total of 151,800 lumens per level.
- 910,800 lumens for the whole module.

1.1.1.3 Turret Module

The turret module consists of several different levels of different sizes:

- Level 1, 30 x 30 m (900 m^2). Height: MD + 0 m
- Levels 2-9, 10 m x 10 m each (100 m^2). Heights:
  - Level 2: MD + 3 m
  - Level 3: MD + 7 m
  - Level 4: MD + 13.5 m
  - Level 5: MD + 16.5 m
  - Level 6: MD + 20.5 m
  - Level 7: MD + 24.5 m
  - Level 8: MD + 28.5 m
  - Level 9: MD + 32.5 m
- Lights are mounted at 2m
- Levels 1-3 are illuminated to 225 lux.
- Levels 4-9 are illuminated to 37.5 lux.
- The required lumens for level 1 is 202,500.
- The required lumens for levels 2 and 3 is 22,500 for each level.
- The required lumens for levels 4 – 9 is 3750 for each level.
- Total lumens required across all levels: 293,200 lumens, consisting of 28 normal lights and two floodlights.

1.1.1.4 Process Modules

- Dimensions of 25 x 30 m (750 m^2) for each level.
- There are 14 process modules. Each module has three levels each, separated by 8 m in height (MD +6.5, +14.5, +22.5) for a total of 42 levels.
- Illumination requirement of 225 lux.
- Each level requires 168,750 lumens, which is satisfied using 18 normal lights and two floodlights per level. The combined total of the process modules is 7,361,400 lumens, consisting of 756 normal lights and 84 floodlights.

1.1.1.5 Summary

A summary of all lights considered as part of the standard operations lighting for the FPSO is shown in **Table A3**

Table A3: Lighting inventory containing a summary of lights used in the modelling of the FPSO.

Location	Quantity	Levels	Number of lights per level	Fixture type
Process Modules	14	1-3	18	Normal
Process Modules	14	1-3	2	Floodlight
Accommodation Module	1	1-6	22	Normal
Turret Module	1	1	14	Normal
Turret Module	1	1	4	Floodlight
Turret Module	1	2-3	4	Normal
Turret Module	1	4-9	6	Normal
Main Deck	1	1	122	Normal
Main Deck	1	1	26	Floodlight

1.1.2 MODU

The two light types selected for input into MODU operations lighting were similar to the FPSO, however were not considered to be "turtle-aware" (**Table A4**), and therefore had a colour temperature of 6500 K (Cool White):

Table A4: Light types used for standard operations lighting in the MODU.

Fixtures	Type	Colour Temperature	Shielding (%)	Power (Lumens)
Normal	LED	6500 K	50	6900
Floodlight	LED	6500 K	50	25,000

Required illumination levels of main areas in the FPSO were provided by Woodside and are outlined in **Table A5**.

Table A5: Illumination levels for different areas in the MODU (note: levels are 150% of the minimum required).

Area type	Areas included	Illumination level (lux)
Operating areas	• Drill Floor • Drill Derrick Base	225
Non-operating areas	• Main Deck	75
Access ways	• Derrick • Accommodation • Draw Works Roof	37.5

The assumptions made regarding lit operations areas on the MODU and the resulting total lumen outputs are summarised in **Sections 1.1.2.1 – 1.1.2.7**.

1.1.2.1 Main Deck

- Dimensions 75 x 75 m (5,625 m^2).
- Level height of 16 m (above sea level).
- Lights mounted at 2 m.
- Required illumination of 75 lux.
- Requires 421,875 lumens, consisting of 33 normal lights and eight floodlights.

1.1.2.2 Accommodation

- Dimensions of 40 x 40 m. The total area of each level is 1600 m^2, however the interior of the module is considered to be shielded and unlit. This leaves only the 2 m-wide access ways around the exterior which equate to an area of 354 m^2.
- Two Levels at MD + 3 m and MD + 7 m.
- Required illumination of 37.5 lux.
- A total of 30 normal lights per level for a total of 60 normal lights and 414,000 lumens.

1.1.2.3 Drill Floor

- Dimensions 40 x 40 m (1,600 m^2).
- Level height of MD + 10 m.
- Lights mounted at 2 m high.
- Required illumination of 225 lux.
- Requires a total of 363,900 lumens consisting of 31 normal lights and six floodlights.

1.1.2.4 Drill Derrick Base

- Dimensions 17 x 40 m (680 m^2).
- Level height of MD + 14 m.
- Lights mounted at 2 m high.
- Required illumination of 225 lux.
- Requires a total of 153,500 lumens consisting of 15 normal lights and two floodlights.

1.1.2.5 Draw Works Roof

- Dimensions 17 x 45 m (765 m^2).
- Level height of MD + 20 m.
- Lights mounted at 2 m high.
- Required illumination of 37.5 lux.
- Requires a total of 34,500 lumens consisting of five normal lights.

1.1.2.6 Derrick

- Dimensions 17 x 17 m (289 m^2).
- 15 levels spaced 5 m apart from MD + 20 m to MD + 90 m.
- Lights mounted at 2 m high on each level.
- Required illumination of 37.5 lux.
- Requires a total of 207,000 lumens consisting of 30 normal lights.
- There are 24 floodlights mounted at MD + 30 m with a total of 600,000 lumens, bringing the final total on the derrick to 807,000 lumens.

1.1.2.7 Summary

A summary of all lights considered as part of the standard operations lighting for the FPSO is shown in **Table A6.**

Table A6: Lighting inventory containing a summary of lights used in the modelling of the MODU.

Location	Quantity	Levels	Number of lights per level	Fixture type
Main Deck	1	1	33	Normal
Main Deck	1	1	8	Floodlight
Drill Floor	1	1	31	Normal
Drill Floor	1	1	6	Floodlight
Drill Derrick Base	1	1	15	Normal
Drill Derrick Base	1	1	2	Floodlight
Draw Works Roof	1	11	5	Normal
Derrick	1	1-15	2	Normal
Derrick	1	5	24	Floodlight
Accommodation Module	1	1-2	30	Normal

1.1.3 Flaring calculations

To generate the power of each flare we used the Stefan Boltzmann Law:

$$P = A\epsilon\sigma T^4,$$

Where P is the power in watts, A is the surface area in metres squared, ϵ is the emissivity (assumed to be 1), σ is the Stefan Boltzmann constant and T is the blackbody temperature of the flame (assumed to be 1800K).

The power in watts for each flare was calculated based on the surface area of the flame (modelled by Woodside for each Scenario – see **Table A7**) and multiplying by the amount of light emitted into the visible spectrum (0.327%). This value is low due to the large proportion of energy that is emitted as heat in the infrared part of the spectrum.

The calculated power was then converted into Lumens using assuming a luminous efficacy of 170 lumens per watt. Each flare is listed in **Table A7**. The base height of the FPSO flare was 180 m and the MODU was 15 m.

Table A7: Flare intensities used as inputs into the modelling for the FPSO and MODU.

Vessel	Scenario	Scenario Description	Colour Temperature	Surface Area (m^2)	Power (Kilowatts)	Power (Millions of Lumens)	Potential Flare Period (d/yr)
FPSO	IS1, CS1, AS1-2	Background	1800 K	16.42	32	5.44	365
FPSO	IS2, CS2	Minor Upset	1800 K	51.71	101	17.12	15
FPSO	IS3, CS3, AS3-6	Unplanned Upset	1800 K	234	456	77.5	12
FPSO	IS4, CS4	Major Upset	1800 K	316	615	105	12
MODU	IS6, CS1-4, AS6	Well Clean Up	1800 K	175	208	35.4	8

JACOBS

LITERATURE REVIEW: THRESHOLDS OF ARTIFICIAL LIGHT & MARINE TURTLE HATCHLINGS

Prepared by

Pendoley Environmental Pty Ltd

For

Jacobs

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PENDOLEY ENVIRONMENTAL

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1 INTRODUCTION

1.1 Background

Hatchling sea turtles typically emerge from their nest on the beach at night (Mrosovsky & Shettleworth 1968) and must crawl rapidly to reach the ocean in order to avoid predation (Salmon 2003). They find the ocean using a combination of topographic and brightness cues, orienting towards the lower, brighter oceanic horizon, and away from elevated darkened silhouettes of dunes and/or vegetation behind the point of their emergence on the beach (Pendoley & Kamrowski 2015; Lohmann et al. 1997; Limpus & Kamrowski 2013; Salmon et al. 1992). Artificial light at night (ALAN) can interfere with these cues, influencing their sea-finding behaviour (Withington & Martin 2003; Pendoley & Kamrowski 2015; Kamrowski et al. 2014). As a result, hatchlings may become disorientated - where they crawl in circuitous paths; or misorientated - where they move in the wrong direction, resulting in an increased mortality rate due to exhaustion, dehydration, or increased exposure to predation (Withington & Martin 2003; Lohmann et al. 1997; Salmon 2003).

On a broader scale, if the threat of ALAN transpires as a long-term impact to emerging hatchlings at a nesting beach, it has the potential to impact an entire marine turtle population. Within Australia, the current threat of ALAN is highlighted by the Commonwealth Government's *Recovery Plan for Marine Turtles 2017 – 2027* (Recovery Plan), which lists ALAN as a moderate or high threat for the recovery of 14 of 22 marine turtle genetic stocks in Australia (Commonwealth of Australia 2017).

In direct response to the recognised threat of ALAN under the Recovery Plan, the Commonwealth Government drafted the *National Light Pollution Guidelines for Wildlife* (the guidelines), which defined a 20 km zone around any development with externally visible lighting where the potential impact of light on listed species (e.g. marine turtles) and their important habitat should be risk assessed in an Environmental Impact Assessment (EIA). As part of the EIA, the guidelines also recommend that project specific control measures to minimise the impact of ALAN identified in the risk assessment be outlined within an Artificial Light Management Plan (Commonwealth of Australia 2020).

Predicting the likelihood of an impact from artificial light on hatchling turtles within the EIA is particularly challenging. This is because there are numerous biological and physical factors that affect the perception of a light source by a hatchling turtle and whether it subsequently impacts the cues they use in sea-finding. This is further complicated by the potential for these factors to act independently or in combination. The factors for consideration include:

- The sensitivity of a hatchling turtle to directional light can be described by a specific 'cone of acceptance' which indicates how much of the world a hatchling views and measures at any one instant, defined by Witherington (1992) as 180° horizontally and 30° vertically. This defined cone of acceptance will only include a limited part of the entire horizontal (360°) and vertical (90°) field-of-view that is available to a hatchling. The light that is visible within this cone of acceptance at any instant in time can critically influence its determination of brightest direction when sea-finding. This means that a hatchling turtle may not perceive a light source outside of this cone of acceptance when sea-finding, furthermore the visibility of the light in this cone of acceptance may vary as it crawls on the beach.

- Local atmospheric conditions can cause light to scatter and increase its visibility as sky glow, with the amount of scattering dependent on the wavelength of the light and the presence of atmospheric dust, salt, and other aerosols at the time of the hatchling's emergence (Kyba et al. 2011). The short wavelength blue light that is most visible to marine turtles scatters more strongly than long wavelength orange and red light producing a highly visible sky glow close to and above the light source. However, because short wavelength light is attenuated more quickly by the atmosphere, the intensity of blue light also decreases rapidly with distance from the light source while the proportion of long wavelength light increases (Kocifaj et al. 2021).
- Presence of cloud can reflect light back to earth and substantially illuminate the surrounding landscape and its visibility to a hatchling turtle, with the amount of light reflected dependent on cloud height, thickness, and the location of the cloud relative to the light source and habitat (Kyba et al. 2011).
- Localised topography or vegetation on a beach may shield light influencing its visibility to a hatchling turtle at the point of emergence or at varying locations on the beach as it crawls.
- The topography behind the point of emergence generates a darkened silhouette that provides a visual cue for a hatchling to orient away from when sea-finding (Limpus 1971; Salmon et al. 1992, Salmon & Witherington 1995). Varying topography and vegetation screening at a beach will therefore influence the strength of this cue to a hatchling when sea-finding and potentially override any influencing cue from visible light.
- The physical properties of light follow the inverse square law which means that the visibility of the light at an area of habitat, as a function of its intensity and spatial extent, decreases with distance from the source. The rate of decrease in light intensity is inversely proportional to the square of the distance between the light source and the receiver, so as the light waves travel away from a light source they spread out, become less concentrated is space and consequently appear less bright to the observer. Therefore, the intensity of visible light in a habitat will vary at different distances away from the light source.
- Artificial light that is rich in short wavelength blue and green is considered most disruptive to marine turtles (Fritsches 2012; Pendoley 2005); however, marine turtles are not equally sensitive to light of all wavelengths meaning its attractiveness differs by species (Pendoley 2005; Horch et al. 2008; Witherington & Bjorndal 1991). Furthermore, while considered less attractive to hatchlings, light with longer wavelengths can still disrupt their behaviour when sea-finding.
- The presence of moonlight can 'smooth out' variations in background light intensity, thus potentially moderating or reducing the disruptive influence of visible artificial light on sea-finding by hatchling turtles (Salmon & Witherington 1992). Therefore, the presence/absence of a moon, its phase, illumination, and direction it rises/sets as viewed from habitat, can influence the visibility of artificial light sources to a hatchling turtle (as described in Salmon & Witherington 1992; Kamrowski et al. 2014; Berry et al. 2013; Tuxbury & Salmon 2005).
- The orientation of the light source in relation to the point of hatchling emergence will influence how likely it could disrupt sea-finding. For example, if the light source is situated directly offshore it can influence the hatchlings sea-finding behaviour by attracting it seaward.

In contrast, a light source adjacent to, or behind a beach, may lead to a different outcome for the hatchling in terms of its success in reaching the ocean.

A further complicating factor influencing the ability of scientists to confidently predict the impact of light on a sensitive receptor is the lack of an agreed upon standard method for modelling, measuring and monitoring light (Hänel et al. 2018; Kalinkat et al. 2021; CMS 2021). Instruments are either restricted in the wavelengths they measure, the detection limits they can achieve or are research grade instruments that require specialised knowledge to operate and maintain. Similarly, the literature acknowledges that there are no conclusive intensity thresholds below which artificial light is not harmful to species and habitats (Schroer et al. 2021) and even the low intensity light characteristic of skyglow can affect organisms (Grubisic et al. 2019; Kupprat et al. 2020).

Recognising these factors and the complexities in establishing a likelihood of impact from a source (or multiple sources) of light to hatchling turtles across varying spatial scales, the guidelines considered the 20 km distance a precautionary limit and based this distance on the limited published studies that described/measured the actual impact of artificial light on hatchling and adult turtles *in situ*. These studies included realised impacts to hatchling turtles from a Liquified Natural Gas (LNG) facility (Kamrowski et al. 2014) and anecdotal observations of disorientation of nesting adults from an aluminium refinery (Hodge et al. 2007) situated 15 km and 18 km from their habitat, respectively.

Other than the distance threshold, the guidelines feature general advice on light limits (i.e. avoid bright white lights and consider Amber or PC Amber LEDS in sensitive habitats) with no other specific limits or thresholds that relate to the physical properties of light and its visibility or direction from important habitat. Recognising the huge variability in light characteristics, visibility and impact on sensitive receptors in different environmental settings, the guidelines recommend a case-by-case approach to assessment of risk to account for the unique physical and biological factors characteristic of a project that could potentially affect impacts. Further, the guidelines recommend an outcomes-based approach to assessing the success of light mitigation and management actions; monitoring (biological and light) and auditing should be used in an adaptive management approach to wildlife protection.

To improve the understanding of the appearance and output of light from a source (e.g. development, activity) and aid the likelihood of impact estimate within an EIA, luminaire details including the wattage, wavelength, and location, can be modelled and combined with local topography data to determine its cumulative directionality, visibility, and intensity at areas of important habitat. While the output of the model is quantified in terms of its intensity, in the absence of any other specific thresholds or limits above or below which an impact could occur, the interpretation of the model in terms of estimating the likelihood of its impact on hatchling behaviour is still limited to a qualitative assessment of the model outcomes by a subject matter expert. The absence of any threshold or limit leads to the EIA following a precautionary principle and prevents any quantitative target being set in terms of how much light needs to be reduced by (e.g. through control measures) to lower the estimated likelihood of an impact occurring.

1.2 Scope of Work

As the Operator for and on behalf of the Browse Joint Venture, Woodside Energy Limited (Woodside) are proposing to develop the Browse hydrocarbon resource located in the Brecknock, Calliance, and

Torosa reservoirs. The Torosa reservoir is located near Sandy Islet within the Scott Reef complex, identified as sensitive turtle nesting habitat for green turtles in the discrete Scott Reef - Browse Island (G-ScBr) genetic stock for which ALAN is recognised as a moderate threat to its recovery (Commonwealth of Australia 2017).

Recognising the absence of any limits or thresholds as well as the many limitations associated with estimating a likelihood of impact from light to hatchling turtles described in **Section 1.1**, Woodside engaged Pendoley Environmental (PENV) to undertake a literature review to determine if thresholds or limits have been defined in the literature that relates to the intensity, visibility, or direction of light from a nesting beach at which an impact to a hatchling turtle could occur. The objective of this literature review was to identify any threshold or limit could be used to improve the interpretation of modelled outputs of light from the resource development and better inform the EIA outcomes.

1.3 Approach

The following combination of keywords were searched within Google Scholar for relevant literature:

- Artificial light
- Turtle
- Hatchling orientation

A total of 182 entries were produced. Each entry was reviewed and discarded unless there was any indication of a defined limit or threshold at which an impact from artificial light to a hatchling turtle was realised. Furthermore, suitable entries were separated into those that indicated a limit or threshold using measurements recorded within a controlled experimental design or measurements recorded *in situ* under natural conditions. Any relevant review paper that featured discussion on thresholds or limits of artificial light was also included.

2 LITERATURE REVIEW

2.1 Review Papers

Gaston et al. (2013) reviewed the ecological impacts of night-time light pollution and featured examples of the levels of lighting (lux) at which night-time lighting has been observed to have biological effects. The setting for all examples was laboratory based and did not feature any example for a marine turtle species. Furthermore, the review paper highlighted the absence of thresholds of light intensity and duration at different wavelengths above which artificial lighting has significant ecological impacts and outlined this absence as a key issue and priority for future research.

Bennie et al. (2016) and Kalinkat et al. (2021) reviewed the ecological effects of artificial light on plants and insects. Both studies emphasised the absence of a defined ecologically meaningful measure of artificial light in the natural environment and in its absence, the importance of developing an understanding of the thresholds at which light-sensitive processes in plants and insects occur.

These gaps were echoed in a 2021 review by the Convention on the Conservation of Migratory Species of Wild Animals, who released a report *The Impact of Light on Different Taxa of Migratory Species* which built on the guidelines (Schroer et al. 2021; CMS 2021). As awareness of the issue of light pollution grows so do the calls for biologist, engineers and physicists to collaborate on establishing standardised assessment methods that can be easily used by non-specialists (Kalinkat et al. 2021; CMS 2021; Schroer et al. 2021)

2.2 Hatchling Orientation and Artificial Light

2.2.1 Experimental Design

Cruz et al. (2018) used an experimental design to measure the orientation of swimming olive ridley (*Lepidochelys coriacea*) hatchlings exposed to lights situated 2 m from the hatchling with different wavelengths (red, 720 nm; yellow, 660 nm, and green, 520 nm) and intensities (0.1 – 3.3 lux, 10.3 – 45.9 lux, 47.5 – 84.2 lux, 91.3 – 140.8 lux, 150.1 – 623 lux). Results indicated that hatchlings were attracted to green and yellow lights at low light intensities (0.1 – 45.9 lux) as well as red lights at high intensities (>39.3 lux). This experiment was undertaken under controlled conditions with no variation in the distance of the light from the hatchling. Conclusions from the study indicated that applying the same experiment at a landscape scale would be beneficial as it may allow a specific light threshold to be defined that could improve protection to hatchling turtles.

Karnad et al. (2009) used controlled arena trial experiments to identify the influence of light wavelength (red, 580 – 800 nm; yellow, 475 – 600 nm; blue, 375 – 575 nm; violet, 300 – 450 nm), intensity (two intensities generated by an LED torch; four LED bulbs and eight LED bulbs of 15,000 mcd), and the influence of vegetation height on the orientation of olive ridley hatchlings. The study found that the wavelength and intensity of light interacted to influence hatchling orientation towards light. Hatchlings were found to orient towards high intensity light more than to low intensity light for all wavelengths except violet. One limitation with the experiment was that its setup involved a constant light source. This meant that the light intensity could not be adjusted to account for the varying sensitivity of hatchling turtles to light of different wavelengths meaning they would perceive some wavelengths as brighter than others. This limited the reporting of an actual intensity value at which an influence on a hatchling turtle occurred.

Tuxbury & Salmon (2005) designed a laboratory experiment involving an arena trial to simultaneously present artificial light (that was known to attract turtles) and natural cues (a dark silhouette of the dune behind the beach) that promoted seaward orientation. The artificial light used in the study was a book light placed 1.2 m from the hatchling at the edge of the arena and had a photon flux of 4.6 – 4.9 x 10^{11} photons/cm^2/s. The study confirmed the inter-related factors that influence hatchling sea-finding including horizon elevation, background illumination, the direction of the light. There was no indication of a limit or threshold at which hatchling sea-finding behaviour was influenced.

Pendoley & Kamrowski (2015) used controlled field-based arena trial experiments involving flatback turtle hatchlings to measure their orientation when different types of light, placed at different orientations and elevations, were visible 150 m away. The type of lights included in the study were high pressure sodium vapour, metal halide, and fluorescent white light. The light's intensity was also varied, with low intensity considered 500 W, medium intensity as 1000 W, and high intensity as 1300 W for the metal halide and high-pressure sodium lights. At medium and high light intensities of all three light types, hatchlings were significantly less oriented towards the ocean when exposed to light at 2° elevation compared to 16° elevation. There was no indication of a limit or threshold at which hatchling sea-finding behaviour was influenced.

Robertson et al. (2016) tested two different type of LED light to determine if they influenced the sea-finding behaviour of loggerhead turtle hatchlings. The results of controlled arena trial experiments indicated that amber light (peak wavelength of 620 nm) influenced hatchling sea-finding whereas the red light (peak wavelength of 640 nm) was less disruptive. The study was limited in that it did not record the actual intensity of the light and therefore no limit or threshold at which hatchling sea-finding behaviour was influenced was provided.

2.2.2 In situ

Price et al. (2018) measured the intensity of visible light (320 – 700 nm) using a Sky Quality Meter (SQM) across various zones of a loggerhead turtle (*Caretta caretta*) nesting beach in Florida. The study investigated the occurrence of hatchling turtle disorientation events recorded at the same beach and compared the orientation of hatchlings in each zone with the light intensity. The study found that luminance from artificial beachfront lighting may be related to increased incidences of hatchling disorientation but did not determine a luminance/intensity threshold at which more disorientations began to occur. It is important to note that the value of the results of this study are limited as the authors misused the SQM by collecting light pollution data on the horizon, in addition to at zenith (i.e. overhead). The SQM can only return accurate data when aimed at zenith and cannot be aimed at landward light sources or out to sea at horizon level (Hänel et al. 2018, Longcore et al. 2020).

Kamrowski et al. (2014) used both *in situ* nest fan measurements and results of controlled arena trial experiments to determine the influence of artificial light on the sea-finding of flatback turtle (*Natator depressus*) hatchlings at Peak and Curtis islands in Queensland. The study also involved the measurement of ambient light using a stellar photometer fitted with a V filter to ensure light at a wavelength of 480 – 660 nm was measured. Results indicated no disruption to hatchling sea-finding at Peak Island, whereas the sea-finding of hatchlings at Curtis Island was shown to be moderately disrupted. Due to constraints with the approach for measuring light, only comparisons of directional light and light between sights was provided. There were no actual quantified light values provided in the study, with only qualitative descriptions of '*the field team observed light levels at Curtis Island that appeared visibly brighter than those observed at Peak Island*' included.

3 SUMMARY

There were no conclusive thresholds/limits of light intensity, or its visibility, defined within reviewed literature that specified that above which would influence hatchling sea-finding behaviour.

There were numerous *in situ* and experimental studies that indicated light of a certain intensity or wavelength influenced hatchling sea-finding behaviour under different lighting scenarios which often involved the placement of lights at different orientations and height from the hatchling. However, no studies were able to account for the numerous inter-related variables that influence the intensity and visibility of artificial light to a hatchling turtle at a landscape scale and were therefore unable to define a threshold or limit.

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Table C1: Impact Level 1 – Continuous Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility **2. Scenario code** **3. Duration of impact** **4. Distance from Sandy Islet**	**Scenario code** **Orientation** **FOV (FME)** **Figure #**	**Life history stage / behaviour and impact pathway**			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1) FPSO **2)** IS1A; CS1A **3)** Continuous throughout 44-year project life **4)** ~29km **1)** MODU (TRD) **2)** IS5 **3)** 18 months at given TR site. **4)** ~20km	IS1A – 0.004 FME **Figure 4a** CS1A – 0.009 FME **Figure 9a** IS5 – 0.001 FME **Figure 8a**	**No impact predicted** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a small area of dim glow low on the horizon, which will have no impact on nesting females. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts, depending upon the intensity.	**No impact predicted** • The modelled radiometric visibility of the light source(s) indicates the facilities will appear as a small area of dim glow within the orientation FOV, which is not likely to have any impact on hatchlings during sea-finding. • In the absence of dunes/topographic features, hatchlings may orient towards artificial light source rather than ocean horizon. • Behavioural response may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of light sources, and lunar phase at emergence.	**No impact predicted** • Potential for hatchling dispersal behaviour to be affected decreases with distance to shore. • Light sources located from ~20 - 29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be very low, and few individuals will be at risk of attraction • Surface currents at Scott Reef will carry hatchlings on, and in the direction, of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will either reach or be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

Table C2: Impact Level 1 – Intermittent Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility 2. Scenario code 3. Duration of impact 4. Distance from Sandy Islet	Scenario code Orientation FOV (FME) Figure #	Life history stage / behaviour and impact pathway			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1) FPSO **2)** IS2A **3)** Flaring Intermittently **4)** ~29km	IS2A – 0.009 FME **Figure 5a**	**No impact predicted** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a small area of dim glow low on the horizon, which will have no impact on nesting females. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts, depending upon the intensity. • Flaring may occur intermittently during 1 nesting season.	**No impact predicted** • The modelled radiometric visibility of the light source(s) indicates the facility will appear as a small area of dim glow within the orientation FOV, which is not likely to have any impact on hatchlings during sea-finding. • In the absence of dunes/topographic features, hatchlings may orient towards artificial light source rather than ocean horizon. • Behavioural response may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of light sources, and lunar phase at emergence. • Duration and rate of flaring is difficult to predict but it is likely to be limited to a small proportion of hatchlings emerging at any time, i.e. the increased brightness and extent of sky glow under different flaring conditions will not be a static long term stressor impacting all emerging hatchlings across an entire nesting season.	**No impact predicted** • Potential for hatchling dispersal behaviour to be affected decreases with distance to shore. • Light sources located from ~20- 29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be very low, and few individuals will be at risk of attraction • Surface currents at Scott Reef will carry hatchlings on, and in the direction, of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will either reach or be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

Table C3: Impact Level 2 – Intermittent Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility **2. Scenario code** **3. Duration of impact** **4. Distance from Sandy Islet**	**Scenario code** **Orientation FOV (FME)** **Figure #**	**Life history stage / behaviour and impact pathway**			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1) FPSO **2)** IS3A, IS4A, IS1B, IS2B **3)** Flaring and overcast intermittently **4)** ~29km **1)** MODU **2)** IS6 **3)** Flaring intermittently **4)** ~20km **1)** FPSO + MODU **2)** CS1B, CS2A, CS3A, CS4A **3)** Flaring intermittently **4)** ~20-29km	IS1B - 0.010 FME **Figure 4b** IS2B - 0.029 FME **Figure 5b** IS3A – 0.031 FME **Figure 6a** IS4A – 0.041 FME **Figure 7a** IS6 – 0.020 FME **Figure 8b** CS1B – 0.012 FME **Figure 9b** CS2A – 0.030 FME **Figure 10a** CS3A – 0.054 FME **Figure 11a** CS4A – 0.065 FME **Figure 12a**	**No impact predicted** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a small area of dim glow low on the horizon, which will have no impact on nesting females. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts, depending upon the intensity. • Flaring may occur intermittently during 1 nesting season.	**Light and light glow highly visible, behavioural impact unlikely** • In absence of dunes/topographic features, hatchlings may orient towards artificial light source and sky glow which might be along the islet rather than directly towards the ocean horizon and may result in disorientation behaviour where hatching crawl in circles while trying to orient themselves. • Behavioural misorientation and disorientation responses may result in hatchlings taking a longer route to the ocean. • Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Maximum predicted continuous flaring could potentially result in all clutches within a season being exposed to artificial light (weeks). • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of	**Light and light glow highly visible, behavioural impact unlikely** • Potential for hatchling dispersal behaviour to be affected decreases with distance from shore. • Light sources located ~20-29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be low, and few individuals will be at risk of attraction. • Surface currents at Scott Reef will carry hatchlings on and in the direction of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

			light sources, and lunar phase at emergence. • Cloud cover and thickness is dynamic and will vary with time leading to a range of potential exposure conditions and impacts that are a function of the duration and rate of flaring and difficult to predict but are likely to be limited to a small proportion of hatchlings emerging at any time, i.e. the increased brightness and extent of sky glow under clouds will not be a static long term stressor impacting all emerging hatchlings across an entire nesting season.		

Table C4: Impact Level 3 – Intermittent Conditions. Key findings of the artificial light impact assessment for green turtles at Scott Reef.

1. Vessel / facility **2. Scenario code** **3. Duration of impact** **4. Distance from Sandy Islet**	**Scenario code** **Orientation FOV (FME)** **Figure #**	**Life history stage / behaviour and impact pathway**			
		Nesting • Reduction in nesting attempts • Disturbance to nest site selection • Disruption to post-nesting sea finding behaviour	**Hatchling sea finding** • Disruption to post-emergence sea finding behaviour	**Hatchling dispersal** • Disruption to in-water dispersal behaviour	**Mating / Internesting / Foraging / Migration** • Disruption to foraging, mating, internesting, migratory behaviours. • Displacement from internesting, foraging, mating habitat
1) FPSO **2)** IS3B, IS4B **3)** Intermittent Flaring and intermittent cloud (< 20 days/yr for each) **4)** ~29km **1)** FPSO + MODU **2)** CS2B, CS3B, CS4B **3)** Intermittent Flaring and intermittent cloud (< 20 days/yr for each) **4)** ~20-29km	IS3B – 0.116 FME **Figure 6b** IS4B – 0.156 FME **Figure 7b** CS2B – 0.103 FME **Figure 10b** CS3B – 0.192 FME **Figure 11b** CS4B – 0.236 FME **Figure 12b**	**Minor impact possible** • The modelled radiometric visibility of the light source(s) flare indicates the facility will appear as a broad area of sky glow encompassing the entire field of view of the turtles at right angles to the beach (seaward) and at the horizon. • Recovery Plan Action Area A9: It is unlikely an Impact Level 3 level of lighting will cause displacement of nesting females from Sandy Islet and any displacement is expected to be minor, limited to individuals potentially exposed to a very short window of high light levels under heavy cloud, and who are likely to move to Browse Island which is part of the same genetic stock as Sandy Islet. • Flaring expected to be limited to 8 – 15 days per year and associated with unplanned upset flaring or well clean up flaring, worst case scenario this occurs during the 17 days of cloudy days reported for the area during the nesting season. Impact is intermittent and limited to one nesting season. • The intensity of the light is between 0.103 and 0.236 FME, so even under the worst-	**Light and light glow highly visible, Minor behavioural impact possible** • The modelled radiometric visibility of the worst-case scenario of Major Upset Flaring plus Well Clean Up Flaring at TRA, with cloud cover at 80% and a ceiling height of 10 km (**CS4B**) shows a bright point source of light on the horizon, and the entire sky illuminated by light. The reflected light and glow extend well beyond the defined orientation FOV box and is almost 4 times brighter than the scenario with no cloud (**CS4A**). • In absence of dunes/topographic features, hatchlings may orient towards artificial light source and sky glow which might be along the islet rather than directly towards the ocean horizon and may result in disorientation behaviour where hatching crawl in circles while trying to orient themselves. • Behavioural misorientation and disorientation responses may result in hatchlings taking a longer route to the ocean.	**Light and light glow highly visible, No behavioural impact predicted** • Potential for hatchling dispersal behaviour to be affected by light decreases with distance from shore. • Light sources located ~20-29 km from Sandy Islet. At this range the density of dispersing hatchlings is expected to be low, and few individuals will be at risk of attraction. • Surface currents at Scott Reef will carry hatchlings on and in the direction of the tidal flow over extended time frames, reducing the number of hatchlings reaching or aggregating around the facility. • Therefore, it is unlikely that large numbers of hatchlings will be attracted to the facility. • Following sunrise, any effect of light sources on hatchlings will be eliminated allowing dispersal behaviour to resume.	**No impact predicted** • Marine turtles do not use light cues to guide breeding behaviours. • No evidence, published or anecdotal, suggests that internesting turtles are impacted by light from offshore vessels or installations. • Large aggregations of adult foraging turtles are not expected to occur in the vicinity of project vessels and facilities. Potential impacts to the low number of foraging turtles is likely limited to short term behavioural changes in response to prey attraction linked to increased visibility of prey. • Light emissions are unlikely to result in displacement of, or behavioural changes to, individuals in these life stages.

		case scenario of Major Upset Flaring plus Well Clean Up Flaring at TRA (**CS4B**), the illumination will fall in the lower range of a full moon brightness, closer to a quarter moon than a half moon. The number of days in a moon cycle that this high level of sky brightness could exceed the illumination from a half to new moon is 14 days, further reducing the potential number of days turtles could be exposed to high light levels under full cloud during the nesting season. • Spectral output of flares outside peak sensitivity for green turtles, reducing potential for behavioural impacts. • Experienced nesting females considered less vulnerable to effects of light on nest site selection, permanent displacement of these individuals is unlikely. • Neophytes may be more vulnerable to nesting disruption, but no published data is available to substantiate this. • Unknown what level of disruption is tolerable before long-term displacement of neophytes may occur. • Sandy Islet and Browse Island green turtles are from the same genetic stock and so should a neophyte be displaced she could potentially move to Browse Island. • Risk of negative impacts to post-nesting sea-finding behaviour considered low, particularly as females are never more than ~30 m from the ocean. • The 5 – 8 year renesting interval for green turtles means that only small subset of breeding females could potentially be exposed to this level of brightness in a single season should it overlap with this level of flaring and cloud cover.	• Consequences are expected to be limited to a negligible increase in energy expenditure given the maximum width of the cay is ~60 m and is not expected to result in reduced survival at the population level. • Flaring expected to be limited to 8 – 15 days per year, associated with unplanned upset flaring or well clean up flaring, worst case scenario this occurs during the 17 days of cloudy days reported for the area during the nesting season. Impact is intermittent and limited to one nesting season. • Not all hatchlings exposed to artificial light are expected to be negatively impacted, due to spectral output and orientation of light sources, and lunar phase at emergence and differences in individual visual sensitivities. • Cloud cover and thickness is dynamic and will vary with time leading to a range of potential exposure conditions and impacts that are a function of the duration and rate of flaring and difficult to predict but are likely to be limited to a small proportion of hatchlings emerging at any time, ie the increased brightness and extent of sky glow under clouds will not be a static long term stressor impacting all emerging hatchlings across an entire nesting season. • Nests will emerge over 8 – 12 weeks at the peak of the nesting season, a small subset of emerging nests could potentially be exposed to this level of brightness in a single season should it overlap with this level of flaring and cloud cover.		

1 ADDDITIONAL SCENARIOS

During the artificial light modelling scope of work, several scenarios were modelled that were used to test how different parameters would affect the model results. This was done to find the worst-case cloud parameters to be included within the report. Of the total 24 modelled scenarios, 18 were included in the report as best- and worst-case scenarios, the remaining 6 Scenarios are included in this appendix. Results and parameters can be found in **Table D1** and the generated Figures in **Figure D1**.

Table D1: Summary of the modelled scenarios, the vessel inventory, cloud parameters, OFOV (FME) and Impact Level. OFOV units are in Full Moon Equivalents (FME; refer to Section 2.1.3).

Vessel	Vessel Parameters		Scenario Name	Cloud Parameters			OFOV (FME)	Impact Level
	Inventory	Period (days/yr)		Cover (%)	Height (km)	Period (d/yr)		
FPSO	Background Flaring	365	**AS1**	30	10	17	0.008	**1**
			AS2	80	10	17	0.010	**1**
	Unplanned Upset Flaring	12	**AS3**	30	10	17	0.089	**2**
			AS4	80	10	17	0.102	**3**
			AS5	30	3	17	0.103	**3**
FPSO + MODU	Unplanned Upset Flaring Well Clean Up Flaring at TRA	12 8	**AS6**	30	10	17	0.176	**3**

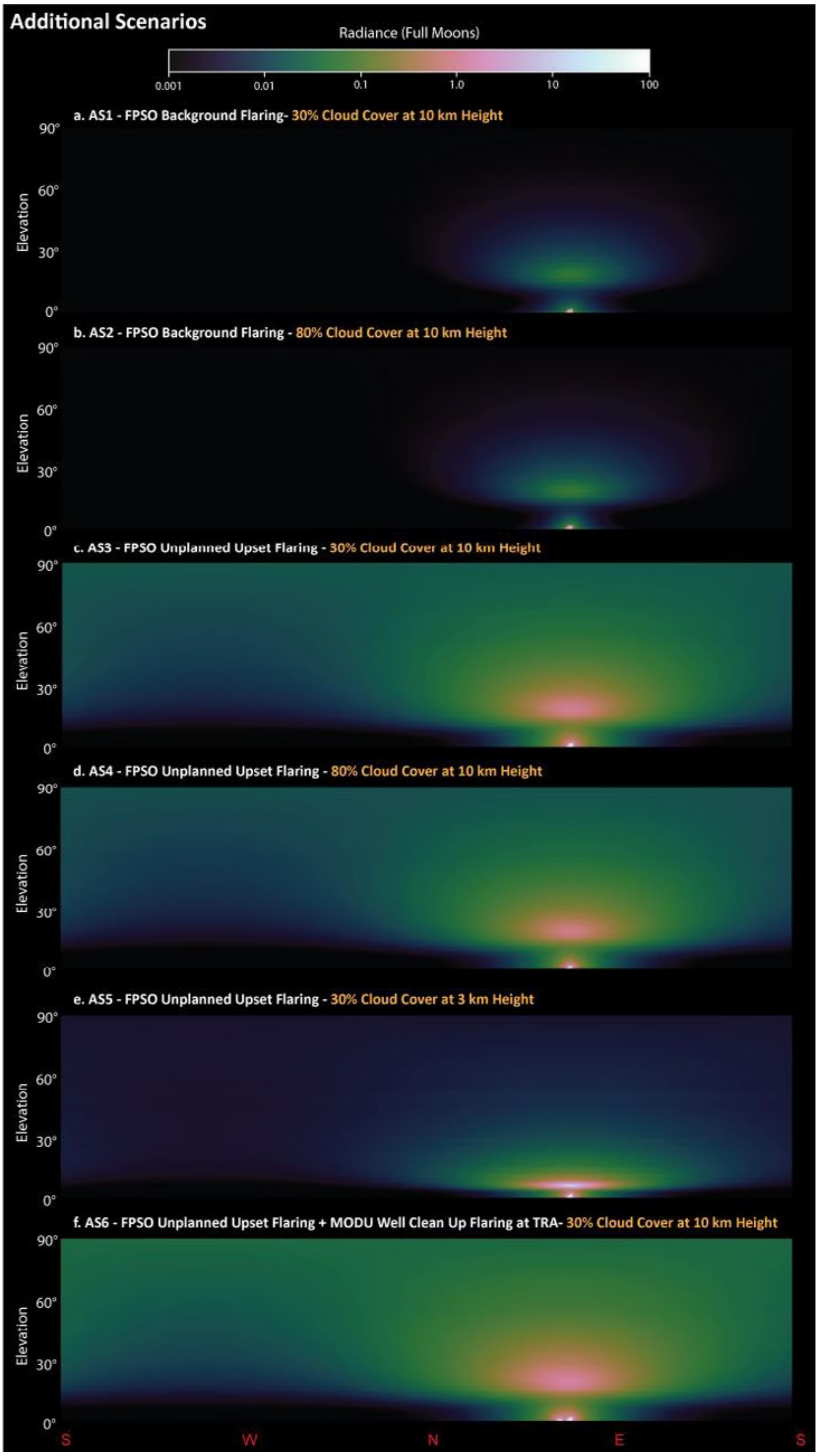

Figure D1: Model outputs for all the Additional Scenarios. a. AS1, b. AS2, c. AS3, d. AS4, e. AS5, and f. AS6.

APPENDIX C MANAGEMENT PLANS

APPENDIX C.4 HYDROCARBON SPILL RISK MANAGEMENT APPROACH

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1 EXECUTIVE SUMMARY

In response to stakeholder comments on the proposed Browse to NWS Project draft EIS/ERD (draft EIS/ERD), this document has been prepared to outline the approach that will be applied on the proposed Browse to NWS Project to reduce the likelihood and consequence of unplanned hydrocarbon release events. This document has been prepared to provide a high-level overview of the key actions that will be implemented in order to reduce the likelihood and consequence of the worst case credible event associated with the proposed Browse to NWS Project, a well loss of containment event. It should be noted that measures pertaining to oil spill response are applicable to other hydrocarbon loss of containment events that were identified as credible within the draft EIS/ERD.

Woodside follows an industry leading process in the development of its oil spill prevention, preparedness and response position for its projects and activities. The objective of the process is to mitigate and manage the risks and impacts from an unplanned hydrocarbon release, and the associated response operations, so that they are controlled to As Low As Reasonably Practicable (ALARP) and acceptable levels.

The outcomes of the process will be presented in an Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA) which, together with the following 'secondary approval' documents, meet the requirements of the relevant regulatory regime governing hydrocarbon spill arrangements that is applicable to the proposed Browse to NWS Project, namely the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and the State Petroleum (Submerged Lands) (Environment) Regulations 2012:

- Activity specific environment plans required under the Commonwealth and State regulations
- Oil Pollution Emergency Arrangements (OPEA)
- Activity specific Oil Pollution Emergency Plans (OPEP) including:
  - First Strike Plans (FSP)
  - relevant Operations Plans
  - relevant Tactical Response Plans (TRPs)
  - relevant supporting plans.

The process of preparing this documentation will be conducted throughout the detailed design and planning phase of a project lifecycle, which the proposed Browse to NWS project has not yet commenced. These 'secondary approvals documents' that will be prepared in accordance with all applicable regulations, are not yet able to be prepared as many of the critical details required to prepare these documents has not yet occurred.

Noting that these detailed documents have not yet been prepared, in order to provide stakeholders a more detailed understanding of the measures that will be in place on the proposed Browse to NWS Project to reduce the likelihood and consequence of hydrocarbon releases, this document outlines the:

- Measures that will be applied to minimise the likelihood of a well loss of containment event
- Source control techniques to be applied and maximum response timeframes to be achieved to reduce the consequence (e.g. release duration) of a well loss of containment event
- Hydrocarbon spill response (remediation) techniques to be applied to reduce the consequence (spill response) of any hydrocarbon release event
- Process that will be followed as part of secondary approvals to ensure risks from hydrocarbon spills are acceptable and risks are ALARP including relevant approvals that must be obtained

- The Operational and Scientific Monitoring frameworks to be applied to inform response activities and monitor the effects of any spill.

A summary of each chapter of this Hydrocarbon Spill Risk Management Approach is provided below.

Reducing the likelihood of well loss of containment events.

A well loss of containment event is classified as any release of hydrocarbon (regardless of size or duration) from primary and secondary well control barriers. In undertaking this risk assessment of a potential major hydrocarbon release, the spill likelihood was evaluated using blowout and well release frequencies based on SINTEF offshore blowout database 2012 (Scandpower, 2013). This uses data from 1991-2010 to determine likelihood for well blowouts and releases. For a gas well, the SINTEF calculated probability of blowout during drilling and completion is 2.93 X 10-4 which means for any given well it is estimated that there is less than 0.000293% probability of a loss of well containment event occurring. The SINTEF data supports a likelihood of 'highly unlikely' for a well blowout with potential to result in the worst-case credible spill.

Furthermore, since the Gulf of Mexico Macondo event, significant improvements in engineering and management controls have been adopted by the industry, further reducing the likelihood of such an event occurring. This can be evidenced in the report by Exprosoft (2017) which reviewed all Loss of Well Control (LOWC) events reported in the SINTEF Offshore Blowout Database for the period 2000–2015. The report describes, categorizes, and analyzes the observed LOWC events for the period 2000–2015, and compares the LOWC frequencies in the US GoM with other regulated areas. For regulated areas (which includes Australia), the frequency of loss of well control events in deep zone of development or exploration wells was 0.25 per 1,000 wells drilled.

At Woodside, this process is managed through the Drilling and Completions (D&C) Management System. The D&C Management System Framework is based on international standards, codes and best practices. Woodside regularly conducts activities in Australia and internationally in accordance with this Framework. A description of this framework is provided in Section 2. In addition, Woodside has provided an overview of the measures that, at a minimum, will be implemented to minimise the likelihood of loss of well containment events from the proposed Browse to NWS Project.

These measures are the minimum that will be applied and have been identified very early in the lifecycle of the proposed Browse to NWS Project, as part of the environmental impact assessment. As project design and planning develops, and as part of the secondary approvals required under the Commonwealth and State regulations, further measures will be identified and assessed to ensure the risk of a significant unplanned hydrocarbon release is reduced to ALARP in accordance with the regulations. The remainder of this Section describes the process that will be undertaken as part of the development of the activity specific Environment Plans (EPs) that will be prepared in accordance with the regulations for acceptance by the Commonwealth and State regulators.

Source control techniques to be applied on the proposed Browse to NWS Project to reduce the consequence of a well loss of containment event.

In the highly unlikely event of a well loss of containment event, source control techniques will be applied to stop the flow of hydrocarbons to the environment from the well.

At all times when drilling is occurring, the capacity and capability to implement the following source control techniques, in the specified timeframes, will be maintained.

- A ROV capable of manually operating the Blow Out Preventor (BOP) (in the event of automatic systems failing) will be available in field for immediate response when determined safe to do so.
- A subsea first response tool kit to remove debris and facilitate installation of a capping stack will be available for deployment at the well loss of containment event site within 11 days of any event.
- Access to a suitable capping stack (either through ownership or membership to a response organisation) will be maintained. The capping stack (on a suitable vessel for deployment) will be

mobilised to site and the capping stack will be available for deployment at the well loss of containment event site within 11[1]-16[2] days of event, with a target of 13 days.

- Relief well capability will be monitored and at all times during the proposed Browse to NWS Project D&C activities, a suitable MODU capable of commencing relief well activities will be able to be mobilised and arrive in the field within 16 days of any well loss of containment event.

This document outlines the presents a level of minimum capability and commitment in relation to source control activities, including maximum response times to enacting particular response techniques. The provision of such detailed commitments at such an early stage in the project development lifecycle demonstrates the commitment to ensuring global best practice to minimising the risk to Scott Reef and surrounding environment. The techniques to be applied and response timeframes are considered to be in alignment with industry best practice.

These measures were identified in the context of the environmental impact assessment and primary approval process for the proposed Browse to NWS Project. As project design and planning matures, and as part of the secondary environmental plans required under the Commonwealth and State regulations, further measures will be identified and assessed to ensure the risk of a significant unplanned hydrocarbon release is reduced to ALARP in accordance with the regulations.

New, emerging and innovative hydrocarbon spill response techniques to be considered for implementation on the proposed Browse to NWS project

Woodside continually reviews the latest emerging technical in relation to hydrocarbon spill management and appraises them for applicability to our operations. This document outlines a series of new or emerging techniques that while currently not considered feasible, may be applicable to the proposed Browse to NWS Project in the future. In relation to a well loss of containment event, these techniques include (but are not limited to):

- Kinetic blow out stopper (KBOS) shut in device, which may have the capability to immediately seal off the flowing well
- Use of an offset capping installation technique or dual vessel capping stack deployment to improve operability of capping installation activities
- The use of a subsea containment system as an alternative to capping stack deployment
- The use of subsea well kill spools to enhance relief well drilling activities.

Further detail on these techniques and their advantages are described in further described in Section 3.2.

Woodside is committed to ongoing monitoring and evaluation of source control technologies and methodologies to ensure it is continually aligned to best practice. Therefore, prior to the submission of environment plan for any drilling activities, which have a maximum duration of five years. Woodside will review best practice spill response techniques including a review of latest standards published by API, IPIECA, IOGP or and relevant regulatory guidelines.

Hydrocarbon Spill Response Techniques to be utilised on the proposed Browse to NWS Project

Available spill response techniques available for use on the proposed Browse to NWS Project will include:

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[1] 11 days is the mobilisation timeframe for the Singapore-based Wild Well Control Inc. capping stack to Port Hedland as calculated in the Australian oil and gas industry response time model (OSRL-APPEA, June 2021). This timeframe assumes the availability of a suitable vessel in Singapore within 24 hours.

[2] 16 days is the estimated mobilisation timeframe based on the OSRL-APPEA response time model (11 days) plus transit time to the spill location and contingency if a suitable vessel is not available within 24 hours.

- Capability for monitoring of spill (and receiving environment) and evaluation of appropriate response techniques to be applied
- Mechanical dispersion
- Containment and recovery
- Shoreline protection and deflection
- In-situ burning*
- Subsea dispersant application*
- Surface dispersant application*
- Shoreline clean-up
- Oiled wildlife response.

*The use of any particular response technique would be subject to a Spill Impact Mitigation Assessment (SIMA) prior to implementation, specifically for in-situ burning or dispersant application which may have larger impacts than the initial spill in some circumstances. Dispersant application is typically not possible without specific regulatory approval (e.g. by NOPSEMA or DMIRS, depending on nature of the spill). The hydrocarbon spill risk management framework outlined in this document provides only a high level summary of the response techniques to be applied on the proposed Browse to NWS Project. It has been prepared in the context of providing supplementary information to address submissions on the draft EIS/ERD. As project design and planning matures, and as part of the secondary approvals required under the Commonwealth and State regulations, further detail of hydrocarbon spill risk mitigation measures will be identified and assessed to ensure the risk of a significant unplanned hydrocarbon release is reduced to ALARP. This assessment utilises probabilistic (stochastic) oil spill modelling of a credible 'worst-case' spill event to establish environmental resources at risk, propose suitable response techniques and ensure response capability.

As part of secondary approval processes, Woodside will undertake further detailed assessment of which response techniques will be most appropriate and specific capability required to implement each technique. The outcomes of that assessment process will be presented in an Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA) prepared to meet the requirements of the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and the State Petroleum (Submerged Lands) (Environment) Regulations 2012. Details of this ALARP process is outlined in Section 7 of this document.

Operational Monitoring

Oil spill response techniques are informed by a real time operational monitoring program. Operational monitoring includes the gathering and evaluation of data to inform the oil spill response planning and operations. It also verifies and ground-truths the pre-emptive spill modelling and continued suitability of the response techniques and capability proposed in the ALARP demonstration. It includes real-time fate and trajectory modelling, spill tracking, weather updates and field observations. This response option is deployed in some capacity for every event.

Woodside maintains an Operational Monitoring Operational Plan. If shoreline contact is predicted, Response Protection Areas (RPAs) will be identified and assessed before contact. If shorelines are contacted, a shoreline assessment survey will be completed to guide effective shoreline clean-up operations. These assessments would then inform which of the suite of verified, site-specific 'Tactical Response Plans' (for locations around the WA coastline) should be activated. The Tactical Response Plans set out the appropriate response techniques, nearest equipment locations and site layout plans for safe, efficient and effective deployment of equipment. These plans also assist the Incident Management Team in mobilising resources commensurate to the nature and scale of the spill.

Scientific Monitoring

A scientific monitoring program (SMP) would be activated following a significant unplanned hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors. This document outlines Woodside's ten Scientific Monitoring programs alongside their objectives, activation triggers and termination criteria.

The SMP would consider receptors at risk (ecological and socio-economic) for the entire predicted Environment that Maybe Affected (EMBA) and in particular, any identified Pre-emptive Baseline Areas (PBAs) for the credible spill scenario(s) or other identified unplanned hydrocarbon releases associated with the operational activities.

Key objectives of the Woodside oil spill SMP are:

- Assess the extent, severity and persistence of the environmental impacts from the spill event
- Monitor subsequent recovery of impacted key species, habitats and ecosystems.

The SMP comprises ten targeted environmental monitoring programs to assess the condition of a range of physico-chemical (water and sediment) and biological (species and habitats) receptors including EPBC Act listed species, environmental values associated with protected areas and socio-economic values, such as fisheries.

2 MINIMISING THE LIKELIHOOD OF HYDROCARBON RELEASE EVENTS

2.1 Woodside approach to minimising likelihood of unplanned hydrocarbon releases from well loss of containment events

Woodside's Management System (WMS) is in place to manage the Company's key risks. Well integrity is one of the major risks Woodside must manage across all assets. The role of Woodside's Drilling and Completions (D&C) function is to provide safe, cost effective, standardised and repeatable drilling, completions and well services to meet the needs of the business and to manage the lifecycle of wells and safeguard well integrity.

This is done mainly through the D&C Management System Framework (Figure 3-1) and its well lifecycle management process and supporting documents. One of the key assurance items is to deliver a Well Operations Management Plan (WOMP) which is a key permissioning document that must be approved by an independent Regulator (either NOPSEMA or DMIRS) prior to constructing, operating and permanently abandoning a well.

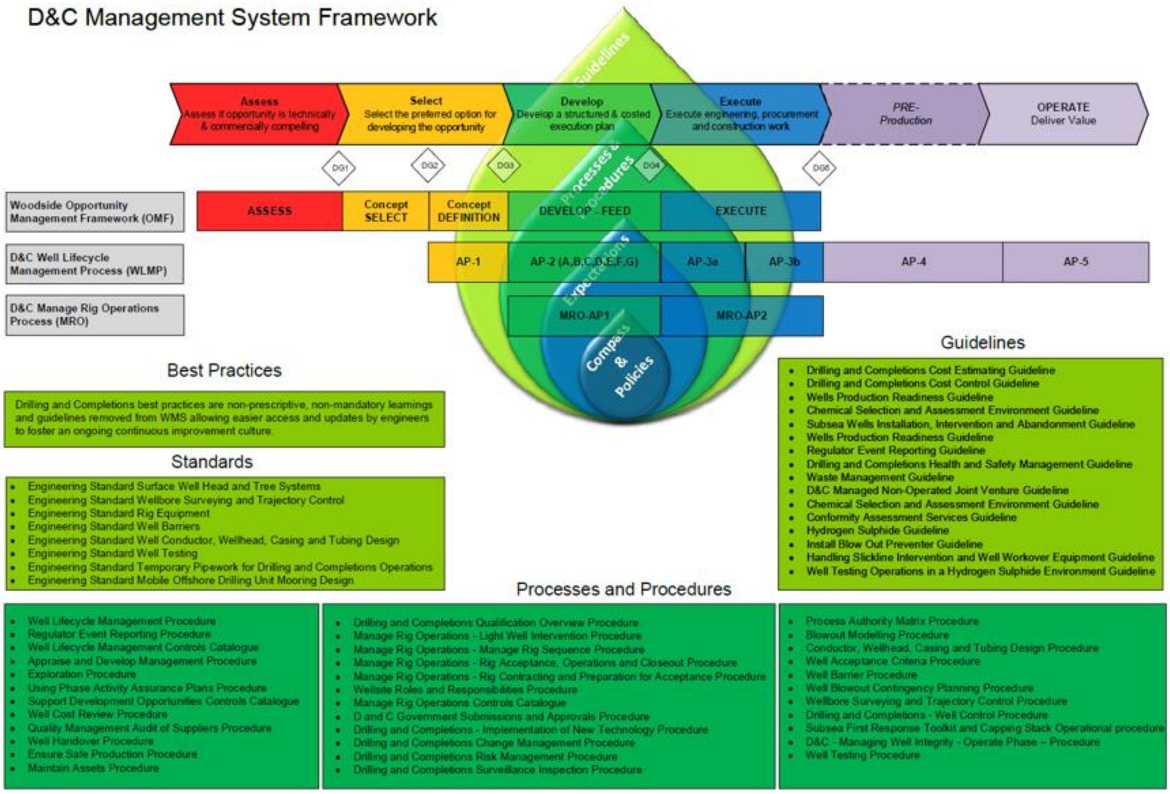

Figure 2-1: Woodside Drilling and Completions Management System Framework

The D&C Management System Framework is based on international standards, codes and best practices, informed by international agencies such as the American Petroleum Institute (API), NORSOK and the International Association of Oil and Gas Producers (IOGP). Below is a non-exhaustive list such standards published by these agencies to which Woodside's management framework complies or will be applied (as relevant) to the proposed Browse to NWS Project;

- API ST 53 - Well Control Equipment Systems for Drilling Wells

    - The purpose of this standard is to provide requirements for the installation and testing of blowout prevention equipment systems on land and marine drilling rigs.
- API ST 64 - Recommended Practice for Diverter Systems Equipment and Operations
    - This standard is intended to provide information on the design, manufacture, quality control, installation, maintenance and testing of the diverter system, and associated components. The diverter system provides a flow control system to direct controlled or uncontrolled wellbore fluids away from the immediate drilling area for the safety of personnel and equipment
- API TR 5C3 - Calculating Performance Properties of Pipe Used as Casing or Tubing
    - This technical report illustrates the equations and templates necessary to calculate the various pipe properties.
- API RP 5C5 - Procedures for Testing Casing and Tubing Connections
    - This Recommended Practice (RP) defines tests to determine the galling tendency, sealing performance, and structural integrity of threaded casing and tubing connections
- API SPEC 5CT - Specification for Casing and Tubing
    - This standard specifies the technical delivery conditions for steel pipes (casing, tubing, and pup joints), coupling stock, coupling material, and accessory material, and establishes requirements for three product specification levels.
- NORSOK D-007 – Well Testing Systems
    - This document describes the technical, functional, and operational requirements for temporary well testing, production clean-up and bleed-off equipment and systems. The equipment and systems are used for hydrocarbon flow from exploration or development wells on both mobile units and fixed platforms.
- NORSOK D002 - System requirements well intervention equipment
    - This standard describes the design, installation and commissioning principles and requirements for the well intervention equipment and their systems and equipment.
- IOGP Report 476 - Recommendations for enhancements to well control training, examination and certification
    - This report provides recommended enhancements to existing industry well control training, examination and certification processes, as well as related philosophies that should be considered for adoption throughout the industry to improve well control preparedness and performance.

Woodside's involvement in industry forums allows it to remain involved in and abreast of the latest industry best practice guidance, this involvement includes:

- active participant of APPEA's Oil Spill Preparedness and Response Working Group
- active participant of APPEA's Drilling Industry Steering Committees
- current chair of the AMOSC Subsea First Response Toolkit Steering Committee
- member of IOGP industry committees e.g. Wells Engineering Committee
- member of the IPIECA Oil Spill Working Group
- member of both the International Maritime Organization Global Initiative groups for South East Asia (GI SEA) and West and Central Africa (GI WACAF) (NB GI program is administered by IPIECA).

- member of Oil Spill Response Limited (OSRL) - the leading industry spill response organisation. In addition to the provision of equipment and personnel response resources during a spill event, OSRL provides advice and guidance to members on good practice during planning. Woodside subscribes to OSRL's quality-assurance review service for pre-submission review of Australian regulatory oil spill plans.

2.2 Measures that will be implemented to minimise the likelihood of the hydrocarbon spills from loss of well containment events.

When implementing the proposed Browse to NWS Project, the following measures (Table 2-1) will be applied at a minimum to minimise the likelihood of a hydrocarbon release occurring due to a well loss of containment event during drilling and completions activities.

These measures were identified in the context of supporting the environmental impact assessment for the proposed Browse to NWS Project at the primary approval stage. As project design and planning develops, and as part of the secondary approvals required under the Commonwealth and State regulations, further measures will be identified and assessed to ensure the risk of any unplanned hydrocarbon release is reduced to ALARP in accordance with the regulations.

Table 2-1: Prevention measures to be implemented for the proposed Browse to NWS Project to reduce the likelihood of a hydrocarbon spill

Measure	Description	Benefit
Regulator acceptance of a Well Operations Management Plan (WOMP)	At the completion of the well design and planning phase, a WOMP will be submitted to NOPSEMA/DMIRS (depending on well jurisdiction) for approval. It will summarise the well design and demonstrate that the well integrity risks have been managed to ALARP. The well design will be in accordance with D&C System and Management Framework and latest best practices at the time of undertaking this work. The sections below summarise in more detail the type of work and activities that go into developing a WOMP.	• Demonstration that the well design and construction process has successfully demonstrated that well integrity risk is ALARP.
Engineering Design	The following measures to be considered during well engineering design to reduce the likelihood of a hydrocarbon release (loss of well integrity) to ALARP: • Utilise industry and Woodside best practices. • Implement learnings from offset wells and hazards encountered. • Perform pore pressure prediction modelling using offset data. • Design fluids to maintain sufficient pressure overbalance to hydrocarbon pressure during well construction and maintain sufficient integrity in the presence of well contaminants. • Design cement barriers to limit the risk of loss of containment of well to ALARP. • Design well architecture (wellhead, conductor, casing, and tubing) to provide or support well barriers that can withstand all planned, foreseeable and survival load cases.	• Understanding the pore pressure regime of the area, utilising area-specific hazard information and using best practices during the well's engineering design allows the creation of a well design that reduces the risk of loss of well control to ALARP.

Measure	Description	Benefit
	• Design well shoe placement with sufficient kick tolerance to allow an influx to be safely circulated out of the well without breaking down the formation at the open hole weak point. • Prepare well barrier diagrams and well acceptance criteria to demonstrate a two-barrier approach to hydrocarbons is utilised during well construction operations. • Create well activity risk management bowtie diagrams to identify controls to manage a hazard. • Conduct a peer review of engineering design with Woodside and JVP subject matter experts. • All wells to be designed to ensure that well kill can occur via a single relief well • Capping stack will be capable of interfacing with wellhead and BOP connectors	
Processes and Procedures	The following processes and procedures to be considered to ensure well construction is executed as planned: • Well Programs and Guidelines, e.g. Detailed Drilling Program (DDP) and Detailed Completions Guideline (DCG), to provide step-by-step instructions to execute drilling and completions activities, and inform operations teams of key hazards and risks pertaining to well construction activities. • Standard Instructions to Drillers (SIDs): detailed step-by-step instructions for each operational activity distributed to all pertinent personnel at the operational site to facilitate a cohesive approach to execution of the activity.	• Processes and procedures allow learnings and best practices to be communicated from well design through to well construction.
Personnel Selection, Placement and Competency	Personnel competency is assessed to ensure employees, contractors, and service providers engaged in well construction activities understand their process safety responsibilities. This may be done through the following methods: • Operations supervisors to have a valid Well Control certification pertaining to their role. • Contracts with drilling service providers detailing minimum experience required from third party personnel. • Qualification to Fly (QOF) system to track third-party personnel experience and competence prior to approving their travel to the operations site.	• Process Safety is integrated into the way D&C conducts well activities on a day-to-day basis. This ensures all parties, employees, contractors and service providers engaged in D&C well activities become exposed and involved in Process Safety.

Measure	Description	Benefit
	• All emergency duty personnel and their deputies must possess the skills and awareness necessary to carry out their respective emergency management roles. Well control drills and exercises are implemented to maintain personnel competency in emergency response. This may be done through the following methods: • An Emergency Communications Exercise conducted by each rig withing 48 hours of arriving at a new location. • A scenario-based exercise involving the facility emergency response teams and activation of the Contractor's onshore emergency centres and the Corporate Incident Coordination Centre (CICC), must be conducted within one month of the commencement of a campaign, and as a minimum at six month intervals thereafter. This Level 2 exercise must include an oil spill related event once a year.	
Operational Status Monitoring	The monitoring of well integrity and adherence to well programs and procedures may be obtained through the following methods: • Daily Drilling Reports (DDRs) provide a summary of each day's operations and outline key reportable outcomes and activities used to monitor the integrity of the well • Well Acceptance Criteria (WAC) list the requirements for establishing the appropriate barriers and controls to ensure well integrity is maintained throughout the well construction phase. The achievement of WAC is witnessed by the offshore supervisor, verified by the responsible party onshore and documented in the DDR. • Well Barrier Diagrams define all barriers that must be in place through well construction activities and are verified by the operations supervisor prior to commencing the respective activity. • Management of Change process: any temporary or permanent deviations from the approved well design or approved procedures and guidelines require a risk assessment and formal approval sought from responsible parties via a Change Control Request Form. • Leading Process Safety Metrics track the status of vulnerable operational processes observed in recent industry events and are included in the DDR. Examples of	• The monitoring of well integrity and adherence to well programs and procedures allows visibility of well control status and a swifter emergency response should there be a loss of well control, thereby reducing the risk of loss of well containment.

Measure	Description	Benefit
	metrics include well control equipment checks, any deviations to D&C Standards and fluid column status.	
Primary Well Control	The implementation and on-going verification of primary well control may be obtained through the following measures: • A minimum of two well barrier enveloped to isolate reservoirs and/or zones with flow potential to subsea/surface. • Well barriers are selected and installed to limit the risk of loss of containment to ALARP. • If the primary well barrier is a fluid column, the following must be met to qualify and verify the barrier: – The hydrostatic head margin exerted by the fluid exceeds the predicted most likely formation pressure at the point of overbalance. – Critical fluid properties and specifications are described prior to any operation – The hydrostatic pressure does not exceed the formation fracture pressure (SHmin) in the open hole including a safety margin which considers circulation events. – The fluid level can be measured, maintained and monitored. – Fluid density changes due to temperature and compressibility in the wellbore are factored into overbalance estimates. – Fluid volumes and flow rates are monitored and flow checks are performed.	• Establishing, qualifying and verifying primary barriers allows reduction of the risk of loss of well containment to ALARP.
Secondary Well Control	Secondary well control is established to mitigate the risk of loss of primary well control. This may be done through the following measures: • The assessment of well control equipment requirements must be conducted for all new campaigns. • Surface well control and associated equipment requirements for well intervention must follow the requirements of NORSOK D002 Well Intervention Equipment Rev 2013. • A third-party Woodside Control equipment Inspector must inspect the well control equipment for workover and subsea intervention prior to each campaign.	• Establishing, qualifying and verifying secondary barriers allows well control to be maintained should primary well control barriers be lost, reducing the risk of loss of well containment to ALARP.

Measure	Description	Benefit
	• Two independent systems for monitoring critical well bore data should be provided (typically by the drilling contractor and mudloggers). • A diverter system must be installed. • Surface BOP stacks must have a minimum 5000 psi configuration. • Subsea BOP stack must be consistent with the requirements of API Standard 53. • Consideration must be given to the appropriate BOP ram configuration and control systems to ensure BOP will reduce risks to ALARP. • A full BOP pressure test must be carried out once the BOP is initially landed Subsequent pressure test frequency is not to exceed 21 days. • BOP rams must be function tested from surface, and remotely (via ROV) every 7 days.	
Well Control Preparedness / Managing Loss of Primary Well Control	Well control preparedness may be accomplished through the following measures: • Formation Integrity Tests (FIT) or Leak-off Tests (LOT) must be carried out after a string of casing has been cemented and before a new section of hole is drilled. • A well "termination rate" sheet must be updated at least daily when a new hole is being drilled. • Best practices and procedures must be followed to prevent kicks while tripping and drilling • Well control drills. • Flow checks must be made as per best practices. • Pit volumes must be independently monitored and any anomalies investigated.	• Well control preparedness allows for a swifter response to the loss of primary well control, reducing the likelihood of a hydrocarbon spill.

3 MINIMISING THE CONSEQUENCE OF WELL LOSS OF CONTAINMENT EVENTS

3.1 Source control techniques to be applied on the proposed Browse to NWS Project

In the unlikely event of a loss of containment event originating from a subsea well, source control will be required to bring the well back under control and to stop hydrocarbons from being released to the environment. Source control is a generic term for all activities related to the direct intervention of a well that has experienced loss of containment, with the intent to halt or control the release of hydrocarbons to the environment.

Table 3-1 outlines the source control response techniques that will, at a minimum, be implemented for the proposed Browse to NWS Project to reduce the consequence of a hydrocarbon spill from a loss of well control.

The techniques to be applied, including provision of maximum response timeframes for each key source control activity, is considered to be in alignment with industry best practice.

For source control planning Woodside's approach is aligned to Regulator and Industry best practices, codes and standards. A non-exhaustive list of these are outlined below:

- UK Oil & Gas Guidelines on Relief Well Planning, Issue 2, March 2013
- ISCWSA Well Intercept Sub committee Ebook v7
- SPE Technical Report on Calculation of WCD SPE-174705-TR
- IOGP Report 594 (Source Control and Emergency Response Planning Guide)
- IOGP Report 591 (Guidance for source control competence and skills)
- Australian Offshore Titleholders Source Control Guidelines
- NOPSEMA Source Control Planning and Procedures Information Paper
- American Petroleum Institute Recommended Practice (API RP) 17W which provides guidelines for the design, manufacture, use, preservation, transportation, and maintenance procedures of subsea capping stacks

Table 3-1: Source control response measures that will be implemented for the proposed Browse to NWS Project to reduce consequence of a hydrocarbon spill

Response technique to be available	Overview of technique	Expected benefits	Response timeframe
Source control via blowout preventer (BOP) intervention	The BOP rams are operated from surface, or via a Remotely Operated Vehicle (ROV), to close the well. The status of the well and any pipe, wire or tooling across the BOP's are considered when selecting the appropriate rams to close the well. In the event of the worst-case scenario with a loss of well containment during drilling operations occurring and the BOP not automatically being shut in, ROV operations to manually operate the BOP would be attempted.	Controlling a loss of well containment at source via BOP intervention would be the most effective way to limit the quantity of hydrocarbon entering the marine environment.	For the proposed Browse to NWS Project, source control via BOP intervention will be available for immediate response. An ROV will be available on the MODU ready for immediate deployment to attempt initial BOP well intervention. A separate ROV will be available (on a separate vessel) to attempt BOP well intervention within 48 hours.
Debris clearance using subsea first response toolkit	Should a blow-out occur that can't be remediated by actuation of BOP closure rams, it is possible there may be debris or damage to equipment that would restrict access to the well to allow further response. A subsea first response toolkit (SFRT) would be deployed to survey the location and remove debris to facilitate deployment of a capping stack. Woodside has contracts in place for year round assistance for the mobilisation, deployment, and operation of the SFRT equipment together with trained and qualified personnel.	Facilitates use and deployment of capping stack onto the well.	In the event of a loss of well containment, the SFRT will be mobilised to site and available for deployment within 11 days.
Source control via debris clearance and capping stack	A suitable and compatible capping stack would be installed on a blowing out well to stop hydrocarbons from escaping to the environment.	Controlling a loss of well containment at source via capping stack would be an effective way to limit the quantity of	A suitable capping stack (on a suitable vessel) will be mobilised to site and the capping stack will be available for deployment within 11[1] - 16[2] days, targeting

		hydrocarbon entering the marine environment.	deployment within 13 days. Once equipment arrives in the field, deployment would commence immediately as metocean and hydrocarbon plume conditions allow for safe deployment. Note 1 - 11 days is the mobilisation timeframe for the Singapore-based Wild Well Control Inc. capping stack to Port Hedland as calculated in the Australian oil and gas industry response time model (OSRL-APPEA, June 2021). This timeframe assumes the availability of a suitable vessel in Singapore within 24 hours. Note 2 - 16 days is the estimated mobilisation timeframe based on the OSRL-APPEA response time model (11 days) plus transit time to the spill location and contingency if a suitable vessel is not available within 24 hours.
Source control via relief well drilling	A Blowout Contingency and Relief Well Plan is created for the worst-case discharges of a campaign and may detail the following: • Worst case discharge rates • Design of a relief well and point of intersection at the blowing out well • Pump rates and pressures capable of killing the blowing out well and establishing primary well control • A list of suitable MODUs in the region with suitable pump capacity that may be mobilised to perform relief well drilling	A relief well aids in the intersection and kill of a blowing out well, establishing primary well control. This is the only guaranteed, 100% reliable technique for stopping a well loss of containment event permanently.	A Blowout Contingency and Relief Well Plan will be created for the worst case release scenarios. A drill rig capable of commencing relief well drilling will be mobilised and in field, available to commence drilling the relief well, within 16 days. Predicted relief well drilling timeframe breakdown is as follows: Source, contract and mobilise MODU: Up to 16 days

				Drilling, casing and look ahead	Up to 47 days	
				Intersection & well kill	Up to 14 days	
				TOTAL:	77 days	

3.2 New, emerging and innovative hydrocarbon spill response techniques to be considered for implementation on the proposed Browse to NWS Project

As part of detailed source control planning activities, all available techniques and strategies will be reviewed, as part of the secondary approval and ALARP demonstration process (See Section 5.2)

At a minimum, based on today's known technology, each of the new and emerging source control techniques outlined in Table 3-2 will be reviewed for their applicability to the proposed Browse to NWS Project and implemented if identified as being required to demonstrate hydrocarbon spill risks have been reduced to ALARP. Each of the techniques below will specifically be considered for implementation on the proposed Browse to NWS Project.

Woodside is committed to ongoing monitoring and evaluation of source control technologies and methodologies to ensure it is continually aligned to best practice. Therefore, prior to the submission of environment plan for any drilling activities, which have a maximum duration of five years. Woodside will review best practice spill response techniques including a review of latest standards published by API, IPIECA, IOGP or and relevant regulatory guidelines.

Table 3-2: New, emerging and non-standard response measures that will reduce the consequence of a hydrocarbon spill that will be assessed prior to implementation of the proposed Browse to NWS Project

Response technique	Overview of technique	Expected benefits	Feasibility considerations
Kinetic blow out stopper (KBOS) emergency shut in device	The Kinetic Blowout Stopper (K-BOS) emergency shut-in device has the potential to increase reliability and effectiveness of blow-out prevention measures	• As a last resort it would allow shut in of a well quickly stopping flow of hydrocarbons.	This emerging technology has not previously been used by Woodside. Drilling contractors have conducted field trials of integrating the emergency shut-in device to the BOP stack. The device may become more widely available in future.

Response technique	Overview of technique	Expected benefits	Feasibility considerations
	above those provided by a subsea BOP stack.	• The K-BOS offers increased ability to shear tubulars that may not be successfully severed by a hydraulic BOP shear ram, while also being controlled independently of the BOP control system.	
Mudline closure device	The system is designed to augment the existing rigs BOP safety system and provides two additional sets of rams with an independent control system. However the gain in system reliability is less than by using K-BOS as the shear ram design is the same as for the BOP.	• Additional control system redundancy	This technology has not previously been used by Woodside.
Offset capping alternative to conventional capping stack deployment	This technique offers a solution in shallow water when worst case discharge rates are too high to install a capping stack conventionally (vertical access). For the proposed Browse to NWS Project, the water depth is in the 'mid water' range so this technique may not be required.	• Solution for capping at high rates when combined with shallow water.	Technical feasibility: • The base case considerations for offset intervention installation equipment (OIE) requires a coordinated response by 4 to 7 vessels working simultaneously outside of the 500m exclusion zone. In the event of a worst-case shallow water gas discharge, the 10% LEL modelled radius extends beyond the area of activity required for the OIE deployment thereby introducing health and safety risk to any vessels required for the initial deployment of the carrier and subsequent operations with ROV during capping operations. Though manageable for single vessels, it is prohibitive for operations requiring SIMOPs with numerous vessels working at 180 degrees from one another.

Response technique	Overview of technique	Expected benefits	Feasibility considerations
			Other factors: • Due to the OIE's size and scale, fabrication of equipment, e.g. mooring anchors, outside of the contractor's scope of supply is likely to require engagement of international suppliers, further increasing complexity and uncertainty in associated time frames. • Screening indicates that mobilising some components of the OIE, based in Italy, can only be mobilised by sea and is likely to erode any time savings realised through stopping flow of the well via a relief well. The March 2019 OSRL exercise in Europe tested deployment of the OIE and highlighted that it will require a 600+MT crane vessel for deployment to ensure there is useable hook height for the crane to conduct the lift of the carrier. Vessels with such capability and a current Australian vessel safety case are not locally or readily available.
Dual vessel capping stack deployment	The capping stack would be handed off from a crane vessel to the anchor handler vessel (AHV) work wire outside of the exclusion zone. The AHV would then manoeuvre the barge into the plume to position the capping stack over the well. In this method, the barge would be in the plume, but the AHV and all personnel would be able to maintain a safe position outside of the gas zone. The capping stack would be lowered on the AHV	While the use of dual vessel to deploy the capping system could reduce the quantity of hydrocarbon entering the marine environment, this is an unproven technology. Additionally, the feasibility issues surrounding a dual vessel capping deployment together with mobilisation lead times for both a cap and required vessels and support equipment, would minimise any environmental benefit.	A dual vessel deployment is somewhat feasible provided a large enough deck barge can be located. Deck barges of 120 m are not, however, very common and will present a logistical challenge to identify and relocate to the region. Furthermore, the longer length barges may need mooring assist to remain centred over the well.

Response technique	Overview of technique	Expected benefits	Feasibility considerations
	work wire so a crane would not be required on the barge.		
Subsea containment system alternative to capping stack deployment	The technique involves the installation of a large containment system on top of the well that directs hydrocarbons to a surface containment system, such as a vessel or tanker.	While the use of a subsea containment system could reduce the quantity of hydrocarbon entering the marine environment, this is an unproven technology. Additionally, the system is unlikely to be feasibly deployed and activated for at least 90 days following a blowout due to equipment requirements and logistics. No environmental benefit is therefore predicted given the release duration is predicted to be 77 days before drilling of a relief well under the adopted control measure.	The timing for mobilisation, deployment and activation of the subsea containment system is likely to be >90 days which is longer than the expected 77 days relief well drilling operations based on the location, size and scale of the equipment required, including seabed piles that can only be transported by vessel.
Subsea well kill spools	For use in shallow or deep water, subsea kill spools facilitate the delivery of high-rate kill fluid to a relief well via subsea hoses. The technique requires the use of a second MODU in deep water, or another vessel with fluid storage and pumping capabilities in shallow water.	Delivery of very high kill rates achievable for well kill: • Avoids requirement for two relief wells (undesirable) • Reduces kill fluid density • Lower kill system pressures • Reduces requirement for additional, high-pressure pump skids Uses conventional pumping line-ups on MODU.	This technology is under consideration by Woodside and initial feasibility studies are complete. The subsea kill spool equipment is available on an 'access' basis, similar to the capping stack. The equipment can be air-freighted to Australia within the required response timeframe. For deep water applications, a second MODU is required to provide additional kill fluid storage and pumping capacity, otherwise the deployment of this technology is uncomplicated. Various installation options are available, e.g. MODU, IMR vessel, construction vessel.

4 HYDROCARBON SPILL RESPONSE TECHNIQUES TO BE IMPLEMENTED ON THE PROPOSED BROWSE TO NWS PROJECT

4.1 Hydrocarbon spill response techniques that will be implemented for the proposed Browse to NWS Project, to reduce consequence of a hydrocarbon spill from a well loss of containment event

The following outlines the spill response techniques that will be applied, at a minimum, to minimise the consequence of loss of containment events. Further details of the nature of this event are outlined in the draft EIS/ERD, to which this document is an Appendix.

As part of the secondary approval process, Woodside will undertake further detailed assessment of the applicable response techniques. The outcomes of that assessment process will be presented in an Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA) prepared to meet the requirements of the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and the State Petroleum (Submerged Lands) (Environment) Regulations 2012.

Woodside's processes for spill response planning and preparedness are aligned with industry and international good practice including, but not limited to, the following:

- Australian Maritime Safety Authority
  - The National Plan Oil Spill Control Agents List
- Department of Parks and Wildlife and Australian Marine Oil Spill Centre
  - Inter-Company Oil Spill Wildlife Response Plan
  - Western Australian Oiled Wildlife Response Plan
- European Maritime Safety Agency
  - Manual on the applicability of oil spill dispersants
- International Petroleum Industry Environment Conservation Association (IPIECA) and International Association of Oil and Gas Producers (IOGP)
  - Dispersants: surface application
- International Tanker Owners Pollution Federation (ITOPF)
  - Fate of Marine Oil Spills, Technical Information Paper
  - Use of Dispersants to Treat Oil Spills, Technical Information Paper
  - Aerial Observation of marine oil spills, Technical Information Paper
  - Use of skimmers in oil pollution response, Technical Information Paper
- National Oceanic and Atmospheric Administration (NOAA)
  - Characteristics of Response Strategies: A Guide for Spill Response Planning in Marine Environments.

Table 4-1 presents the hydrocarbon spill response techniques that will be implemented for the proposed Browse to NWS Project to reduce consequence of a hydrocarbon spill.

Table 4-1: Hydrocarbon spill response techniques that will be available to be implemented for the proposed Browse to NWS Project to reduce the consequence of a hydrocarbon spill from well loss of containment

Response technique	Overview of technique	Outcome	Feasibility
Monitor and evaluate	Monitor and evaluate includes the gathering and evaluation of data to inform oil spill response planning and operations. It includes fate and trajectory modelling, spill tracking, weather updates and field observations. This response option is deployed in some capacity for every event. Operational monitoring is typically undertaken from the outset of a spill. This is needed to assess the nature of the spill and track its location. The data collected from the operational monitoring will inform the need for any additional operational monitoring, deployment of response techniques and may assist post-spill scientific monitoring. It also informs when the spill has entered WA State Waters and control of the incident passes to Western Australia Department of Transport (WA DoT).	Will be effective in tracking the location of the spill, informing when it has entered State Waters, predicting potential impacts and triggering further monitoring and response techniques as required. Monitoring techniques include: • OM01 Predictive modelling of hydrocarbons – used throughout spill. 'Ground-truthed' using the outputs of all other monitoring techniques. • OM02 Surveillance and reconnaissance to detect hydrocarbons and resources at risk – from outset of spill. • OM03 Monitoring of hydrocarbon presence, properties, behaviour and weathering in water – from outset of spill. • OM04 Pre-emptive assessment of sensitive receptors at risk – triggered once OM01, OM02 and OM03 inform likely RPAs at risk. • OM05 Shoreline assessment – once OM02, OM03 and OM04 inform which RPAs have been impacted.	Monitoring of a spill is a feasible response technique and an essential element of all spill response incidents. Outputs will be used to guide decision making on the use of other monitoring/response techniques and providing required information to regulatory agencies including AMSA and WA DoT.
Subsea Dispersant Injection (SSDI) [1]	Application of subsea dispersant may reduce the scale and extent of hydrocarbons reaching the surface and thus reduce spill volumes contacting predicted RPAs. Subsea dispersant injection involves the deployment of a subsea dispersant manifold with associated equipment to inject chemical dispersant directly into the hydrocarbon	Application of subsea dispersant may reduce the scale and extent of hydrocarbons reaching the surface and thus reduce spill volumes contacting predicted RPAs. SSDI can increase dispersed/entrained hydrocarbons which can potentially have higher toxicity to biota in shallow water than naturally dispersed hydrocarbons.	Predicted to be feasible for the subsea release due to the hydrocarbon properties of the proposed Browse to NWS Project condensate. Furthermore, SSDI could potentially be applied from outside the exclusion zone thus could be deployed even when there are high VOC levels at the spill source.

Response technique	Overview of technique	Outcome	Feasibility
	plume in the event of a loss of well containment. As it may take some time to mobilise subsea dispersant equipment, surface dispersants are generally used in the interim to treat oil that makes it to the surface provided appropriate surface concentrations thresholds (>50 g/m^2) are present. The use of subsea dispersants has similar benefits to surface dispersant application including a potential reduction in the volume of hydrocarbons that reach the shoreline thereby reducing impacts to sensitive receptors. In addition to these benefits, subsea dispersant application may reduce volatile organic compound (VOC) levels during surface response operations, reducing risks and hazards to responders.	Entrained oil could potentially impact on sensitive shallow-water receptors e.g. corals, which may be otherwise unaffected. Entrained oil plume likely to be increased resulting in greater spatial extent of entrained oil. The proximity to Scott Reef and the potential for dispersant use to result in impacts to Scott Reef would also influence the decision on the use of subsea dispersants. Where a hydrocarbon spill may potential enter WA State waters, the use of subsea dispersants would be subject to approval from the WA DoT.	This response technique may not be feasible in the event of a worst-case blow-out due to potential high gas flow rates. The proximity to Scott Reef and the potential for dispersant use to result in impacts to Scott Reef would also influence the decision on the use of subsea dispersants. Where a hydrocarbon spill may potential enter WA State waters, the use of subsea dispersants would be subject to approval from the WA DoT.
Surface dispersant application[1]	Surface dispersant application may reduce surface hydrocarbons and therefore prevent, or reduce the scale of, shoreline contact. Surface dispersant may be applied via vessel or aerial means. Priority would be placed on treating high volume surface hydrocarbons closest to the release location as this is where high surface concentrations are predicted, and dispersant application is expected to achieve the greatest environmental benefit. Surface dispersant application is weather and sea-state dependent. Periods of downtime can be expected.	Application of surface dispersant would likely reduce the volumes of hydrocarbons contacting sensitive surface and shoreline receptors. Dispersant can also enhance biodegradation and may reduce VOCs in some circumstances therefore reducing potential health and safety risk to responders. Dispersant can increase dispersed/entrained hydrocarbons which can potentially have higher toxicity to biota in shallow water than naturally dispersed hydrocarbons. Subsurface oil plume likely to increase in size resulting in greater spatial extent of entrained oil.	Dispersants are not generally considered a feasible response technique when applied on thin surface films such as condensate as the dispersant droplets tend to pass through the surface films without binding to the hydrocarbon. This technique may be prevented from being undertaken due to personnel safety issues arising from predicted high local concentrations of atmospheric volatiles. The proximity to Scott Reef and the potential for dispersant use to result in impacts to Scott Reef would also influence the decision on the use of subsea dispersants. Where a hydrocarbon spill may potential enter WA State waters, the

Response technique	Overview of technique	Outcome	Feasibility
		Entrained oil could potentially impact on sensitive shallow-water receptors e.g. corals, which otherwise may have been unaffected.	use of subsea dispersants would be subject to approval from the WA DoT.
Mechanical dispersion	Mechanical dispersion involves the use of a vessel's propeller wash and/or fire hose to target surface hydrocarbons to achieve dispersion into the water column.	This technique is of limited benefit in an open ocean environment where wind and wave action are likely to deliver similar advantages. Additionally, the volatile nature of the oil likely to lead to unsafe conditions in the vicinity of fresh hydrocarbon.	Although the technique is feasible, highly volatile hydrocarbons are likely to weather, spread and evaporate quickly. The volatile nature of the oil likely to lead to unsafe conditions in the vicinity of fresh hydrocarbon. Additionally, any vessel used for mechanical dispersion activities would be contaminated by the hydrocarbon and could potentially cause secondary contamination of unimpacted areas when exiting the spill area. The decontamination of a vessel used for mechanical dispersion activities would result in additional quantities of oily waste requiring appropriate handling and treatment.
In-situ burning[1]	This technique requires calm sea state conditions as is required for containment and recovery operations, which limits its feasibility. Optimum weather conditions are <20 knot wind speed and waves <1 to 1.5 m with oil collected to a minimum 3 mm thick layer.	In-situ burning is only effective where minimum slick thickness can be achieved and where calm metocean conditions can be ensured. There are health and safety risks for response personnel associated with the containment and subsequent burning of hydrocarbons. It is also suggested that the residue from attempts to burn would sink, thereby posing a risk to the environment and/or increase the release of atmospheric pollutants. The longer-term effects of burn residues on the marine environment are not	There is a limited window of opportunity in which this technique can be applied (prior to evaporation of the volatiles) which would be difficult to achieve. Furthermore, this technique may be prevented from being undertaken due to personnel safety issues arising from predicted high local concentrations of atmospheric volatiles.

Response technique	Overview of technique	Outcome	Feasibility
		fully understood and therefore, no assessment of the potential environmental impact can be determined.	
Containment and recovery	Containment and recovery is used to reduce damage to sensitive resources by the physical containment and mechanical removal of hydrocarbons from the marine environment. It has a lower capacity for removing surface oil than the application of dispersant but avoids potential additional impacts created by the resulting increase in entrained hydrocarbons in the water column.	Containment and recovery has an effective recovery rate of 5-10% when a hydrocarbon encounter rate of 25-50% is achieved at BAOAC 4 and 5. It has the potential to reduce the magnitude, probability, extent, contact and accumulation of hydrocarbon on shorelines receptors when suitable encounter rates can be achieved. It also has the potential to reduce the magnitude and extent of contact with submerged receptors by removing oil before further natural entraining/dissolving of hydrocarbons occurs.	Predicted low effectiveness – typical expectation is less than 10% of hydrocarbon released can be contained and recovered. Deepwater Horizon/Macondo was approx. 3–5% with the largest containment and recovery operation ever conducted. Meteorological conditions and sea-state must allow the deployment of booms and skimmers. Surface hydrocarbon would need to be corralled to a sufficient thickness to permit efficient recovery by skimmers. The volatile nature of the hydrocarbon may lead to unsafe conditions near release location.
Shoreline protection and deflection	The placement of protection or deflection booms on and near a shoreline is a response technique to reduce the potential volume of hydrocarbons contacting or spreading along shorelines, which may reduce the scale of shoreline clean-up. Hydrocarbons contained by the booms would be collected where practicable.	Shoreline protection and deflection can be effective at preventing contamination of sensitive resources and can be used to corral oil into slicks thick enough to skim effectively.	If real-time Operational Monitoring activities (OM01, OM02 and OM03) indicate surface hydrocarbons are moving toward shorelines, pre-emptive assessments of sensitive receptors at risk (OM04) and existing TRPs will be utilised to guide shoreline protection and deflection operations, in agreement with WA DoT (for Level 2/3 spills). Protection strategies can be used for targeted protection of sensitive resources.

Response technique	Overview of technique	Outcome	Feasibility
			Access to sensitive areas may cause more negative impact than benefit.
Shoreline clean-up	Shoreline clean-up may be undertaken using a broad range of techniques when floating hydrocarbons contact shorelines. The timing, location and extent of shoreline clean-up activities can vary from one scenario to another, depending on the hydrocarbon type, sensitivities and values contacted, shoreline type and access, degree of oiling, and area oiled. Shoreline clean-up is typically undertaken as a three-phase process: • Phase one (gross contamination removal) involving the collection of bulk oil, either floating against the shoreline or stranded on it. • Phase two (moderate to heavy contamination removal) involving removal or in-situ treatment of shoreline substrates such as sand or pebble beaches. • Phase three (final treatment or polishing) involving removal of the remaining residues of oil.	Shoreline clean-up is an effective means of hydrocarbon removal from contaminated shorelines where coverage is at an optimum level of 250 g/m^2.	If real-time Operational Monitoring activities (OM01, OM02 and OM03) indicate hydrocarbons will contact shorelines, pre-emptive assessments of sensitive receptors at risk (OM04), shoreline assessments (OM05) and existing TRPs will be utilised to guide shoreline protection and deflection operations, in agreement with WA DoT (for Level 2/3 spills). Can reduce or prevent impact on sensitive receptors in most cases. Must ensure, through shoreline assessment, that sensitive sites will benefit from clean-up activities as the response itself may cause more negative impact than benefit through disturbance of habitats and species.
Oiled wildlife response	This technique involves implementing a response in accordance with the Oiled Wildlife Operational Plan. This plan includes the process for the IMT to mobilise resources depending on the nature and scale of the spill. Oiled wildlife operations would be implemented with advice and assistance from the Oiled Wildlife Advisor	Oiled wildlife response is an effective response technique for reducing the overall impact of a spill on wildlife. This is mostly achieved through hazing to prevent additional wildlife from being contaminated and through rehabilitation of those already subject to contamination.	In the event that wildlife are at risk of contamination, oiled wildlife response will be undertaken in accordance with the Wildlife Response Operational Plan as and where required. In addition, any rehabilitation could only be undertaken by trained specialists.

Response technique	Overview of technique	Outcome	Feasibility
	from the Department of Biodiversity, Conservation and Attractions (DBCA). Oiled wildlife response is undertaken in accordance with the Western Australian Oiled Wildlife Response Plan to ensure it is conducted in accordance with legislative requirements under the *Animal Welfare Act* 2002 (WA).		In the event of highly volatile atmospheric conditions surrounding the spill, response options may be limited to hazing to ensure the safety of response personnel.

1 – These techniques may cause environmental impacts greater than that which they seek to reduce, and (as with any measure) would only be implemented after consideration of net environmental benefits, and in the case of dispersant application, with regulatory approval of the specific action.

4.1.1 Hydrocarbon spill response planning document and approvals overview

The documents outlined in Table 4-2 will be used to manage the mitigation, preparedness and response for a hydrocarbon release on the proposed Browse to NWS Project. Each will be prepared to meet relevant regulatory requirements to the satisfaction of regulators.

Relevant regulations are outlined in Table 4-2. Woodside's approach to hydrocarbon spill preparedness and mitigation adheres to Australian regulatory requirements as detailed in Table 5-3 and Table 4-4.

Table 4-2: Hydrocarbon spill preparedness and response documentation

Document	Document overview
Activity specific Environment Plan required under the Commonwealth and State regulations	• Demonstrates that potential adverse impacts on the environment associated with the specific activities associated with the proposed Browse to NWS Project (during both routine and non-routine operations) are mitigated and managed to ALARP and will be of an acceptable level.
Oil Pollution Emergency Plan (OPEP) – Woodside's OPEP is comprised of the following elements:	
OPEA Australia	• Describes the arrangements and processes adopted by Woodside when responding to a hydrocarbon spill from a petroleum activity.
Activity specific Oil Spill Preparedness and Response Mitigation Assessment	• Evaluates response options to address the potential environmental impacts resulting from an unplanned loss of hydrocarbon containment associated proposed Browse to NWS Project activities.
Oil Pollution First Strike Plan (FSP)	• Facility specific document providing details and tasks required to mobilise a first strike response. • Primarily applied to the first 24 hours of a response until a full IAP specific to the event is developed. • Oil Pollution FSPs are intended to be the first document used to provide immediate guidance to the responding IMT.
Operational Plans (including the activity-specific Source Control Emergency Response Plan)*	• Lists the actions required to activate, mobilise and deploy personnel and resources to commence response operations. • Includes details on access to equipment and personnel (available immediately) and steps to mobilise additional resources depending on the nature and scale of a release. • Relevant operational plans will be initially selected based on the Oil Pollution FSP; additional operational plans would be activated depending on the nature and scale of the release.
Tactical Response Plans (TRP)	• Provides options for response techniques in selected Response Protection Areas (RPAs). Provides site, access and deployment information to support a response at the location.
Support Plans	• Support Plans detail Woodside's approach to resourcing and the provision of services during a hydrocarbon spill response.
*Source Control Emergency Response Plan (SCERP)	Activity/campaign plan detailing the feasible source control response techniques and the associated project-specific details required for execution.

Document	Document overview
	SCERP covers: • Blowout prevention (BOP) intervention – attempt an intervention on existing BOP stack on source well head (if conditions allow). • Debris Removal – preparation of the subsea well head/ BOP for running of the capping stack, to ensure a safe working environment, and to provide access to the wellsite for intervention. • Capping Stack – a pressure containment device installed on top of a BOP or Well head/ Xmas tree to either shut in or contain the flow of hydrocarbons to the marine environment. Relief Well Plan covers: • Relief well drilling and dynamic kill – drilling a well to intersect the source and kill (stop) the release of hydrocarbons by dynamic killing and re-establishing well barriers.

Table 4-3: Hydrocarbon spill preparedness and response approach to meet Commonwealth Legislation

Content	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009	Document/Section Reference
Details of (oil pollution response) control measures that will be used to reduce the impacts and risks of the activity to ALARP and an acceptable level	Regulation 13(5), (6), 14(3)	• Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA)
Describes the oil pollution emergency plan (OPEP)	Regulation 14(8)	Woodside's OPEP has the following components: • Woodside Oil Pollution Emergency Arrangements (Australia) (OPEA) • Oil Pollution First Strike Plan (FSP) • OSPRMA
Details the arrangements for responding to and monitoring oil pollution (to inform response activities), including control measures	Regulation 14(8AA)	• OSPRMA • FSP • Activity source control emergency response plan (SCERP)
Details the arrangements for updating and testing the oil pollution response arrangements	Regulation 14(8), (8A), (8B), (8C)	• EP • OSPRMA
Details of provisions for monitoring impacts to the environment from oil pollution and response activities	Regulation 14(8D)	• OSPRMA

Content	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009	Document/Section Reference
Demonstrates that the oil pollution response arrangements are consistent with the national system for oil pollution preparedness and control	Regulation 14(8E)	• OPEA

Table 4-4: Hydrocarbon spill preparedness and response approach to meet Western Australia State regulations

Content	State regulations	Document/Section Reference
Approval of oil spill contingency plan submitted in accordance with condition imposed by Minister	Regulation 15(10) – Petroleum (Submerged Lands) (Environment) Regulations 2012	• OPEA • FSP
	Regulation 15(10) – Petroleum and Geothermal Energy Resources (Environment) Regulations 2012	

5 MANAGEMENT RISK OF HYDROCARBON SPILLS TO AS LOW AS REASONABLY PRACTICABLE – PROCESS FOR EVALUATION AND DEMONSTRATION

5.1 Introduction

The hydrocarbon spill risk management framework outlined in this document provides only a high level summary of the response techniques to be applied on the proposed Browse the NWS Project. It was prepared in the context of providing supplementary information for the assessment of the proposed Browse to NWS Project as part of the environmental impact assessment. As project design and planning matures, and as part of the secondary approvals required under the Commonwealth and State regulations, further detail of hydrocarbon spill risk mitigation measures will be identified and assessed to ensure the risk of a significant unplanned hydrocarbon release is reduced to ALARP.

Woodside follows a well-established process in the development of its oil spill prevention, preparedness, and response position for its projects and activities with the objective of mitigating and managing the risks and impacts from an unplanned hydrocarbon release, and the associated response operations, so that they are controlled to ALARP and acceptable levels.

The outcomes of the process are typically presented in an Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA) in accordance with requirements of the Commonwealth Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 and the State Petroleum (Submerged Lands) (Environment) Regulations 2012 relating to hydrocarbon spill response arrangements.

The following outlines Woodside's ALARP demonstration and evaluation process.

5.2 ALARP demonstration process summary

Woodside's hydrocarbon spill ALARP process is aligned with guidance provided by NOPSEMA in *Oil Spill Risk Management Guidance Note N-04750-GN1488* (2021) and is set out in the 'Woodside Oil Spill Preparedness and Response Mitigation Assessment (OSPRMA) Guidelines'. The ALARP process is summarised as follows:

1. Consider the response planning need in terms of surface area (km^2) and available surface hydrocarbon volumes (m^3) against existing Woodside capability;
2. Consider alternative, additional, and improved options for each response technique/control measure by providing an initial and, if required, detailed evaluation of:
    - predicted cost associated with adopting the control measure
    - predicted change/environmental benefit
    - predicted effectiveness/feasibility of the control measure.
3. Evaluate the risks and impacts of implementing the proposed response techniques, and any further control measures with associated environmental performance to manage these additional risks and impacts.

Woodside considers the risks and impacts from a hydrocarbon spill to have been reduced to ALARP when:

1. A structured process for identifying and considering alternative, additional, and improved options has been completed for each selected response technique

2. The analysis of alternate, additional, and improved control measures meets one of the following criteria:
   - all identified, reasonably practicable control measures have been adopted
   - no identified reasonably practicable additional, alternative and/or improved control measures would provide further overall increased proportionate environmental benefit; or
   - no reasonably practical additional, alternative, and/or improved control measures have been identified.
3. Where an alternative, additional and/or improved control measure is adopted, a measurable level of environmental performance has been assigned
4. Higher order impacts/ risks have received more comprehensive alternative, additional, and improved control measure evaluations and do not just compare the cost of the adopted control measures to the costs of an extreme or clearly unreasonable control measure
5. Cumulative effects have been analysed when considered in combination across the whole activity.

The response technique selection is based on the risk assessment conducted in the EP. The risk assessment identifies the type of oil, volume of release, duration of release, predicted fate, weathering and the EMBA (along with other requirements such as time to impact and predicted volumes ashore). Modelling is then used to inform the SIMA and the prioritisation of suitable response options. The scale of the response techniques selected in the pre-operational SIMA is informed through the assessment of results from deterministic modelling.

6 OPERATIONAL AND SCIENTIFIC MONITORING

6.1 Operational monitoring

Operational monitoring includes the gathering and evaluation of data to inform the oil spill response planning and operations. It includes fate and trajectory modelling, spill tracking, weather updates and field observations. This response option is deployed in some capacity for every event.

Woodside maintains an *Operational Monitoring Operational Plan*. If shoreline contact is predicted, Response Protection Areas (RPAs) will be identified and assessed before contact. If shorelines are contacted, a shoreline assessment survey will be completed to guide effective shoreline clean-up operations. This plan includes the process for the Incident Management Team to mobilise resources depending on the nature and scale of the spill.

Table 6-1 provides details of Woodside's operational monitoring plans that support the successful execution of this response technique.

Table 6-1: Operational monitoring objectives, triggers and termination criteria

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
Operational Monitoring Operational Plan 1 (OM01) Predictive Modelling of Hydrocarbons to Assess Resources at Risk	OM01 focuses on the conditions that have prevailed since a spill commenced, as well as those that are forecasted in the short term (1–3 days ahead) and longer term. OM01 utilises computer-based forecasting methods to predict hydrocarbon spill movement and guide the management and execution of spill response operations to maximise the protection of environmental resources at risk. The objectives of OM01 are to: • Provide forecasting of the movement and weathering of spilled hydrocarbons. • Identify resources that are potentially at risk of contamination. • Provide simulations showing the outcome of alternative response options (booming patterns etc.) to inform on-going Spill Impact Mitigation Assessment (SIMA) and continually assess the efficacy of available response options in order to reduce risks to ALARP.	OM01 will be triggered immediately following a level 2/3 hydrocarbon spill.	The criteria for the termination of OM01 are: • The hydrocarbon discharge has ceased and no further surface oil is visible. • Response activities have ceased. • Hydrocarbon spill modelling (as verified by OM02 surveillance observations) predicts no additional natural resources will be impacted.
Operational Monitoring Operational Plan 2 (OM02) Surveillance and reconnaissance to detect hydrocarbons and resources at risk	OM02 aims to provide regular, on-going hydrocarbon spill surveillance throughout a broad region, in the event of a spill. The objectives of OM02 are: • Verify spill modelling results and recalibrate spill trajectory models (OM01). • Understand the behaviour, weathering and fate of surface hydrocarbons. • Identify environmental receptors and locations at risk or contaminated by hydrocarbons. • Inform ongoing SIMA and continually assess the efficacy of available response options in order to reduce risks to ALARP.	OM02 will be triggered immediately following a level 2/3 hydrocarbon spill.	The termination triggers for the OM02 are: • 72 hours has elapsed since the last confirmed observation of surface hydrocarbons. • Latest hydrocarbon spill modelling results (OM01) do not predict surface exposures at visible levels.

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
	• To aid in the subsequent assessment of the short- to long-term impacts and/or recovery of natural resources (assessed in SMPs) by ensuring that the visible cause and effect relationships between the hydrocarbon spill and its impacts to natural resources have been observed and recorded during the operational phase.		
Operational Monitoring Operational Plan 3 (OM03) Monitoring of hydrocarbon presence, properties, behaviour and weathering in water	OM03 will measure surface, entrained and dissolved hydrocarbons in the water column to inform decision-making for spill response activities. The specific objectives of OM03 are as follows: • Detect and monitor for the presence, quantity, properties, behaviour and weathering of surface, entrained and dissolved hydrocarbons. • Verify predictions made by OM01 and observations made by OM02 about the presence and extent of hydrocarbon contamination. Data collected in OM03 will also be used for the purpose of longer-term water quality monitoring during SM01.	OM03 will be triggered immediately following a level 2/3 hydrocarbon spill.	The criteria for the termination of OM03 are as follows: • The hydrocarbon release has ceased. • Response activities have ceased. • Concentrations of hydrocarbons in the water are below available ANZECC/ ARMCANZ (2018) trigger values for 99% species protection.
Operational Monitoring Operational Plan 4 (OM04) Pre-emptive assessment of sensitive receptors at risk	OM04 aims to undertake a rapid assessment of the presence, extent and current status of shoreline sensitive receptors prior to contact from the hydrocarbon spill, by providing categorical or semi-quantitative information on the characteristics of resources at risk. The primary objective of OM04 is to confirm understanding of the status and characteristics of environmental resources predicted by OM01 and OM02 to be at risk, to further assist in making decisions on the selection of appropriate response actions and prioritisation of resources. Indirectly, qualitative/semi-quantitative pre-contact information collected by OM04 on the status of environmental resources may also aid in the verification of environmental baseline data and	Triggers for commencing OM04 include: • Contact of a sensitive habitat or shoreline is predicted by OM01, OM02 and/or OM03. • The pre-emptive assessment methods can be implemented before contact from hydrocarbons (once a receptor has been contacted by	The criteria for the termination of OM04 at any given location are: • Locations predicted to be contacted by hydrocarbons have been contacted. • The location has not been contacted by hydrocarbons and is no longer predicted to be contacted by hydrocarbons (resources should be reallocated as appropriate).

Operational Monitoring Operational Plan	Objectives	Activation triggers	Termination criteria
	provide context for the assessment of environmental impacts, as determined through subsequent SMPs. OM04 would be undertaken in liaison with WA DoT as the control agency once the oil is in State Waters (if a Level 2/3 incident).	hydrocarbons it will be assessed under OM05).	
Operational monitoring operational plan 5 (OM05) Monitoring of contaminated resources	OM05 aims to implement surveys to assess the condition of wildlife and habitats contacted by hydrocarbons at sensitive habitat and shoreline locations. The primary objectives of OM05 are: • Record evidence of oiled wildlife (mortalities, sub-lethal impacts, number, extent, location) and habitats (mortalities, sub-lethal impacts, type, extent of cover, area, hydrocarbon character, thickness, mass and content) throughout the response and clean-up at locations contacted by hydrocarbons to inform and prioritise clean-up efforts and resources, while minimising the potential impacts of these activities. Indirectly, the information collected by OM05 may also support the assessment of environmental impacts, as determined through subsequent SMPs. OM05 would be undertaken in liaison with WA DoT as the control agency once the oil is in State Waters (if a Level 2/3 incident).	OM05 will be triggered when a sensitive habitat or shoreline is predicted to be contacted by hydrocarbons by OM01, OM02 and/or OM03.	The criteria for the termination of OM05 at any given location are: • No additional response or clean-up of wildlife or habitats is predicted. • Spill response and clean-up activities have ceased. OM05 survey sites established at sensitive habitat and shoreline locations will continue to be monitored during SM02. The formal transition from OM05 to SM02 will begin on cessation of spill response and clean-up activities.

6.2 Oil spill scientific monitoring program

A Scientific Monitoring Program (SMP) would be activated following a significant unplanned hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors. This would consider receptors at risk (ecological and socio-economic) for the entire predicted Environment that Maybe Affected (EMBA) and in particular, any identified Pre-emptive Baseline Areas (PBAs) for the credible spill scenario(s) or other identified unplanned hydrocarbon releases associated with the operational activities.

Mobilisation of field teams for the activated SMPs could generally be achieved within 7-10 days of notification of a spill occurring.

Key primary aim of the SMP is to determine the magnitude of environmental impacts arising from a hydrocarbon spill, where magnitude has extent, severity and persistence (including recovery) dimensions.

The SMP comprises ten targeted environmental monitoring programs to assess the condition of a range of physico-chemical (water and sediment) and biological (species and habitats) receptors including EPBC Act listed species, environmental values associated with protected areas and socio-economic values, such as fisheries. Woodside's ten Scientific Monitoring programs are detailed in Table 6-2 alongside their objectives, activation triggers and termination criteria.

These SMPs have been designed to cover all key tropical and temperate habitats and species within Australian waters and broader, if required.

These SMPs are subject to change from time to time and will be finalized as part of the proposed Browse to NWS Project secondary approval documentation.

Table 6-2: Oil Spill Scientific Monitoring Program – Objectives, Activation Triggers and Termination Criteria

Scientific monitoring Program (SMP)	Objectives	Activation Triggers	Termination Criteria
Scientific monitoring program 1 (SM01) Assessment of Hydrocarbons in Marine Waters	SM01 will detect and monitor the presence, extent, persistence and properties of hydrocarbons in marine waters following the spill and the response. The specific objectives of SM01 are as follows: • Assess and document the extent, severity and persistence of hydrocarbon contamination with reference to observations made during surveillance activities and / or in-water measurements made during operational monitoring. • Provide information that may be used to interpret potential cause and effect drivers for environmental impacts recorded for sensitive receptors monitored under other SMPs.	SM01 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors	SM01 will be terminated when: • Operational monitoring data relating to observations and / or measurements of hydrocarbons on and in water have been compiled, analysed and reported. • The report provides details of the extent, severity and persistence of hydrocarbons which can be used for analysis of impacts recorded for sensitive receptors monitored under other SMPs. SMP monitoring of sensitive receptor sites: • Concentrations of hydrocarbons in water samples are below NOPSEMA guidance note (2019[3]) concentrations of 1 g/m2 for floating, 10 ppb for entrained and dissolved. • Details of the extent, severity and persistence of hydrocarbons from concentrations recorded in water have been documented at sensitive receptor sites monitored under other SMPs.
Scientific monitoring program 2 (SM02) Assessment of the Presence, Quantity and Character of Hydrocarbons in Marine Sediments	SM02 will detect and monitor the presence, extent, persistence and properties of hydrocarbons in marine sediments following the spill and the response. The specific objectives of SM02 are as follows: • Determine the extent, severity and persistence of hydrocarbons in marine sediments across selected sites where hydrocarbons were observed or recorded during operational monitoring. • Provide information that may be used to interpret potential cause and effect drivers for environmental impacts recorded for sensitive receptors monitored under other SMPs.	SM02 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • Response activities have ceased. • Operational monitoring results made during the response phase indicate that shoreline, intertidal or sub-tidal sediments have been exposed to surface, entrained or dissolved hydrocarbons (at or above 0.5 g/m^2 surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation).	SM02 will be terminated once pre-spill condition is reached and agreed upon as per the SMP termination criteria process and include consideration of: • Concentrations of hydrocarbons in sediment samples are below ANZECC/ ARMCANZ (2013[4]) sediment quality guideline values (SQGVs) for biological disturbance. • Details of the extent, severity and persistence of hydrocarbons from concentrations recorded in sediments have been documented.
Scientific monitoring program 3 (SM03) Assessment of Impacts and Recovery of Subtidal and Intertidal Benthos	The objectives of SM03 are: • Characterize the status of intertidal and subtidal benthic habitats and quantify any impacts to functional groups, abundance and density that may be a result of the spill. • Determine the impact of the hydrocarbon spill and subsequent recovery (including impacts associated with the implementation of response options). Categories of intertidal and subtidal habitats that may be monitored include: • Coral reefs • Seagrass • Macro-algae • Filter-feeders SM03 will be supported by sediment contamination records (SM02) and characteristics of the spill derived from OMPs.	SM03 will be activated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • As part of a pre-emptive assessment of PBAs of receptor locations identified by time to hydrocarbon contact >10 days, to target receptors and sites where it is possible to acquire pre-hydrocarbon contact baseline; and • Operational monitoring identified shoreline potential contact of hydrocarbons (at or above 0.5 g/m^2 surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation) for subtidal and intertidal benthic habitat.	SM03 will be terminated once pre-spill condition is reached and agreed upon as per the SMP termination criteria process and include consideration of: • Overall impacts to benthic habitats from hydrocarbon exposure have been quantified. • Recovery of impacted benthic habitats has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.

[3] NOPSEMA (2019) Bulletin #1 – Oil spill modelling – April 2019, https://www.nopsema.gov.au/assets/Bulletins/A652993.pdf
[4] Simpson SL, Batley GB and Chariton AA (2013). Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines. CSIRO and Water Science Report 08/07. Land and Water, pp. 132.

Scientific monitoring Program (SMP)	Objectives	Activation Triggers	Termination Criteria
Scientific monitoring program 4 (SM04) Assessment of Impacts and Recovery of Mangroves / Saltmarsh	The objectives of SM04 are: • Characterize the status of mangroves (and associated salt marsh habitat) at shorelines exposed/contacted by spilled hydrocarbons. • Quantify any impacts to species (abundance and density) and mangrove/saltmarsh community structure. • Determine and monitor the impact of the hydrocarbon spill and potential subsequent recovery (including impacts associated with the implementation of response options). SM03 will be supported by sediment sampling undertaken in SM02 and characteristics of the spill derived from OMPs.	SM04 will be activated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days. • Operational monitoring identified shoreline potential contact of hydrocarbons (at or above 0.5 g/m^2 surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation) for mangrove/saltmarsh habitat.	SM04 will be terminated once pre-spill condition is reached and agreed upon as per the SMP termination criteria process and include consideration of: • Impacts to mangrove and saltmarsh habitat from hydrocarbon exposure have been quantified. • Recovery of impacted mangrove/saltmarsh habitat has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 5 (SM05) Assessment of Impacts and Recovery of Seabird and Shorebird Populations	The Objectives of SM05 are to: • Collate and quantify impacts to avian wildlife from results recorded during OM02 and OM05 (such as mortalities, oiling, rescue and release counts) and undertake a desk-based assessment to infer potential impacts at species population level. • Undertake monitoring to quantify and assess impacts of hydrocarbon exposure to seabirds and shorebird populations at targeted breeding colonies / staging sites / important coastal wetlands where hydrocarbon contact was recorded.	SM05 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented as follows: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days • Operational monitoring predicts shoreline contact of hydrocarbons (at or above 0.5 g/m^2 surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation) at important bird colonies / staging sites / important coastal wetland locations. • Records of dead, oiled or injured bird species made during the hydrocarbon spill or response.	SM05 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Impacts to seabird and shorebird populations from hydrocarbon exposure have been quantified. • Recovery of impacted seabird and shorebird populations has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 6 (SM06) Assessment of Impacts and Recovery of Nesting Marine Turtle Populations	The objectives of SM06 are to: • To quantify impacts of hydrocarbon exposure or contact on marine turtle nesting populations (including impacts associated with the implementation of response options). • Collate and quantify impacts to adult and hatchling marine turtles from results recorded during OM02 and OM05 (such as mortalities, oiling, rescue and release counts) and undertake a desk-based assessment to infer potential impacts at species population levels (including impacts associated with the implementation of response options). • Undertake monitoring to quantify and assess impacts of hydrocarbon exposure to nesting marine turtle populations at known rookeries (including impacts associated with the implementation of response options).	SM06 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring has: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days. • Predicted shoreline contact of hydrocarbons (at or above 0.5 g/m^2 surface, 5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation) at known marine turtle rookery locations. or • Records of dead, oiled or injured marine turtle species made during the hydrocarbon spill or response.	SM06 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Impacts to nesting marine turtle populations from hydrocarbon exposure have been quantified. • Recovery of impacted nesting marine turtle populations has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 7 (SM07) Assessment of Impacts to Pinniped Colonies including Haul-out Site Populations	The objectives of SM07 are to: • Quantify impacts on pinniped colonies and haul-out sites as a result of hydrocarbon exposure/contact. • Collate and quantify impacts to pinniped populations from results recorded during OM02 and OM05 (such as mortalities, oiling, rescue and release counts) and undertake a desk-based assessment to infer potential impacts at species population levels.	SM07 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring has: • As part of a pre-emptive assessment of receptor locations identified by time to hydrocarbon contact >10 days • Identified shoreline contact of hydrocarbons ((at or above 0.5 g/m^2 surface, ≥5 ppb for entrained/dissolved hydrocarbons and ≥1 g/m^2 for shoreline accumulation) at known pinniped colony or haul-out site(s) (i.e. most northern site is the Houtman Abrolhos Islands). or • Records of dead, oiled or injured pinniped species made during the hydrocarbon spill or response.	SM07 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Impacts to pinniped populations from hydrocarbon exposure have been quantified. • Recovery of pinniped populations has been evaluated. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.

Scientific monitoring Program (SMP)	Objectives	Activation Triggers	Termination Criteria
Scientific monitoring program 8 (SM08) Desk-Based Assessment of Impacts to Other Non-Avian Marine Megafauna	The objective of SM08 is to provide a desk-based assessment which collates the results of OM02 and OM05 where observations relate to the mortality, stranding or oiling of mobile marine megafauna species not addressed in SM06 or SM07, including: • Cetacean; • Dugongs • Whale sharks and other shark and ray populations • Sea snakes • Crocodiles. The desk-based assessment will include population analysis to infer potential impacts to marine megafauna species populations.	SM08 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring reports records of dead, oiled or injured non-avian marine megafauna during the spill/ response phase.	SM08 will be terminated when the results of the post-spill monitoring have quantified impacts to non-avian megafauna. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 9 (SM09) Assessment of Impacts and Recovery of Marine Fish associated with SM03 habitats	The objectives of SM09 are: • Characterise the status of resident fish populations associated with habitats monitored in SM03 exposed/contacted by spilled hydrocarbons • Quantify any impacts to species (abundance, richness and density) and resident fish population structure (representative functional trophic groups). • Determine and monitor the impact of the hydrocarbon spill and potential subsequent recovery (including impacts associated with the implementation of response options).	SM09 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented with SMO3.	SM09 will be undertaken and terminated concurrent with monitoring undertaken for SM03, as per the SMP termination criteria process • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.
Scientific monitoring program 10 (SM10) Assessment of physiological impacts important fish and shellfish species (fish health and seafood quality/safety) and recovery	SM10 aims to assess any physiological impacts to important commercial fish and shellfish species (assessment of fish health) and if applicable, seafood quality/safety. Monitoring will be designed to sample key commercial fish and shellfish species and analyse tissues to identify fish health indicators and biomarkers, for example: • Liver Detoxification Enzymes (ethoxyresorufin-O-deethylase (EROD) activity) • PAH Biliary Metabolites • Oxidative DNA Damage • Serum SDH • Other physiological parameters, such as condition factor (CF), liver somatic index (LSI), gonado-somatic index (GSI) and gonad histology, total weight, length, condition, parasites, egg development, testes development, abnormalities. Seafood tainting may be included (where appropriate) using applicable sensory tests to objectively assess targeted finfish and shellfish species for hydrocarbon contamination. Results will be used to make inferences on the health of commercial fisheries and the potential magnitude of impacts to fishing industries.	SM10 will be initiated in the event of a Level 2 or 3 hydrocarbon release, or any release event with the potential to contact sensitive environmental receptors and implemented if operational monitoring (OM01, OM02 and OM05) indicates the following: • The hydrocarbon spill will or has intersected with active commercial fisheries or aquaculture activities. • Commercially targeted finfish and/or shellfish mortality has been observed/recorded. • Commercial fishing or aquaculture areas have been exposed to hydrocarbons (≥0.5 g/m² surface and ≥5 ppb for entrained/dissolved hydrocarbons); and • Taste, odour or appearance of seafood presenting a potential human health risk is observed.	SM10 will be terminated once it is agreed that the receptor has returned to pre-spill condition. The SMP termination criteria process will be followed and include consideration of: • Physiological impacts to important commercial fish and shellfish species from hydrocarbon exposure have been quantified. • Recovery of important commercial fish and shellfish species from hydrocarbon exposure has been evaluated. • Impacts to seafood quality/safety (if applicable) have been assessed and information provided to the relevant stakeholders and regulators for the management of any impacted fisheries. • Agreement with relevant stakeholders and regulators based on the nature and scale of the hydrocarbon spill impacts and/or that observed impacts can no longer be attributed to the spill.

6.2.1 Receptors at risk and baseline knowledge

In order to assess the baseline studies available and suitability for oil spill scientific monitoring, Woodside maintains knowledge of environmental baseline studies through the upkeep and use of its Environmental Knowledge Management System.

Woodside's Environmental Knowledge Management System is a centralised platform for scientific information on the existing environment, marine biodiversity, Woodside environmental studies, key environmental impact topics, key literature and web-based resources. The system comprises a number of data directories and an environmental baseline database. The environmental baseline database was set up to support Woodside's SMP preparedness and as a SMP resource in the event of an unplanned hydrocarbon spill. The environmental baseline database is subject to updates including annual reviews completed as part of the SMP standby contract. This database is accessed pre-PAP to identify Pre-emptive Baseline Areas (PBAs) where hydrocarbon contact is predicted to occur <10 days.

In addition to Woodside's Environmental Knowledge Management System, it is acknowledged that many relevant baseline datasets are held by other organisations (e.g. other oil and gas operators, government agencies, state and federal research institutions and non-governmental organisations). In order to understand the present status of environmental baseline studies a spatial environmental metadata database for Western Australia known as the Industry-Government Environmental Metadata (IGEM) was established. IGEM is a collaboration comprising oil and gas operators (including Woodside), government and research agencies and other organisations. IGEM-held data was integrated into the Department of Water and Environmental Regulation (WA) Index of Marine Surveys for Assessment (IMSA)[5] in 2020. The Index of Marine Surveys for Assessments (IMSA) is an online portal to information about marine-based environmental surveys in Western Australia. IMSA is a project of the Department of Water and Environmental Regulation for the systematic capture and sharing of marine data created as part of an environmental impact assessment (EIA). In the event of an unplanned hydrocarbon release, Woodside intends to interrogate the information on baseline studies status as held by the various databases (e.g. Woodside Environmental Knowledge Management System, IMSA and other sources of existing baseline data) to identify Pre-emptive Baseline Areas (PBAs), i.e., receptors at risk where hydrocarbon contact is predicted to be >10 days, and baseline data can be collected before hydrocarbon contact.

[5] https://biocollect.ala.org.au/imsa#max%3D20%26sort%3DdateCreatedSort

7 ADDITIONAL SUPPORTING INFORMATION

7.1 Interpretation of Scott Reef recovery potential following a 13-day loss of well control event

In preparing the Browse to NWS draft EIS/ERD, modelling was conducted to predict consequences and hydrocarbon fate and dispersion following a range of spill events, including a well loss of containment. As per Regulatory guidance, this modelling estimated the consequence of the spill occurring unconstrained for a duration of 77-days. The 77-day period was estimated based on early information regarding rig mobilisation time and relief well drill time.

Within this HSRMPA, commitments are made that a capping stack would be mobilised to any well experiencing a loss of containment event within 13 days of the event occurring. Successful deployment of a capping stack would stop the flow of hydrocarbons to the environment. To understand the environmental outcomes of this event, oil spill modeling of this scenario was performed for a 13-day spill to the equivalent well loss of containment event contained in the draft EIS/ERD. The results of this modelling are shown in **Appendix A.**

As is logical, the modelling predictions showed a marked reduction in the volume of hydrocarbons released to the Scott Reef environment after a 13-day as compared to 77-day event, reducing the potential for chronic hydrocarbon exposure impacts to the environment and Scott Reef system.

Based on these modelling results, an interpretation is provided to support, that following a 13-day spill event as described, it is predicted that the ecological integrity of Scott Reef would be expected to recover back to levels representing a maximum level of ecological protection (LEP) (refer to **Section 7.1.5.2** for the definition of maximum LEP.

This interpretation is support by results of the AIMS long term monitoring program at Scott Reef which have tracked the condition of shallow coral communities and fish assemblages over 28 years. The long-term reef condition pre-disturbance and post disturbance of this remote reef system's transition from degraded to healthy to degraded states is well documented (refer to Gilmour et al., 2013 and 2022). Based on coral recovery documented for extreme heat stress and wave damage events at Scott Reef, it is predicted that the coral communities (measured as estimates of live coral cover) are expected to recover in a timeframe of over a decade to several decades. This outcome assumes local water quality and fish stocks are largely unaffected in the longer term, as is credible. Such recovery predictions include a return to ecological integrity and a maximum level of ecological protection. However, as has been documented (see Gilmour *et al*. 2022), shifts in community structure (sliding baselines) are likely to continue and be compounded by future disturbance regimes.

Detailed evaluation supporting these predictions are outlined below.

7.1.1 The hydrocarbon spill scenario evaluated

A short-term (13 day) uncontrolled release of 24,000 m^3 unstabilised, Torosa condensate from TRC (previously named TRA-C) well, with a five-day surface release phase followed by an eight-day subsea release phase, representing loss of containment after a loss of well control was modelled (**Appendix A**). The hydrocarbon budget breakdown (condensate fate) calculated for the total released hydrocarbon volume for each release phase based on the characteristics of the Torosa condensate was as follows:

Surface:

- Evaporate within first 24 hrs of exposure = 3,960 m^3 (16.5%)

- Longer evaporation component over several days (low-volatility fraction) = 7,872 m^3 (32.8%)
- Residual fraction = 12,168 m^3 (50.7%).

Subsea:
- Evaporate within first 24 hrs of exposure = 13,056 m^3 (54.4%)
- Longer evaporation component over several days (low-volatility fraction) = 4,968 m^3 (20.7%)
- Residual fraction = 5,976 m^3 (24.9%).

To predict hydrocarbon impacts to Scott Reef ecological thresholds for hydrocarbon exposure were applied as shown in **Table 7-1**.

Table 7-1: Ecological impact thresholds applied to the deterministic hydrocarbon spill modelling to predict potential environmental impacts

Hydrocarbon type	Surface hydrocarbons (g/m^2)	Dissolved hydrocarbons (ppb)	Entrained hydrocarbons (ppb)	Accumulated hydrocarbons (g/m^2)
Torosa condensate	10	50	100	100

7.1.2 Hydrocarbon spill modelling results

The 13-day spill scenario represents a marked reduction in the volume of Torosa condensate released (24,000 m^3) and a predicted reduction of 59,904 m^3 (surface) and 29,420 m^3 (subsea) residual fraction in the waters over Scott Reef as compared to the loss of well containment (well blowout) presented in the proposed Browse to NWS Project draft EIS/ERD (Woodside, 2019)[6]. Controlling a loss of well containment at source via a capping stack would be an effective way to limit the quantity of hydrocarbon entering the marine environment and as outlined in this document, source control measures to reduce the consequence of a hydrocarbon spill include targeting deployment of a capping stack within 13 days will be applied.

The results presented by the deterministic modelling (RPS, 2022) are summarised in Table 7-2 and show minimum times to contact to sensitive receptors including north and South Scott Reef.

Table 7-2: A summary of the deterministic modelling results for the short-term (13 day) uncontrolled release of 24, 000 m3 of unstabilised Torosa condensate from TRA-C well (data source: RPS, 2022)

Scenario	Model parameter	Summary
A short-term (13 day) uncontrolled release of 24,000 m^3 unstabilised, Torosa Condensate from TRA-C well, with a 5-day surface release	Floating	Exposure above the threshold of ≥ 10 g/m^2 are predicted to occur within 5 hours for North Scott Reef and 18 hours for South Scott Reef.

[6] Scenario 1 (worst-case credible hydrocarbon spill) was for a long-term 77-day uncontrolled release of 142,154 m3 of unstabilised Torosa condensate

phase followed by an 8-day subsea release phase, representing loss of containment after a loss of well control.		Sandy Islet, Scott Reef predicted to be contacted at levels ≥10 g/m² within 52 hours
	Entrained	Exposures above the threshold of ≥100 ppb are predicted to occur within 7 hours for North Scott Reef and 15 hours for South Scott Reef. Maximum entrained hydrocarbon concentrations at any depth were: 4,359 ppb at North Scott Reef and 2,589 ppb for Scott Reef South - Lagoon
	Dissolved	Maximum dissolved aromatic hydrocarbon concentrations at any depth were: 3,403 ppb at North Scott Reef and 2, 539 ppb for Scott Reef South - Lagoon
	Shoreline	Maximum shoreline accumulation for Scott Reef Sandy Islet was 10,051 g/m²
Note: Exposure/Contact equals hydrocarbon concentrations that exceed threshold. For dissolved aromatic hydrocarbons these are assumed to extend from the sea surface and to depths of approximately 20 m (subsea plume).		

Scott Reef spans approximately 100 km, consisting of three atoll reefs approximately 20 km in length. Hydrocarbon contact for the three reefs over the modelled five-week period is show in **Figure 7-1**.

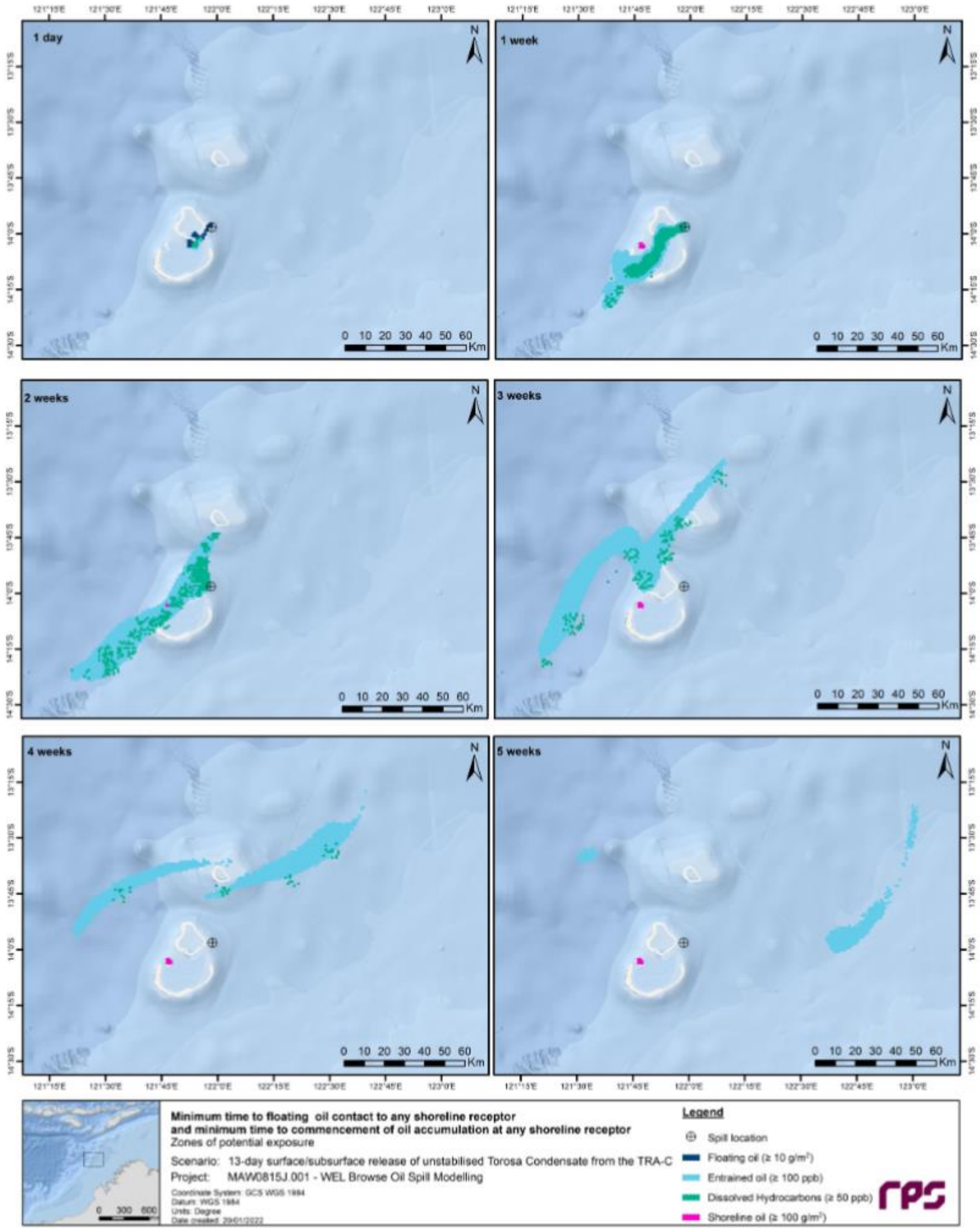

Figure 2.1 Time-varying areal extent of potential exposure at defined floating oil, entrained oil, dissolved aromatic hydrocarbon and shoreline oil threshold concentrations, resulting from a 13-day surface/subsea release of unstabilised Torosa Condensate at the TRA-C well, for the replicate case with the minimum time to floating oil contact with the offshore edge of any shoreline receptor polygon (at a threshold of 10 g/m²) and the minimum time to commencement of oil accumulation at any shoreline receptor (at a threshold of 100 g/m²).

Figure 7-1: Deterministic hydrocarbon spill trajectories for Scott Reef for the short-term scenario – 13 days surface/subsurface blowout of unstabilised Torosa condensate at the TRA-C well. Data source: RPS (2022)

7.1.3 Predicted impacts to corals and coral communities from hydrocarbon exposure

Potential impacts to coral communities in the highly unlikely event of a hydrocarbon release are related to the types and volumes of the hydrocarbon fates that are predicted to contact Scott Reef. The primary impacts are from exposure to floating hydrocarbons through smothering and coating, and exposure to dissolved and entrained hydrocarbons that may result in lethal and sublethal toxicity impacts to corals, other sensitive sessile benthos and mobile invertebrates and vertebrates (fishes) within the upper water column (<20 m depth), including upper reef slopes (subtidal corals) and reef flats (inter-tidal corals), as documented in Section 6.3.21.4 of the Browse to NWS Project draft EIS/ERD (Woodside, 2019).

Further research on toxicity thresholds applicable to tropical marine systems has been published and further support the 50 ppb threshold concentration for dissolved hydrocarbons which is based on poly-aromatic hydrocarbons (PAHs) in the absence of ultraviolet radiation (UVR). The applied dissolved hydrocarbon threshold is lower than that identified by Negri *et al*. (2021) based on a chronic protection threshold for 95% of species and the recommended Target Lipid Model (TLM) threshold for tropical marine ecosystems. It is also applicable to sub-surface blowouts where mono-aromatic hydrocarbons (MAHs) comprise a high proportion of the dissolved hydrocarbons (Negri *et al*. 2021). The thresholds do not account for high levels of UVR which shallow tropical reefs are routinely exposed to and can lead to substantial increases in the toxicity of some oil components through phototoxicity (French-McCay *et al*. 2018; Nordborg *et al*. 2020). Deepwater horizon oil spill comparative risk assessment modelling to evaluate different spill response options applied a surface hydrocarbon threshold of 10 g/m^2 as this is viewed as a conservative, lower threshold for all wildlife and LC50s in the range of 10 ppb for sensitive early life stages to several 100 ppb for less sensitive species and older life stages (French-McCay *et al*. 2018). These hydrocarbon concentration values were similar to results published for coral larvae (Negri *et al.* 2016 and 2021) and adult corals (Turner *et al*. 2021).

7.1.4 Predictions of Scott Reef recovery following a 13-day well loss of containment scenario (13-day release from TRC Well)

The long-term monitoring at Scott Reef by AIMS, funded by the BJV, has afforded remarkable insights into the recovery of remote coral reef systems from acute disturbance (i.e., heat stress and mass bleaching; damaging waves generated by storms and cyclones), Gilmour *et al.,* 2013 and 2022. For the purposes of this assessment, it is assumed that similar patterns of shallow coral community recovery from mass bleaching events (with reference to scale and severity), can be applied to predict the recovery of Scott Reef following an unplanned, highly unlikely release of hydrocarbons. No account of chronic ongoing residual toxicity effects from hydrocarbons is made in this assessment.

Based on the expert opinion report on recovery trajectories of coral communities at Scott Reef (AIMS, 2014) impacts to coral communities at Scott Reef were grouped into shallow-water (≤20 m depth) and deep-water (≥20 m depth). Deep-water communities are located only in the South Reef lagoon and based on the deterministic modelling predictions for dissolved hydrocarbon subsea plumes do not extend below 20 m depth (RPS, 2022), it is therefore assumed that South Reef lagoon is not impacted. Shallow-water coral communities include reef slope habitats at North and South Reef and the lagoon at North Reef (**Figure 7-2**). The reef flat habitat while considered most vulnerable to direct exposure from surface (floating) hydrocarbons supports extremely low coral cover and species diversity and is not included further in the recovery assessment. Hydrocarbon spill exposure will impact the upper slope coral communities. Impact predictions are summarised in Table 7-3, based on the definition of ecological integrity for Scott Reef. Exposure of corals to hydrocarbons in these shallow reef environments of Scott Reef is likely to be patchy and variable depending on the hydrocarbon concentrations and durations of exposure for different areas of the three reefs in the highly unlikely event of a hydrocarbon spill.

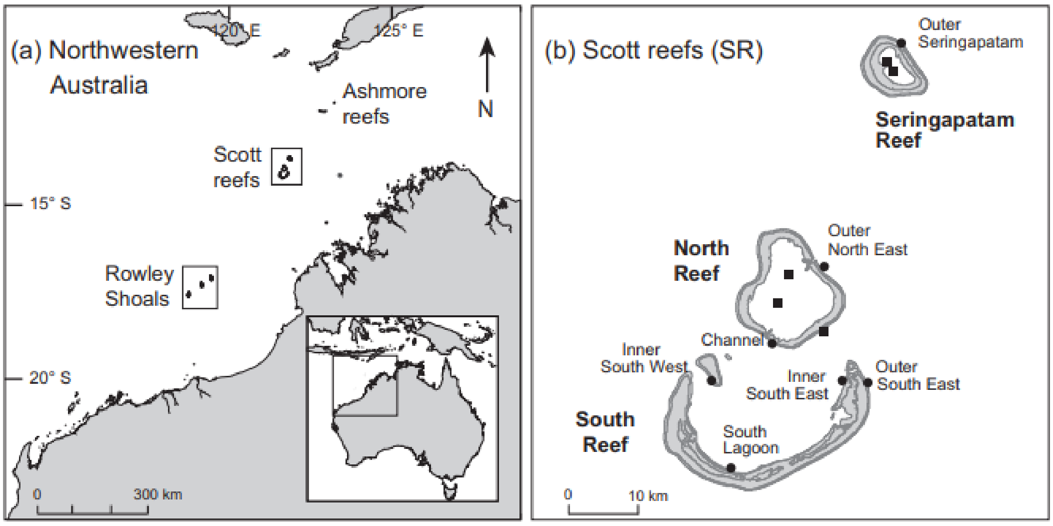

Figure 7-2: Location of Scott Reef and the AIMS' long-term monitoring sites (source: Gilmour et al. 2022)

Table 7-3: Predicted impacts to the coral communities of Scott Reef based on the definition of ecological integrity

Criterion	Attributes	Predicted impact from hydrocarbon spill (13 days)
Abiotic	Oceanographic processes	No impact
	Geomorphology	No impact
	Water quality	Impact – temporary reduction in water quality for multiple weeks at ecological impact hydrocarbon threshold concentrations for floating, dissolved and entrained hydrocarbon fates.
Biotic	Live coral cover	Significant impact though patchy and variable across the affected shallow coral communities. Hydrocarbon exposure above ecological thresholds for the 13-day release are predicted to mainly impact the upper slope, shallow coral communities of South and North Scott Reef and the shallow water North Scott Reef lagoon.
	Coral composition	Significant impact to the mixed coral, branching *Acropora*, *Isopora*, massive *Porites* and soft corals is predicted for all North Scott Reef coral communities, and west and south coral communities of South Scott Reef. The eastern side of South Scott Reef is predicted to experience sublethal/low mortality impacts. Common *Acropora* branching corals have been reported as more susceptible to hydrocarbon exposure than *Porites* massive corals (Yender and Michel, 2010). Assuming parallels in recovery as documented for Scott Reef from mass bleaching and storm events as documented by

Criterion	Attributes	Predicted impact from hydrocarbon spill (13 days)
		Gilmour et al. (2022), life history variation will influence both susceptibility to disturbance and subsequent recovery. Gilmour *et al.* (2022) documented regrowth of injured corals at the least affected communities (composed of corals species such as massive *Porites*) within three years and within five years recorded rapid increases in the cover of the most susceptible corals (including *Acropora*) had occurred. It is noted, however, similar to mass bleaching events at Scott Reef rarer, more susceptible coral taxa may not recover. Furthermore, there will be variation in impacts and recovery among communities across the reef system. Recovery of impacted coral communities is predicted to be in the order of >decade to several decades.
	Algal cover and composition (turf vs macroalgae)	Significant impacts are possible and mixed responses across the different macroalgal groupings (green, brown and reds) and corallines (critical to coral larvae settlement) ranging from no impact to declines in abundance, sublethal impacts (impaired photosynthetic ability) and inhibited growth (Keesing *et al*. 2018).
	Fish assemblages and trophic functional groups (herbivores and piscivores)	Significant impacts possible due to potential exposure to dissolved and entrained hydrocarbons. Fish mortalities are rarely observed as a result of hydrocarbon spills (ITOPF, 2011), however this is generally associated with pelagic fish that reportedly can detect and avoid surface waters underneath hydrocarbon spills by moving into deeper water or away from affected areas. Coral reef site-attached fish will experience a high likelihood of impact either directly or indirectly, with the loss of refuge due to impacts to coral structure in reef areas with highest impacts, i.e., coral mortality.
	Coral recruitment	Adult coral reproduction impairment due to hydrocarbon exposure or a spill coinciding with a primary mass coral spawning period may result in the loss of coral recruitment for that year. Coral recruitment is dependent on the survival and regrowth of adult coral colonies within the Scott Reef system. Given the reproductively closed system, it is imperative that coral larval sources survive and/or recover and the deterministic spill modelling indicates areas of the reef system will not be significantly impacted and will remain a source of coral recruitment.

Recovery

Gilmour *et al*. (2013) documented the recovery of Scott Reef from the mass bleaching event of 1998 was within 12 years based on coral cover, recruitment, generic diversity, and community structure to levels similar to the pre-bleaching years. The recovery from the 1998 mass bleaching may have been even faster if not for a series of more moderate disturbances, including two cyclones, an outbreak of coral disease and a second bleaching event. The published research demonstrated that even coral reefs with a negligible supply of larvae from outside sources can recover relatively quickly from disturbances in the absence of chronic human pressures. An extended long-term data series for Scott Reef and analysis of a second extreme heat stress and mass bleaching event in 2016, showed a disproportionate loss of susceptible coral groups resulting in homogenized communities across Scott Reef, with post-bleaching structure in 1998 and 2016 being more similar than any other time in more than two decades (Gilmour *et al.*, 2022). AIMS are currently documenting the status of the shallow coral communities surveyed in 2021.

Additional considerations:
The importance of maintaining reef fish trophic functional groups for coral recovery
Gilmour et al (2013) reported no phase shift to macroalgae dominated communities associated with the 80% decline in coral cover resulting from the 1998 mass bleaching event. The recorded high densities of herbivorous fishes also increased after the loss of coral, probably in response to the increased cover of turf algae. This finding suggests a surplus grazing capacity within the system that assisted subsequent coral recruitment and survival. Consequently, a high proportion of the coral larvae that were produced locally and settled actually survived. High survival and growth of corals resulted in rapid rates of transition through increasing colony size classes, with corresponding increases in brood stock and reproductive output. Reproductive output and recruitment were similar to pre-disturbance levels within a decade of the bleaching (Gilmour et al 2013). Findings relating to reef fish recovery for Floridian reefs impacted by Deepwater Horizon have shown changes in fish community structure, persistently low densities among certain fish groups (including herbivores) and lasting, community-wide impacts (Lewis *et al*., 2020). The available evidence suggests initial reef fish declines in 2010, likely reflected both mortality and emigration resulting from hydrocarbon exposure and resource limitations on impacted reefs. The dynamics of available substrate with coralline algae (needed for coral larvae settlement) and herbivorous fish inhibiting a phase shift to macroalgal dominated communities is critical to the recovery of Scott Reef in the highly unlikely event of a loss of well containment hydrocarbon spill.

Shifting baselines
Gilmour *et al*. (2022) discussed the future shifts in coral community structure and highlighted the need to consider long-term dynamics, and the mechanism driving local variation when assessing management strategies to slow the rate of degradation. In developing management strategies for the recovery of Scott Reef in the highly unlikely event but catastrophic consequences of an unplanned, large-scale hydrocarbon release the same suite of factors would need to be considered.

7.1.5 Definitions supporting this interpretation

7.1.5.1 Definition of ecological integrity for Scott Reef

Karr et al. (2022) defined ecological integrity as an ecological system able to support and maintain an adaptive biological system comprising the full range of parts and processes expected for that region, a system whose evolutionary legacy remains intact.

EPA (2016a) defines ecological integrity for benthic communities and habitats as ‘the composition, structure, function and processes of ecosystems, and the natural variation of these elements’.Obura et al. (2022) stated ‘coral reef ecological integrity is complex and includes functional, compositional, structural and spatial components and presents challenges when defining one of the most diverse, complex and variable ecosystems in the world’.
With consideration of the above definitions, ecological integrity of Scott Reef is presented as a suite of abiotic and biotic criterion and attributes and these are used to assess hydrocarbon spill impacts and recovery for a short-term (13 day) uncontrolled release of 24,000 m^3 unstabilised, Torosa Condensate from a well loss of containment event at a TRC well (previously named TRA-C) Table 7-4.

Table 7-4: Criterion and Attributes to define Scott Reef Ecological Integrity

Criterion	Attributes
Abiotic	Oceanographic processes
	Geomorphology
	Water quality
Biotic	Live coral cover
	Coral composition
	Algal cover and composition (turf vs macroalgae)
	Fish assemblages and trophic functional groups (herbivores and piscivores)
	Coral recruitment

7.1.5.2 Definition of Maximum level of ecological protection

The definition of Maximum level of ecological protection (LEP) as defined by EPA (2016b) is 'Activities to be managed so that there were no changes beyond natural variation in ecosystem processes, biodiversity, abundance, and biomass of marine life or in the quality of water, sediment and biota'.

7.2 Financial assurance for stakeholder compensation and environmental remediation

Under section 571(2) of the OPGGS Act titleholders are required to have and maintain sufficient financial assurance to meet the costs, expenses and liabilities that may arise in connection with carrying out petroleum activities, including those associated with responding to a major oil spill, as a prior condition of acceptance of an EP. This process requires titleholders to estimate the sum of the greatest reasonably credible costs, expenses and liabilities that may arise from a worst-case petroleum incident as described in the EP for the activity, which includes the cost of carrying out environmental monitoring of the impact of the petroleum incident and operational response measures required for containment, clean up and **remediation** of the environment. NOPSEMA will review evidence to demonstrate titleholders are compliant with this requirement prior to acceptance of each relevant EP.

While there is no equivalent legislative requirement in WA State Waters, Woodside will include an assurance/commitment that is equivalent to that required under S571(2) of the OPGGS Act within EPs prepared for activities within State Waters to avoid any doubt that the BJV will maintain sufficient financial assurance to meet the costs, expenses and liabilities that may arise in connection with carrying out petroleum activities, whether they are occurring in Commonwealth or State waters.

The BJV are committed to maintaining financial resources and capability and implementing all necessary action to fund remediation of natural resources impacted by any unplanned environmental impacts arising from unplanned loss of hydrocarbons from the project.

Compensation

Throughout our 65-year history, Woodside has not experienced any significant uncontrolled release of oil or gas to the environment as a result of loss of well control. This is testament to Woodside's focus on the safety of our people and protection of the environment in which we operate. The ability to effectively respond and recover in the highly unlikely event of a major incident is a key priority for Woodside. In the highly unlikely event of a major spill event from a Woodside well during the proposed Browse to NWS Project activities, Woodside will engage with stakeholders affected by the event. Potentially directly affected stakeholders are identified during the development of the EP. Woodside also has existing channels for stakeholders to contact Woodside including phone and email as outlined on our website and factsheets.

In the highly unlikely event of a major spill, there will be a process in place regarding compensation claims from anyone who believes they have suffered a financial loss as a result. the key principles in Woodside responding to compensation claims include but are not limited to simplicity, fairness and timeliness. Data required to support any claims include but are not limited to a description of the impact, records to demonstrate Woodside's legal liability, economic loss and, for commercial fishing licence holders, data such as spatial distribution and temporal trends in historic catch and effort data. Where there is a meaningful prospect that Woodside would be found to have legal liability, we may assess the claim and pay compensation. The process will be further outlined to stakeholders during the development of EPs for each activity.

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9 GLOSSARY & ABBREVIATIONS

9.1 Glossary

Term	Description / Definition
ALARP	Demonstration through reasoned and supported arguments that there are no other practicable options that could reasonably be adopted to reduce risks further.
Control	The means by which risk from events is eliminated or minimised.
Control measure (risk control measure)	The features that eliminate, prevent, reduce or mitigate the risk to environment associated with PAP.
Credible spill scenario	A spill considered by Woodside as representative of maximum volume and characteristics of a spill that could occur as part of the PAP.
Environment that may be affected	The summary of quantitative modelling where the marine environment could be exposed to hydrocarbons levels exceeding hydrocarbon threshold concentrations.
Incident	An event where a release of energy resulted in or had (with) the potential to cause injury, ill health, damage to the environment, damage to equipment or assets or company reputation.
Loss of Well Control	Uncontrolled flow of formation or other fluids. The flow may be to an exposed formation (an underground blowout) or at the surface (a surface blowout). Flow through a diverter Uncontrolled flow resulting from a failure of surface equipment or procedure
Preparedness	Measures taken before an incident in order to improve the effectiveness of a response
Reasonably practicable	... a computation ... made by the owner, in which the quantum of risk is placed on one scale and the sacrifice involved in the measures necessary for averting the risk (whether in money, time or trouble) [showing whether or not] that there is a gross disproportion between them ... made by the owner at a point of time anterior to the accident. (Judgement: Edwards v National Coal Board [1949])
Receptors at risk	Physical, biological and social resources identified as at risk from hydrocarbon contact using oil spill modelling predictions.
Regulator	NOPSEMA are the Environment Regulator under the Environment Regulations.
Response technique	The key priorities and objectives to be achieved by the response plan Measures taken in response to an event to reduce or prevent adverse consequences.
Threshold	Hydrocarbon concentrations applied to the risk assessment to evaluate hydrocarbon spills.

9.2 Abbreviations

Abbreviation	Meaning
AHV	Anchor Handling Vessel
ALARP	As low as reasonably practicable
APPEA	Australian Petroleum Production and Exploration Association
BOP	Blowout Preventer
CF	Condition Factor
CICC	Corporate Incident Coordination Centre
DBCA	Western Australia Department of Biodiversity, Conservation and Attractions (former Western Australian Department of Parks and Wildlife)
DGP	Detailed Completions Guideline
DDP	Detailed Drilling Program
DDR	Daily Drilling Reports
EMBA	Environment that May Be Affected
FIT	Formation Integrity Tests
FSP	First Strike Plan
GSI	Gonado-somatic index
IOGP	International Association of Oil and Gas Producers
IPIECA	International Petroleum Industry Environment Conservation Association
ITOPF	International Tanker Owners Pollution Federation
KBOS	Kinetic blow out stopper
LSI	liver somatic index
LOT	Leak-off Tests
NEBA	Net Environmental Benefit Analysis
NOAA	National Oceanic and Atmospheric Administration
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
OM	Operational Monitoring
OPEA	Oil Pollution Emergency Arrangements
OPEP	Oil Pollution Emergency Plan
OSPRMA	Oil Spill Preparedness and Response Mitigation Assessment
PBA	Pre-emptive Baseline Areas
QOF	Qualification to Fly
ROV	Remotely Operated Vehicle(s)
RPA	Response Protection Area
SCERP	Source Control Emergency Response Plan
SFRT	Subsea First Response Toolkit
SIDS	Standard Instructions to Drillers
SMP	Scientific Monitoring Program

Abbreviation	Meaning
SSDI	Subsea Dispersant Injection
SFRT	Subsea First Response Toolkit
TRP	Tactical Response Plan
VOC	Volatile Organic Compound
WA DoT	Western Australia Department of Transport
WAC	Well Acceptance Criteria
WOMP	Well Operations Management Plan
WMS	Woodside Management System

Appendix A – Browse TRA-C Well Quantitative Spill Risk Assessment – Deterministic Analysis

MAKING COMPLEX EASY

BROWSE TRA-C WELL QUANTITATIVE SPILL RISK ASSESSMENT - DETERMINISTIC ANALYSIS

Memo

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1 INTRODUCTION

1.1 Background

In 2019, RPS was commissioned by Woodside Energy Ltd (Woodside) to undertake a quantitative spill risk assessment of hypothetical hydrocarbon spill scenarios related to the proposed Browse Joint Venture (BJV) Browse to North West Shelf Project (RPS, 2019). Woodside are now preparing to articulate to the regulator a series of contingency measures for the TRA-C loss of well control scenario (referred to as Scenario 1 in RPS, (2019)) which may be able to halt the release after 13 days instead of 77 days. RPS has been commissioned to support the preparation of environmental approvals documentation for the specified hydrocarbon release scenario. The Browse hydrocarbon resource is located in the Brecknock, Calliance and Torosa reservoirs located approximately 425 km north of Broome and approximately 290 km off the Kimberley coastline.

Woodside identified one hydrocarbon spill scenario for investigation. The scenario was modelled in a stochastic manner and assessed over an annual period, with equivalent weighting of all four calendar quarters achieved through equal replication of simulations in each quarter.

The preliminary outcomes of the stochastic assessment for have been provided to Woodside in a technical memorandum (RPS, 2021). This additional memorandum presents the results of deterministic analysis for Scenario 1 to aid oil spill response planning. Details of the scenario are:

- Scenario: A Short-Term (13-Day) uncontrolled release of 24,000 m^3 of unstabilised Torosa Condensate from the TRA-C well (13° 58' 12.5" S, 121° 58' 37.7" E), with a 5-day surface release phase followed by an 8-day subsea release phase, representing loss of containment after a loss of well control.

1.2 Deterministic Analysis of Spill Scenarios (Phase 2)

After assessing the stochastic modelling (Phase 1) outcomes for Scenario 1, Woodside determined there was a requirement for additional model outputs to be provided for selected replicate simulations in order to inform the oil spill response and contingency planning process.

Deterministic model runs of interest were selected from the stochastic set of replicate simulations according to the following criteria:

- Minimum time to floating oil contact with the offshore edge(s) of any shoreline receptor polygon (at a threshold of 10 g/m^2).
- Minimum time to commencement of oil accumulation at any shoreline receptor (at a threshold of 100 g/m^2).
- Minimum time to entrained oil (at a threshold of 100 ppb) or dissolved hydrocarbons (at a threshold of 50 ppb) contact with the offshore edge(s) of any shoreline receptor polygon.
- Maximum cumulative oil volume accumulated across all shoreline receptors (at concentrations in excess of 100 g/m^2).
- Maximum cumulative oil volume accumulated at any individual shoreline receptor (at concentrations in excess of 100 g/m^2).

The identified runs corresponding to each of the above cases are summarised in Table 1.1 and **Error! Reference source not found.** for Scenarios 1B and 1C, respectively.

Tabulated results showing minimum times for contact to sensitive receptors nominated by Woodside, and maximum concentrations and volumes, have been produced for defined floating oil (10 g/m^2 and 50 g/m^2), shoreline oil (100 g/m^2 and 250 g/m^2), entrained oil (100 ppb) and maximum entrained and dissolved hydrocarbon concentrations. These results are presented in Section 2.

In addition, the following outputs have been produced and delivered separately in shapefile and spreadsheet data formats:

- Mapped floating oil contours at thresholds of 10 g/m^2 and 50 g/m^2.
- Mapped shoreline impacts at thresholds of 100 g/m^2 and 250 g/m^2.

- Time series data of floating oil impacts at receptors.
- Time series data of shoreline impacts at receptors.
- Mapped time series concentration and viscosity data at thresholds of 50 g/m^2/100 g/m^2 and 2,500 cP/5,000 cP, respectively.

Table 1.1 Identified replicate simulation meeting the deterministic analysis selection criteria for Scenario 1.

Replicate	Selection Criteria	Quarter	Run No.	Time/Volume /Area	First/Worst Receptor Contacted
1	Minimum time to floating oil contact with the offshore edge(s) of any shoreline receptor polygon (at a threshold of 10 g/m^2)	4	15	0.8 days	Scott Reef South
2	Minimum time to commencement of oil accumulation at any shoreline receptor (at a threshold of 100 g/m^2)	4	15	1.8 days	Scott Reef South
3	Minimum time to entrained oil (at a threshold of 100 ppb) or dissolved hydrocarbons (at a threshold of 50 ppb) contact with the offshore edge(s) of any shoreline receptor polygon	3	7	0.5 days	Scott Reef South
4	Maximum cumulative oil volume accumulated across all shoreline receptors (at concentrations in excess of 100 g/m^2)	3	10	507 m^3	Scott Reef South
5	Maximum cumulative oil volume accumulated at any individual shoreline receptor (at concentrations in excess of 100 g/m^2)	3	10	507 m^3	Scott Reef South

2 RESULTS OF DETERMINISTIC ANALYSIS

2.1 Overview

This section summarises the risk estimates calculated for the replicate simulations identified as yielding the worst-case outcomes for Scenario 1, according to the criteria described in Section 1.2. The worst-case replicates identified for this scenario are summarised in Table 1.1.

Tabulated results showing minimum times for contact to sensitive receptors nominated by Woodside, and maximum concentrations and volumes, are presented for defined floating oil (10 g/m^2 and 50 g/m^2), shoreline oil (100 g/m^2 and 250 g/m^2), entrained oil (100 ppb) and maximum entrained and dissolved hydrocarbon concentrations.

The minimum time estimates shown in the tables present the shortest time for any oil to drift from the source to both the offshore boundary of a sensitive receptor and to the receptor shoreline, relative to the commencement of the spill.

2.2.1 Scenario: Short-Term (13-Day) Surface/Subsea Blowout of Unstabilised Torosa Condensate at the TRA-C Well

Table 2.1 **Summary of exposure predictions at sensitive receptors resulting from a 13-day surface/subsea release of unstabilised Torosa Condensate at the TRA-C well, for the replicate case with the minimum time to floating oil contact with t offshore edge of any shoreline receptor polygon (at a threshold of 10 g/m²) and the minimum time to commencement of oil accumulation at any shoreline receptor (at a threshold of 100 g/m²).**

Receptor	Minimum time to receptor (hours) for floating oil at		Minimum time to accumulation (hours) of shoreline oil at		Maximum local accumulated concentration (g/m²)	Maximum accumulated volume (m³) along this shoreline, exceeding concentrations of		Minimum time to receptor (hours) for entrained oil at ≥100 ppb	Maximum entrained oil concentration (ppb), at any depth	Maximum dissolve aromatic hydrocarbo concentration (ppb) at any depth
	≥10 g/m²	≥50 g/m²	≥100 g/m²	≥250 g/m²		100 g/m²	250 g/m²			
Argo-Rowley Terrace MP*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Ashmore Reef MP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Browse Island*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Buccaneer & Bonaparte Archipelagos	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Cartier Island MP	NC	NC	NC	NC	NC	NC	NC	NC	<1	<1
Hibernia Reef*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Indonesia	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Indonesian Boundary	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Kimberley MP*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Kimberley Coast	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Oceanic Shoals MP*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Rowley Shoals - Clerke Reef State MP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals - Mermaid Reef MP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Scott Reef North*	5	6	NA	NA	NA	NA	NA	7	4,359	3,403
Scott Reef South	18	118	42	43	10,051	251	251	15	2,489	2,539
Seringapatam Reef*	NC	NC	NA	NA	NA	NA	NA	427	363	830
Sumba	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Ashmore Reef	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Cartier Island	NC	NC	NC	NC	NC	NC	NC	NC	NC	<1
Rowley Shoals - Clerke Reef	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals - Mermaid Reef	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Sahul Banks*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Scott Reef Central	42	NC	42	43	10,051	251	251	181	931	608
Scott Reef Central - Sandy Island	52	NC	42	43	10,051	251	251	193	644	272
Scott Reef North - Flats*	8	18	NA	NA	NA	NA	NA	9	3,971	3,220
Scott Reef North - Lagoon*	15	43	NA	NA	NA	NA	NA	29	2,415	3,403
Scott Reef South - Flats*	66	NC	NA	NA	NA	NA	NA	66	2,179	1,191
Scott Reef South - Lagoon*	15	19	NA	NA	NA	NA	NA	15	2,598	2,539
Adele Island	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

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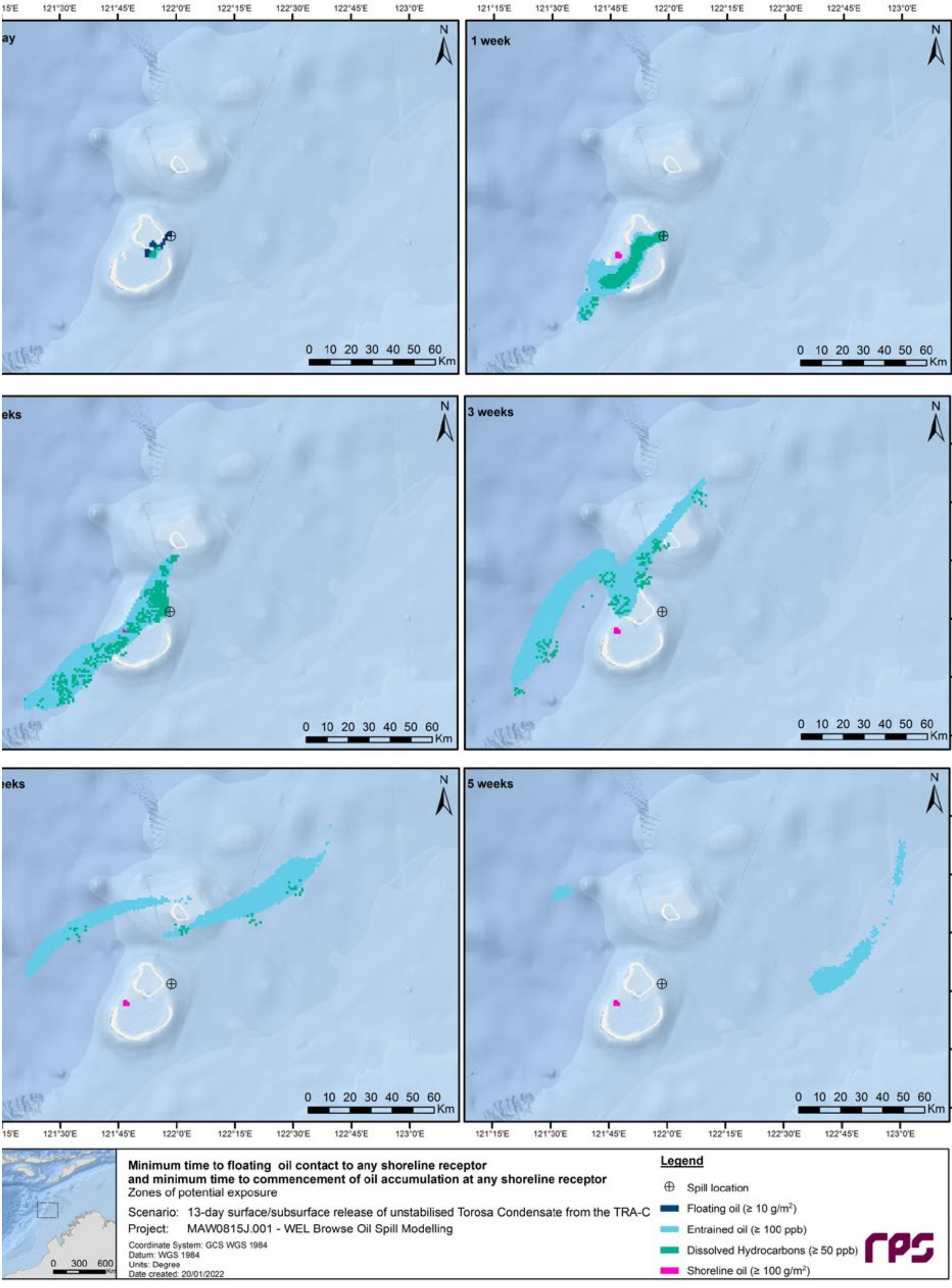
Receptor	Minimum time to receptor (hours) for floating oil at		Minimum time to accumulation (hours) of shoreline oil at		Maximum local accumulated concentration (g/m²)	Maximum accumulated volume (m³) along this shoreline, exceeding concentrations of		Minimum time to receptor (hours) for entrained oil at ≥100 ppb	Maximum entrained oil concentration (ppb), at any depth	Maximum dissolved aromatic hydrocarbo concentration (ppb) at any depth
	≥10 g/m²	≥50 g/m²	≥100 g/m²	≥250 g/m²		100 g/m²	250 g/m²			
Barracouta Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Barracouta Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Barracouta Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Echuca Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Eugene McDermott Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Fantome Bank*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Heywood Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Vulcan & Goeree Shoals*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
WA Coastline	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold. NA: Not applicable.

* Floating oil will not accumulate on submerged features and at open ocean locations.



1 **Time-varying areal extent of potential exposure at defined floating oil, entrained oil, dissolved aromatic hydrocarbon and shoreline oil threshold concentrations, resulting from a 13-day surface/subsea release of unstabilised Torosa Condensate at the TRA-C well, for the replicate case with the minimum time to floating oil contact with the offshore edge of any shoreline receptor polygon (at a threshold of 10 g/m²) and the minimum time to commencement of oil accumulation at any shoreline receptor (at a threshold of 100 g/m²).**

Table 2.2 Summary of exposure predictions at sensitive receptors resulting from a 13-day surface/subsea release of unstabilised Torosa Condensate at the TRA-C well, for the replicate case with the minimum time to entrained oil (at a threshold of 100 ppb) contact with the offshore edge(s) of any shoreline receptor polygon.

Receptor	Minimum time to receptor (hours) for floating oil at		Minimum time to accumulation (hours) of shoreline oil at		Maximum local accumulated concentration (g/m²)	Maximum accumulated volume (m³) along this shoreline, exceeding concentrations of		Minimum time to receptor (hours) for entrained oil at ≥100 ppb	Maximum entrained oil concentration (ppb), at any depth	Maximum dissolved aromatic hydrocarbon concentration (ppb), at any depth
	≥10 g/m²	≥50 g/m²	≥100 g/m²	≥250 g/m²		100 g/m²	250 g/m²			
Argo-Rowley Terrace MP*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Ashmore Reef MP	NC	NC	NC	NC	NC	NC	NC	NC	<1	<1
Browse Island*	NC	NC	NA	NA	NA	NA	NA	700	209	28
Buccaneer & Bonaparte Archipelagos	NC	NC	NC	NC	NC	NC	NC	NC	10	NC
Cartier Island MP	NC	NC	NC	NC	NC	NC	NC	NC	2	<1
Hibernia Reef*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Indonesia	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Indonesian Boundary	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Kimberley MP*	NC	NC	NA	NA	NA	NA	NA	335	322	269
Kimberley Coast	NC	NC	NC	NC	NC	NC	NC	NC	10	<1
Oceanic Shoals MP*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Rowley Shoals - Clerke Reef State MP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals - Mermaid Reef MP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Scott Reef North*	65	NC	NA	NA	NA	NA	NA	28	773	66
Scott Reef South	NC	NC	NC	NC	NC	NC	NC	13	8,036	3,997
Seringapatam Reef*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Sumba	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Ashmore Reef	NC	NC	NC	NC	NC	NC	NC	NC	NC	<1
Cartier Island	NC	NC	NC	NC	NC	NC	NC	NC	<1	NC
Rowley Shoals - Clerke Reef	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals - Mermaid Reef	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Sahul Banks*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Scott Reef Central	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Scott Reef Central - Sandy Island	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Scott Reef North - Flats*	NC	NC	NA	NA	NA	NA	NA	NC	87	4
Scott Reef North - Lagoon*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Scott Reef South - Flats*	NC	NC	NA	NA	NA	NA	NA	20	6,326	3,172
Scott Reef South - Lagoon*	NC	NC	NA	NA	NA	NA	NA	16	7,138	3,172
Adele Island	NC	NC	NC	NC	NC	NC	NC	NC	72	<1
Barracouta Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Barracouta Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Barracouta Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC

Receptor	Minimum time to receptor (hours) for floating oil at		Minimum time to accumulation (hours) of shoreline oil at		Maximum local accumulated concentration (g/m²)	Maximum accumulated volume (m³) along this shoreline, exceeding concentrations of		Minimum time to receptor (hours) for entrained oil at ≥100 ppb	Maximum entrained oil concentration (ppb), at any depth	Maximum dissolved aromatic hydrocarbon concentration (ppb), at any depth
	≥10 g/m²	≥50 g/m²	≥100 g/m²	≥250 g/m²		100 g/m²	250 g/m²			
Echuca Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	<1
Eugene McDermott Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Fantome Bank*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Heywood Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	<1	NC
Vulcan & Goeree Shoals*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
WA Coastline	NC	NC	NC	NC	NC	NC	NC	NC	93	<1

NC: No contact to receptor predicted for specified threshold. NA: Not applicable.

* Floating oil will not accumulate on submerged features and at open ocean locations.

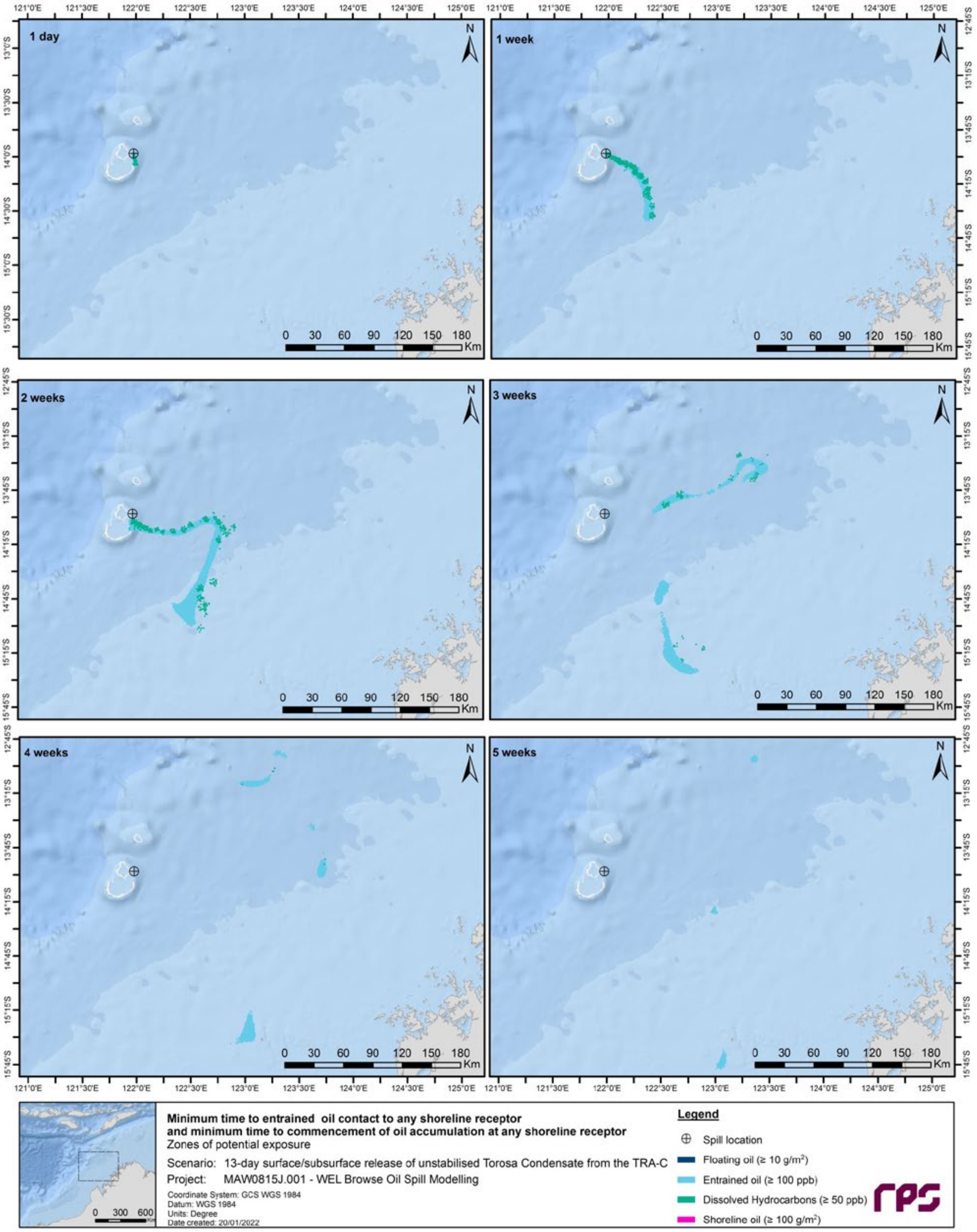


Figure 2.2 **Time-varying areal extent of potential exposure at defined floating oil, entrained oil, dissolved aromatic hydrocarbon and shoreline oil threshold concentrations, resulting from a 13-day surface/subsea release of unstabilised Torosa Condensate at the TRA-C well, for the replicate case with the the minimum time to entrained oil (at a threshold of 100 ppb) contact with the offshore edge(s) of any shoreline receptor polygon.**

Table 2.3 Summary of exposure predictions at sensitive receptors resulting from a 13-day surface/subsea release of unstabilised Torosa Condensate at the TRA-C well, for the replicate case with the minimum time to entrained oil (at a threshold of 100 ppb) contact with the offshore edge(s) of any shoreline receptor polygon.

Receptor	Minimum time to receptor (hours) for floating oil at		Minimum time to accumulation (hours) of shoreline oil at		Maximum local accumulated concentration (g/m²)	Maximum accumulated volume (m³) along this shoreline, exceeding concentrations of		Minimum time to receptor (hours) for entrained oil at ≥100 ppb	Maximum entrained oil concentration (ppb), at any depth	Maximum dissolved aromatic hydrocarbon concentration (ppb), at any depth
	≥10 g/m²	≥50 g/m²	≥100 g/m²	≥250 g/m²		100 g/m²	250 g/m²			
Argo-Rowley Terrace MP*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Ashmore Reef MP	NC	NC	NC	NC	NC	NC	NC	NC	10	<1
Browse Island*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Buccaneer & Bonaparte Archipelagos	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Cartier Island MP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Hibernia Reef*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Indonesia	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Indonesian Boundary	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Kimberley MP*	NC	NC	NA	NA	NA	NA	NA	NC	16	6
Kimberley Coast	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Oceanic Shoals MP*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Rowley Shoals - Clerke Reef State MP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals - Mermaid Reef MP	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Scott Reef North*	7	15	NA	NA	NA	NA	NA	60	4,146	2,528
Scott Reef South	106	126	112	112	18,450	507	507	126	1,197	1,623
Seringapatam Reef*	NC	NC	NA	NA	NA	NA	NA	NC	70	240
Sumba	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Ashmore Reef	NC	NC	NC	NC	NC	NC	NC	NC	6	<1
Cartier Island	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals - Clerke Reef	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Rowley Shoals - Mermaid Reef	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Sahul Banks*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Scott Reef Central	108	126	112	112	18,450	507	507	126	1,197	987
Scott Reef Central - Sandy Island	113	126	112	112	18,450	507	507	126	1,124	737
Scott Reef North - Flats*	10	15	NA	NA	NA	NA	NA	126	2,849	2,356
Scott Reef North - Lagoon*	15	36	NA	NA	NA	NA	NA	127	1,988	2,528
Scott Reef South - Flats*	163	NC	NA	NA	NA	NA	NA	155	652	1,375
Scott Reef South - Lagoon*	100	NC	NA	NA	NA	NA	NA	126	1,197	1,623
Adele Island	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Barracouta Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Barracouta Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Barracouta Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC

Receptor	Minimum time to receptor (hours) for floating oil at		Minimum time to accumulation (hours) of shoreline oil at		Maximum local accumulated concentration (g/m²)	Maximum accumulated volume (m³) along this shoreline, exceeding concentrations of		Minimum time to receptor (hours) for entrained oil at ≥100 ppb	Maximum entrained oil concentration (ppb), at any depth	Maximum dissolved aromatic hydrocarbon concentration (ppb), at any depth
	≥10 g/m²	≥50 g/m²	≥100 g/m²	≥250 g/m²		100 g/m²	250 g/m²			
Echuca Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Eugene McDermott Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Fantome Bank*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Heywood Shoal*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
Vulcan & Goeree Shoals*	NC	NC	NA	NA	NA	NA	NA	NC	NC	NC
WA Coastline	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

NC: No contact to receptor predicted for specified threshold. NA: Not applicable.

* Floating oil will not accumulate on submerged features and at open ocean locations.

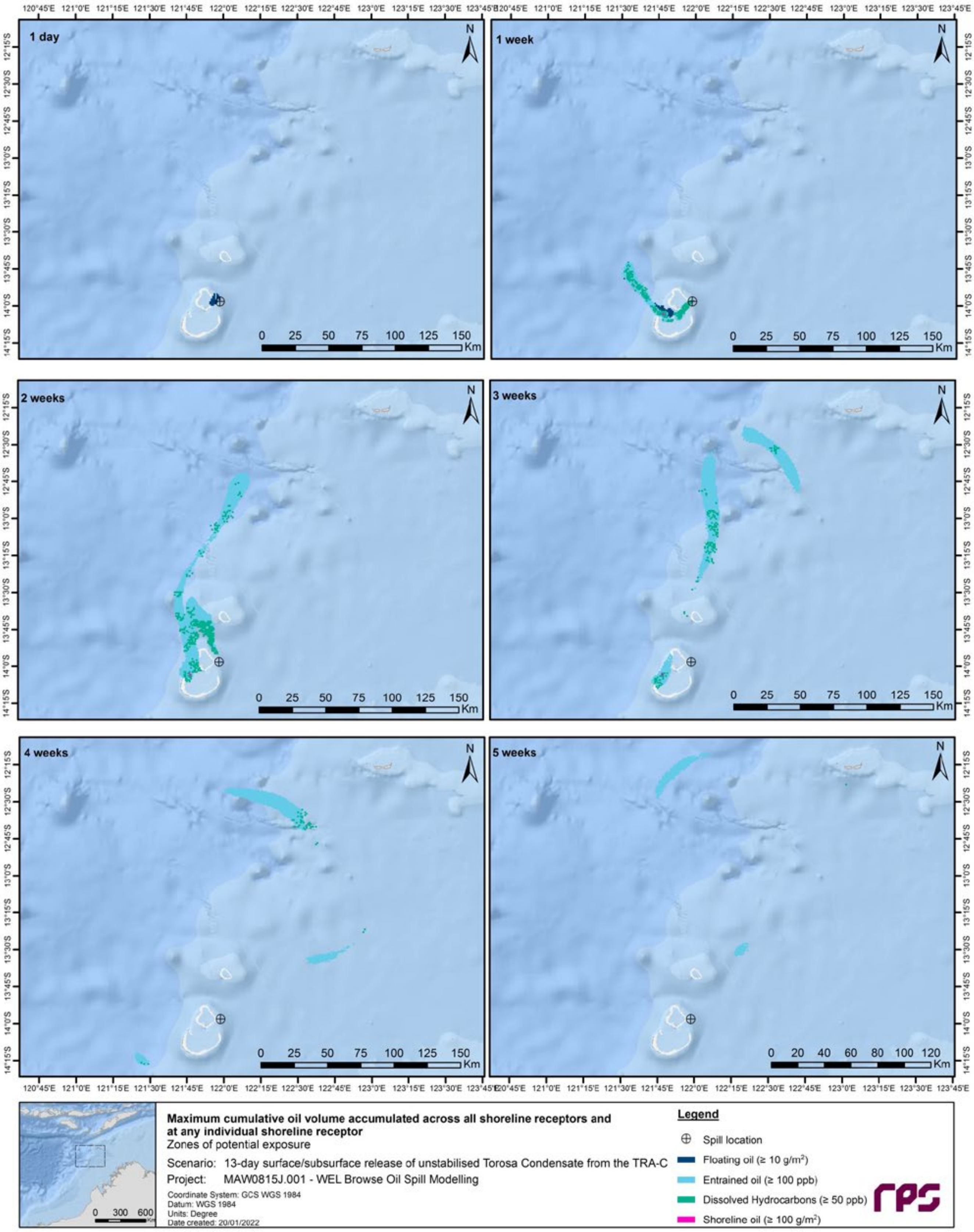


Figure 2.3 **Time-varying areal extent of potential exposure at defined floating oil, entrained oil, dissolved aromatic hydrocarbon and shoreline oil threshold concentrations, resulting from a 13-day surface/subsea release of unstabilised Torosa Condensate at the TRA-C well, for the replicate case with the the minimum time to entrained oil (at a threshold of 100 ppb) contact with the offshore edge(s) of any shoreline receptor polygon.**

3 REFERENCES

RPS 2019, Woodside Browse to NWS Project: Quantitative Spill Risk Assessment – Rev 2, provided to Woodside Energy Ltd by RPS, West Perth, WA, Australia, 19/05/2020.

RPS 2021, Woodside Browse TRA-C Oil - Quantitative Spill Risk Assessment – Rev 0, provided to Woodside Energy Ltd by RPS, West Perth, WA, Australia, 10/12/2021.

APPENDIX C MANAGEMENT PLANS

APPENDIX C.5 PYGMY BLUE WHALE MANAGEMENT PLAN

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1. EXECUTIVE SUMMARY

The primary purpose of this plan is to outline how any underwater anthropogenic noise associated with the proposed Browse to NWS Project (Browse Project) will be managed such that it will not be inconsistent with the Conservation Management Plan (CMP) for the Blue Whale, specifically the requirements of Action A.2.3.

Action Area A.2, Action 3 of the CMP that states that:

> *"anthropogenic noise in biologically important areas (BIAs) will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area"*.

Guidance on the key terms of the CMP and FAQs (DAWE, 2021 and NOPSEMA 2021) have been applied to the development of this plan.

Woodside considers that the management approach outlined in this plan demonstrates, with a high level of confidence, that unacceptable impacts to pygmy blue whales will be prevented, by minimising the risk of injury to pygmy blue whales or displacement of pygmy blue whales from the Scott Reef possible foraging area, as a result of underwater noise emissions associated with the proposed Browse Project.

A detailed overview of each objective of this plan is in **Section 3** and a summary of outcomes is provided in **Section 12**.

Management of Injury from Impulsive noise

The spatial and temporal controls presented in this plan ensure that all activities generating impulsive noise will either be eliminated during the detailed design phase and if they are required, will only occur outside of times/places where pygmy blue whales are likely to be present. A scientific monitoring program will be put in place prior to these activities occurring, to provide a thorough understanding of times and places pygmy blue whales are likely to be present in and around the project area. A requirement to monitor for whales will apply to these activities, which can be immediately ceased if a whale is sighted, on a precautionary basis.

Management of Injury from Vessel noise

Modelling indicated that the greatest distance at which injury may be caused (after 24 hours of continuous exposure) to a whale was 1.5 km, which was associated with installation of the inter-field spurline, which would only affect the possible foraging area for a short duration. For vessels that are present for longer periods, (i.e. MODUs and Torosa FPSO), these were modelled as potentially causing injury (after 24 hours of exposure) at distances of less than 650 m from the noise source. Considering behavioural disturbance (e.g. avoidance) may occur at 120 dB re 1 µPa, and migratory pygmy blue whales typically travel 10s or 100s of kilometres a day, the risk of exposure of a PBW to TTS or PTS from vessel activities is considered highly unlikely.

To further understand injury risk, ANIMAT modelling was conducted to account for whale behaviour and sound exposure (Appendix B). ANIMAT modelling outcomes demonstrated that for the vessel activity with highest risk of injury (BTL installation), 95% of simulation results required a pygmy blue whale to come within 50 m of a vessel's propulsion system to be exposed to noise related injury (PTS). The probability of a PBW coming to such close proximity of a vessel was considered highly unlikely.

For the FPSO and MODU, ANIMAT modelling resulted in no simulated whales being exposed to PTS/TTS.

Disruption of foraging behaviour

It is recognised that the proposed Browse Project may result in the generation of underwater noise in excess of the recognised behavioural response threshold, which has the potential to disrupt pygmy blue whale foraging behaviour. Accordingly, this plan has considered:

- the time of year the activity will be undertaken and the likelihood of pygmy blue whale foraging in the area of potential overlap of the proposed Browse Project and the Scott Reef possible foraging area (BIA) (summarised in **Section 4**)
- the extent, intensity, and duration of sound exposure within the Scott Reef possible foraging area, including residual and cumulative impacts after the application of controls (summarised in **Section 12.2.3**)
- the implementation of any appropriate controls to prevent unacceptable impacts (summarised in **Section 8**).

Best practice management measures in accordance with a precautionary approach have been established within this plan and successful implementation will ensure that, with a high degree of certainty, the anthropogenic noise from the proposed Browse Project will be managed such that any blue whale will be able to continue to utilise the BIA without injury, and no blue whale will be displaced from a foraging area. In this way, the proposed Browse Project will not be inconsistent with the CMP.

- A summary of the information within this plan that is provided in support of this conclusion is presented below.

1.1 Existing Knowledge of Pygmy Blue Whale Activity at Scott Reef

This plan outlines key management principles **(Section 7)** used to determine activity specific controls **(Section 8)** that will be applied to the proposed Browse Project. Spatio-temporal management is a core element of this management approach, underpinned by a comprehensive review of existing knowledge of pygmy blue whale activity at Scott Reef **(Section 4)** and adaptive management **(Section 11)** to respond to uncertainty or possible future changes in understanding of pygmy blue whale activity in the region.

Pygmy blue whales are known to migrate on an annual basis through the Scott Reef possible foraging on their way to and from breeding and feeding grounds within the Banda Sea, Indonesia. The migratory seasons are defined by shoulder and peak periods and exact timings can vary inter-annually.

Evidence collected to date from a variety of techniques including sampling of zooplankton, pygmy blue whale vocalisation data from passive acoustic monitoring (noise loggers), survey observations (vessel-based and aerial) and satellite tracking suggests that Scott Reef is likely to be of less importance for the East Indian Ocean (EIO) pygmy blue whale population than other defined foraging areas. However, the relative importance of Scott Reef as a foraging area for migrating pygmy blue whales remains unclear and as such the possible foraging area will be managed as a known foraging area and BIA for the purposes of the proposed Browse Project.

In known foraging BIAs such as the Perth Canyon, pygmy blue whales can be observed in predictable annual higher abundance, exhibiting foraging behaviours and have extended residence times albeit in large areas of coastal or offshore waters. These observations, behaviours and residence times are not replicated at or in the vicinity of the Scott Reef possible foraging area, despite dedicated, multi-year studies over an extended period, using multiple survey and sampling techniques. Across the Scott Reef possible foraging area from west to east, based the understanding of pygmy blue whale foraging areas and habitat suitability, there is a higher likelihood of prey (krill) availability over the upper slope (with canyon features) habitat to the west of Scott Reef as compared to the featureless, homogeneous seabed habitat of the eastern extent of the BIA. This forms the basis of concluding that the likelihood of foraging by pygmy blue whales while migrating through the BIA is higher for (i) the upper slope habitat in the western extent of the BIA and (ii) potentially the

Scott Reef channel as based on the findings reported by Sutton *et al*. (2019). Survey results for one season (in 2008), have been used to infer a predictable spring period of higher productivity leading to krill swarms that are a predictable food source for southbound migrating pygmy blue whales within the Scott Reef channel. Based on the likelihood of prey availability within suitable foraging habitat and foraging pygmy blue whale activity, a higher relative importance of the Scott Reef channel as a foraging habitat within the Scott Reef possible foraging has been adopted. It is recognised that there are knowledge gaps and scientific uncertainty about the predator-prey dynamics (pygmy blue whale and krill availability) and the potential temporal-spatial importance of the channel. The higher likelihood of foraging pygmy blue whales within the Scott Reef Channel (as presently accepted) underpins the approach to the management of noise and potential impacts to pygmy blue whales within this plan.

1.2 Underwater Noise Characterisation & Assessment

Noise (sound power level) estimates for major activities or vessels, including continuous or impulsive noise, are presented (**Section 5**) based on suitable analogues or indicative design data. Sound propagation modelling (**Section 6)** has then been performed to estimate the distance (R_{max}) from each activity at which certain noise levels will be received, corresponding to potential injury or behavioural disturbance effect thresholds.

Continuous noise sources range from 161.5 dB re 1 µPa.m for well head choke valve noise (at well centres with up to 7 wells) to 191 dB re 1 µPa.m for the rigid pipelay vessel. These activities were estimated to cause potential behavioural responses from pygmy blue whales at onset ranges from <500 m to 9.9 km, respectively.

After the application of elimination, substitution and reduction controls outlined in Section 8, a cumulative ensonified area assessment is provided (**Section 6.3**) and demonstrates:

- There are no planned activities that will occur during peak periods of the pygmy blue whale migratory seasons, that generate noise above 120 dB re 1 µPa within the Scott Reef channel.
- Underwater noise is anticipated to peak during the initial subsea construction phase, during intermittent, short term activities (ie BTL installation concurrent with the MODU activities) that may ensonify (>120 dB re 1 µPa) an area of up to ~123 km^2 (0.95% of Management Zone B). These activities are targeted to occur outside of peak periods of the pygmy blue whale migratory seasons and BTL activities will only impact the BIA for a period of weeks.
- After this initial construction period, the total areal extent of the Scott Reef possible foraging ensonified above 120 dB re 1 µPa during peak pygmy blue whale migratory periods is reduced to ~1 km^2 at the surface (<0.01% of Management Zone B) during normal operations (with mitigations applied, i.e., turning off vessel propulsion or FPSO thrusters if a whale is sighted) and ~22 km^2 at the surface (0.17%) during intermittent (<1 day per fortnight) offtake operations (where vessel propulsion cannot be halted if a whale is sighted, due to offtake spill risks).
- Noise from well-heads during operations may ensonify up to ~4.7 km^2 of the Scott reef possible foraging area, however this noise propagation would not ensonify waters in the top 50 m of the water column, where whales would typically be when transiting to foraging areas or migrating. This value does not account for the predicted marked reductions in noise emissions expected to result from designing well head choke valves to minimise noise.
- Activities outside of the Scott Reef possible foraging area will also be managed, to minimise the risk of disturbance to opportunistic foraging and scientific monitoring will occur in this region to understand the likelihood of pygmy blue whale presence and foraging behaviour occurring.

1.3 Management Approach

The management approach within this plan is aligned with industry best practice (refer to **Section 7.5**) and involves:

- reduction of potential impacts through the application of the hierarchy of controls
- spatio-temporal management principles
- an extensive scientific monitoring program
- an adaptive management program to respond to new scientific or technical information
- decision-making within the adaptive management framework based on scientific data and input from an expert review panel.

Management of underwater noise for the proposed Browse Project is governed by the application of hierarchy of controls with key principles applied summarised below:

- Avoid generating noise at times and/or in places where pygmy blue whales are likely to be present.
- Substitute high noise generating activities with quieter alternatives.
- Engineering will be used to reduce the sound source levels associated with equipment being designed for use on the Project.
- Where an activity cannot be eliminated, substituted or reduced such that noise generated is below behavioural response thresholds, operational mitigations will apply.

1.4 Spatio-Temporal Management Principles

Spatio-temporal management principles will be applied to manage noise within certain areas and at certain times. Two management zones will be applied and managed for the Torosa development and operational activities:

- Management Zone A: Scott Reef channel
- Management Zone B: the wider Scott Reef possible foraging area.

The spatio-temporal management approach proposed will apply a suite of key principles for managing underwater noise within each zone with the aim of eliminating noise propagating within and into the Scott Reef channel (Management Zone A) and minimising noise propagation within the wider Scott Reef possible foraging area (Management Zone B). These key principles are as follows:

Within management zone A during peak and shoulder pygmy blue whale migratory seasons include:

- There shall be no generation of noise capable of causing ‘injury’ to a pygmy blue whale from any source.
- There shall be no generation of noise from vessels (including FPSOs or MODUs) at levels above which may cause disruption to a foraging pygmy blue whale.

Additionally, there shall be no propagation of noise into this zone, from unmitigable long term noise sources above levels which may cause disruption to a foraging pygmy blue whale.

Within management zone B during peak periods of the pygmy blue whale migratory seasons include:

- There shall be no impulsive noise from impact piling or seismic activities including vertical seismic profiling.
- There shall be no vessel activity from which ‘injury’ (e.g. PTS/TTS) from noise exposure could occur (24 hour exposure) at 750 m or more from the source.
- There shall be no unmitigable or continuous long-term noise above levels which may cause a behavioural response beyond a 1 km radius from the source.
- Any mitigable surface activity generating noise at levels which may cause injury or a behavioural response must operate in accordance with an activity specific Whale Management Procedure.

The approach, as set out above ensures that underwater noise emissions will be eliminated, avoided or reduced such that injury to and displacement from foraging by a pygmy blue whale has been minimised to the greatest extent possible and the residual risk is negligible.

1.5 Key Management Actions

Design features and activity specific management measures applicable to anthropogenic noise with as incorporated by the hierarchy of controls and spatio-temporal management principles are presented in **Section 7** and include:

During Design:

- Thrusters on the FPSO **will be** designed to minimise noise generation, with the radius to the pygmy blue whale behavioural response threshold being reduced from ~2.8 km to 570 m if noise reduction from 183 re 1 µPa.m to 178dB re 1 µPa.m (50% thruster utilisation) is achieved.
- Subsea choke valves on well heads at Torosa **will be** designed to minimise noise generation, with initial investigations indicating noise can be reduced by approximately 16.5 dB, meaning the radius at which pygmy blue whale behavioural response threshold is experience would be significantly below the predicted ~500 m horizontal radius. The outcome of this exercise is uncertain, as it has not been possible to identify a vendor that has had to incorporate noise mitigations into well head design before. This design mitigation is a best in class approach to noise mitigation.

During subsea construction and installation:

- At Torosa and Brecknock, MODUs will not use DP systems to hold station while drilling during peak periods of the pygmy blue whale migratory seasons, but instead will be moored.
- Vessels operating in the Scott Reef possible foraging area will be required to implement operational restrictions and observe for pygmy blue whales, with triggers to delay or stop certain activities if whales are sighted within nominated management zones.
- No activities will occur within the Scott Reef Channel.

In relation to impulsive noise from subsea construction and installation activities:

- Non-impulsive noise generating alternatives to impact piling (e.g. suction piling) will be used at all times, where technically feasible.
- Impact piling will not occur in the Scott Reef channel (Management Zone A) at any time or within Management Zone B during peak or shoulder pygmy blue whale migratory periods.
- VSP activities will not occur in the Scott Reef channel (Management Zone A) at any time or within the Zone B during peak pygmy blue whale migration periods.
- A Whale Management Procedure (WMP) will be in place during all impact piling and VSP activities, to observe for whales and respond appropriately in the event that whales are detected within monitoring zones.

During operations (that coincide with peak periods of the pygmy blue whale migratory seasons):

- There will be no unmitigable vessel noise (including from FPSO or MODUs) above the behavioural response threshold within the Scott Reef channel
    - The Torosa FPSO is located in the swell shadow of the Scott Reef system, meaning the thrust required to control heading will be rarely utilised and will be substantially less than other offshore facilities, i.e., Calliance FPSO, significantly minimising long term noise generation from either continuous (weather-vaning FPSO) or intermittent (condensate offloading) activities.

- Concurrent activities at the Torosa FPSO will be restricted to reduce cumulative noise (i.e., supply vessels cannot conduct goods transfers while condensate offtakes are occurring).
- Mitigable noise, including from supply vessels and during condensate offtakes, will not occur unless a Whale Management Procedure is in place to establish exclusion zones where the activity cannot commence if a whale is present and once the activity has commenced, monitoring will continue, and applicable mitigations applied if a whale is observed.

During future tie-back phases:

- Subsea construction or installation activity (e.g., drilling or flowline installation) related to subsequent tiebacks from within the Torosa field will only occur outside of peak periods of the pygmy blue whale migratory seasons.
- Drilling and completions of any Torosa or Brecknock well as part of future (post Torosa RFSU) tieback phases will be required to be completed by a moored MODU when operating during peak periods of the pygmy blue whale season, unless the noise from the DP system would be the equivalent or less than noise generated were it to be moored.

1.6 Scientific Monitoring

Scientific monitoring programs will be designed to obtain a contemporary baseline data on the relative abundance, seasonality and, movement and behaviour of pygmy blue whales within the possible foraging area at Scott Reef prior to the commencement of operations (refer to **Section 10.2**).

On-going data acquisition is planned to occur throughout the life of the proposed Browse Project, which will be important to monitor any changes the movement and behaviour of pygmy blue whales and confirm sound source levels of project activities.

The key objectives of the pygmy blue whale scientific (baseline) monitoring program are as follows:

- To verify and further understand the seasonality, residency time, behaviours and relative abundance of the EIO pygmy blue whale population utilising the Scott Reef possible foraging area to ensure spatio-temporal management areas are appropriately defined.
- Identify the habitats within the Scott Reef possible foraging area that are likely to support predictable aggregations of prey (krill) to ensure spatial management areas are appropriately defined.

Additionally, the following monitoring activities will be put in place in support implementation of this plan:

- Measurement of underwater noise from key activities to verify impact predictions and revise management procedures, if required.
- A technology maturation program to investigate and demonstrate feasibility for technologies to enable real-time detection of pygmy blue whales such as underwater listening stations and/or infra-red detection techniques.

An expert panel will be established to input to the scope and design of the scientific monitoring programs, review findings and decisions leading to changes in the management regime to minimise underwater noise emissions and potential impacts to pygmy blue whales.

1.7 Adaptive Management

An important element of applying a spatio-temporal management principles will be the application of an adaptive management process to verify and modify the management plan principles and triggers when new scientific or technical knowledge becomes available. The application of defined management zones and timing of seasonal controls is presently based on current knowledge regarding the presence and foraging behaviour within the Scott Reef possible foraging area. Findings from the baseline and ongoing (operational phase) scientific monitoring programs will be used to adaptively manage the applied spatio-temporal management regime and activity specific whale management procedures (refer to **Sections 9** and **10**).

Adaptive management will ensure operational measures are aligned to possible changing knowledge or circumstances in space and time. Adaptative management actions and response trigger criteria are outlined in **Section 11**. The majority of actions are focussed on the pre-operational phase of the proposed Browse Project, to provide sufficient time to ensure operational plans can be adapted in response to any trigger criteria being met.

The primary objectives of the adaptive management are:

- Maintain a spatio-temporal management regime that minimises underwater noise emission impacts to pygmy blue whales and ensures the management objectives of the proposed Browse Project are met.
- To identify and execute any need for change to management actions, that will be made in response to triggers or action outcomes and scientific knowledge.

Aims of each key element of the Adaptative Management Plan are outlined below under two key categories – design modifications and spatio-temporal controls.

Design modifications:

- Predict noise levels from the Torosa FPSO thruster and Torosa well head choke valves based on detailed design information to ensure management objectives will be achieved or modifications to management actions are required.
- Validate predicted noise levels from well head choke valves at Calliance to inform if design changes are required for Torosa (applicable to post phase 1 activities).
- Validate predicted noise levels from the Torosa FPSO thruster and well head choke valves to ensure management objectives will be achieved or modifications to management actions are required.

Spatio-temporal controls:

- Ensure boundaries of management zones are appropriately defined and aligned to the most up to date understanding of pygmy blue whale movement and foraging behaviour.
- Ensure temporal restrictions based on seasonal peak and shoulder periods of the pygmy blue whale migration seasons accurately reflect actual pygmy blue whale presence and migratory periods including possible changes over time. Activity scheduling is to then be modified, where required, to meet temporal controls.
- Verify monitoring zone definitions and observation distances applied to relevant activities and designated within WMPs, are valid and accurate for each activity.

2. INTRODUCTION

2.1 Proposed Browse Project

The Browse hydrocarbon resource is located in the Brecknock, Calliance, and Torosa reservoirs, approximately 425 km north of Broome and approximately 290 km off the Kimberley coastline of Western Australia (WA). These three fields will be collectively referred to as the Browse hydrocarbon resources. Hydrocarbon resources contained in these fields are predominately gas, with contingent resources (2C, 100%) of 13.9 trillion cubic feet (tcf) of dry gas, and approximately 390 million barrels of condensate (Woodside resource estimate).

Woodside Energy Ltd (Woodside) is Operator for and on behalf of the Browse Joint Venture (BJV). The participants in the BJV are:

- Woodside Browse Pty Ltd
- Shell Australia Pty Ltd (Shell)
- BP Developments Australia Pty Ltd (BP)
- Japan Australia LNG (MIMI Browse) Pty Ltd (MIMI)
- PetroChina International Investment (Australia) Pty Ltd (PetroChina).

The BJV proposes to develop the Browse hydrocarbon resources using two 1,100 million standard cubic feet per day (MMscfd) (annual daily export average) Floating Production Storage and Offloading (FPSO) facilities. The FPSO facilities will be supplied by a subsea production system and will transport gas to existing North West Shelf (NWS) Project infrastructure via a pipeline which will tie in near the existing North Rankin Complex (NRC) in Commonwealth waters (Note: The NRC is owned by the NWS Joint Venture (NWSJV)[1]).

2.2 Project Area

The overall Project Area for the proposed Browse Project comprises:

- the proposed Browse Development Area (in which the Brecknock, Calliance, and Torosa fields, the FPSO facilities and the subsea production systems, including wells, will be located) (**Figure 2-1**)
- the pipeline corridor within which the proposed Browse Trunkline (BTL) and inter-field spur line will be located (**Figure 2-2**).

[1] The NWSJV comprises six companies: Woodside Energy Ltd. (Operator), BHP Billiton Petroleum (North West Shelf) Pty Ltd, BP Developments Australia Ltd, Chevron Australia Pty Ltd, Japan Australia LNG (MIMI) Pty Ltd, and Shell Australia Pty Ltd. The NWS Joint Venture owns the infrastructure used as part of the North West Shelf Project.

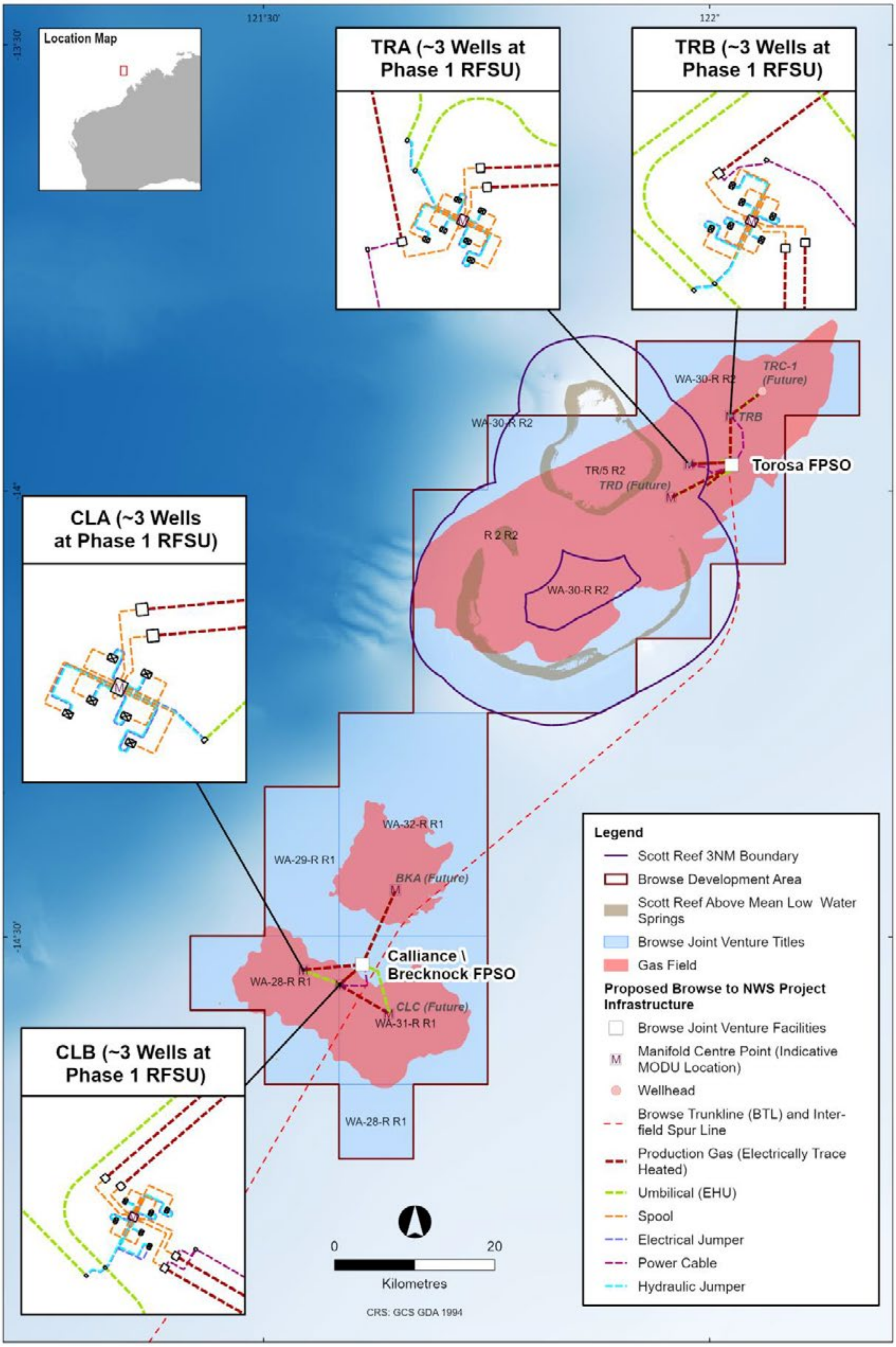


Figure 2-1 Proposed Browse Development Area and notional field layout

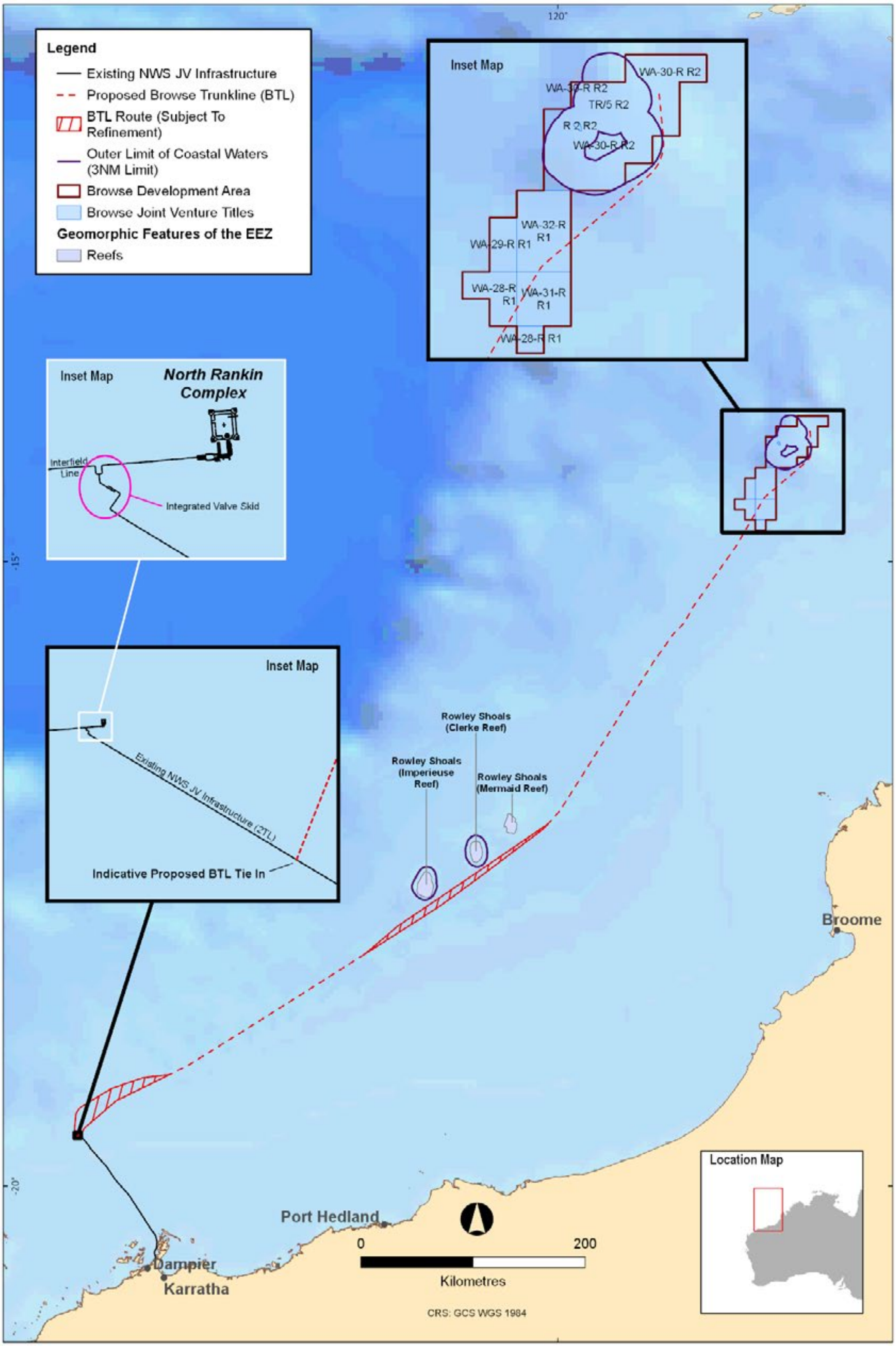


Figure 2-2 Proposed Browse Trunkline (BTL) route

2.3 Project Activities

Activities associated with the proposed Browse Project include:

- Piling for mooring the FPSO facilities, securing the export riser bases and potentially for mooring the MODUs. Suction piling is the most likely option for pile installation, however, depending on the seabed substrate, alternate piling methods such as drilling and cementing or impact piling may be selected
- Development drilling and completions for the development of up to 50 production wells
- Installation and commissioning of the subsea umbilicals, risers and flowlines (SURF)
- Installation and commissioning of the BTL and inter-field spur line
- Installation, hook up and commissioning of the FPSO facilities
- Operations including hydrocarbon extraction, gas processing and export and condensate offloading
- Inspection, maintenance, monitoring and repair activities (IMMR) to ensure the integrity of the infrastructure and identify any problems before they present a risk of loss of containment
- Support activities including logistics support, project vessels and helicopters
- Decommissioning in accordance with good oilfield practice and relevant legislation and practice at the time.

A detailed description of the activities associated with the proposed Browse Project is provided in Section 3.7 of the draft EIS/ERD.

2.4 Construction and Subsea Tie-back Phases and Sequencing

The project will be executed over a number of phases, connecting new wells to the FPSOs to supplement supplies of gas and condensate to the FPSO once production declines from the initial series of wells supplying the FPSO at 'ready for start up' (RFSU).

An indicative overview of project activities outlined below, outlining those activities that may generate noise within (or that may propagate to within) the pygmy blue whale possible foraging area at Scott Reef.

Phase One (pre-RFSU) drilling and completion activities

- Drilling and completions of a total of 6 wells, at two drill centres Torosa A (TRA) and Torosa B (TRB) including installation of well heads and xmas trees. Estimated duration is up to three months per well, or 18 months total. Six wells are also drilled at Calliance drill centres (Calliance A (CLA) and Calliance B (CLB)), although underwater noise from Calliance drilling and completion activities are not anticipated to have any impact in the area.

Phase One (pre-RFSU) subsea and construction activities

- Installation and commissioning of the Browse Inter-field Spur Line (IFL) from the Calliance FPSO to the Torosa FPSO.
- Torosa FPSO installation - Piling for mooring the FPSO facilities, installation, hook up and commissioning of the FPSO facilities and installation of risers at the FPSO location.
- Calliance FPSO installation - Piling for the FPSO moorings
- Connection of drill centres to FPSOs - Installation and connection of subsea umbilicals and flowlines between Phase One drill centres and the respective FPSO.

Phase one (pre-RFSU) subsea installation and construction sequencing

The subsea installation and construction sequencing for activities occurring during Phase One are typically consecutive, not concurrent, as certain activities must be completed prior to other activities commencing. This is relevant to this plan in predicting cumulative noise impacts. The consecutive construction sequence at Torosa during Phase one is shown in **Table 2-1**. Once subsea equipment has been installed, a commissioning phase will occur, which continues for a longer duration than construction but will involve less project vessels.

Table 2-1 Indicative proposed construction sequence associated with initial subsea and construction activities associated with development of the Torosa hydrocarbon field (Phase one (pre-RFSU))

Sequencing	Activity	Duration (indicative)	Vessel type(s)
1	Install Browse Inter-field Spur Line from Calliance FPSO to Torosa FPSO	2 weeks	Large rigid pipelay vessel such as *Solitaire or Castorone*. Accompanied by touchdown monitoring vessel.
2	Install flowlines and subsea equipment (e.g. manifolds) including flood, clean gauge and test (FCGT)	One week to reel-lay two flowlines. One month for other subsea equipment.	Reel-lay vessel such as the Deep Energy or Seven Ocean. Construction vessel such as the *Deep Orient* or *Seven Arctic*.
3	Hook-up the Torosa FPSO to the mooring and subsea system	1 month	Approximately four tugs to hold the FPSO in position, construction vessel to lift and connect mooring chains.
4	Hook-up the Torosa FPSO to the subsea system	2 months	Construction vessel such as the *Deep Orient* or *Seven Arctic*.

Additional Project Phases (Phase 2 – 6)

Indicative activities for phases beyond RFSU (Phase One) are outlined in **Table 2-2**, including the indicative timing of when each phase is anticipated to be ready to produce hydrocarbons. Note that there remains uncertainty in the precise timing, ordering and scope for each phase.

It should be noted that while **Table 2-2** shows phasing of future phases at Calliance, drilling and completion activities and other construction activities associated with future phases of Calliance are not anticipated to produce noise received at relevant injury or behavioural response thresholds within the Scott Reef possible foraging area.

Table 2-2 Indicative project phase and relevant activities occurring after initial RFSU (Phase one)

Phase	Indicative Scope	Indicative Activities	Indicative Timing (Post RFSU)
2	Torosa TRD Development, TRA infill	Drilling & Completion, wellhead and christmas tree installation of: 4 x wells TRD 2 x wells TRA Installation of SURF: TRD to Torosa FPSO	4-6 years
3	Brecknock Development, Calliance West Infill	Drilling & Completion, wellhead and christmas tree installation of: 3 x wells BKA 2 x wells CLB Installation of SURF: BKA to Calliance FPSO	5-8 years
4	Torosa TRC Development, TRA/TRD infill	Drilling & Completion, wellhead and christmas tree installation of: 1 x well TRC 4 x wells (inclusive of both TRA and TRD) Installation of SURF: TRC to Torosa FPSO	5-9 years
5	Calliance West and Brecknock Infill Campaigns	Drilling & Completion, wellhead and christmas tree installation of: 3 x wells CLA 1 x well BKA	8-15 years
6	Calliance East Development	Drilling & Completion, wellhead and christmas tree installation of: 6 x wells CLC Installation of SURF: CLC to Calliance FPSO	11-16 years

Future tieback campaigns

Depending on reservoir outcomes, wells at drill centres not listed above (i.e. TRF & TRH) may be developed and tied back to the Torosa FPSO and additional wells may be drilled at existing drill centres, up to the maximum number of wells (50) planned to occur as part of the Proposal including a maximum of 25 as part of the Torosa field.

The proposed Browse Project requires a maximum of 50 development wells, although even if the median reservoir outcome is achieved, markedly less wells will be developed. There is a 90% probability that less than 46 wells will be required as part of the Proposal, only 21 of which are associated with the Torosa field.

3. PURPOSE

3.1 Management Objectives

The primary purpose of this plan is to outline how any underwater anthropogenic noise associated with the proposed Browse Project will be managed such that it will not be inconsistent with the Conservation Management Plan (CMP) for the Blue Whale, specifically the requirements of Action A.2.3.

The objectives of this plan are to:

- Summarise the significance of the Scott Reef possible foraging area to the pygmy blue whale population, based on existing scientific knowledge (**Section 4**) and summarise the current understanding of underwater noise generating activities (**Section 5**) and the extent of noise propagation (**Section 6**).
- Outline the mitigation approach to be taken to minimise the potential environmental impact of underwater noise emissions within the Scott Reef possible foraging area to the pygmy blue whale population (**Section 7, Section 8** and **Section 9**).
- Outline the scientific monitoring programs to be undertaken to improve confidence in the environmental impact assessment predictions (**Section 10**), and support the adaptive spatio-temporal management regime to reduce potential environmental impacts of underwater noise within the BIA (**Section 11**).
- Provide an environmental impact assessment on the residual sources of underwater noise (once mitigations are applied) (**Section 12**).

Implementation of this plan will achieve the relevant aspects of the relevant Environment Performance Objectives (EPO) of the proposed Browse Project, which are as follows:

- 26 - Undertake the Browse Project in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks, dugongs, seabirds and migratory shorebirds).
- 27 - Undertake the Browse Project in a manner that will not disrupt the migration and feeding of the East Indian Ocean pygmy blue whale population.
- 28 - Undertake the Browse Project in a manner that will not displace the East Indian Ocean pygmy blue whale population from the possible foraging area at Scott Reef.

With specific reference to pygmy blue whales, the above EPOs and specific objectives of this plan aim to achieve the following:

- No significant impact to the pygmy blue whale population (EPBC Act threatened and migratory species) as per EPBC Act MNES significant impact criteria for listed endangered species.
- Demonstrate the proposed Browse Project is not inconsistent with Action A.2.3 of the Conservation Management Plan for the Blue whale (2015-2025), Commonwealth of Australia (2015), in accordance with the EPBC Act.

3.2 Background

One of the key environmental receptors identified during the assessment of impacts and risks from the proposed Browse Project was the East Indian Ocean (EIO) population of the pygmy blue whale (*Balaenoptera musculus brevicauda*). Pygmy blue whales make annual north and southbound migrations utilising the area identified by the migratory BIA which overlaps with the Browse Development Area and may forage at a number of known and possible foraging, including the possible foraging at Scott Reef which overlaps with the Torosa field and proposed location of the Torosa FPSO and associated subsea gathering system.

A number of planned and unplanned aspects (i.e., elements of the proposed Browse Project that can potentially interact with an environmental receptor) were identified within the draft EIS/ERD as having the potential to result in impacts to pygmy blue whales. A key aspect of the proposed Browse Project is the generation of anthropogenic underwater noise. Underwater noise, at high levels, has the potential to either cause injury to or disrupt potentially biologically significant behaviours.

Within the draft EIS/ERD Section 6.3.8.3 states:

> "*Given that relatively low numbers of transient marine mammals are expected to seasonally occur within the Project Area, only slight behavioural modifications are expected to occur, with no long-term effects at a species population level. These impacts are not considered to be significant, based on the MNES significant impact criteria for listed endangered species and are not inconsistent with the recovery objectives within the Conservation Management Plan for the Blue Whale (2015-2025) (Commonwealth of Australia, 2015)".*

Following publication of the draft EIS/ERD and in finalising the EIS and response to comments on the ERD, further information has been requested by the EPA and DAWE in relation to the interim recovery objectives and targets set out in the CMP, in particular, in relation to demonstrating that the proposed Browse Project is not inconsistent with Action A.2(3) which states that:

> "*anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area*".

This plan outlines the potential impacts, proposed mitigations and adaptive management measures that will be applied during the proposed Browse Project to ensure consistency with Action A.2(3) of the CMP and ensure any anthropogenic threats are demonstrably minimised.

3.3 Structure of this Plan

Key elements of this plan are as follows:

- **Section 4** provides an overview of existing contemporary scientific knowledge regarding pygmy blue whales, including an overview of their observed activity at Scott Reef.
- **Section 5** provides an overview of the sources of anthropogenic noise associated with the proposed Browse Project, including the estimated noise generated from these activities and modelling outcomes or predictions of the impacts of this noise.
- **Section 6** provides the results of modelling or estimation of noise from these activities and presents the predicted cumulative underwater noise generation over the project lifecycle.
- **Section 6.4** provides the management objectives, approach and spatio-temporal management principles that will be applied to meet the objectives.
- **Section 8** provides the key design features and key management actions that will be applied to meet the interim recovery objectives as well as an evaluation against Action A.2(3) of the CMP.
- **Section 9** provides an overview of the Whale Management Procedures (WMPs) that will be applied to construction and operational activities.
- **Section 10** outlines the scientific monitoring and noise verification programs that will be applied, to validate management actions and inform adaptive management.
- **Section 11** outlies the adaptive management approach that will be in place to ensure objectives of the plan are supported as new information arises.
- **Section 12** provides a more detailed evaluation supporting the conclusions of the environmental impact assessment for underwater noise and demonstrates that the Proposal is not inconsistent with the Blue Whale Conservation Management Plan.
- **Section 13** outlines the requirement for periodic reviews of the overall management plan and some considerations of the reviews.

3.4 Guidance on Interpretation of the Blue Whale Conservation Management Plan

DAWE has published guidance for key terms applied in the Blue Whale Conservation Management Plan (CMP) on its website, which clarifies terminology in the Blue Whale CMP (DAWE, 2021). NOPSEMA and DAWE subsequently developed a set of frequently asked questions (FAQ) to accompany and support use of the guidance published by DAWE (NOPSEMA, 2021). These FAQs form part of Australian government advice in response to questions about the application of the Blue Whale CMP to environmental impact assessments (EIA).

These guidelines indicate that:

> "*In order to demonstrate, with a high level of confidence, that requirements of the CMP will be met, approvals documentation needs to include content such as:*
>
> - *well-founded Environmental Impact Assessment;*
> - *commitment(s) to implement whale detection that will be effective in detecting whales over the extent and duration of predicted impacts, including provision for detection measures to be scalable based on triggers such as activity timing and location, and whale sighting data; and*
> - *associated management measures that are likely to be effective at preventing unacceptable impacts over the extent and duration scales informed by impact predictions and whale detection data gathered during the activity.*"

3.5 Injury

The Blue Whale CMP, Action A.2(3), requires that:

> "*Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury…"*

DAWE has provided guidance stating that:

> *"For the purposes of interpreting and applying Action A.2 of the Blue Whale CMP, injury is both permanent and temporary hearing impairment (Permanent Threshold Shift and Temporary Threshold Shift) and any other form of physical harm arising from anthropogenic sources of underwater noise.*"

Within this plan, prevention of injury is considered as follows:

- Sound level predictions of activities considered to cause injury, through either permanent or temporary threshold shift and modelling predicting the range from activities at which injury may occur, is outlined in **Section 5** and **Section 6**.
- The management approach and specific management measures for ensuring injury to blue whales is prevented, are outlined in **Section 7** and **Section 8**.
- A summary of how the proposed Browse Project will not be inconsistent with the CMP in **Section 12.1.**

3.6 Displacement from Foraging

DAWE has provided guidance stating that:

> *"The recovery plan requirement, Action Area A.2(3), applies in relation to BIAs. A whale could be displaced from a Foraging Area if impact mitigation is not implemented. This means that underwater anthropogenic noise should not:*
>
> - *Stop or prevent any blue whale from foraging*
> - *Cause any blue whale to move on when foraging*
> - *Stop or prevent any blue whale from entering a Foraging Area*

It is considered that a whale is displaced from a Foraging Area if foraging behaviour is disrupted, regardless of whether the whale can continue to forage elsewhere within that Foraging Area. Mitigation measures must be implemented to reduce the risk of displacement occurring during operations where modelling indicates that behavioural disturbance within a Foraging Area may occur.

This is further described as in areas other than those identified in the CMP and NCVA, where it can be reasonably predicted that blue whale foraging is probably known or whale presence is detected, adaptive management should be used during industry activities to prevent unacceptable impacts (i.e., no injury or biologically significant behavioural disturbance) to blue whales from underwater anthropogenic noise. In-field observations of actual whale feeding are difficult to detect, so indicators of probable foraging should be used as a proxy."

Under FAQ 3, NOPSEMA states that:

"new petroleum activities or offshore projects can be proposed if there is potential for underwater noise within a foraging area to be at a level that is above the relevant published behavioural disturbance threshold for blue whales, provided that the environmental impact assessment considers factors such as:

- *the time of year the activity is proposed to be undertaken*
- *likelihood of blue whale foraging in that area*
- *the extent, intensity, and duration of sound exposure within the Foraging Area, and*
- *the capacity for the activity to be managed during implementation to enable the detection of blue whales, and the undertaking of any appropriate mitigation responses to prevent unacceptable impacts.*

The scientific evidence is summarised, and the proposed mitigation approach documented in this Plan give consideration to these factors.

This guidance has been considered within this plan, including:

- Sound level thresholds considered to cause a behavioural response, which may lead to impacts to a foraging whale as outlined in **Section 3.8**.
- A summary of pygmy blue whale presence detected at Scott Reef as described in **Section 4.5**.
- Sound level predictions of activities above the behavioural response threshold and modelling predicting the range from those activities, is outlined in **Section 5** and **Section 6**.
- The management approach and specific management measures for minimising the risk of behavioural disturbance to foraging pygmy blue whales, are outlined in **Section 7** and **Section 8**.
- Actions to observe for indicators of probable foraging by pygmy blue whales are included in the scientific monitoring program based on prey availability (**Section 10**).

3.7 Consideration of Action Area A.2, Action 3 in context of the CMP

In preparing this plan to ensure the proposed Browse Project is not inconsistent with Action Area A.2, Action 3 of the Blue Whale CMP (Commonwealth of Australia, 2015), consideration has also been given to how the broader CMP treats the threat of noise with reference to the long-term recovery objective of the Blue Whale CMP that states: 'to minimise anthropogenic threats to allow for their conservation status to improve so that Blue Whales can be removed from the EPBC Act threatened species list'.

The Blue Whale CMP considers anthropogenic noise from industrial activities is considered only of 'minor' consequence to the pygmy blue whale, a consequence assessment the Blue Whale CMP describes as precautionary. The likelihood associated with this consequence is 'almost certain'.

The Blue Whale CMP documents a range of known sources of underwater anthropogenic noise in proximity to known (as distinct from possible) foraging areas, and specifically identifies that *"In Australia, shipping noise associated with the port in Fremantle, Western Australia impacts on the known blue whale habitat in the Perth Canyon, and that similarly, shipping noise associated with the Victorian port of Portland is also associated with industrial activity and is on a major shipping route that runs through the Bonney Upwelling. Additionally, there are an increasing number of ports in north-western Australia and existing ports in south-western Australia (Albany and Esperance*". The plan does not contemplate restricting these activities under Action Area A.2, Action 3, with the stated measure of success being "*Improved understanding of the impacts of noise on blue whales and minimise the exposure of blue whales to anthropogenic noise*". It is therefore considered that the intent of the Blue Whale CMP is not to prevent activities which may cause underwater noise above behavioural response thresholds in foraging BIAs but instead to manage anthropogenic noise in BIAs such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area.

3.8 Impact (sound level) Thresholds Applied in this Plan

Potential impacts associated with underwater noise in relation to pygmy blue whales as with all marine fauna are complex and the science in this field is rapidly evolving (NOPSEMA, 2020). Sound levels that equate to impact thresholds vary amongst and within faunal groups and are context dependent with reference to the sound source (impulsive or continuous), low-frequency or high-frequency cetacean species, location, bathymetry, nature of the seabed substrate and other physical factors. The adopted thresholds presented in

Table 3-1 and **Table 3-2** are based on the best data available published in peer-reviewed literature and represent conservative internationally accepted and applied impact evaluation thresholds. The key impact thresholds used in this plan are defined as follows:

- Permanent Threshold Shift (PTS) – PTS is considered a reduction in hearing sensitivity from which marine fauna do not recover (permanent hair cell or receptor damage). PTS is considered injurious. Southall *et al*. (2007) define the minimum exposure criterion for injury as the level at which a single exposure is estimated to cause onset of PTS.
- Temporary Threshold Shift (TTS) or Auditory Fatigue – a temporary reduction in the ability of an individual to perceive sound associated with auditory fatigue. TTS is temporary, and full recovery has been demonstrated in a relatively short timeframes (minutes to hours) (Finneran *et al*., 2017). Like PTS, TTS is considered an injurious effect.
- Behavioural disturbance – typically short-term behavioural responses such as avoidance, displacement, or increased surfacing etc. Occurrence and intensity of behavioural disturbance can be highly variable and depends on a range of factors relating to the individual and situation. Behaviour is expected to return to normal following cessation of the anthropogenic noise.

Table 3-1 and **Table 3-2** summarise the impulsive (primarily associated with hammer piling or seismic activities) and non-impulsive (continuous sound source primarily from vessels) sound impact thresholds that may result in PTS, TTS or behavioural disturbance to low-frequency cetaceans (including pygmy blue whales). Within this plan, noise causing behavioural disturbance is used as a proxy for noise that may disrupt foraging behaviours (e.g., it may cause a whale to move on while foraging).

The radii that correspond to SEL24h typically represent an unlikely worst-case scenario for SEL-based exposure because, more realistically, marine mammals would not stay in the same location or at the same distance from a sound source for an extended period. Therefore, a reported radius for SEL24h criteria does not mean that any animal travelling within this radius from the source will be exposed to PTS or TTS, but rather that it could be exposed if it remained within that range for the entire duration the noise source was occurring or a minimum period of 24 hours.

Table 3-1. Acoustic effects of impulsive noise on low-frequency cetaceans: unweighted SPL, SEL_{24h}, and PK thresholds

Hearing group	NOAA (2019)	NMFS (2018) & Southall *et al.* (2019)			
	Behaviour	PTS onset thresholds* (received level)		TTS onset thresholds* (received level)	
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	PK (L_{pk}; dB re 1 µPa)
Low-frequency cetaceans	160	183	219	168	213

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_p denotes sound pressure level period and has a reference value of 1 µPa.
$L_{pk,flat}$ denotes peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa.
L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa^2s.

Table 3-2. Acoustic effects of continuous noise on low-frequency cetaceans: unweighted SPL and SEL_{24h} thresholds

Hearing group	NOAA (2019)	NMFS (2018); Southall *et al.* (2019)	
	Behaviour	PTS onset thresholds (received level)	TTS onset thresholds (received level)
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)
Low-frequency cetaceans	120	199	179

4. EXISTING KNOWLEDGE: PYGMY BLUE WHALE

4.1 Overview

The blue whale (*Balaenoptera musculus*) is currently listed as Endangered, Migratory and Cetacean under the EPBC Act and Endangered under the WA *Biodiversity Conservation Act 2016* (BC Act, September 2018). There are two subspecies of blue whale that occur within Australian waters and found in the Southern Hemisphere: the Antarctic blue whale, *B. m. intermedia*, and the pygmy blue whale, *B. m. brevicauda*. These two subspecies are differentiated by morphology, distribution, vocalisation and genetics (Commonwealth of Australia, 2015).

The Conservation Management Plan (CMP) for blue whales 2015-2025 (Commonwealth of Australia, 2015) long-term recovery objective is to minimise anthropogenic threats to allow for their conservation status to improve so that they can be removed from the EPBC Act threatened species list. Threats to the blue whale, as identified in the CMP include climate variability and change, noise interference (anthropogenic sources of underwater noise) and vessel disturbance (Commonwealth of Australia, 2015).

Similar to other baleen whale species, blue whales travel long distances twice a year as they generally migrate between breeding grounds at lower latitudes where both mating and calving takes place during the Austral winter, and feeding grounds at higher latitudes during the summer, and the migration routes have overlapping but different spatial distributions (Commonwealth of Australia, 2015). The extent of migrations and the components of the population that undertake such migrations are poorly known. Australian blue whales are represented by three generally recognised and overlapping populations, namely: Antarctic blue whale population; Indo-Australian pygmy blue whale and Tasman-Pacific pygmy blue whale (Commonwealth of Australia, 2015).

The Indo-Australian pygmy blue whales are defined as all those occupying or passing through waters from Indonesia to western and southern Australia. This pygmy blue whale sub-species is now referred to as the East Indian Ocean (EIO) pygmy blue whale population, due to its geographic distribution primarily in the Indian Ocean and south Australian waters (McCauley *et al*. 2018). Pygmy blue whales have known feeding grounds in the Perth Canyon off Western Australia, and the Bonney Upwelling System and adjacent waters off Victoria, South Australia and Tasmania. Individuals migrate between these feeding grounds as well as northwards and southwards along the offshore waters of West Australia to breeding grounds that are likely to include Indonesia (Commonwealth of Australia, 2015). Refer to **Figure 4-1** which shows the pygmy blue whale distribution and foraging areas. These CMP mapped areas[2] correspond to blue whale BIAs based on foraging of varying density and likelihood as mapped in the National Conservation Values Atlas (NCVA), (DAWE 2021). Pygmy blue whales typically inhabit deeper offshore waters historically leading to difficulty in determining migration patterns accurately, however the NCVA includes a defined migration corridor for Western Australian offshore waters (migration BIA), refer to **Figure 4-2**. Migration also seems to be variable, with some individuals appearing as resident to areas of high productivity and others undertaking migrations across long distances (Commonwealth of Australia, 2015).

4.2 Seasonal Migration

Studies over the last ten plus years have contributed valuable insights into the movement and behaviour of pygmy blue whales foraging and migrating through offshore waters of Western Australia. The East Indian Ocean (EIO) pygmy blue whale population is seasonally distributed from Indonesia (a breeding and potential feeding ground) to the southwest of Australia and east across the Great Australian Bight and Bonney Upwelling to beyond the Bass Strait (Blue Planet Marine, 2020). McCauley *et al*. (2018) describes three migratory stages around Australia for the EIO pygmy blue whale population: a 'southbound migratory stage' where whales travel southwards from

[2] Annual high use, known and possible foraging areas and areas of distribution as delineated in the CMP for blue whales

Indonesian waters through offshore Western Australian waters, mostly from October to December but possibly into January of the following year, a protracted 'southern Australian stage' (January to June) where animals spread across southern waters of the Indian Ocean and south of Australia, and a 'northbound migratory stage' (April to August) where animals meander back to Indonesia again. A satellite tagging study (Double *et al*. (2014) showed tagged whales travelled relatively near to the western Australian coastline (100±1.7 km) throughout March and April until reaching the North West Cape. The whales then travelled northwards and offshore (238.0±13.9 km from the coast) during May towards Indonesia and by June, whales were travelling through the Savu and Timor Sea. A migratory BIA is mapped in the NCVA, refer to **Figure 4-2** and the timing of the northbound and southbound migration periods for Western Australia are presented in Double *et al*. (2014) and Thums *et al*. (2022) satellite tagging studies have shown that EOI pygmy blue whale movement off north-west Western Australia is predominately fast, directed travel (modelled high move persistence) with an average migratory swim speed of 2.8±0.9 km hr^{-1} (Thums *et al*., 2022). Tagged pygmy blue whales have been estimated to swim at an average rate of 21 ±0.7 km per day on the northbound migration en-route to the documented migration terminus within the Banda Sea, Indonesia, where their movements indicate breeding and feeding (Double *et al*. 2014; Möller *et al.* 2020 and Thums *et al*., 2022). Southbound migration for EIO pygmy blue whales is less well documented, however acoustic recordings and limited telemetry data indicate a shorter, faster pulse (as compared to the northbound migration) through the offshore waters of north-west Western Australia in November and December (Thums et al., 2022).

Table 4-1 shows the migration periods of the East Indian Ocean pygmy blue whale population for Western Australia (including the Ningaloo Reef and Scott Reef) based on the available data on timing of northbound and southbound migrations detected via acoustic monitoring and based on telemetry data.

Table 4-1 Seasonality of the East Indian Ocean pygmy blue whale population from the North West Cape to Scott Reef, Western Australia. Sources: (Double *et al*., 2014; McCauley, 2011; McCauley *et al*., 2018)

Pygmy blue whale	J	F	M	A	M	J	J	A	S	O	N	D
Northbound migration												
Southbound migration												
Key												
Shoulder period												
Peak period												

4.3 Foraging

Blue whales are the largest animal known to exist and are long-lived. They have the highest known prey requirements of any predator, consuming up to two tonnes of krill per day (Commonwealth of Australia, 2015). Their feeding grounds are therefore required to be in areas of high primary productivity that can support sufficient densities of krill, such as oceanographic upwelling, or frontal systems. The feeding aggregation areas of known and high foraging activity (refer to **Figure 4-2**) for the EIO pygmy blue whale population are: (i) Perth Canyon and adjacent waters off Western Australia (Owen *et al*., 2016); (ii) the Great Southern Australian Coastal Upwelling System (GSACUS) (Möller *et al.,* 2020) including the Bonney Upwelling and other smaller upwelling centres off South Australia, Victoria and Tasmania (Gill 2011; McCauley *et al.,* 2018) and (iii) south of the southern Australian mainland and Tasmania along the sub-tropical convergence zone (Garcia-Rojas *et al.,* 2018) including the Bass Strait (Balcazar *et al*., 2015; McCauley *et al*., 2018). Photo-identification studies and genetic testing have confirmed within and between seasonal linkages of these foraging aggregation areas by individual whales (Garcia-Rojas *et al*. 2018; Attard *et al.* 2018). Additional possible foraging BIAs, Ningaloo Reef and Scott Reef within the Northwest Marine Region, are documented in the CMP **(Figure 4-1**). The delineated foraging and possible foraging areas documented in the CMP (Commonwealth of Australia, 2015) extend over vast offshore areas and the presence and numbers of pygmy blue whales within these change in respect to location and timing. This is primarily due to the availability of prey (krill) which is dependent on the inter-annual fluctuations in oceanographic processes supporting productivity in these areas.

Pygmy blue whale foraging behaviour is well documented for the known foraging areas (foraging BIAs) of the Great Southern Australian Coastal Upwelling System (GSACUS) and Perth Canyon. Key characteristics include:

- High numbers of pygmy blue whales recorded with the Perth Canyon area with 35 individual whales recorded on 33 sighting events over 21 days in 2011 (Double *et al*., 2012; Double *et al*., 2014) and 30 pygmy blue whales (13 tagged and 17 recorded by photo identification) over 21 days for the GSACUS (Möller *et al*., 2020).
- High pygmy blue whale occupancy, for example, within the GSACUS most tagged whales remained in the Bonney Upwelling and adjacent areas, utilising this region from at least January to July (Möller *et al*., 2020) and evidence from one individual tagged pygmy blue whale indicated extended periods, i.e., over a month, are spent within the wider Perth Canyon and Naturaliste Plateau region (Double *et al*., 2012; Double *et al*., 2014).
- Pygmy blue whale feeding behaviour includes surface and deep-dive lunge feeding strategies within these known foraging habitats, and modes of feeding change at different times of day (Owen *et al*., 2016; Möller *et al*., 2020). Furthermore, telemetry data reveals relatively short, intensive lunging behaviour when actively feeding within known foraging habitat with high prey availability, as recorded north of Perth Canyon (Owen *et al*., 2016).

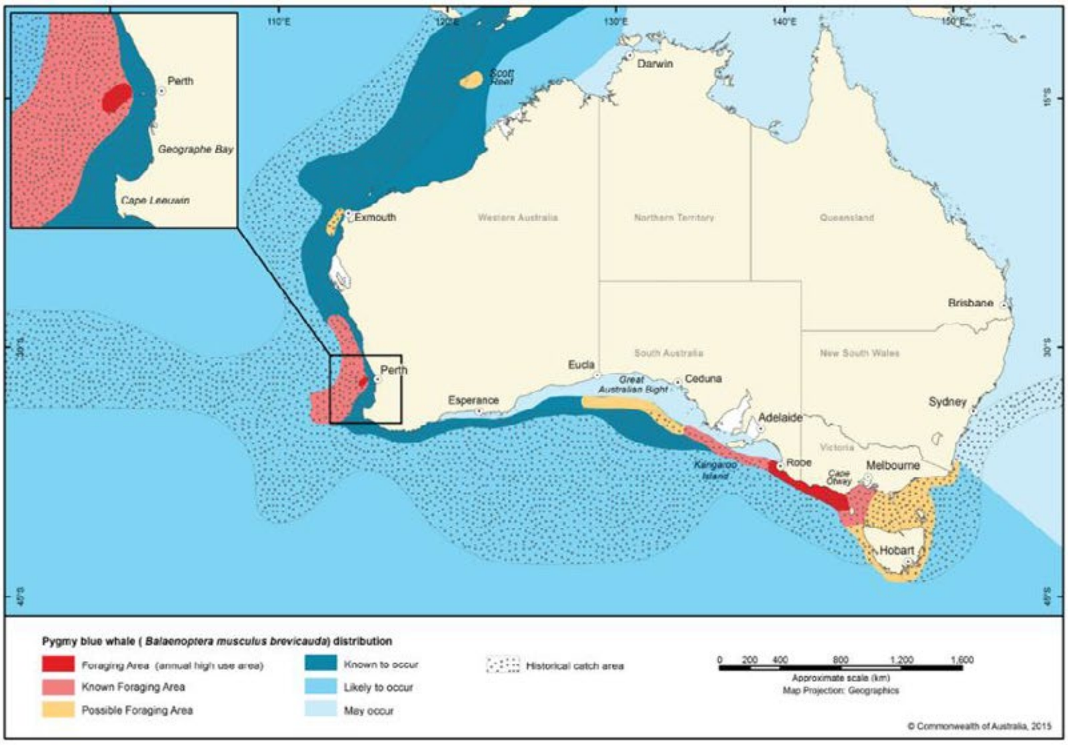
Satellite tagging and movement models have also afforded insights into shorter periods of lower travel rates and high turning angles (area-restricted search (ARS) indicating active foraging at Ningaloo (Double *et al*., 2014); north of the North West Cape and south of West Timor (Möller *et al*., 2020), and three main (extensive offshore) areas as indicated by lower move persistence (Thums *et al*., 2022): southern tip of Western Australia to offshore of Geraldton (including Perth Canyon and canyons to the south and north); Carnarvon to the Rowley Shoals (including Cape Range Canyon and Cloates Canyon and in Indonesian waters. Lower move persistence also overlapped with plateau features, including the Naturaliste Plateau (south-west) and the Exmouth Plateau (north-west), Thums *et al*., (2022). Modelled location estimates for the individual whales were primarily overlying slope waters. The foraging BIAs off North West Cape and Scott Reef only encompassed 7% of the most important foraging areas in the north-west of Western Australia. The home ranges and core-use areas modelled by Sahri *et al.,* (2022) indicated similar areas but the focus was on Indonesia and the analysis based only on the original subset of satellite tracks (Double *et al*., 2014). As observed by Möller *et al*. (2020), the traditional 'feast and famine' model for migrating baleen whales (capital breeders) may not apply to pygmy blue whales and the opportunity for supplementary (opportunistic) feeding during migration (north and southbound) may occur when oceanographic conditions support periods of high productivity and prey availability off the continental shelf of Western Australia. The defined EIOPBW migratory route IMMA (as defined by Marine Mammal Protected Area Task Force[3]) describes pygmy blue whales as income breeders adapted to exploit widely dispersed and ephemeral food sources.

4.4 Population Size

There are a number of data sources estimating the population of the EIOPBW. Abundance estimates based on photo-identification mark-recapture from 1999/2000 to 2004/2005 in the Perth Canyon are between 532 and 1,754 individuals (Jenner *et al.* 2008). These estimates match those (662 to 1,559

[3] https://www.marinemammalhabitat.org/portfolio-item/eastern-indian-ocean-blue-whale-migratory-route/ (accessed in May, 2022).

individuals) determined from acoustic studies in 2004 off the North West Cape of whales migrating southwards (McCauley and Jenner, 2010). Furthermore, a 1992/1993 cruise off southern Western Australia estimated 671 (95% interval 289–1,557) (Kato *et al*., 2007). More recent passive acoustic data estimates a 4.3% growth rate that applies to the proportion of EIO pygmy blue whales using the southeastern Australian coast and may not reflect the full population (whales travelling further west into the Indian Ocean) but does imply an increasing population (McCauley *et al*., 2018). What is not known, is the proportion of the total population these estimates encompass (Commonwealth of Australia, 2015). This is a complex issue as there is the potential for between-year differences in habitat use due to, for example, spatial and temporal differences in primary productivity between years which may bias estimates that are based on only one season of data collection. It is also unknown to what extent and what proportion of the pygmy blue whale population using the Australian feeding aggregations also use feeding habitat outside these areas, such as the relatively more productive Sub-tropical Convergence (Commonwealth of Australia, 2015).



Foraging Area (Annual high use area)	Blue whales are regularly observed feeding on a seasonal basis	Known to occur	Blue whales are known to occur based on direct observations, satellite tagged whales or based on acoustic detections
Known Foraging Area	Known foraging occurs in these areas but is highly variable both between and within seasons	Likely to occur	Blue whales are likely to occur based on occasional observations in the area and nearby areas
Possible Foraging Area	Evidence for feeding is based on limited direct observations or through indirect evidence, such as occurrence of krill in close proximity of whales, or satellite tagged whales showing circling tracks. Blue whales travel through on a seasonal basis, possibly as part of their migratory route	May occur	Evidence for the presence of blue whales through strandings or rare observations
		Historical catch area	Blue whales were caught during the whaling period based on whaling data

Figure 4-1 Distribution of and Biologically Important Areas for the pygmy blue whale, *B. m. brevicauda*, around Australia (Commonwealth of Australia, 2015)

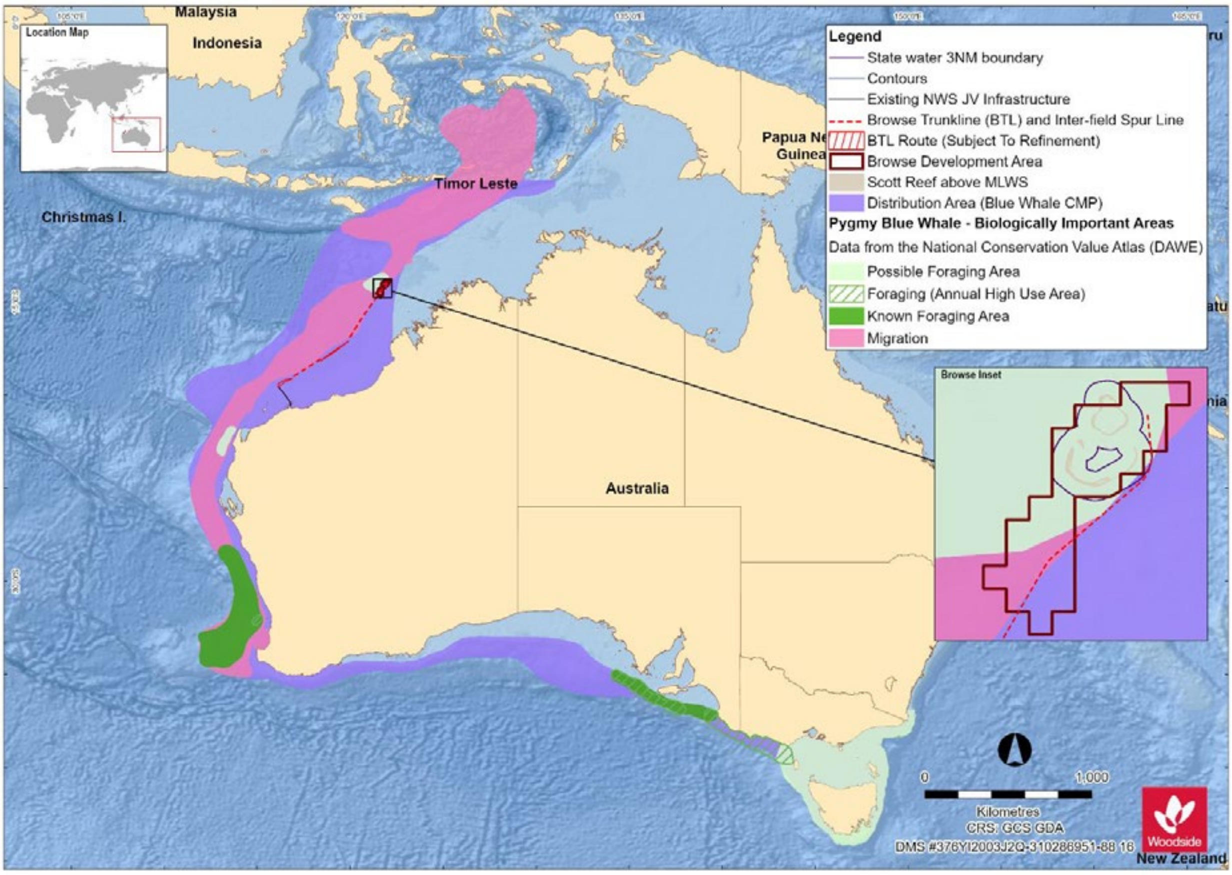


Figure 4-2 Distribution area and foraging/migratory BIAs for pygmy blue whales. Source: National Conservation Values Atlas (NCVA).

4.5 Pygmy Blue Whale Possible Foraging Area at Scott Reef

The possible foraging area at Scott Reef encompasses North and South Scott Reef and the deep-water channel between the reefs, as well as an extensive area of oceanic waters extending west of Scott Reef. The total area of the possible foraging area as defined in the Blue Whale CMP and NCVA at Scott Reef is 12,197.5 km^2. In relation to the proposed Browse Project, all of the drill centres in the Torosa field as well as the Torosa FPSO location are within the possible foraging area and the Torosa, Calliance and Brecknock development areas overlap the migratory BIA for pygmy blue whales (**Figure 4-3**).

Presence and Timing of pygmy blue whale*s at Scott Reef*

Detection of pygmy blue whales in and around the Scott Reef area during the northbound and southbound migration periods has been made over multiple years using both passive acoustic recordings and visual sightings.

The presence of EIO pygmy blue whales was consistently recorded using passive acoustics for the north and southbound migration periods in the Scott Reef Area, including the Scott Reef channel, separating North and South Scott Reef (McCauley 2011). A program of noise logger deployment (funded by the Browse JV) was conducted from 2006 to 2011 and the acoustic detection data acquired used to describe of the presence of whales, fish and anthropogenic noise within and surrounding Scott Reef. McCauley (2011) reported pygmy blue whales migrating through the Scott Reef region twice per year, northbound over mid-April to early August, with peak passage May and June (2007, 2008 and 2009) and southbound in October to December and potentially into January the following year, with peak passage in late October through November (listening period: 2006, 2007 and 2008), **Figure 4-4**. There was evidence for preferred routes used by pygmy blue whales around Scott Reef, primarily to the west of the reef system, based on northbound migration detection.

McCauley (2011) summarised the acoustic detection of pygmy blue whales from the Scott Reef dataset as follows:

- An extended northbound migration of pygmy blue whales past Scott Reef from mid-April to early August detected in 2007, 2008 and 2009. First and last detections 1st April and 14th August (for all PAM datasets).
- A southbound migration pulse of pygmy blue whales from October to mid-January (in 2006 and 2008 but not in 2007). First and last detections 6th October and 17th January (for all PAM datasets).
- No pygmy blue whales were detected inside the Scott Reef southern lagoon.
- Pygmy blue whales were detected travelling through the Scott Reef channel (separating North and South Scott Reef) on at least nine occasions between September 2008 and June 2009. Further analysis of detections for this same period showed 25 individuals were detected in the channel and of those, 14 were estimated to be whales in the middle of the channel.
- Acoustic detection recorded single calling pygmy blue whales 78% of the time but groups of two animals calling were also recorded (18% of the time).
- Inter-annual variability in whale detections were recorded reflecting variation in migratory routes and timing. An increasing number of whales over the 2007 to 2009 northbound migratory seasons and little detection of the southbound migratory pulse in 2007.
- Only between 6-40% of pygmy blue whales passing the North West Cape (Exmouth) pass by Scott Reef. The lower numbers of pygmy blue whales recorded off Scott Reef as compared to the North West Cape suggest only a fraction of the whales which pass up and down the Western Australian waters utilise the shelf break further north and that other migrating pygmy blue whale may move into deeper areas of the Indian Ocean further to the west.

Eight pygmy blue whales were sighted in the Browse basin and six of these whales were in the Scott Reef channel or in its proximity based on the results of dedicated surveys over a period from June 2008 to October 2010, representing over 700 hours of survey effort. Marine megafauna vessel and aerial-based surveys were conducted at Scott Reef and the wider Browse basin by dedicated marine scientists and trained observers (Jenner and Jenner, 2011; RPS Environment and Planning, 2010 and 2012; Sutton *et al*., 2019). The actual pygmy blue whale sightings were as follows:

Visual sightings from dedicated vessel and aerial surveys in 2008:

- A total of five pygmy blue whales sighted at Scott Reef in October 2008 and all on the same day:
    - On 30th October 2008, two blue whales were observed swimming through the Scott Reef channel from the eastern to western entrance. Three additional pygmy blue whales were then observed at the western entrance of the Scott Reef Channel (Sutton *et al*. 2019), refer to **Figure 4-5**.
- Jenner and Jenner (2011) observed one pygmy blue whale on the first day of aerial surveys over Scott Reef on 3rd August 2008; the individual was observed swimming northward <1 km from the western entrance of the channel between North and South Scott Reef.

Additional information:

- No pygmy blue whales were recorded during fine-scale transects carried out in the Scott Reef channel in early and late November 2008.
- Two additional sightings account for the total of seven pygmy blue whales as documented by Sutton *et al* (2019): one pygmy blue whale was observed approximately 200 km east of Scott

Reef in winter (June 2008) and one individual observed approximately 50 km northwest of Scott Reef in spring (November 2008).

In addition to the independent scientific surveys, dedicated marine fauna observer sightings as part of the environmental compliance for seven marine seismic surveys over the period 2005 to 2012 recorded a total of two pygmy blue whale sightings in proximity to Scott Reef (**Table 4-2**). The marine seismic surveys generally operated over the period August to November and employed dedicated and qualified marine fauna observers on watch during daylight hours, representing an estimated >4,500 hours of observation effort (based on 12 hour watch periods per day) during moderate to very good sea state.

Table 4-2 Woodside Marine Seismic Surveys at Scott Reef and surrounds (2005-2012)

Marine Seismic Surveys	Duration
Snarf 3D MSS (2005)	40 days
Torosa 3D MSS (2005)	26 days
Maxima 3D MSS (2007)	57 days
Gigas OBC MSS (2008)	30 days
Rosewall/Calliance 3D MSS (2007/2008)	179 days
Tridacna 3D OBC MSS (2011)	92 days
Rosebud 3D MSS (2012)*	19 days
*Pygmy blue whale sighting x1 (northeast of North Scott Reef in October 2012) and x1 sighting record from 2005 though report unconfirmed)	

Sightings data for a marine seismic survey south of Timor Leste provided evidence that the detection of high pygmy blue whale activity can be recorded by dedicated marine fauna observers as part of the environmental compliance for such surveys. Sightings data from a seismic survey conducted by ENI over a 22 day period in September 2007 off the south of Timor Leste, recorded 13 pods of blue whales (18 individuals) and 8 pods of unidentified large whales (which they concluded were also most likely to be blue whales), Eni Timor Leste (2007).

The far higher number of sightings during this short period south of Timor Leste in comparison to the sightings and acoustic detection at or in proximity to Scott Reef over multiple years indicates that although a number of pygmy blue whales do pass through the Scott Reef area seasonally, its relative importance to the EIO population is likely to be relatively low compared to other areas surveyed along the northbound migratory route. Thums *et al.* (2022) concluded that the importance of Scott Reef is not clear based on the collated analysis of all satellite tracked pygmy blue whale data. However, the regional wide collated Northwest Marine Region PAM data over a ten year period, showed highest effort but lowest call detection for the Scott Reef area in comparison to the southern North West Shelf offshore area (Thums *et al*., 2022).

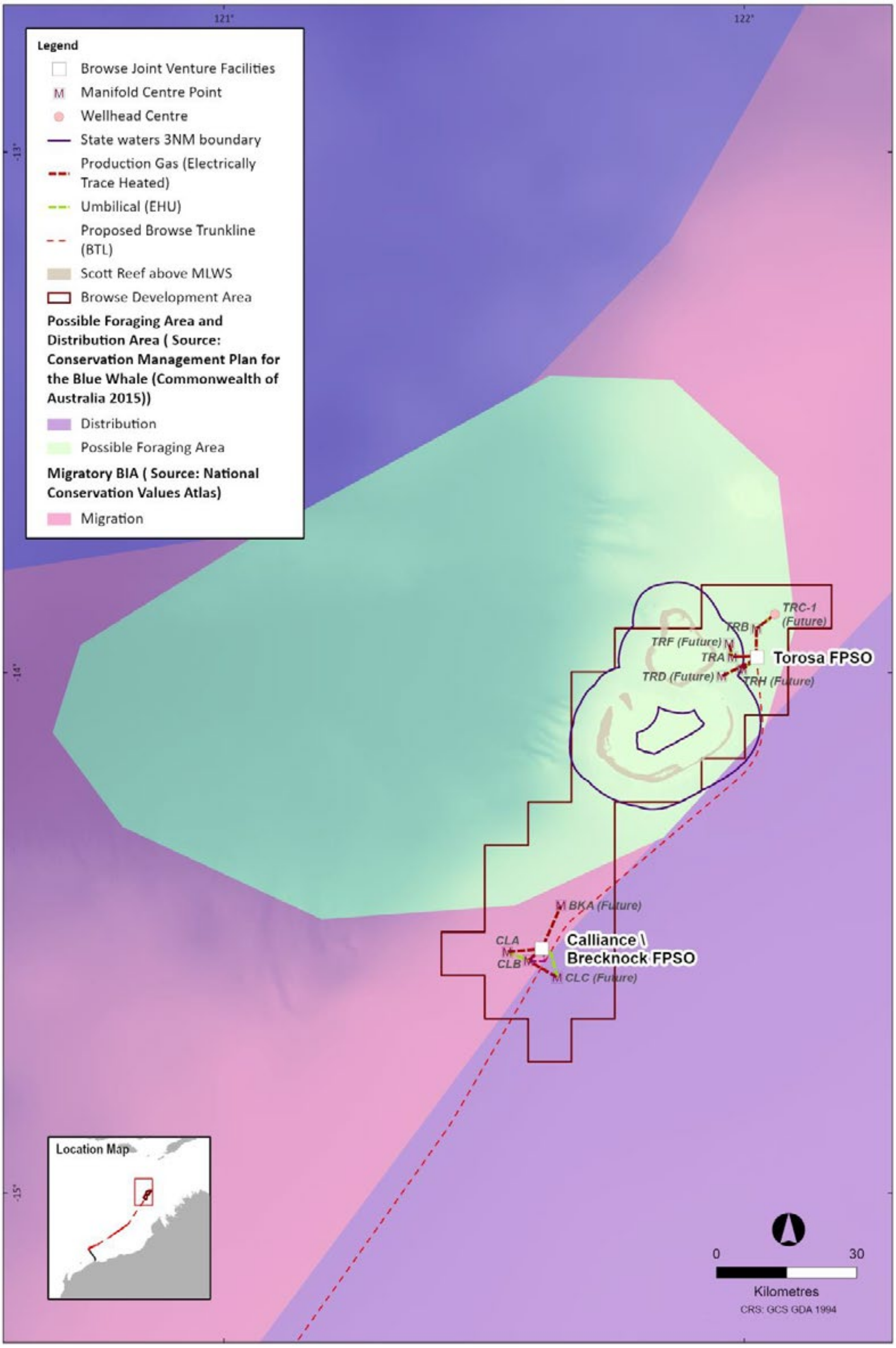


Figure 4-3 The possible foraging area (foraging BIA) for pygmy blue whales at Scott Reef, and migration and distribution BIAs, and the proposed Browse Development Area (source: CMP (Commonwealth of Australia, 2015) and NCVA (DAWE, 2021)

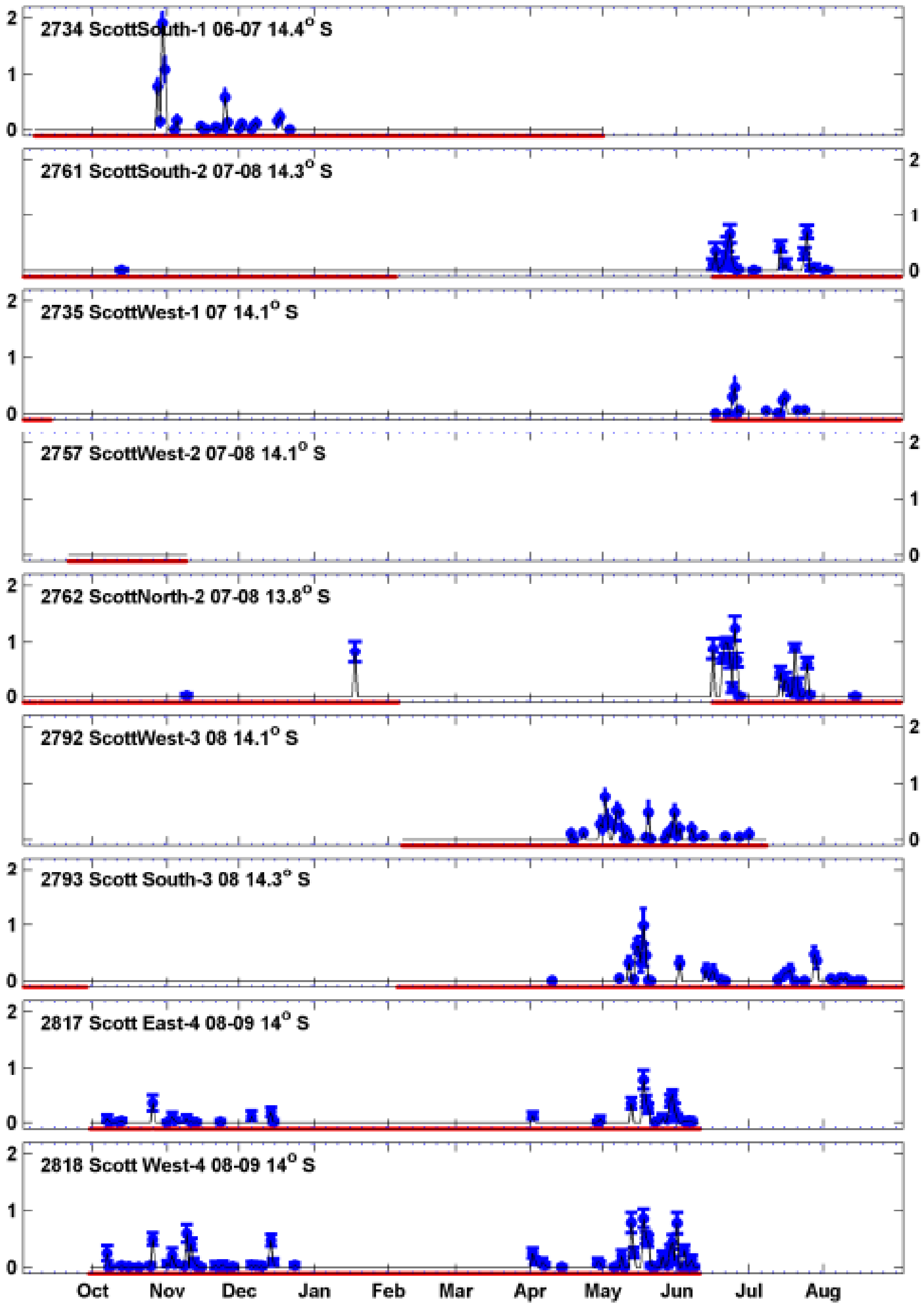


Figure 4-4 Numbers of individual pygmy blue whales calling per 200 seconds averaged in 24 hour periods 12:00 – 12:00 hours, for all Scott Reef logger data available, per calendar year. The full sampling period for each dataset is shown by the bottom red line. Minor tick marks are five day intervals. (McCauley, 2011)

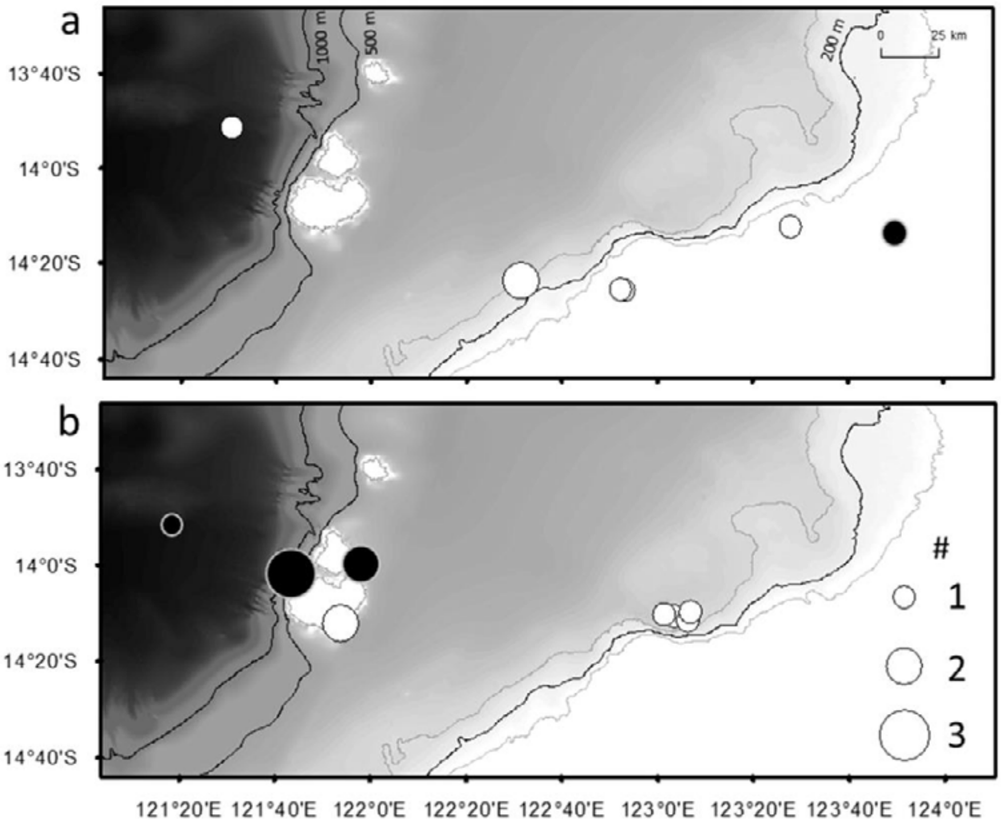


Figure 4-5 Locations of encounters and the number of individuals per encounter for *mysticetes* across the Browse Basin in a) winter b) spring 2008. Black circles indicate encounters of pygmy blue whales (Sutton *et al*. 2019).

4.5.1 Likelihood of Foraging Behaviour

The observed opportunistic feeding behaviour of migrating pygmy blue whales outside known foraging habitat (BIAs) combined with the documented annual spring productivity for the shelf edge of the Browse region and within the Scott Reef area, particularly the Scott Reef channel (Sutton *et al*. 2019) contributed to supporting the delineation of the possible foraging area at Scott Reef.

Scott Reef and the adjacent waters (extending to the west) are defined as a possible foraging BIA. A possible foraging area /BIA as defined in the Blue Whale CMP: "evidence for feeding is based on limited direct observations or through indirect evidence, such as occurrence of krill in close proximity of whales, or satellite tagged whales showing circling tracks". Unlike at the known foraging BIAs such as the Perth Canyon and the Bonney Upwelling, where foraging occurs over extended periods of time on an annual basis, pygmy blue whales at Scott Reef have not been directly observed foraging (no evidence of surface or deep dive lunge feeding). Pygmy blue whales have, however been sighted at Scott Reef (at the entrance and within the channel between North and South Scott Reef) during a spring period of elevated plankton biomass recorded for the wider shelf edge of the Browse region and live krill specimens collected from the central southern edge of the channel (Sutton *et al*. 2019). Evidence reportedly indicating possible foraging habitat and the opportunity for supplementary feeding by southbound migrating pygmy blue whales (Sutton *et al.,* 2019).

Evidence for predictable foraging habitat for pygmy blue whales within the possible foraging area at Scott Reef is unclear. The Scott Reef channel acts as both a conduit for focussing internal waves (solitons) and also as a generator of these waves, due to stratification of the water column and constriction due to being situated between North and South Scott Reef. The Scott Reef channel is a very high energy environment and is expected to be a dynamic environment where strong currents and tidal flow sweep through the inter-reef channel. Sampling of the deep water in the channel suggested that zooplankton were more concentrated in the mixed water layer (less than 100 m depth) than other locations in the area. The zooplankton samples were dominated by large copepods though six species of krill (euphausiids) were also recorded. Brinkman *et al*. (2010), however concluded it was unclear if krill species were at an abundance or density that would support pygmy blue whale feeding. The effects of emergent reefs and submarine features on localised primary productivity were noted in the Marine bioregional plan for the North-west Marine Region (Commonwealth of Australia 2012). A study by CSIRO (Schroeder *et al.,* 2009) indicated that the deep oligotrophic waters of the Indonesian Throughflow Current (ITF) are a barrier to convective upward mixing of nutrients in the region and therefore upwellings within this zone are unlikely to reach the surface, being limited to sub-surface waters above the thermocline. Instances of surface upwellings are likely to be the result of episodic oceanographic events as opposed to predictable seasonal occurrences (Schroeder *et al.,* 2009). Hence, surface chlorophyll values do not necessarily provide an accurate picture of the seasonal primary production that occurs in this region (Schroeder *et al.,* 2009). Nevertheless, the study did acknowledge that the structure of Scott Reef and its interaction with a variety of oceanographic processes may affect local productivity around the reef, with highly localised upwelling and downwelling processes influencing phytoplankton abundance (Schroeder *et al.,* 2009). Brinkman *et al*. (2010), showed horizontal and vertical mixing processes were at their highest within the Scott Reef channel due to the interaction of internal waves and semi-diurnal internal tide with the topography, and the enhanced mixing resulted in a broad chlorophyll maximum spanning a large proportion of the mixing layer below surface waters (25-125 m depth).

The delineated possible foraging area is a very large area with a conservative buffer and it is likely that in reality there are foraging pockets within this BIA associated with habitat suitability and oceanographic processes that periodically support prey availability. **Figure 4-6**, presents the bathymetry for the BIA area of Scott Reef showing the upper slope and canyon features to the west of Scott Reef, the Scott Reef system (including the inter-reef channel) and the deepwater, homogeneous (featureless) habitat of the eastern extent of the BIA, the proposed location of the Torosa field (proposed Browse Project). Modelling of the movement and behaviour of pygmy blue whales based on telemetry data for northbound migration tracks (Thums *et al.*, 2022) showed

89±9.3% of modelled location estimates were overlying slope waters indicating extensive use of the slope habitat by migrating pygmy blue whales off Western Australia. Most important foraging areas as modelled by Thums *et al.* (2022) included the shelf edge from Ningaloo to Rowley Shoals. Adopting the slope habitat as a predictor of habitat suitability would indicate the outer slope with canyon features on the western side of Scott Reef probably has a higher likelihood of seasonal prey availability and foraging habitat for pygmy blue whales. The surrounding open water environment of the eastern extent of the BIA (east of Scott Reef) represents a deep water, homogeneous sediment seabed habitat with a lack of geomorphological seabed features. If krill swarms are present within the water column of this open water environment, they are likely to be ephemeral and patchy in nature, and any pygmy blue whale foraging occurrence is expected to be of a low likelihood and opportunistic in nature.

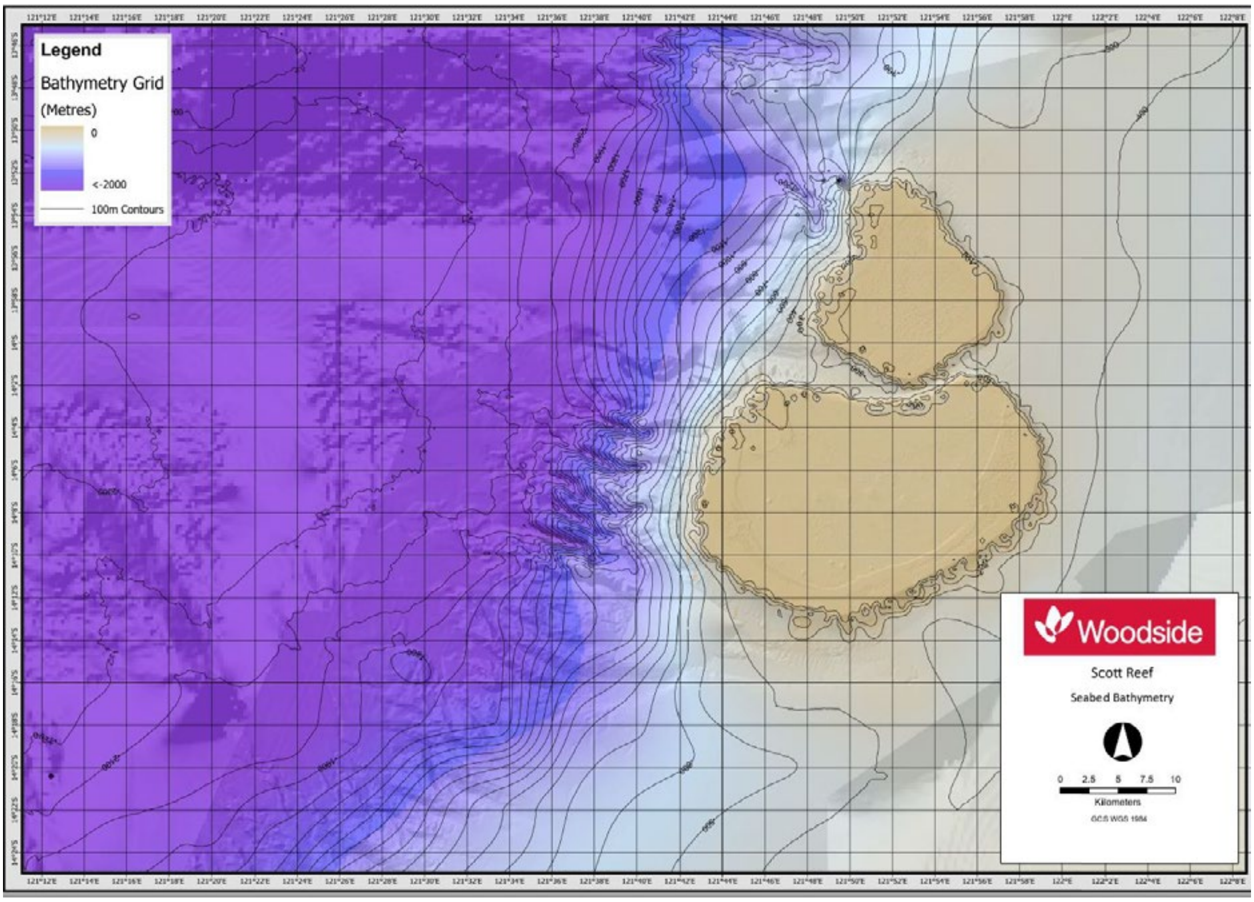


Figure 4-6 Bathymetry and geomorphological Scott Reef structure across the west-east extent of the Scott Reef possible foraging area.

4.5.2 Scott Reef Possible Foraging Area Conclusions

North and southbound pygmy blue whales are known to migrate on an annual basis through the Scott Reef possible foraging area on their way to and from breeding and feeding grounds within the Banda Sea, Indonesia. The migratory seasons are defined by shoulder and peak periods and exact timings can vary inter-annually.

Blue whales travel through the Scott Reef possible foraging area on a seasonal basis as part of their migratory route to and from the Banda Sea. However, existing knowledge of pygmy blue whale relative abundance, movement and behaviour (ENI Timor Leste 2007; McCauley 2011, Double *et al*. 2014; Möller *et al*. 2020 and Thums *et al*., 2022) suggests that visitation rates and residence times are likely to be markedly lower than other known and possible foraging areas to the southwest such as Ningaloo and the Perth Canyon.

Evidence collected to date from a variety of techniques including sampling of zooplankton, pygmy blue whale vocalisation data from noise loggers, survey observations and satellite tag tracking suggests that Scott Reef is likely to be of less importance for the East Indian Ocean (EIO) pygmy blue whale population than other defined foraging areas. However, the relative importance of the entire Scott Reef possible foraging area or areas within it as foraging habitat for migrating pygmy blue whales remains unclear and as such the possible foraging area will be managed as a known foraging area for the purposes of the proposed Browse Project.

In known foraging BIAs such as the Perth Canyon and GSACUS pygmy blue whales can be observed in predictable annual higher abundance, exhibiting foraging behaviours and have extended residence times albeit over extensive areas of coastal or offshore waters. These observations, behaviours and residence times are not replicated at Scott Reef, despite dedicated, multi-year studies over an extended period, using multiple survey and sampling techniques. This leads to the conclusion that if foraging by pygmy blue whales does occur within the wider Scott Reef possible foraging area it is likely that this is opportunistic foraging only, commensurate with the classification of the pygmy blue whale as an income breeder. Based on Sutton *et al.* (2019), who inferred that a predictable spring period of higher productivity occurs within the Scott Reef channel support foraging by pygmy blue whales. A higher relative importance of the Scott Reef channel as a potential foraging habitat within the Scott Reef possible foraging area, particularly, for southbound migrating pygmy blue whales has been adopted within this plan underpinning the adaptive management regime for underwater noise emissions and potential impacts to pygmy blue whales.

5. CHARACTERISATION OF UNDERWATER NOISE

Underwater noise emissions will occur during all stages of the proposed Browse Project. Activities potentially generating underwater noise emissions have been separated into four categories, which aligns to the way in which management measures are applied within this plan. The four key categories and specific noise generating sources in each category are as follows:

- **Subsea and FPSO Construction and Installation**
    - Construction vessels, including
        - Offshore Installation Vessels, including flexible flowline installation vessels, used to install flowlines and other subsea infrastructure (e.g. umbilicals, x-mas trees)
        - Rigid pipelay vessels, used to install the Browse Trunkline and interfield line
        - Anchor holding tugs, used to hold the FPSO in position while permanent anchors are installed
- **Drilling and completions**
    - Mobile offshore drilling unit (MODU) topsides drilling & completion activity and associated facility noise
    - MODU (dynamic positioning system noise)
    - Operation of offshore support vessels (OSVs) to support MODU operations (e.g. goods transfer)
- **Operations**
    - FPSO topsides processing and associated facility noise
    - FPSO thrusters, used for heading control
    - Operation of OSVs to support the FPSO operations (e.g. transferring goods and equipment to the FPSO)
    - Condensate offtake activities, involving a condensate tanker and OSV
    - Well head choke valves
- **Impulsive Noise Source Activities**
    - Impact (hammer) piling
    - Subsurface evaluation using well bore seismic imaging techniques (e.g. vertical seismic profiling)

Sounds source level estimates for various activities/scenarios and these are provided in **Table 5-1**. Supporting information regarding sound source level estimates for each activity is described in **Section 5.1**.

Table 5-1. Sound source level estimates from key Project activities

Sound Source	Sound Level Estimate (dB re 1 µPa·m)	Comments
SURF and FPSO Installation		
Offshore installation or flexible reel-lay vessel (e.g. flowline installation) [1]	181	Short term (1 week per flowline + 1 month for other infrastructure).
FPSO Mooring and subsea Hookup (approx. 4 vessels) [2]	5 x 184	Short term (1 month for FPSO, 2 months for subsea hookup)
Rigid Pipelay Vessel, considering attendant support vessels [3]	191	Short term (2 weeks), estimate includes a single B-type vessel alongside
Drilling and Completions		
MODU (moored) [4]	171	
MODU (moored, with OSV alongside for resupply) [4], [5]	182	Short term (12 hours).
MODU (Using Dynamic Positioning (DP)) [6]	183	
MODU (Using DP, with OSV alongside for resupply) [5], [6]	185	
Operations		
FPSO (No thrusters) [7]	174	
FPSO (Offtake) [5]	186	
FPSO (OSV Resupply, no thrusters) [5], [7]	182	
FPSO (50% thrust) [8]	183	Does not consider available design mitigations.
FPSO (100% thrust) [8]	189	Does not consider available design mitigations.
FPSO (50% thrust + OSV resupply) [5], [8]	185	
FPSO (50% thrust with design mitigations incorporated) [9]	178	Design mitigations for the FPSO thrusters are as described in **Section 8.3**.

FPSO (50% thrust + OSV resupply, with design mitigations incorporated) [5], [9]	183	Design mitigations for the FPSO thrusters are as described in **Section 8.3**.
Wellhead Choke Valves (Excluding design mitigations) [10]	161.5	Design mitigations, not accounted for here, are described in **Section 8.3.**
Offshore support vessel (During Offtake) [5]	186	
Offshore support vessel (During Resupply) [5]	181	
Impulsive Noise Sources		
Vertical Seismic Profiling	Refer Table 5-2	
Driven Piling	185–199 re 1 µPa2·s at 10 m (IHC S-600 and IHC S-1200 hammers, respectively)	Further mitigations can be applied as described in **Section 8.**

[1] Based on *Deep Orient*. Quijano and McPherson 2021.

[2] Based on *Katun*. Hannay et al 2004.

[3] Based on *Castarone and B-Type*. Brodin et al 2022.

[4] Based on *Transocean Polar Pioneer*. Austin et al 2018.

[5] Based on *Fugro Etive.* Brodin et al 2022.

[6] Based on *DPS-1*. Brodin et al 2022.

[7] Based on *Nganhurra* and *Ngujima Yin*. Erbe et al 2013.

[8] Modelled based on example thruster without further design mitigations. Brodin et al 2022.

[9] Estimated based on example thruster with design mitigations. Brodin et al 2022.

[10] Based on supplier estimates.

[11] Estimated by McPherson et al 2019.

[12] Estimated by McPherson et al 2019.

5.1 Information Supporting Sound Source Estimates

5.1.1 SURF and FPSO Construction and installation

The initial (pre-RFSU) construction and installation of subsea and FPSO facilities at the Torosa field location extends for approximately two years (see **Section 2.4**). Various construction vessels will be used for the construction phase of the proposed Browse Project. The operation of motorised vessels involves numerous mechanical processes which create underwater sound as a by-product; these range from sound of the propeller, cavitation caused at the propeller edges, machinery or simply the flow noise of the vessel moving through the water. Sound emitted from vessel differs strongly depending mainly on size, speed, load, type and state of propulsion system, meteorological and oceanographic factors such as sea surface conditions and currents (MacGillivray *et al*. 2018).

Offshore installation vessels (for installation of SURF infrastructure)

Underwater noise from a representative construction vessel (Deep Orient) was measured during DP trials to have sound pressure source levels in the range of 180-182 dB re 1 µPa·m (JASCO 2021).

Rigid pipelay (for installation of the Interfield line)

A rigid pipelay vessel will be required to lay the inter-field spur line between Calliance and Torosa. There is a limited pool of vessels that can lay the inter-field spur line given its size and the water depth. A DNV 2021 underwater noise analysis of thruster usage of the *Castorone* is considered representative of the underwater noise generated by the rigid (interfiled line) pipelay vessel. This analysis estimated an underwater source noise of 191 dB re 1 µPa·m for the dynamic positioning system of the *Castorone* (with a *B-type* vessel alongside). Other vessels when required to work in the vicinity of the rigid pipelay vessel may result in increased sound levels, however these represent short term increases on an already short term activity (two weeks).

Anchor handling (for holding the FPSO in position while permanent anchors are connected)

For FPSO hookup, it is anticipated that approximately four anchor handling vessels would be required. A representative anchor handler (*Katun*) was measured during anchor pull to have sound pressure levels of 184.4 dB re 1 µPa·m (Hannay *et al* 2004).

5.1.2 Drilling and Completions

5.1.2.1 MODU operation

The proposed Browse Project is expected to use a semi-submersible MODU for drilling and completions activities. The noise emissions from a MODU primarily depend upon whether the MODU is moored or using a dynamic positioning (DP) system to hold station (i.e., a constant position to allow for safe operation). The broadband drilling source levels (i.e., noise generated when the facility is moored and does not use DP to hold station) reported in Austin *et al*. (2018) was 170.1 dB re 1 µPa·m for a semi-submersible MODU.

If the propulsion system of a vessel is under heavy load (acceleration, DP) the sound produced by the cavitation process on the propellers will dominate other sources of vessel sound (machinery, hull vibration, etc.). However, the source level depends upon the thruster design, the total number of thrusters and the load placed on each, and as such will change depending upon environmental conditions.

For the proposed Browse Project, a preliminary Dynamic Positioning Analysis has been completed using metocean data to determine the amount of thrust required for a DP MODU to hold position at Torosa drill centres. The DP Analysis utilized metocean data specific to the TRD location and the hull dimensions of a DP MODU that is representative of a typical DP MODU that may be used for the proposed Browse Project. The Dynamic Positioning Analysis concluded that a typical DP MODU designed with eight 3.8 MW thrusters would only require 40% of four thrusters to safely maintain position in a 1-year return period non-cyclonic condition, which would result in an underwater sound source level of approximately 183 dB re 1 µPa·m.

5.1.2.2 Offshore Support vessels

Updated analysis by DNV for the proposed Browse Project based on the *Fugro Etive* indicates a representative mean source level (MSL) of 185.5 dB re 1 µPa·m, when the *Fugro Etive* is in an offtake arrangement.

During a resupply activity where an OSV is holding a steady position alongside another vessel (e.g., MODU, FPSO or construction vessel) to which goods are being transferred, an OSV is required to utilise its DP system to maintain a steady position. During resupply, an OSV is estimated to have an individual sound source level of 181.3 dB re 1 µPa·m, based on analysis by DNV.

The discrepancy between noise levels in the offtake arrangement and the OSV resupply is based on different expected levels of thruster utilisation, which is based on marine operational advice. The azipull thrusters (at the stern) are primarily used for propulsion, as opposed to the bow/retractable thrusters which are primarily used for dynamic positioning. During OSV resupply, the propulsion thrusters are typically used less than the dynamic positioning thrusters. This is different from OSV use during offtake scenarios where the OSV applies force to maintain tension in the offtake arrangement, and therefore the propulsion thrusters are utilised at higher levels.

5.1.3 Operations

5.1.3.1 Torosa FPSO (Standard operations without using thrusters for heading control)

In the majority of weather conditions, no mechanical propulsion will be required to hold the Torosa FPSO in the correct position for safe operation, so any noise from the facility will be from the propagation of vibration from mechanical equipment (e.g. compressors, pumps) through the vessel hull and into the water column. The FPSO will weathervane (freely move) on the turret mooring during this time.

The vessel type and specifications of the Torosa FPSO are similar to the Woodside FPSO facilities *Ngujima Yin* and *Nganhurra*, from which JASCO gathered measurements in 2010 (Erbe et al. 2013). The measured spectra for these two vessels were averaged and used as a surrogate for the FPSO facility. Because the *Ngujima Yin* and *Nganhurra* were moored, they were not offloading, and the weather was calm, they were not using any form of position or propulsion system when they were measured. The only noise being generated from these vessels was from topsides mechanical noise and facility vibration, representative of what would be typically expected to occur from the Torosa FPSO. These averaged source levels were used in this report to model FPSO operations without using thrusters. The draft EIS/ERD characterised the FPSO sound source levels without thrusters as 174 dB re 1 µPa·m.

5.1.3.2 FPSO using thrusters for heading control

For certain discrete activities, it may be advantageous to use the FPSO's thrusters to hold the FPSO on an optimal heading (e.g., to prevent unplanned FPSO movements during helicopter approach). The proposed Torosa FPSO facility is a turret moored production vessel, with thrusters to assist with operational heading control. It is approximately 370 m long and 67 m wide with a draft of 16 m. Each of the Torosa FPSO's thrusters is anticipated to be rated at 3 MW.

For the draft EIS/ERD, the underwater noise sound source level was estimated considering only the FPSO thruster power as the design of the FPSO thrusters were at a limited stage of maturity. It should be noted that the estimate considered the power of the thrusters at the time, which was two 5 MW thrusters. The assessment considered the two thrusters had a collective sound source level of 189 dB re 1 µPa·m, when the thrusters were used at 50% utilisation.

The DNV Propellor Underwater Noise Modelling (DNV 2021) for the FPSO considered a more refined FPSO thruster design (2x3 MW) as well as general parameters for a typical propellor that may be used for the Torosa FPSO. The typical propellor parameters (revolutions per minute, number of blades and diameter) were based on indicative standard propellor designs currently considered by the proposed Browse Project. It should be noted that propellor vendor selection has not been finalised.

The DNV Propellor Underwater Noise Modelling study shows that the two thrusters with reduced power (i.e. 3 MW as opposed to 5 MW assumed in draft EIS/ERD) resulted in a collective sound source level for the FPSO of 183 dB re 1 µPa·m (inclusive of machinery noise). This is at the comparable thruster utilisation of 50% which aligns to the management approach for the peak pygmy blue whale seasons outlined in **Section 8**.

Further, the DNV Propellor Underwater Noise study provided a preliminary analysis on mitigations that may be incorporated into the design of the FPSO thrusters to further reduce underwater noise. The study considered three key mitigation options:

- decrease propellor tip load factor from 100% up to 70%: Up to 5 dB reduction
- increase propellor diameter from 3 m to 4 m: Up to 8 dB reduction
- increase the number of propellor blades from 4 to 6: Up to 4 dB reduction.

It should be noted that the DNV Propellor Underwater noise study considered mitigations from a hypothetical perspective without engagement from propellor vendors, and therefore the technical feasibility of these mitigations have not yet been demonstrated. Future design work will involve engagement of propellor vendors to determine the feasibility of including these mitigations in design. The potential mitigations are cumulative, i.e., if all the mitigations were applied to the fullest modelled extent this may result in a total underwater noise source level reduction of up to 16 dB.

5.1.3.3 Supply vessel operations supporting FPSO

During the Operate phase, support vessels will be required to transport goods to and from the Torosa FPSO. There are anticipated to be up to six supply runs per month at the Torosa FPSO, with offloading expected to take around six hours, but would occur for no more than 12 hours.

During support vessel operations, it will be necessary for the Support Vessel to use its dynamic position system to stay in a safe position during the supply operation. In rare conditions, the Torosa FPSO itself would also need to use its thrusters for heading control, if the supply vessel DP was insufficient to remain in a safe location for the activity to occur.

Individual sound source levels for OSVs servicing the FPSO are the same as for the OSVs servicing the MODU (refer **Section 5.1.2.2**).

5.1.3.4 FPSO conducting condensate offtake

In the draft EIS/ERD, operational noise during offtake was described as having two noise sources during the offtake activity; the FPSO thrusters (at 2x5 MW) and an OSV's DP system. As described in **Sections 5.1.3.2** and **5.1.3.3**, in the draft EIS/ERD sound source level for these vessels were 189 dB re 1 μPa·m and 183 dB re 1 μPa·m, respectively.

Further, advice from Woodside's marine operational experts has confirmed that FPSO thrusters are seldom used during the offtake arrangement. Thrusters may be used temporarily to assist with offtake hookup (e.g. during the first two hours of the activity), however once the offtake tanker is hooked up and the OSV is maintaining tension on the offtake tanker, the FPSO does not use thrusters and instead weathervanes. Circumstances in which the FPSO would require considerable thrust are exceptional. The OSV is characterized as having a sound source characterization of 185.5 dB re 1 μPa·m during this activity based on the DNV Propeller Underwater Noise Study.

5.1.3.5 Subsea infrastructure operation (wellheads - choke valve)

Noise will also be generated during hydrocarbon extraction as a result of the operation of the well heads and subsea infrastructure. This infrastructure is located on the seabed in deep water (ie noise from operation of the TRD well heads is being generated at ~385m below the surface). In the draft EIS/ERD, the characterisation of underwater noise associated with subsea wellheads was based on McCauley (2002), who recorded noise from an oil producing subsea wellhead associated with the Cossack Pioneer FPSO and estimated the broadband source level to be 161.5 dB re 1 μPa·m (SPL).

Subsea choke valve noise propagation was undertaken as part of a previously proposed Development Concept. The modelling was undertaken based on the TRD drill centre location (Duncan, 2011). Underwater noise from subsea wellheads was modelled to determine the geographical range over which noise from the proposed Browse project subsea wellheads might be expected to occur (Duncan, 2011). The source level recorded by McCauley (2002) (ie 161.5 dB re 1 μPa·m) was used in the modelling. The modelling was based on a configuration of seven wellheads at the TRD drill centre, spaced 20 to 40 m apart and 4.5 m above the seabed in a water depth of approximately 400 m.

Modelling completed by Duncan (2011) shows that noise levels typically fall below 120 dB re 1 uPa m within 500 m of the wellheads. It should be noted that 500 m is a horizontal distance considering the loudest point in the water column (which for a wellhead is close to the seabed). The behavioural threshold of 120 dB is not reached at the surface according to Duncan (2011) modelling, instead extending up to between 100m and 50 m below the surface (**Figure 5-1**).

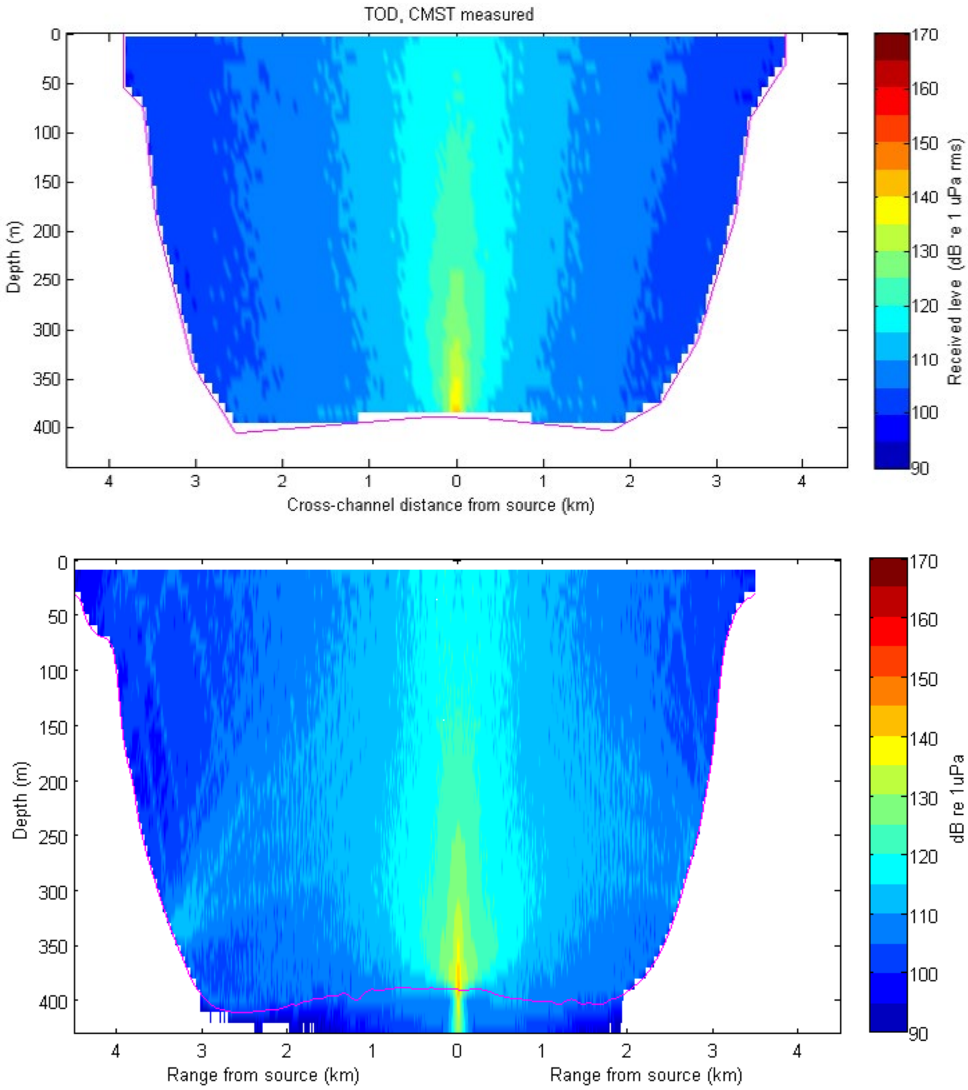


Figure 5-1 Estimated received levels within the channel at the TRD location based on a choke valve noise from seven well heads, each estimated at 161.5 dB re 1 μPa·m. Top plot was calculated by image method, bottom plot using Parabolic equation. Details in Duncan, 2011.

To increase confidence in the characterisation of underwater noise associated with subsea wellheads, the two subsea equipment vendors currently considered for the procurement of the proposed Browse Project subsea infrastructure were commissioned to determine the amount of underwater noise associated with their specific well head design for the anticipated range of flow properties.

The two vendors provided an analysis of noise conducted in accordance with the 3rd edition of the IEC 60534-8-3 Standard. It should be noted that IEC 60534-8-3 is a recognised international standard for calculating noise from choke valves for safety management purposes in atmospheric conditions, with a confidence interval of +/- 5 dB based on empirical data. Appropriate factors were applied to account for the different acoustic impedance of air and seawater, as well as accounting for the different pressure reference values used for safety risk assessments and underwater noise environmental impact assessment.

Both vendors found that under all expected operational conditions, the expected underwater noise emitted by a subsea choke valve is below 161.5dB re 1μPa.m.

Further, both vendors were invited to propose further underwater noise emissions reductions techniques that could be applied to the wellhead or choke valve to reduce underwater noise. Vendors arrived at different potential solutions to mitigating underwater noise, with focus on application of either increased pipe wall thickness or acoustic insulation. The further investigation and application of these mitigations are discussed in **Section 8**.

It should be noted that at the current level of engineering design maturity, there remains some uncertainty in the estimated underwater noise source levels including benefits of identified mitigations. Further design work in FEED will be able to more accurately determine the underwater noise reduction estimate.

5.2 Impulsive noise – impact piling & vertical seismic profiling

5.2.1 Driven Piling Activities

An acoustic modelling study developed for the draft EIS/ERD predicted that for piling for the FPSO mooring broadband (10 Hz to 25 kHz) sound energy at 10 m for each penetration depth will range from 184.6–199.4 dB re 1 µPa2 · s (inclusive of both IHC S-600 and IHC S-1200 hammers) with the peak sound energy concentrated in the frequency range 70 to 300 Hz, with levels from the pile at the shallowest modelled penetration depth having the highest energy. Although highly unlikely, impact piling may be required for mooring the MODU, however if required these piles are expected be significantly smaller than those used for the FPSO mooring system.

5.2.2 Vertical Seismic Profiling

Well bore seismic imaging techniques, including Vertical Seismic Profiling (VSP), use a small seismic airgun array. This assessment considered a 750 in^3 array operated at 6 m with a broadband (10–25,000 Hz) unweighted per-pulse SEL source level of 214 dB 1 µPa^{2}m^{2}s in the broadside and endfire direction (McPherson et al., 2019) The well bore seismic process is repeated as required for different stations in the well. Specifications for the 750 in^3 array are summarised in **Table 5-2**.

Table 5-2 Far-field source level specifications for the 750 in^3 array, for a 6 m operational depth. Source levels are for a point-like acoustic source with equivalent far-field acoustic output in the specified direction. Sound level metrics are per-pulse and unweighted.

Direction	Peak source pressure level ($L_{S,pk}$; dB re 1 µPa·m)	Per-pulse source SEL ($L_{S,E}$; dB 1 µPa^{2}m^{2}s)	
		10–2000 Hz	2000–25,000 Hz
Broadside	239.8	214.0	168.7
Endfire	240.1	214.1	175.3
Vertical	239.7	214.0	173.2
Vertical (surface affected source level)	239.7	216.2	176.1

6. NOISE MODELLING RESULTS

6.1 Overview

Noise propagation modelling results are presented within the EIS/ERD for a number of the key project activities/ To inform this management plan, noise propagation from additional project activities were modelled, or modelling revised, based on controls identified within this plan.

Supporting this modelling was detailed analysis on the noise (and potential mitigations) that would be generated by key proposed Browse Project activities including FPSO, MODU and OSV (DNV (2021 & 2022). The result of this analysis is presented in **Section 5.1.2** and **5.1.3**.

Updated estimates of the potential distance at which relevant sound exposure levels as relevant to pygmy blue whales (See Section 3.8) are presented in **Table 6-1**. Results are presented as the distance (maximum radius (R_{max})) from an activity at which these sound levels would potentially be received. Modelling outputs are from Green *et al* (2022a and 2022b **Appendix A and B** respectively) and where necessary have been used to interpolate distances for activities where relevant analogues were available. All results are estimates as final activity/vessel selection has not occurred and would be updated and validated, as outlined in Section 11.

Activities which did not generate noise above 120dB anywhere within the Scott Reef possible foraging area are not presented here but are shown in the Browse to NWS Project draft EIS/ERD (as modelled by McCauley 2019).

Table 6-1 Summary of estimated SPL Maximum-over-depth horizontal distances to pygmy blue whale behavioural response threshold (120 dB re 1 µPa) and LF cetacean injury (TTS) threshold

Sound Source	Distance to Behavioural Impact Threshold (R_{max})	Distance to TTS (injury – $SEL24_h$) threshold (R_{max})	Comments
Subsea and FPSO Construction and Installation			
Offshore installation or flexible reel-lay vessel (e.g. flowline installation)	2.2 km [1]	0.46 km [1]	
FPSO Mooring and subsea Hookup (approx. 5 vessels)	2.44 km [1]	0.53 km [1]	Cumulative impacts of up to five vessels considered
Rigid Pipelay Vessel, considering attendant support vessels (Used for BTL/IFL installation)	9.9 km [1]	2.16 km [1]	Cumulative impact of installation and support vessel considered
Drilling and Completion Activities			
MODU (moored)	0.49 km [2]	130 m [2]	
MODU (moored with OSV alongside for resupply)	2.3 km [2] - TRA 3.1 km [2] - TRD	0.35 km [2]	Resupply predicted to take between 6 and 12 hours

Sound Source	Distance to Behavioural Impact Threshold (R_{max})	Distance to TTS (injury – $SEL24_h$) threshold (R_{max})	Comments
MODU (Using Dynamic Positioning to hold steady position (DP))	4.5 km [2]	0.51 km [2]	
MODU (Using DP, with OSV alongside for resupply)	5.5 km [2]	0.58 km [2]	
Operations			
FPSO (No thrusters)	0.57 km [3]	90 m [3]	
FPSO (Offtake)	2.7 km [2]	0.63 km m [2]	
FPSO (OSV Resupply, no thrusters)	2.3 km [1]	0.5 km [1]	
FPSO (50% thrust)	2.8 km [2]	0.46 km [2]	Does not account for design mitigations.
FPSO (100% thrust)	8.8 km [3]	1.5 km [3]	
FPSO (50% thrust with OSV alongside)	3.9 km [1]	0.7 km [1]	FPSO thrusters would not typically be required, this is an unlikely activity. Does not account for design mitigations.
FPSO (50% thrust with design mitigations incorporated)	1.7 km [2]	220 m [2]	Estimate assumes target design mitigations are achieved
FPSO (50% thrust with design mitigations incorporated and OSV alongside)	2.5 km [1]	0.5 km [1]	Estimate assumes target design mitigations are achieved
Wellhead Choke Valves at each well centre	0 m (At surface) 0.5 km (At seabed) [4]	<100 m [4]	Does not consider design mitigations. Distance is per drill centre, which may include up to 6 wells online at any time
Offshore support vessel (In Transit)	2.3 km [3]	0.4 km [3]	
Impulsive Noise Source Activities			
Vertical Seismic Profiling	1.6 km [3]	1.7 km [3]	

Sound Source	Distance to Behavioural Impact Threshold (R_{max})	Distance to TTS (injury – SEL24$_h$) threshold (R_{max})	Comments
Driven Piling	17.2 km [3]	29.5 km [3]	

[1] Green et al 2022b. JASCO Modelling Report #02742 (**Appendix B**).

[2] Green et al 2022a. JASCO Modelling Report #02589 (**Appendix A**).

[3] McPherson et al 2019. JASCO Modelling Report #01824

[4] Duncan 2010. Appendix F14 to Browse FLNG EIS. Note distance to TTS interpolated based on comparing behavioural and TTS R_{max} ranges from [1], [2] and [3].

6.2 Noise Modelling Uncertainty

All modelling inherently involves a degree of uncertainty and real-world outcomes can be expected to deviate from modelled results. Modelling underwater noise associated with sound sources is complex, as the amount of sound generated changes with different thruster utilisation (which may vary as metocean conditions and activity requirements change). It should also be noted that while 120 dB re 1 µPa has been selected as the behavioural response threshold in accordance with well-established impact assessment practice, behavioural response is not binary.

In order to manage these uncertainties, results presented in **Section 6** are presented with the following conservatisms:

- Modelling is based upon highly conservative estimates of the underwater noise sources, which are unlikely to be exceeded throughout field life. Therefore, modelling results should be interpreted as representative of worst-case conditions, not of normal year-round conditions. Further details are described in **Section 5**.
- *Example 1: MODU Dynamic Positioning Thruster Utilisation is modelled based on the amount of thrust required for the MODU to maintain station in worst case 1-in-1 year return period metocean events (non-cyclonic). These metocean conditions are unlikely to be representative of average year-round conditions.*
- *Example 2: OSV Thruster Utilisation during offtake is modelled based on marine advice on the limit of safe operational conditions (ie the maximum metocean conditions in which it is safe to conduct the activities). These metocean conditions are unlikely to be representative of average year-round conditions.*
- Modelling reports demonstrate that the extent to which noise travels before it attenuates below the behavioural response threshold is not uniform, and underwater noise may travel further in a particular direction due to unique geomorphology. Modelling reports manage this by showing graphical images of the extent of the ensonified areas, and by presenting two estimates of the distances to reach the behavioural response threshold, the R_{95} and the R_{max}. The R95 represents the 95th percentile distance to reach the behavioural response threshold of any direction from the point source. The Rmax represents the longest distance to reach the behavioural response threshold.
- All distances in this report are presented as Rmax and all ensonified areas have been presented as perfect circles with Rmax as the radius. In so doing, the report presents a highly conservative estimate of the actual ensonified area.

By presenting continuous underwater noise sources estimated based on their peak noise levels, and by presenting ensonified areas as perfect circles with a radius based on the maximum distance to the behavioural threshold, this report presents highly conservative estimates of the ensonified areas above the behavioural response thresholds. Results should be interpreted as absolute worst case scenarios in order to manage ongoing uncertainty associated with modelling results.

6.3 Cumulative Noise Above Behavioural Response Thresholds in the possible foraging area

To inform a cumulative impact assessment, both the Browse to NWS draft EIS/ERD and the Browse Supplement provided a characterisation of the cumulative impact of underwater noise spatially within the Scott Reef possible foraging area. Within the draft EIS/ERD, analysis focused on identifying activities that may occur simultaneously over the life of the Project and identifying the maximum proportion of the Scott Reef possible foraging area that is ensonified above 120 dB re 1 µPa at any particular time as is relevant to this management plan.

To provide estimates of cumulative impacts that might better inform management measures to be applied within this plan, the following provides a quantitative description of cumulative underwater noise in the Scott Reef possible foraging area during key stages of the proposed Browse Project. The analysis presented in this section accounts for design features and management measures that have been outlined in **Section 8**, and provides a distinction between ensonified areas in the wider Scott Reef possible foraging area and the Scott Reef channel (further discussed in **Section 6**). The analysis shows ensonified areas expected during peak periods of the pygmy blue whale migratory seasons when management measures have been applied. Ensonified areas outside of these seasons may be increased from those presented in this section.

To provide a visual representation, **Figure 6-1** through **Figure 6-8** show the spatial extent of the ensonified areas described in each of the key phases of the activities.

6.3.1 Phase One Drilling and Completions (During pygmy blue whale migratory periods)

Prior to the initial construction and installation of subsea and FPSO facilities at the Torosa field, a MODU is expected to be present, drilling for up to two years. As per the mitigations in **Section 8**, the MODU will not use Dynamic Positioning (DP) to hold station during peak pygmy blue whale seasons, unless the MODU has a DP system designed to reduce noise to less than 174 dB re 1µPa.m.

Unmitigable noise: MODU (moored)

For the majority of the time, underwater noise associated with this activity will be limited to the operation noise from topsides MODU equipment. The approximate ensonified area is 0.8 km^2 (<0.01% of the). This is represented by the solid green line on **Figure 6-1.**

Mitigable noise scenario: MODU (moored w/ OSV conducting resupply/close safety standby)

When an OSV comes alongside a moored MODU (e.g. to transfer goods or as required for safety reasons in certain circumstances (e.g. helicopter landing)), the underwater noise will be dominated by the OSV using its DP system to maintain position. This activity will be governed by a Whale Management Procedure (WMP) (refer **Section 6.4**) and noise could be abated, or the activity not commenced, if a foraging pygmy blue whale was present. The total approximate ensonified area in this scenario is ~16 km^2 (0.12% of the possible foraging area (represented by the dashed green line on **Figure 6-1)**. When the OSV is not conducting goods transfer, it (and up to one other OSV) will remain in the region of the MODU, but would be required to monitor for pygmy blue whales and avoid areas where they may be more likely to be present (e.g. Scott Reef channel).

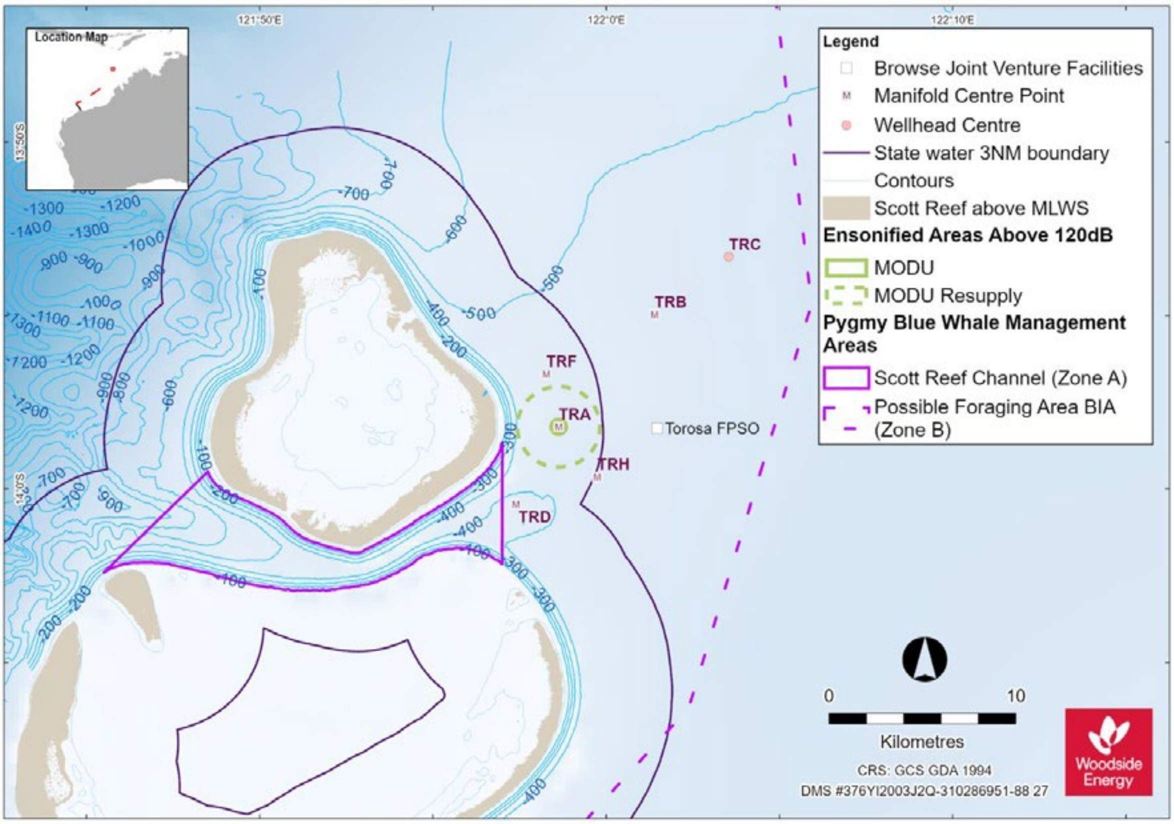


Figure 6-1 Illustrative peak cumulative ensonified areas (above 120 dB) during Phase One Drilling and Completions (Moored MODU) prior to subsea construction commencement. Drilling at TRA shown as a representative scenario.

6.3.2 Subsea and FPSO Construction and Installation (Pre-RFSU)

The initial (pre-RFSU) construction and installation of subsea and FPSO facilities at the Torosa field location extends for approximately two years, during which time the drilling and completion activities of Phase 1 wells will be ongoing. As outlined in **Section 5.1**, each of the key activities in the construction sequence (spur-line installation, subsea installation and FPSO hookup) are consecutive, not concurrent. Therefore, it is not anticipated that these activities will co-occur and therefore they are not anticipated to contribute spatially to cumulative underwater noise.

Noise Scenario: Inter-field Spur Line Installation (unmitigable) + MODU

The rigid pipelay vessel installing the Inter-field Spur Line from Calliance FPSO to Torosa FPSO is a very short term noise source, however when at the northernmost end of the Inter-field Spur Line, modelling indicates that noise from the rigid pipelay vessel will exceed 120dB within the Scott Reef Channel. Noise associated with the Rigid Pipelay Vessel is unmitigable, i.e., due to holding the pipeline in position, the vessel cannot deactivate DP upon sighting a whale.

To minimise the risk of behavioural impacts within the Channel, the Rigid Pipelay Vessel will target to not enter the possible foraging area during peak pygmy blue whale migratory periods, but may still end up approaching the limits of the possible foraging area. The associated ensonified area above 120dB within the possible foraging area is ~107 km^2, shown as the black line on **Figure 6-2.**

If a MODU is also present, the total underwater noise rises to ~108 km^2 (0.83% - unmitigable) or ~123 km^2 (0.95% - mitigable) when an OSV is conducting resupply or close safe standby, as described in **Section 5**. The MODU and MODU resupply are shown as the green solid and dashed lines respectively on **Figure 6-2.**

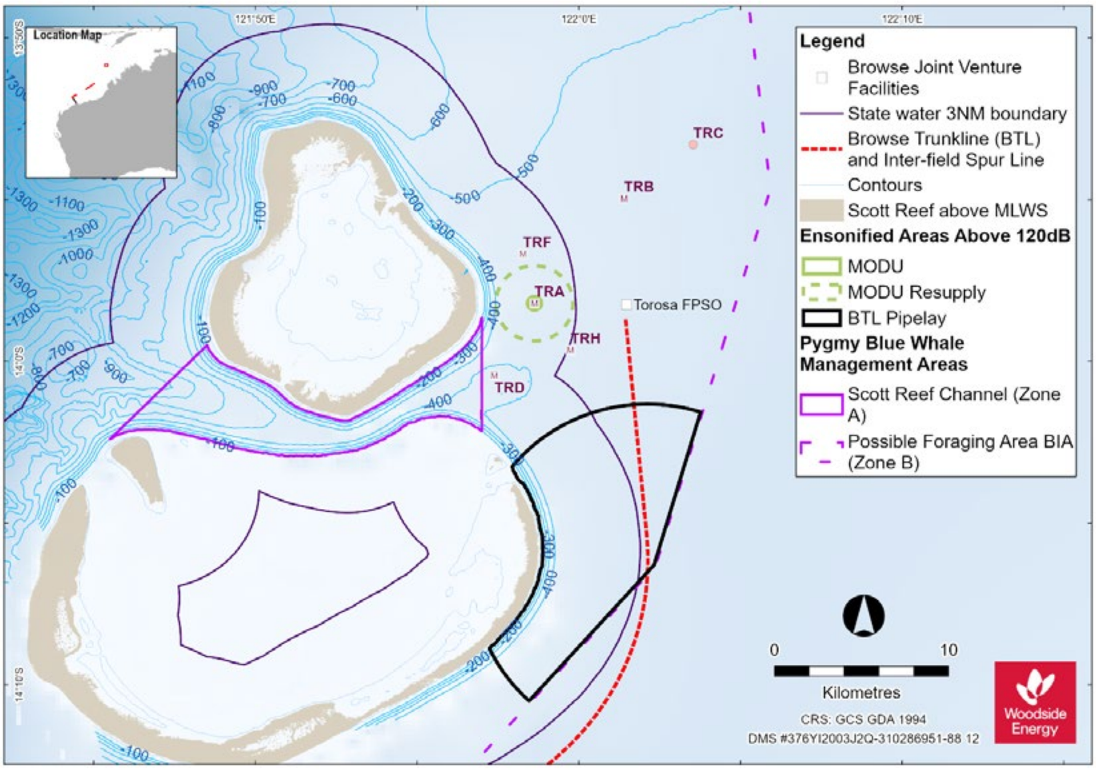


Figure 6-2 Illustrative peak cumulative ensonified areas (above 120dB) during Inter-Field Spur Line Installation, at the limits of the possible foraging area. Scenario shows a concurrent moored MODU drilling at TRA.

Noise Scenario: Subsea Flowline Installation (unmitigable) + MODU

A representative scenario that will occur during subsea construction (pre-RFSU) is the installation of subsea flowlines and associated equipment at TRB. Similar to the Rigid Pipelay Vessel, the Subsea Reel-Lay Vessel and Construction Vessel are considered to be unmitigable, ie due to holding the flowline in position, the Subsea Reel-Lay Vessel cannot deactivate Dynamic Positioning upon sighting a whale. The ensonified area associated with Subsea Reel-Lay Vessel or Construction Vessel is approximately ~15 km^2, this is shown as the solid light orange line on **Figure 6-3**.

If a MODU is also present at the other drill centre (noting that reel-lay vessel and MODU cannot spatially overlap for safety reasons), the underwater noise rises to ~15.4 km^2 (0.12%) (unmitigable) or ~ 31 km^2 (0.24%) when an OSV is conducting resupply or close safe standby (mitigable), as described in **Section 6.3.1**. The MODU and MODU resupply are shown as the green solid and dashed lines, respectively in **Figure 6-3**.

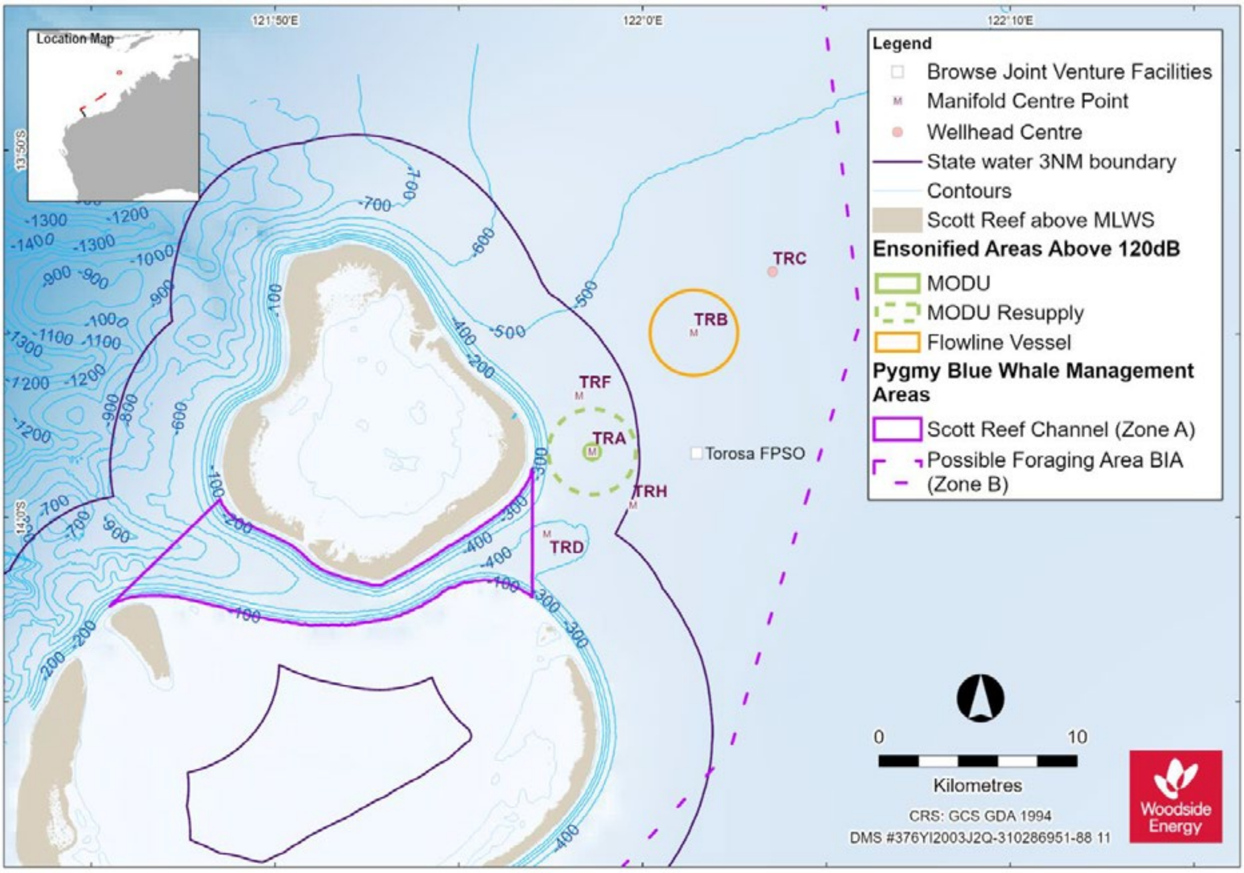


Figure 6-3 Illustrative peak cumulative ensonified areas (above 120dB re 1 μPa) during subsea installation ie flowline reel-lay (Pre-RFSU). Scenario shows a moored MODU drilling at TRA concurrent with reel-lay at TRB.

Noise Scenario: FPSO Hookup (unmitigable) + MODU

After the arrival of the FPSO, the first key activity will be to hook up the FPSO to its mooring chains. This involves the loudest noise sources associated with the FPSO installation and commissioning period, however recent modelling has considerably reduced the ensonified area (above 120dB) estimates.

Underwater noise modelling shows that the temporary noise sources associated with each activity are not expected to overlap. Note that post Torosa FPSO hook up to the mooring chains (short term <1 month), vessel support may still be required, however less vessels are expected than the Torosa FPSO hook up. The approximate ensonified area associated with FPSO hookup is ~19 km^2. This is shown as the dark orange line in **Figure 6-4.**

If a MODU is also present, the total underwater noise rises to ~19.5 km^2 (0.15%) (unmitigable) or ~35 km^2 (0.27%) when an OSV is conducting resupply or close safe standby (mitigable), as described in **Section 6.3.1**. The MODU and MODU resupply are shown as the green solid and dashed lines respectively in **Figure 6-4.**

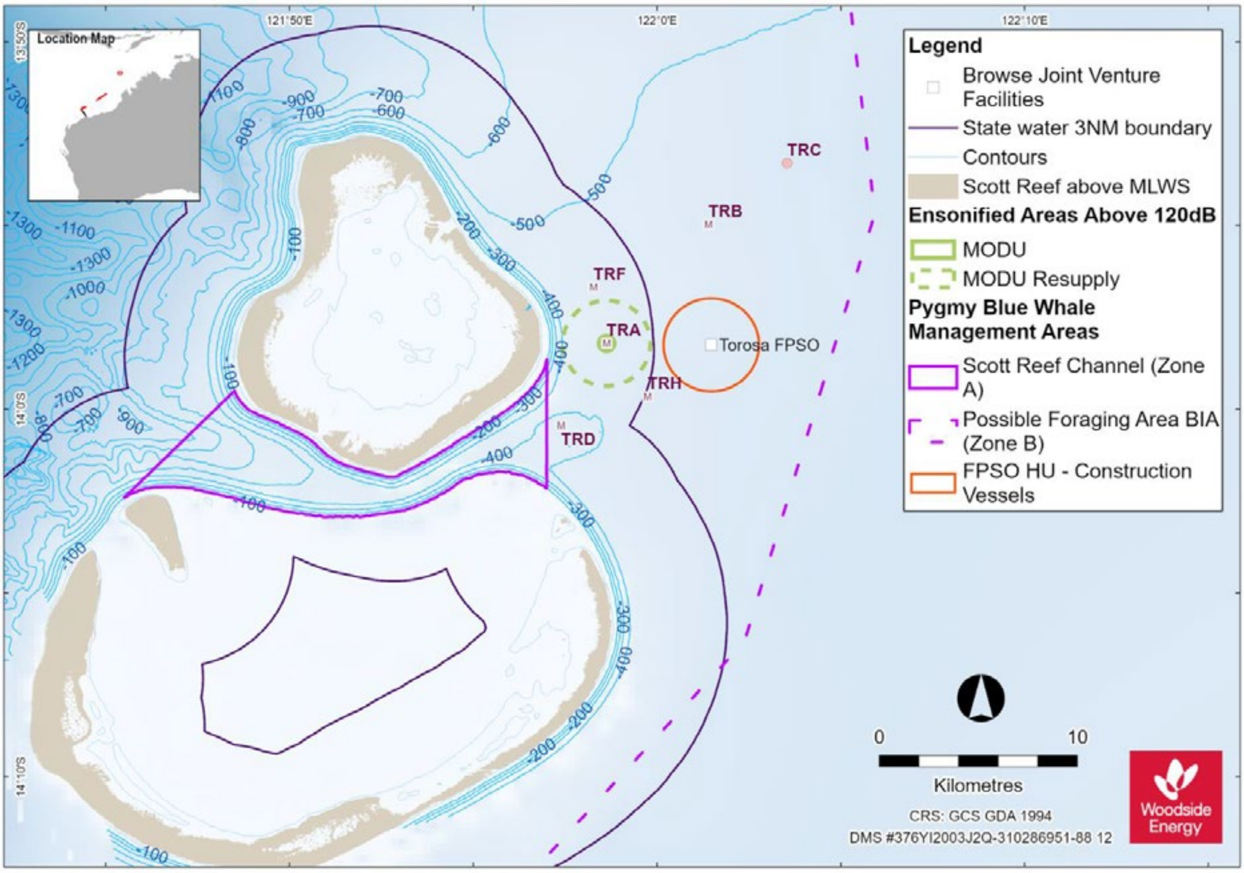


Figure 6-4 Illustrative peak cumulative ensonified areas (above 120dB re 1 μPa) during FPSO hook up (Pre-RFSU). Scenario shows a moored MODU drilling at TRA concurrent with the installation of the Torosa FPSO.

6.3.3 Operations

For the majority of the Project life, no major in-field activities are predicted to occur within the possible foraging area during pygmy blue whale migratory seasons, other than activities at the Torosa FPSO, and production from wellheads at multiple drill centres.

Unmitigable noise scenario: FPSO (not using thrusters for heading control) and well heads

During normal operations and weather conditions, there is no requirement for the Torosa FPSO to use thrusters to maintain a safe or efficient heading due to the sheltered nature of the FPSO location. Therefore, the only underwater noise source will be the FPSO's topsides machinery (estimated at 174 dB re 1 µPa·m) and choke valve (well head) noise, which would occur from between two and six well centres at any given time over the project life. Operation from more than two drill centres is not expected to occur until approximately 5 years from RFSU.

Underwater noise associated with choke valve (well head) noise originates from the seabed (~ 350-500 m deep) as opposed to the sea surface (as is the case for vessels). Modelling of well head noise by Duncan (2010) indicated that exceedances of the 120dB threshold from well head noise is not anticipated to occur for drill centres at surface, and will be limited to water depths of greater than 50 m. The distinction between underwater noise at the seabed and underwater noise at surface, is exemplified in the red circles in **Figure 6-5a** and **Figure 6-5b.** To avoid repetition, later figures only show underwater noise at surface.

It should also be noted that while ANIMAT modelling was not conducted on well heads specifically, ANIMAT modelling on a louder noise source (the FPSO machinery noise – 174 dB re 1 µPa·m) resulted in no simulated whales being exposed to TTS. Given the ANIMAT modelling accounts for animal behaviour and the FPSO machinery noise is close to the surface and louder than well head choke valves, the ANIMAT modelling provides further evidence that wellheads are not considered to pose a credible TTS risk to foraging or migrating pygmy blue whales.

In relation to FPSO noise, with no thrusters in use, the maximum distance to the 120 dB threshold is 540 m, which corresponds to a cumulative ensonified area (including well heads) of 5.7 km^2 (0.04% of the possible foraging area) at the seabed or 1.0 km^2 (<0.01% of the possible foraging area) at the surface. Ensonified areas from FPSO noise is represented by the solid blue line on **Figure 6-5**, and is also shown for other scenarios in **Figure 6-6**, **Figure 6-7** and **Figure 6-8**.

FPSO machinery noise and well head noise is considered unmitigable, as there is no adaptive management action that can make FPSO quieter, as it would require a full shutdown of the FPSO, including the power generation system, thereby making the FPSO uninhabitable by personnel.

Mitigable noise scenario: FPSO (not using thrusters for heading control while OSV alongside)

During the majority of OSV resupply scenarios, it is anticipated that the Torosa FPSO thrusters will not be required for an OSV resupply to occur. In these scenarios, the majority of the noise will be generated by the OSV using its dynamic positioning system to remain alongside the FPSO, anticipated to be at 181.3 dB re 1 µPa·m. FPSO machinery will also contribute underwater noise (174 dB re 1 µPa·m). In this scenario, the approximate ensonified area based on the behavioural response threshold and an R_{max} onset range of 2.3 km is ~21 km^2 (0.16% of the possible foraging area). This is represented by the dashed line on **Figure 6-5.**

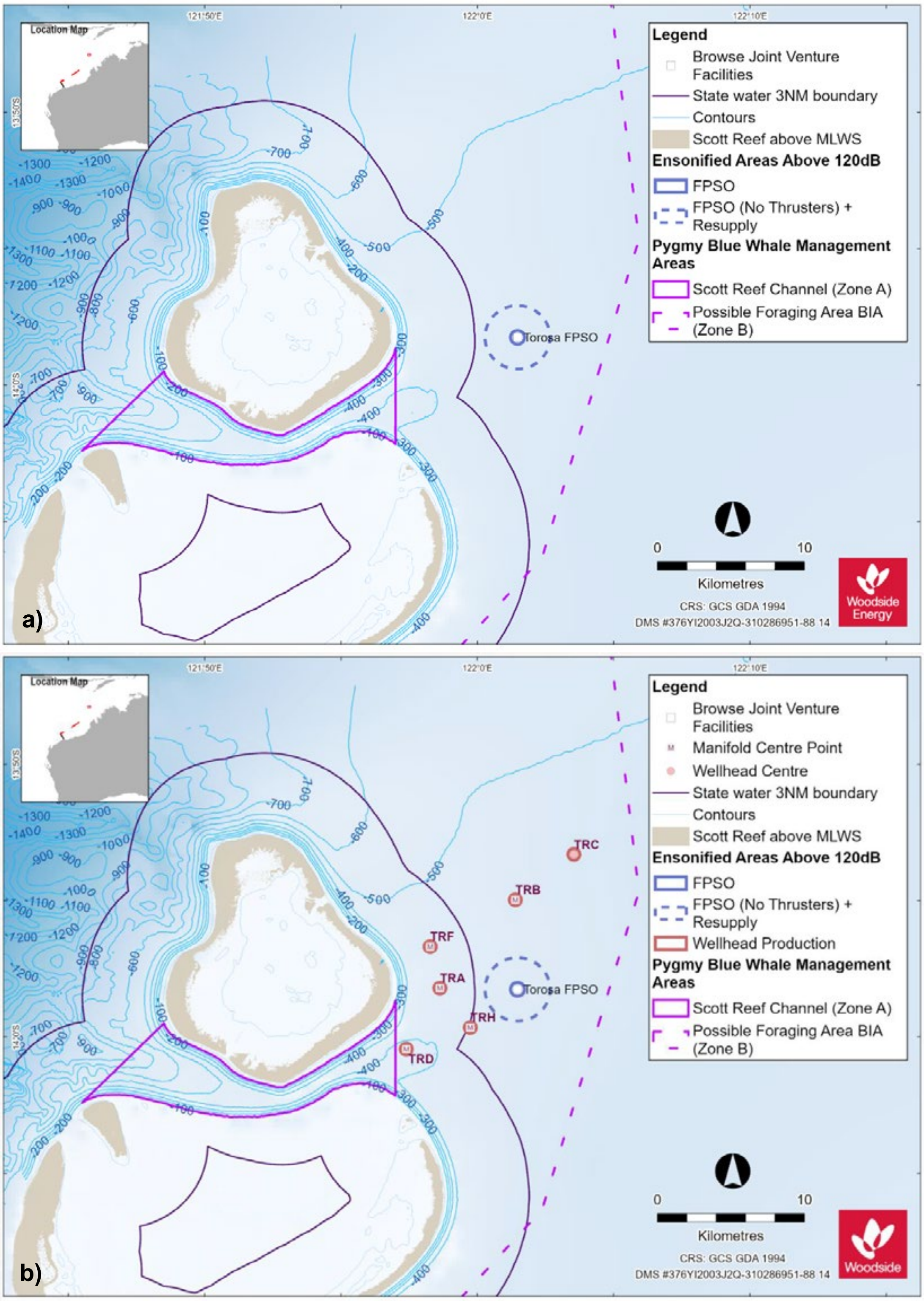


Figure 6-5 Illustrative peak cumulative ensonified areas during normal operation of Torosa, showing typical operation of the Torosa FPSO (no thrusters, solid blue line) and re-supply with FPSO thrusters off (dashed line) as well as subsea well heads. Presented at surface (a) and seabed (b).

Intermittent noise scenario: FPSO (Condensate Offtake)

FPSO condensate offtakes are routine events taking around 24 hours. When an offtake occurs, the approximate combined ensonified area from this source at surface is 22 km^2 (~0.17% of the possible foraging area based on a behavioural response threshold onset range of 2.7 km. This is represented by the blue dashed line in **Figure 6-6**. Condensate offtakes will be subject to pre-start visual observations to ensure that no pygmy blue whales are present, however thrust may be required from the OSV at all times during the offtake (to prevent offtake hose spills). Therefore, the OSV may not be able to deactivate thrusters upon sighting a whale. Condensate offtakes will not occur concurrently with OSV re-supply activities during peak periods of the pygmy blue whale migration season.

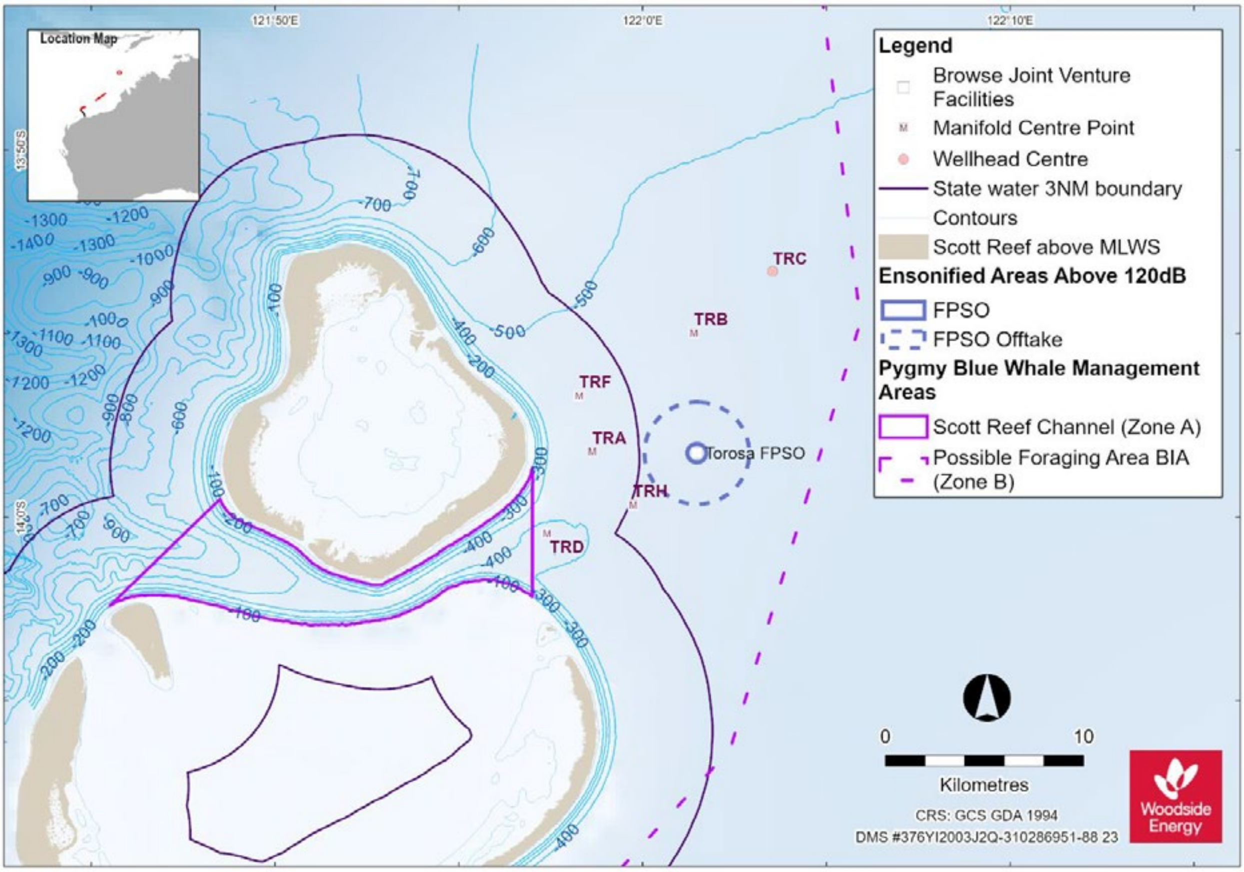


Figure 6-6 Illustrative, peak cumulative ensonified areas during normal operation of Torosa, showing condensate offtake from the Torosa FPSO (dashed line). Subsea well head noise does not propagate to sea surface.

Mitigable noise scenario: FPSO (using thrusters for heading control with OSV resupply)

For certain discrete activities, it may be advantageous to use the FPSO's thrusters to hold the FPSO on an optimal heading (e.g., to prevent unplanned FPSO movements during helicopter approach). As per the management mitigations in **Section 8,** underwater noise generated from the FPSO thrusters will targeted to achieve 178 dB re 1µPa.m for normal thrust requirements and operational use will be limited to thrust that generates 178 re 1µPa.m. The most amount of underwater noise generated occur in the circumstance the FPSO requires thrusters to be online, when an OSV is alongside (e.g., conducting a resupply). In this scenario, the approximate ensonified area based on the behavioural response threshold and an R_{max} onset range of 2.5 km is ~24 km^2 (~0.19% of the possible foraging area). This is represented by the dashed blue line in **Figure 6-7**.

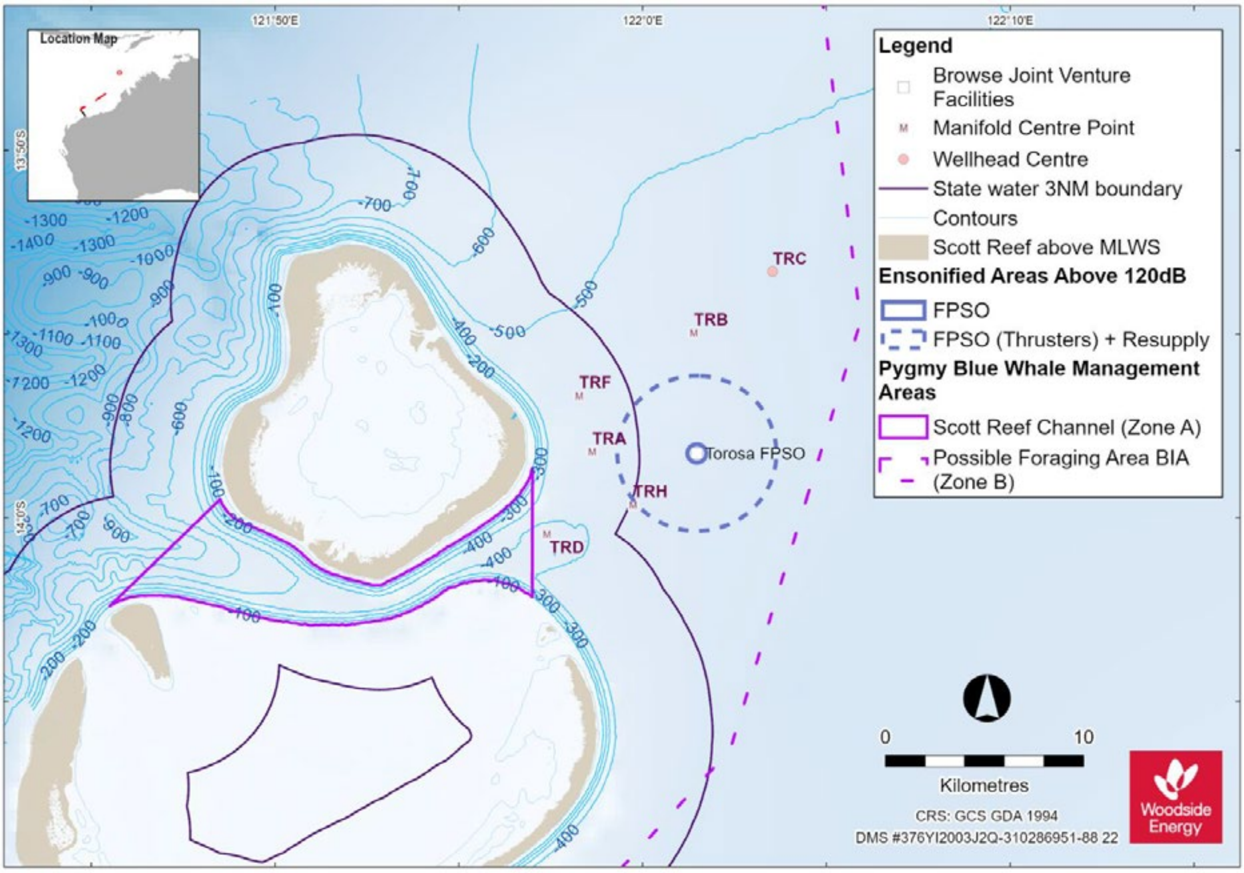


Figure 6-7 Illustrative peak cumulative ensonified areas during normal operation of Torosa, showing typical operation of the Torosa FPSO (no thrusters, solid blue line) and OSV re-supply with FPSO thrusters on (dashed line). Subsea well head noise does not propagate to sea surface.

6.3.4 Subsequent Subsea Tie-back Phases

Subsea tie-back phases that will occur after the initial Torosa FPSO RFSU period are described in 2.4. The cumulative noise impact from these phases considers the following mitigations;

- During subsequent subsea tie-back phases, installation of subsea equipment (e.g. flowlines) will occur outside of peak pygmy blue whale seasons or won't be required as drill centres are already connected to the FPSO.

- Drilling and completions activities will continue to be required however, as per Phase One Construction, no MODU that may generate noise sufficient to be received at >120 dB re 1 µPa within the Scott Reef channel will hold station using Dynamic Positioning at Torosa during peak periods of pygmy blue whale migratory seasons.

During subsequent subsea tie-back phases, the key activities that may occur simultaneously include:

- a FPSO (solid blue line on **Figure 6-8**), which may include a condensate offtake or OSV resupply event (dashed blue line on **Figure 6-8**).
- a moored MODU, which may include OSV resupply (solid and dashed green lines on **Figure 6-8**)
- production from wellheads at multiple drill centres (not shown – no ensonified area at surface).

It should be noted that subsequent subsea tie-back phases (after phase one construction) are anticipated to overlap with pygmy blue whale seasons for up to 10 years.

Normal Scenario: MODU (moored) + FPSO (not using thrusters for heading control)

This scenario represents two sources, the FPSO using thrusters (up to 178 dB re 1 µPa·m) and a moored MODU combined with wellhead noise. The approximate ensonified area is 1.0 km^2 within 50 m of the sea surface (<0.01% of the possible foraging area) or ~6 km^2 at the seabed (~0.04% of the possible foraging area) assuming all planned wells are operating simultaneously.

Mitigable noise scenario: MODU (moored with OSV conducting resupply) + FPSO (during OSV resupply with thrusters)

OSV resupplies and FPSO condensate offtakes are routine, short term events taking up to 12 and 24 hours, respectively. In the event that a MODU OSV resupply and an FPSO OSV resupply occurred simultaneously overlapped, the approximate ensonified area (depending on drill centre location) of these sound sources is ~54 km^2 (~0.41% of the possible foraging area). However, OSV activities can be delayed or stopped in the event a whale is sighted, with impacts of this scenario described above.

Note that during OSV resupply scenarios to a moored MODU at TRD only, ensonification of the Scott Reef channel (above 120 dB re 1 µPa) may occur for up to ~3.1 km^2, however if a pygmy blue whale is sighted and the OSV activity is ceased, there will be no ensonification of the Scott Reef channel (above 120 dB re 1 µPa). Temporal restrictions are already in place for TRD drilling activities.

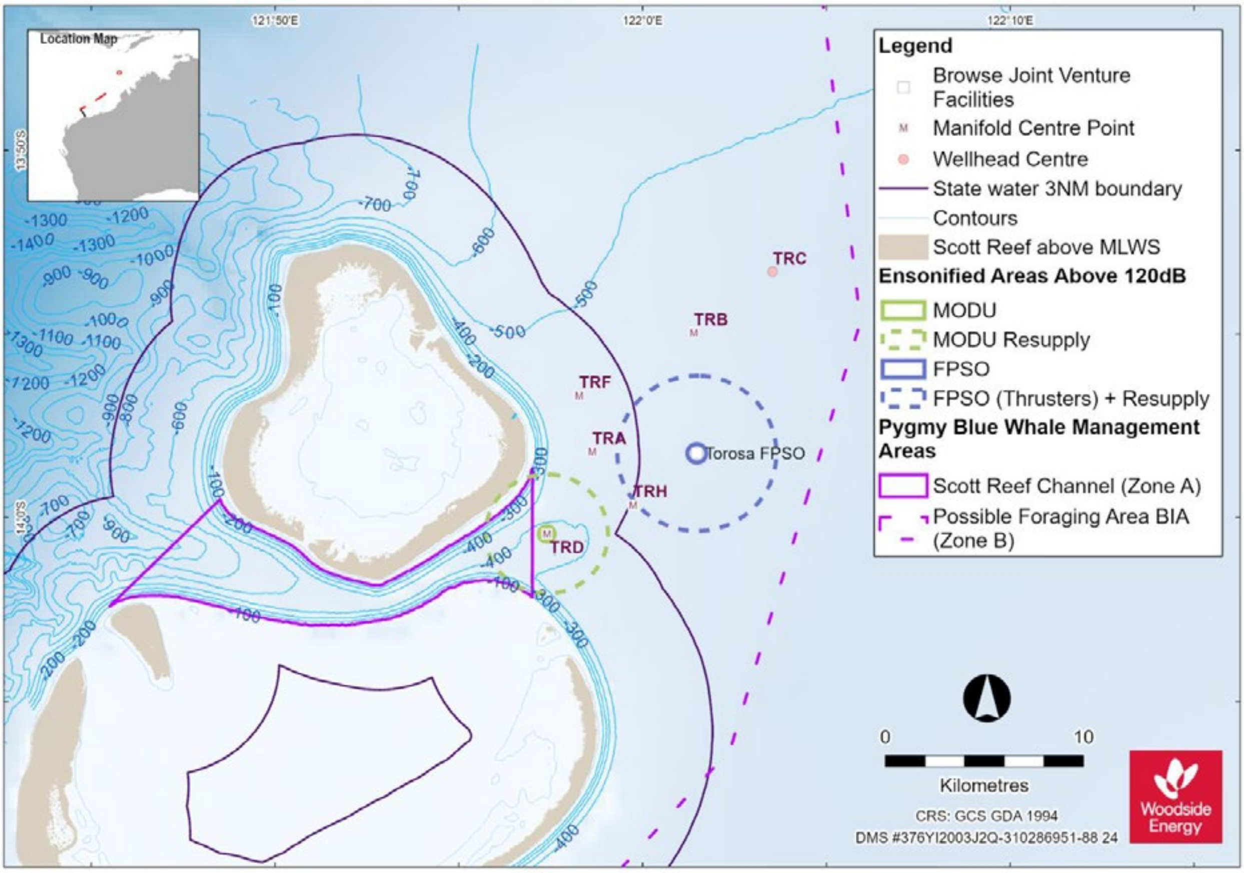


Figure 6-8 Indicative, illustrative peak cumulative ensonified areas during future subsea tieback phases, showing impact of a moored MODU drilling at TRD occurring concurrently with operation (including potential re-supply) of the Torosa FPSO.

6.3.5 Impulsive Noise Source Activities

Impulsive noise source activities (VSP and driven piling) will not occur during the peak pygmy blue whale seasons.

6.3.6 Summary of Cumulative and Additive Underwater Noise in the Possible Foraging Area

Table 6-2 provides a summary of the ensonified areas above 120 dB during pygmy blue whale peak seasons. This table considers the maximum ensonified area in the possible foraging area and Scott Reef Channel for two types of continuous noise sources under two scenarios:

- **Mitigable continuous noise sources** estimates the maximum ensonified area, but where further mitigations could be applied if a whale was observed.
- **Residual continuous noise sources** estimates the maximum noise impact, but where no further mitigations are possible and represents the residual risk of behavioural disturbance.

For clarity, OSV resupply scenarios or FPSO thruster use scenarios are considered to be examples of mitigable noise sources, as DP systems/heading control systems can be deactivated upon detection of a pygmy blue whale, when safe and practical to do so. Once thrusters are deactivated, the remaining facility noise is considered residual noise.

Table 6-2 includes a description of the approximate durations of each of the activities. The construction activities with the largest underwater noise ensonified area estimates are restricted to the early life of the Project. Drilling and Completion activities (post Phase One) may not be consecutive, and will depend upon the timing that subsequent phase wells are required to maintain Torosa FPSO production.

Table 6-2 Cumulative Ensonified Area Estimates (above 120 dB) for activities potentially occurring during peak periods of the pygmy blue whale migratory seasons. Estimates presented as ensonified areas within the top 50m of the surface unless otherwise indicated.

Activities (*mitigable source in italics*)	**Duration**	**Maximum Ensonified Areas from Stated Activities**			
		Possible Foraging Area excluding Scott Reef Channel (Zone B)		**In Scott Reef Channel (Zone A)**	
		Mitigable Sources	**Residual Sources[4]**	***Mitigable Sources***	**Residual Sources**
Phase One drilling and completions (prior commencement of subsea & FPSO construction)					
Typical: MODU (Moored)	Up to two years	0.8 km^2 (0.01%)	0.8 km^2 (0.01%)	-	-
Intermittent: Moored MODU *(OSV Alongside)*		15.9 km^2 (0.12%)	0.8 km^2 (0.01%)	-	-
Phase One subsea construction and installation, concurrent with D&C					
Intermittent: IFL spurline installation within 9km of the possible foraging area + moored MODU at TRA or TRB *(with OSV alongside)*	Approximately two weeks.	122.9 km^2 (0.95%)	107.8 km^2 (0.83%)	-	-
Intermittent: SURF Installation + moored MODU at TRA or TRB *(OSV alongside)*	One week (each for two flowlines) + up to 1 month for other infrastructure, in a single year.	30.6 km^2 (0.24%)	15.4 km^2 (0.12%)	-	-
Intermittent: FPSO & SURF Hook Up Activities + moored MODU at TRA or TRB *(with OSV alongside)*	Up to three months, in a single year	34.6 km^2 (0.27%)	19.5 km^2 (0.15%)		

[4] Based on application of Whale Management Plan (**Section 9**) requirements including deactivation of FPSO thrusters, vessel propellers where practicable.

Activities (*mitigable source in italics*)	Duration	Maximum Ensonified Areas from Stated Activities			
		Possible Foraging Area excluding Scott Reef Channel (Zone B)		In Scott Reef Channel (Zone A)	
		Mitigable Sources	**Residual Sources[4]**	***Mitigable Sources***	**Residual Sources**
Operations					
Continuous: FPSO (no thrusters online) + Wellheads	Project life (up to 44 years)	-	1.0 km^2 (<0.01%) 5.7 km^2 (0.04%) - received seabed	-	-
Continuous: FPSO *(using thrusters)* + Wellheads	Thrusters predicted to be required for <5% of metocean conditions	13.8 km^2 (0.11%)	1.0 km^2 (<0.01%) - surface 5.7 km^2 (0.04%) - seabed	-	-
Intermittent: FPSO (*no thrusters*, *with OSV resupply*) + Wellheads	During resupply, 12 hours max (six times a month)	21.2 km^2 (0.16%)	1.0 km^2 (<0.01%) - surface 5.7 km^2 (0.04%) - seabed	-	-
Intermittent: FPSO (*using thrusters, with OSV resupply*) + Wellheads	During resupply, 12 hours max (six times a month)	24.3 km^2 (0.19%)	1.0 km^2 (<0.01%) - surface 5.7 km^2 (0.04%) - seabed	-	-
Intermittent: FPSO (*conducting condensate offtake*) + Wellheads	Maximum of fortnightly during project life, 24 hours per activity.	Not mitigable once offtake commences.	22.4 km^2 (0.17%) – surface 27.1 km^2 (0.21%) - seabed	-	-
Subsea Tie-back Phases					
Continuous: Moored MODU + FPSO *(using thrusters)* + Wellheads	Tie back and associated drilling and completion activities may occur for a cumulative period of up to 10 years within the 44 year project life	13.8 km^2 (0.11%)	1.8 km^2 (0.01%) - surface 5.7 km^2 (0.04%) - seabed	-	-
Intermittent: Moored MODU *(OSV resupply)* + FPSO (*Condensate Offtake*) + Wellheads		53.8 km^2 (0.41%)	27.9 km^2 (0.21%)	8.96 km^2 (14.9%)	-

6.4 Cumulative TTS and PTS exposure in the possible foraging area

The previous section describes the distances from noise sources to behavioural response thresholds based on underwater noise propagation modelling to determine the Sound Power Level (SPL; dB re 1µPa). The distances at which TTS and PTS may occur may also be determined using the same propagation modelling, but are instead calculated on the accumulated Sound Exposure Level (SEL; dB re 1 µPa2.s). The accumulated Sound Exposure Level is a metric of sound energy that a receiver accumulates over a period of time. Propagation modelling is able to determine the Sound Exposure Level that a whale may experience at any given location, provided the whale does not move over the period of exposure.

If the stationary whale is present for a longer period of time, then the distance within which they must remain stationary from the noise source to experience TTS or PTS increases. In environmental impact assessments it is convention to use a time period for assessment of 24 hours, corresponding to the TTS and PTS thresholds presented in **Table 3-2.** Therefore, when considering the distances at which TTS and PTS may occur for the purposes of environmental impact assessment, it is important to note that an animal at the edge of this distance must remain approximately stationary for the entire 24 hours in order to experience TTS/PTS respectively. Results of this modelling were summarised and presented in **Table 6-1**.

6.4.1 Animal Movement in Exposure Modelling

Distances to accumulated Sound Exposure Levels can be determined through sound propagation modelling, however dependence on a hypothetical stationary whale has limited relevance to marine fauna such as pygmy blue whales, which are highly mobile and therefore are highly unlikely to remain at the edge of the calculated TTS/PTS range for a continuous 24-hour period. TTS/PTS exposure distances based on propagation modelling alone therefore are of limited relevance to determining the probability of TTS and PTS exposure.

To account for this, animal movement can be incorporated into an exposure model, referred to as ANIMAT modelling. ANIMAT modelling considers representative animal density, movement and behavioural characteristics to model how a whale moves through the water column and then determine the Sound Exposure Level accumulated by the whale as it moves in relation to an underwater noise source. For the proposed Browse to NWS Project draft EIS/ERD modelling, detailed information on pygmy blue whales was derived from a range of sources that used multi-sensor tags to record fine-scale dive and movement behaviour (Owen *et al.,* 2016; AIMS unpublished data 2021), as well as satellite tags to record travel speed (Thums and Ferreira, 2021), refer to Cusano *et al.*, 2022 (Appendix C).

It should be noted that the ANIMAT modelling does not consider a behavioural (avoidance) response to the underwater noise source, which is highly conservative, particularly if the noise is causing injury.

As ANIMAT modelling is a separate exercise from underwater noise propagation modelling, ANIMAT modelling has only been conducted on some of the key underwater noise sources anticipated to occur over the life of the Project (Cusano *et al*. 2022 – **Appendix C**):

- Torosa FPSO (no thrusters)
- Torosa FPSO Offtake
- MODU using DP at TRD[5]
- Cumulative Scenario – Torosa FPSO Offtake and MODU using DP[5] at TRD

ANIMAT modelling results are presented in two different metrics:

[5] Noting that since the ANIMAT modelling was undertaken, mitigation measures exclude a MODU station keeping using Dynamic Positioning at Torosa during Peak Pygmy Blue Whale season. This notwithstanding, the example remains a useful datapoint to inform assessment.

- The 95th Percentile Exposure Range [ER_{95}]: This presents the closest approach distance to the noise source that 95% of the simulated receivers whose modelled accumulated Sound Exposure Level exceeded the TTS or PTS threshold. Ie *is the 95th percentile estimate of how close an animal must come (instantaneously) to a noise source to experience TTS/PTS once animal behaviour is accounted for.*
- The Probability of Exposure (in the 95th Percentile Exposure Range) [PER95]: This presents the proportion of simulated receivers that entered the 95th Percentile Exposure Range whose modelled accumulated Sound Exposure Level exceeded the TTS or PTS threshold. Ie *is the conditional probability estimate that an animal which enters the 95th Percentile Exposure Range (instantaneously) will experience TTS/PTS.*

ANIMAT modelling results from Cusano *et al*. 2022 (**Appendix C**) are summarised in **Table 6-3**.

Table 6-3 Summary of estimated 95th Percentile Exposure Ranges and Probabilities of Exposure (in the 95th Percentile Exposure Range) for Pygmy Blue Whale ANIMATs. Results present the worst case ANIMAT simulations, considering North Bound Migration, South Bound Migration and Foraging pygmy blue whales.

Thresholds (dB re 1 µPa² · s)		MODU on DP at TRD		Torosa FPSO (No thrusters)		Torosa FPSO Offtake		MODU on DP at TRD + FPSO Offtake	
		ER_{95}	P_{ER95}	ER_{95}	P_{ER95}	ER_{95}	P_{ER95}	ER_{95}	P_{ER95}
PTS (SEL_{24h})	**179**	0m	0	0m	0	10m	33%	10m	12%
TTS (SEL_{24h})	**199**	30m	53%	0m	0	50m	46%	50m	34%

The results in **Table 6-3** demonstrate that while estimates of Accumulated Sound Exposure Level Ranges determined by sound propagation modelling show a larger distance over which the TTS and PTS thresholds may be exceeded for a whale that is present and stationary for 24 hours, when animal behaviour is accounted for the risk of TTS and PTS, ANIMAT modelling shows of all simulated whales exposed to TTS/PTS, 95% had come within 50m/10m (respectively) of the vessel sound source.

The activity with the highest potential for PTS/TTS (considering duration and frequency of occurrence and noise size) was the FPSO Offtake Scenario. The TTS range for this activity as determined by sound propagation modelling considering a stationary receiver over 24 hours is 630 m. ANIMAT modelling demonstrates that most (95%) of simulated whales that would be exposed to sound exposure level accumulation above the TTS threshold (ie could experience TTS injury) came within 50m of the noise source – a significantly smaller exposure distance.

6.4.2 Consideration of PTS/TTS Likelihood

This section explains the application of the ANIMAT modelling to determine likelihood of causing injury (i.e., PTS/TTS) to a pygmy blue whale. Prior to considering mitigative controls, it is important to also consider the likelihood of pygmy blue whale presence and behaviours (migrating and foraging) with reference to activity locations (i.e., Torosa FPSO) and the possible foraging area at Scott Reef, refer to **Section 4.5.1**.

In considering the role of controls in determining the likelihood of causing injury**, Section 9** describes the Whale Management Procedures that will apply to proposed Browse Project Activities with mitigable underwater noise. Under the Whale Management Procedures, crew staffing these activities are required to monitor for, and react to detection of (if practicable), an approaching pygmy blue whale. Monitoring distances presented in **Section 9** are significantly larger than the approximately 10m or 50m distance (ER_{95}) that a pygmy blue whale would typically need to come within a noise source to experience an accumulated Sound Exposure Level that exceeds the PTS or TTS thresholds, respectively.

It is considered highly unlikely that a pygmy blue whale would choose to travel towards the noise source (given the distance a which behavioural response occurs is anticipated to exceed the TTS/PTS ER_{95} range considerably), and it is further considered that implementation of the Whale Management Procedure controls (ie deactivation of vessel propulsion systems or FPSO thrusters when practicable to do so) would substantially reduce the likelihood of the pygmy blue whale arriving within 50m of the noise source without the source being deactivated or reduced. For activities where deactivating the noise source is a practicable option under a Whale Management Procedure, PTS or TTS exposure to a pygmy blue whale is therefore considered to be highly unlikely and is not assessed further.

For activities where the ER_{95} distance is either modelled (Torosa FPSO machinery only) or anticipated to be zero based on interpolation of modelling results (MODU machinery only and subsea wellhead choke valves – noting their sound source level is lower than the FPSO machinery only sound source level), PTS or TTS exposure is also considered to be highly unlikely, and is not assessed further.

The activities where deactivating a noise source is not an option and are anticipated to have an ER_{95} >0m include the FPSO Offtake (OSV) and the Rigid Pipelay Vessel. The Rigid Pipelay Vessel is not assessed further, as this one-off activity is short term in duration and is targeted to occur outside of Peak Pygmy Blue Whale season.

Given that:

- The eastern extent of the possible foraging area is considered in this plan to have a low likelihood of foraging by pygmy blue whales as compared to the western extent of the possible foraging area, as outlined in **Section 4.5**.
- For a pygmy blue whale to experience PTS or TTS from the OSV during an offtake arrangement, it must typically come within 10m or 50m (ER_{95} range) of the OSV's propulsion system respectively.
- FPSO Offtake will be conducted under a Whale Management Procedure (refer **Section 9**), requiring crew to monitor for Pygmy Blue Whales within 3 km for 30mins. It is not credible that a pygmy blue whale could reside within 50m of the offtake vessel without detection, and then be exposed to a high accumulated Sound Exposure Level as propulsion commences.
- The behavioural response range for the FPSO Offtake scenario (driven by the OSV) is approximately 2.7 km. Therefore, in order for the whale to enter a distance within which it is likely to be exposed to PTS/TTS, it must travel at least 2.6 km beyond its behavioural response threshold.
- FPSO offtakes are an intermittent activity, occurring up to once per fortnight. Assuming the peak Pygmy Blue Whale periods include the entire months of May, June and November, there is only approximately up to 6 days of the year where pygmy blue whales are likely to be regionally present in order for this risk to occur.

It is considered that the risk of a pygmy blue whale being exposed to TTS or PTS from an FPSO Offtake activity with the proposed Browse Project activities is highly unlikely.

In summary, having considered the full range of vessel and facility underwater noise sources in the context of ANIMAT modelling, it is considered that the risk of a pygmy blue whale being exposed to TTS or PTS from any vessel associated with proposed Browse Project activities is highly unlikely.

7. MANAGEMENT APPROACH

This section outlines the approach to the management of the potential underwater noise impacts on pygmy blue whales that will ensure that management objectives for the Project and this plan, as outlined in **Section 3.1** are achieved. This management approach has been applied to develop the proposed Design Features and Management Measures, including their timing and reporting, which are presented in **Section 8**.

Also presented within **Section 8** are the corrective action triggers and the corrective actions to be implemented should the mitigation and management measures not be implemented correctly, or the performance standard not be met. These corrective actions include the implementation of the adaptive management approach which is presented in **Section 11**.

The management approach incorporates the following key framework components:

- The Hierarchy of Controls
- Spatio-temporal Management Principles
- Adaptive Management
- Scientific Monitoring

A review of industry best practice management approaches is also provided for context.

7.1 Hierarchy of Controls

In accordance with Woodside's HSE risk management procedures, risk reduction measures should be prioritised and categorised in accordance with the hierarchy of controls, where risk reduction measures at the top of the hierarchy take precedence over risk reduction measures further down. The use of the hierarchy demonstrates that underwater noise impacts have been minimised by first considering those controls which would be most effective at managing underwater noise. The proposed design features and management measures **(Section 8)** have been developed using the hierarchy of controls described in **Table 7-1**.

Table 7-1 Hierarchy of controls applied to management of underwater noise within this plan

Control	Definition	Application
Elimination	Avoid generating noise when or where pygmy blue whales are likely to be present.	Schedule activities to avoid certain areas at certain times, in accordance with spatio-temporal management principles.
Substitution	Substitute high noise generating activities with quieter alternatives.	Use alternatives to dynamic positioning such as mooring and use suction piling in preference to hammer piling.
Reduction	Use engineering controls & design to reduce the sound source levels associated with activities.	• Include design mitigations on long term, new-build sources of noise for the proposed Browse Project facilities (ie Torosa FPSO thrusters, wellhead choke valves); and • Apply speed restrictions to vessel activities.
Mitigation	Where an activity cannot be eliminated, substituted or reduced such that noise generated is below behavioural response thresholds), apply operational mitigations.	Apply Whale Management Procedures (WMPs) (refer **Section 9**) to monitor for, and react to detection of (if practicable), an approaching pygmy blue whale in

		accordance with spatio-temporal management principles.

7.2 Spatio-temporal Management Principles

Sightings and acoustic data (summarised in **Section 4**) have confirmed pygmy blue whale presence on north and southbound migrations within the Scott Reef possible foraging area including within the Scott Reef channel, for example, during the spring season for southbound migration season (Sutton *et al*. 2019). There are limitations to the data collected to date, such as the date of acquisition, an absence of data on the relative importance of Scott Reef, i.e., the proportion of the population utilising the Scott Reef possible foraging area and importantly, actual records of pygmy blue whale foraging behaviour and prey availability. It is, therefore, not possible to adequately assess the relative importance of the Scott Reef possible foraging area to the pygmy blue whale population and the relative importance of the Scott Reef channel within the possible foraging area as a predictable foraging habitat for pygmy blue whales.

Based on the productivity associated with the Scott Reef channel and sightings of pygmy blue whales reported by Sutton *et al*. (2019), the Scott Reef channel within the wider Scott Reef possible foraging area may be more important as a predictable foraging habitat for migrating pygmy blue whales, particularly, during the spring period. Noting the existing scientific uncertainty around the relative importance of the BIA and the Scott Reef channel within the BIA to the pygmy blue whale population, a precautionary approach of adopting spatial avoidance of noise propagation within the Scott Reef channel will be applied. Furthermore, temporal avoidance and minimisation of noise propagation within the wider BIA when pygmy blue whale are present will be implemented. Thus, providing a spatio-temporal management regime that, in combination with the hierarchy of controls (**Section 7.1**) minimises potential underwater noise impacts on pygmy blue whales and provides recognition that habitat utilisation by foraging pygmy blue whales may not be homogenous within the wider Scott Reef possible foraging area.

Two management zones will be applied and managed for the Torosa development and operational activities, Scott Reef channel – Management Zone A and the wider Scott Reef possible foraging area – Management Zone B, **Figure 7-1**. The spatio-temporal management approach proposed will apply a suite of key principles for managing underwater noise within each zone with the aim of eliminating noise propagating into the Scott Reef channel (Management Zone A) and minimising noise propagation within the wider Scott Reef possible foraging area (Management Zone B). These key principles are outlined in **Table 6-2.**

An important element of applying a spatio-temporal management regime is an adaptive management process to the plan, particularly, incorporation of scientific knowledge as it is gained. The spatial boundaries of these zones and pygmy blue whale timing considerations will be reviewed and if appropriate revised based on outcomes of the scientific monitoring program (refer to Sections 10 **and** 11**).Table 7-2 Key Principles applied at each of the spatial management zones**

Management Zone	Key Principles	Activities requiring mitigation (Section 8) to align with principles[1]
Zone A	Within this zone, during peak and shoulder pygmy blue whale migratory seasons: • There shall be no generation of noise capable of causing 'injury' to a pygmy blue whale from any source. • There shall be no generation of noise from vessels (including FPSOs or MODUs) at levels above which may cause disruption to a foraging pygmy blue whale.	**Activities requiring temporal mitigations** Hammer piling at the Torosa FPSO location. VSP at TRD. Use of a MODU holding station (using a dynamic positioning system) at TRA, TRD and TRH). **Activities requiring mitigation under a whale management procedure[2]**

Management Zone	Key Principles	Activities requiring mitigation (Section 8) to align with principles[1]
	Additionally, there shall be no propagation of noise into this zone, from unmitigable long term noise sources above levels which may cause disruption to a foraging pygmy blue whale.	MODU support vessel operations at TRA, TRD & TRH
Zone B	Within this zone and during peak pygmy blue whale migratory seasons: • There shall be no impulsive noise from impact piling or seismic activities including vertical seismic profiling. • There shall be no vessel activity from which 'injury' (e.g. PTS/TTS) from noise exposure could occur (24 hour exposure) at 750 m or more from the source. • There shall be no unmitigable or continuous long-term noise above levels which may cause a behavioural response beyond a 1 km radius from the source.	**Activities requiring temporal mitigations** Use of a MODU holding station (using a dynamic positioning system) at TRB, TRC, TRF or BKA. Installation of the interfiled line within 9 km of the boundary of Zone B. Vertical seismic profiling at Torosa wells excluding TRD. **Activities requiring mitigation under a whale management procedure[2]** Use of the Torosa FPSO Thrusters (subject to design mitigations). Supply vessels transferring goods to the Torosa FPSO, MODUs at Torosa well centres or BKA or subsea construction vessels at Torosa infrastructure. Subsea installation of Torosa flowlines and associated subsea equipment.
All other areas	During peak pygmy blue whale migratory seasons: • All activities generating noise at levels which may cause injury or a behavioral response to a pygmy blue whale must operate in accordance with an activity specific Whale Management Procedure.	**Activities requiring mitigation under a whale management procedure[2]** Supply vessels transferring goods to a moored MODU at the Brecknock Drill Centre All subsea construction and operational activities at Calliance and Brecknock Installation of the IFL/BTL more than 9 km from the boundary of Zone B

1 – i.e. as they generate noise that without further mitigation, may be inconsistent with the principle. Subject to detailed activity specific noise assessment.

2 – These noise sources, may be inconsistent with the Principle, but through the application of a WMP to observe for whales can be mitigated to a point where they are consistent with the principle because they can be stopped if a whale is sighted or observed.

7.2.1 Description of Spatial Management Zones

The two spatial management zones are further described and are presented in **Figure 7-1**.

Management Zone A – Scott Reef Channel

Management Zone A is the Scott Reef channel. It is considered to be a unique feature and as having the high likelihood as foraging habitat to support pygmy blue whale foraging behaviour that maybe affected by proposed Browse Project activities (See **Section 4.5**) and will therefore be afforded the highest degree of caution.

Sutton *et al*. (2019) describes that "*Cooler and nutrient rich waters flush up into the Scott Reef channel helping to promote primary and secondary productivity. While the location of Scott Reef on* *the edge of a steep decline would likely inherit typical slope effects (i.e. upwelling), the channel would help to concentrate the flow of nutrient rich waters and facilitate inundation of the atoll's lagoons. For Browse Cliffs, the steep bathymetry interacting with local circulation would promote upwelling, which was observed during winter.*" A steep decline referred to in Sutton *et al.* (2019) occurs on the western side of the Scott Reef channel (i.e. not the side where proposed Browse infrastructure is located). While limited scientific evidence is available to delineate the area that has the highest potential to support pygmy blue whale foraging behaviour, the description by Sutton *et al.* (2019) indicates that it is the channel width that is important (i.e. concentrating nutrient rich water flow arising from the western slope). The eastern 400 m depth contour is therefore not currently considered a relevant boundary for Zone A but rather channel width.

In absence of a formal definition, the “Scott Reef Channel” is defined by perpendicular north/south boundary line where North Scott Reef meets South Scott Reef – the most narrow section and most clearly delineated as a channel. This aligns to the definition of the Scott Reef Channel the Browse FLNG Project Ministerial Conditions (EPBC 2013/7079). Conditions set for the Browse FLNG Project outlined the additional mitigations that needed to apply within the “Scott Reef Channel” area, recognising the increased potential for the presence of whales and other animals within in the channel.

Due to revisions to the Project during preparation of this plan, no activities are planned to occur within Management Zone A, however, this management measures reflect that there is a potential for vessel activity or noise to occur within this Zone, if not managed or for the definition of this zone to change in response to future scientific information.

Management Zone B – Other areas within the Scott Reef Possible Foraging Area

Management Zone B comprises the pygmy blue whale possible foraging area excluding the Scott Reef channel (Zone A) and the outer slope area to the west of Scott Reef. Based on the present understanding of habitat suitability and likelihood of pygmy blue whale foraging (refer to **Section 4**), Zone B encompasses the eastern extent of the Scott Reef possible foraging area where pygmy blue whales migration occurs but is less important as foraging habitat as krill swarms, if present are ephemeral and patchy and more dispersed when compared to Zone A. Accordingly, it is considered that it is highly unlikely noise generating activities will disturb pygmy blue whale biologically important behaviour (i.e., foraging) within this zone. It is recognised that the wider Scott Reef possible foraging area may potentially be used for opportunistic foraging by migrating pygmy blue whales.

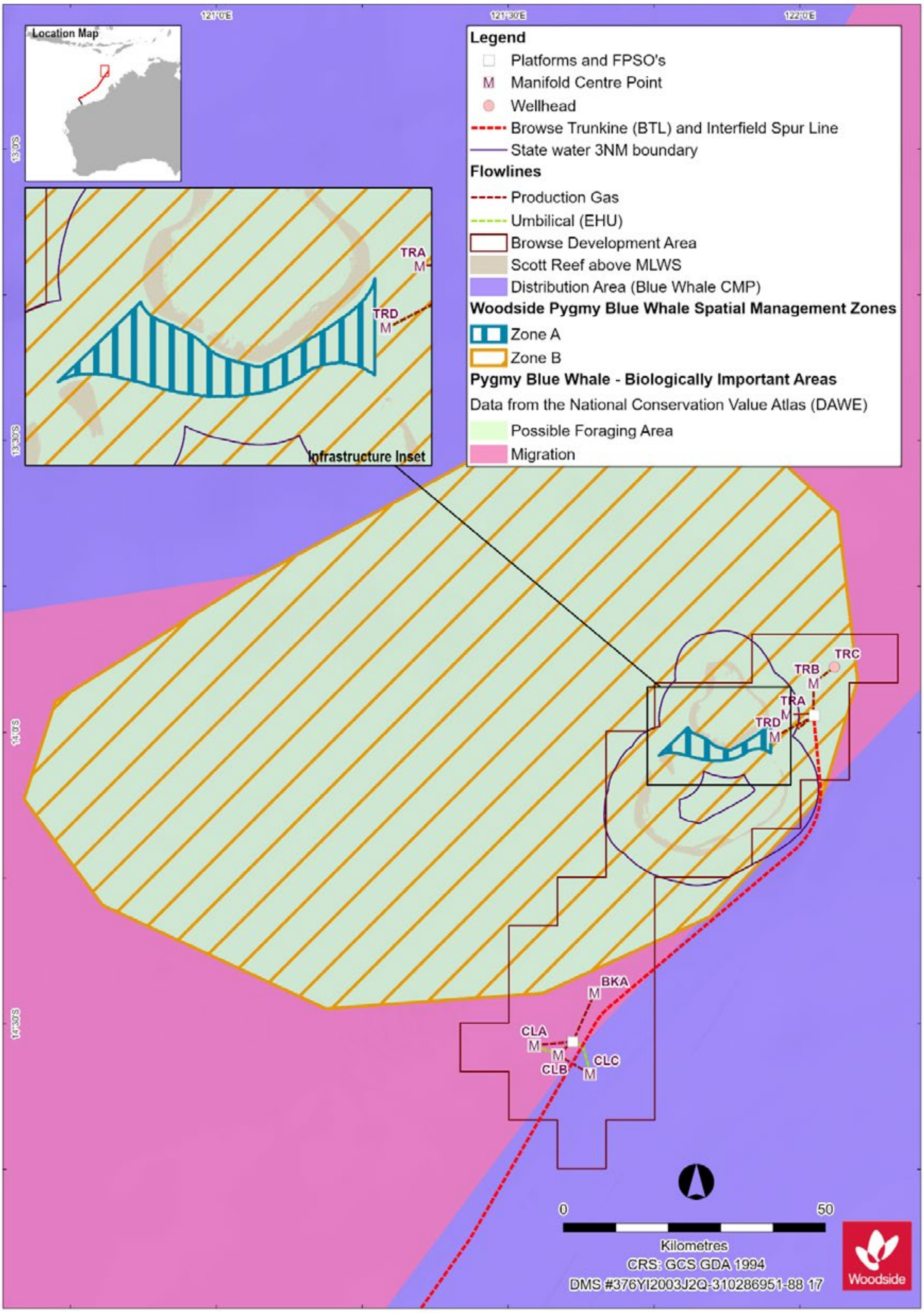


Figure 7-1. Pygmy blue whale spatial management zones for the Browse Development Area

7.3 Definition of Peak and Shoulder Pygmy Blue Whale Migratory Periods

Within this plan, the temporal management principles are based on the likelihood of a pygmy blue whale encounter within Management Zones A and B that encompass the Scott Reef possible foraging area during the peak and shoulder periods within the north and southbound migratory seasons. The key management actions relate to activities with larger noise footprints being restricted in both the peak and shoulder periods, whereas activities with reduced footprints primarily having restrictions only within peak periods.

The definition of the peak and shoulder periods for migratory seasons is described below. Indicatively the peak/shoulder periods are based on historic passive acoustic data but supported by telemetry data for the northbound migratory season (refer to **Section 4.2**) and indicate shoulder and peak periods by months of the year. Finer resolution and confirmation of the shoulder/peak periods will be informed by proposed baseline scientific monitoring programs, which will include measures to establish a contemporary baseline of pygmy blue whale occurrence and timing within the Scott Reef possible foraging area. Such information will be updated throughout the project life cycle via operational phase scientific monitoring programs.

Peak Period

Peak pygmy blue whale migratory period is defined period within one standard deviations of the mean peak presence of whale abundance during both the southbound and northbound migratory periods. This definition, based on statistical likelihood of PBW presence to be informed by the baseline monitoring data, means that the “peak” period would be the time periods of which 2/3rds of migratory whales are present and the shoulder would encompass slightly less than 1/3rd.

Shoulder Period

Peak pygmy blue whale migratory period is defined period between one and two standard deviations of the mean peak presence of whale abundance during both the southbound and northbound migratory periods. Less than one third of migratory whales would therefore be present during the ‘shoulder period’.

Other times

It is plausible that a pygmy blue whale may be sighted within the Scott Reef potential foraging area at any time of year, but as part of the baseline monitoring period a multi-year monitoring program to detect pygmy blue whale presence will be conducted and applying this data set to the defined peak/shoulder period means less than 5% of any whale sighting data would fall out of the defined shoulder and peak periods.

7.4 Scientific Monitoring

Current scientific knowledge to support ongoing management for pygmy blue whales is limited throughout their geographic range because of the elusive nature of the whales, and logistical and scientific methodology constraints of operating in remote, offshore settings. The studies for the proposed Browse Project have used a range of techniques to improve our understanding of pygmy blue whale occurrence, seasonality and use of the project area through vessel and aerial based surveys, biological oceanography studies and passive acoustic monitoring (**Section 4**). Many of these studies have been undertaken over multiple years.

The scientific monitoring program supporting this plan is further detailed in **Section 10.**

7.5 Expert Panel

Given the complexity of the PBWMP it is appropriate to ensure expert advice is sought and incorporated into the management program. An expert panel will be established and it is proposed that these experts will review the appropriateness of the PBWMP in managing potential impacts from anthropogenic noise on pygmy blue whales and review and design of any scientific monitoring activities supporting the plan. The expert panel will have a role in reviewing the outcomes of scientific monitoring and verifying data is being appropriately interpreted and incorporated into the adaptive management program.

Experts forming this panel will be selected based on their demonstrated relevant experience and independence from implementation of the activity. Experts should have at least five but preferably ten years experience in the relevant disciplines including evidence of having contributed to the peer reviewed knowledge base. Participants should not be directly involved in contributing to elements of the program. Experts will preferentially have expertise in the fields of either baleen whale ecology or underwater noise impacts & management.

7.6 Review of Industry Best Practice

A synthesis of noise reduction guidance, frameworks, implementation program and projects that have been adopted or otherwise endorsed by intergovernmental policy fora, individual governments and international agreements/organisations by Chou *et al* (2021) provides insights into international best practice noise mitigation measures. Chou *et al*. (2021) differentiated industrial noise as (1) incidental and (2) deliberate. Incidentally radiated noise sources include those generated by oil and gas activities and associated vessel traffic. In contrast, deliberately radiated noise sources include those from airguns associated with oil and gas seismic surveys.

Noise mitigation strategies highlighted by Chou *et al* (2021) and Bröker (2019):

- Spatio-temporal mitigation strategies including avoidance of noise-generating activities in areas or during times of high animal density, including biologically important areas such as breeding and feeding.
- Quieting technologies including design specifications and regular maintenance of propeller, hull and onboard machinery to reduce cavitation and surface roughness.
- Other mitigating methods such as developing noise exposure limits and acoustic impact thresholds for different species, use of acoustic deterrent devices (ADDs), reducing ship speed and soft-start or ramp up procedures for seismic surveys to prevent physical injury.
- Exclusion zones as a key mitigation measure to reduce the likelihood of auditory damage due to exposure to high sound levels. Exclusion zones are zones around a source sound that are monitored for presence of marine mammals by marine mammal observers and passive acoustic monitoring systems. Such safety or injury zones are mainly used during seismic survey operations to avoid injury to marine mammals. Exclusion zones to mitigate behavioural responses are not a common practice for seismic surveys, however there are examples where such mitigation actions have been applied such as for the small population of western gray whales off Sakhalin. There are no documented industry case studies for the application of exclusion zones for long-term continuous noise sources and the mitigation of behavioural response impacts.

  Furthermore, noise mitigation measures are based on scientific exposure criteria that are an evolving science and will need to be reviewed and incorporated into the adaptive management approach of the proposed Browse Project. Southall (2021) in discussing the evolution of the marine mammal noise exposure criteria including temporary and permanent threshold shift onset levels and a descriptive spectrum of behavioural response severity from benign to lethal, highlights the needed ongoing requirement for research to build on available data and continue to improve criteria.

8. DESIGN FEATURES AND MANAGEMENT MEASURES

8.1 SURF and FPSO Construction and Installation

Table 8-1 outlines the design features / management measures that will be applicable to the following activities:

- SURF installation - construction vessels and reel-lay vessel
- FPSO installation, and mooring/riser hook-up - construction vessels
- Inter-field spurline installation – rigid pipelay vessel
- Offshore support vessels – general support and supply vessels.

Table 8-1 Mitigation and management measures applicable to anthropogenic noise from construction and support vessels

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
Undertake the Browse Project in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks, dugongs, seabirds and migratory shorebirds). Undertake the Browse Project in a manner that will not disrupt the migration and feeding of the East Indian Ocean pygmy blue whale population. Undertake the Browse Project in a manner that will not displace the East Indian Ocean pygmy blue whale population from the possible foraging area at Scott Reef.	**Construction Scheduling** Optimise execution schedule to avoid Torosa FPSO hook up (including riser hook up) and IFL installation (within 9 km of Zone B) occurring simultaneously and to target conducting these short term activities outside of peak pygmy blue whale migration season.	Prior to activity execution	• Project execution schedule	• Schedule optimisation hasn't been demonstrated	• Review schedule
	Contracting and procurement Contractors operating construction vessels proposed to operate (or cause noise above 120dB re 1 µPa) within Management Zone B will be required to identify specific requirements that will be available / put in place to reduce noise.	Prior to vessel commencing activity in the field.	• Noise mitigation assessment report	• Noise mitigation options not assessed by <3 months prior to activity commencement.	• Assess noise mitigation options prior to mobilisation.
	Spatial Exclusion Zones No construction, installation, support vessel or MODU will enter Management Zone A with the exception of environmental monitoring or emergency/spill response activities or SOLAS situations (i.e. in situations where the vessel master considers that complying with the requirement would adversely affect the safety or security of the vessel or its passengers or crew, or in situations where the vessel master is bound to provide assistance (under SOLAS Chapter V) upon receiving a distress signal from any source that persons are in distress at sea).	Construction, operations and decommissioning.	• Vessel operational records	• Plans, procedures or contractor instructions etc do not include requirement to comply with this condition.	• Update documentation to ensure compliance with condition
	Vessel speed Within Zone A, vessels will not travel at speeds greater than 6 knots unless required for SOLAS. Within Zone B vessels will not travel at speeds greater than 12 knots in the peak pygmy blue whale migration periods, unless required for SOLAS. All interactions between vessels and marine fauna will comply with EPBC Regulations 2000 – Part 8 Division 8.1, and in the Australian National Guidelines for Whale and Dolphin Watching and the Whale Shark Code of Conduct, whereby unless in a permitted emergency situation, vessels will not travel at speeds greater than the speed restrictions prescribed for marine fauna encounters.	Construction, operations and decommissioning.	• Vessel operational records	• Vessels recorded as travelling at speeds greater than 6 knots within Zone A, unless required for SOLAS. • Vessels recorded as travelling at speeds greater than 12 knots within Zone B during peak pygmy blue whale migration periods, unless required for SOLAS.	• Undertake an investigation into the cause of the non-compliance. • Report non-compliance to DAWE and DWER. • Implement further training/inductions. • Adaptive management – management of travel restriction timing via monitoring program and real-time detection.

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
	Whale Management Procedure – Construction activities All construction vessels are required to implement a vessel specific Whale Management Procedure (WMP) in accordance with **Section 9.2.2**	Construction phases.	• Vessel operational records. • Marine fauna observation records.	• WMP not prepared in place for each relevant activity, prior to activity commencing.	• Implement a WMP prior to mobilisation.
	Whale Management Procedure – Offshore Support Vessels (e.g. conducting goods transfer etc) All supply vessels are required to implement a vessel specific Whale Management Procedure (WMP) in accordance with **Section 9.2.2**.	Construction, operations and decommissioning.	• Vessel operational records. • Marine fauna observation records.	• WMP not implemented correctly.	• Undertake an investigation into the cause of the non-compliance. • Report non-compliance to DAWE and DWER. • Review WMP and implement changes to the procedure if warranted. • Implement further training/inductions.
	Offshore Support Vessels (on standby) At times where a support vessel is required to be on safety standby in the field, the vessel will limit engine (or thruster) use to that required to maintain heading and safe position unless required for SOLAS. Vessels will maintain separation from supported activities to minimise cumulative impacts.	Construction, operations and decommissioning	• Vessel operational records • Marine fauna observation records.	• Vessel standby procedures not implemented correctly.	• Undertake an investigation into the cause of the non-compliance. • Report non-compliance to DAWE and DWER. • Review Whale Management Procedure and make and implement changes to the procedure if warranted. • Review vessel standby procedures and make and implement changes to the procedure if warranted. • Implement further training/inductions.

8.2 Drilling and Completions

Table 8-2 outlines the design features / management measures that will be applicable to the following activities:

- MODUs operating within the Torosa or Brecknock fields
- Offshore Support Vessels assisting drilling and completions are considered in **Table 8-1**

Table 8-2 - Mitigation and management measures applicable to anthropogenic noise from drilling and completions activities

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
Undertake the Browse Project in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks, dugongs, seabirds and migratory shorebirds). Undertake the Browse Project in a manner that will not disrupt the migration and feeding of the East Indian Ocean pygmy blue whale population. Undertake the Browse Project in a manner that will not displace the East Indian Ocean pygmy blue whale population from the possible foraging area at Scott Reef.	**Contracting and procurement** Contractors operating MODUs proposed to operate (or cause noise above 120dB re 1 µPa) within Management Zone A or Zone B will be required to identify specific requirements that will be available / put in place to reduce noise.	During MODU Contracting.	• Noise mitigation assessment report	• Noise mitigation options not assessed <3 months prior to activity commencement.	• Assess noise mitigation options prior to mobilisation.
	Drilling of wells at any Torosa or Brecknock well centre (excluding TRD) During peak pygmy blue whale migration periods, any MODU operating at a Torosa or Brecknock well centre (excl. TRD) must not use a dynamic positioning system / thruster that generates noise over 174 dB re 1 µPa·m, other than when arriving/departing at the well centre (which must be done in accordance with a WMP detailed in **Section 9.2.2**) unless for safety or emergency purposes. The use of a DP capable MODU that is moored during pygmy blue whale migration periods, that achieves the specified noise limit, is acceptable.	Drilling of relevant wells during peak pygmy blue whale migration period.	• Project schedule. • MODU activity records.	• Activity occurs outside of specifications.	• Immediately re-establish compliance with the management measure, when safe and practicable to do so. • Undertake an investigation into the cause of the non-compliance. • Undertake a risk assessment of to determine the potential impacts of the non-compliance. • Report non-compliance to DAWE and DWER.
	Drilling of wells at the TRD well centre Any MODU operating at the TRD well centre during peak and shoulder pygmy blue whale migratory periods must not use a dynamic positioning system that generates noise over 174 dB re 1 µPa·m, other than when arriving/departing at the well centre (which is subject to the requirements of a WMP detailed in **Section 9.2.2**) unless to maintain safety and integrity of the MODU or well. The use of a DP capable MODU that is moored during drilling is acceptable.	Drilling of wells at the TRD well centre during peak or shoulder pygmy blue whale migration period.			
	Whale Management Procedure – MODU Transit/OSV Supply A Whale Management Procedure will be in place during MODU transit between well centres and OSV resupply activities in accordance with **Section 9.2.2**.	During construction and decommissioning	• WMP compliance report.	• WMP not implemented correctly.	• Immediately re-establish compliance with the management measure, when safe and practicable to do so. • Undertake an investigation into the cause of the non-compliance. • Undertake a risk assessment of to determine the potential impacts of the non-compliance. • Report non-compliance to DAWE and DWER.

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
	Offshore Support Vessels (on standby to MODU) At times where a support vessel is required to be on standby to a MODU, if the vessel is not moored, the vessel will remain at least 4 km from any MODU on DP and 1km from a moored MODU. The vessel will then limit engine (or thruster) use to that required to maintain heading and safe distance unless support vessel is required to be closer to manage safety during specific activities (ie helicopter landings, personnel working over the side) required for SOLAS.	During drilling and completions activities.	• Vessel operational records.	• Vessel standby procedures not implemented correctly.	• Undertake an investigation into the cause of the non-compliance. • Report non-compliance to DAWE and DWER. • Review Whale Management Procedure and make and implement changes to the procedure if warranted. • Review vessel standby procedures and make and implement changes to the procedure if warranted. • Implement further training/inductions.

8.3 Operations

Table 8-3 outlines the design features / management measures that will be applicable to the following activities:

- Torosa FPSO (including supporting vessel based activities)
- Well heads within the Torosa field

Table 8-3 Mitigation and management measures applicable to anthropogenic noise from Operations

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
Undertake the Browse Project in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks, dugongs, seabirds and migratory shorebirds). Undertake the Browse Project in a manner that will not disrupt the migration and feeding of the East Indian Ocean pygmy blue whale population. Undertake the Browse Project in a manner that will not displace the East Indian Ocean pygmy blue whale population from the possible foraging area at Scott Reef.	**Torosa FPSO design (thrusters)** • The Torosa FPSO will incorporate measures to reduce noise generated by the vessels' thrusters. The following design optimisations are to be considered and incorporated if feasible; propellor diameter, number of blades and measures to reduce tip loading. • Torosa FPSO thrusters will produce noise of less than 178 dB re 1 µPa·m during expected conditions in which thrusters are required during peak pygmy blue whale migration periods.	During FEED	• Feasibility assessments of Torosa FPSO thruster noise mitigations, ALARP demonstration and updated design.	• Design studies estimate FPSO thruster noise will exceed 178 dB re 1 µPa·m (at 50% thrust utilisation).	• Further improve thruster design or if further noise reductions not possible, implement adaptive management measures, such as limiting the maximum thruster utilisation during peak pygmy blue whale migration periods.
	Torosa FPSO design (machinery) • The Torosa FPSO will incorporate measures to reduce noise generated through normal operation of the vessel – for example through inclusion of measures to reduce propagation of noise and vibration through the hull. • The Torosa FPSO will target operational noise of 174 dB re 1 µPa·m or less during normal operations.	During FEED	• Feasibility assessments of FPSO facility noise mitigations, ALARP demonstration and updated design.	• Machinery noise not minimised during FPSO design	• Revise FPSO machinery design to include measures for noise propagation reduction.
	Well head choke valve noise • All well heads to be installed within the Torosa field will incorporate measures to reduce noise from choke valves. This includes installation of acoustic insulation or increased wall thickness if feasible. • The design of well heads will target operational noise of less than 161.5 dB re 1 µPa·m.	During FEED	• Feasibility assessments of well head choke noise mitigations, ALARP demonstration and updated design.	• Design studies estimate wellhead noise will exceed 161.5 dB re 1 µPa·m.	• Undertake noise propagation modelling and determine if noise will propagate into Management Zone A and redesign wellhead choke valves to ensure Management Zone A not impacted.
	Well head choke valve noise • No operation of well heads that will cause impact (noise above behavioural impact threshold) within Management Zone A during peak and shoulder pygmy blue whale migration periods.	During operations	• Well head noise monitoring	• Well head noise above behavioural threshold within Management Zone A during peak or shoulder pygmy blue whale migration seasons	• Manage operations to re-establish compliance with the management measure, ie by ceasing wellhead operation if no other options are immediately available. Consider further mitigations to be applied to reduce noise from choke valves, and re-verify.
	Supply vessel planning and logistics • Supply vessel operations supporting the Torosa FPSO shall be minimised as far as practicable during peak pygmy blue whale migration seasons and not occur concurrently with condensate offtake operations.	During operations	• Vessel operational records.	• More than three supply vessel runs occurring per month during peak pygmy blue whale migration seasons • Supply vessel runs occur concurrent with condensate offtakes	• Undertake an investigation into the cause of the non-compliance. • Report non-compliance to DAWE and DWER • Undertaken investigation into opportunities to further optimise logistics (goods transfer) operations

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
	Whale Management Procedure – Torosa FPSO Operations A WMP will be implemented (**Section 9.2.2**) governing the following activities on the Torosa FPSO during peak pygmy blue whale migration seasons: • Utilising thrusters for heading control • OSV resupply activities • Preparing for a condensate offtake.	During operations	• Vessel operational records. • Marine fauna observation records.	• WMP not implemented correctly.	• Undertake an investigation into the cause of the non-compliance. • Report non-compliance to DAWE and DWER. • Review WMP and implement changes to the procedure if warranted. • Implement further training/inductions.

8.4 Impulsive Activities – Impact Piling & Vertical Seismic Profiling

Table 8-4 outlines the design features / management measures that will be applicable to the following activities:

- Vertical seismic profiling (Section 5.2.2)
- Impact piling (Section 5.2.1)

Table 8-4 Mitigation and management measures applicable to anthropogenic noise from impact piling and vertical seismic profiling

Management objective	Design features / management measures	Timing	Monitoring / Reporting	Corrective Action Triggers	Corrective Action
Undertake the Browse Project in a manner that prevents physical injury to marine fauna (cetaceans, marine turtles, whale sharks, dugongs, seabirds and migratory shorebirds). Undertake the Browse Project in a manner that will not disrupt the migration and feeding of the East Indian Ocean pygmy blue whale population. Undertake the Browse Project in a manner that will not displace the East Indian Ocean pygmy blue whale population from the possible foraging area at Scott Reef.	**Spatial restrictions to impulsive noise activities** Impact piling or VSP will not ever occur in the Scott Reef Channel.	At any time	• Project schedule and planning documentation. • Impact piling and VSP records.	• Impact piling or VSP occurs in the Scott Reef Channel.	• Immediately cease impact piling or VSP activities in the Scott Reef Channel. • Undertake an investigation into the cause of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER.
	Spatial restrictions to impulsive noise activities Impact piling or VSP will never be conducted within Management Zone B during peak pygmy blue whale migration periods. Optimise schedule execution to avoid impact piling occurring within Management Zone B during peak and shoulder periods within pygmy blue whale migration periods.	During FEED	• Project schedule and planning documentation. • Impact piling and VSP records.	• Impact piling or VSP occurs in Management Zone B during peak periods within pygmy blue whale migration periods. • Schedule optimisation hasn't been demonstrated.	• Immediately cease impact piling or VSP activities in Management Zone B. • Undertake an investigation into the cause of the non-compliance. • Implement measures to ensure no further non-compliance occurs. • Report non-compliance to DAWE and DWER. • Review schedule.
	Whale Management Procedure – Impulsive Noise A WMP will be implemented (**Section 9.2.3**) during all impact piling and VSP activities.	At any time	• Activity records. • Marine fauna observation records.	• WMP not implemented	• Undertake an investigation into the cause of the non-compliance. • Report non-compliance to DAWE and DWER. • Review WMP and implement changes to the procedure if warranted. • Implement further training/inductions.

8.5 Alternative assessment

The following noise reduction mitigations were considered but not implemented.

8.5.1 Relocation of the Torosa FPSO to outside the Scott Reef possible foraging area

Given that Torosa FPSO represents a continuous noise source above 120 dB re 1 µPa, in line with the hierarchy of controls outlined in **Section 7.1**, consideration has been given to whether the FPSO could be located to where noise would not propagate to within the possible foraging area (ie approximately 20 km further east of its current location). An initial justification for the selected location of the Torosa FPSO was provided in the draft EIS/ERD.

Noting the priority given to controls higher up the hierarchy of controls, the environmental impact reduction benefit associated with eliminating the FPSO noise within the possible foraging area is considered to be limited as:

- The key scenarios where underwater noise is generated from the FPSO (ie using thrusters) can be managed using Whale Management Plans to reduce the likelihood of disrupting a pygmy blue whale while foraging;
- Unmitigable noise from the FPSO during normal operations ensonifies a very small percentage of the possible foraging area (~0.01%). This small ensonified area does not affect the Scott Reef channel or other locations within the BIA thought to support foraging activity.
- There is inherent uncertainty regarding possible pygmy blue whale foraging behaviour in the possible foraging area therefore moving the FPSO outside of the possible foraging area may not result in any reduction of potential impacts to foraging homogenous nature of the FPSO location and an arbitrary location beyond the BIA boundary, particularly if overall underwater noise increases when the FPSO is moved, as would be likely due to the need for increased thruster use (discussed further below).

Noting the environmental impact reduction benefit is considered to be negligible, there are a number of key risks and impacts introduced by a change in FPSO location:

a) **Torosa project infeasible due to lost production due to increased pressure drop.** Pressure management is critical to producing hydrocarbons. Hydrocarbons from the reservoir are conveyed from the reservoir to the FPSO facility under pressure from the reservoir (ie without subsea compression), and the hydrocarbon pressure drops along the flowline conveying the hydrocarbons from the reservoir to the facility, with the pressure drop increasing as the flowline length increases. The flowline lengths in the FPSOs current position already reduce the pressure by around 200 bar, from an expected reservoir pressure of 300-350 bar.

   Substantially increasing the flowline lengths will substantially increase the pressure drop, and will significantly reduce the overall amount of hydrocarbons that can be viably produced. The impact of increased pressure drop will be exacerbated as the reservoir pressure drops and will further reduce flowline capacity during the depletion compression phase. Adding additional compression may be required but is not considered further, as this would have higher impacts than the FPSO facility equipment. Further, other challenges associated with hydrate and wax management may increase the minimum flow rate that the subsea system can operate at, further reducing the hydrocarbon reserves that can be extracted.

b) **Increased use of thrusters from metocean conditions.** The key drive of the design case for FPSO thrusters is typically the management of a predominant swell from the south-west direction within the North-west Marine Region. However, the metocean conditions at the Torosa FPSO location have been measured to be relatively benign due to the sheltering effect of Scott Reef from the south-west swell. An analysis of 40-year hindcast Metocean information shows increasing average (P50) significant wave height (Hs – a representation of sea state), which correlates with increasing thruster use the further away from Scott Reef the FPSO is moved (refer **Figure 8-1**).

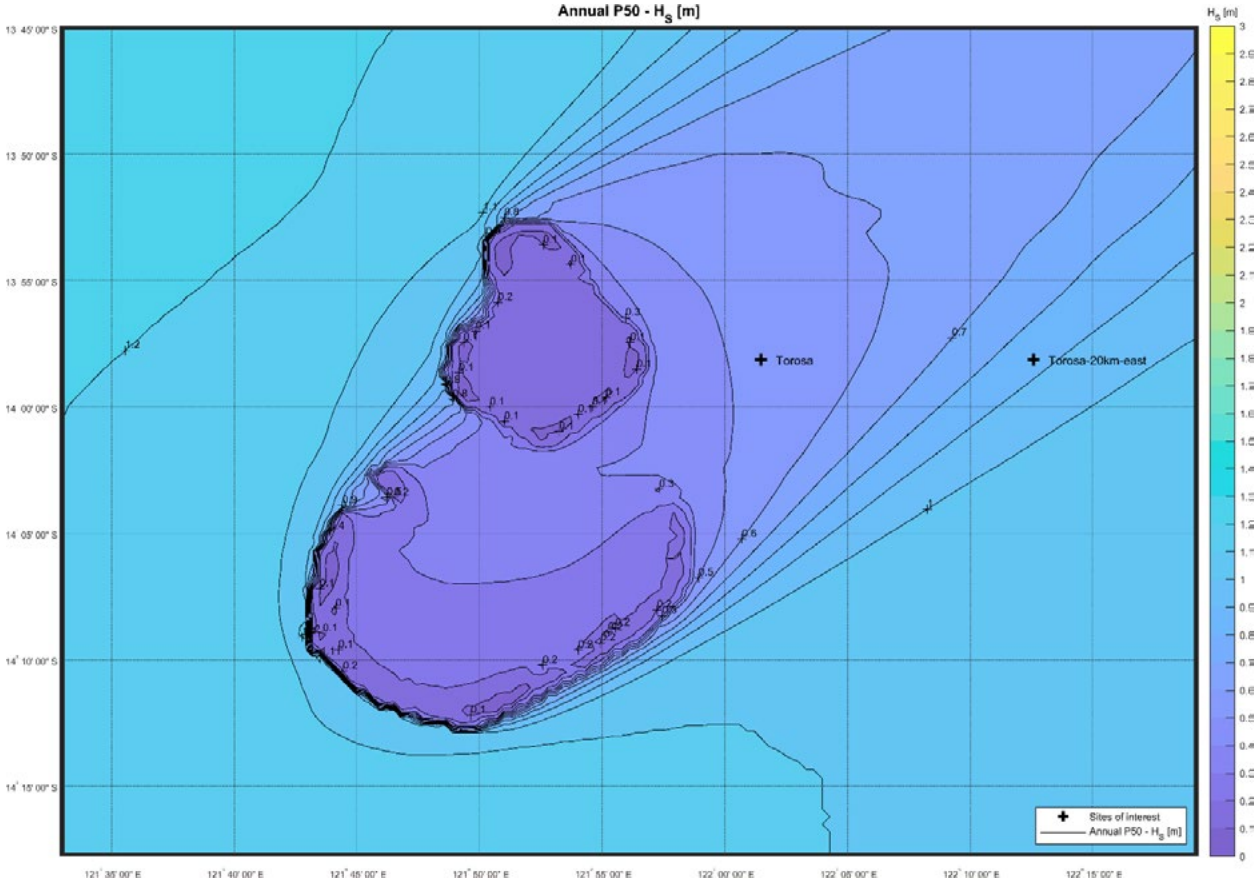


Figure 8-1. Sheltering Effect of Scott Reef on Mean (P50) Significant Wave Height (Hs)

Moving the FPSO approximately 20 km east (necessary to eliminate noise associated with activities such as offtake from ensonifying the Scott Reef possible foraging area above 120 dB re 1 µPa), or even further to the north-east, would increase the risk of more frequent and substantial use of the FPSO thrusters, and therefore the level of overall underwater noise being generated.

c) **Feasibility of Active Heating.** The proposed Browse Project is proposing to use active heating of the flowlines as the technology for managing the risk of hydrate formation and blockage in the subsea system, with the active heating only required during shut-down and start-up operations. As described in Chapter 7 of the draft EIS/ERD, active heating is a substantial energy efficiency improvement, as the alternative requires continuous MEG dosing and a highly energy intensive MEG regeneration plant on the facility.

Increasing the flowline lengths would increase the technical risks and commercial costs associated with active heating. At this stage it is currently not known if it is economically viable to supply active heating over this distance, particularly given current limitations on the amount of power that can be transmitted through the FPSO Swivel System. If a MEG regeneration plant were to be used in place of the active heating technology, this would potentially increase Torosa facility CO_2 emissions by 100,000 tonnes per year.

d) **Installation Risks.** With the current FPSO location, a flowline can be installed from a single continuous reel lay activity. If the flowline lengths increase, a flowline will need to be installed in two parts on the sea bed, with a significantly more complex activity to pick up and weld the flowlines together. Note that the flowline infrastructure is substantially more complex than the Browse Trunkline, in that the flowline integrates a number of services including: the pipe-in-pipe fitted with insulation, two optical fibre cables and up to 12 active heating electrical cables in the annulus between the inner and outer pipe. Unlike the BTL (where welds occur as pieces are laid from the vessel), this activity will require the lifting of the previously installed flowlines from the seabed in order to perform the welding of the inner and outer pipes as well as splicing of all optical fibre and active heating electrical cables. Given the complexity of the flowline infrastructure, this substantially increases the risks of technical problems arising during installation.

Conclusion

Further to the above key impacts, additional materials and subsea disturbance would increase the overall environmental impact with a decision to move the FPSO outside of the Scott Reef possible foraging area, while providing negligible environmental benefit. Based on the above key risks, moving the FPSO further away from the Torosa reservoir would challenge the viability of developing the Torosa field.

8.5.2 Elimination of Drilling and Completion activities at the Torosa and Brecknock fields during Peak periods of the Pygmy Blue Whale Migratory Seasons

Consideration has been given to whether drilling and completion activities could be eliminated at the Torosa and Brecknock fields during pygmy blue whale migratory seasons. There are two possibilities that would achieve this:

1. Relocate the drill centres to outside of the Scott Reef possible foraging area

The current location of the proposed drill centres is designed to optimise access to hydrocarbon reserves across the Torosa field. Based on current and expected technology, there is a maximum distance that wells can be drilled to effectively recover hydrocarbons. Relocating the drill centres to outside of the Scott Reef possible foraging area would not allow access to the majority of the hydrocarbons at Torosa, and would not allow for a viable development.

2. Avoid drilling and completion activities during peak periods of the pygmy blue whale migratory seasons

Eliminating drilling and completion activities during the peak periods of the pygmy blue whale migratory seasons would result in the inability to drill during three months of the year (May, June and November) based on current understanding. As per the management measures provided in **Section 8**, a MODU at Torosa will not use a dynamic positioning system to hold station during peak periods of the pygmy blue whale migratory seasons. In order to achieve this management measure, a MODU with conventional mooring capability may be selected by the Project (or DP MODU with substantially lower than typical noise).

If the proposed Browse Project does select a conventionally moored MODU, then it may not be possible to conduct drilling and completions activities during cyclone season. The combination of not being able to drill in cyclone season and not being able to drill during peak periods of the pygmy blue whale migratory seasons results in substantial impacts on the available time of the year where drilling and completion activities are acceptable, with the longest time period being three months from August-October. As it takes up to approximately three months to drill and complete each well, this schedule would not be viable to provide wells ready for Torosa FPSO RFSU, or for any future phases.

9. WHALE MANAGEMENT PROCEDURES

9.1 Overview

Whale Management Procedures (WMPs) are operational procedures that will be applicable to a range of activities during execution of the proposed Browse Project. The WMPs will outline the mitigations that must be applied in relation to monitoring for and responding to sightings of pygmy blue whales. The principles of the WMPs can also be applied at other locations where biologically important behaviours may occur (e.g., the migratory BIA). Activity specific WMPs will be developed as further details of the activity (i.e., timing, vessel type) are known, during the execution phase of the proposed Browse Project. The principles of the WMPs are outlined below – each relevant activity will have to apply these principles to develop a WMP specific to that activity.

As per **Section 8**, the following activities must have a WMP in place prior to field work commencing:

- All vessels operating in the Scott Reef possible foraging area (including construction, support/supply vessels, MODUs and the Torosa FPSO) and any construction vessel operating within 9 km distance from the BIA (**Section 9.2.2**)
- Impact piling activities (**Section 9.2.3**)
- VSP activities (**Section 9.2.4**).

The purpose of the WMPs is to ensure that appropriate mitigation measures are implemented to reduce the risk of displacement of pygmy blue whales from foraging occurring where modelling has indicated that behavioural disturbance within the possible foraging area may occur. This intent is consistent with guideline produced by DAWE (2021).

The intent of the WMPs for project vessels (continuous noise source) is not to manage the risk of injury to a whale as TTS could not credibly occur as a result of these activities. For vessel based activities, distances to TTS thresholds are typically met within 400 m of an individual vessel (max 1.5 km for cumulative impact of multiple construction vessels). Therefore, as injury from exposure to vessel noise requires exposure for more than 24 hours, the risk of this occurring is not considered credible given the daily distances typically travelled by pygmy blue whales during migratory periods.

Impulsive noise activities present a different injury risk and are subject to their own management procedures which are designed to ensure that appropriate mitigation measures are implemented to reduce the risk of injury to pygmy blue whales as well as displacement of pygmy blue whales from the possible foraging area occurring during operations where modelling indicates that injury or behavioural disturbance within the possible foraging area may occur.

The key elements of the WMPs are outlined below and have been developed based on guidance with EPBC Act Policy Statement 2.1 procedure, Bröker (2019) and recently approved Environment Plans governing activities in high use foraging areas for the pygmy blue whales (e.g. Beach Energy 2021).

9.2 Principles of the Whale Management Procedures

The following key principles must be incorporated into each WMP:

- Impact assessment - A description of the area that may be impacted by anthropogenic noise from the activity. This will inform the area in which response measures / mitigations will be applied.
- Monitoring – An overview of how/when monitoring for pygmy blue whales will be undertaken, including which techniques will be employed and a justification for non-standard techniques.
- Response measures - What actions will be taken if a pygmy blue whale is observed within or approaching a monitoring zone.

- Reporting – detailed records of observations and mitigative actions must be taken, including and non-conformances or corrective actions.

9.2.1 Pygmy Blue Whale Observation Techniques

Currently, the most common technique for detecting whales from vessels utilise visual observation techniques, either from a Marine Mammal Observer (MMO)[6] on board the source vessel or, from a plane/helicopter. Occasionally, this is supplemented by observational techniques such as PAM, infra-red or night vision. Within this plan, if there is a requirement to observe for whales and these observations rely on visual techniques, these observations must be performed during daylight hours with the corresponding activity not occurring in periods of low visibility, if visual observations are to be utilised. Alternative observation techniques can be applied if it can be validated as having an equal or greater accuracy of whale sighting as an MMO during daylight hours.

9.2.2 Whale Management Procedures for Project Vessels (Including FPSO & MODU)

Vessels operating on the proposed Browse Project may be required to comply with a vessel specific whale management procedure, depending on the type, location and timing of the activity being conducted.

Prior to undertaking specified activities that may generate noise above a threshold predicted to elicit a behavioural response from a pygmy blue whale and where mitigative actions are possible, the vessel must determine the Monitoring Zone applicable for that vessel, activity type and location.

The **Monitoring Zone** for each vessel is the distance at which a behavioural response may be elicited from a pygmy blue whale, which is currently estimated based on a behavioural impact threshold of 120 dB re 1 µPa (See **Section 3.8**). The Monitoring Zone must consider cumulative/additive noise. Monitoring Zones are not required where an activity being undertaken in Management Zone B will cause behavioural responses within 1 km of the sound source (as for normal operations, refer to **Table 6-1**).

Noise estimates or modelling results are available for surrogates of each vessel expected to operate as part of the proposed Browse Project. The monitoring zone must be determined (including justification of the noise estimate) prior to the vessel commencing relevant activities. Indicative Monitoring Zones for key vessel activity types are outlined in **Table 9-1**.

Table 9-1 Indicative monitoring zones for key vessel types and activity

Activity	Indicative Monitoring Zone (Radius)
Supply vessel approaching construction (e.g. pipelay) vessel to conduct re-supply	6 km*
DP MODU in transit and prepared to connect to moorings at well location	5 km
Supply vessel approaching moored MODU to conduct re-supply	4 km*
Vessels approaching FPSO to conduct offtake	3 km
Supply vessel approaching FPSO to conduct re-supply (when FPSO thrusters are not being used for heading control)	3 km
Supply vessel approaching FPSO to conduct re-supply (when FPSO thrusters are required for heading control)	4 km*

[6] Marine Mammal Observer – a dedicated and suitably trained person who must not have any other duties that impede their ability to engage in visual observations during the required observation period. They may have other duties on board the vessel at other times.

*From the centrepoint of the combined vessel noise field which may be less than the specified distance from each vessel's observation point

To minimise the impacts of noise to pygmy blue whales, the following measures will be implemented prior to undertaking specified activities that may generate noise above a threshold predicted to elicit a behavioural response from a pygmy blue whale:

- **Pre-start-up visual observations:** Prior to entering a location established as an Exclusion Zone, observations (see **Section 9.2.1**) must be made of the Monitoring Zone for a continuous period of 30 minutes. This includes a continuous 30 minute period after which a pygmy blue whale has been identified as leaving the Monitoring Zone. The vessel should not enter the Exclusion Zone until the observations of the Monitoring Zone has confirmed the pygmy blue whales are not present.
- **Operating procedures:** During the operations within the Exclusion Zone, observations of the Monitoring Zone must continue. If a pygmy blue whale enters the Monitoring Zone, reasonable action must be taken to safely reduce noise from the activity to reduce the likelihood that the whale is caused to move on from an area in which it may have been foraging. This may include (where safe and practicable to do so) ceasing the activities (including ceasing use of thruster on the FPSO), moving the vessels away from the sighted pygmy blue whale and avoiding sudden accelerations or change in direction during transit.
- **Restart after pygmy blue whale induced shut down:** Prior to recommencing the activity after a shut down due to a pygmy blue whale sighting within the exclusion zone, pre-start up visual observations as described above must be undertaken.

9.2.3 Whale Management Procedures for Management of impulsive noise – Impact Piling

To mitigate the risk of injury to and/or displacement of blue whales from the possible foraging area as a result of impact piling activities:

- A 3000 m Monitoring Zone will be applied
- An Exclusion Zone will be implemented so as to ensure that whales are not exposed to Sound Exposure Levels of greater than or equal to 183 dB re 1 p Pa2.s. The Exclusion Zone will be no less than a 2000 m radius around the pile hammer.

If impact piling is to be utilised, then to minimise the impacts of noise to pygmy blue whales, the following measures will be implemented:

- Impact piling is not to occur within Management Zone A (the Scott Reef channel).
- Black out period: No impact piling shall occur during peak periods of pygmy blue whale migratory seasons in Management Zone B.
- Pre-start-up visual observations: Visual observations for pygmy blue whales must be undertaken to the extent of the Monitoring Zone for at least 30 minutes before the commencement of impact piling activities. Impact piling may not commence until the observations of the Monitoring Zone has confirmed pygmy blue whales are not present.
- Operating procedures: The following procedures will be implemented during operations:
    - Visual observations of the Monitoring Zone will be maintained continuously during impact piling to identify if any pygmy blue whales enter the Exclusion Zone.
    - If pygmy blue whales are sighted within the Exclusion Zone, action to suspend all impact piling within the Exclusion Zone will be taken within 2 minutes or as soon as safely possible.
    - Impact piling activities will not recommence until the pygmy blue whales are observed to move outside the Exclusion zone or 30 minutes have passed since the last sighting.

- Soft ‘fairy taps’ start procedures: Impact piling activities will be initiated at the soft ‘fairy taps’ start level and then build up to full operating impact force. The soft ‘fairy taps’ start procedures will only commence if no pygmy blue whales have been sighted within the Exclusion Zone during the pre-start-up visual observations.

9.2.4 Whale Management Procedure for Management of impulsive noises – Vertical Seismic Profiling (VSP)

To minimise impacts to whales, Part A ‘Standard Management Procedures’ of the EPBC Act Policy Statement 2.1 - Interaction between offshore seismic exploration and whales (Seismic Guidelines) will be implemented during all VSP operations, using a 1000 m Monitoring Zone, 500 m Exclusion Zone and a 1,000 m Low Power Zone. For operations within the Scott Reef Channel the Monitoring Zone and Exclusion Zone will be increased to a 2000 m horizontal radius from the acoustic source.

The 1000 m low power zone will be used where it can be demonstrated that the received sound exposure level for each shot will not exceed 160 dB re 1Pa2s, for 95% of acoustic shots at 1000 m range.

In addition, during the peak periods of the pygmy blue whale migratory seasons, the following management measures will be implemented during all Vertical Seismic Profiling (VSP) operations:

- **Black out period:** No VSP shall occur within Management Zone A during peak periods of the pygmy blue whale migratory seasons.
- **Pre-start-up visual observations**: Visual observations for pygmy blue whales must be undertaken to the extent of the Monitoring Zone for at least 30 minutes before the commencement of VSP activities. VSP may not commence until the observations of the Monitoring Zone has confirmed pygmy blue whales are not present.
- **Operating procedures**: The following procedures will be implemented during operations:
    - Observations of the Monitoring Zone will be maintained continuously during VSP to identify if any pygmy blue whales enter the Exclusion Zone.
    - If pygmy blue whales are sighted within the Exclusion Zone, action to suspend all VSP within the Exclusion Zone will be taken within 2 minutes or as soon as safely possible.
    - VSP activities will not recommence until the pygmy blue whales are observed to move outside the Exclusion zone or 30 minutes have passed since the last sighting.

10. SCIENTIFIC MONITORING PROGRAM

10.1 Overview

As outlined within Section 6.3.8 of the draft EIS/ERD and Section 4.4.2 of the Supplement Report to the draft EIS/ERD, scientific monitoring and verification programs have been proposed in relation to pygmy blue whales and underwater noise.

A scientific monitoring program is planned, to confirm and update baseline data on the distribution, relative abundance, seasonality and behaviour of pygmy blue whales within the possible foraging area at Scott Reef (refer to **Section 9**). On-going data acquisition at relevant times throughout the proposed Browse Project will be a key component of the scientific monitoring program. The program will continue monitoring pygmy blue whales and confirm sound source levels of project activities.

The key objectives of the pygmy blue whale monitoring program are as follows:

- To verify and further understand the seasonality, residency time, behaviours and relative abundance of the EIO pygmy blue whale population utilising the possible foraging area at Scott Reef.
- Investigate technology to improve real-time detection of pygmy blue whales.

These objectives will be achieved through the implementation of three key monitoring programs.

- Baseline monitoring program (**Section 10.2**) – This scope will focus on characterising and measuring the ambient soundscape (physical, anthropogenic and biological), as well as determining the presence, spatial and temporal distribution of whale species within the Development Area (including foraging and migratory BIAs). This monitoring program will address the commitment to verify and further understand the seasonality, residency time, behaviours and proportion of the EIO pygmy blue whale population utilising the possible foraging area at Scott Reef. Results will be utilised as part of an adaptive management program (**see Section 11**)
- Operational monitoring Program – ongoing passive acoustic monitoring and oceanographic monitoring to track seasonality and predict peak periods within the northbound and southbound migratory seasons.
- Real time detection – A program to identify and implement viable real-time detection systems for pygmy blue whales that can be implemented into this Management Plan to improve outcomes where observation is relied upon (e.g. application of Whale Management Procedures, Section **9**).

10.2 Baseline Monitoring Program (Indicatively 2023 – 2028)

A baseline monitoring program will be designed and implemented to understand and maintain currency of pygmy blue whale (and other whales) movement and behaviour within and in proximity to the proposed Browse Project. Baseline data collection, ongoing monitoring and real-time detection of marine mammals with a focus on pygmy blue whales will inform the operational basis of management controls and mitigation to support the management approach.

The two primary objectives of the baseline monitoring programs are to:

- To verify and further understand the seasonality, residency time, behaviours and relative abundance of the EIO pygmy blue whale population utilising the possible foraging area at Scott Reef.
- Identify the habitats within the Scott Reef BIA that are likely to support predictable aggregations of prey to ensure spatial management areas are appropriately defined.

A detailed description of the monitoring program will be detailed in a pygmy blue whale baseline monitoring program to be finalised within six months of approval of this management plan. The program will incorporate an independent peer review.

The key components identified as part of the baseline monitoring program are presented in **Table 10-1**. The passive acoustic monitoring (PAM) will be designed and executed to obtain information on the ambient soundscape and the presence of pygmy blue whales (and other whales).

Table 10-1 Overview of baseline monitoring program applicable to Pygmy Blue Whales

Type	Parameters	Locations	Timing
Verify and further understand the seasonality, residency time, behaviours and relative abundance of the EIO pygmy blue whale population utilising the possible foraging area at Scott Reef			
Passive Acoustic Monitoring – seabed landers at specific locations	Presence and timing of pygmy blue whales based on vocalising individual whales	Lander deployment design to optimise detection of pygmy blue whales on western and eastern entrances and within the Scott Reef Channel and eastern extent of the possible foraging area. Lander deployment design to optimise detection of pygmy blue whales within the migratory BIA overlap with the Calliance and Brecknock facility locations	Commence three years out from commencement of any Project development activities Three years continuous PAM monitoring
PAM - autonomous underwater vehicles (AUVs) such as gliders or Autonomous surface vessels (ASVs) for regional context and the relative importance of the Scott Reef possible foraging area	Presence, distribution and timing of pygmy blue whales within and outside the Scott Reef possible foraging area based on vocalising individual whales	Possible foraging area at Scott Reef Migratory BIA area overlap with Calliance and Brecknock Migratory BIA area overlap and proximity to Browse trunkline route	Design PAM glider survey relevant in space and time to collect broader geographical scale data
Vessel-based visual and drone-based surveys	Presence and timing, behaviour of pygmy blue whales Life-stage, gender and health of pygmy blue whales sighted	Specific to Scott Reef channel area and eastern extent of the possible foraging area.	Commence three years out from commencement of any Project development activities Five years of bi-annual survey trips of the Scott Reef channel area, targeting peak north and southbound migratory periods (based on PAM records when available, intelligence gathering from other studies, tourism activities in Timor Leste etc.
Telemetry	Distribution, movement and behaviour – horizontal and vertical	Satellite tagging of pygmy blue whales, such as: Limpet tags to track long distance migrations Archival pop-off tags (miniPAT) to record diving behaviour	Commence three years out from commencement of any Project development activities
Identify the habitats within the Scott Reef possible foraging area that are likely to support predictable aggregations of prey to ensure spatial management areas are appropriately defined.			
Oceanographic sampling and krill	Water column profiling and hydroacoustic backscatter monitoring	Scott Reef channel area and surrounds (wider Browse basin)	Commence three years out from commencement of any

Type	Parameters	Locations	Timing
(pygmy blue whale prey) availability	to detect and predict krill abundance, occurrence - depth in water column and distribution (spatial and temporal scales)		Project development activities Bi-annual during shoulder and peak periods for north and south bound migrating pygmy blue whales
Mapping/modelling of regional productivity as a proxy to prey (krill) location and availability	Remote sensing techniques to identify environmental drivers of prey availability and prediction of krill blooms in space and time or proxy to indicate lead time to krill blooms	Regional – targeting known and possible foraging areas	Commence three years out from commencement of any Project development activities

10.2.1 Passive Acoustic Monitoring

Moored omni-directional acoustic recording 'stations' will be deployed in order to quantify the soundscape within the proposed monitoring locations. Bottom mounted recorders are proposed for this long-term monitoring application as this configuration leads to the most stable platform, minimising mooring noise although alternative configurations with equivalent outcomes may be included.

A determination of the final recording station design will be made once final monitoring locations are determined as water depth is a key consideration for the equipment selection and design.

The proposed duty cycle for the recorders is an important consideration for the monitoring program. The duty cycle must allow for the quantification of both ambient soundscape and marine mammal presence equally well. A reduction of the duty cycle impacts negatively on the ability to detect cetaceans and determine call rates. Generally, more frequent short listening periods improve the accuracy of daily presence estimates of cetaceans. Overall, subsampling effects are most pronounced for low and/or temporally clustered vocal activity (Thomisch *et al*. 2015).

A sampling rate sufficient to acquire acoustic frequencies up to 30 kHz is required to detect baleen whales and to measure anthropogenic and geophony. In order to monitor for the presence of toothed whales, a sampling rate that allows at least 100 kHz to be resolved is proposed. A minimum 15-minute duty cycle is proposed. This duty cycle will comprise of a minimum of 50% recording time for baleen whales along with sampling at higher frequencies for odontocetes (to optimise detection of beaked whales and similar species that have relatively short detection distances) and the smallest period of sleep that allows the recorder to function for the desired deployment period.

Initially, the recorder servicing trips will be conducted every 6 months to validate data quality and to ensure that the monitoring is meeting the desired objectives. After approximately the first three deployments (dependent on results) service trips may be conducted annually.

10.2.2 Sampling Design

A determination of the specific number and location of the acoustic recording 'stations' within the monitoring locations (e.g. Torosa and Brecknock/Calliance) will take into consideration a number of key factors during the planning and execution phase. The following sampling design process will be implemented during the planning and execution phase of the monitoring program.

1. Compilation and analysis of relevant environmental data for the Browse Development Area. This includes current data, bathymetry and sound speed profiles. These parameters have a strong influence on ambient noise.
2. Modelling to assist in determining optimal recorder locations.

3. Mooring designs and modelling of mooring performance.
4. Recorder configuration design (duty cycle configuration, sampling frequency).

Expert advice will be sought in developing the design of the monitoring program to ensure any outcomes meet the objectives of the program and will be statistically valid.

10.2.3 Challenges for Monitoring and Detection of Pygmy Blue Whales

Pygmy blue whales migrate and forage in oceanic areas of Western Australian waters that are generally offshore and remote posing challenges to the operational feasibility of monitoring as outlined:

- Despite being one of the largest known animals to have ever existed they are elusive, spending long periods underwater, taking short surface intervals (to breathe) and move over vast areas of remote, deep offshore oceans.
- Populations were severely depleted by commercial whaling with many only recently discovered, together with population specific important life-stage habitats and locations only recently identified or are yet to be discovered.
- Population recovery and quantitative estimates on numbers are not accurately known, only estimated from passive acoustic detection and little information exists on population structure.
- The numbers of pygmy blue whales migrating through the Scott Reef possible foraging area are only a subset (estimated 6-40%) of the EIO pygmy blue whale population and detection within the vast area of the BIA will present challenges in optimising survey designs.
- Telemetry studies have confirmed individual whales undertake extensive transboundary migrations that intersect with major shipping lanes, commercial fishing activities and existing offshore oil and gas facilities that pose current pressures and threats to pygmy blue whale populations.

10.3 Operational Monitoring

Components of the baseline monitoring program such as the passive acoustic monitoring will be maintained for the construction and operational phases of the proposed Browse Project.

The exact components and elements of the operational monitoring program will be determined following a review of the implementation of the baseline monitoring program. As per Section 7.5, an expert panel will be utilised to input into the design of this ongoing monitoring program.

10.4 Technology Investigation for Real-Time Detection of Pygmy Blue Whales

A key component of the site-specific activities for the construction and operational phases of Brecknock/Calliance and Torosa is real-time detection of pygmy blue whales for specific activity Whale Management Procedures (WMPs). As detailed in **Section 9**, the WMPs require qualified marine mammal observers for visual monitoring of whales and as such, operations are restricted to daylight hours. Advancements in marine mammal detection technology may simplify the marine mammal observation process and provide an opportunity to reduce reliance on visual identification techniques. To date, technological detection methods have been explored as complementary or alternative methods to visual monitoring in low visibility conditions for seismic surveys. Verfuss *et al*. (2018) reviewed such methods and concluded that the efficiency will depend on animal behaviour and environmental conditions but using a combination of complementary systems generally improves the overall detection performance. A component of the scientific monitoring program will include a research and development program on real-time detection technologies with the goal of operationally feasible, cost-effective and robust real-time detection technology for the proposed Browse Project.

Advances in technology and innovation are expected to enable such innovations such as connection of PAM systems to communications systems within the subsea infrastructure to provide real time information back to the FPSO. This data will be used to inform and improve scientific knowledge and also be used to inform management measures.

Results of the passive acoustic monitoring and visual observation surveys during the baseline monitoring program will be used to inform the design and location of the ongoing passive acoustic monitoring program. Furthermore, data processing advancements using AI may be such that results of an ongoing monitoring program can be near-to or real-time and support verification of the spatial and temporal controls and mitigation management measures to prevent noise impacts to pygmy blue whales.

Real time monitoring and detection of vocalizing whales, through the use of an underwater listening station (ULS), is already being used in Boundary Pass (50 km south of Vancouver) by the Vancouver Fraser Port Authority. The ULS comprises installed listening stations that send data back to an interpretation system, providing real time analysis both of the noise signature of passing vessels and detection of vocalizing whales to inform real time adaptive changes to shipping activities.

Methods of real-time whale detection technology that are currently implemented and/or under development that may be considered for further investigation are listed in **Table 10-2**.

Table 10-2 Real-time whale detection technologies for further investigation

Detection method	Benefits	Constraints
Drone surveillance for monitoring of exclusion zones	Identify whale presence, species and behaviour such as foraging Detection can reduce likelihood of encountering pygmy blue whales at a distance that may cause injury or behavioural response Leverage data (photographic imagery) for scientific studies on pygmy blue whales	Drone equipment suitable for offshore flying conditions and the requirement for dedicated drone pilots Type of drones (commercial to military use) determines flying range and time which varies from limited (range is within sight and duration times short) to extended (distance range of 100s km and flight durations of 24-28 hours). Type and feasibility of operation to support activity specific monitoring requires further investigation
Passive acoustic monitoring – landers, autonomous underwater vehicles (AUVs) and autonomous surface vehicles (ASVs)	AUVs deployable from support vessels and can be programmed on specific routes Based on signature vocalisation can detect whale species	Data upload and processing delays access to whale detection information. Technology relies of whale vocalisation for detection and pygmy blue whale vocalisation for Western Australia currently not well understood in terms of relating calls to population structure and behaviour such as foraging.
Infra-red thermal imaging	Can be used at night and periods of low visibility. Can increase likelihood of detecting whale presence BRII project – industry, NOPSEMA and AAD supporting concept development of such technology for whale detection	Limitations on detection distance/depth, interpretation of data (identification of whale type for example) and practicality of implementation.

Detection method	Benefits	Constraints
RADAR	360° detection zone Can be deployed from MODUs and FPSOs – fixed top-side infrastructure or support vessels	Requires whales to be on surface for detection Limited to short range detection (<1 km) in optimal sea conditions Moderately affected by high sea state, fog and heavy rain Issues with detection of false positives from wave crests, surface debris and buoys Inability to differentiate between whale species

11. ADAPTIVE MANAGEMENT

11.1 Adaptive Management Approach

Adaptive management is a form of structured decision-making that will be applied in relation to achieving the stated objectives of this management plan (**Section 3.1**).

Adaptive management is an iterative process that integrates monitoring and evaluation of processes with flexible decision-making, where adjustments can be made to controls and mitigation management approaches based on observed outcomes (NOAA, 2021).

The adaptive management approach will be important in linking the latest scientific or technical information about the proposed Browse Project activities to decision making. Adaptive management will be applied throughout the proposed Browse Project, informed by the scientific monitoring, impact prediction reviews and environmental responses, thereby providing critical feedback to inform future decision making on key controls and mitigation management.

There are two key elements of the adaptive management approach, each with a series of management actions;

- Incorporation of scientific monitoring data into spatio-temporal management controls (Section 11.1.2). These actions are in place to ensure the latest data gathered as part of the baseline or operational scientific monitoring programs are used to inform spatio-temporal management controls; and
- Sound source verification (SSV) during design and operations (**Section 10** and **Section 11**). These actions involve estimating (through modelling) and measuring the noise generated by key infrastructure, including well heads, the Torosa FPSO and MODU. This monitoring will address the commitment to confirm source levels of underwater noise emissions for key project aspects to verify the impact predictions in the EIS and supplemental information.

A series of adaptive management actions are proposed, for each of which the following are described:

- **Aim / Purpose -** What is the adaptive management action designed to achieve
- **Methodology -** What actions will be undertaken to achieve the aim
- **Timing -** When will the action be implemented
- **Adaptive response trigger** - Upon completion of the action, what will trigger an adaptive response mechanism (e.g. change to management action / control)
- **Adaptive Response -** What change to management actions will be made in response to triggers or action outcomes.

11.1.1 Sound Source Verification

Table 11-1 outlines the adaptive monitoring program relevant to the design of the proposed Browse Project. This section of the program is relevant to elements of the project where noise can be reduced through design optimisation, including the FPSO thrusters and well head choke valves. The primary purpose of this element of the plan is to ensure that as design matures the management principles outlined in this plan can be achieved and to ensure and operational management actions are appropriately implemented.

Whale management procedures will be an integral part of activities, ensuring that observations for whales are undertaken and whales are detected so that underwater noise sources can be managed to minimise the impact of underwater noise. Of particular importance to the effectiveness of Whale Management Procedures is the size of the monitoring zone, which is initially informed by modelling of the underwater noise source characteristics but for long term activities, in field measurements will be used to ensure these management measures are appropriate.

Table 11-1 Adaptive monitoring program relevant to the design of the proposed Browse Project

Action #	Aim / Purpose	Methodology	Timing	Adaptive Response Trigger	Adaptive Response
1	Ensure noise from the Torosa FPSO thruster is designed to generate noise below 178 dB re 1 µPa·m when operating at 50% thrust capacity, to ensure any monitoring zone within a whale management procedure is less than 3 km.	Modelling or other predictive technique will be used to estimate the sound generated from the proposed thruster design using suitably qualified contractor	Prior to finalisation of FPSO thruster design	Modelling indicates FPSO thruster will generate noise above 178 dB re 1 µPa.m when operating at 50% capacity.	Revise operational procedures to restrict thruster use (e.g. capacity) to ensure the monitoring zone for the FPSO when using thrusters at 50% capacity is less than 3 km.
2	Predict noise from the Torosa well head choke valves.	Sound source characterisation using suitably qualified contractor	Prior to finalisation of Torosa well head choke valve design	Model sound propagation of well heads to determine if noise (>120dB re 1 µPa) impacts extend to beyond 1 km of any well centre within Zone B or impact on the Scott Reef Channel.	Re-design or re-locate well centres to ensure operation of well heads does not impact the Scott Reef Channel.
3	In field verification of Torosa FPSO noise to verify monitoring zone distance (within whale management procedures	In field sound measurements	During the first year of operation of the Torosa FPSO	Measured sound levels of FPSO indicates FPSO thruster is generating noise above 178 dB re 1 µPa.m when operating at 50% capacity.	Implement operational procedures to restrict thruster use to a power level that ensures management objectives can be met.

	for the MODU) is aligned to modelling and is appropriate				
4	Validate predicted noise from the TRD well head choke valves.	In field sound measurements	During the first year of operation of the TRD well heads	Measured sound levels of well head choke valves indicates noise (>120dB re 1 µPa) impacts extend to beyond 1 km of the TRD within Zone B or impact on Scott Reef Channel (Zone A).	Identify corrective actions, such as modification of flow rates to reduce choke valve noise or installation of additional mitigations.
5	Verify behavioural response noise thresholds remain applicable	Scientific literature on noise threshold levels, expert opinion, temporal restrictions for peak pygmy blue whale migration periods are tracked and updated	Every three years	Scientific literature indicates change to rationale supporting 120 dB re 1 µPa as indicator for disturbance to pygmy blue whale foraging behaviour.	Update management procedures to ensure latest noise thresholds are incorporated into plans, to ensure they continue to achieve stated objectives.
6	In field verification of MODU noise to verify monitoring zone distance (within whale management procedures for the MODU) is aligned to modelling and is appropriate	In field sound verification	During the first year of each long-term noise source	In field sound verification predicts monitoring zones (distance from activity at which behavioural disturbance is predicted) are greater than those outlined in Table 9-1.	Update whale management procedure for the MODU

11.1.2 Incorporation of Scientific Monitoring Data into Spatio-temporal Management Controls

A series of spatial and temporal controls have been established to achieve the aims of this management plan, based on management principles described in Section 7.2.

Timing of expected occurrence of pygmy blue whales at Scott Reef has been informed by many previous infield scientific monitoring programs, however, the migratory patterns of the EIO pygmy blue population are presently not well described and variable in time and space. Additional verification and monitoring work is being proposed to occur as part of the proposed Browse Project, to add to the existing body of information of pygmy blue whale presence at Scott Reef and the wider foraging area. The monitoring data will help further define the shoulder and peak seasonality periods for north and southbound migration, with design of the monitoring and interpretation of results to be subject to review by an independent expert or experts.

Table 10 2 Adaptive Management Approach used to Verify Applicability of Spatial and Temporal controls

Action #	Aim / Purpose	Methodology	Timing	Adaptive Response Trigger	Adaptive Response
7	Update definition of peak and shoulder migratory period based on whale presence observations.	As per Table 10-1. Survey design is subject to review by independent experts.	Baseline monitoring is targeted to commence within 12 months of approval of this plan. Ongoing reviews of spatial and temporal management measures to be undertaken prior to first activities and then prior to 'phase 2' activities as defined in Section 2.3 and every five years thereafter.	New scientific monitoring data is available that can be used to update the period defined as either the peak and shoulder pygmy blue whale migratory period.	Planned activities must be revised to ensure they are occurring within the required timing windows based on any updates to definition of peak/shoulder migratory periods.
8	Verify the location at which pygmy blue whale foraging behaviour occurs or potentially may occur within the Scott Reef possible foraging area to ensure spatial management areas are appropriate	As per Table 10-1. Survey design is subject to review by independent experts.		Significant potential for, or foraging behaviour observed, beyond Scott Reef Channel (Zone A).	Revise the boundary of spatial management areas, with revisions to be subject to independent expert review.

12. OUTCOME

Woodside has conducted an evaluation of the proposed Browse Project against the Blue Whale CMP as part of the primary approvals process under the EPBC Act. As part of this, an evaluation has been undertaken in relation to Action 3 of Action Area A.2 of the CMP which is the pertinent action in relation to this plan.

Action Area A.2, Action 3 of the CMP states:

> "*Anthropogenic noise in biologically important areas will be managed such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area* (Commonwealth of Australia, 2015)."

Woodside considers that the management approach outlined in this plan demonstrates, with a high level of confidence, that unacceptable impacts to pygmy blue whales will be prevented, by minimising the risk of injury to pygmy blue whales or displacement of pygmy blue whales from the Scott Reef possible foraging area, as a result of underwater noise emissions associated with the proposed Browse Project.

Consistency of proposed Project activities with other relevant actions within the CMP are considered within the EIS/ERD.

12.1 Injury

Impulsive Noise

The spatial and temporal controls presented in this plan ensure that all activities generating impulsive noise will either be eliminated during the Project detailed design phase and if they are required, will only occur outside of times/places where pygmy blue whales are likely to be present. A scientific monitoring program will be put in place prior to these activities occurring, to provide a thorough understanding of times and places pygmy blue whales are likely to be present in and around the Project Area. A requirement to monitor for pygmy blue whales will apply to these activities, which can be immediately ceased if a whale is sighted, on a precautionary basis.

The following measures will be in place to ensure no pygmy blue whale within the possible foraging area is injured due to impulsive noise:

Elimination

- Impact piling or VSP will not occur in Management Zone A (**Figure 7-1**) at any time.
- Impact piling will not occur within Management Zone B (**Figure 7-1**) during peak periods of the pygmy blue whale migration seasons (**Table 4-1-**)
- The schedule will be optimised to avoid impact piling occurring within Management Zone B during peak and shoulder periods within pygmy blue whale migration periods
- VSP will not occur within Management Zone B (**Figure 7-1**), during peak pygmy blue whale migration periods (**Table 4-1--**).

Substitution

- Wherever technically feasible (which is governed by geological conditions), piling will be done using non-impact piling techniques (e.g. suction piling) which does not generate impulsive noise.

Mitigation

- Where impacting piling and VSP activities do occur, whale management procedures will be implemented to ensure there is no exposure of pygmy blue whales to impulsive noise capable of causing injury. This includes the use of exclusion zones, pre-start procedures and shut down procedures.

The substitution and elimination controls are designed to ensure that activities associated with impulsive noise sources that may result in PTS and TTS do not occur spatially or temporally where pygmy blue whales may be present. This will substantially reduce the potential for injury to occur to pygmy blue whales. The mitigation controls further reduce any minor residual risk of such impacts occurring should pygmy blue whales be present outside of the spatial and temporal management areas.

Vessel noise

Unlike impulsive noise which can potentially cause injury to cetaceans after only brief exposure periods, the injury thresholds (e.g. PTS, TTS) for vessel noise are based on 24 hour exposure periods (shorter exposure periods can cause PTS, but at increasingly shorter distances). The greatest distance at which injury may be caused (after 24 hours of continuous exposure) to a whale was 1.5 km (during a short term construction activity involving multiple vessels). Typically, vessels (including MODU and FPSO) operating as part of the proposed Browse Project present injury risk at less than 650 m from a source. Considering behavioural disturbance (e.g. avoidance) may occur at 120 dB re 1 µPa, and migrating pygmy blue whales typically travel 10s or 100s of kilometres a day, the risk of exposure of a pygmy blue whale PBW to TTS or PTS from vessel activities is not considered credible.

ANIMAT modelling presented within this plan further supports conclusions that risks of noise induced injury to hearing is highly unlikely to occur as a result of vessel based continuous noise and mitigations proposed for general vessel activities are likely to be effective at further reducing this already highly unlikely risk.

Wellhead noise

Modelling completed by Duncan (2011) shows that noise levels typically fall below 120 dB re 1 uPa m within 500 m of the wellhead drill centre. It should be noted that 500 m is a horizontal distance considering the loudest point in the water column (which for a wellhead is close to the seabed). The behavioural threshold of 120dB is not reached at the surface according to Duncan (2011) modelling, instead extending up to approximately 100 m below the surface.

The distance towards the TTS injury thresholds has been estimated as 100 m based on other modelling results presented for the proposed Browse Project. This is also defined as a horizontal distance considering the loudest point in the water column. It is not considered credible that the TTS threshold is reached at the surface given the behavioural threshold does not reach the surface. It is considered highly likely that the vertical distance to the TTS threshold would not extend beyond the behavioural threshold (ie 100 m below the surface).

Pygmy blue whales spend the vast majority of their time close to the sea surface (Owen et al. 2016) in depths shallower than 100 m. While a pygmy blue whale may temporarily dive within the area where TTS may occur from a well head, it is not considered credible based on known behaviour that a pygmy blue whale will reside below the 100 m water depth, within 100 m lateral distance of a wellhead drill centre, for a sufficient portion of the 24 hours that would be required for TTS to occur. Therefore, wellheads are not considered to pose a credible TTS risk to foraging or migrating pygmy blue whales.

It should also be noted that while ANIMAT modelling was not conducted on well heads specifically, ANIMAT modelling on a louder noise source (the FPSO machinery noise – 174 dB re 1 µPa·m) resulted in no simulated whales being exposed to TTS. Given the ANIMAT modelling accounts for animal behaviour and the FPSO machinery noise is close to the surface and louder than well head choke valves, the ANIMAT modelling provides further evidence that wellheads are not considered to pose a credible TTS risk to foraging or migrating pygmy blue whales.

12.2 Displacement from Foraging

It is recognised that the proposed Browse Project may result in the generation of underwater noise in excess of the recognised behavioural response threshold, which has the potential to disrupt pygmy blue whale foraging behaviour.

Accordingly, this plan has considered:

- the time of year the activity will be undertaken and the likelihood of pygmy blue whale foraging in that area (summarised in **Section 4**)
- the extent, intensity, and duration of sound exposure within the Scott Reef possible foraging area, including residual and cumulative impacts after the application of controls (summarised in **Section 12.2.3**
- the undertaking of any appropriate controls to prevent unacceptable impacts (summarised in **Section 8**).

Best practice management measures in accordance with a precautionary approach have been established within this plan and successful implementation will ensure that, with a high degree of certainty, the anthropogenic noise from the proposed Browse Project will be managed such that any blue whale will be able to continue to utilise the BIA without injury, and no blue whale will be displaced from a foraging area. In this way, the proposed Browse Project will not be inconsistent with the CMP.

This conclusion is further supported by the evidence presented below.

12.2.1 Outcomes Following Application of Spatio-temporal Management Principles

Available scientific evidence of pygmy blue whale foraging in the possible foraging area has been documented in **Section 4**. All available scientific research indicates that there is limited evidence of foraging behaviour, with only a small number of pygmy blue whales estimated to pass through the Scott Reef region as substantiated from cetacean sightings, satellite tracking and acoustic logger data. However, it is recognised that pygmy blue whale foraging potential exists in this area and this is more likely to occur to the west of Scott Reef and potentially in the Scott Reef channel and therefore underwater noise must be more strictly managed within this area. To this end, additional controls are in place for Management Zone A (Scott Reef Channel, **Figure 7-1**) as compared to the wider Scott Reef possible foraging area (Management Zone B, **Figure 7-1**). Migratory patterns indicate peak pygmy blue whale presence at Scott Reef is currently considered as May, June and November. This will be subject to further validation through baseline and ongoing scientific monitoring programs and results used within an adaptive management process supporting review and revision of spatio-temporal controls in response to monitoring outcomes, if required and supported by expert peer-review.

The proposed management approach outlined in **Section 6** applies the hierarchy of controls including spatio-temporal management principles to minimise the source of underwater noise at the times and locations where pygmy blue whales are of a higher likelihood to be present and foraging may occur. In particular, key underwater noise generating activities will not be conducted during peak periods of pygmy blue whale migratory seasons as follows:

Activities potentially impacting Management Zone A:

- Impact piling or VSP will not occur in Management Zone A (**Figure 7-1**) at any time.
- No subsea construction (e.g., flowline) or drilling and completions activities will occur within Management Zone A (**Figure 7-1**) during the peak or shoulder periods of the pygmy blue whale migration seasons.
- Any MODU operating at the TRD drill centre (located in Management Zone B but close to border of Management Zone A) during the peak or shoulder periods of the pygmy blue whale migration seasons must not use a dynamic positioning system or thrusters that generate noise over 174

dB re 1 µPa·m unless arriving at or departing the drill centre (which must be done in accordance with a WMP detailed in **Section 9.2.2).** The use of a dynamic positioning capable MODU that is moored during drilling is acceptable.

Activities potentially impacting Management Zone B (**Figure 7-1**):

- Impact piling or VSP activities will not occur during peak periods of the pygmy blue whale migration seasons.
- During peak pygmy blue whale migration periods, any MODU operating at a Torosa or Brecknock well centre (excl. TRD) must not use a dynamic positioning system / thruster that generates noise over 174 dB re 1 µPa·m, other than when arriving/departing at the well centre (which must be done in accordance with a WMP detailed in **Section 9.2.2**). The use of a dynamic positioning capable MODU that is moored during pygmy blue whale migration periods, that achieves the specified noise limit, is acceptable.
- Any MODU operating at the TRD drill centre during the peak or shoulder periods of the pygmy blue whale migration seasons must not use a dynamic positioning system or thrusters that generate noise over 174 dB re 1 µPa·m unless arriving at or departing the drill centre (which must be done in accordance with a WMP detailed in **Section 9.2.2)**. The use of a dynamic positioning capable MODU that is moored during drilling is acceptable.
- Torosa FPSO thrusters will be designed and/or operated to produce less than 178 re 1 µPa·m for operations required during peak pygmy blue whale migratory periods.

12.2.2 Management Measures

Planned design features and management measures to prevent displacement of pygmy blue whales from the Scott Reef possible foraging area are detailed in **Section 8**. These include:

During Design:

- Thrusters on the FPSO **will be** designed to minimise noise generation, with the radius to the pygmy blue whale behavioural response threshold being reduced from ~2.8 km to 570 m if noise reduction from 183 re 1 µPa.m to 178dB re 1 µPa.m (50% thruster utilisation) is achieved.
- Subsea choke valves on well heads at Torosa **will be** designed to minimise noise generation, with initial investigations indicating noise can be reduced by approximately 16.5 dB, meaning the radius at which pygmy blue whale behavioural response threshold is experience would be significantly below the predicted ~500 m horizontal radius. The outcome of this exercise is uncertain, as it has not been possible to identify a vendor that has had to incorporate noise mitigations into well head design before. This design mitigation is a best in class approach to noise mitigation.

During subsea construction and installation:

- At Torosa and Brecknock, MODUs will not use DP systems to hold station while drilling during peak periods of the pygmy blue whale migratory seasons, but instead will be moored.
- Vessels operating in the Scott Reef possible foraging area will be required to implement operational restrictions and observe for pygmy blue whales, with triggers to delay or stop certain activities if whales are sighted within nominated management zones.
- No activities will occur within the Scott Reef Channel.

In relation to impulsive noise from subsea construction and installation activities:

- Non-impulsive noise generating alternatives to impact piling (e.g. suction piling) will be used at all times, where technically feasible.
- Impact piling will not occur in the Scott Reef channel (Management Zone A) at any time or within Management Zone B during peak or shoulder pygmy blue whale migratory periods.

- VSP activities will not occur in the Scott Reef channel (Management Zone A) at any time or within the Zone B during peak periods of the pygmy blue whale migratory seasons.
- A Whale Management Procedure (WMP) will be in place during all impact piling and VSP activities, to observe for whales and respond appropriately in the event that whales are detected within monitoring zones.

During operations (that coincide with peak periods of the pygmy blue whale migratory seasons):

- There will be no unmitigable vessel noise (including from FPSO or MODUs) above the behavioural response threshold within the Scott Reef channel
    - The Torosa FPSO is located in the swell shadow of the Scott Reef system, meaning the thrust required to control heading will be rarely utilised and will be substantially less than other offshore facilities, i.e., Calliance FPSO, significantly minimising long term noise generation from either continuous (weather-vaning FPSO) or intermittent (condensate offloading) activities.
- Concurrent activities at the Torosa FPSO will be restricted to reduce cumulative noise (i.e., supply vessels cannot conduct goods transfers while condensate offtakes are occurring).
- Mitigable noise, including from supply vessels and during condensate offtakes, will not occur unless a Whale Management Procedure is in place to establish exclusion zones where the activity cannot commence if a whale is present and once the activity has commenced, monitoring will continue and applicable mitigations applied if a whale is observed.

During future tie-back phases:

- Subsea construction or installation activity (e.g., drilling or flowline installation) related to subsequent tiebacks from within the Torosa field will only occur outside of peak periods of the pygmy blue whale migratory seasons.
- Drilling and completions of any Torosa or Brecknock well as part of future (post Torosa RFSU) tieback phases will be required to be completed by a moored MODU when operating during peak periods of the pygmy blue whale season, unless the noise from the DP system would be the equivalent or less than noise generated were it to be moored.

12.2.3 Residual Risk Outcomes

After the application of the spatio-temporal management framework as well as the elimination, substitution and reduction controls outlined in **Section 8**, a cumulative ensonified area assessment has been provided in **Section 6.3** that demonstrates the following:

- There are no planned activities that will occur during peak periods of the pygmy blue whale migratory seasons, that generate noise above 120 dB re 1 µPa within the Scott Reef channel.
- Underwater noise is anticipated to peak during the initial subsea construction phase, during intermittent, short-term activities (ie IFL installation with concurrent MODU operations) that may ensonify (>120 dB re 1 µPa) an area of up to ~123 km^2 (0.95% of Management Zone B). These activities are targeted to occur outside of the peak periods of the pygmy blue whale migratory seasons.
- After this initial construction period, the total areal extent of the Scott Reef possible foraging area ensonified above 120 dB re 1 µPa during peak pygmy blue whale migratory periods is reduced to ~1 km^2 at the surface (<0.01% of Management Zone B) during normal operations (with mitigations applied ie turning off vessel propulsion or FPSO thrusters if a whale is sighted) and 22 km^2 at the surface (0.17%) during intermittent (<1 day per fortnight) offtake operations (where vessel propulsion cannot be halted if a whale is sighted, due to offtake spill risks).
- Noise from well-heads during this period may ensonify a seabed area up to 5.7 km^2, however, this noise would not impact waters in the top 50 m of the water column and this estimate does

not account for the significant reductions in noise expected to result from designing well head choke valves to minimise noise.

- Activities outside of the Scott Reef possible foraging area will also be managed, to minimise the risk of disturbance to opportunistic foraging pygmy blue whales and scientific monitoring will occur in this region to understand the likelihood of pygmy blue whale foraging behaviour occurring.

12.2.4 Consistency with the Blue Whale Conservation Management Plan

In preparing this plan to ensure the proposed Browse Project is not inconsistent with Action Area A.2, Action 3, consideration has been given to how the broader CMP treats the threat of noise interference to the stated objective of the Plan; to minimise anthropogenic threats to allow for their conservation status to improve so that Blue Whales can be removed from the EPBC Act threatened species list.

It is considered that the intent of the Plan is not to prevent activities which may cause underwater noise above behavioural response thresholds in foraging areas, but instead to manage anthropogenic noise in biologically important areas such that any blue whale continues to utilise the area without injury, and is not displaced from a foraging area.

Given that mitigation and management measures have been applied such that:

- The risk of exposure of a Pygmy Blue Whale to TTS or PTS from vessels or wellheads is considered highly unlikely
- There are no planned activities that will occur during peak periods of the pygmy blue whale migratory seasons, that generate noise above 120 dB re 1 μPa within the Scott Reef Channel (Management Zone A)
- After the initial construction phase, the total areal extent of the Scott Reef possible foraging area ensonified above 120 dB re 1 μPa and where no further mitigations based on whale sightings are possible, is reduced to:
    - ~1.0 km^2 at sea surface (<0.01% of Management Zone B) or 4.7 km^2 at seabed (0.04%) during normal operations
    - ~22.4 km^2 at sea surface (or 0.17% of Management Zone B) or 27.1 km^2 (0.21%) at seabed during FPSO condensate offtake

Best practice management measures in accordance with a precautionary approach have been established within this plan and successful implementation will ensure that, with a high degree of certainty, the anthropogenic noise from the proposed Browse Project will be managed such that any blue whale will be able to continue to utilise the BIA without injury, and no blue whale will be displaced from a foraging area. In this way, the proposed Browse Project will not be inconsistent with the CMP.

13. PLAN REVIEW

In order to ensure the effectiveness and efficiency of the management measures outlined in this plan, as well as the outcomes of scientific monitoring program it is important to allow for periodic review of the overall management plan and for revisions, if approved by the Minister, to be implemented.

Such reviews may include but is not limited to the following considerations:

- Modification of any of the proposed management measures following implementation and review of effectiveness.
- Removal, update or modification to the Blue Whale CMP
- Review of spatial extent of possible foraging area and/or management zones as a result of monitoring
- Review of expected timing of presence of pygmy blue whales and definition of peak and shoulder periods for migratory seasons following monitoring outcomes
- Review of the scientific monitoring program with reference to design (number of monitoring stations, duration, survey techniques and knowledge gaps), outcomes and expert opinion
- Publication of peer-reviewed data that contributes to the knowledge of the EIO pygmy blue whale population and data that supports modification to proposed management measures and/or removes uncertainty associated with application of a precautionary approach.

In absence of any of the above review triggers, the plan will be reviewed and updated at least every five years.

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15. ACRONYMS

Acronym	Meaning
2C	Contingent resources
2TL	Second trunkline
ASV	Autonomous underwater vehicle
AUV	Autonomous surface vehicle
BIA	Biologically important area
BJV	Browse Joint Venture
BTL	Browse Trunkline
Cal/Brec	Calliance and Brecknock fields
CMP	Conservation Management Plan
DAWE	Department of Agriculture, Water and the Environment
DP	Dynamic positioning
EIA	Environmental impact assessment
EIO	East Indian Ocean
EIOPBW	East Indian Ocean pygmy blue whales
EIS	Environmental Impact Statement
EP	Environment Plan
EP Act	*Western Australia Environmental Protection Act* 1986
EPBC Act	*Environment Protection and Biodiversity Conservation Act* 1999
EPO	Environment Performance Objective
EQMP	Environmental Quality Management Plan
ERD	Environmental Review Document
FAQ	Frequently asked questions
FCGT	Flood, clean, gauge and test
FPSO	Floating Production Storage and Offloading
HUC	Hook up and commissioning
IFL	Interfield line (rigid pipeline between Torosa and Calliance FPSO)
IMMR	Inspection, maintenance, monitoring and repair activities
MMscfd	Million standard cubic feet per day
MODU	Mobile offshore drilling units
MSL	Mean source level
NCVA	National Conservation Values Atlas
NOPSEMA	National Offshore Petroleum Safety and Environment Authority

Acronym	Meaning
NRC	North Rankin Complex
NWS	North West Shelf
NWSJV	NWS Joint Venture
OSV	Offshore support vessel
PAM	Passive acoustic monitoring
PFA	Possible Foraging Area
PTS	Permanent Threshold Shift
PBW	Pygmy Blue Whale
RFSU	Ready for start up
Required for SOLAS	In situations where the vessel master considers that complying with a requirement of this plan would adversely affect the safety or security of the vessel or its passengers or crew, or in situations where the vessel master is bound to provide assistance (under SOLAS Chapter V) upon receiving a distress signal from any source that persons are in distress at sea, the requirement does not apply.
SEL	Sound exposure level
SPL	Sound pressure level
SSV	Sound source verification
SURF	Subsea, Umbilicals, Risers Flexibles
Surface waters	Approximately top 30m of the water column
tcf	Trillion cubic feet
TTS	Temporary Threshold Shift
VSP	Vertical Seismic Profiling
WA	Western Australia
WMP	Whale Management Procedures

Appendix A - Woodside Browse to NWS Vessel Noise Acoustic Modelling (Green et al 2022a)

Woodside Browse to NWS Vessel Noise

Acoustic Modelling

JASCO Applied Sciences (Australia) Pty Ltd

13 July 2022

Submitted to:

Aaron McDonald

Woodside Energy

Contract 4510700453

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Executive Summary

The Browse Joint Venture (BJV) proposes to develop the Brecknock, Calliance, and Torosa fields (collectively known as the Browse resources) via the development drilling of wells and the installation of a subsea production system that will supply two 1100 million standard cubic feet per day (annual daily export average) Floating Production Storage and Offloading (FPSO) facilities. The Browse Project gas will be transported from the FPSO facilities to the existing NWS Project infrastructure via an approximately 900 km long trunkline. Each FPSO will have a turret mooring system that will be stabilised using mooring lines secured to the seabed by piles. JASCO Applied Sciences previously modelled pile driving operations, vertical seismic profiling (VSP) during drilling operations, Mobile Offshore Drilling Unit (MODU), FPSO operations and Operational Support Vessel (OSV) operations, with the results presented in McPherson et al. (2019).

The BJV provided revised information about the MODU and FPSO operations for the present modelling study, which considers the following scenarios:

- The operations of a Mobile Offshore Drilling Unit (MODU) using only four thrusters at TRA and TRD drill centre locations (as opposed to eight).
- The operations of a MODU in a ‘moored’ configuration using no thrusters.
- The resupply of the MODU during drilling operations at TRA and TRD drill centre locations.
- FPSO operational noise for the Torosa FPSO without heading control, with heading control (thrusters operating), and with optimised heading control.
- Torosa FPSO operational noise during offtake, including the FPSO without heading control, an Offshore Support Vessel (OSV) near the FPSO, and a noiseless condensate tanker.
- Aggregate scenarios that include MODU drilling operations at TRD and the Torosa FPSO during offtake operations.

The objective of this modelling study was to determine ranges to acoustic exposure thresholds representing the best available science for permanent threshold shift (PTS), temporary threshold shift (TTS), and behavioural disturbance of marine fauna including marine mammals, turtles, and fish.

Acoustic fields caused by pressure were modelled and are presented as sound pressure levels (SPL) and accumulated sound exposure levels (SEL) as appropriate for noise effect criteria for continuous (vessel) noise sources. The effects of range-dependent environmental properties on sound propagation in the study area were accounted for by the numerical models.

The modelled sources are as follows:

- *An FPSO facility* that is 370 m long and 67 m wide. This was modelled under:
  - Typical operations, with no heading control and no offtake, only operating processing and associated equipment.
  - Heading control (thrusters operating), representative of typical operational conditions.
  - Heading control (thrusters operating) with optimised thrusters, representative of typical operational conditions.
  - Offtake, during which the FPSO is only operating processing and associated equipment, with an OSV under DP located 700 m behind the FPSO, and a noiseless condensate tanker located between the two.
- *A representative MODU* that is 100 × 80 m, under DP, representative of typical operational loads during 1-year (non-cyclonic) return interval metocean conditions. This was modelled using:
  - Four thruster sources operating at 40% capacity.
  - A central machinery source, representative of a typical drilling operation.

- *A representative OSV*, a DP vessel that is 92.95 m long (vessel design based on the Marin Teknikk MT6016 hull) under DP, representative of typical operational loads during maximum safe operating conditions and resupply operations. This was modelled using five thruster sources operating at a defined capacity, based on the specification of the *Fugro Etive*, as follows:
    - Two Rolls-Royce AZP100 thrusters.
    - Two Rolls Royce TT 2200 DPN thrusters.
    - One Rolls-Royce AZP1001 thruster.

The analysis considered multiple commonly used effect criteria, with the key results of the acoustic modelling summarised below.

Marine Mammals

- The results for the United States (US) National Marine Fisheries Service (NMFS 2018) criteria applied for marine mammal PTS and TTS for vessels are assessed here for a 24 hour period. Vessels are considered to be active continuously across the 24 hour period unless specified otherwise in the table heading. The maximum ranges to PTS are summarised in Tables 1 and 2.
- The maximum ranges to the US National Oceanic and Atmospheric Administration (NOAA 2019) marine mammal behavioural response criterion of 120 dB re 1 µPa (SPL) are summarised in Tables 3 and 4.
- For the aggregate scenario considering both TRD MODU drilling and FPSO offtake operations, it was found that due to the separation between the sites, ranges to PTS and TTS thresholds were unaltered compared to the individual operations. Maximum range to the behavioural response level was increased, and this is shown in Table 5.

Table 1. *Marine mammal SEL_{24h}, TRA and TRD Drill Centres*: Maximum (R_{max}) horizontal ranges (km) to modelled maximum-over-depth PTS thresholds from NMFS (2018).

Hearing group	Threshold for PTS, SEL_{24h} (dB re 1 µPa²s)[a]	Range R_{max} (km)					
		MODU (on DP)	MODU (Moored)	OSV (6 h)	OSV (12 h)	MODU Resupply (OSV 6 h)	MODU Resupply (OSV 12 h)
TRA Drill Centre							
LF cetaceans	199	<0.05	—	<0.05	0.06	0.06	0.06
MF cetaceans	198	<0.05	—	<0.05	<0.05	<0.05	<0.05
HF cetaceans	173	0.09	<0.05	0.06	0.10	0.10	0.11
TRD Drill Centre							
LF cetaceans	199	0.06	<0.05	0.06	0.06	0.06	0.06
MF cetaceans	198	0.06	<0.05	<0.05	<0.05	0.06	0.06
HF cetaceans	173	0.09	<0.05	0.06	0.09	0.10	0.11

[a] Frequency weighted.

Table 2. *Marine mammals, SEL_{24h}, activities at Torosa FPSO location*: Maximum (R_{max}) horizontal ranges (km) to modelled maximum-over-depth PTS thresholds from NMFS (2018).

Hearing group	Threshold for PTS, SEL_{24h} (dB re 1 µPa²s) [a]	Range R_{max} (km)		
		FPSO, Heading Control	FPSO, Heading Control (Optimised Thrusters)	FPSO Offtake
LF cetaceans	199	<0.05	<0.05	0.07
MF cetaceans	198	<0.05	—	<0.05
HF cetaceans	173	0.06	<0.05	0.11

[a] Frequency weighted.
A dash indicates the level was not reached.
FPSO offtake includes an FPSO, a noiseless condensate tanker and an OSV

Table 3. *Marine mammal behaviour, TRA and TRD Drill Centres*: Summary of maximum behavioural disturbance ranges.

SPL (L_p; dB re 1 µPa)	Range R_{max} (km)			
	MODU (under DP)	MODU (Moored)	OSV	MODU Resupply
TRA Drill Centre				
120[a]	4.49	0.49	2.21	4.95
TRD Drill Centre				
120[a]	4.10	0.49	3.14	5.49

[a] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).

Table 4. *Marine mammal behaviour, activities at Torosa FPSO location*: Summary of maximum behavioural disturbance ranges.

SPL (L_p; dB re 1 µPa)	Range R_{max} (km)		
	FPSO, Heading Control	FPSO, Heading Control (Optimised Thrusters)	FPSO Offtake
120[a]	2.82	1.67	2.67

[a] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).
FPSO offtake includes an FPSO under DP, a noiseless condensate tanker and an OSV.

Table 5. *Marine mammal behaviour, Aggregate Scenario*: MODU under DP at TRD and Torosa FPSO Offtake, summary of maximum behavioural disturbance ranges.

SPL (L_p; dB re 1 µPa)	Range R_{max} (km)
120[a]	4.68

[a] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).

Sea Turtles

The maximum ranges for the Finneran et al. (2017) criteria applied for sea turtles are summarised in Tables 6 and 7. There were no significant differences in ranges for the aggregate scenario compared with the individual operations.

Table 6. *Sea turtle SEL_{24h}, TRA and TRD Drill Centres*: Maximum-over-depth ranges (in km) to PTS threshold.

Threshold for PTS, SEL_{24h} (dB re 1 µPa²s)[a]	Range R_{max} (km)					
	MODU (under DP)	MODU (Moored)	OSV (6 h)	OSV (12 h)	MODU Resupply (OSV 6h)	MODU Resupply (OSV 12 h)
TRA Drill Centre						
220[b]	<0.05	—	<0.05	<0.05	<0.05	<0.05
TRD Drill Centre						
220[b]	0.06	—	—	<0.05	0.06	0.06

[a] Frequency weighted.
[b] Threshold for turtle-weighted SEL_{24h} (Finneran et al. 2017).
A dash indicates the level was not reached.

Table 7. *Sea turtle SEL_{24h}, activities at Torosa FPSO location*: Maximum-over-depth ranges (in km) to PTS threshold.

Threshold for PTS, SEL_{24h} (dB re 1 µPa²s)[a]	Range R_{max} (km)		
	FPSO, Heading Control	FPSO, Heading Control (Optimised Thrusters)	FPSO Offtake
220[b]	—	—	<0.05

[a] Frequency weighted.
[b] Threshold for turtle-weighted SEL_{24h} (Finneran et al. 2017).
A dash indicates the level was not reached.

Fish

- Sound produced by the operations could cause physiological effects and recoverable injury to some fish species, but only if the animals are in close proximity to the sound sources (within a planar range of 60 m) for 48 hours. Temporary impairment due to TTS could occur at similar short ranges if fish remain at the same range for long periods of time (12 hours). The ranges are very similar for all scenarios.
- There is no increased risk to fish from aggregate scenarios.

1. Introduction

JASCO Applied Sciences (JASCO) performed a modelling study of underwater sound levels associated with the Browse to North West shelf (NWS) Project development of the Brecknock, Calliance, and Torosa fields (collectively known as the Browse resources) by the Browse Joint Venture (BJV). This development will involve drilling wells and installing a subsea production system that will supply two 1100 million standard cubic feet per day (annual daily export average) Floating Production Storage and Offloading (FPSO) facilities. Gas will be transported from the FPSO facilities to the existing NWS Project infrastructure via an approximately 900 km long trunkline. Each FPSO will have a turret mooring system that will be stabilised using mooring lines secured to the seabed by piles. JASCO previously modelled pile driving operations, vertical seismic profiling (VSP) during drilling operations, Mobile Offshore Drilling Unit (MODU), and FPSO operations and Operational Support Vessel (OSV) operations. This previous work was presented in McPherson et al. (2019).

The BJV provided revised information about the MODU and FPSO operations for the present modelling study, which considers the following scenarios:

- The operations of a Mobile Offshore Drilling Unit (MODU) using only four thrusters at TRA and TRD drill centre (as opposed to eight).
- The operations of a MODU in a 'moored' configuration using no thrusters.
- The resupply of the MODU during drilling operations at TRA and TRD drill centres.
- FPSO operational noise for the Torosa FPSO without heading control, with heading control (thrusters operating), and with optimised heading control.
- Torosa FPSO operational noise during offtake, including the FPSO without heading control, an Offshore Support Vessel (OSV) near the FPSO and a noiseless condensate tanker.
- Aggregate scenarios that include MODU operations at the TRD drill centre and the Torosa FPSO during offtake operations.

The modelling study specifically assessed ranges from operations where underwater sound levels reached thresholds corresponding to various levels of impact on marine fauna. The animals considered here included marine mammals (pygmy blue whales, *Balaenoptera musculus brevicauda*), sea turtles, and fish (including fish eggs and larvae). Due to the variety of species considered, there are several thresholds for evaluating effects, including: mortality, injury, temporary reduction in hearing sensitivity, and behavioural disturbance.

The modelling methodology considered source directivity and range-dependent environmental properties. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), and or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria for non-impulsive (continuous) noise sources.

The geographic coordinates for the modelled sites are provided in Table 8 and an overview of the modelling area is shown in Figure 1.

Table 8. Location details for the modelled sites

Site	Source	Latitude (S)	Longitude (E)	MGA (GDA94), Zone 51		Water depth (m)
				X (m)	Y (m)	
TRA Drill Centre	MODU (centre)	13° 58′ 12.50″	121° 58′ 37.70″	389521	8455338	425
	OSV (centre)	13° 58′ 12.49″	121° 58′ 35.70″	389461	8455338	425
TRD Drill Centre	MODU (centre)	14° 00′ 26.64″	121° 57′ 23.58″	387315	8451207	392
	OSV (centre)	14° 00′ 26.63″	121° 57′ 21.58″	387255	8451207	392
Torosa FPSO	FPSO (centre)	13° 58′ 15.06″	122° 01′ 28.53″	394647	8455281	463
	OSV (centre)	13° 58′ 14.94″	122° 00′ 59.03″	393762	8455281	460

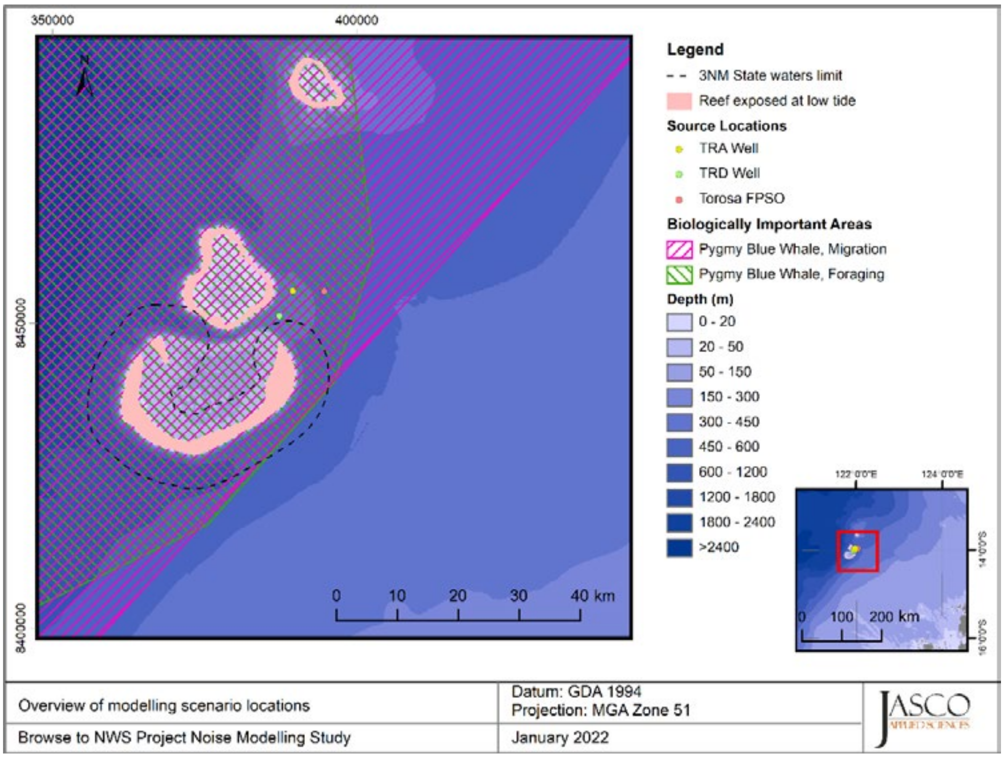

Figure 1. Overview of the modelled area and local features

1.1. Acoustic Modelling Scenario Details

The modelled sources are as follows:

- *An FPSO facility* that is 370 m long and 67 m wide. This was modelled under:
    - Typical operations, with no heading control and no offtake, only operating processing and associated equipment
    - Heading control (thrusters operating), representative of typical operational conditions
    - Heading control (thrusters operating) with optimised thrusters, representative of typical operational conditions
    - Offtake, during which the FPSO is only operating processing and associated equipment

- *A representative MODU* that is 100 × 80 m under DP, representative of typical operational noise during 1-year (non-cyclonic) return interval metocean conditions. This was modelled using:
  - Four thruster sources operating at 40% capacity
  - A central machinery source, representative of a typical drilling operation
- *A representative MODU* that is 100 × 80 m moored (no DP), representative of typical operational noise during drilling. This was modelled using:
  - A central machinery source, representative of a typical drilling operation.
- *A representative OSV*, a DP vessel 92.95 m long (vessel design based on the Marin Teknikk MT6016 hull) under DP, representative of typical operational noise during maximum safe operating conditions and resupply operations. This was modelled using five thruster sources operating a defined capacity, based on the specification of the *Fugro Etive*, as follows:
  - Two Rolls-Royce AZP100 thrusters.
  - Two Rolls Royce TT 2200 DPN thrusters.
  - One Rolls-Royce AZP1001 thruster.

These vessels were modelled in varying configurations at the three different locations shown in Figure 1. Scenarios are summarised in Table 9.

At both TRA and TRD drill centress, the OSV is positioned directly adjacent to the MODU, holding station on the MODU’s west side (Figure 2). Note that this figure shows co-ordinates for the TRA drill centre, but the relative vessel positioning is identical at the TRD drill centre. Resupply was only modelled for the DP MODU, not the moored MODU.

At the Torosa FPSO location, the OSV is positioned 700 m due west of the centre point of the FPSO, representative of an offtake scenario. This scenario also includes a tanker vessel, which has been treated as silent in the modelling. Figure 3 shows the layout for the Torosa location.

Table 9. Modelled scenarios

Scenario	Description	Sources	Length of operation
TRA drill centre			
1(a)	MODU drilling (under DP)	MODU drilling and thrusters (4 × 40%)	24 h
1(b)	MODU drilling (moored)	MODU drilling, no thrusters	24 h
2	Offshore Support Vessel	Support vessel (DP)	6 and 12 h
3	MODU resupply	MODU drilling and thrusters (4 × 40%) Support vessel (DP)	
TRD drill centre			
4(a)	MODU drilling (under DP)	MODU drilling and thrusters (4 × 40%)	24 h
4(b)	MODU drilling (moored)	MODU drilling, no thrusters	24 h
5	Offshore Support Vessel	Support vessel (DP)	6 and 12 h
6	MODU resupply	MODU drilling and thrusters (4 × 40%) Support vessel (DP)	
Torosa FPSO location			
7(a)	FPSO using heading control	FPSO thrusters and topsides machinery	24 h
7(b)	FPSO using optimised heading control	Optimised FPSO thrusters and topsides machinery	
8	FPSO offtake	FPSO with topsides machinery Silent Tanker Support vessel (DP)	
TRD drill centre and Torosa FPSO locations			
9	MODU drilling at TRD, Torosa FPSO Offtake	MODU drilling and thrusters (4 × 40%) Support vessel (DP) FPSO with topsides machinery Silent Tanker	24 h

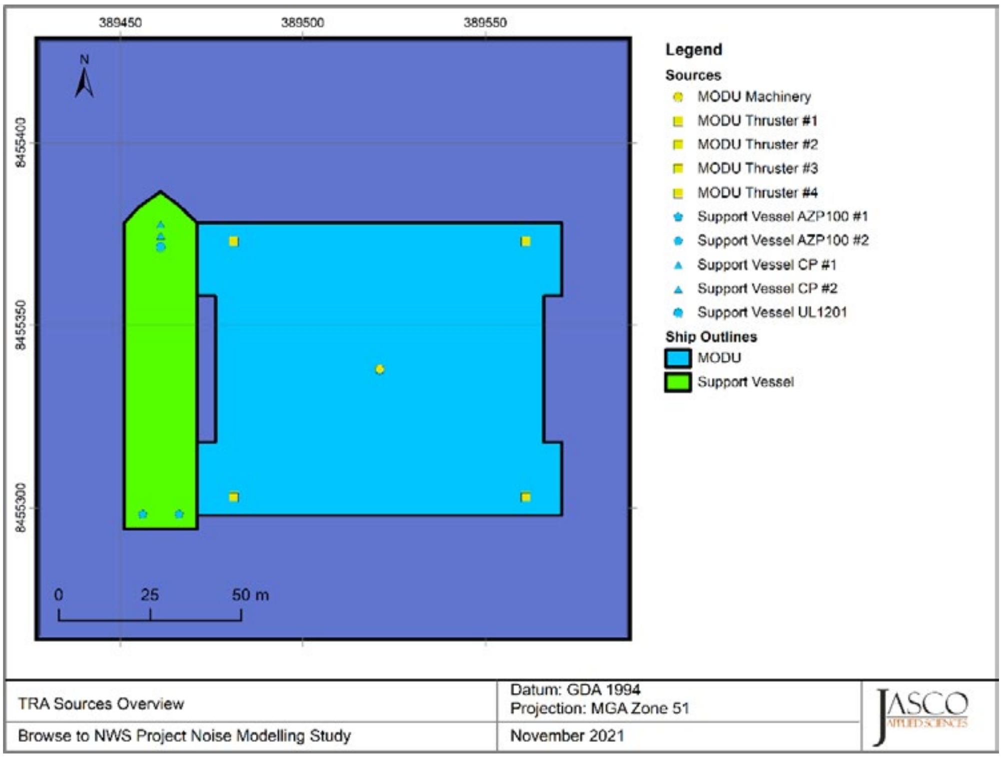

Figure 2. Overview of source layout at the TRA drill centre. Relative positioning of vessels is identical to that at the TRD drill centre. Locations for all sources are shown.

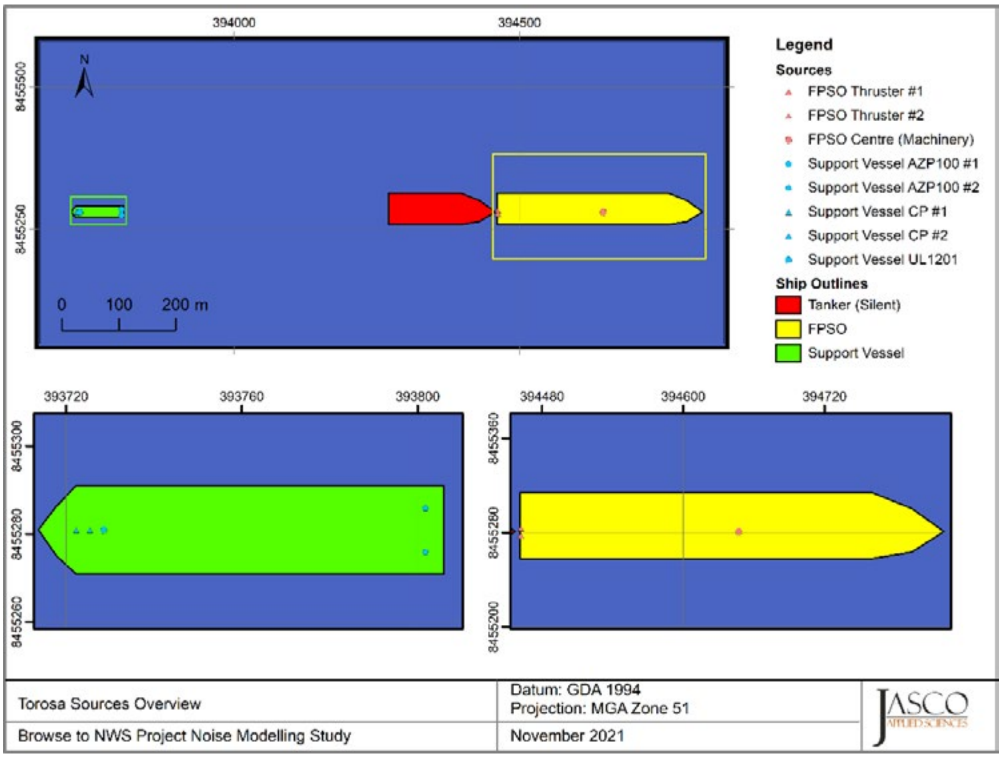

Figure 3. Overview of source layout at Torosa FPSO location, with detail on specific source positioning for FPSO and OSV. Locations for all sources are shown.

2. Noise Effect Criteria

To assess the potential impacts of a sound-producing activity, it is necessary to first establish exposure criteria (thresholds) for which sound levels may be expected to have a negative impact on animals. Whether acoustic exposure levels might injure or disturb marine fauna is an active research topic. Since 2007, several expert groups have developed SEL-based assessment approaches for evaluating auditory injury, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), and the United States National Marine Fisheries Service (NMFS 2018). The number of studies that investigate the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

Several sound level metrics, such as PK, SPL, and SEL, are commonly used to evaluate noise and its effects on marine life (see Appendix A.3). In this report, the duration of the SEL accumulation is integrated over the operational time periods for each vessel, as defined in Table 9.

Appropriate subscripts indicate any applied frequency weighting (Appendix A.3.3). The acoustic metrics in this report reflect the updated ANSI and ISO standards for acoustic terminology, ANSI S1.1 (R2013) and ISO 18405:2017 (2017).

This study applies the following noise criteria (Sections 2.1–2.2 and Appendix A.3.1), chosen for their acceptance by regulatory agencies and because they represent current best available science:

- Frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from NMFS (2018) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in marine mammals. This criteria was applied for consistency with previous work (McPherson et al. 2019).
- Marine mammal behavioural threshold based on the current interim U.S. National Oceanic and Atmospheric Administration (NOAA 2019) criterion for marine mammals of 120 dB re 1 µPa SPL (L_p) for non-impulsive sound sources. This is identical to the previously applied behavioural response threshold, however the reference has been updated.
- Sound exposure guidelines for fish, fish eggs, and larvae (Popper et al. 2014).
- Frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran et al. (2017) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in sea turtles.

2.1. Marine Mammals

The criteria applied in this study to assess possible effects of non-impulsive sources on marine mammals are summarised in Table 10; Cetaceans (low-, mid-, and high-frequency) were identified as the hearing groups requiring assessment. Details on thresholds related to auditory threshold shifts or hearing loss and behavioural response are provided in A.3, with frequency weighting explained in detail in Appendix A.3.3. Of particular note, whilst the newly published Southall et al. (2021) provides recommendations and discusses the nuances of assessing behavioural response, the authors do not recommend new numerical thresholds for onset of behavioural responses for marine mammals.

Table 10. Criteria for effects of non-impulsive noise exposure, including vessel noise on marine mammals: SPL and Weighted SEL_{24h} thresholds.

Hearing group	NOAA (2019)	NMFS (2018)	
	Behaviour	PTS onset thresholds (received level)	TTS onset thresholds (received level)
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)
LF cetaceans	120	199	179
MF cetaceans		198	178
HF cetaceans		173	153

L_p denotes sound pressure level period and has a reference value of 1 µPa.
L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa²s.

2.2. Fish, Sea Turtles, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to continue developing noise exposure criteria for fish and sea turtles based on work began by a NOAA panel two years earlier. The Working Group developed guidelines with specific thresholds for different levels of effects for several species groups (Popper et al. 2014). The guidelines define quantitative thresholds for three types of immediate effects:

- Mortality, including injury leading to death.
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma.
- TTS.

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. However, as these depend upon activity-based subjective ranges, these effects are not addressed in this report, and are included in Table 11 for completeness only. Because the presence or absence of a swim bladder has a role in hearing, fish susceptibility to injury from noise exposure depends on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Sea turtles, fish eggs, and fish larvae are considered separately.

Table 11 lists the relevant effects thresholds from Popper et al. (2014) for shipping and continuous noise. Some evidence suggests that fish sensitive to acoustic pressure show a recoverable loss in hearing sensitivity, or injury when exposed to high levels of noise (Scholik and Yan 2002, Amoser and Ladich 2003, Smith et al. 2006); this is reflected in the SPL thresholds for fish with a swim bladder involved in hearing. Finneran et al. (2017) presented revised thresholds for turtle injury, considering frequency weighted SEL, which have been applied in this study (Table 12).

Table 11. Criteria for vessel noise exposure for fish, adapted from Popper et al. (2014).

Type of animal	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	(N) Low (I) Low (F) Low	170 dB SPL for 48 h	158 dB SPL for 12 h	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Sea turtles	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

Sound pressure level dB re 1 µPa.
Relative risk (high, moderate, low) is given for animals at three ranges from the source defined in relative terms as near (N), intermediate (I), and far (F).

Table 12. Acoustic effects of continuous noise on sea turtles, weighted SEL_{24h}, Finneran et al. (2017).

PTS onset thresholds (received level)	TTS onset thresholds (received level)
Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)
204	189

L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa²s.

3. Methods

The operations considered in this study will occur at the Torosa fields, specifically at the TRA and TRD drill centres and FPSO location, at depths ranging from 390–463 m. Environmental parameters (bathymetry, sound speed profile and geoacoustics) from McPherson et al. (2019) was reused. Details are provided in Appendix C.2.

For the purposes of the environmental impact assessment process, the Browse Joint Venture have proposed acoustic source parameters for certain vessels under specific conditions. Where the BJV have proposed acoustic source parameters, these are provided on the basis of underwater radiated noise source modelling commissioned from DNV's Noise and Vibration division. The underwater radiated noise source modelling considers specific dynamic positioning and heading control system designs of representative vessels under a range of different operating conditions. The BJV have conservatively selected the thruster utilisation for modelling based on marine operational advice regarding specific sea state conditions. Further information regarding the development of the BJV's acoustic source parameters can be found in the BJV's Pygmy Blue Whale Management Plan.

3.1. Acoustic Source Parameters

3.1.1. Mobile Offshore Drilling Unit

Sound source locations and spectrum estimates for the MODU sources were based on the *Seadrill West Sirius*, which is equipped with eight Rolls-Royce UUC 355 thrusters (Figure 4).

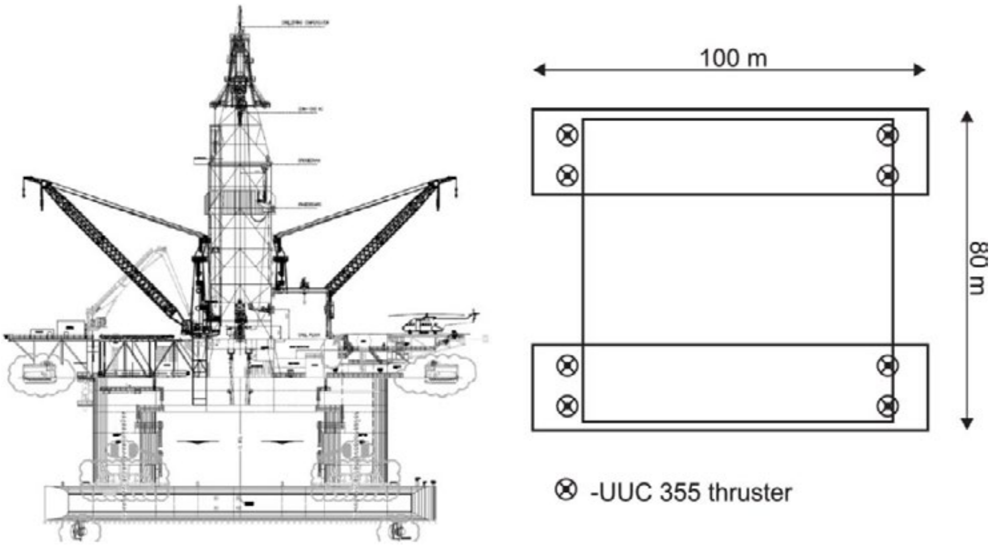

Figure 4. *Seadrill West Sirius* technical drawing showing thruster locations

This study modelled each MODU under dynamic positioning as five sources, representing four active thrusters running at 40% capacity, plus a source for noise incurred by drilling operations. The source levels for the thrusters were theoretically determined, and provided by the Browse Joint Venture (BJV), whilst the spectrum for drilling and machinery noise was taken from a recorded spectrum reported by Austin et al. (2018) for the *Transocean Polar Pioneer*, a similar semi-submersible drilling unit. Broadband source levels are 170.7 dB re 1 µPa and 176.5 dB re 1 µPa for the machinery noise and thrusters, respectively, making the combined broadband source level 182.8 dB re 1 µPa. The moored MODU was represented by the machinery/drilling noise only. The Figure 5 shows the decidecade band monopole source levels.

Machinery noise was modelled as a point source located at the centre of the MODU with a source 12.6 m depth based on 0.7 × ship draft (18 m for *West Sirius*) as specified in ISO 17208-1 (2016). Source depths for the thrusters were set to equal the draft, at 18 m.

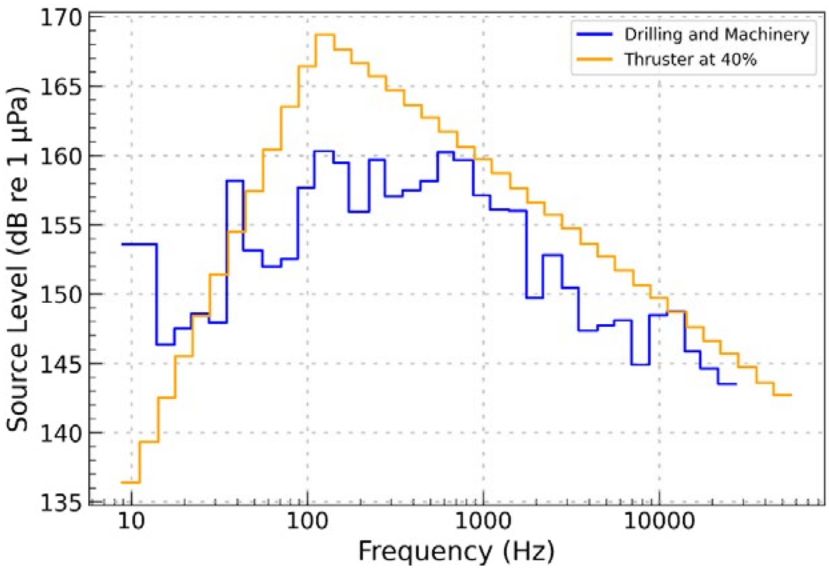

Figure 5. Decidecade band monopole source levels for MODU sources. Drilling and machinery levels from recorded spectrum of *Transocean Polar Pioneer*, 40% thrusters from theoretical data provided by the BJV.

3.1.2. Offshore Support Vessel

Sound source levels for the OSV were based on the *Fugro Etive*, a general purpose vessel 92.95 m in length, and 19.7 m in breadth, featuring two stern azipull thrusters (Rolls-Royce AZP100), two bow controllable pitch thrusters (Rolls-Royce TT 2200 DPN), and a retractable azimuthing thruster (Rolls-Royce UL1201).

For the FPSO offtake, each thruster was modelled as an individual source, operating at 40% capacity, from theoretically developed source levels provided by the BJV. Broadband source levels for these thrusters are 181.2, 174.7, and 174.9 dB re 1 µPa, respectively, giving a total broadband SL of 185.5 dB re 1 µPa. Source level spectra are shown in Figure 6.

For the MODU resupply scenarios, each thruster was modelled as an individual source, with the bow and retractable thrusters operating at 40% capacity, and the stern azipull thrusters operating at 20%, from theoretically developed source levels provided by the BJV. Broadband source levels for these thrusters are 173.3, 174.7, and 174.9 dB re 1 µPa, respectively, giving a total broadband SL of 181.3 dB re 1 µPa. Source level spectra are shown in Figure 7.

The BJV's selection of different levels of thrust for different OSV thrusters in the offtake and OSV resupply scenarios is based on marine operational advice. The azipull thrusters (at the stern) are primarily used for propulsion, as opposed to the bow/retractable thrusters which are primarily used for dynamic positioning. During OSV resupply, the propulsion thrusters are typically used less than the dynamic positioning thrusters during OSV resupply. This is different from OSV use during offtake scenarios where the OSV applies force to maintain tension in the offtake arrangement, and therefore the propulsion thrusters are utilised at higher levels.

Thruster locations, diameters, and depths were derived by referring to a technical drawing and cross-referencing this with the known length and breadth of the ship. Monopole source depths Z_s were calculated using the following equation, derived from Gray and Greeley (1980):

$$Z_s = Z_{prop} - 0.85 \cdot \varphi_{prop} \quad (1)$$

where Z_{prop} is the depth at the bottom of the propeller and φ_{prop} is the diameter of the propeller. Thus, depths were calculated as 3.2 m for the AZP100, 6.4 m for the UL1201, and 3.4 m for the CP thrusters.

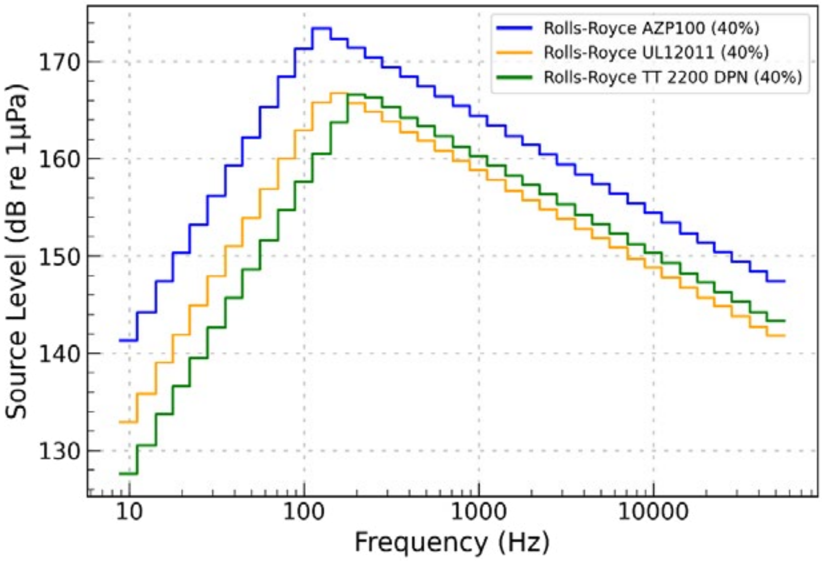

Figure 6. Decidecade band monopole source levels for OSV thruster sources during FPSO offtake. These spectra represent thrusters working at 40% capacity.

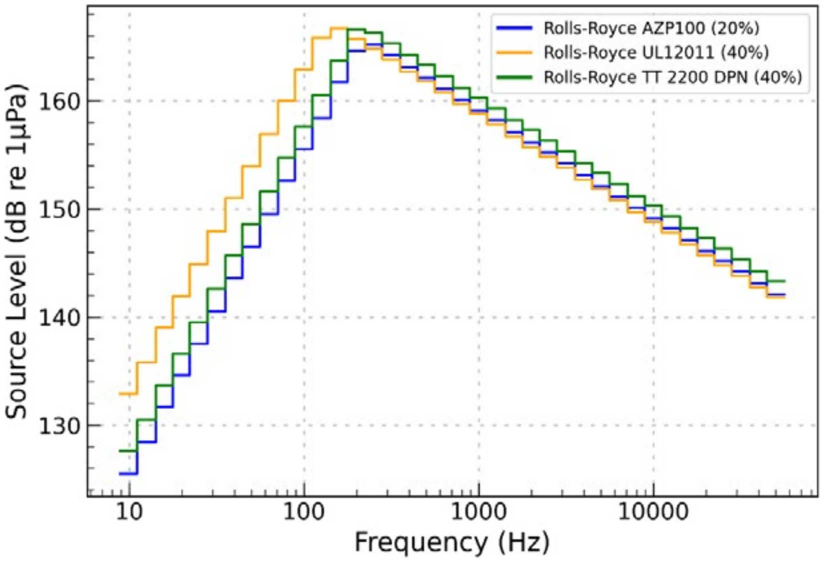

Figure 7. Decidecade band monopole source levels for OSV thruster sources during MODU resupply. These spectra represent thrusters working at 20 and 40% capacity.

3.1.3. Floating Production, Storage, and Offloading (FPSO) Facility

The proposed FPSO facility is a permanently moored, heading controlled production vessel approximately 370 m long and 67 m wide with a draft of 16 m. While in heading control mode, it operates on two stern thrusters positioned laterally on the keel at the stern of the ship 6 m apart.

The major sources of noise from this vessel are the two thrusters and noise associated with pumps, generators, and other machinery within the vessel. As a proxy for the latter noise source, an average of two source levels measured by Erbe et al. (2013) from the FPSO facilities *Nganhurra* and the *Ngujima Yin*, with a broadband source level of 173.9 dB re 1 µPa, was used. The thrusters were modelled as two separate point sources using theoretical source level spectra for 3000 mm nozzled 4 bladed fixed pitch propellers (FPPs), provided by the BJV. These had a broadband source level of 179.5 dB re 1 µPa.

In combination, the machinery noise and two thruster sources reach a broadband source level of 183 dB re 1 µPa. A future design target for the FPSO is a broadband source level of 178 dB re 1 µPa. Given the input spectra, it was calculated that a broadband reduction of 6.6 dB per thruster would be required to reach this target. An offset of −6.6 dB was therefore applied to the thruster spectrum for this additional hypothetical scenario. Figure 8 shows the source spectra for machinery and thrusters with and without the level reduction applied. It can be seen that a broadband reduction of thruster level would have greatest impact in terms of exceeding the machinery noise at frequencies of 80 Hz and above.

Machinery noise was modelled as a point source at the planar centre of the vessel at a depth of 8 m, which is 50% of the draught, consistent with the approach taken in McPherson et al. (2019). The thrusters were modelled as two separate point sources positioned 6 m apart at the stern of the ship (relative to the position of the machinery source) at a depth of 16.5 m, specified by the BJV. Thruster sources were not enabled for the FPSO offtake scenarios.

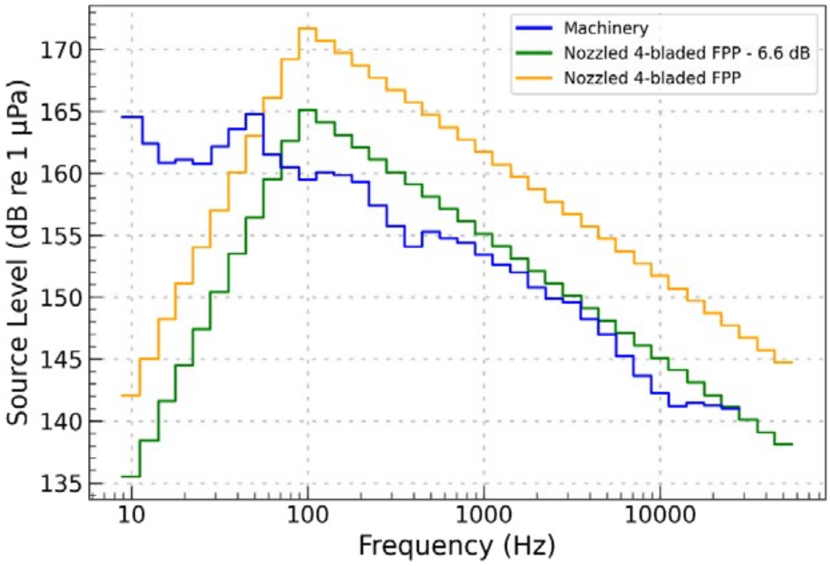

Figure 8. Source levels used for FPSO facility

3.2. Modelling Sound Propagation

JASCO's combined Marine Operations Noise Model (MONM) and gaussian beam acoustic ray-trace model (BELLHOP) were used to predict the acoustic field at frequencies from 10 Hz to 63 kHz. Details on these models are included in Appendix B.1.

Accumulated SEL was calculated using the following equation:

$$L_{E,24h} = L_E + 10\log_{10}(T) \tag{2}$$

where L_E is the per-second energy source level (output by MONM-BELLHOP) and T is the total number of operational seconds in a 24-hour period.

In the modelled scenarios, the FPSO at Torosa, the FPSO offtake activities, and the MODU (either under DP or moored) are considered to be in continuous operation, whilst the OSV during resupply operations at the TRA and TRD drill centres is modelled in operation for both 6 and 12 hours (see Table 9). Using Equation 2, Constant operation over 24 hours yields an offset of 49.3 dB, whilst for 12 hours this is 46.4 dB, and for 6 hours 43.3 dB. These offsets were applied to the relevant calculated received levels.

4. Results

Sound field results for all scenarios are presented in this section as tables and maps showing propagation ranges and isopleths with relevant effect thresholds. These are organised to show SPL results (Tables 13–16, Figures 9–19), followed by SEL results (Tables 17–19, Figures 20–34). The results for the aggregate scenario (Scenario 9, Table 9) are provided in Tables 20–22 and Figures 35–36.

A table entry showing <0.05 indicates a case where a particular noise level has been exceeded in the modelling, but at a range shorter than the minimum grid interpolation distance of 50 m. Figures are presented for each vessel in isolation, as well as offtake and resupply scenarios involving aggregation of noise from multiple vessels.

4.1. Tables

Table 13. *TRA/TRD drill centres, SPL*: Maximum (R_{max}) and 95% ($R_{95\%}$) planar ranges (in km) to various SPL levels from the centroids of the vessels involved.

SPL (L_p; dB re 1 µPa)	MODU (under DP)		MODU (Moored)		OSV		MODU Resupply	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
TRA Drill centre								
180	—	—	—	—	—	—	—	—
170	<0.05	<0.05	—	—	<0.05	<0.05	<0.05	<0.05
160	<0.05	<0.05	—	—	<0.05	<0.05	<0.05	<0.05
150	0.08	0.08	—	—	0.06	0.06	0.07	0.07
140	0.22	0.22	<0.05	<0.05	0.17	0.16	0.27	0.26
130	0.69	0.67	0.15	0.15	0.53	0.51	0.96	0.91
120[a]	4.49	2.87	0.49	0.47	2.21	2.10	4.95	3.79
110	13.82	12.39	2.28	2.18	10.89	6.78	17.06	12.96
TRD Drill centre								
180	—	—	—	—	—	—	—	—
170	<0.05	<0.05	—	—	<0.05	<0.05	<0.05	<0.05
160	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
150	0.09	0.09	<0.05	<0.05	0.06	0.06	0.09	0.07
140	0.22	0.22	<0.05	<0.05	0.17	0.16	0.26	0.25
130	0.69	0.67	0.15	0.15	0.54	0.51	1.11	0.99
120[a]	4.10	2.73	0.49	0.47	3.14	2.04	5.49	3.66
110	12.97	11.24	2.25	2.13	10.36	6.12	16.49	11.65

[a] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).
A dash indicates the level was not reached.

Table 14. *Torosa FPSO location, SPL*: Maximum (R_{max}) and 95% ($R_{95\%}$) planar ranges (in km) to various SPL levels from the centroids of the vessels involved.

SPL (L_p; dB re 1 µPa)	FPSO, Heading Control		FPSO, Heading Control (Optimised Thrusters)		FPSO Offtake	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
180	—	—	—	—	—	—
170	<0.05	<0.05	—	—	<0.05	<0.05
160	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
150	0.06	0.06	<0.05	<0.05	0.07	0.07
140	0.21	0.19	0.09	0.08	0.25	0.24
130	0.66	0.63	0.34	0.32	0.99	0.94
120[a]	2.82	2.66	1.67	1.55	2.67	2.49
110	13.05	9.78	5.65	5.19	9.45	8.14

[a] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).
FPSO offtake includes an FPSO, a noiseless condensate tanker and an OSV.
A dash indicates the level was not reached.

Table 15. *TRA/TRD drill centres, SPL, fish effect thresholds*: Maximum (R_{max}) and 95% ($R_{95\%}$) planar ranges (km) from the vessels to modelled maximum-over-depth SPL thresholds based on the quantifiable thresholds for fish with a swim bladder involved in hearing (Popper et al. 2014).

SPL (L_p; dB re 1 µPa)	MODU (under DP)		MODU (Moored)		OSV		MODU Resupply	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
TRA Drill centre								
170[a]	<0.05	<0.05	—	—	<0.05	<0.05	<0.05	<0.05
158[b]	<0.05	<0.05	—	—	<0.05	<0.05	<0.05	<0.05
TRD Drill centre								
170[a]	0.06	0.06	—	—	<0.05	<0.05	<0.05	<0.05
158[b]	0.06	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

[a] Recoverable injury (Popper et al. 2014)
[b] TTS

Table 16. *Torosa FPSO location, SPL, fish effect thresholds*: Maximum (R_{max}) and 95% ($R_{95\%}$) planar ranges (km) from the vessels to modelled maximum-over-depth SPL thresholds based on the quantifiable thresholds for fish with a swim bladder involved in hearing (Popper et al. 2014).

SPL (L_p; dB re 1 µPa)	FPSO, Heading Control		FPSO, Heading Control (Optimised Thrusters)		FPSO Offtake	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
170[a]	<0.05	<0.05	—	—	<0.05	<0.05
158[b]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

[a] Recoverable injury (Popper et al. 2014)
[b] TTS
FPSO offtake includes an FPSO, a noiseless condensate tanker and an OSV.
A dash indicates the level was not reached.

Table 17. *TRA drill centre, SEL_{24h}*: Maximum (R_{max}) and 95% ($R_{95\%}$) planar ranges (km) from the vessels to modelled maximum-over-depth PTS and TTS thresholds for marine mammals (NMFS 2018) and sea turtles (Finneran et al. 2017).

Hearing group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)[a]	MODU (under DP)		MODU (Moored)		OSV (6 h)		OSV (12 h)		MODU Resupply (OSV 6 h)		MODU Resupply (OSV 12 h)	
		R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
PTS													
LF cetaceans	199	<0.05	<0.05	—	—	<0.05	<0.05	0.06	0.06	0.06	0.06	0.06	0.06
MF cetaceans	198	<0.05	<0.05	—	—	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
HF cetaceans	173	0.09	0.09	<0.05	<0.05	0.06	0.06	0.07	0.07	0.09	0.09	0.10	0.09
Sea turtles	220	<0.05	<0.05	—	—	—	—	—	—	<0.05	<0.05	<0.05	<0.05
TTS													
LF cetaceans	179	0.51	0.50	0.12	0.12	0.24	0.23	0.35	0.33	0.55	0.52	0.58	0.55
MF cetaceans	178	0.08	0.08	—	—	0.06	0.06	0.06	0.06	0.07	0.07	0.07	0.07
HF cetaceans	153	0.77	0.75	0.30	0.29	0.43	0.42	0.66	0.64	0.89	0.86	1.02	0.98
Sea turtles	200	<0.05	<0.05	—	—	<0.05	<0.05	0.06	0.06	0.06	0.06	0.06	0.06

[a] Frequency weighted.
A dash indicates the level was not reached.

Table 18. *TRD drill centre, SEL_{24h}*: Maximum (R_{max}) and 95% ($R_{95\%}$) planar ranges (km) from the vessels to modelled maximum-over-depth PTS and TTS thresholds for marine mammals (NMFS 2018) and sea turtles (Finneran et al. 2017).

Hearing group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)[a]	MODU (under DP)		MODU (Moored)		OSV (6 h)		OSV (12 h)		MODU Resupply (OSV 6 h)		MODU Resupply (OSV 12 h)	
		R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
PTS													
LF cetaceans	199	0.06	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
MF cetaceans	198	0.06	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
HF cetaceans	173	0.09	0.09	<0.05	<0.05	<0.05	<0.05	0.06	0.06	0.10	0.09	0.10	0.09
Sea turtles	220	0.06	0.06	—	—	—	—	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
TTS													
LF cetaceans	179	0.51	0.50	0.13	0.13	0.25	0.24	0.35	0.33	0.54	0.51	0.58	0.55
MF cetaceans	178	0.07	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07	0.07	0.07	0.07
HF cetaceans	153	0.77	0.75	0.30	0.29	0.43	0.42	0.66	0.63	0.90	0.86	1.02	0.98
Sea turtles	200	0.07	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

[a] Frequency weighted.
A dash indicates the level was not reached.

Table 19. *Torosa FPSO location, SEL_{24h}*: Maximum (R_{max}) and 95% ($R_{95\%}$) planar ranges (km) from the vessels to modelled maximum-over-depth PTS and TTS thresholds for marine mammals (NMFS 2018) and sea turtles (Finneran et al. 2017).

Hearing group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)[a]	FPSO, Heading Control		FPSO, Heading Control (Optimised Thrusters)		FPSO Offtake	
		R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
PTS							
LF cetaceans	199	<0.05	<0.05	<0.05	<0.05	0.07	0.07
MF cetaceans	198	<0.05	<0.05	—	—	<0.05	<0.05
HF cetaceans	173	0.06	0.06	<0.05	<0.05	0.11	0.10
Sea turtles	220	—	—	—	—	<0.05	<0.05
TTS							
LF cetaceans	179	0.46	0.43	0.22	0.21	0.63	0.60
MF cetaceans	178	<0.05	<0.05	<0.05	<0.05	0.07	0.07
HF cetaceans	153	0.66	0.63	0.34	0.32	1.24	1.18
Sea turtles	200	<0.05	<0.05	<0.05	<0.05	0.06	0.06

[a] Frequency weighted.
A dash indicates the level was not reached.

4.1.1. Aggregate Scenario

Table 20. *Torosa FPSO location and TRD drill centre, Aggregate FPSO offtake and MODU under DP, SPL*: Maximum (R_{max}) and 95% ($R_{95\%}$) planar ranges (in km) to various SPL levels from the centroids of the vessels involved.

SPL (L_p; dB re 1 µPa)	R_{max} (km)	$R_{95\%}$ (km)
180	—	—
170	<0.05	<0.05
160	<0.05	<0.05
150	0.09	0.07
140	0.24	0.22
130	1.00	0.85
120[a]	4.68	2.54
110	15.45	9.78

[a] Threshold for marine mammal behavioural response to continuous noise (NOAA 2019).
A dash indicates the level was not reached.

Table 21. *Torosa FPSO location and TRD drill centre, Aggregate FPSO offtake and MODU under DP, SPL, fish effect thresholds*: Maximum (R_{max}) and 95% ($R_{95\%}$) planar ranges (km) from the vessels to modelled maximum-over-depth SPL thresholds based on the quantifiable thresholds for fish with a swim bladder involved in hearing (Popper et al. 2014).

SPL (L_p; dB re 1 µPa)	R_{max} (km)	$R_{95\%}$ (km)
170[a]	<0.05	<0.05
158[b]	<0.05	<0.05

[a] Recoverable injury (Popper et al. 2014)
[b] TTS
FPSO offtake includes an FPSO, a noiseless condensate tanker and an OSV.

Table 22. *Torosa FPSO location and TRD drill centre, Aggregate FPSO offtake and MODU under DP, SEL$_{24h}$*: Maximum (R_{max}) and 95% ($R_{95\%}$) planar ranges (km) from the vessels to modelled maximum-over-depth PTS and TTS thresholds for marine mammals (NMFS 2018) and sea turtles (Finneran et al. 2017).

Hearing group	Threshold for SEL$_{24h}$ ($L_{E,24h}$; dB re 1 µPa²s)[a]	R_{max} (km)	$R_{95\%}$ (km)
PTS			
LF cetaceans	199	<0.05	<0.05
MF cetaceans	198	<0.05	<0.05
HF cetaceans	173	0.09	0.09
Sea turtles	220	<0.05	<0.05
TTS			
LF cetaceans	179	0.63	0.53
MF cetaceans	178	0.07	0.07
HF cetaceans	153	1.24	1.06
Sea turtles	200	0.07	<0.05

[a] Frequency weighted.

4.2. Maps

4.2.1. Maximum-over-depth SPL Sound Fields

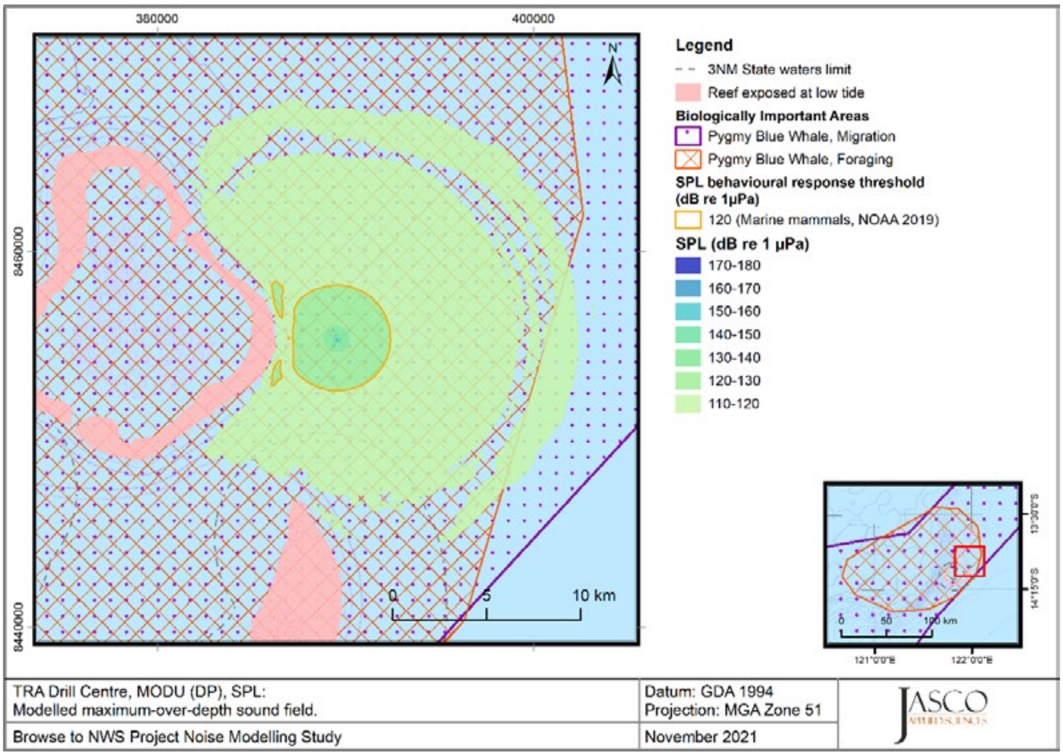

Figure 9. *TRA Drill centre, MODU, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

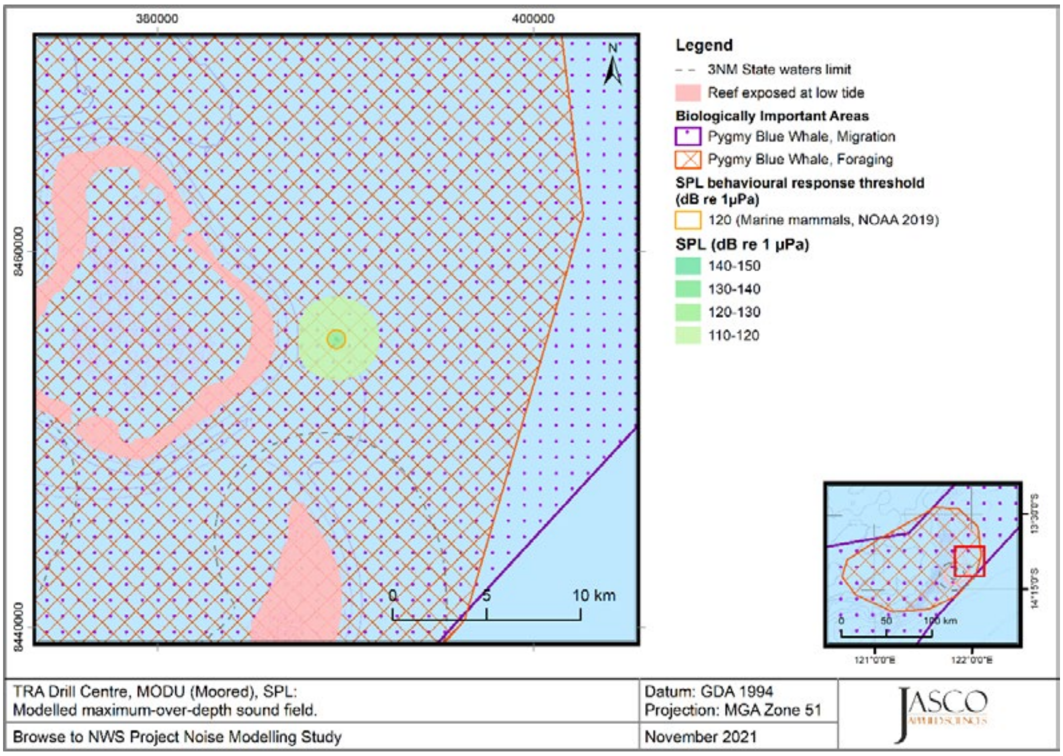

Figure 10. *TRA Drill centre, MODU (Moored), SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

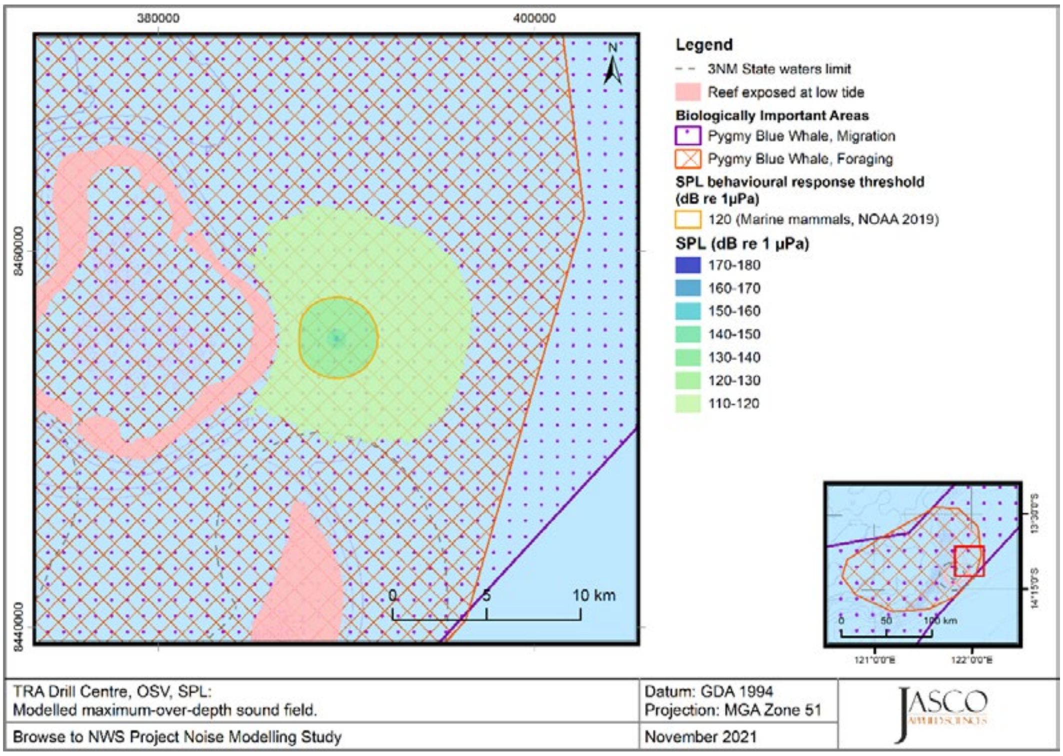

Figure 11. *TRA Drill centre, OSV, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

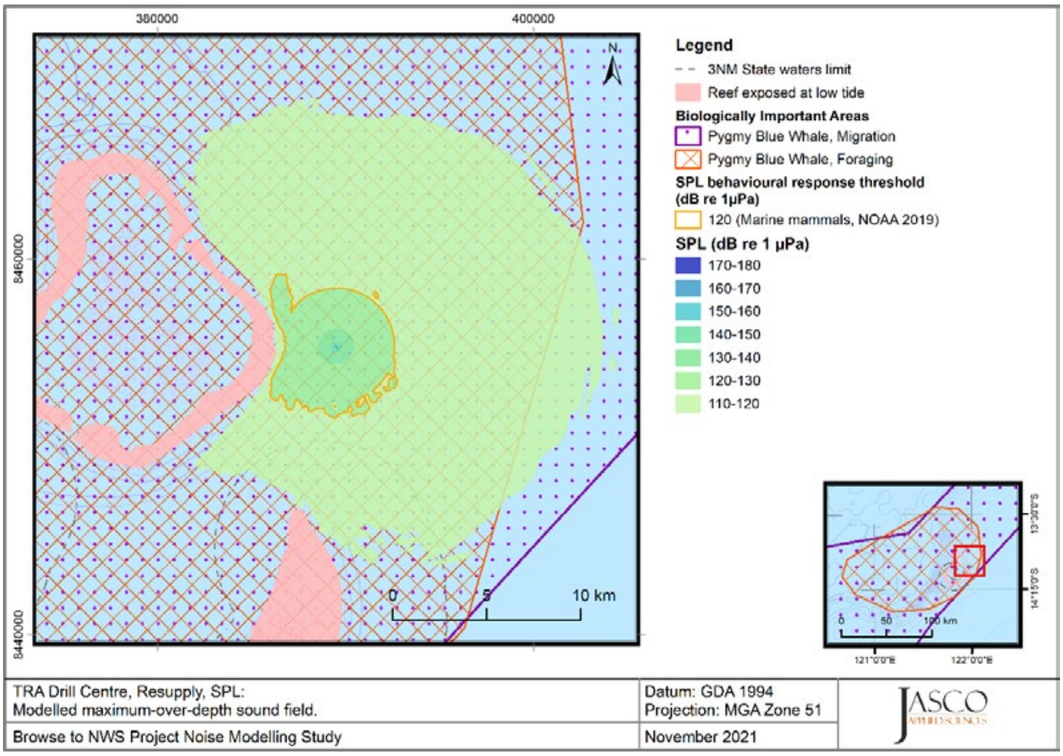

Figure 12. *TRA Drill centre, MODU under DP resupply, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

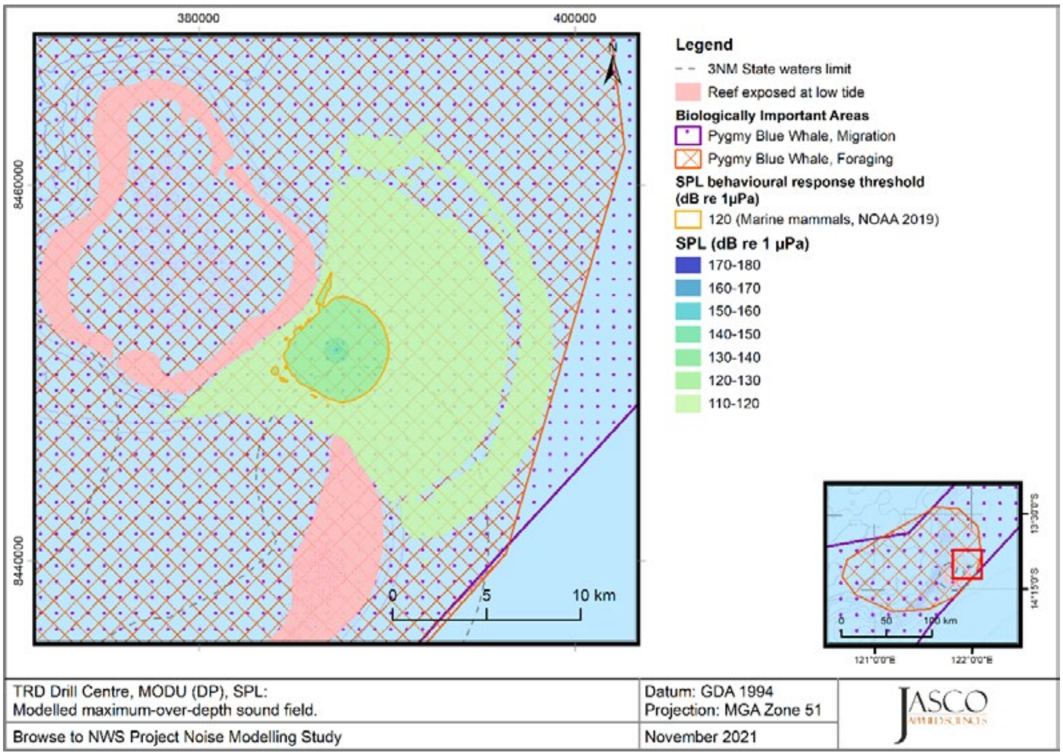

Figure 13. *TRD Drill centre, MODU, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

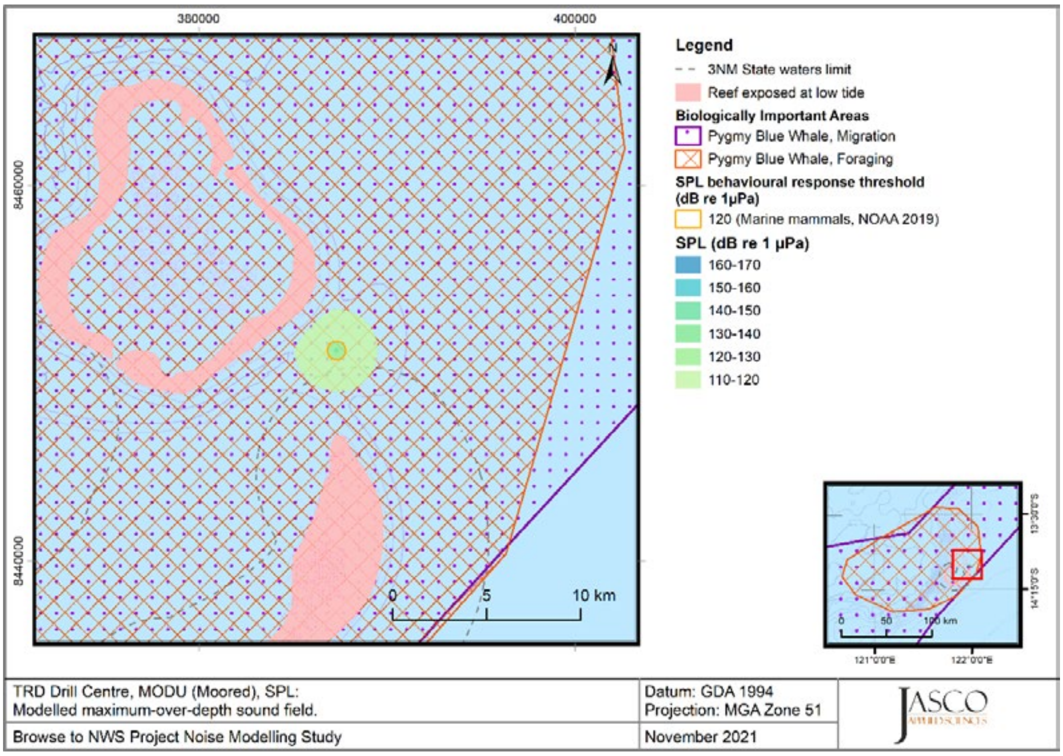

Figure 14. *TRD Drill centre, MODU (Moored), SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

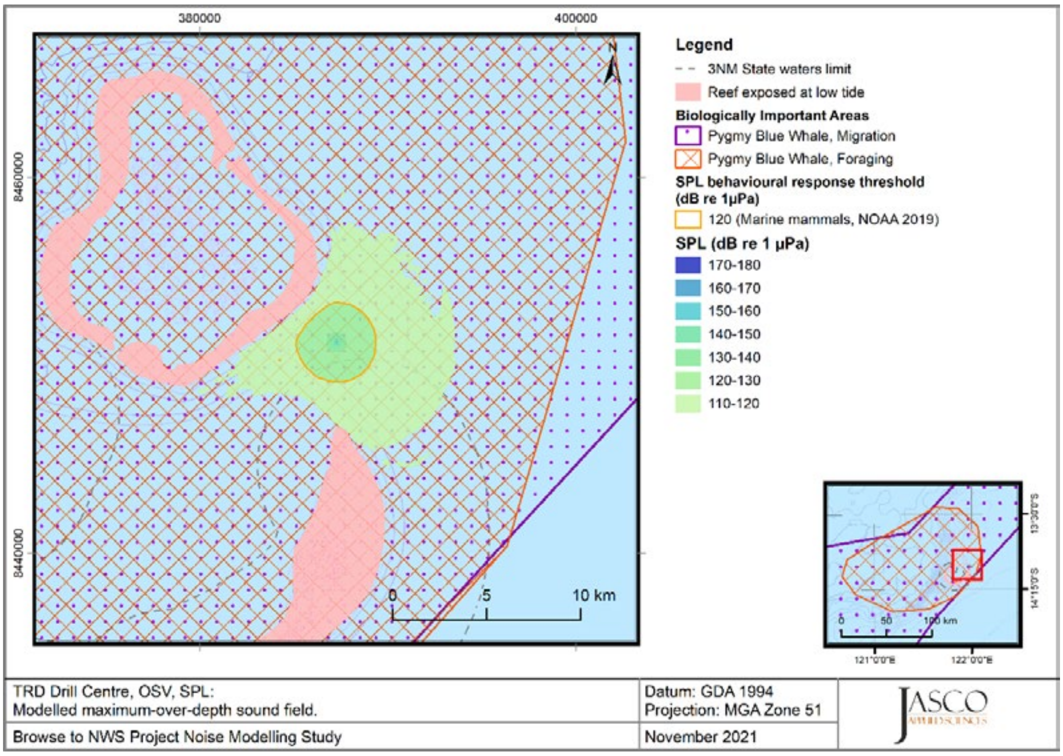

Figure 15. *TRD Drill centre, OSV, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

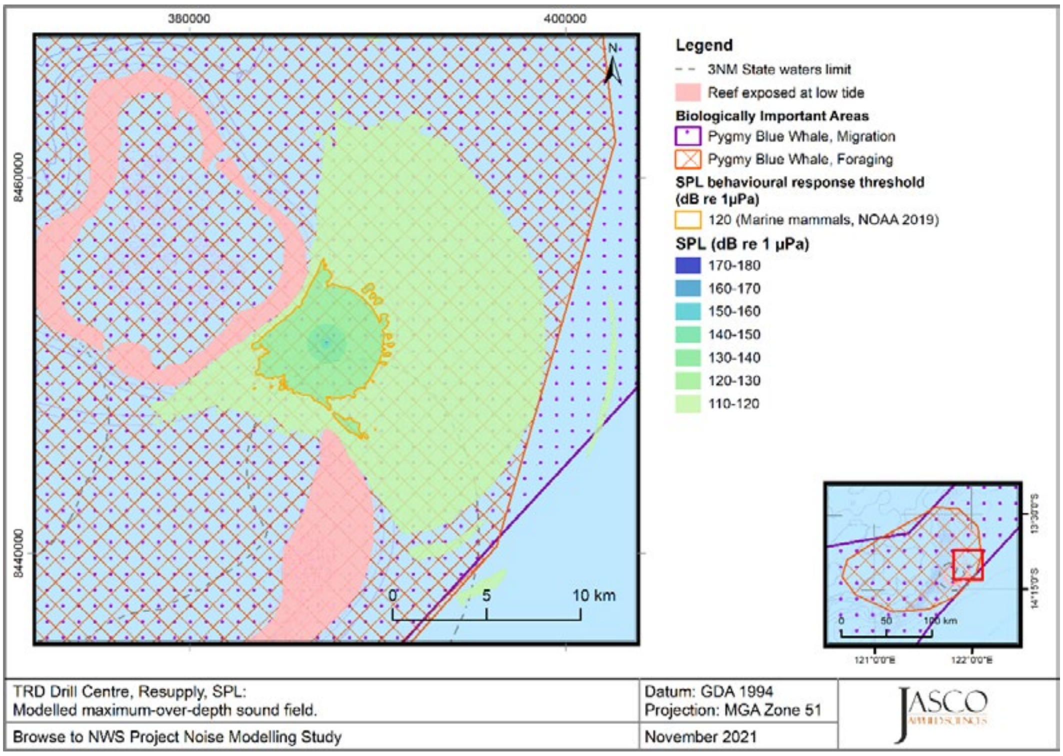

Figure 16. *TRD Drill centre, MODU under DP resupply, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

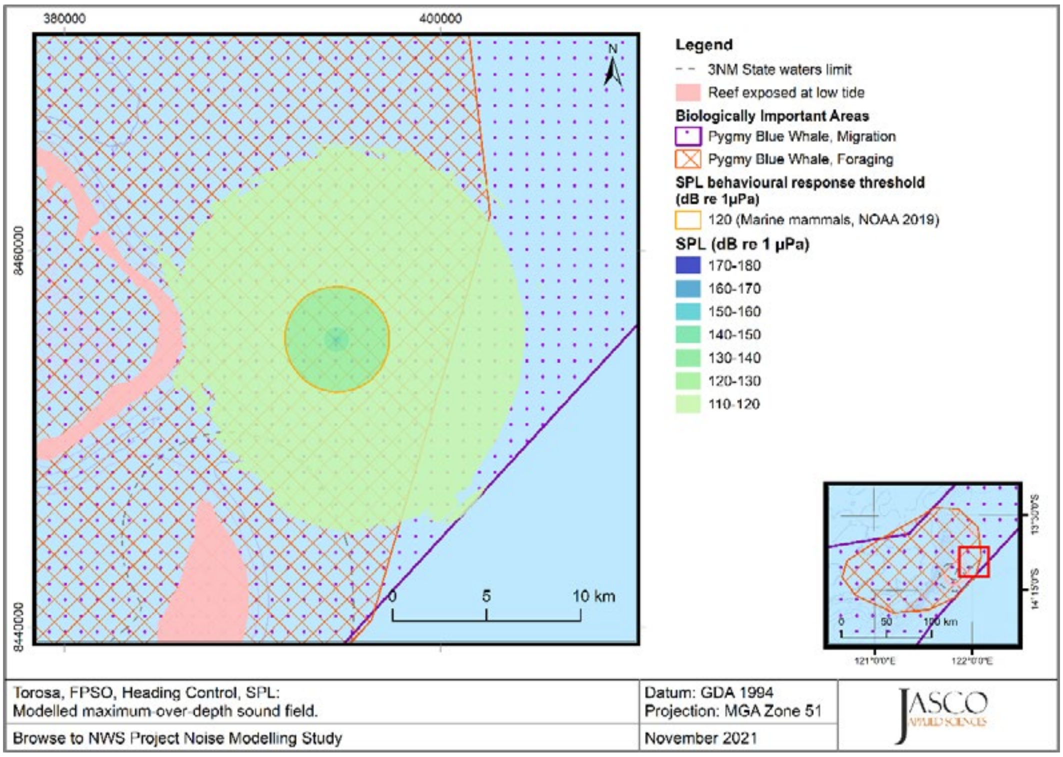

Figure 17. *Torosa location, FPSO, Heading Control, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

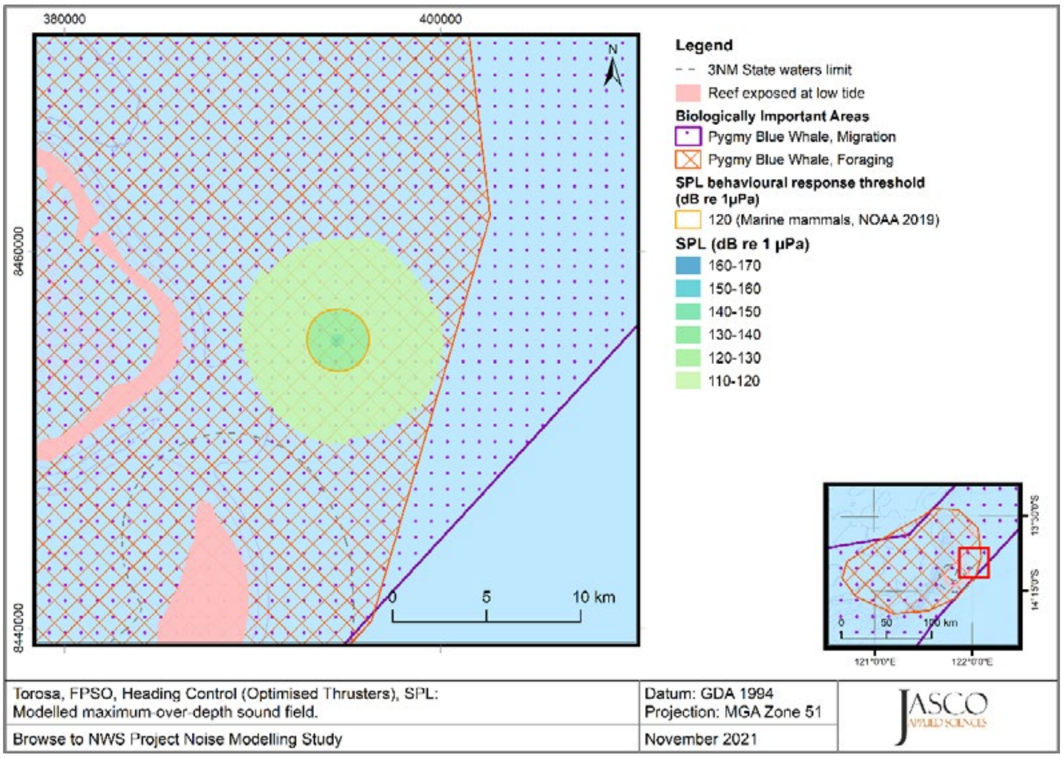

Figure 18. *Torosa, FPSO, Heading Control (Optimised Thrusters), SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

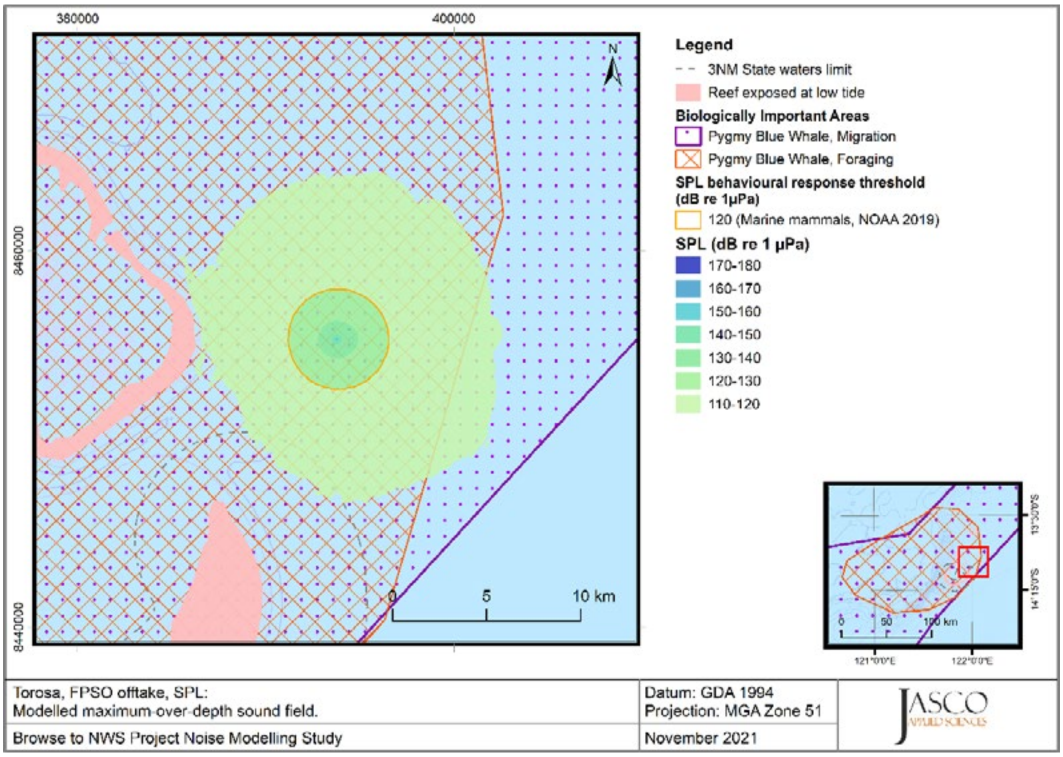

Figure 19. *Torosa location, FPSO Offtake, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

4.2.2. Accumulated SEL Sound Fields

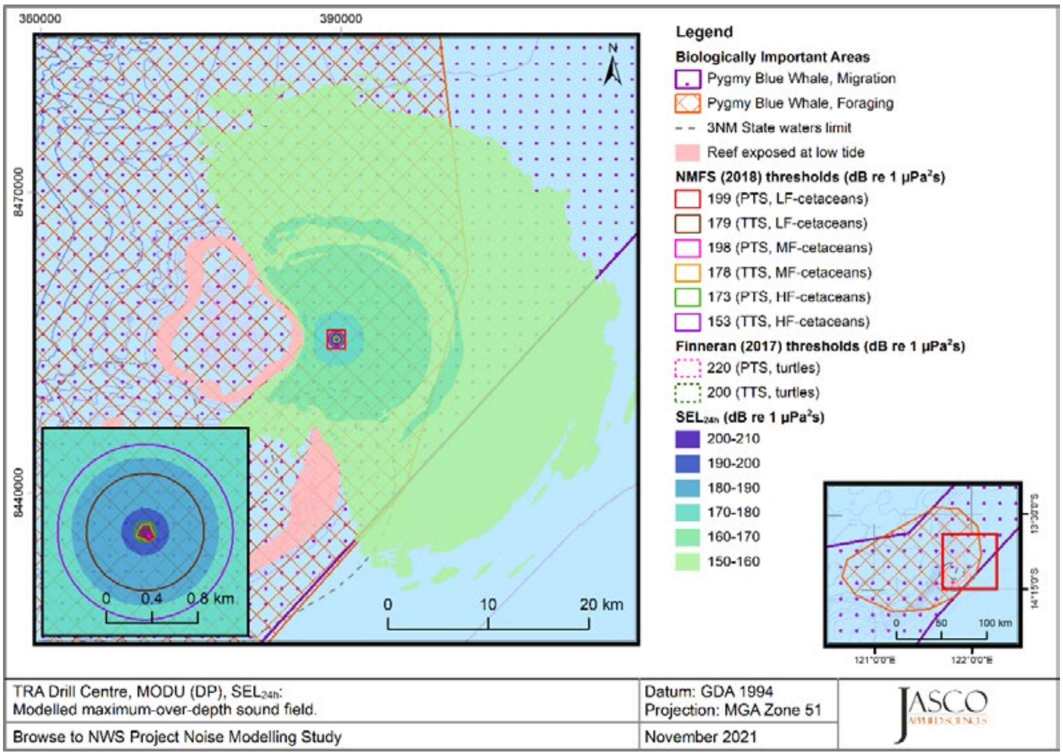

Figure 20. *TRA Drill centre, MODU, SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

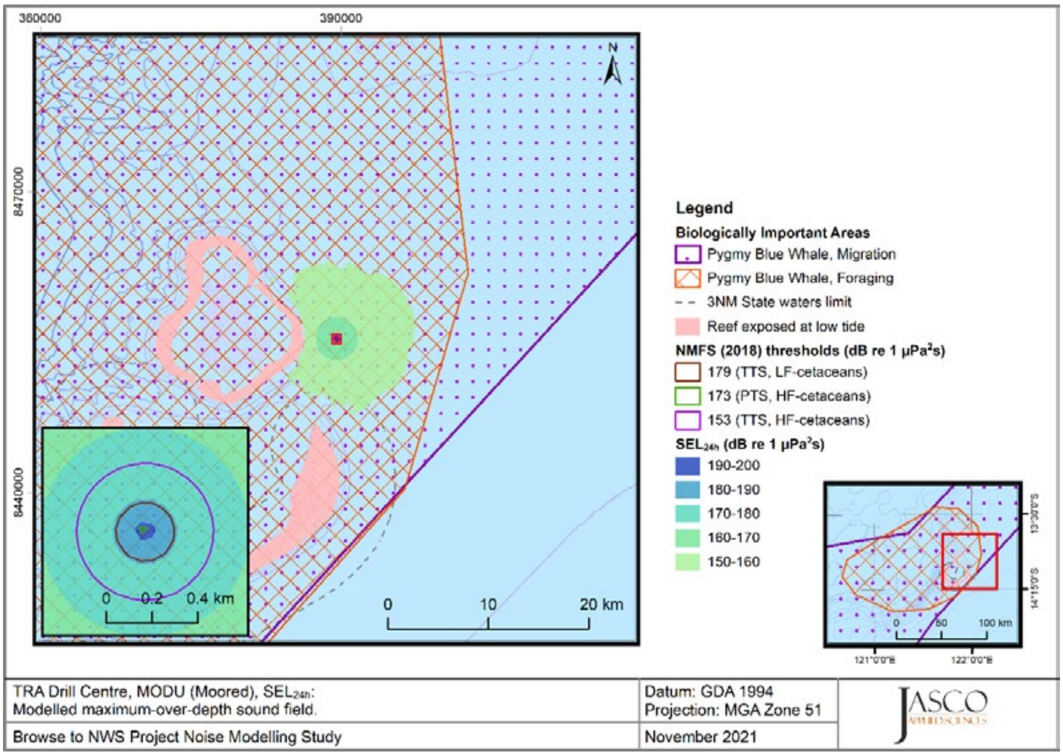

Figure 21. *TRA Drill centre, MODU (Moored), SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{6h}$ results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

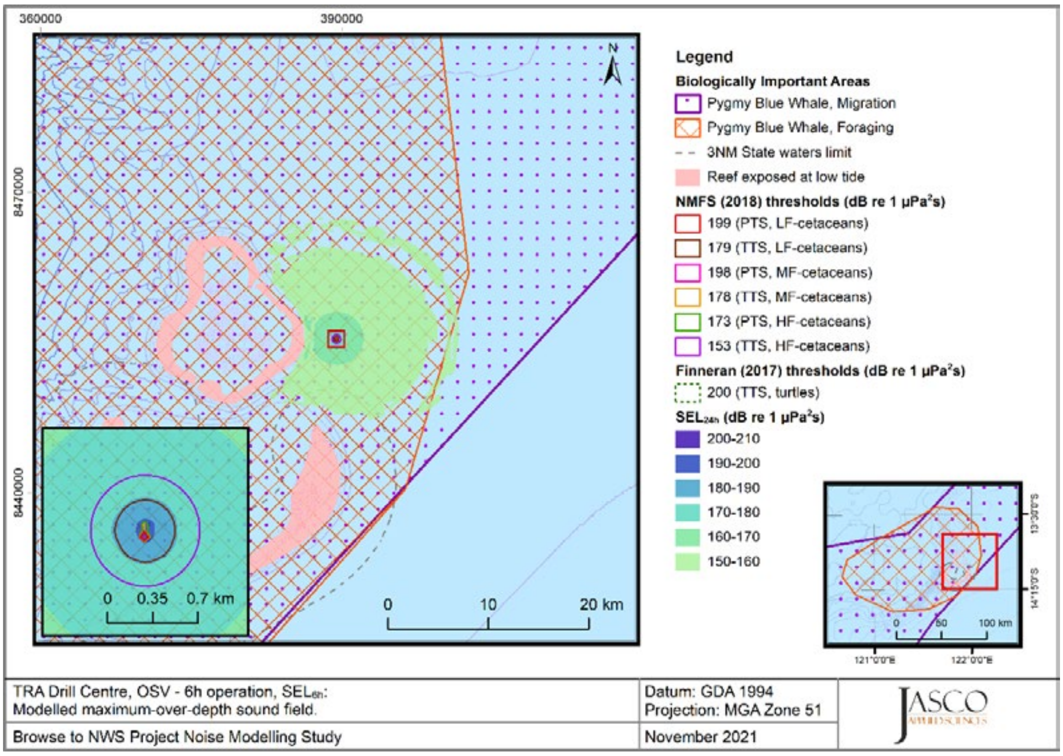

Figure 22. *TRA Drill centre, OSV-6 h operation, SEL$_{6h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{6h}$ results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

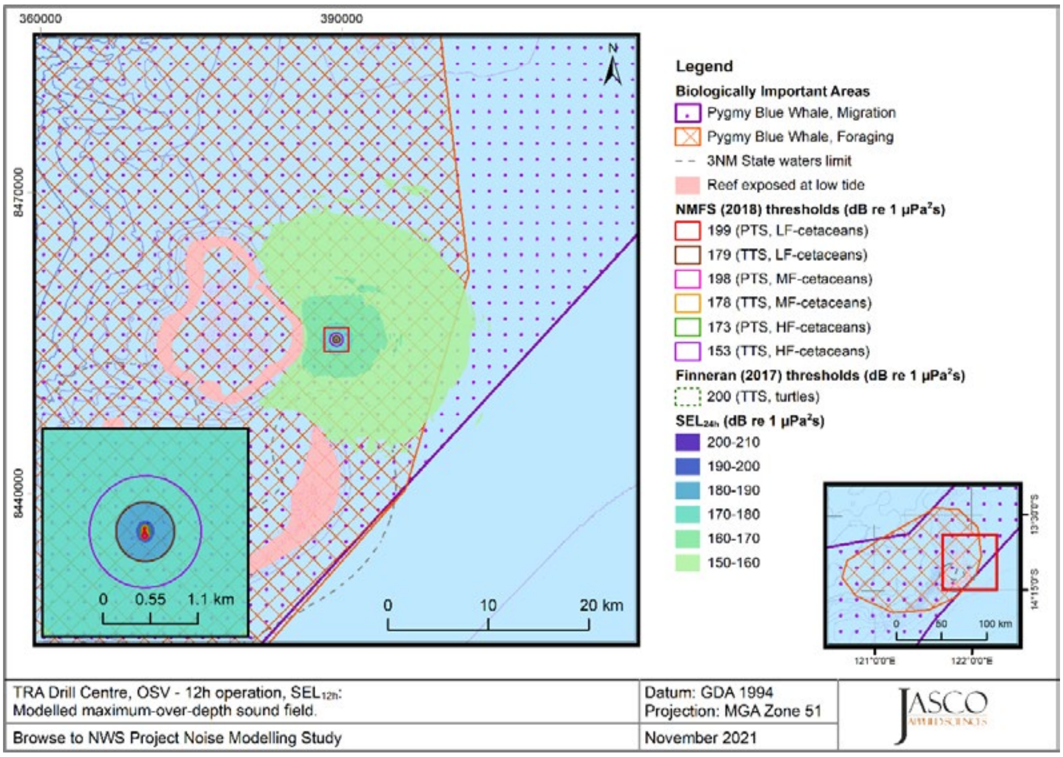

Figure 23. *TRA Drill centre, OSV-12 h operation, SEL$_{12h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{12h}$ results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

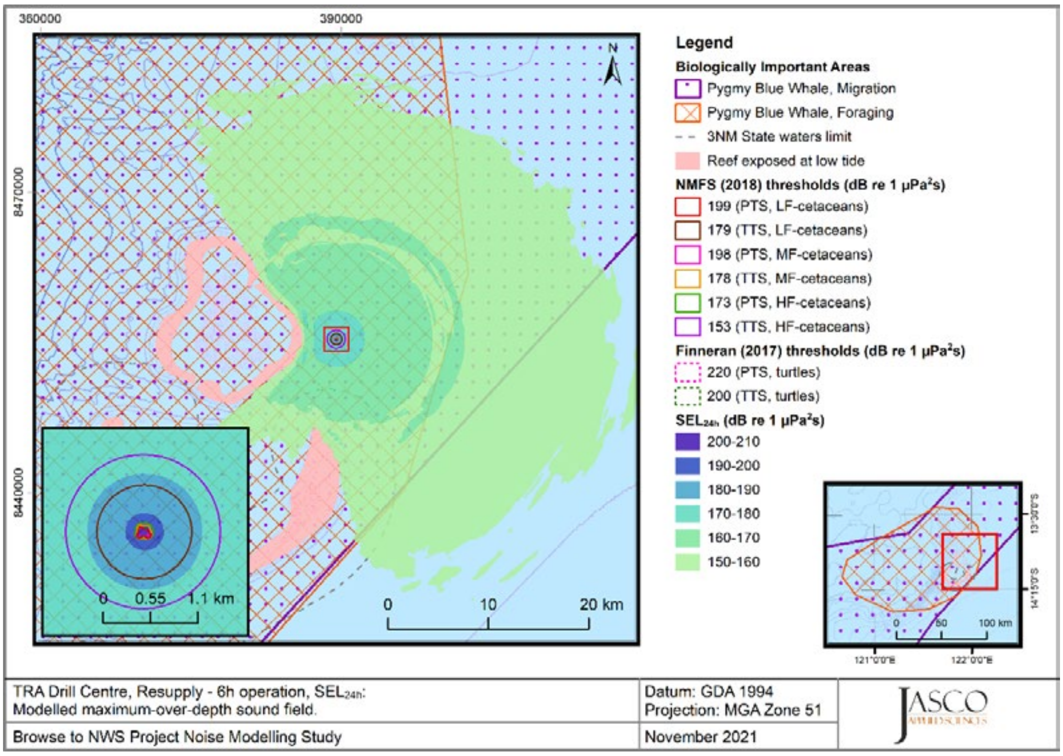

Figure 24. *TRA Drill centre, MODU under DP resupply-6 h operation, SEL24h*: Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

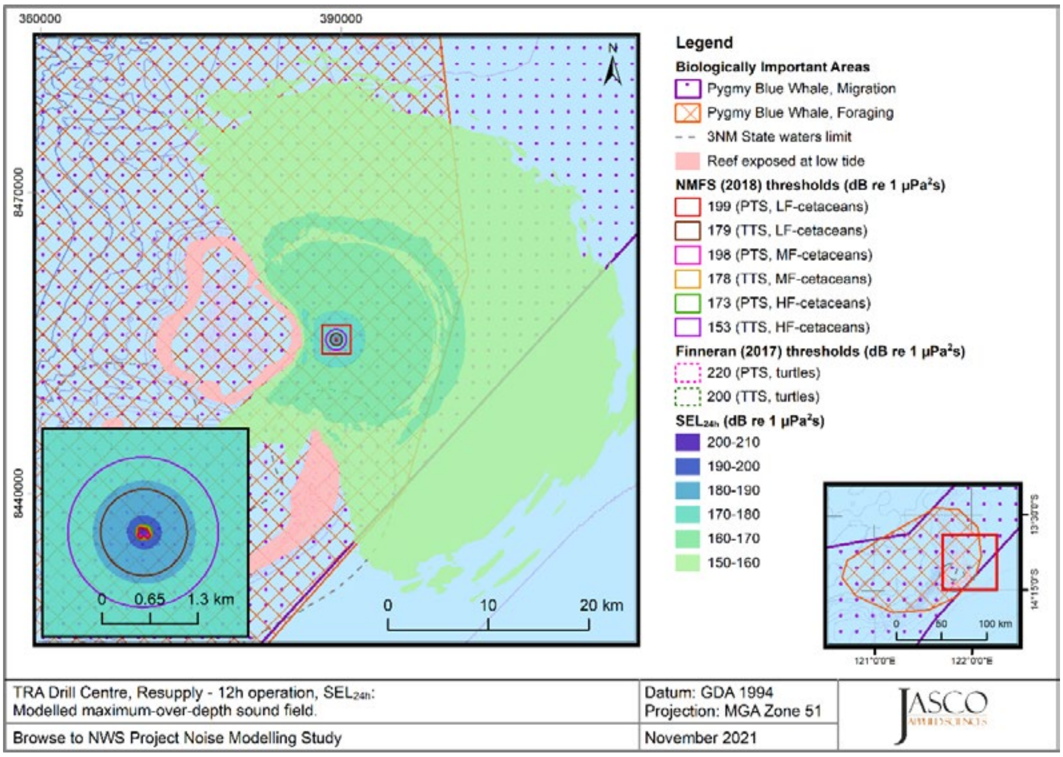

Figure 25. *TRA Drill centre, MODU under DP resupply-12 h operation, SEL24h*: Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

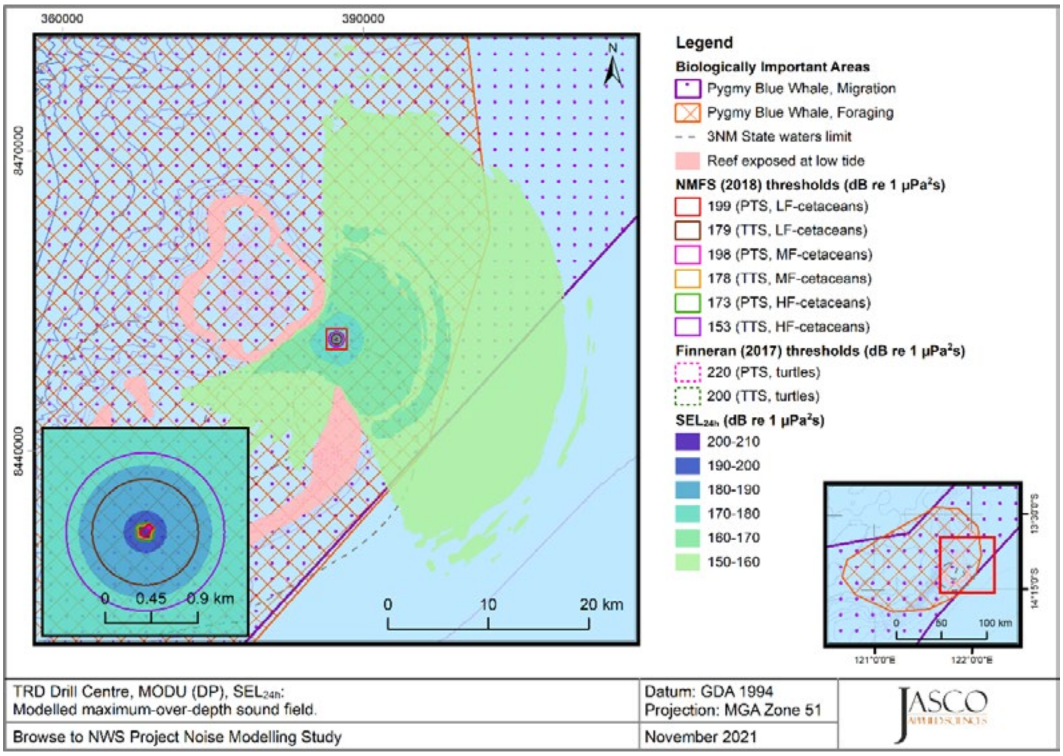

Figure 26. *TRD Drill centre, MODU, SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

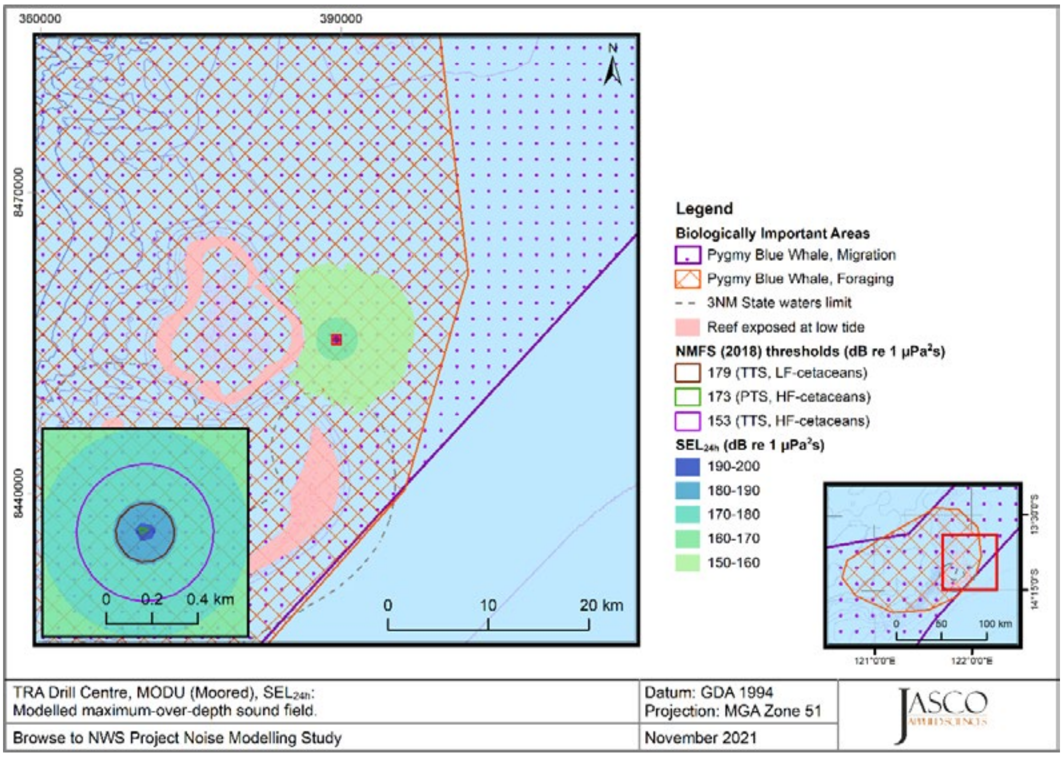

Figure 27. *TRD Drill centre, MODU (Moored), SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{6h}$ results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

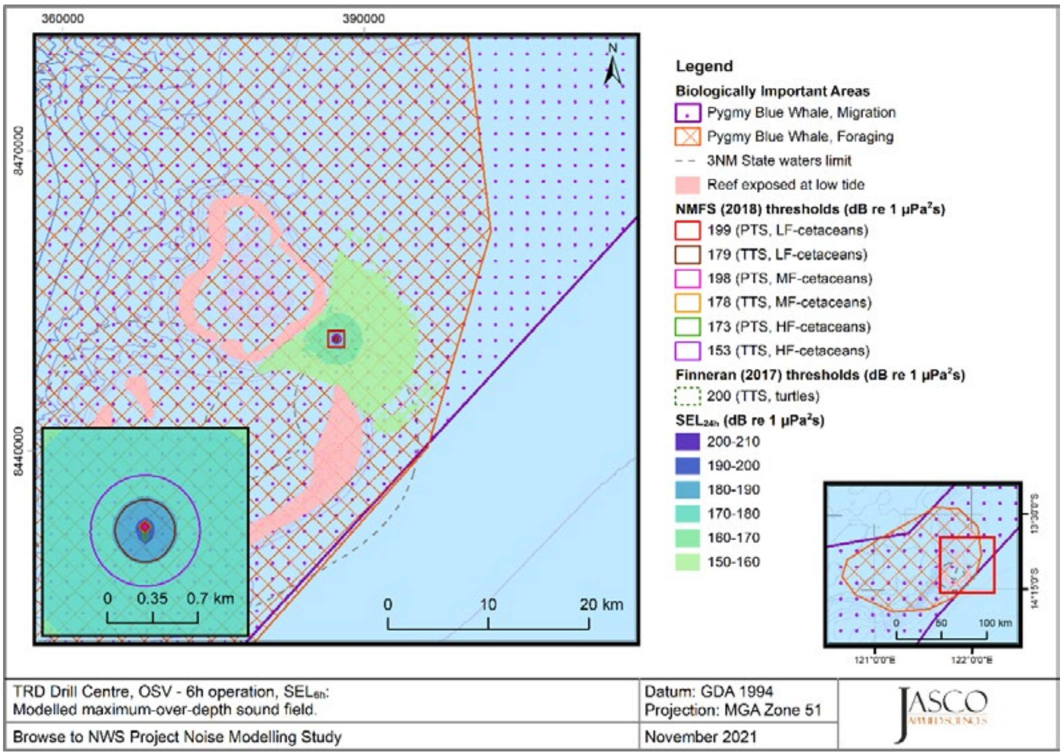

Figure 28. *TRD Drill centre, OSV-6 h operation, SEL_{6h}*: Sound level contour map showing unweighted maximum-over-depth SEL_{6h} results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

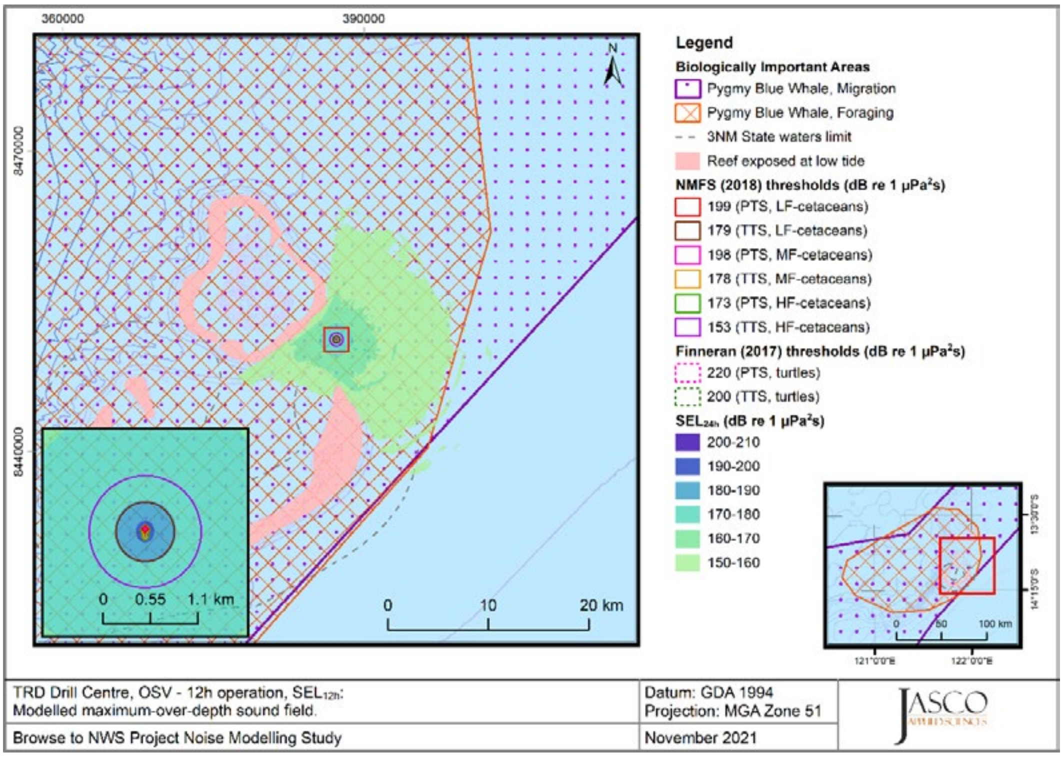

Figure 29. *TRD Drill centre, OSV-12 h operation, SEL_{12h}*: Sound level contour map showing unweighted maximum-over-depth SEL_{12h} results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

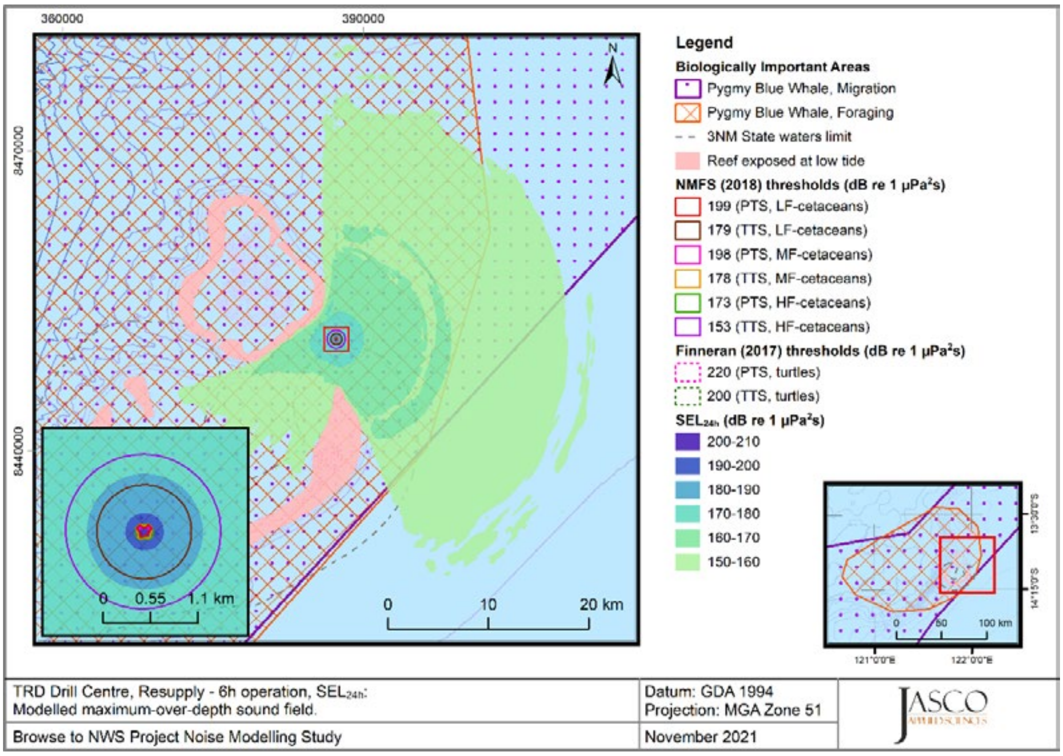

Figure 30. *TRD Drill centre, MODU under DP resupply-6 h operation, SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

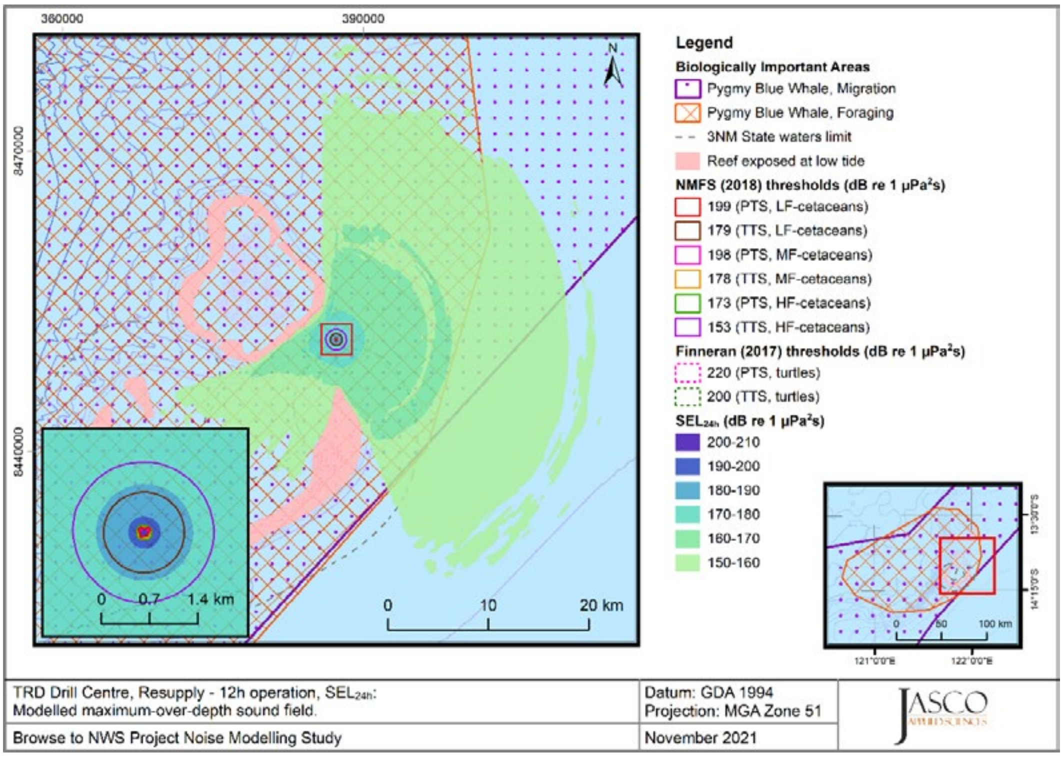

Figure 31. *TRD Drill centre, MODU under DP resupply-12 h operation, SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

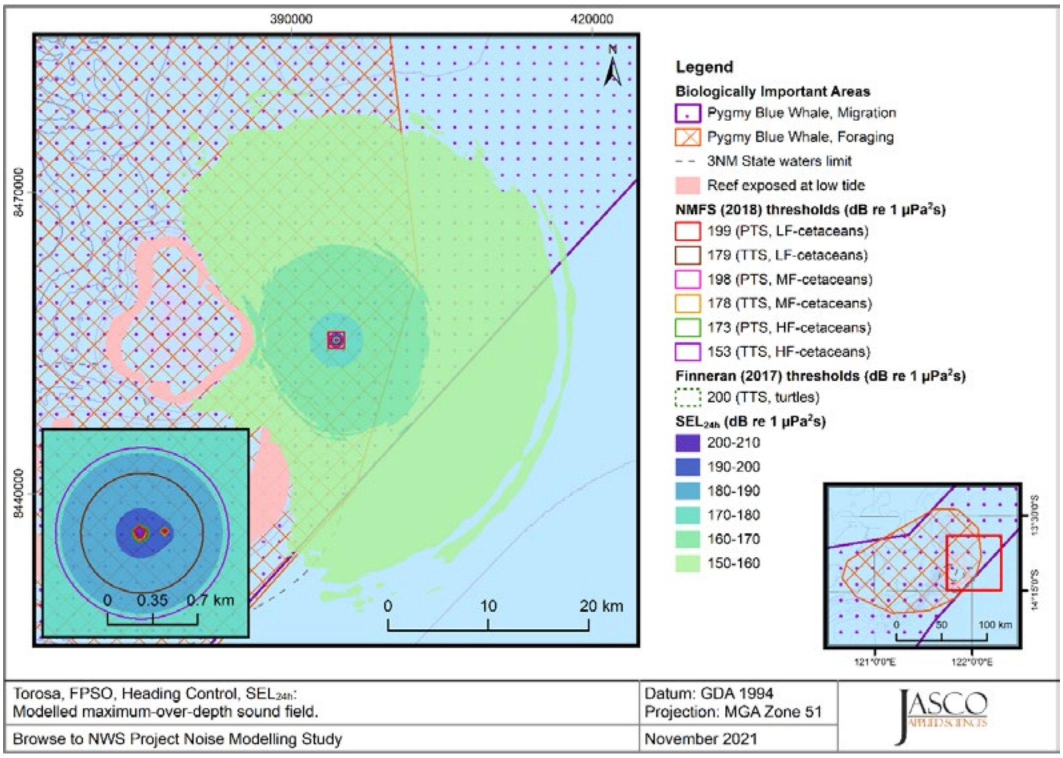

Figure 32. *Torosa location, FPSO, Heading Control. SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

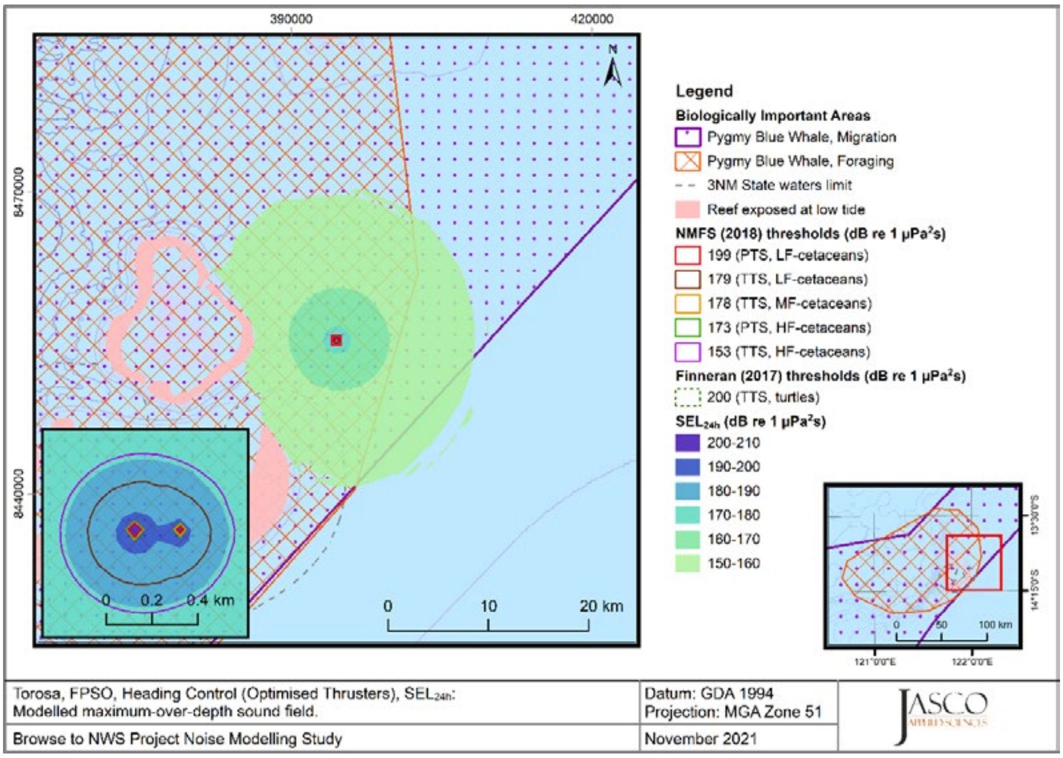

Figure 33. *Torosa FPSO, Heading Control (Optimised Thrusters), SEL$_{24h}$*: Sound level contour map showing unweighted maximum-over-depth SEL$_{24h}$ results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

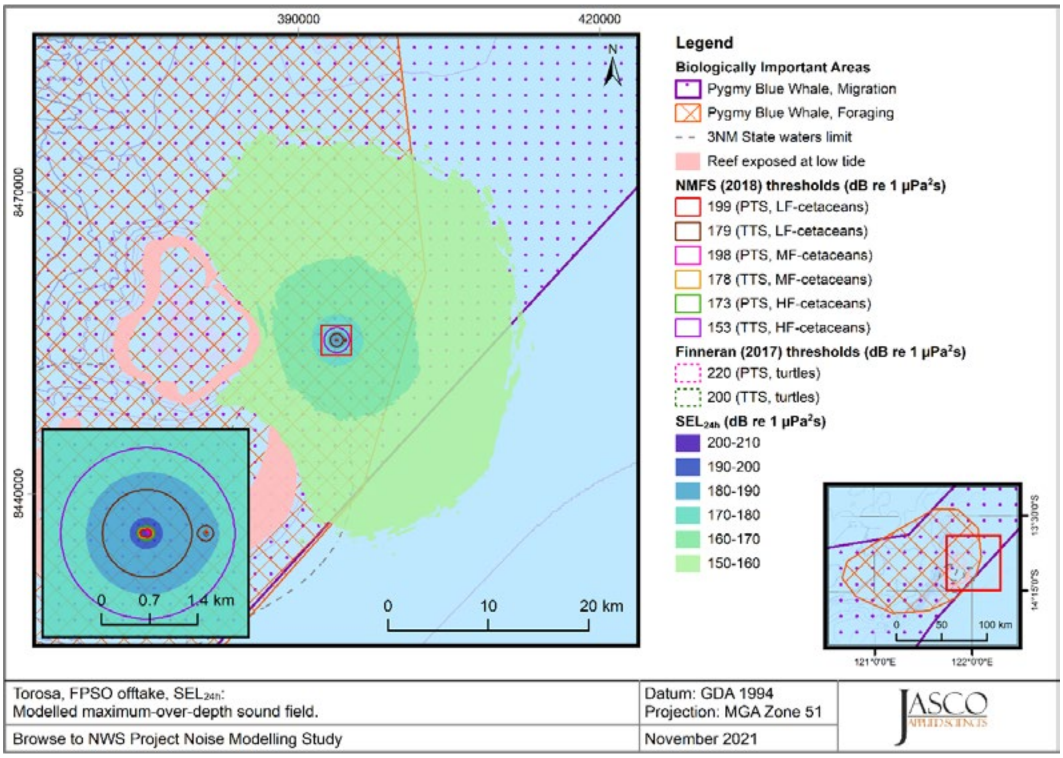

Figure 34. *Torosa location, FPSO Offtake, SEL_{24h}*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

4.2.3. Aggregate Scenario

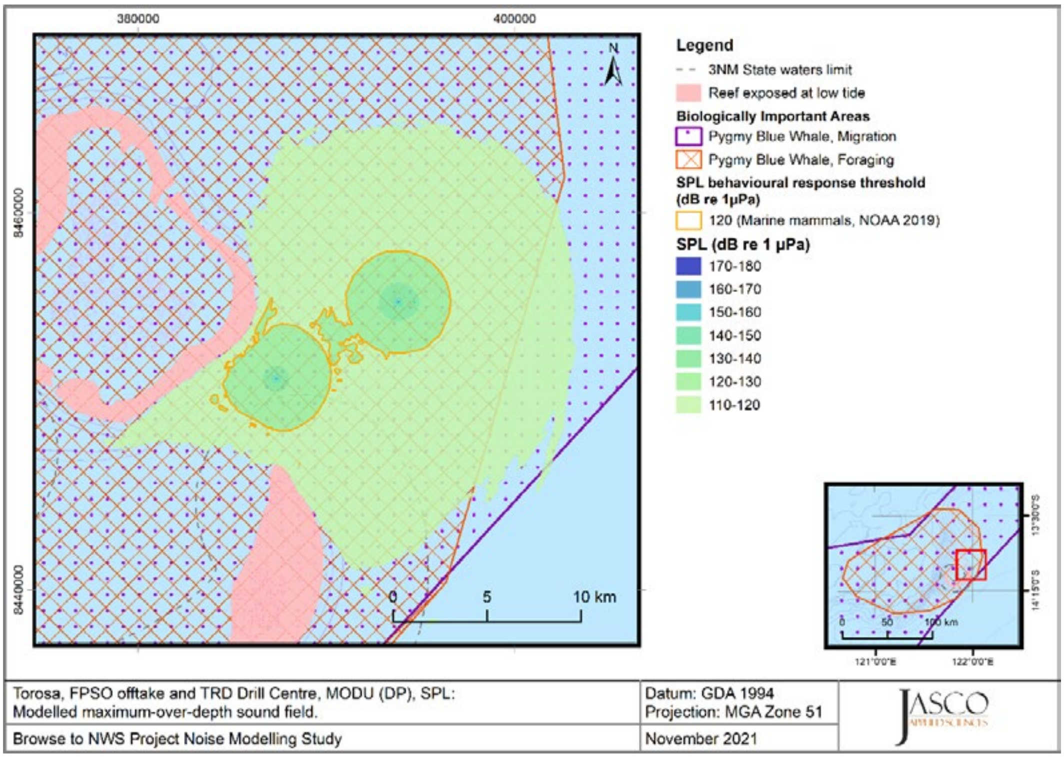

Figure 35. *Torosa FPSO location and TRD Drill centre, Aggregate FPSO offtake and MODU under DP, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 μPa).

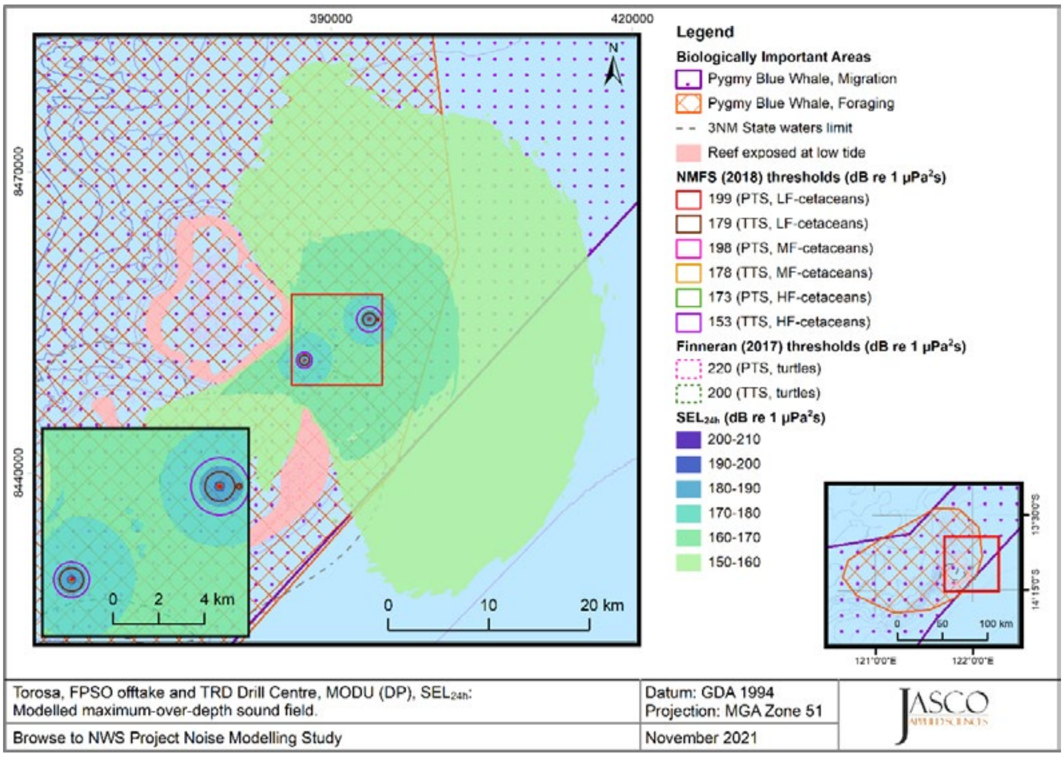

Figure 36. *TRD Drill Centre, Aggregate FPSO offtake and MODU under DP, SEL_{24h}*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

5. Discussion

5.1.1. Acoustic Propagation

Results have been presented showing the propagation of sound from a dynamically positioned and moored MODU during drilling operations at both TRA and TRD drill centres, and an FPSO using heading control at Torosa, with associated offshore support vessels (OSVs). Single-vessel and combination scenarios were modelled at each location, as well as an aggregate scenario involving the MODU at the TRD drill centre and the FPSO offtake scenario at the Torosa field.

The main influence on sound propagation is the bathymetry in the local area. In particular, the nearby presence of Scott Reef blocks most propagation in westerly and south-westerly directions. This is especially true of sources at the TRA and TRD drill centres, as both of these are closer to the reef than the facility at Torosa. Looking at the maps in Figures 17–19, it can be seen that the presence of Scott Reef does not significantly affect propagation from Torosa at the levels of interest for SPL, whereas Figures 9–16 clearly show the effect of the reef on the propagation from the TRA and TRD drill centres. The SEL_{24h} levels are visibly affected by the reef from all sites, though not at ranges that affect any relevant thresholds (see Figures 20–34).

5.1.2. Exposure Thresholds

At the TRA and TRD drill centres, there are several significant effects of combining the MODU (under DP) and OSV sources in the resupply scenarios. At the TRA drill centre, the SPL behavioural threshold range for marine mammals is almost 5 km for the resupply scenario, and at the TRD drill centre it exceeds 5 km, whereas it is between 2–4.5 km for scenarios with single vessels including thruster sources. This is mirrored in SEL_{24h} TTS threshold ranges for high-frequency cetaceans, which are above 0.9 km for multi-vessel scenarios, but generally less than 0.8 km for single-vessel scenarios (see Tables 17 and 18). The omission of the thrusters in the ‘moored’ MODU scenarios significantly reduce threshold ranges, from 4.49 km to 0.5 km for marine mammal behavioural disturbance, and from 0.77 km to 0.3 km for the high-frequency cetacean TTS threshold.

One phenomenon of note is that the FPSO offtake scenario has a shorter range to the 120 dB marine mammal SPL disturbance threshold (2.67 km) than the standalone FPSO on heading control scenario (2.82 km; see Table 14). This is despite the fact that the broadband source level of the OSV, the dominant source in the offtake scenario, is 185.5 dB re 1 µPa, whereas the broadband source level of the FPSO with heading control is lower, at 183 dB re 1 µPa. The machinery source on the FPSO has much more energy at low frequencies than any of the thruster sources on the OSV. These low frequencies are less readily absorbed, and it is possible this is causing the observed effect. This is also reflected in the fact that at levels above 130 dB, ranges are shorter for the offtake scenario than for the FPSO on heading control scenario.

For the aggregate scenario including both FPSO offtake and the MODU under DP at the TRD drill centre, it was found that due to the separation between the sites, ranges to PTS and TTS thresholds (Table 22) were not significantly different than the individual operations (Tables 18 and 19). Maximum behavioural threshold ranges (Table 20), on the other hand, increased by 580 m relative to the MODU operating in isolation under DP (Tables 13 and 14). The $R_{95\%}$, however, is not significantly altered from either scenario in isolation, indicating that this increase in R_{max} is probably due to a specific propagation path between the two sites (see Figure 35).

Glossary

Unless otherwise stated in an entry, these definitions are consistent with ISO 80000-3 (2017).

absorption

The reduction of acoustic pressure amplitude due to acoustic particle motion energy converting to heat in the propagation medium.

animal movement modelling

Simulation of animal movement based on behavioural rules for the purpose of predicting an animal's experience of an environment.

attenuation

The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

auditory frequency weighting

The process of applying an auditory frequency weighting function. In human audiometry, C-weighting is the most commonly used function, an example for marine mammals are the auditory frequency weighting functions published by Southall et al. (2007).

auditory frequency weighting function

Frequency weighting function describing a compensatory approach accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity. Example hearing groups are low-, mid-, and high-frequency cetaceans, phocid and otariid pinnipeds.

azimuth

A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

broadband level

The total level measured over a specified frequency range.

cetacean

Any animal in the order Cetacea. These are aquatic species and include whales, dolphins, and porpoises.

continuous sound

A sound whose sound pressure level remains above ambient sound during the observation period . A sound that gradually varies in intensity with time, for example, sound from a marine vessel.

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 80000-3:2006).

decidecade

One tenth of a decade. *Note*: An alternative name for decidecade (symbol ddec) is "one-tenth decade". A decidecade is approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct) and for this reason is sometimes referred to as a "one-third octave".

decidecade band

Frequency band whose bandwidth is one decidecade. *Note*: The bandwidth of a decidecade band increases with increasing centre frequency.

decibel (dB)

Unit of level used to express the ratio of one value of a power quantity to another on a logarithmic scale. Unit: dB.

ensonified

Exposed to sound.

far field

The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point.

flat weighting

Term indicating that no frequency weighting function is applied. Synonymous with unweighted.

frequency

The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: f. 1 Hz is equal to 1 cycle per second.

frequency weighting

The process of applying a frequency weighting function.

frequency-weighting function

The squared magnitude of the sound pressure transfer function. For sound of a given frequency, the frequency weighting function is the ratio of output power to input power of a specified filter, sometimes expressed in decibels. Examples include the following:

- *Auditory frequency weighting function*: compensatory frequency weighting function accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.
- *System frequency weighting function*: frequency weighting function describing the sensitivity of an acoustic acquisition system, typically consisting of a hydrophone, one or more amplifiers, and an analogue to digital converter.

geoacoustic

Relating to the acoustic properties of the seabed.

hearing group

Category of animal species when classified according to their hearing sensitivity and to the susceptibility to sound. Examples for marine mammals include very low-frequency (VLF) cetaceans, low-frequency (LF) cetaceans, mid-frequency (MF) cetaceans, high-frequency (HF) cetaceans, very high-frequency (VHF) cetaceans, otariid pinnipeds in water (OPW), phocid pinnipeds in water (PPW), sirenians (SI), other marine carnivores in air (OCA), and other marine carnivores in water (OCW) (NMFS 2018, Southall et al. 2019). See **auditory frequency weighting functions**, which are often applied to these groups. Examples for fish include species for which the swim bladder is involved in hearing, species for which the swim bladder is not involved in hearing, and species without a swim bladder (Popper et al. 2014).

hertz (Hz)

A unit of frequency defined as one cycle per second.

high-frequency (HF) cetacean

See **hearing group**.

isopleth

A line drawn on a map through all points having the same value of some quantity.

level

A measure of a quantity expressed as the logarithm of the ratio of the quantity to a specified reference value of that quantity. Examples include sound pressure level, sound exposure level, and peak sound pressure level. For example, a value of sound exposure level with reference to 1 μPa^2 s can be written in the form *x* dB re 1 μPa^2 s.

low-frequency (LF) cetacean

See **hearing group**.

mid-frequency (MF) cetacean

See **hearing group**.

monopole source level (MSL)

A source level that has been calculated using an acoustic model that accounts for the effect of the sea-surface and seabed on sound propagation, assuming a point-like (monopole) sound source. Also see **radiated noise level**.

M-weighting

See **auditory frequency weighting function** (as proposed by Southall et al. 2007).

***N* percent exceedance level**

The sound level exceeded *N* % of the time during a specified time interval. Also see **percentile level**.

non-impulsive sound

Sound that is not an impulsive sound. A non-impulsive sound is not necessarily a continuous sound.

octave

The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

parabolic equation method

A computationally efficient solution to the acoustic wave equation that is used to model propagation loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of propagation loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

percentile level

The sound level not exceeded *N* % of the time during a specified time interval. The *N*th percentile level is equal to the (100−*N*)% exceedance level. Also see ***N* percent exceedance level**.

permanent threshold shift (PTS)

An irreversible loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

point source

A source that radiates sound as if from a single point.

pressure, acoustic

The deviation from the ambient pressure caused by a sound wave. Also called sound pressure. Unit: pascal (Pa).

propagation loss (PL)

Difference between a source level (SL) and the level at a specified location, PL(x) = SL − L(x). Also see **transmission loss**.

radiated noise level (RNL)

A source level that has been calculated assuming sound pressure decays geometrically with distance from the source, with no influence of the sea-surface and seabed. Also see **monopole source level**.

received level

The level measured (or that would be measured) at a defined location. The type of level should be specified.

reference values

standard underwater references values used for calculating sound **levels**, e.g., the reference value for expressing sound pressure level in decibels is 1 µPa.

Quantity	Reference value
Sound pressure	1 µPa
Sound exposure	1 µPa^2 s
Sound particle displacement	1 pm
Sound particle velocity	1 nm/s
Sound particle acceleration	1 µm/s^2

sound

A time-varying disturbance in the pressure, stress, or material displacement of a medium propagated by local compression and expansion of the medium.

sound exposure

Time integral of squared sound pressure over a stated time interval. The time interval can be a specified time duration (e.g., 24 hours) or from start to end of a specified event (e.g., a pile strike, an airgun pulse, a construction operation). Unit: Pa^2 s.

sound exposure level

The level (L_E) of the sound exposure (E). Unit: decibel (dB). Reference value (E_0) for sound in water: 1 µPa^2 s.

$$L_E := 10\log_{10}(E/E_0)\,\mathrm{dB} \;= 20\log_{10}\left(E^{1/2}/E_0^{1/2}\right)\,\mathrm{dB}$$

The frequency band and integration time should be specified. Abbreviation: SEL.

sound field

Region containing sound waves.

sound pressure

The contribution to total pressure caused by the action of sound.

sound pressure level (rms sound pressure level)

The level ($L_{p,\mathrm{rms}}$) of the time-mean-square sound pressure (p^2_{rms}). Unit: decibel (dB). Reference value (p^2_0) for sound in water: 1 µPa^2.

$$L_{p,\mathrm{rms}} := 10\log_{10}(p^2_{\mathrm{rms}}/p^2_0)\ \mathrm{dB}\ = 20\log_{10}(p_{\mathrm{rms}}/p_0)\ \mathrm{dB}$$

The frequency band and averaging time should be specified. Abbreviation: SPL or Lrms.

sound speed profile

The speed of sound in the water column as a function of depth below the water surface.

source level (SL)

A property of a sound source obtained by adding to the sound pressure level measured in the far field the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 µPa^{2}m^2.

spectrum

An acoustic signal represented in terms of its power, energy, mean-square sound pressure, or sound exposure distribution with frequency.

temporary threshold shift (TTS)

Reversible loss of hearing sensitivity. TTS can be caused by noise exposure.

transmission loss (TL)

The difference between a specified level at one location and that at a different location, TL(x1,x2) = L(x1) − L(x2).

unweighted

Term indicating that no frequency weighting function is applied. Synonymous with flat weighting.

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Appendix A. Underwater Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially pulsed sound such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate sound and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow International Organization for Standardization definitions and symbols for sound metrics (e.g., ISO 2017, ANSI S1.1-2013).

A.1. Acoustic Metrics

The sound pressure level (SPL or L_p; dB re 1 µPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T; s). It is important to note that SPL always refers to an rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T g(t)\,p^2(t)\,dt\Big/p_0^2\right)\,\text{dB} \quad \text{(A-1)}$$

where $g(t)$ is an optional time weighting function. In many cases, the start time of the integration is marched forward in small time steps to produce a time-varying SPL function. For short acoustic events, such as sonar pulses and marine mammal vocalizations, it is important to choose an appropriate time window that matches the duration of the signal. For in-air studies, when evaluating the perceived loudness of sounds with rapid amplitude variations in time, the time weighting function $g(t)$ is often set to a decaying exponential function that emphasizes more recent pressure signals. This function mimics the leaky integration nature of mammalian hearing. For example, human-based fast time-weighted SPL ($L_{p,fast}$) applies an exponential function with time constant 125 ms. A related simpler approach used in underwater acoustics sets $g(t)$ to a boxcar (unity amplitude) function of width 125 ms; the results can be referred to as $L_{p,boxcar\ 125ms}$. Another approach, historically used to evaluate SPL of impulsive signals underwater, defines $g(t)$ as a boxcar function with edges set to the times corresponding to 5% and 95% of the cumulative square pressure function encompassing the duration of an impulsive acoustic event. This calculation is applied individually to each impulse signal, and the results have been referred to as 90% SPL ($L_{p,90\%}$).

The sound exposure level (SEL or L_E; dB re 1 µPa^2 s) is the time-integral of the squared acoustic pressure over a duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)\,dt\Big/T_0 p_0^2\right)\,\text{dB} \quad \text{(A-2)}$$

where T_0 is a reference time interval of 1 s. SEL continues to increase with time when non-zero pressure signals are present. It is a dose-type measurement, so the integration time applied must be carefully considered for its relevance to impact to the exposed recipients.

SEL can be calculated over a fixed duration, such as the time of a single event or a period with multiple acoustic events. When applied to pulsed sounds, SEL can be calculated by summing the SEL of the N individual pulses. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the N individual events:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right) \text{ dB} \quad \text{(A-3)}$$

Because the SPL(T_{90}) and SEL are both computed from the integral of square pressure, these metrics are related numerically by the following expression, which depends only on the duration of the time window T:

$$L_p = L_E - 10\log_{10}(T) \quad \text{(A-4)}$$

$$L_{p90} = L_{\mathrm{E}} - 10\log_{10}(T_{90}) - 0.458 \quad \text{(A-5)}$$

where the 0.458 dB factor accounts for the 10% of pulse SEL missing from the SPL(T_{90}) integration time window.

Energy equivalent SPL (L_{eq}; dB re 1 µPa) denotes the SPL of a stationary (constant amplitude) sound that generates the same SEL as the signal being examined, $p(t)$, over the same time period, T:

$$L_{\mathrm{eq}} = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)\,dt \Big/ p_0^2\right) \quad \text{(A-6)}$$

The equations for SPL and the energy-equivalent SPL are numerically identical. Conceptually, the difference between the two metrics is that the SPL is typically computed over short periods (typically of 1 s or less) and tracks the fluctuations of a non-steady acoustic signal, whereas the L_{eq} reflects the average SPL of an acoustic signal over time periods typically of 1 min to several hours.

A.2. Decidecade Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analysing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. A decidecade is sometimes referred to as a "1/3-octave" because one tenth of a decade is approximately equal to one third of an octave. Each decade represents a factor 10 in sound frequency. Each octave represents a factor 2 in sound frequency. The centre frequency of the ith band, $f_{\mathrm{c}}(i)$, is defined as:

$$f_{\mathrm{c}}(i) = 10^{\frac{i}{10}} \text{ kHz} \quad \text{(A-7)}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decade band are defined as:

$$f_{\mathrm{lo},i} = 10^{\frac{-1}{20}} f_{\mathrm{c}}(i) \quad \text{and} \quad f_{\mathrm{hi},i} = 10^{\frac{1}{20}} f_{\mathrm{c}}(i) \quad \text{(A-8)}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure A-1). The acoustic modelling spans from band $f_c(1) = 10\ Hz$ to $f_c(37) = 63\ kHz$.

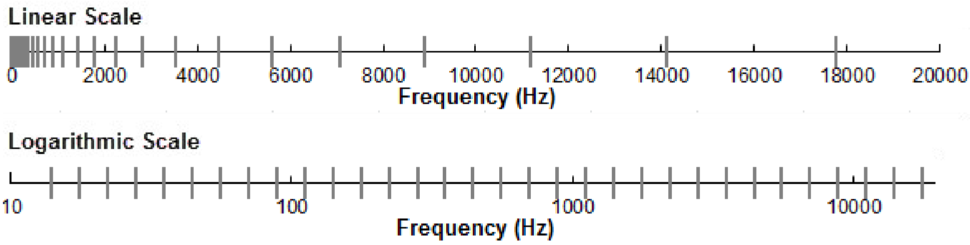

Figure A-1. Decidecade frequency bands (vertical lines) shown on both linear and logarithmic frequency scales

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{\mathrm{lo},i}$ and $f_{\mathrm{hi},i}$:

$$L_{p,i} = 10\log_{10} \int_{f_{\mathrm{lo},i}}^{f_{\mathrm{hi},i}} S(f)\,\mathrm{d}f \;\; \mathrm{dB} \tag{A-9}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10\log_{10} \sum_{i} 10^{\frac{L_{p,i}}{10}}\,\mathrm{dB} \tag{A-10}$$

Figure A-2 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient sound signal. Because the decidecade bands are wider than 1 Hz, the decidecade band SPL is higher than the spectral levels at higher frequencies. Acoustic modelling of decidecade bands requires less computation time than 1 Hz bands and still resolves the frequency-dependence of the sound source and the propagation environment.

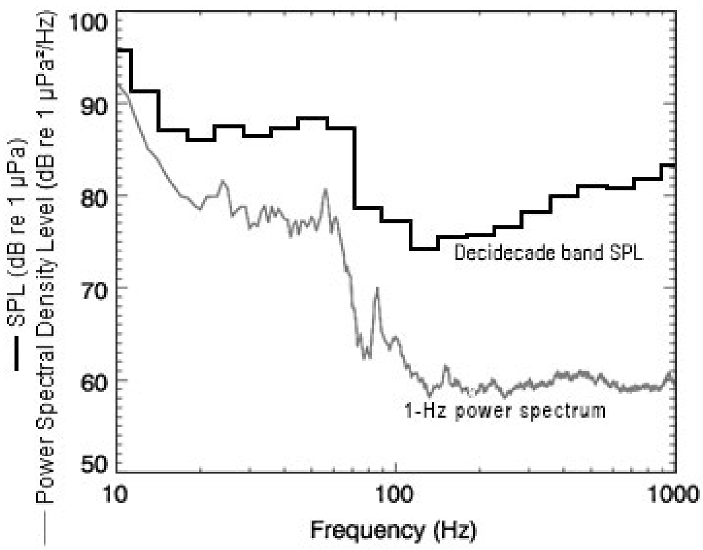

Figure A-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient sound shown on a logarithmic frequency scale. Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the power spectrum.

A.3. Marine Mammal Impact Criteria

It has been long recognised that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for both injury and disturbance. The following sections summarize the recent development of thresholds; however, this field remains an active research topic.

A.3.1. Injury and Hearing Sensitivity Changes

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.3.3). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LF and HF cetaceans while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HF cetaceans of 179 dB re 1 $\mu Pa^2 \cdot s$. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LF cetaceans on results obtained from MF cetacean studies. In particular they referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LF cetaceans of 192 dB re 1 $\mu Pa^2 \cdot s$.

As of 2017, an optimal approach is not apparent. There is consensus in the research community that an SEL-based method is preferable either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalised technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes injury criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). The latest revision to this work was published in 2018 (NMFS 2018). Southall et al. (2019) revisited the interim criteria published in 2007; all noise exposure criteria in NMFS (2018) and Southall et al. (2019) are identical (for impulsive and non-impulsive sounds), however the mid-frequency cetaceans from NMFS (2018) are classified as high-frequency cetaceans in Southall et al. (2019), and high-frequency cetaceans from NMFS (2018) are classified as very-high-frequency cetaceans in Southall et al. (2019).

A.3.2. Behavioural response

Numerous studies on marine mammal behavioural responses to sound exposure have not resulted in consensus in the scientific community regarding the appropriate metric for assessing behavioural reactions. However, it is recognised that the context in which the sound is received affects the nature and extent of responses to a stimulus (Southall et al. 2007, Ellison and Frankel 2012, Southall et al. 2016).

NMFS currently uses step function (all-or-none) threshold of 120 dB re 1 µPa SPL (unweighted) for non-impulsive sounds to assess and regulate noise-induced behavioural effects to marine mammals (NOAA 2019). The 120 dB re 1 µPa threshold is associated with continuous sources and was derived based on studies examining behavioural responses to drilling and dredging, referring to Malme et al. (1983), Malme et al. (1984), and Malme et al. (1986), which were considered in Southall et al. (2007). Malme et al. (1986) found that playback of drillship noise did not produce clear evidence of disturbance or avoidance for levels below 110 dB re 1 µPa (SPL), possible avoidance occurred for exposure levels approaching 119 dB re 1 µPa. Malme et al. (1984) determined that measurable reactions usually consisted of rather subtle short-term changes in speed and/or heading of the whale(s) under observation. It has been shown that both received level and proximity of the sound source is a contributing factor in eliciting behavioural reactions in humpback whales (Dunlop et al. 2017, Dunlop et al. 2018).

A.3.3. Marine Mammal Frequency Weighting

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal’s sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

In 2015, a US Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left(\frac{\left(\frac{f}{f_{lo}}\right)^{2a}}{\left(1+\left(\frac{f}{f_{lo}}\right)^{2}\right)^{a}\left(1+\left(\frac{f}{f_{hi}}\right)^{2}\right)^{b}}\right) \tag{A-11}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA’s technical guidance that assesses noise impacts on marine mammals (NMFS 2016, NMFS 2018). A further update to these weighting functions is presented in Southall (2019), whereby mid- and high- frequency cetaceans are now known as high- and very-high-frequency cetaceans. Table A-1 lists the frequency-weighting parameters for each hearing group; Figure A-3 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by NMFS (2018) and Finneran et al. (2017).

Hearing group	a	b	f_{lo} (Hz)	f_{hi} (Hz)	K (dB)
LF cetaceans (baleen whales)	1.0	2	200	19,000	0.13
MF cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
HF cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*)	1.8	2	12,000	140,000	1.36
Sea turtles	1.4	2	77	440	2.35

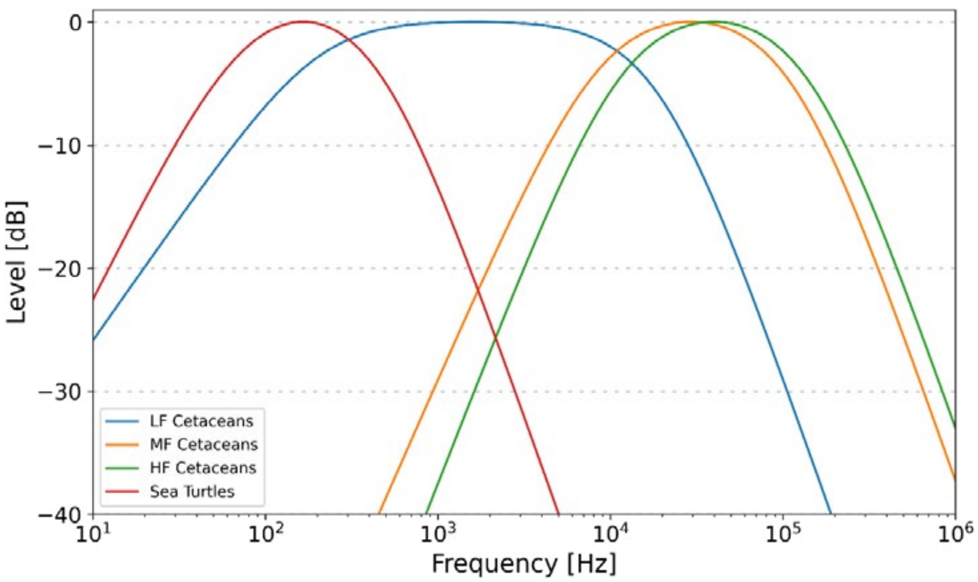

Figure A-3. Auditory weighting functions for functional marine mammal hearing groups as recommended by NMFS (2018) and Finneran et al. (2017)

Appendix B. Sound Source Propagation

B.1. Marine Operations Noise Model

Underwater sound propagation (i.e., transmission loss) at frequencies of 10 Hz to 1.6 kHz was predicted with JASCO's Marine Operations Noise Model (MONM). MONM computes SEL over 1 s for non-impulsive sources, at a specified source depth. Sound propagation at frequencies of 2 kHz and greater was computed via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

MONM computes acoustic propagation via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the US Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor. Additionally, BELLHOP accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water (Fisher and Simmons 1977). This type of sound attenuation is important for frequencies higher than 5 kHz and cannot be neglected without noticeably affecting the model results.

MONM computes acoustic fields in three dimensions by modelling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as $N\times$2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding $N = 360°/\Delta\theta$ number of planes (Figure B-1).

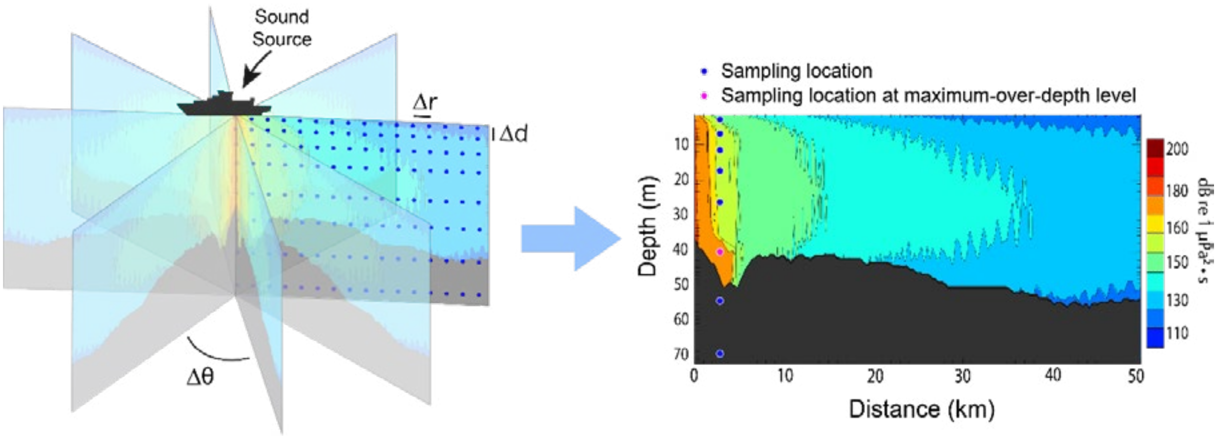

Figure B-1. The $N\times$2-D and maximum-over-depth modelling approach used by MONM

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of decidecade bands. Sufficiently many decidecade frequency-bands, starting at 10 Hz, are modelled to include most of the acoustic energy emitted by the source. At each centre frequency, the transmission loss is modelled within each of the N vertical planes as a function of depth and range from the source. The decidecade received per-pulse SEL are computed by subtracting the band propagation loss values from the directional source level in that frequency band. Composite broadband received per-pulse SEL are then computed by summing the received decidecade levels.

The received per-pulse SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size (Δr in Figure B-1). At each sampling range along the surface, the sound field is sampled at various depths (Δd in Figure B-1), with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest for the sound speed profile. For areas with deep water, sampling is not performed at depths beyond those reachable by marine mammals. The received per-pulse SEL at a surface sampling location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SEL are presented as colour contours around the source.

MONM's predictions have been validated against experimental data from several underwater acoustic measurement programs conducted by JASCO (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Martin et al. 2015).

Appendix C. Additional Methods and Parameters

C.1. Estimating Ranges to Threshold Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the seafloor for each location in the modelled region. The predicted ranges to specific levels were computed from these contours. Two ranges relative to the source are reported for each sound level: R_{max}, the maximum range to the given sound level over all azimuths, and $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure C.1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in Figure C.1a. In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In contrast, in strongly radially asymmetric cases such as shown in Figure C.1b, $R_{95\%}$ neglects to account for substantial protrusions in the footprint. In such cases, R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features that affect propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

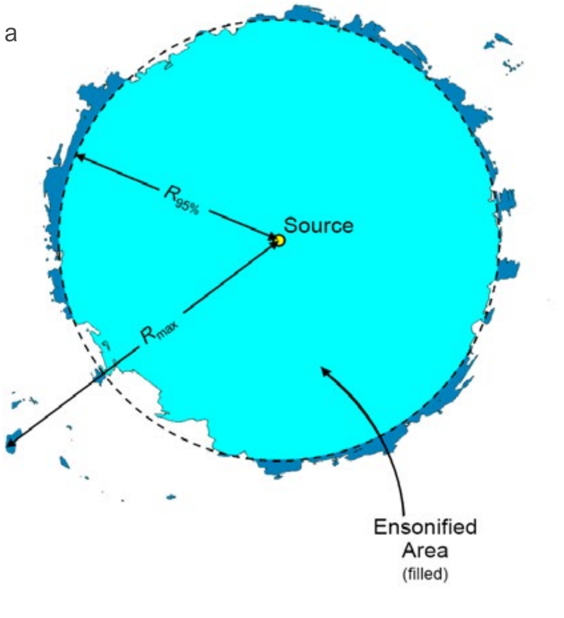

Figure C.1. R_{max} and $R_{95\%}$ ranges shown for two contrasting scenarios. Cyan indicates the ensonified areas bounded by $R_{95\%}$, whilst dark blue indicates the ensonified areas beyond $R_{95\%}$ that determine R_{max}.

C.2. Environmental Parameters

The parameters used are the same as applied in McPherson et al. (2019).

C.2.1. Bathymetry

Water depths (Mean Sea Level) at close- and mid-range from the pile were provided by Woodside. Within ~5–7 km from the pile, the data has a grid resolution of 2 × 2 m, while data at the passage between Scott Reef South and Scott Reef Central has a grid resolution of 1 × 1 m. Bathymetry data with grid resolution of 10 × 10 m was provided as far as 33 km northeast of the pile, and as far as 85 km southwest of the pile. Modelling was conducted along 80 km long radials emanating from the pile in all directions. For this reason, the high-resolution data was complemented using the Australian Bathymetry and Topography Grid, a 9 arc-second grid rendered for Australian waters (Whiteway 2009). The data were adjusted for an increase of 1.7 m in depth (Bureau of Meterology 2019), so the modelling results correspond to the most conservative propagation conditions at maximum tide at Scott Reef. Bathymetry data were re-gridded onto a Map Grid of Australia (MGA) coordinate projection (Zone 51) with a regular grid spacing of 50 × 50 m.

C.2.2. Sound speed profile

The sound speed profile in the area was derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

Mean monthly sound speed profiles were derived from the GDEM profiles at distances less than 76 km around the modelled site. The June sound speed profile is expected to be most favourable to longer-range sound propagation across the entire year. As such, June was selected for sound propagation modelling to ensure precautionary estimates of ranges to received sound level thresholds. Figure C-2 shows the resulting profile, which was used as input to the sound propagation modelling.

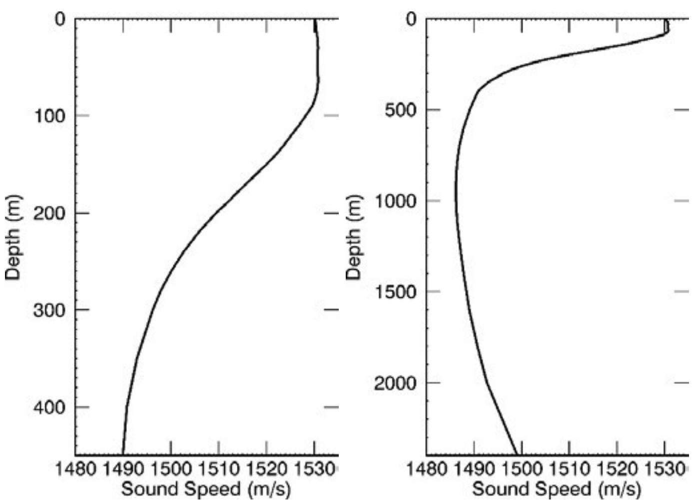

Figure C-2. The modelling sound speed profile corresponding to June: (left) top 450 m and (right) full profile. Profiles are calculated from temperature and salinity profiles from *Generalized Digital Environmental Model* V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

C.2.3. Geoacoustics

In previous acoustic studies in the area (Duncan 2014, McPherson et al. 2019), the modelling area was divided into three seabed types, with a silt seabed typical of the continental slope considered for most of the modelling area, and coarser gravel and limestone in the areas in and around the reefs. Due to the type of propagation modelling used in this study, however, the silt seabed was used for the entire modelling area. This is detailed in Table C-1.

Table C-1. Continental slope geoacoustic profile. Within each depth range, each parameter varies linearly within the stated range. The compressional wave is the primary wave, and the shear wave is the secondary wave.

Depth below seafloor (m)	Material	Density (g/cm^3)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–50	Silt	1.70–1.75	1566–1627	1.0	210	1.5
50–100		1.75–1.80	1627–1686			
100–150		1.80–1.85	1686–1742			
150–200		1.85–1.90	1742–1795			
>200		1.90	1795			

Appendix B - Woodside Browse to NWS Vessel Noise Acoustic Modelling Phase 2 (Green et al 2022b)

Woodside Browse to NWS Vessel Noise

Acoustic Modelling Phase 2

JASCO Applied Sciences (Australia) Pty Ltd

24 May 2022

Submitted to:

Aaron McDonald
Woodside Energy
Contract 4510700453

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The results presented herein are relevant within the specific context described in this report. They could be misinterpreted if not considered in the light of all the information contained in this report. Accordingly, if information from this report is used in documents released to the public or to regulatory bodies, such documents must clearly cite the original report, which shall be made readily available to the recipients in integral and unedited form.

Contents

Figures

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Executive Summary

The Browse Joint Venture (BJV) proposes to develop the Brecknock, Calliance, and Torosa fields (collectively known as the Browse resources) via the development drilling of wells and the installation of a subsea production system that will supply two 1100 million standard cubic feet per day (annual daily export average) Floating Production Storage and Offloading (FPSO) facilities. The Browse Project gas will be transported from the FPSO facilities to the existing NWS Project infrastructure via an approximately 900 km long trunkline. Each FPSO will have a turret mooring system that will be stabilised using mooring lines secured to the seabed by piles. JASCO has previously modelled pile driving operations, vertical seismic profiling (VSP) during drilling operations, Mobile Offshore Drilling Unit (MODU), FPSO, and Operational Support Vessel (OSV) operations. This previous work was presented in McPherson et al. (2019) and Green et al. (2022).

The present study serves as an update to the latter, and considers the following additional scenarios based on new information from the BJV:

- Flowline installation using a flexible reel-lay vessel near the TRA drill centre.
- Initial mooring and subsea hook-up of the FPSO facility.
- Rigid pipelaying operations at three discrete locations along a line terminating at the Torosa Gas Export Riser Base (GERB).
- Resupply operations at the FPSO with various levels of thruster utilisation.

The objective of this modelling study was to determine ranges to acoustic exposure thresholds representing the best available science for permanent threshold shift (PTS), temporary threshold shift (TTS), and behavioural disturbance of marine fauna including marine mammals, turtles, and fish.

Acoustic fields caused by pressure were modelled and are presented as sound pressure levels (SPL) and accumulated sound exposure levels (SEL) as appropriate for noise effect criteria for non-impulsive (vessel) noise sources. The effects of range-dependent environmental properties on sound propagation in the study area were accounted for by the numerical models.

The modelled sources are as follows:

- The flexible reel-lay vessel Skandi *Hercules*, 109.5 m x 24 m.
- Five anchor-handling tugs, 75.3 m x 18 m, used in the initial positioning of the FPSO facility.
- The rigid pipelay vessel Saipem *Castorone*, 325 m x 39 m. This is modelled using sources representing:
    - Two forward tunnel thrusters
    - One aft tunnel thruster
    - Three forward azimuth thrusters
    - Three aft azimuth thrusters
- A B-type vessel, 141 m x 25 m, under holding DP, modelled using sources representing:
    - Two forward tunnel thrusters
    - Two aft tunnel thrusters
    - One forward azimuth thruster
    - One aft azimuth thruster

- An FPSO facility, 370 m x 67 m. This was modelled under:
  - Typical operations with no heading control, only operating processing equipment and related machinery
  - Heading control (thrusters operating), representative of typical operational conditions
  - Heading control (thrusters operating) with optimised thrusters, representative of typical operational conditions
- A representative OSV, a DP vessel 92.95 m long (vessel design based on the Marin Teknikk MT6016 hull) under DP, representative of typical operational noise during maximum safe resupply operations. This was modelled using five thruster sources operating a defined capacity, based on the specification of the *Fugro Etive*, as follows:
  - Two Rolls-Royce AZP100 thrusters, operating at 20%
  - Two Rolls Royce TT 2200 DPN thrusters, operating at 40%
  - One Rolls-Royce AZP1001 thruster, operating at 40%

The analysis considered multiple commonly used effect criteria, with the key results of the acoustic modelling summarised below.

Marine Mammals

- The results for the United States (US) National Marine Fisheries Service (NMFS 2018) criteria applied for marine mammal PTS and TTS for vessels are assessed here for a 24-hour period. Vessels are considered to be active continuously across the 24-hour period. The maximum ranges to PTS are summarised in Tables 1–3.
- The maximum ranges to the US National Oceanic and Atmospheric Administration (NOAA 2019) marine mammal behavioural response criterion of 120 dB re 1 µPa (SPL) are summarised in Table 4.

Table 1. *Marine mammal SEL_{24h} flexible reel-lay and FPSO mooring,*: Maximum (R_{max}) horizontal ranges (km) to modelled maximum-over-depth PTS thresholds from NMFS (2018).

Hearing group	Threshold for PTS, SEL_{24h} (dB re 1 µPa²s)[a]	Range R_{max} (km)	
		Flexible Reel-Lay	FPSO Mooring
LF cetaceans	199	<0.05	<0.05
MF cetaceans	198	—	—
HF cetaceans	173	<0.05	<0.05

[a] Frequency weighted.

Table 2. *Marine mammal SEL_{24h} rigid pipelay,*: Maximum (R_{max}) horizontal ranges (km) to modelled maximum-over-depth PTS thresholds from NMFS (2018).

Hearing group	Threshold for PTS, SEL_{24h} (dB re 1 µPa²s)[a]	Range R_{max} (km)		
		Final Linepipe Resupply	Mid-Point	Gas Export Riser Base
LF cetaceans	199	0.10	0.08	0.07
MF cetaceans	198	<0.05	<0.05	<0.05
HF cetaceans	173	0.20	0.15	0.15

[a] Frequency weighted.

Table 3. *Marine mammal SEL_{24h} FPSO resupply,*: Maximum (R_{max}) horizontal ranges (km) to modelled maximum-over-depth PTS thresholds from NMFS (2018).

Hearing group	Threshold for PTS, SEL_{24h} (dB re 1 µPa²s)[a]	Range R_{max} (km)		
		FPSO (Machinery Only), OSV	FPSO (Heading Control), OSV	FPSO (Optimised Heading Control), OSV
LF cetaceans	199	0.06	0.20	0.19
MF cetaceans	198	—	0.19	—
HF cetaceans	173	0.06	0.25	0.20

[a] Frequency weighted.

Table 4. *Marine mammal behaviour, all scenarios*: Summary of maximum behavioural disturbance ranges.

SPL (L_p; dB re 1 µPa)	Range R_{max} (km)							
	Flexible Reel-Lay	FPSO Mooring	Rigid Pipelay			FPSO Resupply		
			Final Line pipe Resupply	Mid-Point	Gas Export Riser Base	FPSO (Machinery Only), OSV	FPSO (Heading Control), OSV	FPSO (Optimised Heading Control), OSV
120[a]	2.16	2.44	9.85	8.30	9.40	2.29	3.92	2.54

[a] Threshold for marine mammal behavioural response to non-impulsive noise (NOAA 2019).

Sea Turtles

The maximum ranges for the Finneran et al. (2017) criteria applied for sea turtles are summarised in Table 5.

Table 5. *Sea turtle SEL_{24h}, all scenarios*: Maximum-over-depth ranges (in km) to PTS threshold.

Threshold for PTS, SEL_{24h} (dB re 1 µPa²s)[a]	Range R_{max} (km)							
	Flexible Reel-Lay	FPSO Mooring	Rigid Pipelay			FPSO Resupply		
			Final Linepipe Resupply	Mid-Point	Gas Export Riser Base	FPSO (Machinery Only), OSV	FPSO (Heading Control), OSV	FPSO (Optimised Heading Control), OSV
220[b]	—	<0.05	<0.05	<0.05	<0.05	—	—	—

[a] Frequency weighted.
[b] Threshold for turtle-weighted SEL_{24h} (Finneran et al. 2017).
A dash indicates the level was not reached.

Fish

Sound produced by the operations could cause physiological effects and recoverable injury to some fish species, but only if the animals are in proximity to the sound sources (within a planar range of 200 m) for 48 hours. Temporary impairment due to TTS could occur at similar short ranges if fish remain at the same range for long periods of time (12 hours). The ranges are very similar for all scenarios.

1. Introduction

JASCO Applied Sciences Australia (JASCO) performed a modelling study of underwater sound levels associated with the Browse to North West shelf (NWS) Project development of the Brecknock, Calliance, and Torosa fields (collectively known as the Browse resources) by the Browse Joint Venture (BJV). This development will involve drilling wells and installing a subsea production system that will supply two 1100 million standard cubic feet per day (annual daily export average) Floating Production Storage and Offloading (FPSO) facilities. Gas will be transported from the FPSO facilities to the existing NWS Project infrastructure via an approximately 900 km long trunkline. Each FPSO will have a turret mooring system that will be stabilised using mooring lines secured to the seabed by piles. JASCO has previously modelled pile driving operations, vertical seismic profiling (VSP) during drilling operations, Mobile Offshore Drilling Unit (MODU), FPSO, and Operational Support Vessel (OSV) operations. This previous work was presented in McPherson et al. (2019) and Green et al. (2022).

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- Rigid pipelaying operations at three discrete locations along a line terminating at the Torosa Gas Export Riser Base (GERB).
- Resupply operations at the FPSO with various levels of thruster utilisation.

The modelling study specifically assessed ranges from operations where underwater sound levels reached thresholds corresponding to various levels of impact on marine fauna. The animals considered here included marine mammals (pygmy blue whales, *Balaenoptera musculus brevicauda*), sea turtles, and fish (including fish eggs and larvae). Due to the variety of species considered, there are several thresholds for evaluating effects, including: mortality, injury, temporary reduction in hearing sensitivity, and behavioural disturbance.

The modelling methodology considered source directivity and range-dependent environmental properties. Estimated underwater acoustic levels are presented as sound pressure levels (SPL, L_p), and or accumulated sound exposure levels (SEL, L_E) as appropriate for different noise effect criteria for non-impulsive (continuous) noise sources.

1.1. Acoustic Modelling Scenario Details

The modelled sources are as follows:

- The flexible reel-lay vessel Skandi *Hercules*, 109.5 m length and 24 m breadth.
- Five anchor-handling tugs (AHTs), 75.3 m x 18 m, used in the initial positioning of the FPSO facility.
- The rigid pipelay vessel Saipem *Castorone*, 325 m x 39 m. This is modelled using sources representing:
    - Two forward tunnel thrusters
    - One aft tunnel thruster
    - Three forward azimuth thrusters
    - Three aft azimuth thrusters

- A B-type vessel, 141 m x 25 m, under holding DP, modelled using sources representing:
  - Two forward tunnel thrusters
  - Two aft tunnel thrusters
  - One forward azimuth thruster
  - One aft azimuth thruster
- An FPSO facility, 370 m x 67 m. This was modelled under:
  - Typical operations with no heading control, only operating processing equipment and related machinery
  - Heading control (thrusters operating), representative of typical operational conditions
  - Heading control (thrusters operating) with optimised thrusters, representative of typical operational conditions
- A representative OSV, a DP vessel 92.95 m long (vessel design based on the Marin Teknikk MT6016 hull) under DP, representative of typical operational noise during maximum safe resupply operations. This was modelled using five thruster sources operating a defined capacity, based on the specification of the *Fugro Etive*, as follows:
  - Two Rolls-Royce AZP100 thrusters, operating at 20%
  - Two Rolls Royce TT 2200 DPN thrusters, operating at 40%
  - One Rolls-Royce AZP1001 thruster, operating at 40%

The geographic coordinates for the modelled sites are provided in Table 6 and an overview of the modelling area is shown in Figure 1. Scenarios are summarised in Table 7.

For the FPSO mooring scenario, one AHT is positioned directly alongside the final position of the FPSO, with the remaining four positioned 500 m distant from the FPSO in the four ordinal directions, as shown in Figure 2.

For the rigid pipelay scenario, no resupply will be required for the final 10 km of the pipelay. Hence, the rigid pipelay vessel has been modelled with the attendant B-type vessel at this final resupply location, and with no B-type for subsequent modelling locations approaching the GERB (Table 7).

Figure 3 shows the relative positioning of the two vessels for the FPSO resupply scenario. This scenario is somewhat similar to the offtake scenario presented in the previous study (Green et al. 2022). In the resupply scenario in the current study, however, the OSV is positioned directly alongside the FPSO (Figure 3), whereas in the offtake scenario from Green et al. 2022 it was located 700 m away.

Table 6. Location details for the modelled sites

Site	Source	Latitude (S)	Longitude (E)	MGA (GDA94), Zone 51		Water depth (m)
				X (m)	Y (m)	
TRA Well	Skandi Hercules	13° 58′ 12.50″	121° 58′ 37.70″	389521	8455338	425
Torosa	FPSO (centre)	13° 58′ 15.06″	122° 01′ 28.53″	394647	8455281	463
	OSV (centre)	13° 58′ 15.06″	122° 01′ 28.53″	394647	8455324	463
Rigid Pipelay Line	Final Resupply	14° 04′ 06.20″	122° 01′ 58.48″	395590	8444496	478
	Mid-Point	14° 01′ 24.25″	122° 01′ 42.66″	395095	8449470	467
	GERB	13° 58′ 41.81″	122° 01′ 26.78″	394598	8454459	462

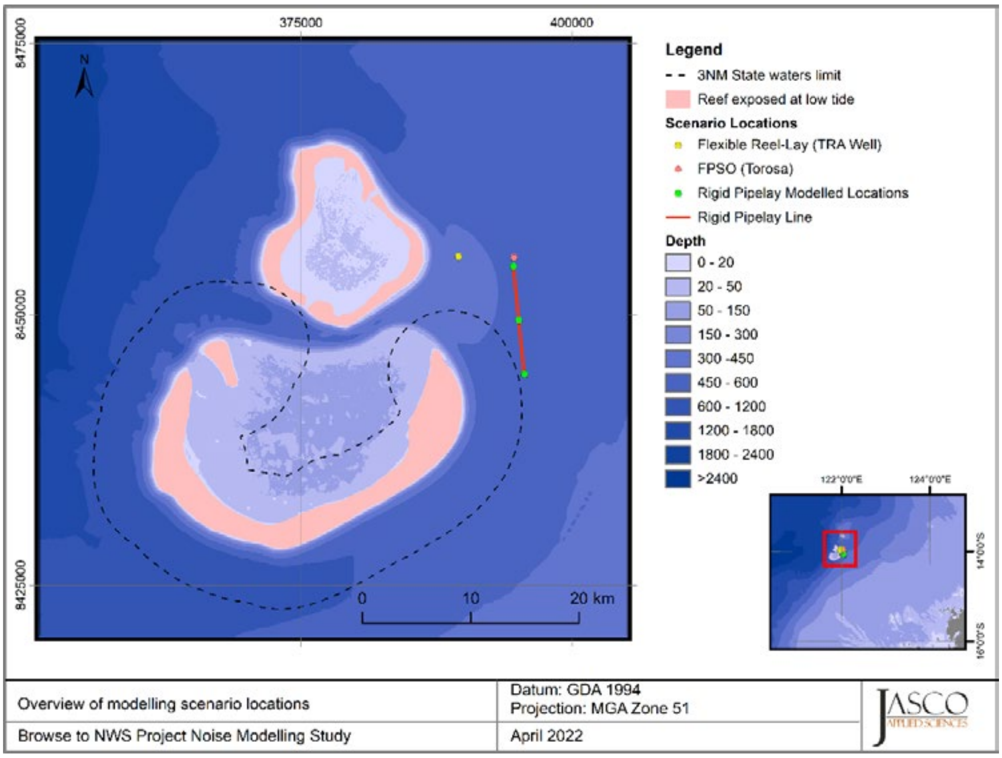

Figure 1. Overview of the modelled area and local features

Table 7. Modelled scenarios

Scenario	Description	Sources
1	Flexible Reel-Lay	Skandi Hercules, Single Monopole Source
2	FPSO Mooring and Subsea Hookup	5 x Anchor Handling Tugs
3(a)	Rigid Pipelay at Final Resupply Location	Castorone Thrusters (3 x tunnel, 6 x azimuth) B-type Thrusters (4 x tunnel, 2 x azimuth)
3(b)	Rigid Pipelay at Mid-Point	Castorone Thrusters (3 x tunnel, 6 x azimuth)
3(c)	Rigid Pipelay at GERB	
4(a)	FPSO Resupply (Machinery Only)	FPSO Machinery OSV Thrusters x 5
4(b)	FPSO Resupply (50% Thrusters)	FPSO Machinery FPSO Thrusters x 2 OSV Thrusters x 5
4(c)	FPSO Resupply (Mitigated Thrusters)	FPSO Machinery FPSO Thrusters x 2 (Reduced Level) OSV Thrusters x 5

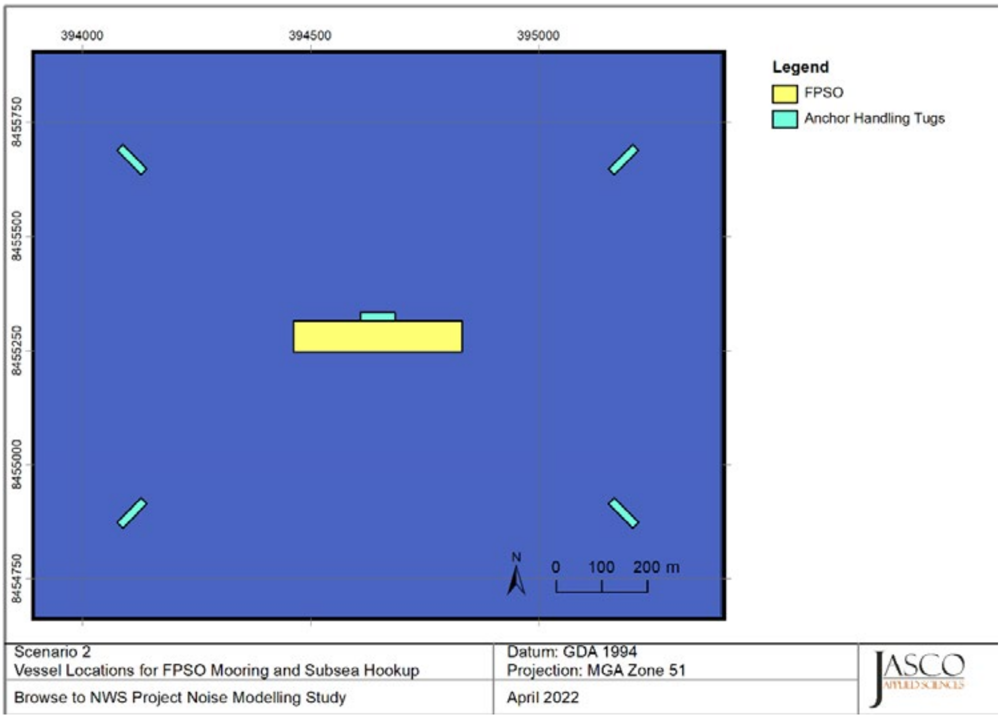

Figure 2. Overview of anchor handling tug source positioning for Scenario 2 relative to final positioning of FPSO. Note that in this scenario, the FPSO is treated as silent since it is neither utilising thrusters nor processing hydrocarbons.

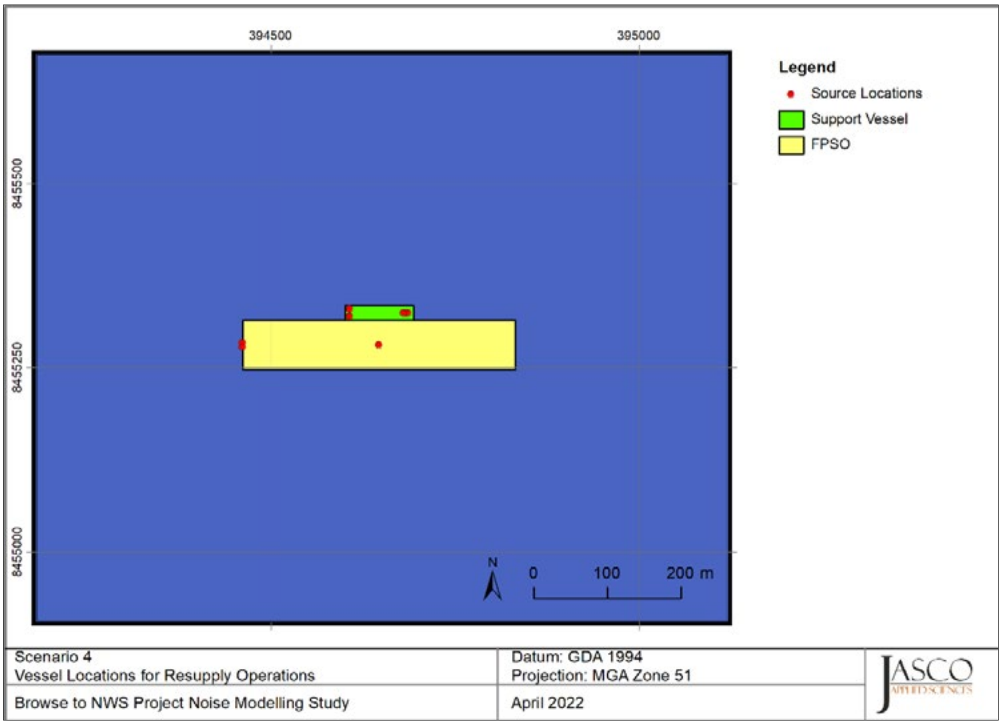

Figure 3. Overview of FPSO and OSV positioning for Scenario 4.

2. Noise Effect Criteria

To assess the potential impacts of a sound-producing activity, it is necessary to first establish exposure criteria (thresholds) for which sound levels may be expected to have a negative impact on animals. Whether acoustic exposure levels might injure or disturb marine fauna is an active research topic. Since 2007, several expert groups have developed SEL-based assessment approaches for evaluating auditory injury, with key works including Southall et al. (2007), Finneran and Jenkins (2012), Popper et al. (2014), and the United States National Marine Fisheries Service (NMFS 2018). The number of studies that investigate the level of behavioural disturbance to marine fauna by anthropogenic sound has also increased substantially.

Several sound level metrics, such as PK, SPL, and SEL, are commonly used to evaluate noise and its effects on marine life (see Appendix A.3). In this report, the duration of the SEL accumulation is integrated over the operational time periods for each vessel, in this case 24 hours.

Appropriate subscripts indicate any applied frequency weighting (Appendix A.3.3). The acoustic metrics in this report reflect the updated ANSI and ISO standards for acoustic terminology, ANSI S1.1 (R2013) and ISO 18405:2017 (2017).

This study applies the following noise criteria (Sections 2.1–2.2 and Appendix A.3.1), chosen for their acceptance by regulatory agencies and because they represent current best available science:

- Frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from NMFS (2018) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in marine mammals. This criteria was applied for consistency with previous work (McPherson et al. 2019, Green et al. 2022).
- Marine mammal behavioural threshold based on the current interim U.S. National Oceanic and Atmospheric Administration (NOAA 2019) criterion for marine mammals of 120 dB re 1 µPa SPL (L_p) for non-impulsive sound sources. This is identical to the previously applied behavioural response threshold, however the reference has been updated.
- Sound exposure guidelines for fish, fish eggs, and larvae (Popper et al. 2014).
- Frequency-weighted accumulated sound exposure levels (SEL; $L_{E,24h}$) from Finneran et al. (2017) for the onset of permanent threshold shift (PTS) and temporary threshold shift (TTS) in sea turtles.

2.1. Marine Mammals

The criteria applied in this study to assess possible effects of non-impulsive sources on marine mammals are summarised in Table 8; Cetaceans (low-, mid-, and high-frequency) were identified as the hearing groups requiring assessment. Details on thresholds related to auditory threshold shifts or hearing loss and behavioural response are provided in Appendix A.3, with frequency weighting explained in detail in Appendix A.3.3. Of particular note, whilst the newly published Southall et al. (2021) provides recommendations and discusses the nuances of assessing behavioural response, the authors do not recommend new numerical thresholds for onset of behavioural responses for marine mammals.

Table 8. Criteria for effects of non-impulsive noise exposure, including vessel noise on marine mammals: SPL and Weighted SEL_{24h} thresholds.

Hearing group	NOAA (2019)	NMFS (2018)	
	Behaviour	PTS onset thresholds (received level)	TTS onset thresholds (received level)
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^{2}s)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^{2}s)
LF cetaceans	120	199	179
MF cetaceans		198	178
HF cetaceans		173	153

L_p denotes sound pressure level period and has a reference value of 1 µPa.
L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa^{2}s.

2.2. Fish, Sea Turtles, Fish Eggs, and Fish Larvae

In 2006, the Working Group on the Effects of Sound on Fish and Turtles was formed to continue developing noise exposure criteria for fish and sea turtles based on work began by a NOAA panel two years earlier. The Working Group developed guidelines with specific thresholds for different levels of effects for several species groups (Popper et al. 2014). The guidelines define quantitative thresholds for three types of immediate effects:

- Mortality, including injury leading to death.
- Recoverable injury, including injuries unlikely to result in mortality, such as hair cell damage and minor haematoma.
- TTS.

Masking and behavioural effects can be assessed qualitatively, by assessing relative risk rather than by specific sound level thresholds. However, as these depend upon activity-based subjective ranges, these effects are not addressed in this report, and are included in Table 9 for completeness only. Because the presence or absence of a swim bladder has a role in hearing, fish susceptibility to injury from noise exposure depends on the species and the presence and possible role of a swim bladder in hearing. Thus, different thresholds were proposed for fish without a swim bladder (also appropriate for sharks and applied to whale sharks in the absence of other information), fish with a swim bladder not used for hearing, and fish that use their swim bladders for hearing. Sea turtles, fish eggs, and fish larvae are considered separately.

Table 9 lists the relevant effects thresholds from Popper et al. (2014) for shipping and non-impulsive noise. Some evidence suggests that fish sensitive to acoustic pressure show a recoverable loss in hearing sensitivity, or injury when exposed to high levels of noise (Scholik and Yan 2002, Amoser and Ladich 2003, Smith et al. 2006); this is reflected in the SPL thresholds for fish with a swim bladder involved in hearing. Finneran et al. (2017) presented revised thresholds for turtle injury, considering frequency weighted SEL, which have been applied in this study (Table 10).

Table 9. Criteria for vessel noise exposure for fish, adapted from Popper et al. (2014).

Type of animal	Mortality and Potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: No swim bladder (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: Swim bladder not involved in hearing (particle motion detection)	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) Moderate (I) Moderate (F) Low
Fish: Swim bladder involved in hearing (primarily pressure detection)	(N) Low (I) Low (F) Low	170 dB SPL for 48 h	158 dB SPL for 12 h	(N) High (I) High (F) High	(N) High (I) Moderate (F) Low
Sea turtles	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) High (I) High (F) Moderate	(N) High (I) Moderate (F) Low
Fish eggs and fish larvae	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) Low (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) Moderate (I) Moderate (F) Low

Sound pressure level dB re 1 µPa.
Relative risk (high, moderate, low) is given for animals at three ranges from the source defined in relative terms as near (N), intermediate (I), and far (F).

Table 10. Acoustic effects of non-impulsive noise on sea turtles, weighted SEL_{24h}, Finneran et al. (2017).

PTS onset thresholds (received level)	TTS onset thresholds (received level)
Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^{2}s)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^{2}s)
220	200

L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa^{2}s.

3. Methods

This study considers operations occurring at the Torosa fields, including flowline installation at the TRA location, rigid pipelaying on a line terminating at the Gas Export Riser Base (GERB), and operations at the FPSO location. Environmental parameters (bathymetry, sound speed profile and geoacoustics) were taken from McPherson et al. (2019). Details are provided in Appendix C.2.

3.1. Acoustic Source Parameters

3.1.1. Flexible Reel-Lay Vessel

Most of the noise incurred by the operation of the flowline installation vessel will be caused by cavitation from its dynamic positioning (DP) thrusters. Measurements of the similar flexible lay and construction vessel *Deep Orient* detailed in Quijano and McPherson (2021) were used as source levels. The *Deep Orient* is a 135 m long DP2 medium construction vessel with 11,500 kW of installed power. In this study, linear extrapolation was used to generate source levels for frequency bands down to 10 Hz, as shown in Figure 4. The resultant modelled broadband SL for this vessel is 181 dB re 1 µPa.

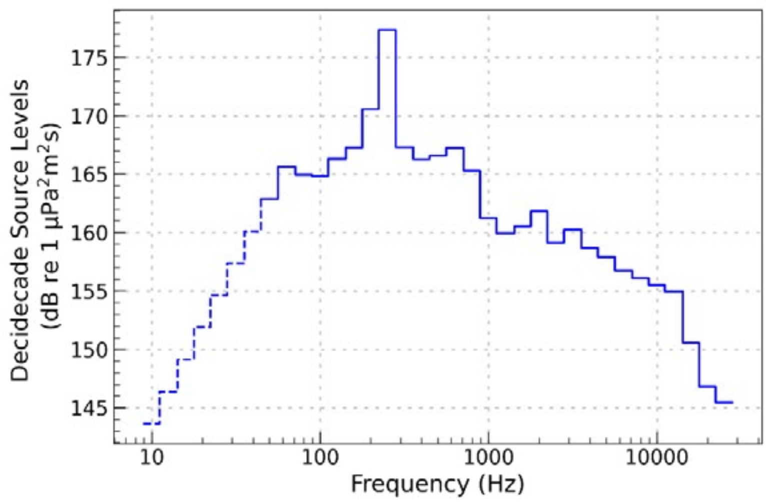

Figure 4. Decidecade band monopole source levels used for Skandi *Hercules*. Measured levels from *Deep Orient*. Frequencies below 50 Hz generated by linear extrapolation from lowest available frequency bands, indicated by dashed line.

3.1.2. Anchor Handling Tugs

Sound source levels for the five tugs involved with FPSO mooring were based on recorded levels for the anchor handling tug *Katun*, recorded whilst performing an anchor pull operation (Hannay et al. 2004). Since anchor handling is a large part of the FPSO mooring operation, these source levels were considered particularly appropriate, as opposed to any recorded source levels of tugs in transit. In this case, recorded levels were not available above 10 kHz, so higher frequencies have been linearly extrapolated from the available data. Figure 5 shows the decidecade band monopole source levels that were used for each tug. These levels resulted in a broadband source level of 184.4 dB re 1 µPa per tug.

Each of these tugs features four main sources of cavitation – two main propellers, forward and aft thrusters. Thruster locations, diameters, and depths were derived by referring to a technical drawing and cross-referencing this with the known length and breadth of the ship. Monopole source depths Z_s were calculated using the following equation, derived from Gray and Greeley (1980):

$$Z_s = Z_{prop} - 0.85 \cdot \varphi_{prop} \quad (1)$$

where Z_{prop} is the depth at the bottom of the propeller and φ_{prop} is the diameter of the propeller. Thus, thruster source depths were determined as 2.34 m, 3.48 m, and 4.03 m for the main propellers, forward, and aft thrusters, respectively. Since these vessels were modelled as single monopole sources, a single source depth of 3.05 m was calculated as the mean of these depths and used for the model.

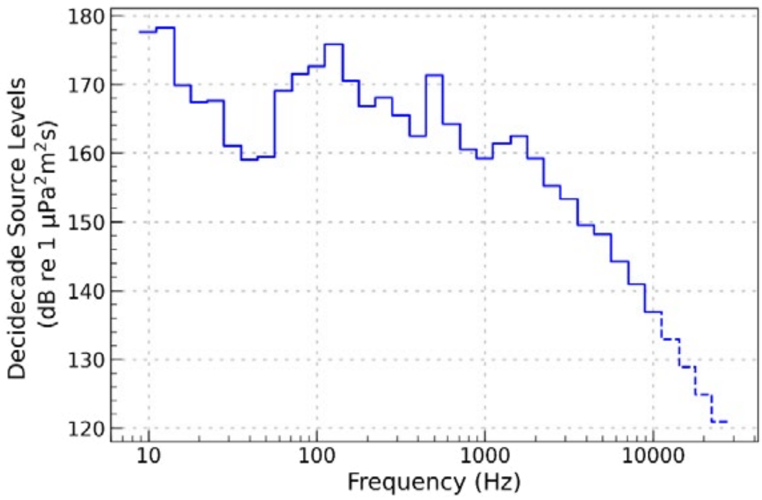

Figure 5. Decidecade band monopole source levels used for tugs involved with FPSO mooring operation. Measured levels from *Katun*. Frequencies above 10 kHz generated by linear extrapolation from highest available frequency bands, indicated by dashed line.

3.1.3. Rigid Pipelay Vessel

The Saipem *Castorone* is a Class 3 pipelay vessel featuring DP, planned for use for rigid pipelaying operations. It has a length of 325 m, a width of 39 m, and a draft of 10.6 m, and features nine thrusters – three tunnel thrusters and six azimuth thrusters. These were each modelled separately as point sources at depths of 1.8 m, 6.1 m, and 11.8 m, which were determined in reference to vessel schematics and following Equation 1. The source level spectra for the individual *Castorone* thrusters were based on 50% power predictions provided by the BJV, and are shown in Figure 6, this matches the consideration of the vessel in Connell et al. (2022). The resultant broadband energy source level (ESL), accounting for all thrusters, is 189.8 dB re 1 µPa; this ESL was not used in the modelling, but is provided for reference only.

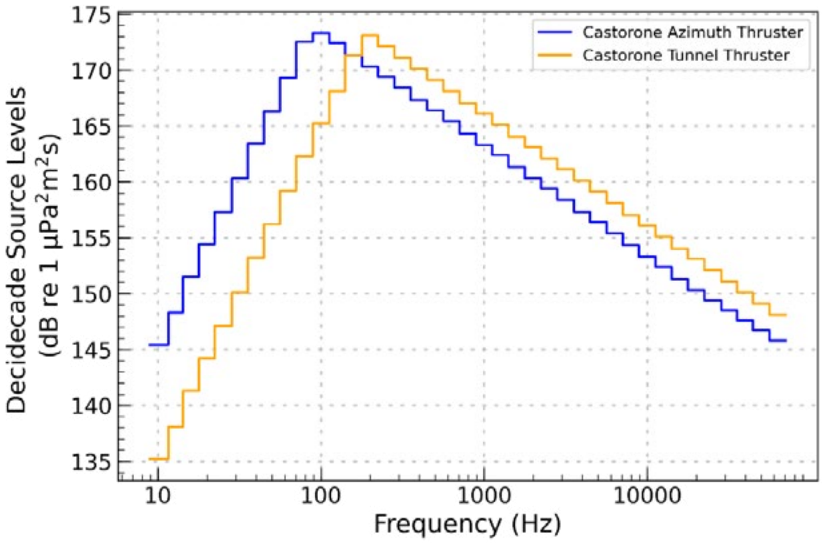

Figure 6. Decidecade band monopole source levels used for Saipem *Castorone*. Levels representative of thrusters operating at 50% power.

3.1.4. B-type Vessel

The B-type vessel will operate next to the *Castorone* in the final line pipe resupply location. It has a length of 141 m, a width of 25 m, and a draft of 8.92 m. The B-type vessel features six thrusters – four tunnel and two azimuth. These were modelled separately as point sources at depths of 6.7 m and 7.2 m for the forward and aft tunnel thrusters, respectively, and 6.9 m for both azimuth thrusters. Depths were again determined following Equation 1. Source level spectra for the two types of thrusters used in the B-type were based on levels provided by the BJV, representative of 40% power matching the consideration of the vessel in Connell et al. (2022), these are shown in Figure 7. In this case, the broadband ESL is 185.7 dB re 1 µPa; this ESL was not used in the modelling, but is provided for reference only.

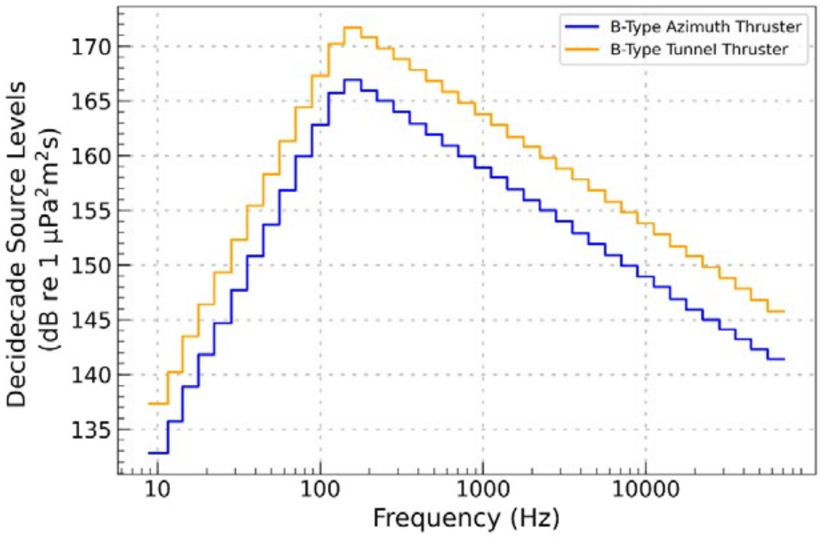

Figure 7. Decidecade band monopole source levels used for B-type vessel. Levels representative of thrusters operating at 40% power.

3.1.5. Offshore Support Vessel

Sound source levels for the OSV were based on the *Fugro Etive*, a general purpose vessel 92.95 m in length, and 19.7 m in breadth, featuring two stern azipull thrusters (Rolls-Royce AZP100), two bow controllable pitch thrusters (Rolls-Royce TT 2200 DPN), and a retractable azimuthing thruster (Rolls-Royce UL1201). The azipull thrusters are primarily used for propulsion, as opposed to the bow/retractable thrusters which are primarily used for dynamic positioning. During OSV resupply, the propulsion thrusters are typically used less than the dynamic positioning. Each thruster was modelled as an individual source based on levels provided by the BJV. These are representative of the bow and retractable thrusters operating at 40% capacity and the stern azipull thrusters operating at 20%; levels are shown in Figure 8. The overall broadband ESL is 181.3 dB re 1 µPa; this ESL was not used in the modelling, but is provided for reference only.

Thruster locations, diameters, and depths were derived by referring to a technical drawing and cross-referencing this with the known length and breadth of the ship, again with reference to Equation 1. Thus, depths of 3.2 m, 6.4 m, and 3.4 m were used for the AZP100, UL1201, and CP thrusters, respectively.

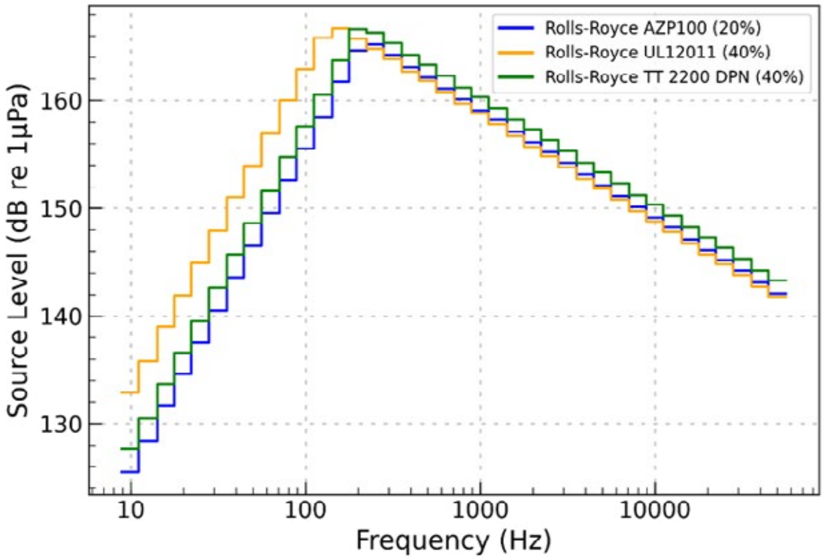

Figure 8. Decidecade band monopole source levels for OSV thruster sources during FPSO resupply. These spectra represent thrusters working at 20 and 40% capacity.

3.1.6. Floating Production, Storage, and Offloading (FPSO) Facility

The proposed FPSO facility is a permanently moored, heading controlled production vessel approximately 370 m long and 67 m wide with a draft of 16 m. While in heading control mode, it operates on two stern thrusters positioned laterally on the keel at the stern of the ship 6 m apart.

The major sources of noise from this vessel are the two thrusters and noise associated with pumps, generators, and other machinery within the vessel. As a proxy for the latter noise source, an average of two source levels measured by Erbe et al. (2013) from the FPSO facilities *Nganhurra* and the *Ngujima Yin*, with a broadband source level of 173.9 dB re 1 µPa, was used. The thrusters were modelled as two separate point sources using theoretical source level spectra for 3000 mm nozzled 4 bladed fixed pitch propellers (FPPs), provided by the BJV. These had a broadband source level of 179.5 dB re 1 µPa.

In combination, the machinery noise and two thruster sources reach a broadband source level of 183 dB re 1 µPa. A future design target for the FPSO is a broadband source level of 178 dB re 1 µPa.

Given the input spectra, it was calculated that a broadband reduction of 6.6 dB per thruster would be required to reach this target. An offset of −6.6 dB was therefore applied to the thruster spectrum for this additional hypothetical scenario. Figure 9 shows the source spectra for machinery and thrusters with and without the level reduction applied. It can be seen that a broadband reduction of thruster level would have greatest impact in terms of exceeding the machinery noise at frequencies of 80 Hz and above.

Machinery noise was modelled as a point source at the planar centre of the vessel at a depth of 8 m, which is 50% of the draught, consistent with the approach taken in McPherson et al. (2019). The thrusters were modelled as two separate point sources positioned 6 m apart at the stern of the ship (relative to the position of the machinery source) at a depth of 16.5 m, specified by the BJV.

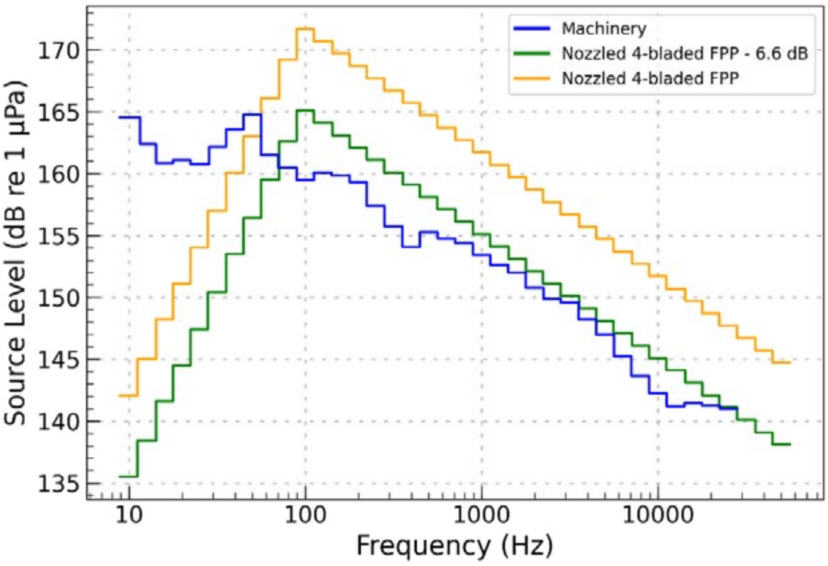

Figure 9. Source levels used for FPSO facility

3.2. Modelling Sound Propagation

JASCO's combined Marine Operations Noise Model (MONM) and gaussian beam acoustic ray-trace model (BELLHOP) were used to predict the acoustic field at frequencies from 10 Hz to 63 kHz. Details on these models are included in Appendix B.1.

Accumulated SEL was calculated using the following equation:

$$L_{E,24h} = L_E + 10\log_{10}(T) \tag{2}$$

where L_E is the per-second energy source level (output by MONM-BELLHOP) and T is the total number of operational seconds in a 24-hour period.

In the modelled scenarios all vessels are considered to be in continuous operation. Using Equation 2, constant operation over 24 hours yields an offset of 49.3 dB. This offset was applied to the relevant received levels to calculate metrics related to SEL.

4. Results

Sound field results for all scenarios are presented in this section as tables and maps showing propagation ranges and isopleths with relevant effect thresholds. Maximum-over-depth SPL results are presented in Tables 11 to 18 and Figures 10 to 17, while accumulated SEL results are presented in Tables 19 to 22 and Figures 18 to 25.

4.1. Tables

Table 11. *TRA Flexible Reel-Lay, SPL*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the centroids of the vessels involved.

SPL (L_p; dB re 1 µPa)	R_{max} (km)	$R_{95\%}$ (km)
180	—	—
170	—	—
160	—	—
150	0.05	0.05
140	0.17	0.17
130	0.55	0.53
120[a]	2.16	2.06
110	10.83	6.71

[a] Threshold for marine mammal behavioural response to non-impulsive noise (NOAA 2019).
A dash indicates the level was not reached within the resolution of the model.

Table 12. *FPSO Mooring, SPL*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the centroids of the vessels involved.

SPL (L_p; dB re 1 µPa)	R_{max} (km)	$R_{95\%}$ (km)
180	<0.05	<0.05
170	<0.05	<0.05
160	<0.05	<0.05
150	<0.05	<0.05
140	0.14	0.13
130	0.96	0.76
120[a]	2.44	2.20
110	22.55	18.97

[a] Threshold for marine mammal behavioural response to non-impulsive noise (NOAA 2019).

Table 13. *Rigid Pipelay, SPL*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the centroids of the vessels involved. Scenario descriptions are given in Table 7.

SPL (L_p; dB re 1 µPa)	Final Linepipe Resupply		Mid-Point		Gas Export Riser Base	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
180	<0.05	<0.05	—	—	<0.05	<0.05
170	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
160	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
150	0.15	0.14	0.11	0.11	0.12	0.10
140	0.56	0.52	0.49	0.45	0.50	0.45
130	2.52	2.39	2.31	2.17	2.31	2.16
120[a]	9.85	7.64	8.30	6.88	9.40	7.05
110	24.55	18.77	20.66	17.53	21.26	18.07

[a] Threshold for marine mammal behavioural response to non-impulsive noise (NOAA 2019).
A dash indicates the level was not reached.

Table 14. *FPSO, SPL:* Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) to sound pressure level (SPL) from the centroids of the vessels involved. Scenario descriptions are given in Table 7.

SPL (L_p; dB re 1 µPa)	OSV Resupply		FPSO (Heading Control), OSV		FPSO (Optimised Heading Control), OSV	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
180	—	—	—	—	—	—
170	—	—	0.19	0.19	—	—
160	<0.05	<0.05	0.19	0.19	0.19	0.19
150	0.06	0.06	0.24	0.24	0.19	0.10
140	0.17	0.16	0.40	0.35	0.26	0.24
130	0.56	0.52	0.97	0.90	0.64	0.59
120[a]	2.29	2.20	3.92	3.60	2.54	2.43
110	9.27	6.57	13.91	10.89	9.34	7.78

[a] Threshold for marine mammal behavioural response to non-impulsive noise (NOAA 2019).
A dash indicates the level was not reached within the resolution of the model.

Table 15. *TRA Flexible Reel Lay, SPL, fish effect thresholds*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the vessels to modelled maximum-over-depth sound pressure level (SPL) thresholds based on the quantifiable thresholds for fish with a swim bladder involved in hearing (Popper et al. 2014). Scenario descriptions are given in Table 7.

SPL (L_p; dB re 1 µPa)	R_{max} (km)	$R_{95\%}$ (km)
170[a]	—	—
158[b]	<0.05	<0.05

[a] Recoverable injury (Popper et al. 2014)
[b] TTS
A dash indicates the level was not reached within the resolution of the model.

Table 16. *FPSO Mooring, SPL, fish effect thresholds*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the vessels to modelled maximum-over-depth sound pressure level (SPL) thresholds based on the quantifiable thresholds for fish with a swim bladder involved in hearing (Popper et al. 2014). Scenario descriptions are given in Table 7.

SPL (L_p; dB re 1 µPa)	R_{max} (km)	$R_{95\%}$ (km)
170[a]	<0.05	<0.05
158[b]	<0.05	<0.05

[a] Recoverable injury (Popper et al. 2014)
[b] TTS

Table 17. *Rigid Pipelay, SPL, fish effect thresholds*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the vessels to modelled maximum-over-depth sound pressure level (SPL) thresholds based on the quantifiable thresholds for fish with a swim bladder involved in hearing (Popper et al. 2014). Scenario descriptions are given in Table 7.

SPL (L_p; dB re 1 µPa)	Final Linepipe Resupply		Mid-Point		Gas Export Riser Base	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
170[a]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
158[b]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

[a] Recoverable injury (Popper et al. 2014)
[b] TTS

Table 18. *FPSO, SPL, fish effect thresholds*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the vessels to modelled maximum-over-depth sound pressure level (SPL) thresholds based on the quantifiable thresholds for fish with a swim bladder involved in hearing (Popper et al. 2014). Scenario descriptions are given in Table 7.

SPL (L_p; dB re 1 µPa)	OSV Resupply		FPSO (Heading Control), OSV		FPSO (Optimised Heading Control), OSV	
	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
170[a]	—	—	0.19	0.19	—	—
158[b]	<0.05	<0.05	0.19	0.19	0.19	0.19

[a] Recoverable injury (Popper et al. 2014)
[b] TTS
A dash indicates the level was not reached.

Table 19. *TRA Flexible Reel Lay, SEL_{24h}*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the vessels to modelled maximum-over-depth frequency-weighted SEL_{24h} permanent threshold shift (PTS) and temporary threshold shift (TTS) thresholds for marine mammals (NMFS 2018) and sea turtles (Finneran et al. 2017). Scenario descriptions are given in Table 7.

Hearing group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)[a]	R_{max} (km)	$R_{95\%}$ (km)
PTS			
LF cetaceans	199	<0.05	<0.05
MF cetaceans	198	—	—
HF cetaceans	173	<0.05	<0.05
Sea turtles	220	—	—
TTS			
LF cetaceans	179	0.46	0.45
MF cetaceans	178	<0.05	<0.05
HF cetaceans	153	0.90	0.88
Sea turtles	200	<0.05	<0.05

[a] Frequency weighted.
A dash indicates the level was not reached.

Table 20. *FPSO Mooring, SEL_{24h}*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the vessels to modelled maximum-over-depth frequency-weighted SEL_{24h} permanent threshold shift (PTS) and temporary threshold shift (TTS) thresholds for marine mammals (NMFS 2018) and sea turtles (Finneran et al. 2017). Scenario descriptions are given in Table 7.

Hearing group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)[a]	R_{max} (km)	$R_{95\%}$ (km)
PTS			
LF cetaceans	199	<0.05	<0.05
MF cetaceans	198	—	—
HF cetaceans	173	<0.05	<0.05
Sea turtles	220	<0.05	<0.05
TTS			
LF cetaceans	179	0.53	0.36
MF cetaceans	178	<0.05	<0.05
HF cetaceans	153	0.13	0.12
Sea turtles	200	<0.05	<0.05

[a] Frequency weighted.
A dash indicates the level was not reached.

Table 21. *Rigid Pipelay, SEL_{24h}*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the vessels to modelled maximum-over-depth frequency-weighted SEL_{24h} permanent threshold shift (PTS) and temporary threshold shift (TTS) thresholds for marine mammals (NMFS 2018) and sea turtles (Finneran et al. 2017). Scenario descriptions are given in Table 7.

Hearing group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)[a]	Final Linepipe Resupply		Mid-Point		Gas Export Riser Base	
		R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
		PTS					
LF cetaceans	199	0.10	0.09	0.08	0.08	0.07	0.07
MF cetaceans	198	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
HF cetaceans	173	0.20	0.18	0.15	0.14	0.15	0.15
Sea turtles	220	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
		TTS					
LF cetaceans	179	2.16	2.05	1.82	1.70	1.82	1.70
MF cetaceans	178	0.12	0.12	0.10	0.09	0.11	0.10
HF cetaceans	153	2.96	2.80	2.85	2.72	2.86	2.72
Sea turtles	200	0.10	0.10	0.08	0.08	0.08	0.07

[a] Frequency weighted.
A dash indicates the level was not reached.

Table 22. *FPSO, SEL_{24h}*: Maximum (R_{max}) and 95% ($R_{95\%}$) horizontal distances (in km) from the vessels to modelled maximum-over-depth frequency-weighted SEL_{24h} permanent threshold shift (PTS) and temporary threshold shift (TTS) thresholds for marine mammals (NMFS 2018) and sea turtles (Finneran et al. 2017). Scenario descriptions are given in Table 7.

Hearing group	Threshold for SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²s)[a]	FPSO (Machinery Only), OSV		FPSO (Heading Control), OSV		FPSO (Optimised Heading Control), OSV	
		R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)	R_{max} (km)	$R_{95\%}$ (km)
PTS							
LF cetaceans	199	0.06	0.06	0.20	0.20	0.19	0.19
MF cetaceans	198	—	—	0.19	0.19	—	—
HF cetaceans	173	0.06	0.06	0.25	0.24	0.20	0.20
Sea turtles	220	—	—	—	—	—	—
TTS							
LF cetaceans	179	0.47	0.45	0.71	0.65	0.52	0.49
MF cetaceans	178	0.06	0.06	0.20	0.20	0.19	0.19
HF cetaceans	153	1.00	0.96	1.19	1.14	1.03	1.00
Sea turtles	200	0.06	0.06	0.20	0.20	0.19	0.19

[a] Frequency weighted.
A dash indicates the level was not reached.

4.2. Maps

4.2.1. Maximum-over-depth SPL Sound Fields

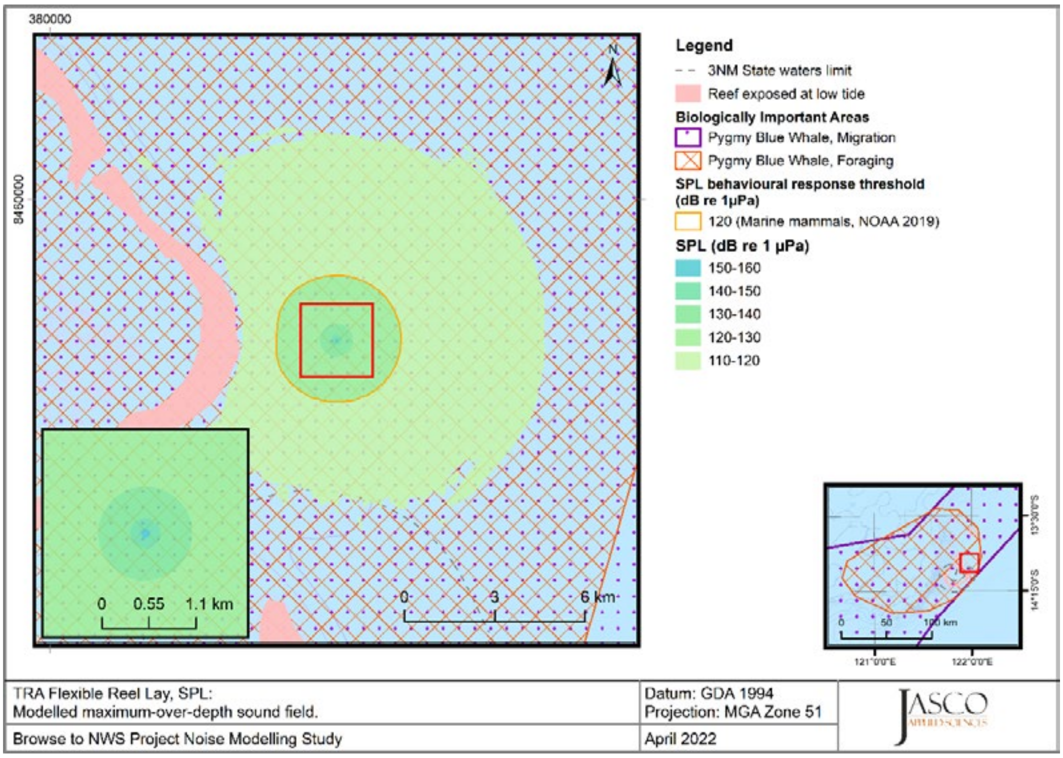

Figure 10. *TRA Flexible Reel Lay, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

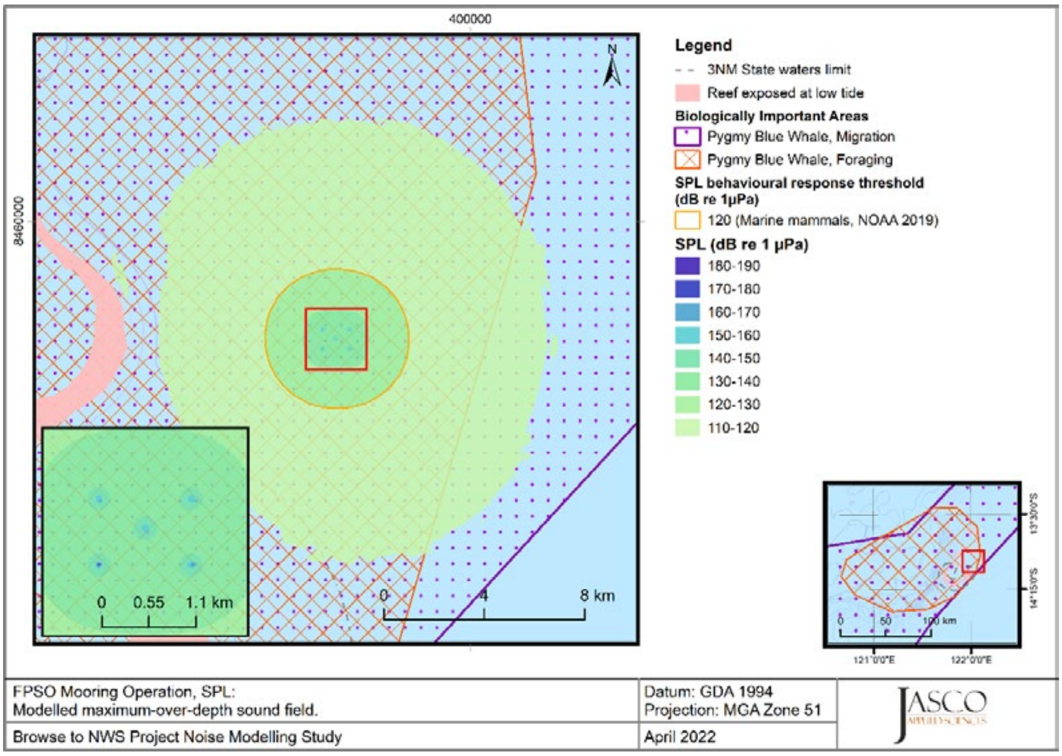

Figure 11. *FPSO Mooring, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

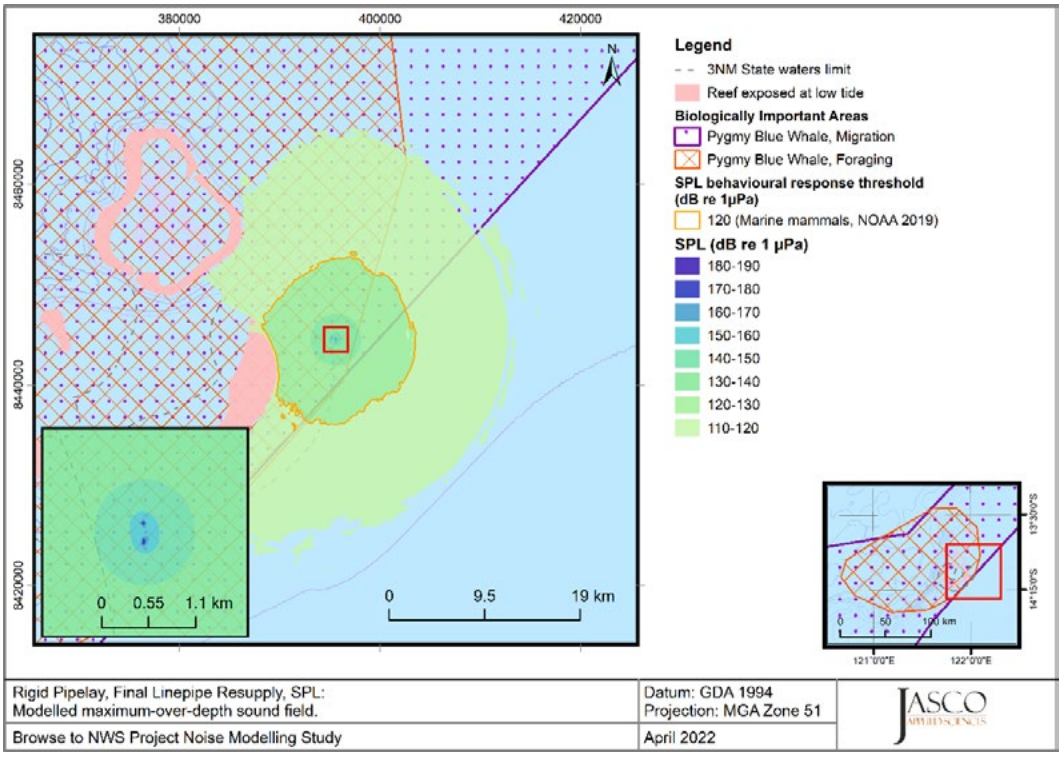

Figure 12. *Rigid Pipelay, Final Linepipe Resupply, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

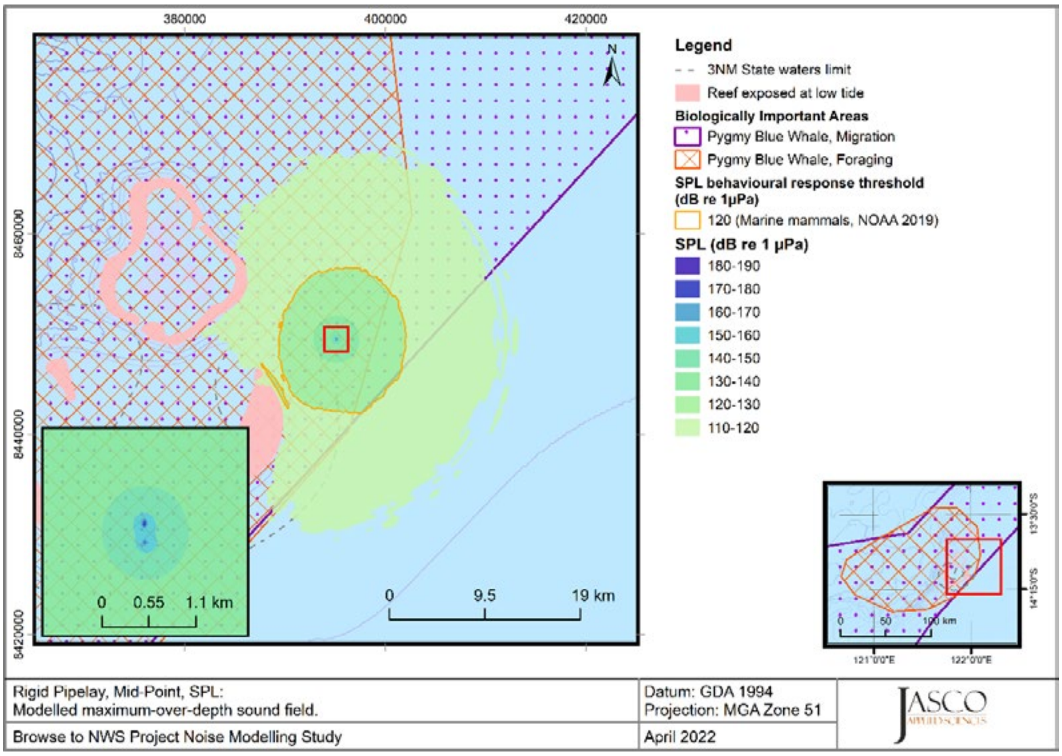

Figure 13. *Rigid Pipelay, Mid-Point, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

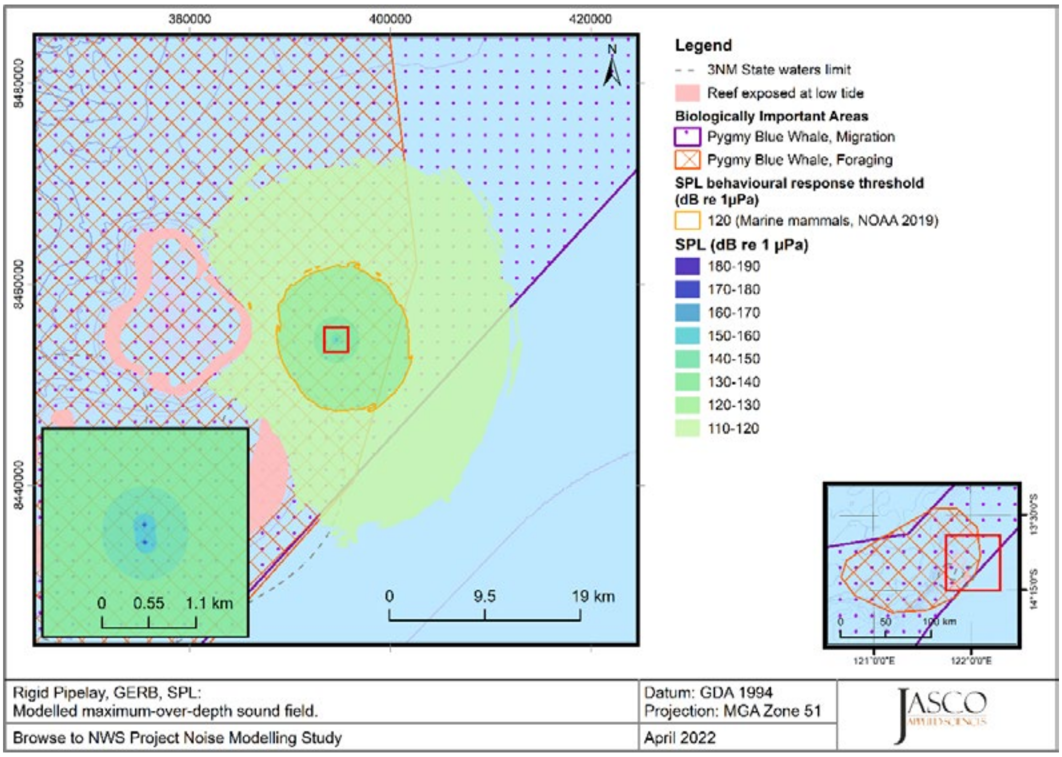

Figure 14. *Rigid Pipelay, Gas Export Riser Base, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

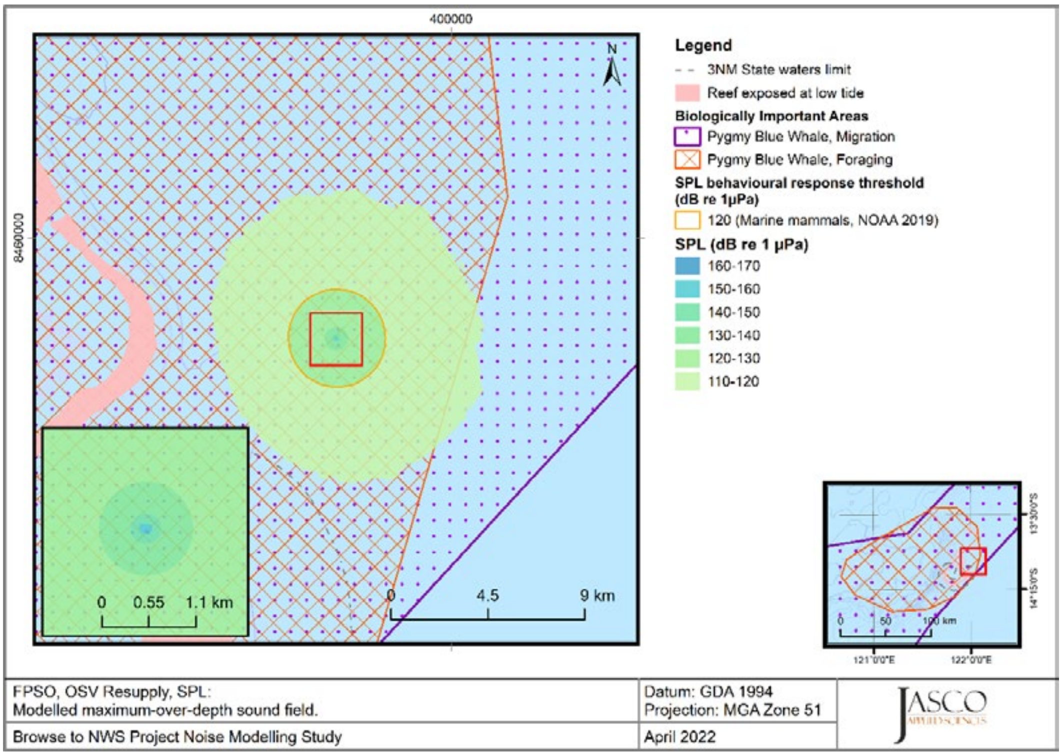

Figure 15. *FPSO, OSV Resupply, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

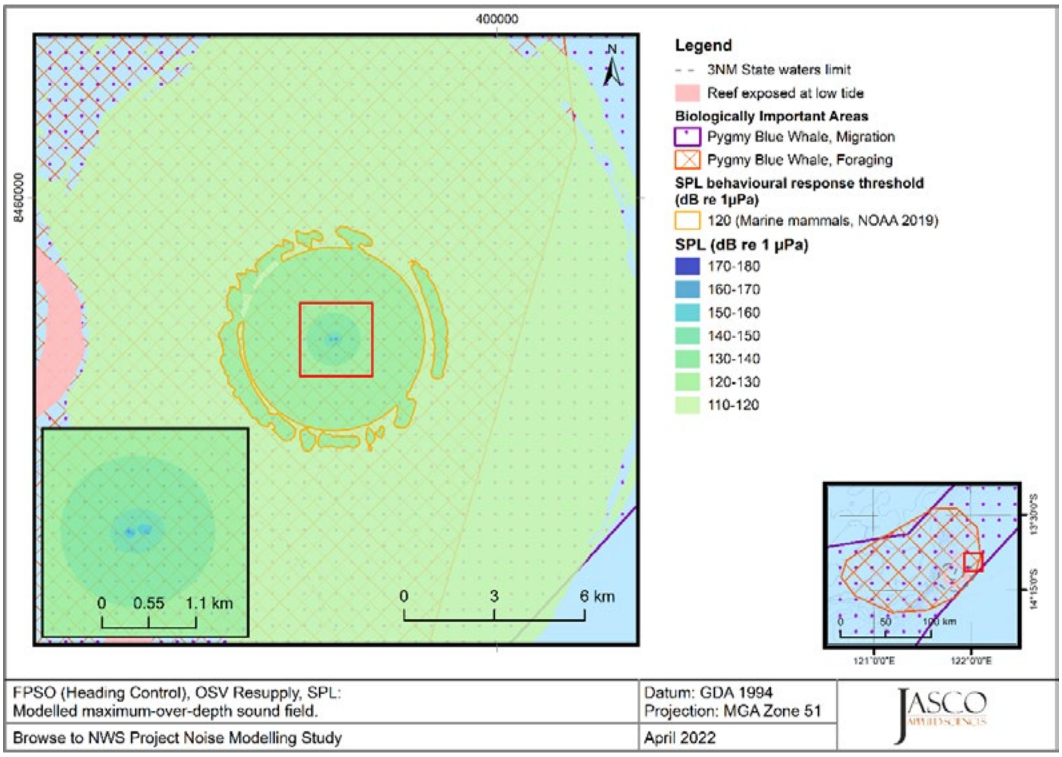

Figure 16. *FPSO (Heading Control), OSV Resupply, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

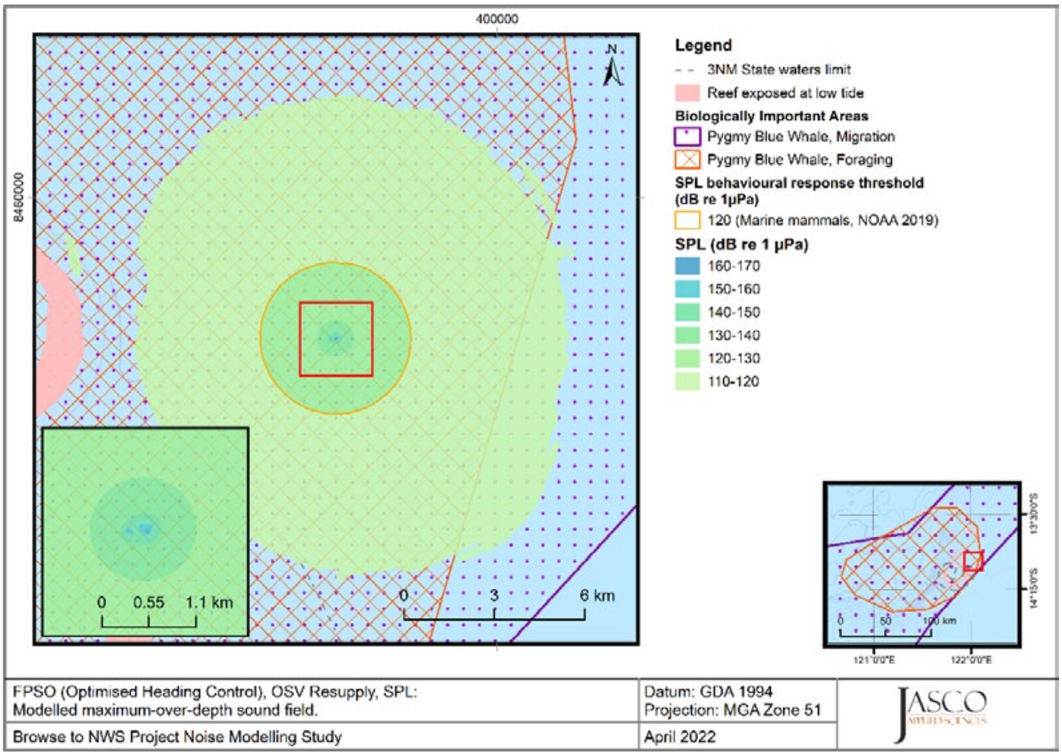

Figure 17. *FPSO (Optimised Heading Control), OSV Resupply, SPL*: Sound level contour map, showing maximum-over-depth results. Isopleth shows marine mammal behavioural criteria (120 dB re 1 µPa).

4.2.2. Accumulated SEL Sound Fields

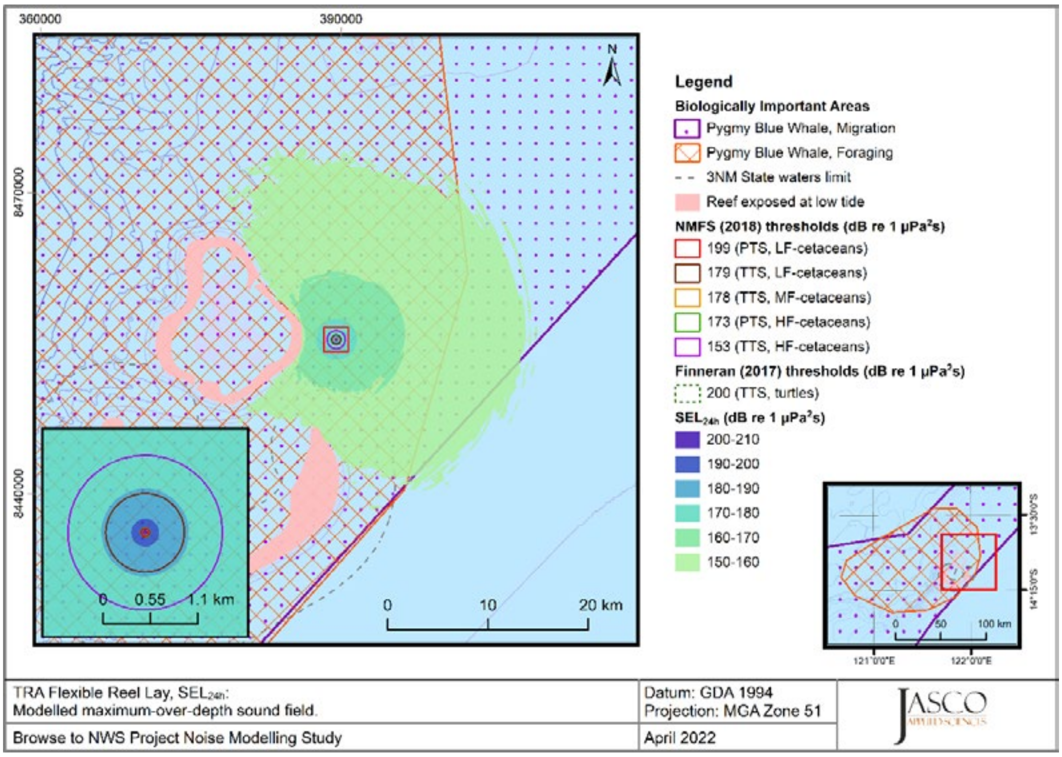

Figure 18. *TRA Flexible Reel Lay, SEL_{24h}*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

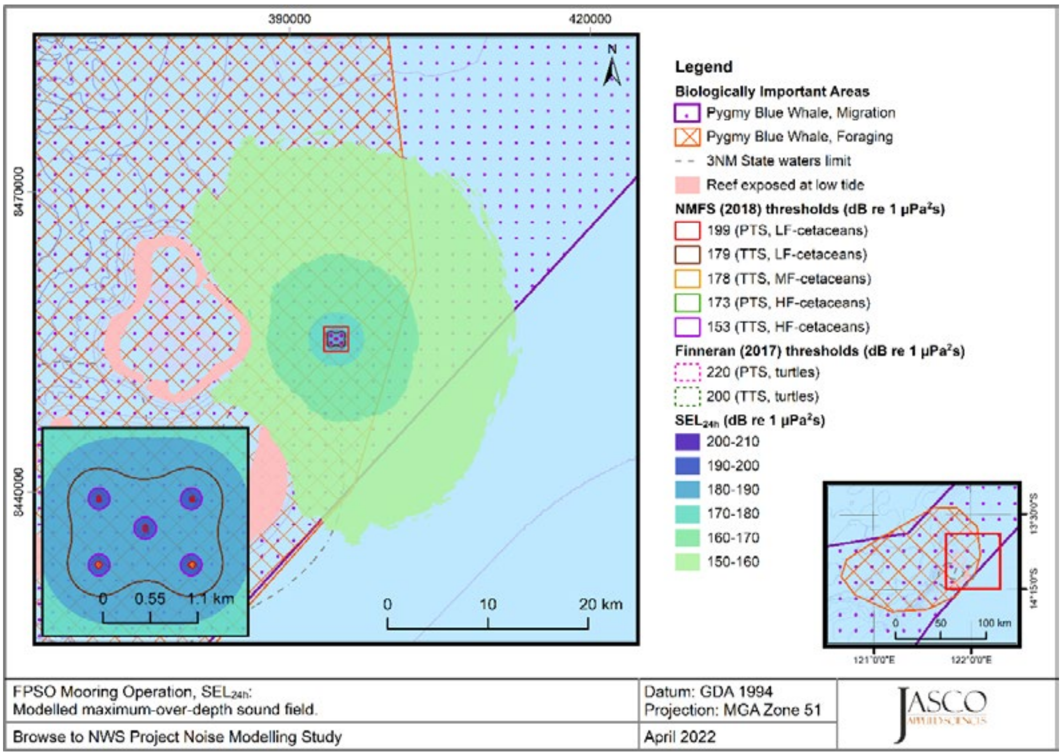

Figure 19. *FPSO Mooring Operation, SEL_{24h}*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

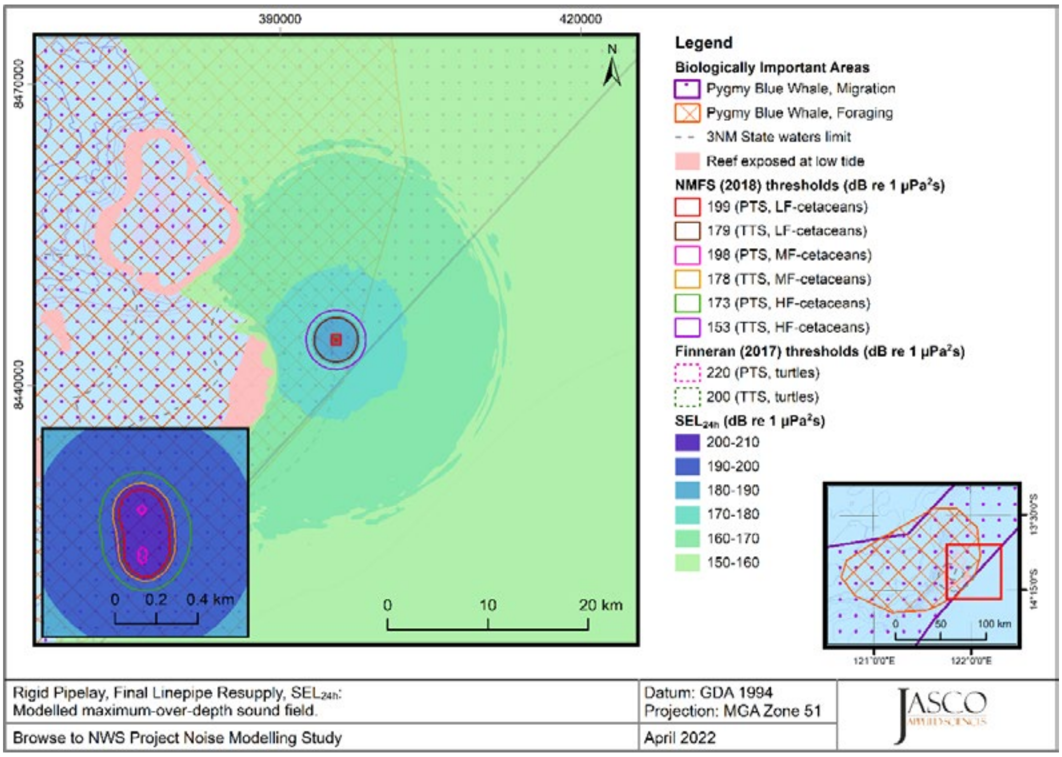

Figure 20. *Rigid Pipelay, Final Linepipe Resupply, SEL_{24h}*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

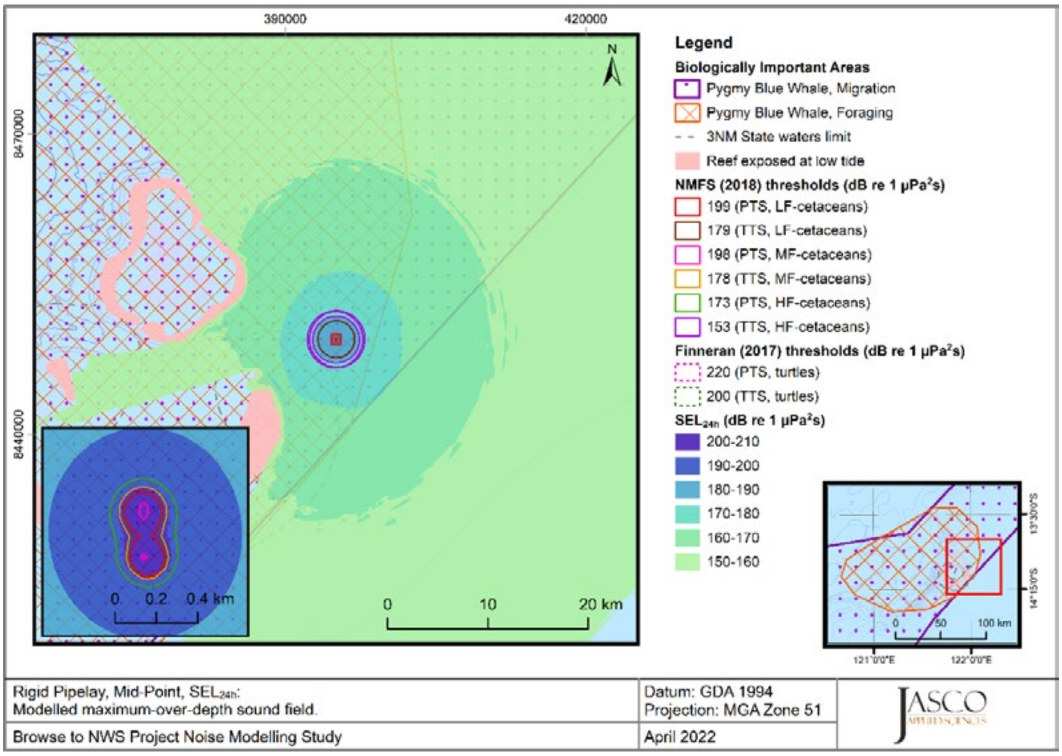

Figure 21. *Rigid Pipelay, Mid-Point, SEL24h*: Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

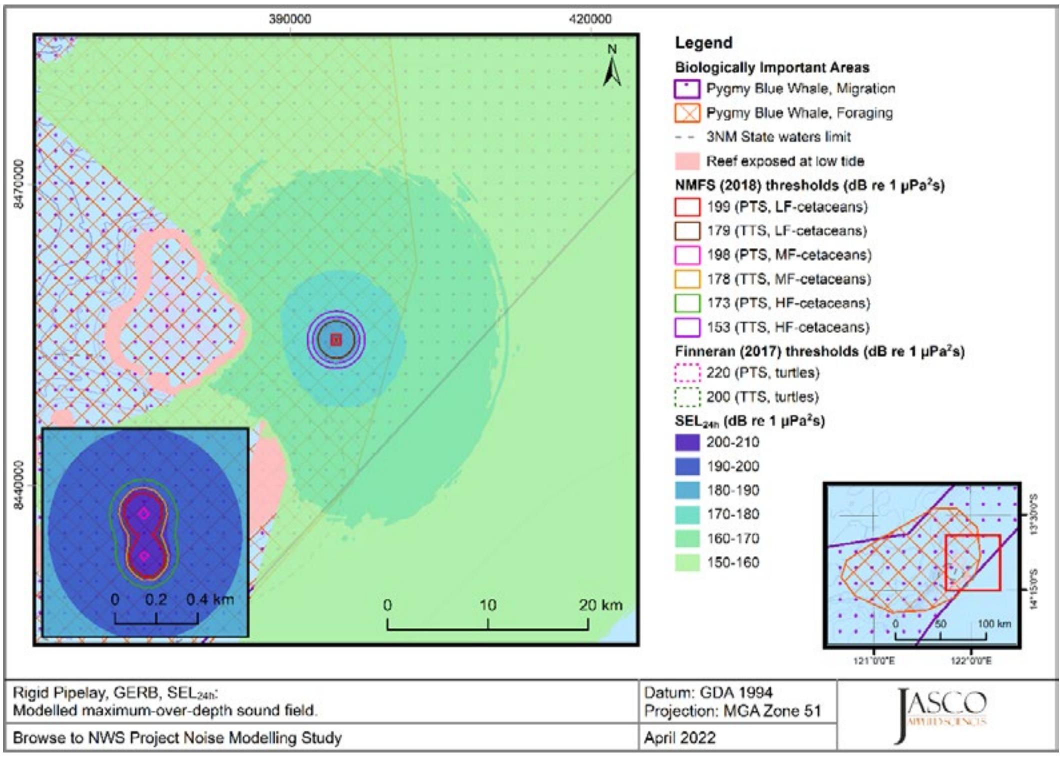

Figure 22. *Rigid Pipelay, Gas Export Riser Base, SEL24h*: Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

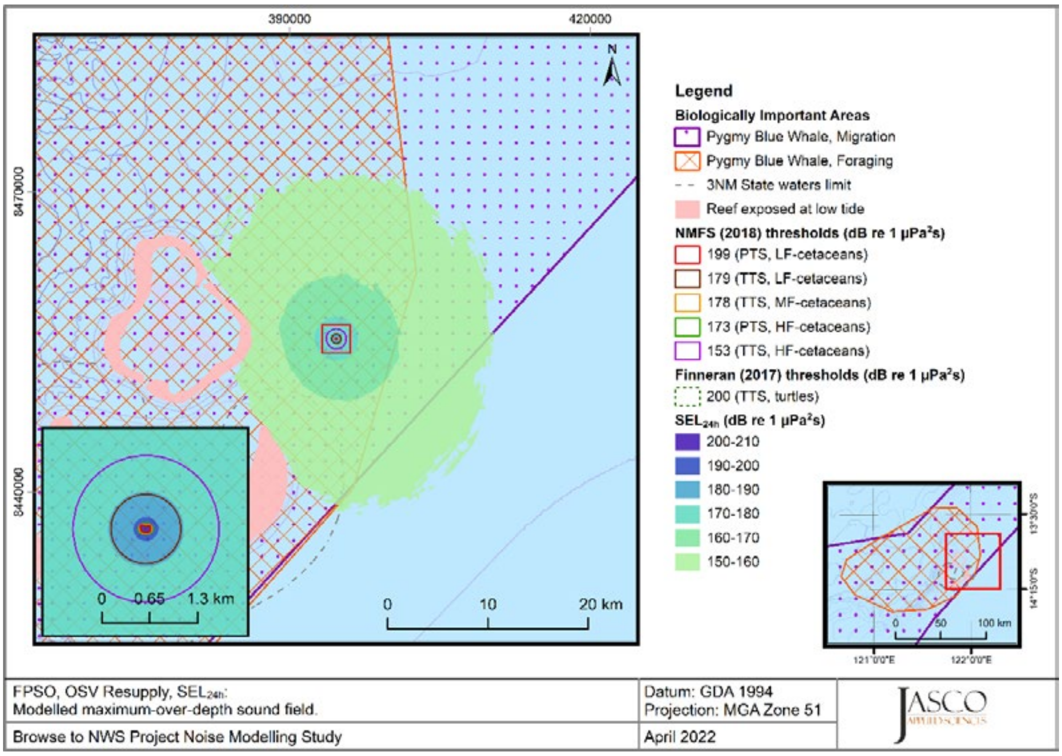

Figure 23. *FPSO, OSV Resupply, SEL24h*: Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

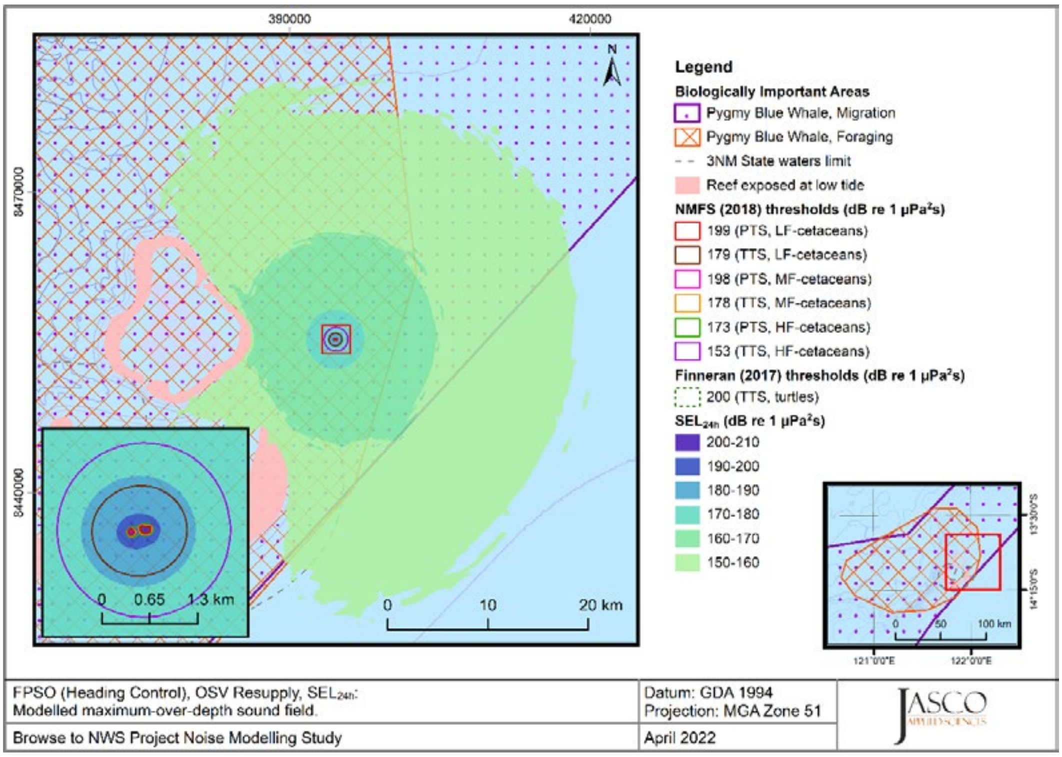

Figure 24. *FPSO (Heading Control), OSV Resupply, SEL24h*: Sound level contour map showing unweighted maximum-over-depth SEL24h results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

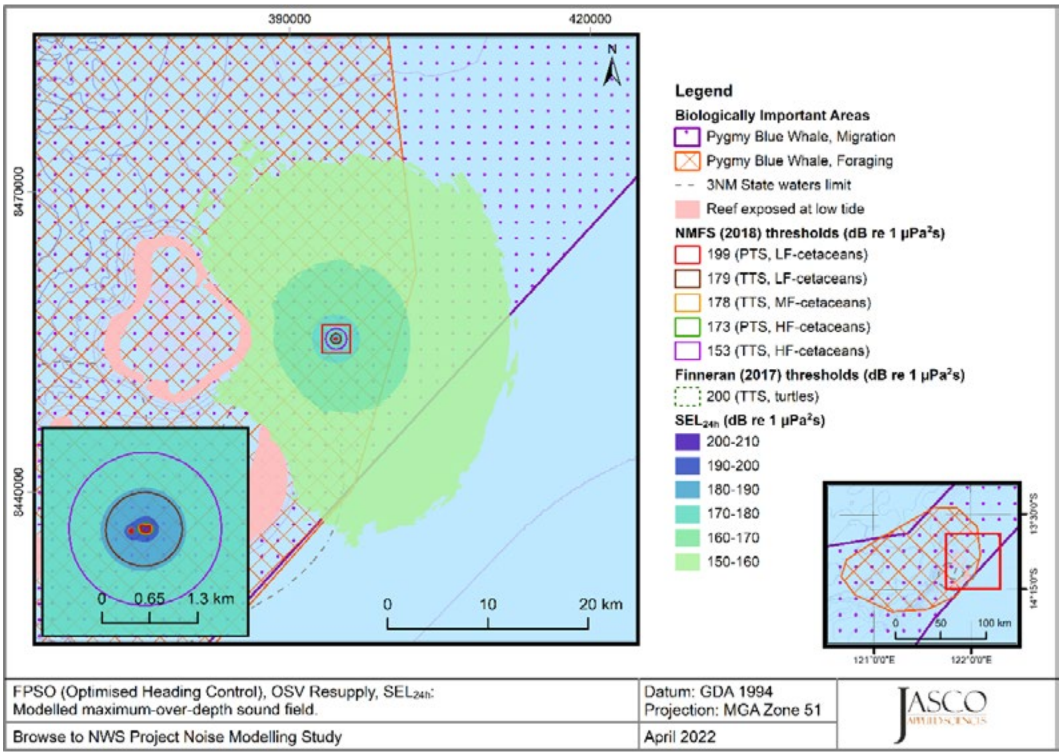

Figure 25. *FPSO (Optimised Heading Control), OSV Resupply, SEL_{24h}*: Sound level contour map showing unweighted maximum-over-depth SEL_{24h} results, along with isopleths for PTS and TTS thresholds in low, mid, and high-frequency cetaceans and sea turtles.

5. Discussion

Results have been presented showing the propagation of underwater sound from various vessels, including flexible reel-lay and rigid pipelay vessels, AHTs during an FPSO mooring operation, and an FPSO resupply scenario featuring various levels of heading control and an associated OSV. The rigid pipelay vessel, OSV, and FPSO were modelled using individual thruster sources, whereas the AHTs and flexible reel-lay vessel were modelled using a single representative point source.

The main influence on sound propagation is the bathymetry in the local area. The nearby presence of Scott Reef blocks much of the sound propagation in a westerly direction. This is especially evident for the operations nearest the reef, including the flexible reel-lay and rigid pipelay operations, but somewhat less prevalent in the FPSO resupply scenarios. This is due to the greater distance of this scenario from the reef and generally lower source levels involved. Figures 15–17 show that the reef does not affect propagation from the FPSO resupply scenario at levels of interest for SPL. It should be noted, however, that though in other scenarios the propagation is more influenced by the reef, it is only for the final resupply location of the rigid pipelay vessel that it has any real effect on ranges of interest (see Figure 12). Similarly, it can be seen that although SEL_{24h} levels are visibly affected by the reef from all sites, this does not occur at ranges that affect any relevant thresholds (see Figures 18–25).

Of the three modelled locations for the rigid pipelay scenario, SEL_{24h} threshold distances are largely consistent between the two locations modelled without the attendant B-type vessel (GERB and mid-point), and slightly higher for the final linepipe resupply location with the attendant B-type (see Table 21). This is probably due to the additional sound energy from the B-type vessel but may also be influenced by the somewhat increased water depth at this location. Interestingly, for the SPL distances, R_{max} to 120 dB re 1 µPa is slightly shorter at the mid-point than at GERB, whereas distances to higher SPL levels are very similar (see Table 13). This might be due to the aforementioned influence of the reef on propagation.

Despite the AHTs having a nominally higher broadband monopole source level (Section 3.1.2) than the OSV (Section 3.1.5) and FPSO under heading control (Section 3.1.6), R_{max} distances to the 120 dB re 1 µPa threshold were larger for the FPSO resupply scenario under heading control than for the FPSO mooring scenario. Maximum ranges were 3.92 km for FPSO resupply under heading control (Table 14) compared to 2.44 km for FPSO mooring (Table 12). The main reason for this is that the shallow source depth for each AHT (3.05 m) does not support long-range propagation at the low frequencies which dominate the broadband source level (Figure 5).

Results presented in Table 14 indicate that optimising the FPSO heading control reduces SPL threshold ranges significantly relative to using non-optimised heading control, and brings them close to the modelled ranges where the FPSO is modelled using machinery noise only. For instance, activating heading control increases the range to the 120 dB re 1 µPa threshold by 1.63 km. Using optimised heading control, however, this increase is only 250 m. The effect on SEL_{24h} ranges (Table 22), however, is dependent on the species considered. There is, for instance, very little effect on distances to turtle thresholds, probably due to the fact that turtles have more limited sensitivity to the mid-to-high frequency ranges most affected by optimising the heading control (compare Figure A-3 to Figure 9). There is more of an effect on the TTS ranges for LF cetaceans, which are sensitive to a relatively broad range of frequencies.

Glossary

Unless otherwise stated in an entry, these definitions are consistent with ISO 80000-3 (2017).

absorption

The reduction of acoustic pressure amplitude due to acoustic particle motion energy converting to heat in the propagation medium.

attenuation

The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

auditory frequency weighting

The process of applying an auditory frequency weighting function. In human audiometry, C-weighting is the most commonly used function, an example for marine mammals are the auditory frequency weighting functions published by Southall et al. (2007).

auditory frequency weighting function

Frequency weighting function describing a compensatory approach accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity. Example hearing groups are low-, mid-, and high-frequency cetaceans, phocid and otariid pinnipeds.

azimuth

A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

broadband level

The total level measured over a specified frequency range.

cetacean

Any animal in the order Cetacea. These are aquatic species and include whales, dolphins, and porpoises.

continuous sound

A sound whose sound pressure level remains above ambient sound during the observation period. A sound that gradually varies in intensity with time, for example, sound from a marine vessel.

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 80000-3:2006).

decidecade

One tenth of a decade. *Note*: An alternative name for decidecade (symbol ddec) is "one-tenth decade". A decidecade is approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct) and for this reason is sometimes referred to as a "one-third octave".

decidecade band

Frequency band whose bandwidth is one decidecade. *Note*: The bandwidth of a decidecade band increases with increasing centre frequency.

decibel (dB)

Unit of level used to express the ratio of one value of a power quantity to another on a logarithmic scale. Unit: dB.

ensonified

Exposed to sound.

far field

The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point.

flat weighting

Term indicating that no frequency weighting function is applied. Synonymous with unweighted.

frequency

The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: f. 1 Hz is equal to 1 cycle per second.

frequency weighting

The process of applying a frequency weighting function.

frequency-weighting function

The squared magnitude of the sound pressure transfer function. For sound of a given frequency, the frequency weighting function is the ratio of output power to input power of a specified filter, sometimes expressed in decibels. Examples include the following:

- *Auditory frequency weighting function*: compensatory frequency weighting function accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.
- *System frequency weighting function*: frequency weighting function describing the sensitivity of an acoustic acquisition system, typically consisting of a hydrophone, one or more amplifiers, and an analogue to digital converter.

geoacoustic

Relating to the acoustic properties of the seabed.

hearing group

Category of animal species when classified according to their hearing sensitivity and to the susceptibility to sound. Examples for marine mammals include very low-frequency (VLF) cetaceans, low-frequency (LF) cetaceans, mid-frequency (MF) cetaceans, high-frequency (HF) cetaceans, very high-frequency (VHF) cetaceans, otariid pinnipeds in water (OPW), phocid pinnipeds in water (PPW), sirenians (SI), other marine carnivores in air (OCA), and other marine carnivores in water (OCW) (NMFS 2018, Southall et al. 2019). See **auditory frequency weighting functions**, which are often applied to these groups. Examples for fish include species for which the swim bladder is involved in hearing, species for which the swim bladder is not involved in hearing, and species without a swim bladder (Popper et al. 2014).

hertz (Hz)

A unit of frequency defined as one cycle per second.

high-frequency (HF) cetacean

See **hearing group**.

isopleth

A line drawn on a map through all points having the same value of some quantity.

level

A measure of a quantity expressed as the logarithm of the ratio of the quantity to a specified reference value of that quantity. Examples include sound pressure level, sound exposure level, and peak sound pressure level. For example, a value of sound exposure level with reference to 1 μPa^2 s can be written in the form *x* dB re 1 μPa^2 s.

low-frequency (LF) cetacean

See **hearing group**.

mid-frequency (MF) cetacean

See **hearing group**.

monopole source level (MSL)

A source level that has been calculated using an acoustic model that accounts for the effect of the sea-surface and seabed on sound propagation, assuming a point-like (monopole) sound source. Also see **radiated noise level**.

M-weighting

See **auditory frequency weighting function** (as proposed by Southall et al. 2007).

non-impulsive sound

Sound that is not an impulsive sound. A non-impulsive sound is not necessarily a continuous sound.

octave

The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

parabolic equation method

A computationally efficient solution to the acoustic wave equation that is used to model propagation loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of propagation loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

permanent threshold shift (PTS)

An irreversible loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

point source

A source that radiates sound as if from a single point.

pressure, acoustic

The deviation from the ambient pressure caused by a sound wave. Also called sound pressure.
Unit: pascal (Pa).

propagation loss (PL)

Difference between a source level (SL) and the level at a specified location, $PL(x) = SL - L(x)$. Also see **transmission loss**.

radiated noise level (RNL)

A source level that has been calculated assuming sound pressure decays geometrically with distance from the source, with no influence of the sea-surface and seabed. Also see **monopole source level**.

received level

The level measured (or that would be measured) at a defined location. The type of level should be specified.

reference values

standard underwater references values used for calculating sound **levels**, e.g., the reference value for expressing sound pressure level in decibels is 1 µPa.

Quantity	Reference value
Sound pressure	1 µPa
Sound exposure	1 µPa^2 s
Sound particle displacement	1 pm
Sound particle velocity	1 nm/s
Sound particle acceleration	1 µm/s^2

sound

A time-varying disturbance in the pressure, stress, or material displacement of a medium propagated by local compression and expansion of the medium.

sound exposure

Time integral of squared sound pressure over a stated time interval. The time interval can be a specified time duration (e.g., 24 hours) or from start to end of a specified event (e.g., a pile strike, an airgun pulse, a construction operation). Unit: Pa^2 s.

sound exposure level

The level (L_E) of the sound exposure (E). Unit: decibel (dB). Reference value (E_0) for sound in water: 1 µPa^2 s.

$$L_E := 10\log_{10}(E/E_0)\ \text{dB}\ = 20\log_{10}\left(E^{1/2}/E_0^{1/2}\right)\ \text{dB}$$

The frequency band and integration time should be specified. Abbreviation: SEL.

sound field

Region containing sound waves.

sound pressure

The contribution to total pressure caused by the action of sound.

sound pressure level (rms sound pressure level)

The level ($L_{p,\text{rms}}$) of the time-mean-square sound pressure (p^2_{rms}). Unit: decibel (dB). Reference value (p_0^2) for sound in water: 1 µPa^2.

$$L_{p,\text{rms}} := 10\log_{10}(p^2_{\text{rms}}/p_0^2)\ \text{dB}\ = 20\log_{10}(p_{\text{rms}}/p_0)\ \text{dB}$$

The frequency band and averaging time should be specified. Abbreviation: SPL or Lrms.

sound speed profile

The speed of sound in the water column as a function of depth below the water surface.

source level (SL)

A property of a sound source obtained by adding to the sound pressure level measured in the far field the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 $\mu Pa^2 m^2$.

spectrum

An acoustic signal represented in terms of its power, energy, mean-square sound pressure, or sound exposure distribution with frequency.

temporary threshold shift (TTS)

Reversible loss of hearing sensitivity. TTS can be caused by noise exposure.

transmission loss (TL)

The difference between a specified level at one location and that at a different location, TL(x1,x2) = L(x1) − L(x2).

unweighted

Term indicating that no frequency weighting function is applied. Synonymous with flat weighting.

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Appendix A. Underwater Acoustic Metrics

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 μPa. Because the perceived loudness of sound, especially pulsed sound such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate sound and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow International Organization for Standardization definitions and symbols for sound metrics (e.g., ISO 2017, ANSI S1.1-2013).

A.1. Acoustic Metrics

The sound pressure level (SPL or L_p; dB re 1 μPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T; s). It is important to note that SPL always refers to an rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T g(t)\,p^2(t)\,dt\Big/p_0^2\right)\,\mathrm{dB} \tag{A-1}$$

where $g(t)$ is an optional time weighting function. In many cases, the start time of the integration is marched forward in small time steps to produce a time-varying SPL function. For short acoustic events, such as sonar pulses and marine mammal vocalizations, it is important to choose an appropriate time window that matches the duration of the signal. For in-air studies, when evaluating the perceived loudness of sounds with rapid amplitude variations in time, the time weighting function $g(t)$ is often set to a decaying exponential function that emphasizes more recent pressure signals. This function mimics the leaky integration nature of mammalian hearing. For example, human-based fast time-weighted SPL ($L_{p,fast}$) applies an exponential function with time constant 125 ms. A related simpler approach used in underwater acoustics sets $g(t)$ to a boxcar (unity amplitude) function of width 125 ms; the results can be referred to as $L_{p,boxcar\ 125ms}$. Another approach, historically used to evaluate SPL of impulsive signals underwater, defines $g(t)$ as a boxcar function with edges set to the times corresponding to 5% and 95% of the cumulative square pressure function encompassing the duration of an impulsive acoustic event. This calculation is applied individually to each impulse signal, and the results have been referred to as 90% SPL ($L_{p,90\%}$).

The sound exposure level (SEL or L_E; dB re 1 μPa² s) is the time-integral of the squared acoustic pressure over a duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)\,dt\Big/T_0 p_0^2\right)\,\mathrm{dB} \tag{A-2}$$

where T_0 is a reference time interval of 1 s. SEL continues to increase with time when non-zero pressure signals are present. It is a dose-type measurement, so the integration time applied must be carefully considered for its relevance to impact to the exposed recipients.

SEL can be calculated over a fixed duration, such as the time of a single event or a period with multiple acoustic events. When applied to pulsed sounds, SEL can be calculated by summing the SEL of the N individual pulses. For a fixed duration, the square pressure is integrated over the duration of interest. For multiple events, the SEL can be computed by summing (in linear units) the SEL of the N individual events:

$$L_{E,N} = 10\log_{10}\left(\sum_{i=1}^{N} 10^{\frac{L_{E,i}}{10}}\right) \text{dB} \tag{A-3}$$

Because the SPL(T_{90}) and SEL are both computed from the integral of square pressure, these metrics are related numerically by the following expression, which depends only on the duration of the time window T:

$$L_p = L_E - 10\log_{10}(T) \tag{A-4}$$

$$L_{p90} = L_\mathrm{E} - 10\log_{10}(T_{90}) - 0.458 \tag{A-5}$$

where the 0.458 dB factor accounts for the 10% of pulse SEL missing from the SPL(T_{90}) integration time window.

Energy equivalent SPL (L_{eq}; dB re 1 µPa) denotes the SPL of a stationary (constant amplitude) sound that generates the same SEL as the signal being examined, $p(t)$, over the same time period, T:

$$L_\mathrm{eq} = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)\,dt \Big/ p_0^2\right) \tag{A-6}$$

The equations for SPL and the energy-equivalent SPL are numerically identical. Conceptually, the difference between the two metrics is that the SPL is typically computed over short periods (typically of 1 s or less) and tracks the fluctuations of a non-steady acoustic signal, whereas the L_{eq} reflects the average SPL of an acoustic signal over time periods typically of 1 min to several hours.

A.2. Decidecade Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analysing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. A decidecade is sometimes referred to as a "1/3-octave" because one tenth of a decade is approximately equal to one third of an octave. Each decade represents a factor 10 in sound frequency. Each octave represents a factor 2 in sound frequency. The centre frequency of the ith band, $f_\mathrm{c}(i)$, is defined as:

$$f_\mathrm{c}(i) = 10^{\frac{i}{10}}\,\text{kHz} \tag{A-7}$$

and the low (f_lo) and high (f_hi) frequency limits of the ith decade band are defined as:

$$f_{\mathrm{lo},i} = 10^{\frac{-1}{20}} f_\mathrm{c}(i) \quad \text{and} \quad f_{\mathrm{hi},i} = 10^{\frac{1}{20}} f_\mathrm{c}(i) \tag{A-8}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure A-1). The acoustic modelling spans from band $f_c(1) = 10\ Hz$ to $f_c(37) = 63\ kHz$.

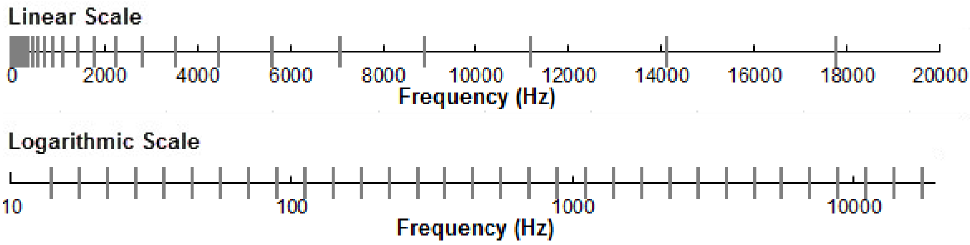

Figure A-1. Decidecade frequency bands (vertical lines) shown on both linear and logarithmic frequency scales

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{\mathrm{lo},i}$ and $f_{\mathrm{hi},i}$:

$$L_{p,i} = 10 \log_{10} \int_{f_{\mathrm{lo},i}}^{f_{\mathrm{hi},i}} S(f)\, \mathrm{d}f \;\; \mathrm{dB} \tag{A-9}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10 \log_{10} \sum_{i} 10^{\frac{L_{p,i}}{10}} \, \mathrm{dB} \tag{A-10}$$

Figure A-2 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient sound signal. Because the decidecade bands are wider than 1 Hz, the decidecade band SPL is higher than the spectral levels at higher frequencies. Acoustic modelling of decidecade bands requires less computation time than 1 Hz bands and still resolves the frequency-dependence of the sound source and the propagation environment.

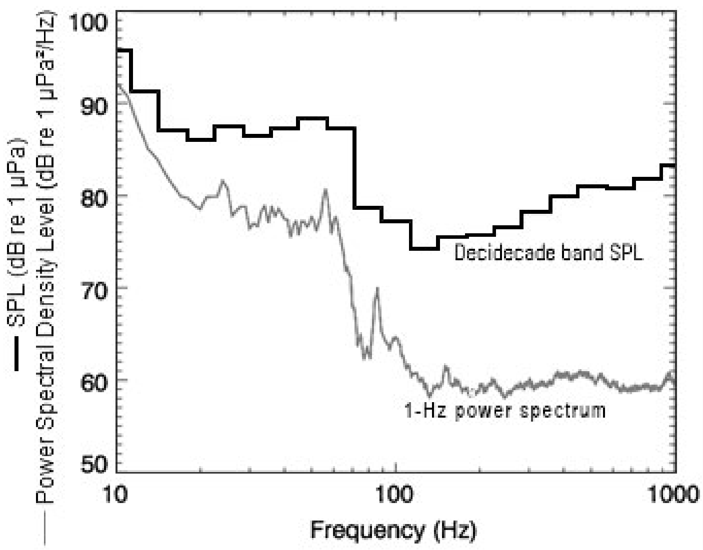

Figure A-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient sound shown on a logarithmic frequency scale. Because the decidecade bands are wider with increasing frequency, the decidecade band SPL is higher than the power spectrum.

A.3. Marine Mammal Impact Criteria

It has been long recognised that marine mammals can be adversely affected by underwater anthropogenic noise. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater noise sources and the possibility that impulsive sources—primarily airguns used in seismic surveys—could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater noise sources (NMFS 1998, ONR 1998, Nedwell and Turnpenny 1998, HESS 1999, Ellison and Stein 1999). In the years since these early workshops, a variety of thresholds have been proposed for both injury and disturbance. The following sections summarize the recent development of thresholds; however, this field remains an active research topic.

A.3.1. Injury and Hearing Sensitivity Changes

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new noise exposure criteria. Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and SEL_{24h} thresholds, where the subscripted 24h refers to the accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: low-, mid- and high-frequency cetaceans (LF, MF, and HF cetaceans, respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.3.3). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it implies a 3 dB exchange rate).

Wood et al. (2012) refined Southall et al.'s (2007) thresholds, suggesting lower injury values for LF and HF cetaceans while retaining the filter shapes. Their revised thresholds were based on TTS-onset levels in harbour porpoises from Lucke et al. (2009), which led to a revised impulsive sound PTS threshold for HF cetaceans of 179 dB re 1 µPa^2·s. Because there were no data available for baleen whales, Wood et al. (2012) based their recommendations for LF cetaceans on results obtained from MF cetacean studies. In particular they referenced Finneran and Schlundt (2010) research, which found mid-frequency cetaceans are more sensitive to non-impulsive sound exposure than Southall et al. (2007) assumed. Wood et al. (2012) thus recommended a more conservative TTS-onset level for LF cetaceans of 192 dB re 1 µPa^2·s.

As of 2017, an optimal approach is not apparent. There is consensus in the research community that an SEL-based method is preferable either separately or in addition to an SPL-based approach to assess the potential for injuries. In August 2016, after substantial public and expert input into three draft versions and based largely on the above-mentioned literature (NOAA 2013, 2015, 2016), NMFS finalised technical guidance for assessing the effect of anthropogenic sound on marine mammal hearing (NMFS 2016). The guidance describes injury criteria with new thresholds and frequency weighting functions for the five hearing groups described by Finneran and Jenkins (2012). The latest revision to this work was published in 2018 (NMFS 2018). Southall et al. (2019) revisited the interim criteria published in 2007; all noise exposure criteria in NMFS (2018) and Southall et al. (2019) are identical (for impulsive and non-impulsive sounds), however the mid-frequency cetaceans from NMFS (2018) are classified as high-frequency cetaceans in Southall et al. (2019), and high-frequency cetaceans from NMFS (2018) are classified as very-high-frequency cetaceans in Southall et al. (2019).

A.3.2. Behavioural response

Numerous studies on marine mammal behavioural responses to sound exposure have not resulted in consensus in the scientific community regarding the appropriate metric for assessing behavioural reactions. However, it is recognised that the context in which the sound is received affects the nature and extent of responses to a stimulus (Southall et al. 2007, Ellison and Frankel 2012, Southall et al. 2016).

NMFS currently uses step function (all-or-none) threshold of 120 dB re 1 µPa SPL (unweighted) for non-impulsive sounds to assess and regulate noise-induced behavioural effects to marine mammals (NOAA 2019). The 120 dB re 1 µPa threshold is associated with non-impulsive sources and was derived based on studies examining behavioural responses to drilling and dredging, referring to Malme et al. (1983), Malme et al. (1984), and Malme et al. (1986), which were considered in Southall et al. (2007). Malme et al. (1986) found that playback of drillship noise did not produce clear evidence of disturbance or avoidance for levels below 110 dB re 1 µPa (SPL), possible avoidance occurred for exposure levels approaching 119 dB re 1 µPa. Malme et al. (1984) determined that measurable reactions usually consisted of rather subtle short-term changes in speed and/or heading of the whale(s) under observation. It has been shown that both received level and proximity of the sound source is a contributing factor in eliciting behavioural reactions in humpback whales (Dunlop et al. 2017, Dunlop et al. 2018).

A.3.3. Marine Mammal Frequency Weighting

The potential for noise to affect animals depends on how well the animals can hear it. Noises are less likely to disturb or injure an animal if they are at frequencies that the animal cannot hear well. An exception occurs when the sound pressure is so high that it can physically injure an animal by non-auditory means (i.e., barotrauma). For sound levels below such extremes, the importance of sound components at particular frequencies can be scaled by frequency weighting relevant to an animal's sensitivity to those frequencies (Nedwell and Turnpenny 1998, Nedwell et al. 2007).

In 2015, a US Navy technical report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is expressed as:

$$G(f) = K + 10\log_{10}\left(\frac{\left(\frac{f}{f_{lo}}\right)^{2a}}{\left(1+\left(\frac{f}{f_{lo}}\right)^2\right)^a\left(1+\left(\frac{f}{f_{hi}}\right)^2\right)^b}\right) \tag{A-11}$$

Finneran (2015) proposed five functional hearing groups for marine mammals in water: low-, mid-, and high-frequency cetaceans, phocid pinnipeds, and otariid pinnipeds. The parameters for these frequency-weighting functions were further modified the following year (Finneran 2016) and were adopted in NOAA's technical guidance that assesses noise impacts on marine mammals (NMFS 2016, NMFS 2018). A further update to these weighting functions is presented in Southall (2019), whereby mid- and high- frequency cetaceans are now known as high- and very-high-frequency cetaceans. Table A-1 lists the frequency-weighting parameters for each hearing group; Figure A-3 shows the resulting frequency-weighting curves.

Table A-1. Parameters for the auditory weighting functions used in this project as recommended by NMFS (2018) and Finneran et al. (2017).

Hearing group	a	b	f_{lo} (Hz)	f_{hi} (Hz)	K (dB)
LF cetaceans (baleen whales)	1.0	2	200	19,000	0.13
MF cetaceans (dolphins, plus toothed, beaked, and bottlenose whales)	1.6	2	8,800	110,000	1.20
HF cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*)	1.8	2	12,000	140,000	1.36
Sea turtles	1.4	2	77	440	2.35

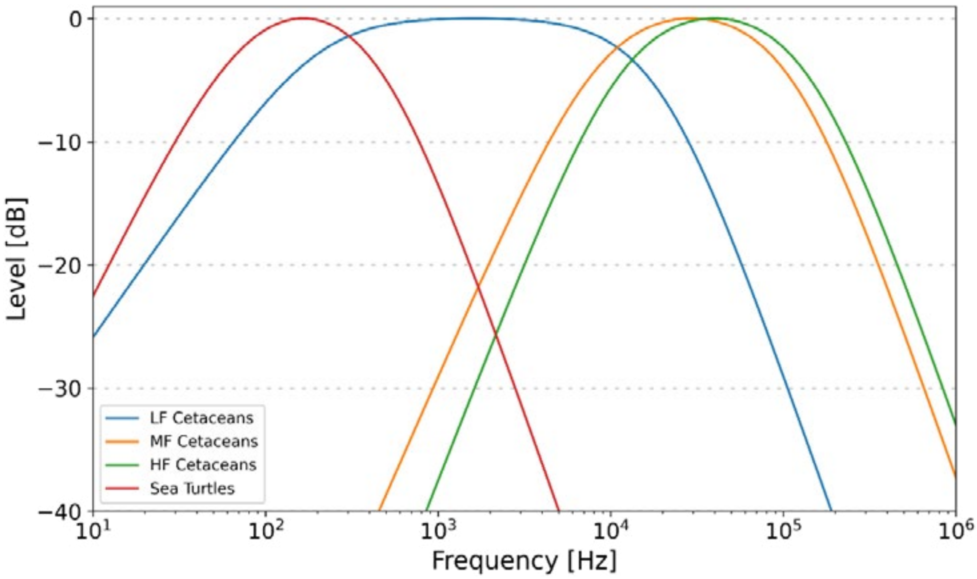

Figure A-3. Auditory weighting functions for functional marine mammal hearing groups as recommended by NMFS (2018) and Finneran et al. (2017)

Appendix B. Sound Source Propagation

B.1. Marine Operations Noise Model

Underwater sound propagation (i.e., transmission loss) at frequencies of 10 Hz to 1.6 kHz was predicted with JASCO's Marine Operations Noise Model (MONM). MONM computes SEL over 1 s for non-impulsive sources, at a specified source depth. Sound propagation at frequencies of 2 kHz and greater was computed via the BELLHOP Gaussian beam acoustic ray-trace model (Porter and Liu 1994).

MONM computes acoustic propagation via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the US Naval Research Laboratory's Range-dependent Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modelled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor. Additionally, BELLHOP accounts for sound attenuation due to energy absorption through ion relaxation and viscosity of water (Fisher and Simmons 1977). This type of sound attenuation is important for frequencies higher than 5 kHz and cannot be neglected without noticeably affecting the model results.

MONM computes acoustic fields in three dimensions by modelling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding $N = 360°/\Delta\theta$ number of planes (Figure B-1).

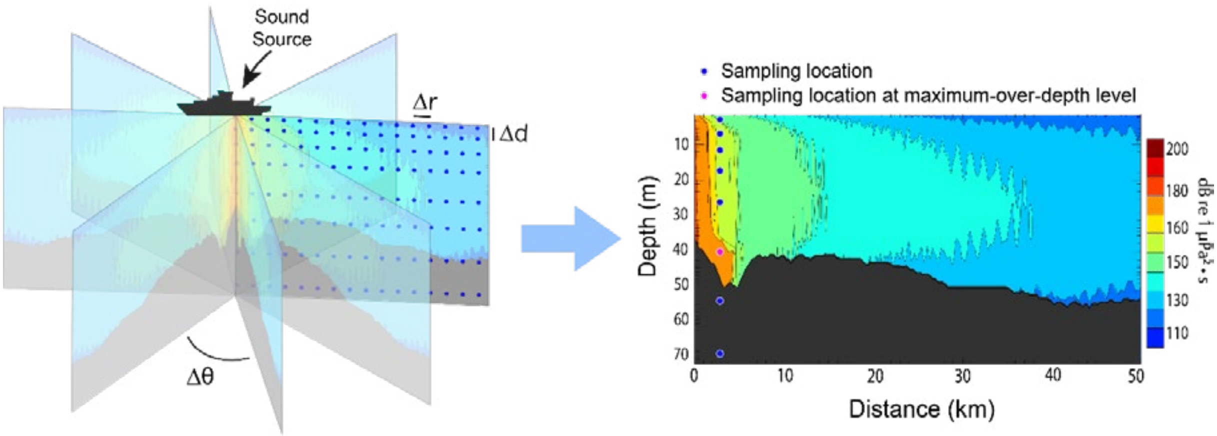

Figure B-1. The N×2-D and maximum-over-depth modelling approach used by MONM

MONM treats frequency dependence by computing acoustic transmission loss at the centre frequencies of decidecade bands. Sufficiently many decidecade frequency-bands, starting at 10 Hz, are modelled to include most of the acoustic energy emitted by the source. At each centre frequency, the transmission loss is modelled within each of the N vertical planes as a function of depth and range from the source. The decidecade received per-pulse SEL are computed by subtracting the band propagation loss values from the directional source level in that frequency band. Composite broadband received per-pulse SEL are then computed by summing the received decidecade levels.

The received per-pulse SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size (Δr in Figure B-1). At each sampling range along the surface, the sound field is sampled at various depths (Δd in Figure B-1), with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest for the sound speed profile. For areas with deep water, sampling is not performed at depths beyond those reachable by marine mammals. The received per-pulse SEL at a surface sampling location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SEL are presented as colour contours around the source.

MONM's predictions have been validated against experimental data from several underwater acoustic measurement programs conducted by JASCO (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Martin et al. 2015).

Appendix C. Additional Methods and Parameters

C.1. Estimating Ranges to Threshold Levels

Sound level contours were calculated based on the underwater sound fields predicted by the propagation models, sampled by taking the maximum value over all modelled depths above the seafloor for each location in the modelled region. The predicted ranges to specific levels were computed from these contours. Two ranges relative to the source are reported for each sound level: R_{max}, the maximum range to the given sound level over all azimuths, and $R_{95\%}$, the range to the given sound level after the 5% farthest points were excluded (see examples in Figure C.1).

The $R_{95\%}$ is used because sound field footprints are often irregular in shape. In some cases, a sound level contour might have small protrusions or anomalous isolated fringes. This is demonstrated in Figure C.1a. In cases such as this, where relatively few points are excluded in any given direction, R_{max} can misrepresent the area of the region exposed to such effects, and $R_{95\%}$ is considered more representative. In contrast, in strongly radially asymmetric cases such as shown in Figure C.1b, $R_{95\%}$ neglects to account for substantial protrusions in the footprint. In such cases, R_{max} might better represent the region of effect in specific directions. Cases such as this are usually associated with bathymetric features that affect propagation. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the non-uniformity of the acoustic environment.

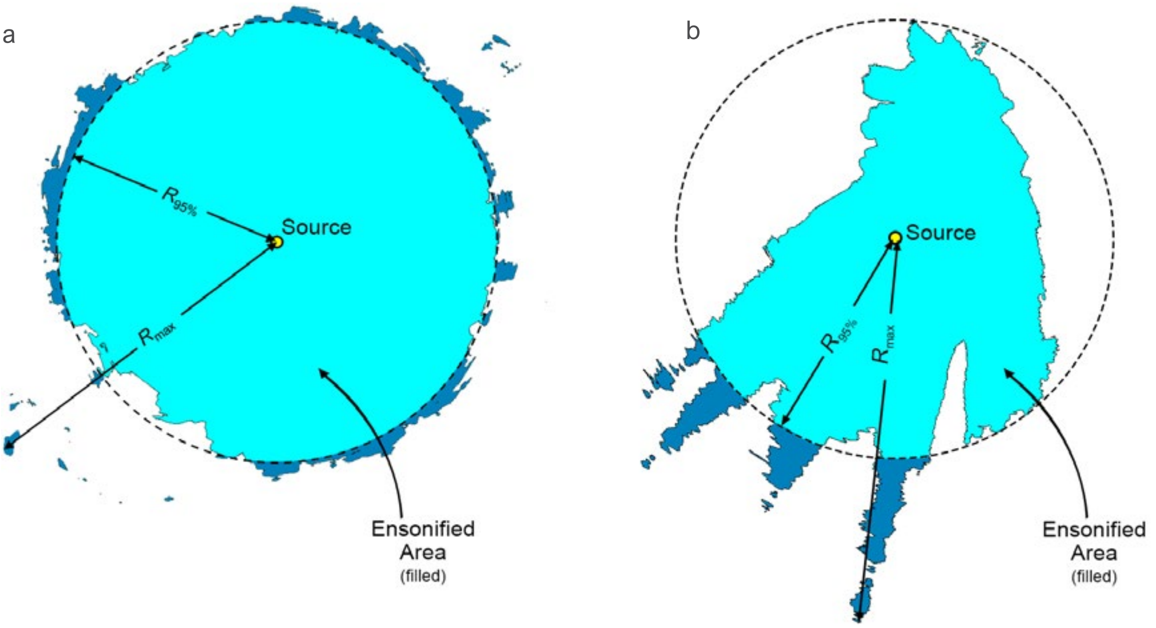

Figure C.1. R_{max} and $R_{95\%}$ ranges shown for two contrasting scenarios. Cyan indicates the ensonified areas bounded by $R_{95\%}$, whilst dark blue indicates the ensonified areas beyond $R_{95\%}$ that determine R_{max}.

C.2. Environmental Parameters

The parameters used are the same as applied in McPherson et al. (2019).

C.2.1. Bathymetry

Water depths (Mean Sea Level) at close- and mid-range from the Torosa field were provided by the BJV. Within ~5–7 km from the pile, the data has a grid resolution of 2 × 2 m, while data at the passage between Scott Reef South and Scott Reef Central has a grid resolution of 1 × 1 m. Bathymetry data with grid resolution of 10 × 10 m was provided as far as 33 km northeast of the pile, and as far as 85 km southwest of the pile. Modelling was conducted along 80 km long radials emanating from the pile in all directions. For this reason, the high-resolution data was complemented using the Australian Bathymetry and Topography Grid, a 9 arc-second grid rendered for Australian waters (Whiteway 2009). The data were adjusted for an increase of 1.7 m in depth (Bureau of Meterology 2019), so the modelling results correspond to the most conservative propagation conditions at maximum tide at Scott Reef. Bathymetry data were re-gridded onto a Map Grid of Australia (MGA) coordinate projection (Zone 51) with a regular grid spacing of 50 × 50 m.

C.2.2. Sound speed profile

The sound speed profile in the area was derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to Coppens (1981).

Mean monthly sound speed profiles were derived from the GDEM profiles at distances less than 76 km around the modelled site. The June sound speed profile is expected to be most favourable to longer-range sound propagation across the entire year. As such, June was selected for sound propagation modelling to ensure precautionary estimates of ranges to received sound level thresholds. Figure C-2 shows the resulting profile, which was used as input to the sound propagation modelling.

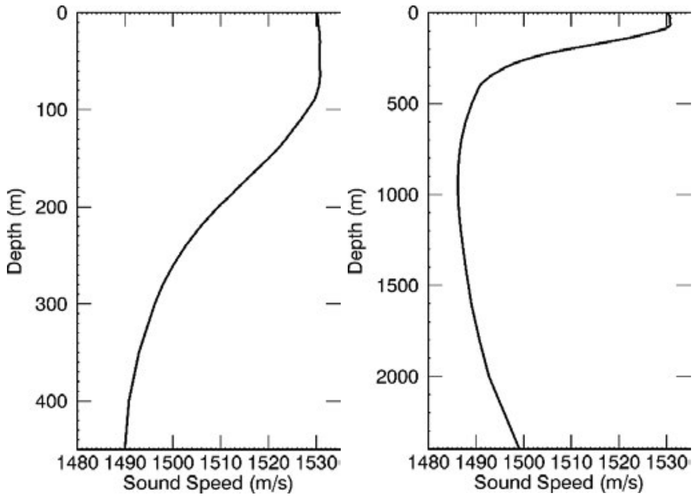

Figure C-2. The modelling sound speed profile corresponding to June: (left) top 450 m and (right) full profile. Profiles are calculated from temperature and salinity profiles from *Generalized Digital Environmental Model* V 3.0 (GDEM; Teague et al. 1990, Carnes 2009).

C.2.3. Geoacoustics

In previous acoustic studies in the area (Duncan 2014, McPherson et al. 2019), the modelling area was divided into three seabed types, with a silt seabed typical of the continental slope considered for most of the modelling area, and coarser gravel and limestone in the areas in and around the reefs. Due to the type of propagation modelling used in this study, however, the silt seabed was used for the entire modelling area. This is detailed in Table C-1.

Table C-1. Continental slope geoacoustic profile. Within each depth range, each parameter varies linearly within the stated range. The compressional wave is the primary wave, and the shear wave is the secondary wave.

Depth below seafloor (m)	Material	Density (g/cm^3)	Compressional wave		Shear wave	
			Speed (m/s)	Attenuation (dB/λ)	Speed (m/s)	Attenuation (dB/λ)
0–50	Silt	1.70–1.75	1566–1627	1.0	210	1.5
50–100		1.75–1.80	1627–1686			
100–150		1.80–1.85	1686–1742			
150–200		1.85–1.90	1742–1795			
>200		1.90	1795			

Appendix C - Woodside Browse to NWS Vessel Animat Modelling (Cusano et al 2022)

Woodside Browse to NWS Vessel Noise

Animat Modelling

JASCO Applied Sciences (Australia) Pty Ltd

11 February 2022

Submitted to:

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Woodside Energy
Contract 4510700453

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Contents

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Executive Summary

JASCO Applied Sciences performed an acoustic exposure analysis study of pygmy blue whales near a migratory and feeding Biologically Important Area (BIA) where they intersected the planned development and installation area for the Brecknock, Calliance, and Torosa fields (collectively known as the Browse resources) proposed by the Browse Joint Venture (BJV). Previously, acoustic modelling was conducted for Mobile Offshore Drilling Unit (MODU) and Floating Production Storage and Offloading (FPSO) operations to determine ranges to acoustic exposure thresholds representing the best available science for potential injury, impairment and behavioural reactions of marine fauna including marine mammals, turtles, and fish (Green et al. 2021).

The aim of the present study was to employ animal movement (animat) modelling simulations in conjunction with these previously computed three-dimensional sound fields to predict the range at which pygmy blue whales are expected to be exposed above threshold criteria for permanent threshold shift (PTS), temporary threshold shift (TTS) and behavioural response. To achieve this, the JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to integrate the sound fields with species-typical behaviour, with the pygmy blue whales represented by animats. JASMINE results provide a probabilistic estimate of sound exposure, which can be compared to acoustic thresholds to determine ranges.

Animat modelling focussed on migrating pygmy blue whales (*Balaenoptera musculus brevicauda*) in the migratory BIA and feeding pygmy blue whales in the foraging BIA. The behaviour of migrating pygmy blue whales was modelled with a directional bias of 230 degrees to represent the south-bound migration and 30 degrees to represent the north-bound migration, while feeding pygmy blue whales were presumed to remain in the feeding BIA to represent the behaviour of whales on a feeding stopover during their migration.

To generate statistically reliable probability density functions, and thus range estimates, model simulations were run with animat densities of 3 animats/km^2. The modelling results are not related to real-world density estimates for pygmy blue whales as the number of animals potentially exposed is not calculated.

Four exposure modelling scenarios were simulated to correspond with a selected subset of the scenarios from the acoustic modelling, with each simulation run for a period of 24 hours to match the acoustic modelling approach. Using the distribution of ranges of animats predicted to be exposed to sound levels above threshold, the 95th percentile exposure range ($ER_{95\%}$) was computed. Within the $ER_{95\%}$, there is generally some proportion of animats that do not exceed threshold criteria. This reason is different for different thresholds, however could include animats not being exposed long enough to exceed accumulated SEL thresholds, or swimming at depths which are not ensonified to a level which could lead to exposure. Therefore, the probability that an animat within that distance was exposed above threshold within the $ER_{95\%}$ was also computed (P_{exp}).

Noise effect metrics included sound exposure levels (SEL), and sound pressure level (SPL), The results of the animat analysis predicted that the $ER_{95\%}$ of migrating pygmy blue whales potentially exposed to sound levels above the U.S National Marine Fisheries Service (NMFS) (2018) PTS and TTS criteria were up to 0.01 km (P_{exp} 3-33%) and 0.05 km (P_{exp} 27-78%) respectively, from all scenarios using SEL_{24h} metrics (Table 1). The maximum $ER_{95\%}$ for exposures above the U.S. National Oceanic and Atmospheric Administration (NOAA) (2019) behavioural threshold from all scenarios was 2.78 km, with a P_{exp} of 81%.

The estimated exposure ranges for PTS and TTS for all scenarios were shorter than comparable ranges to threshold reported in Green et al. (2021). This was expected because previous modelling efforts did not incorporate both moving sources and moving receivers, but rather assumed that, as per the NMFS (2018) criteria, SEL_{24h} is a cumulative metric that reflects the dosimetric effect of noise levels within 24 hours considering that an animal is consistently exposed to such noise levels at a fixed position.

The estimated exposure ranges for the behavioural SPL criteria were comparable to the acoustic ranges (Green et al. 2021), although $ER_{95\%}$ and (P_{exp}) for foraging animats was consistently higher than for migrating animats. This difference arises from the way in which the foraging and migrating animats sample the water column. Foraging animats dive deeper and spend more time at depth than migrating animats. Because of this, they are exposed to sound levels exceeding the behavioural threshold at longer ranges. There was no quantifiable difference between the northbound and southbound migratory simulations for TTS, PTS, or behavioural thresholds.

One aggregate scenario was run to simulate the potential effects with all sources running simultaneously. As was observed in the acoustic modelling analysis, exposure ranges for the aggregate scenario were not significantly different than during individual operations (Green et al. 2021).

Table 1. Summary of animat simulation results. The 95th percentile exposures ranges ($ER_{95\%}$) in km and probability of animats being exposed above threshold within the $ER_{95\%}$ (P_{exp} (%)) are provided.

Threshold		Scenario 4(a) MODU under DP at TRD		Scenario 7 Torosa FPSO		Scenario 8 Torosa FPSO Offtake		Scenario 9 Aggregate Scenario	
Description	Threshold level (dB)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)
South-bound migrating pygmy blue whales									
TTS (SEL_{24h})	179[a]	0.02	27	0	0	0.05	46	0.05	34
PTS (SEL_{24h})	199[a]	0	0	0	0	0	0	0	0
Behavioural response (SPL)	120[b]	2.22	76	0.37	73	1.38	88	2.22	82
North-bound migrating pygmy blue whales									
TTS (SEL_{24h})	179[a]	0.03	39	0	0	0.04	78	0.04	40
PTS (SEL_{24h})	199[a]	0	0	0	0	0.01	25	0.01	3
Behavioural response (SPL)	120[b]	2.28	83	0.37	71	1.49	81	2.28	90
Foraging pygmy blue whales									
TTS (SEL_{24h})	179[a]	0.03	53	0	0	0.01	50	0.03	41
PTS (SEL_{24h})	199[a]	0	0	0	0	0.01	33	0.01	12
Behavioural response (SPL)	120[b]	2.68	92	0.52	100	1.91	92	2.78	81

[a] LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa²·s)
[b] SPL (L_p; dB re 1 µPa)

1. Introduction

JASCO Applied Sciences (JASCO), performed an acoustic exposure analysis study for pygmy blue whales (*Balaenoptera musculus brevicauda*) in association with the planned Browse to North West shelf (NWS) Project development of the Brecknock, Calliance, and Torosa fields (collectively known as the Browse resources) by the Browse Joint Venture (BJV). This development will involve drilling wells and installing a subsea production system that will supply two 1100 million standard cubic feet per day (annual daily export average) Floating Production Storage and Offloading (FPSO) facilities. Gas will be transported from the FPSO facilities to the existing NWS Project infrastructure via an approximately 900 km long trunkline. Each FPSO will have a turret mooring system that will be stabilised using mooring lines secured to the seabed by piles.

The acoustic modelling results were used in conjunction with animal movement modelling simulations to predict the distance at which pygmy blue whales are expected to be exposed above threshold criteria for injury (temporary threshold shift (TTS) and permanent threshold shift (PTS)), and behavioural response. Sound exposure distribution estimates are determined by moving large numbers of simulated animals (animats) through a modelled time-evolving sound field, computed using specialised sound source and sound propagation models. This approach provides the most realistic prediction of the maximum expected root-mean-square sound pressure level (SPL, L_p) and the temporal accumulation of sound exposure level (SEL, L_E) for comparison against the relevant thresholds.

The present animat modelling study considers the following scenarios:

- The operations of a Mobile Offshore Drilling Unit (MODU) during drilling operations using four thrusters at the TRD drill centre.
- FPSO operational noise for the Torosa FPSO without heading control.
- Torosa FPSO operational noise during offtake, including the FPSO without heading control, an Offshore Support Vessel (OSV) near the FPSO and a noiseless condensate tanker.
- Aggregate scenarios that include MODU operations at TRD and the Torosa FPSO during offtake operations.

Green et al. (2021) conducted a detailed sound modelling study, and the resulting sound fields were used to predict animat sound exposures. The geographic coordinates for the modelled sites that were used in the current analysis are provided in Table 2 and an overview of the acoustic modelling area is shown in Figure 1.

Table 2. Location details for the modelled sites from Green et al. (2021). Sites and sources used in animat exposure modelling are highlighted in bold.

Site	Source	Latitude (S)	Longitude (E)	MGA (GDA94), Zone 51		Water depth (m)
				X (m)	Y (m)	
TRA Well	MODU (centre)	13° 58′ 12.50″	121° 58′ 37.70″	389521	8455338	425
	OSV (centre)	13° 58′ 12.49″	121° 58′ 35.70″	389461	8455338	425
TRD Well	**MODU (centre)**	**14° 00′ 26.64″**	**121° 57′ 23.58″**	**387315**	**8451207**	**392**
	OSV (centre)	14° 00′ 26.63″	121° 57′ 21.58″	387255	8451207	392
Torosa FPSO	**FPSO (centre)**	**13° 58′ 15.06″**	**122° 01′ 28.53″**	**394647**	**8455281**	**463**
	OSV (centre)	**13° 58′ 14.94″**	**122° 00′ 59.03″**	**393762**	**8455281**	**460**

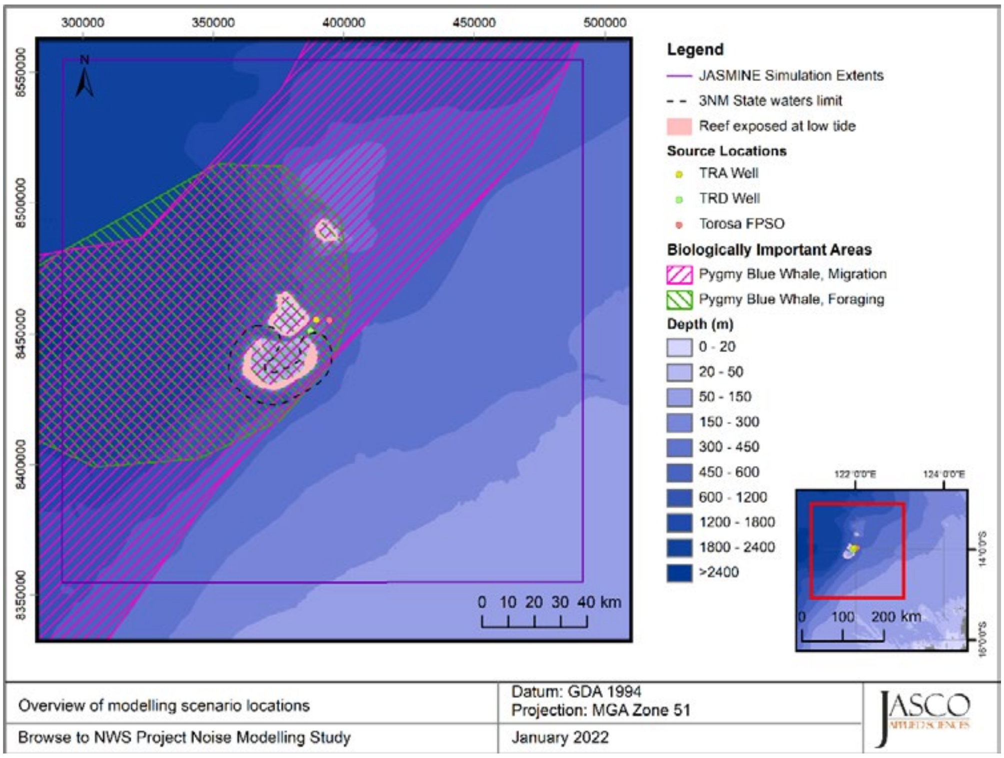

Figure 1. Overview of the modelled area and local features.

1.1. Exposure Modelling Scenario Details

For the planned Browse to NWS Project development, source and propagation modelling were conducted (Green et al. 2021) to generate sound fields which were used in conjunction with animal movement modelling. The acoustic modelled sources were as follows:

- *An FPSO facility* that is 370 m long and 67 m wide. This was modelled under:
  - Typical operations, with no heading control and no offtake, only operating processing and associated equipment,
  - Heading control (thrusters operating), representative of typical operational conditions,
  - Heading control (thrusters operating) with optimised thrusters, representative of typical operational conditions, and
  - Offtake, during which the FPSO is only operating processing and associated equipment.
- *A representative MODU* that is 100 × 80 m under DP, representative of typical operational noise during 1-year (non-cyclonic) return interval metocean conditions. This was modelled using:
  - Four thruster sources operating at 40% capacity, and
  - A central machinery source, representative of a typical drilling operation.
- *A representative OSV*, a DP vessel 92.95 m long (vessel design based on the Marin Teknikk MT6016 hull) under DP, representative of typical operational noise during maximum safe operating conditions and resupply operations. This was modelled using five thruster sources operating at a defined capacity, based on the specification of the *Fugro Etive*, as follows:
  - Two Rolls-Royce AZP100 thrusters,
  - Two Rolls Royce TT 2200 DPN thrusters, and
  - One Rolls-Royce AZP1001 thruster.

These vessels were modelled in varying configurations at the three different locations shown in Figure 1. Animat exposure modelling scenarios were simulated for Scenarios 4(a), 7, 8, and 9. The acoustic scenarios and animat scenarios are summarised in Table 3.

Table 3. Modelled scenarios from Green et al. (2021). Scenarios used in animat exposure modelling are highlighted in bold.

Scenario	Description	Sources	Length of operation	Animat Modelling
TRA well				
1(a)	MODU drilling	MODU drilling and thrusters (4 × 40%)	24 h	Not Considered
1(b)	MODU drilling (moored)	MODU drilling, no thrusters	24 h	Not Considered
2	Offshore Support Vessel	Support vessel (DP)	6 and 12 h	Not Considered
3	MODU resupply	MODU drilling and thrusters (4 × 40%) Support vessel (DP)	24 h 6 and 12 h	Not Considered
TRD well				
4(a)	**MODU drilling**	**MODU drilling and thrusters (4 × 40%)**	**24 h**	**Considered**
4(b)	MODU drilling (moored)	MODU drilling, no thrusters	24 h	Not Considered
5	Offshore Support Vessel	Support vessel (DP)	6 and 12 h	Not Considered
6	MODU resupply	MODU drilling and thrusters (4 × 40%) Support vessel (DP)	24 hr 6 and 12 h	Not Considered
Torosa				
7	**FPSO**	**Topsides machinery**	**24 h**	**Considered**
7(a)	FPSO using heading control	FPSO thrusters and topsides machinery	24 h	Not Considered
7(b)	FPSO using optimised heading control	Optimised FPSO thrusters and topsides machinery	24 h	Not Considered
8	**FPSO offtake**	**FPSO with topsides machinery Silent Tanker Support vessel (DP)**	**24 h**	**Considered**
TRD well and Torosa				
9	**MODU drilling at TRD, Torosa FPSO Offtake**	**MODU drilling and thrusters (4 × 40%) Support vessel (DP) FPSO with topsides machinery Silent Tanker**	**24 h**	**Considered**

The migratory and foraging BIAs overlap with the project area. Simulated animats were seeded only within the BIAs to represent the spatial distribution of this species. Animat exposure modelling simulation extents and animat seeding areas (BIAs) are shown in Figure 1.

2. Noise Effect Criteria

The noise effect criteria which were considered for pygmy blue whales in this assessment are the same as those applied and described in the acoustic modelling study (Green et al. 2021). The criteria relate to assessing permanent threshold shift (PTS), temporary threshold shift (TTS) and behavioural response in pygmy blue whales and are summarised in Table 4.

Table 4. Criteria for effects of non-impulsive noise exposure, including vessel noise on marine mammals: SPL and Weighted SEL_{24h} thresholds.

Hearing group	NOAA (2019)	NMFS (2018)	
	Behaviour	PTS onset thresholds (received level)	TTS onset thresholds (received level)
	SPL (L_p; dB re 1 µPa)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^{2}s)	Weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^{2}s)
LF cetaceans	120	199	179
MF cetaceans		198	178
HF cetaceans		173	153

L_p denotes sound pressure level period and has a reference value of 1 µPa.
L_E denotes cumulative sound exposure over a 24 h period and has a reference value of 1 µPa^{2}s.

3. Methods

3.1. Animal Movement and Exposure Modelling

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was used to predict the exposure of animats to sound arising from the vessel and equipment operations. JASMINE integrates the predicted sound field with biologically meaningful movement rules for each marine mammal species (pygmy blue whales for the current analysis) that results in an exposure history for each animat in the model. In JASMINE, the sound received by the animats is determined by the proposed operations. As illustrated in Figure 2, animats are programmed to behave like the marine animals that may be present in an area. The parameters used for forecasting realistic behaviours (e.g., diving and foraging depth, swim speed, surface times) are determined and interpreted from marine mammal studies (e.g., tagging studies) where available, or reasonably extrapolated from related or comparable species. For cumulative metrics, an individual animat's sound exposure levels are summed over a 24 h duration to determine its total received energy, and then compared to the relevant threshold criteria. For single-exposure metrics metrics, the maximum exposure is evaluated against threshold criteria for each 24 h period. For additional information on JASMINE, see Appendix A.

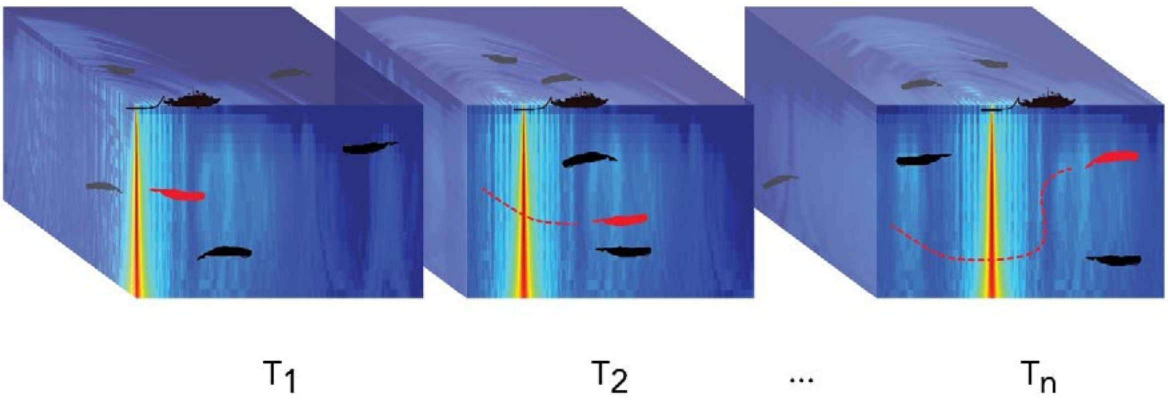

Figure 2. Cartoon of animats in a moving sound field. Example animat (red) shown moving with each time step (T_n). The acoustic exposure of each animat is determined by where it is in the sound field, and its exposure history is accumulated as the simulation steps through time.

The simulation was run for a representative period of 24 hours to coincide with the acoustic modelling effort. The modelling results presented in this report are not related to real-world density estimates for pygmy blue whales within the migration BIA and the number of animals potentially exposed was not calculated. To evaluate PTS, TTS, and behavioural response, exposure results were obtained using detailed behavioural information for migrating and feeding pygmy blue whales (described in Section 3.1.2). The spatial distribution of animats was restricted to the BIAs for all assessed scenarios, with the migration behavioural profile limited to the migration BIA and the feeding behavioural profile limited to the foraging BIA.

Model parameters related to spatial and temporal sampling were selected to appropriately capture both the swimming behaviours and the predicted sound fields. Within the context of the project-specific simulation parameters, including source characteristics, swimming behaviours, and bathymetry, a seeding density of 3 animats per km^2 was determined to provide sufficient sampling of the model space and to generate statistically reliable exposure range estimates (see Appendix A.1.3 for additional details). This resulted in 97 346 south-bound migrating animats, 86 769 north-bound migrating animats and 55 649 foraging animats across all modelling scenarios. Additionally, each animat was programmed to sample the model space every 5 seconds. For example, an animat swimming at 1 m/s would sample the sound field every 5 meters along its track.

3.1.1. Exposure-based Radial Distance Estimation

The results from the animal movement and exposure modelling provided a way to estimate radial distances to effect thresholds. The distance to the closest point of approach (CPA) for each of the animats was recorded. The $ER_{95\%}$ (95% Exposure Range) is the horizontal distance that includes 95% of the animat CPAs that exceeded a given effect threshold (Figure 3). Within the $ER_{95\%}$, there is generally some proportion of animats that do not exceed threshold criteria. The probability that an animat is exposed above threshold within the $ER_{95\%}$ is provided in the results tables.

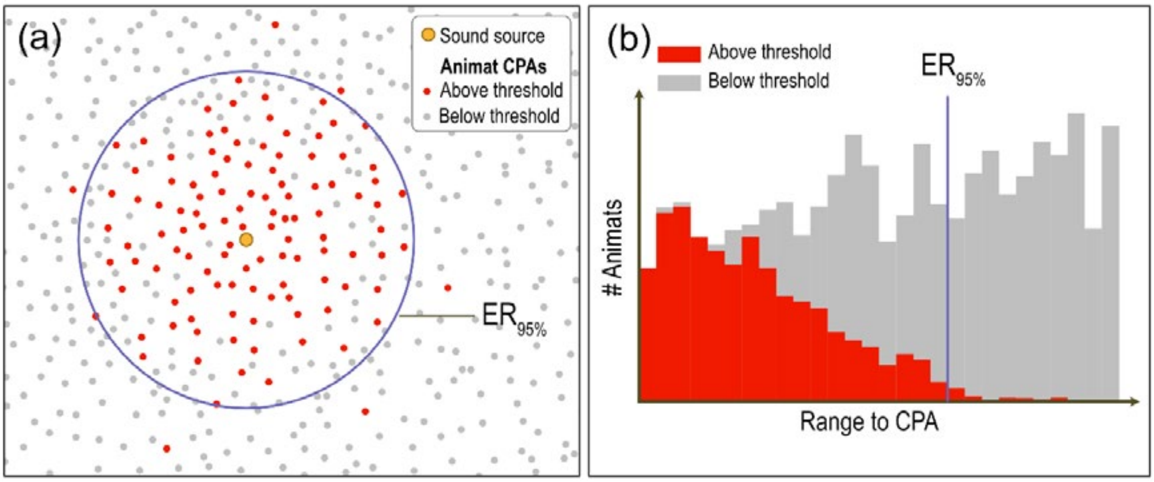

Figure 3. Example distribution of animat closest points of approach (CPAs). Panel (a) shows the horizontal distribution of animats near a sound source. Panel (b) shows the distribution of distances to animat CPAs. The 95% exposure range ($ER_{95\%}$) is indicated in both panels.

3.1.2. Pygmy Blue Whale Behaviour

The Browse to NWS Project development is within the migration and foraging BIAs for pygmy blue whales, therefore both behaviours were considered. Additionally, the south-bound and north-bound migrations were both modelled. Detailed information on pygmy blue whales was derived from a range of sources that used multi-sensor tags to record fine-scale dive and movement behaviour (Owen et al. 2016, AIMS unpublished data 2021), as well as satellite tags to record travel speed (Thums and Ferreira 2021).

Multi-sensor tags typically record the depth of an animal along with various movement parameters such as swim speed and their body’s orientation. Owen et al. (2016) equipped a sub-adult pygmy blue whale with a multi-sensor tag off Western Australia. They identified dives for the tagged animal as migratory, feeding, or exploratory (i.e., no lunges recorded which would indicate feeding). Pygmy blue whales in the simulation area are presumed to be either migrating or feeding depending on the BIA in which they are located, and so the two behavioural profiles were modelled separately. Exploratory dives were considered to be part of migratory behaviour, and so the two dive types were modelled together such that the animats were migrating 95% of the time and engaged in exploratory dives 5% of the time (Owen et al. 2016). For the feeding behavioural profile, animats were assumed to be engaged in feeding behaviour 100% of the time. Using data from Owen et al. (2016), the approximate length of a bout of exploratory dives could be determined, as well as the average (± SD) depth of this dive type.

The speed of travel and turn angle (i.e., the change in heading between satellite locations) for all dive behaviours were calculated from data presented in Thums and Ferreira (2021), who analysed data from satellite tags deployed on pygmy blue whales in the Northwest Marine Region. All remaining parameters were calculated from two multi-sensor tags deployed on pygmy blue whales off Western Australia (AIMS unpublished data 2021).

The behaviour of migrating pygmy blue whales was modelled to reflect animats transiting through the modelling area on a 230° track for the southward migration, and a 30° track for the northward migration. This represents the animals migrating along the west coast of Australia from their breeding grounds in Indonesia (Double et al. 2014, Thums and Ferreira 2021).

4. Results

A summary of radial distances to exposure thresholds for pygmy blue whales, along with probability of exposure for each modelled scenario (Table 3) are included in Table 5-Table 7. Results include $ER_{95\%}$ exposure ranges calculated for the 120 dB behavioural response threshold and SEL thresholds for both TTS and PTS, and the probability of an animat being exposed above the threshold within the $ER_{95\%}$.

Table 5. Summary of animat simulation results for south-bound migrating pygmy blue whales. The 95th percentile exposures ranges ($ER_{95\%}$) in km and probability of animats being exposed above threshold within the $ER_{95\%}$ (P_{exp} (%)) are provided.

Threshold		Scenario 4(a) MODU under DP at TRD		Scenario 7 Torosa FPSO		Scenario 8 Torosa FPSO Offtake		Scenario 9 Aggregate Scenario	
Description	Threshold level (dB)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)
TTS (SEL_{24h})	179[a]	0.02	27	0	0	0.05	46	0.05	34
PTS (SEL_{24h})	199[a]	0	0	0	0	0	0	0	0
Behavioural response (SPL)	120[b]	2.22	76	0.37	73	1.38	88	2.22	82

[a] LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)
[b] SPL (L_p; dB re 1 µPa)

Table 6. Summary of animat simulation results for north-bound migrating pygmy blue whales. The 95th percentile exposures ranges ($ER_{95\%}$) in km and probability of animats being exposed above threshold within the $ER_{95\%}$ (P_{exp} (%)) are provided.

Threshold		Scenario 4(a) MODU under DP at TRD		Scenario 7 Torosa FPSO		Scenario 8 Torosa FPSO Offtake		Scenario 9 Aggregate Scenario	
Description	Threshold level (dB)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)
TTS (SEL_{24h})	179[a]	0.03	39	0	0	0.04	78	0.04	40
PTS (SEL_{24h})	199[a]	0	0	0	0	0.01	25	0.01	3
Behavioural response (SPL)	120[b]	2.28	83	0.37	71	1.49	81	2.28	90

[a] LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)
[b] SPL (L_p; dB re 1 µPa)

Table 7. Summary of animat simulation results for foraging pygmy blue whales. The 95th percentile exposures ranges ($ER_{95\%}$) in km and probability of animats being exposed above threshold within the $ER_{95\%}$ (P_{exp} (%)) are provided.

Threshold		Scenario 4(a) MODU under DP at TRD		Scenario 7 Torosa FPSO		Scenario 8 Torosa FPSO Offtake		Scenario 9 Aggregate Scenario	
Description	Threshold level (dB)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)	$ER_{95\%}$ (km)	P_{exp} (%)
TTS (SEL_{24h})	179[a]	0.03	53	0	0	0.01	50	0.03	41
PTS (SEL_{24h})	199[a]	0	0	0	0	0.01	33	0.01	12
Behavioural response (SPL)	120[b]	2.68	92	0.52	100	1.91	92	2.78	81

[a] LF-weighted SEL_{24h} ($L_{E,24h}$; dB re 1 µPa^2·s)
[b] SPL (L_p; dB re 1 µPa)

Figures 4-6 show histograms of CPA ranges for each animat in the migratory and foraging simulations. The exposure ranges from animal movement modelling are indicated along with both the $R_{95\%}$ and R_{max} from acoustic propagation modelling.

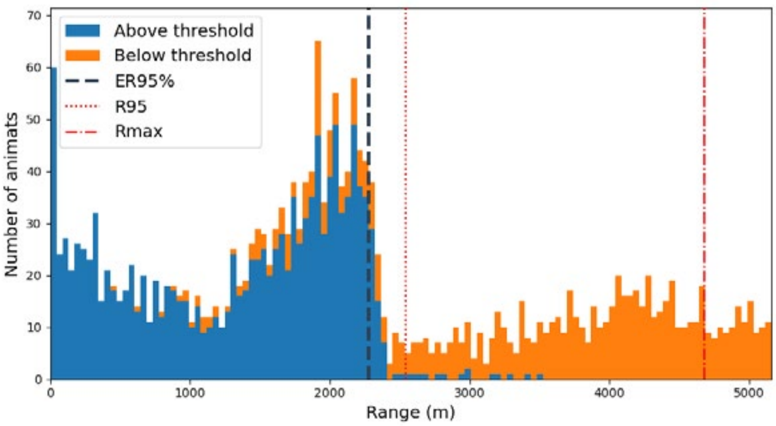

Figure 4. *North-bound migration animats*: CPA range histogram for animats for the MODU under DP at TRD drill centre). Bar colours indicate whether the animats exceeded the SPL behavioural threshold.

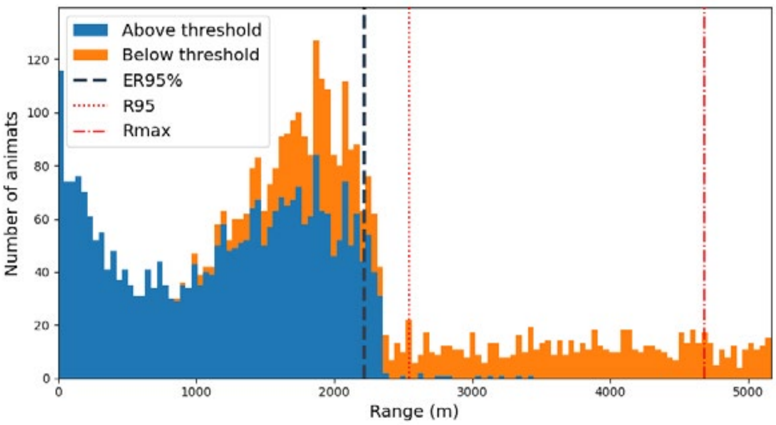

Figure 5. *South-bound migration animats:* CPA range histogram for animats for the MODU under DP at TRD drill centre. Bar colours indicate whether the animats exceeded the SPL behavioural threshold.

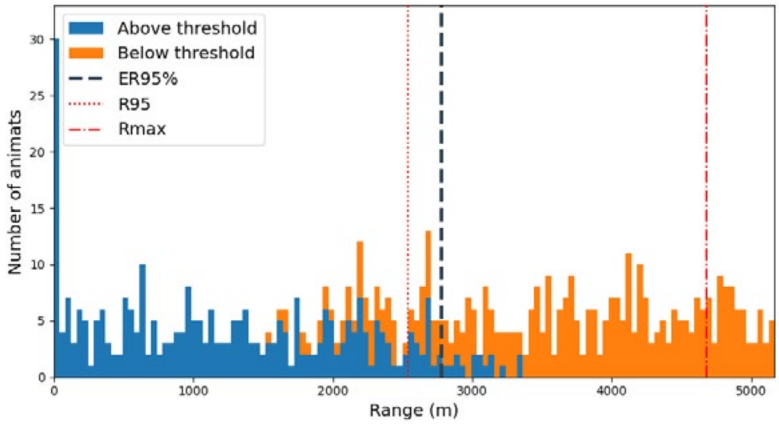

Figure 6. *Foraging animats*: CPA range histogram for animats for the MODU under DP at TRD drill centre.

To provide context and a demonstration of the movements and exposures of animats, during the modelling, 20 random animat tracks were saved from Scenario 9, the aggregate scenario for foraging animats. The animats for which the exposure history is saved are nominated prior to seeding into the simulation, thus their path and exposures are unknown. Of these 20 random animats which had their history saved, only 11 were exposed to the sound field, i.e. came close enough to the source to be exposed. The track for the animat which approached closest to the sound sources (23 km), and thus experienced the highest SPL (95 dB re 1 µPa) and SEL (136 dB re 1 µPa^{2}s) is shown in Figure 7. Figure 8 shows the range to the source as well as the accumulated SEL during the course of the simulation for that animat.

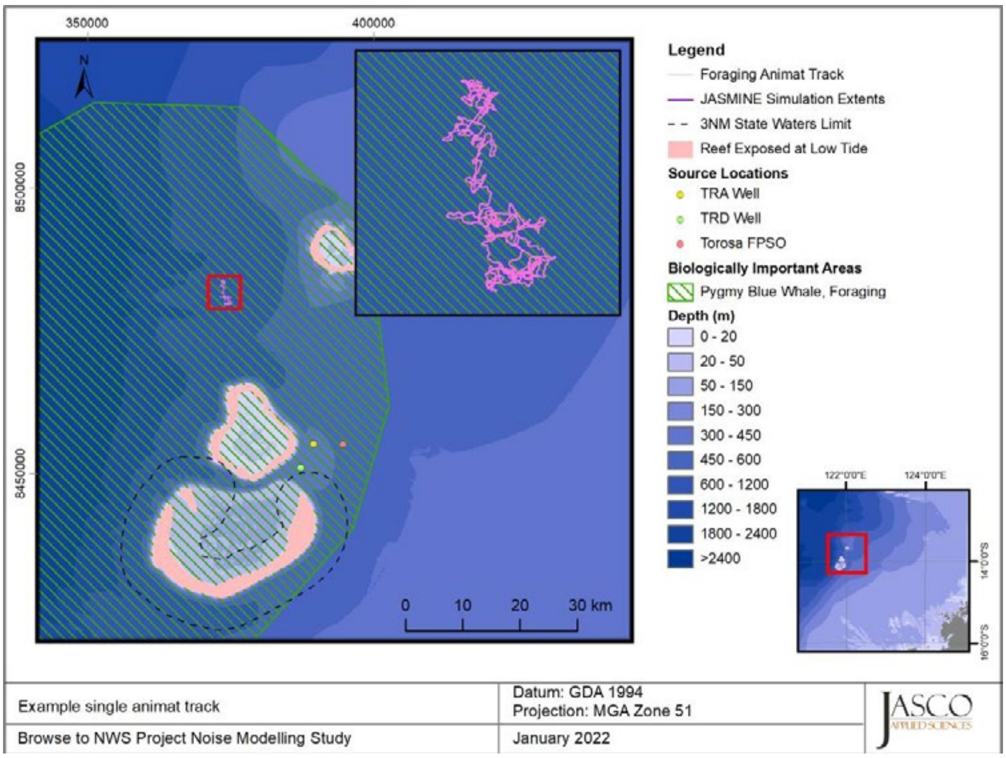

Figure 7. Overview of an example animat track.

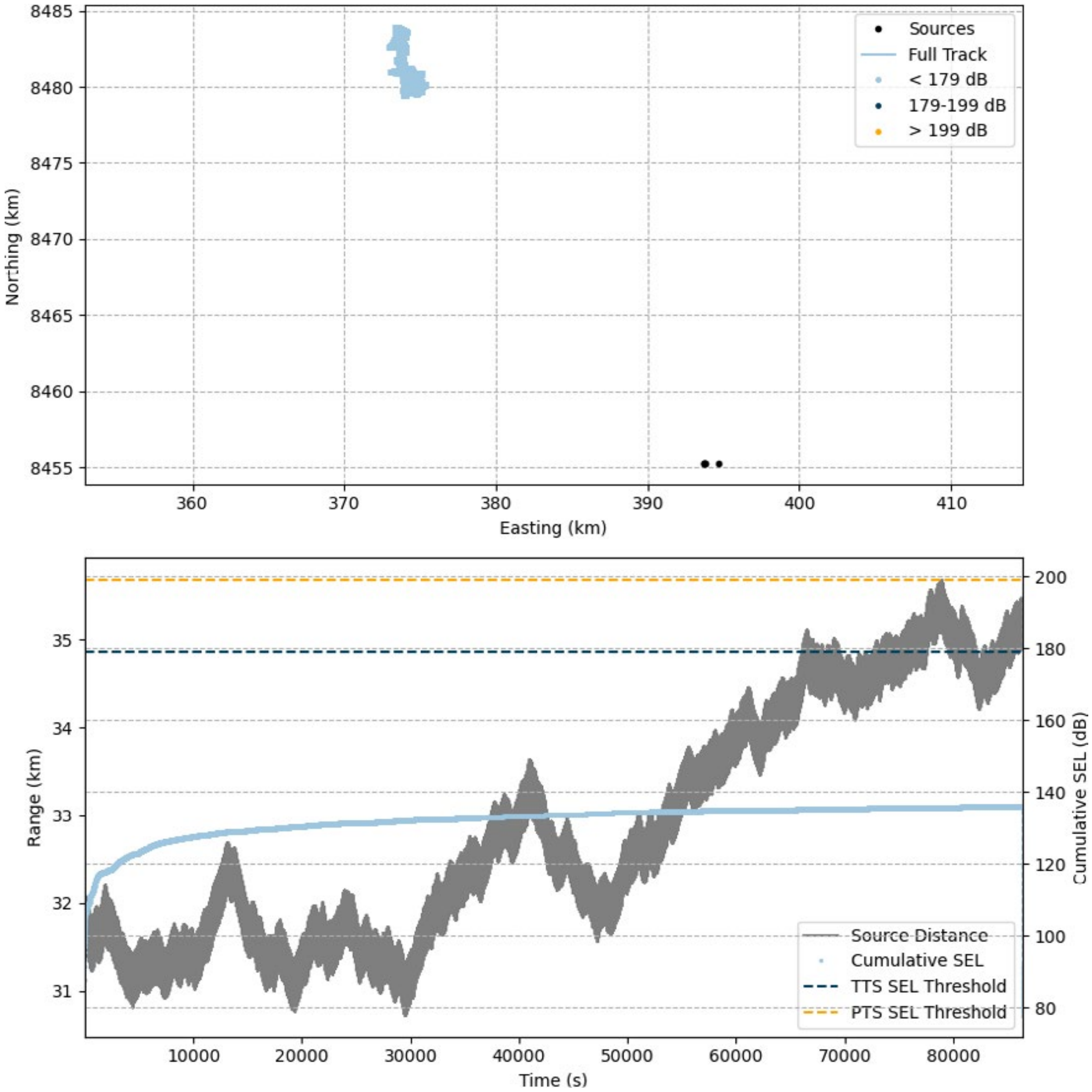

Figure 8. Example animat track from a foraging animat during Scenario 9. TTS and PTS thresholds refer to the criteria for effects of non-impulsive noise exposure on low-frequency cetaceans.

5. Discussion

This animal movement and exposure analysis was done to predict the effects of the development and installation operations for specific scenarios relating to the operation of an MODU under DP at the TRD drill centre, the FPSO at the Torosa location and the aggregate of both activities on both migrating and foraging pygmy blue whales. Exposure ranges for the 120 dB SPL behavioural response threshold aligned with those predicted by acoustic modelling, although the foraging exposure ranges were consistently slightly longer than those calculated for migrating animats. Ranges to PTS and TTS thresholds were minimal for both migrating and foraging behaviours.

Similar to the results presented in the acoustic modelling, exposure ranges for TTS, PTS and behavioural response during the aggregate scenario were not significantly different than during the individual operations (Green et al. 2021). The sites are far enough apart that their summed fields do not contribute to a quantifiable increase in the affected areas.

There was no significant difference between the predicted exposure ranges for northward versus southward migration. While the presence of the reef did influence the movement of the animats near the development area, the distribution of individual animats was not greatly restricted or modified within the TTS, PTS, and behavioural ranges of the sources. The histograms of CPA ranges for these behaviours (Figures 4 and 5) have a similar shape and predict similar exposure ranges, but because the reef effectively blocks a substantial portion of northbound animats from reaching the source area, the number of exposed animats is lower.

For the aggregate scenario (Scenario 9), the probability of exposure (P_{exp}) within $ER_{95\%}$ for the TTS SEL_{24h} threshold ($\leq$0.05 km) varied between 34 and 41%. Within $ER_{95\%}$ for the PTS SEL_{24h} threshold (<0.01 km), P_{exp} varied between 0 and 12%. For behavioural SPL threshold, P_{exp} within $ER_{95\%}$ (<2.3 km) varied between 80 and 90%. These results indicate that some, but not all, animats exposed within the $ER_{95\%}$ were exposed above threshold. This is because the received level at any given position is a function of not only the range to the source but also the vertical position in the water column and the overall path that the animat traversed through the three-dimensional sound field. For example, an animat might approach within the predicted exposure range but if they are traveling more quickly on average than other animats, they may not accumulate as much exposure, or they may be spending more time at depths with quieter sound levels.

5.1. Behavioural effects

Exposure ranges for single exposure metrics, such as the SPL behavioural response criteria, are typically comparable to the predicted acoustic ranges. Acoustic ranges are conservatively calculated using the maximum-over-depth sound fields while exposure ranges account for animats sampling the water column vertically. Because of this, exposure ranges will typically be slightly lower than the corresponding acoustic ranges.

For the behavioural threshold, the maximum $ER_{95\%}$ was 2.78 km. This aligns with the $R_{95\%}$ and R_{max} ranges from static acoustic modelling which were 2.54 km and 4.68 km, respectively. The $ER_{95\%}$ for the 120 dB behavioural threshold was consistently longer for foraging than for migrating pygmy blue whales. This is due to the behavioural profiles of the animats and the way in which they sampled the water column vertically. Migrating animats spend most of their time doing relatively shallow dives that keep them in the upper 30-60 m of the water column, where predicted received levels are lower (see Figure 9).

Although foraging animats may spend a greater amount of time in any given area due to their slower swimming speed and higher course variation (Figure 7), they perform deeper dives than migrating animats (average 312±80m and 30±31m, respectively) and spend more time at those depths.

Therefore, the foraging animats are, on average, exposed to received levels that exceed the behavioural threshold at longer ranges.

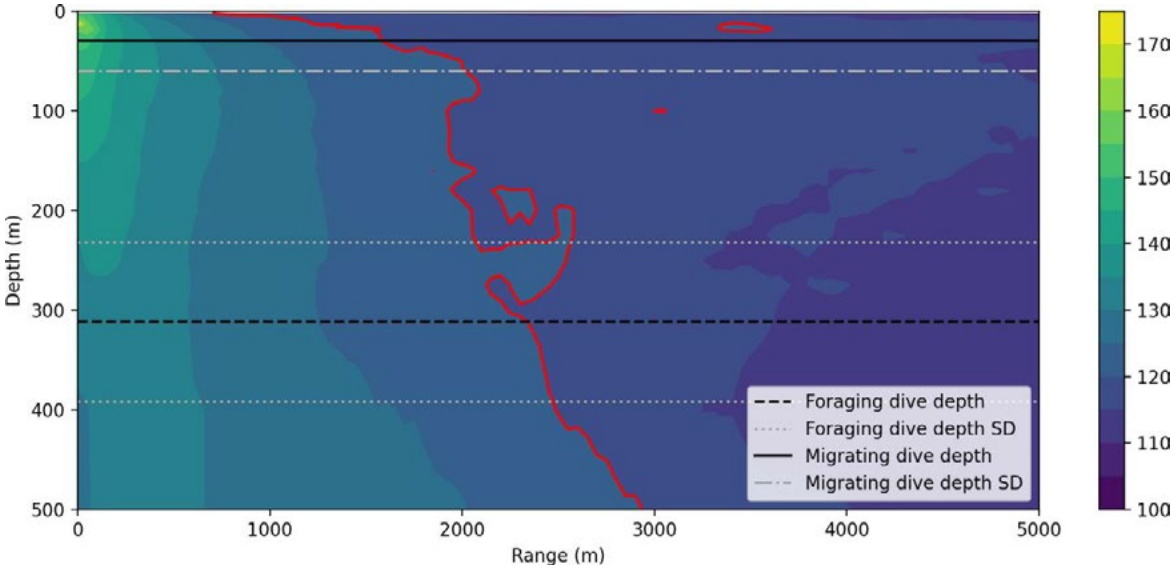

Figure 9. Slice plot showing a profile of the summed SPL sound levels interpolated along a profile centred on the TRD MODU location and extending outward at an azimuth of 45°. The 120 dB contour level is highlighted in red.

5.2. TTS and PTS

Exposure ranges from animal movement modelling for cumulative metrics such as TTS and PTS are typically shorter than those predicted using acoustic propagation modelling because of the shorter dwell time of the moving animats. Results for all scenarios aligned with this pattern, with all exposure ranges being shorter than the corresponding acoustic ranges. In some cases, particularly for Scenario 7 wherein only the FPSO machinery was modelled, there were no animats exposed above threshold, and both PTS and TTS exposure ranges were effectively zero. For the aggregate scenario (Scenario 9), the maximum $ER_{95\%}$ for SEL_{24h} thresholds was ≤0.05 km for TTS and ≤0.01 for PTS, compared to <0.53 km and <0.05 km respectively for the static acoustic modelling. Note that TTS and PTS ranges may be less than the minimum range step in the acoustic model because animats sample the area at a finer resolution.

Glossary

Unless otherwise stated in an entry, these definitions are consistent with ISO 80000-3 (2017).

animal movement modelling

Simulation of animal movement based on behavioural rules for the purpose of predicting an animal's experience of an environment.

auditory frequency weighting

The process of applying an auditory frequency weighting function. In human audiometry, C-weighting is the most commonly used function, an example for marine mammals are the auditory frequency weighting functions published by Southall et al. (2007).

auditory frequency weighting function

Frequency weighting function describing a compensatory approach accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity. Example hearing groups are low-, mid-, and high-frequency cetaceans, phocid and otariid pinnipeds.

cetacean

Any animal in the order Cetacea. These are aquatic species and include whales, dolphins, and porpoises.

continuous sound

A sound whose sound pressure level remains above ambient sound during the observation period. A sound that gradually varies in intensity with time, for example, sound from a marine vessel.

decibel (dB)

Unit of level used to express the ratio of one value of a power quantity to another on a logarithmic scale. Unit: dB.

flat weighting

Term indicating that no frequency weighting function is applied. Synonymous with unweighted.

frequency weighting

The process of applying a frequency weighting function.

frequency-weighting function

The squared magnitude of the sound pressure transfer function. For sound of a given frequency, the frequency weighting function is the ratio of output power to input power of a specified filter, sometimes expressed in decibels. Examples include the following:

- *Auditory frequency weighting function*: compensatory frequency weighting function accounting for a species' (or functional hearing group's) frequency-specific hearing sensitivity.
- *System frequency weighting function*: frequency weighting function describing the sensitivity of an acoustic acquisition system, typically consisting of a hydrophone, one or more amplifiers, and an analogue to digital converter.

geoacoustic

Relating to the acoustic properties of the seabed.

hearing group

Category of animal species when classified according to their hearing sensitivity and to the susceptibility to sound. Examples for marine mammals include very low-frequency (VLF) cetaceans, low-frequency (LF) cetaceans, mid-frequency (MF) cetaceans, high-frequency (HF) cetaceans, very high-frequency (VHF) cetaceans, otariid pinnipeds in water (OPW), phocid pinnipeds in water (PPW), sirenians (SI), other marine carnivores in air (OCA), and other marine carnivores in water (OCW) (NMFS 2018, Southall et al. 2019). See **auditory frequency weighting functions**, which are often applied to these groups. Examples for fish include species for which the swim bladder is involved in hearing, species for which the swim bladder is not involved in hearing, and species without a swim bladder (Popper et al. 2014).

level

A measure of a quantity expressed as the logarithm of the ratio of the quantity to a specified reference value of that quantity. Examples include sound pressure level, sound exposure level, and peak sound pressure level. For example, a value of sound exposure level with reference to 1 μPa^2 s can be written in the form *x* dB re 1 μPa^2 s.

low-frequency (LF) cetacean

See **hearing group**.

non-impulsive sound

Sound that is not an impulsive sound. A non-impulsive sound is not necessarily a continuous sound.

permanent threshold shift (PTS)

An irreversible loss of hearing sensitivity caused by excessive noise exposure. PTS is considered auditory injury.

pressure, acoustic

The deviation from the ambient pressure caused by a sound wave. Also called sound pressure.
Unit: pascal (Pa).

received level

The level measured (or that would be measured) at a defined location. The type of level should be specified.

reference values

standard underwater references values used for calculating sound **levels**, e.g., the reference value for expressing sound pressure level in decibels is 1 μPa.

Quantity	Reference value
Sound pressure	1 μPa
Sound exposure	1 μPa^2 s
Sound particle displacement	1 pm
Sound particle velocity	1 nm/s
Sound particle acceleration	1 $\mu m/s^2$

sound

A time-varying disturbance in the pressure, stress, or material displacement of a medium propagated by local compression and expansion of the medium.

sound exposure

Time integral of squared sound pressure over a stated time interval. The time interval can be a specified time duration (e.g., 24 hours) or from start to end of a specified event (e.g., a pile strike, an airgun pulse, a construction operation). Unit: Pa^2 s.

sound exposure level

The level (L_E) of the sound exposure (E). Unit: decibel (dB). Reference value (E_0) for sound in water: 1 µPa^2 s.

$$L_E := 10 \log_{10}(E/E_0)\ \text{dB}\ = 20 \log_{10}\left(E^{1/2}/E_0^{1/2}\right)\ \text{dB}$$

The frequency band and integration time should be specified. Abbreviation: SEL.

sound field

Region containing sound waves.

sound pressure

The contribution to total pressure caused by the action of sound.

sound pressure level (rms sound pressure level)

The level ($L_{p,\text{rms}}$) of the time-mean-square sound pressure (p_{rms}^2). Unit: decibel (dB). Reference value (p_0^2) for sound in water: 1 µPa^2.

$$L_{p,\text{rms}} := 10 \log_{10}(p_{\text{rms}}^2/p_0^2)\ \text{dB}\ = 20 \log_{10}(p_{\text{rms}}/p_0)\ \text{dB}$$

The frequency band and averaging time should be specified. Abbreviation: SPL or Lrms.

temporary threshold shift (TTS)

Reversible loss of hearing sensitivity. TTS can be caused by noise exposure.

unweighted

Term indicating that no frequency weighting function is applied. Synonymous with flat weighting.

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Appendix C - Woodside Browse to NWS Vessel Animat Modelling (Cusano et al 2022)

Appendix A. Animal Movement and Exposure Modelling

Animal movement and exposure modelling considers the movement of both sound sources (if mobile) and animals over time. Acoustic source and propagation modelling are used to generate 3-D sound fields that vary as a function of distance to source, depth, and azimuth. Sound sources are modelled at representative sites and the resulting sound fields are assigned to source locations using the minimum Euclidean distance. The sound received by an animal at any given time depends on its location relative to the source. Because the true locations of the animals within the sound fields are unknown, realistic animal movements are simulated using repeated random sampling of various behavioural parameters. The Monte Carlo method of simulating many animals within the operations area is used to estimate the sound exposure history of the population of simulated animals (animats).

Monte Carlo methods provide a heuristic approach for determining the probability distribution function (PDF) of complex situations, such as animals moving in a sound field. The probability of an event's occurrence is determined by the frequency with which it occurs in the simulation. The greater the number of random samples, in this case the more simulated animats, the better the approximation of the PDF. Animats are randomly placed, or seeded, within the simulation boundary at a specified density (animats/km^2). Higher densities provide a finer PDF estimate resolution but require more computational resources. To ensure good representation of the PDF, the animat density is set as high as practical allowing for computation time. The animat density is much higher than the real-world density to ensure good representation of the PDF. The resulting PDF is scaled using the real-world density.

Several models for marine mammal movement have been developed (Ellison et al. 1987, Frankel et al. 2002, Houser 2006). These models use an underlying Markov chain to transition from one state to another based on probabilities determined from measured swimming behaviour. The parameters may represent simple states, such as the speed or heading of the animal, or complex states, such as likelihood of participating in foraging, play, rest, or travel. Attractions and aversions to variables like anthropogenic sounds and different depth ranges can be included in the models.

The JASCO Animal Simulation Model Including Noise Exposure (JASMINE) was based on the open-source marine mammal movement and behaviour model (3MB, Houser 2006) and used to predict the exposure of animats to sound arising from the anthropogenic activities. Animats are programmed to behave like the species likely to be present in the survey area. The parameters used for forecasting realistic behaviours (e.g., diving, foraging, aversion, surface times, etc.) are determined and interpreted from marine species studies (e.g., tagging studies) where available, or reasonably extrapolated from related species. An individual animat's modelled sound exposure levels are summed over the total simulation duration to determine its total received energy, and then compared to the assumed threshold criteria.

JASMINE uses the same animal movement algorithms as 3MB (Houser, 2006), but has been extended to be directly compatible with JASCO's Marine Operations Noise Model (MONM) and Full Waveform Range-dependent Acoustic Model acoustic field predictions, for inclusion of source tracks, and importantly for animats to change behavioural states based on time and space dependent modelled variables such as received levels for aversion behaviour, although aversion was not considered in this study.

A.1.1. Animal Movement Parameters

JASMINE uses previously measured behaviour to forecast behaviour in new situations and locations. The parameters used for forecasting realistic behaviour are determined (and interpreted) from marine species studies (e.g., tagging studies). Each parameter in the model is described as a probability distribution. When limited or no information is available for a species parameter, a Gaussian or uniform distribution may be chosen for that parameter. For the Gaussian distribution, the user determines the mean and standard deviation of the distribution from which parameter values are drawn. For the uniform distribution, the user determines the maximum and minimum distribution from which parameter values are drawn. When detailed information about the movement and behaviour of a species are available, a user-created distribution vector, including cumulative transition probabilities, may be used (referred to here as a vector model; Houser 2006). Different sets of parameters can be defined for different behaviour states. The probability of an animat starting out in or transitioning into a given behaviour state can in turn be defined in terms of the animat's current behavioural state, depth, and the time of day. In addition, each travel parameter and behavioural state has a termination function that governs how long the parameter value or overall behavioural state persists in simulation.

The parameters used in JASMINE describe animal movement in both the vertical and horizontal planes. The parameters relating to travel in these two planes are briefly described below.

Travel sub-models

- **Direction**– determines an animat's choice of direction in the horizontal plane. Sub-models are available for determining the heading of animats, allowing for movement to range from strongly biased to undirected. A random walk model can be used for behaviours with no directional preference, such as feeding and playing. In a random walk, all bearings are equally likely at each parameter transition time step. A correlated random walk can be used to smooth the changes in bearing by using the current heading as the mean of the distribution from which to draw the next heading. An additional variant of the correlated random walk is available that includes a directional bias for use in situations where animals have a preferred absolute direction, such as migration. A user-defined vector of directional probabilities can also be input to control animat heading. For more detailed discussion of these parameters, see Houser (2006) and Houser and Cross (1999).
- **Travel rate**–defines an animat's rate of travel in the horizontal plane. When combined with vertical speed and dive depth, the dive profile of the animat is produced.

Dive sub-models

- **Ascent rate**–defines an animat's rate of travel in the vertical plane during the ascent portion of a dive.
- **Descent rate**–defines an animat's rate of travel in the vertical plane during the descent portion of a dive.
- **Depth**–defines an animat's maximum dive depth.
- **Reversals**–determines whether multiple vertical excursions occur once an animat reaches the maximum dive depth. This behaviour is used to emulate the foraging behaviour of some marine mammal species at depth. Reversal-specific ascent and descent rates may be specified.
- **Surface interval**–determines the duration an animat spends at, or near, the surface before diving again.

A.1.2. Exposure Integration Time

The interval over which acoustic exposure (L_E) should be integrated and maximal exposure (L_p) determined is not well defined. Both Southall et al. (2007) and the NMFS (2018) recommend a 24 h baseline accumulation period, but state that there may be situations where this is not appropriate (e.g., a high-level source and confined population). Resetting the integration after 24 h can lead to overestimating the number of individual animals exposed because individuals can be counted multiple times during an operation. The type of animal movement engine used in this study simulates realistic movement using swimming behaviour collected over relatively short periods (hours to days) and does not include large-scale movement such as migratory circulation patterns. For this study, a representative 24-hour period was simulated.

Ideally, a simulation area is large enough to encompass the entire range of a population so that any animal that could approach the source during an operation is included. However, there are limits to the simulation area, and computational overhead increases with area. For practical reasons, the simulation area is limited. In the simulation, every animat that reaches a border is replaced by another animat entering at the opposing border—e.g., an animat crossing the northern border of the simulation is replaced by one entering the southern border at the same longitude. When this action places the animat in an inappropriate water depth, the animat is randomly placed on the map at a depth suited to its species definition. The exposures of all animats (including those leaving the simulation and those entering) are kept for analysis. This approach maintains a consistent animat density and allows for longer integration periods with finite simulation areas.

A.1.3. Seeding Density and Scaling

Seeding density refers to the spatial sample rate, in units of animats/ km^2, used in the simulation. It is not related to the real-world animal density, but rather is a model parameter that controls the how samples are drawn from the model space. The minimum required seeding density for any given project depends on several factors such as bathymetry, source characteristics, and the behavioural profile of the animats, with the main constraint being computation time and resources. Seeding density is adjusted as needed based on model conditions specific to a project or project area.

In the present study, the exposure criteria for continuous sounds were used to determine the number of animats exceeding exposure thresholds. To generate statistically reliable probability density functions, all simulations were seeded with an animat density of 3 animat/km^2 over the entire simulation area. The modelling results are not related to real-world pygmy blue whale densities and the number of real-world animals potentially exposed was not calculated.

APPENDIX D SUBMISSIONS

APPENDIX D.1 SUPPORT / NO OBJECTION LETTERS

31 February 2020

Dr Tom Hatton
The Chairman
Environmental Protection Authority
Prime House, 8 Davidson Terrace
Joondalup WA 6027

Lodged online via the EPA consultation hub: https://consultation.epa.wa.gov.au/

Dear Dr Hatton

PROPOSED BROWSE TO NORTH WEST SHELF PROJECT (STATE WATERS AND COMMONWEALTH WATERS) AND NORTH WEST SHELF PROJECT EXTENSIONS – PUBLIC CONSULTATION

The Chamber of Minerals and Energy of Western Australia (CME) is the peak resources sector representative body in Western Australia. CME is funded by member companies responsible for more than 85 per cent of the State's mineral and energy production and workforce employment.[1]

The value of royalties received from the sector totalled $6.8 billion in 2018-19,[2] accounting for 21 per cent of State Government general revenue.[3] In addition to contributing 40 per cent of the State's total industry Gross Value Added,[4] commodity export earnings from the sector have helped Australia withstand the global financial crisis and post-recovery period of 2007-10.[5,6] The sector is thus a key driver of local, State and Australian economies. For example, a sample of members operating in the Pilbara electoral district had directly supported over 750 community organisations and 300 businesses in 2017-18.[7]

CME welcomes the opportunity to provide a submission to the Environmental Protection Authority (EPA), as host for the combined consultation platform, for the proposed Browse to North West Shelf Development (NWS) (both State and Commonwealth Waters) and NWS Project Extension (the NWS Project). This letter expresses support for the development as proposed by Woodside Energy Ltd (Woodside), to develop new natural gas fields off the Kimberley Coast with connection into the existing liquefied natural gas (LNG) facilities on the Burrup Peninsula.

Context

It is important policy and regulation recognises the essential role of natural gas in achieving a lower emissions and reliable energy future. Natural gas can materially contribute to Western Australia's and Australia's energy security, reliability and economic prosperity, while also reducing global greenhouse gas (GHG) emissions by displacing higher emission fuels. Further to the Liquid Fuel Security Review's interim report,[8] LNG has its role in diversifying Australia's fuel sources to address pricing and resilience issues associated with tightening of the global oil market.

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[1] Sum of average number of individuals directly employed by member producers in 2018-19, excludes non-operating sites. Government of Western Australia, *2018-19 Economic indicators resources data*, Safety Regulation System, Department of Mines, Industry Regulation and Safety, August 2019.

[2] Government of Western Australia, *Annual report 2018-19*, Department of Mines, Industry Regulation and Safety, November 2019, p. 77.

[3] Government of Western Australia, *2018-19 Annual report on State finances*, Department of Treasury, September 2019, p. 8

[4] Duncan, A. and Kiely, D., *BCEC Briefing note WA economic update*, Bankwest Curtin Economics Centre, November 2019, p. 4.

[5] Commonwealth of Australia, *Resources and energy quarterly*, Office of the Chief Economist, Department of Industry, Innovation and Science, December 2018, p. ii.

[6] Commonwealth of Australia, *Resources 2030 Taskforce*, Department of Industry, Innovation and Science, December 2018, p. 20.

[7] CME, *2017-18 WA resource sector operations*, May 2019: https://cmewa.com.au/wp-content/uploads/2019/06/Pilbara-1.pdf.

[8] Commonwealth of Australia, *Liquid fuel security review Interim report*, Department of the Environment and Energy, April 2019, p. 4.

The Chamber of Minerals & Energy of Western Australia [redacted]

Natural gas will also play a necessary and complementary role in providing energy stability and affordability to the South West Interconnected System which is increasingly being disrupted by distributed energy resources such as solar photovoltaics. Establishment of the Energy Transformation Strategy and its Taskforce to address these challenges evidences these concerns at the State level.

The International Energy Agency's (IEA) Sustainable Development Scenario, aligning with the Paris Agreement to hold global temperature rises to well below 2 degrees Celsius in this century, reflects the importance of affordable, reliable and modernised energy sources. According to the IEA's outlook, gas demand for electricity in Asia will double to 2040.[9]

According to the Intergovernmental Panel on Climate Change (IPCC):

> *"GHG emissions from energy supply can be reduced significantly by replacing current world average coal-fired power plants with modern, highly efficient natural gas combined-cycle power plants or combined heat and power plants, provided that natural gas is available and the fugitive emissions associated with extraction and supply are low or mitigated".*[10]

Electricity generated from gas has on average half the GHG emissions of electricity generated from coal. This highlights the global role Western Australian natural gas can play in meeting current and future energy needs with lower emissions.

Potential benefits

With Australia becoming the largest exporter of LNG in the world,[11] the time is right to secure continued use of existing infrastructure at the NWS Karratha Gas Plant (KGP). This will sustain and stimulate economic growth of the Pilbara region for decades to come. The Western Australian resources sector has a well-established track record of creating jobs and exporting commodities.

Developing Browse and processing of third-party gas and fluids at the KGP is an efficient and effective use of existing infrastructure. Due to the scale of capital investment required, this is preferable to a greenfields development. Use of existing land-based infrastructure to support a new gasfield will also reduce onshore impacts such as native vegetation clearing that would otherwise be required should an entirely new gas plant instead be pursued.

The NWS Project incorporates a range of options to manage carbon dioxide, minimise emissions and their potential impacts. This includes the NWS's commitment to a 40 per cent reduction in nitrogen oxide, with Browse including efficient aero-derivative gas turbines, active heating in flowlines and batteries for peak power supply into its design.

CME understands the NWS Project is expected to deliver significant benefits to local communities, the Western Australian and broader Australian economy during its expected operating life of over 40 years. This may include:

- increased revenue from royalties and payroll tax,
- continued, long-term employment opportunities,
- associated economic benefits to the City of Karratha through voluntary partnerships, rates, fees and charges, and
- benefits accrued to the wider community through company contributions and reduced need for social welfare, etc.

Currently, the NWS operations has over 690 employees with 60 per cent of these employees residing locally.

Woodside has commissioned ACIL Allen Consulting to prepare a detailed economic impact assessment of the flow on benefits of successfully delivering the NWS Project alongside the proposed Scarborough Project,

---

[9] IEA, South East Asia Energy Outlook 2019, https://www.iea.org/reports/southeast-asia-energy-outlook-2019

[10] IPCC, *Summary for policy makers 4.2.2* in Climate change 2014: Mitigation of climate change, contribution of working group III to the fifth assessment report of the IPCC , November 2014, p. 21.

[11] EnergyQuest, *Australia formally becomes world's largest exporter of LNG,* media release, 6 January 2020.

i.e. the Pluto-NWS Interconnector and Pluto LNG projects (the Burrup Hub vision).[12] Their modelling indicates it will boost Australia's Gross Domestic Product by $414 billion between 2019-63, of which 99 per cent will be in Western Australia.[13] The Burrup Hub has the potential to sustain an average of more than 4,000 jobs per annum nationally between 2019-63, with about half of these jobs in Karratha and Broome.[14] This will contribute to the State Government's priorities of creating an extra 30,000 jobs in regional Western Australia.

Conclusion

CME encourages the EPA to support the proposals submitted by Woodside regarding development of the Burrup Hub vision. CME believes these proposals will support the McGowan Government in achieving outcomes outlined in Diversify WA, i.e. deliver a stronger and more resilient economy, supported by the creation of secure and quality jobs.

Should you have questions regarding this letter, please contact [redacted] Director – Policy & Advocacy, on [redacted] or via email at [redacted]

Yours sincerely

[redacted]

Chief Executive Officer

Copy:

[redacted]
Premier; Minister for Public Sector Management; State Development, Jobs and Trade; Federal-State Relations

[redacted]
Minister for Environment; Disability Services; Electoral Affairs

[redacted]
Minister for Energy; Mines and Petroleum; Industrial Relations

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[12] ACIL Allen Consulting, *Economic impact of Woodside's future developments*, insights, 3 July 2019.

[13] ACIL Allen Consulting, *Burrup Hub Economic impact assessment*, development summary brochure, June 2019, p. 3: https://www.acilallen.com.au/uploads/files/page/31/BurrupHubDevelopmentSummaryBrochure-1562111185.pdf.

[14] Ibid.

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6 February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10,
JOONDALUP DC, WA 6919

PROPOSED BROWSE TO NORTH WEST SHELF PROJECT
COMMONWEALTH - ENVIRONMENTAL IMPACT STATEMENT

The Broome Chamber of Commerce & Industry (BCCI) is pleased to support the Browse to NWS Project and their draft Environmental Impact Statement (EIS) and Environmental Review Document (ERD).

The BCCI was established in 1987 and has approximately 400 members from around 15 industry sectors in the West Kimberley. Our vision is to create an adaptable, diverse and multi-industry business community driving a strong local economy.

Since its inception, the BCCI has recognised the significant and positive impact that responsible development of the Browse basin will have on Broome, the West Kimberley, West Australia and Australia as a whole.

Woodside has had a long association with Broome and is acknowledged as a "good corporate citizen" by the business community. Their engagement process with the local community and provision of relevant information to date has been open, effective and comprehensive. We look forward to welcoming them back to Broome.

The Regional Context
Whilst Broome and the surrounding region is internationally recognised as a world class tourist destination, this often masks the fact that this is also an area of significant social disadvantage with too few economic drivers underpinning growth and far too many young indigenous people unable to participate in the broader economy. Without long term economic drivers producing year round demand for local jobs, goods and services, the region will never attain the scale of activity to underpin the social and built infrastructure a sustainable, growing prosperous community requires to provide equality of opportunity for all residents.

Our branding as a tourist destination also masks the wealth of opportunities that the region and its people have to offer. The tourist industry has for many years acknowledged that its sector can and does effectively coexist and thrive alongside a range of other industries including the oil & gas sector,

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logistics, mining, agriculture and aquaculture. The growth of these other industries is essential and helps provide year round economic inputs which assist in overcoming the seasonal nature of demand related to tourism sector.

The construction and operational phases of the proposed NWS Extension Project are critical to Broome and the region's growth trajectory and its ability to develop into a major regional service and logistics centre.

Positive Impacts

The BCCI is pleased to note that many of the above issues and concerns are acknowledged and incorporated into the Browse to NWS Project Environmental Impact Statement / Environment Review Document: -

> The proposed Browse to NWS Project will clearly deliver significant benefits to our local community, the State of WA and the broader Australian economy during its approximate 40+ year operations.
>
> The NWS Project Extension has the potential to provide continued, long term employment and social opportunities and other economic benefits to Broome and broader community for several decades to come.

ACIL Allen prepared a Burrup Hub Economic Impact Assessment (EIA) and notes the potential benefits that may flow to the Shire of Broome and the broader Western Australian and Australian economies: -

> The proposed Browse to NWS and NWS Extension projects have the potential to boost the GDP of Australia by $289 billion between 2019-2063, of which 99% will be in WA.
>
> These projects have the potential to generate $493 million of annual average operational expenditure in Western Australia, including $15 million of spend per annum for Broome logistic support activities.
>
> The successful combined progress of these projects has the potential to create an average of more than 2,700 jobs per annum nationally between 2019-2063, almost 1,400 of these will be in Karratha and Broome.

[redacted]

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Effective Use of Infrastructure

The BCCI also acknowledges that developing Browse and processing Browse gas in Karratha is an efficient and effective use of existing infrastructure and more sustainable than a green-fields development in the Kimberley.

Utilizing Broome as a supply base will underpin expansion in the capacity and capability of the Broome port through the construction of the proposed $110 million Kimberley Marine Supply Base. This will also cement Broome as an alternative and vital cost effective logistics hub and gateway from the north for seaborn trade and underpin a variety of sectors requiring cost effective export facilities.

Natural gas from the Browse will also make a material contribution to the energy security and economic prosperity of WA and Australia. LNG will be part of the world's future energy mix for decades to come and the Browse to NWS and NWS Extension projects must be part of this future.

The Local Environment

Woodside have been carrying out extensive environmental research projects in our region for over two decades. Our marine environment is a vital asset. Through our consultation sessions and the documentation provided we have been satisfied that they have assessed all reasonably identifiable risks and have mitigated those risks accordingly.

A Cleaner Energy Future

Both State and Federal Government regulators and policymakers must recognise the role of natural gas in achieving a cleaner energy future. To have reliable energy and lower emissions, natural gas is essential for the foreseeable future. Western Australia's clean gas is an ideal partner with renewables to provide the necessary system stability.

Both the Browse to NWS Project and NWS Project Extension have incorporated a range of options to manage CO_2 and minimise emissions, and their potential impacts.

This includes: -

The NWS's commitment to a 40% reduction in NOx.

Efficient aero-derivative gas turbines, active heating in flowlines and batteries for peak power supply.

Production of gas from the Browse will also contribute to accelerating the reduction of greenhouse gas emissions globally by displacing higher emissions fuels.

[redacted]

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The BCCI also welcomes the focus on bio sequestration of CO_2 rather than geo sequestration. We consider this has a greater net benefit to the community by providing greater opportunities to the agricultural and indigenous business sectors to participate in this process.

The responsible development of the Browse provides a generational opportunity for Broome to cement its aspiration to become a major logistics hub for the north. We support the NWS Project Extension and acknowledge the comprehensive body of work and research contained in the Projects Environmental Review Document and the Browse to NWS Project's Draft Environmental Impact Statement / Environmental Review Document.

Woodside have satisfied any concerns raised during our extensive engagement and community briefing sessions. We look forward to the project entering FEED and a final investment decision at the earliest opportunity.

Yours sincerely

[redacted]

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To Whom It May Concern,

Re: Woodside Energy Ltd EIS/ ERD:

Proposed Browse to North West Shelf Project - State Waters - Public Environmental Review

Proposed Browse to North West Shelf Project – Commonwealth - Environmental Impact Statement

Purpose

The purpose of this correspondence is to provide the wholehearted support of the Broome Future Alliance Ltd. (BFA) to the Browse to Northwest Shelf project as proposed by Woodside Energy Ltd (Woodside) for and on behalf of the Browse Joint Venture partnering organisations.

BFA has been privy to consistent information as provided by Woodside over the past 18 months, including having presentations from and direct access to the Environmental Management team responsible for the Draft EIS/ ERD report.

Based on that material, our reading of the draft EIS/ ERD analysis, impact and risk assessment processes and overall findings, together with our confidence in Woodside based on its enviable environmental management record, the BFA Board acknowledges and supports Woodside's assertion that:

> *"The Browse Joint Venture considers that the proposed Browse to NWS Project can be implemented in a manner that will result in significant socio-economic benefits while limiting environmental impacts and risks so that they are consistent with relevant regulations, policies, plans, principles and guidance."(P. 26)*

Background

Broome Future Alliance Ltd (BFA) is a not-for-profit community based body established for the purpose of guiding and facilitating the implementation of the Broome Growth Plan (BGP) - the strategic blueprint for the growth of Broome (operating as the Kimberley regional hub) and the West Kimberley region to 2036. The BGP was commissioned by the WA State Govt and endorsed in 2018 by the Hon Alannah MacTiernan MP, Minister for Regional Development. The Minister also endorsed the Broome Future Alliance Ltd, a hybrid institutional and community-based Board of Management as the body to oversee, promote, advocate and assist in the BGP implementation. (For more about the BFA Structure and Purpose refer Attachment A)

The relationship between the BFA and Woodside Energy dates to 2013, following the decision to not proceed with the James Price Point development concept. At that time, Broome Future Ltd, and independent not-for-profit company was established under the inaugural Chair, Dr. Ken Michael AC – former Governor of WA and funded by organisations and individuals with commercial and community interests in Broome and the wider Kimberley region.

Over time , and following the completion of the WA Government initiated and funded Broome Growth Plan (BGP), it was determined that Broome Future Ltd be morphed into a newly transitioned board incorporating four (4) key institutional organisations (Shire of Broome, Nyamba Buru Yawuru, Broome Chamber of Commerce and Industry and Kimberley Development Commission as well as local community based independent directors.

The context of this backgrounding is to establish the longevity, significance, experience, understanding of the BFA and its individual directors with Woodside Energy and it's commercial approach to the Browse hydrocarbon resources, and our capacity to provide this supporting opinion with respect to the Draft EIS/ERD study.

Discussion/ Comment

Stakeholder Consultation

The directors of our Board, in their capacity as directors and their respective community and professional roles, have had the opportunity to attend presentations, individual consultations and, from time to time, direct access to the Woodside Energy Environmental Management specialists leading and / or involved in the development of the draft EIS/ERD.

Woodside Energy, as the lead operator in the Browse Joint Venture, must be congratulated on their continued presence in, and contribution to, the Shire of Broome community, including and most importantly the indigenous communities on the Dampier Peninsula. Information access and consultation on the development of the Browse Hydrocarbon proposal has been 1st class and highly appreciated by our community at all levels. The stakeholder consultation is extremely well covered in Section 4 of the Draft EIS. The BFA endorses those submissions.

Environmental Impact/ Risks and Management Strategies

Woodside, through previous concept studies into accessing the Browse resources, has developed a formidable amount of environmental, scientific, cultural and indigenous heritage data and information along the journey. As stated in the report, this information has been incorporated into this draft EIS/ERD along with additional data based on the more definitive development process of the Browse to Northwest Shelf project, namely the establishment of subsea infrastructure and two floating production storage offtake (FPSO) facilities, connected to existing NWS Project infrastructure via the ~900 km Browse Trunkline (BTL).

It is our understanding that the construction and operation of the proposed operation will predominantly utilise proven industry construction, installation and ongoing management processes and practices – like that already in place in developing, constructing and operating the Shell and Impex Browse Basin facilities.

We also note the overall expertise and reputational excellence of Woodside as Australia's largest independent oil and gas company, with a global portfolio recognised for its world-class capabilities as an explorer, a developer, a producer and a supplier of energy and for its renowned reputation for their environmental management, safety, reliability and efficiency across all its operating assets. This is no better evidenced than Woodsides commitment to environmental management being recognised by the Australian Petroleum Production and Exploration Association (APPEA) as the recipient of the Environment Excellence Award in 2009, 2012, 2015, 2016, 2017 and 2019.

As such, given its outstanding Environmental, Health, Safety and Welfare record, the Broome Future Alliance board has no hesitation in supporting Woodside Energy's draft EIS/ ERD research and overall conclusions, or to be given final approval to undertake the Browse to NWS project.

Green House Gas (GHG)

We note Woodsides forecast estimate with respect to GHG emissions over the life of the project, and the need to undertake mitigation and abatement strategies during that cycle.

Woodside has made our Board aware of its management policy and practices toward GHG emissions, from which we have drawn confidence that this important global issue is being actively managed through Woodsides corporate management processes and cascaded through the organisation, including fostering continuous improvement activities at all levels.

In saying that, we also note the importance of LNG to Australia and the world as an effective measure to move away from other fossil fuel-based energy given it's lower GHG emission outcomes – some 50% - 60% less than coal as an example. There is no doubt that LNG is part of the world's future energy mix and the Browse to North West Shelf and NWS Extension projects should be part of this future to provide energy and economic security, and opportunities and benefits for the Kimberly / Pilbara regions region, the State of WA and Australia overall.

Economic and Social Impact

As stated, over the journey from the James Price Point concept to current day, the Broome and wider region community recognises the foundational economic and social value of the commercialisation of the Browse resources. Given our remote geographic location, with a widely dispersed, relatively small population, development opportunities tied to the resource sector investment is vitally important to sustainable growth, infrastructure, economic and social investment and development. Of course, such developments need to be balanced from social, cultural and environmental perspectives. They also need to be patiently communicated socialised and continuously managed in order to ensure the community is comfortable and supportive, based on all information being available, given the communities strong protection for our pristine environment and social and cultural history and expectations.

The Draft EIS/ERD comprehensively details the consultation and communication actions of Woodside Energy, and in this case specifically the Broome- Dampier Peninsula community. To say it has been comprehensive, consistent and transparent is an understatement.

Following on from the disappointment and divisions created by the James Price Point concept process and final decision not to proceed, Woodside has maintained a permanent presence within our community. As it has continued to study the optimally commercial utilisation of the Browse region LNG resource, Woodside has maintained open dialogue with all levels of the community - state and local government, business sector , large and small, community based groups (including Broome Future Alliance) the wider community and of course the indigenous traditional owners within Broome and the Dampier Peninsula.

Woodside has continued to provide support, cash and in kind, to our region on a range of initiatives including most importantly education, training and skill development with specific focus on supporting the most disadvantaged members of our community. This has been most welcome and appreciated by the community.

Woodside has committed to using Broome as the supply chain and logistics hub for its Browse operations. Coupled with the services already supplied to the Shell and Impex facilities, this creates additional industrial scale and offers increased potential to contribute to the economy of Broome. The project further enhances the opportunity to develop Broome – West Kimberley transport and logistics hub operations for further utilisation by a range of industries and developing the Australia – Asia supply chain with Broome being an important internationally capable logistics hub – with year round reliable sea, air and road transport access routes. This has generated a level of excitement within the town for the potential this offers in terms of economic growth, skills development and employment opportunities.

If there is any doubt on Broomes desire to further develop its Port of Broome capacity and transport /logistics hub potential, underpinned through the Oil and Gas support activities, this was overwhelmingly demonstrated at the 22 Dec 2019 Shire of Broome Annual Electors meeting attended by some 300 people. At this meeting the following Motion was put and overwhelmingly supported:

"That the Shire of Broome Council:

> *1. Reaffirms its continued support and strategy for the Port of Broome to become a more significant and effective logistics hub and marine support base for the Kimberley, the North West and the State; and*
> *2. Request the Shire President write to the Premier of Western Australia and the Minister for Ports to reiterate Council's support for the development of the Port of Broome. "*
> (http://broome.infocouncil.biz/Open/2019/12/EMT_12122019_MIN_1638_AT.PDF)

A key element of the Port of Broome development is the Kimberley Marine Supply Base (KSMB) project. The following extract explains this project:

"On September 20, 2019 the Minister for Ports, Hon Alannah MacTiernan, announced the State Government's approval of the lease agreements at the Port of Broome to enable the Kimberley Marine Support Base project to proceed to the next stage.

*"The proposed $110 million facility will be constructed and funded by Kimberley Marine Support Base (**KMSB**) Pty Ltd, and comprises of a floating wharf, along with associated onshore terminal facilities. The KMSB proposal will provide complimentary facilities for maritime trade and tourism." (Kimberley Ports Authority media release: https://www.kimberleyports.wa.gov.au/Port-of-Broome/Corporate-Info/Kimberley-Marine-Supply-Base-Proposal)*

The KMSB is a game changer for the future development of Broome – West Kimberley transport and logistics hub vision. In conjunction with the existing KPA Port operations, the KMSB will provide year-round world-class servicing for the O&G operations access to the Browse Basin operations for the next 50 years. In addition, the flow on capability for Cruise Liner access will greatly enhance the tourism industry. Further, the port capability opens further exciting opportunities to seriously develop the Broome/ Kimberley and associated regions supply chains, notably penetration into and with Asia. In turn this enables a range of industries – resources, agriculture and others – to investigate future market development opportunities. We believe this activity, building blocks if you like, with Woodside's Browse project being another important aspect, will lead, over time, to transformational economic growth and employment opportunities, and as such will also positively impact the education, training and skill development opportunities and needs within the community.

The Browse Basin facilities will utilise FIFO workers during construction and at least initially in operational phase. Our community vision is to undertake a long term view of ensuring our local education, training and skills development initiatives and available labour pool will enable a substantial amount of these workers, and those of the emerging attendant businesses to be established in the community, to live and work within Broome and the Kimberley. We understand Woodside share a similar vision.

These comments underpin why we, and the Broome- West Kimberley community at large is supportive of Woodside's Browse to NWS project. The direct and indirect, immediate and long term benefits the project brings are vitally important to the immediate lift in our economic activity and confidence. In conjunction with other projects and developments, it provides enormous opportunity to secure the Broome- West Kimberley long term sustainability as a thriving, prosperous community and a great place to live.

The ACIL Allen study commissioned by Woodside, is detailed in the report at section 6.4 and clearly shows the exceptional economic benefits this project brings to Broome ($15m spend per annum), The Kimberley and Pilbara regions, and the Western Australian and Australian economies.

The draft EIS/ERD also states:

"Overall, stakeholders on the Dampier Peninsula expressed support for the proposed Browse to NWS Project, but there was a desire to see clear benefit for their communities." P.97.

This is certainly a true and correct statement not only for the Dampier Peninsula communities who are immensely important to this project, but also the overall Broome and wider region community.

Woodside Energy has demonstrated positive commitment to date over the period it has been determining its Browse strategy. Subject to State/ Commonwealth government approval of the project, we as a community are increasingly confident that FID for this project will proceed. We are also confident that Woodside as the proponent of this project will individually, and collectively with the other Browse Basin operators, continue to work positively , generously and innovatively to ensure the community does indeed see clear long term, community building , sustainable benefits over the longevity of the Browse Basin resources project.

Conclusion:

Over a period of many years, Woodside has, along with its detailed studies into the technical aspects of its Browse strategy, gathered an enormous amount of environmental and scientific ecological data on the overall area to be impacted by this operation. This is evidenced in the substance of this report. Further, Woodside has undertaken professional, environmentally acceptable processes and analysis to study the environmental impacts of the proposed project to enable them to conclude that:

> "the proposed Browse to NWS Project can be implemented in a manner that will result in significant socio-economic benefits while limiting environmental impacts and risks so that they are consistent with relevant regulations, policies, plans, principles and guidance." (P. 26).

Woodsides overall conclusion (Section 9) states:

> "Woodside has considered the outcomes of the impact and risk assessment process and developed a range of mitigation and management measures to be implemented throughout the life cycle of the proposed Browse to NWS Project. In consideration of the unique values of Scott Reef and surrounds, the principles of ESD, the objects of the EPBC Act and EP Act and other relevant requirements, Woodside has concluded that the nominated environmental objectives for the proposed Browse to NWS Project will be met, the predicted impacts from planned activities and the potential risks from unplanned events and incidents have been reduced to an Acceptable level and that the proposed Browse to NWS Project can be implemented in a manner that will result in significant socio-economic benefits, while avoiding unacceptable environmental impacts."

On the basis of our reading and assessment (albeit non-scientific) of the Draft EIS/ ERD and our working history with Woodside over a long period of time as this project has evolved, we have a high level of confidence in Woodsides professionalism in gathering, reviewing and analysing all the environmental data to form their overall conclusion.

We are also confident on Woodsides commitment not only to the overall environment to be impacted by this project, but the deep understanding it has gained from traditional owners and the wider community on the immense importance and responsibility it must place in protecting the land and sea for now and the future.

Woodsides environmental management record is enviable and, we understand, unblemished, and recognised as industry best practice. Its overall corporate management philosophy, processes and practices are world class and industry best practice, and it has built a strong values-based culture within its workforce with environmental management of all its assets fundamental in that system.

It is for these reasons Broome Future Alliance is very encouraged by the outcomes of the Draft EIS/ERD study and look forward to the State and Commonwealth agencies review and findings in due course.

Yours Sincerely

[redacted]

Chair
Broome Future Alliance Ltd.
10/02/2020

Attachment A

Broome Future Alliance Board structure

[redacted]	**Chair** (Independent)	
	Director (Institutional representative)	**CEO**, Nyamba Buru Yawuru (NBY)
	Director (Institutional representative)	**President**, Shire of Broome
	Director (Institutional representative)	**President**, Broome Chamber of Commerce and Industry (BCCI)
	Director (Institutional representative)	**Director**, Kimberley Development Commission (KDC)
	Director (Independent)	Retired businessman, Fmr President, Shire of Broome et al.
	Director (Independent)	CEO, Goolarri Media
	Director	West Kimberley business owner, **President- Derby – West Kimberley Shire,** Deputy President, Kimberley Development Commission (KDC)
Vacant Position	Director (Independent)	

Broome Future Alliance Charter (extract)

Strategic Intent

Mission Statement

Broome Future Alliance will advocate for, promote and facilitate environmentally sustainable, economic, social and cultural development in Broome and the West Kimberley Region in areas where there are strong economic fundamentals and where broad community alignment can be achieved.

Vision – People, Place and Prosperity

Broome and the West Kimberley Region will be a vibrant, prosperous and cohesive community. People in the Region will, enjoy a high level of economic independence and have access to modern, fit-for-purpose infrastructure and amenities that are nestled in one of the world's most spectacular natural and culturally rich environments.

Core Values

In executing on its mission to achieve its vision, Broome Future Alliance adheres to the following core values:

- **Apolitical**
  Broome Future Alliance is not a political organisation. In its advocacy it works with all political parties and accepts subscribers from all political persuasions.

- **Consultative and Inclusive**

In building community cohesion around development, Broome Future Alliance endeavours to be inclusive of all members of the community and in forming positions on issues, seeks to consult the opinions of key stakeholders and the wider community.

- **Evidence-based**
  All opinions and positions adopted by Broome Future Alliance on development issues are based on interpretation of evidence and the best research and analysis that is available at the time.

- **Economic Fundamentals**
  In addition to being based on consultation and evidence, Broome Future Alliance formulates its advocacy, promotional and facilitation strategies based on sound and practical economic principles.

- **Solutions-oriented**
  Broome Future Alliance does not shy away from the difficult issues. It tackles complex and controversial issues by identifying aspects of the issue in which there is common interest and then applies its consultative, evidence and economic principles-based approach to identifying, promoting and facilitating a widely acceptable solution.

- **An Alliance of Leadership**
  Broome Future Alliance does not seek to replace or replicate the democratically elected community leadership, or other sector or community interest organisations. Rather it works to form an alliance of that leadership and integrate that leadership with the wider community.

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[redacted]

12 February 2020

Dr Tom Hatton
Chairman
Environmental Protection Authority
Locked Bag 10
JOONDALUP DC WA 6919

Submitted online via the www.epa.wa.gov.au website

Tom
Dear Dr ~~Hatton~~,

RE: Public consultation – Browse to North West Shelf Project and the North West Shelf Project Extension proposals

The Australian Petroleum Production & Exploration Association (APPEA) is pleased to provide comment to the Environmental Protection Authority (EPA) on the following proposals:

- Proposed Browse to North West Shelf Project including the Public Environmental Review (PER) for assessment of the project in State Waters and the Environmental Impact Statement (EIS) for assessment by the Commonwealth; and,
- Proposed North West Shelf Project Extension assessment by Public Environmental Review.

Both proposed projects are operated by Woodside Energy Ltd on behalf of its Joint Venture Participants and represent significant, long-term development opportunities for the West Australian and Australian economies.

The oil and gas industry in Western Australia

APPEA is the peak national body representing upstream oil and gas explorers and producers with interests in Australia. APPEA's member companies account for more than 95 per cent of Australia's petroleum production, the majority of which is produced from facilities located in Western Australia (WA). Further details about APPEA and the Australian oil and gas industry can be found at www.appea.com.au.

As is well known by the Government, the oil and gas industry in WA, including the development of onshore resources, is a major contributor to the state and national economies, creating jobs and business opportunities whilst providing gas to domestic consumers and generating export revenue in sales of Liquefied Natural Gas (LNG).

[redacted]

appea.com.au australian petroleum production & exploration association limited [redacted]

appea

WA is also the most energy and gas-dependent economy in Australia with natural gas supplying more than half of our primary energy needs[1]. LNG production facilities also supply more than half of the WA's domestic gas supply[2].

WA projects can play a key role in lowering global emissions and our LNG exports are contributing to a cleaner energy sector in Asia. With natural gas being a cleaner, affordable and reliable fuel source, WA exports can help emerging LNG import markets increase their energy security whilst reducing their emissions had they consumed more carbon intensive fuels. According to updated Australian Government estimates, Australia's LNG exports have the potential to reduce global emissions by at least 159 million tonnes of CO_2-e per year[3] – equal to 30 per cent of Australia's total annual emissions.

Demand for natural gas is also expected to grow 36 per cent by 2040[4], providing a quarter of global energy demand. WA, as a leading exporter of LNG, will be one of the main suppliers meeting this increasing global demand. Importantly, supplying LNG to overseas customers does not have to come at the expense of the environment.

The Browse to North West Shelf Project and the North West Shelf Project Extension proposals

The Browse to North West Shelf (NWS) project proposal is a nationally significant project that will develop three fields off the Kimberley coast – Brecknock, Calliance and Torosa – by piping the gas to the existing Karratha Gas Plant of the North West Shelf Joint Venture on the Burrup Peninsula. Utilising these existing onshore gas processing facilities is a more sustainable approach than building a new greenfield facility, and from an economic perspective also helps support long-term employment opportunities and economic benefits to the Pilbara region and the wider WA economy, with around 700 people employed during normal NWS operations. In addition, with the Torosa field located in State waters, the project would provide royalties to the State beyond those dues paid to the Commonwealth such as Petroleum Resources Rent Tax and other income taxes.

The NWS Project Extension proposal will allow the existing Karratha Gas Plant to continue to operate by processing third party gas and liquids as current reservoirs deplete and capacity becomes available in the infrastructure. The extension of the NWS includes some replacement of equipment, plant and machinery, as required, with Woodside stating that it would look to adopt modern technologies when these updates occur.

In economic modelling undertaken by ACIL Allen[5], the proposed Browse to NWS and the associated NWS extension project proposals are together estimated to boost Australia's GDP by $289 billion over 2019-2063[6].

As mentioned in ACIL Allen's report "*The proposed Browse and North West Shelf Extension are expected to result in a significant direct contribution to the Australian economy through capital and operational spending, employment, taxation and royalty payments, and exports. The*

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1 www.energy.gov.au/publications/australian-energy-update-2019 - Table O.
2 gbbwa.aemo.com.au/#home
3 https://www.minister.industry.gov.au/ministers/taylor/media-releases/australias-national-greenhouse-gas-inventory-june-2019-quarterly
4 www.appea.com.au/media_release/global-gas-demand-delivers-opportunities-for-australia
5 www.acilallen.com.au/insights/future-development
6 www.acilallen.com.au/uploads/files/page/31/BrowseDevelopmentSummaryBrochure-1562111138.pdf

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majority of these direct impacts will be realised in Western Australia including in the Pilbara and the Kimberley regions."

Emissions management of the proposals

Both the Browse to NWS project and the NWS project extension proposals include several options to manage CO_2 and minimise emissions. The NWS has committed to reducing NOx by 40 per cent, and the Browse to NWS proposal has incorporated a number of energy efficiency technologies in the design of its facilities such as efficient aero-derivative gas turbines, active heating in flowlines and batteries for peak power supply.

In summary, given the significant economic contribution these two proposals would make to both the State of Western Australia and the Australian economy, as well as the approach taken by operator Woodside to make these developments as sustainable as possible whilst helping to meet global energy demand with cleaner-burning natural gas, APPEA encourages the EPA to support the proposals submitted by Woodside and its Joint Venture Participants.

Yours sincerely,

[redacted]

Director – Western Australia

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appea.com.au australian petroleum production & exploration association limited [redacted]

[redacted]

12 February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10,
JOONDALUP DC, WA 6919

PROPOSED BROWSE TO NORTH WEST SHELF PROJECT
COMMONWEALTH - ENVIRONMENTAL IMPACT STATEMENT

I am writing to support Woodside Energy Ltd (Woodside) as Operator for and on behalf of the Browse Joint Venture, who is proposing to develop the Brecknock, Calliance and Torosa fields located approximately 425km north of Broome in the offshore Browse Basin.

The Browse to North West Shelf (NWS) proposal which comprises subsea infrastructure and two Floating Production Storage and Offloading facilities (FPSO) connected to existing NWS infrastructure via a 900-kilometre trunk line is a vital project for Broome, the West Kimberley, WA and Australia.

Woodside has carried out extensive local consultation with the community in the West Kimberley in the last year.

Their explanations of the project detailed at Broome Chamber of Commerce & Industry sessions and the comprehensive measures proposed to safeguard the land and sea environment have satisfied me that all reasonable risks associated with the project have been mitigated.

The energy produced by this project will play a critical role in transitioning to cleaner energy over time. Scope 3 emissions associated with the Browse gas are also very likely to replace higher CO2 emitting energy sources thereby creating an overall reduction in emissions globally.

Woodside have been associated with Broome as a base for oil and gas exploration and project support for several decades and have proved to be an excellent corporate citizen for the region.

This project is of local and national importance and should be supported and approved by both State and Federal regulatory bodies.

Yours faithfully

[redacted]

Sell Smarter! Rent Smarter!

PRD nationwide

12 February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10,
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[redacted]

PRDnationwide Broome [redacted]

[redacted]

12 February 2020

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Yours faithfully

[redacted]

NAME [redacted]
Address [redacted]

12 February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10,
JOONDALUP DC, WA 6919

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Yours faithfully

NAME
[redacted]

12 February 2020

[redacted]
Broomecrete
[redacted]

The Chairman
Environmental Protection Authority
Locked Bag 10,
JOONDALUP DC, WA 6919

PROPOSED BROWSE TO NORTH WEST SHELF PROJECT
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Yours faithfully

[redacted]

[redacted]

Sherkane Pty Ltd [redacted]

11 February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10,
JOONDALUP DC, WA 6919

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COMMONWEALTH - ENVIRONMENTAL IMPACT STATEMENT

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Woodside have been associated with Broome as a base for oil and gas exploration and project support for several decades and have proved to be an excellent corporate citizen for the region.

This project is of local and national importance and should be supported and approved by both State and Federal regulatory bodies.

Yours faithfully

[redacted]

[redacted]

12 February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10,
JOONDALUP DC, WA 6919

PROPOSED BROWSE TO NORTH WEST SHELF PROJECT COMMONWEALTH - ENVIRONMENTAL IMPACT STATEMENT

I am writing to support Woodside Energy Ltd (Woodside) as Operator for and on behalf of the Browse Joint Venture, who is proposing to develop the Brecknock, Calliance and Torosa fields located approximately 425km north of Broome in the offshore Browse Basin.

The Browse to North West Shelf (NWS) proposal which comprises subsea infrastructure and two Floating Production Storage and Offloading facilities (FPSO) connected to existing NWS infrastructure via a 900-kilometre trunk line is a vital project for Broome, the West Kimberley, WA and Australia.

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12 February 2020

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Environmental Protection Authority
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Woodside has carried out extensive local consultation with the community in the West Kimberley in the last year. Having attended a number of these, I am satisfied with the level of risk mitigation they have in place to protect the land and sea environment.

Woodside has a long history in Broome and I believe they will continue to make a very positive contribution to our community.

The energy produced by this project will play a critical role in transitioning to cleaner energy over time. This project will be highly beneficial to both the local and national economy and will be highly regulated and subject to extensive oversight.

For the reasons mentioned above, I believe this project should be supported and approved by both State and Federal regulatory bodies.

Yours faithfully

[redacted]

[redacted]

12 February 2020

The Chairman
Environmental Protection Authority
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Woodside has carried out extensive local consultation with the community in the West Kimberley in the last year.

Their explanations of the project detailed at various Industry information sessions and their commitment to ensuring that strict measures will be put in place to safeguard the environment leaves me in no doubt that they have the required protocols in place to mitigate against any possible damage.

The energy produced by this project will no doubt play a critical role in transitioning to cleaner energy. Scope 3 emissions associated with the Browse gas are also very likely to replace higher CO_2 emitting energy sources thereby creating an overall reduction in emissions globally.

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12 February 2020

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CHARTER

Property

REAL ESTATE AGENTS
PROPERTY CONSULTANTS
COMMERCIAL & INDUSTRIAL
DEVELOPMENT CONSULTANTS
PROJECT MANAGEMENT
AUCTIONEERS
PROPERTY MANAGERS
[redacted]

12 February 2020

The Chairman
Environmental Protection Authority
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Yours faithfully

[redacted]

Director
Charter Property Group
West Perth and Broome Offices

[redacted]

[redacted]

12 February 2020

The Chairman
Environmental Protection Authority
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Yours faithfully

[redacted]

NYAMBA BURU YAWURU

11th February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10,
JOONDALUP WA 6919

RE: PROPOSED BROWSE TO NORTH WEST SHELF PROJECT
COMMONWEALTH - ENVIRONMENTAL IMPACT STATEMENT

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Kind regards,

[redacted]

[redacted]
Chief Executive Officer

NYAMBA BURU YAWURU [redacted] | WWW.YAWURU.ORG.AU

[redacted]

12 February 2020

The Chairman
Environmental Protection Authority
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Woodside have been associated with Broome as a base for oil and gas exploration and project support for several decades and have proved to be an excellent corporate citizen for the region.

This project is of local and national importance and should be supported and approved by both State and Federal regulatory bodies.

Yours faithfully

[redacted]

[redacted]

[redacted]

12 February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10,
JOONDALUP DC, WA 6919

PROPOSED BROWSE TO NORTH WEST SHELF PROJECT
COMMONWEALTH - ENVIRONMENTAL IMPACT STATEMENT

I am writing to support Woodside Energy Ltd (Woodside) as Operator for and on behalf of the Browse Joint Venture, who is proposing to develop the Brecknock, Calliance and Torosa fields located approximately 425km north of Broome in the offshore Browse Basin.
The Browse to North West Shelf (NWS) proposal which comprises subsea infrastructure and two Floating Production Storage and Offloading facilities (FPSO) connected to existing NWS infrastructure via a 900-kilometre trunk line is a vital project for Broome, the West Kimberley, WA and Australia.
Woodside has carried out extensive local consultation with the community in the West Kimberley in the last year.
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Woodside has carried out extensive local consultation with the community in the West Kimberley in the last year. Their explanations of the project detailed at Broome Chamber of Commerce & Industry sessions and the comprehensive measures proposed to safeguard the land and sea environment have satisfied me that all reasonable risks associated with the project will be mitigated during their operations.

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12 February 2020

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13 February 2020

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12 February 2020

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Director

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12 February 2020

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BROOME INTERNATIONAL AIRPORT

12 February 2020

The Chairman
Environmental Protection Authority
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COMMONWEALTH - ENVIRONMENTAL IMPACT STATEMENT

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Woodside has carried out extensive local consultation with the community in the West Kimberley, and we are satisfied us that all reasonable risks associated with the project have been mitigated.

Broome International Airport (BIA) has had a long and close association with Woodside as they have used Broome as a base for oil and gas exploration and project support for several decades. BIA works with the current operators in the Browse Basin, and would welcome the opportunity to continue to work with Woodside deliver the Browse to NWS proposal.

This project is of local and national importance and should be supported and approved by both State and Federal regulatory bodies.

Yours faithfully

[redacted]

Chief Executive Officer
Broome International Airport Pty Ltd

11 February 2020

[redacted]

The Chairman
Environmental Protection Authority
Locked Bag 10,
JOONDALUP DC, WA 6919

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When this project was last proposed to be brought on land at James Price Point, opponents of the project called for it to be subsea piped south, Now many years on Woodside have proposed just that, to pipe the gas south the very same people that were earlier calling for it to be piped are now saying they don't want the project at all.

Broome desperately needs the jobs, infrastructure and population a project like this will bring.

I fully support Woodside and believe they have earnt the right to progress this project after years of community involvement and investment.

Yours faithfully

[redacted]

[redacted]

12 February 2020

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Woodside have been associated with Broome as a base for oil and gas exploration and project support for several decades and have proved to be an excellent corporate citizen for the region.

This project is of local and national importance and should be supported and approved by both State and Federal regulatory bodies.

As an employer of over 25 people for the past 30 years we see this and other projects that go through "due process" as vital to the economy of the Kimberley and supporting employment opportunities for **all** people in this region.

Yours faithfully

[redacted]

[redacted]

11 February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10,
JOONDALUP DC, WA 6919

PROPOSED BROWSE TO NORTH WEST SHELF PROJECT
COMMONWEALTH - ENVIRONMENTAL IMPACT STATEMENT

I am writing as a long time and concerned resident of Broome to support Woodside Energy Ltd (Woodside) as Operator for and on behalf of the Browse Joint Venture, who is proposing to develop the Brecknock, Calliance and Torosa fields located approximately 425km north of Broome in the offshore Browse Basin.

The Browse to North West Shelf (NWS) proposal which comprises subsea infrastructure and two Floating Production Storage and Offloading facilities (FPSO) connected to existing NWS infrastructure via a 900-kilometre trunk line is a vital project for Broome, the West Kimberley, WA and Australia.

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This project is of local and national importance and is vital for the the prosperity of Broome and the West Kimberley which should be supported and approved by both State and Federal regulatory bodies.

[redacted]

11 February 2020

[redacted]

The Chairman
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Yours faithfully

[redacted]

KMSB
Kimberley Marine Support Base

12th February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10,
Joondalup DC, WA 6919

Browse to North West Shelf Project – Commonwealth Environmental Impact Statement

We write in support of Woodside Energy Ltd (Woodside) as Operator for and on behalf of the Browse Joint Venture, who is proposing to develop the Brecknock, Calliance and Torosa fields located approximately 425km north of Broome in the offshore Browse Basin.

From briefings and review of the Browse to NWS Project Environmental Impact Statement / Environment Review Document, it is clear that the project will be a significant contributor to economic activity in Broome and the surrounding areas. This will be done while ensuring a responsible development that minimises impacts on the environment.

At KMSB, we are committed to the reduction of environmental impacts wherever possible and understand the role of natural gas in achieving a cleaner energy future. To have reliable energy and lower emissions, natural gas is essential.

Natural Gas can make a material contribution to the energy security and economic prosperity of WA and Australia while contributing to the reduction of greenhouse gas emissions globally by displacing higher emissions fuels.

[redacted]

Director
Kimberley Marine Support Base
[redacted]

Kimberley Marine Support Base Pty Ltd
[redacted]

[redacted]

NGARLUMA & YINDJIBARNDI FOUNDATION LTD.

[redacted]

"Together We Are Strong"

March 10, 2020

Environmental Protection Authority
Prime House, 8 Davidson Terrace
Joondalup WA 6027

ENVIRONMENTAL REVIEW
Northwest Shelf Project Extension ERD/EIS
Browse to North West Shelf Project ERD/EIS

The NYFL Review of the Northwest Shelf Project Extension and the Browse to Northwest Shelf Project Environmental Review and Impact Statement Documents is well under way. We expect the review to be completed prior to the end of March 2020. Regular reporting on the progress of the review has been supplied to NYFL, and to date no items of significance have been highlighted by the NYFL Environmental Consultancy team. NYFL intends to provide a letter of support to WEL for these two projects on the completion of the review.

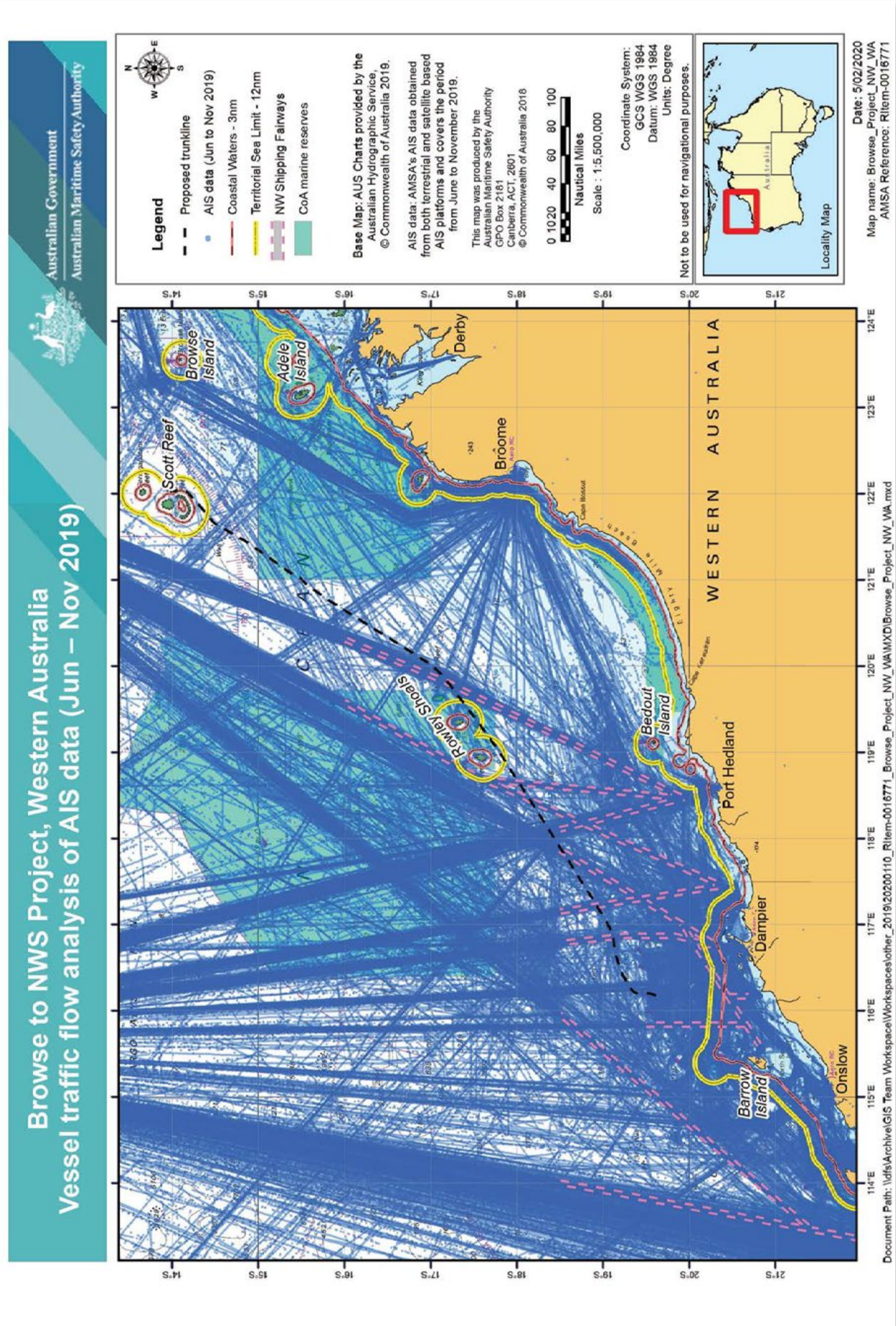
Kind Regards

[redacted]

[redacted]

APPENDIX D SUBMISSIONS

APPENDIX D.2 AUSTRALIAN MARITIME SAFETY AUTHORITY


Australian Government
Australian Maritime Safety Authority
Browse to NWS Project, Western Australia
Vessel traffic flow analysis of AIS data (Jun – Nov 2019)
Legend
Proposed trunkline
AIS data (Jun to Nov 2019)
Coastal Waters - 3nm
Territorial Sea Limit - 12nm
NW Shipping Fairways
CoA marine reserves
Base Map: AUS Charts provided by the Australian Hydrographic Service, © Commonwealth of Australia 2019.
AIS data: AMSA's AIS data obtained from both terrestrial and satellite based AIS platforms and covers the period from June to November 2019.
This map was produced by the Australian Maritime Safety Authority GPO Box 2181 Canberra, ACT, 2601 © Commonwealth of Australia 2018
0 10 20 40 60 80 100
Nautical Miles
Scale : 1:5,500,000
Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree
Not to be used for navigational purposes.
Locality Map
Date: 5/02/2020
Map name: Browse_Project_NW_WA
AMSA Reference: RItem-0016771
Scott Reef
Browse Island
Adele Island
Derby
Broome
Rowley Shoals
Bedout Island
Port Hedland
Dampier
Barrow Island
Onslow
WESTERN AUSTRALIA
114°E
115°E
116°E
117°E
118°E
119°E
120°E
121°E
122°E
123°E
124°E
14°S
15°S
16°S
17°S
18°S
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20°S
21°S
Document Path: \\dfs\Archive\GIS Team Workspace\Workspaces\other_2019\20200110_RItem-0016771_Browse_Project_NW_WA\MXD\Browse_Project_NW_WA.mxd

APPENDIX D SUBMISSIONS

APPENDIX D.3 ANON - 57NR-WV52-Z (TRANSITION KWOORABUP DENMARK)

Transition Kwoorabup Denmark

[redacted]

The Browse to North West Shelf project in Commonwealth waters

submission to the EPA

3/2/20

Thank you for the opportunity to make a submission to the EPA on the The Browse to North West Shelf project in Commonwealth waters.

We strongly request that the EPA find against this project.

Firstly, this proposal is close to several Commonwealth Marine **Reserves** and threatens the ecological resilience of those marine reserves; the impact on these commonwealth reserves (and also state reserves) must be considered. The Commonwealth is required to protect the intricate ecology of Benthic sediments and the Euphotic zones within these reserves. The potential impacts from the commission and operation of the storage and offloading facilities, and connecting pipeline is unknown a far as we are aware.

Also, the regional Ord River Estuary, Eighty Mile Beach, Roebuck Bay, and Ashmore Reef Reserves stand to be impacts by any disasters such as oil spills and facility damage. Even sites around Australia's island tin the Indian Ocean may also be affected.

A similar threat would hang over the **mangrove** forests of Northern WA, and the Northern Territory (home to 39% of all coastal mangroves in Australia) plus impacts from increased industrial pollutants, trace nutrients, sediment and pH fluctuations.

The risk extends to our **wetlands** and the preservation of wetlands of international importance with the potential to wreak havoc on both Marine & Coastal Zone wetlands, and Inland wetlands.

The threat to our **marine fauna** is not acceptable. The area hosts species of sea snake that are 'critically endangered', species of endangered turtles; and the vulnerable Australian Sea Lion, with rare species of jellyfish to the north. Whales migrate along through the area, to give birth and nurse their young, including three species of whale that are 'endangered'. This project will affect the migration of whales, rays, and associated marine animals.

Increasing industrial activity at the Burrup Peninsula as part of the North west Shelf expansion will lead to further physical, and chemical damage from emissions and pollution, beyond the enormous damage already done.

The Burrup Peninsula holds world renown aboriginal **rock art,** more than a million examples, an archaeological record of traditional use of the area over thousands of years. It is an expression to stories, customs and knowledge of the transitional owners' land and connects them to the events and people of the past and their beliefs today. It deserves, and surely will receive, world heritage recognition.

It is now well recognised that gas is not a transitional fuel, not cleaner than coal. Gas is complementing, not replacing coal, and our gas exports are vastly increasing global **emissions**.

Enormous amounts of **methane** gas are released into the atmosphere during an LNG facility's lifespan. These emissions (maybe as much as 1/10th of the entire volume of the gas resource) escape during drilling, extraction, transportation and combustion. We are informed that the total Browse Basin and this project will emit some 2.7% of Australia's total emissions, and the offshore components will emit at least 112 million tonnes to 2050. The project would lock in such emissions for decades.

It is easily recognised that emissions impacts from the extension of the Browse-NWS-Burrup gas will significantly risk the global requirement of holding temperatures to 1.5C on 2005 levels. It has been reported that "total emissions from the extraction, venting and processing of gas, both onshore and offshore, from the proposed Browse field project will equal 200 million tonnes of CO^2 over a minimum 31 years' field life (112 offshore, 88 onshore). The Browse project, if approved, will be the most emissions intensive development in Australia, adding an additional 7 million tonnes of CO^2e just through venting and pumping the gas 900km and about another 7.6 million tonnes CO^2e from processing at the North West Shelf LNG facility".

In conclusion, there should be no approval given to any new gas projects or their expansion, such as the Browse to North West Shelf project, as such developments are against the 2015 Paris Climate Agreement. The Browse to North West Shelf project in Commonwealth waters also puts Commonwealth Marine Reserves, and associated and regional ecology (wetland, mangroves) and marine fauna at grave risk. And any contribution to expanding industrial activity on Burrup risks further damage to the invaluable rock art there.

Sincerely

[redacted]

[redacted]

APPENDIX D SUBMISSIONS

APPENDIX D.4 ANON - 57NR-WV5H-P (WESTERN AUSTRALIAN FISHING INDUSTRY COUNCIL (WAFIC)

WAFIC FISHING PEARLING AQUACULTURE

10th February 2020

The Chairman
Environmental Protection Authority
Locked Bag 10
JOONDALUP DC WA 6919

Dear Chairman

REFERENCE: **Western Australian Fishing Industry Council (WAFIC) Comment – Environmental Impact Statement for the State Waters component and Commonwealth Waters component of the Browse to North West Shelf Project**

Woodside Energy Ltd (Woodside) corporate affairs staff kindly provided WAFIC information specific to the commercial fishing sector to assist in a more user-friendly review of the proposed Woodside Browse to North West Shelf Project in state and commonwealth waters.

Note the following comments from the Western Australian Fishing Industry Council (WAFIC)

- ***Physical presence: Disturbance to Other Users***
  - Woodside noted that the long-term 500 metre safety exclusion zone around the FPSO is a relatively small area overlapping commercial fisheries therefore displacement activities is not expected to impact commercial fishing activities.
    - WAFIC requests Woodside reassess this point. The impact is not based on the area of the 500 metre (permanent) exclusion zone over any one commercial fishery, it is a 500 metre (permanent) exclusion zone impact on the fishable areas / fished areas of a fishery.
  - Note snagging risk to commercial fishers, especially to trawl fisheries (North West Slope Trawl and Pilbara Trawl). Woodside's "Adopted Controls" of "ongoing consultation with commercial fishers etc that operate in the Project Area will be undertaken".
    - What does this mean? What are your targeted outcomes of this ongoing consultation? How will you remediate any potential impact to the commercial fishers who may be operating in this area?
  - Woodside notes the low fishing effort expected in the area of the project and that wells etc are marked on navigational charts and that wells are in water depths greater than 350 metres with no known subsea features of significance and fish populations, it is not considered that the loss of access within the petroleum safety zones (representing a fraction of the area of the fisheries) will affect current fishing levels.
    - North West Slope Trawl fish between 200 and 750 metres water depth, the key indicator species is the mud dwelling scampi. Commercial fishers may potentially fish these areas.
    - Woodside is expecting commercial fishers to "give up" access rights for the 100% exclusive use of Woodside. Please note, the Woodside safety exclusion zones are not the only safety exclusion zones in the northwest shelf. How many other safety exclusion zones are overlapping these fisheries – you cannot assess the Woodside zones in isolated context. Cumulative impacts across a range of issues are significant.
    - It may be a lower fishing effort but, every bit adds up – if the commercial fishing industry lost "all" low fishing effort areas, over time this will come at a significant cost to our industry.

WESTERN AUSTRALIAN FISHING
INDUSTRY COUNCIL INC

[redacted]

wafic.org.au

WAFIC FISHING PEARLING AQUACULTURE

Title: Proposed Browse to North West Shelf Project – Supplement Report to the draft EIS/ERD

2.

- ***Physical Presence: Light and Underwater Noise***
  - Woodside notes that light emissions and underwater noise impacts will be negligible with no expected significant subsequent impact to fisheries "
    - Woodside confirms there will be underwater noise monitoring of an operational well be undertaken to inform an adaptive management approach for noise management for the TRD and TRE wells if required.
    - Will there be ongoing noise and light monitoring of the FPSO?

- ***Marine Discharges: Drilling and Completions discharges***
  - Note this will be "managed in such a manner to avoid impacts to Scott Reef shallow water benthic communities and habitats"
    - How will this be managed and will there be ongoing monitoring?
    - Are any other shallow water areas located within this project boundaries and if so, how does Woodside plan to mediate this?
    - There is a difference between "avoid" and not occurring at all. What happens if Woodside cannot "avoid" negative marine discharges? Considering this is a long life project, does Woodside plan to review and monitor to ensure that the original avoidance strategy actually occurs over the life of the project without any negative or cumulative impacts, especially to the commercial fishing resource?

- ***Unplanned Hydrocarbon Releases***
  - Woodside notes that "in general, fisheries have the potential to be impacted by an unplanned hydrocarbon release through direct impacts to target populations or prey species and fishing gear and from the exclusion of users from a fishing area, potentially resulting in lost revenue".
    - It is not a "potential " loss – depending on the size of the unplanned hydrocarbon spill there will be a loss.
    - This loss is not restricted to impacts on target key indicator species (eg tainted fish) and gear and restriction or loss of access to an area, it also will impact the fish spawn and could potentially wipe out an entire years' spawning cycle and therefore ongoing longer cumulative repercussions and significant reduction of the sustainable viability of a commercial fishery.
    - Reputation damage could potentially be significant resulting in long term lack of demand and or lower market price.
    - Woodside notes that the risk of unplanned large spill is highly unlikely, this may be so from a desk analysist perspective. We didn't expect the Deepwater Horizon incident therefore we must look at this as a probable outcome.
    - There is no mention at all in the information sent to WAFIC of any form of compensation to loss and or damages to commercial fishers. On behalf of commercial fishers WAFIC seeks further information on Woodside's planned process should commercial fishers / a commercial fishery suffer financial, ongoing and cumulative loss.

I look forward to a reply to the WAFIC submission in due course.

Yours sincerely

[redacted]

INDUSTRY COUNCIL INC

[redacted]

wafic.org.au

APPENDIX D SUBMISSIONS

APPENDIX D.5 ANON - 57NR-WV5N-V (PATRONS OF THE UWA ROCK ART CONSERVATION PROJECT)

Browse – NWS Expansion/ Burrup Hub Proposals

In our view, as Patrons of the UWA Rock Art Conservation Project, it is in the critical interests of the State and the world that these projects be rejected. We make the same submission for all three projects – which should be considered together - as their combined emissions will significantly and negatively impact on the Burrup rock art and on WA's total Greenhouse Gas emissions.

Our concerns with the Browse - NWS expansion proposals are due to the environmental, social and cultural impacts that these projects are likely to have on:

(a) The ancient indigenous rock art (petroglyphs) located on the Peninsula and surrounds.

Maintenance of the rock surface patina is vital for preservation of the petroglyphs. The project would result in increased sulphur dioxide and nitrogen dioxide emissions released during gas processing, which mix with moisture in the air to form **acid** that **dissolves the rock surface patina**.

The surface patina is formed with rock surface pH near neutral (pH 7), however the pH of rocks with petroglyphs across Burrup Road from the Woodside plant have fallen to 3.81, which can only have occurred as a result of mineral acids from industry. Scientists have stated that the patina will inevitably be dissolved once the pH falls to such low levels.

We note concerns expressed by scientists that **existing governmental conditions** on industry to protect the art **have not been implemented:** https://theconversation.com/where-art-meets-industry-protecting-the-spectacular-rock-art-of-the-burrup-peninsula-72964

In the March 2018 Senate Inquiry report, the majority strongly recommended inter alia that: "(a) **Urgent steps be taken to reduce and control industrial emissions** on the Burrup."

These findings echo the 2012 assessment of the Australian Heritage Commission that **industrial development on the Burrup poses a high risk** to the universal values standard required for World Heritage listing and that "**further industry would render it critical**".

There has been a **lack of cumulative counting** of the effects of total emissions from Browse NWS projects, together with the emissions from all existing industry on the Burrup peninsula, ships serving Dampier Port and fugitive emissions and off-shore venting of high-CO2 reservoirs in Commonwealth waters.

The impacts of total emissions must be calculated, considered, regulated and monitored.

In our view it is vital that **current and future emissions should be strictly regulated to be at or near zero**. We understand that technologies exist that can limit NOx and SOx emissions to near zero.

Given Woodside's high profits, there can be no financial impediment to Woodside employing such technology. Furthermore, under the Polluter Pays principle it is appropriate that the company bears the financial burden of reducing emissions.

(b) <u>Increasing WA's greenhouse gas emissions (CO2, methane, nitrous oxide) which affects Australia and the world by increasing the impacts of climate change.</u>

Given the **severe impacts of global heating** as evidenced in Australia's recent calamitous bushfires, it would be the height of irresponsibility – and in clear contravention of the Precautionary Principle and the Principle of Intergenerational Equity - to allow the expansion of a large and polluting fossil fuel industry.

Natural gas is not a 'clean alternative' – it is a **fossil fuel**, like oil & coal, that is around 90% methane, which is 34 times more potent than CO2 in trapping heat.

Furthermore, it is clear that **WA cannot expand the LNG industry and meet its policy goal of net-zero emissions by 2050.**

Given the importance of this site and its immense environmental, social and cultural heritage values, we urge the EPA to recommend against these proposals.

Yours sincerely

[redacted]

Patrons, UWA Rock Art Conservation Project

21 January 2020

Woodside Energy

APPENDIX D SUBMISSIONS

APPENDIX D.6 ANON - 57NR-WV5Y-7

Submission to the Western Australian Environmental Protection Authority in relation to Woodside Energy Ltd Northwest Shelf Project Extension Environment Review Document: EPA Assessment No. 2186

9 February 2020

To Whom It May Concern:

RE: Submission to Protest the approval of the Northwest Shelf (Browse Basin) gas field being developed

<u>My Interest in the Rock Art on the Burrup</u>

I am an [redacted] Australia from the [redacted], having arrived in [redacted]. I ran my own [redacted] practice, based in [redacted], for many years, and spent a good deal of my career working with the Aboriginal communities in the WA regional areas. I have grown to love and respect their cultural, through many years of contact with them. I am also an artist, and have a love of the Aboriginal paintings, both on the rock surfaces, and the petroglyph rock art, found on the Burrup Peninsula.

In [redacted], I joined a Friends of Australian Rock Art tour for a week of visits to the Rock Art on the Burrup Peninsula. The breadth of the artwork, and the quantity of it was overwhelming. They say that there are more than one million pieces of rock art on the Burrup. (I grew up in [redacted] where there are also paintings by the [redacted], and also petroglyph rock art.) The difference is that the art on the Burrup is more than 40,000 years old, and is a continuous record of man's activities on planet Earth. Surely, this is one of the most important pieces of human history for all of mankind to be found on planet Earth, and needs to be protected and preserved at all costs. It is currently at risk of dissolving, due to the emissions over the Burrup from the industry located in the industrial estate.

<u>How Industry was allowed to develop on the Burrup</u>

Unfortunately, and much to my dismay, when we arrived on the Burrup, it was not the pristine outback landscape that I had anticipated, but rather a large factory processing LNG for Woodside and the Joint Ventures Project, managed by Woodside, as well as other industries. How on earth was industry allowed to co-locate on such a sacred cultural site? I then learned of the Flying Foam Massacre, in the 1860's, which totally wiped out the Yabararra tribe, keepers of this region, by the new white settlers.

So when it came to Native Title claims over this land, because it had not been "continuously occupied" by the local tribe (as they no longer existed!), it fell outside the Native Title claim criteria, and so it was opened up to an industrial development site.

Architecturally, the current Burrup industrial site is an expensive site to develop, because of the rocks. An alternative location is the [redacted] located South of Karratha, which would save all future projects a significant amount of money on site development, if they located on Maitland, rather than on the Burrup site. This would also ensure that no more rock art would be "moved" or interfered with for the construction of other projects. It would also mean that the NEAR ZERO EMISSIONS would have a lesser impact on the rock art on the Burrup.

1

Industries on the Burrup are many and varied

There are many industries and activities which compromise the cultural heritage of this region:

[redacted] was developed by **Rio Tinto**, to ship the iron ore from the Hammersley Iron Mine in Newman to Asian markets for refining. The ships carrying the ore pollute the air with the poor quality fuel that they are allowed to burn.

[redacted] **operated by Woodside.** Liquid natural gas was discovered off the shore of the Burrup, and the LNG processing plant was constructed by Woodside to develop the gas field, and bring the gas to shore, where it is turned into a liquid, for export shipping. (It is the process of turning the gas into a liquid that contributes to the pollution emissions that we are seeing on the Burrup.) And in calculating emissions, only scope 1 and 2 emissions are calculated, yielding a 7.7mtonnes/year, and excluding the 80.2mt/year of Scope 3 emissions when the gas is processed in another country.

In a quote from Woodside's own website: "Woodside is among six companies accused of making deceptive public statements in an attempt to get free carbon permits. The Australian Conservation Foundation says the companies exaggerated in public, but told a different story to their shareholders and investors. In June 2009, the ACF lodged an official complaint with the Federal consumer affairs watchdog asking that the matter be investigated.[21] The Australian Competition and Consumer Commission took no action against the companies.[22"] " So, if they are not held responsible for emissions, why should they aim at NET ZERO Emission?

The Joint Venture Plant for gas is also operated by Woodside.

The [redacted] was constructed, to produce fertilizer, which is also a highly toxic and polluting industry, owned by a consortium of investors.

An [redacted] was constructed, with strict guidelines about set-backs, in case there is ever an explosion within the plant. Being an architect, I noted that the set-backs are not adhered to, nor are there adequate earth berms to protect other industry located on the Burrup. (Who approved this design, I ask myself?)

[redacted] **built and currently awaiting a licence to operate, (**having deceitfully operating without its own licence for many months), presenting itself as an "extension" to the current licence held by the [redacted]

And now the West Australian government is promoted MORE industry to co-locate on the Burrup, which will add to the already polluted atmosphere, and further regress our New Zero emissions to meet the Paris Climate Change agreement by 2050.

If the Browse Basin is allowed to be developed, it would add 4xs the pollutants to the air of an already polluted environment, to produce for fossil fuel, into a declining marketplace. As other countries around the world start to shift to non-fossil fuel alternatives, the market is falling out of what was a very lucrative industry (Woodside's profits last year was in excess of $1billion, as shown on their website). From a business investment point of view, the numbers would not be stacking up on investor's monies in this project, with the world facing Climate Change issues, and global warming issues. Developing the Browse gas field is highly risky, with a 900km line to even get the product to the shore for processing. International companies, who are part of this consortium, do have strict environmental guidelines to adhere to, and their shareholders will be requiring these targets be met, which will make it even less viable as an investment of their funds.

2

Monitoring of Emissions on the Burrup

Who is responsible for monitoring what is happening on the Burrup as far as emissions and pollutions and health issues are concerned? It appears as if the industry has been given a "carte blanc" to do whatever it wants to do. There appears to be no compliance requirement to the WA government, and with no one checking on what's really happening on the ground (or in the air). Industry is doing whatever increases their bottom line, with no regard as to their moral responsibility to protect and guard the scared rock art located immediately adjacent to their production plants.

I have spent the past few years educating myself about the rock art, how it is produced, and how it can be produced because of the patina that forms on the rock surfaces because the pH stayed at about 7 for many thousands and thousands of years. However, since industry and shipping have located on the Burrup, the pH has now dropped to such a level that the micro-organisms that grow on the rock surface can no longer grow (+3pH), due to the acid rain that falls on it, because of the emissions on the Burrup. The patina is microns thick, and at the current rate of destruction, the patina may dissolve entirely within our lifetimes. There is a call for a study to investigate how quickly the patina is dissolving, and the major causes of this happening. Until we get definitive data, this rate of dissolving is still unknown, but we know the lower levels pH WILL dissolve the patina—it's only a question of time.

World Heritage Listing for the Rock Art on the Burrup

For more than a decade, the WA government has indicated that they would nominate the Burrup Rock Art for World Heritage Listing. But nothing was actually done to expedite this. Finally, last year, the WA Government, backed by MAC (Murujuga Aboriginal Council), the local custodians of the site, agreed to submit the site for tentative World Heritage Listing. It took nearly a year to complete the study, at great expense, and the site has now been nominated. Assessment by UNESCO takes nearly 2 years to complete, and this will take the application to 2022.

In the meantime, the WA Government is supporting more developments like the BROWSE Basin gas field to be developed, who are asking for a licence until 2070, to process the gas on shore on the Burrup, adjacent to the current industrial plants. The gas in the BROWSE basin is different than the current gas being processed by Woodside. It is located in a strata that is full of Carbon Dioxide, and when it is mined, it will release carbon dioxide into the ocean and the atmosphere at a rate that would pollute more than 4xs the Adani Coal Mine, currently being considered for development in Queensland. As the current level of emissions from the combined industry is destroying the rock art now, what will happen when and if the new project is allowed to proceed? **THERE WILL BE NO MORE ROCK ART---MAN WILL HAVE OBLITERATED 40,000+ YEARS OF HISTORY just to make a profit.**

And the assessment for World Heritage Listing will be denied, because the site is too compromised. So, the government is seen to "look good" because they supported the nomination, knowing full well if more industry is developed on the Burrup, further compromising the air quality, they can blame the UNESCO assessment team for not approving the site, not themselves contributing to the deniable of World Heritage Listing.

So what is the cultural significance of this rock art? If you compare it to other World Heritage Listed Sites, this is how it looks:

Taj Mahal---a couple of hundred years old
Pyramids in Egypt---2,000 years old

Cave Paintings in France---8,000 years old
Rock Art on the Burrup---40,000+ years old. And no one knows anything about it!! How can this be? Surely the petroglyphs on the Burrup are some of the most important markings of mankind on the planet.

Climate Change

It is sad to note that there is no public access to any recording and reporting of emissions currently being spewed into the atmosphere on the Burrup. When Woodside was asked to supply the emission data on the site to the Friends of Australian Rock Art, they refused to make this data available, so that the pollution could be assessed, and the damage to the rock art investigated further. Climate change is happening. We need to hold large industry responsible for their contribution to the pollution. They need to be given targets to comply with. **There are technologies currently available that will reduce the emissions at the Woodside plant down to net zero. The cost of implementing these new technologies to the site has been assessed at approximately 1.5% of their annual profit for one year to install the new scrubbers.** You would hope that the shareholders of the company would demand that this be done, in order to mitigate the rise in temperatures due to Climate Change, and other natural disasters we have seen throughout the Australian continent in the past year.

And if the net zero targets are not met, there should be significant fines applied, and even jail terms for those responsible for non-compliance. This is a REAL Climate Change issue, causing all kinds of natural disasters, health risks, and escalating temperatures, with severe consequences to all inhabitants on Earth, as the sea level will rise due to increased temperatures, releasing methane into the air, which is currently trapped in the ice. Methane is 25 times more destructive than the CO2!!

Shifting to non-fossil fuel based technologies

There are other ways to produce energy, technologies that already exist: solar power, photovoltaic arrays, wind turbines, wave power, electric cars, etc. If the government starting supporting these industries in lieu of the LNG industry**, we would not need to open the BROWSE Basin, as the call for fossil fuels will decline over time.** We need to be pro-active in accelerating this shift away from fossil fuel use, as well as coal to more sustainable technologies. ACT is already 100% renewable energy sourced. For WA, a simple example of this would be if the WA Government started purchasing electric cars for their fleets, which would then flood the 2nd hand market in two years' time, and the general population would then have access to electric cars, at a reduced rate, and start the shift away from fossil fuel engines. 70% of the cars purchased in WA are 2nd hand cars…what a great opening into the marketplace this would be. UK will stop producing internal combustion cars by 2025. If there is no market for fossil fuels, there is no need to develop the Browse Basin at all.

Health Concerns

Health issues in Karratha and Dampier for workers and residents are of concern, and they can be put down to living in an environment full of emissions from the industry on the Burrup, including CO_2, NO_2 and $PM_{2.5}$. There is strong evidence that these emission are affecting the health of the people living in this area. Results from the Pilbara Health Profile Planning and Evaluation Unit report in Nov 2018 show children aged between 0-14 years are hospitalised for lung disorders of asthma (1.7xs more than the WA State Average) and bronchiectasis, which is damage and widening of the airways (11.5xs more than the WA state average.) And what of the workers who are at the plants, inhaling emissions on a daily basis? Surely, there will eventually be class action suits against both Woodside

4

and the government that allow this to happen. Isn't it time for the WA state government to start enforcing measures to mitigate this health risk? Didn't anyone learn anything from Wittenoom, and the Asbestos lung diseases? It can happen again, and should happen again, if no action is taken to reduce the emissions on the Burrup.

Summary

As for protecting the rock art on the Burrup, all industries currently located there MUST be required to meet NET ZERO targets within a very short time frame. Technologies currently exist to do this. We cannot allow industry to destroy the cultural heritage of this unique site.

All future development must be located at the Maitland Industrial Estate, on the other side of Karratha, where it will not interfere with the rock art, and again meet the NET ZERO emission targets.

Ships must be required to use a low-toxic fuel, to reduce their emissions at the Dampier port.

From a business review point of view, with a rapidly declining market for fossil fuels, there would be no need to develop the Browse Basin, if governments around the world take up the Climate Change initiative, and proactively promote passive energy sources. **For WA, rather than continue to be one of the worst polluters in Australia, you can change this around to become a world-leader in initiatives that will showcase how to reduce, and then eliminate, the use of fossil fuels.**

There are three separate submissions being called for at the present time. And yet they are all intrinsically linked, and part of the same project. But no one agency will be charged with assessing all three responses to the call for submissions, when in fact, it should all form a part of the same assessment and evaluation of submissions. It IS all a part of the same project, after all! I will be sending my submission to all three proposals for consideration, as it needs to be looked at by all the assessors.

Yours sincerely,

[redacted]

(m) [redacted]

5

APPENDIX D SUBMISSIONS

APPENDIX D.7 ANON - 57NR-WV7B-J

North West Shelf Project Extension - Public Environmental Review
Submission - [redacted]

1. **Principles to Observe**

The following key Principles are well established globally and the WA Government claims to uphold them. For this claim to be credible the following points need to be observed:

Precautionary

While evidence is mounting that the existing pollution load on Murujuga is incompatible with the long-term survival of the local rock art, this principle demands at least a pause in the rush to expand and consolidate the industrial footprint in the region. Any claimed uncertainty over the impact of emissions on the rock art of the Burrup peninsula must be tested against the open source monitoring currently underway.

Polluter pays

Woodside must be required to spend a small proportion of its profits on reducing nitrogen and acid-forming emissions to practically zero, as is technically feasible, by implementing existing world best practices. This should not be money subtracted from its tax liabilities which would effectively result in tax-payers funding corporate pollution.

Intergenerational equity

This principle is being ignored when there is a significant risk of the irreplaceable cultural heritage on Murujuga being destroyed by industrial pollution before today's children are the age of today's decision makers.

Appendix H to the Woodside submission agrees to protect the heritage values of the site "whilst recognising the economic and social benefits of the Burrup Peninsula industries for the people of WA".

This is a meaningless "motherhood" statement which must be enforceable through rigorous monitoring and regulation requirements or else discounted as public relations and spin.

2. **North West Shelf Expansion**

The Woodside proposal to extend the NWS plant life to 2070 is entirely incompatible with any realistic net-zero emissions reduction target for 2050.

It would involve extending the life of existing infrastructure far beyond that originally planned and financed for. It's a massive free-kick for Woodside and its shareholders with equally massive negative consequences for the environment, tax-payers, the local inhabitants and the unique and irreplaceable Murujuga rock art.

In economic terms the externalities have not been accounted for.

3. **Browse Basin Expansion**

To utilize the proposed NWS expansion, production in the Browse Basin is set to massively increase. The scope of this expansion will cross WA / Commonwealth boundaries on the sea floor and in terms of responsibility. How can the State Government claim to be responsibly managing the future impact of this expansion when in truth no-one will have authority to assess the project's global impacts from:

- offshore pollution from venting and transporting gas hundreds of kilometres via pipelines;
- onshore pollution from processing; and
- emissions from burning gas overseas?

North West Shelf Project Extension - Public Environmental Review
Submission - [redacted]

4. WA's Climate Policy

This Consultation has been launched when WA's climate policy is not yet complete and the EPA has just released draft guidelines for assessing major polluting projects. These will require proponents to submit plans showing how they will "reasonably and practicably avoid, reduce and offset emissions to contribute to the state's aspiration of net-zero emissions by 2050."

To allow the NWS Project Extension's target-busting suite of proposals to be processed and potentially allowed before the State's climate policy is in place would reduce that policy to fig leaf status. We can't pretend to be serious about emissions while allowing a project of global significance and multi-decade impact to proceed as if it does not need to be included in our climate policy calculations.

The east coast of Australia has the Adani coal mine and in the NWS Project Extension we have our own challenge to the Government and citizens of the state and nation. Jobs and growth versus local and global long-term environmental degradation. The choice is ours.

APPENDIX D SUBMISSIONS

APPENDIX D.8 ANON - 57NR-WV7V-6 (AUSTRALIAN PARENTS FOR CLIMATE ACTION)

Australian Parents for Climate Action

The Chairman
Environmental Protection Authority
Locked Bag 10
Joondalup DC WA 6919

11 February 2020

Dear Sir/Madam

Australian Parents for Climate Action is an organisation whose membership is everyday mums and dads who speak up about climate issues on behalf of their children. We demand change from all sectors of society so that Net Zero emissions are achieved in the shortest timeframe possible so that our children will have the best future possible.

This letter is in response to the Browse to North West Shelf (NWS) Project and North West Shelf (NWS) Extension Project proposals, which are open for public submissions to 12 February 2020. These proposals collectively provide for the development of the Browse gas field and the extension of Karratha Gas Plant approvals to allow Browse gas to be produced to 2070.

The world needs to have achieved Net Zero emissions by 2050 at the latest. The extraction and processing of gas has been shown to increase, not decrease, emissions.

These proposals are not in the public interest. The greenhouse gas impact 'acceptability assessment'[1] is flawed as outlined below, and as such, the proposals are not consistent with ecologically sustainable development nor can Australia accommodate these emissions and still meet its Paris Climate Agreement commitments.

The Browse proposals seek to justify project greenhouse gas emissions based on the International Energy Agency (IEA) 2018 World Energy Outlook (WEO) "Sustainable Development Scenario". The proposals argue that project emissions are acceptable because the 2018 WEO indicated that global natural gas demand would continue to increase to 2040 and that natural gas offers benefits in terms of coal-to-gas switching. The Browse proposals argue that *"increased gas use is not only consistent with the [Sustainable Development Scenario] but necessary if the goals of climate change mitigation, air quality improvements and energy access are to be achieved."*[2]

However, the 2019 WEO, released in November 2019, has significantly revised the role of gas in its latest energy outlook. The IEA states *"The world urgently needs to put a laser-like focus on bringing down global emissions"*[3] and, under its revised Sustainable Development Scenario, which "charts a path fully aligned with the Paris Agreement", significantly revises and reduces the role of gas. Under the 2019 WEO revised scenario, natural gas is predicted to reach a global high point by the late 2020s, before declining to lower than 2018 levels by 2040.[4] In the Asian market specifically, demand continues a little longer (into the 2030s) however, by 2040, "LNG demand is falling back in several markets".[5] In other words, falling back *sooner than halfway* through the project's 31 to 44 year economic life.

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Other key justifications for gas cited in the Browse proposals are also now in doubt. This includes whether LNG will be price-competitive with local Asian gas supplies (the IEA notes there is "significant uncertainty … as to the scale and the durability of demand for imported LNG")[6]; whether LNG facilities will be fully utilised[7]; and whether coal-to-gas switching in Asian markets has an economic case (i.e., coal-to-gas switching is considered out-of-reach without a $60/tonne CO_2 price on carbon)[8]. Renewables are now the lowest-cost source of new power generation[9] and hydrogen could also be price-competitive for many applications by 2030[10]. The IEA further noted that "a fast-moving energy sector would change the game" for gas production and only those with "low-cost resources and tight control of costs and environmental performance would be in the position to benefit".[11] Browse gas, in particular, has very high CO_2 content in its raw gas, so inherently doesn't stack up well for 'environmental performance'.[12]

Concerningly, the three-part nature of the approvals process for Browse means no one authority will assess the entire impact of what, ultimately, is a single project. Nowhere in the Browse proposals is an estimate of whole-of-project emissions.

Calculations (based on Tables 7-5 and 7-9 of the Browse to NWS Project Draft EIS/ERD and Tables 6-12, 6-15 and 6-16 of the NWS Extension Project PER) suggest the development's direct emissions could add between 12.5-19.7 $MtCO_2e$ to Australia's total emissions (this equates to up to 15% of the amount of emissions Australia committed to reduce by 2030 under the Paris Climate Agreement) and represent 0.07-0.17%[13] of total global emissions. In other words, the Browse development would be the source of more emissions (including direct emissions in producing the gas and indirect use of burning the gas) than the *direct emissions of 88 of the world's countries*,[14] each of which is party to the Paris Climate Agreement and therefore committed to reducing emissions.

The commitments to offset emissions from the proposals are also weak and insufficient. The Browse to NSW Project proposal commits to mitigate or offset around 25% of its emissions in an 'average' operating year (this equates to only around 14% of its 'peak' year), whereas the NWS Project Extension looks to an 'interim' offset of 330,000 tonnes CO_2e in total (equating to less than <1% of annual emissions) sometime before 2030. Despite seeking approval to operate to 2070, the proposals do not substantially or convincingly address how the project would contribute to Western Australia's 'aspiration of net zero by 2050'[15].

International energy forecasts and the current LNG market itself[16] throw the present need for this project into doubt. In light of this, the fact that Woodside is proposing simultaneously development of its nearby Scarborough field (and the Scarborough gas resource estimate was increased by 52% in November 2019) should also be considered.[17]

The Australian and Western Australian governments would be remiss in their national and global responsibilities to not give serious consideration to these factors. The world's remaining carbon budget is already set to be depleted by current, under construction and operational infrastructure—without significant new proposals.[18] It would be remiss in light of the clear warnings and revised 2019 scenarios issued by the International Energy Agency to achieve strong emissions cuts. And it would be remiss under the Paris Climate Agreement, as the Australian Government's own 2019 report[19] indicates that the direct emissions from these proposals, which equate to around 2.3-3.7% of Australia's total 2019 emissions, cannot be accommodated or offset by 2030 and still enable Australia to meet its international commitments.

Our international commitments are not a secondary concern to Australian jobs and the broader Australian community. These commitments are a primary concern to achieving ecologically sustainable development and enabling Australian children to grow up in a world where their health, environment, economic opportunities and security is assured.

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[1] Browse to NWS Project Draft EIS/ERD, p.698

[2] Browse to NWS Project Draft EIS/ERD, p.698.

[3] https://www.iea.org/reports/world-energy-outlook-2019

[4] https://www.iea.org/reports/world-energy-outlook-2019/gas#abstract

[5] IEA, The Oil and Gas Industry in Energy Transitions: Insights from IEA analysis", Page 71.

[6] https://www.iea.org/reports/world-energy-outlook-2019/gas#abstract

[7] IEA, The Oil and Gas Industry in Energy Transitions: Insights from IEA analysis", Page 71.

[8] https://www.iea.org/reports/world-energy-outlook-2019/gas#abstract

[9] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/May/IRENA_Renewable-Power-Generations-Costs-in-2018.pdf

[10] https://hydrogencouncil.com/wp-content/uploads/2020/01/Path-to-Hydrogen-Competitiveness_Full-Study-1.pdf

[11] IEA, The Oil and Gas Industry in Energy Transitions: Insights from IEA analysis", Page 12.

[12] https://www.reuters.com/article/us-australia-lng-carbon-fb/factbox-projected-co2-emissions-from-top-australia-lng-projects-idUSTRE7491FU20110510; https://www.afr.com/companies/energy/carbon-speedbump-may-hit-woodsides-dealmaking-on-lng-20190308-h1c68k

[13] Browse to NWS Project Draft EIS/ERD lists project emissions as 0.06-0.16% of global emissions; 0.07-0.17% comes from including the NWS Extension Project emissions; excluding the processing of existing North West Shelf gas through the Karratha Gas Plant. See: Tables 7-5 and 7-9 of the Browse to NWS Project Draft EIS/ERD and Tables 6-12, 6-15 and 6-16 of the NWS Extension Project PER.

[14] https://en.w kipedia.org/w ki/List_of_countries_by_greenhouse_gas_emissions

[15] https://www.der.wa.gov.au/images/documents/your-environment/climate-change/Greenhouse%20Gas%20Emissions%20Policy%20for%20Major%20Projects.pdf

[16] https://ieefa.org/exxonmobils-woods-still-betting-on-long-term-growth-in-global-lng-market/; https://www.afr.com/companies/energy/seeds-of-next-lng-glut-already-being-sown-report-20200108-p53pom

[17] https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/110819-woodside-lifts-australia-scarborough-gas-resource-estimate-by-52

[18] https://www.weforum.org/agenda/2020/02/capturing-and-storing-co2-will-be-key-to-the-clean-energy-transition-heres-why/

[19] http://www.environment.gov.au/climate-change/publications/emissions-projections-2019

Thankyou for taking the time to consider our submission and we ask that when you make a decision on this project that you close your eyes and imagine your children and grandchildren, and the world these projects will leave for them. Don't imagine the best case scenario, imagine the worse, because this is what you may be leaving for the world's children.

Sincerely

[redacted]
On behalf of
Australian Parents for Climate Action
[redacted]

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APPENDIX D SUBMISSIONS

APPENDIX D.9 ANON - 57NR-WV8T-5

Submission to Assessment 2191: [redacted]
Proposed Browse to NW Shelf Project (Commonwealth Waters)

The 'controlling provisions' identified in your Overview as being relevant to the Commonwealth component of Woodside's EIS **under the EPBC Act are:**
• National heritage values of a National Heritage Place
• Listed threatened species and communities
• Listed migratory species
• The Commonwealth marine area, **the protected matter being the environment generally.**

The Australian environmental community is painfully aware that the EPBC Act is dismally outdated; it is shameful that a Federal Environmental Protection Act should not factor in a proposed project's impact on the global climate. (Global warming was mosts definitely well-known and much talked about at the time of this Act's last review 10 years ago!) It is greatly hoped that the current review of this Act (submissions due in April!) with mobilisation by the major national environmental NGO's, will mean that the to-be-revised Act will be able to block such proposals on the grounds of excessive impact on the climate, such as this one, [redacted], due to emit SIX BILLION TONNES of CO2e-.

The 4th 'controlling provision' does mention **'the protected matter being the environment generally'.** Warmer temperatures with the concomitant de-oxygenation and acidication of the oceans are negatively affecting marine life around the planet, and this will only get worse with further global heating. I am no marine biologist but I know that this sounds bad!

The NWS proposal also threatens several Ramsar wetlands of International Importance, undermining Australia's longstanding commitment to the Ramsar Convention, signed in 1975.

The Burrup Peninsula rock art/Murujuga Petroglyphs.
This collection of a million+ items of rock art is utterly unique, representing 50,000 years of human history, containing the world's oldest surviving depiction of a human face, and having deep meaning for the Traditional Owners. The move to have the area declared a UNESCO World Heritage Site has recently moved closer and apparently has a good chance of success.
Murujuga World Heritage listing one step closer 28 January 2020
A Tentative List Submission for the Murujuga Cultural Landscape has been formally transmitted by the Australian Government to the UNESCO World Heritage Centre so the area can be added to Australia's World Heritage Tentative List later this year.
https://www.mediastatements.wa.gov.au/Pages/McGowan/2020/01/Murujuga-World-Heritage-listing-one-step-closer.aspx

Some physical and chemical damage has already occurred; the Burrup Hub proposal seriously threatens it further. But conversely, surely a successful World Heritage listing in 2022 will threaten the social licence (at least!) of an extension of LNG processing in the vicinity for another 50 years!

If the EPA does approve the project, Woodside's EIS should at the very least include a comprehensive strategy for managing the impact of processing emissions on the petroglyphs**, with a world-class air quality monitoring program and a guarantee that acidity damage is managed regularly and thoroughly.**

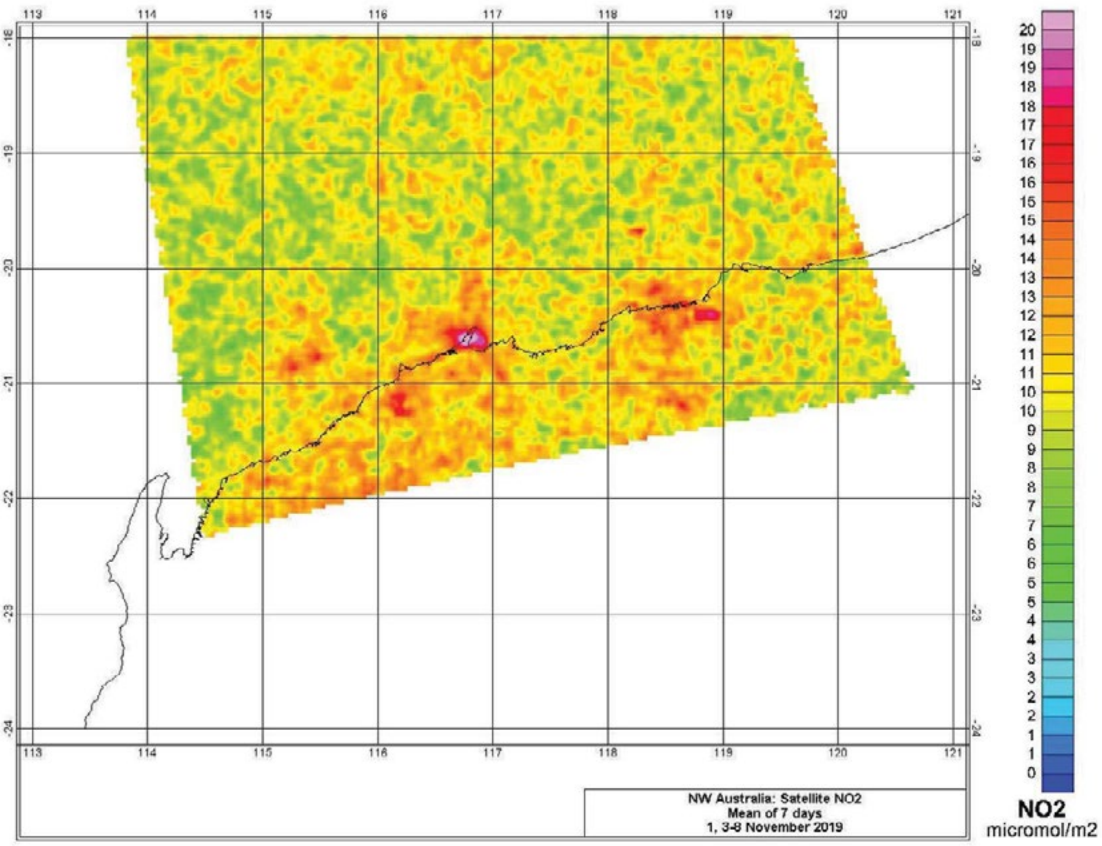
APPENDIX D SUBMISSIONS

APPENDIX D.10 ANON-57NR-WV53-1

Air Pollution over the Burrup Peninsula

I have not seen any data from ground monitoring stations for any of the polluting gases associated with Industry on the Burrup (Transport, Ammonia, Explosives) because none are freely available.

However, nitrogen dioxide (NO2) data from a European space satellite, the Sentinel-5P, has been freely available since 2018. Data averaged over 7 days shows clearly that NO2 is anomalously high over an area about 20 km in diameter (the resolution is about 6 km) centred over the Burrup near the natural gas treatment plant. No similar anomalies from averaged data are seen over Port Hedland or the major mining towns of Tom Price and Newman, though much wider anomalies are well known over major world cities. It is highly likely that the natural gas and other industries based on the Burrup Peninsula are responsible for this anomaly, and for the well-known increase in pH measured at rock surfaces on the Burrup, which will destroy the Rock-Art.



The existing industry on the Burrup is evidently producing significant acid air pollution (including NO2) over the Burrup such that it can be detected by satellites. If the Browse Basin gas is piped to the Burrup Hub for processing then polluting emissions will hugely increase, as will also damage to the Rock-Art. This will likely make it impossible for the Burrup to achieve the World Heritage status that WA is applying for.

Moreover, from a global perspective, greenhouse gas emissions will also hugely increase, making this one of the largest and most polluting fossil fuel projects in the world. The outcome will be that neither WA nor Australia will be able to meet their Governments' stated policy goals of “net-zero emissions by 2050”.

Although apparently separate projects, the three proposals are totally integrated as the Burrup Hub. This environmentally disastrous project should not be approved.

[redacted]

24/1/2020

APPENDIX D SUBMISSIONS

APPENDIX D.11 ANON - 57NR-WV75-5

Member for the Mining & Pastoral Region
in the Western Australia Legislative Council
[redacted]

[redacted]

Dr. T. Hatton

The Chairman, Environmental Protection Authority

Locked Bag 10, Joondalup DC

WA 6919

Dear Dr. Hatton, Chairman

RE: Proposed Browse to North West Shelf Project – Commonwealth Component

I tender this submission, regarding the proposed expansion by the Browse Joint Venture, on the North West Shelf (NWS), in the hopes of highlighting the many potential environmental threats borne by this project. *The Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) lists nine matters of national environmental significance. An expansion in industry in this area directly places six of these matters at risk – the only exceptions relating to nuclear issues, CSG development, and Queensland's Great Barrier Reef, which are all outside of the scope of this submission.

The EPBC Act (1999) enhances the management and protection of Australia's heritage places, including World Heritage properties. The NWS venture presents a significant threat to the tangible cultural history of Western Australia's First People. Although the proposal is for mostly-offshore infrastructure, the products will be brought onshore via the Burrup Peninsula Industrial Hub; a site of human activity and habitation since the Pleistocene era[1]. On the sole basis of age alone, the Lascaux Caves of France have achieved international

[1] https://media.australianmuseum.net.au/media/dd/documents/1687_complete.68d847c.pdf

Member for the Mining & Pastoral Region
in the Western Australia Legislative Council
[redacted]

[redacted]

recognition and protection, via UNESCO, and it would be reasonable to expect the same protections be awarded in this case also. Whilst the preservation of Murujuga Petroglyphs has never been a priority of government, the Honourable Minister Dawson (Minister for Environment) announced[2] that "[the] preparation of the tentative list submission [for the Burrup peninsula] has begun.", begging the question of the fate of industry in the area when it falls under UNESCO protection.

The recent surge in industrial activity at this site has already led to irreparable physical damage (from construction) and chemical damage from a universal, lax approach to emissions and pollution. The Venturers intend to dredge the seabed – allowing for the pipeline – both during construction and also at regular intervals for maintenance. The ERD supplied by the proponent goes to great lengths to characterise the heritage values of the terrestrial Murujuga petroglyphs however, it does not consider those cultural remains that are presently submerged in coastal waters[3], due to the rise in sea levels since the last glacial maximum. The extent and nature of the submerged cache is uncertain, and not addressed by the Venturer's ERD. Considering the proponents seek to dredge the sea floor to install pipelines, it would be good practice to first record and evaluate the cache and identify risks and management plans for such artefacts.

The cultural artefacts – either physical or intangible - of Australia's First peoples is Modern Australia's access to a millennia-old culture; intrinsically tied to lands, waters, and the life they support. A loss of this heritage through such casual and unnecessary destruction is a loss of heritage for all Australians, and a loss for the

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[2] Question Without Notice No. 31 asked in the Legislative Council on 13 February 2019 by Hon Robin Chapple
[3] Dortch, 2002; DOI: 10.1080/03122417.2002.11681739

Member for the Mining & Pastoral Region
in the Western Australia Legislative Council

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wider global community. The coasts and waters of our North are themselves sites of intangible cultural history. It cannot be argued, in any capacity, that this Joint Venture seeks to preserve the cultural landscape and it is not unreasonable to fear that this venture represents a precedent in large-scale cultural erasure by Industry.

Also listed as a matter of national environmental significance, this Joint Venture proposal could foreseeably jeopardise several Ramsar wetlands. The *Environment Protection and Biodiversity Conservation Act* (1999), Subdivision B, §16.1.a-b, states explicitly that "a person must not take action that is likely to have a significant impact on the ecological character of a declared Ramsar wetlands"[4]. Perhaps not a priority of the current Government, Australia has a long-standing and international commitment to the preservation of wetlands of international importance under *The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat* ("the Ramsar Convention"; "the convention on wetlands"). The Australian wetland classification system, agreed to by the ANZECC Wetlands Network in 1994, identifies three types of wetland (A, B, and C) and the proposal of the Joint Venturers has the capacity to wreak havoc on both Marine & Coastal Zone (type A), and Inland wetlands (type B). Given the history of environmental mismanagement, pollution, and opacity in the Industrial Sector in Australia, it is reasonable to assume that the commission and operation of the proposed structures would bear additional, unforeseen environmental risk. Whilst it is noted that the proposal is mostly off-shore, a rudimentary understanding of ocean ecology highlights the threat posed by an increased, extractive industry presence within the vicinity of Ramsar wetlands. A quick overview[5] gives seven sites at potential risk, in case of a potential ecological incident such as oil spills, damage to the structures, et cetera. Roebuck Bay, Eighty-mile Beach, Ord river floodplain/estuary, and Ashmore Reef

[4] Cf *The Act*, §17B
[5] https://www.environment.gov.au/system/files/pages/d3389750-50fc-4ed3-9e2a-0652b74913f8/files/ramsar-sites-australia.pdf

Member for the Mining & Pastoral Region
in the Western Australia Legislative Council

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Nature Reserve stand to be more-directly affected in such an instance - and even potentially those sites around Christmas Island, and the Cocos/Keeling Islands, by way of the South Equatorial Current. Additionally, ecological disturbances offshore in our north could be reasonably argued to pose further threats to the mangrove forests of Northern WA, and the Northern Territory (home to 39% of all coastal mangroves in Australia) through increased industrial pollutants, trace nutrients, sediment and pH fluctuations.

The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) lists, amongst its matters of national environmental significance "listed threatened species and ecological communities". The waters around WA, including around the proposed site of the works, are home to myriad mammal, reptile, fish and invertebrate species. The Department of Parks & Wildlife[6] list the three WA species of sea snake as *'critically endangered'*, three species of whale listed as *'endangered'*, three species of endangered turtles in WA; going on to list several more aquatic mammals -- such as the Australian Sea Lion – as *'vulnerable'*, alongside fish, invertebrate, and bird species. These are just a sample of those species that are under federal protection, many of which inhabit the coasts and warmer seas of our far north. Many cetaceans take advantage of these warmer currents to give birth and nurse young; a behaviour jeopardised by construction of an extractive industrial structure and the disturbances associated with drilling into the oceanic crust. When one also considers the role of vocalisations and sound in whale and dolphin populations, it becomes apparent how detrimental increased construction and operational noise may be, especially for newborn calves. Whilst industrial disasters are often critically anticipated and rectified, it is a terrifying gambit to risk entire taxa of aquatic species for the bottom line of a multinational corporation, – let alone

[6] https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/fauna_notice.pdf

Member for the Mining & Pastoral Region
in the Western Australia Legislative Council

[redacted]

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the profit margins of several multinationals in simul – even more so when one considers the limited operation timeline of a fossil fuels venture in the fallout of current unprecedented national climate aberrations.

In similar vein, through a series of bottle-necks between Australia, Timor-Leste, Papua New Guinea, and Indonesia, migratory aquatic organisms are channelled directly through the site of the proposed offshore structures. As argued above, the disturbances borne by commission alone are enough to discredit the project as environmentally unsound. In addition to directly interrupting the migratory path of cetaceans, marine teleosts, and their predators; any local, small-scale dependants on these natural movements are at risk. One need only look to other projects in this state to discern the alarming pattern of non-compliance and ravenous extractive methodology. Given the enormity of their available resources, the ability of the Joint Venturers to misreport, obscure, and omit ecological data, if they should choose to do so, is a very genuine fear. Again, it must be said that this proposal is rewarding for a few, at the risk of total collapse of our marine ecology – not just locally but across an international area.

The Commonwealth marine area is any part of the sea, including the waters, seabed, and airspace, within Australia's exclusive economic zone and/or over the continental shelf of Australia, that is not State or Northern Territory water; typically extending from three to two-hundred nautical miles from the coast. The proposal by these Joint Venturers sits adjacent to several Commonwealth Marine Reserves[7]. The proposal by these Joint Venturers threatens the ecological resilience of those several Commonwealth Marine Reserves[8]. The commission and operation of two Floating Production Storage and Offloading facilities (connected to existing NWS infrastructure via a 900-kilometre trunk line) will obviously have discrete effects at a local level.

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[7] http://www.environment.gov.au/system/files/pages/709fa30c-d649-4d66-8dfb-b831d1f9ec16/files/national-map.pdf
[8] http://www.environment.gov.au/system/files/pages/709fa30c-d649-4d66-8dfb-b831d1f9ec16/files/national-map.pdf

Member for the Mining & Pastoral Region
in the Western Australia Legislative Council

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It is therefore prudent to consider the possible influences on the surrounding commonwealth reserves -- "containment", as a remedial measure, is impossible in such a volume of water. These arguments are independent and supplementary to the Commonwealths obligations to protect the intricate ecologies of Benthic sediments and the Euphotic zones within Its jurisdiction, which serve to further discredit this proposal on severe ecological grounds. In similar vein, Dr. K. Miller *et alia*, of the Australian Institute of Marine Science, have recently identified a novel species of siphonophores within the Kimberly Marine Park[9]. As a potential novel species, the organism has yet to be adequately characterised, with Dr Miller going on to work alongside taxonomic expert Dr. Mapstone, of the London National History Museum. On the grounds that this organism is yet to be fully understood[10] in either an ecological or physiological context, the Proponents have not addressed conservation or management of this species. Following this incredible discovery, the omission of this important facet of ecological management demands the project be suspended until these organisms are better understood and their management can be undertaken with a resilient scientific backing.

In similar vein, it cannot be said with any certainty that State and National Marine Parks, and other similar designations, are entirely safe from the effects of a several-company infrastructure expansion. The Oceanic Shoals Marine Park, Ashmore Reef Marine Park, Cartier Island Marine Park, Joseph Bonaparte Gulf Marine Park, Kimberley Marine Park, Argo-Rowley Terrace Marine Park, Mermaid Reef, Dampier, and Montebello Marine Park lie adjacent or down-current[11] to the proposed site with Gascoyne Marine park, Roebuck Marine

[9] https://www.watoday.com.au/national/western-australia/extremely-rare-marine-creature-discovered-off-wa-s-north-west-coast-20200123-p53u5s.html; **cf also:** https://www.smh.com.au/national/western-australia/extremely-rare-marine-creature-discovered-off-wa-s-north-west-coast-20200123-p53u5s.html
[10] Doctor Miller herself is quoted as saying "We can't manage things that we don't know exist...This is our best chance to be able to collect one of these really fragile animals intact and preserve [the organism] in a way that we can identify it properly."
[11] https://parksaustralia.gov.au/marine/parks/north-west/montebello/

Member for the Mining & Pastoral Region
in the Western Australia Legislative Council

[redacted]

[redacted]

Park, and Ningaloo Reef potentially vulnerable in the worst-case scenario. This doesn't account for the possibility of damages to the ecology of neighbouring jurisdictions, such as Indonesia, which may come to influence our relationships with neighbouring powers. It follows therefore that this project directly threatens the environmental (and by proxy; recreational) qualities of the area – a blatant disregard for the spirit of the *Australia–Indonesia Memorandum of Understanding regarding the Operations of Indonesian Traditional Fishermen in Areas of the Australian Fishing Zone and Continental Shelf – 1974.*

Also worthy of concern, the projects adjacency to Rowley Shoals, and Scott and Seringapatam Reefs, is of serious concern in relation to coral communities. The venturers, in feigned earnest, propose to survey coral populations in the area once every five years[12]. The shallow coral habitats are most vulnerable to hydrocarbon coating by direct contact with surface slicks during periods when corals are tidally-exposed, particular during spring low tides. Coral communities have the potential to be impacted from exposure to floating hydrocarbons through smothering and coating, and exposure to dissolved and entrained hydrocarbons[13]. Exposure to dissolved and entrained hydrocarbons (≥50 ppb and 100 ppb, respectively) has the potential to result in lethal or sub-lethal toxic effects to corals and other sensitive sessile benthos within the upper water column, including upper reef slopes (subtidal corals) and reef flat (intertidal corals). Should a hydrocarbon release occur at the time of coral spawning (at potentially affected coral locations), there is the potential for a significant reduction in successful fertilisation and coral larval survival. The coasts and waters of WA contribute, hugely, to

[12] P51
[13] §4.4.2.3, p55

Member for the Mining & Pastoral Region
in the Western Australia Legislative Council

[redacted]

[redacted]

our tourism sector This proposal – in addition to our waters, heritage, and ecology – now threatens human recreation and enjoyment of our coral reefs.

By gambling with millennia-old ecosystems, people's livelihoods, ecological stability, and our tourism sector, the government wishes to secure employment for a select few, already working within the extractive industry. This will be achieved through the questionable FIFO proforma already wreaking havoc in our State's communities. The possible returns on this foolish bet are negligible for the average Australian who doesn't trade commodities by the tonne. This expansion is to line the pockets of our biggest polluters. To even consider an expansion in LNG while half our country faces the collapse of entire ecosystems is absolutely ludicrous. This expansion represents a choice on behalf of Government. It's not about jobs, economic growth, or giving Australians a "fair go"; this expansion is to sell the very water itself at a blood-stained profit, while a select few make billions of dollars from the carnage.

It is my hope, as we pass into the eleventh hour of unprecedented climate and environmental change, these concerns are taken in earnest; our marine species are protected and able to flourish, and we cease to give *carte blanche* to those who would profitably destroy our lands and waters, our heritage, and our quality of life.

Member for the Mining & Pastoral Region
in the Western Australia Legislative Council

[redacted] [redacted]

Yours sincerely,

[redacted]

[redacted]

Member for the Mining and Pastoral Region

February 11th, 2020

Woodside Energy

APPENDIX D SUBMISSIONS

APPENDIX D.12 ANON - 57NR-WV79-9

11 February 2020 [redacted]

Draft EIS / ERD / PER Submission: Browse Development

1. Introduction

The Browse Joint Venture, operated by Woodside, is seeking Western Australian Government and Australian Government approvals to develop the Browse Basin and produce liquefied natural gas for up to 50 years, to 2070. This submission is lodged in response to the following proposals, open for public submissions until 12 February 2020:

- Browse to North West Shelf Project (Commonwealth and State components)
- North West Shelf Extension Project

Together, these proposals provide for the development of the Browse Basin by the Joint Venture.

The comments in this submission relate to impact and acceptability of the greenhouse gas emissions from these proposals. In particular, this submission draws attention to changes between the International Energy Agency (IEA) 2018 World Economic Outlook for gas, which is discussed in the Browse proposals to justify project emissions, and the more recently released 2019 World Economic Outlook, which significantly revises and reduces the role of gas under its Sustainable Development Scenario in order to achieve Paris objectives.

2. Project Emissions

The proposals set out the greenhouse gas emissions arising from the development as follows. Table 1 estimates Scope 1 (direct) emissions and Table 2 estimates Scope 1-3 (direct and indirect) emissions.

Table 1: Annual contribution to Australia's Emissions (Scope 1)

Component	Annual Contribution to Australia's Emissions (Scope 1)	Total Life-of-Project GHG
Browse to North West Shelf Project (Commonwealth, including State component)	Average Year: **6.4 – 6.8** $MtCO_2e$ gross; **4.8 – 5.2** $MtCO_2e$ net Peak Production: **11.4 – 12** $MtCO_2e$ gross; **9.8 – 10.4** $MtCO_2e$ net (p. 686, Table 7-5)	Between **200 – 272** (depending on field life of between 31 and 44 years and success of GHG mitigation measures) (p. 686, Table 7-5)
North West Shelf Extension Project	**7.7** (p.111, Table 6-12)	**385** (p.111, Table 6-12)
Total	**Between ~ 12.5 – 19.7** (depending on average year versus maximum year and success of GHG mitigation measures)	**Between ~ 585 – 657** (depending on field life of between 31 and 44 years and success of GHG mitigation measures)

Table 2: Percentage contribution to Annual Global Emissions (Scope 1, 2 and 3)

Component	Total Annual and Life-of-Project Emissions	% Contribution to Global Emissions (Scope 1 and 3)
Browse to North West Shelf Project (Commonwealth, including State component)	Estimated annual GHG emissions: Between **32 – 55** (average year -peak year) Estimated life-of-project emissions: **995 – 1330** (depending on field life of between 31 and 44 years) (p.688, Table 7-9)	Full lifecycle (Scope 1 and Scope 3): **0.06% to 0.15%** of global GHG emissions (depending on the NDC scenario considered) (p.695, Table 7-13)
North West Shelf Extension Project	Estimated annual GHG emissions: **80.19** Estimated life-of-project emissions: **4,009.31** (based on 50 years operation of Karratha Gas Plant at maximum capacity) (p.112, Table 6-15)	Direct emissions (Scope 1 & 2 only): **0.01-0.03%** of global emissions (depending on NDC scenario considered) Full lifecycle (Scope 1, 2 and 3) **0.16% to 0.37%** of global GHG emissions (depending on the NDC scenario considered and maximum operation of Karratha Gas Plant which also includes the processing of Northwest Shelf Gas) (2017 actual from Northwest Shelf Project: 0.16%) (p.113, Table 6-16)
Total	***Likely between 0.07% and 0.17% associated with extracting and processing Browse Basin gas*** *(Note: Scope 3 from the proposals is not added together as this would double-count the end-use of the gas).*	

3. Australia's Performance Against Paris Climate Agreement

Much has been written in the past month on Australia's performance against its Paris Agreement commitments and the fact that Australia is not on track to meet these commitments without the controversial use of Kyoto carry-over credits.

In Australia's Nationally Determined Contributions (NDCs), Australia announced a 26–28% reduction of greenhouse gas emissions by 2030 below 2005 levels, including land use, land-use change, and forestry (LULUCF).[1] In 2005, Australia's net greenhouse emissions across all sectors including LULUCF totaled 610.6 610.6 $MtCO_2e$.[2] Australia's 2030 target is between 440–452 $MtCO_2e$ including LULUCF.[3]

Per the Australian Government's own 2019 emissions projections (Table 3), at best Australia is tracking towards a 16.3% reduction in 'real' terms (excluding carryover credits). Virtually no 'real' progress is projected in the 2020s (Figure 1). These projections do not include either Scarborough or Browse LNG developments (see Figures 2 and 3).

Table 3: Australia cumulative emissions to 2030($MtCO_2$-e)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Budget trajectory (26%)	504	498	492	486	481	475	469	463	458	452
Budget trajectory (28%)	502	495	488	482	475	468	461	454	447	440
2019 emissions projections*	524	522	521	517	516	514	513	515	515	511

*This does not include the 411 Mt CO_2-e overachievement from previous targets

Source: Australia's Emission Projections 2019, Department of Environment and Energy

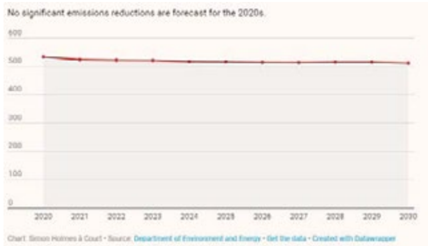

Figure 1: Australia's emissions projections

Figure 2 LNG projects included in Australia's Emission Projections, 2019

Source: Australia s Emission Projections, 2019

Western Australia's LNG sector is one of the biggest contributors to Australia's direct emissions. The five currently operating LNG projects emit around 32 $MtCO_2e$ per annum;[4] this will increase to around 49 $MtCO_2e$ per annum accounting for Scarborough and Browse projects (Figure 4).

In 2019, Western Australia's LNG sector was responsible for full life cycle emissions (direct and indirect) of 193.2 $MtCO_2e$.[5] That is the equivalent of 36% of Australia's direct emissions for the year 2018. It equates to more total emissions from a single sector in a single state, than the individual, direct emissions of 150 of the world's countries.[6] Again, this does not account for the proposed Scarborough and Browse projects, nor are these projects included in the Australian Government's 2019 emissions projections.

The Browse proposals will increase Australia's annual Scope 1 emissions in the range of 12.5 to 19.7 $MtCO_2e$ (depending on average year versus peak production year and the success of GHG mitigation measures). This is equivalent of between 2.3-3.7% of Australia's reported 2019 Scope 1 emissions (538.9 $MtCO_2e$ as at March 2019, which was up on the previous year primarily due to LNG exports[7]).

Australia's commitment is to reduce emissions by between 158-170 $MtCO_2e$ from 2005 levels. Scope 1 emissions from the Browse proposals equate to 7-12% of Australia's committed reduction.

Despite this, the Australian Government—or perhaps, more so, Australia's elected officials—are nevertheless pushing for Browse to be developed, stating that the Browse Joint Venture's retention leases are unlikely to be extended when they come up for renewal in 2020, unless the joint venture demonstrates progress on Browse.[8]

2

Figure 3 Existing and Proposed LNG

Source: Clean State & CCWA Report, October 2019

	Project	Operator	Start	End date	Production capacity (Mt)	GHG emissions per year (MtCO2-e)
Current	North West Shelf	Woodside joint venture (JV) [illegible]	1989	Mid 2030s	16.9	7.6
	Pluto	Woodside JV [illegible]	2012	40 years	4.9	2
	Gorgon	Chevron JV [illegible]	2016	40 years	15.6	8.74*
	Wheatstone	Chevron JV [illegible]	2018	30 years	8.9	10
	Prelude	Shell JV [illegible]	2018	25 years	3.6	2.3-2.7
Proposed Burrup Hub expansion*	Browse Basin	Woodside JV [illegible]	2026	2070	11.9	14.6
	Scarborough	Woodside/BHP	2023	2055	9	2.6

Current: = 29.64 - 32.04 $MtCO_2e$

Proposed: = 17.2 $MtCO_2e$

Total = 46.84 – 49.24 $MtCO_2e$

Figure 4 WA LNG sector existing and proposed emissions

Source: Clean State & CCWA Report, October 2019

Note: Emissions estimate varies slightly from Draft EIS/ERD based on earlier reference documentation

4. Global Gas Supply and Demand

4.1 Revised 2019 WEO Sustainable Development Scenario

The annual World Energy Outlook (WEO), prepared by the International Energy Agency (IEA) provides a roadmap for the world's energy future.

The Browse to NWS Project EIS references the 2014 and 2018 WEO reports (presumably? See footnote [1]). In particular, the Draft EIS/ERD greenhouse gas assessment includes discussion of the 'Sustainable Development' scenario that was first presented in 2018 WEO.

The 2019 WEO was released on 13 November 2019 and presents significant revisions to demand and production for the 'Sustainable Development' scenario. The authors of the draft EIS/ERD greenhouse gas study would not have had access to the 2019 WEO at the time of preparing their assessment. The project rationale and greenhouse gas assessment must, however, be considered in light of the most up-to-date reporting.

I note also that Woodside's supplementary public report, "Comparative Life Cycle Assessment: Browse and Scarborough" dated 14 November 2019 and peer reviewed by CSIRO also describes the Sustainable Development scenario from the 2018 WEO – not the 2019 revised scenario that charts a different course for gas.[9]

The **2019 WEO** discusses three scenarios[10]:

- **"Current Policy Scenario",** which represents a business as usual case, with international energy demand increasing by 1.3% each year to 2040, "unrestrained by further efforts to improve efficiency" and which "would result in a relentless upward march in energy-related emissions, as well as growing strains on almost all aspects of energy security".
- **"Stated Policies Scenario",** which incorporates today's policy intentions and targets. International energy demand increases by 1% per year to 2040. Natural gas is forecast to address a third of this demand. In this scenario, the "rise in emissions slows but, with no peak before 2040, the IEA notes that the world falls far short of shared sustainability goals."
- **Sustainable Development Scenario,** which "charts a path fully aligned with the Paris Agreement by holding the rise in global temperatures to "well below 2ºC ... and pursuing efforts to limit [it] to 1.5ºC". Under this scenario, "sharp emission cuts are achieved across the board thanks to multiple fuels and technologies providing efficient and cost-effective energy services for all."

In presenting the **2019 WEO report**, IEA Executive Director, Dr Fatih Birol, stated:

> ***"The world urgently needs to put a laser-like focus on bringing down global emissions. This calls for a grand coalition encompassing governments, investors, companies and everyone else who is committed to tackling climate change."***[11]

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[1] The full citations for "IAE, 2014" and "IAE, 2019" referred to on page 690 are not included in the draft EIS/ERD reference list and the "IAE, 2019" certainly does not refer to the 2019 WEO, per discussion. It is more likely the 2018 WEO, per references in Woodside's report, "Comparative Life Cycle Assessment: Browse and Scarborough", 14 November 2019.

3

With respect to the future of gas, the 2019 WEO describes the following pathways for demand and supply (refer to):

- In the **Stated Policies** scenario, overall global gas demand continues to rise from 3,955 bcm in 2018 to 5,405 bcm in 2040 (Figure 5). Global production similarly continues to rise from 3,661 bcm in 2018 to 5,405 bcm in 2040 (Figure 6). However, this approach *will not* achieve Paris objectives.

- In the **Sustainable Development** scenario, which is crucial to holding temperatures below 2ºC, overall global gas demand slightly rises from 3,955 bcm to 4,264 bcm by 2030, then *declines*, relative to 2018 demand, to 3,855 bcm (Figure 5). Similarly, overall gas supply rises slightly from 3,955 in 2018 to 4,265 bcm in 2030, then *declines* to 3,840 bcm in 2040 (Figure 6). Within this mix, "Asia Pacific" gas sees a moderate 31% increase (from 598 bcm to 786 bcm—by 188 bcm overall—by 2040).

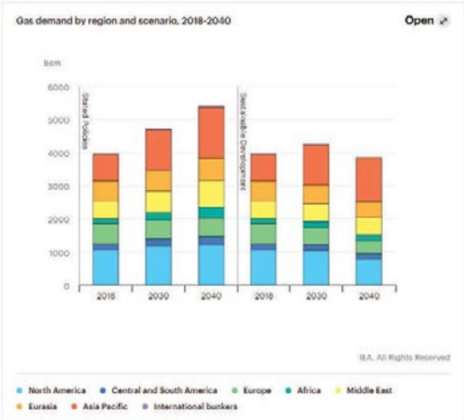

Figure 5: WEO 2019 Gas Demand 2018 - 2040

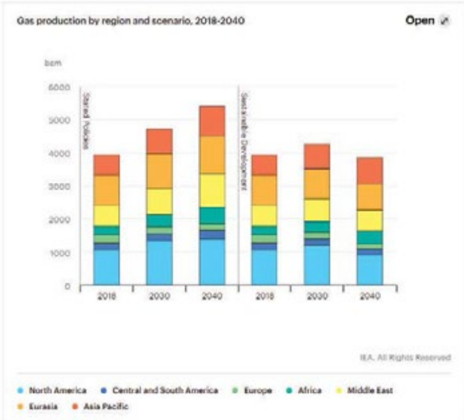

Figure 6: WEO 2019 Gas Production 2018 - 2040

Source: https://www.iea.org/reports/world-energy-outlook-2019/gas#abstract

Note that the Browse to NWS Project draft EIS/ERD (p.690) states:

> *"... natural gas continues to increase until at least 2040, the end of the period modelled (Figure 7-3). In the consumer countries relevant to the proposed Browse to NWS Project, gas consumption grows by 130% between 2017 and 2040. This suggests that increased gas use is not only consistent with the SDS but necessary if the goals of climate change mitigation, air quality improvements and energy access are to be achieved."*

As described above, the 2019 WEO Sustainable Development scenario revises global demand to rise slightly to 2030, then fall such that 2040 gas demand is less than 2018 levels. Anticipated supply has also been revised in parallel. Indeed, the **2019 WEO** states:

> ***In the Sustainable Development Scenario, natural gas consumption increases over the next decade at an annual average rate of 0.9% before reaching a high point by the end of the 2020s. After this, accelerated deployment of renewables and energy efficiency measures, together with a pickup in production of biomethane and later of hydrogen, begins to reduce consumption.***

With respect to Asia specifically, and as stated above, the IEA now forecasts 31% rise in total gas (i.e., local gas and LNG) not 130% as quoted in the Browse to NSW Project proposal. The IEA also notes 'until the late 2030s ... demand for LNG in Asia is robust" however by 2040, "LNG demand is falling back in several markets' in the Sustainable Development Scenario.[12] This is sooner than halfway through the Browse development's proposed 31 to 44 year economic life.

4

4.2 LNG Component of Gas Demand

The **2019 WEO report** makes the further observations regarding LNG component of gas demand:

> ***"There is significant uncertainty, however, as to the scale and the durability of demand for imported LNG. Emerging markets in Asia face higher costs for imports than for domestically produced gas. Even though spot gas prices fell to record lows in 2019 on the back of ample LNG supplies, over the long-term end-user prices generally seem set to rise: unless they do, LNG suppliers will be unable to recover their long-term investment costs or governments will have to continue to subsidise the cost of LNG imports. The LNG industry therefore faces a struggle to gain a strong foothold in developing markets where affordability is a key consideration."***[13]

The IEA's supplementary report, "The Oil and Gas Industry in Energy Transitions" (2020) adds that:

> ***"By 2040, LNG demand is falling back in several Asian markets in the Sustainable Development Scenario. There is a risk, therefore, that some LNG export facilities are not fully utilised."***[14]

This has a flow-on effect for investment decisions made on the basis of 30+ year project lifespans. The Browse development is forecasting a 31 to 44-year field life and is seeking approval to 2070.

4.3 Coal-to-Gas Switching

The Browse to NWS Project draft EIS/ERD (p.689) also makes the following argument regarding coal-to-gas switching:

> *The IPPC's 2014 Synthesis Report said that "GHG emissions from energy supply can be reduced significantly" by switching to gas. According to the IPCC, electricity generated from gas has on average half the GHG emissions of electricity generated from coal (IPCC, 2014). According to the International Energy Agency (IEA), in 2018 coal-to-gas switching helped avert 95 MT of CO2 emissions (IEA, 2019)".*

Regarding coal-to-gas switching, the **2019 WEO** view is:

> ***"Coal-to-gas switching can provide "quick wins" for global emissions reductions… Today's commodity prices paid by utilities today mean that most of the coal-to-gas switching potential identified in our analysis is out of reach … However, this could change if a higher price was put on CO2 emissions … In emerging Asian markets, higher costs of imported gas and a younger coal fleet mean carbon prices would need to exceed \$60/tonne CO2 in order to create an economic case for switching."***[15]

In other words, the ability for coal-to-gas switching to result in emissions reductions now looks less feasible.

Regarding the emissions savings from gas versus coal for electricity: the 2019 WEO also makes the point that 25% of 'associated gas' (i.e., the fugitive emissions from oil wells and fields) is a wasted opportunity and in 2018 was 200 bcm – more than the annual LNG imports of Japan and China combined. The emissions 'savings' claimed by gas producers are overstated. The Australian Government's own reports indicate the extent of fugitive emissions.

4.4 Oversupply

Recent analysis by Bernstein Research indicates the "seeds of the next LNG glut are being sown" (Australian Financial Review, 8 January 2020) for the mid-2020s. Bernstein note that in addition to Browse gas which is a 'possibility', Woodside's Scarborough Project (also in Western Australian and undergoing environmental approvals), as well as Papua New Guinea (stalled), Mozambique and US-based projects are vying to proceed.[16] Meanwhile, Qatar (the lowest cost gas producer) is also aspiring to boost LNG production more than 60% from its North Field by 2027.[17]

Exxon Mobil, on 3 February 2020, noted "there was no rush to develop the [P'nyang] project" in PNG, originally earmarked for a financial investment decision in 2020, because in the 'oversupplied environment", "new projects would need to compete within the existing portfolio".[18]

It also appears that a further contributing factor to current ultra-weak LNG spot market prices (in addition to oversupply) has been a milder Asian winter.[19] Anthropogenic global warming, perhaps? A trend that is set to continue? A glut of LNG does not help the gas industry (profitability) nor the environment.

4.5 'Clean', Affordable, Reliable Energy

The Browse to NWS Project draft EIS/ERD states (p.689):

> *"The scientific consensus on climate change, and the commitment of global governments to reduce emissions, is clear. There is also a need to both improve local air quality and increase access to modern energy sources. Access to clean, affordable and reliable energy improves living standards dramatically and the world's growing population is driving increased energy demand."*

There is no doubt that access to energy is crucial to development. Gas, however, is increasingly not the means to provide it based on 'clean, affordable, reliable' criteria. As the Centre for International Climate Research notes, natural gas has been the dominant driver of global emissions since 2012, and "unabated natural gas use merely cooks the planet more slowly than coal".[20]

4.5.1 Electricity Generation

With respect to electricity generation, putting aside the matter of baseload reliability (with intermittency issues being addressed via significant price drops in rechargeable lithium-ion battery technology), Bernstein Research has previously noted that as solar is a clean, cheap, reliable technology, that will get cheaper over time, whereas fossil fuel extraction costs will keep rising.[21] The International Renewable Energy Agency (IRENA) 'Renewable Power Generation Costs in 2018' report found:

> *"In most parts of the world today, renewables are the lowest-cost source of new power generation. As costs for solar and wind technologies continue falling, this will become the case in even more countries. These cost reductions are set to continue to 2020 and beyond."*[22]

The IEA "The Oil and Gas Industry in Energy Transitions" supplementary report (2020) observed that a fast-moving energy sector would change the game for upstream investment. While "investment in existing and some new fields remains part of the picture", "as overall investment falls back and markets become increasingly competitive, only those with low-cost resources and tight control of costs and environmental performance would be in the position to benefit".[23]

4.5.2 Other Sectors

A new report released by the Hydrogen Council, prepared by global consultancy McKinsey, indicates that with a step-up in investment (<5% of annual global energy spend), the cost of hydrogen production and distribution could decrease by up to 50% by 2030.[24] Analysis found that hydrogen would be cost-competitive across more than 20 applications, including commercial vehicles, long-range transport, industrial heating, residential heating and cooling and industry feedstock.

The dramatic, global changes ahead for both electricity generation and other sectors, together with a host of technical factors for Browse (including environmental performance and economic considerations such as high carbon dioxide content of the reservoir[25] and energy required to extract and pump the gas from Browse fields), means the Browse development faces significant challenges in terms of its long-term competitiveness and sustainability at a time when both public opinion, and financial risk evaluation, is shifting.

This must be carefully weighed when assessing the proposals.

4.6 Existing Plant

With regard to existing plant (such as the North West Shelf LNG Plant at Karratha), the 2019 WEO notes:

> *"If the world is to turn today's emissions trend around, it will need to focus not only on new infrastructure but also on the emissions that are "locked in" to existing systems. That means addressing emissions from existing power plants, factories, cargo ships and other capital-intensive infrastructure already in use."*[26]

The proposal to extend the life of the Northwest Shelf Gas Plant at Karratha means "wholesale reductions in emissions are difficult to achieve"[27].

How can this be considered acceptable for a proposal that seeks approval to operate to 2070?

5. Browse to NWS Project Impacts

5.1 Greenhouse Gas Contribution

The Browse to NWS Project Executive Summary, Page 24 states:

> *"Scope 1 and Scope 3 emissions from the proposed Browse to NWS Project could contribute in the range of 0.06% to 0.15% global GHG emissions. Given these estimates, it is not considered credible that as a standalone project, GHG emissions from the proposed Browse to NWS Project will significantly impact sensitive environmental receptors."*

This statement is of course deliberately worded in terms of linking this individual project to specific impacts to 'receptors'. In fact, Australian Prime Minister Scott Morrison himself said very recently, in response to the Australian bushfires, that it is 'not a credible suggestion' that Australia's carbon emissions can be linked to any one fire.[28] True—however, as Garnaut predicted in the 2008 Climate Change Review, it is absolutely credible that anthropogenic carbon emissions as a whole have contributed to the severity of Australia's 2020 bushfires, and this is reflected in more than 100 bushfires burning simultaneously in 'catastrophic'-rated fire conditions. The Browse to NWS Project greenhouse gas assessment presents a description of potential impacts arising from climate change, which emissions 'may contribute to' as a whole.

With respect to the estimate provided of the project's greenhouse gas contribution, the Browse to NWS Project will have, *as a single project*, the equivalent greenhouse gas emissions (Scope 1 and Scope 3) as the direct emissions of many of the world's countries. When coupled with the NWS Extension Project GHG contribution, total GHG associated with extracting and processing Browse Basin gas is in the order of 0.07% to 0.17% (refer Table 1).

Table 4 lists those countries which, in 2017, contributed between 0.07% and 0.17% of global emissions. Every country listed in Table 4 has ratified the Paris Agreement. There are a further 88 countries which each had less than 0.07% global emissions contribution.[29]

Table 4: Countries with global emissions contributions between 0.07% and 0.17% (2017)

Morocco	78.8839	0.17%
Austria	78.4743	0.17%
Tanzania	77.9457	0.17%
New Zealand	75.0919	0.17%
Azerbaijan	69.7221	0.15%
Syria	65.8195	0.15%
North Korea	63.8065	0.14%
Finland	63.5322	0.14%
Portugal	62.0311	0.14%
Kenya	60.1371	0.13%
Ireland	59.2123	0.13%
Serbia	59.0182	0.13%
Ecuador	58.2656	0.13%
Hungary	56.9204	0.13%
Bulgaria	54.8549	0.12%
Singapore	52.9509	0.12%
Denmark	52.8873	0.12%
Switzerland	51.5705	0.11%
Sweden	50.8451	0.11%
Zambia	50.1033	0.11%
Central African Republic	49.2281	0.11%
Bolivia	46.8039	0.10%

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Table 4: Countries with global emissions contributions between 0.07% and 0.17% (2017)(cont'd)

Norway	46.5925	0.10%
Cuba	46.5085	0.10%
Afghanistan	44.4157	0.10%
Slovakia	40.3202	0.09%
Democratic Republic of the Congo	39.5590	0.09%
Mongolia	38.6367	0.09%
Sri Lanka	38.3764	0.08%
Paraguay	37.5747	0.08%
Nepal	36.0311	0.08%
Tunisia	35.6478	0.08%
Yemen	35.5020	0.08%
Uruguay	34.0277	0.08%
Bahrain	33.4062	0.07%
Uganda	33.3506	0.07%
Dominican Republic	33.1665	0.07%
Ivory Coast	31.9609	0.07%
Ghana	30.8917	0.07%
Jordan	30.8217	0.07%

Writing this submission in February 2020, knowing what we do regarding the implications of climate change, the implication in the Browse to NWS Project draft EIS/ERD that 0.06 to 0.15% (or 0.07 to 0.17% for all proposals) doesn't matter is completely disingenuous. On the journey to carbon neutral by 2050, we *must* evolve from the 'small contributions don't matter' rhetoric and 'let's downplay our contribution so it sounds negligible' rhetoric. At this point, *all* contributions to the world's carbon budget matter. Every individual, company and government have a responsibility to be aware and act in an environmentally responsible manner – and every fossil fuel producer especially.

It is extremely concerning that Australia's elected officials fail to treat Australia's need to reduce emissions as a grave responsibility: treating emissions reductions as an accounting matter rather than a global risk; and the science as 'debatable' because other 'opinions' cross their desks.[30]

5.2 Socioeconomic Impacts

Citing Australian government reports, the Browse to NWS Project Draft EIS/ERD broadly touches upon 'possible' impacts of climate change on Australian social, economic and cultural aspects on page 694, Table 7-12. The Draft EIS/ERD notes there is an "inherent uncertainty in estimating the [social and economic] impacts of climate change".

This inherent uncertainty in the ability to 'quantify' impacts arguably arises from: (1) at what temperature we manage to stabilise warming; (2) the extent to which societies are able to respond and adapt.

It is fair to say that of all the 'possible' impacts listed in Table 7-12, nearly all have *already* been experienced. They are *already present*. They are *'impacts'*.

The problem with tables like 7-12 is that while these 'summaries' 'tick the box', they fail to highlight the significance of the potential impacts. Climate change disrupts nature, and in its January 2020 report, *Nature Risk Rising: Why the Crisis Engulfing Nature Matters for Business and the Economy,* the World Economic Forum in collaboration with PwC noted that: the "global economy is embedded in Earth's broader ecosystems and dependent on them." Over half the world's GDP is highly or moderately dependent on nature ($44 trillion of economic value generation) and "as nature declines, the prospects for business success and future prosperity dwindle".[31]

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One small example to illustrate this point:

> *60% of coffee varieties are in danger of extinction due to climate change, disease and deforestation. If this were to happen, global coffee markets – a sector with retail sales of $83 billion in 2017 – would be significantly destabilized, affecting the livelihoods of many smallholder farmers.*[32]

But this is not just a matter for primary industries. Many industries still have 'hidden dependencies' through their supply chains. PwC assessed the reliance on natural capital assets of 163 sectors, based on the economic value creation of each industry. Even in the oil and gas sector, around 40% of industry and supply chain GVA has a high or medium dependency on nature.[33]

It is not the role of the Draft EIS/ERD to deep dive into all these issues and present a full financial accounting. However, it is important that Draft EIS/ERD report authors and Government assessors are aware that summary tables downplay the reach of impacts. A greater than 1.5 degree temperature compromises the quality of life not only of future generations, but literally the security of all children born today. See https://www.abc.net.au/news/2019-12-06/how-climate-change-has-impacted-your-life/11766018 for a compelling summary that should bring this home to any Australian parent (Figure 7). My daughter is two years old, and I am writing this submission for her.

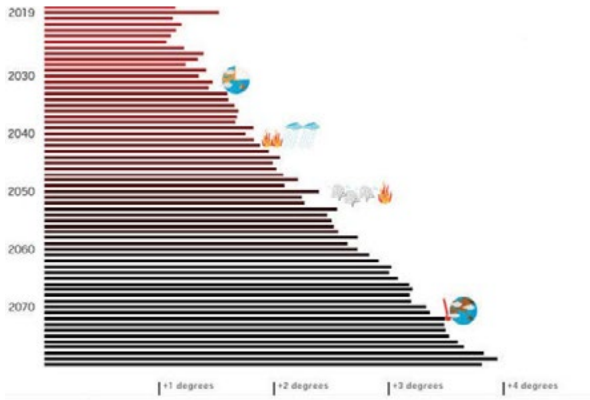

Figure 7: Business-as-usual global temperature increase
Source: https://www.abc.net.au/news/2019-12-06/how-climate-change-has-impacted-your-life/11766018 based on IPCC

5.3 Cumulative Impacts

Not only is there no discussion of the emissions of the proposals as a whole (Browse to NWS Project combined with NWS Extension Project), unlike other chapters of the Browse Draft EIS/ERD, there is no assessment of cumulative impacts.

Cumulative impacts are the "successive, incremental and combined impacts (both positive and negative) of an activity on society, the economy and the environment".[34] Cumulative impacts can arise from the aggregation of impacts from other known, proposed projects (e.g., which have received approval but are not yet built, or which are undergoing a regulatory approval process). A cumulative impact assessment should be prepared which quantifies the potential emissions (Scope 1-3) of the Browse proposals and all other proposed fossil fuel projects across Australia (e.g., Scarborough, Browse, Adani, Narrabri, China Stone). All these projects relate directly to our ability to meet our international climate commitments and therefore share common receptors and impact pathway. It would be irresponsible—negligent, in fact—of the state and Australian governments to continue to approve major polluting projects without oversight and understanding of all the potential greenhouse gas emissions they are greenlighting.

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6. Project Mitigations

6.1 Browse Proposal Commitments

The Browse to NWS Project proposals commit the Browse Joint Venture to a total of ~1.6 Mtpa CO_2e greenhouse gas reduction initiatives through processing improvements and native tree planting partnership programs. This is around 14% of gross Scope 1 emissions in the 'peak' production year, or 25% in an 'average' year.

As an 'interim' target, the NWS Project Extension proposal commits to avoid, reduce or offset 330,000 tonnes CO_2e from the Karratha Gas Plant by 2030; continue emissions optimisation; set annual targets for flaring and fuel consumption; and cap annual (Scope 1 and 2) emissions of 7.7 Mtpa CO_2e. This is <1% of Scope 1 emissions, sometime before 2030 (i.e., worded such that it is not necessarily every year before 2030).

6.2 Net Zero by 2050

Despite seeking approval to operate to 2070, the proposals do not convincingly address how the project would contribute to Western Australia's 'aspiration of net zero by 2050'.[35]

A recent study identifies that requiring the Western Australian LNG industry to offset 30 Mtpa CO_2e emissions via projects within Western Australia would create around 4,000 jobs for the state, more jobs than the LNG sector itself. This would directly benefit the Western Australian economy and environment.[36] Presently, Browse to NWS project is potentially looking toward a 0.6 Mtpa CO_2e investment via a Heads of Agreement with Greening Australia, with 'an initial focus in Western Australia' (Draft EIS/ERD, p.698).

Offsets are only part of the answer, however. Global energy growth needs to be increasingly addressed through renewable sources, of which Western Australia has abundant opportunities.

7. Acceptability Assessment

The Browse to NWS Project Draft EIS/ERD provides an 'assessment of the acceptability' of project emissions in Section 7.8, Table 7-14. The upfront summary, and the assessment presented throughout this table, in response to each of the listed considerations (ESD, etc.) is flawed.

For example, the Draft EIS/ERD states (p.698):

> *"Overall, in the context of Australia's international commitments and local legislation and policy, it is considered that given the proposed mitigation of emissions, safeguard mechanism obligations and the importance of gas as a clean and reliable source of energy in the current and future energy mix, GHG emissions from the proposed Browse to NWS Project are acceptable."*

This statement is not consistent with the changing political, technological, economic and energy landscape, and certainly not consistent with the most recent commentary on natural gas, including the 2019 WEO.

7.1 Paris Agreement

As described in Section 3, without the controversial use of carry-over credits, Australia is by no means on track to meet its Paris Agreement objectives. Inconveniently, and unfortunately, heating in the Earth's oceans and atmosphere won't slow in response to creative accounting. Western Australian LNG emissions are fundamentally undermining Australia's national GHG reduction efforts[37] and the Browse proposals' *net* Scope 1 emissions (which are not presently accounted for in Australian Government emissions projections) represent around 7-12% of the annual reduction that Australia has committed to achieve. Where does the Browse Joint Venture, Western Australian Government, and Australian Government plan for these 'new' emissions to otherwise be offset?

Based on the 2019 Australian Government emissions projects (Table 3), there does not appear to be any opportunity to accommodate these emissions and still meet Paris commitments (with or without carry over credits).

7.2 The Role of Gas

The Browse proposals assert, based on the 2018 WEO, "increased gas use is not only consistent with the [Sustainable Development Scenario] but necessary if the goals of climate change mitigation, air quality improvements and energy access are to be achieved" (Browse to NWS, p.689).

As discussed in Section 4, the Sustainable Development Scenario has been substantially revised in the 2019 WEO. The importance of gas in the energy mix to mitigate climate change is declining. Claims by Australia's elected officials that gas still has a key role as a 'transitional' fuel are out-of-date and no longer supported by the latest Australian and international energy research. Gas is not a 'clean' fuel.

Instead of continuing to grow to 2040, the 2019 WEO Sustainable Development Scenario sees gas to reach a high point globally by the end of the 2020s and waning in Asia by the end of the 2030s—less than half-way through the project's 31 to 44 year economic life. Other key factors are also now in doubt, including (1) whether LNG will be price-competitive with local gas supplies; (2) whether LNG facilities will be fully utilised; and (3) whether coal-to-gas switching in Asian markets has an economic case.

These are key considerations that underscore the acceptability of emissions from these proposals.

The likelihood is diminishing that Browse gas will have a financially viable (profitable) future to 2070 (as the proposals seek), with global political, financial, technological, energy and social changes underway.

For example, within the past month:

- Investment giant Blackrock wrote: "Climate change has become a defining factor in companies' long-term prospects."[38] This is on the back of fossil-fuel divestment commitments that had reached USD $11 trillion as at September 2019.[39]
- The International Energy Agency has noted "the oil and gas industry faces the strategic challenge of balancing short-term returns with its long-term licence to operate" as societies demand reductions in emissions. It has proposed options in its 2020 "The Oil and Gas Industry in Energy Transitions" report for ways the gas sector can address these challenges, through improvements to its own footprint and investment in capital-intensive clean energy to assist them to reach maturity, e.g., carbon storage and utilisation, low-carbon hydrogen, biofuels, and offshore wind.[40]
- The Bank of International Settlement, one of the world's most powerful financial institutions, has warned central banks that climate change could spark the next global financial crisis and that central banks may have to mobilise forces, or other intervene to buy carbon-intensive assets to preserve financial and price stability[41] due to governments allowing the fossil fuel sector to keep expanding, deferring asset stranding and requiring more disruptive policy.
- Mr. Mark Carney, the Governor of the Bank of England and the UK Prime Minister's Finance Advisor for COP26 in Glasgow, announced it was time for the financial sector to deliver on climate change and stated "To reach net zero every country, every company, every bank, every pension fund, every investor, every pension fund around the world will need to make some big changes."[42]
- The World Economic Forum Global Risk Report 2020 was, for the first time, dominated by climate change-linked environmental issues, with failure to mitigate and adapt to climate change as the key concern for the Forum's network of business leaders, NGOs, academics and others.[43]

The signals aren't on the horizon – they're here. The 2019 WEO is increasingly showing that to stabilise global temperature between 1.5 and 2 degrees, gas as well as coal will be displaced by cheaper, cleaner, reliable renewable alternatives by the 2030s. Another glut of LNG harms our environment during a decade in history when we *must* stabilise greenhouse gas emissions *and* substantially reduce emissions to not set off irreversible climate triggers.

7.3 Ecologically Sustainable Development

Failure to address climate change is not consistent with ecologically sustainable development. The science on climate change is settled. Climate projection models have been found to be quite accurate at predicting global temperature increase[44] and are continuously improving.[45] Climate change introduces risks to global health, security, trade, economic development and gender equality (the latter being a major driver of economic growth). A greater than 1.5-2 degree C temperature compromises the quality of life not only of future generations, but literally the security of all children born in Australia and the world today.

8. Final Comments

8.1 Environmental and Energy Decision Makers

The 2019 WEO states: *"Energy decision makers need to take a hard, evidence-based look at where they stand and the implications of the choices they make."*

It is extremely concerning that the three-part nature of the approvals process for this project means no one authority will assess the entire impact of what is ultimately a single project. It is also concerning that this is being assessed before the WA EPA draft greenhouse gas emissions guideline, which was released on 9 December 2019, is finalised.[46]

It is the responsibility of Western Australian and Australian Government decision makers to have significant, up-to-date levels of understanding of: Australian and international energy demand, the ramifications of climate impacts, the associated social and economic costs and feasible and emerging mitigations. This includes elected officials in the Australian Government getting up-to-speed and acting upon the no longer disputable science and risks of climate change, and—as cited in numerous recent studies[47]—the vast economic opportunities for Australia to advance non-fossil fuel technologies and industries.

8.2 Browse Joint Venture

To those reading this submission—project staff, environmental consultants—I understand you are seeking positive environmental outcomes from this development and to minimise many of the environmental and social potential impacts (beyond GHG).

For the reasons set out in Section 7.2, the Browse development is increasingly not in the public interest. It may also not be in Woodside and the Browse Joint Venture's interest (i.e., considering the financial viability of 31 to 44-year field life, operations to 2070). In seeking to progress both Scarborough and Browse, Woodside is doubling its business risk on multiple fronts, including reputational and financial.[48] Woodside knows this,[49] though considering it 'unfair' is a somewhat off the mark. Consider the impact of climate change to the world's most vulnerable populations. The reality is energy transition could have commenced in greater earnest years ago; instead, fossil fuel stocks *are* the new tobacco and the fossil-fuel shareholder base is shrinking.[50]

Woodside is seeking 6% average growth year-on-year to 2028.[51] The company has alternatives and is eying renewables and "is serious about" hydrogen in the future.[52] McKinsey, in the January 2020 Hydrogen Council report, has demonstrated significant opportunities for investment and development of hydrogen in the next 10-15 years, and its synergies with the capabilities of gas producers. Woodside itself has stated, "hydrogen is here today, and it's the energy of the future."[53]

If I had $30 billion to invest, I know where I'd be putting my money. And right now, it wouldn't be doubling down on new LNG projects on the Burrup Peninsular.

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APPENDIX D SUBMISSIONS

APPENDIX D.13 ANON - 57NR-WVNF-D

[redacted]

The Chairman, Environmental Protection Authority

Locked Bag 10

Joondalup DC

WA 6919

Dear Dr Hatton, on behalf of the Commonwealth,

Re: Browse to North West Shelf Development proposal (Commonwealth component)

I tender this submission regarding the Browse to North West Shelf extension project in order to highlight the significant environment, ecological, and social threat such a project will pose. In consideration to the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), this project will directly place six of the nine matters of national environmental significance at significant risk -- world heritage properties, national heritage places, wetlands of international importance (listed under the Ramsar Convention), listed threatened species and ecological communities, migratory species protected under international agreements, and Commonwealth marine areas. The risk to the environment, cultural heritage, biodiversity and the substantial greenhouse gas emissions of the project, is why the Commonwealth must reject the Browse to North West Shelf extension.

World heritage properties and national heritage places.

As the Commonwealth will be aware, the Burrup Peninsula is home to one of the largest, densest and most diverse collection of petroglyphs. In fact, with the support of the State Government and the Federal Government, the Murujuga Aboriginal Corporation has submitted an application to the United Nations Educational, Scientific and Cultural Organisation World Heritage Centre so the area can be added to Australia's World Heritage Tentative List later this year. After 12 months on the Tentative List, the site will be eligible for the UNESCO World Heritage list.

The Murujuga Petroglyphs are a collection of more than 1 million petroglyphs which span 36,857 hectares across the peninsula and surrounding Dampier archipelago. This rock art is not only a tangible link to the stories, customs, knowledges, ad history of the Traditional Custodians, and one of the world's largest living cultures, the Murujuga Petroglyphs are a vital historical insight to the former flora and fauna of the area, and the Traditional Custodians use of this landscape more than 50, 000 years ago. Given sites of lesser archaeological age and living cultural significance, have been granted UNESCO World Heritage listing, it is highly plausible the Murujuga Petroglyphs will too receive this listing. However, the industrialisation of the area is putting the future of this cultural, spiritual and archaeological significant site at extreme risk.

[redacted]

Industry pollutants are the biggest risk to the future of the Murujuga Petroglyphs. The pollutants from the industrialisation of the area, including nitrogen dioxide, nitrous oxide, carbon monoxide, methane, ammonia, dust-sized ammonium nitrate particles and greenhouse gas equivalents, are causing irreversible damage. The two major impacts that result from these pollutants are acid rain, which degrades rock surfaces and affects human health, and the risk of nitrogen deposits from industrial emissions that will exponentially increase the local growth of microbes and plants, and this poses a massive threat to the rock art.

The cumulative impacts of emissions on the petroglyphs from heavy industry -- particularly the North West Shelf Project -- on the peninsula was highlighted in a Senate inquiry report. The report warned that increased emissions were damaging the surface of the rock art and causing it to degrade. In fact, a joint response by five Labor senators said the evidence of colour change was "statistically significant". The concerns about major flaws in the monitoring program was also expressed by senators as well as criticism on industry bodies failures to comply with conditions under the EPBC Act by submitting monitoring reports late and the failure to immediately adopt the recommendations of an independent report on air quality monitoring. So, I ask, what assurance with the Commonwealth seek to ensure history doesn't repeat?

In light of these concerns, I urge the Commonwealth to, at the very least, to pause the approval of this project until further assessment can be undertaken on the impact cumulative emissions will have on this cultural heritage, and what the outcome of the world heritage submission is.

Wetlands of international importance

The Browse to North West Shelf project contradicts Australia's long-standing international commitment to the preservation of wetlands of international importance under The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat by directly jeopardising several wetlands, including a Ramsar wetland. The wetlands in question are Roebuck Bay, the Ord River floodplain and estuary, the Ashmore Reef Nature Reserves and of course, the Eighty-Mile Beach Ramsar site. These sites stand to be severely impacted by ecological disasters such as oil spills and facility structure damage. While sites around Christmas Island, and the Cocos and Keeling Islands are also at risk due to movement of the South Equatorial Current. Additionally, any ecological disaster would have profound impacts on the mangrove forests of Northern WA, and the Northern Territory -- which are home to 39 per cent of all coastal mangroves in Australia -- through increased industrial pollutants, trace nutrients, sediment and pH fluctuations.

[redacted]
Member for East Metropolitan Region
[redacted]

Listed threatened species and ecological communities, and migratory species

With the world amid the sixth mass extinction, it is vitally important we do all that we can to protect our ecology, particularly species which are considered threatened, vulnerable or endangered. Western Australian waters, particularly those surrounding the Browse Development Zone and Scott Reef, are home to a myriad of species whose survival will be at risk if this proposal goes ahead as planned. Of these are three species of sea snake, which the Department of Biodiversity, Conservation and Attractions (DBCA) lists are critically endangered, three species of whale listed as 'endangered', three species of endangered turtle, the Australian Sea Lion which is listed as vulnerable, along with several other vulnerable species of fish, bird and invertebrate.

The other key consideration regarding threatened species is the recent discovery of a new species of siphonophore in the Kimberley Marine Park. This species has not been included in Woodside's Environmental Review Document, therefore there is no management plan and extreme uncertainty regarding the impact on the extremely rare marine creature. As such, Woodside must be required to undertake a management plan before this project can proceed any further.

Migratory species

In terms of migratory species, the warmer currents surrounding the Browse Development area play host to cetaceans who migrate along the west coast to give birth and nurse their young. While a series of bottlenecks between Australia, Timor-Leste, Papua New Guinea and Indonesia have created a channel for migratory aquatic organisms to travel directly through the site of the proposed offshore structures. This proposal will not only directly be interrupting the migratory path of cetaceans, marine teleosts, and their predators; any local, small-scale dependants on these natural movements are at risk.

Commonwealth marine areas

This proposal sits adjacent to several Commonwealth Marine Reserves and the NWS threatens the ecological resilience of those marine reserves. As it is impossible to "contain" the potential impacts from the commission and operation of two Floating Production Storage and Offloading facilities, the impact on surrounding commonwealth reserves and state reserve must also be considered. Particularly the impact that construction of gas pipelines, floating facilities, shipping routes, and potential hydrocarbons spills will have on the intricate ecology of Benthic sediments and the Euphotic zones. The Browse to North West Shelf extension proposal poses severe ecological concerns.

LEGISLATIVE COUNCIL WESTERN AUSTRALIA

[redacted]
Member for East Metropolitan Region
[redacted]

Final remarks

The final remarks I'd like to make in relation to the Browse to North West Shelf project - Commonwealth waters, is the consideration of the impact that this project will have on the climate crisis. Not only will construction, shipping movements and potential ecological disasters devastate the local biodiversity, the significant greenhouse gas emissions from this project will have widespread implications for our ecological communities, the health of all Western Australian and Australia's international commitments.

The Browse project, if approved, will be the most emissions intensive development in Australia, adding an additional 7 million tonnes of CO2e just through venting and pumping the gas 900km and about another 7.6 million tonnes CO2e from processing at the North West Shelf LNG facility. While the total emissions from venting offshore, and processing onshore will equal 200 million tonnes of CO2 over a minimum 31 years' field life. The Browse to North West Shelf project alone will emit pollution equivalent to 2.7 per cent increase over Australia's total 2005 baseline. However, as the Environmental Protection Guidelines only apply to the project within the state's jurisdiction, the majority of the emission created by this project will occur from the high-CO2 reservoirs Commonwealth Waters, which have not been included in Woodside's calculation of total emissions.

By approving this project, the floodgates will open, so to speak, on the massively polluting Burrup Hub project. If the Browse to North West Shelf project is approved, along with the remaining aspects of the Burrup Hub, scope 1 emissions from Liquified Natural Gas production will account for 47 per cent of Western Australia's total emissions. Over the next twelve years, the total cumulative emissions from WA's five current LNG facilities (384Mt) will cancel out the entire amount of abatement expected to be delivered under the Federal Emissions Reduction Fund (375Mt). So at the total cost of $4.55 billion, the ERF is effectively an Australian taxpayer-funded offset program for Chevron and Woodside's operations to 2031.

Given that no one authority is assessing the overall greenhouse gas emission of the Burrup Hub project there is a significant risk to the global requirement of holding temperatures to 1.5C on 2005 levels. In a world that must be decarbonising to survive, this project fails to make environmental, social, or economic sense. I strongly urge the Commonwealth to reconsider environmental approval for the Browse to North West Shelf project.

Yours sincerely,

[redacted]

APPENDIX D SUBMISSIONS

APPENDIX D.14 ANON - 57NR-WVNH-F (NGARLUMA ABORIGINAL CORPORATION)

NGARLUMA
ABORIGINAL CORPORATION

RNTBC (Registered Native Title Body Corporate) [redacted]

12 February 2020

Environmental Protection Authority
Prime House, 8 Davidson Terrace
Joondalup WA 6027

To Whom it May Concern

Re: North West Shelf Project Extension - Public Environmental Review

Browse to North West Shelf Project - Public Environmental Review and Environmental Impact Statement

We **attach** a public submission in respect of the above proposals.

The submission is comprised of:

1. Background Information relevant to the submission; and
2. Submissions on the public documents in the form of a Table.

NAC is available to meet with the EPA to answer any questions it may have in relation to the submission and to provide any additional information that may be requested.

Yours sincerely,

Ngarluma Aboriginal Corporation RNTBC

Head Office [redacted]

Phone: [redacted]

www.ngarluma.com.au

[redacted]

1. Background to Submission

(a) NAC and Ngarluma People

The Ngarluma People are represented through the Ngarluma Aboriginal Corporation RNTBC (**NAC**). NAC is the "Prescribed Body Corporate" set up under the *Native Title Act 1993* (Cth) to hold and manage the Federal Court's determination of the Native Title of the Ngarluma People in *Daniel v State of Western Australia* [2005] FCA 536 (**Daniel Determination**) and to manage and protect all Ngarluma Traditional Country (**Ngarluma Country**), including the Proposal area.

In 2003 in *Daniel v State of Western Australia* [2003] FCA 666 (**Daniel Decision**), and then after an appeal, and again in 2007 in *Moses v State of Western Australia* [2007] FCAFC 78, the Ngarluma People were recognised as native title holders. The Full Federal Court has agreed that the Ngarluma People have Native Title rights and interests to an area within Ngarluma Country in the Pilbara. Subsequently, the Ngarluma People were also determined, through a consent determination in the Federal Court in *Samson on behalf of the Ngarluma People v State of Western Australia* [2015] FCA 1438, as native title holders in the towns' areas within their traditional country.

While each of the Ngarluma Yindjibarndi Yaburara and Wong Goo TT OO groups made native title claims over the Burrup and surrounding areas, only Ngarluma and Yindjibarndi peoples were determined to hold native title. The Yindjibarndi people were determined to hold native title to the south of the Ngarluma determined area and well to the south of the Burrup.

The name "Wong-Goo-TT-OO" was adopted by certain native claimants for the purpose of their native title claim. It is not the traditional name of any group of Aboriginal people: Daniel Decision at [50] and [354]. The Federal Court found that the claim should be dismissed with the proviso that the dismissal is "*without prejudice to any right the [*Wong-Goo-TT-OO people*] may have as Ngarluma or Yindjibarndi people (and not as members of the [Wong-Goo-TT-OO]) to hold native title rights and interests*": Daniel Determination at [24]. This finding was upheld on appeal.

The Federal Court also found that the Yaburura claim to the Burrup should be dismissed. The trial judge was not satisfied that the Burrup was inhabited by the Yaburara group and found that even if it did inhabit the Burrup it disappeared as an identifiable group early in the Twentieth Century.

The Ngarluma People disagree with the determination that native title does not exist on the Proposal area and believe it is inconsistent with current understandings of the relevant standard of proof in native title cases. The Ngarluma People maintain that the original inhabitants of the Proposal area constituted a sub-group of the Ngarluma People and formed part of the relevant society of native title holders. Further, as the determined native title holders for Ngarluma Country, they maintain they have primary responsibility to look after the Burrup.

Ngarluma traditional laws and customs, affirmed by the Federal Court, include an obligation and right to forage and to visit and look after and protect Ngarluma Country from harm, including physical harm to the bush and the coast, its plants and animals and places such as the array of Aboriginal sites and other significant places within the Proposal area.

The Ngarluma, through the NAC, are the recognised Traditional Owners to Warmalana (Depuch Island) to the east of the Proposal area and are the sole holders of the reserve management order for the island. Alike to the Proposal area on the Burrup, there is no longer "native title" to that island and yet the State Government has recognised the Ngarluma as the Traditional Owners. Again, alike to the Proposal area, Warmalana is a sacred place with Aboriginal sites of enormous importance and significance. Warmalana is a Protected Area under the *Aboriginal Heritage Act 1972* (WA) and an A Class Reserve.

2

The obligations, the duties and the Traditional Owner rights of the Ngarluma at Warmalana apply equally to the Burrup area of the Proposal. On the Burrup Peninsula and the surrounding islands, Ngarluma knowledge of gender specific Dreaming stories, totemic affiliation to archaeological iconography and other associations, demonstrate continued heritage connection and ongoing 'active' title to the Burrup Peninsula, through customary use wherever possible.

(b) Social Impact of the North West Shelf Project on Ngarluma People

One of the best studies of the impacts of development, including the North West Shelf (**NWS**) Project, on Ngarluma People was written by Dr Mary Edmunds in 1989 (*They Get Heaps: A Study of Attitudes in Roebourne Western Australia*, Aboriginal Studies Press, 1990). In her report Dr Edmunds documents how the massive expansion of Karratha driven by the NWS Project significantly altered the social landscape and further marginalised the Ngarluma People.

Karratha, by 1989, was predominantly a white town (10 Aboriginal families out of 11,000 people) and, as is the case today, most Ngarluma People resided in Roebourne.

Dr Edmunds found that:

> *"It has also changed the position of Roebourne from administrative and commercial centre for the region -… into a shunned backwater" (7)*
>
> *"In social and demographic terms, the result for Roebourne is not just that business and facilities have been shifted from Roebourne to Karratha but that these developments crystallise and emphasise the oppositional character of black and white."*

At the time little or no work was done by the proponents or the State to assess the social impact of the Proposal. As Dr Edmunds writes "*social planning was subordinated to economic development*".

Ngarluma People are still suffering from the social impact of the NWS Project today in relation to population growth, housing, community amenity and lifestyle, community safety and wellbeing and resilience. They have also not benefited economically from the NWS Project. NAC is not currently aware of any Ngarluma People who are employed by the NWS Joint Venture (**JV**) or of any Ngarluma businesses contracted by the NWS JV.

The NWS JV does not have a modern native title agreement with NAC on behalf Ngarluma People. There is an earlier agreement made with the Ngarluma and Yindjibarndi people in which benefits are directed through another corporation called Ngarluma Yindjibarndi Foundation Ltd (**NYFL**). This is an old agreement which was made in the late 1990's and NYFL was created by and exists for the purpose of this agreement.

(c) Social Surroundings

To describe the Ngarluma People's relationship to Traditional Country, for the Ngarluma, Country does not belong to any one person but to all Ngarluma people. Country, and obligations to protect it, was passed from Ngarluma ancestors to the current generations and thence to the coming generations. The Ngarluma People have a personal and spiritual link to their Country. They cannot leave it, and they are an inseparable part of it and all the other living things. Country is Ngarluma people. Traditional Country, the Ngarluma People and the spirits that inhabit Traditional Country are considered to be one entity. Any denial of the Ngarluma people's access to Traditional Country, including through participation in cultural heritage and environmental protection and management, is denying not only the Ngarluma people, but also the Ngarluma culture and the ability for the Ngarluma People to extend that culture and cultural knowledge to their children to ensure the existence of the Ngarluma culture in the future.

Importantly, the Environmental Protection Authority (**EPA**) acknowledges the importance of Aboriginal heritage factors and the vulnerability of Aboriginal sites and other country in Western Australia.

The EPA's Environmental Factor Guideline-Social Surroundings confirms a key objective is "*to protect social surroundings from significant harm".* It refers to the need for Aboriginal heritage surveys and environmental consultation as a means to address impacts on social surroundings. The EPA may require proponents to undertake *"Aboriginal heritage and cultural surveys, which may include anthropological and/or archaeological surveys, as well as proposed impact avoidance and mitigation measures"*, a "*description of proposed management and monitoring arrangements*" and "*analysis of cumulative impacts*".

The Ngarluma peoples' heritage values are inextricably part of the "environment". The definition of "environment" in the *Environmental Protection Act 1986* (WA) (**EP Act**) matches the Ngarluma people's connection to Country and Country's relationship to them. "Environment" is defined in the EP Act as "*living things, their physical, biological and social surroundings, and interactions between all these*."

"Social surroundings" as they apply to people mean "aesthetic, cultural, economic and social surroundings to the extent that those surroundings directly affect or are affected by (Ngarluma) physical or biological surroundings" (Section 3, EP Act). The Ngarluma People's whole way of life, their traditional laws and customs are directly affected by the physical and biological parts of what Country is to them. As mentioned above, the Ngarluma and Country are one entity and what hurts or damages Country does, in effect, the same to Ngarluma People.

A study done over 20 years ago entitled "*Indigenous Participation in Commonwealth Environmental Impact Assessment*" (June 1996), which was prepared for the Commonwealth Environment Protection Agency, points out how, with respect to EIA, "indigenous perspectives have frequently been neglected", and that "*ineffective EIA has contributed to the marginalisation of indigenous peoples as a result of rapid resource development in previously remote regions. There has been a failure to fully involve indigenous peoples in the assessment process, and to evaluate the impacts of development on indigenous peoples effectively*."

The study continues, "*In all areas, indigenous peoples wish to defend their cultural heritage and natural environments. They are subject to potential social impacts in all areas*" (page i, "Executive Summary").

As is stated in the study, *"environmental impacts may concern Indigenous people because of custodial responsibilities and use of land and species. Environmental impacts may also have cultural effects. It is unwise to separate environmental and social impacts, since these are inter-related through Indigenous culture and perceptions"* (page ii).

(d) NAC and Renewable Energy Future

NAC is committed to a renewable energy future, both to reduce the impact of emissions on cultural heritage and the environment and to create economic opportunities for Ngarluma People.

Renewable energy also has the potential to create long term sustainable economic benefits and revenue for future generations of Ngarluma People after the gas and iron ore resources are depleted.

NAC has offered to work with the State to identify land within the native title determination outside of the Proposal area that could be managed by NAC to develop renewable sources of energy for industry including the Proposal being assessed.

2. North West Shelf Project Extension - Submissions

Aspect	Comment
Air quality	Given the likely origin of the third-party gas and liquids is known and exploratory drilling will have been conducted, which should include some compositional analysis, further clarity should be provided around the composition of the expected third-party feeds compared to current feed streams and any areas of uncertainty associated with this. This would provide some reassurance that the assertion that emissions can be adequately managed by engineering controls and the air quality modelling is indeed representative of future emissions from Karratha Gas Plant (**KGP**). Modelling of future operational scenarios include the KGP emissions improvements, which incorporates a 40% reduction in NOx emissions by the end of 2030 based on NOx emissions reported for a five-year average, covering the 2013/14 to 2017/18 financial year (ERD Table 6-9). Given there is uncertainty around the impacts of NOx on the local environment, specifically the potential for the formation of acid species from the deposition of NOx gases onto rock art surfaces (ERD section 6.5.4.1), the precautionary principle should be applied, and NOx should be mitigated to the fullest extent possible. No detail on the activities to realise the 40% NOx reduction have been provided. In order for Woodside to set such a target regarding an emission reduction, it is assumed that preliminary feasibility studies have been completed. Can Woodside share further detail regarding the proposed NOx reduction measures to demonstrate that it is an achievable target? Further, is there potential for further reduction of NOx emissions beyond 40% within the lifetime of the Proposal? Have options such as removing emissions sources from the Burrup Peninsula been explored? While the commitment to a 40% reduction in NOx by 2020 is reiterated throughout the Environmental Review Document (**ERD**), it is not clear if or how Woodside is anticipating that this reduction target would be formally adopted and how they will be held accountable to meeting the commitment. A maximum estimate of NOx emissions of 8,900 tpa is quoted in ERD Table 2-2 based on maximum output for each turbine. It is not clear if this figure is based on the current operating scenario with the low NOx technology implemented only at LNG Trains 4 and 5 and therefore will reduce by 2030 when the 40% NOx reduction target is realised.

5

Aspect	Comment
Greenhouse gas (**GHG**) emissions	The argument that natural gas is the lowest carbon fossil fuel (NWS Project Extension Greenhouse Gas Management Plan Table 3-1) is not sufficient to justify the extension of the Proposal to 2070 given that it is a significant contributor to the State's GHG emissions. A commitment to a 330,000 tpa reduction is a small reduction to the 7.7 Mtpa emissions footprint, (the footprint is significantly greater if emissions from Browse gas to be processed at the KGP are taken into account – see below submission on the Browse to NWS (Commonwealth) component of the Proposal) and does not demonstrate sufficient support of the State Emissions Policy to achieve net-zero GHG emissions by 2050. Given the Proposal would extend halfway into the second half of the century, a more significant commitment to offsetting the potential global warming impacts of the Proposal should be required to meet the current State Government policy. This should include working with NAC and the State to identify and develop locations outside the Proposal area in which to generate renewable energy for the Proposal. Furthermore, a specific commitment to investment in offsets with long term benefits at the local and or regional level, and in particular to address the social impacts of the proposal on Ngarluma and other Aboriginal people, should be prioritised.

Cultural Heritage Management Plan	As set out in the background, NAC represents the Ngarluma People who are the Traditional Owners of the Proposal area. NAC considers the Cultural Heritage Management Plan is deficient in the following respects:
	• It does not identify or refer to NAC as a stakeholder for the purposes of Woodside's Cultural Heritage Management Procedures.
	• It does not provide for incident reporting to NAC.
	• It does not contemplate the involvement of NAC (or any other Aboriginal people) in cultural awareness training (see Management Action MA1).
	• It does not set out a transparent application process available to NAC and its members in respect of permission to access Aboriginal cultural heritage sites within the development (MA2).
	• It does not set out a process for communication with NAC in relation to odour complaints (MA3).
	• In relation to the Murujuga Rock Art Strategy and the Murujuga Rock Art Stakeholder Reference Group (MA 6);
	    ○ No Ngarluma People are members of the Reference Group.
	    ○ MAC is the only Aboriginal Corporation represented on the Reference Group (which for the reasons given in the Background does not represent the Ngarluma People and is not independent of the State and Woodside).
	    ○ The Strategy does not provide for the reporting of results to NAC or for NAC to be involved in reviews of the Strategy.
	In relation to the adaptive management and review process, NAC should be identified and given a role in the monitoring, review, evaluation and updating of the Cultural Heritage Management Plan.

6

Aspect	Comment
Social Surrounds	Other than the potential impacts to Aboriginal cultural heritage, the voluntary Social Impact Assessment (SIA) carried out by Woodside, while mentioned in the ERD (Section 5.4.1 - Advisian 2019), was not made available for review; instead a briefing was provided by Woodside personnel on the outcomes of the SIA and management plans in place. Through the SIA, Woodside has identified six key areas that carry potential risks and benefits as a result of the project – Economic development, employment and skills development; Population growth; Housing and accommodation, Community amenity and lifestyle; Community safety, wellbeing and resilience; and Indigenous cultural heritage and relations. Woodside's social and community activities in the key areas highlighted by the SIA will be implemented through a Social Impact Management Plan (SIMP). It is understood that Woodside will publish fact sheets on the SIMP and each of the keys areas in due course. Notwithstanding the above, NAC is concerned in light of the history of the NWS Project set out in the background that Woodside has not carried out an SIA in respect of, nor proposed measures to mitigate, the impact of the Proposal on Ngarluma and other Aboriginal People. Further, neither the Commonwealth nor the State have sought to ensure that Woodside carry out such an assessment or otherwise address the impact of the Proposal on Aboriginal People. Whilst it is acknowledged that the scope of the EPA's assessment is limited to assessing impacts resulting from changes to the environment as a result of Proposal implementation, it is also noted that under Section 44(2a) of the EP Act, the EPA can provide other advice and recommendations to the Minister for the Environment in its assessment report in relation to broader matters that should be considered by other decision making authorities with regard to the implementation of a proposal, if approved. Of relevance to the above is the current variation to the North West Gas Development (Woodside) Agreement 1979 (the State Agreement) includes requirements for Woodside to: • Prepare and implement a community development plan, which describes Woodside's strategies for achieving community and social benefits in and around the Pilbara. • Prepare a local participation plan, which outlines strategies that Woodside will use, including its third party contractors, to maximise local industry participation benefits as far as it is reasonable and economically practicable, includes strategies for the supply of services, labour, works, materials, plant, equipment or supplies for the Project. Therefore, at a minimum, NAC is of the view that Woodside should commit to: 1. Set targets and goals for working with NAC to achieve outcomes in relation to - housing and accommodation, community amenity and lifestyle; and community safety, wellbeing and resilience for Ngarluma People in the community participation plan required by the State Agreement. 2. Set targets and goals for working with NAC to achieve outcomes with respect to employment of Ngarluma People in relation to the Proposal and Ngarluma participation in the supply of services, labour, works, materials, plant, equipment or supplies for the Proposal in the local participation plan required by the State Agreement.

7

Browse to North West Shelf Project – Commonwealth

Aspect	Comment
Greenhouse gas (GHG) emissions	While LNG is championed as providing lower emissions than other fossil fuels, there are still significant carbon emissions predicted from the Browse to NWS Project. Furthermore, despite using a third-party toiling plant for processing, the project footprint is significantly higher than the baseline of other LNG projects, which is understood to be due to higher reservoir carbon dioxide content and the considerable distance that the gas will be piped requiring significant energy input. Woodside has committed to offsetting emissions for the increased carbon footprint of the project above baseline; however, no further commitment has been made to offset emissions within the baseline. The resources are being extracted within Australian waters; therefore, some commitments to further offsetting emissions to facilitate meeting the Commonwealth Government's reduction targets of 26-28% on 2005 levels by 2030 should be made. Since Woodside has researched and invested in offset programs and understands the benefits, a plan to contribute further offsetting of emissions that cannot be avoided should be expected, with key milestones and detail on how accountability is going to be maintained. Recent public criticism of the Browse to NWS project has included the perception that the project carbon dioxide emissions have been split up in order to be less than transparent. Is Woodside able to provide a simplified flow diagram showing where each part of the total CO_2 emissions is to be released from the proposed extraction and processing of the Browse gas fields?

8

APPENDIX D SUBMISSIONS

APPENDIX D.15 ANON - 57NR-WVNK-J (THE BEELIAR GROUP)

Public submission – Proposed Browse to North West Shelf Project & North West Shelf Project Extension

the BEELIAR GROUP

https://thebeeliargroup.com/

Prepared by the Beeliar Group of Professors for Environmental Responsibility. Our group of 35 Professors was formed in January 2017 out of concern over the process used to plan and implement the Perth Freight Link and Roe Highway Stage 8.

12 February 2020

* † *

Context for the Submission

1. This is a public submission to support the community consultation being undertaken on the proposed Browse to North West Shelf Project and the North West Shelf Project Extension. Those proposals are operated by Woodside Energy Ltd (Woodside) on behalf of their Joint Venture Partners.

2. The Beeliar Group supports the public submission made by Dr [redacted] and the comments and recommendations made therein regarding the effects of the North West Shelf Project Extension on air quality and public health.

3. The Beeliar Group also supports the public submission made by the Friends of Australian Rock Art, and notes that the Australian Government recently lodged a submission for the Murujuga cultural landscape on Western Australia's Burrup Peninsula to be included on Australia's world heritage tentative list, which is the first formal step toward achieving global recognition for the 50,000-year-old gallery of more than one million petroglyphs.

4. We note the proposal description for the North West Shelf Project Extension provided on the website of the WA Environmental Protection Authority (EPA):

   > Woodside Energy Ltd (Woodside) as Operator for and on behalf of the North West Shelf Joint Venture proposes the ongoing operation of the North West Shelf Project to enable the processing of third party gas and fluids through the North West Shelf Project facilities until around 2070.

5. We note that the proposal description for the proposed Browse to North West Shelf Project provided on the website of the WA Environmental Protection Authority (EPA):

   > Woodside Energy Ltd (Woodside) as Operator for and on behalf of the Browse Joint Venture, is proposing to develop the Browse Development Area located approximately 425km north of Broome in the offshore Browse Basin.
   >
   > The Browse to North West Shelf (NWS) proposal in State waters surrounding Scott Reef

involves drilling and completion, installation, commissioning, operation, well repair and workover, and decommissioning of up to 24 subsea wells and associated infrastructure located in Western Australian State waters.

Development of the remaining proposal elements is subject to assessment by the Commonwealth and includes two Floating Production Storage and Offloading facilities (FPSO) connected to existing NWS infrastructure via a 900-kilometre trunk line.[1]

6. We recognise that the proposed Browse to North West Shelf Project action/proposal:
   a. spans State and Commonwealth jurisdictions; and
   b. is being independently assessed under both the *Environmental Protection Act 1986* (WA) (EP Act) (Public Environmental Review) and the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act).

7. For clarity, our submission relates to the State assessment for the North West Shelf Project Extension and to both the State and Commonwealth assessments for the proposed Browse to North West Shelf Project. Unless stated otherwise, the submissions refer generally to the assessments of both proposals. We refer specifically to the EP Act and the EPBC Act or to the State and Commonwealth assessments as relevant.

8. The term "assessment documentation" refers to the documents relating to the assessment of the two proposals under both Acts, including the North West Shelf Project Extension Environmental Review Document and the Draft EIS/ERD document for the Browse to North West Shelf Project.

9. We note that, for the assessment under the EPBC Act, the proposed action by Woodside is a controlled action, and requires assessment and approval under the EPBC Act before it can proceed. The relevant controlling provisions are:
   - National heritage values of a National Heritage place (ss 15B & 15C);
   - Listed threatened species and communities (s 18 & 18A);
   - Listed migratory species (ss 20 & 20A); and
   - Commonwealth marine area, the protected matter being the environment generally (ss 23 & 24A).

[1] http://www.epa.wa.gov.au/media-statements/woodside%E2%80%99s-browse-and-north-west-shelf-proposals-out-public-comment

Contents of Public Submission

1 Suggested outcomes from the State and Commonwealth assessments

Submission 1:

The State and Commonwealth decision-making authorities should find that:

(1) the two proposals will contribute to climate change; and
(2) the effects of that climate change will have significant impacts on the matters protected under the **EP Act** (the 'environment' of the State) and under the **EPBC Act** (the matters of national environmental significance for the four controlling provisions for the Browse to North West Shelf Project action).

Accordingly, the State and Commonwealth decision-making authorities should:

(1) refuse approval for the two proposals; or
(2) grant approval but impose substantive conditions on GHG emissions.

By "substantive" we mean avoidance, reduction, and/or offset measures that will result in much lower Scope 1 GHG emissions from the two projects than Woodside and the joint venture partners currently proposes.

2	**Woodside and the joint venture partners have failed to mitigate their companies' exposure to climate risk**

Submission 2:

Article 2(1)(c) of the Paris Agreement provides:

> This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:
>
> ...
>
> **Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.** (emphasis added)

Investor and community pressures concerns about climate risk now occupy the heart of mainstream investing. Financiers are abandoning companies that fail to mitigate exposures to climate change risks.[2]

Submission 3:

1. Woodside and the joint venture partners fear that State regulatory controls on GHG emissions will harm their ability to obtain finance.

2. To use the framework for climate-related risk developed by the Task Force on Climate-related Financial Disclosures (TFCD),[3] Woodside and the joint venture partners argue that the climate-related risk for the two proposals is a "Policy" risk, associated with a change or evolution in the State regulatory approach for GHG emissions. Thus terms such as "policy shock" and ad hominem comments like "boffin" are used to disparage members of the EPA.

3. As regards their ability to obtain finance, the relevant climate-related risks for Woodside and the joint venture partners are:

a. litigation risk:
As Noel Hutley SC and Sebastian Hartford-Davis concluded in their March 2019 supplementary opinion on climate change and directors' duties: "the exposure of individual directors to 'climate change litigation' is increasing, probably exponentially, with time."[4]

b. market risk
Climate change and the transition to a lower carbon economy create vicissitudes in the supply and demand for products, including LNG.

[2] See, e.g., *The Green Swan: Central Banking and Financial Stability in the Age of Climate Change* (January 2020): https://www.bis.org/publ/othp31.pdf
[3] https://www fsb-tcfd.org/publications/
[4] https://cpd.org.au/2019/03/directors-duties-2019/

c. reputational risk:
As the authors of the TFCD report note, climate change raises important issues of corporate social responsibility: "Climate change has been identified as a potential source of reputational risk tied to changing customer or community perceptions of an organization's contribution to or detraction from the transition to a lower-carbon economy."

4. We must reach net zero emissions by 2050. This outcome cannot be negotiable, it is a global agreement and the State must be part of this or else the focus of the world's financing institutions will turn on us.

5. Woodside and the joint venture partners are seeking to keep production increasing right through this period and even into 2070. They have no plan for phasing in Green Hydrogen.

6. Financiers will see the two proposals as risky not because of the regulatory controls being placed on them, but because the markets for LNG will be turning off and looking for Green Hydrogen not natural gas.

7. If Woodside and the joint venture partners can't produce a Plan for Natural Gas Phase-Out and Green Hydrogen Phase-In then they will not be attractive to the market.

8. Government processes need to support this transition. If not the industry will collapse as its markets fall away. This is not good economic planning as well as not good environmental planning.

3	**Decision-makers must consider the Paris Agreement mitigation objectives**

Submission 4:
Every emission of GHGs increases the concentration of GHGs in the atmosphere, and thus contributes to reaching the critical concentrations of 430 ppm (for a 1.5°C target) and 450 ppm (for a 2°C target).

Submission 5:
The limited remaining carbon budget for the 1.5°C target (430 ppm) and 2°C target (450 ppm) means that each failure to impose a reduction in GHG emissions now will require future reductions to be more stringent (and likely more costly and/or onerous to implement) to stay within the confines of an even more limited remaining carbon budget.

Submission 6:
Each reduction in GHG emissions makes the 1.5°C and 2°C targets more practicable to achieve, as the reduction leaves more of the remaining carbon budget unused. Just as every emission of GHGs increases the atmospheric concentration of GHGs, every reduction in GHGs keeps a portion of the carbon budget intact.

Comment

10. The 2018 IPCC *Special Report on Global Warming of 1.5°C*,[5] Paris Agreement-compatible global pathways to net zero CO_2 and greenhouse gas (GHG) emissions consistent with the Paris Agreement long term temperature goal entail a reduction of 45% by 2030 from 2010 levels.

11. The IPCC *Special Report on Global Warming of 1.5°C* report also shows clearly that delays in reducing emissions on this timescale will likely make meeting the Paris Agreement much more expensive and/or infeasible.

12. Downscaling these global energy scenarios to Australia indicates that domestic reductions by 2030 need be at least 44% from 2005 levels.

13. State and Commonwealth decision-makers must have regard to the mitigation objectives and actions expressed in Article 2 and Article 4 of the Paris Agreement, namely that:
    a. Limiting global warming to well below 2°C and striving to limit the temperature increase to 1.5°C will significantly reduce the risks and impacts of climate change (Article 2); and
    b. To achieve this temperature goal, greenhouse gas emissions must peak as soon as possible

[5] https://www.ipcc.ch/sr15/

and then reduce rapidly to achieve net zero greenhouse gas emissions by 2050, with developed countries leading with economy-wide absolute emissions reduction targets (Article 4).

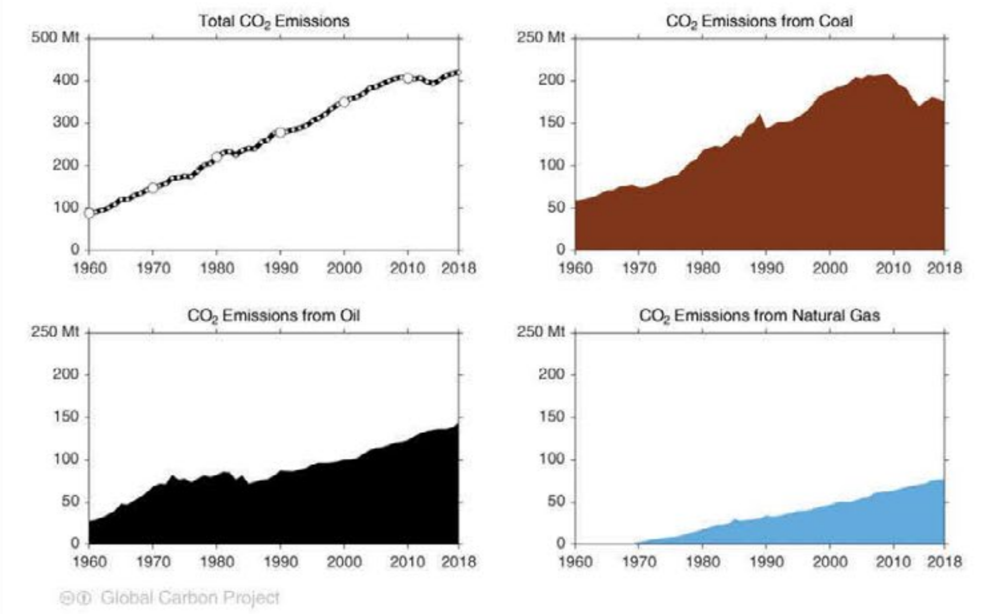
14. Emissions from oil and natural gas are increasing rapidly and are driving Australia's overall growth in fossil CO_2 emissions (Figure 1).

15. For Australia is to meet its emission reduction targets under the Paris Agreement, new natural gas developments must use carbon capture and storage.

Figure 1: CO_2 emissions from fossil fuels in Australia (in million tonnes)

Source: https://www.globalcarbonproject.org/carbonbudget/ & https://theconversation.com/global-emissions-to-hit-36-8-billion-tonnes-beating-last-years-record-high-128113

Data Source: UNFCCC, CDIAC, BP, USGS



4	The proposals are not ecologically sustainable development

Submission 7:

The manner in which Woodside and the joint venture partners propose to develop the Browse reservoir and to operate the North West Shelf Project facilities will create residual GHG emissions that are significant in a State, national, and global context because the annual and cumulative emissions from the two projects combined will (inter alia):

a. consume substantial portions of the global carbon budgets for the 1.5°C and 2.0°C targets;
b. make the Browse to North West Shelf LNG value chain the largest, or near largest, source of GHG emissions of all Australian resource projects;
c. prevent Western Australia from achieving 1.5°C and 2.0°C-compatible pathways; and
d. consume a substantial portion of the carbon budget for Australia to achieve its current Nationally Determined Contribution (NDC) under the Paris Agreement.

Submission 8:

The cumulative emissions are therefore important, notable and of State, national, and international consequence in:

a. an absolute sense (the magnitude of GHG emissions) given relevant emissions reductions targets and carbon budgets;
b. the contribution they will make to climate change (as quantified by their Global Warming Potential (GWP) or other emission metric);
c. in terms of the partial responsibility that Australia (and Western Australia) have for climate change and for reducing GHG emissions;
d. the implications for international equity in a State and national context; and
e. the issues of fairness and equity they present because they will comprise such a substantial portion of State and Australia GHG emissions for several decades.

Submission 9:

The manner in which Woodside, and the joint venture partners for the two proposals, proposes to exploit the Browse reservoir and operate the North West Shelf Project facilities will not use, conserve and enhance the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased.

Submission 10:

The implementation of the two proposals in their current form will privatise the profits from the use of a community resource and socialise the associated environmental, cultural and public health costs.

Comment

16. The proposed Browse to North West Shelf Project addresses the decline in the North West Shelf Joint Venture's existing gas reserves by developing a new gas reserve with a high reservoir CO_2 content (Browse). The North West Shelf Project Extension extend and expands the operation of North West Shelf Project facilities.

17. The assessment documentation reports annual Scope 1 emissions of 4.8 mt CO_2–e/year (Browse to NWS - average year) and 7.7 mt CO_2–e/year (NWS Shelf Extension).[6]

18. The assessment documentation reports total annual emissions of 36.8 mt CO_2–e/year (average) (Scope 1 and 3) for the proposed Browse to North West Shelf Project and 87.89 mt CO_2–e/year (average) (Scope 1, 2, and 3) for the North West Shelf Project Extension.

19. The assessment documentation indicates an expected field life of 31 years and an extended field life of 44 years for proposed Browse to North West Shelf Project and that the North West Shelf Project Extension will operate until around 2050.

20. In accord with established principles of international law and Australia's obligations and commitments under international climate change agreements, Australia has partial responsibility for climate change and its impacts and must account for at least the Scope 1 GHG emissions from the two proposals.

21. It is the community – not Woodside and the joint venture partners – that will bear the burden of the consequences of the two proposals, which include contributions to climate change, reductions in air quality (and consequent impacts on human health and amenity), and impacts on Aboriginal cultural heritage (rock art).

[6] The assessment documentation leaves the actual Scope 1 position for the proposed Browse to North West Shelf Project unclear.

5	**The two proposals are inextricably linked and the separate assessments obscure the overall carbon footprint**

Submission 11:
The proposed Browse to North West Shelf Project, through the use of FPSO facilities in Commonwealth waters, effectively removes more than half of the action's Scope 1 emissions from State regulatory oversight.

Submission 12:
The two proposals are inextricably linked and, in examining the contributions that the two projects will make to climate change, the emissions from the two proposals should be considered together.

Comment

22. The proposed Browse to North West Shelf Project action moves offshore a portion of the processing that previously occurred on land and separates the emissions from the Browse reservoir supply chain across two Safeguard facilities.[7]

23. The emissions from Browse to North West Shelf Project Safeguard facility will nonetheless be attributable to Western Australia as the *National Greenhouse and Energy Reporting Act 2007* (Commonwealth) requires the emissions from a facility to be attributed to a State or Territory. This creates the unusual position where a State is nominally responsible for emissions that it has no regulatory control over.

[7] We presume the proposed Browse to North West Shelf Project will have its own Safeguard facility – the assessment documentation is unclear on this point.

6 Decision-makers must consider cumulative emissions

Submission 13:
1. For both proposals, the proper focus of the decision-making authorities should be on the proposal's cumulative greenhouse gas emissions, the potential for those cumulative emissions to contribute to climate change, and the consequences of climate change for the subject matters of interest. 2. Emissions of CO_2 accumulate in the atmosphere and long-term climate change reflects cumulative (cf annual) CO_2 emissions. Whether a project's emissions occur over 40 years or 4 years does not matter for 2075 climate change or eventual peak warming – it is the cumulative emissions not the timescale that is important.

Submission 14:
Decision-makers must grasp the size of the issue that the world and Australia faces from the next phase of development in the North West Shelf. The annual and cumulative Scope 1 and Scope emissions from the Browse to North West Shelf Project and North West Shelf Project proposals alone exceed those proposed for Carmichael Coal Mine project (Adani).

Submission 15:
1. The impact of a polluting project increases in significance as time goes on, even if annual emissions are held constant. 2. This is because the same annual emissions amount will consume a greater and greater fraction of the diminishing available global carbon budget every year. 3. The IPCC *Special Report on Global Warming of 1.5°C* and IEA 1.5°C Sustainable Development Goals based carbon budget shows that between 2025 and 2040 (the period of Browse major production) global natural gas production must decline and reduce in emissions intensity. 4. The magnitude and intensity of production from the two proposals is inconsistent with this. Nonetheless Woodside and the joint venture partners fail to mitigate the climate risk associated with their projects by (e.g.) applying carbon capture and storage technology or implementing full offsetting of residual GHG emissions.

Submission 16:
Particularly when cumulative emissions are taken into account, there is no proper basis for the assertions made in the assessment documentation that:

a. the residual emissions from the two proposals are inconsequential at a global scale; and
b. Browse-derived LNG, and North West Shelf Project-processed LNG generally, will reduce global GHG emissions.

Comment

24. Decision-makers must focus on cumulative emissions from a proposal because, particularly for long-lived GHGs, the impact of the physical effects associated with climate change (e.g. increased ocean temperature, ocean acidification, and more extreme weather events) on a subject matter can only be evaluated over time (c.f. focusing on a single, short-term event or circumstance).

25. It takes many hundreds of years to thousands of years for natural biophysical processes to remove CO_2 that human activities (e.g. combustion of fossil fuels) have added to the Earth's carbon cycle. Warming caused by CO_2 emissions is effectively irreversible over decadal to multi-century timescales.

7	**Decision-makers must recognise that all greenhouse gas emissions contribute to climate change**

Submission 17:
A basic premise of our current scientific and legal frameworks for the relationship between greenhouse gases and climate change is that all emissions of greenhouse gases contribute to global warming.

Submission 18:
A second premise is that all emissions can be traced to impacts because GHG emissions disperse throughout the atmosphere and have a relatively uniform effect.

Submission 19:
A third premise of our legal framework for the relationship between greenhouse gases and climate change is that the emissions contribution of a party can be used as a proxy for its contribution to an impact.

Comment

26. A basic premise of our current scientific understanding and legal frameworks for the relationship between greenhouse gases and climate change is that all emissions of greenhouse gases contribute to global warming.

27. A second premise is that all emissions can be traced to impacts because GHG emissions disperse throughout the atmosphere and have a relatively uniform effect.[8]

28. A third premise of our legal framework for the relationship between greenhouse gases and climate change is that the emissions contribution of a party can be used as a proxy for its contribution to an impact.[9]

29. "Greenhouse gases" like carbon dioxide (CO_2) and methane (CH_4) are gases that trap heat in the atmosphere. The contribution of a greenhouse gas to global warming depends on: the amount of the gas in the atmosphere (concentration); the length of time the gas stays in the atmosphere (lifetime); and the ability of the gas to absorb energy (radiative efficiency). Carbon dioxide and methane are "well-mixed" greenhouse gases meaning that they have lifetimes long enough to be relatively homogeneously mixed in the troposphere.

[8] Burger, M., Wentz, J., & Horton, R. (2020). The Law and Science of Climate Change Attribution. *Columbia Journal of Environmental Law*, 45(1). https://doi.org/10.7916/cjel.v45i1.4730; available at: https://journals.library.columbia.edu/index.php/cjel/article/view/4730

[9] Burger, M., Wentz, J., & Horton, R. (2020). The Law and Science of Climate Change Attribution. *Columbia Journal of Environmental Law*, 45(1). https://doi.org/10.7916/cjel.v45i1.4730; available at: https://journals.library.columbia.edu/index.php/cjel/article/view/4730

30. Emission metrics such as Global Warming Potential (GWP) can be used to quantify the relative and absolute contributions to climate change of emissions of different greenhouse gases and of emissions of greenhouse gases from different sources (e.g. countries, sectors, or facilities).[10]

31. The GWP of a greenhouse gas reflects its lifetime radiative efficiency, and is a measure of how much energy the emissions of 1 tonne of that gas will absorb over a chosen period of time, relative to the emissions of 1 tonne of carbon dioxide (which is the reference gas). Gases with a higher GWP absorb more energy, per unit of mass, than gases with a lower GWP, and thus contribute more to global warming.

32. GWPs are a basic methodological architecture for the Australia's National Greenhouse Accounts and for the Emissions and Energy Reporting System (EERS) under the *National Greenhouse and Energy Reporting Act 2007*. Section 2.02 of the *National Greenhouse and Energy Reporting Regulations 2008* (Commonwealth) provides that the GWP of carbon dioxide is 1 and that the GWP of methane is 25.

33. Courts, both in Australia and internationally, have recognised that all emissions of greenhouse gases contribute to global warming. In *Gloucester Resources Ltd v Minister for Planning* (2019) 234 LGERA 257, 370 [514], Justice Brian Preston (Chief Judge of the NSW Land and Environment Court) observed:

> **All GHG emissions contribute to climate change**
> All of the direct and indirect GHG emissions of the Rocky Hill Coal Project will impact on the environment. All anthropogenic GHG emissions contribute to climate change. As the IPCC found, most of the observed increase in global average temperatures is due to the observed increase in anthropogenic GHG concentrations in the atmosphere. The increased GHG concentrations in the atmosphere have already affected, and will continue to affect, the climate system.

34. The Scope 1 and Scope 3 GHG emissions from the two proposals increase concentrations of GHGs in the atmosphere and therefore well lead to positive radiative forcing and warming of Earth's surface, with consequent physical effects (e.g. particularly increased ocean temperature, ocean acidification, and more extreme weather events).

35. As regards Scope 3 emissions, we submit that the decision-making authorities can be satisfied that Scope 3 emissions will increase concentrations of GHGs in the atmosphere, and that it is practicable to estimate the amount of GHGs that will be emitted through the transport and combustion of Browse-derived LNG or LNG produced at the North West Shelf Project facilities in China, India, Japan, and elsewhere.

[10] Myhre, G., and others. (2013). 'Anthropogenic and Natural Radiative Forcing.' In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. [Stocker, T.F., and others (eds.)]. Cambridge University Press. Available at: https://www.ipcc.ch/report/ar5/wg1/

8	**For the Commonwealth assessment, the relevant events or circumstances for the Scope 1 and Scope 3 emissions are the physical effects associated with climate change**

Submission 20:
Relevant events or circumstances for the Scope 1 and Scope 3 emissions for the proposed Browse to North West Shelf action are the physical effects associated with climate change, particularly increased ocean temperature, ocean acidification, and more extreme weather events.[11] These physical effects affect biota, e.g. increased sea surface temperatures can cause coral to bleach. As discussed above, the impact of an action on matters of environmental significance should be assessed on the basis of the cumulative emissions from the action.

Comment

36. The meaning of "impact" is addressed in s 527E of the EPBC Act to include an "event or circumstance" which is a direct consequence of the action. An "event or circumstance" is not defined in the EPBC Act, so those words are to be given their ordinary meaning.

37. The phrase "significant impact" is also not defined in the EPBC Act but has been construed as meaning an "impact that is important, notable or of consequence having regard to its context or intensity": *Booth v Bosworth* (2001) 114 FCR 39 [90].

38. The term "impact" is defined by reference to whether an event or circumstance is an impact of an action and a distinction is drawn between an event or circumstance which is a direct consequence of an action as opposed to an event or circumstance that is an indirect consequence of an action. An event or circumstance that is an indirect consequence of an action will be an "impact", subject to s 527E(2), only if the action is "a substantial cause of that event or circumstance": s 527E(1)(b)).

39. If the Minister (or her delegate) has decided under Division 2 of Part 7 that an action is a controlled action, the relevant impacts of the action are the impacts that the action (a) has or will have or (b) is likely to have on the matter protected by each provision of Part 3 that the Minister has decided under that Division is a controlling provision for the action. The controlling provisions are indicated above.

40. Sub-section 527E(2) provides for when there is a primary action and a secondary action which is taken by a different person as a consequence of the primary action and when an event or circumstance consequential upon the secondary action is an impact of the primary action. For an event or circumstance to be an indirect consequence of an action, it must be

[11] See *Australian Conservation Foundation Incorporated v Minister for the Environment and Energy* [2017] FCAFC 134 [61] (25 August 2017) (Full Court of the Federal Court of Australia).

demonstrated that the action is a "substantial cause" of that event or circumstance (s 527E(1)(b)) and that the criteria prescribed by s 527E(2) are met.

41. Relevant events or circumstances for the Scope 1 and Scope 3 emissions for the proposed Browse to North West Shelf action are the physical effects associated with climate change, particularly increased ocean temperature, ocean acidification, and more extreme weather events.[12]

42. These physical effects affect biota, e.g. increased sea surface temperatures can cause coral to bleach. As discussed above, the impact of an action on matters of environmental significance should be assessed on the basis of the cumulative emissions from the action.

43. This is because the physical effects of climate change associated with emissions of a long-lived GHGs over the operational lifetime of the action will manifest in multiple events and circumstances over time and may cause persistent changes in the environment (e.g. in temperature and pH) that will exert cumulative and synergistic impacts on biota.

[12] See *Australian Conservation Foundation Incorporated v Minister for the Environment and Energy* [2017] FCAFC 134 [61] (25 August 2017) (Full Court of the Federal Court of Australia).

9	**Decision-makers should not apply a simple mechanistic notion of causation in assessing impacts and should consider Australia's partial responsibility for climate change**

Submission 21:
Australia is subject to its own independent obligations under international law and under international agreements to which it is a signatory (e.g. the United Nations Framework Convention on Climate Change, UNFCC). Those obligations oblige Australia to comply with its partial responsibility for climate change and to do its part to reduce GHG emissions and prevent harmful climate change.

Submission 22:
This partial responsibility extends to decision-making under Commonwealth and State legislation and requires decision-makers to evaluate the significance of GHG emissions within the national, regional or local context over which decision-makers have regulatory authority.

Submission 23:
The EPBC (Part 9) and the EP Act (Part IV) do not require decision-makers to apply a simple mechanistic notion of causation in assessing impacts. When assessing a potential impact of climate change on a particular subject matter, decision-makers do not need to satisfy themselves as to a causal chain extending from the moment of emission through the process of radiative forcing to the manifestation of a specific event or circumstance associated with climate change (e.g. abnormally warm sea surface temperatures) and the consequence of that event or circumstance for the subject matter of interest (e.g. a coral bleaching event).

Submission 24:
The decision authorised by s 130 of the EPBC Act is a decision to allow, or not to allow a proposed action, which will, or is likely to, have a significant impact on a matter protected by a provision in Part 3 of the EPBC Act. The matters relevant to the decision are prescribed (primarily in Part 9), but there is no particular matter of which the Minister must be satisfied. In making the decision, the Minister is not required to make intermediate decisions concerning "impacts" or the causes of impacts.[13]

Submission 25:
The assessment of a proposed action (or a proposal) must, within the relevant statutory framework, be responsive to the nature of the impacts that a proposed action (or proposal) will

[13] *Australian Conservation Foundation Incorporated v Minister for the Environment and Energy* [2017] FCAFC 134 [61] (25 August 2017) (Full Court of the Federal Court of Australia)

cause, or is likely to cause, on the subject matter of interest.

Failure to do so will render the law – principally Part 9 of the EPBC Act and Part IV of the EP Act – impotent to regulate the GHG emissions from proposed actions (and proposals), even where climate change is likely to have a serious, and in some cases catastrophic, impact of the subject matter in question.

10	A basis for evaluating the significance of a project's emissions

Comment

44. A basis by which the significance of the GHG emissions from the two projects can be evaluated is described in Table 1 below.

Table 1: Description of a basis by which to evaluate the significance of a project's emissions
(1) The emissions of long-lived GHGs from many emitters, including the project in question, disperse and commingle to a well-mixed state in the atmosphere. (2) Emitters differ in their emission contributions (e.g. the suites of GHGs emitted and the amounts emitted). (3) Emission metrics (e.g. Global Warming Potential, GWP) can quantify the relative and absolute contributions to climate change of these emission contributions. (4) Radiative forcing from atmospheric GHGs leads to an event or circumstance (e.g. increased ocean temperature, ocean acidification, more extreme weather events) that negatively affects the environment (e.g. increased sea surface temperatures leads to coral bleaching and ultimately to coral mortality). (5) The commingled emissions and the complex nature of climate change means that regulators have no feasible means by which to determine whether any individual emitter's emissions caused the event or circumstance. (6) The regulator can therefore apply a presumption of indivisibility, and each of the emitters can be deemed to have partial responsibility for the event or circumstance, provided their emissions contribution exceeds some *de minimis* threshold. (7) The project's emissions contribution, expressed quantitatively through an emission metric, can be used as a proxy for the scope of its partial responsibility for the event or circumstance. (8) The regulator can assess the significance or importance of the project's partial responsibility for the event or circumstance by comparing the emissions contribution of the project with the emissions contributions of other emitters within a relevant context. (9) The relevant context may include: a. the statutory jurisdiction of the regulator (e.g. the State of Western Australia, including State waters); b. the GHG emissions apportioned to a State or Territory (as indicated in the most recent *State and Territory Greenhouse Gas Inventories*) or to Australia as a whole (as indicated in the most recent *National Greenhouse Gas Inventory*); c. a relevant emissions reduction target; or d. a relevant carbon budget.

11	**Decision-makers should not accept Woodside's claims of emissions reductions because its LNG will displace coal in import countries and should instead accept Woodside's admission that the correct proposition is that gas has benefits over coal in generating electricity**

Submission 26:

Claims of emissions reductions from a coal-gas energy switch must be based on empirical studies across the entire natural gas value/supply chain (or chains), including upstream, midstream and downstream participants.[14]

There are at several areas of uncertainty that Woodside has not adequately addressed:

a. whether imported Woodside LNG will in fact displace coal in the import country;
b. whether desired emissions reductions will occur because of the complexity of LNG supply chains and thus the potential for emissions at multiple stages in the supply chain;
c. whether appropriate technologies (e.g. closed cycle gas turbine technology for high efficiency electricity generation) for minimising emissions will be used in import countries; and
d. whether suitable methodologies can be developed to measure and report reductions in emissions given the complexity of LNG supply chains and still-evolving frameworks for monitoring, reporting and verification (MRV) in China.

Submission 27:

Woodside correctly acknowledges that the uncertainty underlying its claim that natural gas has the potential to contribute significantly to the reduction in global greenhouse gas emissions and appropriately proposes that the claim be taken as the proposition that natural gas has benefits over the use of coal in generating electricity.

Submission 28:

1. Woodside LNG exported to Asian markets may reduce emissions if:
   (a) fugitive gas emissions are sufficiently low across the LNG value chain (and these emissions are accurately measured and estimated);
   (b) Woodside LNG is used in high efficiency electricity generation technology in destination markets[15]; and
   (c) if that electricity displaces generation that previously came from coal (i.e. an actual coal-gas switch) or is likely, in the circumstances, to have displaced generation that would otherwise came from coal (and not from some other energy source, including renewables).

2. However, the assessment information does not contain information capable of supporting an inference that Woodside LNG will, as a question of fact, reduce emissions from electricity generation in China, India, Japan, and other Asian markets.

[14] https://www.ccacoalition.org/en/resources/reducing-methane-emissions-across-natural-gas-value-chain-guiding-principles
[15] https://gisera.csiro.au/wp-content/uploads/2019/07/GISERA_G2_Final_Report-whole-of-life-GHG-assessment.pdf

3. The claim that Woodside LNG may reduce emissions is based on conjecture rather than empirical information about the use of Woodside LNG for electricity generation in China, India, Japan, and other Asian markets.

Submission 29:

Adequate support for a claim of emissions reduction from Woodside's LNG requires a study similar to the CSIRO GISERA project (published 2019[16]) which conducted a whole of life GHG emissions assessment for a gas supply chain, but which extends the geographic scope of the assessment to include LNG combusted for generation of electricity in China, India, and other Asian markets.

Submission 30:

1. A role for gas in facilitating the integration of renewables in Asian markets is a different claim that Woodside's claim of emissions reduction through coal-gas switching, and the assessment documentation provides no empirical information to support an inference that Woodside LNG would, as a question of fact, facilitate the integration of renewables in Asian markets.

2. This latter point is significant because the extent to which Woodside LNG would facilitate the integration of renewables depends on a range of factors, not least of which is that the cost of imported Woodside LNG may often be higher than domestic or imported gas from other sources (e.g. from gas pipelines).

Submission 31:

1. Claims of avoided emissions by coal-gas switching, and any inferences to be drawn from them for the purpose of the EPBC and EP Act assessments, must not overstate the conclusions reported in the studies on which those claims are based.

2. For example, Woodside relies on the IEA's estimate of 95 mt CO_2-e of avoided emissions in 2018 because of coal-to-gas switching. This IEA estimate is based on <u>all</u> forms of natural gas (not just LNG) and more than half of the avoided emissions occurred in the United States and Europe.

3. The claims must properly reflect the limitations of those studies and the uncertainties in their estimates of historical avoided emissions or predictions of future avoided emissions in particular scenarios.

Submission 32:

Claims of avoided emissions, and any inferences to be drawn from them for the purpose of the EPBC and EP Act assessments, must have proper regard to the inherent limitations of those

[16] https://gisera.csiro.au/wp-content/uploads/2019/07/GISERA_G2_Final_Report-whole-of-life-GHG-assessment.pdf

studies and the conclusions reported in them, including that:

- the conclusions reported in the studies are projections based on predictive modelling and scenario data;
- the predictive modelling was conducted at national and regional-level scales and was based on certain assumptions and scenario data that also had important limitations;
- the predictive modelling and scenario data was necessarily coarse in that the study was limited in its ability to include within-country information about (e.g.) the diversity and complexity of LNG supply chains within China, India, and other markets; the technology that would be used for electricity generation (and, specifically, whether high efficiency electricity generation would be used); and the prices (and price fluctuation) of Woodside LNG and other energy sources within China, India, and other markets and in Asian spot markets; and
- there are diverging opinions about the plausibility of scenarios modelled and the assumptions on which the studies were based.

Submission 33:

Realistic, evidence-based claims of avoided emissions for Woodside LNG must account for, among other things:

- competition with lower-cost domestic or imported gas in Asian markets, and the implications of increasing global competition to supply the Asian region with gas;
- the complexity of LNG supply chains, within and between countries, and in relation to LNG supplied through long-term supply contracts and through the spot market;
- the sensitivity of avoided emissions to fugitive emissions and the emissions intensities of supply chains for Woodside LNG generally;
- the range of technologies that would be used for electricity generation (and, specifically, whether high efficiency electricity generation would be used); and
- Woodside LNG displacing:
  (a) natural gas produced elsewhere (which would mean overall emissions would remain about the same or would increase because of the emissions intensities associated with Browse-derived LNG); or
  (b) renewables (which would increase overall emissions).

Submission 34:

1. Claims of avoided emissions based on the assumption that the total delivered volume of Browse LNG produced to 2040, supplied into the diverse and dynamic gas markets and supply chains in China, Japan, India, and other Asian countries (whether by long-term supply contracts or through the spot market or otherwise), will – in a straight MWh for MWh switch – displace electricity generated from coal and oil are implausible, and provide no rational basis for claims of emissions reductions.

2. In this regard, we support, the recent observations[17] from two ANU researchers in the Crawford School of Public Policy at ANU, Frank Jotzo and Salim Mazouz:

   In a statement accompanying the latest quarterly emissions figures, the Department of Environment and Energy stated:

[17] https://theconversation.com/australias-energy-exports-increase-global-greenhouse-emissions-not-decrease-them-118990

Australia's total LNG exports are estimated to have the potential to lower emissions in importing countries by around 148Mt CO_2-e [million tonnes of carbon dioxide equivalent] in 2018, if they displace coal consumption in those countries.

In truth, the assumption that every unit of Australia's exported gas displaces coal is silly. The claim of a 148Mt saving is wrong and unfounded. The real number would be much smaller, and there could even be an increase in emissions as a result of LNG exports.

For the most part, exported gas probably displaces natural gas that would otherwise be produced elsewhere, leaving overall emissions roughly the same. Some smaller share may displace coal. But it could just as easily displace renewable or nuclear energy, in which case Australian gas exports would increase global emissions, not reduce them.

Submission 35:

The assessment documentation does not contain any evidence, drawn from life cycle assessments or other methodologies across the entire gas supply chain, including upstream, midstream and downstream components (e.g. combustion of gas by electricity producers in China, Japan, India, and other Asian markets), that describes GHG emissions from the North West Shelf Extension Project (including, specifically, from the Browse reservoirs) and is based on:

(a) existing data for supply chains associated with the North West Shelf Project; and also

(b) plausible future output scenarios of LNG production given probable future sales volumes of LNG into Asian markets, appropriate ranges of reservoir CO_2, and realistic assumptions about the technologies used for electricity generation and the proportion of LNG that displaces electricity produced by coal and oil combustion.

Implication:

The EPA and the relevant State and Commonwealth Ministers therefore do not have any reliable information on which to infer any reduction in Scope 3 emissions from the North West Shelf Extension Project or the proposed Browse to North West Shelf Project that are based on the assertion that electricity derived from the combustion of (i) gas from the Browse reservoirs or (ii) LNG produced by the North West Shelf Project will displace electricity derived from the combustion of coal or oil in China, Japan, India, and other Asian markets.

Submission 36:

The assessment documentation for both proposals does not contain any:

(1) **empirical evidence** that any electricity producer in China, Japan, Southeast Asia, and India has, as a question of fact, switched from using coal to using LNG that was supplied from the North West Shelf Extension Project (e.g. case studies of clients from long-term supply contracts);

(2) **information relating to the:**

a. the probability that any electricity producers in China, Japan, India, and other Asian markets will switch from using coal to using LNG supplied from the North West Shelf Extension Project (including, specifically, LNG derived from gas extracted from the Browse reservoirs); or

b. the competiveness, in price (and other relevant market factors), of LNG supplied from the North West Shelf Extension Project (and specifically, also to LNG derived from Browse reservoir) against other energy options for energy producers in China, Japan, Southeast Asia, and India, including coal, natural gas from domestic or imported sources, and renewables.

Implication:

The EPA and the relevant State and Commonwealth Ministers therefore do not have any reliable information on which to infer any reduction in Scope 3 emissions from the North West Shelf Extension Project or the proposed Browse to North West Shelf Project on the basis that gas from reservoirs for the proposed Browse to North West Shelf Project or LNG produced by the Karratha Gas Plant will displace other high carbon fossil fuel energy sources (e.g. coal) in China, Japan, Southeast Asia, and India (e.g. through a coal-gas energy switch in those locations).

Comment

45. In the 'Quarterly Update of Australia's National Greenhouse Gas Inventory for March 2019', the Department of the Environment and Energy discussed a recent (July 2019) CSIRO report 'Whole of Life Greenhouse Gas Emissions Assessment of a Coal Seam Gas to Liquefied Natural Gas Project in the Surat Basin, Queensland, Australia'.[18]

46. The Quarterly Update stated[19]:

> **Role of gas in the transition to cleaner, more efficient energy systems**
> Natural gas has a clear greenhouse gas benefit over coal when combusted. Natural gas produces around 52 kg CO_2-e per gigajoule compared to around 90 kg CO_2-e per gigajoule from black coal.
>
> There has been debate about whether the greenhouse gas emission benefit of gas over coal still holds when all emissions associated with gas production (for example fugitive emissions) are included. The CSIRO has recently released a report looking at this issue.
>
> The CSIRO undertook a comprehensive life cycle assessment of all greenhouse gas emissions associated with coal seam gas-LNG production, from those associated with upstream production at the well head through to liquefaction, including external emissions such as construction.
>
> The CSIRO report found that the use of coal seam gas from the Surat Basin to displace Queensland thermal coal for electricity generation produces a substantial greenhouse gas emission saving.

[18] https://gisera.csiro.au/wp-content/uploads/2019/07/GISERA_G2_Final_Report-whole-of-life-GHG-assessment.pdf
[19] Australia's emissions projections 2018 (Department of the Environment and Energy, 2018): https://www.environment.gov.au/climate-change/publications/emissions-projections-2018

Use of coal seam gas from the Surat Basin in an open cycle gas turbine would give a reduction in emissions of 31 per cent and a reduction of 50 per cent for gas used in a closed cycle gas turbine when compared to generation from the use of Queensland thermal coal.

The report also concludes that ensuring high efficiency electricity generation (for example via closed cycle gas turbine technology) is important in realising the potential climate benefits of natural gas where it replaces coal fired electricity generation.

47. The CSIRO report adds some necessary contextual information to what is presented in the Quarterly Update (emphasis added):

In the present study, we cannot calculate directly the GHG emissions reduction of LNG exports from Curtis Island, Queensland, relative to coal-fired electricity generation in Asia because we do not know the proportion of gas used to displace what would have been produced from coal. However, we have estimated the efficiency of electricity production by natural gas based on Scope 1 unit processes from gas production in Australia as 6.0 MWh/tonne LNG and 8.16 MWh/tonne LNG for Open Cycle Gas Turbine (OCGT) and Closed Cycle Gas Turbine (CCGT) generation, respectively. These generation rates produced GHG intensities of 0.73 t CO_2-e/MWh (OCGT) and 0.53 t CO_2-e/MWh (CCGT). In Australia, if Surat Basin natural gas was used to displace domestic coal fired electricity generation, GHG emissions intensities would be 0.66 t CO_2-e/MWh (OCGT) or 0.48 t CO_2-e/MWh (CCGT) representing a reduction in emission compared with coal of 31% and 50%, respectively. These GHG emissions reductions following domestic use of natural gas occur because emissions associated with liquefaction, shipping and regasification are avoided (representing 9.9% of total life-cycle emission of electricity generation in Asia). It is clear from these results that ensuring high efficiency electricity generation (eg via CCGT technology) is important in realising the potential climate benefits of natural gas where it replaces coal fired electricity generation.

48. This contextual information and the rigorous whole of life greenhouse gas emissions assessment applied in the CSIRO study suggests that any claim of emissions reductions due to the displacement of coal in an import country must be substantiated through a comprehensive assessment of the whole life cycle (LNG supply chain) to ensure emissions throughout the entire supply chain are adequately measured and reported. For example, the analysis in the CSIRO study used two separate assessment methodologies (multi-regional input-output (MRIO) and life-cycle assessment (LCA)) to estimate emissions from different components of the gas supply chain, based on commercial-in-confidence data.

49. There are two basic areas of uncertainty for claims of emissions reductions because of coal displacement.

50. First, there is uncertainty as to whether imported Australian LNG would displace coal in the import country. Whether LNG-coal substitution occurs in the import country will depend on the prices of LNG and other energy sources in the import country, as well as other factors. Imported LNG can also displace renewable energy sources in the import country, leading to an increase in emissions, and delay the structural transition to renewable energy sources.

51. Second, other issues that create uncertainty are the complexity of LNG supply chains, the technology that would be used for electricity generation (and, specifically, whether high efficiency electricity generation would be used), and the methodologies that would be used to measure and report emissions.

52. It is preferable for claims for emissions reductions based on coal displacement to be founded on:
    a. a commercial agreement between an Australian LNG exporter and an electricity producer or energy company with an entire LNG supply chain in the import country; and
    b. an agreed methodology for how emissions reductions from the LNG-coal substitution arrangement would be accounted in terms of nationally determined contributions (NDCs) for the Paris Agreement, in accordance with Article 6.

12	**Failure to consider the IPCC Special Report on Global Warming of 1.5°C**

Submission 37:
The assessment documentation refers frequently to statements about natural gas in the IPCC 2014 Synthesis Report. However, the assessment documentation does not refer to the *Special Report on Global Warming of 1.5°C*, which supersedes and significantly changes the guidance around natural gas. For example, the share of primary energy from natural gas declines in mitigation pathways compatible with 1.5°C warming except in some pathways with widespread deployment of carbon capture and storage.

13	IEA perspectives on LNG & IEA scenarios

Submission 38:
In its *World Energy Outlook*[20], published 13 Nov 2019, the IEA stated: There is significant uncertainty as to the scale and durability of demand for imported LNG in developing markets around the world. LNG is a relatively high-cost fuel; investment in liquefaction, transportation and regasification adds a considerable premium to each delivered gas molecule. Competition from other fuels and technologies, whether in the form of coal or renewables, loom large in the backdrop of buyer sentiment and appetite to take volume or price risk.

Comment

53. Another 2019 IEA report, *The Role of Gas in Today's Energy Transitions*[21] (published July 2019), observed that in both India and China:

> …at the prevailing gas prices, new onshore wind and solar photovoltaic (PV) are much cheaper ways to generate electricity than new combined-cycle gas turbines (CCGTs). Under these circumstances, the major contribution of gas-fired generation to displacing coal is likely to be an indirect one, by aiding the integration of renewables. (page 12)

54. The 2019 IEA report, *The Role of Gas in Today's Energy Transitions*[22] (published July 2019), also states that:

> Beating coal on environmental grounds sets a low bar for natural gas, given there are lower-emissions and lower cost alternatives to both fuels. The falling cost of renewable technologies in the power sector is the clearest case in point. In many power markets, wind and solar PV are already among the cheapest options for new generation, and the role of gas is coming under pressure as a result. (page 16)

55. As regards the IEA Sustainable Development Scenario, the 2019 IEA report, *The Role of Gas in Today's Energy Transitions*[23] (published July 2019), states that:

> Renewable energy and efficiency measures are the most important drivers of the energy sector transition of the Sustainable Development Scenario – a scenario that is fully consistent with the Paris Agreement. Natural gas still plays a role in this scenario, although this varies by country, sector, and timeframe. (page 19)

[20] https://www.iea.org/reports/world-energy-outlook-2019
[21] https://www.iea.org/reports/the-role-of-gas-in-todays-energy-transitions
[22] https://www.iea.org/reports/the-role-of-gas-in-todays-energy-transitions
[23] https://www.iea.org/reports/the-role-of-gas-in-todays-energy-transitions

14 Emission intensities for LNG derived from the Browse reservoir

Submission 39:

The emissions intensity of LNG derived from the proposed Browse to North West Shelf project depends critically on the emissions avoidance and reduction measures implemented in the gas production processes.

Comment

56. A life cycle assessment for the study of the Browse reservoir reported that upstream gas production processes accounted for 32% of the "electricity climate change results" for Browse-derived LNG combusted in China (based on the data, assumptions, and modelling approach applied in that study) (See figure below).[24]

Figures 5.2 & 5.3 from life cycle assessment for the study of the Browse reservoir[25]

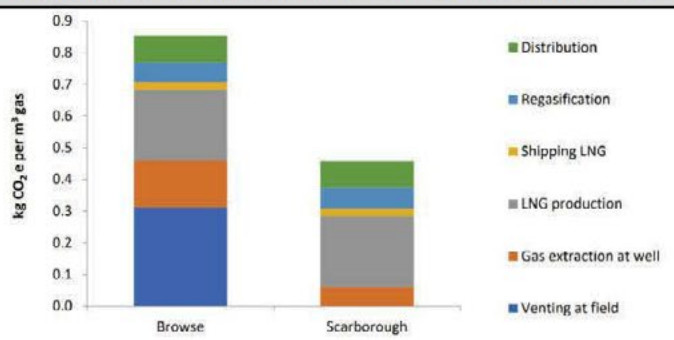


Figure 5-2 kg CO_2e for 1m³ from gas Distributed in China

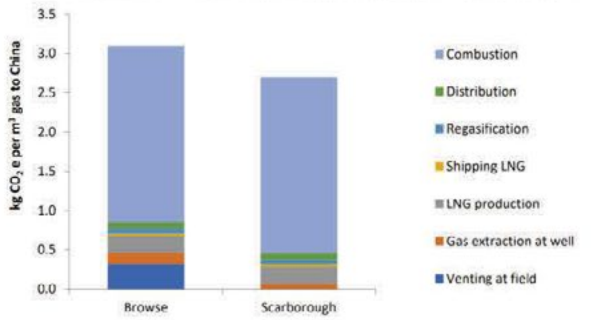


Figure 5-3 kg CO_2e per 1m³ of Gas Converted to Electricity in China from LNG Sourced from Scarborough and Browse Gas Fields, using Combined Cycle Gas Power Plant

[24] https://www.erm.com/contentassets/782dd692a5a546db8ea0c0fa052d4e70/woodside-energy-limited-life-cycle-assessment.pdf (page 24)
[25] Ibid.

the BEELIAR GROUP

30

15	**Inadequacy of measures to avoid and reduce greenhouse gas emissions** **Need for carbon capture and storage** **Inadequacy of offsets for residual greenhouse gas emissions**

Submission 40:
Woodside must take further action to decarbonise its LNG supply chains by, among other measures: a. integrating renewables into upstream and downstream LNG infrastructure over which Woodside has operational control to reduce emissions from process energy requirements; and b. equip its LNG infrastructure with carbon capture, storage and utilisation (CCUS) technologies to reduce emissions from upstream and downstream processes.

Submission 41:
Woodside has not proposed adequate measures to avoid and reduce GHG emissions from the proposed Browse to North West Shelf Project (EPBC assessment) and the North West Shelf Project Extension (EP Act assessment). Among other measures, Woodside should implement: (a) carbon capture and storage; and (b) an integrated energy solution that draws primarily upon power from renewable sources to meet process energy requirements at the Karratha Gas Plant (supplemented by dispatchable power from gas).

Submission 42:
Woodside has not proposed adequate measures to offset residual GHG emissions from the proposed Browse to North West Shelf Project (Commonwealth assessment) and the North West Shelf Project Extension (State assessment).

Submission 43:
Given the projected 50 year life of the North West Shelf Project, Woodside should implement electric drive systems to meet process energy requirements at the Karratha Gas Plant, with the electricity primarily obtained from renewable (wind and/or solar) sources, supplemented by dispatchable power from gas turbine generators to generate electricity.

Submission 44:
The Safeguard facility for the proposed Browse to North West Shelf Project, as a new facility from 2020, will need to need to operate from "benchmark" baseline, based on benchmark emissions intensities (that is, the best, least emissions intensive standard for production) and an independently audited forecast of production. The proposed avoidance and mitigation measures are far from least emissions intensive standard for production for this type of facility.

Comment

57. Fuel gas use for refrigerant compressor gas turbines (55%) and electricity generation (15%) account for 70% of CO_2-e emissions for the Karratha Gas Plant.[26] The Greenhouse Gas Greenhouse Gas Benchmarking Report notes that:
    a. typically the largest source of emissions at an LNG facility is from the fuel consumption associated with the operation of the refrigeration compressor and power generator drivers;
    b. there are two main options for selection and design of the drivers – direct drive and electric drive;
    c. electric drive systems use an electric motor to drive the compressors, which are less common, but can achieve higher efficiencies and hence lower GHG emissions; and
    d. if the electricity for the electric drive systems is from renewable sources, then this can offer a lower intensity method of driving the compressors.

58. Woodside has contemplated the partnering of gas with renewables.[27] For example, the North West Shelf Project Extension Greenhouse Gas Management Plan notes that natural gas "enables greater use of renewables by matching their intermittent nature with dispatchable power" and "partnering with renewables, as a dispatchable power source that can enable their greater use".

59. The Woodside Petroleum CDP Climate Change Questionnaire 2019,[28] published 20 November 2019, also describes, in section C2.4a, "opportunities for LNG to partner with renewables to provide integrated energy solutions" and notes the "models we are developing for integrated energy solutions in the Pilbara". It also states, in section C2.5 (Describe where and how the identified risks and opportunities have impacted your business.):

    We are exploring opportunities for LNG to partner with renewables to provide integrated energy solutions. Renewables are well suited to providing off-grid power but they need a reliable and flexible backup, which LNG can provide. The models we are developing for integrated remote power generation in the Pilbara can also offer a reliable and sustainable source of power in non-OECD countries, supporting SDG 7 Affordable and Clean Energy.

60. Notwithstanding these statements and Woodside's obvious consideration of the integration of renewables, the assessment documentation for both proposals proposes no integrated energy solution combining renewables and gas for its North West Shelf Project facilities.

[26] Draft EIS/ERD: Appendix F North West Shelf Project Extension Greenhouse Gas Benchmarking Report
[27] https://thewest.com.au/business/energy/australasian-oil-and-gas-exhibition-and-conference-2019-woodside-eyes-solar-power-to-cut-lng-emissions-ng-b881136300z
[28] Available at https://www.woodside.com.au/sustainability/climate-change and https://www.cdp net/en

16	**Woodside uses an internal carbon price to guide its decision-making and is well positioned to accommodate offset costs for all residual emissions**

Submission 45:
Woodside uses an internal carbon price to guide its decision-making[29] and is well positioned to accommodate annual offset costs for all residual emissions for both the proposed Browse to North West Shelf Project and the North West Shelf Project Extension.

Comment

61. The Woodside Petroleum CDP Climate Change Questionnaire 2019,[30] published 20 November 2019, identifies, in section C4.3c, an internal carbon price as a method that Woodside uses to drive investment in emissions reduction activities, and states:

> Woodside includes a carbon price in its major investments based on expectations of current and future prices. We also apply these where appropriate when making other financial and operational decisions. We consider a range of scenarios in major decisions and in some of these scenarios, regulatory carbon prices are not expected to be implemented, so do not affect the decision.

[29] The materials (slide pack) for Woodside's Investor Briefing Day 2019 refer to a carbon price of ~\$40/tCO_2e and the Woodside Petroleum CDP Climate Change Questionnaire 2019 also refers to a internal carbon price (https://files.woodside/docs/default-source/sustainability-documents/transparency-documents/submissions/woodside---cdp-response-2018.pdf?sfvrsn=97e56785_4).

[30] Available at https://www.woodside.com.au/sustainability/climate-change and https://www.cdp net/en

17	The offsetting of all residual emissions is practicable

Submission 46:
A condition that each proposal offsets all residual direct emissions, following best practice efforts to avoid and reduce emissions, accords with the approaches applied for previous proposals, including the Greenhouse Gas Abatement Program developed by Woodside Energy Ltd to meet the conditions imposed in Ministerial Statement 757 in relation to the Pluto Liquified Natural Gas Development.

18	Methane emissions & Methane Guiding Principles

Submission 47:
Woodside has failed to undertake studies to adequately understand methane and other GHG emissions across the whole natural gas supply chain, and to engage with downstream participants in export markets for that purpose. To comply with Principle 2 of the Methane Guiding Principles, Woodside must undertake a study similar to the CSIRO GISERA project (published 2019[31]) which conducted a whole of life GHG emissions assessment for a gas supply chain, but which extends the geographic scope of the assessment to include LNG combusted for generation of electricity in China, India, and other Asian markets.

Comment

62. Methane emissions accounts for 1.0% (proportion of CO_2-e) of the Scope 1 emissions for the proposed Browse to North West Shelf project and about 4% of total operated emissions (CO_2-equivalent basis) for the North West Shelf Extension project.

63. The North West Shelf Project Extension Greenhouse Gas Management Plan notes that in April 2018 Woodside became a signatory to the Methane Guiding Principles.[32] A 'signatory' is defined as a company with direct responsibility for the management of methane within its business activities and which has signed the Methane Guiding Principles. A signatory is represented on the Steering Committee and Methane Guiding Principles Network.

64. The five Methane Guiding Principles are said to focus on priority areas for action along the natural gas supply chain, from production to the final consumer.[33] The signatories intend for them to be applied concurrently. In the context of Methane Guiding Principles, methane emissions refer to venting, fugitive (unintended) emissions, and incomplete combustion, including during flaring.

65. Principle 2 of the Methane Guiding Principles states, in part:

    2. Advance strong performance across the gas supply chain

    Given that it is necessary to understand methane emissions across the whole natural gas supply chain, we seek to engage with upstream, midstream and downstream participants to undertake studies to that end.

[31] https://gisera.csiro.au/wp-content/uploads/2019/07/GISERA_G2_Final_Report-whole-of-life-GHG-assessment.pdf
[32] https://methaneguidingprinciples.org/signatories-and-supporting-organisations/
[33] https://methaneguidingprinciples.org/methane-guiding-principles/

19	**LNG is a driver of a rise in greenhouse gas emissions in Australia and WA**

Submission 48:
LNG is a driver of a rise in greenhouse gas emissions in Australia and WA

Comment

66. The 'Quarterly Update of Australia's National Greenhouse Gas Inventory for March 2019'[34] included a Special Topic discussion of natural gas (at pages 23-26) which states (in part):

> Underlying recent trends in national emissions are trends in emissions from natural gas supply. Emissions occur during exploration, extraction, production, processing, and pipeline transmission and distribution. Emissions also occur from the final conversion of gas to LNG at liquefaction plants where gas is cooled to -161°C to become a liquid for export.
>
> Australia's annual gas production has increased over 100 billion cubic metres or nearly 500 per cent in the period 1990 to 2018. When compared to Australia's other primary fuel production, gas has outpaced oil, metallurgical coal and thermal coal.
>
> The underlying driver of Australia's gas growth in recent years has been the rapid expansion of the liquefied natural gas (LNG) export industry (Figure ST1). Australia is the world's second largest exporter of LNG and is forecast to overtake Qatar in 2020 to be become the largest.

67. Trends in greenhouse gas emissions for Western Australia differ from all other States and follow a similar trend to the Northern Territory. The 2017 State and Territory Greenhouse Gas Inventories reported that greenhouse gas emissions in Western Australia and the Northern Territory increased 23.4% and 25.5% from 2005 to 2017, respectively. In contrast, emissions in the other States declined from 2005 to 2017 (New South Wales: 18.2% decline, Victoria: 10.3% decline, Queensland: 13.6% decline, South Australia: 37.0% decline, Tasmania: 95.2% decline).

68. Oil and gas extraction was the highest emitting industry in WA for 2017-8.[35] In contrast, electricity supply was the highest emitting industry in NSW, Queensland, Victoria, and South Australia for 2017-8.

[34] http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/quarterly-update-australias-nggi-mar-2019
[35] National Greenhouse and Energy Reporting data for 2017–18 (Clean Energy Regulator - February 2019) (data for corporations) - http://www.cleanenergyregulator.gov.au/NGER/Pages/Published%20information/Data%20highlights/2017%E2%80%9318-published-data-highlights.aspx

69. The Clean Energy Regulator reported that, of Australia's top 10 greenhouse gas emitters (scope 1) for 2017-8, eight were electricity producers and two were LNG producers (Chevron Holdings Australia Pty Ltd, 12.0 million tonnes and Woodside Petroleum Ltd, 10.0 million tonnes).[36]

[36] Ibid.

20	**The current Commonwealth framework does not adequately constrain greenhouse gas emissions and is best seen as setting a floor for the regulation of large facilities**

Submission 49:
Based on current emissions trends and projections, Australia will not meet its current nationally determined contribution (NDC) under the Paris Agreement and will be constrained in the ambition of the new or revised NDCs the Australian Government must submit for 2020 (and then at 5-year intervals after that).

Submission 50:
The safeguard mechanism under the *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* is best viewed as setting a floor for the regulation of emissions from facilities with direct Scope 1 emissions of more than 100,000 tonnes of CO_2-e, which the States can exceed through their own legislative and executive action.

Comment

70. As its NDC under the Paris Agreement, Australia committed to reducing emissions by between 26% and 28% below 2005 levels by 2030.

71. The Department of the Environment and Energy has reported that:
    a. total emissions in 2030 are projected to be 563 Mt CO_2-e, which is 7% below 2005 levels (605 Mt CO_2-e); and

    b. emissions to 2030 are projected to grow 4% above 2020 levels, driven by higher emissions from LNG production, increased transport activity, a declining forest sink in the LULUCF (land use, land use change and forestry) sector, and growth in agricultural activity after a return to average seasonal conditions.[37]

72. The intent of the Safeguard Mechanism is to ensure that emissions reductions achieved through the Emissions Reduction Fund are not cancelled out by increases in emissions above business-as-usual levels elsewhere (and, specifically, in the emissions from facilities with direct scope 1 emissions of more than 100,000 tonnes of CO_2-e).

73. The current Commonwealth regulatory framework will not effectively constrain greenhouse gas emissions to enable Australia to meet its current 2030 target.

74. Current settings allow for 'baseline creep' as – in the absence of any overall 'cap' or budget for emissions from large emitting facilities – companies are allowed to increase the

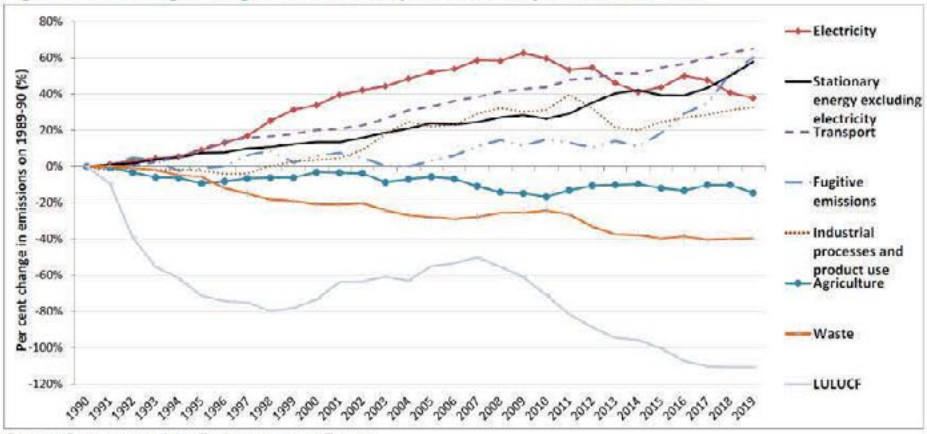
[37] Australia's emissions projections 2018 (Department of the Environment and Energy, 2018): https://www.environment.gov.au/climate-change/publications/emissions-projections-2018

baselines for facilities over time (e.g. because of production growth, natural emissions variability or other circumstances) and new facilities enter operation.

75. The effect of the added emissions from baseline creep at existing facilities and from the addition of new facilities over time is to entrench a 'business-as-normal' approach. This entrenchment is evident in ongoing increases in emissions from three key sectors – stationary energy excluding electricity, fugitive emissions, and industrial processes and product use (see the figure below).

Source: Department of the Environment and Energy, *Quarterly Update of Australia's National Greenhouse Gas Inventory for March 2019* (released August 2019): http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/quarterly-update-australias-nggi-mar-2019

Figure 5: Percentage change in emissions, by sector, since year to March 1990



Source: Department of the Environment and Energy

Queries & Contact Information

We welcome the opportunity to provide clarification or to discuss any queries, and may be contacted through [redacted] by phone at [redacted] or by email at [redacted]

Yours sincerely,

[redacted]

[redacted]

Members of the Beeliar Group: https://thebeeliargroup.com/ the BEELIAR GROUP

APPENDIX D SUBMISSIONS

APPENDIX D.16 ANON - 57NR-WVNP-Q

[redacted]

Member for the South West Region

Dr Tom Hatton
Chairperson, Environmental Protection Authority
8 Davidson Terrace
JOONDALUP WA 6027

Dear Dr Hatton,

The three projects at the centre of this public consultation - the Browse to North West Shelf project in Commonwealth waters; the Browse to North West Shelf project in State waters; and the North West Shelf project expansion – are deeply flawed, and should not receive environmental approval.

The Hon [redacted], the Hon [redacted], and the [redacted] providing detailed submissions which cover key aspects these projects. I support their stances and will add detail in relation to particular issues.

Gas is not a transition fuel

The environmental credentials of this project rest heavily on the assumption that LNG is a useful transition fuel in the move to low or near-zero carbon energy. However, modelling shows that the use of gas as a "bridge" fuel has 'potential for delays in deployment of near-zero-emission technologies to offset all climate benefits from replacing coal energy systems with natural gas energy systems, especially if natural gas leakage is high, and the natural gas energy system is inefficient'[1] and that 'both shale gas and conventional natural gas have a larger GHG than do coal or oil, for any possible use of natural gas and particularly for the primary uses of residential and commercial heating'[2]. Looking at the next 20 years, an appropriate time scale given the rapid development of renewable technologies, modelling shows that 'plants using natural gas with a 4% leakage rate (will) have similar climate

[1] Zhang et al. 2016. Climate benefits of natural gas as a bridge fuel and potential delay of near-zero energy systems. *Applied Energy*. 167:317.
[2] Howarth. 2014. A bridge to nowhere: methane emissions and the natural gas footprint of natural gas. *Energy Science & Engineering*. 2 (2):47.

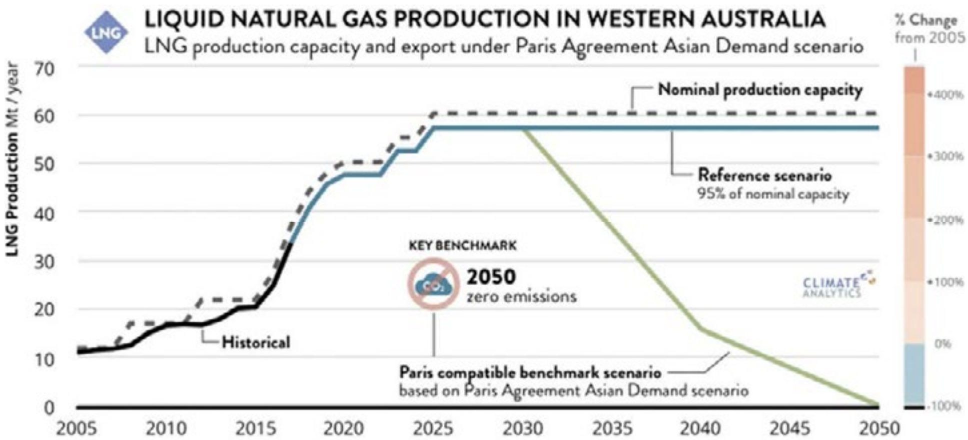
[redacted]

Email [redacted]
Phone [redacted]
Address [redacted]
Postage [redacted]

Printed on 100% recycled paper with vegetable based ink impacts as those using coal, but are no worse than coal'[3]. It is not good enough to be 'no worse than coal'.

Furthermore, as Professor [redacted] from Stanford University's School of Earth, Energy and Environmental Sciences explains, 'Globally, most of the new natural gas being used isn't displacing coal, it's providing new energy'[4]. We therefore need to reduce, minimise and offset gas emissions, immediately. The Browse project offers no environmental advantages, and brings enormous environmental risks.

As Climate Analytics explains, if Western Australia is to meet its obligations under the Paris Agreement, production of LNG will have to drop dramatically from 2030 – preferably immediately – to 2050. The planned Burrup gas hub is neither environmentally nor economically feasible under this scenario.



Source: Climate Analytics. 2019. A 1.5°C Compatible Carbon Budget for Western Australia. P.41.

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[3] Farquharson et al. 2017. Beyond global warming potential: A comparative application of climate impact metrics for the life cycle assessment of coal and natural gas. *Industrial Ecology.* 21(4): 857.
[4] CCWA and Clean Slate. 2019. *Browse Burrup Hub Report.*

2

1. Browse to North West Shelf project in Commonwealth waters

Petroglyphs

Black et al. undertook rigorous analysis that revealed a serious knowledge deficit in relation to petroglyphs, the rock art images which 'capture thousands of years of human culture and spiritual beliefs through a changing environment' which are a '*priceless, irreplaceable, historical and archaeological treasure of global significance*'[5]:

> Murujuga ('Burrup Peninsula') in northwest Western Australia contains the largest concentration of petroglyphs in the world. A substantial petrochemical industrial complex has been placed in close proximity to this cultural treasure. *A review of the publically available research reports used by governments to justify establishment of industry and the levels of acceptable emissions reveals the research is not scientifically credible in design, methodology, analysis or interpretation*. Each report has serious errors, which renders most results to be of little value. There remains a knowledge deficit on the condition of petroglyphs. ***No credible decisions about the effects of industry on the rock art can be made using the reports***[6].

The researchers continue:

> Concerns were raised in the early 2000s (Bednarik 2002) about the potential impact of increased industrial emissions, particularly acidity, on bleaching of petroglyphs and adjacent rock surfaces from erosion of the ferruginous patina crust. Monitoring changes in rock surface colour and mineralogy were chosen as appropriate macroscopic means for assessing likely changes to rock art due to industrial emissions (Summaries of proposed rock art monitoring studies 2004). ***The magnitude of change considered detrimental for rock art appears not to have been set.*** However, governments have used reports from this research on air pollutants, colour change and mineralogy at rock art sites (Gillett 2008; Lau et al. 2013; Lau et al. 2007; Lau et al. 2008; Lau et al. 2010; Lau et al. 2009; Lau et al. 2011; Lau et al. 2012; Markley et al. 2014; Markley et al. 2015) to justify continued establishment of industry on Murujuga[7].

For instance, the Lau et al. (2007) report suffers from 'insufficient replication - the design of this controlled experiment was inadequate to show whether there was a statistically significant effect of gaseous fumigation on either rock surface colour or mineralogy'. Black et al. detail numerous other weaknesses in the main body of petroglyph research that the Government appears to rely

[5] Black et al. 2017. Inadequacies of research used to monitor change to rock art and regulate industry on Murujuga ('Burrup Peninsula'), Australia. *Rock Art Research* 34 (2):130, emphasis added.
[6] Ibid p.130
[7] Ibid p.130

3

on. The Browse decisions must be made on the basis of better scientific information than that which has been utilised in the past.

The Burrup Peninsula is estimated to contain more than one million rock art images in the form of petroglyphs. Researchers estimate that ‘5–25 per cent of rock art on the Burrup has been removed or destroyed as a result of iron mining, industrial expansion and poor archaeological advice’[8]. This must not continue. The Government cannot reasonably make decisions that put this cultural treasure at risk – it would be cultural vandalism, yet another manifestation of the “logic of elimination”[9] that historians argue lies behind the destruction of petroglyphs and the ecology of Murujiga, and the ongoing tragedy that despite the fact that Governments and resource companies have implemented substantial measures to protect the rock art…damage to the petroglyphs from industrial emissions continues at an alarming rate’[10]. The fact that we do not need gas as a transition fuel to move to a low carbon future would make this an even more bitter pill to swallow.

Wetlands

These projects would increase the risk of degradation of Ramsar wetlands at Roebuck Bay, Eighty Mile Beach, Ord River Floodplain and Ashmore Reef National Nature Reserve for example if there are oil spills[11]. More research is needed to understand the impact of the oil and gas industries on wetlands around the Burrup, international research indicates possible problems. For instance, studies of the Deepwater Horizon (DWH) oil spill show that ‘the presence and location of crude oil in the soil profile can impact soil redox conditions which could alter biogeochemical processes over the long term and induce oxygen stress on wetland vegetation and organisms in the soil’[12]. Other research demonstrates that recovery of wetlands after oil spills is ‘at least partially related to the magnitude of the impact such that greater recovery occurred at sites that had greater impact’[13].

[8] Zarandona and Antonio. 2015. Towards a theory of landscape iconoclasm. *Cambridge Archaeological Journal*. 25 (2):461-475.

[9] MacDonald. 2019. In the landscape of extinction: the life of Murujuga’s ancient rock art. *Australian and New Zealand Journal of Art*. 19(2): 233-252.

[10] Ibid p. 237

[11] https://www.environment.gov.au/system/files/resources/0d08923b-a60d-4564-9af2-a7023b7aaf29/files/ramsar-sites_0.pdf

[12] Levine et al. 2017. Crude oil effects on redox status of salt marsh soil in Louisiana. *Soil Science of America Journal.* 81 (3): 647.

[13] Shapiro et al. 2016. Vegetation impact and recovery from oil-induced stress on three ecologically distinct wetland sites in the Gulf of Mexico. 4(2):33.

Threatened species and ecological communities

These projects pose risks to a number of Commonwealth Marine Reserves. Scott Reef may be impacted and is likely to be vulnerable to – Western Australian research shows that 'larval production and recruitment underpin the maintenance of coral populations, but these early life history stages are vulnerable to extreme variation in physical conditions'[14].

2. **Browse to North West Shelf project in State waters**

Submissions from my colleagues Robin Chapple and Tim Clifford will touch on a number of issues including air quality, social surroundings, and marine environmental quality and I endorse their views.

Oil and gas can impact on marine environmental quality:

> Offshore hydrocarbon exploration and production (E&P) activities can overlap in space and time with marine mammal populations. These activities, especially seismic surveys, can generate loud sound levels that propagate well in the marine environment. Exposure of marine mammals at varying distances from the source of these sounds can result in a range of different impacts, from auditory injury to behavioral responses and masking[15].

The proposed Browse projects may impact on vulnerable, endangered and critically endangered species such as turtles, sea snakes, seabirds, and shallow water fish species.

> These activities can overlap…with marine mammal populations in different stages of their life cycle-that is, during migration or at their feeding and breeding grounds. Exposure to both loud continuous or impulsive marine sounds can potentially have several types of impacts on marine mammals. These can be classified into different categories such as mortality, injury to the hearing system (Permanent Threshold Shift [PTS]), temporary reduced hearing sensitivity (Temporary Threshold Shift [TTS]), behavioural disturbance, and communication masking. When unmitigated, sound levels generated by some sound sources, such as sonar, can have lethal effects on cetaceans (Simmonds & Lopez-Jurado, 1991; D'Amico et al., 2009)…Exposure of marine mammals to airguns at close range or for a prolonged period...has the potential to result in damage at the cellular level of the hearing system, commonly referred to as injury (PTS), or a shift in hearing sensitivity measured in decibels (dBs) referred to as TTS, also known as auditory fatigue (Southall et al., 2007, 2019; Finneran, 2016).

[14] Gilmour et al. 2016. Coral reproduction in Western Australia. *PeerJ*. 4:1.
[15] Bröker et al. 2019. An overview of potential impacts of hydrocarbon exploration and production on marine mammals and associated monitoring and mitigation measures. *Caracas*. Iss.284: 576.

Additionally, monitoring studies of various species of marine mammals indicate that animals can respond to sound generated by seismic surveys, drilling, or the presence of industry vessels in manners that include head turning to regulate exposure levels, movement away from the sound, or temporary cessation of behaviors such as feeding or swimming (Nowacek et al., 2007; Southall et al., 2007; Ellison et al., 2011). Another example of potential behavioral effects of sound are impacts to communication between conspecifics as marine sound has been observed to influence the number of vocalizations in baleen whales (Di Iorio & Clark, 2010; Blackwell et al., 2013, 2015; Cerchio et al., 2014). Marine sounds generated by the Exploration and Production (E&P) industry also have the theoretical ability to mask vocalizations used for navigation, communication, or prey localization (Southall et al., 2007; Sills et al., 2017)[16].

3. **North West Shelf project expansion**

I argue that none of the projects, including this one, should go ahead. However, any proposal should include provisions for carbon offsets that cover Scope 1, 2 and 3 emissions. This makes environmental sense, but it also makes good business sense. I have argued in other submissions that businesses must step up must more effectively to help us fight climate change and reverse environmental degradation. Leading international business and industry bodies are also calling for this. For instance, a core component of the World Business Council for Sustainable Development's Climate Policy activities is to

> …foster strong policy signals and economic incentives promoting **a race-to-the-top** where sustainable solutions can succeed. **We actively call for policies that are consistent with ambitious action on climate and enable business-led solutions to scale and speed implementation of the Paris Agreement**[17].

In this case, the projects should not go ahead. If they do, all emissions should be offset. Cutting edge technology should be used to minimise emissions and energy use.

Conclusion

Woodside's claim that 'the Burrup hub could process more gas than the entire volume extracted from the North West Shelf since startup in 1984'[18] is extremely alarming, given the evidence that emissions associated with this industry will exacerbate climate change, increase the threats to ecosystems and species at risk, and that the government's ability to make credible decisions about the protection of petroglyphs is completely undermined by the use of faulty methodology.

[16] Ibid.

[17] https://www.wbcsd.org/Programs/Climate-and-Energy/Climate/Climate-Action-and-Policy

[18] https://www.woodside.com.au/our-business/burrup-hub

Given the weight of scientific evidence, none of these three projects should be granted environmental approval. While I know that the EPA does not take economic issues into account, I think it is worth emphasising that these projects with enormous environmental risks are also economically risky if we are to meet our obligations under the Paris Agreement. They cannot be justified.

Yours sincerely,

[redacted]

[redacted]

APPENDIX D SUBMISSIONS

APPENDIX D.17 AUSTRALIAN MARINE CONSERVATION SOCIETY (AMCS)

Australian Marine Conservation Society

Protecting our Oceans since 1965

To:

Dr Tom Hatton (Chairperson Environmental Protection Authority WA) via email:
[redacted]

David Fredericks (Secretary Department of Environment and Energy) via email:
[redacted]

12 February 2020

Dear Sirs

Submission to Assessment 2191: Proposed Browse to North West Shelf Project (State Waters)
Submission to Assessment 2191: Proposed Browse to North West Shelf Project (Commonwealth Waters)
Submission to Assessment 2186: North West Shelf Project Extension

The Australian Marine Conservation Society (AMCS) is the leading charity devoted solely to caring for Australia's oceans and their wildlife. AMCS has over 250,000 members and supporters from coast to coast across Australia, who we represent and work with on key marine issues facing the nation. As well as a substantial supporter base in Western Australia, AMCS has an office and team in Perth.

AMCS works with science and conservation centres to support solutions that use best available science to deliver healthier outcomes for our oceans. Our focus includes working to protect special places in the oceans and tackling threats to marine life such as climate change.

We write in relation to the above assessments of the proposed North West Shelf projects - #2191 State Waters, #2191 Commonwealth Waters and #2186. Thank you for the opportunity to make submission to these consultations.

AMCS is aware that the conservation sector, including Conservation Council of Western Australia, is making a detailed submission and so we do not provide detailed comments on the assessments here.

However, we wish to register our opposition to these proposals and to urge you to reject them. AMCS is deeply concerned about the carbon pollution and impacts on marine life that would be associated with these projects were they to proceed.

If the proposed Browse Basin and North West Shelf projects were to go ahead, the Burrup Hub would become one of the largest and most polluting fossil fuel projects in the world. The approval of this scale of new fossil fuel project is not consistent with Western Australia meeting its policy target of net-zero emissions by 2050 or Australia meeting its Paris Agreement climate targets. To protect our climate and our oceans we must rapidly reduce emissions, not proceed with major new fossil fuel projects.

Australian Marine Conservation Society
Become a Sea Guardian Today: www.marineconservation.org.au
[redacted]

Protecting our Oceans
since 1965

In addition to the climate impacts of this mega-project, it presents very significant risks for marine species and ecosystems. Oil and gas drilling and associated operations and will disturb, injure or kill marine fauna and irreversibly degrade critical habitat for endangered species, including marine turtles and cetaceans.

AMCS is concerned that Woodside's proposed activities threaten the sensitive marine environment of Scott Reef, one of the most important and biodiverse marine environments in Australia. It is known that Scott Reef is an important feature for a remarkably diverse range of cetaceans. How can we be reasonably assured that the multiple, cumulative impacts on all of these species from the proposed intensive oil and gas activity at Scott Reef can be comprehensively assessed and understood, let alone managed?

I ask you to consider the context for your decisions where we mark this moment in human history as one when coral reefs – which support more than 25% of all ocean species – are already and demonstrably suffering enormous harm from ocean heating, unsustainable development and other impacts. This context alone should be sufficient to reject these proposals.

Oil and gas operations such as the Browse Basin/North West Shelf developments are not compatible with a sensitive marine environment like the Scott Reef and are totally inconsistent with maintaining the safe climate conditions that Scott Reef and other marine environments rely on.

Once again, on behalf of our supporters, I urge you to reject these proposals.

[redacted]

CEO, Australian Marine Conservation Society

Australian Marine Conservation Society

Become a Sea Guardian Today: www.marineconservation.org.au

[redacted]

APPENDIX D SUBMISSIONS

APPENDIX D.18 CCWA / CLEAN STATE

Clean State

ccwa

Australia's most polluting fossil fuel mega project

Why Woodside's Burrup Hub developments should not proceed

The Conservation Council of WA is proud to present this report as the state's foremost non-profit, nongovernment conservation organization, representing almost 150,000 supporters and 105 member groups.

CCWA has been an advocate for conservation and a sustainable Western Australia for more than 50 years, working directly with the government, media, industry, community groups, and political parties to promote a more sustainable WA and to protect our natural environment.

Clean State advocates for action on climate change in Western Australia. Clean State promotes solutions to address WA's biggest polluters in ways that create thousands of jobs and exciting opportunities for communities and businesses across the state.

We acknowledge that we meet and work on the land of the Nyoongar people. We pay respect to their Elders – past, present, and future – and acknowledge the important role all Aboriginal and Torres Strait Islander people continue to play in advancing a more sustainable Western Australia.

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Summary

The Burrup Hub project is a $50bn Liquified Natural Gas (LNG) mega-project led by Woodside Energy, involving the development of two new giant offshore gas fields and other petroleum resources, including onshore fracking developments for export from the Northwest of Western Australia.

> **"The Burrup Hub would be the most polluting project ever to be developed in Australia, delivering some of the world's dirtiest LNG for up to 50 years. With estimated total emissions of over 6 billion tonnes (gigatons) of carbon pollution across its lifetime, the proposal has profound implications for the global climate across generations."**
>
> **– Piers Verstegen, Director, Conservation Council of Western Australia**

If the Burrup Hub were to proceed, it would:

- **Be the most polluting project ever to be developed in Australia,** producing some of the dirtiest gas in the world and releasing around four times the pollution of the proposed Adani coal mine;
- **Be in direct breach of Australia's commitments on climate change,** undermine international climate goals in the Paris Agreement and directly contravene public commitments on climate change by the companies involved;
- **Require over 50 wells drilled to extract oil and gas from beneath the pristine Scott Reef off the Kimberley coast,** impacting endangered marine life in a globally significant biodiversity hotspot;
- **Risk health impacts for local communities and workers** from exposure to industrial pollution;
- **Cause permanent damage to the world's most extensive collection of Aboriginal rock art,** nominated for World Heritage listing on the Burrup Peninsula (Murujuga);
- **Open up Western Australia to a large scale fracking and onshore gas industry** which would put groundwater, communities and agriculture at risk;
- **Deliver few benefits, while transferring billions of dollars of costs to West Australians.**

Overall, this project has fundamental flaws and dangerous environmental risks that have not and cannot be adequately addressed.

Proponents including Woodside, Shell, BP and Chevron are seeking environmental approvals for this project and planning on making investment decisions during 2020.

However, Woodside's Burrup Hub project is not a fait accompli. Environmental approvals are yet to be granted, decisions to sanction the project are yet to be made, and capital must be raised.

This report sets out the case for why the Burrup Hub should not proceed given the very significant environmental impacts, investment risks, few benefits, and the profound and irreversible consequences for the global climate.

Contents

Overview of the proposal and its proponents

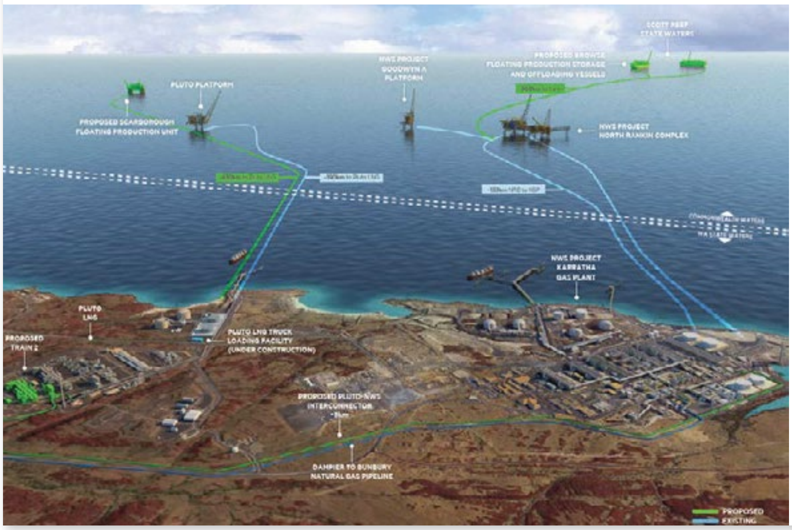
What is the Burrup Hub project?

Woodside's Burrup Hub project involves the development of two giant new gas fields (Browse and Scarborough) and other onshore and offshore gas resources in Western Australia's Northwest. The gas would be piped to two giant existing LNG production and export facilities, Pluto and North West Shelf, located on the Burrup Peninsula in the Pilbara region of Western Australia's Northwest. These facilities would be expanded, extended, and linked to create a massive LNG processing hub. The project involves $AU50bn in capital investment for the development of the gas fields, connector pipes, upgraded processing facilities and other infrastructure.

The companies behind this project

The Burrup Hub project is proposed by some of the world's largest oil and gas companies. Australian company Woodside Energy is the lead proponent of the projects, which involve several different joint ventures and other commercial relationships including with Shell, BP, BHP, Chevron and other partners (Table 1).

Woodside's 25 top shareholders collectively own 22.4% of the company. This list is provided at Appendix 1 of this report.



Ownership of Burrup Hub components

Table 1

Project	% Australian Owned	Operator	Joint Venture Partners
North West Shelf LNG processing facility	33.4%	Woodside	Woodside (16.7%), BHP (16.7%), BP (16.7%), Chevron (16.7%) Shell (16.7%); Mitsubishi (8.3%), Mitsui (8.3%)
Browse Basin gas-field	30.6%	Woodside	Woodside (30.6%), Shell (27%), BP (17.3%), PetroChina (10.7%), Mitsubishi (7.2%), Mitsui (7.2%)
Scarborough gas-field	100%	Woodside	Woodside (75%), BHP (25%)
Pluto LNG processing facility	100%	Woodside (owned & operated)	

Other companies involved with the Burrup Hub

Other gas companies earmarked to supply gas to the project (including fracking and on-shore projects).

Mitsui (previously AWE) and **Beach Energy** (owned by Seven West Holdings)

- Waitsia project, Perth Basin
- Beharra Springs project, Perth Basin

Strike Energy and **Warrego Energy**

- West Erregulla Project, Perth Basin
- Western Gas - Equus project, offshore

"The figures we've calculated for Woodside's Burrup Hub 'vision' are more like our worst nightmare. 6 billion tonnes of greenhouse gas pollution over this project's lifetime is not consistent with the scientific, technological, or moral action required to comply with our international obligations to bring emissions down urgently and completely decarbonize by 2050."

–Chantal Caruso, Clean State policy analyst and spokesperson

Carbon pollution and climate change impacts

If it were to become operational, the Burrup Hub project would be Australia's largest pollution source, when all direct and indirect emissions are accounted for. Due to the very high emissions intensity of the gas produced, and the long lifespan of the proposal, it is inconsistent with maintaining a safe climate and meeting international commitments on climate change.

Australia's most polluting project

When measured in absolute terms, the Burrup Hub project would be Australia's most polluting fossil fuel project ever to be developed, with a total lifetime carbon footprint of over 6 billion tonnes of CO2 (6.218 gigatons).

The project would cause both direct or 'Scope 1' emissions released in Australia from energy use venting CO2, fugitive emissions, flaring and other sources, as well as indirect or 'Scope 3' emissions from burning the gas after it is sold, either in Australia or overseas.

Table 2[1]

Project	Annual pollution (scope 1 only) Mtpa CO2e-	Annual pollution (Including scope 3) Mtpa CO2e-	Total pollution (over 50 year project life) Mt CO2e-
Browse Basin gas (processed through North West Shelf LNG)	6.8	44.8	1,602 (1.6 gigatons)
Scarborough gas (processed through Pluto LNG facility)	4.3	44	1,347 (1.3 gigatons)
Total Burrup Hub (new gas only) (proposed new gas-fields including Scarborough and Browse)[2]	13	120	5140 (5.1 gigatons)
Total Burrup Hub (all gas including existing reserves)	16.1	139	6086 (6 gigatons)

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Burrup Hub compared with other sources of pollution

Over its proposed 50-year lifetime the Burrup Hub project would release over 6 billion tons (gigatons) of carbon pollution, equivalent to 11x Australia's annual emissions.[3]

Each year the Burrup Hub project would result in 139 million tonnes of carbon pollution (including scope 3 emissions), equivalent to:

- over 4x the emissions of the proposed Adani Carmichael coal mine[4]
- 35 of the largest, dirtiest coal-fired power stations[5]
- the entire national emissions of New Zealand, Ireland, Norway and Bolivia[6]
- over a quarter of Australia's entire national emissions[7]

Each year, the direct emissions (scope 1) from the Burrup Hub project generated here in WA (16mtpa) would be equivalent to:

- almost 8x more than the annual emissions reduction delivered by Australia's 2.1 million solar rooftops
- 4 coal fired power stations the size and age of WA's Muja power station
- half the emissions abatement already delivered under the Morrison government's $4.5 bn Emissions Reduction Fund (RET)[8].

Every year the Burrup Hub project is equivalent to the **entire national emissions of New Zealand, Ireland, Norway and Bolivia combined**

Every year until 2070

total climate damage from the Burrup Hub project is equivalent to:

= 35 coal fired power stations

The dirtiest gas in the world

All fossil fuels cause carbon pollution and contribute to climate change, but when measured in tonnes of pollution per unit of energy produced (emissions intensity), some fuel sources and projects are far more polluting than others.

If the Browse Basin development were to proceed, **it would have a carbon intensity of nearly one tonne of CO2 for every tonne of LNG produced** - amounts which are nearly double the Australian average. This makes the Burrup Hub the most carbon-intensive LNG project anywhere in Australia, and one of the highest in the world (Fig 1 & 2).

The Browse pollution trifecta

The reason for the very high emissions from the Browse Basin development is three-fold:

1. Very high CO2 contained in the gas field, which Woodside plans to vent into the atmosphere
2. The considerable amount of energy required to extract the gas from the low-pressure field and pump it 900km to the onshore processing plant
3. Australia's oldest and least efficient LNG facility utilised to process the gas

"The high CO2 in the reservoir is exacerbated by the NWS infrastructure, among the world's oldest and least-efficient LNG projects."
– Wood Mackenzie, October 2019

Woodside's carbon con

In its Public Environmental Review documents, Woodside has claimed that the "GHG performance of Karratha Gas Plant compares well against other LNG facilities".[13] However in order to make this claim, the company has conveniently excluded two major pollution sources that occur even before the gas reaches the processing plant - the venting of 'reservoir CO2', and the energy use required to extract and pump the gas onshore. These pollution sources will add 3.6million tonnes of CO2e- per year (on average) according to other documents released by the company.[14]

Once this additional pollution is factored in, the emissions intensity of LNG produced from the Browse Basin will be almost 1 tonne of CO2 for every tonne of LNG produced. This is significantly higher than any of the international LNG projects in Woodside's own comparisons (Fig 1 & 2). Woodside has also made misleading and contradictory statements about the impacts that carbon pricing or carbon offsetting requirements would have on the Browse Basin and Burrup Hub projects (see section titled 'Carbon Risks' in this report).

The role of gas and LNG in driving global climate change

While there is much focus on coal, gas is a fossil fuel that causes similar levels of carbon pollution when all of its lifecycle emissions are taken into account including the production, processing, transport and combustion.

In 2019, pollution from the production and use of LNG took over from coal as the biggest factor driving the increase in global emissions. [9]

Figure 1: Emissions intensity of Browse Basin LNG compared with other WA LNG projects[15]

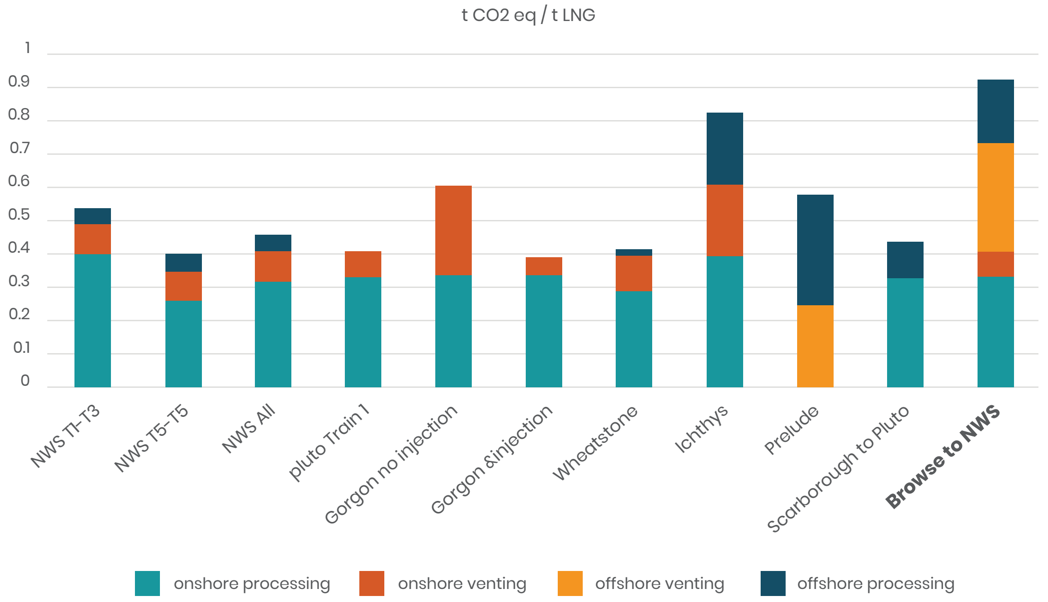
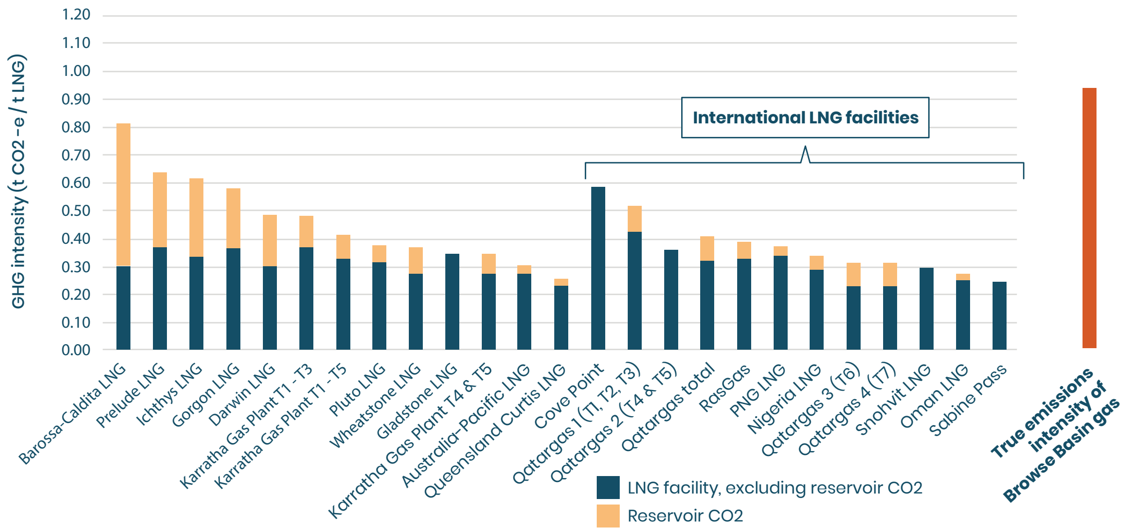


Figure 2: Emissions intensity of Australian and global LNG projects[16]



"Globally, most of the new natural gas being used isn't displacing coal, it's providing new energy."
– Prof. Rob Jackson,Stanford University School of Earth, Energy & Environmental Sciences[10]

In its most recent reports, the IPCC has made clear that significant near- and long-term reductions in natural gas production and methane emissions are needed urgently to meet the temperature goals established under the Paris Agreement.[11]

A comprehensive analysis of existing and planned LNG infrastructure released in June 2019 by Global Energy Monitor[12] found that when compared with coal, global LNG expansion presents as great, or greater a threat to the global climate. The report calls for a worldwide moratorium on new LNG production.

Empty promises: what the proponents have said about carbon pollution

Several of the companies involved in Woodside's Burrup Hub project have made public pledges to shareholders and investors to reduce total pollution and/or reduce the pollution intensity of the oil and gas they sell.

Woodside: The lead proponent of the Browse Basin and North West Shelf LNG project told shareholders in 2019 that it is committed to reducing its pollution to net zero emissions by 2050.[17]

Shell: Shell announced in 2017 that it intended to cut its carbon footprint by about 20% by 2035 and by about 50% by 2050.[18] According to the company, this includes all the emissions from the life cycle: from production to processing and then to transportation and final use.

BP: BP has committed to three strategies to respond to climate change – reducing emissions from operations, improving its products and creating low carbon businesses. The company says it will reduce operational emissions by 3.5 million tons per year by 2025 and aims to "provide lower emissions gas."[19] BP's new CEO is expected to announce more ambitious carbon pollution targets, including for scope 3 emissions which account for almost 90% of BPs 491 million tonnes of emissions in 2018.[20]

BHP: Best known in WA for iron ore BHP is a partner in both the inefficient North West Shelf LNG plant that will process gas from Browse and the Scarborough gas-fields. In 2019 BHP set goals to decarbonize its operations.[21]

The Burrup hub project is inconsistent with the above commitments and proceeding with this development would demonstrate their climate promises to be meaningless and misleading.

Worse, Woodside has a track record of strongly campaigning against action on climate change in Western Australia, most recently leading a fierce campaign against the state's independent Environmental Protection Authority (EPA) for suggesting LNG projects should reduce and offset carbon pollution.

Woodside has proposed no efforts to reduce or mitigate the massive carbon pollution that would result from the Burrup hub developments, despite a WA Government policy that states projects should contribute to the state's net-zero emissions goal by 2050.

Environment, culture and health impacts

Impact on marine life – Scott Reef

Teeming with unique and endangered marine life off the remote Kimberley coast, Scott Reef is one of the most ecologically significant marine environments in the world.

Oil and gas drilling and production as part of the Browse Basin development would have a devastating effect on this pristine area.

The remote reefs and lagoons covering over 600km2 provide a sanctuary for nesting giant sea turtles, pygmy and blue whales, huge pods of dolphins, dugongs and many other species of endangered marine life.

"This pristine marine region provides nesting, feeding and/or migratory habitat for endangered green sea turtles as well as for loggerheads, flatbacks, hawksbills, leatherback and olive ridley sea turtles – all protected marine species. Whales, dolphins, whale sharks and other marine species are known to rely on Scott Reef."

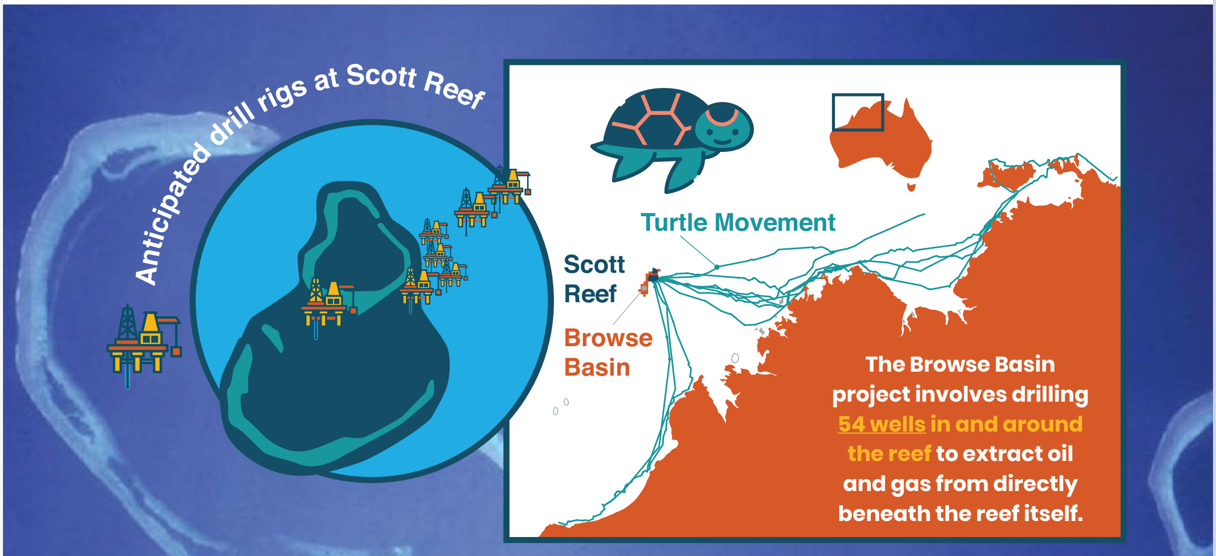
– Teri Shore, Program Director Turtle Island Restoration Network (TIRN), www.SeaTurtles.org

The Browse Basin project involves drilling 54 wells in and around the reef to extract oil and gas from directly beneath the reef itself. Woodside's risk models predict that a mixed gas and oil spill would last 77 days, spreading across the reef, and as far as 800 km from the site, at concentrations lethal to marine life.

Industrial noise, oil spills, toxic water discharge, light pollution and heavy shipping operations all disturb, endanger and kill marine life, threaten breeding and nesting for ancient turtles and other species, and would turn Scott Reef into an industrial landscape where once a pristine ecosystem existed.

"Direct and indirect impacts to marine turtles and habitat are generated by construction and operations from dredging, pile driving, drilling, seismic blasting, lighting and flaring, vessel strikes, toxic discharges, trash including plastics, air pollution, water pollution, oil spills, fuel spills and noise."

– Teri Shore, Program Director Turtle Island Restoration Network (TIRN), www.SeaTurtles.org



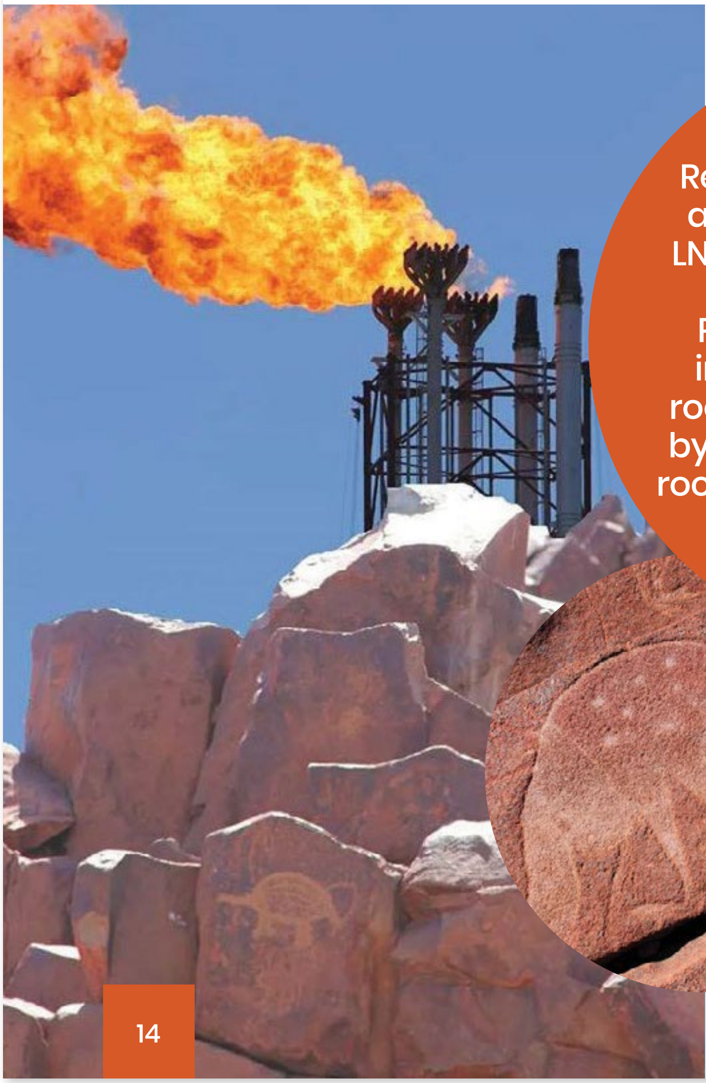
Background aerial image of Scott Reef | Credit: NASA

Impacts on cultural heritage - Murujuga rock art

The Burrup Hub project would also have a devastating impact on a globally significant cultural heritage site that the Australian Government has nominated for World Heritage listing. The North West Shelf and Pluto LNG facilities earmarked to process the new gas are already located within one of the world's oldest and most extensive areas of Aboriginal rock art - Murujuga. Murujuga contains an estimated one million examples of rock carvings dating back at least fifty thousand years, including the first recorded image of a human face.

The impacts of LNG processing on this rock art has led to a Senate Inquiry and has drawn concern from Murujuga Traditional Owners and rock art experts around the world.

> "This rock art is unique in the world. The Burrup Peninsula is the only documented place where the cultural history and spiritual beliefs of humankind for over fifty thousand years remain preserved in art. Industrial pollution from LNG processing is eating away at the surface of the petroglyphs and destroying this irreplaceable treasure."
>
> **– Rock Art Expert Dr John L Black AM FTSE FAIAST FASAP FNSA**



Research has shown that acid gas emissions from LNG processing and linked industry on the Burrup Peninsula have directly increased the acidity of rock surfaces on Murujuga by 1000-fold, dissolving the rock surface and destroying the rock art.

Risks to the health of people and communities

The processing of natural gas to produce LNG is extremely pollution-intensive, releasing emissions that have direct effects for public health and wellbeing for people living near or working at the facilities.

In 2016 -17 the LNG plants Woodside proposes to be utilised for the Burrup Hub project were among the highest industrial point source polluters of harmful air pollutants in Western Australia, releasing 8,000 tonnes of nitrogen dioxide, 97 tonnes sulphur dioxide and 16,000 tonnes of volatile organic compounds (VOC's), as well as PM2.5, ozone, mercury, and other heavy metals. Air pollutants of this type can cause serious health impacts, including heart disease, stroke, lung cancer, asthma and diabetes, even at low levels of exposure.

Woodside has undertaken some ambient air quality monitoring in Karratha and other locations around its LNG processing plants, however, the company has refused to release the full data from this monitoring, and the limited data that has been released is insufficient to provide evidence of public safety.

> "There is no reasonable and practicable way of identifying the frequency and degree of risk people living and working in the Burrup Peninsula experience as a consequence of breathing the air pollution resulting from LNG production. Therefore, the true nature, extent and duration of health burden caused by this pollution is unknown."
>
> **– Dr Sajni Gudka (Ph.D)**[22]

In addition to air pollution, the GHG emissions from the planned Burrup joint venture will contribute significantly to further global heating and increase the frequency of extreme weather events and bushfires such as those currently being experienced in Australia. The health impacts both physical and psychological from such events are profound and long-lasting.

Risks from fracking to supply gas to Burrup Hub

A significant portion of the gas that would be required to supply the Burrup Hub project over its proposed 50 year lifetime has not been identified by Woodside in its environmental assessment documents, however it is clear that even if the large Browse Basin and Scarborough gas fields are successfully developed they will not sufficient to supply the demand for gas that will be created by this project. This raises serious questions about where this additional gas would be sourced from and and what the impacts of extracting this gas would be.

> The Burrup Hub could process more gas than the entire volume extracted from the North West Shelf since 1984.
>
> **– Woodside Petroleum [23]**

Recently it has been revealed that Woodside plans to source additional gas for the Burrup Hub from onshore gas fracking, and has been negotiating with several companies to provide this gas including seven West Media owned Beach Energy[24] (see list of identified companies and projects under 'overview' section of this report).

To date, fracking projects have struggled to make their projects viable due to high production cost, limited demand for gas on the WA domestic gas market, and the McGowan Government's fracking moratorium which is now in the process of being lifted. The areas targeted for fracking under the McGowan Government's new fracking policy include vast areas of the Midwest wildflower country, thousands of hectares of the state's most productive farmland, and vast areas across the Kimberley where Traditional Owners have strongly opposed fracking on Aboriginal lands.

The Burrup Hub project will pave the way for a substantial fracking industry to become established in WA in order to supply gas for export markets.

Fracking leases and drinking water resources
Source https://www.dmp.wa.gov.au/Documents/Petroleum/PD-CI-POD-115D.pdf

Gas fracking presents very significant threats to the environment that are different from conventional offshore gas extraction. These include health impacts resulting from air and water pollution, damage to groundwater aquifers, contamination of ground and surface water, elevated emissions of powerful greenhouse gasses, biodiversity loss and habitat damage, and large-scale industrialisation of rural and natural landscapes.

Supplying gas at the scale required for the Burrup Hub could require thousands of fracking wells. These wells would be drilled through groundwater aquifers including the Yarragadee aquifer which provides much of Perth's drinking water.

Initially, fracking projects that are located close to existing gas pipelines in the Perth Basin are being targeted to supply the Burrup Hub, however with additional gas demand, new pipelines could open up the vast Canning Basin in the Kimberley to supply gas to this project.

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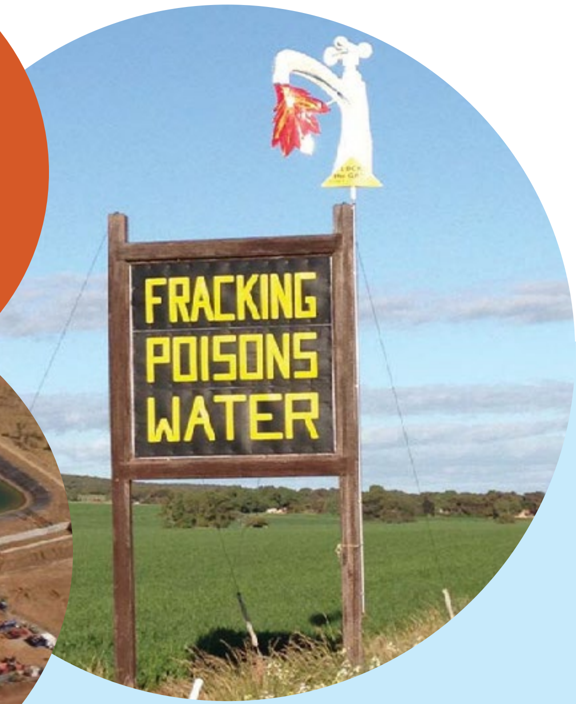
Buru Energy Kimberley



Geraldton Fracking sign

Farmers Rod and Annette Copeland

Few benefits for West Australians

While the Burrup Hub and Browse Basin projects are claimed to have considerable benefits for Western Australia the reality is that the LNG industry has not lived up to these claims in the past and is unlikely to in the future.

Few jobs from WA's smallest employer

It may come as a surprise to learn the petroleum industry is the smallest employer in Western Australia of any sector.[25] (Fig 3) This is partly because the industry has been allowed to source a high proportion of its labour from offshore. With the LNG plants as part of this project already built, the bulk of the work generated by the Browse Basin and Burrup Hub will be offshore, and the vast bulk of the engineering will likely be shipped in from overseas.

The two giant offshore facilities for Ichthys LNG were entirely built in Korea as was Shell's Prelude floating LNG facility. Onshore LNG plants are built mainly overseas as modules that are assembled on site.

Woodside currently employs around 3500 people, and it is estimated over 4000 will be employed over the peak construction period of the Burrup Hub project. This compares to almost 2000 Western Australians currently employed in WA's renewable energy industry,[26] 8400 currently employed by McDonalds, or over 135,000 in the healthcare industry.[27]

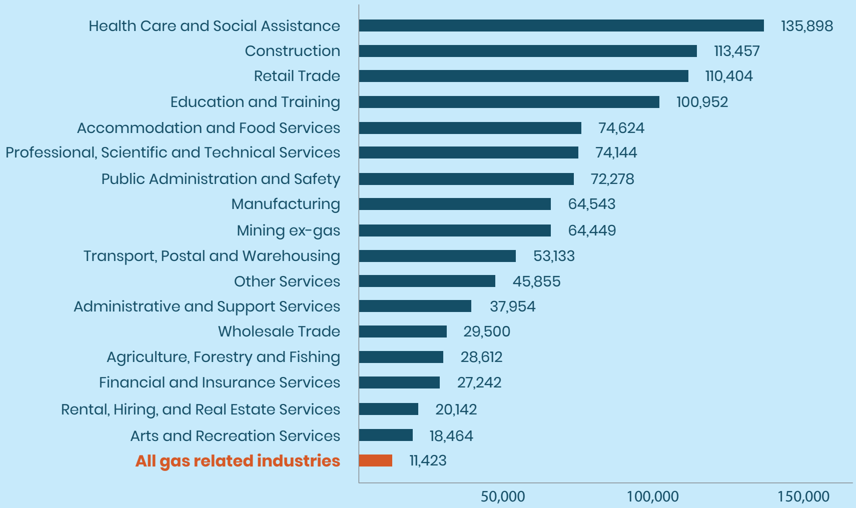
WA Premier Mark McGowan has also refused to disclose to Parliament the details of agreements with Woodside to deliver local benefits, local content or royalties from the Burrup hub projects, drawing strong criticism from the WA Opposition, the Greens and National Party. [28]

The Reserve Bank of Australia has confirmed that the benefits of future LNG development in Australia, including the Browse Basin and Burrup Hub are likely to be modest, saying:

> **"the effect on Australian living standards will be less noticeable given the low employment intensity of LNG production, the high level of foreign ownership of the LNG industry and, in the near term, the use of deductions on taxation payments."**
>
> **– Reserve Bank of Australia[29]**

Source: The Australia Institute

Figure 3: WA employment by industry



Meanwhile, a new study published in January 2020 has shown that the solar PV, battery storage, and wind power sectors will serve as the major job-creating technologies by 2050, with renewable energy responsible for 80% of future job opportunities, up from 28% of energy jobs in 2015. Conversely, the fossil fuel and nuclear industries are expected to see their share of energy jobs fall from a 70% share to only 3% over the same forecast period.[30]

Woodside paid just $492.7 million tax on an income of $10.3 billion, an effective income tax rate of 4.8%.

Little royalties or tax, while profits and jobs flow overseas

Most LNG projects in WA have paid no royalties to date for the gas they are exporting and contribute very little tax when compared with the enormous profits they have been reporting to shareholders.

Figures from the Australian Taxation Office[31] show that in the 2017-18 financial year the 12 companies involved in WA's 5 LNG facilities made an income of over $62.9 billion in 2017/18 but paid just $1.54 billion in tax -
an effective income tax rate of 2.54%.

Chevron and Shell, who are responsible for 70% of WA's LNG pollution and are both foreign-owned, paid no tax on $9.775 billion income. Specifically;

- Chevron made $5.27 billion in revenue in 2017/18 but paid no tax. Chevron made $15.77 billion in the five years to 2017/18 and paid zero tax.[32]
- Shell made $4.57 billion in 2017/18 and paid no tax. Shell reported $47.5 billion between 2013-2016, and paid only $1.1 billion in corporate tax for those three years, equivalent to a 2% tax rate.[33]

Woodside paid just $492.7 million tax on an income of $10.3 billion, an effective income tax rate of 4.8%.

Western Australia does not need the gas

While the vast majority of the gas produced by the Browse Basin and Burrup Hub project will be exported as LNG, it will also supply gas (15% of LNG produced) to the WA domestic market under the Domestic Gas (domgas) Reservation Policy.

It is however questionable as to whether the WA domestic market needs LNG produced by the Browse Basin and Burrup Hub because:

- WA has sufficient alternative gas supplied from other LNG projects with requirements to supply domgas, including the Chevron Wheatstone and Gorgon LNG projects;
- Demand growth for domestic gas in WA is projected to be low; and
- There are significant opportunities to transition WA manufacturing, minerals processing and other industries to cheaper renewable energy.

The Australian Energy Market Operator (AEMO) has projected Western Australian domestic gas demand to grow at an annual rate of just 1.5% over the next decade.[34] However, this growth projection is likely to be an overestimate. The AEMO projection assumes demand growth from mineral processing, manufacturing and other industries including lithium and battery metals; however, new and existing industries are increasingly likely to utilise renewable energy solutions which are already cost-competitive with gas and are reducing in cost all the time.

> "Renewable energy is affordable and reliable now. Many businesses are already paying 20 to 50% less for electricity by switching to renewables, and renewable energy could be 30 to 50% cheaper in just 10 years. With Australia's unparalleled resources in solar and wind energy, we could electrify all industrial processes."
>
> **– Beyond Zero Emissions, Electrifying Industry, 2018[35]**

While gas has been described as a 'transition fuel', it is unlikely that this will lead to significant increases in demand for gas. The use of gas generators as a backup energy provider for intermittent renewable generation will mean that gas-fired power stations will sit idle for much of the time. Battery technology is increasingly able to provide this service in a more efficient and affordable way.

More importantly, Western Australia has access to the world's best renewable energy resources. Development of these energy sources, coupled with the electrification of industrial operations has the potential to support a clean manufacturing and industry boom here in WA without the need for gas.

> "Australia has the potential to become an energy superpower in the low carbon world economy, but it needs to shake off the shackles of those with ideological or vested interest in the old ways of supplying energy. Western Australia can benefit from its own vast and diverse renewable energy, mineral, land and marine resources and play a vital role contributing to the national and global transition to a zero carbon energy future,"
>
> **– Professor Ross Garnaut**

West Australians would be left with a $17.6 billion pollution bill

Western Australia has a carbon pollution reduction target of net zero emissions by 2050, consistent with its obligations under the Paris Agreement and global efforts to limit temperature rise to 1.5 degrees celsius.

Setting aside the more than 5 billion tonnes of 'scope 3' carbon pollution that the Burrup Hub project will emit over its lifetime when the LNG is burnt overseas, Clean State has estimated the project will also generate over 700 million tons of 'scope 1' carbon pollution over its lifetime here in Western Australia.[36] This is equal to the emissions of 177 new coal-fired power stations burning for a year.

Woodside has not committed to any significant abatement measures or carbon offsetting to deal with this massive volume of carbon pollution,[37] which will have the effect of transferring the cost of reducing these emissions to other parts of the WA economy. For every tonne of CO2 that the Burrup Hub project directly emits, Western Australians will have to pick up the bill to find an equivalent emissions reduction or offset somewhere else in WA.

> "The Premier is stating that the policy is by 2050 there will be zero net emissions, but he cannot have that if he allows these projects to emit the amount of CO2 that they are expected to emit. He might give them an exemption, but if he does that and he meets his policy requirements, other projects will have to pick up the load and compensate for them. If these projects go ahead, they will make a huge contribution to the total volume of CO2 and other greenhouse gas emissions in Western Australia."
>
> **– ex WA Liberal Premier Mike Nahan[38]**

The cost of the enormous pollution bill that would be passed on by Woodside to Western Australians can be calculated using an indicative carbon price. **At a carbon price of $25 per tonne of carbon, the Browse Basin project would transfer a cost of $17.6 billion to the West Australian people over the life of the project.**

West Australians reject the Browse Basin and Burrup Hub

Given the major concerns and the very limited benefits from the Browse Basin and Burrup Hub project, it is not surprising that research conducted by Patterson Research Group and Thinkfield Research[39] shows the proposal is not supported by the majority of the West Australian community.

The research, conducted in September 2019 (with a sample size of 925), found that:

- Nearly two thirds (64%) of people surveyed strongly support phasing out gas and replacing it with renewable energy in WA, with only 14% disagreeing with this proposition.
- A clear majority (nearly 60%) of West Australians support a ban on new gas developments.
- Of those who expressed a view about the Browse Basin LNG development, a clear majority (65%) oppose the project. Just 23% of respondents believe it should go ahead, and even when jobs and other benefits are considered, the level of support for the Browse Basin project does not increase significantly.
- Western Australians (80%) overwhelmingly support requirements for WA's biggest polluters to offset their climate damage through job-creating projects like tree planting, carbon farming and renewable energy. Woodside has not committed to providing carbon pollution offsets as part of the Burrup Hub and Browse Basin projects.
- Almost three quarters (73%) of respondents believe that the State Government should follow the advice of the EPA on controlling carbon pollution from WA's biggest polluters in the LNG industry. Just 11% disagree with this.
- If the Browse Basin and Burrup Hub projects were to proceed and the state is to meet its carbon pollution reduction goals, then other sectors of the economy would have to cut emissions to make up for the pollution released by these projects. Less than a quarter (23%) of respondents believe that it is acceptable for the broader community to bear the costs of reducing pollution from WA's LNG industry.

This research suggests that Woodside does not enjoy a strong social license to proceed with these developments in Western Australians, with a clear majority opposing the projects and supporting a phase-out of LNG production in the state.

A clear majority of West Australians support a ban on new gas developments.

Risk to investors and shareholders

Capital investment of up to $AU50bn is required for the Burrup hub project to proceed. However, the climate and environmental impacts of the projects, as well as the softening global demand for LNG as import countries implement their Paris Agreement plans make these projects risky from an investment perspective. There is a significant likelihood that the project becomes an expensive stranded asset as the world shifts towards cheap renewable energy and away from highly polluting energy sources like the LNG that would be produced by the Burrup Hub project.

Carbon risks

To date, Woodside has failed to disclose carbon risks associated with the Burrup Hub project and have withheld clear, accurate information about the carbon pollution that would result from the proposal. Public statements from the company about the impact of future carbon pricing and climate change policies on the project have been contradictory, suggesting a high degree of uncertainty.

On the one hand, Woodside has claimed that the Browse Basin and Burrup Hub project is robust at a carbon price of $40 per tonne. However, Woodside's CEO has also attacked proposals by the WA Environmental Protection Authority (EPA) to require offsetting of carbon pollution at a much lower cost per tonne, claiming this would make the project unviable and risk 'billions of dollars investment into Western Australia'.

Any statements made by Woodside about carbon risk of this project should be treated with extreme caution and investors should be wary of any project which has not fully disclosed carbon risks.

The WA State Government has announced a policy that major projects must develop Greenhouse Gas Management Plans' that details their contribution towards achieving the State's aspiration of net zero emissions by 2050.

The McGowan Government is committed to working with all sectors of the Western Australian economy towards achieving net zero greenhouse gas emissions by 2050.[40]

–WA Government Greenhouse Gas Emissions Policy

Despite this, Woodside has proposed no significant mitigation efforts or commitments to reduce pollution from the Browse Basin and Burrup Hub projects in its environmental assessment documents. It is unlikely that this project would be approved with no conditions to reduce pollution. Even if such approval were given now, future requirements to reduce pollution and/or carbon pricing arrangements are almost certain to be imposed in the future as Australia moves to a more proactive position on climate change.

Global demand for LNG

It is also unlikely that global demand for LNG will remain stable for the life of this project, or event for the near term. With the price of renewable energy declining fast, the current glut of gas globally and governments implementing climate change policies consistent with the Paris Agreement, the demand for LNG is likely to reduce within the timeframe of the project significantly.

> "Global implementation of the Paris Agreement means that growth in the use of natural gas cannot continue. Scenarios vary, however a common denominator is that in the next decade natural gas demand would have to peak and begin to decline, and in central case estimates fairly rapidly." **– Climate Analytics, 2019,**[41]

Global Energy Monitor has identified up to $US1.3 trillion in global investment in new LNG infrastructure is at risk globally due to existing and planned LNG infrastructure becoming stranded assets as investor support and demand wanes for the next wave of oil and gas projects in Australia[42] and as climate action and cheap renewable energy are likely to make LNG uncompetitive in the medium term.[43]

Fossil fuels are the 'new tobacco'

> **"We are not the cigarette industry and do not want to be viewed as such. And that is a very real risk if we do not take action now. With new employees coming into the industry, do they want to be part of an industry that at the moment is getting a bit of a black eye to be quite frank with you and I think unfairly. [Climate change] has certainly come onto my risk register as the largest thing that we need to be thinking about as a company. So five years ago climate change was not the biggest issue that we were dealing with. Today it's by far the biggest issue."**
>
> **– Peter Coleman, Woodside Chief Executive. January 14, 2020**

Banks, Investors and Insurers are also recognizing the risk of supporting projects that pose a threat to the climate. Six global development banks have committed to ending funding for fossil fuel extraction,[44] and Sweden's central bank has recently sold bonds from Alberta, Western Australia and Queensland due to greenhouse gas emissions being too high.[45]

The world has reached a tipping point, with the global weighted average cost of new renewables now within the cost range of fossil-fuels and still falling.[46] Fossil fuel companies are dropping out of the top ten most valuable companies. Once a market leader, the fossil fuel sector has been a poor investment for a decade.

Former hedge fund manager and Host of CNBC's Mad Money has said oil stocks are 'in the death knell phase' comparing them to tobacco.

> **"I'm done with fossil fuels … they're just done. We're starting to see divestment all over the world," Cramer said. "You're seeing divestiture by a lot of different funds. It's going to be a parade. It's going to be a parade that says, 'Look, these are tobacco and we're not going to own them.'"**
>
> **– Jim Cramer Jan 31, 2020[47]**

In fact, the non-renewable energy sector finished dead last among industries in the Standard & Poor's 500 in 2018, in the wake of years of underperformance. In 1980, seven of the top 10-ranked companies in the Standard & Poor's index were oil and gas companies. Today, there are none. In 1980, energy companies comprised 28% of the S&P 500. Today, it is closer to 4%. According to the Institute for Energy Economics and Financial Analysis, "the outlook for oil and gas companies is weak, at best.[48]

With the economics for renewables changing so rapidly the real risk to WA's fossil-fuel-based export market is the pace at which other countries and sectors innovate and electrify away from climate damaging projects.

Reputational, litigation and direct action risks

Associating with this project could bring significant reputational and financial risk to other companies and contractors working on the project, and to finance institutions, banks and other trading partners. Given the size and scale of the pollution and other environmental impacts that would result from this project, it is an obvious target for protest, advocacy and climate litigation in the future.

> "It is only a matter of time before the courts are forced to step in and hold government accountable as they have done with Big Tobacco and Big Pharma".
>
> **– Tasmanian barrister and former Liberal staffer Greg Barns.[49]**

There is a rising global trend in climate litigation against governments and corporations for failing to take action on climate change or for approving climate-damaging projects. Recent examples include that the UK government is being sued for approving Europe's biggest gas fired power station,[50] and the landmark 'Urgenda' case saw the Dutch supreme court uphold a class action against the Dutch government for failure to act on climate change.[51]

Meanwhile protests about Woodside and Chevron and the Browse Basin and Burrup Hub projects are 'just getting started' according to mining industry reports.[52] The companies involved have already been targeted by protest action and Western Australia's peak conservation organisation has signalled the potential for legal challenges to the project's approvals.

> "We're scrutinising the nature of the approvals that have been given already … we are already very concerned that they're not properly taking into consideration climate change and carbon risk. Certainly we'll be seeking opportunities to challenge those in the courts…"
>
> **– Piers Verstegen, Director Conservation Council of WA[53]**

Environmental approvals

Environmental approvals for this project are highly complex and cannot be taken for granted. Approvals are required for at least seven different project elements from the State and Commonwealth Governments, each component requiring multiple assessment and approval decisions. The potential for delay and added cost are significant.

The separation of the project into several separate elements has resulted in a failure to address the overall cumulative environmental impacts and risks, obscuring critical information from government and other stakeholders including the public, investors, and shareholders. This approach increases the level of risk surrounding the project, including the risk of future litigation.

Recent LNG projects operating in sensitive environments such as the Chevron Barrow Island LNG project have been delayed significantly and suffered very high cost overruns due to environmental compliance requirements and technical difficulties. Investors can assume that the same would occur for the Browse Basin and other developments as part of the Burrup Hub project.

In 2013 it was estimated that the Chevron Gorgon project resulted in a 46% cost blowout to $US54 billion. In 2017, Chevron's departing head told Wall Street the $US17 billion cost blowout at Chevron's Gorgon LNG project taught the US oil major it needed to do more homework before starting mega-projects.

> "We have to verify every single aspect of these projects in advance, because we're on the hook for them, regardless of the kind of contract that we sign."
>
> **– Chevron chief executive John Watson[54]**

Browse Basin has a history of costly and contentious failure

The giant Browse Basin gas field off the remote Kimberley coast has always been a contentious, complex, and technically challenging proposition. The high costs of developing the remote offshore fields, the multiple corporate ownership structure, and serious and intractable environmental concerns, including very high carbon intensity have scuttled several previous attempts at developing the resource.

In 2012, Woodside proposed to construct an LNG production facility in Scott Reef itself, however this was met with strong opposition from environmental groups and was not progressed further. Woodside's next attempt, a giant greenfields LNG project at James Price Point on the pristine Kimberley coast sparked one of the biggest environmental battles in Australia's history. Against the background of fierce opposition from environmental groups and Traditional Owners, the proposal was eventually stopped in the courts when the environmental approval was found to be unlawful, and in boardrooms where the ongoing delays and opposition to the project made it unviable on commercial grounds.

> **"We invested about 4.5 million man hours and had hundreds of Woodsiders who dedicated years trying to come up with a way to make this land-based development commercially viable... When the final number came in at more than $80 billion, it was obvious these efforts were in vain."**
>
> **–Woodside vice-president Roger Martin[55]**

The current attempt to bring Browse online, pumping the gas 900km to shore as part of the Burrup Hub development is shaping up to be just as technically and environmentally challenging as previous attempts to develop the resource. While some preliminary approvals have already been granted, the true extent of the environmental and climate impacts of the development and the associated costs and technical challenges of developing the resource is poorly understood.

James Price Point, Kimberley, WA | Credit: Jill Swanson/ACF

Conclusion

The $AU50bn Burrup Hub and Browse Basin mega-project is one of the most polluting and environmentally risky projects ever to be proposed in Australia. At a time when the world is seeking to transition to clean energy sources rapidly, this project would be a huge step backwards in global efforts to tackle climate change. Investment in this project is not consistent with action needed to prevent dangerous global warming and will only contribute to a global failure to meet the goals of the Paris Agreement.

The project also carries significant other environmental risks including damage to one of Australia's most unique and biodiverse marine ecosystems, irreversible impacts on cultural values that are proposed for World Heritage listing, and risks to the health of communities.

The project would deliver few benefits for West Australians and presents significant reputational and investment risks for investors and proponents. Woodside does not have a strong social license to proceed with the project, with the majority of Western Australians wanting to see gas production phased out and replaced by renewable energy.

The Burrup Hub project is not a fait accompli. Complex environmental assessment processes are still underway, and approvals are yet to be granted for the most significant and contentious aspects of the project. Decisions to sanction the project are still required from a number of corporate partners, and capital must be raised before the projects can proceed. Joint venture partners and investors can exercise options to divest or withhold investment in the projects.

Given the very significant environmental risks, investment risks, few benefits, and the profound and irreversible consequences for the global climate, the Burrup Hub mega project should not proceed.

WA's LNG industry must also demonstrate how its 5 existing facilities, which our previous 'Runaway Train' report found to emit 32mtpa of direct emissions in WA every year, will be fully decarbonized or phased out by 2050.

Environmental approvals should not be issued for the project, and investors and banks should avoid exposure to the proposals. Oil and gas companies should instead pursue opportunities to develop alternative low carbon energy sources rather than locking themselves into a risky, unpopular and highly polluting future with the Browse and Burrup Hub proposals.

Appendix 1

Top 25 Shareholders of Woodside Energy[56]

Ownership	Name	Shares	Current Value	Change %	Portfolio %
6.09%	BlackRock, Inc.	57,411,725	$1.9b	0%	0.04%
6.02%	The Vanguard Group, Inc.	56,772,669	$1.9b	6.02%	0.04%
1.39%	Norges Bank Investment Management	13,056,529	$433.2m	0%	0.04%
0.97%	Legg Mason, Inc.	9,152,100	$303.7m	-1.40%	2.27%
0.85%	First Sentier Investors (Australia) IM Ltd	7,998,328	$265.4m	0%	0.50%
0.69%	Dimensional Fund Advisors LP.	6,543,516	$217.1m	-0.07%	0.03%
0.64%	Eastspring Investments (Singapore) Limited	6,051,339	$200.8m	23.89%	0.39%
0.62%	Commonwealth Superannuation Corporation	5,843,471	$193.9m	0%	2.86%
0.58%	Invesco Ltd.	5,481,874	$181.9m	-0.12%	0.03%
0.53%	State Street Global Advisors, Inc.	5,006,329	$166.1m	-1.53%	0.01%
0.51%	Link Market Services Limited, Asset Management Arm	4,803,115	$159.4m	0%	75.83%
0.46%	Australian Foundation Investment Company Limited	4,360,000	$144.7m	0%	1.85%
0.37%	Geode Capital Management, LLC	3,520,051	$116.8m	-5.74%	0.02%
0.35%	Orbis Investment Management Limited	3,340,836	$110.8m	0%	0.27%
0.31%	AMP Capital Investors Limited	2,884,675	$95.7m	0%	0.26%
0.28%	Schroder Investment Management (Singapore) Ltd	2,646,456	$87.8m	0%	0.35%
0.21%	Teachers Insurance and Annuity Association of America - College Retirement Equities Fund	2,017,159	$66.9m	-1.81%	0.01%
0.20%	Standard Life Aberdeen plc	1,908,450	$63.3m	-1.17%	0.02%
0.20%	Australian United Investment Company Limited	1,900,000	$63.0m	0%	4.98%
0.20%	Deutsche Asset & Wealth Management	1,895,953	$62.9m	1.03%	0.02%
0.20%	UBS Asset Management	1,880,753	$62.4m	11.34%	0.01%
0.19%	Charles Schwab Investment Management, Inc.	1,786,345	$59.3m	-0.64%	0.01%
0.19%	Netwealth Investments Ltd.	1,749,071	$58.0m	0%	1.62%
0.18%	J.P. Morgan Asset Management, Inc.	1,735,912	$57.6m	-0.38%	0.01%
0.18%	Argo Investments Limited	1,700,873	$56.4m	0%	0.96%

Endnotes

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Clean State

Get involved

cleanstate.org.au

@cleanstatewa

@cleanstatewa

CleanStateWA

info@cleanstate.org.au

[redacted]

Environmental Protection Authority of WA
Locked Bag 10
Joondalup DC, WA, 6919
Via email: info.epa@dewr.wa.gov.au
12 February 2020

Dear [redacted]

SUBMISSION TO ASESSMENTS:

- **2191: Proposed Browse to North West Shelf Project (state waters);**
- **2191: Proposed Browse to North West Shelf Project (commonwealth waters); and**
- **2186: North West Shelf Project Extension**

I am pleased to provide you a submission to the proposed Browse to North West Shelf Project.

Clean State is an independent initiative providing research and analysis on Western Australia's LNG industry.

Our submission to the assessment process is in the form of a **detailed report** which provides a thorough investigation of the carbon emissions from the proposed Burrup Hub project, as well as environmental and heritage impacts.

Our report, '*Australia's most polluting fossil fuel mega project: Why Woodside's Burrup Hub developments should not proceed*' was completed specifically to be considered as part of the assessment process. It is attached and is also available online at www.cleanstate.org.au

1. Key findings of our report on the Burrup Hub project

- Woodside's Burrup Hub project will be the most polluting project to be developed in Australia, ever. Over its 50-year lifetime, the Burrup Hub will generate over 6 billion tonnes (gigatons) of carbon pollution (scope 1 &3). (See table overleaf). That's equivalent to 11 times Australia's annual emissions.

- Annual pollution from the Burrup Hub project (scope 1&3) will be 139 million tonnes, which is over 4 times more than that of the proposed Adani coal mine, and the equivalent of 35 new coal fired power stations the size and intensity of Muja.

- Direct annual emissions (scope 1 from state and commonwealth waters) from the Burrup Hub project will be **16.1 million tonnes**. This is equivalent to four new coal fired power stations the size of Muja.

1

[redacted]

Project	Annual pollution (scope 1 only) Mtpa CO2e-	Annual pollution (Including scope 3) Mtpa CO2e-	Total pollution (over 50 year project life) Mt CO2e-
Browse Basin gas (processed through North West Shelf LNG)	6.8	44.8	1,602 (1.6 gigatons)
Scarborough gas (processed through Pluto LNG facility)	4.3	44	1,347 (1.3 gigatons)
Total Burrup Hub (new gas only) (proposed new gas-fields including Scarborough and Browse)[2]	13	120	5140 (5.1 gigatons)
Total Burrup Hub (all gas including existing reserves)	16.1	139	6086 (6 gigatons)

- Will produce some of the dirtiest gas in the world – a fact Woodside have attempted to hide. The 'carbon intensity' of gas extracted from the Browse Basin (0.95 tonnes per tonne of LNG produced) will be nearly double the Australian average and the Burrup Hub will produce some of the dirtiest, most carbon-intensive LNG anywhere in in the world.

- Makes WA's commitment to reaching net zero by 2050 impossible and is in direct breach of Australia's commitments on climate change. This project undermines international action towards the Paris Agreement and directly breaks public promises made by Woodside, Shell, BP and BHP to reduce emissions particularly in relation to emissions intensity.

- The project will require 54 wells to be drilled in and around the pristine Scott Reef off the Kimberley coast to extract oil and gas, impacting 58 endangered marine and migratory species in a globally significant biodiversity hotspot. Subsea drilling, seismic testing, industrial noise, light pollution, and heavy shipping operations will have devastating consequences for the reef and directly impact iconic endangered species including Humpback whales and giant Green turtles.

- The industrial emissions from the project will cause permanent damage to the world's most extensive collection of Aboriginal rock art, nominated for World Heritage listing on the Burrup Peninsula (Murujuga). Acid gas emissions (in the form of acid rain and atmospheric events) from Woodside's LNG facilities and other industry on the Peninsula are already destroying the rock art,

[redacted]

with research showing acidity of rock surfaces has increased by 1000 times since industry was established there. Significant expansion to these facilities would make the damage far worse.

- Industrial emissions risk health impacts for local communities and workers from exposure to industrial air pollution, which Woodside have failed to monitor and report on to date.

2. The proposal should be rejected outright based purely on its carbon impact

Clean State is shocked by the scale of emissions this project will generate and by the audacity of Woodside to put forward this project for assessment without any attempt to avoid, minimize or offset its emissions.

The state government has endorsed Australia's target of 26-28% pollution reduction from 2005 levels and set an aspirational target of net zero emissions by 2050. In contrast, growth in pollution from existing WA LNG facilities since 2005 has *increased* WA's total emissions by 36% above 2005 levels, and the planned Burrup Hub project would see WA LNG emissions grow to 60% above the 2005 baseline. Worse, emissions will continue well beyond 2050 when emissions must be zero.

The proposal as it stands is a $50bn commitment 3-4 degrees of global warming.

Clean State believes the EPA should reject this proposal outright for these reasons alone.

3. Misleading information in Woodside's proposal documents should be investigated

Clean State is also alarmed at the multiple examples of misleading, flawed, or outdated information in Woodside's proposals, including the fact that the EIS documents:

- Do not clearly report estimated methane emissions, and what is reported is substantially lower than published leakage rates
- Deliberately underestimates the global warming potential of methane by using outdated metrics
- Attempt to conceal the magnitude of the reservoir CO_2 emissions and the true emissions intensity of the Browse basin gas
- Use an unrealistic and discredited projection of global gas demand, which is at odds with other projections
- Incorrectly claims that new GHG emissions from the sub-proposals are small on a global scale, instead of analysing them at a national and state level
- Has attempted to minimise the true impact of the Burrup Hub project in its entirety, by splitting up the proposed megaproject into independent sub-proposals; and

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[redacted]

- Incorrectly claims that gas has half the emissions intensity as coal.

4. Woodside's claim that gas is 'cleaner' than coal and will displace emissions overseas is dangerous and unfounded

Woodside has made claims throughout the proposals that switching from coal to gas will decrease greenhouse emissions. For example:

> *"Numerous independent energy and climate bodies agree that natural gas has a significant role to play in achieving both a reduction in net global emissions and an increased access to a reliable modern energy supply that supports a progressive transition to renewable energy sources..*
>
> *"The IPPC's 2014 Synthesis Report said that "GHG emissions from energy supply can be reduced significantly" by switching to gas. According to the IPCC, electricity generated from* ***gas has on average half the GHG emissions of electricity generated from coal*** *(IPCC, 2014).[1]"*

Clean State has investigated these proposals and can confirm the evidence does not support these claims. For example:

- **To achieve the Paris goals and stay within the IPCC carbon budget, gas needs to reduce not increase.** The IPCC has said the world needs to be fully decarbonized by 2050 to keep within 1.5 degrees of warming. To achieve this, it calculated a 'carbon budget' that shows it is crucial for emissions to begin falling after 2020. Any delay beyond this will make the trajectory to net zero emissions almost technologically and economically impossible to achieve. The increasing and uncontrolled emissions of the LNG industry are in breach of the Paris Agreement and the best available science. This is why energy and climate analysts are calling for a moratorium on LNG development globally. If emissions continue to rise beyond 2020 or even remain level, the IPCC temperature goals set in Paris become almost unattainable.

- **All modelled pathways in the IPCC Special Report that limit warming to 1.5° involve deep reductions in gas production and methane emissions[2]:**

    - Modelled pathways that limit global warming to 1.5°C with no or limited overshoot involve deep reductions in emissions of methane and black carbon
    - In energy systems, primary energy from gas in 2030 is reduced by 25% and in 2050 is reduced by 74% (relative to 2010); and
    - The use of Carbon Capture and Storage (CCS) would allow the electricity generation share of gas to be just 8% of global electricity in 2050

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[redacted] Clean State

- **A major international review of LNG infrastructure found the threat to the climate from LNG is 'as large or larger than coal'.**[3] Research also shows that if global coal use was eliminated overnight, burning the oil and gas reserves already being exploited would still take the world past 1.5°C.[4]

- **Methane levels negate any claimed 'advantage' over coal.** Gas is mostly methane, an extremely potent greenhouse gas that traps 86 times more heat over a 20-year period[5,6] and is around 120 times more powerful per ton compared with CO_2[7]. The IPCC has reported methane to have 86 times the potency of carbon dioxide for a 20-year horizon and 34 times the potency of carbon dioxide for a 100-year horizon. Methane is responsible of 25% of global warming to date.[8] When the gas industry claims that gas is 'cleaner' than coal, it's not including the huge amounts of methane released into the atmosphere at all stages over its lifetime, known as 'fugitive emissions'. These emissions escape during drilling and extraction, transportation in pipelines and storage, and eventual combustion and is estimated to be as much as 9% of the entire volume of the gas resource. Even worse, a series of reports including a recent study in Science[9] has shown that gas's lifecycle methane emissions are much higher than previously estimated and even further undermine the notion of any climate advantage over coal.[10]

  Fugitive emissions are the fifth largest source of greenhouse gas emissions in Australia and growing, at 10% of the total and rising, of which the gas industry is responsible for 43%[11,12]. The Intergovernmental Panel on Climate Change (IPCC) modelling shows to limit global warming to 1.5°C, we need to make substantial reductions in fugitive emissions. Despite this, Australia's fugitive emissions have increased by 60% since 2004.[13]

- **Woodside has used outdated figures to claim electricity generated from gas has half the emissions of electricity generated from coal.** Woodside have used 2011 IPCC estimates of the electricity emissions intensity of gas (450kgCO2-e/MWh) and coal (1,000kgCO2-e/MWh)[14]. However, since 2011 there has been a downward trend in coal emissions intensity as older, more polluting, coal generators have been retired or upgraded and the median emissions intensity has moved closer to the lower boundary of 740 kg CO2-e/MWh. According to independent WA research body Sustainable Energy Now (SEN) who have provided detailed analysis of this issue in their submission, once methane figures are taken into consideration for gas, (which had to be estimated as Woodside fail to provide quantified methane emissions) the emissions intensity of Browse LNG rises to at least 616 kg/Co2 (SEN p15). This means Browse LNG is 83% as intensive as coal at the very least.

- **Australian gas is not 'reducing emissions overseas'.** Clean State investigated these claims in our 'Runaway Train' report and found no evidence that Australian gas is reducing emissions overseas. According to the IEA report The Role of Gas in Today's Energy Transitions, most of the push for coal-to-gas switching in China is occurring in urban areas to replace coal-fired boilers in residential and industrial settings (which are a major contributor to poor air quality), not power plants.[15] Further, Prof.

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[redacted]

Rob Jackson, Stanford University School of Earth, Energy & Environmental Sciences stated "Globally, most of the new natural gas being used isn't displacing coal, it's providing new energy.".

Australia is now the largest exporter of coal and gas. It is a fact to say Australian LNG is being burnt *in addition to* Australian coal overseas. For every tonne of LNG produced in Australia around 2.8 tonnes of greenhouse gas pollution is emitted when combusted in a second country. Australia exported 70 million tonnes of LNG in 2018, which will emit 197 million tonnes of CO2 when burned. **Even worse, Woodside estimate the Browse Basin gas will emit up to 4.3 tonnes for every tonne combusted overseas. This means the gas produced by the Burrup Hub project will result in in 122.9 million tonnes of additional scope 3 emissions when burnt overseas.** This is a gargantuan amount of additional, preventable emissions.

- **Even if Woodside's claim that 95mt was "averted" globally by coal-to-gas switching in 2018 were true, this figure will be dwarfed by the scope 3 emissions of the Burrup Hub project.** Woodside claim "The IEA has calculated that the coal-to-gas switching helped avert 95 mt of CO2 emissions in 2018" [11, p. 689, 12, p. 118]. But even if this were true, the annual Scope 1, 2 & 3 emissions from the Burrup Hub of 139 mtpa will dwarf the emissions purportedly being averted by coal to gas switching globally!

- **New gas projects will only lock in another 40-60 years of greenhouse gas pollution.** Another common myth is that gas is a 'transition fuel' to a cleaner economy. But how long will this transition take and what is the actual goal? The reality is that exploiting new gas fields and building new gas infrastructure requires massive multibillion-dollar investments and decades of operation to becoming profitable. Gas plants being built or expanded today could still be operating beyond 2050, when we know emissions must be reduced to net zero. Woodside even wants to operate its proposed $50 billion Burrup Hub expansion **until 2070.** As the world implements the Paris agreement the inevitable phase out of gas, combined with the falling cost of renewable alternatives, will make new LNG projects untenable and unprofitable in the long term.[16] This throws into question their financial viability and puts these investments at high risk of becoming stranded assets. By locking in decades of carbon pollution, any new LNG expansion is on a collision course with the Paris Agreement and is at a very real risk of becoming a stranded asset.

5. Woodside has made no credible effort to address carbon pollution and climate change

Woodside's lack of credible efforts to avoid and reduce carbon pollution and climate damage resulting from this and the broader Burrup Hub project are grounds alone for the EPA to reject the project as environmentally unacceptable.

In its proposal, Woodside has:

- Made no credible effort to avoid, reduce or offset the carbon pollution impacts of this project as required under the Environmental Protection Act;

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- Made no attempt to address State, Commonwealth or international carbon pollution reduction goals and policies;
- Made no credible attempt to justify their public claims that the project would result in reductions in global carbon pollution;
- Made no meaningful effort to engage with the latest climate science, carbon budgets or global analysis of climate change trends and impacts;
- Presented no analysis of carbon pollution abatement options and their costs and feasibility;
- Proposed actions that go directly against their own corporate commitments on climate change and carbon pollution, and those of other Joint Venture partners in the proposal.

Furthermore, Woodside have attempted to obscure the overall cumulative impacts of their projects on the global climate by failing to disclose anywhere in the several thousand pages of documents that have been released, what the overall cumulative carbon pollution impact of the Burrup Hub mega project would be.

- **Mitigation efforts for the NWS LNG facility**

Woodside has said it will *"to avoid, reduce or offset 330,000 tpa of CO2e from the KGP by 2030" in* its EIS document for the extension proposal. For the years prior to 2030 it can be assumed that less or no abatement will be delivered by Woodside.

330,000 tonnes per annum is 0.4% of the 7.7Mtpa Woodside are seeking approval to continue emitting at from NWS LNG indefinitely. This is insignificant. When seen in the context of the Burrup Hub total emissions it is a miniscule fraction of total pollution.

- **Offsetting for reservoir emissions**

Woodside has made public commitments that it would offset 'equity' reservoir CO2 for its LNG projects, however these commitments are not included in the EIS documents. Woodside's equity in the Browse field is around 30% so if its equity share of reservoir gas were to be offset this would presumably be 30% of the reservoir gas. However, the lack of commitment to this offsetting in the EIS shows that Woodside are seeking to do this purely as a voluntary undertaking which would not be enforceable and would potentially fail to comply with national and international carbon accounting and reporting regimes that require permanence, additionality, and verifiability standards to be met. The offsetting has not been reflected in net emisions projections supplied by Woodside, suggesting the company does not want to be held accountable for this voluntary offsetting and will be free to decide to cease it at any time or not commence it in the first place. As such this commitment is pure corporate greenwashing.

- **The Safeguard Mechanism**

Woodside have made claims about emissions reductions that will be required pursuant to the Commonwealth Safeguard mechanism. These claims are not credible given the Safeguard mechanism has to date allowed increased in pollution from LNG production, new safeguard limits are speculative as they are yet to be determined for the facility, and as a policy instrument the Safeguard Mechanism has

[redacted]

utterly failed to control industrial emissions to date. It is likely that the Safeguard Mechanism will require no, or negligible abatement. Woodsides claim that meeting the Safeguard Mechanism requirements is a sufficient 'contribution' to meeting the WA State GHG reduction target of net zero emission by 2050 is duplicitous.

In short, the proposal is an audacious approach demonstrating that Woodside's only corporate commitment on climate change is to hide the size and scale of their pollution while maintaining an unsubstantiated pretense that burning more fossil fuels is part of the solution.

6. The proposal is fundamentally inconsistent with the carbon budget that is available to WA under the Paris Agreement.

In a groundbreaking report released on 25 November 2019, Climate Analytics modeled a Carbon Budget for WA that is compatible with the Paris Agreement goals of limiting global warming to 1.5°C. (Attached).

The '1.5°C Compatible Carbon Budget for WA'[17] is a significant and extremely relevant report that includes a detailed 1.5°C compatible carbon budget for all sectors of the Western Australian economy (including LNG) and models GHG emissions pathway consistent with the Paris Agreement in each of those sectors.

It found:

- WA's 1.5 degree compatible carbon budget for the period 2018-2050 is estimated at around 950 MtCO2. If Western Australia maintains its current emissions rate, it would consume this budget within 12 years
- With the right policies and technologies, Western Australia can spread this budget over the next 30 years, so that it achieves zero CO2 emissions by 2050, but the pathway to stay within this budget is critical: CO2 emissions must peak around 2020 and reductions of about 37% by 2030, 81% by 2040 (all compared to 2005) and zero emissions by 2050 are needed.

The Report also found the LNG industry could completely decarbonize by 2050, without using offsets at all. It provides detailed modeling to show this would be possible through:

- Ensuring that reservoir CO2 for all facilities is captured and stored rather than released to the atmosphere;
- Processes in the LNG plant that require energy for refrigeration can mostly be electrified with renewable energy, with the recommendation to phase in renewable energy so that by 2030 50% of gas used in LNG manufacturing is replaced by renewables and 90% by 2035 and 100% by 2050; and
- Binding regulatory requirements on the LNG industry to meet or exceed greenhouse gas intensity benchmarks consistent with emission reductions or conditions.[18]

[redacted]

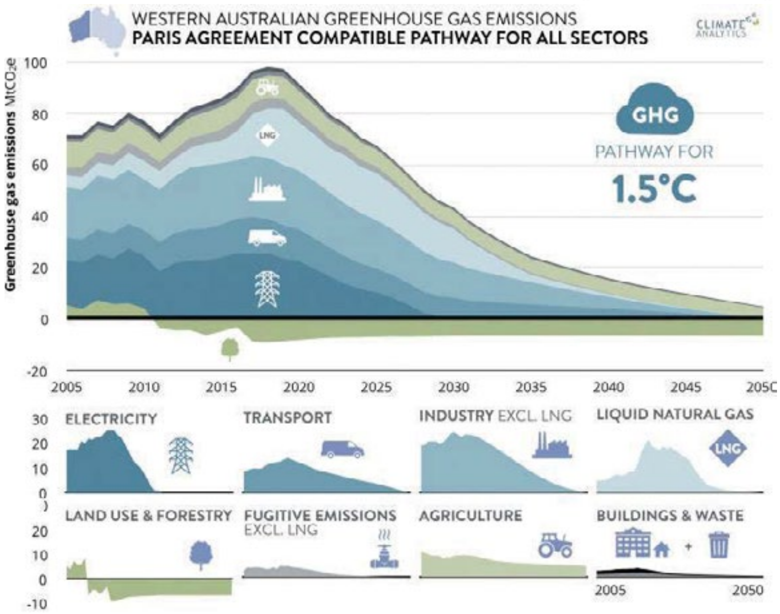

Figure 1: A Paris Agreement Compatible Carbon Budget for WA
Source: Climate Analytics

7. Five new reports make the strongest case yet for the EPA to reject new fossil fuel projects

Clean State also submits the following five reports for urgent consideration as further scientific evidence that the EPA must not make any allowance for projects which significantly increase Western Australia's greenhouse gas pollution.

- The 'Emissions Gap' report by the United Nations Environment Program in November 2019 provided the first-ever estimate of annual cuts needed to stay on track with the Paris Agreement, and **found global emissions must fall by 7.6% each year for the next decade to keep within 1.5°C of warming**.[19] The key headline messages and conclusions of the report also included:

  - GHG emissions continue to rise, despite scientific warnings and political commitments
  - Even if current commitments are met, the world is on course to exceed 3°C in global temperature rise
  - To close the emissions gap by 2030, annual emissions in 2030 need to be 32 gigatons CO2-e lower than current unconditional Nationally Determined Contributions (NDCs) imply for the 1.5°C goal which means **the levels of ambition must increase at least fivefold for the 1.5°C goal;** and

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- Although the number of countries announcing net zero GHG emission targets for 2050 is increasing, only a few countries have so far formally submitted long-term low-emission development strategies to the UNFCCC.

The Report identifies two critical entry points for accelerating emissions reduction: decarbonization of the energy sector through renewables and energy efficiency, which could help reduce emissions by 12.1 Gt (or the equivalent of the annual output of nearly 2.5 million coal power stations) by 2050; and electrification of transport, which could reduce the sector's carbon emissions by up to 72% in 2050.

This finding further strengthens the case against the Burrup Hub project and indeed any new fossil fuel projects, given the importance of decarbonizing the electricity and transport sectors as soon as possible. Allowing new LNG facilities is inconsistent with the decarbonization of these sectors and only locks in another 20-50 years of fossil fuel use in energy and transport systems.

- The November 2019 'Production Gap' report by the Stockholm Environment Institute, *International Institute for Sustainable Development*, Overseas Development Institute, Climate Analytics, Centre for International Climate Research, and United Nations Environment Program found globally, **we are producing 175% more gas than would be consistent with a 1.5C pathway by 2030**[20] (Figure 2).

Global coal, oil, and gas production (exajoule or EJ) under four pathways, 2015-2040. Physical units are displayed as secondary axes: billion tonnes per year for coal, million barrels per day for oil, and billion cubic meters per year for gas. The 2015 global fossil fuel production values derived from model ensembles of 1.5°C and 2°C mitigation pathways differ from historical estimates from IEA and national plans and projections and have not been harmonized.

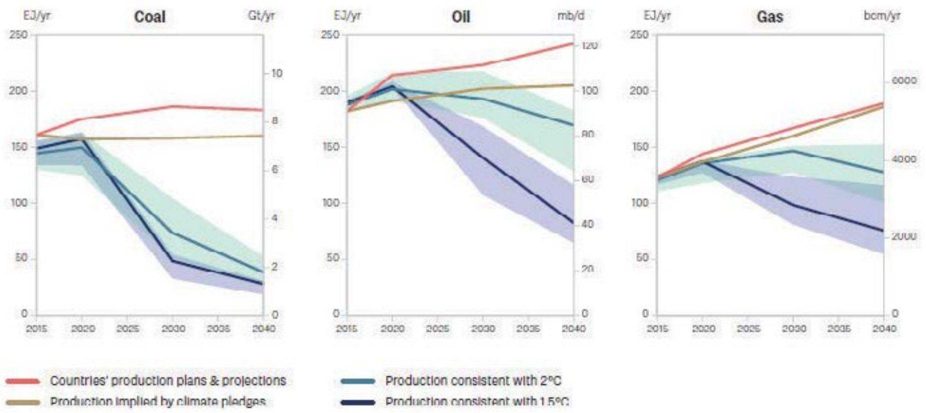

Figure 2: The Production Gap in global coal, oil and gas production 2015-2040
Source: SEI, IISD, ODI, Climate Analytics, CICR, UNEP

Released 20 November 2019, '*The Production Gap*' report provides the first ever estimation of the discrepancy between national plans and projections for fossil fuel production and global production levels consistent with 1.5°C or 2°C pathways.

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It found:

- Countries are producing 400% more coal, 200% more oil, and 175% more gas than would be consistent with a 1.5C pathway by 2030
- For gas, IPCC scenarios show its production declining less rapidly than that of other fuels but it must still decline, whether that downward path starts soon (under a 1.5°C pathway) or around 2030 (under a 2°C pathway). The gaps between planned gas production and 1.5°C and 2°C pathways are substantial and grow much wider starting in 2030. (Fig.2) With average lifetimes of 20 years or longer for pipelines, terminals, wells, and platforms, **the report concludes the time to begin planning for a wind-down of gas production is, as with other fossil fuels, already upon us.**
- **The role of gas as a transition fuel is not supported by recent studies**, including research that has found increasing gas production may instead lead to a net increase in global emissions and a delay in near-zero energy systems due to methane leakage, lower prices and greater availability stimulating higher overall energy use and emissions, and the rapid advance of renewable energy and battery technologies have decreased the need for a potential gas bridge.
- The report concludes**, 'the continued rapid expansion of gas supplies and systems risks locking in a much higher gas trajectory that is consistent with a 1.5°C or 2°C future'**.

Australia is the world's leading exporter of coal and LNG. Government projections show coal production growing another 34% by 2030 relative to 2018 levels and gas production growing 33% by 2030 relative to 2018 levels.

- The December 2019 Global Carbon Project annual report of trends in the global carbon cycle reported **global fossil CO2 emissions are projected to rise by 0.6% in 2019** (range: –0.2% to +1.5%) **due to sustained growth in the consumption of natural gas and oil, and despite a decline in coal use (Fig 3).**[21]

The Global Carbon Budget is produced annually by the Global Carbon Project (GCP), with a global consortium of 58 research institutions from around the world, and is a comprehensive global analysis that provides the latest assessment of the global carbon cycle, including anthropogenic carbon dioxide emissions, and their redistribution among the atmosphere, ocean and terrestrial biosphere. It is

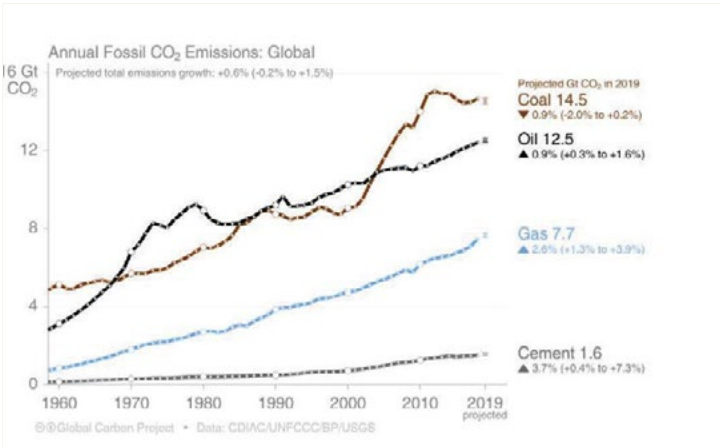

Figure 3: Annual trends in the global carbon cycle
Source: Global Carbon Project

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produced through peer-reviewed scientific papers.

It also found the recent growth in low carbon technologies (solar, wind, electric vehicles) have – at best – only slowed the growth in global fossil fuel emissions, and have not led to aggressive emission reductions necessary in line with the "well below 2°C" global warming limit set out by the Paris Agreement to avoid the worst impacts of climate change. On this point, the CSIRO, part of the global consortium contributing to the annual analysis said

> "There has been uptake of low-carbon technologies around the world including solar and wind power, and electric vehicles, but the demand for energy is outpacing development - so these technologies are generally meeting new demand rather than replacing CO2 emitting technologies, and that's particularly the case in developing countries".[22]

- Climate change was the biggest driver of internal displacement over the last decade and is responsible for forcing 20 million people a year, or **two people every second**, to leave their homes. (Oxfam, 2019)

These findings further strengthen the case against the claim that WA LNG projects are 'displacing' emissions elsewhere, and adds support to the adoption of a science-based no new fossil fuel projects position.

Conclusion

Clean State urges the EPA to reject Woodside's Burrup Hub proposal. Its gargantuan greenhouse gas emissions of 6 billion tonnes over its lifetime are completely inconsistent with urgent action needed to limit global warming to 1.5 degrees, and it poses an unacceptable level of risk to Western Australia's natural environment, cultural heritage, and human health.

Yours sincerely,

[redacted]

[redacted]

Policy Analyst and Spokesperson, Clean State Initiative

<u>Attachments:</u>

- *'Australia's most polluting fossil fuel mega project. Why Woodside's Burrup Hub developments should not proceed'. Clean State. February 2020*
- *1.5°C Compatible Carbon Budget for WA. Climate Analytics. December 2019.*

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[redacted] Clean State

[1] Woodside Petroleum. Proposed Browse to NWS project draft EIS/ERD. 2019 page 689 at: https://files.woodside/docs/default-source/current-consultation-activities/australian-activties/propsed-browse-to-north-west-shelf-project---draft-eis-erd.pdf?sfvrsn=12d274a8_6

[2] IPCC Special Report – Global warming of 1.5 Degrees. 2018 p16-17

[3] Nace, Plant and Browning (2019). The New Gas Boom. Tracking Global LNG Infrastructure. At https://globalenergymonitor.org/wpcontent/uploads/2019/06/NewGasBoomEmbargo.pdf

[4] https://www.carbontracker.org/reports/breaking-the-habit/

[5] https://thinkprogress.org/more-bad-news-for-fracking-ipcc-warns-methane-traps-much-more-heat-than-we-thought-9c2badf392df/

[6] IPCC report at https://www.climaterealityproject.org/blog/natural-gas-not-bridge-fuel-got-many-alternatives

[7] Yale at https://www.yaleclimateconnections.org/2016/08/is-natural-gas-a-bridge-fuel/

[8] Global Energy Monitor (2019) The New Gas Boom.

[9] http://science.sciencemag.org/content/early/2018/06/20/science.aar7204

[10] https://www.vox.com/energy-and-environment/2018/7/13/17551878/natural-gas-markets-renewable-energy

[11] https://www.climatecouncil.org.au/wp-content/uploads/2018/06/CC_MVSA0143-Briefing-Paper-Australias-Rising-Emissions_V8-FA_Low-Res_Single-Pages3.pdf

[12] Methane leakage across the gas supply chain is estimated to be between 1-9% of total gas production[12] - and even higher for gas produced unconventionally (via fracking)[12].

[13] Quarterly Update of Australia's National Greenhouse Gas Inventory for the March Quarter 2019 at http://www.environment.gov.au/climate-change/climate-science-data/greenhouse-gas-measurement/publications/quarterly-update-australias-nggi-mar-2019

[14] Woodside Petroleum. Proposed Browse to NWS project draft EIS/ERD. 2019 page 689 at: https://files.woodside/docs/default-source/current-consultation-activities/australian-activties/propsed-browse-to-north-west-shelf-project---draft-eis-erd.pdf?sfvrsn=12d274a8_6 ; and Intergovernmental Panel on Climate Change (IPCC), Summary for Policymakers Renewable Energy Sources and Climate Change Mitigation, in IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, R. O. Edenhofer, Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G. Hansen, S. Schlömer, C. von Stechow Editor. 2011, Cambridge University Press: Cambridge. Page 19

[15] https://www.iea.org/publications/roleofgas/

[16] https://globalenergymonitor.org/new-gas-boom/

[17] Climate Analytics. 2019. 'A 1.5°C compatible carbon budget for Western Australia' at https://climateanalytics.org/publications/2019/a-15c-compatible-carbon-budget-for-western-australia/

[18] Climate Analytics. 2019. 'A 1.5°C compatible carbon budget for Western Australia' at https://climateanalytics.org/latest/western-australias-paris-agreement-15c-carbon-budget-is-just-12-years-of-present-emissions-report/

[19] https://sdg.iisd.org/news/1-5c-almost-impossible-without-deeper-and-faster-cuts-warns-unep-emissions-gap-report/

[20] https://productiongap.org/2019report/

[21] https://cicero.oslo.no/en/posts/news/natural-gas-and-oil-use-push-up-global-co2-emissions-in-2019-according-to-latest-data

[22] https://www.globalcarbonproject.org/carbonbudget/19/files/Australia_CSIRO_GCB2019.pdf

APPENDIX D SUBMISSIONS

APPENDIX D.19 CONSERVATION COUNCIL OF WA

conservation council of western australia (inc.) abn [redacted]

Conservation Council of Western Australia
ccwa
Look forward

Dr Tom Hatton,
Chair, Environmental Protection Authority
By email: [redacted]

12/2/2020

RE:

Assessment 2191 Browse to NWS Project (State Waters)
Assessment 2191 Browse to NWS Project (Commonwealth Waters)

The Conservation Council of Western Australia is grateful for the opportunity to comment on this proposal. For convenience, we have provided one submission that addresses both State and Commonwealth elements of the proposal, setting out where relevant the different matters as they relate to the respective jurisdictions.

As Western Australia's peak conservation organization, representing over 100 community-based member groups and the broader interests of Western Australians in the protection of the environment, we are deeply alarmed by this proposed development, which is a component of the larger Burrup Hub development proposed by Woodside.

Our analysis indicates that the Burrup Hub, should it go ahead as proposed by Woodside and the other joint venture partners, would be Australia's most polluting fossil fuel project. It would also produce the dirtiest (most carbon intensive) gas in the world from the Browse Basin. These two facts alone make the development unconscionable and unacceptable from an environmental perspective. When the impacts on marine life, cultural and World Heritage values, health and other impacts are taken into consideration, the Burrup Hub project and its respective components must be rejected on environmental grounds. As part of this submission and in support of this conclusion, we attach the report Australia's most polluting fossil fuel mega project: Why Woodside's Burrup Hub developments should not proceed.

The additional preliminary submission provided below sets out additional detailed analysis to support this conclusion in respect of the Browse to NWS element of the Burrup Hub.

Concerns with EIA Process

We have previously raised concerns about the approach towards the assessment of this project and its components, including the lack of assessment of cumulative and combined impacts of the total development on significant marine and terrestrial environmental values, world heritage places, cultural values, health and of course the climate. We reiterate our position here that the assessment process that is being undertaken for the various elements of the Burrup Hub is inadequate and ineffective, and does not and cannot meet the objectives of EIA under the Environmental Protection Act. As such, the provision of this submission should not be taken as an acceptance by CCWA that the assessment process for this project is either valid or acceptable as a complete EIA process under the Act.

Duration and timing of public consultation

In order to provide an opportunity for public participation in environmental decision-making and to maximise the level of scientific scrutiny in State and Commonwealth environmental impact assessments, there is an established procedure for formal periods in which public comments may be provided on the environmental review documentation. These processes are detailed in the EPA's Administrative Procedures and Procedures Manual, and in the EPBC Act. We consider that the current consultation arrangements cannot be considered adequate for assessment of the proposal.

We acknowledge that the public comment period for this proposal is longer than the minimum two weeks (Procedures Manual, p 13) and the EPBC Act minimum of four weeks (Administrative Procedures, p 5609 / EPBC Act, section 103(3)). However, the period applied still does not reflect the level of public interest, environmental significance and complexity in the proposal. Ordinarily these characteristics warrant an extension of the period, being "usually two to twelve weeks" (Procedures Manual, p 13).

For the Learmonth Pipeline Fabrication Facility (Assessment No. 2208), for example, the public comment period in 2019 was eight weeks with no holiday periods involved. The Wheatstone Development – Gas Processing, Export Facilities and Infrastructure (Assessment No. 1754) was open for ten weeks of public comment with no holiday periods. Other proposals open for eight weeks of public comment with no holiday periods involved include the Albany Port Expansion Project (Assessment No. 1594), the Gorgon Gas Development Fourth Train Expansion (Assessment No. 1889) and the Bluewaters Power Station Expansion (Assessment No. 1733). We consider this proposal to be at least as contentious, environmentally significant and complex as these assessments. From this comparison it is clear that at any other time of the year this proposal would warrant at least an eight week public comment period. The public comment period should therefore have been at a minimum a further addition of two weeks (a total of ten weeks) to reflect the characteristics and context of the assessment.

In the exceptional circumstances of a number of other important consultation periods coinciding with this comment period (such as the review of the EP Act, State native vegetation policy, EPA greenhouse gas policy, NOPSEMA oil and gas regulation, and of particular note the related yet additional and separate North West Shelf Project Extension proposal and the dual EPBC Act processes), as well as the Christmas holiday period and the catastrophic fires and fire conditions affecting much of the nation during this period, the most appropriate period for public comment would be twelve weeks as contemplated in the Procedures Manual. Indeed, it is difficult to see how any other proposal or circumstances could warrant the twelve week high end of the scale in the Procedures Manual.

Given the above factors and the complexity of the assessments that are being undertaken, the thousands of pages of technical information that has been released, the failure of the proponent to provide this in a synthesised format to enable the examination of total, cumulative, synergistic and interactive impacts, it has not been possible to undertake a thorough examination of the issues and impacts associated with this proposal.

Supplementary comments

Given the factors outlined above, CCWA takes this opportunity to advise the EPA that further submissions will be provided in the future as supplementary information to support the necessarily preliminary and incomplete material contained in this submission. We have engaged professional experts to provide additional analysis and primary

In addition, we urge the EPA to require the proponent to provide additional information for comment in the form of supplementary submission processes. The purpose of the public consultation period is to enable informed comments to be provided on the impacts of the proposal. We have identified several key pieces of information and data necessary to make such informed comments which are missing from the ERD. In particular, we note that the proponent has not provided:

- Greenhouse Gas Management Plan
- Other Management Plans
- Data to enable assessment of health impacts
- Marine monitoring and other data to enable assessment of impacts on the marine environment
- The conclusion and results of independent studies regarding the impacts of acid gas emissions from LNG processing on Murujuga rock art

We consider that the failure to provide sufficient information as outlined above has undermined the quality of this consultation. Where the EPA or DoEE identifies information and data has not been provided adequately, and accordingly requests further information from the proponent, that information must be subject to further public comment periods. Not to do so will serve to incentivise proponents withholding information from the ERD to evade public scrutiny. Without due provision of information for public scrutiny the integrity, legitimacy and utility of the assessment process is fundamentally compromised, as well as likely increasing the amount of EP Act appeals against a section 44 report produced in such circumstances.

We strongly encourage the EPA to exercise its broad powers under sections 40(2a) and (4) of the EP Act in this regard, including through provision of supplementary comment periods where further information is obtained. For the EPBC Act assessment, the Minister for Environment should consider requiring further scrutiny through an inquiry, under section 90 of the EPBC Act.

Thank you for considering this submission.

CCWA COMBINED SUBMISSIONS

Assessment 2191 Browse to NWS Project (State Waters)
Assessment 2191 Browse to NWS Project (Commonwealth Waters)

Overview

Woodside Energy Ltd (**Proponent**) proposes to develop the Browse hydrocarbon resources using two Floating Production Storage and Offloading (**FPSO**) facilities (**Proposal**). The FPSOs will be supplied by a subsea production system and will export gas to existing North West Shelf (**NWS**) Project infrastructure via a proposed Browse Trunkline (**BTL**) which will tie in near the North Rankin Complex (NRC) in Commonwealth waters. The expected lifetime for operation of the Proposal is up to 50 years.

The assessment of the Proposal under the EPBC Act and EP Act is being undertaken as a coordinated assessment between the Department of Environment and Energy (**DoEE**) and Environmental Protection Authority (**EPA**). The proponent has developed a single draft Environmental Impact Statement (**EIS**)/Environmental Review Document (**ERD**) document (**draft EIS/ERD**) that relates to the assessment of the Proposal under the *Environment Protection and Biodiversity Act 1999* (Cth) (**EPBC Act**) and the *Environmental Protection Act 1986* (WA) (**EP Act**). Accordingly, these submissions address the issues with draft EIS/ERD together.

Under the EPBC Act, the Proposal will have adverse impacts on the following matters of national environmental significance (**MNES**):

- National heritage values of a National Heritage Place
- Listed threatened species and communities
- Listed migratory species
- The Commonwealth marine area, the protected matter being the environment generally

Under the EP Act, the Proposal will have adverse impacts on the following environmental factors:

- Benthic Communities and Habitats
- Marine Environmental Quality
- Marine Fauna
- Air Quality

In our view, these impacts are not acceptable and mean that the Proposal should not be approved by the DoEE or EPA...

Key Issues with Proposal

CCWA will cover in detail the following five adverse impacts of the Proposal including;

1. Greenhouse Gas Emissions and Climate Change
2. Murujuga Rock Art
3. Environmental Values of Scott Reef
4. Marine Fauna
5. Human Health

1. GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE

IMPACTS

WA is the only Australian jurisdiction to have experienced a substantial increase (27%) in greenhouse gas emissions (**GHGe**) between 2000 and 2016, and has the second highest per capita emissions of all Australian states and territories, with emissions per capita well above those of other developed economies, including resource-based economies such as Canada.[1] Climate Analytics reports that the increase in WA's GHGe is largely due to the expansion of LNG production and export, drawing on conventional gas resources.[2]

In the draft EIS/ERD, the Proponent estimates that the average total (scope 1 and 3) GHGe of the Proposal will be 36.8 MtCO2-e per annum (**mtpa**). The Proposal will therefore result in substantial additional emissions that will increase WA, Australian and global GHGe and which would not have occurred without the processing of Browse gas.

The total emissions resulting from the processing of the Browse Basin-derived gas at the NWS LNG facility (including processing emissions and direct emissions from the offshore Browse Basin field due to CO2 venting and energy use) are summarised below:

Project	Annual pollution (scope 1 only) Mtpa CO2e-	Annual pollution (including scope 3) Mtpa CO2e-	Total pollution (over 50 year project life) Mt CO2e-
Browse Basin gas (processed through North West Shelf LNG)	6.8	44.8	1,602 (1.6 gigatons)

The draft EIS/ERD states that scope 1/upstream emissions will primarily occur from reservoir gas venting, fuel combustion and intermittent flaring. It also acknowledges that scope 3/third party consumption emissions form the largest part of the overall emissions related to the Proposal but that it "is expected that the majority of these GHG emissions will occur internationally and be managed and mitigated through local and international emissions control frameworks".[3]

[1] Environmental Protection Authority, *Mitigating Greenhouse Gas Emissions*, (Withdrawn Technical Guidance, March 2019) 3.
[2] Climate Analytics, *Wester Australia's Gas Gamble - Implications of natural gas extraction in WA* (March 2018).
[3] Draft EIS/ERD, p 688.

The Proponent estimates that, taking into account planned mitigation and offsetting measures, the Proposal's GHGe could contribute in the range of 0.09-0.15% of global GHG emissions in 1.5°C and 2°C NDC pathways respectively.

The causal link between cumulative GHGe from proposals such as the current Proposal and climate change and its impacts was recently confirmed by the NSW Land and Environment Court in *Gloucester Resources Limited v Minister for Planning* [2019] NSWLEC 7 (***Gloucester***) which stated:

> *"There is a causal link between the [mine's] cumulative GHG emissions and climate change and its consequences. The [mine's] cumulative GHG emissions will contribute to the global total of GHG concentrations in the atmosphere. The global total of GHG concentrations will affect the climate system and cause climate change impacts. The [mine's] cumulative GHG emissions are therefore likely to contribute to the future changes to the climate system and the impacts of climate change."*[4]

WA is particularly vulnerable to the impacts of climate change, with climate impacts already being experienced globally and in WA. Dr Belinda Robson, Associate Professor in Environmental and Conservation Sciences at Murdoch University, has noted that southwestern Australia has been experiencing severe impacts of climate change for several decades, mostly expressed in declining rainfall, but also affecting surface and groundwater levels.[5] Dr Robson states that these are not 'predicted' changes, but actual, large, documented impacts. If concentrations of GHGe in the atmosphere continue to increase, Dr Robson predicts that the rate of climatic drying and warming in the Southwest will also increase, accelerating rates of ecosystem degradation, and may cause extinctions of freshwater species as they are already seriously imperilled by existing climate change.[6] It is likely also to see the loss of whole freshwater ecosystems to permanent drying, affecting human health, recreation and our outdoor way of life.[7] Dr Robson warns that if action is not taken now, it will soon be too late to prevent catastrophic losses of both species and ecosystems across the southwest.[8]

The recently released Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in WA Final Report also recognises the current and predicted environmental and health impacts of climate change in WA, stating:

> *"…since 1950 most of Western Australia has experienced an average rise of 0.10˚C to 0.20˚C in temperature per decade, with increased rainfall in much of the State but with significantly decreased rainfall in the State's South-West, where it has fallen by up to 50 mm per decade… Projections of climate, and their potential impacts into the future, depict serious consequences for Western Australia and its people (CSIRO and Bureau of Meteorology 2016). The projected impacts of climate change extend to human health (Australian Academy of*

[4] *Gloucester Resources Limited v Minister for Planning* [2019] NSWLEC 7 [525].

[5] CSIRO, *Water Yields and Demands in south-west Western Australia* (December 2009).

[6] Chambers et al. 'Report Card of Climate change and Western Australian Aquatic Ecosystems; Impacts and adaptation responses' (2011) *National Climate Change Adaptation Research Facility*.

[7] Ibid.

[8] Ibid.

Science 2015; Mora et al. 2017) and even to 'existential risk', that is a permanent, large and negative consequence to humanity."[9]

Dr [redacted] Senior Lecturer in Atmospheric Science at Murdoch University and a Lead Author for Chapter 1 of the IPCC Special Report on Global Warming of 1.5°C, also reports that rapid reductions in GHGe are required now to avoid climate change impacts in WA.

"The southwest of Western Australia is the "canary in the coal mine" for anthropogenic climate change. With its hot and dry summers and cool and wet winters, future climate change means even hotter summers and dryer winters. Reductions in greenhouse gas emissions need to happen now, across all sectors, and any increase in emissions is not consistent with the best available science on climate change and its impacts."[10]

The draft EIS/ERD acknowledges that the Proposal's contributes to global GHGe, and that global GHGe could have potential adverse climate change impacts on sensitive receptors within Australian jurisdictions such as species, ecosystems, and social, economic and cultural impacts.

Despite the above, the Proponent concludes that "overall, in the context of Australia's international commitments and National and State legislation and policy, it is considered that given the proposed mitigation of emissions, the offsetting measures proposed and the importance of gas as a clean and reliable source of energy in the current and future energy mix, GHG emissions from the proposed Browse to NWS Project are acceptable".[11] As addressed in detail below, the mitigation and offsetting measures proposed by the Proponent are grossly inadequate. Further, market substitution claims that the Proponent relies on to justify the Proposal's substantial GHGe are not substantiated or backed by credible evidence. Accordingly, the impacts of the Proposal's GHGe on sensitive receptors cannot be considered acceptable.

NO CONSIDERATION OF IMPACTS OF CUMULATIVE EMISSIONS FROM BURRUP HUB PROJECT

The draft EIS/ERD does not refer to or consider the cumulative impact of emissions from the broader "Burrup Hub" project. In particular, it does not consider the impacts of the Proposal's GHGe in the context of emissions from related proposals including the NWSP Extension Proposal, Scarborough offshore or onshore proposals and the Pluto LNG Development, stating:

… greenhouse gas emissions associated with the developments listed above (NWSP Extension, Scarborough and Pluto LNG Development) is not addressed further in this draft draft EIS/ERD, as they are assessed in their respective assessment documents.[12]

We emphasise that the emissions from proposals forming the "Burrup Hub" project cannot simply be considered in isolation, but that assessments must instead consider the cumulative emissions and other impacts of the proposals. This is supported by the findings of the Court in *Gloucester* (see

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[9] *Independent Scientific Panel Inquiry into Hydraulic Fracture Stimulation in WA* (Final Report, September 2018) 365.

[10] K. Ruthrof, D. Breshears, J. Fontaine, R. Froend, G. Matusick, **J. Kala**, B. Miller, P. Mitchell, S. Wilson, M. van Keulen, N. Enright, D. Law, T. Wernberg, and G. E. St. J. Hardy (2018) Subcontinental heat wave triggers terrestrial and marine, multi-taxa responses, ***Scientific Reports***, 8, 13094, doi.org/10.1038/s41598-018-31236-5. See also Cowan, T., Purich, A., Perkins, S., Pezza, A., Boschat, G., Sadler, K., (2014). More frequent, longer, and hotter heat waves for Australia in the twenty-first century. J. Clim. 27 (15), 5851-5871. https://journals.ametsoc.org/doi/full/10.1175/JCLI-D-14-00092.1

[11] Draft EIS/ERD, p 698.

[12] Ibid 696.

quote above). The Court also emphasised the importance of considering the cumulative impacts of emissions from projects in EIA in *Gray v Minister for Planning* [2006] 152 LGERA 258, stating*:*

> *"one important consideration [in environmental impact assessment] must be the assessment of cumulative impacts of proposed activities on the environment".*[13]

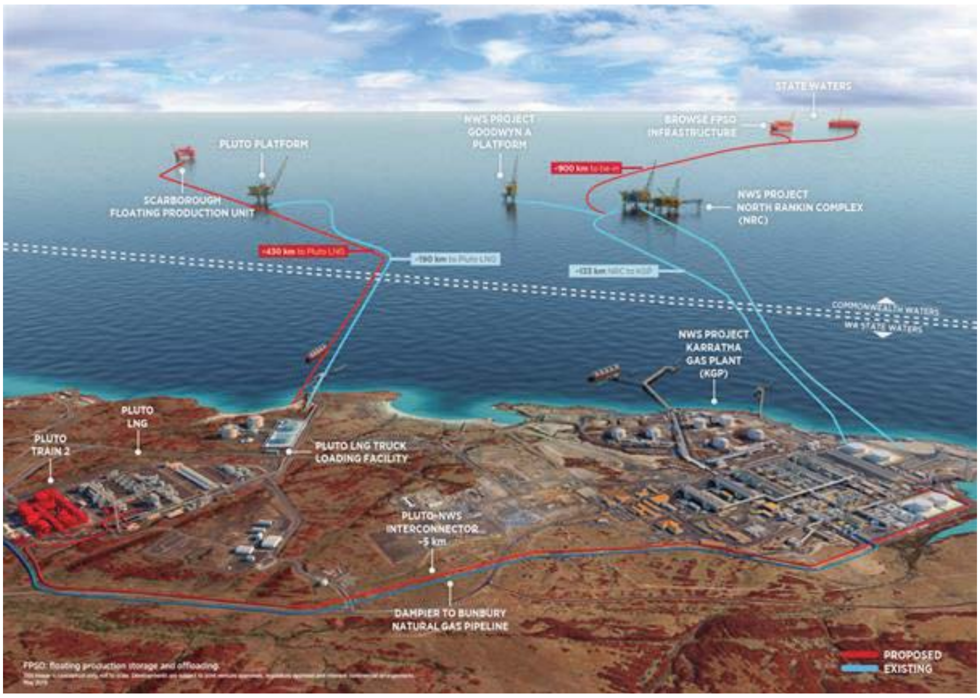
The "Burrup Hub" project seeks to expand LNG processing at existing facilities through the processing of Browse and Scarborough gas and will result in substantial additional GHGe. Woodside recognises the interconnected nature of these proposals on its website, stating:

> *"To realise the Burrup Hub vision a number of activities are being advanced simultaneously: Scarborough; Pluto Train 2; Browse to NWS Project; NWS Project Extension and Pluto-NWS Interconnector...*
>
> *The Burrup Hub involves the proposed development of some 20 to 25 trillion cubic feet (Tcf) of gross (100%) dry gas resources from Scarborough, Browse and Pluto, relying on our proven liquefied natural gas (LNG) facilities – Pluto LNG and the North West Shelf Project*.
>
> *We propose to link these facilities to create the Burrup Hub which could also provide the infrastructure to accelerate other offshore Pluto gas reserves and also enable future development of third-party resources."*[14]

We also refer to the following diagrammatic representation of the "Burrup Hub" project, available on Woodside's website, which reflects the interconnected nature of the purportedly separate proposals:

[13] *Gray v Minister for Planning* [2006] NSWLEC 720, [122].

[14] https://files.woodside/docs/default-source/our-business---documents-and-files/burrup-hub---documents-and-files/burrup-hub-fact-sheet.pdf?sfvrsn=a45e92ce_20.



In our view, considering the emissions of each proposal in isolation is inappropriate and prevents the proper consideration of the total overall, aggregated and cumulative impacts of the "Burrup Hub" project. However, in recognition that the decision has been made to assess the proposals separately, we submit that the cumulative environmental impacts that can be identified in relation to the Proposal should be addressed in the final EIS/ESD and assessed by the EPA and DoEE.

Overview

No credible effort to address carbon pollution and climate change

Woodside's lack of credible efforts to avoid and reduce carbon pollution and climate damage resulting from this and the broader Burrup Hub project are grounds alone for the EPA to reject the project as environmentally unacceptable.

In its proposal, Woodside has:

- Made no credible effort to avoid, reduce or offset the carbon pollution impacts of this project as required under the Environmental Protection Act;
- Made no attempt to address State, Commonwealth or international carbon pollution reduction goals and policies;
- Made no credible attempt to justify their public claims that the project would result in reductions in global carbon pollution;

- Made no meaningful effort to engage with the latest climate science, carbon budgets or global analysis of climate change trends and impacts;
- Presented no analysis of carbon pollution abatement options and their costs and feasibility;
- Failed to consider the overall cumulative climate change and carbon pollution impacts of the whole project and all of its components;
- Proposed actions that go directly against their own corporate commitments on climate change and carbon pollution, and those of other Joint Venture partners in the proposal.

Furthermore, Woodside have attempted to obscure the overall cumulative impacts of their projects on the global climate by failing to disclose anywhere in the several thousand pages of documents that have been released, what the overall cumulative carbon pollution impact of the Burrup Hub mega project would be.

In short, the proposal presents a deeply arrogant approach demonstrating that Woodside's only corporate commitment on climate change is to hide the size and scale of their pollution while maintaining an unsubstantiated pretense that burning more fossil fuels is part of the solution. The proposal shows that Woodside's public statements on climate change are pure greenwash.

Woodside's proposed carbon pollution abatement efforts are insulting and hardly worth commenting on, such is their negligible impact on emissions reduction. They are summarised below.

Mitigation efforts for the NWS LNG facility

Woodside has said it will "to avoid, reduce or offset 330,000 tpa of CO2e from the KGP by 2030." In its EIS document for the extension proposal. For the years prior to 2030 it can be assumed that less or no abatement will be delivered by Woodside.

330,000 tonnes per annum is 0.4% of the 7.7Mtpa Woodside are seeking approval to continue emitting at from NWS LNG indefinitely. This is insignificant. When seen in the context of the Burrup Hub total emissions it is a miniscule fraction of total pollution.

Offsetting for reservoir emissions

Woodside has made public commitments that it would offset 'equity' reservoir CO2 for its LNG projects, however these commitments are not included in the EIS documents. Woodside's equity in the Browse field is around 30% so if its equity share of reservoir gas were to be offset this would presumably be 30% of the reservoir gas. However, the lack of commitment to this offsetting in the EIS shows that Woodside are seeking to do this purely as a voluntary undertaking which would not be enforceable and would potentially fail to comply with national and international carbon accounting and reporting regimes that require permanence, additionality, and verifiability standards to be met. The offsetting has not been reflected in net emisions projections supplied by Woodside, suggesting the company does not want to be held accountable for this voluntary offsetting and will be free to decide to cease it at any time or not commence it in the first place. As such this commitment is pure corporate greenwashing.

Safeguard Mechanism

Woodside have made claims about emissions reductions that will be required pursuant to the Commonwealth Safeguard mechanism. These claims are not credible given the Safeguard mechanism has to date allowed increased in pollution from LNG production, new safeguard limits are speculative as they are yet to be determined for the facility, and as a policy instrument the Safeguard Mechanism has utterly failed to control industrial emissions to date. It is likely that the Safeguard Mechanism will require no, or negligible abatement. Woodsides claim that meeting the Safeguard Mechanism requirements is a sufficient 'contribution' to meeting the WA State GHG reduction target of net zero emission by 2050 is duplicitous.

ACCEPTABILITY UNDER ENVIRONMENTAL PROTECTION ACT 1986 (WA)

MANAGEMENT AND MITIGATION OF GHGE

Emissions Reduction Measures

While the draft EIS/ERD acknowledges that the Proposal will result in substantial GHGe and contribute to 0.09-0.15% of global GHG emissions in 1.5°C and 2°C NDC pathways respectively, it refers to the proposed emissions reduction measures and offsetting measures, and "the importance of gas as a clean and reliable source of energy in the current and future energy mix" to argue that the environmental impact of the Proposal's GHGe is acceptable. In our view, this argument is completely false and unfounded.

The Proponent refers to the following energy efficiency and emissions reductions measures that have been incorporated into the design of the Proposal:

- waste heat recovery units on gas turbines [estimated emissions reduction - 0.70 MT CO2-e/annum]
- active heating system used to prevent hydrate formation in flowlines avoiding the requirement for an energy intensive MEG regeneration plant [estimated emissions reduction - 0.20 MT CO2-e/annum]
- batteries for peak power supply [estimated emissions reduction - 0.10 MT CO2-e/annum] + efficient aero-derivative gas turbines [estimated emissions reduction - 0.02 MT CO2-e/annum]
- use of nitrogen to purge the flare stack rather than hydrocarbon gas [estimated emissions reduction - expected less than <0.1 MT CO2e/annum]

The draft EIS/ERD also states that the Proposal has proposed a GHG Abatement Plan (GGAP) to "continuously review mechanisms to mitigate and manage GHG emissions and compliance with SGM baseline requirements through Australian carbon credit units to offset anticipated excess emissions over baseline".[15]

The Proponent states that these measures will reduce scope 1 emissions from up to 5.8 mtpa to 4.8 mtpa and will save 31 Mt over the life of the Proposal.[16] The Proponent estimates the total emissions reduction from the above measures will be approximately 1 mtpa on average per year.

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[15] Draft EIS/ERD, p 24.

[16] Ibid 696.

These proposed mitigation measures are therefore grossly inadequate and not acceptable to manage or mitigate the impacts of the Proposal's GHGe.

The proponent has not published its proposed GGAP and as such it is impossible to evaluate it. **This plan must be released for public consultation prior to the conclusion of the project assessment.**

We emphasise that for the Proposal's GHGe to be considered consistent with the EPA's environmental objective and acceptable under the EP Act, it must achieve a net reduction in GHGe. As this measures will result in the Proposal increasing WA's GHGe, they cannot be considered acceptable.

Offsetting Measures

The Proponent acknowledges that the GHGe from the Proposal will likely exceed the facility baseline under the Safeguard Mechanism by 50 Mt CO2 –e, meaning that will be legally obliged to offset these emissions in accordance with the rules of the SGM through the surrender of Australian carbon credits units (**ACCUs**).[17] We emphasise that the Emissions Reduction Fund and its Safeguard Mechanism has been criticised as unlikely to reduce Australia's emissions beyond business-as-usual.[18] The EPA noted the lack of formal linkage between the Safeguard Mechanism and Australia's NDC in its Technical Guidance document for Mitigating Greenhouse Gas Emissions withdrawn in March 2019. It also provides no certainty that those offsets will actually be required or delivered at all. Further, proponents can apply to have their baselines under the Safeguard Mechanism varied if production increases. Accordingly, obligations under the Safeguard Mechanism cannot be taken seriously and the fact that the Proposal's GHGe will exceed the facility's baseline demonstrates its blatant inappropriateness.

While the draft EIS/ERD refers to offsetting opportunities (industry methods, land-based solutions including savannah burning, environmental planning, native tree planting and human induced land restoration) and geosequestration, the Proponent does not commit to offsetting any emissions that are not reduced by the mitigation measures addressed above or legally required to be offset under the Safeguard Mechanism. This means that the Proponent seek to not mitigate or offset the majority of its annual total scope 1 emissions. It is therefore clear that the Proponent is doing the bare minimum to address its substantial GHGe.

In our view, the management and mitigation of the Proposal's GHGe proposed by the Proponent is grossly inadequate and not acceptable. To the extent that the Proposal increases domestic and global GHGe, the Proponent should be required to outline and implement measures that mitigate and offset all residual emissions and ensure that the Proposal achieves a net reduction in emissions. Given the availability of land-based offsets is limited (given the limited amount of land), this could be achieved through alternative measures such as geosequestration of CO2. While the Proponent addresses the potential for geosequestration of Browse reservoir CO2, it states that it is a "high risk, high cost mitigation option"[19] and therefore makes no commitment to implement geosequestration.

We emphasise that the cost or convenience of offsetting measures is not a valid consideration for the EPA. If the Proponent cannot effectively reduce or offset all the Proposal's residual emissions to

[17] Ibid 24.

[18] Carbon Market Institute, *Exposure Draft Amendments: Safeguard Mechanism Rule Consultation* (online, September 2018) 3.

[19] Draft EIS/ERD, p 698.

achieve a net reduction outcome, the Proposal cannot be considered environmentally acceptable or consistent with the EPA's GHG Guideline.

ACCEPTABILITY ASSESSMENT

We emphasise that the new environmental objective proposed in the EPA's draft *Environmental Factor Guideline: Greenhouse Gas Emissions* (currently still subject to consultation) is "to reduce net greenhouse gas emissions in order to minimise the risk of environmental harm associated with climate change". While this guideline is not binding on the EPA, in our view it should apply the new objective when assessing the acceptability of the impacts from the Proposal's GHGe.

The Proponent argues that no *direct* impacts to benthic communities and habitats, marine environmental quality or marine fauna are predicted to occur as a result of Proposal's GHGe in order to conclude that the impacts are acceptable. It further states that climate change induced impacts to benthic communities and habitats, marine environmental quality or marine fauna resulting from the Proposal are "difficult to predict and likely immeasurable"[20] and that global GHG emissions will continue to have an effect on trends in receptor condition and potential significant impacts may occur as a result. While the Proponent acknowledges that the Proposal will contribute up to 0.15% of global GHGe, it concludes that it is not credible that, as a stand-alone project, GHGe from the Proposal will significantly impact benthic communities and habitats, marine environmental quality or marine fauna, and as such, the relevant EPA objectives for the environmental factors will be met.

We strongly oppose the Proponent's reliance on the lack of a direct link between GHGe from the Proposal and impacts on the environment and the difficulties associated with predicting and measuring these impacts to argue that the Proposal is acceptable. The EP Act defines "significant proposal" as meaning a proposal likely, if implemented, to have a significant effect on the environment. There is no requirement for such impacts to be direct, with the full Federal Court stating in *Minister for Environment and Heritage v Queensland Conservation Council* [2004] FCAFC 190 that assessments of the impacts of proposals should include "each consequence which can reasonably be imputed as within the contemplation of the proponent of the action, whether the consequences are within the control of the proponent or not".[21]

As addressed above, the NWS Land and Environment Court confirmed in the recent case of *Gloucester* that cumulative GHGe from proposals will contribute to global GHGe and the adverse impacts associated with climate change. Scientific evidence also confirms that emissions need to be reduced to limit global warming to 1.5℃ and reduce adverse impacts associated with climate change. Accordingly, the Proposal, which will substantially increase domestic and global GHGe and therefore the risk of climate change induced impacts, cannot be considered consistent with the EPA's environmental objective of reducing GHGe and minimising the risk of environmental harm associated with climate change, or acceptable under the EP Act.

Further, we note that applying a carbon budgets approach, no increase in GHGe can be considered acceptable. Internationally agreed science has established that the carrying capacity of the global atmosphere to ensure a 'safe' and sustainable climate (compatible with 1.5℃ warming) has already been exceeded. The Court in *Gloucester* explained the carbon budget approach with reference to

[20] Draft EIS/ERD, p 700.

[21] *Minister for Environment and Heritage v Queensland Conservation Council* [2004] FCAFC 190 [57].

evidence from Professor Will Steffen, Emeritus Professor at the Fenner School of Environment and Society, as follows:

> *A commonly used approach to determine whether the NDCs of the parties to the Paris Agreement cumulatively will be sufficient to meet the long term temperature goal of keeping the global temperature rise to between 1.5ºC and 2ºC is the carbon budget approach… The carbon budget approach "is a conceptually simple, yet scientifically robust, approach to estimating the level of greenhouse gas emission reductions required to meet a desired temperature target", such as the Paris Agreement targets of 1.5ºC or 2ºC (Steffen report [38])…Once the carbon budget has been spent (emitted), emissions need to become "net zero" to avoid exceeding the temperature target. "Net zero" emissions means the magnitude of CO2 emissions to the atmosphere is matched by the magnitude of CO2 removal from the atmosphere (Steffen report, [40]).* [441]

In relation to new fossil fuel developments, the Court noted Professor Steffen's evidence:

> *Professor Steffen considered that the phasing out of fossil fuel combustion necessitates not exploiting and burning most of the world's existing fossil fuel reserves: "Most of the world's existing fossil fuel reserves – coal, oil and gas – must be left in the ground, unburned, if the Paris accord climate targets are to be met. I say that because the exploitation, and burning, of fossil fuel reserves leads to an increase in CO2 emissions when meeting the Paris accord climate targets requires a rapid and deep decrease in CO2 emissions." (Steffen report, [50]). [446]*
>
> *Professor Steffen considered that if most of the world's existing fossil fuel reserves need to be left in the ground unburned, no new fossil fuel developments should be allowed: "An obvious conclusion that follows from this fact is that: No **new** fossil fuel development is consistent with meeting the Paris accord climate targets. That is, paragraphs 47-50 above demonstrate clearly that to meet the Paris accord, emissions must be reduced rapidly and deeply (cf Figure 3 below), and to do this requires the rapid phase-out of **existing** fossil fuel mines/wells. It is an obvious conclusion that no new fossil fuel developments can therefore be allowed." (Steffen report, [51]).* [447]

Given the above and the inadequacy of the proposed mitigation and offsetting measures, it is clear that the Proposal will increase, rather than reduce, GHGe and climate change impacts and therefore cannot be considered environmentally acceptable by the EPA under the EP Act. Accordingly, the EPA must recommend against implementation of the Proposal.

<u>NO SUBSTANTIATION OF MARKET SUBSTITUTION CLAIM</u>

The Proponent relies on the market substitution argument (I.E. that LNG is replacing coal and reducing global emissions) to argue that the Proposal has the potential to contribute significantly to the reduction in global GHGe by displacing higher carbon intensive power generation (e.g. coal-gas energy switch) and may potentially have a positive impact via the reduction of emissions. Accordingly, it concludes that impacts from GHGe are low and acceptable. In particular, it argues that emissions "are anticipated to be less than if equivalent energy were to be generated from coal" and states:

> *"Based on the comparison between electricity generated from Browse LNG and the electricity generated from coal, 121 kgCO2e/kWh is emitted in Australia (22% of 550) and 450 kgCO2e/kWh is saved in the global energy system. In this case, every tonne of GHG emitted in Australia could displace 3.7 tonnes of GHG elsewhere in the global energy system."*[22]

The Proponent acknowledges that the positive impacts via reduction of global emissions is "uncertain in a global context"[23] and does not provide sufficient justification or quantification of the claimed emissions reduction caused by displacing coal in LNG importing countries. We note that there has been a general global shift away from coal towards cleaner energy/fuel sources such as renewables and that recent analysis by the Global Carbon Project reveals that LNG is the primary driver of global GHGe since 2012 and that oil and gas use in China contribute more to emissions growth than coal.[24] Glen Peters, Research Director at CICERO further states in the report:

> *"While there may be some short-term emissions reductions from using natural gas instead of coal, natural gas consumption needs to be phased out quickly to meet ambitious climate goals"*.[25]

Accordingly, if this argument is to be accepted by the EPA, the Proponent must demonstrate the actual reductions they claim in the form of verified carbon credits or other verified accounting mechanism.

ACCEPTABILITY UNDER ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (CTH)

MANAGEMENT AND MITIGATION

As addressed above, the emissions reduction and offset measures proposed by the Proponent in the draft EIS/ERD are grossly inadequate to manage or mitigate the impacts from the Proposal's GHGe on MNES including listed threatened migratory species, threatened ecological communities, the Commonwealth Marine Area or the environment.

ACCEPTABILITY ASSESSMENT

The Proponent argues that no *direct* impact on MNES' including listed threatened migratory species, threatened ecological communities, the Commonwealth Marine Area or the environment are predicted to occur as a result of the Proposal's GHGe. It also states that climate change induced impacts are "difficult to predict and likely immeasurable"[26] and that global GHG emissions will continue to have an effect on trends in receptor condition and potential significant impacts may occur as a result. While the Proponent acknowledges that the Proposal will contribute up to 0.15% of global GHGe, it concludes that it is not credible that, as a stand-alone project, GHGe from the Proposal will not have significantly impact listed threatened species or migratory species, threatened ecological communities, the Commonwealth Marine Area or the environment. To this end, it refers to GHG Abatement Plan and compliance with NGER/SGM baseline requirements to offset excess

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[22] Draft EIS/ERD, p 689.

[23] Ibid 700.

[24] Global Carbon Project, "Natural gas and oil push up global CO2 emissions in 2019" (press release, 4 December 2019) 2 <https://www.globalcarbonproject.org/carbonbudget/19/files/Norway_CICERO_GCB2019.pdf>.

[25] Ibid 3.

[26] Draft EIS/ERD, p 699.

emissions over the baseline to conclude that the impacts of the Proposal's GHGe are acceptable under the EPBC Act.

We strongly oppose the Proponent's reliance on the lack of direct link between GHGe from Proposal and impacts on environment and the difficulties associated with predicting and measuring these impacts to argue that the impacts from the Proposal's GHGe on MNES are acceptable. The EPBC Act refers to significant impacts on MNES. Section 527E provides that an event or circumstance is an impact of an action if it is a direct or indirect consequence of the action (provided the action is a substantial cause of the event or circumstance). Accordingly, there is no requirement for impacts to be directly caused by the Proposal's GHGe, the emissions just need to be a substantial cause of the impacts. Relevantly, the EPBC Policy Statement on Indirect Impacts confirms that relevant indirect consequences or impacts can include 'downstream impacts'.[27]

Further, we reiterate the comments above about the findings of the full Federal Court in relation to the consideration of indirect impacts of proposals in *Minister for Environment and Heritage v Queensland Conservation Council* [2004] FCAFC 190. As addressed above, the Court in *Gloucester* confirmed that cumulative GHGe from proposals contribute to global GHGe and climate change induced impacts. The fact that the relevant impacts are difficult to predict does not mean that there is not a "real chance or possibility" that the substantial additional GHGe from the Proposal will have significant impacts on the relevant MNES.

As addressed above, the mitigation and offsetting measures and GHG Abatement Plan proposed by the Proponent in the draft EIS/ERD are grossly inadequate. In particular, they only reduce a small amount of the Proposal's GHGe and offset emissions the Proponent is legally obliged to offset under the Safeguard Mechanism as a result of exceeding its baseline. This means they will not effectively manage or mitigate the significant impacts of the Proposal's GHGe on listed threatened migratory species, threatened ecological communities, the Commonwealth Marine Area or the environment in accordance with the MNES Significant Impact Guidelines, meaning the Proposal cannot be considered acceptable under the EPBC Act. Accordingly, DoEE must recommend against implementation of the Proposal.

NO SUBSTANTIATION OR EVIDENCE OF MARKET SUBSTITUTION CLAIM

The Proponent relies on the market substitution argument (LNG is replacing coal and reducing global emissions) to argue that the Proposal may potentially have a positive impact via the reduction of emissions. As addressed above, the Proponent does not provide sufficient justification or quantification of the claimed emissions reduction caused by displacing coal in LNG importing countries. If this claim is to be accepted by DoEE, the Proponent must demonstrate the actual reductions they claim in the form of verified carbon credits or other verified accounting mechanism.

Given it is clear that the Proposal will increase, rather than decrease, domestic and global GHGe and the climate science which reinforces that urgent and rapid reductions in emissions are required to avoid adverse climate change impacts, we emphasise that the Proposal cannot be considered environmentally acceptable by the DoEE under the EPBC Act. Accordingly, the DoEE should recommend against approval of the Proposal.

[27] https://www.environment.gov.au/system/files/resources/f96c4a92-ffb1-4b77-befe-e2fd9130b0d8/files/epbc-act-policy-indirect-consequences.pdf

ACCEPTABILITY UNDER ENVIRONMENTAL PRINCIPLES

Environmental principles are contained in section 4A of the EP Act and section 3A of the EPBC Act. The principles that are included in both the EP Act and EPBC Act include the precautionary principle, the principle of intergenerational equity, the conservation of biological diversity and ecological integrity and improved valuation, pricing and incentive mechanisms.

The Proponent argues that the Proposal is consistent with the environmental principles on the basis that gas will provide clean and reliable energy that is "paramount to the lifting of worldwide living standards", "expected to play a key role in the future energy mix (as a partner to intermittent renewables)" and "has the potential to contribute significantly to the reduction in global GHG emissions by displacing higher carbon intensive power generation (e.g. coal burning)".[28[1]] It concludes that given the importance of gas in the current and future energy mix, the planned emission mitigation and offsetting to reduce GHGe (which, as demonstrated below, are grossly inadequate) and the broader socio-economic benefits of the Proposal to Australia and WA, the environmental principles have been met.

We strongly disagree with this conclusion. In our view, the impacts of the Proposal's substantial GHGe are not consistent with, or acceptable under, the environmental principles of either the EP Act or the EPBC Act for the following reasons:

1. Precautionary principle – the Proposal is clearly inconsistent with this principle as it will increase GHGe and contribute to climate change impacts, which will result in serious and irreversible environmental damage. Accordingly, lack of full scientific certainty as to the extent of the impacts and the Proposal's quantitative contribution to those impacts should not be used as a reason for EPA, DoEE and the relevant Ministers to postpone measures to prevent environmental degradation by ensuring the Proposal is not allowed to proceed. To uphold this principle, the Proposal should only be allowed to proceed if the Proponent is able to demonstrate with scientific certainty (also being independently verifiable) that the Proposal will not cause serious and irreversible environmental damage. This has not been done.
2. Principle of intergenerational equity - the Proposal is clearly inconsistent with this principle as it will increase GHGe and contribute to long-term climate change impacts for future generations. For the Proposal as currently proposed, the burden of these impacts and the increasingly severe measures required to avert or mitigate them as time progresses will disproportionately be borne by future generations. Indeed, the Proposal "locks in" significant greenhouse gas emissions and other impacts without recourse for those activities to be stopped by future generations. Accordingly, EPA, DoEE and the relevant Ministers are required to ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations by ensuring the Proposal is not allowed to proceed.
3. Principle of biological diversity and ecological integrity - the Proposal is clearly inconsistent with this principle as it will increase GHGe and contribute to the detrimental impacts of climate change impacts on biological diversity and ecological integrity. Climate change has a broad range of potential impacts which will affect biological diversity and ecological integrity through, for example, habitat loss, extreme weather events and sea level rise. As the principle dictates that biological diversity and ecological integrity should be a *fundamental* consideration, the

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28[1] Draft EIS/ERD, p 699.

proponent's arguments as to potential economic benefits cannot outweigh these significant concerns as to the impacts of the Proposal. To safeguard biological diversity and ecological integrity, EPA, DoEE and the relevant Ministers must not allow the Proposal to proceed.

4. Improved valuation, pricing and incentive mechanisms – the Proposal is clearly inconsistent with the polluter pays principle in particular as the Proponent only proposes to reduce 1 Mtpa of its GHGe and offset emissions it is legally required to offset under the Safeguard Mechanism in the draft EIS/ERD. We also note that the Proponent has stated that it assumes a $40/tCO2-e "carbon price" – to not include that in the current Proposal is a clear example of contradiction to this principle. The currently proposed measures mean that the costs of abating and offsetting the remaining GHGe will be borne by others – such as different sectors of the economy, or taxpayers. To accurately reflect the full life cycle costs of the Proposal, including use of non-renewable gas resources as well as greenhouse gas emissions, the Proponent must take responsibility for these impacts through at a minimum providing for net zero emissions through offsets. In order to promote improved valuation, pricing and incentive mechanisms, EPA, DoEE and the relevant Ministers must not allow the Proposal to proceed as currently proposed. If the proposal is allowed to proceed, then any emissions from the proposal that are not abated or offset by the proponent will effectively transfer a cost to other parts of the economy or Australian taxpayers who will have to bear the cost of offsetting these emissions through reductions in other sectors in order to meet Australian and State emissions reduction targets. At a carbon price of $20 per tonne, this could result in a bill of over $17 billion being transferred to Australian taxpayers from the entire Burrup Hub project (scope 1 emissions only). This is not consistent with the polluter pays principle.

As the impacts of the Proposal's GHGe clearly do not meet the environmental principles under the EP Act or EPBC Act, it cannot be considered acceptable. Accordingly, the EPA and DoEE should recommend against implementation of the Proposal.

Policy Precedent for Commonwealth Assessment of GHG - Shell Prelude FLNG

Pollution abatement and acceptability

We note that the previous Commonwealth Assessment of the Shell Prelude FLNG facility in Commonwealth waters in April 2010 resulted in a recommendation to the Minster that the project must demonstrate no net increase in Australia's GHG emissions. This is the appropriate policy precedent to apply to the assessment of Greenhouse Gas emissions in Commonwealth waters such as are proposed in this development. The recommendation report stated:

> *"the Department recommends that prior to commissioning the facility that Shell develops and submits a Greenhouse Gas Strategy to the Minister for approval. The Greenhouse Gas Strategy must include measures to ensure that the proposed FLNG facility will not result in a net increase to Australia's total GHG emissions."* [29]

The context for this recommendation was the uncertainty surrounding the introduction of a Carbon Pollution Reduction scheme or similar economy-wide policy framework for controlling GHG emissions. Currently, no uncertainty exists as there is no proposal to establish such a scheme and

[29] RECOMMENDATION REPORT Prelude Floating Liquefied Natural Gas Facility (EPBC 2008/4146)

the existing Emissions Reduction Fund (ERF) and Safeguard Mechanism have manifestly failed to achieve the objective of reducing carbon pollution overall, or from industrial sources.

A Commonwealth approval for this project with conditions that are weaker than the Shell PRelude recommendation from a decade ago amount to an unacceptable weakening of environmental protection and emissions reduction efforts at a time when they must be very significantly strengthened.

Displacement of dirtier fuels

The Shell Prelude Recommendation Report also deals with the displacement or market substitution claim, providing the following comments on that aspect of the proposal:

> *Shell notes in the EIS that when the CO2 emissions intensity of the FLNG facility are compared with like for like other fossil fuels (e.g. coal) on a well to wheels basis, the FLNG facility could potentially have a net positive impact, but only if the export of Prelude LNG displaces more carbon intensive fuels in power stations. The Department notes that Shell has not proposed to replace any emitters currently using more carbon intensive fuels, and as such, operation of the FLNG facility will add to Australia's total GHG emissions.*

Similarly, Woodside has also not proposed to replace any other emitters and as such the operation of the proposal will add significantly to Australia's total GHG emissions, at a time when the need to reduce emissions is now more significant and urgent given the lack of action to reduce carbon pollution in the intervening decade, and the removal of effective economy-wide measures to deliver emissions reductions. Woodside and others campaigned for the removal of the carbon tax and other emissions reduction policies and the consequences of this are that Australia's emissions are rising instead of falling. In this context it is not responsible to allow additional emissions sources that would make this problem worse. The lack of an effective national policy instrument to reduce carbon pollution means that no significant new emissions sources can be permitted.

ACCEPTABILITY UNDER OTHER ASPECT OR RECEPTOR REQUIREMENTS INCLUDING STATE, FEDERAL AND INTERNATIONAL STANDARDS, LAWS, POLICIES AND GUIDELINES

THE PARIS AGREEMENT

The Paris Agreement was adopted by the international community, including Australia, on 12 December 2015 and entered into force on 4 November 2016. Article 2(1)(a) of the Paris Agreement states that it aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change".

The Special Report on Global Warming of 1.5°C published by the IPCC in October 2018 reinforces that rapid reductions in emissions are required to limit global warming to 1.5°C and avoid adverse impacts associated with climate change.[30] Despite this, Australia's emissions continue to increase, with the Commonwealth Department of Energy's recently published Quarterly Update of Australia's

[30] Intergovernmental Panel on Climate Change, 'Global Warming of 1.5ºC' (October 2018) 95.

National Greenhouse Gas Inventory: March 2019, revealing that Australia's emissions for the year to March 2019 have increased 0.6% or 3.1 MT Co2-e on the previous year, primarily due to increased LNG exports (18.8%).[31] Australia is currently ranked as the worst-performing and lowest-scoring country in the world on climate action (Sustainable Development Goal 13) according to the 2019 Sustainable Development Report.[32]

Given GHGe in WA and Australia continue to increase rather than decrease, in our view, any increase GHGe from the approval of new pollution sources is clearly inconsistent with the goals of the Paris Agreement (especially if a carbon budgets approach is applied). This is supported by the Court's finding in *Gloucester* that approval of a project which will increase GHG emissions is likely to run counter to actions that are required to achieve rapid reductions in GHG emissions necessary for net zero emissions and limiting temperature rise to 1.5-2°C.[33]

In relation to the acceptability of the Proposal under the Paris Agreement, the Proponent merely states that the Proposal has the potential to contribute to the reduction in global GHGe by displacing higher carbon intensive power generation (e.g. coal burning).[34] As addressed above, these claims of market substitution are not sufficiently substantiated or proven by credible evidence. Accordingly, allowing the Proposal to proceed, without mitigation or offsetting measures that can effectively ensure that its substantial GHGe are reduced or achieve a net benefit outcome, is inconsistent with the objectives of the Paris Agreement.

AUSTRALIA'S NATIONALLY DETERMINED CONTRIBUTION

The Paris Agreement requires each country to put forward its own Nationally Determined Contribution (**NDC**) and to pursue "domestic mitigation measures, with the aim of achieving the objectives of such contributions".[35] The Australian Government has committed to a NDC of reducing Australia's emissions by 26-28% by 2030 against a 2005 baseline. As discussed above, Australia's emissions continue to increase. A report by Climate Transparency indicates that Australia's current NDC target is not consistent with the Paris Agreement's temperature limit and would lead to a warming of between 2°C and 3°C if Australia's reductions were followed to a similar level globally.[36] A 2018 report by the United Nations Environment Programme also found that Australia is not on track to meet its NDC commitment under the Paris Agreement to reducing its 2005 emissions by 26-28% by 2030[37] and, more recently, the 17 June 2019 update on the Climate Action Tracker website reports that Australia's emissions are set to far outpace its "insufficient" NDC target.[38] Further, the

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[31] Quarterly Update of Australia's National Greenhouse Gas Inventory: March 2019, Commonwealth of Australia 2019, p 3 <http://www.environment.gov.au/system/files/resources/6686d48f-3f9c-448d-a1b7-7e410fe4f376/files/nggi-quarterly-update-mar-2019.pdf>.

[32] Sustainable Development Solutions Network, *Sustainable Development Report 2019* (June 2019) 69.

[33] *Gloucester Resources Limited v Minister for Planning* [2019] NSWLEC 7 [526].

[34] Draft EIS/ERD, p 700.

[35] United Nations Framework Convention on Climate Change*, Paris Agreement*, COP21/CMP11, (22 April 2016 adopted 4 November 2016) Article 4 (2).

[36] Climate Transparency, 'Brown to Green: The G20 Transition to a Low-Carbon Economy', *Climate Transparency* (Infographic Summary) <https://www.climate-transparency.org/wp-content/uploads/2019/01/BROWN-TO-GREEN_2018_Australia_FINAL.pdf>.

[37] United Nations Environment Programme, *Emissions Gap Report 2018* (November 2018).

[38] Climate Action Tracker, 'Country summary' *Climate Action Tracker* (17 June 2019) <https://climateactiontracker.org/countries/australia/>.

UN Global Compact network states that according to projections Australia's emissions are tracking toward being 4% below 2005 levels at best and 3.5% above 2005 levels at worst.[39]

The draft EIS/ERD acknowledges that the emissions reduction task to achieve Australia's NDC is currently 328 MT CO2-e. Despite the Proposal having the potential to increase Australia's emissions, the Proponent states in the draft EIS/ERD that it is not expected to prevent Australia meeting its NDC commitments.[40] In our view, this argument is completely false and unfounded. By causing substantial GHGe, the Proposal will increase Australia's GHGe and further jeopardise ourability to achieve our insufficient NDC. Accordingly the Proposal is not consistent with Australia's NDC commitments under the Paris Agreement.

<u>NET ZERO EMISSIONS TARGET</u>

On 28 August 2019 the WA Government released its *Greenhouse Gas Emissions Policy for Major Projects* which contains an aspirational target of achieving net zero GHGe by 2050. The Proponent has made a public commitment to net zero emissions by 2050 yet there is no reference to this target in the draft EIS/ERD. Instead, the draft EIS/ERD merely states that "Woodside is continuing to work to reduce (net) emissions intensity through improvements in energy efficiency, investments in biosequestration projects and innovation in our production processes".[41]

In our view, allowing the Proposal to proceed with a maximum lifetime of 44 years and substantial additional GHGe cannot be considered consistent with the target of net zero GHGe by 2050. Given WA's GHGe continue to increase, achieving net zero emissions implies a decrease, rather than increase, in emissions.

2. MURUJUGA ROCK ART

<u>IMPACTS</u>

The draft EIS/ERD states that there are no National Heritage Places identified within the Project Area that may be affected by the Proposal and that potential impacts on the national heritage values, including aboriginal heritage values, of the listed National Heritage Place on the Dampier Archipelago that may be associated with the onshore processing of the Browse gas by the NWS JV, will be assessed and addressed within the ERD for the NWSP Extension Proposal (EPA 2186, EPBC 2018/8335).

However, emissions of oxides of nitrogen (**NOx**), sulphur dioxide (**SO2**) and CO2 emissions from the Proposal and the broader "Burrup Hub" project will likely contribute to the formation of acid which dissolves the outer rock surface patina and degrades and destroys rock art irreversibly, and thereby will accelerate the weathering effects on the Murujuga rock art. DWER's Murujuga Rock Art Strategy recognises that anthropogenic emissions may have adverse impacts on the Murujuga rock art by

[39] Global Compact Network Australia,'Australia Delivers First Voluntary National Review on SDGs as Governments Reaffirm Commitment to Agenda 2030, Global Compact Network Australia (31 July 2018) <http://www.unglobalcompact.org.au/sdgs/non-business-advancing-the-sdgs/sdg-13>.

[40] Draft EIS/ERD, p 700.

[41] Ibid 679.

accelerating the weathering of petroglyphs beyond natural rates.[42] Dr John L Black also notes in his submission on the ERD for the NWSP Extension Proposal that:

> *"There is strong scientific evidence that emissions from the Woodside plant are already dissolving the outer patina of rocks close to the Woodside site. Observations on Murujuga show clearly that the petroglyphs will be lost once the patina is destroyed. The impacts of emissions on the rock art are cumulative over time. Allowing continued high emissions will almost certainly damage Australia's unique heritage."*[43]

We note that French cave paintings in the Vézère Valley have been provided stringent protections against even CO2 emissions from tourists' breath.[44] In our view, similar protection should be provided to the Murujuga rock art, which is some 23,000 years older than the French cave paintings.

NO CONSIDERATION OF INDIRECT AND CUMULATIVE IMPACTS OF EMISSIONS ON ROCK ART

As addressed above, the Proposal forms part of the broader "Burrup Hub" project which seeks to expand the LNG processing operations and will therefore increase emissions of NOx, SO2 and CO2 and potential adverse impacts on the Murujuga rock art. In particular, the Proposal and the broader "Burrup Hub" project have the potential to result in changes in air quality causing deposition on nearby heritage features of the Murujuga rock art.

Despite this, the draft EIS/ERD does not consider the indirect and cumulative impact of emissions from the Proposal on the Murujuga rock art in the context of the broader "Burrup Hub" proposal. In our view, these impacts must be considered and managed in the final EIS/ERD and assessed by both the EPA and DoEE.

ACCEPTABILITY UNDER ENVIRONMENTAL PROTECTION ACT 1986 (WA)

As addressed above, the EP Act does not require significant impacts from proposals on WA's environment to be direct. Further, it does not limit assessment of environmental impacts to activities within the scope of a proposal, but rather requires the EPA to assess the impacts of proposals on the WA environment. It is clear that the Proposal's atmospheric and GHG emissions will indirectly contribute to cumulative impacts of the broader "Burrup Hub" project on the Murujuga rock art.

It is therefore not appropriate for these impacts to be excluded from the scope of the draft EIS/ERD. The indirect and cumulative impacts of emissions from the Proposal on the Murujuga rock art must be considered, managed and mitigated by the Proponent in the final EIS/ERD and assessed by the EPA in accordance with the EPA's Environmental Factor Guidelines for Air Quality and Social Surroundings, the Murujuga Rock Art Strategy and other relevant policy and guidance.

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[42] https://www.der.wa.gov.au/images/documents/our-work/programs/burrup/Murujuga_Rock_Art_Strategy.pdf

[43] Dr John Black, Submission to the Western Australian Environmental Protection Authority in relation to Woodside Energy Ltd North West Shelf Project Extension Environment Review Document: EPA Assessment No. 2186, 7 February 2020.

[44] Australian Senate, Environment and Communications References Committee, 'Protection of Aboriginal Rock Art of the Burrup Peninsula' (March 2018), p 98 (available here: https://www.aph.gov.au/~/media/Committees/ec_ctte/BurrupPeninusla/report.pdf?la=en).

ACCEPTABILITY UNDER ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (CTH)

As addressed above, the EPBC Act does not require significant impacts on MNES' to be direct. It also does not necessarily require National Heritage Places to be within the scope of the proposal. The MNES Significant Impact Guidelines provide that an action is likely to have a significant impact on the National Heritage values of a National Heritage place if there is a real chance or possibility that it will cause:

- one or more of the National Heritage values to be lost
- one or more of the National Heritage values to be degraded or damaged
- one or more of the National Heritage values to be notably altered, modified, obscured or diminished.

Accordingly, the focus is on the *impact* of the relevant action or proposal on the National Heritage values of the National Heritage Place, not the exact location of the National Heritage Place itself. While there are no National Heritage Places directly in the Project Area, the indirect and cumulative impact of emissions from the Proposal and its connection to expanded processing of Browse gas at the NWSP Extension Proposal on the nearby Murujuga rock art must be considered and addressed in the final EIS/ERD and assessed by the DoEE under the EPBC Act.

3. ENVIRONMENTAL VALUES OF SCOTT REEF

IMPACTS

Cumulatively, the scale of the drilling proposed would impact heavily on the quality of the marine environment through long-term seabed disturbance and marine discharges. In the draft EIS/ERD, Woodside proposes to drill up to 54 production wells to access the gas resource, in and around Scott reef. Each well has a total impact radius of 200m, with a total seabed disturbance footprint from all the production wells of 6.78km2. Figure 1 (attached) shows the location of the mobile offshore drilling units (MODUs) in the immediate vicinity of the nature reserve. All 7 of the Torosa MODU's are located within a 13.3km radius of the centre of Scott reef.

The production wells will be drilled to depths of between 3,500 and 4,500m vertical depth beneath sea level to intersect the reservoirs. The EIS/ERD states that "in order to reach the optimum location in the reservoir, the well may be drilled at inclination (up to horizontally), to maximise the recovery of reservoir fluids."[45] Woodside acknowledges that using horizontal drilling techniques to extract the high-pressured reservoir fluids will cause a reduction in the reservoir's pressure, which has the potential to result in the compaction of the overhanging rock strata leading to potential gradual subsidence (sinking) of the seabed.[46]

The installation of subsea infrastructure such as manifolds, flowlines, umbilicals, mooring systems and risers necessitates further acute seabed disturbance. Seabed preparation works will be undertaken using ploughing and 'mass flow excavation techniques.'[47] This includes 20 piles for the

[45] Draft EIS/ERD, p798
[46] Ibid, p609
[47] Ibid, p72

riser bases, and up to 12 piles to secure each FPSO. Suction piles are up to 10m in diameter and 30m in length. The total extent of seabed disturbance from subsea activities is 48.28km2.[48]

The various types of marine discharges, including toxic contaminants, proposed in the EIS/ERD will also impact heavily on the quality of the marine environment around Scott reef. During drilling, wireline logging activities undertaken for formation evaluation, which the proponent notes "may contain radioactive sources." Aside from this, the remainder of the EIS/ERD is silent on what exactly the radioactive sources are and relies on previous modelling from 2011 to inform the impact assessment.[49]Other significant contaminants to be released in the Scott reef area include drilling fluids, hydrotest fluids, the contents of underperforming wellbores, mono-ethylene glycol and the waste product from hydrocarbon recovery. Hydrotesting of the BTL will involve discharge of up to 846,000m3 hydrotest fluids overboard. Between the two FPSO's, up to 11,446m3 of the produced wastewater product will be processed and discharged overboard, containing hydrocarbon compounds, metals, ammonia and 'radioactive materials.'[50]

Due to the scale and duration of the proposed project, the risk of a hydrocarbon oil spill is very real and would cause immense damage to Scott reef and the quality of the surrounding marine environment. The draft EIS/ERD includes quantitative spill risk assessment of hypothetical spill scenarios. Scenario 1 models a long-term (77 day) release from a surface/subsea blowout of unstabilised condensate at the TRC drill centre. The study predicts that floating oil (at concentrations above 10g/m2) could be found 143km from the spill site, and entrained oil (at concentrations above 100-ppb) could be found up to 863km from the spill site.[51]

Several important studies[52] have highlighted the devastating impacts of hydrocarbon spills for coral reefs and benthic habitats. Condensate oil could come into contact with corals by mixing with sand or sediment and becoming dense enough to sink to the bottom, by mixing with the water column through open ocean turbidity or by directly coming into contact with reef in the intertidal zone during low tides. Condensate can kill coral or impede reproduction, growth, behaviour and development.[53]

The quality of the marine environment at Scott reef is particularly vulnerable to the impacts of marine discharges and hydrocarbon spills, due to several factors. Scott reef's lagoon waters have low levels of turbidity (between 0.04-0.15 NTU)[54] which means contaminants and hydrocarbons take longer to dilute. The clear water of the marine environment also exposes the benthic communities and habitats of Scott reef to high levels of ultraviolet radiation (UV) which can increase the toxicity of some components in condensate and oil. Additionally, projected sea temperature increases may affect the toxicity of oils to benthic communities and habitats.[55]

ACCEPTABILITY UNDER ENVIRONMENTAL PROTECTION ACT 1986 (WA)

Marine Environmental Quality is a relevant environmental factor for the EPA in its assessment of the project. The EPA's objective for this factor is 'to maintain the quality of water, sediment and biota so

[48] Ibid, p311
[49] Draft EIS/ERD, p 843
[50] Ibid
[51] Draft EIS/ERD, p 633
[52] CSIRO (2016), NORR (2013), Li-Hua Lee, Hsing-Juh Lin (2013), Buskey, E.J., H.K. White, and A.J. Esbaugh. (2016),
[53] NORR (2013)
[54] Draft EIS/ERD, p 124
[55] Cooper et al., 2010; AIMS, 2012.

that environmental values are protected'.[56] Under the EP Act, this extends to the maintenance and protection of the environment itself and is measured in terms of ecological structure, function and process.

The designation of level of ecological protection is also relevant to the EPA's assessment of the proposals environmental impact. As a designated nature reserve and a place of extremely high conservation value, the pristine marine environment of Scott reef warrants the maximum level of ecological protection.

Issues/omissions with the EIS/ERD

There are several omissions in the Draft EIS ERD which do not provide the EPA with the necessary level of detail to conclude that the impact of the proposal is 'acceptable', and that the EPA's objective for Marine Environmental Quality can be achieved over the proposed 44-year lifespan of the project. These include;

- Insufficient detail in the EIS/ERD about the discharge of radioactive materials from wireline logging activities and the produced water by-product for the EPA to safely conclude that the impact of the project is 'acceptable' or to guarantee that the attainment Marine Environmental Quality Factor objective.
- The capricious reliance on dilution of produced water discharges to avoid poisoning Scott reefs benthic habitats and communities and the quality of the marine environment. The proposal to dispose of over 5.7 million litres a day of produced water containing trace amounts of marine toxins including hydrocarbons, heavy metals, mercury, ammonia, and MEG is materially unsafe, given that Woodside advises of uncertainty about the amount of toxins in the water.[57] Woodside also rejects the avoidance of produced water discharge by reinjection due to complexity and cost.
- The unreasonable proximity of the proposed drilling activities to the sensitive marine environment of Scott reef, and Woodside's reliance on previous modelling to ensure that it won't cause major issues through subsidence and compaction of rock strata. Noting that, when considering a significant impact on the marine environment, the EPA may have regard to the extent (intensity, duration, magnitude and geographical footprint) of the impact, the proponents lack of detailed analysis about risk modelling for subsidence issues is of major concern in the interests of a fully informed assessment, particularly of cumulative impacts.
- Insufficient detail in the draft EIS/ERD about the composition of the drilling fluid that will be discharged into the marine environment. Woodside defers including this in the EIS/ERD until the 'well design is confirmed'.
- Insufficient detail in the EIS/ERD about the composition of the wellbore content which Woodside plans to flow back to the MODU and discharge if a well is underperforming. The EIS/ERD does not describe the discharge, except to sat that its contents are 'too dangerous' to filter or treat.
- Inadequate methodology for the unplanned hydrocarbon release modelling. The RPS assessment models a hydrocarbon release from the TRC drill centre, and tests the probabilities of contact at specified receptors, including at Scott reef central (Sandy Islet). In order to properly determine the risk of a hydrocarbon release to these receptors, for the purposes of proper assessment, it should have used the most impacting well centre, which is TRE located in the middle of Scott reef North and Scott reef South.
- The proponent in its EIS/ERD, and the EPA in its assessment, are required to consider the cumulative impacts of the proposal. It takes the approach of evaluating all the impacts as being 'acceptable', and then is too brief in making its cumulative assessment. In total, the various stressors on the quality of

[56] EPA Marine Environmental Quality: Environmental Factor Guideline (2016), p1
[57] Draft EIS/ERD, p 1197

the marine environment will significantly diminish the quality of the Scott reef area, from large-scale industrialisation of the projects proposed 44-year life span.

In the draft EIS/ERD, the proponent concludes that the proposals cumulative impacts on the key ecological receptors for the environmental values of Scott reef, particularly water quality and benthic communities and habitats, are 'acceptable'. In our view, these conclusions are deeply flawed because it is not based on sufficient evidence about the most harmful aspects of the proposal. If these conclusions are to be accepted by the EPA, the proponent must provide further information on the omissions identified above, in order to make a fully informed assessment about the acceptability of significant impacts to the environmental values of Scott reef.

ACCEPTABILITY UNDER ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (CTH)

Impacts are on MNES affected by the project which are dealt with under the above section and in other sections of this document. Further analysis is required to identify specific impacts on MNES within the state waters component of the project on Scott Reef. CCWA wishes to provide further information on these aspects at a later date.

4. MARINE FAUNA

IMPACTS

The project poses a significant threat to the incredible diversity of marine life that contribute to the ecological integrity of Scott reef. An extraordinary amount of marine fauna are widespread across the project area, which provides crucial provides nesting, feeding and/or migratory habitat for endangered green sea turtles as well as for loggerheads, flatbacks, hawksbills, leatherback and olive ridley sea turtles. Whales, dolphins, whale sharks and other marine species are known to rely on Scott Reef, and are among 20 listed Threatened species, 38 listed Migratory marine species, 404 mollusc species and 117 echinoderm species.[58] A list of all the Matters of National Environmental Significance (MNES) that may be impacted by the proposal, and their conservation listing, is found on page 1020 of the draft EIS/ERD.

A range of impacts to marine fauna are described in the EIS/ERD, which vary from the planned discharge of toxic contaminants into the marine environment to underwater noise and light emissions. The nature of the impacts that these activities will have will also varies significantly, according to the different behaviours between species and how they utilise the habitat. This submission will summarise the impacts to two key threatened species which rely heavily on the project area, namely blue pygmy whales and green turtles.

Green turtles (Chelonia mydas)

Successful conservation of the green turtles at Scott Reef is of national and international importance for maintaining the biological diversity and integrity of the species. Green turtles are listed as a vulnerable, migratory, marine species under the EPBC Act, and vulnerable under the BC Act.

The Green turtles at Scott Reef form a distinct genetic stock, known as the Scott Reef-Browse stock, which is one of the three genetically distinct stocks existing in Western Australian waters. There are only a few large nesting aggregations of the green turtles left in the world, and Australia has some of

[58] Marsh (1986)

the largest aggregations in the Indo-Pacific region. Each year, the majority of the stock's mature green turtles return to Sandy Islet, an unvegetated sand cay in the central south part of Scott reef, to their nesting and internesting habitat and to lay up to five clutches of eggs.[59] At sexual maturity (20–50 years old), the turtles may make another long journey back to Scott Reef, where they mate and lay their eggs on Sandy Islet. When the eggs hatch, hatchlings emerge and the cycle continues.[60]

Green turtles are primarily herbivorous, foraging on algae, seagrass and mangroves. In their pelagic juvenile stage, they feed on algae, pelagic crustaceans and molluscs.[61] Turtles are highly migratory, utilising widely dispersed habitats throughout their life cycle. After laying their eggs on Sandy Islet, the female turtles swim for months, covering several hundred kilometres, to return to their foraging grounds. Some swim along the coast of northern Australia as far as the Queensland border, while others swim south along the coast of tropical Western Australia. The AIMS publication '*Discovering Scott Reef: 20 years of exploration and research*' illustrates the migratory pathways of the Scott Reef-Browse stock along the West Australian coast.[62]

Threats to turtles

According to the proposal, the light emissions will occur from the offshore facilities, MODU and project vessels during all phases of the proposed Browse to NWS Project, including from general operations and from the flaring of excess gas. This will impact heavily on habitat critical to the survival of the stock.

Artificial lighting is an important threat to marine turtles that can disrupt hatchling orientation and sea finding behaviour and the sea finding behaviour of adult green turtles. As hatchlings emerge from the nest, they orient towards the sea using the low elevation light horizon. Crossing and swimming away from the beach is thought to imprint the hatchlings with the cues that allow individuals to return to their natal region for breeding as adults.[63]

Acute and chronic noise interference is also a significant threat to the survival of the stock, as it may result in avoidance of critical habitat and in some situations physical damage to turtles. Acute noise is generated by activities such as pile driving, seismic activity, some forms of dredging, explosions, blasting and sonar. McCauley et al. (2000) have conducted studies to replicate exposure to underwater loud noise, which have demonstrated that turtles show behavioural responses, including to become more erratic.[64]

The survival of the stock is also threatened by acute and chronic chemical and terrestrial discharge, and the risk of a long-term unplanned hydrocarbon release. There is well documented evidence of the detrimental effects from encountering oil either via external contact, ingestion or inhalation, resulting in breathing, sight or gastro-intestinal injuries.[65] Oil present on or near a beach can persist in sticky or toxic forms in the environment (sand and sediments) for many years. Marine turtle nesting behaviour can uncover this resulting in sticky oil adhering to adults, eggs or hatchlings causing both physical (smothering) and physiological (toxic) effects. Oil is highly toxic to turtle eggs,

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[59] Gilmour, 2013

[60] Ibid, p12

[61] Boyle MC and Limpus CJ (2008)

[62] https://www.aims.gov.au/publications/discovering-scott-reef

[63] Lohmann KJ, Witherington B, Lohmann CMF and Salmon M (1997) Orientation, navigation, and natal beach homing in sea turtles. In The Biology of Sea Turtles, Volume I, Lutz PL and Musick JA, Eds. CRC Press, Washington D.C. pp 107-135.

[64] McCauley RD, Fewtrell J, Duncan AJ, Jenner C, Jenner M-N, Penrose JD, Prince RIT, Adhitya A, Muchdoch J and McCabe K (2000)

[65] Lutcavage ME, Lutz PL, Bossart GD and Hudson DM (1995) Physiologic and clinicopathologic effects of crude oil on loggerhead sea turtles. Archives of Environmental Contamination and Toxicology 28: 417-422.

and the toxic components can penetrate the skin and carapace of hatched and older marine turtles affecting respiration, salt gland function and blood chemistry.[66] Acute terrestrial discharges can also cause considerable loss of seagrass habitat due to light limitation that in turn can result in decreased turtle health, starvation, increased stranding and decreased breeding condition. These pulse events may also deliver sudden high contaminant loads to the system.[67] While the event itself may be of short duration, the loss of the seagrass meadows may continue to impact turtle health for several years.[68]

Whales

This submission focuses specifically on proposed impacts to pygmy blue whales (Balaenoptera musculus brevicuda), and the acceptability of these impacts under the EP Act and the EPBC Act. However, these impacts will also apply to several other MNES whale species which are known to utilize in the Scott reef area. These other species include Humpback whales, Sei whales and Fin whales (which are all listed as vulnerable under the EPBC) and Bryde's whale (which is migratory species under the EPBC Act).

We note that the draft EIS/ERD does not include any reference to the other subspecies of Blue whale known to occur in Australian waters, the True Blue Whale (Balaenoptera musculus intermedia), which suggests that the species will not be impacted by the development. We also note that the documented information in the draft EIS/ERD with respect to whale species is largely informed by a Woodside copyrighted research study, which notes that 'of the two southern subspecies, only the pygmy blue whale has been observed in the region around Scott Reef.'[69] CCWA challenges this accuracy of this assertion, and has sought independent expert advice on this aspect of the proposal. We expect that this will provide further information to be provided by way of supplementary information on this matter.

Blue whales, the largest living animals, are found in all the oceans of the world. The pygmy blue whale (Balaenoptera musculus) is currently listed as an endangered migratory species under the Commonwealth Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act). The International Whaling Commission (IWC), the international body regulating whaling, banned blue whale takes from 1966, due to the significant reduction in population numbers. The decline of blue whale numbers has also been recognised by the International Union for the Conservation of Nature (IUCN), which has listed blue whales in their endangered category. Similarly, blue whales have been listed in the appendices of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Indo-Australian pygmy blue whales inhabit Australian waters as far north as Scott Reef, the Kimberley region, and west of the Pilbara, as far south as south-west Australia, across to the Great Australian Bight and the Bonney Upwelling, and to waters as far east as off Tasmania.

Pygmy blue whales follow an annual migratory path off the coast of Western Australia that runs adjacent to Scott reef, feeding in mid-high latitudes and migrate to lower temperate/tropical waters

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[66] Shigenaka G, ed. (2010) Oil and Sea Turtles Biology Planning and Response. U.S. Department of Commerce, Washington, DC. pp 116.

[67] Limpus CJ, Limpus DJ, Saviage M and Shearer D (2012) Health assessment of green turtles in south and central Queensland following extreme weather impacts on coastal habitat during 2011. Conservation Technical and Data Report 2011: 1-13.

[68] Ralph PJ, Durako MJ, Enriquez S, Collier C and Doblin MA (2007) Impact of light limitation on seagrasses. Journal of Experimental Marine Biology and Ecology 350: 176-193.

[69] Gilmour, p 170

to mate and breed. They pass to the west of Scott Reef, closer to the edge of the continental shelf, and prefer to travel alone or in small groups. In 2008, five pygmy blue whales were observed in the channel between the North and South reef, where Woodside are proposing to construct the TR-E well.

The long-term recovery objective for blue whales is to minimise anthropogenic threats to allow for their conservation status to improve so that they can be removed from the EPBC Act threatened species list. One of the key interim recovery objectives in the recovery plan is to ensure that anthropogenic threats are demonstrably minimised.

Threats to pygmy blue whales

The proposal includes various different noise pollution sources, both acute and chronic. These sources include from drilling, completion and installation activities (including vessel movements on DP and vertical seismic profiling), noise generated from subsea infrastructure during operations, from pile driving and vessel noise.

Noise pollution from the project's development activities, including long-term seabed disturbance, pose a major threat to the blue whales, and is known to induce behavioural and avoidance reactions and significantly disturb communication between whales.[70] In water, sound is transmitted very efficiently, which allows noise generated by drilling and ongoing operations to travel long distances (Richardson et al 1995).

Blue whales produce strong, low frequency moans that have been recorded in the frequency range of 12.5-200Hz.[71] However, higher frequency (up to 524Hz) blue whale sounds, thought to be those of pygmy blue whales, have been recorded.[72] Richardson explains that most baleen whales are sensitive to frequencies below 1KHz but they can hear sounds above this range. They are likely to hear sounds below the detectable range for humans and many whale calls include sounds at below 50Hz.[73]

Drilling sound usually exhibits tones below 2 kHz, with harmonics present to 10 kHz and can vary substantially between operations.[74] Acoustic field measurements of pile driving show that source, or near-source levels are typically in the range of 210 to 250 dB[75] and frequency is predominantly <1kHz,[76] although they can extend to much higher frequencies,[77] including at least 100 kHz.[78] In deep water, the sound pressures of the pile can be much longer meaning that the area impacted by the noise is greater.[79] Modelling for FPSO operations including DP considered each thruster as an individual source with a representative broadband (10 Hz to 63 kHz). The frequencies of these noise pollution sources interfere heavily with the communication range of blue whales and are demonstrated to cause avoidance behaviours which impacts on their migratory routes.

[70] (McCauley et al 1998).

[71] (Richardson et al 1995)

[72] (Ljungblad et al 1997).

[73] Draft Recovery Plan for Blue Whales in Australian Waters (2009)

[74] (Austin et al., 2018; Kyhn et al., 2014).

[75] (Bailey et al., 2010; McHugh, 2005; Tougaard et al., 2009)

[76] (Matuschek and Betke, 2009; Robinson et al., 2012, 2007; Tougaard et al., 2009)

[77] (MacGillivray, 2018),

[78] (Tougaard et al., 2009)

[79] (MacGillvray, 2018)

The effects of elevated noise levels on marine mammals is known to include: avoidance of an area, tissue rupture, hearing loss, disruption of echolocation, masking (the inability of a whale to detect sounds important to it), habitat abandonment, aggression, calf abandonment, and behavioural disturbance. It is the high intensity signals with high peak pressures received at very short range that can cause acute impacts such as injury and death.[80]

Ambient, ongoing noise from drilling operations can have other significant impacts, including hearing impairment (e.g. permanent and temporary threshold shifts) masking of communication, displacement, and other significant behavioural changes (including to vocal behaviour).

The proposal also carries the risk of direct impacts to pygmy blue whales from vessel collisions and uncontrolled hydrocarbon releases, which are exacerbated by the 44-year lifespan of the project.

OVERVIEW OF ACCEPTABILITY

CCWA notes that there are several elements of the Draft EIS ERD which have failed to provide the EPA with the necessary level of detail to accurately conclude that the impact of the proposal is 'acceptable', and that the EPA's objective for marine fauna can be achieved over the proposed 44-year lifespan of the project. These include;

- Misleading statements in evaluating the impacts of underwater noise emissions on the risk of potential impacts to green turtles. In the EIS, Woodside justifies its assessment of the risk as 'minor', based on the argument that the noise emissions affect a 'very small portion of offshore waters' (i.e. the ocean), and will only occur within several hundred metres of the source. This justification deliberately ignores the fact that the TRE drill centres is located adjacent to habitat critical to the survival of the Scott reef-Browse stock of green turtles.
- Prejudicial methodology was used for the light density modelling, which informs the evaluation and assessment of light pollution impacts of green turtles. Woodside reuses its light density modelling from previously proposed FLNG facilities at Torosa.[81] The major source of light emissions, the flare of the pilot flame, was not included in this assessment. It is completely unsatisfactory that the most impactful source (flaring) was excluded from the lighting modelling.
- It downplays the impact that the potential seabed subsidence risk could have on habitat critical to the survival of the green turtle. While the EIS/ERD acknowledges that 'slight impacts' are predicted to occur from drilling (i.e. sinking of the seabed), it concludes that 'reef growth rates are expected to match or exceed any sea level reduction' and considers the impact 'acceptable'. This evaluation is unfounded and discounts the vulnerability of the Sandy Islet habitat to sea level rise, cyclones and industrial threats. Loss of habitat will significantly impact on the ecological functioning and process of the green turtle stock.
- It assesses the impacts on pygmy blue whales as 'acceptable', but fails to demonstrate any meaningful mitigation or amendments to the proposal to reduce these impacts. The EIS/ERD states that 'it is acknowledged that pygmy blue whales have been recorded in the channel between North and South Scott reef'. However, Woodside has proposed to build its TRE drilling unit and up to five production wells in this channel. The EIS/ERD contains no trace of feasible mitigation or proposals to change the location of the TRE well to reduce the intolerable impact of the drilling noise on the pygmy blue whales.
- The EIS/ERD does little to offer protections for this vulnerable population other than to follow EPA lighting guidelines if practicable and to monitor the population. As with other major WA oil

[80] Conservation Management Plan for the Blue Whale (2015).
[81] Draft EIS/ERD, p 366

and gas operations, monitoring the demise or decline of a sea turtle population does not equate to a mitigation or protection.

ACCEPTABILITY UNDER ENVIRONMENTAL PROTECTION ACT 1986 (WA)

'Marine Fauna' is a relevant environmental factor in the EPA's assessment of the project. The stated objective for this factor is 'to protect marine fauna so that biological diversity and ecological integrity are maintained.' According to the EPA, this requires consideration of the composition, structure, function and processes of ecosystems, and the natural variation of these elements. In assessing proposed impacts against this objective, the EPA acknowledges the importance of protecting marine fauna for their ecological roles and notes that some species, and groups of species, have critical roles to play in maintaining key ecological functions and processes within the system.

The EPA's *Statement of Environmental Principles, Factors and Objectives* provides guidance on the meaning of the term 'significant impact'. When considering significant impacts in relation to a proposal, the EPA may have regard to various matters, including;

- values, sensitivity and quality of the environment which is likely to be impacted
- extent (intensity, duration, magnitude and geographic footprint) of the likely impacts
- consequence of the likely impacts (or change)
- resilience of the environment to cope with the impacts or change
- cumulative impact with other existing or reasonably foreseeable activities, developments and land uses connections and interactions between parts of the environment to inform a holistic view of impacts to the whole environment

In the draft EIS/ERD, the proponent concludes that the proposals cumulative impacts on the key ecological receptors for the environmental values of Scott reef, particularly water quality and benthic communities and habitats, are 'acceptable'. In our view, these conclusions are deeply flawed because it is not based on sufficient evidence about the most harmful aspects of the proposal. If these conclusions are to be accepted by the EPA, the proponent must provide further information on the omissions identified above, in order to make a fully informed assessment about the acceptability of significant impacts to the environmental values of Scott reef.

ACCEPTABILITY UNDER ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999 (CTH)

The DOEE determined that the proposal is a controlled action and that it is being assessed at an EIS/ERD level of assessment. The DOEE's decision notice identified several Matters of National Environmental Significance (MNES) as being relevant to the proposed Browse to NWS Project. There are 20 Listed Threatened species and 38 Listed Migratory Species.

As a vulnerable, migratory marine species under the EPBC Act, green turtles are considered as a key MNES for the purposes of this assessment. The *Recovery plan for marine turtles in Australia* (2017) provides guidance on key threats for the Scott Reef-Browse stock of green turtles in assessing the significant impacts of the proposal on the species. Relevantly to this proposal, it identifies light pollution, habitat modification, noise interference (acute and chronic), chemical and terrestrial discharge (acute and chronic) and vessel disturbance as key threats to be considered in the assessment.

The *Matters of National Environmental Significance: Significant Impact Guidelines* provide further guidance for assessing significant impacts in the proposal. Based on information in the Recovery Plan and other independent research, it is clear that the Sandy Islet nesting and internesting area for the Scott reef- Browse Island Stock is an area necessary to maintain genetic diversity and long term evolutionary development, and maintenance of the stock which is arguably essential to the survival and recovery of the species. Accordingly, the area is correctly described as habitat critical to the survival of the species.

As described below, the proposal contains several activities which would heavily impact on the Sandy Islet nesting and internesting area, including light interference, drilling activities and marine discharges. These activities have several implications for the species. There is a real chance that they will reduce the area of occupancy, adversely affect habitat critical to the survival, disrupt the breeding cycle and fragment this important sub-population of green turtles.

5. HUMAN HEALTH

IMPACTS

The proposed project poses major health risks to workers and resident communities in the Dampier Peninsula area, including the nearby town of Karratha. If the proposal goes ahead, an additional 6.8mtpa of gas pollution from Browse Basin will be processed at the Karratha Gas Plant facility (KGP). [82] The processing of this additional LNG over 44 years is likely to release harmful quantities of atmospheric pollutants, with the potential to cause serious health effects.

Over the length of the proposal, emissions occur from the flaring associated with the gas processing plant, and gas conditioning process vents (such as for CO2 removal from reservoir gas) and combustion of fuel gas for power generation for other processes, such as liquefication.[83]

The processing of Browse gas at the KGP will emit large volumes of four harmful air pollutants.

- nitrogen dioxide (NO2), as representative pollutant for nitrogen oxides (NOx)
- sulfur dioxide (SO2), as representative pollutant for sulfur oxides (SOx), which include also sulfur monoxide (SO), sulfur trioxide (SO3), and other combinations of sulfur and oxygen.
- ozone (O3) – as a secondary pollutant, resulting from the interaction between NOx and volatile organic compounds (VOCs).
- airborne particulate matter (PM10), which also includes particulate matter of size 2.5 microns and lower (PM2.5).

A recent Western Australian literature review of the health impacts of these air pollutants, found that short-term and long-term exposure to ambient SO2, NO2, O3, PM10 and PM2.5 are strongly associated with;

- increase in daily respiratory and cardiovascular mortality;
- increase in emergency room and/or hospital admissions for:
- respiratory causes such as wheezing, exacerbation of asthma, respiratory infections, decline in respiratory function, COPD; and

[82] Woodside, 2019

[83] Woodside NWS Project Extension Air Quality Management Plan, 2019

- cardiovascular causes such as high blood pressure, chest pain, thrombotic events, arrhythmias, ischemic heart failure.[84]

Nitrogen dioxide

Significant health effects can occur from ambient exposure to emissions of large quantities of NO2. NOx was determined to be the predominant risk emission from the facility associated with air quality potentially impacting human health.[85] NO2 is of concern not only because of the health effects associated with exposure directly to NO2, but also because NO2 is a precursor to other air pollutants. In the atmosphere, nitric acid (NO) is oxidised to NO2. NO and NO2, collectively referred to oxides of nitrogen (NOx) then co-exist in complex equilibrium that is influenced by the presence of atmospheric oxidants such as O3, VOCs, sunlight and other factors.[86] In recent years there has been a significant increase in the number of studies that have investigated and reviewed the effects of NO2 on health.[87]

Exposure to short-term NO2 is linked to increases in all-cause, cardiovascular and respiratory mortality and is associated with hospital admissions, emergency department visits, asthma and chronic obstructive pulmonary disease. The evidence is supported by human controlled studies, some of which show increased inflammation of airways and hyperresponsiveness at NO2 levels as low as 0.2ppb in healthy individuals.[88]

Studies of children with asthma show associations between NO2 and reductions in lung function, increases in cough, night-time asthma and school absenteeism. There is also strong evidence of an association between long-term exposure to NO2 and the incidence of asthma and wheeze. This new evidence suggests that NO2 exposure may cause asthma rather than just exacerbate existing asthma.[89]

Ozone

Ozone is not emitted directly from the Proposal but is formed through anthropogenic sources via chemical reactions between oxides of nitrogen and other emissions such as VOCs and CO in the presence of ultraviolet light.[90]Ozone (O3) at ground level is one of the major constituents of photochemical smog. There has been a significant volume of literature focusing on the short-term and long-term effects of exposure to O3 in the ambient air.

Short-term exposure to O3 can cause adverse respiratory effects such as difficulty of breathing (e.g., shortness of breath and pain when taking a deep breath) and inflammation of the airways. There is also an association between short-term O3 exposure and cardiovascular and respiratory mortality, as well as cardiovascular and respiratory hospital admissions.[91] Long-term exposure to O3 is likely to be one of many causes of asthma development. Evidence shows that exposure to O3 can also aggravate pre-existing lung diseases such as asthma, emphysema, and chronic bronchitis/COPD.[92]

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84 Urban Impact Project 2020

85 Woodside, 2019

86 Urban Impact Project

87 (WHO 2013b; USEPA 2016; NEPC 2019)

88 (NEPC, 2019). (Barnett, 2005; Erbas, 2005).

89 American Lung Association, 2020

90 Seinfeld and Pandis, 2016

91 COMEAP, 2015; USEPA, 2013; WHO, 2013a

92 Nuvolone, 2018

Recent evidence indicates that short- and long-term ozone exposure contributes to metabolic disease, including diabetes." "Evidence from recent epidemiologic studies of short-term ozone exposure and hospital admission or emergency department visits observed associations at concentrations as low as 31 ppb".[93]

Sulfur dioxide

In recent years, the health effects of exposure to SO2 in ambient air have been well studied and reviewed by agencies such as USEPA (2008), WHO (2006) and the California EPA (OEHHA, 2011).

Population-based epidemiological studies have reported a link between short-term SO2 exposure and daily mortality, respiratory effects, and cardiovascular effects.[94] Statistically significant decrements in lung function accompanied by respiratory symptoms, including wheeze, chest tightness and shortness of breath, have been clearly demonstrated following exposure to 0.4–0.6 ppm SO2.[95] An acute effect of short-term exposure at rest to 0.2 ppm SO2 is a change in heart rate variability, particularly impacting on young adults and asthmatics.

Several studies have observed positive associations between ambient SO2 concentrations and emergency department visits or hospital admissions for cardiovascular diseases (e.g. all cardiovascular diseases, cardiac diseases and cerebrovascular diseases), particularly among individuals of 65+ years of age.[96] One study reported a 3% excess risk in cardiovascular disease hospital admissions per 0.75 ppb incremental change in 24-hour average SO2 in single-pollutant models.[97]

Low birth weight, premature birth or other measures of foetal growth restriction have also been associated with high exposure to S02 in a number of studies.[98] One study evaluated the reproductive and developmental effects of SO2 and found that exposure to SO2 has effects on both male and female reproductive health as well as developmental toxicity including pre-term birth, offspring growth, pregnancy loss and congenital malformations.[99][100]

ACCEPTABILITY UNDER ENVIRONMENTAL PROTECTION ACT 1986 (WA)

Air quality is a relevant environmental factor for the EPA's assessment of the project. The objective for this factor is 'to maintain air quality and minimise emissions so that environmental values are protected'.[101] According to the Air Quality Environmental Factor Guideline, air quality is defined as 'the chemical, physical, biological and aesthetic characteristics of air.' The EPA declares that in the context of this factor and achievement of the objective, the EPA's primary focus is maintaining air quality and minimising emissions for human health and amenity.

Relevant to the EPA's assessment of significant impacts under this factor is existing background air quality through monitoring and accepted proxy data, and analysis of potential health and amenity impacts using recognised criteria and standards informed by Australian and international

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93 USEPA 2019

94 Appendix B Health Assessment, NEPC, 2018

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96 NEPC, 2018

97 Jalaludin et al. (2006)

98 Dugandzic, 2006), Leem (2006), Sagiv (2005)

99 NEPC, 2018

100 2011 the Californian Office of Environmental Health Hazard Assessment (OEHHA)

101 Air Quality Environmental Factor Guidelines, p1

standards.[102] In the EIS/ERD the proponent relies on its own air quality monitoring results from 2009-2015, measured against the Australian National Environment Protection (Ambient Air Quality) Measures (NEPM).

Recent studies have concluded that the air concentration limits set by the NEPM are for too high for the protection of a healthy population and recieving environment.

- The findings of a 2019 USA EPA report suggests that the maximum limit for ozone is closer to 30ppb, which is well below the current NEPM limit of 100ppb.
- A 2019 report from Doctors for the Environment Australia suggests that there is no safe level for exposure to nitrogen dioxide and the maximum value should be less than 9 ppb. This is exorbitantly lower than the current NEPM limit for atmospheric nitrogen dioxide which is 120ppb.
- From 2011 to 2015 there were significantly higher potential preventable hospitalisations for respiratory causes in children aged 0-14 years of age in the towns of Karratha, Port Headland and Newman than for the average of Western Australia.
- Significantly, hospitalisation for bronchiectasis, which is damage and widening of the airways, was 11.5 times greater in these areas than the state average.
- These results suggest that the emissions on the Burrup Peninsula are already affecting the health of young people in the region.

There is no safe exposure limit for the emissions that will result from the NWS LNG project as a result of processing gas produced from the Browse Basin gas field, which will directly result from this proposal. That is to say the substances that will be emitted are harmful to human health at any concentration. Synergistic effects of the emissions, both in the environment and in the human body have the potential to further increase harm. As a result, it is certain that there will be some health impacts arising from the development for workers at the facility and for residents in the town of Karratha. The question is whether these health impacts are considered to be acceptable or not and this is a question that cannot be answered without consultation with those affected.

The proponent has provided insufficient evidence to demonstrate that these impacts on public health are acceptable. Further research is required into the existing exposure levels and their impacts over time before it can be assumed that it is safe to continue these exposure levels for decades into the future. **An independent Health Impact Assessment is required to consider these factors properly before a judgement about acceptability can responsibly be made**. Such a process must include direct consultation with both workers and surrounding communities, including the release of full analysis of what these workers and communities are being exposed to, at what concentrations, frequency and over what duration. Only then can the communities who are impacted by this proposal evaluate whether the impacts are acceptable.

Furthermore, the climate change impacts that this project will directly contribute to through Greenhouse Gas emissions will have significant impacts on the health of Western Australians and others around the world, including through the impacts of extreme weather events such as fires, floods, cyclones and heatwaves.

Conclusion

102 Environmental Factor Guidelines, page 2

The proposal is environmentally unacceptable and cannot be made acceptable. The proposal should be rejected under both State and Commonwealth laws. The proposal is necessarily a component of a much larger proposal which would be the most polluting project in Australia's history, producing the dirtiest gas in the world. This is the last thing that the world needs at a time when the impacts of climate change are already being felt in devastation fashion across the country and the world. This proposal would make those impacts worse.

The project has failed to demonstrate any efforts to avoid, minimise and offset carbon pollution. The proposal is missing key information that would be necessary to evaluate impacts on health, the marine environment and cultural values proposed for World Heritage listing, however the information that has been provided would strongly suggest that the impacts on these values are also unacceptable and unable to be mitigated to acceptable levels.

If the project is to be approved, enforceable requirements must be put in place to require the proponent to ensure that the project does not result in any additional carbon pollution from either direct (scope1) or indirect (scope 3) sources.

Attachments

Figure 1: Torosa Drilling Units (MODU's)

Woodside Energy

APPENDIX D SUBMISSIONS

APPENDIX D.20 CCWA / CLIMATE ANALYTICS

CLIMATE ANALYTICS

A 1.5°C COMPATIBLE CARBON BUDGET FOR WESTERN AUSTRALIA

WA's role in implementing the Paris Agreement and capturing opportunities in a decarbonising global economy

NOVEMBER 2019

CLIMATE ANALYTICS

CONTENTS

Cover photo: Darkydoors
Ningaloo Reef and Cape Range national park, a World Heritage area near Exmouth, Western Australia.

CLIMATE ANALYTICS

EXECUTIVE SUMMARY

This study analyses what actions Western Australia needs to take to play its role in global and national efforts to limit warming to 1.5°C.

Western Australia is on the frontline of climate impacts and has a vital interest in the world, and Australia as a whole, taking sufficient action fast enough to keep global warming within the Paris Agreement's 1.5°C temperature limit to protect its unique and iconic ecosystems, coastal and agricultural regions, and the health and well-being of its population.

WA's iconic ecosystems and World Heritage sites such as Ningaloo are threatened by warming above 1.5°C and are already showing substantial damage with global mean warming of 1°C. Marine heatwaves are already damaging fisheries and causing massive seagrass loss at Shark Bay.

Declining rainfall and rising temperatures in the southwest are placing escalating pressure on agriculture, water resources and there are early indications of agricultural productivity failing to keep up due to the impacts of a warming and drying climate. These changes are also threating WA's unique biodiversity-rich land ecosystems.

Sea level rise is causing escalating problems on the coast, with accelerating beach erosion and retreat threatening infrastructure, homes and lifestyles and are the first signs of the consequences of the accelerating global sea level rise now being observed in many towns and coastal parts of Western Australia. As the Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5°C (IPCC SR15) has established, every increment of global warming will rapidly escalate damages, impacts and risks. WA's coral reefs, such as at Ningaloo, face losses of 70-90% with 1.5°C of warming, and virtually complete losses of more than 99% with 2°C of global mean warming above pre-industrial levels.

This study aims to provides key Paris Agreement compatible carbon budget benchmarks and greenhouse gas reduction pathways for Western Australia consistent with the state playing its role in global efforts to limit warming to 1.5°C. The results include state wide emission reduction goals needed for 2030, options for WA to meet its aspirational net zero greenhouse gas (GHG) emissions goal for 2050, and the broad policy changes needed to meet this budget.

WA and the National context

The Australian national reduction target for 2030 of a 26-28% reduction compared to 2005 emission levels is inadequate. National reductions in the range of 44-61% by 2030 are needed to be consistent with the level of action Australia needs to take in global efforts to limit warming to 1.5°C and to meet the Paris Agreement's long-term temperature goal. These emission reductions are needed by 2030 to put the country on a cost-efficient pathway to achieve zero net GHG emissions by around 2050.

The 1.5°C compatible state level greenhouse gas target for Western Australia estimated in this report is a reduction of 49% by 2030 (from 2005 levels). Whilst this is within the Paris Agreement compatible national emissions reductions range for Australia as whole it should be noted that the reductions by 2030 for Western Australia are likely to be slightly less than the total national reductions that Australia will need to achieve, due to the particularly energy intensive character of the Western Australian economy, and in particular its very large liquified natural gas (LNG) sector.

In the national context, when Australia begins to deal seriously with the question of national emission reductions, it cannot be assumed that the other states will accept Western Australia doing less than them. We have not examined these issues in this report, but it is clear that policymakers in Western Australia need to be cognisant of the relative levels of action between the states. The experience with the European Union has shown that each state will have its own set of arguments on what is a fair and economically effective division of mitigation responsibilities.

Although, in August 2019, Western Australia adopted an 'aspirational goal' of achieving net zero GHG emissions by 2050, as of yet it does not have any targets for renewable energy nor does it have a specific 2030 reduction target. Western Australia and New South Wales are now the only states or territories without a renewable energy target. Several other states are moving ahead with more ambitious action and there are appears to be little or no coordination between the states on this, and it cannot be assumed that these states are contemplating Western Australia taking a lesser share of the emissions reduction burden than themselves.

Western Australia has unique opportunities to develop its own vision and strategy and reap the benefits of being a global leader in implementing the Paris Agreement. It is highly independent from the federal level, with its own independent energy system, as well as prime renewable energy and mineral resources. It is therefore well-placed to demonstrate its independence from the failings on climate action at federal level.

WA has the opportunity to develop new added-value manufacturing industries and create employment opportunities while moving away from being an exporter of carbon to becoming an exporter of zero emission energy carriers (green hydrogen, ammonia, or electricity) and products, in particular to neighbouring South East Asian countries. It also has unique challenges, with the physical scale of the LNG industry, and the extensive and deep links this industry has with the political parties and government of Western Australia raise important public policy issues in relation to long-term public interest and climate governance in the state. Nevertheless, the abundance of capacity, renewable energy resources and links to important Asian markets mean that there is a transition strategy open to the state to explore, which would allow it to decarbonise the LNG industry and transform into a major exporter of renewable energy, either directly via electricity or through green hydrogen exports.

A significant part of the study focuses on a Paris Agreement compatible carbon budget for the energy and industry sectors in Western Australia as the largest source of greenhouse gas emissions in the state is carbon dioxide emitted from fossil fuel combustion and use. Globally, carbon dioxide (CO_2) is the main driver of human induced climate change and ocean acidification, and CO_2 from fossil fuels is the largest source, accounting for about 66% of total GHG emissions globally.

In Western Australia, energy and industry emissions are the largest source of greenhouse gases, with CO_2 and methane (CH_4) emissions from fossil fuel use for energy and industry accounting for 89% of total GHG emissions from the state (excluding LULUCF). The most rapidly growing source of greenhouse gases in Western Australia is the LNG sector, with a more than threefold increase (318%) since 2005, with the sector doubling in size over the last five years and set to increase by nearly 50% by the late 2020s.

We know from the IPCC Special Report on 1.5°C (SR15) that to meet the 1.5°C limit in the Paris Agreement, CO_2 emissions from all sources need to peak around 2020, fall by 45% by 2030 compared to 2010 levels, and reach net zero around 2060. This report also shows that the energy transformations required to achieve this are technically and economically feasible and can have large sustainable development benefits. To develop a carbon budget for Western Australia, we draw upon the modelling framework that gives these global results and apply it within the West Australian context so that the

CLIMATE ANALYTICS

CO_2 emissions budget as well as the energy system transformation dynamics are consistent with the global results.

Carbon budget for Western Australia energy and industry sectors: Key conclusions

The carbon budget for Western Australia's fossil fuel CO_2 emissions for the period 2018-2050 is estimated at around 950 $MtCO_2$. This is about 0.17% of the remaining global carbon budget. **If Western Australia maintains its current emissions rate, it would consume this budget within 12 years**.

With the right policies and modern technologies, Western Australia can spread this budget over the next 30 years, so that it achieves zero CO_2 emissions by 2050, but the pathway to stay within this budget is critical: CO_2 emission reductions of about 37% by 2030, 81% by 2040 (all compared to 2005) and zero emissions by 2050 are needed.

Delays in reducing emissions will imply faster reductions later to stay within the carbon budget, implying higher costs and disruption, and a risk of locking in further fossil fuel infrastructure.

Carbon budgets (emission pathways) for each sector and for all energy/industry emissions are shown below in Table 1 (Figure 1) as well as necessary reductions pathway 2030 and 2040 compared to 2005, so that all sectors reduce emissions to zero by or before 2050.

Table 1: Paris Agreement compatible energy and industry carbon budget for Western Australia 2018-2050 by sector and total, with sectoral and total reductions by 2030 and 2040. Source for historical data: AGEIS (2019). LNG sector emissions include emissions from venting/fugitive emissions (own estimate). Note that the increase in emissions in the LNG sector by 170% in 2030 compares to an increase of 630% in the reference (business as usual) case. Electricity generation reaches zero before 2040, all other sectors by 2050.

Sector	Paris Agreement compatible carbon budget 2018-2050 $MtCO_2$	Remaining years at 2017 emissions rates	2005 Baseline $MtCO_2$	Share of current emissions (2017)	2030 reduction (compared to 2005 baseline) CO_2 only	2040 reduction (compared to 2005 baseline) CO_2 only
Electricity generation	160	6	17.5	31%	-95%	--100%
Transport	207	15	8.8	18%	-16%	-54%
Industry: LNG Sector	208	16	3.6	17%	+170%	-73%
Fugitive emissions (excl. LNG)	25	6	1.6	5%	-55%	-90%
Industry: other	328	15	18.1	28%	-30%	-77%
Buildings	22	12	1.2	2%	-41%	-70%
Total energy/industry emissions	**949**	**12**	**50.8**	**100%**	**-37%**	**-81%**
Total energy/industry excluding LNG sector	**716**	**11**	**45.6**	**79%**	**-53%**	**-79%**

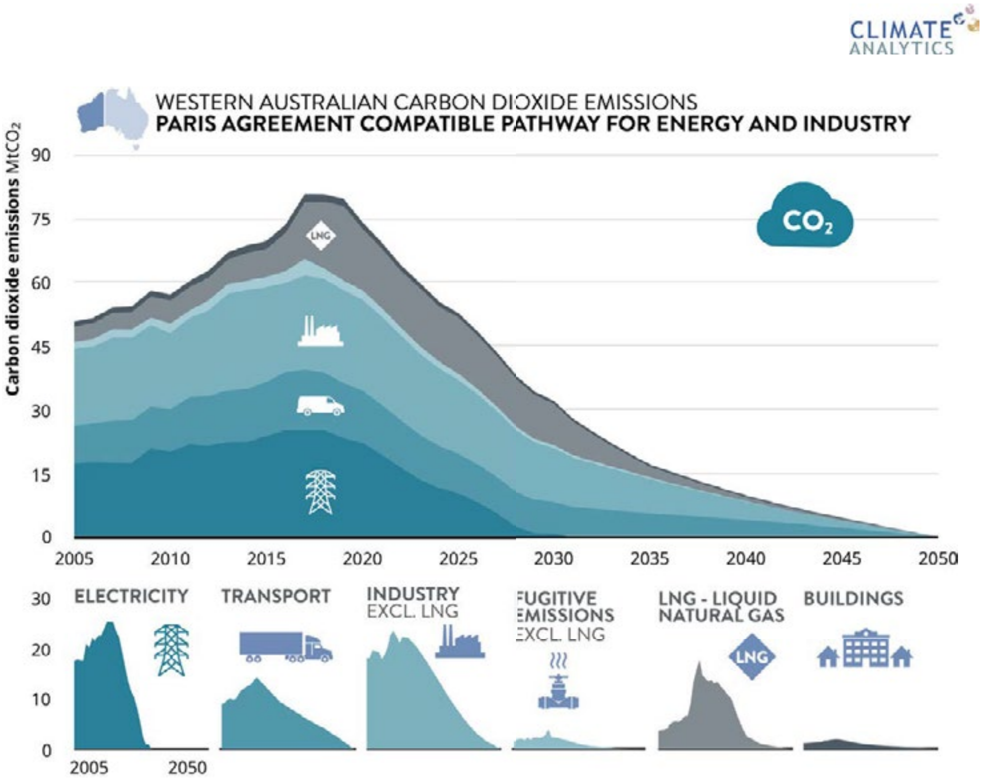

Figure 1: CO_2 emissions pathway for each of the sectors and energy and industry following transformation is consistent with the Paris agreement in each of those sectors. Total CO_2 emissions peak around 2020 and decline to about 37% below 2005 levels in 2030, for total budget of around 950 $MtCO_2$. Excluding the LNG industry, energy and industry CO_2 emissions would reduce by about 53% by 2030 below 2005 levels, for a total budget of 716 $MtCO_2$.

Achieving zero greenhouse gas emissions by 2050 – need for fast reductions by 2030

Total GHG emissions (including LULUCF) would need to peak as soon as possible and fall by 49% below 2005 levels by 2030. This translates into a reduction by 52% in 2030 compared to 2010. This is a key milestone for Western Australia – and Australia – to do their part to keep the Paris Agreement long-term temperature goal within reach and avoid the risks of escalating costs and institutional and economic lock-ins of carbon-intensive infrastructure, which will then be costly or more difficult to phase out later.

Unlike the other sectors, agriculture and waste emissions are difficult, if not impossible, to reduce to zero. Even with all the other transformational measures described in this report, remaining missions from these sectors would need to be compensated with negative emissions from the LULUCF sector.

In the LULUCF sector, native vegetation clearing and deforestation essentially need to stop by 2025. Non-CO_2 GHG emissions from the LULUCF sector would need to continue to decline slowly consistent with recent trends. A large sink in the land use sector would need to be maintained over the next decades.

With these assumptions, WA could achieve net zero emissions around 2050. Significant research is needed to evaluate trade-offs and ensure that a focus on carbon storage does not lead to unintended consequences for the agricultural economy, biodiversity, water and other elements of environmental value.

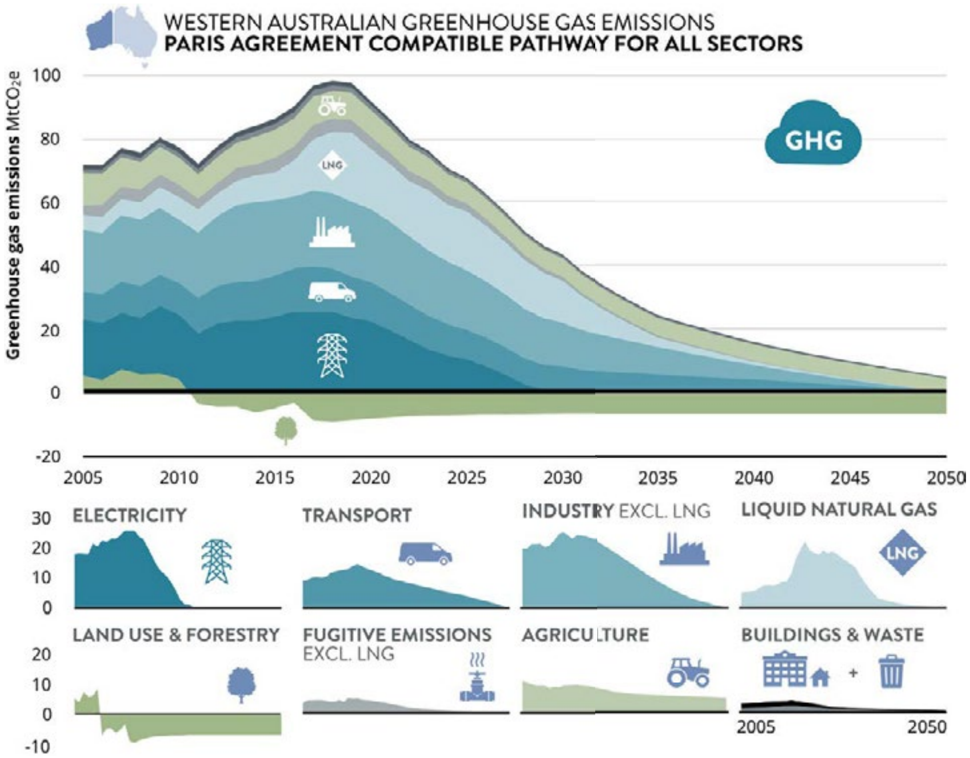

Figure 2: GHG emissions pathway for each of the sectors following a transformation consistent with the Paris Agreement in each of those sectors. Total GHG emissions peak around 2020 and decline to about 49% below 2005 levels in 2030, reaching net zero around 2050 contingent upon maintaining a large sink in the LULUCF sector. Consistent with national projections, the LULUCF sink is expected to slowly decline from recent high levels due to saturation of reforestation and other activities. It also assumes vegetation conversion (deforestation in broad terms) leading to emissions is effectively halted by 2025, which would require policy intervention. National projections assume ongoing deforestation losses.

Staying within the budget: A unique set of opportunities for Western Australia

Western Australia has prime resources that are needed to implement the Paris Agreement including first class wind and solar resources, minerals and critical materials for batteries and other technologies. Technologies associated with renewable energy, such as batteries and electric vehicles require natural resources available in Western Australia and the state is already the world leader in lithium production.

Green hydrogen offers Western Australia an option to transition the LNG industry into a renewable energy export industry as the state has a number of advantages:

- Ability to offer lower landed costs of hydrogen,
- Proximity to markets,
- Well established energy trading relationships,
- Experience in large scale energy infrastructure construction,
- Possibility of supplying hydrogen from a range of sources

Western Australia has a lot to gain from such a strategy, if such a transition is planned well, given it can move away from relying on exporting fossil fuels (LNG) towards exporting zero emissions energy

carriers (direct electricity or green hydrogen) or zero emissions energy intensive products such as zero emissions steel – with opportunities for additional manufacturing employment.

One of the key comparative advantages that Western Australia has is its geopolitical proximity to Asian energy markets, its relationship through the LNG industry with these markets, and through the export of mineral commodities. It is these advantages that have led, amongst other things, to the rise of the export on a global scale of iron ore, other minerals and LNG, but it is also this context that gives rise to a unique opportunity to effect a transition away from carbon intensive fuels to zero carbon industries.

The transition to a zero-carbon economy in Asia will require large amounts of energy, hence the market for energy carriers similar to LNG will not disappear. A number of Asian economies have - or are - developing hydrogen strategies, for a variety of different reasons, including energy security and climate change. A Paris Agreement driven decline in Asian demand for LNG would be matched by a corresponding increase in demand for clean energy carriers, in particular green hydrogen.

The key elements of the zero-carbon transition outlined here for the LNG industry involve developing new markets for green hydrogen, which requires a major ramping up of renewable energy generation capacity in regions near to the present LNG facilities. This fundamental transition in the energy market driven by Paris Agreement needs to be fully anticipated by the government based on independent scientific and objective analysis of likely market developments, rather than selective application of scenarios by industry. Unless the government has available to it independent and scientifically rigorous analyses, rather than those put forward by sectoral interests, there is a serious risk that it will fail to anticipate and miss the transition opportunities available to it, and large disruptions could occur that otherwise it would have avoided. Other Australian states appear to be moving ahead with elements of this transition strategy, which Western Australia probably should have led.

LNG sector in Western Australia: Need to transition

Emissions from the LNG industry that occur in Western Australia are estimated here to be around 22 Mt of carbon dioxide equivalent (CO_2e) per annum in 2019, about 22-25% of the state's emissions, and can be expected to approach 35 Mt CO_2e/year (30-33% of 2005 state emissions) or higher by the late 2020s if all present plans go ahead and the plants operate close to full capacity.[1]

The reference case for LNG cumulative emissions for 2018-2050, if not abated, are likely to be in the range of 1 $GtCO_2$, of the same order as the entire carbon budget for Western Australia – or equivalent to about 14 times the state's entire emissions in 2005. When the LNG is burnt offshore in power stations significantly greater missions occur but these are not counted domestically in Australia or in Western Australia. Under the agreed international greenhouse gas accounting systems used in the UNFCCC, Kyoto Protocol and the Paris Agreement, emissions are accounted for in the country in which the LNG is consumed.[2]

LNG manufacturing is an emissions intensive process and in Western Australia is estimated to have a total greenhouse gas intensity in the range of 0.39-0.74 tonnes of CO_2 equivalent per tonne of LNG ($tCO_2e/tLNG$) produced depending upon the plant, the gas reservoir being exploited and the timeframe.

1 These emissions are sometimes referred to as Scope 1 emissions.
2 These emissions are sometimes referred to as Scope 3 emissions.

The average intensity over the last 20 years is about 0.4 tCO_2/tLNG produced, with this intensity projected to increase over the next decade to close to 0.6 tCO_2e/tLNG.

There are three or four main sources of emissions: venting of CO_2 that naturally occurs in the gas reservoir which has to be extracted in the LNG manufacturing process, and is normally vented into the atmosphere; the energy used in converting the natural gas stream into its liquefied form is substantial - requiring about 9% of the energy content embedded per unit of LNG – and leads to significant CO_2 emissions; fugitive emissions from the liquefaction process plant are also significant; finally, in some cases in Western Australia natural gas is used to power pumping systems that move the gas onshore.

Apart from planned capture of CO_2 and storage in geological formations at the Gorgon plant, very few greenhouse gas mitigation measures have been announced or planned at any scale in Western Australian LNG facilities.

Under the Paris Agreement, demand for unabated natural gas in the power sector in Asia, a major source of Western Australian LNG demand, is likely to peak by around 2030 and then decline to close to zero between 2050 and 2060. This is a robust result of an analysis of 1.5°C compatible mitigation pathways assessed by the IPCC to be consistent with the Paris Agreement Long-term Temperature goal, and taking into account that Carbon Capture and Storage (CCS) is increasingly unlikely to be able to compete with renewable energy and storage. Renewable energy and storage provide a more cost-effective solution and additional benefits for sustainable development, with costs continuing to fall, while there are no observed cost improvements for CCS in power generation and incomplete capture would need to be compensated with additional, and likely expensive, efforts to remove carbon dioxide from the atmosphere. These pathways show that Paris Agreement implementation is likely to result in a substantial reduction in natural gas demand in the power sector in Asia without CCS, reducing from peak levels in 2030 to close to zero by 2050.

Irrespective of whether or not the demand reductions implicit in the Paris Agreement Asian power demand scenario above occur, the cumulative emissions of the LNG industry need to be reduced substantially and the basic options examined here - through carbon capture and storage of reservoir CO_2 and by introducing renewable energy quickly into the LNG manufacturing process - would need to be deployed in either case. In the reference case, the scale of the emission reductions would be substantially larger than in the Paris Agreement Asian power demand case.

An essential option for abatement in the LNG sector is to ensure that reservoir CO_2 is captured and stored, rather than released into the atmosphere. In Western Australia this is a very significant component of the overall emissions from LNG production. CO_2 in the natural gas reservoir has to be captured from the gas stream in any event to produce LNG, and its storage and transport to an appropriate geological storage reservoir should be well within the means of the industry to achieve. The broad approaches assumed here is that the level of CCS planned for the Gorgon plant of 80% from 2019 is phased in to all LNG plants from around 2023. This would avoid around 171 $MtCO_2e$ of emission in the Paris Agreement Asian power demand scenario and 304 $MtCO_2e$ of emissions in the reference case.

Processes in the LNG plant themselves require electricity and energy for refrigeration and these can mostly be electrified with clean renewable energy. About 9% of the energy content of LNG is used, in the form of natural gas, to manufacture the product. The corresponding CO_2 emissions can be avoided by using renewables in the LNG manufacturing process, which in large part is essentially driven by aeroderivative gas turbines. Phasing in of renewable energy so that by 2030 50% of natural gas uses in LNG manufacturing are replaced by renewable energy and 90% by 2035 and ultimately 100% by 2050 would directly avoid around 123 $MtCO_2e$ of emissions in the Paris Agreement Asian power demand scenario and close to 395 $MtCO_2e$ of emissions in the reference case. Taking into account the likely co-reduction of other liquefaction process related emissions the GHG reductions induced by introducing renewable energy in this way could be up to 184 and 441 $MtCO_2e$ respectively.

Applying the options described above to the reference case to LNG production would reduce the peak emissions from Western Australia LNG manufacturing to around 300% above 2005 levels from a projected 600% increase by the mid 2020s in the case of no policy action. This would bring emissions back to about 176% above 2005 levels in 2030, 16% below 2005 levels in 2040 and 46% below in 2050. Zero CO_2 emissions would be needed by 2050 to be Paris Agreement compatible.

Under the Paris Agreement Asian power demand scenario the decline in natural gas demand from 2030 combined with the mitigation options discussed (carbon capture and storage, electrification), LNG related emissions in 2030 would be about 175% above 2005 levels, around 80% below by 2040 and approach zero by 2050.

To achieve these emissions reductions in the absence of a carbon pricing system would require the state government to introduce binding regulatory requirements on the LNG industry to meet or exceed greenhouse gas intensity benchmarks consistent with these emission reductions or conditions, or more specific technology standard based requirements that would apply to both existing and planned facilities.

Key conclusions for climate policy in Western Australia

It is critically important to take a whole of economy approach to a climate strategy and take into account the role of the power sector in decarbonising end use sectors. Our study confirms the importance of **fast reductions in the short and medium term.**

It is key to decarbonise the power sector via a fast transition to renewable energy, taking advantage of the vast potential and low and falling costs of renewable energy and storage technologies and the opportunities for a range of sectors. Every sector will need to contribute to reducing emissions. This would also contribute to achieving other objectives, such as reduced air pollution, protection of biodiversity, sustainable economic development and high-quality employment including in rural Western Australia. Building agricultural resilience to climate change through changes to management practices and regenerative agriculture approaches will help farming communities to adapt to climate change. This would also contribute to mitigation by increasing the storage of carbon in agricultural landscapes, whilst minimising adverse unintended side effects.

The following are conclusions relevant for policy in Western Australia:

- **The need to develop a whole of the economy roadmap and strategy and detailed sectoral roadmaps and strategies in line with Paris Agreement**. This strategy needs to be based on the Paris Agreement Long Term Temperature goal and the importance of **limiting warming to 1.5°C** and the urgent need to **peak emissions and reduce them by around half by 2030**.
- **Strategies and roadmaps need to be based on Paris Agreement scenarios and analysis, that should be developed in a process with the broad participation of all stakeholders – industry and trade unions, civil society, as well as regional and local governments**. Use of non-Paris Agreement compatible energy scenarios in government planning and economic projections risks blinding government to the inevitable policy transitions that need to be made.

- **The pathway to zero is critical and it is dangerous to focus only on an endpoint of net zero emissions by 2050.** The path to get there matters – both in terms of the cumulative emissions and their impact on temperature, as well as in terms of the technical and economic transition pathways and policy implications for the near future.
- **Energy and industry are the key sectors that need to be addressed for full decarbonisation.**
- **Overall and sectoral strategies and roadmaps need to take into account the critical role of electricity generation transitioning to renewable energy and becoming fully decarbonised by the 2030s,** to contribute to the decarbonisation of end use sectors through direct or indirect electrification.
- **There will be a large increase in electricity demand and therefore a massive ramping up of renewable energy capacity – solar and wind – and this needs to be factored in when planning the transition in electricity generation, with clear targets and management of grid development, distribution systems and market regulation, as well as infrastructure for microgrids and off-grid solutions.**
- **Strategy of "sector coupling"[3] not only helps other sectors such as transport and industry reduce emissions and decarbonise, but also helps to provide grid stability with variable renewable energy – wind and solar – through battery or other storage and demand side management**. Sector coupling helps, for example, people to integrate successfully their electric vehicle (transport sector) and charging via home-based photovoltaics (PV) and battery storage systems (buildings) with the power grid as a whole (energy and industry) whilst boosting the reliability and efficiency of the entire electricity distribution system (whole of economy).
- **Sectoral strategies and roadmaps need to lead to the development of clear mid-term sectoral targets and policies to create incentives and develop the necessary infrastructure** that are consistent with a Paris Agreement sectoral pathway, for example:
  - **Electricity generation**: **one third renewable share by 2025, 90% renewable by 2030 and 100% in the early 2030s.** This means phasing out coal before 2030 and gas shortly afterwards.
  - **Industry: increase efficiency, reduce emissions by 30% in 2030 and 100% in 2050**
  - **Transport: prepare for rapid roll out of electric vehicles and trucks based on batteries and renewable hydrogen powered fuel cells (FCEV) by developing infrastructure** such as charging stations for electric vehicles or hydrogen fuel cell trucks, and through government procurement and supply policies, establish targets for modal shift to public transport and support more cycling and walking, and replace bus fleets with electric and/or FCEV buses.
  - **Forestry**: **halt deforestation as soon as possible and but not later than 2025, develop and secure biological sinks while preserving biodiversity, taking into account climate change.**

It is important to address open research questions in a targeted way, ensuring knowledge is developed and shared broadly with stakeholders, and draw upon, and mobilise, the extensive capabilities of the West Australian research community through the establishment of innovative research funding and coordination centres and/or mechanisms**.** This is important for example for research on the **role of the land-use sector** and how it can contribute to CO_2 uptake and **negative emissions** either through the sustainable use of biomass and carbon capture and storage or through enhancing and sustaining sinks in forests and ecosystems.

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3 Integrating a renewable energy system, connecting energy using sectors such as buildings, transport and industry with the power sector. See for example the discussion at https://www.irena.org/energytransition/Power-Sector-Transformation/Sector-Coupling

The necessity to transform the state's economy from its present energy and carbon intensive configuration to a renewable, zero carbon one poses unique challenges (and provides unique opportunities). To meet this challenge, a number of countries have introduced, or are planning to introduce comprehensive climate change legislation, including mechanisms for establishing legally binding carbon budgets for a period such as five years that are ratcheted up based on scientific and technical assessments. They are also planning to provide appropriate legislative powers and capacity to manage the transition.

The Western Australian government should seriously consider introducing comprehensive climate change legislation, such as a "zero carbon" law. There are many things that the state can do to advance the policy agenda needed to halt the growth of emissions and begin the transition towards zero that is required to protect the state from the worst effects of climate change. Introducing legislation specially designed for this purpose appears to be of critical importance.

INTRODUCTION

This report provides key carbon budget and emissions pathway benchmarks for the energy and industry sectors for Western Australia that are consistent with the state playing its role in national and global efforts to limit global mean warming to 1.5°C above pre-industrial levels. The Paris Agreement's long-term temperature goal (LTTG) aims to limit global average warming to 1.5°C above pre-industrial levels[4]. With the present level of warming at about 1°C above preindustrial levels, limiting warming to 1.5°C will require urgent and rapid action globally. The IPCC Special Report on 1.5°C (SR15) has shown that this remains feasible provided action is initiated very soon. Main messages from the IPCC (2018a) SR15 include:

- Climate Change poses a severe threat, with impacts and risks being significantly lower at 1.5°C compares to 2°C or higher temperature increases above pre-industrial levels.
- Avoiding these severe risks is still feasible, but requires cutting global greenhouse gas (GHG) emissions by 45% -about half - by 2030 compared to 2010 levels, and reaching zero CO_2 emissions from all sources by 2050 globally, and net zero GHG emissions globally by 2070.

Whilst these global reductions levels are not applicable exactly to each national and sub-national context they do provide a basic orientation for policy and the emission pathways needed to meet the Paris Agreement: a 45% reduction in energy and industry CO_2 emission or GHG emissions by 2030 compared to 2010 corresponds to about a 40% and 45% reduction compared to 2005 levels for Western Australia respectively.

Because of the key role of energy and industry CO_2 emissions to achieve the Paris Agreement temperature goal, the carbon budget for Western Australia will focus on what the state's fossil (energy and industry) CO_2 emission limits need to be across all sectors of the economy and energy system, in order to be compatible with its contribution to meeting the Paris Agreement's 1.5°C limit. In addition, the study looks at implications for the overall greenhouse gas pathway to achieve net zero emissions by 2050, in line with Paris Agreement and the WA State Government's 'aspirational' objective, including necessary reductions in non-energy sectors (agriculture and waste), and the role of the land use sector to compensate for remaining GHG emissions, in particular from agriculture. The study will provide key conclusions regarding necessary CO_2 and total GHG reductions by 2030 and key sectoral strategies and policies across all sectors, taking into account Western Australia's unique situation, responsibility and opportunities.

To estimate a carbon budget and emissions pathways for Western Australia consistent with necessary global and national efforts to limit warming to 1.5°C, we use multiple lines of evidence from the scientific and technical literature, making use of state-of-the-art analysis and modelling of technically and economically feasible and plausible emissions pathways and technologies. We also consider sustainability constraints (for example limits to the use of biomass and negative emissions technologies) and economic considerations (we aim to minimise costs).

The requirement for deep carbon dioxide reductions and zero emissions means that all emitters - both large and small - will need to take part. It is argued by some in Australia that because it is a small global emitter - about 1.1% to 1.4% of global emissions - then its actions are irrelevant and not necessary.

4 Article 2.1 of the Paris Agreement (PA) defines its long-term temperature goal (LTTG) as "[h]olding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change" (UNFCCC 2015).

However, small emitters, under 2% of global emissions of CO_2, added up to close to 30% of global CO_2 emissions in 2017, showing that achieving zero CO_2 emissions, or even very deep reductions, cannot be achieved without comparable action by all smaller emitters. Western Australia, with an independent energy system and unique opportunities and resources, as well as interest in achieving the 1.5°C limit to protect its unique natural resources, has a special responsibility to act in line with what these necessary efforts.

The **focus of the study is on domestic emissions**, and analyse specifically how much the **growing LNG sector** is contributing to these emissions, but also how it has to and can also contribute to necessary emissions reduction. We will provide an **outlook on the current large carbon footprint and the opportunities for Western Australia** to instead contribute to global emissions reductions through exporting zero emissions energy carriers and products.

PARIS AGREEMENT LONG TERM TEMPERATURE GOAL AND 1.5°C WARMING LIMIT

The long-term temperature goal (LTTG) of the Paris Agreement (PA) is

> *"[h]olding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognising that this would significantly reduce the risks and impacts of climate change"* (UNFCCC 2015, Art. 2.1 PA).

The legally binding long-term temperature goal is, by design, both a substantive and legal strengthening of the previous international goal of holding warming below 2°C, agreed in Cancun at UNFCCC COP16 in 2010[5]. This goal is to be operationalized through the Agreement's different enabling elements, in particular Article 4.1 which establishes a timetable for peaking global GHG emissions as soon as possible, rapidly reducing these, with zero GHG emissions to be achieved globally in the second half of this century. The timetable for these global reductions and timing of achieving zero GHG emissions is to be based on the best available science.

The Paris Agreement LTTG requires a substantially lower level of warming be achieved than the former 2°C Cancun goal, which is still often referred to in Australia. Scientifically, the 2°C Cancun goal is interpreted as emission pathways that have a likely (66% or higher) probability of holding warming below 2°C. Peak 21st century warming in the published mitigation pathways consistent with the 2°C Cancun goal is 1.7-1.8°C and generally these pathways have less than a 50% probability of warming below 1.5°C by 2100[6].

The specific language of the Paris Agreement LTTG means warming should not rise above a level <u>well below</u> 2°C – which means peak 21st century warming needs to be lower than 1.7-1.8°C achieved in

5 UNFCCC 1/CP.16 The Cancun Agreements, Paragraph 4: "Further recognizes that deep cuts in global greenhouse gas emissions are required according to science, and as documented in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, with a view to reducing global greenhouse gas emissions so as to hold the increase in global average temperature below 2 °C above preindustrial levels, and that Parties should take urgent action to meet this long-term goal, consistent with science and on the basis of equity; also recognizes the need to consider, in the context of the first review, as referred to in paragraph 138 below, strengthening the long-term global goal on the basis of the best available scientific knowledge, including in relation to a global average temperature rise of 1.5 °C"

6 Note that in the underlying scientific literature, probabilities of holding warming below a certain level for a particular emissions pathway consider uncertainties in the global carbon cycle and climate system. In this context, for example a "median" warming level associated with a particular global emissions pathway means that 50% of a large collection of climate/carbon-cycle models shows warming above, and 50% shows warming below, the specified warming level, for that particular emissions pathway.

pathways consistent with the 2°C Cancun goal with a likely probability (66% or higher probability). The Paris Agreement LTTG excludes interpretations that would have warming rise above a level well below 2°C before declining to a level well below 2°C by, for example, 2100. The latter appears to be a common misunderstanding in the Australian policy debate. In addition, it is important to note that the only temperature limit referred to in the Paris Agreement is 1.5°C above preindustrial levels.

The IPCC (2018a) Special Report on Global Warming of 1.5°C (IPCC SR15) has assessed the impacts of global mean temperature increase of 1.5°C above pre-industrial levels, as well as the impacts avoided compared to higher levels of warming including 2°C. The report details the extent of global warming so far and the risks and impacts for both natural and human systems.

The projected risks on human and natural systems are vast, and the risk levels take a massive leap between 1.5°C to 2°C warming above pre-industrial levels (Climate Analytics 2019a). One example, is that limiting warming to 1.5°C degrees could mean 420 million fewer people would be exposed to exceptional heatwaves in contrast to 2°C global warming (IPCC 2018a). Risks of species losses and extinction are less likely in 1.5°C scenario compared to a warmer climate of 2°C (IPCC 2018a). Keeping warming well below 1.5°C is essential to prevent these adverse impacts.

The impacts of climate change are already being experienced in Western Australia, and the south-west is particularly vulnerable to climate change impacts. The latest data shows average annual temperatures will increase and annual rainfall is declining in the southwest, the intensity and duration of hot spells are projected to rise and increase in frequency (Dept Primary Industries and Regional Development 2019). Modelling suggests the drying trend will continue, with higher risks of droughts and bushfires (Dept Primary Industries and Regional Development 2019). Changes in climate has negative repercussions on the agricultural sector and water supply. Western Australia has experienced sea level rise twice the rate of the global average (Climate Commission 2011). Rising sea levels has created severe risks of coastal erosion in Western Australia (Seashore Engineering 2019).

Western Australia is an internationally recognised biodiversity hotspot. Iconic flora and fauna, such as the quokka, Carnaby's cockatoo and tingle trees, in addition to the Ningaloo reef are at risk from climate change (Climate Commission 2011). The erosion and decline of our native animals, reef, and beaches, also erodes at the identity and culture of the Western Australian. It impacts the quality of life and the drivers of Western Australian tourism. Western Australia has reached a critical crossroad and needs to play its part in climate change mitigation.

Already today marine heatwaves are being observed, such as the record marine heatwave of 2011, with unprecedented sea temperature levels and warming anomalies of 2-4°C persistent for more than 10 weeks, which led to massive coral bleaching in the Ningaloo and Shark Bay region and possibly permanent impacts on algae and marine seagrass of and around Shark Bay (around 36% of the bay's seagrass meadows died off) as well as further negative impacts on other species along the food chain.

Global mitigation pathways for the 1.5°C limit – it matters how we get to net zero

Given the strengthening of the long-term temperature goal in the Paris Agreement, compared to the Cancun Agreements, emissions pathways compatible with the PA must increase substantially both the margin and likelihood by which warming is held below 2°C, and simultaneously satisfy the 1.5°C limit.

The IPCC (2018a) Special Report on 1.5°C (SR15) adopted and published in October 2018 has assessed a new generation of mitigation pathways based on Integrated Assessment Models that examine the technical and economic feasibility of holding warming below 2°C and in particular limiting warming to 1.5°C, simultaneously considering many dimensions of sustainable development. The IPCC (2018a)

SR15 currently provides the "best available science" for operationalising the LTTG and defining key elements of the emission pathway in Article 4.1, because it provides the most comprehensive and up-to-date assessment of mitigation.

The IPCC (2018c) SR15 Summary for Policymakers (SPM) defined 1.5°C compatible mitigation pathways as those with no- or limited overshoot above 1.5°C warming:

- "no- overshoot"- limit median global warming to 1.5°C throughout the 21st century without exceeding that level
- "low-overshoot" - a brief and limited overshoot (<0.1°C) with median peak warming below 1.6°C around the 2060s and drop below 1.5°C by the end of the century (around 1.3°C warming by 2100).

The IPCC (2018a) SR15 is very clear about the increases in climate risks between 1.5°C and 2°C, which reinforces the clause of the LTTG that limiting warming to 1.5°C "would significantly reduce the risks and impacts of climate change". It is important to note that the 2°C Cancun goal ("hold below 2°C") pathways discussed in much of the literature and in the IPCC reports predating the Paris Agreement do not provide a perspective on limiting the temperature increase to 1.5°C.

In policy terms, if the 2°C goal were to be used as a guide, the resulting 2030 emissions levels would be far above those in 1.5°C-compatible pathways, as shown in IPCC SR15, so that the 1.5°C limit would be out of reach, unless extreme carbon dioxide removal levels are achieved by 2050, which the Special Report does not deem feasible for technical, economic and sustainability reasons (Wachsmuth, Schaeffer, and Hare 2018).

The IPCC (2018a) SR15 clearly shows that rapidly reducing global GHG emissions by 2030 – by around 45% compared to 2010 (see Figure 3) – is a key milestone towards limiting warming to 1.5°C and avoiding the risks of escalating costs and institutional and economic lock-ins with carbon intensive infrastructure, which will then be costly or more difficult to phase out later. Delaying emissions reductions would reduce the flexibility of future response options and increase the reliance on negative CO_2 emissions - taking CO_2 from the atmosphere – using Carbon Dioxide Removal (CDR) technologies. All pathways require a rapid decarbonisation of energy systems by 2050, with global anthropogenic CO_2 emissions at net zero by around 2050, and total GHG emissions zero globally by around 2070. Figure 3 below provides an illustration of these pathways.

A 45% reduction in global GHG emissions by 2030 compared to 2010 corresponds to an emissions level of 25-30 $GtCO_2eq$/year by 2030. Excluding pathways that exceed the CDR sustainability limits identified in the IPCC SR15 implies faster reduction of greenhouse gas emissions by 2030 – to a level of 25-28 $GtCO_2eq$/year (Climate Analytics 2019e).

Full implementation of the current Nationally Determined Contributions (NDCs) corresponds to an emissions level of 52-58 Gt CO_2eq/year, nearly twice as much as the 1.5°C compatible pathways imply. The IPCC (2018a) SR15 therefore concludes that the ambition level of the current Paris Agreement national emission commitments – NDCs - are not consistent with limiting global warming to 1.5°C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030. The Climate Action Tracker (2018b) shows this pathway reflecting the ambition level of current NDCs leads to warming reaching 3°C by 2100. It should also be noted, the Climate Action Tracker estimates that with current policies (as of December 2018), the median warming is projected to result in a rise of 3.3°C by 2100 (Climate Action Tracker 2018b). Whilst 3°C warming is itself likely to be extremely damaging, and catastrophic to many systems, there is at least a one in 10 chance (10%) that the current policy pathway could lead to global warming reaching, or exceeding, 4.5°C by 2100 (Climate Action Tracker 2018b).

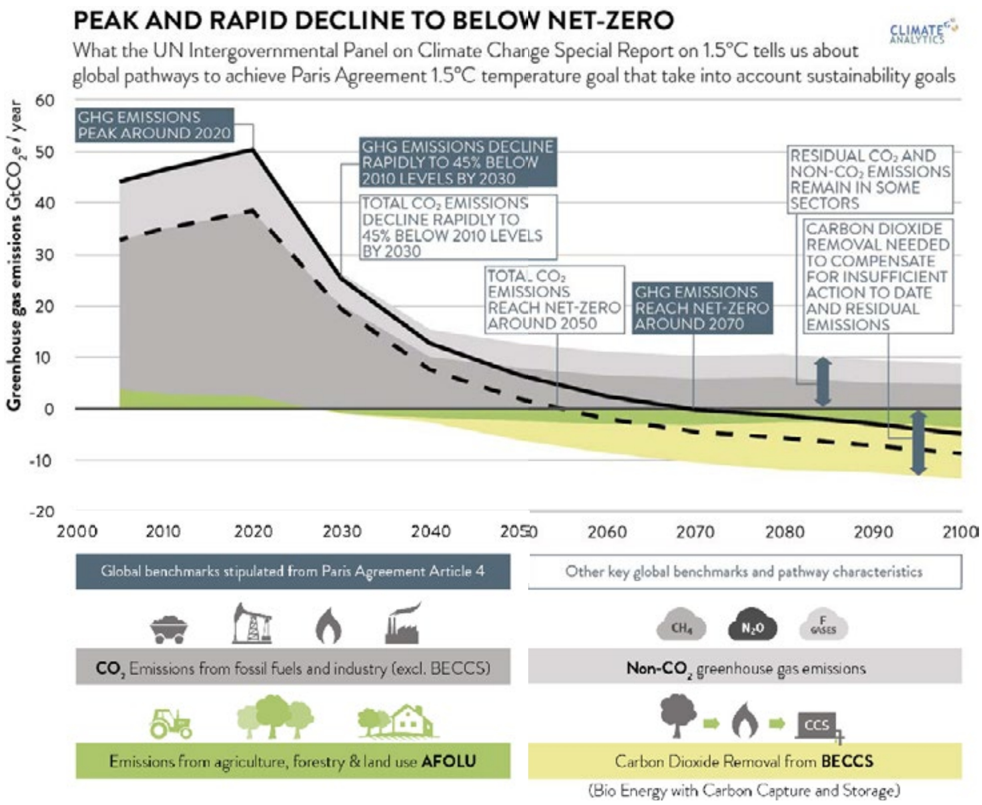

Figure 3: Illustration of the three benchmarks in Paris Agreement Article 4.1 for operationalisation of Article 2.1 (dark blue boxes) and global decarbonisation benchmarks (white box). This representative pathway is the median across all 1.5°C-compatible pathways from the IPCC (2018a) SR15 that reach levels of Carbon Dioxide Removal (CDR) below the upper end of estimates for sustainable, technical and economic potential around 2050 from SR15 in the sector of Agriculture, Forestry and Land-Use (AFOLU), as well as via Bioenergy combined with Carbon Capture and Storage (BECCS)[7]. Source: (Climate Analytics 2019e).

Whole of Economy Approach to net zero emissions – Transformations across all sectors

The IPCC SR15 outlines the range of mitigation strategies that can achieve the emissions reductions required to follow the pathways consistent with the PA LTTG described above. All pathways require a rapid decarbonisation of energy systems, with global net anthropogenic CO_2 emissions declining by about 45% from 2010 levels by 2030 and reaching net zero around 2050. In addition, substantial reductions of emissions of non-CO_2 greenhouse gases such as methane and nitrous oxide from agriculture, industry and other sectors are needed, and as well as a phase-out of HFCs (Climate Analytics 2019e).

7 All emissions and removals where calculated from the median emissions levels across the 46 pathways in the SR15 scenario database that are 1.5°C compatible, that satisfied the limits to CDR mentioned, and that reported data for all variables included here Source: SR15 scenario database (IIASA 2018) https://data.ene.iiasa.ac.at/iamc-1.5c-explorer

Achieving the Paris Agreement Long-term Temperature Goal requires transformative systemic change across the whole economy and society that is integrated with sustainable development to achieve the required deep cuts in GHG, and in particular CO_2 emissions. Carbon dioxide emissions from energy and industry need to reach net zero across all sectors of the economy by around 2060 globally and by around 2050 for a highly developed country like Australia. In addition, steep reductions in deforestation are needed.

The key characteristics of 1.5°C consistent global sectoral transformations based on the scenarios assessed by the IPCC are the following (Climate Analytics 2019e).

- Fully decarbonised primary energy supply by mid-century;
- Large energy demand reductions across all end-use sectors by 2030;
- Large reductions of fossil fuel use, in particular coal (-64% by 2030, -75% by 2050) and oil (- 11% by 2030, -60% by 2050);
- For natural gas, scenarios show a large range of changes by 2030, up to 20% increase and a 25% decrease, and up to a 55% reduction by 2050 with some models showing about the present levels (5% above 2010).
- Lower reductions in coal and natural gas correspond to those scenarios where it is assumed there is a high level of carbon capture and storage (CCS) deployment, which at present seems unlikely given the reducing costs of renewable energy and storage technologies.
- Rapid increase in the use of renewable energy;
- Bioenergy is used in many 1.5°C pathways, both with CCS (BECCS) and without, with uncertainties regarding limits to sustainable use
- Full decarbonisation of electricity generation by 2050, mainly through increased use of renewable energy reaching shares of over 50% by 2030 and over three-quarters by 2050 globally, and phase-out of coal by 2040 globally.
- Electrification of end-use sectors (transport, buildings, and some industry processes) and decarbonisation of final energy other than electricity, for example through the use of biofuels, hydrogen or other zero emissions energy carriers (aviation, shipping, and some industry processes)
- Net-zero land-use emissions between 2025 and 2040, requiring a steep reduction in deforestation and the adoption of policies to conserve and restore land carbon stocks and protect natural ecosystems.
- By 2050, negative emissions will already need to be on a multi-Gigatonne per year scale.

It is important to understand that all these sectoral transformations are needed – it is not a choice of one or the other and there is no room for offsetting one against the other.

Main energy transformation features of 1.5°C compatible pathways

Rapid reductions in energy demand across all sectors are fundamental for 1.5°C compatible pathways that also limit negative emissions through carbon capture technologies. The 1.5°C compatible transformation will require significant additional investment worldwide in low-emission infrastructure as well as redirection of financial resources from carbon-intensive investments toward low-emissions infrastructure.

A rapid and almost complete global phase-out of coal by 2040 in the power sector is a universal message from the new scenario results with many regions in particular OECD phasing out coal much earlier (around 2030/31). The share of coal for electricity generation (without CCS) shows a steep reduction in 1.5°C compatible pathways to 80% below 2010 levels by 2030 (Climate Analytics 2019d).

Substantial reductions in oil use by 2050 are also projected, coming in at around 30-80% lower than 2010 levels. By 2030, oil would need to decline by up to 35% below 2010 levels, but some models show an *increase* of up to 5%, reflecting assumptions about a lower and slower uptake of electric vehicles and transport than in other models.

For natural gas globally, 1.5°C compatible scenarios in line with the Paris Agreement long-term temperature goal assessed by the IPCC show a large range of changes by 2030, but have a median reduction of about 13% below 2010 levels, and by 2050 a 58% reduction compared to 2010 levels for those pathways that do not deploy carbon capture and storage (CCS). A high level of carbon capture and storage (CCS) deployment is very unlikely given the rapidly reducing costs of renewable energy and storage technologies. The use of CCS as a mitigation option in many scenarios is assessed on the basis of capacity factors in the order of 80–90%, which is not likely to be achieved in combination with a high penetration of variable renewables. Due to the high marginal cost of electricity production, CCS plant would be pushed out of operation first (Brouwer, 2015).

Figure 4 shows the projected demand for natural gas for electricity generation without CCS in the Asian region for 1.5°C compatible scenarios, which are assessed by the IPCC to be in line with the Paris Agreement long-term temperature goal. Demand for gas in the power sector will likely peak around 2030 and go down dramatically. These 1.5°C compatible pathways are compared to the IEA B2DS (below 2°C scenario) from 2016 which is not fully Paris Agreement compatible. This pathway peaks higher in 2030 but still drops quickly afterwards. A more recent scenario published by the IEA, the Sustainable Development Scenario (SDS) is also far from Paris Agreement compatible and has an even higher level of natural gas use after 2030 than the B2DS scenario. The SDS scenario substantially exaggerates the amount of natural gas used in the power sector and is an outlier compared to model assessments of limiting warming to 1.5°C. The SDS natural gas use in the Asian region is still rising in 2040 unlike any other of the published 1.5° compatible scenarios. The inconsistency between the IEA SDS scenario and the Paris agreement's 1.5°C temperature limit has been acknowledged by the IEA in its recent 2019 World Energy Outlook. The agency has signalled it will do further the work on the subject8. Whilst industry has chosen to emphasise the IEA SDS scenario this is the obvious reasons as the continued growth of natural gas aligns very well with their interests. Government, stakeholders, financial institutions and others however need to look carefully at scenarios which are fully Paris compatible to understand where the world may head as well as where it needs to go and therefore to be better able to understand and confront the transition challenges ahead.

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[8] See WEO 2019, page 30: "The trajectory for emissions in the Sustainable Development Scenario is consistent with reaching global "net zero" carbon dioxide (CO2) emissions in 2070. If net emissions stay at zero after this point, this would mean a 66% chance of limiting the global average temperature rise to 1.8 degrees Celsius (°C) above pre-industrial levels (or a 50% chance of a 1.65 °C stabilisation). In the light of the Intergovernmental Panel on Climate Change Special Report on 1.5 °C, we also explore what even more ambitious pathways might look like for the energy sector, either via "net negative" emissions post-2070 or by reaching the "net zero" point even earlier" at https://www.iea.org/weo2019/

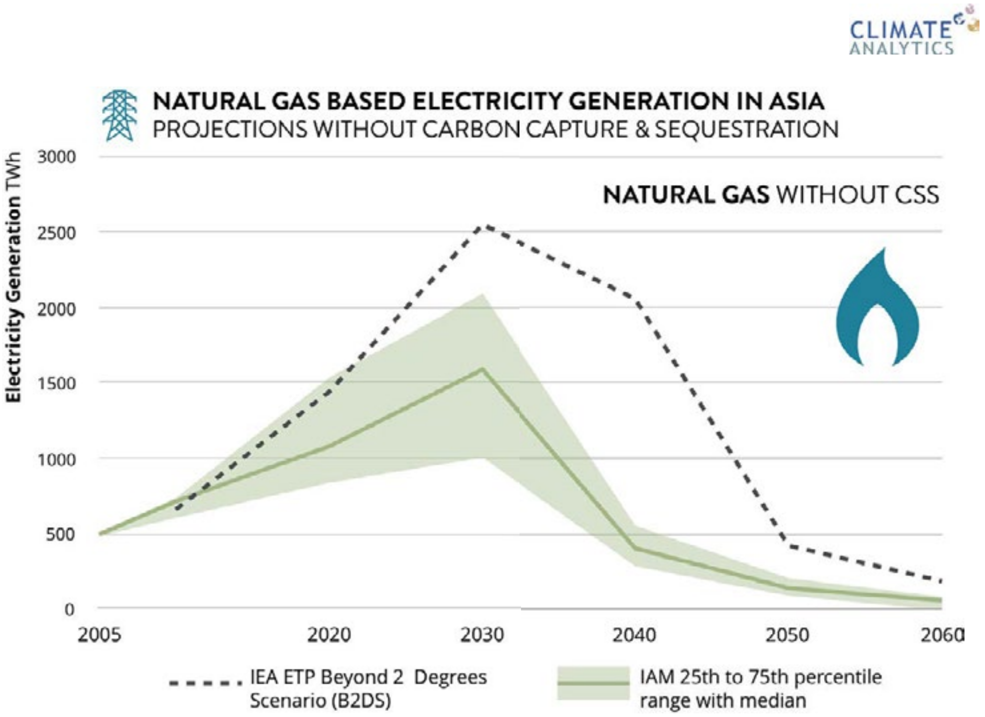

Figure 4: Electricity generation from natural gas without CCS. Shown are the median for PA-compatible Integrated Assessment Models (IAM), as well as the results from the IEA ETP B2DS used in the current study for some of the underlying pathways, both for the Asia region. Source:(Climate Analytics 2019c). The relative cost of CCS makes deployment of this technology unlikely in our assessment. The earlier IEA B2DS scenario shows a much higher natural gas demand than more recent fully Paris compatible scenarios.

The IPCC assessment of mitigation pathways clearly shows (Climate Analytics 2019e). that the continued use of natural gas would only be consistent with the Paris Agreement temperature goal if used with carbon capture and storage (CCS). Even then it would play only a small role in electricity generation by 2050 at around 8% of global electricity generation. Due to incomplete CO_2 capture rates, the use of gas with CCS would have to be balanced out with additional carbon dioxide removal (CDR). While the political, economic, social and technical feasibility of solar energy, wind energy, and electricity storage technologies has improved dramatically over the past few years, with costs dropping rapidly over the last few decades with corresponding growth trajectories much faster over the last years than expected (IRENA 2019b), CCS in the electricity sector has not shown similar improvements, with costs of CCS not coming down over the last decade. Together with more limited co-benefits than renewable energy, this cost trend makes these technologies increasingly unlikely to be able to compete with renewable energy, which is not yet reflected in many energy-economy models (Climate Analytics 2019e).

An important conclusion from this analysis is that sooner or later Western Australia will have to transition away from exporting natural gas, given CCS is increasingly unlikely to be able to compete with renewable energy and storage due to incomplete capture rates, no observed cost improvements in contrast to continuing cost improvements for renewable energy and storage technologies, as well as large additional benefits of renewable energy for sustainable development.

In all scenarios that limit warming to 1.5°C, renewable energy (excl. biomass) has to be ramped up quickly to supply 50-65% of total primary energy by 2050[9], displacing fossil fuels from traditional markets for power generation, mobility and heating. Renewables reach a particularly high share in electricity supply of 45-65% in 2030 and 70-85% in 2050. The political, economic, social and technical feasibility of solar energy, wind energy, and electricity storage technologies has improved dramatically over the past few years, with costs dropping rapidly over the last few decades with corresponding growth trajectories much faster than expected (IRENA 2019b). These fast developments enable more stringent near-term mitigation than currently planned.

The decrease in use of fossil-fuels and increase in renewables is associated with a major shift in investments, where global annual investments in low-carbon energy technologies overtake fossil investments by around 2025 in 1.5°C pathways (IPCC 2018b). The IPCC (2018a) Special Report shows that annual investment in low-carbon energy technologies and energy efficiency increase rapidly by a factor of 4-5 by 2050 compared to 2015. Compared to 2°C pathways, total energy-related investments in both supply and demand side increase by 12%.

9 Information on this was included by IPCC authors in the final draft of the SPM , but was not included in the final government-approved SPM. This data can however be extracted from the publicly available scenario data in IPCC's online scenario database: (IIASA 2018) https://data.ene.iiasa.ac.at/iamc-1.5c-explorer/

ROLE OF LAND SECTOR IN 1.5°C PATHWAYS

Limiting warming to 1.5°C will require global-scale transitions in global and regional land use, and in agricultural practices. In the near term, a focused effort will be needed to rapidly reduce and then reverse CO_2 emissions from land use. The majority of 1.5°C-compatible pathways achieve net zero land use emissions between 2025 and 2040, requiring a steep reduction in deforestation and the adoption of policies to conserve and restore land carbon stocks and protect natural ecosystems. By 2050, negative emissions will already need to be on a multi-Gigaton scale. This will likely require the deployment of bioenergy with carbon capture and storage in addition to reforestation, afforestation, and other land-based activities for sequestering carbon, such as land restoration and improved soil management (Climate Analytics 2019e).

Limiting warming to 1.5°C will require marked reductions in non-CO_2 emissions in the agriculture sector, even though these cannot be reduced to zero. Substantial reductions can be achieved through enhanced agricultural management and best practice farming on the supply side (for example, manure management, improved livestock feeding practices, and more efficient fertiliser use), as well as through demand side mitigation opportunities such as dietary shifts to healthier, more sustainable diets and measures to reduce food waste (Climate Action Tracker 2018c, 2019c).

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WA ECONOMY AND ITS CONTRIBUTION TO 1.5°C – CHALLENGES AND OPPORTUNITIES

Economy and Emissions profile

Western Australia's economy relies heavily on the mining of minerals and petroleum/gas, producing a significant proportion of the world's minerals and petroleum commodities. Mining currently generates 30% of Gross State Product (GSP) (in 2017-2018) and about 8% of employment (in 2018-2019). In terms of employment, the largest sectors are services industries (including retail, trade, healthcare, social assistance, and tourism) (72%), followed by construction (9%) in 2018-2019 (Government of Western Australia 2019a).

By far the biggest component of the mining industry is the mining and export of iron ore with AU$ 78.2 billion sales in 2018-2019 (share of 54% of minerals and petroleum sales), followed by LNG with AU$ 29 billions of sales (share of 20%). Both sectors have grown strongly over the past years, with Western Australia now being the source of 14% of global LNG exports (Government of Western Australia 2019b).

The heavy dependence on the resource extraction and export is reflected in the sectoral composition of GHG emissions: In 2017, more than 30% of all greenhouse gas emissions came from the mining sector (including gas extraction and processing, in particular LNG processing) – a bit more than the electricity supply (29%), and followed by manufacturing with 17% of greenhouse gas emissions, and agriculture with a share of 11%. The mining sector emissions have increased sharply since 2015, mostly due to the sharp increase in LNG processing and related emissions.

In 2017, Western Australia contributed 16.6% to Australia's total national emissions (all GHG, with LULUCF) and emissions have increased by 23.5% since 2005 (DEE 2019)[10], despite a reported decrease in emissions in the land use sector (LULUCF) from being a source of 5.3 Mt to being a sink of 8.8 Mt in

10 AGEIS trend data result in different share and increase, due to different LULUCF data – KP categories.

2007[11]. **Without the highly fluctuating and uncertain LULUCF emissions, Western Australia's GHG emissions contribute 17.6% to national emissions and have increased by 47% since 2005.**

Energy and industry (fossil fuel) CO_2 emissions are by far the most important current source of emissions and are the largest source of emissions increases. CO_2 emissions account for 83% of all WA GHG emissions excluding LULUCF, with almost all of these from fossil fuel combustion (which is 84% of total CO_2 emissions without LULUCF). The second largest source of CO_2 emissions are fugitive CO_2 emissions mostly from venting during gas extraction and processing (contributing 11% to total CO_2 emissions), and a smaller share of 4% from industrial processes (for example cement production). In addition, fugitive methane emissions are also related to extracting and use of fossil fuels with a share of 5% of total GHG emissions without LULUCF. **Together, fossil fuel energy and industry related CO_2 and methane (CH_4) emissions add up to a share of 89% of total GHG emissions (without LULUCF).**

Because of the large share of emissions from energy and industry, in particular energy industry (mainly LNG processing), **Western Australia contributes 20% to the national energy and industry (fossil) CO_2 emissions and these have increased even more than overall GHG - by 60% since 2005. (See** Table 2**).**

As discussed earlier, decarbonising energy and industry sectors and reaching net zero carbon emissions from fossil fuel and industry across all sectors of the economy by around 2060 globally and by around 2050 for a highly developed country like Australia is a key strategy to achieve the Paris Agreement temperature goal. This will be achieved through eventually phasing out all fossil fuels not only for power generation but for all other industry processes. This is why this study focuses on the carbon budget and emission pathways for fossil fuel and industry related CO_2 emissions.

The largest emitting sector in Western Australia is industry with a share of 48% of CO_2 emissions (excluding LULUCF) in 2017 (see Figure 5 and Figure 6). It is also the sector with the highest increase since 2005 - by 74% since 2005. Here we follow the sectoral definition used in greenhouse gas accounting (see Annex I for further details) and include the following categories under the Industry sector:

- direct combustion in manufacturing and other industry sectors, including mining,
- direct combustion in energy industry (in particular LNG processing),
- fugitive emissions (CO_2 and Methane) from energy industry (that is from coal mining, as well as extraction, production and processing of gas), and
- industrial processes (mostly CO_2 emissions from cement and ammonia production) and product use (non-CO_2 emissions).

Within industry, it is the fast ramping up of LNG processing that has contributed most to the increase of emissions. It alone has a share of 18%, and CO2 emissions have tripled since 2005.

Electricity use in industry is not accounted for under the industry sector, but under the electricity generation sector, which is the second largest sector (31% share, increase of 44% since 2005), followed by transport (17% share, increase of 61% since 2005). The buildings sector contributes 2% of direct CO_2 emissions, and these have increased by 62% since 2005. Indirect emissions from the building sector due to electricity use are accounted for under the electricity generation sector.

11 This is based on the published state inventory. However, there are uncertainties around LULUCF data. Here we look at the emissions profile without LULUCF.

Other, non-energy or industry related emissions – mainly from agriculture – need to be reduced as well, but are not expected to be reduced to zero. In Western Australia, about half (51%) of the other emissions (not fossil fuel and industry related CO_2 emissions) are from agriculture (methane and nitrous oxide emissions) which makes up 10% of total WA GHG emissions. This is the only sector where emissions have actually decreased (by 12% since 2005). Industrial processes and product use contribute 8% to other GHG emissions, through emissions from use of F-gases, which can largely be phased out.

Table 2 shows emissions from these sectors in the past as well as their current share. The LNG sector is shown separately because of its large contribution to emissions and emissions growth.

Table 2 Western Australia energy and industry sector carbon dioxide emissions ($MtCO_2$) and total Western Australia greenhouse gas emissions ($MtCO_2e$). Industry emissions include manufacturing and mining, energy industries excluding electricity, fugitive emissions, and process emissions and product use. The LNG Sector is shown separately because of its large contribution to emissions and emissions growth. Source: AGEIS (2019), own estimates (for LNG). Fugitive emissions outside the LNG sector are also shown separately because of the different nature of mitigation options. See discussion of emissions pathways for economic sectors, and Annex I for details regarding the categorisation of sectors.

Sector	2005	2010	2017	Share of 2017 emissions (excl. LULUCF)	Increase 2017 Since 2005 in %
Carbon dioxide – $MtCO_2$					
Electricity generation	17.5	20.1	25.2	31%	44%
Transport	8.8	10.0	14.2	17%	61%
Industry (excluding LNG)	18.1	17.9	22.2	27%	23%
LNG (including CO^2 venting/fugitives)	3.5	5.2	14.5	18%	318%
Fugitives - other	1.2	2.5	2.5	3%	110%
Buildings	1.2	1.4	1.9	2%	62%
Total energy and industry	50.3	57.1	80.6	99%	60%
Agriculture	0.7	0.7	0.9	1%	39%
Waste	0.0	0.00	0.00	0%	29%
Total WA emissions w/o LULUCF	**50.9**	**57.8**	**81.5**	**100%**	**60%**
LULUCF	12.3	6.5	-10.8		-188%
Greenhouse gases – $MtCO_2e$					
Electricity generation	17.6	20.2	25.4	27%	44%
Transport	9.1	10.3	14.6	15%	60%
Industry (excluding LNG)	19.5	19.9	23.9	25%	23%
LNG (including CO^2 venting/fugitives)	5.0	7.5	17.8	19%	256%
Fugitives - other	0.6	0.3	0.6	1%	10%
Buildings	1.3	1.5	2.0	2%	54%
Total energy and industry	**53.0**	**59.8**	**84.3**	89%	59%
Agriculture	10.2	8.7	9.0	10%	-12%
Waste	1.4	1.8	1.5	2%	5%
Total WA emissions w/o LULUCF	64.7	70.2	94.8	100%	47%
LULUCF	15.9	10.1	-7.8		-149%

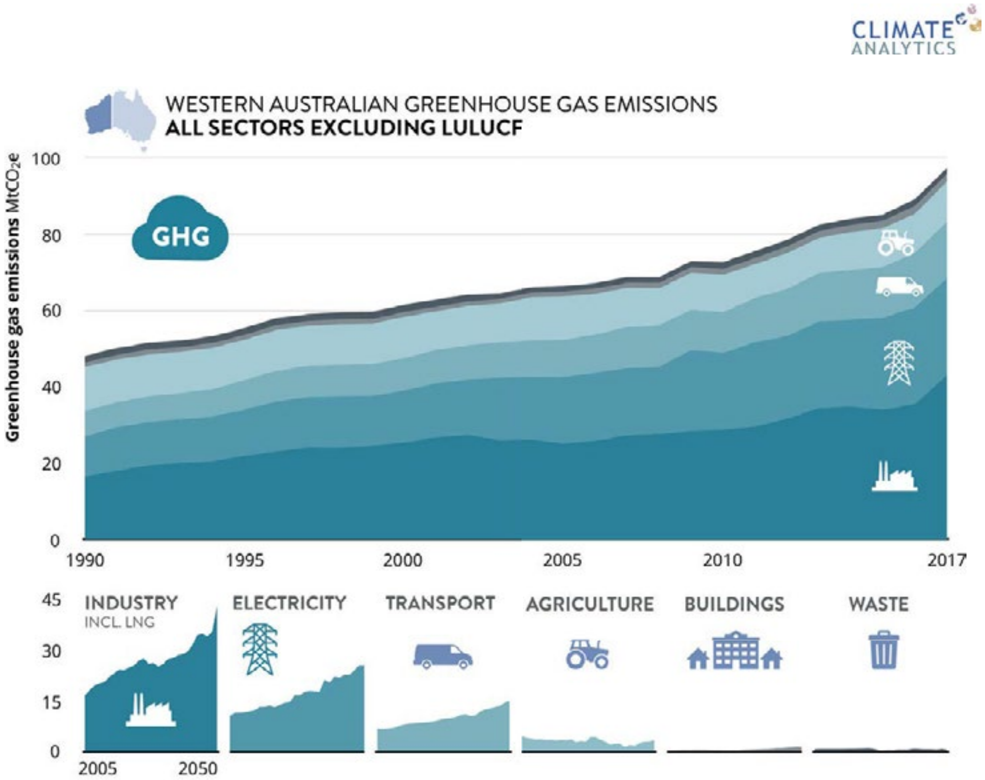

Figure 5: Historical emissions in Western Australia by sector, based on national greenhouse gas accounting. See also

Table 2 and annex II for explanation of sectors. Emissions and removals from land use, land-use change and forestry are not shown. Source: AGEIS (2019).

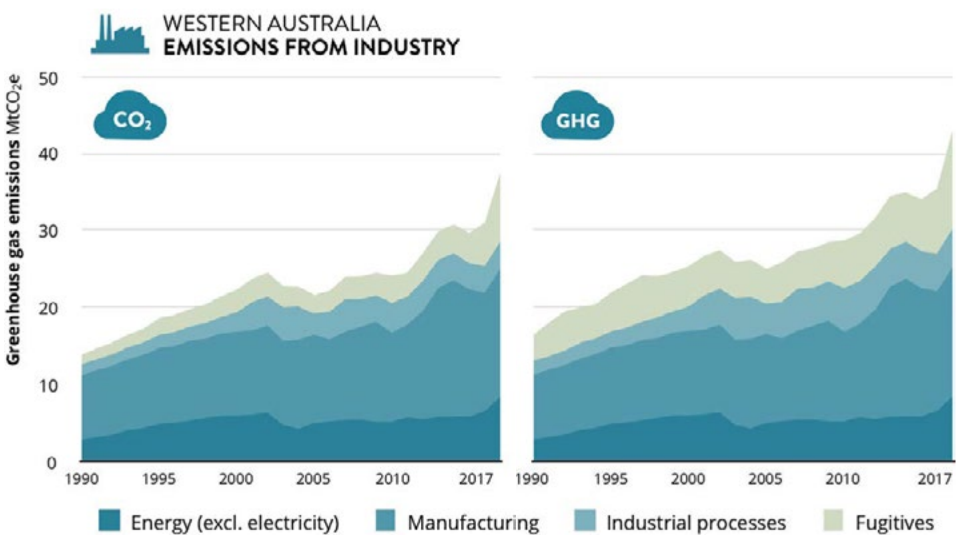

Figure 6 : Historical emissions in Western Australia in the industry sector – CO_2 (left) and all Greenhouse gases (right), with subsectors based on national greenhouse gas accounting. Most of industry emissions are CO_2 emissions, see also

Table 2 and see Annex II for explanation of sectors. Source: AGEIS (2019).

Electricity generation and distribution in WEstern Australia– ready for the future?

Electricity generation in Western Australia is the second largest source of emissions (after industry) and contributes almost a third (31% share in 2017) to energy and industry carbon emissions, and these have increases by 44% since 2005. Despite having an independent electricity system and market[12], Western Australia and New South Wales are the only states that do not have a renewable energy target. Nor does Western Australia have an energy efficiency scheme. The state is lagging behind other states and territories with renewable energy despite having prime resources for solar and wind. Similarly, Western Australia does not have energy saving schemes, despite Victoria, New South Wales, South Australia and the ACT having schemes in place (ESIA 2018). In 2018 Western Australia had a low renewable energy share of only 8% of power generation, well below the national share of 19% (Department of the Environment and Energy 2019, Table O). However 27% of WA households have installed rooftop solar (Climate Council 2018) – the third highest proportion of all states and territories behind Queensland and South Australia.

2018 – a boom year for investment in Renewable energy in Australia – only saw two projects completed in WA with a total of 30 MW capacity (two solar farms, Emu Downs and Northam). A further 395 MW are under construction or financially committed (Clean Energy Council 2019), and a further eight projects with a total of 1GW of capacity have been approved for connection in December 2018, including a 210MW wind farm in the Mid-West. By October 2020, a total of 515 MW is expected to connect, including a 100 MW solar farm (Merredin) (RenewEconomy 2019e).

While uptake of large-scale renewable energy is still slow compared to other states, solar PV has become the largest source of generation capacity in the South West Interconnected System (SWIS) (WA Government. 2019) with households and businesses increasingly switching to rooftop solar and batteries, leading to a lower peak demand and challenging the management of the "most isolated grid of its size in the world" (RenewEconomy 2019e), with rooftop solar possibly tripling over the next ten years, forcing operational demand below a level of 700 MW, seen as a threshold below which system security becomes challenging to secure (RenewEconomy 2019d).

The WA government expects the share of renewable energy in the SWIS to double from around 16% to a share of over a third by 2030. It has reacted to the challenge for the isolated SWIS with the development of an Energy Transformation Strategy (WA Government. 2019). A number of innovative stand-alone power systems, distributed energy resources and microgrid trials are currently operating in Western Australia, in particular in regional and remote areas (WA Parliament 2019).

Given the prime resources for solar and wind and availability of infrastructure and skilled workforce, there is an increasing interest in large scale projects to generate power from renewable energy and store it in hydrogen for export into neighbouring Asian countries: A large scale combined wind and solar 15 GW project (twice the current capacity of installed large-scale wind and solar) is in development in the Pilbara, focusing on green hydrogen production for domestic and export markets, targeting mainly Japan and South Korea and expecting a very large market for green hydrogen over time (RenewEconomy 2019b). Another project is planned near Kalbarri, proposed by Hydrogen Renewables Australia with plans for up to 5 GW combined solar and wind to supply production of low-cost hydrogen (RenewEconomy 2019c). ARENA is looking into options for starting to use hydrogen domestically, before the export market develops, by injecting it into gas networks, or using it in transport or in industry, for example for the production of ammonia (instead of using natural gas, with

12 The electricity market is not part of the NEM and the gas market is not part of the eastern Australian gas market.

a potential of a sevenfold increase in electricity generation from renewable energy in order to produce hydrogen in addition to meeting the direct electricity demand (RenewEconomy 2019a).

There is an increasing recognition including with the WA Government's Green Hydrogen strategy, of the opportunities through the large potential for renewable energy, in particular solar and wind, combined with available infrastructure and skilled workforce in the energy industry – and the proximity of energy hungry Asian countries, some of them currently main importers of Western Australian natural gas.

WA needs to develop its own strategy and targets

Western Australia, with its own, independent energy system and unique resources and opportunities, needs to do its fair share to contribute to achieve the Paris Agreement temperature goal. Western Australia has an important role to play in reducing national emissions, given it is currently largely responsible for national emissions increasing, in particular because of the increase in emissions from LNG processing.

Given it is well known that the current federal emission reduction target of 26-28% reduction compared to 2005 levels that the government has committed to in its Nationally Determined Contribution (NDC) to the Paris Agreement is not consistent with the Paris Agreement (Climate Action Tracker 2019; Climate Analytics 2019b) and given the failure of the federal government to recognise this and even to develop any policies that would ensure achieving the insufficient current target for 2030, there is no reason for Western Australia to align with the federal target and its inadequate policies. To the contrary, as we can see in other countries, there is a responsibility and opportunities for subnational states to show leadership and move ahead with emissions reductions and an energy transition to renewable energy, and energy efficiency that benefits the state's economy, as can be seen in South Australia, or in California in the USA.

As we have outlined above, Western Australia has an own vital interest in achieving the Paris Agreement 1.5°C temperature limit, to protect its unique and iconic ecosystems and the services these provide, including the economic value through tourism, its agricultural regions, and the health well-being of its population.

Western Australia also has globally prime resources that are needed for the Paris Agreement consistent transition to renewable energy, not only with globally first-class wind and solar resources, but also with minerals and critical materials needed for batteries and other technologies.

Again, Western Australia has a lot to gain from such a strategy, if such a transition is planned well, given it can move away from relying on exporting fossil fuels (LNG) towards exporting zero emissions energy carriers (direct electricity or green hydrogen) or zero emissions energy intensive products such as zero emissions steel – with opportunities for additional manufacturing employment.

A fair share contribution

In addition to Australia's own domestic emission reductions to meet the Paris Agreement, Australia also needs to make a contribution to assisting other countries and reducing their emissions, which gives rise to what is called a "fair share" contribution to global emission reductions. This general fairness principle is one of the underpinning elements of the Paris Agreement. For wealthier countries, such as Australia, this almost always means that a "fair share" contribution when expressed in terms of national emission reductions by a certain date is greater than the least-cost domestic emission reductions consistent with meeting the global temperature goal of the Agreement.

It is easy to confuse a "fair share" contribution of a country or region with the actual domestic reductions a country needs to make. In this study we have focused on the budget for the actual domestic reductions that Western Australia needs to make and the least cost emission pathway to achieve this.

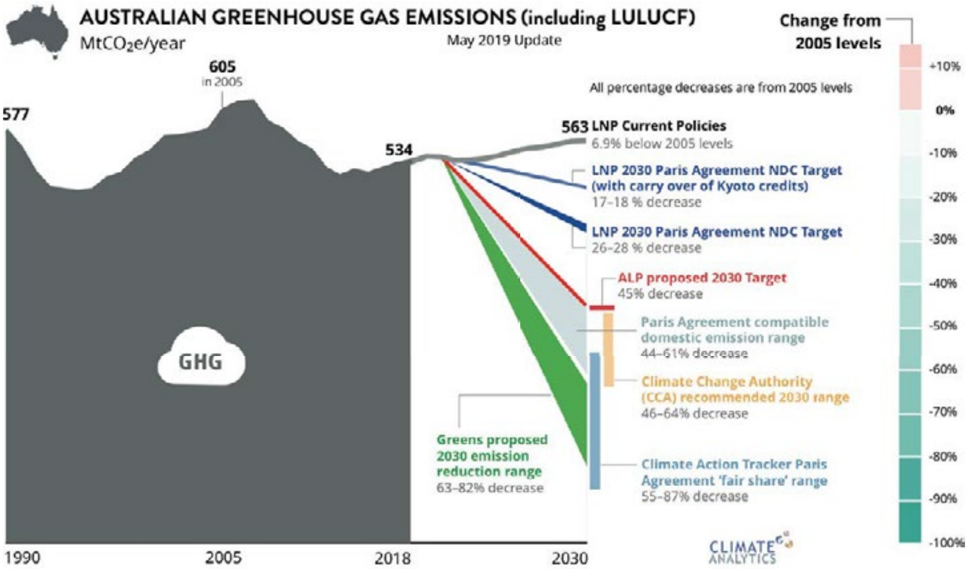

Figure 7: Schematic overview of national emission targets proposed by political parties on the May 2019 Australian Federal election compared to Paris Agreement compatible domestic emission pathways, Climate Action Tracker estimated fair share emission reduction ranges, and the 2015 recommended 2030 range of the Climate Change Authority. This figure shows the emission reductions with respect to emissions including land use, land use change and forestry

Australia, being a developed country, needs to make both domestic emission reductions and contributions to assisting poorer countries in order to move the Paris Agreement in reducing theirs. An estimation of what reasonable domestic emission reductions need to meet global climate goals such as the Paris Agreement to be made by Australia can be derived from examining what global, integrated assessment and energy models are telling us about the kind of energy transformations, and other actions, are needed in different regions, including Australia's own. For this evaluation we have applied one set of models, that provides a good perspective on the least-cost domestic emission reductions for Australia[13]. Given the reductions in renewable energy costs and storage, ongoing reductions in electric vehicle costs and other technological developments these emission reductions may indeed be conservative.

A Paris Agreement compatible 2030 domestic emission commitment target would be in the range of 44-61% emission reduction by 2030 below 2005 emissions, including land use change and forestry sources. Excluding land use change and forestry sources a Paris Agreement compatible domestic emission commitment target would be in the 35-55% reduction by 2030 from 2005 emission levels. There is a large range of least cost domestic emission reductions for Australia deriving from Paris

13 The pathway is derived from results from IAMs (Integrated Assessment Models) results under RCP 1.9 scenarios of (Rogelj et al. 2018) and methods of (Sferra et al. 2019)

Agreement global emission pathways due in part to the range of model results in the scientific literature.

If Australia's Paris Agreement 2030 NDC were to be expressed as a fair share target and be consistent with the range of scientific assessments of this it would be in the range of a 55-87% reduction below 2005 emission levels[14], including land use change and forestry sources (48-85% reduction below 2005 emission levels, excluding land use change and forestry sources). A fair share target represents a country's contribution to meeting the Paris Agreement globally, which includes domestic emission reductions plus contributions to reductions elsewhere, the NDC goal. There is a large range because of the wide range of fairness viewpoints in the scientific literature, with the range here drawn from the Climate Action Tracker (2019).

What this would mean in practice is that the total sum of domestic reductions + emission reductions overseas (from climate finance or acquisition of emission units) would need to add up to the total NDC "fair share" target. In general, this means that in addition to domestic emission reduction targets, the fair share contribution requires further effort abroad. If, for example, the fair share NDC was for a 70% reduction by 2030 then it could mean that domestic reductions of about 50% were achieved and emission units equivalent to 20% of the 2005 base year were supported by Australia internationally.

WA Climate policy in national and international context

Currently, there is no coherent climate or energy transition policy in Western Australia. Western Australia and New South Wales are the only states or territories without any renewable energy target. While WA has recently, in August, finally joined other states adopting an aspirational goal of achieving net zero greenhouse gas emissions by 2050, it does not have any targets for renewable energy nor does it have a specific 2030 reduction target, which Victoria and Queensland have adopted, and Victoria has also legislated. A discussion about the development of a State Government policy and roadmap was initiated with the Issues paper in September this year (WA Government 2019b).

There are elements of policies in energy and resources sector that are relevant for the development of the overall climate strategy, such as the Energy Transition Strategy and the Renewable Hydrogen Strategy. However, none of these are using the relevant Paris Agreement benchmarks outlined in the previous section, with the only exception of the issue paper referring to "well below 2°C" (but omitting the Paris Agreement's 1.5°C limit) and the 'aspirational' 2050 net zero greenhouse gas emissions target. In order to keep the 1.5°C limit within reach achieving key short-term benchmarks to peak emissions by around 2020 and reduce emissions by around 45% below 2010 levels by 2030 are essential.

Opportunities from transition to Renewable energy

Several studies have found that WA's transition to renewable energy is technically and financially feasible. Lu, Blakers and Stocks found that 90% to 100% renewable electricity is technically and financially feasible for SWIS of WA (Lu, Blakers, and Stocks 2017). They modelled several high renewable penetration scenarios and found renewables can be deployed and balance the grid, with different options available from solar PV, wind, and pumped hydro energy storage (Lu et al. 2017).

14 The higher limit (55%) is the boundary between 1.5°C Paris Agreement Compatible and 2°C Compatible and the lower limit (87%) the bottom of fair share range between Role Model and 1.5°C Paris Agreement Compatible (Climate Action Tracker 2019).

An analysis (Rose et al. 2016)[15] of different options for an 85% or even complete decarbonisation of electricity supply by 2030 for Western Australian South West Interconnected System (SWIS), focuses on ensuring reliability and grid stability, including a combination of energy efficiency measures and currently available technologies such as residential and commercial roof top photovoltaic systems, solar thermal power stations with heat storage, wind power and distributed battery storage systems. Laslett et al. (2017) also looks at a new technology option for longer-term storage of excess electricity by producing gas - so called "Power-to-Gas" technology, which can build on the gas infrastructure in Western Australia, using the ample solar and wind resources for electricity. Other options studied are wave power (presently in development stage) and biomass (from oil Mallee) to replace natural gas, as well as pumped hydro storage. These studies also assume an increased electricity demand due to an increased uptake of electric vehicles. They confirm what has been shown for other parts of Australia or other countries and globally: gas can play a limited role in a transition phase to 100% renewable energy, but with a declining share in electricity generation, given gas capacity would be mostly used to cover periods of low variable renewable energy power. Current development and falling costs of storage technologies would reduce this transition role even further.

WA is in close proximity to Asian countries with huge energy demand and global pressure to decarbonise their economies from the Paris Agreement. WA can offer renewable sources of energy, to help meet energy demand in Asia without the emissions of conventional energy sources. Furthermore, the natural resources needed in renewable energy related technologies create opportunities for the WA industry sector.

Technologies associated with renewable energy, such as batteries and electric vehicles require natural resources available in WA. The global demand for battery-based energy storage and electric vehicles requires resources that are mined in WA, and the state is informally dubbed "Lithium Valley". WA has huge reserves of battery materials such as lithium, nickel, cobalt, manganese and alumina (Dept. of Jobs Tourism Science and Innovation. 2019). WA is already the world leader in lithium production, and has rare earth minerals used for electric motors (Dept. of Jobs Tourism Science and Innovation. 2019).

The government has realised WA is in a position to benefit from the renewables boom, and published the "Future Battery Industry Strategy Western Australia", detailing the supportive government approach to create the industry, including attracting investment, facilitating projects, research and technology for sector development and new opportunities for domestic uptake in battery technology (WA Government n.d.). The state aims to have a future battery industry by 2025, and so far, the state has set up a Funding Assistance Register to support the battery sector including research groups, mining and processing companies, renewable energy companies and enterprises in the battery value chain (PV Magazine 2019). This is an approach that could also be followed for other opportunities to develop manufacturing value chains in Western Australia.

Green hydrogen offers WA an option to transition the LNG industry in renewable energy export industry (Climate Analytics 2018b). A report commissioned by the Australian Renewable Energy Agency (ARENA) found that prospective markets for Australian hydrogen were China, Japan, Republic of Korea, and Singapore (ACIL Allen Consulting 2018). The report lists the competitive position for Australia in the hydrogen market, which applies to WA. The factors mentioned include Australia's ability to offer lower landed costs of hydrogen, proximity to the market, having well established energy trading relationships and experience in large scale energy infrastructure construction, and the possibility of supplying hydrogen from a range of sources (ACIL Allen Consulting 2018). The report modelled 3 scenarios of different levels of demand for hydrogen (ACIL Allen Consulting 2018). The direct economic contribution

15 See also (Climate Analytics 2018b; Laslett et al. 2017)

in hydrogen production for export is estimated at A$201 million in the low demand scenario, $417 million in the medium scenario and $903 million in the high scenario for 2030 (ACIL Allen Consulting 2018). Although, these estimates are for Australia in general, WA has the opportunity to take the lead role in Australia's hydrogen development, considering its close proximity to Asia and renewable resource potential in its sparsely populated huge landmass.

In addition, a scheme involving energy efficiency can tackle pressing issues within Australia to help deal with escalating energy prices and the need for network upgrades to meet peak demands (ESIA 2018). The Energy Saving Industry Association (ESIA) has developed a policy setting guide serving as a case for introducing energy saving schemes in WA from 2019 to 2030 (ESIA 2018).

The widespread adoption of renewable energy technologies would create employment opportunities along the supply chain. Sustainable Energy Now (SEN) found that the development of new renewable energy infrastructure in WA could create 37,000 job years in construction, 6,000 job years in manufacturing and 1,400 job years for operations and maintenance (SEN 2017). The Climate Institute assessed the impacts of a clean energy boom in WA, finding that the large untapped resources of renewables offers opportunities for state-wide employment of over 4,700 new jobs in the electricity sector by 2030 (The Climate Institute 2011).

The Asia Renewable Energy Hub (2019a) is a wind and solar project proposed in the Pilbara in WA, with 15GW of wind and solar to be developed over 6,500 square kilometres. The project can power local industry and export to the Asia market using green hydrogen. The project has secured land, it has been granted Lead Agency Status by the WA government, and construction is scheduled to commence in 2022/3, and the first electricity generation is expected 2023/4 (The Asian Renewable Energy Hub 2019a). The Hub claims the $21 billion project would create 3,000 construction jobs over 10 years and 400 jobs for maintenance and operations, and the employment of a further 11,500 for indirect jobs (The Asian Renewable Energy Hub 2019b).

WESTERN AUSTRALIA'S ECONOMIC SECTOR PATHWAYS

In this section, the core of this study, we outline results of the energy system scenario analysis across all sectors of WA economy. We provide, for each sector, a **Paris Agreement compatible emissions pathway that is based on underlying least-cost emissions pathways**, and cost optimal pathways for the electricity sector. We also look at implications for fuel mix, key technologies, and sectoral transformations and key sectoral strategies and policies at state level.

Building Sector – Decarbonising through Efficiency and Electrification

The buildings sector (including both residential and commercial buildings) contributes 2% of direct CO_2 emissions, and these have increased by 62% since 2005, rising until 2016 and declining slightly in 2017. Indirect emissions from the building sector due to electricity use are accounted for under the electricity generation sector.

While the building sector is already largely (56%) using electricity and therefore is already decarbonised with power generation shifting to renewable energy, electrification is a key strategy to accelerate this decarbonisation either directly or indirectly through replacing fossil fuel combustion with biomass or (not included in the underlying model but likely a more sustainable option) "green" hydrogen (generated from renewable electricity). Full decarbonisation of this sector by 2050 leads to a **carbon budget for 2018-2050 of about 22 $MtCO_2$, and a reduction by 41% in 2030 compared to 2005. At current emissions rates, this budget would be used up in 12 years.**

Despite an increase in efficiency and resulting lower energy demand, electricity demand would increase slightly, by 23% from 2014 to 2050 due to electrification. Gas demand would go down both in absolute terms as well as in terms of the share of overall demand for buildings, and oil demand would decrease even faster, essentially phased out by 2040.

Key policies to support this development at state level are incentive schemes to refurbish existing buildings, as well as additional regulation and incentives to reduce energy demand, aiming for near net zero energy (fossil fuel free) new buildings from 2020 onwards, support programmes and information campaigns (working with local councils and appliances retailers) to install heat pumps and electric appliances to replace natural gas, as well as developing supporting regulation and research and development to support blending (green) hydrogen into the gas grid and eventually replacing natural gas with hydrogen in the grid, building on lessons learned from the ARENA (2018) pilot project with ATCO and on international experiences.

An essential further policy would be ambitious renewable energy targets and planning for ramping up renewable energy, taking into account additional electricity demand through decarbonisation of buildings and other end-use sectors.

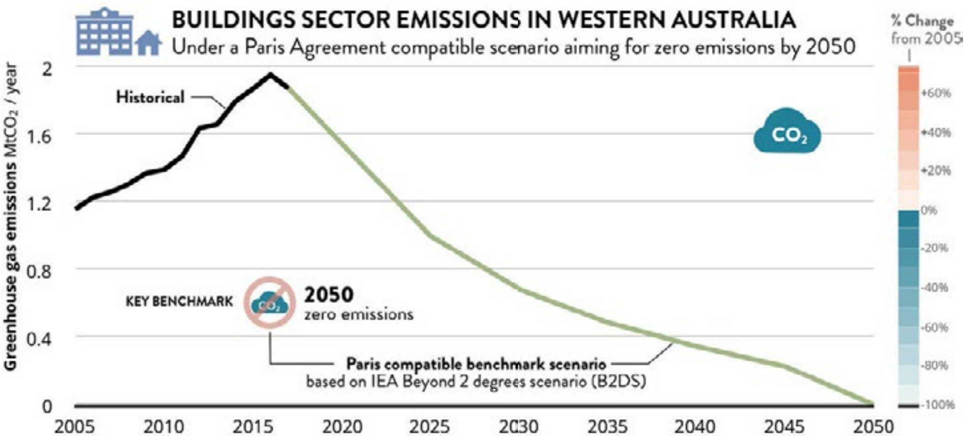

Figure 8: Carbon emissions from the buildings sector (residential and commercial) in Western Australia, for Paris Agreement benchmark scenarios based on the IEA "Beyond 2 Degrees" Scenario (B2DS) downscaled to Western Australia, with the benchmark of full decarbonisation by 2050, used to calculate the sectoral carbon budget) and adjusted to take into account historical emissions until 2017 Delayed mitigation leads to the need for more reductions to keep within the same budget (cumulative emissions).

Table 3: Fuel mix for WA building sector under a Paris Agreement compatible pathway based on technology assumptions in IEA (2017) ETP B2DS and benchmark of full decarbonisation by 2050, (delayed pathway). 2014: Historical data, Source Australian Energy Statistics.. Natural gas could be replaced with hydrogen in the gas grid (the underlying model did not assume availability of green hydrogen infrastructure)

		PARIS COMPATIBLE BENCHMARK SCENARIO		
	2014	2030	2040	2050
Oil	15%	3%	1%	0%
Natural gas	18%	14%	9%	0%
Electricity	56%	68%	75%	85%
Biomass	11%	15%	15%	15%
All fuels	100%	100%	100%	100%

Transport sector – Decarbonising with shift to electric mobility and green hydrogen

Transport is the third largest contributor to emissions, after industry and electricity generation. Emissions have increased by 61% since 2005, and it contributes 17% to energy and industry carbon emissions. Western Australia gas one of the highest rates of car use per person in the world and emissions intensity of vehicles is very high compared to international standards (WA Government 2019b). The WA state government has a goal to increase the number of homes in the Perth and Peel region to close proximity to public transport nodes by 45% from 2018 to 2031 (WA Government 2019a). Plans involve a new METRONET infrastructure, and 18 new train stations, and new precincts (WA Government 2019a). The Western Australian Electric Vehicles Working Group was created in 2018 to coordinate government action in delivering EV outcomes in the state (Dept. of Water and Environmental Regulation 2019). The group was established after the WA Minister for Water; Innovation and ICT; and Science, Hon. Dave Kelly MLA signed the Memorandum of Understanding on Electric Vehicles. The MOU was signed by several parties in Australia, to identify opportunities to accelerate the transition to EVs, with current uptake of EV in Western Australia well behind global average.

This section focuses on the energy transformation that needs to happen in Western Australia's transport sector in line with the Paris Agreement long term goal: full decarbonisation by 2050, in line with previous analysis on Paris Agreement benchmarks for achieving a fully decarbonised passenger and freight land transport by 2050 (Climate Action Tracker 2016, 2018c). This is supported by recent technological developments and opportunities through electrification and introduction of renewable hydrogen or synthetic fuels generated with electricity from renewable energy, as outlined in a national energy system scenario analysed earlier by Climate Analytics, where the transport sector (like other energy sectors) is fully decarbonised by 2050 (Climate Analytics 2018b; Teske et al. 2016).

Oil consumption is expected to decline sharply over time and phased out by 2050, mainly due to increasing reliance on clean electricity generation powering electric vehicles but also due to increased use of hydrogen fuel cell trucks for freight transportation.

For the Paris compatible benchmark scenario, **we get a total carbon budget of about 207 MtCO_2 and a reduction by 16% in 2030 compared to 2005. At current (2017) emissions, this budget would be used up after 15 years.**

The reduction by 2030 compared to 2050 is slower than in other sectors, given the high increase of emissions. However, and important benchmark is that **last fossil fuel combustion engine car should be sold before 2035** in order to achieve full decarbonisation of passenger transport by 2050. Similarly, infrastructure needs to be addressed now to achieve full decarbonisation of freight transport by 2050.

For aviation, technologies are also emerging zero emissions fuels and/or propulsion systems. The International Renewable Energy Agency (IRENA) (2018) has reported on a variety of pathways to produce renewable jet fuel, short range electric aircraft, and hybrid electric propulsion systems. Here we assume full decarbonisation by 2050, which in the case of aviation might imply the need for negative CO_2 emissions to compensate for remaining fossil fuel use if decarbonisation is not achieved by 2050.

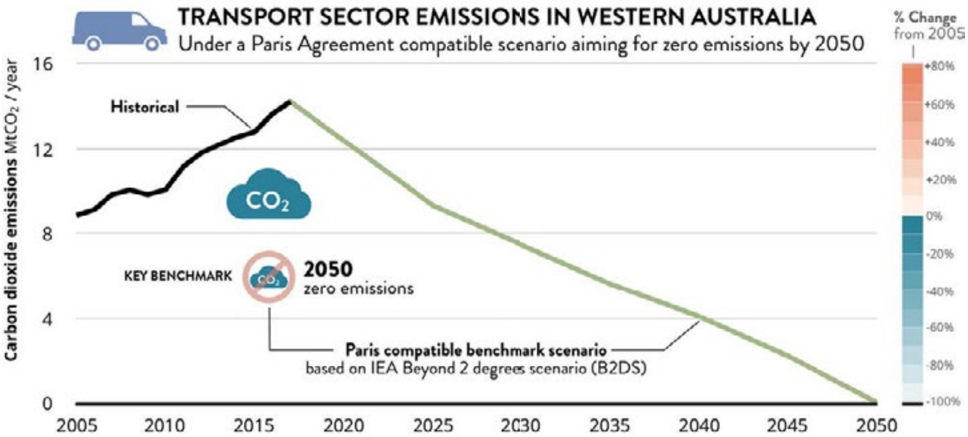

Figure 9: Carbon emissions from the transport sector in a Paris Agreement compatible pathway for Western Australia based on an IEA Technology scenario (IEA B2DS scenario) and the benchmark of full decarbonisation by 2050. We show the original pathway starting decarbonisation in 2014, and an adjusted pathway taking into account the sharp increase in real emissions from 2014 to 2017, keeping within the same carbon budget.

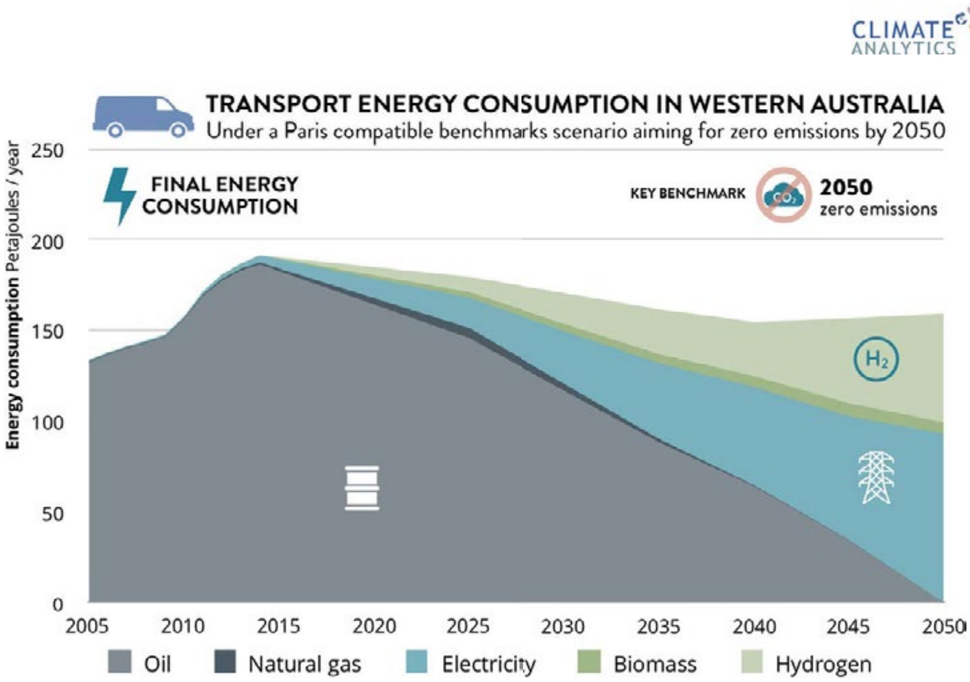

Figure 10 : Energy demand and fuel mix for the transport sector in a Paris Agreement compatible pathway for Western Australia based on an IEA Technology scenario (IEA B2DS scenario) and the benchmark of full decarbonisation by 2050. This pathway starts decarbonisation in 2014, and an adjusted pathway taking into account the sharp increase in real emissions from 2014 to 2017, keeping within the same carbon budget, has been developed to create the Paris Agreement pathway in Figure 8 and Table 4.

Table 4: Fuel mix for WA transport sector under a Paris Agreement compatible pathway based on technology assumptions in IEA (2017) ETP B2DS and benchmark for decarbonisation by 2050.

		PARIS COMPATIBLE BENCHMARK SCENARIO		
	2014	2030	2040	2050
Oil	97%	63%	39%	0%
Natural gas	1%	2%	0%	0%
Electricity	2%	23%	38%	58%
Biomass	0%	2%	4%	4%
Hydrogen	0%	10%	19%	38%
All fuels	100%	100%	100%	100%

Electric car sales are increasing worldwide, especially in countries like Norway or sub national states like California. Those countries and states have successfully introduced incentives and policies to accelerate the adoption of electric vehicles and other e-mobility options including metros, trams etc. An increasing number of countries are introducing targets to ban internal combustion cars, ending the sale of fossil-fuel dependent internal-combustion engines. For example, the UK plans to stop the production of petrol and diesel cars by 2040, Scotland stepped up this target to phase out combustion cars by 2032, France by 2040, and Netherlands by 2030 (World Economic Forum 2017).

Key State policy implications include:

- The need to support modal split away from individual passenger car transport to public transport, cycling, and walking, including through urban and regional planning
- Develop a roadmap and strategy to roll out charging infrastructure and hydrogen fuelling infrastructure with industry
- Work with local councils to support procurement towards electric mobility, including shifting to replace bus fleet with EV buses, building on international examples.

Industry: Manufacturing, Energy Industry –zero emissions through electrification, zero emission fuels, process innovation, energy and material efficiency

As outlined above, industry is the largest emitting sector in Western Australia with a total share of 48% of CO_2 emissions in 2017 – higher than the contribution from electricity generation. It is also the sector with the highest increase since 2005 - by 74% since 2005.

Here we consider direct combustion emissions in manufacturing and mining, excluding the LNG sector (analysed separately in the next section, given the importance of the LNG sector both for WA industry and its emissions[16].), as well as fugitive emissions because of the different nature of mitigation options. We also take into account process emissions (for example from cement or ammonia production) and emissions from product use.

These emissions from direct combustion in manufacturing and mining (excluding LNG sector) and from industrial processes and product use together comprise a share of 28% of energy and industry carbon emissions and have increased by 23% compared to 2005 (see table 2).

We analyse this part of the industry sector based on the analysis of international and national scenarios and research on option for electrification of industrial processes (BZE 2018) and international best practice examples (see Annex for details) and taking into account the specific Western Australia economic profile and structure and show how the Western Australian industry sector can achieve zero CO_2 emissions by 2050, discussing implications for key sectors: manufacturing and mining.

In some industry sectors, greenhouse gas emissions originate not only from fuel combustion to generate heat or electricity, but also from fuel combustion needed to start certain chemical reactions in particular for steel, cement, and ammonia production. Apart from increasing efficiency and

16 Fugitive emissions for production of natural gas for domestic use (factoring out gas used in producing LNG), oil production and coal production are calculated with respect to the published inventory of these sources and government energy balance and/or data. These calculations are done in such a way that they are consistent with the federal Government's December 2018 greenhouse gas projections and related historical emissions time series. This means that where our approach results in fugitives exceeding the results are scaled to the government inventory and/or starting point for greenhouse gas projections in 2018. For the purposes of calculating LNG emissions in this report a bottom-up, plant by plant, approach has been taken which reconciles quite closely with Clean Energy Regulator reports and other data sources. The domestic gas fugitives for Western Australia are inferred as the difference between the total gas fugitives and LNG estimates based on our approach over the historical period. Projections of domestic gas fugitives going forward are based on domestic gas demand arising from the modelling results in this work multiplied by the recent historical fugitive emissions intensity ($MtCO_2e$/PJ) of domestic gas production. Whilst this does not capture the decreasing intensity of fugitives estimated for domestic natural gas industry in Australia and evident in government inventories, because natural gas is phased out in the Paris agreement scenario there is no real benefit to modelling more complicated assumptions. Fugitives from West Australian coal production is calculated with respect to national emission factors historically, and projected forward based upon the projected coal demand in the Paris agreement scenario modelled in this report, with the recent average fugitive emissions intensity ($MtCO_2e$/PJ) of coal production applied. Fugitives from domestic oil production in Western Australia are calculated in a similar way. Overall, the estimate of fugitives based on the methods used here are quite close to the published government inventories. Nevertheless, there are significant differences and the scaling down of inventories could make small but significant (2.5-5%) difference to the future carbon budget calculated for Western Australia. Under the reference pathway where it could be assumed that oil production (e.g. condensates and other natural gas liquids) tracks LNG production this could amount to 50 Mt CO_2e cumulative extra emissions in the period 2018 to 2050, and for the Paris Agreement Asian demand scenario, could amount 250 Mt CO_2e cumulative extra emissions for the same period.

decarbonising energy supply, decarbonisation of these sectors (cement and ammonia production are currently relevant for Western Australia) requires a shift in production methods (including more circular production routes) or in product use (Climate Analytics 2018a). Steel and cement manufacturing are among the most carbon intensive industries involving process emissions. While Western Australia does not have steel production at present, it does have the potential to introduce zero emissions steel production based on its iron ore and renewable energy resources. Process emissions contribute a share of 9% to industry greenhouse gas emissions in Western Australia, mainly from cement production. The largest share of CO_2 emissions is from direct combustion for heat demand in industry.

Full decarbonisation of the industry sector by 2050 implies eventually replacing coal, oil, and gas with renewable energy not only for power generation but also for heat demand in industry, with hydrogen as a renewable fuel option for high-temperature applications in the industry sector, together with biomass. Gas can also be replaced by renewably-produced hydrogen as feedstock for ammonia production. While cement production is often considered a difficult to abate sector, recent research shows the possibility for full decarbonisation, mainly driven by replacing conventional production methods with new, low-carbon alternatives such as geopolymer cement instead of carbon-intensive process of producing Portland Cement from limestone. It can also include the need to take up remaining carbon emissions. While often the need for Carbon Capture and Storage (CCS) is assumed for decarbonising cement production, other technologies are available such as mineral carbonation that can be implemented at lower cost (BZE 2018).

Renewable energy alternatives exist for all applications of industrial natural gas use, not only for power generation but also for lower output temperatures and high temperature thermal processes as well as chemical feedstock, as studied by ARENA (2015). Recent interest internationally (IRENA 2019a) and nationally (ACIL Allen Consulting 2018, CSIRO 2018) in the development of strategies for (renewable) hydrogen including at national and state level offer opportunities for a faster decarbonisation of industry sectors in Western Australia.

More recent cost estimates, with CSIRO (2018) in the National Hydrogen Roadmap estimating that in or around 2025, clean hydrogen could be cost-competitive with existing industrial feedstocks such as natural gas, and energy carriers such as batteries in many applications[17], making it much more likely for these to become least cost options in particular with adequate policies in place at federal and state level.

Recent estimates show that hydrogen technology can be competitive with coal-based plants for steel production by 2030, with the cost of renewable hydrogen falling below $2.20 a kilogram (Bloomberg 2019).

While Western Australia does not have steel production at present, this opens opportunities for developing a new manufacturing industry.

An important strategy across all industry (and other end use) sectors is an increase in energy efficiency. Australia is lagging behind most other developed and even many developing countries with policies to incentivise energy efficiency. Such policies can and have to also be introduced at state level. However, energy efficiency cannot be the only focus for decarbonisation of industry, and needs to be complementary to decarbonisation in particular through electrification, which in itself also increases energy efficiency.

17 See also (Bloomberg 2019)

In our scenario, emissions start reducing more slowly than in other sectors – by 30% in 2030 compared to 2005, mainly due to efficiency gains, but also with industry processes starting to get electrified and fossil fuels starting to get replaced by biomass or green hydrogen. Direct electrification of processes increases to 80% by 2050, with replacement of coal with gas or biofuels for remaining heating processes over the next ten years, and replacement of fossil fuels by green hydrogen and fossil fuels phased out completely by 2050, coal faster (by 2040). Natural gas demand increases only slightly reaching a peak before 2030 and then declining. Electrification, including the use of green hydrogen, leads to an increase in demand for electricity which needs to be decarbonised ramping up renewable energy power generation.

Based on this scenario, we calculate a carbon budget for the industry sector excluding LNG production and processing for 2018-2050 of **328 Mt CO_2 and emissions would have to be reduced by 30% in 2030 compared to 2005. At current emission level, the budget would be used up within 15 years.** Emissions from electricity generation are not included in this budget, but in the budget for power generation.

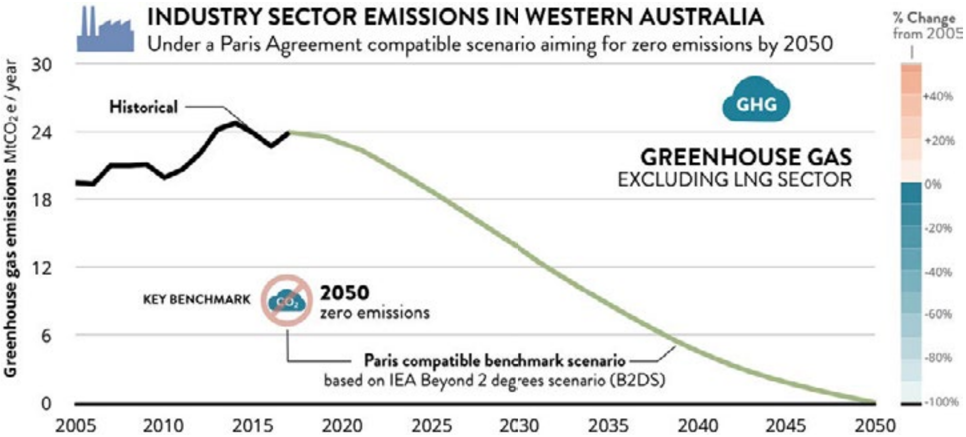

Figure 11: Carbon emissions from the industry sector (excluding LNG sector) in a Paris Agreement compatible pathway for Western Australia based on analysis of national and international scenarios and indicators with the PROSPECTS tool (Climate Action Tracker 2018a) and the benchmark of full decarbonisation by 2050. We show historical data until 2017 (Source AGEIS 2019).

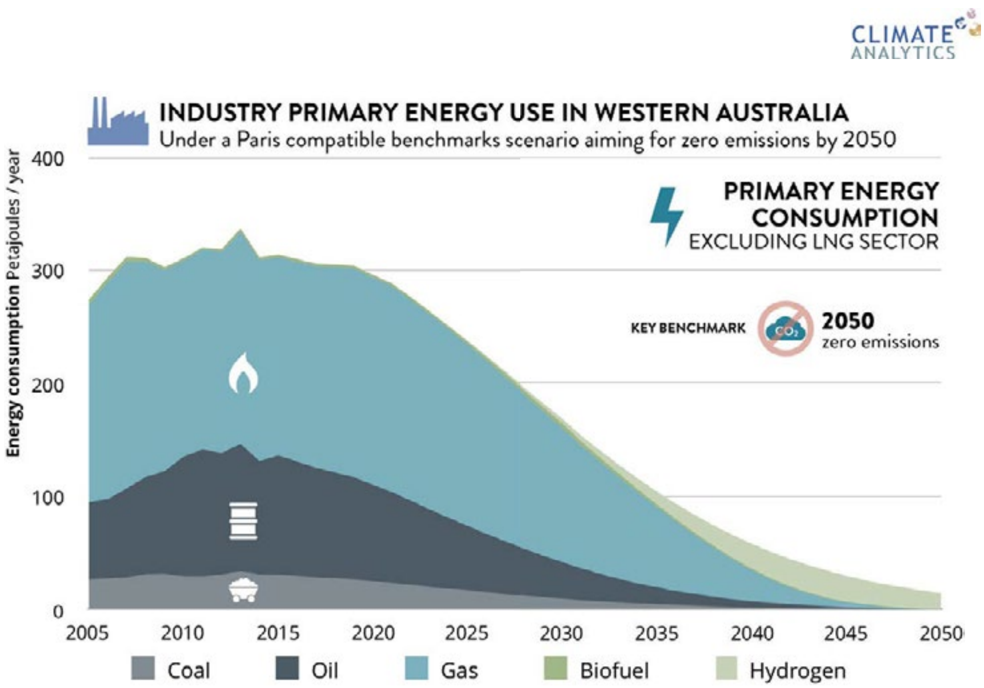

Figure 12: Primary Energy demand and fuel mix for direct combustion in the industry sector (excluding LNG sector) in a Paris Agreement compatible pathway for Western Australia based on analysis of national and international scenarios and indicators with the PROSPECTS tool (Climate Action Tracker 2018a) and the benchmark of full decarbonisation by 2050. We show historical data until 2017 (Source AGEIS 2019). It is important to note that this does not include electricity demand, as emissions from power generation are included in the power sector. The scenario assumes electrification of industry processes reaching 80% in 2050, and fossil fuels being gradually replaced by biomass and, increasingly, green hydrogen. This leads to increased electricity demand taken into account in the mitigation pathway for the power sector.

Table 5: Fuel mix for WA industry sector (excluding LNG sector) under a Paris Agreement compatible pathway based on technology assumptions from a range of scenarios, as analysed with the PROSPECTS tool (Climate Action Tracker 2018a) and benchmark for decarbonisation by 2050. Source: Own calculations, 2014 historical value: Australian Energy statistics.

		PARIS COMPATIBLE BENCHMARK SCENARIO		
	2014	2030	2040	2050
Oil	32%	19%	10%	0%
Natural gas	57%	70%	47%	0%
Coal	10%	6%	3%	0%
Biomass	1%	3%	3%	3%
Hydrogen/Solar Thermal	0%	2%	38%	95%
All fuels	**100%**	**100%**	**100%**	**100%**

This scenario is an indicative Paris Agreement compatible benchmark scenario, based on existing international scenarios and analysis of mitigation options and least cost mitigation pathways, applied to the Western Australia context and structure of the industry sector. It is outside of the scope of this report to look at new manufacturing and export opportunities, for example for zero emissions steel, aluminium, cement production or for export of green hydrogen or other energy carriers.

Given the complexity and diversity of the industry sector, there is a need to develop detailed industry specific scenarios involving stakeholders from industry, trade unions, and civil society, in order to derive roadmaps for research, development, and deployment. This can be the basis to develop a transition strategy, bringing all stakeholders on board, and including roadmaps to take advantage of unique opportunities and competitive advantage of Western Australia.

An important element of a decarbonisation strategy for the industry sector is to include an assessment of macroeconomic impacts and impacts for employment in regions, as well as developing a transition strategy for regions affected by phasing out production and use of coal as well as extraction, processing and use and export of gas, developing roadmaps for new manufacturing industries in specific regions.

Western Australia also needs to introduce an energy savings scheme, as it is one of the states without any such scheme (ESIA 2018).

Power sector – decarbonising fast and delivering zero emissions power for electrified end use sectors

As discussed above, electricity generation in Western Australia is the second largest source of emissions (after industry) and contributes almost a third (31% share in 2017) to energy and industry carbon emissions, and these have increases by 44% since 2005.

This section provides a pathway for Western Australia's power sector, under a Paris Agreement cost optimal compatible emissions pathway, considering key technology and market trends, the state context (see above) and previously analysed international, national and sectoral scenarios for fossil fuel and renewable energy benchmarks (coal phase out, only short transition role for gas, move towards 100% renewable energy with storage and transmission).

In all 1.5°C compatible pathways fast decarbonisation of the power sector paves the way for deeper emissions reduction in other sectors by means of increasing electrification. This implies a very fast ramp up of renewable energy generation, to take into account a fast growth in electricity demand in the 2030s when electrification kicks in considerably across end use sectors, reaching an almost fourfold demand in 2050 compared to the reference case.

While even in the reference case, renewable energy quickly becomes the dominant source of electricity generation, reaching 50% ahead of 2030, 70% in 2040, and 95% in 2050, driven by the cost-competitiveness of renewable energy technology, the Paris Agreement benchmark pathways reaches a third in the mid 2020s, and around 90% in 2030, with a fully renewable energy based and fully decarbonised electricity generation by 2035– but with much higher absolute generation given the higher electricity demand (see Figure 13 and Figure 14).

We take into account the announcement by the WA government (Booth 2019) for a staged shut down of two of the remaining four coal units in 2022, as well as the projections by the AEMO (2019) and available information about already approved connections for 2019-2021 (RenewEconomy 2019e) for expected increase in rooftop solar and large-scale wind and solar projects, with half a gigawatt scale growth in utility scale PV over the next few years and a share of 65% of Variable Renewable Energy (VRE) supply expected by 2024 AEMO (2019).

The assumed growth of rooftop solar at 25% per year until it reaches an assumed maximum share of 80% from present 27%, and the continued growth in large-scale renewable energy projects leads to lowering demand for gas, being phased out in the early 2030s, and coal being phased out before 2030 already, with wind and solar becoming the main power sources from the early 2020s onwards (See

Figure 15). While some of this development is already occurring due to market forces, it will need a careful management as well as clear policy direction, given the crucial role of the power sector to address additional demand from electrification of end-use sectors.

The carbon budget we calculate for power sector is 160 Mt CO_2, requiring emissions reductions of 95% by 2030 from 2005 levels, and reaching zero emissions in the early 2030s. At current level of emissions, this budget would be used up after only 6 years.

Key benchmarks for the electricity generation pathway for Western Australia are:

- **Coal is phased out before 2030, and gas shortly after**
- **Renewable energy share needs to grow from 8% now to a third in the mid 2020s and 90% in the early 2030s.**
- **Renewable energy capacity needs to ramp up very fast to take into account an expected increase in demand from electrification of end-use sectors.**

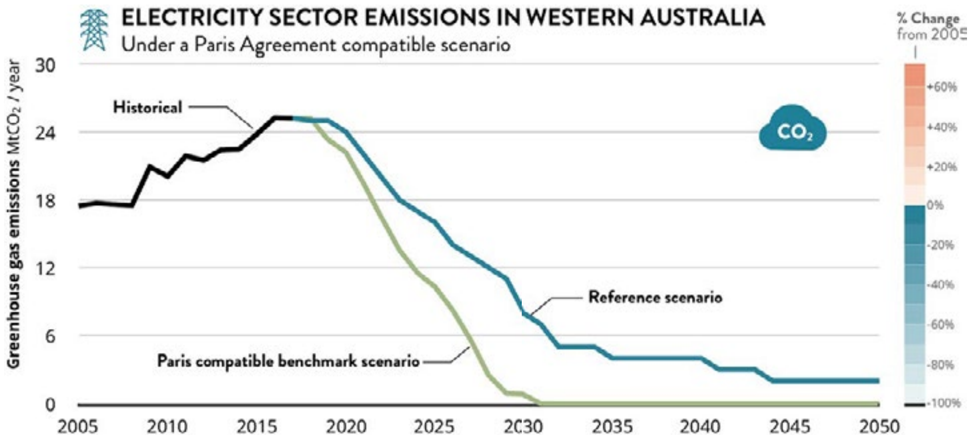

Figure 13: Emissions from power generation in Western Australia - Reference and Paris Agreement Pathways. The power sector needs to and can decarbonise by the early 2030s.

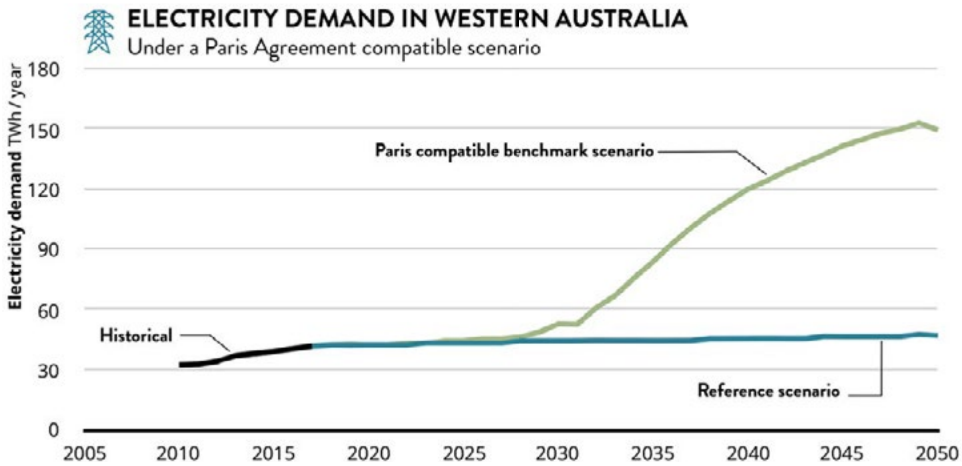

Figure 14: Electricity demand in Western Australia - Reference and Paris Agreement Pathways. With electricity demand increasing due to electrification of end-use sectors (transport, buildings, industry), electricity demand increases by a factor of 3.7 by 2050 compared to current levels, despite increased energy efficiency in end-use sectors.

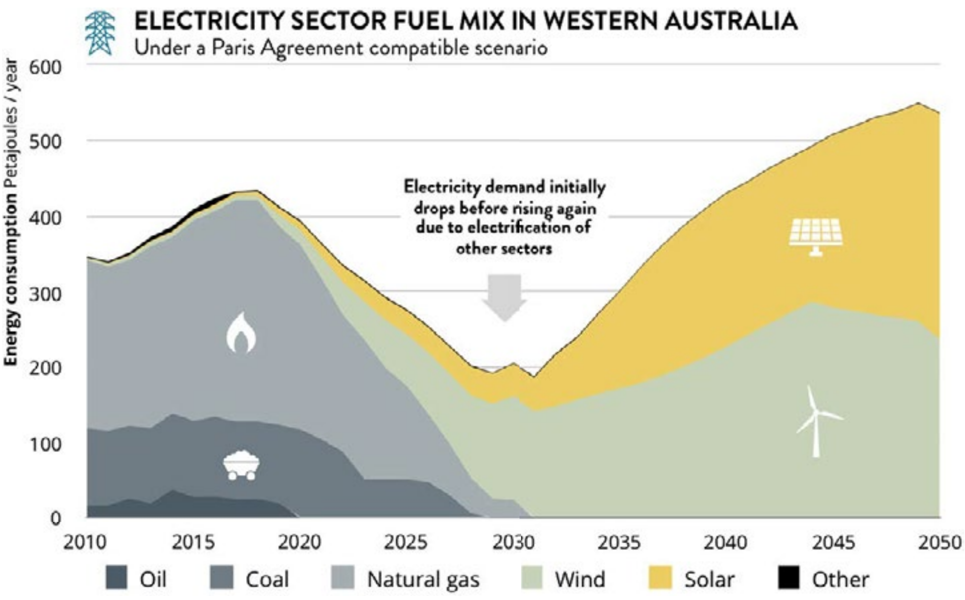

Figure 15: Western Australia's Fuel Mix for the Paris Agreement Pathway. Solar and Wind energy become dominant sources from the early 2020s. Coal is phased out before 2030, and gas shortly after 2030.

The analysis of a Paris Agreement compatible benchmark scenario shows the critical importance of a whole of economy approach to a climate strategy, and the need to take into account the role of the power sector in decarbonising end use sectors.

The WA government has developed an Energy Transition Strategy (WA Government. 2019), as a reaction to the current developments in the market, including the increased share of distributed energy resources, battery systems, and microgrids. This can be developed further to integrate a roadmap with clear midterm targets, taking into account the increased electricity demand and the need for a fast decarbonisation, including phasing out coal before 2030 and gas by the early 2030s. This needs to provide planning certainty for legislation and market design, transmission and storage investments and fast ramping up of large scale solar and wind projects.

LNG Sector: preparing for transition to zero carbon, green hydrogen

The LNG sector is analysed with more detail and granularity, given its importance for WA economy and emissions profile, as well as its contributions to international emissions. We show:

- A mitigation pathway in comparison to a business as usual pathway
- Implications of reduced gas demand globally/in Asia in a Paris Agreement pathway
- Options for decarbonisation of LNG processing through electrification.

The liquefied natural gas (LNG) sector has grown rapidly in Western Australia over the last decades, doubling in size over the last five years to about 45 million tonnes of LNG (MtLNG) per annum production in 2018[18] capacity, and is set to increase by about 35% to 60 MtLNG p.a. by, or shortly after, 2025 (Figure 16). The primary energy demand for gas in the LNG processing sector has increased correspondingly and now approaches 240 PJ per year.

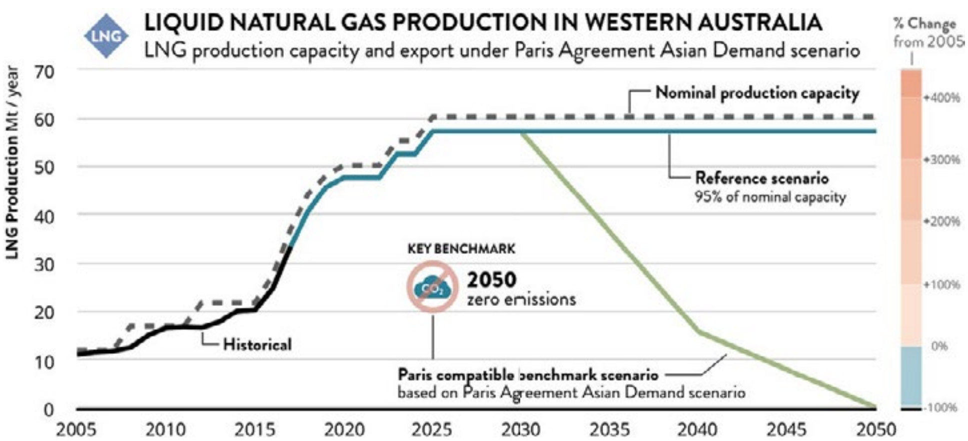

Figure 16 Growth of LNG production capacity and exports until 2019, with projections until 2030 based upon projected changes/increases in LNG production capacity and assuming 95% of nominal capacity is produced and exported. LNG exports in the reference case are limited to 95% of nominal LNG production capacity.

[18] See https://www.jtsi.wa.gov.au/docs/default-source/default-document-library/wa-lng-profile---september-2019.pdf?sfvrsn=413f701c_6

CLIMATE ANALYTICS

Along with the rapid growth of CO_2 emissions from the natural gas used to produce LNG[19], fugitive emissions from LNG processing and related activities and venting of the CO_2 from the natural gas reservoirs, have also increased rapidly. Emissions from the LNG industry in WA are estimated here to be approaching 22 Mt CO_2e per annum and can be expected to approach 35 Mt CO_2e per annum by the late 2020s[20].

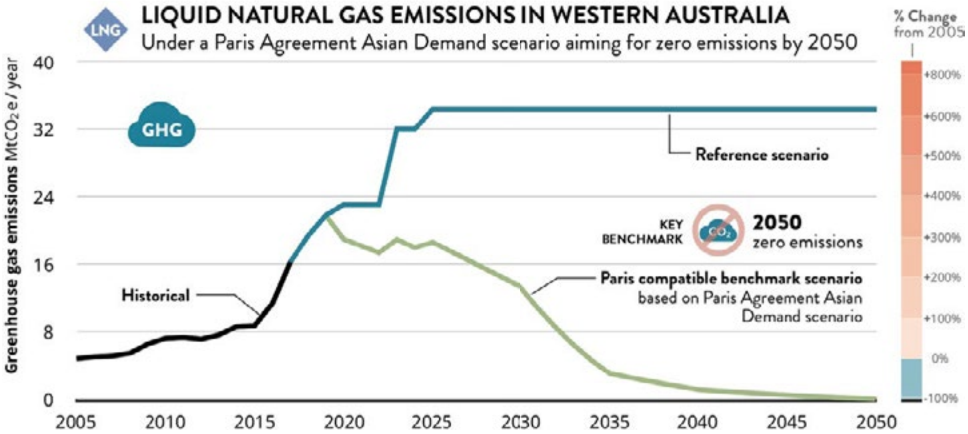

Figure 17 Growth of LNG processing emissions in Western Australia from natural gas used in liquefaction, CO_2 from natural gas reservoirs and fugitive emissions from the LNG manufacturing process until 2019 with projections to 2030. Whilst the intensity of CO_2 emissions from direct energy use and liquefaction have remained fairly stable, in terms of tonnes of CO_2 per tonne of LNG produced, there has been an increase in CO_2 vented from natural gas reservoirs due to the concentration of CO_2 in more recently exploited natural gas reservoirs. The reference case projection does not include CO_2 CCS at the Gorgon LNG plant, however this is included in the Paris Agreement case and explains the drop of total emissions from 2019 to 2020, when it is assumed that the Gorgon CO_2 CCS is capturing 80% of the reservoir CO_2 and storing it in a secure geological formation.

Apart from planned capture of CO_2 and storage in geological formations at the Gorgon plant very few greenhouse gas mitigation measures have been announced or planned at any scale in Western Australian LNG facilities.

With the reference case emissions of the natural gas industry of at least 1 billion tonnes of CO_2 equivalent greenhouse gas emissions between 2018 and 2050 it is clear that there has to be substantial mitigation if the sector is to become Paris Agreement compatible. The projected cumulative emissions from the present trajectory of the LNG industry in Western Australia equal or exceed a Paris Agreement compatible carbon budget for the state.

Global implementation of the Paris Agreement means that the recent growth in the use of natural gas cannot continue, whether for the power sector or in other applications. Scenarios vary, however a common denominator is that in the next decade natural gas demand would have to peak and began to decline, and in central case estimates fairly rapidly. A critical variable in this equation is the likely role of carbon capture and storage. We view that deployment of CCS technology particular in the context

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19 For every tonne of LNG produced it is assumed that natural gas equivalent to 9% of the energy content of the LNG is required for the manufacturing process.

20 Emissions from LNG production facilities are estimated here based on standard emission factors, energy balance, physical estimates of CO_2 losses from natural gas reservoirs and plant specific emission intensity based on environmental impact statements and other studies. These estimates are approximately 5% lower than the Clean Energy Regulator Scope 1 plant specific reports for the NWS Karratha, Pluto and Gorgon operations in Western Australia in 2017/18. The estimated Wheatstone emissions are only 45% of the CER Scope 1 reports for 2017/18, however this may be do higher than normal emissions associated with the scaling up of operations at this plant. In general LNG operations also supply domestic gas and data in respective EIS documents emissions associated with this are of order of 5% of the LNG related emissions.

of gas turbines used in the power sector as being very unlikely due to high cost and the fact that this technology cannot eliminate 100% of emissions.

As shown above, the analysis of global mitigation pathways in line with the Paris Agreement as assessed by the IPCC shows that under the Paris Agreement demand for natural gas in the power sector in Asia, a major source of LNG demand, is likely to peak by around 2030 and then decline to close to zero between 2050 and 2060 (Figure 4). One scenario therefore for the LNG industry in Western Australia under Paris Agreement implementation would be to more or less follow the modelled trajectory for natural gas demand in the power sector in Asia for the period 2030 to 2060 which would result in a substantial reduction in LNG demand, reducing from peak levels in 2030 to close to zero by 2050.

Of course, the transition to a zero-carbon economy in Asia will require large amounts of energy, hence the market for energy carriers similar to LNG will not disappear, and this is where the potential for renewable hydrogen exports from Western Australia becomes much more visible. A number of East Asian economies have, or are developing hydrogen strategies, for a variety of different reasons, including energy security and climate change. A Paris Agreement driven decline in Asian demand for liquefied natural gas would be matched by a corresponding increase in demand for clean energy carriers, in particular Green Hydrogen. Hence the key elements of the zero-carbon transition outlined here for the LNG industry involved building up new markets for green hydrogen, which needs a major ramp up in renewable energy generation capacity in regions near to the present LNG facilities.

A decline in demand for LNG industry consistent with the Paris Agreement reaching close to zero by 2050 would reduce all LNG related emissions very substantially. Nevertheless, in order to meet the commitments of the Paris Agreement, and stay within the carbon budget and minimise the need for negative emissions, significant additional abatement measures would need to be introduced. These would include extending carbon capture and storage for reservoir CO_2 losses to all LNG plant in Western Australia as well as replacing a significant fraction of natural gas used in LNG processing by renewable electricity. The broad approaches assumed here is that the level of CCS planned for the Gorgon plant of 80% from 2020 (which would capture approximately 60% of present total CO_2 reservoir emissions for LNG operations in WA) extended to all plant from 2023, combined with the phasing in of renewable energy so that by 2030, 50% of LNG manufacturing natural gas use is replaced by renewable energy, 90% by 2035 and by 2050, 100%.

Irrespective of whether or not the demand reductions implicit in the scenario above occur, the cumulative emissions of the LNG industry need to be reduced substantially in the basic options examined here would need to be deployed in either case. In the reference case, the scale of the emission reductions to be achieved through carbon capture and storage of reservoir CO2 and by introducing renewable energy quickly into the LNG manufacturing process would be substantially larger than in the Paris Agreement Asian power demand case. For completeness we show both scenarios which achieve similar levels of cumulative reductions by 2050.

Applying the options described above to the reference case LNG production, as is shown in Figure 19 would reduce the peak emissions from Western Australia LNG manufacturing to around 300% above 2005 levels from a projected 600% increase by the mid 2020’s in the case with no policy action. This would bring emissions back to about 176% above 2005 levels in 2030, 16% below 2005 levels in 2040 and 46% below in 2050. Zero CO_2 emissions would be needed to be Paris Agreement compatible.

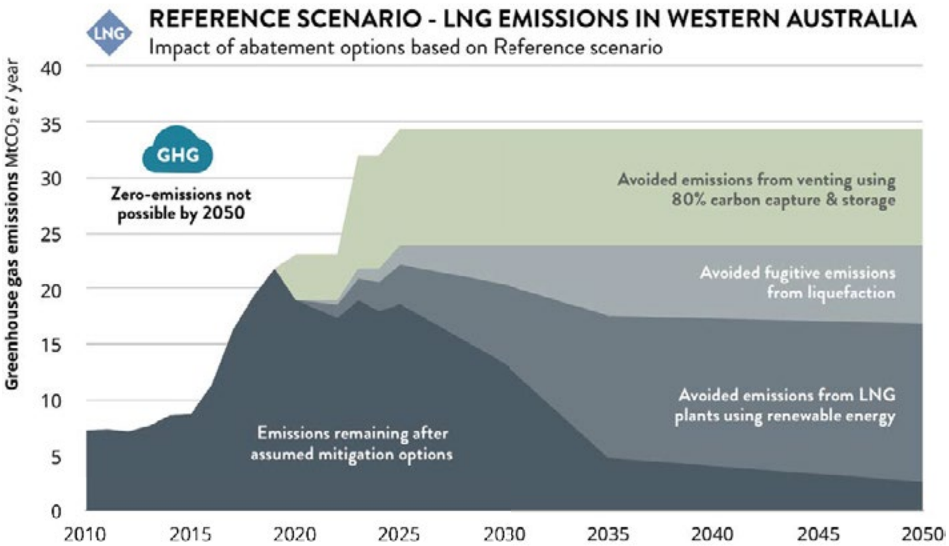

Figure 18 Relative role of the abatement options described in the text for reference case LNG demand and see Table 6. Zero emissions are not achieved by 2050. The cumulative emissions remaining between 2018 and 2050 after the assumed mitigation options are applied in this reference scenario is 323 MtCO2e. This amounts to approximately one third of the Western Australian Paris agreement compatible carbon budget for the energy system. There could be more or less emissions left depending upon the rate and scale of the actual mitigation options deployed.

Under a Paris Agreement induced decline in demand from 2030 combined with the mitigation options discussed (carbon capture and storage, electrification), this would lead to LNG related emissions in 2030 being about 175% above 2005, around 80% below 2005 levels by 2040 and approach zero by 2050 (Figure 19).

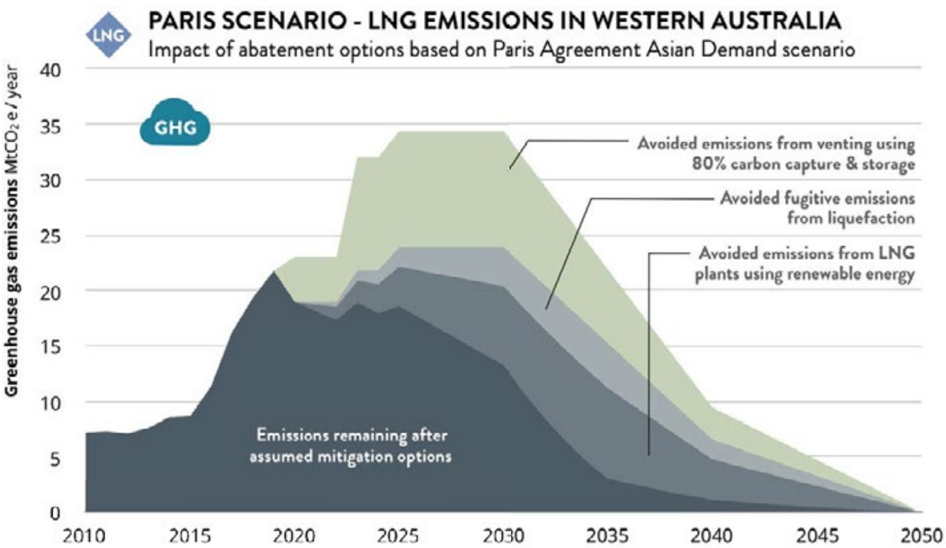

Figure 19 Relative role of different elements of a Paris Agreement LNG demand reduction scenario and mitigation options in reducing emissions from the reference case to close to zero emissions by 2050. The cumulative emissions remaining between 2018 and 2050 after the assumed mitigation options are applied un this Paris Agreement LNG demand scenario is 274 $MtCO_2e$. This amounts to approximately about 29% of the Western Australian Paris agreement compatible carbon budget for the energy system. There could be more or less emissions left depending upon the rate and scale of the actual mitigation options deployed.

Table 6 below compares the reference case and Paris Agreement LNG demand reduction scenario. In the reference case, with no abatement, cumulative emissions in the period 2018-2050 are likely to be in the range of 1 $GtCO_2$, of the same order as the entire carbon budget for WA. A Paris Agreement Asian demand reduction scenario would reduce this by over 60% to around 438 $MtCO_2e$ without abatement options. Cumulative emissions can be reduced much further to around 274 $MtCO_2e$ through CCS and renewable energy replacing natural gas in the LNG manufacturing process. With this the LNG industry would take up about a quarter of the WA carbon budget for this period. The cumulative emissions from the reference case with all mitigation options is about 20% higher at about 320 $MtCO_2e$, and zero emissions would not be reached. This would imply the need for the LNG industry to generate negative CO_2 emissions elsewhere to compensate.

Table 6 Cumulative emissions from LNG Reference and Paris Agreement scenarios

Cumulative emissions 2018-2050 $MtCO_2e$	Paris Asian Natural Gas power demand	Contribution to avoided emissions (%)	Reference case – production at 2030 levels	Contribution to avoided emissions (%) [21]
Reference case cumulative emissions 2018-2050	1,067		1,074	
Cumulative Paris carbon budget emissions	274		323	
Where do avoided Emissions come from?				
Demand decline	438	56%	0	9%
Avoided CO_2 from renewabilizing LNG plant	123	16%	395	40%
Avoided CO_2 from venting with 80% CCS	171	20%	304	41%
Avoided liquefaction fugitives	61	8%	146	20%
Total avoided emissions	**793**		**745**	

The WA government provides strong support to the LNG industry, epitomized in the new LNG Futures Facility. The Premier Mark McGowan announce $10 million to support the facility, aiming for WA to be a global leader in developing and testing LNG technology (WA Government 2019c). It has been argued that the facility will "future-proof" the state's LNG industry (WA Government 2019c) to ensure the industry persists into the future, however there is little sign that this has taken of the fundamental energy transitions required to meet the Paris Agreement goals globally. A further large LNG project, Browse is proposed by Woodside that could scale up the LNG industry in WA, if approved, with start-up likely around 2026 (Toscano 2019). The Scarborough gas field is proposed also for development which would extend the life of the North West Shelf Project (Reputex 2018).

To ensure the transition outlined here, in particular the need to extend the level of CCS planned for the Gorgon plant of 80% capture and storage of reservoir CO_2 from 2020 to all LNG operations from 2026, combined with the phasing in of renewable energy for liquefaction, the government would have to likely introduce regulation given there is no carbon pricing at federal level.

If there is less demand reduction than assumed here, the same emissions pathway needs to be reached. This would imply a higher abatement to be reached with CCS and renewabilisation of the LNG manufacturing process.

21 May not add to 100% due to rounding errors.

Requesting offsetting emissions would not be a viable option to achieve this mitigation pathway, as the mitigation achieved outside of the LNG sector (for example as noted in the (Reputex 2018) report would need to be implemented in any case, and not to compensate for no, or insufficient, mitigation in the LNG sector. A requirement for offsetting would only be viable for any mitigation below the pathway outlined here. This would imply, de facto, a pricing mechanism that would allow raising funds for some of the mitigation outlined for other sectors, which can be justified given the high cumulative emissions in the LNG sector since 2005.

Carbon budgets for Western Australia energy and Industry sectors

Table 7 summarises the results the preceding analysis to produce a Western Australian Paris Agreement compatible budget and pathway and related sectoral carbon budgets and pathways for the period 2018-2050, as well as benchmarks for emission reductions for 2030 compared to 2005 levels to establish both the state and its key sectors on 1.5°C compatible pathways.

We calculate the carbon budget for Western Australia's fossil fuel (energy and industry) CO_2 emissions for the period 2018-2050 to be a bit below 1 $GtCO_2$, which is about 0.17% of the remaining global carbon budget until zero emissions.

Table 7: Paris Agreement compatible energy and industry carbon budget for Western Australia 2018-2050. Source for historical data: AGEIS 2019. LNG sector emissions include emissions from venting/fugitive emissions (own estimate).

Sector	Paris Agreement compatible carbon budget 2018-2050 $MtCO_2$	2030 reduction (compared to 2005 baseline) CO2 only	2005 Baseline $MtCO_2$	Remaining years at 2017 emissions rates
Electricity generation	160	-95%	17.5	6
Transport	207	-16%	8.8	15
Industry: LNG Sector	208	+170%	3.6	16
Fugitive emissions (excl. LNG)	25	-55%	1.6	6
Industry: other	328	-30%	18.1	15
Buildings	22	-41%	1.2	12
Total energy/industry emissions	**949**	**-37%**	**50.8**	**12**
Total energy/industry excluding LNG sector	**716**	**-53%**	**45.6**	**11**

Figure 20 shows the pathway for CO_2 emissions from energy and industry towards zero emissions that is consistent with this budget.

An overall CO_2 emission reduction of about 37% by 2030 from 2005 levels, 81% by 2040 and zero emissions by 2050 is needed to limit cumulative emissions to the carbon budget to its 950 million tonne carbon budget.

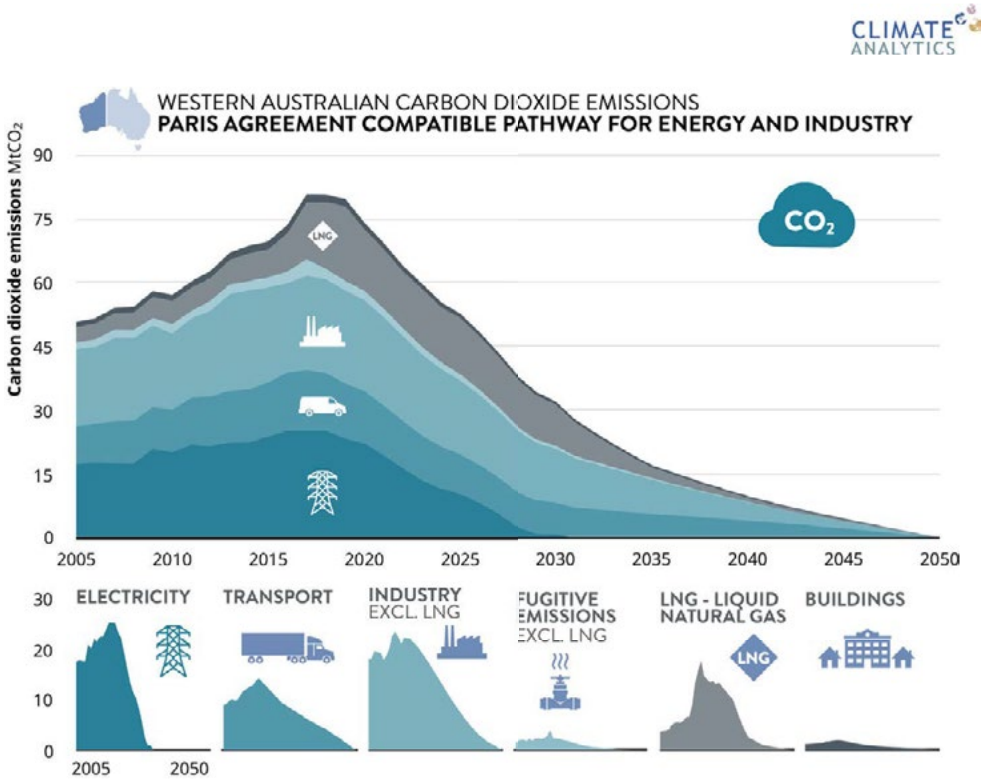

Figure 20. CO_2 emissions pathway for each of the sectors and energy and industry following transformation is consistent with the Paris agreement in each of those sectors. Total CO_2 emissions peak around 2020 and decline to about 37% below 2005 levels in 2030, for total budget of around 950 Million Tonnes CO_2. Excluding the LNG industry, energy and industry CO_2 emissions would reduce by about 53% by 2030 below 2005 levels, for a total budget of 716 $MtCO_2$.

A key conclusion is the need to **reduce emissions in the immediate term** given the current growth in emissions – every delay in reducing emissions will imply faster reductions later to stay within carbon budget, implying higher costs and disruption, and risks locking further into fossil fuel infrastructure.

If current (2017) emission rates were to be continued, the overall energy and industry carbon budget of about 950 Mt CO_2 would be consumed within 12 years.

Another key conclusion is that the electricity sector needs to and can reduce emissions faster than any other sector, by 95% in 2030 compared to 2005 (and zero by 2035). All sectors except for LNG and transport would have to be reduced faster than the Australian reduction target of 26-28% by 2030. The transport sector would need to reduce emissions by about 16% by 2030 compared to 2005 levels. On the other hand, the peculiarities of the LNG industry mean that its increase would be limited to about 170% increase above its 2005 levels (compared to a reference case increase of 630%), however it would be reaching reductions of about 73% below 2005 levels by 2040 and 100% by 2050.
We compare our findings and estimated carbon budget for Western Australia's energy and industry sectors for plausibility against other methodologies used to generate national or state carbon budgets, to confirm our estimate is a robust estimate for a Paris Agreement, compatible energy and industry carbon budget for Western Australia:

- If we apply Australia's share of current global emissions of about 1.1% of global fossil fuel (energy and industry) emissions in 2017 (C. Le Quéré et al.2018) to the global carbon budget of 610 $GtCO_2$ (range 555 to 730 Gt) until the year of zero emissions estimated earlier (Climate Analytics 2019a), this results in a budget for Australia of 6.7 $GtCO_2$ (range 6.1-8.0 $GtCO_2$). With the current Australian share of 20% for Western Australia of fossil energy and industry CO_2 emissions the Western Australia budget would be **1.3 $GtCO_2$ (range 1.2- 1.6 $GtCO_2$).**
- Total **global carbon budget until 2100 is considerably lower** than until net zero emissions, implying the need for negative emissions after reaching net zero. Australia's share of this budget until 2100 would be, based on the current 1.1% share of global emissions, 5.2 GtCO2 (range 3.5-7.7 GtCO2), and **WA's share** would be **1.0 GtCO2** (range 0.7 – 1.5 GtCO2) based on a 20% share.
- As a cross check for consistency against the global carbon budget derived from Integrated Assessment Modelling results outlined above, we have produced an estimated budget for Australian energy related CO_2 emissions over 2018-2050 in the range of 4.8-6.6 $GtCO_2$. A 20% share for Western Australia would correspond to **1.0 to 1.3 $GtCO_2$**.
- Based on a national scenario for decarbonising the entire energy system, we have, earlier, estimated a national budget for Australia of about 5.5 Gt CO_2. Assuming a share of 20% of this national budget for Western Australia, corresponding to the share of energy CO_2 emissions in 2017, this would result in a budget of **about 1 $GtCO_2$ and is confirmed with this study.**

ACHIEVING ZERO GREENHOUSE GAS EMISSIONS BY 2050

In order to assess how Western Australia gets to net zero GHG emissions by 2050, we have analysed Paris Agreement consistent mitigation pathways in sectors outside of energy and industry, and also take into account emissions apart from carbon in energy and industry – mainly industrial emissions from product use (so called F-Gases) that can be phased out, as well as fugitive emissions that will be phased out with the phasing out of fossil fuel extraction.

The key remaining sectors are agriculture (10% of WA emissions) and waste (small share of 2% of WA emissions). While there are cost effective options to considerably reduce emissions from waste, that are already being implemented in other countries, agriculture is a more challenging sector, and emission cannot be reduced to zero.

Remaining emissions will have to be compensated by negative emissions from the land-use sector.
It is also important to look at how Western Australia will contribute to negative emissions beyond reaching net zero, consistent with the Paris Agreement.

The carbon budget derived in this report for energy and industry is focused on the budget up to the point in time of net zero emissions. While this study aims at providing guidance on a budget that would limit the need for negative emissions, this does not mean that the need for negative emissions after achieving net zero emissions can be ignored. The timing, scale and opportunities for net negative emissions needs to also be analysed in the Western Australian context in future work. The need for negative emission technologies and their deployment on a sustainable basis would need to be considered for the energy system transformation and land-use sector strategies in Western Australia, and is beyond the scope of this study. However, by developing sector specific mitigation pathways, we are providing a benchmark pathway for overall greenhouse gas emissions in Western Australia.

CLIMATE ANALYTICS

Agriculture Sector

The agriculture sector is responsible for 10% of emissions in WA (Figure 2) and the sector's emissions have been on an upward trajectory since 2008 (DEE 2019). Agriculture is a sector that is highly vulnerable to climate change, especially, temperature changes, hot spells, frost, rainfall intensity, drought and water supply, cyclones, and fire risk (Dept. Primary Industries and Regional Development 2019a). Despite these risks, there is not a state specific climate policy under the list of current initiatives on the WA Department of Primary Industries and Regional Development website (Dept. Primary Industries and Regional Development 2019b). There is also a lack of specific mitigation analysis and scenarios, with national scenarios published in the past focusing on offsetting emissions from agriculture with sequestration in forests.

Emissions from agriculture cover emissions from enteric fermentation, manure management, manure applied to soils and left on pasture, rice cultivation, and other land-related emissions from synthetic fertilisers, crop residues and cultivation of organic soils. Thus, here we do not cover emissions from electricity use or fuel combustion from operating equipment, which are included in the energy-related emissions covered in pervious subsections. The bulk of agriculture greenhouse gas emissions we cover in this part are methane and nitrous oxide.

To derive the projections of non-energy emissions from the Agriculture sector for the "Paris Agreement Compatible Scenarios", we applied the growth rate of non-CO_2 emissions from the agriculture sector for the OECD region over 2016-2050 based on the 1.5°C pathways assessed in the Special Report on Global Warming of 1.5°C by the Intergovernmental Panel on Climate Change (IPCC 2018a). The subset of scenarios excludes those that exceed the sustainability limits for carbon-dioxide removal options identified in the SR 1.5 and the underlying literature. The higher ambition level of the "Paris Agreement Compatible Scenarios" is based on the most ambitious end of the ranges given by the selected scenarios from IPCC (2018a), projecting an annual average rate of -1.9 % p.a. reduction of non-CO_2 emissions from agriculture sector in the OECD region over 2016-2050.

Applied to Western Australia, this implies a potential reduction by 43% in 2030 and 56% in 2050 compared to 2005.

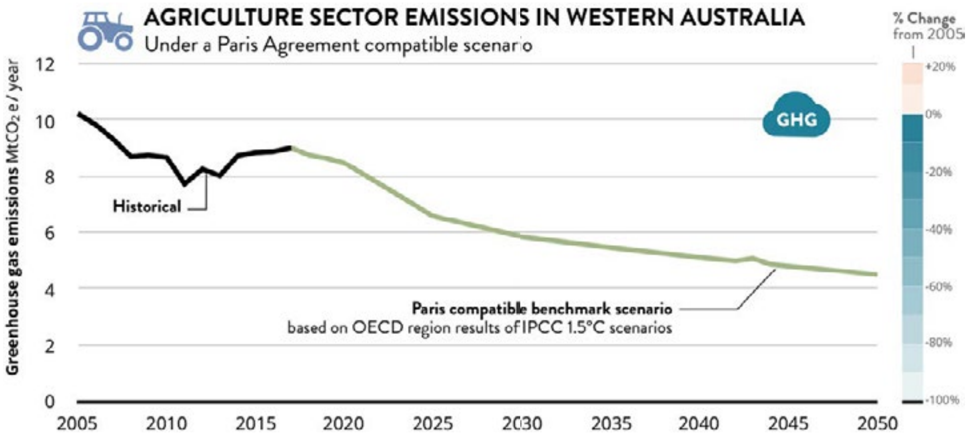

Figure 21: Western Australia Paris Agreement benchmark scenario for the agriculture sector, based on OECD region resutls of global scenarios analysed by the IPCC that are consistent with the Paris Agreement Temperature goal. See text for details. Emissions are reduced by about half towards the end of the century.

In the underlying scenarios, key mitigation options are enhanced agricultural management (e.g. manure management, improved livestock feeding practices, and more efficient fertiliser use), as well as demand side measures such as dietary shifts to healthier, more sustainable, low-meat diets and measures to reduce food waste. The underlying scenarios do not, however, offer a complete assessment of mitigation options and do not generally cover e.g. large-scale replacement of meat by plant-based proteins and cultured meat, novel technologies such as methanogen inhibitors and vaccines, nor synthetic and biological nitrification inhibitors (see IPCC 2018a).

There are no national scenarios published that lead to reductions in emissions from agriculture. The Deep Decarbonisation Pathway Scenario (ClimateWorks Australia 2014) leads to an increase in emissions by 2050 by 20%. A recently published study (FABLE Consortium 2019) also assumes agriculture emissions to stay at a level of 80 Mt CO2eq in 2050.

Waste Sector

The waste sector accounts for 2% of the state's emissions (Figure 2) and the emissions in the waste sector have increased 5% since 2005 (DEE 2019). Western Australian had the highest rates of waste kilograms per capita compared to Australia's other states and territories (all waste excluding fly ash) (Waste Authority WA 2019). In the same year, WA had the second to highest rates in amount of waste to landfill, and came joint second to worst for lowest rate of resource recovery (at 48%) (Waste Authority WA 2019). The state government has a target of 75% of waste generated in WA to be reused or recycled by 2030, through the State Waste Strategy (WA Government 2019a; Waste Authority WA 2019).

Emissions from waste are primarily due to the release of landfill gas from anaerobic decomposition of waste material in landfills as well as due to waste water treatment. These would mainly include methane and nitrous oxide emissions. To derive the projections of emissions from waste sector for the Paris Agreement Compatible Benchmark Scenario, similar to the agriculture sector, we applied annualized growth rates for the OECD region over 2018-2050 based on the regional pathways assessed in the Special Report on Global Warming of 1.5°C by the Intergovernmental Panel on Climate Change (IPCC 2018b). Under the '1.5°C Paris Agreement compatible' pathway, the emissions from waste sector shows a reduction by 69% in 2030 and about 77% in 2050. Mitigation in the waste sector has been identified as highly cost effective and could even return a net profit (IPCC 2018b).

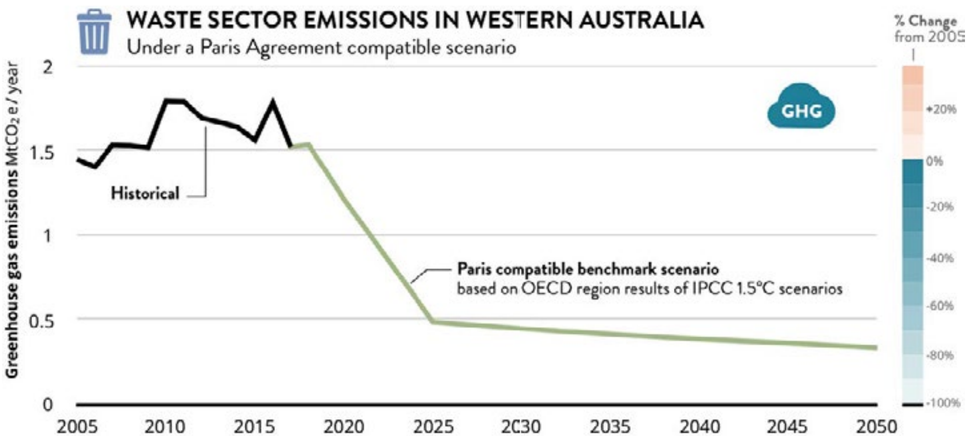

Figure 22: WA Waste Emissions PA Scenario MtCO$_2$e (historical data 1990 to 2017, from AGEIS). The PA benchmark scenario is based on the results for the OECD region of a PA 1.5 scenario assessed by the IPCC.

Western Australia would need to reduce organic waste levels, creating a smaller task in also diverting the rest of organic waste from landfill. Current organic material in landfill areas will continue to emit GHG emissions until fully decomposed, making it imperative to begin plans to divert all organic matter. Western Australia's waste policy needs to be more ambitious and focus on organic material waste, with specific emissions targets for an emissions reduction pathway for this sector. Local government policy needs to align with state level policy and targets to tackle waste at the source.

LULUCF Sector

The land use, land use change and forestry (LULUCF) sector has a history of high fluctuations in emissions in WA. The LULUCF has transitioned between being an emissions source to an emissions sink in 1999, back to an emissions source in 2003, and then an emissions sink from 2011 to current (AGEIS 2019). The WA government plans to create five million hectares of new national, parks, marine parks, and other conservation reserves, which converts to a 20% increase in the WA conservation estate (WA Government n.d.). The plan is under development and the WA government is in consultation with stakeholders such as local governments, conservation groups and Traditional Owners (WA Government n.d.).

It is beyond the scope of this study to examine scenarios for land use, land use change and forestry however to enable a total greenhouse gas pathway for Australia it is important to make some simple stylised assumptions about the likely future trajectory of the carbon sink in this sector. In recent years the LULUCF sector has become a significant sink, storing carbon in forests, vegetation and soils. A number of projections indicate that the recent sink will reduce gradually over the next decade without substantial incentives to maintain and increase it. In this scenario we assume that the vegetation deforestation essentially stops by 2025, and that the non-CO_2 GHG emissions from the LULUCF sector decline slowly consistent with recent trends. Absent a detailed assessment we have assumed that the sink would reduce following the December 2018 Federal Government projections (Department of the Environment and Energy 2018) so that by 2030 it is about 30 percent below 2017 levels. For the purpose of this stylised scenario we maintain the sink at a constant level after that time until 2050.

A CSIRO assessment of potential for land sector carbon sequestration by Bryan et al (2015) indicated substantial potential for additional storage of carbon from a variety of different activities in agricultural land in Australia. Whilst the results were not specifically reported for Western Australia, this region was modelled, and a number of conclusions are relevant.

Firstly, policies that focus on carbon storage alone do not generate significant benefits for biodiversity, and policies that favour environment and biodiversity values will result in lower levels of carbon storage. Secondly, even with large incentives, the inertia in agricultural systems and in the terrestrial biosphere means that there will be low amounts of additional carbon storage by 2030. Thirdly there is a significant trade-off between a focus on carbon uptake and water values, with a high focus on carbon reducing available water significantly.

These factors indicate a significant research need to evaluate trade-offs and ensure that a focus on carbon storage does not lead to unintended consequences for the agricultural economy, biodiversity water and other environmental values. Figure 24 shows the relative scale of the increase land sink required to offset ongoing LNG sector emissions if there is no abatement at source.

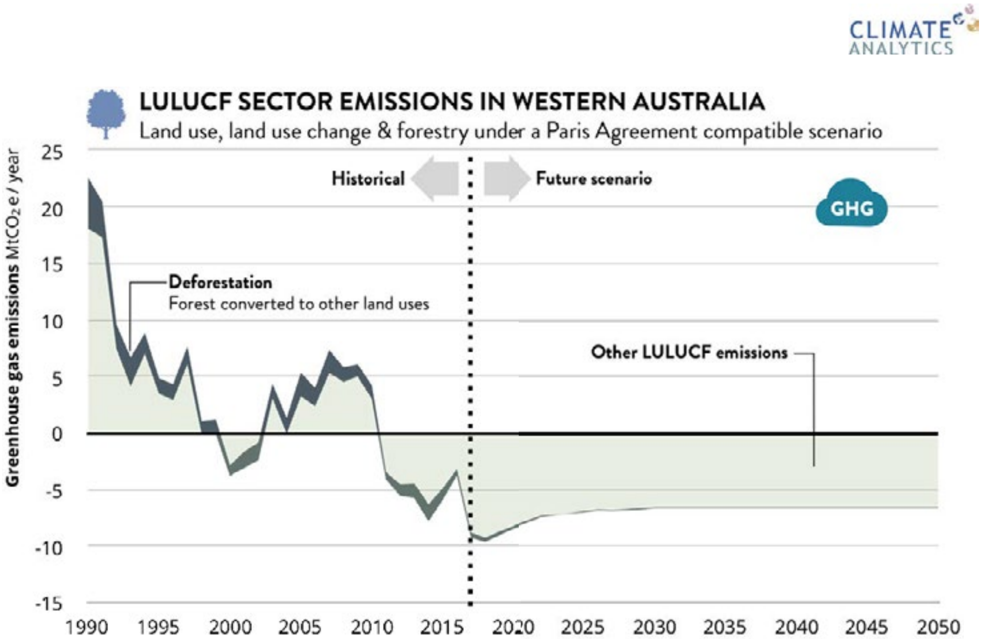

Figure 23 This figure shows the historical trajectory of land use, land use change and forestry (LULUCF) drawn from the June 2019 "State and Territory Greenhouse Gas Inventories 2017" for total LULUCF for all greenhouse gases (mainly carbon dioxide) and deforestation (defined as Forest converted to other land uses). A stylised scenario for the future development of the sector is shown assuming deforestation ending by 2025 and the recent uptake of CO_2 due to afforestation reforestation and other processes gradually reduces without further policies, essentially following the relative pathway from the December 2018 national greenhouse gas projections for the Australia wide LULUCF sink, maintained at 2030 levels until 2050.

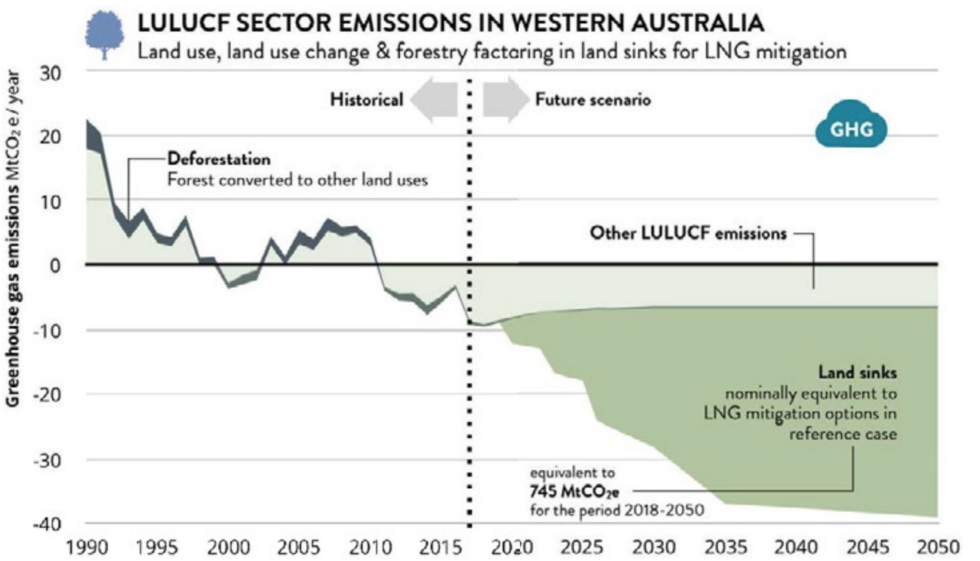

Figure 24 As in Figure 23 but showing the additional annual land sink nominally equivalent to the LNG mitigation options in reference case and shown in Table 6 and which total around 745 $MtCO_2e$ for the period 2018-2015.

Overall pathway

Figure 25 shows the overall greenhouse gas emissions in the Paris Agreement Benchmark Pathway for Western Australia. The only remaining emissions in 2050 would be from the agriculture and waste sector. They would need to be compensated with negative emissions from the Land-use sector.

GHG emissions would need to peak as soon as possible and then reduced steeply, **overall by 49% in 2030 compared to 2005 (35% without LULUCF)**. This is a much stronger reduction than the national federal target and confirms the inadequacy of that target and of assuming it as a benchmark for Western Australia. It is within albeit at the lower end of the range estimated for a domestic federal emissions reduction target for 2030 in line with the Paris Agreement.

This pathway achieves net zero emissions around 2050, if the size of the sink in the Land-use sector is maintained at high levels. Not shown is the pathway after 2050, where emissions would need to continue to be negative, leading to a net uptake of CO_2.

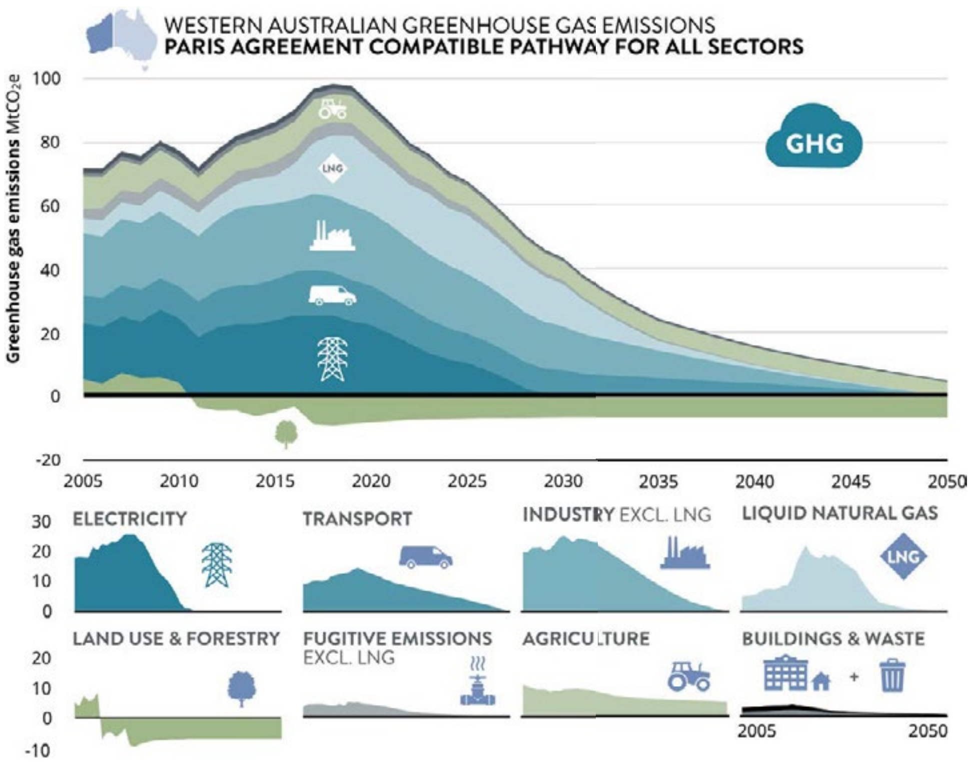

Figure 25 GHG emissions pathway for each of the sectors following transformation consistent with the Paris Agreement in each of those sectors. Total GHG emissions peak around 2020 and decline to about 63% below 2005 levels in 2030, reaching net zero in the 2040s contingent upon maintaining the recent large sink in the LULUCF sector.

CONCLUSIONS AND OUTLOOK

Policy Implications

This analysis has produced an energy and industry Paris Agreement compatible carbon budget for Western Australia that is consistent with the global carbon budget and the necessary global and national energy transformation across different regions required to limit warming to 1.5°C.

It shows how the **Western Australia carbon budget relates to the global carbon budget** and also provides information on the **emissions pathway** by which the budget needs to be met in order to ensure the Paris Agreement goal to limit warming to 1.5°C does not get out of reach.

It shows how this needs to be complemented with reductions in the **sectors outside of energy** and industry, in particular agriculture and waste, and the **role of land use and forestry to compensate** for **remaining emissions in particular from agriculture** that cannot be fully decarbonised.

It confirms the importance of **fast reductions in the short and medium term**, and the key strategy to decarbonise the power sector by a fast transition to renewable energy, taking advantage of the **vast potentials and low and falling costs of renewable energy and storage technologies** and the opportunities for a range of sectors.

Key conclusions for climate policy in Western Australia:

- Need to develop a **whole of the economy roadmap and strategy** and **detailed sectoral roadmaps and strategies** in line with Paris Agreement. This strategy needs to be based on the Paris Agreement Long Term Temperature goal and the importance of **limiting warming to 1.5°C** and the urgent need to **peak emissions and reduce them by 2030**.
- Such strategies and roadmaps need to be based on **robust scenarios and analysis**, that should be developed in a process with **broad participation of all stakeholders** – industry and trade unions, civil society, regional and local governments.
- It is **dangerous to focus only on an endpoint of net zero emissions by 2050.** The pathway there matters – both in terms of the cumulative emissions and their impact on temperature, as well as in terms of the technical and economic transition pathways and policy implications for the near future.
- **Energy and industry** are the **key sectors** that need to be addressed for full decarbonisation.
- The overall and sectoral strategies and roadmaps need to take into account the critical role of **electricity generation transitioning to renewable energy and fully decarbonised by the 2030s,** to contribute to the decarbonisation of end use sectors through direct or indirect electrification.
- Such a strategy involves a large increase in electricity demand and therefore a **massive ramping up renewable energy capacity – solar and wind** - that takes this into account and needs to be factored in when planning the transition of electricity generation, with clear targets and management of grid development and market regulation, as well as infrastructure for microgrids and off grid solutions.
- This strategy of "**sector coupling**" not only helps other sectors such as transport and industry reduce emissions and decarbonise, but also helps providing stability of the grid with variable renewable energy – wind and solar - through battery or other storage and demand side management.

- Sectoral strategies and roadmaps need to lead to the development of clear mid-term **sectoral targets** that are consistent with a Paris Agreement sectoral pathway, such as targets for expansion of renewable energy capacity that take sector coupling into account, and targets for electrification of transport and a shift to public transport and more cycling and walking, as well as targets for efficiency and shift to zero emissions fuels in industry, as well as a target to stop deforestation and develop and secure biological sinks while preserving biodiversity, taking into account climate change.
- In addition to roadmaps and targets, sectoral strategies need to include necessary near term transformational **policies to create incentives and develop the necessary infrastructure** to allow for a timely transition, such as charging stations for electric vehicles or hydrogen fuel cell trucks, or expanded public transport. This can also include **state-level legislation** to ensure sectoral targets are met despite the lack of action at federal level.
- **Every sector will have to contribute** to reducing emissions, and **linking it to other objectives** such as reduced air pollution, protection of biodiversity, sustainable economic development and high quality employment including in regional Western Australia.
- It is important to **address open research questions** in a targeted approach, and ensuring knowledge is developed and shared broadly with stakeholders. This is important for example for the **role of the land-use sector** and how it can contribute to uptake of CO_2 and **negative emissions** either through the sustainable use of biomass and carbon capture and storage or through enhancing and sustaining sinks in forests and ecosystems.

Western Australia has unique opportunities to develop its own vision and strategy and reap benefits of being a global leader in implementing the Paris Agreement, independent of the current failure at the federal level: with its own independent energy system, unique opportunities, prime renewable energy but also minerals resources, it has the opportunity to develop new manufacturing industries with added value and employment creation and moving away from being an exporter of carbon to becoming an exporter of zero emissions energy carriers (green hydrogen, ammonia, or electricity to neighbouring South East Asian countries) and products.

ANNEX I: METHODOLOGY AND MODELLING APPROACH

We have used as the starting point for developing the 1.5°C compatible energy and industry pathway for Western Australia global and regional data from the "Beyond 2°C Scenario" (B2DS) in the "Energy Technology Perspective" (ETP 2017) report of the International Energy Agency (IEA 2017). The ETP model enables a technology-rich, bottom-up analysis of the global energy system. We recently analysed the B2DS and this analysis (Climate Action Tracker 2018b) is reproduced in the next paragraphs.

The IEA (2017) estimated that the B2DS pathway has a peak global warming of 1.75°C above pre-industrial with a 50% likelihood meaning that its warming exceeds that of a 1.5°C compatible scenario. In its estimation of the peak warming level associated with the B2DS scenario, the IEA assumed that non-CO2 GHG would add about 0.35°C to the CO2-only warming. We however have evaluated the IEA B2DS pathway applying the same climate model approach to warming levels as was used in the IPCC Special Report on 1.5°C and earlier IPCC Fifth Assessment Report, enabling a comparison of "like with like" with the IPCC 1.5°C compatible scenario set. As the IEA provides only energy-related CO2 emissions, land-use and non-CO2 GHG emissions need to be estimated. When we assume comparable non-CO2 GHG emissions pathways to the ones analysed by the IPCC, and allow for negative emissions also comparable to the IPCC 1.5 pathways, we find that the B2DS scenario until 2050 is a close analogue climatically to the more recent 1.5°C compatible pathways.

There are however significant caveats, some related to the limitations of downscaling (see below) and others to the faster than expected cost reductions in key technologies for decarbonisation in particular renewable energy, storage (battery and pumped storage), electric vehicles and renewable hydrogen.

Since the IEA (and in general scenarios in the scientific literature) does not provide scenario data at sub-national state levels, nor at national level for Australia, in this report we first downscale the results of the B2DS scenario for the OECD region to Queensland, by using a model-based approach: SIAMESE (Simplified Integrated Assessment Model with Energy System Emulator) (Sferra et al. 2019).

SIAMESE is a reduced complexity IAM (Integrated Assessment Model), which provides cost-optimal emission pathways at the country, or state level, taking into account the complex interactions between economic growth, energy consumption and carbon emissions. While downscaling the energy-sector results from a given model (e.g. the IEA/ETP 2017), SIAMESE takes into account a coherent set of assumptions in line with a "middle of the road" socio-economic storyline (Dellink et al. 2017; Fricko et al. 2017). This storyline relies on a continuation of historical trends regarding technological developments and GDP growth at the country (or state) level. At the same time, SIAMESE has a cost optimisation perspective when allocating how much a country or a region would need to contribute to global emissions reductions in line with the Paris Agreement long term goal.

The SIAMESE downscaling approach can be applied to the overall economy (e.g. scaling down the overall primary energy consumption and emissions), or to individual sectors (e.g. transport, power and others). SIAMESE takes as input the original IEA B2DS (pathways for the OECD region, which start in 2014 in this scenario) and the observed energy consumption and emissions data for Western Australia. Based on the SIAMESE simulation we calculate the B2DS compatible carbon budget for Western Australia' transport and building sectors as the cumulative emissions remaining from 2018 to 2050 considering historical emissions until 2017.

Limitations of the downscaling are embedded in the driving scenario, which in this case is weak in several areas including decarbonization in industry, electrification of transport, and costs of renewable hydrogen as an energy carrier. We therefore use the SIAMESE simulation and estimate of a B2DS compatible carbon budget as an initial estimate which provides an upper bound on the carbon budget for the transport and building sector to evaluate against the Paris Agreement benchmark of achieving zero CO2 emissions by around 2050 for developed economies. These leads to Paris Agreement benchmark budgets for transport and building sectors, as well as fuel mix and demand estimates, in particular electricity demand. Given electrification is an important strategy for decarbonisation of transport and building sectors, the paris Agreement benchmark pathways for these sectors imply an increased electricity demand.

To determine the pathway and carbon budget for the electricity sector, given its important role for decarbonising end use sectors, but also to make sure it is consistent with global cost-optimal mitigation pathways consistent with the Paris Agreement temperature goal.

We compare the IEA B2DS results for the OECD region with the 1.5°C pathways assessed in the Special Report on Global Warming of 1.5°C by the Intergovernmental panel on Climate Change (IPCC SR 1.5, 2019). These pathways lead to peak warming to at most 1.6°C and subsequently return warming to below 1.5°C by 2100 with at least 50% probability. The subset of scenarios we consider here excludes those that exceed the sustainability limits for carbon-dioxide removal options identified in the literature. Fuss et al. (2018) identify a sustainability limit of 0-3.6 GtCO2 (removal)/yr for Agriculture, Forestry and Other Land Use (AFOLU), and 0.1 – 5 GtCO2/yr for Bioenergy with Carbon Capture and Storage (BECCS) in 2050, as also reflected in the IPCC SR1.5. We apply these limits to the average of each of the corresponding pathway values between 2040-2060 to filter out pathways which exceed them. The cumulative CO2 emissions from the electricity sector in OECD of the IEA ETP B2DS scenario over its time horizon (2014-2060) are on the high side compared to the range of the IPCC 1.5 scenarios (applying the 25th to 75th percentile range, as is commonly used in IPCC SR1.5, i.e. the range covers half of the pathways, while a quarter of pathways has cumulative emissions below this range, and the final quarter of pathways lie above this range). Staying on the more ambitious end of the range of CO2 budgets would minimise the amount of negative emissions needed for Paris Agreement compatibility over the second half of the century. The lower end of the range of IPCC SR1.5 pathways assessed here exceeds the cumulative CO2 emissions from IEA ETP B2DS by about 30%. Detailed assumptions will be published in (Climate Action Tracker 2019 b – AUS SU report).

As the downscaling model SIAMESE does not resolve technologies within either the fossil-fuel or renewable energy sectors, as well as for scenario analysis of the electricity supply sector, we apply the Australian electricity system optimisation model AUSeMOSYS, developed by Climate Analytics based on the current version of the Open Source energy Modelling SYStem (OSeMOSYS). The model provides a cost-optimised energy system pathway to meet the given demand for electricity, and taking into account the limit to cumulative emission derived as described, as well as taking into account increased electricity demand in industry, transport, and buildings from decarbonisation through electrification. The AUSeMOSYS model is multi-regional, dividing Australia into seven regions including New South Wales (NSW), Queensland (QLD), Victoria (VIC), Tasmania (TAS), South Australia (SA), Western Australia (WA), and Northern Territory (NT). The model time horizon covers the period from 2010 until 2050 in 1-year-steps, while each year is split into six time slices. Here we analyse the results for the Western Australia region. For a detailed description of the modelling framework and assumptions we refer to (Climate Action Tracker 2019 b – AUS SU report). Specific assumptions for Western Australia based on available projections for renewable energy uptake are explained in the main text.

Given the importance contribution and very region-specific economic profile of the industry sector in Western Australia, we determine the electricity demand and fuel mix as well as related emissions for the industry sector, by analysing a range of scenarios and literature related to key benchmarks for selected indicators, and applying them to the specific Australian and Western Australia context with the scenarios analysis tool PROSPECTS developed by the Climate Action Tracker consortium (Climate Action Tracker 2019 – Methodology annex), applied for an analysis of scaling up mitigation action options for Australia (Climate Action Tracker 2019b – Australia scaling up report, forthcoming), and downscaling this to Western Australia specific economic and energy system as well as emissions input data.

Assumptions for other sectors (LNG, agriculture, waste, land-use), not directly modelled, are explained in the main report.

CLIMATE ANALYTICS

ANNEX II: SCOPE OF EMISSIONS BY SECTOR FROM THE AUSTRALIAN GREENHOUSE EMISSIONS INFORMATION SYSTEM (AGEIS).

Energy and Industry Emissions

Electricity generation emissions are from fuel combustion for public electricity and heat production (AGEIS 1.A.1.a).

Transport sector includes fuel combustion emissions from domestic aviation (AGEIS 1.A.3.a), road transportation (AGEIS 1.A.3.b) (cars, light commercial vehicles, heavy duty trucks and buses, motorcycles, and other), railways (AGEIS 1.a.3.c), domestic navigation (AGEIS 1.A.3.d) (pleasurecraft and domestic marine). It does not include other transportation (AGEIS 1.A.3.e) which is included in the industry sector (consistent with the sector definition in the IEA ETP).

LNG Production includes emissions from fuel combustion for LNG processing (included in AGEIS 1.A1) and emissions from fugitives related to LNG (as a subsector of Industry) (own estimates).

Industry other emissions include:

- Energy industries (AGEIS 1.A.1) minus public electricity and heat production (AGESIS 1.a.1.a). This includes fuel combustion from petroleum refining, manufacture of solid fuels industries (i.e. coal mining, gas production and distribution minus fuel combustion for LNG processing) and other energy industries.
- Manufacturing industries and construction (AGEIS 1.A.2) includes fuel combustion emissions from iron and steel; non-ferrous metals; chemicals pulp, paper and print; food processing, beverages, and tobacco; non-metallic minerals; and other, as well as agriculture, forestry and fisheries energy sector emissions (AGEIS 1.A.4.c).
- Fugitive emissions from fuels (AGEIS 1.B) including from coal mining (underground and surface mines); oil (exploration, crude oil production, transport, refining and storage, and distribution); natural gas (exploration, production, transmission and storage, distribution and other); and venting and flaring. (Fugitives (AGEIS 1.B) data is categorized as confidential on AGESIS. We calculate it here by deducting fuel combustion (AGEIS 1.A.) from energy (AGEIS 1.) and based on own estimates.
- Industrial Processes (AGEIS 2) which includes the mineral, chemical, metal and electronic industries; plus non-energy products from fuels and solvent use; product uses as substitutes for ozone depleting substances, and other.

Building sector emissions include fuel combustion from commercial/ institutional (AGEIS 1.A.4.a) and residential buildings (AGEIS 1.A.4.b).

Other sectors (non-energy and industry related emissions)

Agriculture emissions (AGEIS 3) from enteric fermentation, manure management, rice cultivation, agricultural soils, prescribed burning of savannas, field burning of agricultural residues, liming, urea application and other carbon-containing fertilisers.

Waste emissions (AGEIS 5) include solid waste disposal, biological treatment of solid waste, incineration and open burning of waste, wastewater treatment and discharge, other.

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Climate Analytics is a non-profit climate science and policy institute based in Berlin, Germany with offices in New York, USA, Lomé, Togo and Perth, Australia, which brings together interdisciplinary expertise in the scientific and policy aspects of climate change. Our mission is to synthesise and advance scientific knowledge in the area of climate change and on this basis provide support and capacity building to stakeholders. By linking scientific and policy analysis, we provide state-of-the-art solutions to global and national climate change policy challenges.

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CLIMATE ANALYTICS

IMPACT OF BURRUP HUB FOR WESTERN AUSTRALIA'S PARIS AGREEMENT CARBON BUDGET

February 2020

EXECUTIVE SUMMARY

This study analyses the impact of the Burrup Hub LNG projects for Western Australia's carbon budget under the Paris Agreement and its net zero emissions 2050 goal. It builds on the comprehensive study published earlier on Western Australia's carbon budget under the Paris Agreement, which developed sectoral and overall benchmarks for Western Australia's emissions pathway.

The Burrup Hub is not consistent with Western Australia implementing the Paris Agreement and achieving its objective of net zero emissions by 2050, as well as with the global emission reductions necessary to implement the Paris Agreement. This is in stark contrast with the claims by the project proponents, that emissions from the project are "acceptable" and that the impact is "low":

The fast ramping up of LNG processing has contributed most to the increase of greenhouse gas emissions in Western Australia. As of 2018, the LNG sector comprising the LNG facilities within the Burrup Hub had a share of 18% of WA's CO_2 emissions (excl. LULUCF), and these CO_2 emissions have tripled since 2005.

Emissions from the LNG industry in WA are estimated here to be 20 Mt CO_2e per annum currently and can be expected to approach 30 Mt CO_2e per annum by the late 2020s with the Burrup Hub contributing half to this and approaching 15 Mt per annum and the North West Shelf (NWS) alone contributing about a third (11 Mt per annum) over the proposed lifetime until 2070.

Annual emissions from the Burrup Hub from 2025 onwards would be as high as 16% of current WA greenhouse gas emissions and 36% of total emissions across all sectors (excluding the uncertain Land use, land-use change and forestry, LULUCF sector) in 2030 in a pathway for WA consistent with the Paris Agreement.

The projected cumulative emissions from the present trajectory of the LNG industry in Western Australia for 2018-2050 equal a Paris Agreement compatible carbon budget for all energy and industry sectors for the state until 2050 of about 950 Mt C02 (Climate Analytics, 2019a). **The Burrup Hub alone, if it were to go ahead as planned, would take up about half of the total WA energy and industry carbon budget by 2050. Cumulative emissions of the Burrup Hub until 2070 would take up around 80% of WA's carbon budget.**

The claim that the project will help reducing global emissions through increasing the use of gas globally ignores recent scientific literature and market developments: Global implementation of the Paris Agreement means that the recent growth in the use of natural gas cannot continue, whether for the power sector or in other applications. **Under the Paris Agreement demand for natural gas in the power sector in Asia, a major source of LNG demand, is likely to peak by around 2030 and then decline to close to zero between 2050 and 2060.**

The **mitigation measures** outlined by the project proponents **rely on offsetting** and are **inadequate** to achieve the necessary emissions reductions, which would have to include the following key elements of the transition of the LNG sector in Western Australia:

- Adjust to demand reduction for natural gas in Asia under the Paris Agreement;
- Carbon capture and storage of reservoir carbon dioxide;
- Introducing renewable energy quickly into LNG manufacturing process.

CLIMATE ANALYTICS

CONTENTS

INTRODUCTION

This report provides an assessment of the implications of the Burrup Hub liquefied natural gas (LNG) projects, including the Browse Basin to North West Shelf and North West Shelf expansion proposals for Western Australia's carbon budget and emissions pathway benchmarks that are consistent with the state playing its role in national and global efforts to limit global mean warming to 1.5°C above pre-industrial levels, including the state objective of net zero greenhouse gas (GHG) emissions by 2050 as published by Climate Analytics (2019a).

In Climate Analytics (2019a), we calculated the carbon budget for Western Australia's fossil fuel (energy and industry) CO_2 emissions for the period 2018-2050 in line with the Paris Agreement to be **about 950 Mt CO_2 which if current emission rates were to be continued, would be consumed within 12 years.** To stay within this budget, it is essential to decarbonise all energy and industry sectors and reach zero carbon emissions from fossil fuel and industry across all sectors of the economy by around 2050 (and around 2060 globally). This is consistent with the state's own objective of reaching net zero greenhouse gas emissions by 2050 and eventually phasing out all fossil fuels not only for power generation but for all other industry processes.

The fast ramping up of LNG processing has contributed most to the increase of emissions in Western Australia. As of 2018, the LNG sector comprising the LNG facilities within the Burrup Hub had a share of 18% of WA's **CO_2 emissions (excl. LULUCF)**, and these CO_2 emissions have tripled since 2005. An important conclusion from the study is that sooner or later **Western Australia will have to transition away from exporting natural gas.**

This raises the question of the impact and risks of such a large new gas development as proposed with the Burrup Hub, including the Browse basin to NWS proposal and the NWS extension proposal, and its consistency with the Paris Agreement.

THE BURRUP HUB

The project proponent, Woodside claims that the greenhouse gas emission impacts of North West Shelf Project Extension and the Browse to North West Shelf Project are "acceptable".

The Browse to North West Shelf Project and NWS Project Extension are part of Woodside's larger Burrup Hub "vision" as a regional WA production centre. The Hub will advance the current Pluto LNG and NWS facilities through linking proposed projects, including a Scarborough floating production unit; Pluto Train 2; Browse to NWS Project; NWS Project Extension and the Pluto-NWS interconnector (Woodside, 2019a). The Hub plans to develop approximately 40 trillion cubic feet of gross dry gas resources from Scarborough, Browse, Pluto and NWS facilities accelerated with new infrastructure to allow for the processing of third party resources and other Pluto offshore reserves (Woodside, 2019a). The Scarborough to Pluto Train 2 plans to expand the existing Pluto facility to include a second gas processing train, with its first cargo scheduled in 2024 (Woodside, 2019a). The Pluto-KPG Interconnector entails a pipeline to transport gas from Pluto to the NWS Karratha Gas Plant, with start-up scheduled for 2022 (Woodside, 2019a). The Browse to NWS Project is targeted to start up around 2026, and involves two floating production storage and offloading units delivering gas through a pipeline to NWS (Woodside, 2019a). The NWS Project Extension will use gas from the Browse to NWS Project for over 30 years, and allows for the processing of third party gas (Woodside, 2019a).

It is important to take into account the Browse to NWS and NWS Project Extension as part of the larger Burrup Hub, to fully assess the impact. In particular, the NWS Project extension will extend the life of these integrated facilities to 2070 and beyond, and allow for processing not only from Browse but resources from the interconnected facilities and other third party gas (Woodside, 2019a) despite the state target of net zero emissions by 2050. The Burrup Hub spans the jurisdictions of state and federal waters with approvals needed from the Western Australian Environmental Protection Agency (EPA) and the Commonwealth Department of Environment and Energy. Separating the 'vision' into several proposals subject to different authority approval, with different timeframes obscures the total greenhouse gas emissions impact. It is important to assess the project through a strategic integrated approach to understand the impact of the Hub's cumulative emissions.

In this report, we analyse the contribution of the Burrup Hub project with its proposed mitigation plan to emissions in WA and how they impact on WA achieving the state's objective of net zero emissions by 2050 as well as achieving an emissions pathway consistent with the Paris Agreement Long Term Temperature Goal (LTTG).

In addition we analyse the contribution of the project to global emissions and whether the proposed project is consistent with the Paris Agreement LTTG.

LNG SECTOR IN WESTERN AUSTRALIA: TRANSITION NEEDED FOR PARIS AGREEMENT

In Climate Analytics (2019a) we have shown how each sector of WA's economy needs to contribute to decarbonisation and reaching net zero emissions in 2050. The key elements of the transition of the LNG sector in Western Australia identified in our study are the following:

- Adjust to demand likely reduction for natural gas in Asia under the Paris Agreement;
- Capture and storage of reservoir carbon dioxide that is otherwise vented to the atmosphere;

- Introducing renewable energy quickly into LNG manufacturing process.

We have shown that under the Paris Agreement, demand for unabated natural gas in the power sector in Asia, a major source of Western Australian LNG demand, is likely to peak by around 2030 and then decline to close to zero between 2050 and 2060 (**Figure 1**). This is a robust result of an analysis of 1.5°C compatible mitigation pathways assessed by the IPCC to be consistent with the Paris Agreement Long-term Temperature goal, and taking into account that Carbon Capture and Storage (CCS) is increasingly unlikely to be able to compete with renewable energy and storage.

Renewable energy and storage provide a more cost-effective solution and additional benefits for sustainable development, with costs continuing to fall, while there are no observed cost improvements for CCS in power generation and incomplete capture would need to be compensated with additional, and likely expensive, efforts to remove carbon dioxide from the atmosphere. These pathways show that Paris Agreement implementation is likely to result in a substantial reduction in natural gas demand in the power sector in Asia without CCS, reducing from peak levels in 2030 to close to zero by 2050.

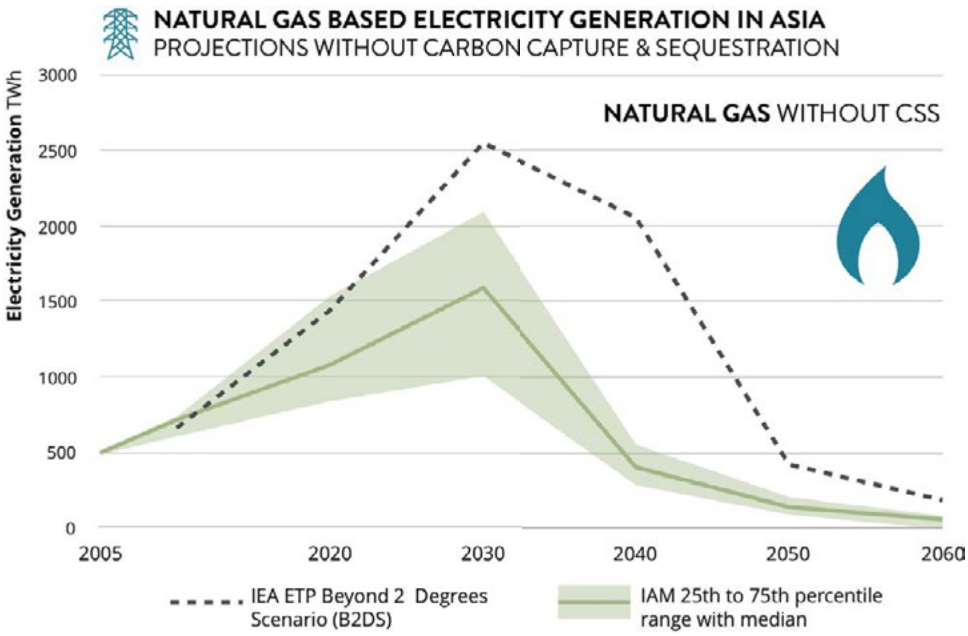

Figure 1: Electricity generation from natural gas without CCS. Shown are the median for PA-compatible Integrated Assessment Models (IAM), as well as the results from the IEA ETP B2DS used in the current study for some of the underlying pathways, both for the Asia region. Source:(Climate Analytics, 2019b). *The relative cost of CCS makes deployment of this technology unlikely in our assessment. The earlier IEA B2DS scenario shows a much higher natural gas demand than more recent fully Paris compatible scenarios. Source: Climate Analytics* (2019a).

Short and medium term policy recommendations or investment decisions based on the benchmarks and projections for coal and gas power generation that rely on CCS use but are not transparent about the extent of their reliance on this technology (as presented by the WEO Sustainable Development Scenario, SDS as used by Woodside) will most likely lead to wrong decisions, considering the low adoption rates of this technology and other concerns related to the use of these technologies for fossil fuel power plants.

The Sustainable Development Scenario (SDS) from the International Energy Agency is a significant outlier for coal and gas-fired power generation compared to Paris Agreement compatible pathways, even when CCS is included. The implied reliance on CCS to lie within the bounds of the Paris Agreement pathways, calls into question the wisdom of the use of the WEO SDS as a benchmark for policy and investment decisions.

Irrespective of whether or not the demand reductions implicit in the Paris Agreement Asian power demand scenario above occur, the cumulative emissions of the LNG industry need to be reduced substantially and the basic options examined in Climate Analytics (2019a) through carbon capture and storage of reservoir CO_2 and by introducing renewable energy quickly into the LNG manufacturing process - would need to be deployed in either case. In the reference case, the scale of the emission reductions would be substantially larger than in the Paris Agreement Asian power demand case.

In Climate Analytics (2019a) we have estimated a carbon budget for Western Australia's fossil fuel CO_2 emissions for the period 2018-2050 at around 950 $MtCO_2$, about 0.17% of the remaining global carbon budget. The LNG sector carbon budget within this report was estimated at 208 $MtCO_2$. While all energy and industry emissions would have to be reduced by 37% in 2030 compared to 2005, the LNG sector would still increase emissions by 170%, but then reduce by 73% in 2040 to reach zero in 2050.

BURRUP HUB LNG PRODUCTION AND WESTERN AUSTRALIA'S EMISSIONS

The proposed Burrup Hub is a significant contribution to the projected continued growth of the LNG sector in Western Australia, which has doubled in size over the last five years to about 45 million tonnes of LNG (MtLNG) per annum production capacity in 2018[1], and is set to increase by about 35% to 60 MtLNG p.a. by, or shortly after, 2025 including the Burrup Hub with the extension of NWS and expansion of Pluto facilities (Climate Analytics 2019). The Burrup Hub facilities would comprise 44% of the total LNG capacity Figure 2: Growth of LNG production capacityFigure 2).

Browse production is currently anticipated by Woodside (2019d, p. 682) by mid-2020, and steady state is expected after 5 years and until about 2040 with other gas resources expected to feed into the NWS facility. With the high $C0_2$ content in the Browse Basin, we estimate an increase in emissions intensity of the NSW facility from currently 0.4 $tC0_2$/t LNG to above 0.7 $tC0_2$/t LNG in the 2030s, leading to an increase of the average emissions intensity for all WA facilities to above 0.5 $tC0_2$/tLNG in the 2030s.

The greenhouse gas intensity of LNG production is calculated based on the upstream emissions from extractor natural gas and pumping it to LNG processing facilities, the venting of CO_2 from the natural gas reservoir, and the emissions from natural gas used in the liquefaction process. This is expressed in tonnes of CO2 equivalent per tonne of LNG (tCO2e/tLNG).

The method used in this report to estimate the GHG intensity of each of these steps is based on, or calculated from, data published by Woodside in its various reports.

Woodside has tended to separate elements of this greenhouse gas intensity equation into different parts obscuring the full intensity of LNG production, particularly at the north-west shelf plant based on the Browse gas. As a consequence the greenhouse gas intensity factors used here are higher than quoted in the North-West Shelf extension environmental review document (Woodside, 2019).

1 See (WA Government, 2019)

For example we calculate the total CO_2 venting intensity for Browse sourced NWS LNG to be in the range of 0.36 to 0.43 $tCO_2e/tLNG$ compared to 0.08 $tCO_2e/tLNG$ reported in Table 6-17 of (Woodside, 2019). The difference is because the lower intensity figure only accounts for the CO_2 vented at the NWS plant itself and does not include the CO_2 vented in the Browse production and transmission process.

Similarly the reported intensity of the NWS plant does not include the upstream emissions due to the natural gas required to produce the gas and pump it to the NWS plant, which amounts to about 0.16-0.19 $tCO_2e/tLNG$.

Along with a liquefaction intensity of 0.32 $tCO_2/tLNG$ we calculate that Browsed sourced NWS LNG production has a GHG intensity in the range of 0.85-0.97 tCO2/tLNG. We have used a value of 0.90 tCO2/tLNG as a likely average for Browse sourced NWS LNG production, more than double the report intensity of 0.41 $tCO_2/tLNG$ for the NWS Plant at full production (Table 6-17, (Woodside, 2019)).

Woodside (2019d, 2019c) assesses the GHG impact in separate documents, one referring to the Browse to NWS proposal, addressing the upstream emissions, and a separate assessment of the NWS expansion project, assessing the downstream emissions.

Woodside (2019d)(2019d) concludes that GHG emissions, including estimated contributions of NWS scope 1 emissions attributable to the proposed processing of Browse feed gas by the NWS and scope 1 and 3 emissions are “acceptable”.

In Climate Analytics (2019a) we estimated the greenhouse gas emissions based on the projected LNG production. Here we update this estimate based on the data provided by the project proponents.
We also showed that a Paris Agreement pathway for Western Australia consistent with the state reaching its objective of net zero emissions in 2050 implies decarbonising all energy and industry sectors, including the LNG sector, by 2050.

The total (Scope 1) emissions from the LNG industry in WA are based on estimates of CO_2 losses from natural gas reservoirs and plant specific emissions intensity based on available environmental impact statements and other studies (see Climate Analytics 2019a).

Along with the rapid growth of CO_2 emissions from the natural gas used to produce LNG[2], fugitive emissions from LNG processing and related activities and venting of the CO_2 from the natural gas reservoirs, have also increased rapidly. **Emissions from the LNG industry in WA are estimated here to be 20 Mt CO_2e per annum currently and can be expected to approach 30 Mt CO_2e per annum by the late 2020s[3] with the Burrup Hub contributing half to this and approaching 15 Mt per annum and the NWS alone contributing about a third (11 Mt per annum) over the proposed lifetime until 2070 (Figure 3).**

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2 For every tonne of LNG produced it is assumed that natural gas equivalent to 9% of the energy content of the LNG is required for the manufacturing process.

3 Emissions from LNG production facilities are estimated here based on standard emission factors, energy balance, physical estimates of CO_2 losses from natural gas reservoirs and plant specific emission intensity based on environmental impact statements and other studies. These estimates are approximately 5% lower than the Clean Energy Regulator Scope 1 plant specific reports for the NWS Karratha, Pluto and Gorgon operations in Western Australia in 2017/18. The estimated Wheatstone emissions are only 45% of the CER Scope 1 reports for 2017/18, however this may be do higher than normal emissions associated with the scaling up of operations at this plant. In general LNG operations also supply domestic gas and data in respective EIS documents emissions associated with this are of order of 5% of the LNG related emissions. This is an updated estimate compared to our previous study, and includes carbon dioxide sequestration in Gorgon.

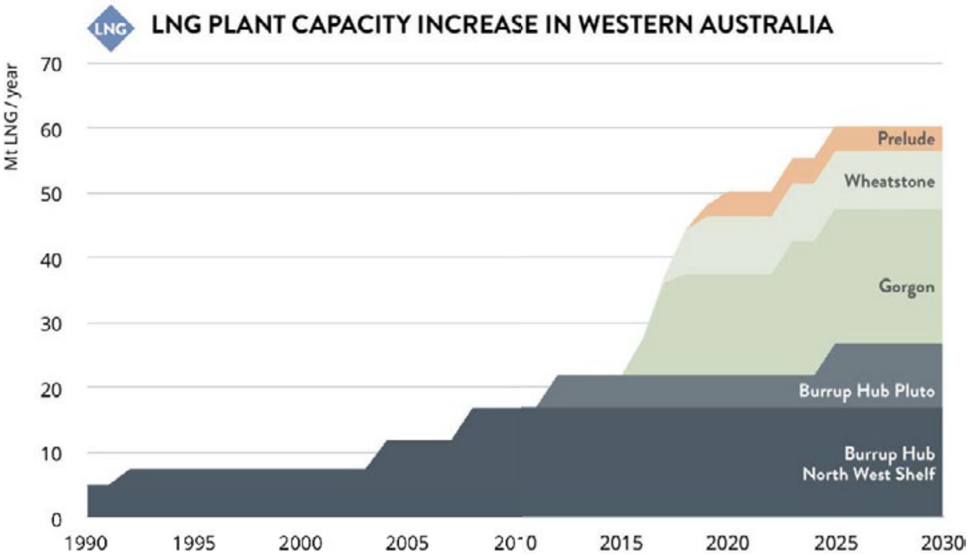

Figure 2: Growth of LNG production capacity in Western Australia. Various sources.

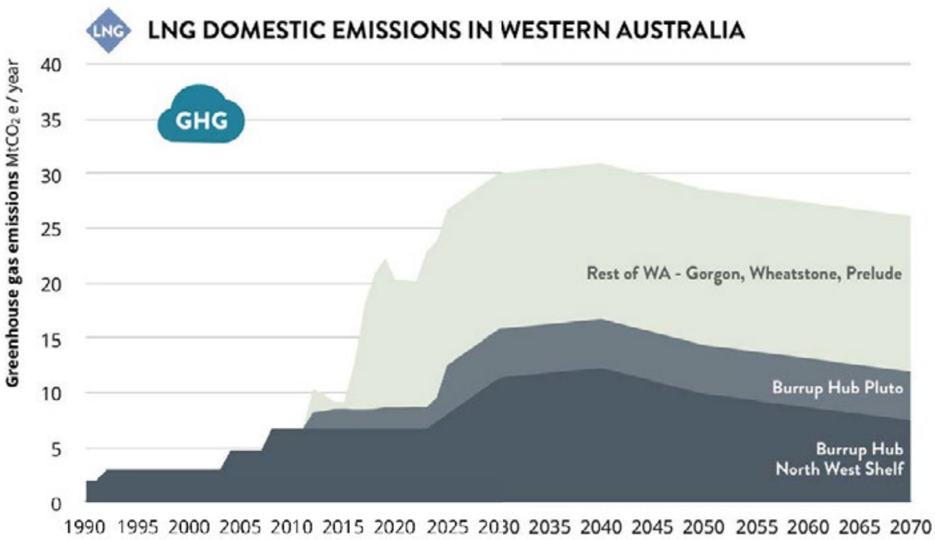

Figure 3 Growth of LNG related emissions (Scope 1) in Western Australia from natural gas used in liquefaction, CO_2 from natural gas reservoirs and fugitive emissions from the LNG manufacturing process until 2019 with projections to 2030. Whilst the intensity of CO_2 emissions from direct energy use and liquefaction have remained fairly stable, in terms of tonnes of CO_2 per tonne of LNG produced, there has been an increase in CO_2 vented from natural gas reservoirs due to the concentration of CO_2 in more recently exploited natural gas reservoirs. The reference case projection includes CO_2 CCS at the Gorgon LNG plant, which explains the drop of total emissions from 2019 to 2020, when it is assumed that the Gorgon CO_2 CCS is capturing 80% of the reservoir CO_2 and storing it in a secure geological formation. The figure includes the contribution of the of the Burrup Hub comprising the NWS and Pluto LNG plant and the gas resources that supply them including the Browse basin. It is important to note that the emissions are linked to production capacity and for the early historical period are different from the actual emissions from plant that was not then operating at full capacity.

To assess the significance, we compare annual and cumulative emissions with corresponding total emissions in Western Australia as well as with Paris Agreement consistent benchmarks as identified in (Climate Analytics, 2019a). Results are shown in Table 1.

The projected cumulative emissions from the present trajectory of the LNG industry in Western Australia for 2018-2050 equal a Paris Agreement compatible carbon budget for all energy and industry sectors for the state until 2050 of about 950 Mt CO_2 (Climate Analytics, 2019a). **The Burrup Hub alone, if it were to go ahead as planned, would take up about half of the total WA energy and industry carbon budget by 2050. Cumulative emissions of the Burrup Hub until 2070 would take up around 80% of WA carbon budget[4].**

Annual emissions from the Burrup Hub from 2025 onwards would be as high as 16% of current WA greenhouse gas emissions and 36% of emissions across all sectors (excluding the uncertain Land use, land-use change and forestry, LULUCF sector) in 2030 in a pathway for WA consistent with the Paris Agreement. This clearly shows that the Burrup Hub is not consistent with Western Australia implementing the Paris Agreement and achieving its objective of net zero emissions by 2050.

This is in stark contrast with the claims by the project proponents, that emissions from the project are "acceptable" (Woodside, 2019d, p. 2191).

Table 1 Estimated annual and cumulative emissions from Burrup Hub and total LNG Sector, compared with current emissions in Western Australia and Paris Agreement benchmarks

	Annual emissions 2030 (Mt CO_2 e)	Share of current WA emissions (2017) (%)	Share of WA emissions PA Pathway 2030	Cumulative emissions 2018-2050 (Mt CO_2 e)	Share of WA PA carbon budget (%) [5]	Cum. Em. 2018-2070 (Mt CO_2 e)	Share of WA PA carbon budget (%) [6]
Burrup Hub – NWS	11.4	12%	26%	334	35%	507	53%
Burrup Hub - Pluto	4.5	5%	10%	130	14%	219	23%
Burrup Hub total	**15.8**	**17%**	**36%**	**464**	**49%**	**726**	**76%**
LNG Sector rest WA	14.2	15%	33%	**457**	**48%**	**742**	**78%**
LNG Sector total	**30.5**	**32%**	**69%**	**922**	**97%**	**1468**	**154%**

Mitigation of LNG emissions - Paris Agreement and net zero emissions objective

Woodside does not explain how the Browse to NWS shelf proposal would be in line with the aspirational target of net zero GHG emissions by 2050, and only refers to "continuing to work to reduce (net) emissions intensity through improvements in energy efficiency, investments in biosequestartion projects and innovation in our production processes, also referring to its published Climate Change

4 Note this is a conservative estimate, as we have only derived a carbon budget for WA until 2050, which does not take into account the need for negative emissions after 2050, see Climate Analytics (2019).

5 Carbon Budget is estimated for fossil fuel – energy and industry – CO_2 emissions. Emissions estimated from LNG Sector are almost completely (about 98%) comprised by CO_2 emissions.

6 Note that the carbon budget for 2018-2070 would be lower than the 2018-2050 budget, due to the need for negative emissions after 2050.

Policy (Woodside, 2019b). This **implies relying on offsetting**, which we have shown is not consistent with the WA state objective of net zero emissions and the Paris Agreement carbon budget, given mitigation achieved outside of the LNG sector that would be used for offsetting would need to be implemented in any case, and not to compensate for no, or insufficient, mitigation in the LNG sector.

In order to meet the commitments of the Paris Agreement significant abatement measures would need to be introduced in the LNG sector. These would include extending carbon capture and storage for reservoir CO_2 losses to all LNG plants in Western Australia as well as replacing a significant fraction of natural gas used in LNG processing by renewable electricity.

The broad approaches assumed in our previous report (Climate Analytics 2019a) is that the level of CCS planned for the Gorgon plant of 80% from 2020 (which would capture approximately 60% of present total CO_2 reservoir emissions for LNG operations in WA) extended to all plant from 2023, combined with the phasing in of renewable energy so that by 2030, 50% of LNG manufacturing natural gas use is replaced by renewable energy, 90% by 2035 and by 2050, 100%.

One scenario therefore for the LNG industry in Western Australia under Paris Agreement implementation would be to more or less follow the modelled trajectory for natural gas demand in the power sector in Asia for the period 2030 to 2060 which would result in a substantial reduction in LNG demand, reducing from peak levels in 2030 to close to zero by 2050 (Climate Analytics, 2019a). A decline in demand for LNG industry consistent with the Paris Agreement reaching close to zero by 2050 would reduce all LNG related emissions very substantially.

Irrespective of whether or not the demand reductions in Asia discussed above occur, the cumulative emissions of the LNG industry need to be reduced substantially in the basic options examined here would need to be deployed in either case. In the reference case, the scale of the emission reductions to be achieved through carbon capture and storage of reservoir CO2 and by introducing renewable energy quickly into the LNG manufacturing process would be substantially larger than in the Paris Agreement Asian power demand case. For completeness we show both scenarios which achieve similar levels of cumulative reductions by 2050.

Applying the options described above to the reference case LNG production in our original study as is shown in Figure 5 would reduce the peak emissions from Western Australia LNG manufacturing to around 300% above 2005 levels from a projected 600% increase by the mid 2020's in the case with no policy action. This would bring emissions back to about 176% above 2005 levels in 2030, 16% below 2005 levels in 2040 and 46% below in 2050. Zero CO_2 emissions would be needed to be Paris Agreement compatible.

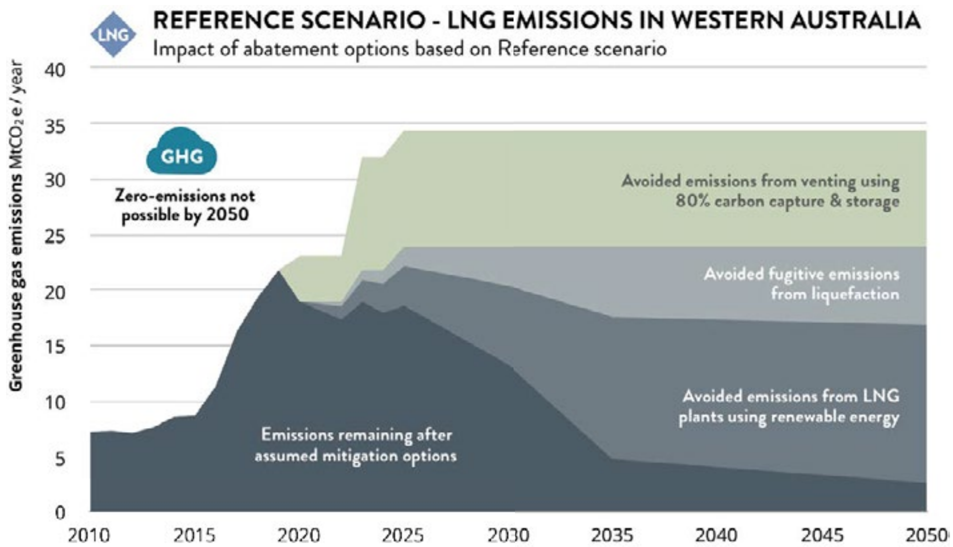

Figure 4 Relative role of the abatement options described in the text for reference case LNG demand from Climate Analytics (2019a). (Difference in reference case due to updated estimate. The reference scenario shown here does not yet include sequestration for the Gorgon facility. Source: Climate Analytics (2019a).

Under a Paris Agreement induced decline in demand from 2030 combined with the mitigation options discussed (carbon capture and storage, electrification), this would lead to LNG related emissions in 2030 being about 175% above 2005, around 80% below 2005 levels by 2040 and approach zero by 2050 (Figure 5).

Woodside claims that Browse to NWS project is compliant with the Safeguard Mechanism of the Australian Government (Woodside, 2019d). It has been shown repeatedly that the Safeguard Mechanism is inadequate as a policy to achieve emission reductions in line with the insufficient NDC, let alone in line with the Paris Agreement (Climate Action Tracker, 2019).

Woodside's (2019d) measures for the Browse to NWS Project beyond meeting the inadequate safeguard mechanism and relying on offsetting/carbon credits include "waste heat recovery units, active heating for hydrate management, the use of batteries and the use of nitrogen to purge the flare stack" which amount to only 1 MtCO2e reduction per year.

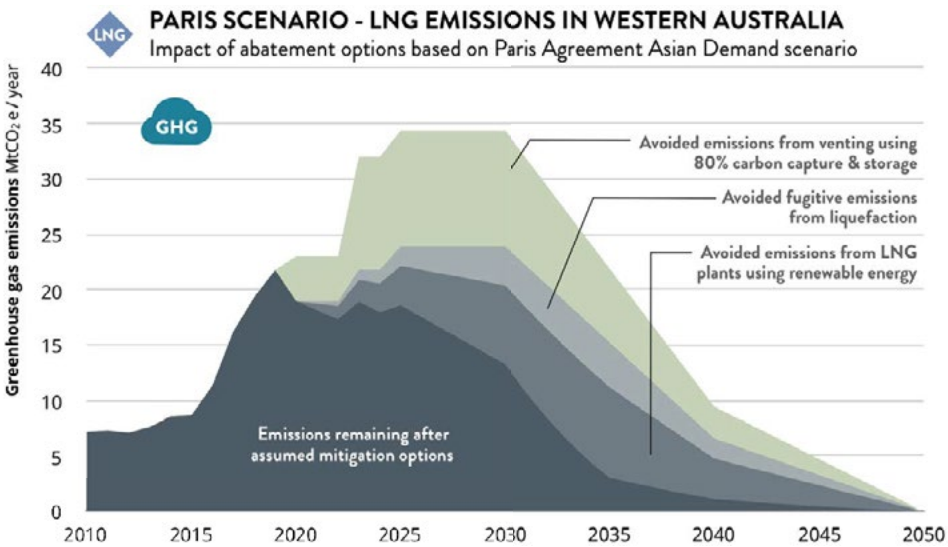

Figure 5: Relative role of different elements of a Paris Agreement LNG demand reduction scenario and mitigation options in reducing emissions from the reference case to close to zero emissions by 2050. The cumulative emissions remaining between 2018 and 2050 after the assumed mitigation options are applied un this Paris Agreement LNG demand scenario is 274 MtCO_2e. This amounts to approximately about 29% of the Western Australian Paris agreement compatible carbon budget for the energy system. There could be more or less emissions left depending upon the rate and scale of the actual mitigation options deployed.

CONTRIBUTION TO GLOBAL EMISSIONS AND PARIS AGREEMENT

When the LNG is burnt offshore in power stations significantly greater missions occur but these are not counted domestically in Australia or in Western Australia under the agreed international greenhouse gas accounting systems used in the UNFCCC, Kyoto Protocol and the Paris Agreement, as emissions are accounted for in the country in which the LNG is consumed. These emissions are referred to as Scope 3 emissions.

We estimate the Scope 3 emissions of the Burrup Hub to be around 120 Mt CO_2 e per annum[7] from 2025 onwards, with NWS contributing 75 Mt CO_2 e per annum. Cumulative Scope 3 emissions for 2025 to 2070 (until the end of planned lifetime) of 5.5 Gt CO_2e are equal to about 1.2% of the total global energy and industry carbon budget for 2018-2100 calculated based on Paris Agreement consistent mitigation pathways (Climate Analytics 2019) and about the same as the share of the global carbon budget estimated for Australia's energy and industry emissions.

Global implementation of the Paris Agreement means that the recent growth in the use of natural gas cannot continue, whether for the power sector or in other applications. The analysis of global mitigation pathways in line with the Paris Agreement as assessed by the IPCC shows that under the Paris Agreement demand for natural gas in the power sector in Asia, a major source of LNG demand, is likely to peak by around 2030 and then decline to close to zero between 2050 and 2060, as shown above.

[7] Based on current and projected production of 16.9 Mt LNG per annum at NWS and 9.9 the emission factor used by Woodside for LNG (3.13 kg CO_2e/kg LNG) and the LPG, domestic gas and condensate estimates provided by Woodside (n.d.). For Pluto, we assume a proportional contribution for domestic gas, condensates and LPG, which leads to a share of 36% of Scope 3 emissoins from Burrup Hub coming from Pluto.

Woodside (2019d:678) refers to Australia being expected to restate its NDC in 2020 and update it in 2025. This is against the COP 26 decision agreed to also by Australia that confirms the need to increase ambition by 2020 to close the gap as also outlined in UNEP Emissions gap reports (UNEP, 2019) and IPCC Special Report (2018). Given the need to peak emissions in 2020 and to close the 2030 ambition gap this implies NDCs need to be ratcheted up in 2020, and it is not consistent with the Paris Agreement to wait until 2025.

Woodside (n.d.) refers to gas as a solution to climate change, including referring to the IPCC AR5 SYR (IPCC, 2014) stating that "switching from coal to gas-fired power can significantly reduce GHG emissions". However, Woodside ignores the more recent IPCC (2018) assessment relevant for achieving the Paris Agreement Long Term Temperature goal (LTTG) of limiting warming to 1.5°C to significantly reduce the impacts and risks of climate change. Woodside have justified the Browse to NWS project using the IEA's World Energy Outlook (WEO) Sustainable Development Scenario (Woodside, 2019d). This scenario is not 1.5 degrees Paris Compatible, as it limits temperatures rise to 1.7 to 1.8 degrees (Woodside, 2019d). Overall the Sustainable Development Scenario finds gas demand grows modestly to 2030 and reduces to present levels by 2040 (IEA, 2019). The WEO highlights the uncertainty surrounding the scale and durability of demand for LNG demand in developing countries, due to price sensitivity, competition from other technology which risks of suppliers being unable to recover investment costs (IEA, 2019) posing a huge stranded asset risk to WA and investors.

As shown above, the SDS is not an appropriate benchmark for short and medium term policy recommendations or investment decisions as it is not consistent with the Paris Agreement temperature goal nor is it transparent about the extent of reliance on CCS technology. In addition, it is a significant outlier for coal and gas-fired power generation compared to Paris Agreement compatible pathways, even when CCS is included.

Woodside argue that LNG is an 'ideal partner" to intermittent renewable energy (Woodside, 2019d). Alternative firming capacity can be provided by batteries and other storage technology, which have been found to be more cost effective than gas in many geographies, including Australia. The CSIRO and AEMO found the levelized cost of solar and wind is lower than gas and other electricity generation options (Graham, Hayward, Foster, Story, & Havas, 2018). "Firm" solar and wind with two to six hours of battery storage or hydro is still more cost effective than gas or other fossil fuel generation (Graham et al., 2018). IRENA (2019) found that the costs of renewable energy has declined to the point that it is cheaper than new natural gas options without financial assistance. Bloomberg New Energy Finance found similar results, with wind and solar providing the cheapest form of electricity generation across two thirds of the world (BloombergNEF, 2019). An increasing number of studies shows the feasibility of 100% renewable energy.

CONCLUSIONS

We have shown that it is important to integrate all projects related to the Burrup Hub to assess implications for greenhouse gas emissions and consistency with the Paris Agreement and emission targets.

In contrast to the claims by Woodside that the greenhouse gas emissions impacts are "acceptable", we show that emissions from the Burrup Hub including the proposed NWS extension and Browse to NWS project would contribute significantly to Western Australia's emissions and make it impossible for Western Australia to achieve a pathway consistent with the Paris Agreement and its state objective of net zero greenhouse gas emissions by 2050.

The Burrup Hub, if it were to go ahead as planned, would take up about half of the total WA energy and industry carbon budget by 2050. Cumulative emissions of the Burrup Hub until 2070 would take up more than 80% of WA carbon budget.

Annual emissions from the Burrup Hub from 2025 onwards would be as high as 16% of current WA greenhouse gas emissions and 35% of emissions across all sectors (excluding the uncertain Land use, land-use change and forestry, LULUCF sector) in 2030 in a pathway for WA consistent with the Paris Agreement. This clearly shows that the Burrup Hub is not consistent with Western Australia implementing the Paris Agreement and achieving its objective of net zero emissions by 2050.

Mitigation measures proposed by Woodside are inadequate compared to the scale of reductions needed to be consistent with the Paris Agreement, and rely significantly on offsetting emissions for example with biosequestration, which contradicts the need to reduce emissions across all sectors.

The claim by Woodside that the project will contribute to reducing emissions globally is not consistent with the recent scientific literature and mitigation pathways consistent with the Paris Agreement Long-term temperature goal, and therefore ignores the large risk of creating stranded assets through investing in fossil fuel infrastructure when there is a need to phase out fossil fuels, including gas, to achieve the Paris Agreement long-term temperature goal.

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Climate Analytics is a non-profit climate science and policy institute based in Berlin, Germany with offices in New York, USA, Lomé, Togo and Perth, Australia, which brings together interdisciplinary expertise in the scientific and policy aspects of climate change. Our mission is to synthesise and advance scientific knowledge in the area of climate change and on this basis provide support and capacity building to stakeholders. By linking scientific and policy analysis, we provide state-of-the-art solutions to global and national climate change policy challenges.

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APPENDIX D SUBMISSIONS

APPENDIX D.21 DWERDT247368 CMS17489 (NAME REDACTED)

Appendix A Technical Studies

Appendix A.1 Browse Project Desktop Lighting Assessment

Woodside Energy

APPENDIX D SUBMISSIONS

APPENDIX D.22 FRIENDS OF AUSTRALIAN ROCK ART INC (FARA)

FARA submission RE Browse-NWS Extension, due 12 February 2020

Submitted by Dr [redacted] geologist and environmental scientist on behalf of Friends of Australian Rock Art Inc (FARA)

Summary

FARA urges the EPA and DWER to reconsider as a matter of urgency the North West Shelf Project Extension (hereafter, the NWS Extension), including the associated offshore Browse gas field and floating facilities (in State and Commonwealth waters), and the 900km connecting pipeline. It is imperative that the Western Australian and the Commonwealth governments act in the interests (both short- and long-term) of all citizens, rather than facilitating the profits of industry and the perceived but not actual benefits to the State. In addition to reducing greenhouse emissions, **definitive action would also reduce the acidic industrial emissions that are continuing to degrade the irreplaceable and unique Aboriginal heritage preserved in the Murujuga rock engravings.**

While we recognise that industry infrastructure is now established on the Burrup Peninsula and is unlikely to be removed, **the State and Commonwealth governments could be much more proactive** by:

- requiring stricter emissions controls and greater carbon offsets,
- regulating and monitoring promised carbon offsets to ensure they happen,
- restricting rather than encouraging new industrial development, and
- diverting future development to the [redacted] including the [redacted] and [redacted] proposals.

We are profoundly concerned about many aspects of the 3-part NWS Extension (Burrup Hub), and present detailed points in subsequent sections of this submission.

In summary, we are particularly anxious about the NWS Extension for these reasons:

1. There is no one authority that will assess the entire impact in terms of all offshore pollution from venting, pollution from transporting gas hundreds of kilometres via pipelines, fugitive emissions and onshore pollution from processing, and emissions from burning gas overseas. There is an immediate need for cumulative accounting of the effects of total emissions from the NWS Extension projects, emissions from all existing industry already operating on the Burrup Peninsula, emissions from ships serving Dampier Port for all current industries and proposed, and the fugitive emissions and offshore venting of high-CO2 reservoirs in Commonwealth waters (EPA guidelines only apply to areas of state jurisdiction). It is imperative that the EPA and DWER require the total emissions to be accurately calculated, and then evaluate, regulate and monitor their impacts. Furthermore, detailed assessments and monitoring results must be made available to the public in a timely manner, so that industry is truly accountable for all of their emissions.

2. The NWS Extension will hugely increase WA's greenhouse gas emissions (especially CO2, methane, and nitrous oxide) which affects Australia and the world by increasing the impacts of climate change, including extreme temperatures, sporadic/changed rainfall patterns, uncertainty of agricultural productivity, increased severity of hazards (bush fires, fire tornadoes, floods, landslides, and coastal erosion), sea level rise and displacement of people living in low-lying areas. If these

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projects go ahead, the Burrup Hub would be one of the largest and most polluting fossil fuel projects in the world, and it is fundamentally intended to continue emitting huge amounts of greenhouse gases until 2070, which is totally unacceptable to the people of Australia. Woodside's only commitment to a greenhouse gas mitigation plan for the onshore part of the project is to avoid, reduce or offset 330,000 tonnes of emissions from the gas plant by 2030. This is an incredibly small fraction of the total 7.6 million tonnes of CO2 emissions/year currently emitted through this plant. And Woodside's announcement to offset reservoir emissions for its portion of the joint venture by 0.6 million tonnes/year from 2021, doubling from 2025 is also a fraction of the total. **We need real commitments to big emissions reductions and big offsets.**

3. **Total sulphur dioxide and nitrogen dioxide emissions will** substantially increase as a result of releases during gas processing onshore at Dampier. Emissions of sulphur and nitrogen dioxides mix with moisture in air to form strong acids which **dissolve the rock surface patina and destroy the Murujuga rock carvings** on the Burrup Peninsula. Measurements of rock surfaces near the Karratha gas plant show there has been a 1000-fold increase in acidity (lower pH) on rock surfaces from preindustrial times and additional gas processing will further these the acid deposition on the rocks and thus destroy the Aboriginal rock engravings which are an important part of Australia's cultural heritage – we and the traditional custodians of Murujuga are all concerned about this lost heritage and knowledge.

4. There are **well-known negative impacts of industrial emissions on human health**, as highlighted by the UN and Australian health agencies (e.g. USEPA, 2019; Doctors for the Environment Australia, 2019; Adelaide University Report, online). The impacts include breathing difficulty during exertion, exacerbated asthma and new cases of asthma, respiratory infections, decline in respiratory function, chronic obstructive pulmonary disease, high blood pressure, and an increased risk of heart problems for people already at risk. The State cannot ignore the effects of poor air quality, when experienced regularly due to proximity to industrial sources, on local Indigenous communities, the towns of Dampier and Karratha, visitors to Murujuga, and industry workers in the Dampier region. A recent analysis of the health of Karratha, Port Hedland and Newman residents (Anderson et al., 2018) shows that potentially preventable hospitalizations relating to lung disorders for children up to 11 years old was from 1.7 to 11.5 times more than for the WA State average. Similar figures for chronic obstructive pulmonary disease and congestive heart failure in people over 65 years were 2.75 and 1.5 times, respectively, more than the state average.

5. Woodside argues that "wholesale reductions in emissions are difficult to achieve" because they are extending the life of the existing old and inefficient plant rather than building a new plant, with modern technology and decreased emissions. Since the **technology exists, they should be required to implement it immediately to reduce their emissions to the lowest possible level.** In the case of sulphur and nitrous oxide emissions, this could substantially reduce the impact on the Murujuga rock art, and more generally reduce Western Australia's appalling level of contribution to global greenhouse gas emissions. If the NWS Extension proposal is to be accepted, there should be **a strict timetable for these emissions controls to be put in place**.

6. In addition, public consultation about the NWS Extension proposals was (conveniently) launched when WA's climate policy is not yet completed, and the EPA has just released draft guidelines for assessing major polluting projects, which will require proponents to submit plans that show how they will “reasonably and practicably avoid, reduce and offset emissions to contribute to the state’s aspiration of net-zero emissions by 2050.” It is alarming and disconcerting that the NWS Extension proposals do not include such plans, and they will not be subject to scrutiny on this critical point.

Woodside's consultations with FARA have been disingenuous. While they “listen” they don't show any goodwill by releasing existing monitoring data or working to advance the promised monitoring program – all intended to delay any real action. Similarly the WA government continues to make unsupportable statements that their policies can both promote industry and preserve the rock art, and yet they have shown little to no backbone in requiring industry to reduce emissions when it is technically feasible, or more importantly construct new industry off the Burrup Peninsula. All of this indicates that the public consultation process is essentially a sham – we have only to read the West Australian's 2 page spread (1/31/20) where Premier McGowan did not even mention the rock art. That **shows yet another example of exactly what the government values, and the lack of importance it places on Australia's irreplaceable Aboriginal cultural heritage**. As a result, Woodside continues to either overstate the certainty of data that supports their case or omit important information on human and environmental health impacts of their emissions.

LNG is the fastest growing source of pollution in Australia and it is driving the growth in our national emissions. Despite what we are told, **gas is not clean,** especially since is is mostly methane, which is 34 times more potent than CO2 in trapping heat. Furthermore, if the State and Commonwealth governments were honest, they would explain that they do not consider LNG to be a transition fuel – **the Browse-NWS Extension project** and all its associated new infrastructure (some paid for by taxpayers), **is only profitable when operated over many decades**; the calculated return is based on at least 2050-2070. Critically, since the major international and national banks and insurance companies are all moving away from fossil fuels, the **NWS project will likely become a stranded asset**, especially as the cost of renewables continues to drop and the environmental cost of burning gas rises. Taxpayers continue to forced to subsidize big industry, through tax benefits and infrastructure projects, while being told that we couldn't possibly subsidize sustainable alternatives.

Gas is WA's already biggest emissions polluter and this project with existing LNG facilities will together emit almost half of WA's annual emissions making it more likely Australia will not meet even our global aspirational commitments unless all other states compensate for WA's higher emissions. And we know that we need to reduce emissions long before 2050 to achieve net zero. Western Australia should decide to tackle its emissions through the creation of clean jobs and investment in renewable technologies, which we have the resources and technology to do. Gas is not part of the solution for climate change, or the solution to sustainably power WA into the future. **We strongly urge you to reject Woodside’s proposal as the State should be pursuing the cheap and abundant renewable resources we have available right here in WA.**

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Specific aspects of the NWS Extension proposals that are of critical concern to FARA
(Points from Woodside's ER Document, are discussed by figure or section number)

Figures 2-1 and 2-2:
The development envelope is shown to pass through and past islands of the Dampier Archipelago, and continue offshore. This is especially critical because rocks on these islands likely contain some very early Aboriginal engravings, made when sea level was lower, and therefore represent extra-significant cultural heritage sites, which have yet to be documented. Emissions from ships contain substantial quantities of sulphur and nitrous oxides which when mixed with atmospheric moisture produces acid deposition on rocks, including those containing rock art. In addition, emissions when combined with salt water spray, can also form hydrochloric acid. **These acids all dissolve the thin layer of patina and destroy the rock art – very low pH measurements (3.5 – 4) have been obtained from rocks near the Woodside gas plant flare.** Equally importantly, ships' emissions, and fugitive emissions from pipelines, also release ongoing and large volumes of greenhouse gases for decades into the future.

Sections 2.7, Woodside's Management System and 2.7.1, NWS Project Historical Environmental Performance
Woodside's management system (WMS) has lofty statements, but FARA and the WA public are waiting to see a real commitment to their public statement of "commitment to minimising adverse effects on the environment from its activities and to improving environmental performance" (p. 27) – so far, Woodside has set a very low bar for reducing emissions of all types: "Key improvements in design, processes, and technology have been incorporated in the NWS Project facilities as the opportunity has arisen" (p. 27) – the proposed NWS extension provides the perfect opportunity! Woodside's ongoing insistence on building new facilities on the Burrup Peninsula, rather than on the mainland, and on processing gas from particularly dirty reservoirs increases total emissions and their incredibly damaging effects on the rock art, public health, and on our global environment.

Particularly insidious is the incorrect reporting of data to support false statements that Woodside has made "overall improvements in emissions, in particular NOX emissions to air, as shown in Figure 2-3 and reduction in the number of regulatory reportable dark smoke events as shown in Figure 2-4" (p. 27-28). However, the same graph is in the Karratha Gas Plant Annual Environmental Report (July 2018 To June 2019), where it states that the reduction in NO_x emissions was due simply to a change in the method of calculation rather than additional scrubber technology. Furthermore, no dark smoke events are shown for 2018 (Fig. 2-4, p. 28), although it was clearly observed in August 2018 by many international visitors for much of the period they were in Karratha for the World Heritage Summit. Why should we or the public have any faith in Woodside's statements? Much more could be done to reduce their emissions if Woodside actually made the commitment to do so, and the State held them accountable through accurate monitoring and reporting.

Woodside claims that "as operator of the NWS Project, it is committed to achieving a level of environmental management and performance consistent with national and international standards and statutory obligations." However, this is not good enough especially if they want to be considered a global player with a social licence to operate. There have been too many years of saying one thing and then delaying the implementation of changes and improvements that would reduce negatives effects on our shared environment. There is ample evidence that Woodside as an industry is not doing enough to reduce soaring greenhouse gas emissions or the specific acidic pollutants which are damaging the rock art

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of the Dampier Archipelago.

Appendix E: Air quality impact assessment

Fundamentally, **some of the major conclusions presented about air quality impacts in this Appendix are based on insufficient, incorrect or old data.** ***For example:***

– Woodside's modelling does not account for all emissions, even though they say it is cumulative; there is no accounting of offshore flaring and fugitive emissions which impact both global emissions and take up of carbon dioxide into the ocean. It is well known that CO_2 uptake in the ocean (from the atmosphere) has increased at an alarming rate, and this lower ocean pH is contributing substantially to the vulnerability of coral reef ecosystems, including Scott Reef which is in the immediate vicinity of the Browse Basin offshore platforms sites. Coral reefs are not the only casualty of increased acidity in the ocean – plankton are also greatly impacted. As they form the base of the marine food web, there will be further downward pressure on commercial fish/food stocks and more importantly, the entire marine ecosystem which is already under intense attack from plastic and petroleum pollutants.

– Much of the air quality modelling is based on incomplete or old data, which is particularly concerning as it would underestimate the true level and concentration of emissions. There is a lack of much, or any, collection and reporting of recent data which is a crucial problem because of the increased industrial emissions on the Burrup Peninsula in the last 10-15 years and importantly the increase in <u>cumulative</u> emissions, including:

- increased NO_x emissions when Yara's fertilizer plant starting producing in 2006;
- substantially increased production at the Karratha gas plant in 2008, when an extra train was added;
- increased SO_2 especially from shipping when Pluto started producing in 2012;
- start up of the Yara TAN plant in 2017, although this has been mostly off line so we don't know the true impact/quantity of its nitrous oxide emissions which are particularly important for the petroglyphs;
- doubling of iron ore mined and shipped since 2008.

– It is not possible to evaluate the estimates of emissions given for the Urea and Methanol proposals (p. 27) – are these realistic? Again, these particular industries will have an big <u>impact of cumulative acidic emissions</u> and thus the Murujuga rock art, so we need to have confidence before any new proposals can be adequately evaluated and assessed.

– There are inadequate data sets for benzene, toluene and xylene (BTX), for Karratha and Dampier (really only in 2009, so only that year is reported in Table 3-7). This was well before major sources of BTX came on line with the opening of Pluto 1, when a new monitoring program should have been required and initiated. The Burrup air quality data were collected from 2009-2015, but none of the post-2009 data are presented. Why? The data reviews might be recent but the obvious lack of recent data means that conclusions drawn from the modelling are based on inadequate and incomplete data, and should be viewed with extreme caution (*The Precautionary Principle*). Furthermore, it is important to ask: why was there no requirement for ongoing data collection, analysis and reporting? It has been known for many years that the Burrup petroglyphs are internationally significant and a matter of extreme concern to the traditional custodians of Murujuga.

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– There is no discussion of the impact of emissions on rock art located on the islands along the shipping and pipeline route out of Dampier Port, and as mentioned above, fugitive and ships' emissions will be absorbed by the marine environment along the entire length of the pipeline and transport routes. In addition, Table 4-10 (p. 26) purportedly contains modelled estimates for total SO2, NOx and VOC for ship running continuously at the dock (Burrup = 13 berths; Cape Lambert = 5). Surprisingly, the SO2 and NOx are exactly the same, although values for VOC and particulates differ markedly. These data should be checked for accuracy and if there are errors or omissions, the correct data should be required and properly evaluated.

– Section 3.6 on SO2 is completely inadequate and out of date. They reference a 2010 review report stating that "conservative assumptions were applied to several fixed industrial emission sources, noting very low sulfur in fuel concentrations". Which sources? What is low – what were the numerical results? They then erroneously conclude the "most sources are at or near the level of detection" – any undergraduate student could identify multiple holes in this set of conclusions given that no data are provided. Finally, they state that shipping is the most significant source of SO2 emissions, but that "maximum hourly average concentrations would not be expected to exceed 10 ppb for most locations away from engine exhausts on ships", and yet, Woodside is supposedly addressing cumulative deposition? This SO2 doesn't disappear – it mixes with atmospheric moisture and is deposited on rocks and degrades the petroglyphs – this is why we need to know cumulative deposition rates and variations.

– Section 3.7 presents deposition data, although there are only monitoring results for several 1-2 year intervals between 2004 to 2014. The deposition flux calculated by Gillett (2008) was based on superseded emissions conditions with far more industrial activity since data were collected between 2004-2008. Text accompanying Table 3-8 says total S and N flux data "have been reasonably consistent over time", but for the 3 years of data collected since 2008, total sulfur wasn't even analyzed (or at least the results are not presented). The obvious lack of recent data means that conclusions drawn from the modelling are based on inadequate and/or incomplete data, and should be viewed with extreme caution (*The Precautionary Principle*).

– All emissions from offshore venting and fugitive emissions, and all the emissions due to transport (gas via pipeline and ships), seem to be omitted from tables in Section 4.4. NOx from "ship berths" is mentioned in Table 4-1 (p. 18), but there isn't an explanation of how it would change in future if more gas is processed and shipped/year compared to now.

– Furthermore, some of the air quality data that have been collected have not been made public (commercial-in-confidence), thereby making it impossible to check or confirm their modelling. Woodside is very quick to disregard so-called unpublished data or scientific reports, and yet they are masters of hiding data from the public who have every right to know what is being done in our shared State and Commonwealth environment. This is yet another indication of their true unwillingness to be honest about the total and cumulative environmental impacts of the Browse-NWS Extension, and its associated offshore platforms and pipelines.

However, while acknowledging some deficiencies in the available data, Woodside does not exercise the caution required, as dictated by the Precautionary Principle, the Principle of Intergenerational Equity, and the Principle of Waste Reduction.

Appendix H: Rock art literature review (includes modelling of deposition)

Fundamentally, the conclusions reached in this Appendix are based overly on insufficient data and or reliance on discredited reports. Furthermore, there is incomplete attention to some published studies (Black et al., 2017) that indicate there are likely cumulative negative effects associated with industrial emissions of compounds that result in acidic deposition on the Murujuga rocks, including those containing invaluable Aboriginal carvings. While the NWS Extension proponents acknowledge some of the deficiencies of past monitoring reports, including those produced by CSIRO, again they do not exercise caution as dictated by the Precautionary Principle. Instead they conclude that they will act to change their strategies only after new monitoring data are collected.

Section 2.3
There is a statement about the “robust heritage protection status”; however, it is clear that IF this status exists, it has not been enforced given that neither the State or Commonwealth governments have developed a robust ongoing monitoring program (even after they committed again to do this), nor are they regulating to adequately protect the unique and invaluable rock art. As happens in nearly every industry and government document, they include the escape clause that they will protect the heritage ”whilst recognising the economic and social benefits of the Burrup Peninsula industries for the people of WA“ … However, they have not yet protected the cultural heritage contained in rocks of Murujuga and don't have a rigorous and enforceable plan in place.

Similarly, the Woodside document quotes another 'escape clause' provided by Premier McGowan regarding World Heritage nomination: “With appropriate management, the WA government considers that industry and tourism can successfully co-exist with the cultural heritage and environmental values of Murujuga”. There is no detail about the basis for drawing this conclusion, either by the State government or by Woodside. What is appropriate management? How will it be monitored? These details are essential and evidence of compliance must be provided in a timely and publicly accessible manner.

Section 3.2.2:
Importantly, this section does not state that after extensive review, the Senate enquiry and DWER found that the CSIRO report and science were inadequate – Woodside does not report the true level of scrutiny. Instead this Appendix reports the results of some old studies that were based on incomplete or old data (including that used in Woodside's modelling). Instead, Woodside says that the 2018 Senate report recommended that a Murujuga Rock Art Strategy and monitoring program be initiated and funded, and a Stakeholder Group be set up (SECRC, 2018). While true, the Woodside document neglects to mention that this Group is heavily weighted toward government and industry, which we consider to be a cause for concern since decisions could be easily biased away from the long-term protection of the rock art. In addition, there have been lengthy delays and still no monitoring program is in place after 18 months, during which time, emissions and their impacts continue.

Section 4.2: Air quality and Deposition monitoring
Table 4-1 does not completely report some published studies including the very relevant paper by Black et al. (2018), although they know of the research and have been sent a copy.

Table 4-2
Importantly, this table shows that Woodside has not considered it appropriate or necessary to undertake any air quality monitoring, despite knowing and admitting that their industry is a major emitter of many air pollutants. Of course, the WA State government is equally culpable for not requiring close monitoring of air quality throughout the many years that Woodside and other industry have operated on the Burrup Peninsula.

Section 4.2.1: Key findings of Gillet (2010) monitoring program
All are reported in qualitative, rather than quantitative terms: "small enhancement of SO2 and HNO3" and a "larger enhancement of in NO2 at 'industry' sites compared with 'background' sites". This is unacceptable. What are the actual values and percentages?

In addition, the discussion of key findings of Strategen (2018) analysis concludes that the TSP concentrations were reasonably consistent across the three sites suggesting an absence of significant direct impacts from individual sources. However, the model used under-predicts emissions concentrations, possibly by 5 times according to Gillett.

Section 4.2.2, including figures 4-7 to 4-11: Air Quality and Deposition Monitoring, Discussion
The section opens **"**Whilst DWER describes the results from previous air quality monitoring programs as 'reliable and targeted' it is recommended that improvements could be made...". This again represents a major omission given that the CSIRO data, which Woodside repeatedly uses as supporting data during meetings with FARA, were essentially discredited.

Section 4.3.1
In this section on air quality modelling and deposition, Woodside states that "the SKM (2003) report concluded maximum concentrations of SO2 are found close to shipping berths, while NO2 emissions from industrial facilities are much hotter emissions with higher release points (stacks) which *aids dispersion of NO2 and causes maximum concentrations to be located further away from these sources."* These maximum concentrations don't disappear – where are they and what is being directly affected? Detailed and comprehensive monitoring data must be collected in order to answer these questions. However, there is actually regular data from BOM that show that a 'rain' cloud appears over the Burrup Peninsula and industrial region despite the very clear BOM evidence that it is not associated with rain. The truth is clear: this is the emissions cloud from Woodside and other industry on the Burrup.

Section 4.3.2.
Woodside does not abide by the Precautionary Principle, although it readily admits that: "as highlighted in SKM (2003; 2006; 2009) reports, there are significant uncertainties associated with the modelled deposition rates due to assumptions of surface resistance for water, soil and vegetation. Consequently, modelled deposition rates are indicative only and deposition monitoring is recommended for further clarity" (p. 521). Given those uncertainties, and the now out-of-date original data reported by SKM, why hasn't Woodside been closely monitoring their emissions to increase the accuracy of the modelling results? They have had many years to implement their own monitoring program which would have shown a true adherence to this all-important principle which they are quick to tout, especially if these data were made available to be fully scrutinized by stakeholders and the public.

There is some selective reporting of past work in various parts of the Woodside proposal and appendices. They refer to modelling and conclusions drawn from publications which are later admitted to be inappropriate or incomplete.

Section 4.4.2: Deposition Flux of NOX and SOX, Discussion:
This states that Gillet's (2008, 2010) conclusions were determined by the Senate Enquire (2018) to be inappropriate for Murujuga rock art. “Consequently, currently there is no empirical evidence for an acceptable critical acid load for rock surfaces on the Burrup Peninsula, beyond which rock art would be impacted.” So, new long-term monitoring program is out for tender and has been so for many months, without any apparent progress to initiate this essential data collection.

Section 4.8.2: Colour Change & Spectral Mineralogy Monitoring, Discussion:
Woodside concludes that the existing longitudinal monitoring data set they present is globally unique and provides useful baseline to inform future research; however, this is partly ill-founded given that the methodology and results of some earlier monitoring programs have been criticized (Black and Diffey, 2016; Senate Environment and Communications References Committee, 2018).

And they conclude in **Section 6,** that “It is recognised that whilst there is anecdotal evidence and stakeholder concerns that observable changes may have occurred, no published peer reviewed studies have identified measurable or observable changes to rock art as a result of industrial emissions to date. …. Notwithstanding these criticisms the studies remain the most comprehensive large-scale investigation into the potential for industrial emissions to impact rock art.” Part of the reason there is not more published peer-reviewed work is because Woodside won't actually allow others to use their data. This is not in the spirit of advancing knowledge about this very important topic which is essential for preserving the petroglyphs for future generations.

Appendix C: NWS Project Extension Cultural Heritage Management Plan (CHMP)

We are told that this "CHMP has been prepared to ensure operation of the NWS Project does not compromise the environmental values of the Burrup Peninsula (including the National Heritage Place and Murujuga National Park) and to manage potential impacts of the Proposal on cultural heritage" and that "this CHMP assumes that all known recorded uses of the Proposal development envelope and areas immediately adjacent to it by Aboriginal people holds environmental value." And yet Woodside also admits that "reduced amenity to heritage features within these areas [Murujuga Nat Pk & Dampier Archipelago.] may occur as a result of Proposal activities." What does this actually mean? What level of trade off do they and the State government consider to be acceptable? As with so many statements made in these many pages of Browse-NWS Extension documents, there is no attempt to reconcile the disconnect because their statements and their actual intentions based on the nature of this massively polluting project. Similarly, there are motherhood statements about implementing an adaptive management plan to address the potential impact to rock art from industrial emissions after the new DWER Strategy/Plan data are collected and released. Can we believe them?

2.3.1 Proposal Activities Potentially Affecting Key Environmental Factors

Woodside incorrectly minimizes the amount of SO2 (Section 2.3.1) by omitting sources from transport, including pipelines and ships, and doesn't mention carbon compounds (CO2, CH4 and CO) which also affect cultural heritage through climate change (loss of biodiversity) and production of carbonic acid (degrades rock art):

"The key emissions from the Proposal in terms of potential impact to rock art include NOX, volatile organic compounds (VOCs) pertaining to photochemical intensity of NO/NO2 formation) and small contributions of sulphur dioxide (SO2) arising from power generation and process emissions."

While Woodside states (Section 3.1) that "unreasonable emissions of odorous substances from the Proposal have the potential to cause nuisance or public amenity concerns" they do not address potential and real health impacts of emissions on people living and working nearby, or on visitors to the area including traditional custodians who are visiting sites of cultural significance. Section 4.2.3 merely documents the existence of a complaint procedure, but does not mention or address any reported health impacts that FARA has presented during previous meetings and submissions (described above).

Section 2.4: Rationale and approach

Woodside states that to develop the CHMP they assessed results ambient air quality modelling, deposition of NOx and Sox, and uncertainties as to the potential for accelerated weathering of Aboriginal rock art due to industrial emissions. However, this submission has already described and discussed the inadequacies of some of the modelling and the incomplete data on which it was based. Woodside acknowledges that there are "uncertainties as to the potential for accelerated weathering of Aboriginal rock art on the Burrup Peninsula due to industrial emissions." And yet, in each of the meetings FARA has had with Woodside, they appear unwilling to exercise a reasonable amount of caution in decision-making with regard to protecting the internationally and culturally significant petroglyphs. They repeat in their documents that "to address the uncertainty associated with these potential impacts, an adaptive management approach will be implemented,

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together with the Proposal providing for opportunity to substantially reduce air emissions of concern (NOX and VOC emissions).” However, there has been ample time to enact an adaptive management approach by collecting data over the last decade and acknowledging the actual threat posed to the rock art and human health by the industrial emissions.

They also state that “Where key emissions from the Proposal have potential to impact the Murujuga rock art, management measures have been proposed in line with the work that Woodside is participating in through the Strategy and the Stakeholder Reference Group.” However, we note that this Stakeholder Reference Group is heavily weighted toward industry and seems to move at less than glacial pace (given the climate-induced warming that has accelerated glacial retreat globally). When will we see a good faith effort to act responsibly by exercising the major Principles of the EPA: precaution, intergenerational equity, and waste reduction/responsible resource use?

Table 4-1 Management Actions
MA4: Adopt practicable and efficient technologies to reduce air emissions to prevent impacts to terrestrial and nearshore vegetation of heritage and conservation value.
While this sounds laudable, we note that they set a <u>non-binding target</u> of 40% reduction of NOx achieved by 31 December 2030. In addition, there will there be public accountability for their monitoring and reporting activities in order that we the public can truly “verify achievement of emission reduction targets”? Past experience suggests that details will not be made public.

Section 5, MA5 - Implement an adaptive management plan addressing the potential impact to rock art from industrial emissions
Woodside states that “currently, there is a lack of scientific understanding of the impacts of air emissions on petroglyphs and therefore it is difficult to set appropriate management actions in this CHMP.” Again, they choose to ignore the work done by a number of scientists (including MacLeod, 2005; Pillans and Fifield, 2013; Duffy et al., 2017; Black et al., 2017, 2018) that shows, either actually or theoretically, that the rock art has changed / will deteriorate due to increased industrial emissions, and Woodside is responsible for a large proportion of these emissions.

Woodside states that it will continue to support with money, abide by new cultural heritage regulations, and participate in the Stakeholder group, but <u>when will they commit to actually preserving the cultural heritage found on the Burrup and surrounding Dampier Archipelago?</u>

Section 5: Stakeholder consultation
This section of the documents causes us particular aggravation because after multiple meetings with Woodside (including in 2018, 2019), FARA can only conclude that Woodside believe their interests and actions to be protected by the State Government (past and present) and the relevant State agencies, as summarized here: “All comments received during the public review period that relate to this CHMP will be considered, and changes made to this CHMP <u>where required</u>.” They don't feel a need to respond unless they are forced to do so, and the State government seems unwilling to impose the necessary restrictions on industry proposals. This is a matter of grave concern to FARA and the people of Western Australia who should have confidence that public consultation actually means something. It is NOT a box-ticking exercise to us. All the while, the unique and internationally significant petroglyphs, recognized as being irreplaceable Aboriginal cultural heritage, continue to degrade. **The State must act now to reduce emissions and especially those that affect human health and the Murujuga rock art.**

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APPENDIX D SUBMISSIONS

APPENDIX D.23 SUBMISSION ON BROWSE-BURRUP HUB_ REDACTED

Browse basin and NorthWest Shelf development.

Dear Mr Hatton,

I encourage the EPA, and the individuals within it, to stand forcefully and very publicly behind the environmentally protective decisions it makes, more forcefully than during the shameful events of last year, when the WA government overrode your excellent recommendations on the offsets front.

When citizens lose confidence in their public institutions, their participation in civil discourse will certainly decline. With declining public participation the EPA will become increasingly irrelevant, except as a rubber stamp for development proposals. With declining public participation, the EPA will be saying that few submissions on proposals were received, and will report or conclude that there is little public concern, and project proponents will have carte-blanche…

Jobs

The Browse basin and Northwest shelf proponents, and a subservient (to industry) State Government will no doubt claim that there are many jobs associated with the proposal.

The EPA should not accept this argument. Proponents nearly always overstate these benefits, or present them in a way that is deceptive - and this almost certainly the case with this proposal. The EPA needs to make a critical assessment of the reality of such claims.

Often within these 'Lots of jobs' claims there seems to be some kind of false dichotomy being presented. As if you can only have *n* number of jobs if *this* project goes ahead. Clearly this is absurd. There will be jobs in other areas, especially so if 'senile' industries are not kept on a kind of life-support such as not paying the full costs of their activities.

Some of the jobs that would be created may not be the kind of job that should necessarily be counted as a 'good thing'. Working for Woodside itself, will also increasingly become a matter of shame for those employees - and this certainly cannot be a 'good' job to have.

Heritage

This proposal represents an increasing threat to national heritage. Australia, and Western Australia in particular, is increasingly seen as international pariahs when it comes to making appropriate responses to the climate change threat.

The proposal is sociopathic, more polluting than any other LNG project in the world, a proposed action that appears to be without regard for other people on this planet, future generations of humans on this planet, and for the many ecosystems that support human life, but with regard only to Woodside itself and shareholders. To behave without regard for others is sociopathic, and I do not want this behaviour by Woodside to become part of Australia's "heritage".

Far far better to reject this proposal, and by this rejection begin to redeem Australia's, and Western Australias heritage in the eyes of the world.

[redacted]

APPENDIX D SUBMISSIONS

APPENDIX D.24 WILDERNESS SOCIETY OF WA

Wilderness Society

The Wilderness Society WA Submissions Team

Submission Assessment
Proposed Browse to North West Shelf
Woodside Energy

12/02/2020

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Issues for Consideration

Introduction

The Environmental Protection Authority (EPA) has sought public comment on the draft environmental review prepared by Woodside Energy Ltd.'s (Woodside) for the proposed development of the Brecknock, Calliance and Torosa gas fields. The Wilderness Society of WA has reviewed the State component of the draft ERD/ EIS, specifically the Torosa gas fields. We have found significant gaps and inconsistencies in the information provided for public review. As such, we find it difficult to accurately assess the project's environmental credentials. However, the information made available raises a number of concerns regarding risks to fauna, water quality and sensitive marine environments.

1. Impacts on Marine Fauna

The North-west marine region, proposed area for the Browse to NWS Project Area, provides a diversity of unique habitat to species listed as Matters of National Environmental Significance (MNES) under Part 13 (Species and Communities) of the EPBC Act; species listed under the WA Biodiversity Conservation Act 2016 (BC Act); as well as significant populations of internationally threatened species. The PMST (Protected Matters Search Tool) identified 20 listed threatened species and 38 listed migratory marine/wetland species as potentially occurring within the Project Area.

1.1. Seabirds and Migratory Shorebirds

Due to the broad geographical range of seabirds, many of the species in the Region have the potential to occur in the Project area. The following protected seabird species are likely to occur in the Project area and/or interact with the Proposed Action:

- Australian Lesser Noddy: Listed vulnerable and marine under the EPBC Act and Endangered under the WA WC Act. Approximately 200 individuals were recorded at Scott Reef by Smith et al. 2004.
- White-tailed Tropicbird: Listed marine and migratory under the EPBC Act and migratory under the WA WC Act. White-tailed tropicbirds are known to breed at Rowley Shoals which are located over 25 km from the pipeline route. The BTL route intersects an identified BIA at Rowley Shoals which is a known foraging area.
- Red-tailed Tropicbird: Listed marine and migratory under the EPBC Act and migratory and Priority 4 under the WA WC Act. Red-tailed tropicbirds are known to breed at Rowley Shoals, located over 25 km from the BTL route.
- Little Tern: Listed marine and migratory under the EPBC Act and migratory under the WA WC Act. Approximately 500 individuals were recorded at Scott Reef by Smith et al. 2004 and BIAs (known resting areas) for the species have been identified at both Scott Reef and Rowley Shoals.

Seabirds and migratory shorebirds may be affected by atmospheric noise emissions from helicopters transiting between Broome Heliport and the Browse Development Area. In particular, bird species present around Roebuck Bay and Cable Beach (<1 km from the Broome Heliport) and roosting birds at Scott Reef may be affected. Anthropogenic disturbance is identified in the Wildlife Conservation Plan for Migratory Shorebirds as a threat to the conservation of migratory shorebirds (Commonwealth of Australia, 2015c).

Seabirds and migratory shorebirds at Scott Reef may also be affected by light emissions from project vessels and the MODU operating in the State Proposal Area. The exact mechanism for navigation of migratory birds is not clear. Therefore, there is a risk that artificial light sources along migratory pathways may alter natural patterns, specifically in the absence of terrestrial landmarks.

1.2 Marine Mammals

Marine mammal species that are likely to occur in the Project area or interact with the Proposed Action are:

Blue Whale / Pygmy Blue Whales

Blue Whale/Pygmy Blue Whales are listed as endangered, migratory and marine under the EPBC Act and Endangered under the WA WC Act. There is a proportion of the population of pygmy blue whales that will transit during migration within and adjacent to the Browse Development Area. There have been sightings of feeding pygmy blue whales within the Browse Development area. Examination of the evidence and interpretation of the data from various studies and surveys conducted over the years, including most recent data from satellite tracking of whale movements, and information on movement and behaviour of pygmy blue whales collected from known feeding areas such as Perth Canyon, suggests that Scott Reef may be utilised for foraging by a proportion of the pygmy blue whale population during their passage between regular feeding grounds in the south and breeding grounds to the north.

Humpback Whales

Humpback Whales are listed vulnerable, migratory and marine under the EPBC Act and Conservation Dependent under the WA WC Act. The Project area, including the entire BTL route, is located towards the outer edge of the main humpback whale migration corridor, and humpback whales are therefore expected to only occasionally transit through this area.

Bryde's Whales

Bryde's Whale is listed as migratory and marine under the EPBC Act. Bryde's whales are likely to occur in low numbers along the BTL route.

Spinner Dolphins

Spinner Dolphins are listed as marine under the EPBC Act and listed as Priority 4 under the WA WC Act. Spinner Dolphins are found in tropical, subtropical and, occasionally warm temperate waters. Spinner Dolphins were the most commonly encountered small cetacean during aerial and vessel surveys at Scott Reef.

The primary source of potential impacts to marine mammals in the State Proposal Area is from underwater noise emissions during construction and operations. Predicted underwater noise emissions associated with key activities within the State Proposal Area may result in localised avoidance and/or behavioural disturbance of marine mammals within the vicinity of the proposed activities.

Large whales are more vulnerable to vessel collisions, particularly those species whose behaviour includes extended surface 'milling' time (Laist et al., 2001). Pygmy blue whales demonstrate limited behavioural responses to avoiding vessel collisions, with some undertaking slow shallow dives. While Woodside's draft ERD acknowledges that pygmy blue whales are vulnerable to vessel collisions, they state that the mammal is not expected to occur in high densities within the State Proposal Area or within State waters along the route that vessels will traverse when transiting to and from the Project Area. This assumption is concerning as it is well documented that the mammals intersect the same area used by Woodside's vessels. For example, it is noted that the Conservation Management Plan for the Blue Whale (Commonwealth of Australia, 2015a) documents a possible foraging area within the vicinity of the Scott Reef. The plan also recognises vessel disturbance as a key threat to blue whales.

Although spinner dolphins are very agile in the water and often display positive behaviours to the presence of vessels (e.g. bow-riding), there are significant numbers of recorded vessel collisions with dolphins across Australia (DoEE, 2017). The risk of collision is likely to be higher during the southern migration given the broader migratory corridor and the presence of cow and calf pairs travelling at slower speeds with a higher proportion of time spent at the surface.

As such, the Wilderness Society of WA believes several vulnerable, endangered and migratory marine mammals are at significant risk of vessel strike and/or noise induced collisions.

1.3 Marine Reptiles

Marine Turtles

Six species of marine turtles occur within Australian waters: the Leatherback Turtle, Loggerhead Turtle, Olive Ridley Turtle, Green Turtle, Hawksbill Turtle and Flatback Turtle. All six marine turtle species are known to occur within the NWMR and are protected under the EPBC Act and BC Act.

Green Turtle

Green turtles are listed as vulnerable, migratory and marine under the EPBC Act and 'vulnerable' under the WA WC Act.

Sandy Inlet at Scott Reef is a known green turtle nesting site. Green turtles nesting on Sandy Islet have an estimated 20 km inter-nesting buffer located primarily to the south and west of Sandy Islet over sandy substrates, with a sand patch at the southern end of Sandy Islet Reef appearing to function as an inter-nesting area of some significance. This nesting and inter-nesting area has identified as a BIA and as habitat critical to the survival of green turtles in the DoEE's Recovery Plan for Marine Turtles 2017-2027 (Commonwealth of Australia, 2017).

Hawksbill Turtle

Hawksbill turtles are listed vulnerable and migratory under the EPBC Act and 'vulnerable' under the WA WC Act. Although only one individual hawksbill turtle has been recorded nesting at Sandy Islet over four years of monitoring. Sandy inlet and a 20 km inter-nesting buffer have been identified as a BIA for this species.

BIAs are spatially delineated areas where aggregations of individuals of a species are known to display biologically important behaviours (Department of the Environment and Energy, 2019b). These behaviours may include breeding, foraging, resting and/or migration.

Protection of these nesting and inter-nesting habitats is necessary to maintain genetic diversity for marine turtle species. The nesting and inter-nesting habitat critical for survival for each species of marine turtle is relevant to the Project Area.

The primary sources of potential impacts to marine turtles are artificial light emissions from the MODU and underwater noise emissions resulting from potential pile driving activities, drilling and the MODU DP.

Specific behavioural response to artificial light emissions by marine turtles relates to altered nocturnal behaviours (as described by Witherington and Martin,1996) and include disorientation and misorientation. Exposure of marine turtles to artificial light can result in changes to their natural behaviour, in particular with regards to nesting. Sandy Islet (nesting habitat) and a 20 km intersecting buffer of the surrounding waters, are recognised as habitat critical to the survival of green turtles for the Scott Reef-Browse Island genetic stock in the Recovery Plan for Australian Marine Turtles 2017-2027. This Plan identifies light pollution as a moderate risk to the Scott Reef-Browse Island green turtle genetic stock and a high risk to the WA hawksbill turtle population (Commonwealth of Australia, 2017a). The long-term recovery objective for marine turtles is to minimise anthropogenic threats, to allow for the conservation status of marine turtles to improve so that they can be removed from the EPBC Act threatened species list. The proponent recognises that artificial lighting associated with the MODU and proposed facilities may have the potential to override and disorientate natural hatchling cues, potentially attracting individuals towards the structure, but diminishes the problem saying that the intensity of the light reaching the area is very low (less than 0.1 Lux) and that these impacts will be limited to behavioural (avoidance) impacts and would not result in any lasting effects.

Additionally, turtles may be particularly vulnerable to vessel strike while surfacing to rest or breathe.

Cumulative impacts may occur as a result of simultaneous exposure to these sources. For example, nesting turtles or hatchlings attracted by light emissions from the MODU would subsequently be exposed to noise emissions from the MODU. Cumulative impacts to marine turtles may also occur as a result of attraction, resulting from light emissions and concurrent exposure to other temporary, higher intensity noise emissions such as pile driving and VSP noise emissions. Cumulative impacts could also occur as a result of non-simultaneous exposure to light and noise emissions. For example, decreased nesting success as a result of behavioural impacts from noise emissions (i.e. females avoiding nesting habitat at Sandy Islet) combined with decreased hatchling survival rates due to disorientation from light emissions, would have a combined impact on the overall population success of green turtles.

The proponents acknowledge the particularly high risk for marine turtles but deem many of them as temporary. This assumption is problematic and dangerous. It places the viability of marine turtle populations at increased risk because very little is known about the habitats, ecology, and biology of the marine turtle populations in WA. As such, Woodside's assertion is not supported by evidence or baseline data.

Short-Nosed Sea Snake

Short-nosed sea snakes are critically endangered species under EPBC Act.

Even though, according to the survey, the species is not considered likely to occur in the

Project area in significant numbers, the PMST search identified the short-nosed sea snake as having suitable habitat in the area.

The species suffered a considerable decline in numbers during (now more frequent) severe coral bleaching episodes at Scott Reef and the commencement of oil and gas exploration (causing noise from seismic drilling) in its habitat.

The Short-Nosed Sea Snake is at significant risk from marine discharges and underwater noise emissions, resulting from the proposed Browse to NWS Project.

1.4 Fish

The PMST search identified seven threatened fish species (of which four are also migratory) plus an additional five migratory that are not considered threatened, where either the species or the species habitat may occur. The PMST search also identified 40 seahorse and pipefish which are likely to be present within the Project area. The fish species that are likely to occur in the Project area or interact with the Proposed Action include:

- Whale Shark: Listed vulnerable, migratory and marine under the EPBC Act and 'other specially protected fauna' Endangered under the WA WC Act.

Preliminary research on the migration patterns of whale sharks in the western Indian Ocean, as well as isolated and infrequent observations of individuals, indicate that a small number of the whale shark population migrate through the wider Browse region. Tagging and tracking of whale sharks indicates that individuals may occasionally pass by within the vicinity of Scott Reef. Based on the available information, it is expected that whale sharks may occur within the Project Area, albeit in low numbers.

- Shortfin Mako Shark: Listed migratory and marine under the EPBC Act and protected under International Agreement. It is likely to occur in the Project area.
- Longfin Mako Shark: Listed migratory and marine under the EPBC Act and protected under International Agreement. It is likely to occur in the Project area.

Credible impacts from light emissions from the MODU and project vessels associated with the Proposal, are expected to be restricted to localised fish attraction. The whale shark is the only threatened fish species that is likely to occur within the State Proposal Area, albeit infrequently and in low numbers. Impacts from light emissions are not documented for this species, although this has been identified as an area for further research within the latest conservation advice for this species.

It is well established that many organisms including elasmobranchs and some bony fish, can detect both natural and anthropogenic magnetic fields, which many species use for directional movement, foraging and migration.

For the most sensitive fish groups (fish with swim bladder involved in hearing) sounds levels from the piling activities could exceed mortality levels within 200-210 m of the noise source.

As regarding interaction with vessels, whale sharks are at particular risk due to their slow swimming behaviour and propensity to spend significant portions of time at the surface. Studies have indicated that whale sharks spend approximately 25% of their time less than 2 m from the surface and greater than 40% in the upper 15 m of the water column. Conservation advice for the whale shark (Threatened Species Scientific Committee, 2015) identifies vessel strike from large vessels as a key threat.

1.5 Recommendations

While the assessment concluded that the impacts on the fauna of the proposed Browse to NWS Project are considered acceptable, the Wilderness Society strongly disagrees. In fact, we think that negative impacts on critically endangered species should be taken seriously, as this may breach principles 1 - 3 of the Environmental Protection Act 1986 by contributing to the irreversible extinction of a species and reduce biological diversity and ecological integrity (Environmental Protection Act 1986, s 4A), while the proponent seems to constantly undermine the effects and minimise the importance of the impacts. On this basis, the proposal should be rejected.

2. Impacts on Marine Water Quality

The Browse draft EIS/ERD includes modelling which demonstrates reductions in both water quality and sediment quality will occur in the State Proposal Area as a result of offshore discharge of drill waste products and other waste fluids. The Browse draft EIS/ERD noted: [1]

> *These impacts are predicted to arise primarily from the discharge of drill cuttings and fluids during development drilling, with less significant impacts predicted to occur throughout the duration of the proposed Browse to NWS Project activities (e.g. through subsea discharges from the subsea infrastructure). There is a large body of knowledge indicating a discharge of cuttings with adhered fluids dilutes rapidly. These studies have found that that within 100 m of the discharge point, a drilling cuttings and fluid plume released at the surface will have diluted by a factor of at least 10,000, while J.M. Neff (2005) stated that in well-mixed oceans waters (as is likely to be the case within the drilling area), drilling fluid was diluted by more than 100-fold within 10 m of the discharge.*

Given the proximity of wells and subsea infrastructures to sensitive marine environments (marine parks and reefs), an Environmental Quality Management Plan (EQMP) which applies the framework and principles outlined in the *Environmental Quality Management Plan* in the *WA EPA Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016c)* will be developed.[2] Specifically, Woodside has proposed a range of potential strategies to mitigate the impact of discharged drill cuttings and waste fluid at the TRA, TRD, TRE and TRF locations in order to protect Scott Reef's benthic communities and habitats specifically.[3] However, it appears that the mitigation measures outlined in Section 8.2.6 are not in line with widely used international practice standards for offshore discharge, and could be strengthened to ensure the protection of water quality, benthic communities and marine fauna.

2.1 Non-Water Based Drilling Fluids (NWBF)

Drilling activities within State waters will involve the construction of up to 24 wells. Drilling will create drill cuttings and a range of waste fluids. Drill cuttings contaminated with

[1] Proposed Browse to NWS Project – Draft EIS/ERD, 906.
[2] Ibid.
[3] Ibid.

residual Non-Water Based Drilling Fluids (NWBF) and Water Based Drilling Fluids (WBF) will be discharged into the marine environment.[4] Due to time constraints, this submission will focus on synthetic oil based or NWBF drilling fluids. NWBF are composed of a hydrocarbon base and other inorganic compounds including metals such as cadmium, copper, mercury, lead and zinc.[5] The hydrocarbon and metals content of NWBF (including the synthetic oils used by Woodside), are known to cause contamination of marine ecosystems.[6]

Woodside has proposed to extract a significant portion of the NWBF from drill cuttings before discharging contaminated drill cuttings into the marine environment. However, discharge of waste fluids into State waters will occur as unrecovered drill fluids in drill cuttings and other fluids such as produced water. In order to mitigate impact on water quality, Woodside noted that the "whole" concentration of drill fluid residue on cuttings will not be discharged into the State waters. Prior to discharge, drill cuttings will be cleaned so that 6.9% (average) of NWBF residue remains on the cuttings:[7]

"The cuttings with retained NWBF will also pass through a cuttings dryer and associated SCE, to reduce the average oil on cuttings to 6.9% wt/wt or less on wet cuttings, prior to discharge.."

In many countries around the world, oil-based drilling fluids are considered hazardous substances. Consequently, many oil and gas producing regions have enforced strict standards which require either zero NWBF content or very limited NWBF content (as a concentration) of drill cuttings before they can be discharged into the marine environment. A comparison of the parameters set by the major oil and gas regions in the world is discussed below:

2.2 Offshore Discharge of NWBF Internationally

Offshore NWBF Discharge in China

China has three levels of assessment depending on the offshore area:[8]

- Area 1: oil content is less than 1%;
- Area 2: oil content is less than 3%; and
- Area 3: oil content is less than 8%.
- In some offshore areas, such as the Bohai Sea, zero discharge of NWBF is allowed.

Comparatively, Woodside's Browse project is proposing to discharge close to 7% NWBF concentrate (on average) into State waters. This is close to the top allowable range in China (8%).

[4] Ibid 896.
[5] Neff, J. (2010) Fates and Effects of Water Based Drilling Muds and Cuttings in Cold-Water Environments. *A Scientific Review Prepared for Shell Exploration and Production Company*, Houston, Texas.
[6] Durell. G. and Neff, J (2018) Effects of Offshore Oil Exploration and Development in the Alaskan Beaufort Sea: Long-Term Patterns of Hydrocarbons in Sediments. *Integrated Environmental Assessment and Management.* Vol. 15, no. 2.
[7] Proposed Browse to NWS Project – Draft EIS/ERD, 897.
[8] Zhiqiang, H., et al (2018) A Review of Treatment Methods for Oil-based Drill Cuttings. *IOP Conf. Series: Earth and Environmental Science* 170, p. 2.

Offshore NWBF Discharge in the United States and Brazil

The United States Environmental Protection Agency has a zero-discharge policy for NWBF in all areas since 2000.[9] Brazil also enforces a zero -discharge policy (with some modifications).

Offshore NWBF Discharge in Norway

Norway allows less than 1% NWBF residue in cuttings discharged offshore and enforces a zero-discharge policy in the Barents Sea.

A recent Norwegian study noted that in order for NWBF to achieve the relatively low toxicity/impacts of Water Based Drill Fluids (WBDF), discharge concentrations need to be in the vicinity of **0.1%** which may be achieved with new thermomechanical cuttings cleaning (TCC) technology.[10] In contrast, the cutting cleaning technology used during construction of the Browse project retains an average of 6.9% NWBF drilling fluid.[11] This is significantly higher than the 0.1% concentration required to reduce toxicity to the level achieved by water based drilling fluids.

Offshore NWBF Discharge in the North Sea

The OSPAR Commission (reference at page 898 of the Browse draft ERD) sets discharge standards for offshore emissions in the North Sea. The OSPAR Commission has banned discharge of diesel based NWBF since the early 1984 and **synthetic oil-based drilling fluids** have effectively been banned since 2000/2001 due to the OSPAR, 2003a decision (paragraph 3.1.6).[12] They have set allowable NWBF discharge parameters as:[13]

"…oil-based drill cuttings not only need to contain less than 1% oil, but also pass toxicity tests to determine whether they are hazardous substances. The cut-off values for the toxicity test parameters are as follows:
1) Persistency: Half-life of 50 days;
2) Liability to Bio-accumulate: log octane-water partition co-effective ≥4 or bio-concentration factor ≥500;
3) Toxicity: acute LC50 (Lethal Concentration 50) or EC50 (Effective Concentration 50) ≤1 mg/l, long-term NOEC ≤0. Mg/l."

Thus, the OSPAR Commission sets a stringent upper allowable standard of **less than 1%** NWBF residue) for cuttings to be discharged offshore. In addition, OSPAR sets toxicity parameters. In comparison, it appears that Woodside has proposed a synthetic oil concentrate which is 7 times OSPARS guidelines.

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[9] United States EPA, December 2000, Development Document for Final Effluent Limitations Guidelines and Standards for Synthetic-Based Drilling Fluids and other Non-Aqueous Drilling Fluids in the Oil and Gas Extraction Point Source Category, EPA-821-B-00-013.
[10] Vik et al., 2014 referenced in OSPAR Commission (2019) Assessment of the disturbance of drill cuttings during decommissioning. Offshore Oil and Gas Industry Series. p 14.
[11] Proposed Browse to NWS Project – Draft EIS/ERD, 897.
[12] Neff, J. (2010) Fates and Effects of Water Based Drilling Muds and Cuttings in Cold-Water Environments. *A Scientific Review Prepared for Shell Exploration and Production Company*, Houston, Texas.
[13] Zhiqiang, H., et al (2018) A Review of Treatment Methods for Oil-based Drill Cuttings. *IOP Conf. Series: Earth and Environmental Science* 170, p.2.

2.3 Environmental Impacts of NWBF

The Wilderness Society does not agree with Woodsides assertion that NWBFs cause limited environmental impacts.[14] Despite the abundance of industry survey data over a long period of time, impacts of both NWBF and WBF on benthic communities are not well understood and are only starting to be illuminated through trend analysis.

A 2017 analysis of 16 industry benthos surveys noted that environmental impacts of NWBF on benthic communities were found up to 1.2 km away from discharge points.[15] Severity of impacts was linked to regional variations related to tidal current regimes which resulted in changes to the spatial extent of the cutting dispersion. However, in the central and northern parts of the North Sea where cutting piles did not disperse, toxicity and ecological impacts lasted for 6-8 years. Much of the harmful effects to benthic communities of oil-based drilling fluid (including those composed of the olefins or esters used by Woodside) was primarily due to "…sediment oxygen depletion caused by the bio-degrading of the hydrocarbons in the mud."[16] Some sublethal impacts of sediments containing barites (also found in water based drill fluids) are also coming to light.

The OSPAR Commission noted that the effects of oil-based drilling fluid could be found 2-5 km from the well sites.[17] OSPAR also noted that anaerobic degeneration of NWBF in cutting piles occurs very slowly and only to a depth of approximately 20-50 cm into a cutting pile. Thus, the oil in deeper parts of the pile remained unchanged and posed a toxicity risk to sensitive environments and fisheries for > 5 years after formation and again during decommissioning/ disturbance.[18] Since OSPAR banned the use of NWBF, the diversity and composition of benthic communities in the North Sea has recovered significantly.

2.4 Summary and Recommendations

In Summary, most oil and gas producing countries/ regions in the world have implemented either a zero-discharge policy, or an upper limit of 1% on offshore discharge of NWBFs. China has one of the most lenient oil content discharge policies and sets allowable discharge concentrate of NWBF according to geographical region. This includes a zero-discharge policy at the lower end of the continuum and an 8% at the upper end. China's upper end is close to Woodside's average proposed discharge off WA's north coast. Parameters outlined in the Browse draft EIS/ERD appear to be out of step with accepted international industry practice. The average limit of 7% concentrate proposed for Browse appears to be nearly 7 times the international average and is well outside the OSPAR Commission's recommendations. The toxic and ecological detriment of oil-based drilling fluids on sensitive environments and marine fauna are not well understood and have been demonstrated, in some cases, to last for between 6-8 years and may be detected between 1

[14] Proposed Browse to NWS Project – Draft EIS/ERD, 897.

[15] Henry, L-A. et. al. (2017) Historical Scale and Persistence of Drill Cutting Impacts on North Sea Benthos, *Marine Environmental Research* 129, 219 – 228.

[16] Durell. G. and Neff, J (2018) Effects of Offshore Oil Exploration and Development in the Alaskan Beaufort Sea: Long-Term Patterns of Hydrocarbons in Sediments. *Integrated Environmental Assessment and Management.* Vol. 15, no. 2, p. 28.

[17] Bakke et al., 2013, referenced in OSPAR Commission (2019) Assessment of the disturbance of drill cuttings during decommissioning. Offshore Oil and Gas Industry Series, p. 26.

[18] Ibid, 22.

-5 km from discharge sites. These impacts may re-emerge at the same concentrations during decommissioning.

Given the above information, the Wilderness Society of WA cannot agree that Woodside's mitigation strategies are providing the highest level of risk mitigation to sensitive marine environments. On this basis, at the least, Woodside should be required to implement NWBF offshore discharge parameters and concentrations in line with OSPAR guidelines.

2.5 Additional Questions Regarding Use of NWBF

The Wilderness Society of WA believes the proposal does not contain enough details to allow for full assessment of the proposal's environmental impacts. As such, we request the following additional information:

- When will synthetic oil-based drilling fluids be used in State waters? The draft EIS/ERD is equivocal in this regard. As such, it is difficult to assess the environmental impacts of the Browse project without the specific modelling information and data relating to the TRE and TRD sites.
- Why is Woodside using synthetic oil-based drilling fluids when use of these are effectively banned in most other oil and gas producing regions in the world?
- Will Woodside implement toxicity parameter and concentration guidelines for offshore discharge of NWBF in line with OSPAR recommendations?

3. Greenhouse Gas Emissions

The Wilderness Society of WA agrees with the findings and recommendations contained in Sustainable Energy Now's assessment submission to the EPA regarding Woodside's Browse to NWS project.

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APPENDIX D SUBMISSIONS

APPENDIX D.25 ANON-57NR-WVNR-S (DENMARK ENVIRONMENT CENTRE INC)

Denmark Environment Centre Inc

[redacted]

12 February 2020

Dr Tom Hatton
Chairman
Environmental Protection Authority
Department of Water and Environmental Regulation
Prime House – 8 Davidson Terrace Joondalup

[redacted]
Minister for Environment
Department of Environment
[redacted]

Dear Dr Hatton

Submission to Assessment 2191: Proposed Browse to North West Shelf Project (Commonwealth Waters)

Standing of the Denmark Environment Centre Inc
The Denmark Environment Centre (DEC) was formed in 1987 and is a not-for-profit community group which promotes environmental and conservation interests in the South Coast Region. The DEC owns its office building in Denmark and finances its own overheads and ongoing core business costs. The DEC is the major environment centre in the South West of WA. Some of WA's most impressive natural features, our old growth forests, spectacular wild coastline and river systems and major National Parks, all fall within our region.

The Commonwealth is assessing the project on four matters of national environmental significance, as identified by the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.

- National heritage values of a National Heritage Place;
- Listed threatened species and communities;
- Listed migratory species; and
- The Commonwealth marine area.

The DEC believe that other matters, including World heritage properties, and Wetlands of international importance must also be included in the assessment, as well as the overall impact of greenhouse gas emissions.

Heritage (both World Heritage properties and National heritage values):
The DEC has concerns about the proposed North West Shelf (NWS) venture, which presents a significant threat to the cultural, heritage and history of Western Australia's Aboriginal People.
The Burrup Peninsula is home to one of the largest, and most diverse collections of rock art, or petroglyphs, in the world -the Murujuga Petroglyphs.
In January 2020, the federal government lodged a submission to UNESCO to nominate Murujuga for World Heritage listing. It is estimated to contain more than one million petroglyphs. These provide an archaeological record of traditional use of the area over thousands of years. The rock art has deep meaning for the Traditional Owners. It provides a link to stories, customs and knowledge of their land and connects them to the events and people of the past and their beliefs today.
Murujuga Petroglyphs should have its unique cultural, spiritual and archaeological values internationally recognised at the highest level. Given sites of similar age, such as the Lascaux Caves of France, have achieved international recognition and protection via UNESCO, it is reasonable to expect future recognition to a

1

similar degree. Recent surges in industrial activity at the Burrup Peninsula has already led to irreparable physical damage (from construction) and chemical damage from due to emissions and pollution.

Wetlands:
The NWS proposal may put in danger several Ramsar wetlands and contradict Australia's long-standing and international commitment to the preservation of wetlands of international importance under *The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat.* The proposal has the potential to cause irreparable damage on both Marine & Coastal Zone wetlands, and Inland wetlands. Noting that the consultation sought is relating to the offshore components of the project, a basic understanding of ocean ecology highlights the threat posed by an increased, extractive industry presence within the vicinity of Ramsar wetlands. Sites including Roebuck Bay, Eightymile Beach, Ord river floodplain/estuary and Ashmore Reef Nature Reserves stand to be affected by potential ecological disasters such as oil spills and facility structure damage. While sites around Christmas Island, and the Cocos/Keeling Islands may also be impacted by way of the South Equatorial Current.
Additionally, ecological disturbances offshore in our north could pose further threats to the mangrove forests of Northern WA, and the Northern Territory (home to 39% of all coastal mangroves in Australia) through increased industrial pollutants, trace nutrients, sediment and pH fluctuations.

Threatened species and ecological communities:
The project area is rich in species diversity and is home to significant populations of internationally threatened species - mammal, reptile, fish and invertebrate species. The Department of Parks & Wildlife list the 20 threatened species and 38 migratory species known to utilize habitat in different parts of the project area. The endangered Pygmy Blue whale makes an annual migration path via the Scott reef region and have been observed utilizing the channel in between the north and south reef (the proposed location for the TRE well). There are over 10 species of dolphins at Scott reef. The most common species, the long-snouted spinner dolphin, lives in pods of up to hundreds of individuals. The Browse to NWS Trunkline (subsea pipeline), which runs 900 km from the Scott reef region back to the Karratha Gas Plant, via other pristine marine areas such as Rowley Shoals. The Browse trunkline runs in very close proximity to the Humpback Whale's migratory route, posing great risk to the species from any faults or unplanned discharges from the pipeline.
There are three WA species of sea snake as critically endangered, three species of whale listed as endangered, three species of endangered turtles in WA; and it lists several more aquatic mammals, such as the Australian Sea Lion, as vulnerable, alongside fish, invertebrate, and bird species.
The warmer currents surrounding the area in question, play host to cetacean who migrate along the west coast to give birth and nurse their young. While a series of bottle-necks between Australia, Timor-Leste, Papua New Guinea and Indonesia have created a channel for migratory aquatic organisms to travel directly through the site of the proposed offshore structures.
This proposal will not only directly interrupt the migratory path of cetaceans, marine teleosts, and their predators; any local, small-scale dependants on these natural movements are also at risk.

The proposed location for TRE well is also in extremely close proximity to Sandy Islet – which is a breeding ground for a distinct genetic stock of endangered Green Turtles. Light and noise impacts are well known to disturb and disrupt the breeding, foraging and migratory habits of green turtles.

Commonwealth Marine area:
This proposal sits adjacent to several Commonwealth Marine Reserves and the NWS threatens the ecological resilience of those marine reserves.
The proponent proposes 30 wells to be drilled in the Commonwealth areas. The seismic impacts, as well as light and noise pollution and marine discharges from drilling activities are also well known to affect the breeding and migratory patterns of endangered species which rely on Scott reef; including spinner dolphins, blue pygmy whales, green turtles and hawksbill turtles. The proponent for the project must provide more details about the impacts to the Scott reef region and the Rowley shoals region and the proponent is preventing a proper assessment of the true scale of impacts to these marine areas. Scott reef is still

recovering from consecutive mass-bleaching events in 1998 and 2016, which will be greatly hindered by the proposed drilling activities and discharges.
As it is impossible to "contain" the potential impacts from the commission and operation of two Floating Production Storage and Offloading facilities (connected to existing NWS infrastructure via a 900-kilometre trunk line), the impact on surrounding commonwealth reserves and state reserve must also be considered. Commonwealths obligations to protect the intricate ecology of Benthic sediments and the Euphotic zones within Its jurisdiction, which serve to further discredit this proposal on severe ecological grounds.

Other concerns:
The Browse Basin and the NWS extension project will emit 2.7% of Australia's total emissions:

- The offshore components will emit at least 112 million tonnes CO^2e to 2050 (the minimum expected field life).
- The Browse basin gas has an emissions intensity of above the average for Australian LNG exports.

Conclusion
The DEC recommends to the Australian Minister for Environment , to reject the current proposal because it poses an unacceptable level of risk to Western Australia's environment.

General comments
Western Australia should be technological leaders in renewable energy, exporting products and vision to the world. Instead, the EPA are considering the proposed Browse to North West Shelf Project that may contribute to climate change. We all deserve to live in a safe, clean, healthy environment with plans for a sustainable future - the Browse to North West Shelf Project and North West Shelf expansion raises many concerns and questions.

No approval should be given to any new fossil fuel project, as any new fossil fuel development is incompatible with the goal of the 2015 Paris Climate Agreement.

The Browse project, if approved, will be the most emissions intensive development in Australia, adding an additional 7 million tonnes of CO^2e just through venting and pumping the gas 900 km and about another 7.6 million tonnes CO^2e from processing at the North West Shelf LNG facility.

This project alone will emit pollution equivalent to 2.7% increase over Australia's total 2005 baseline.

Despite what the industry claims, gas is not cleaner than coal, and is not a transitional fuel. Huge amounts of methane, known as fugitive emissions, is released into the atmosphere during an LNG facility's lifespan. These emissions escape during drilling and extraction, transportation in pipelines and storage, and eventual combustion. It's estimated to be as much as 9% of the entire volume of the gas resource.

Methane is an extremely potent greenhouse gas that traps 86 times more heat than CO^2 over a 20-year period, and is responsible for 25% of global warming to date. These elevated methane levels have increased by 60% in Australia over the last 15 years and negate any advantage gas has over coal. The reality is Australian gas is being burnt in addition to coal, and our exports are significantly increasing global emissions. Any new gas projects will lock in another 40-60 years of carbon pollution.

The Burrup Peninsula is a place of strong environmental, ecological and heritage significance, these proposals put this all at risk.

The Burrup Peninsula is home to one of the largest, most diverse collections of rock art, or petroglyphs, in the world – the Murujuga Petroglyphs. The federal government in January 2020 and Murujuga Aboriginal Corporation submitted a nomination to UNESCO for World Heritage Listing.

The proposal will put at risk several Ramsar wetlands and bring into question Australia's long-standing and international commitment to the preservation of wetlands of international importance.

The waters around the proposed site, are home to a numerous species that are listed as critically endangered, endangered or vulnerable. A new species of siphonophore has just been discovered in the Kimberley Marine Park.

Yours faithfully

[redacted]

[redacted]

Deputy Convenor for DEC

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Promotional video: Woodside's Burrup Hub Vision

Woodside Energy Nov 18, 2018

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Australia 1.46% of global emissions 541 924 Gg CO2-e 2013 (excluding land use…)

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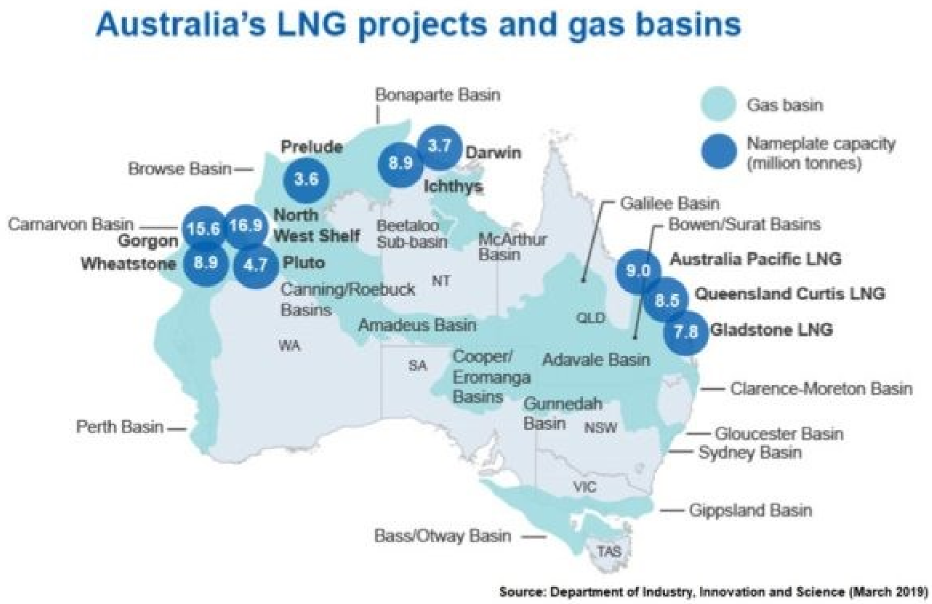
Centre for Rock Art Research at UWA. Jo McDonald and Peter Veth - Petroglyphs at Burrup (engraving). Ken Mulvaney has done work in the archaic faces.

APPENDIX

Existing projects[1]

- The North West Shelf Venture began shipping cargoes in 1989. The project has since grown to include five production units (or trains). It now produces up to 16.3 million tonnes per annum (mtpa) of LNG.
- Darwin LNG began production in 2006. This one-train project produces up to 3.7mtpa.
- Pluto started production in April 2012. It has one 4.3mtpa production train.
- Queensland Curtis LNG began production in December 2014. It has two producing LNG trains.
- Gladstone LNG began production from its first train in September 2015. Train 2 expected to be ready for start-up by the end of the year with the first LNG in the second quarter of 2016.
- Australia Pacific LNG began production from its first train in December 2015.
- Gorgon shipped its first cargo in March 2016.
- Wheatstone's first cargo was in October 2017.
- Ichthys first cargo was October 2018.
- Prelude first cargo was March 2019.



[1] https://www.appea.com.au/oil-gas-explained/operation/australian-lng-projects/

History of LNG Accidents[2] (cross checked from other internet sites)

• The Cleveland Disaster, U.S. 1944

• Methane Princess Spill, 1965. The LNG discharging arms on a vessel which were disconnected before the liquid lines had been completely drained – caused another LNG accident.

• Jules Verne Spill, May 1965. Failure of the liquid level instrumentation – caused another LNG accident.

• La Spezia, Italy, 1971.

• Montreal East, Quebec, Canada, 1972.

• Staten Island Tank Fire, USA, 1973.

• Massachusetts Barge Spill, July 1974.

• Aquarius Spill, September 1977. Difficulties in the liquid level gauge system – caused another LNG accident.

• Das Island, United Arab Emirates, March 1978. Failure of a bottom pipe connection of an LNG tank– caused another LNG accident.

• Cove Point, Maryland, 1979. LNG leak from a high-pressure pump found its way into an electrical conduit – caused another LNG accident.

• Mostafa Ben Bouliad Spill, April 1979. A check valve in the piping system of a 125,000 cubic meter vessel failed – caused another LNG accident.

• Pollenger Spill, April 1979. Leaking from a valve gland – caused another LNG accident.

• Bontang, Indonesia, 1983.

• Nevada Test Site, Mercury, NV, 1987.

• Bachir Chihani, Hull Cracking, 1990.

• Mediterranean Off Gibraltar, Minor LNG Carrier "Collision," November 13, 2002.

• Algeria, LNG Facility Explosion, January 19, 2004.

• Trinidad Tobago, June 13, 2004. LNG turbine explodes.

• Belgium, July 31, 2004.

• Norway, September 20, 2004.

• USA, March 2005. LNG Causes Pipeline Leaks and house explosion.

• Nigeria, August 2005. 28-inch Liquefied Natural Gas underground pipeline exploded.

• India, September 17, 2005.

• Savannah, GA March 14, 2006.

• Trinidad & Tobago May 18 & May 21 & June 6, 2006. Fire at LNG Plant.

• Ship carrying liquid gas burns off Jordan July 13, 2006. "AMMAN, Jordan.

• LNG Tanker Adrift Off Cape Cod Needs Rescue February 11, 2008.

• Washington, March 31, 2014 U.S. LNG Explosion.

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[2] https://www.timrileylaw.com/LNG.htm

7

Current Scientific Name ⟵ Listed Scientific Name EPBC Listed Threatened & Migratory Species	Common Name
Anous tenuicatris melanoos	Australian Lesser Noddy
Anous stolidus	Common Noddy
Arenaria interpres	Ruddy Turnstone
Balaenoptera borealis	Sei Whale
Balaenoptera edeni	Bryde's Whale
Balaenoptera musculus brevicauda	Pygmy Blue Whale
Balaenoptera physalus	Fin Whale
Calonectris leucomelas	Streaked Shearwater
Caretta	Loggerhead Turtle
Chelonia mydas	Green Turtle
Dermochelys coriacea	Leatherback Turtle, Leathery Turtle,
Fregata ariel	Lesser Frigatebird, Least Frigatebird
Hirundo rustica	Barn Swallow
Lepidochelys olivacea	Olive Ridley Turtle,
Megaptera novaeangliae	Humpback Whale
Natator depressus	Flatback Turtle
Phaethon lepturus	White-tailed Tropicbird
Phaethon rubricauda	Red-tailed Tropicbird
Sternula albifrons	Little Tern
Sula leucogaster	Brown Booby

Papesula abbotti	Abbotts booby
Eretmochelys coriacea	Hawksbill turtle
Stenelia longirostris	Spinner dolphin

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Woodside Energy

APPENDIX D SUBMISSIONS

APPENDIX D.26 REDACTED-1

From: [redacted]
To:
Subject: RE: Fwd: Submission Three Browse-NWS extension proposals [DLM=For-Official-Use-Only]
Date: Thursday, 20 February 2020 8:09:09 AM

Begin forwarded message:

From: [redacted] <[redacted]>
Date: 12 February 2020 at 12:28:07 am AEDT
To: "[redacted]
Subject: Submission Re: Three Browse-NWS extension proposals

Dear Dr Tom Hatton (Chairperson Environmental Protection Authority WA),
David Fredericks, Secretary Department of Environment and Energy, and
Mike Rowe, DWER:

After reading Woodside's documents RE: their proposed Browse Basin - North West Shelf (NWS) extension project, and the two associated offshore components (wells and bringing the gas to the Burrup Peninsula for processing), I am extremely concerned about the devastating effect these would have on the Murujuga rock engravings. The rock art is internationally significant and part of Australia's cultural heritage. It should not be degraded or destroyed in the interest of profits and at the greater expense of increased global emissions of greenhouse gases. Importantly, the emissions from these proposed projects contain substantial amounts of sulfur and nitrogen dioxides which form sulfuric and nitric acids when the emissions mix with atmospheric moisture. These acids break down the patina on the rock surface which of course destroys the rock carvings.

In order to truly evaluate the environmental impact of these industrial emissions, it is imperative that the total cumulative emissions from industries on the Burrup Peninsula must be calculated, considered, regulated and monitored. Only then can the actual emissions from the Browse-NWS expansion projects be calculated to estimate the extra harm they will do to the environment and the ancient rock art. Furthermore, the Burrup Hub proposals should not be approved until the promised monitoring program has been initiated by the WA government's Rock Art Strategy Stakeholder Committee, and they have real data to comment on the consequences of an increased pollutant load.

The emissions from processing, transporting, and burning the LNG are a huge source of carbon dioxide and methane which Australia must curtail. I am also very concerned about the health impacts of industrial emissions on local workers and residents of the Burrup Peninsula and Karratha region, given the high levels of air pollution that are consistently visible on BOM images. Much of this could be reduced if Woodside and other industries were forced to have the highest possible level of scrubber and other technology to reduce emissions -- some of their huge profits could be reduce harm to the petroglyphs, human health and well being.

EPA has a responsibility to Aboriginal Australia, as well as the entire population, to protect the irreplaceable cultural heritage contained in the Murujuga petroglyphs rather than facilitate the short-term profits of the gas industry.

[redacted]

Woodside Energy

APPENDIX D SUBMISSIONS

APPENDIX D.27 REDACTED-2

Submission to the Western Australian Environmental Protection Authority in relation to Woodside Energy Ltd North West Shelf Project Extension Environment Review Document: EPA Assessment No. 2186

[redacted]

10 Feb 20

Consultation re Submission to the Western Australian Environmental Protection Authority in relation to Woodside Energy Ltd North West Shelf Project Extension Environment Review Document: EPA Assessment No. 2186

https://consultation.epa.wa.gov.au

I write to express my concerns relative to this submission to the Western Australian EPA by Woodside Energy Ltd as it relates to Aboriginal rock art.

On page 18 of the Executive Summary Social Surroundings (Heritage) Woodside cites the WA EPA Objective viz: ***To protect social surroundings from significant harm.***

Woodside Energy Ltd identifies risks to the rock art under the following subheading within the Executive Summary.

Potential Impacts and Risks
Accelerated weathering of rock art due to industrial emissions.

"The residual risk to rock art following the implementation of mitigation and management measures including the Murujuga Rock Art Strategy *is assessed to be moderate*. The residual risk for all other potential impacts is assessed as low for unplanned risks and slight for planned impacts".

Mitigation

"Woodside commits to support the Murujuga Rock Art Strategy and implementation of the Framework (such as maintain emissions contributions below that which lead to unacceptable levels of impacts to rock art)".

My concerns

No where in the document can I find any reference to how Woodside Energy Ltd will address the issue of the effect of decreasing pH (resulting from the production of nitric and sulphuric acids from nitrogen and sulphur dioxides in the atmosphere) upon the rock art by destruction of the patina protecting the underlying rock as described by Black et al (2017, 2018).

Woodside Energy Ltd claims on p523 that 'no data was presented to link industrial air emission or subsequent deposition to changes in pH on Murujuga rock surfaces.' This ignores published information (Black et al. 2018).

What assurances will the EPA demand and enforce with respect to the control of atmospheric levels of nitrogen oxide and sulphur dioxide released into the atmosphere as part of the overall project? Currently Woodside is releasing 8,900 tonnes per year of oxides of nitrogen NO_x (as nitrogen dioxide, Table 2-2) and smaller amounts of sulphur dioxide.

Surely a risk to the rock art of "moderate" after mitigation measures is unacceptable. Why would the risk not be minimal or slight? This would suggest the mitigation methods are not adequate.

Yours Sincerely

[redacted]

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APPENDIX D SUBMISSIONS

APPENDIX D.28 ANON - 57NR-WV7F-P (DOCTORS REFORM SOCIETY OF WESTERN AUSTRALIA)

DRS DOCTORS REFORM SOCIETY

[redacted]

Proposed Browse to North West Shelf Project - State Waters - Public Environmental Review

Proposed Browse to North West Shelf Project – Commonwealth - Environmental Impact Statement

North West Shelf Project Extension - Public Environmental Review

We must consider the health impacts of the gas industry

The Doctors Reform Society of WA is a health organisation which aims to improve health for all people in a socially just and equitable way. We believe that human health depends fundamentally on a healthy environment. We accept the scientific consensus that anthropogenic global warming is occurring, that this is a great hazard to health, and that urgent action to combat this is required.[1]

It is from our health perspective that we wish to make a brief submission to the current consultations on the North West Shelf projects in Western Australia. It is vital that Australian governments, including the Western Australian state government, respond to climate change not just as an environmental issue or an energy issue but also as a serious health issue.

Health and climate change

The current and potential future health implications of climate change are profound.[2,3] Health impacts of climate change include both direct effects (heatwaves, storms, flooding, drought, fire) and indirect effects (such as malnutrition due to food insecurity, displacement of populations due to rising sea levels, changing patterns of infectious diseases, mental illness, pollution-induced physical illness, and conflict).[3] Health effects of climate change are expected to be greatest amongst socioeconomically deprived communities. Even now, climate change is estimated to cause hundreds of thousands of deaths annually, globally.[4] As for the future, a recent report from the Intergovernmental Panel on Climate Change found confidently that without substantial mitigation efforts, there is a “high to very high risk of severe, widespread and irreversible impacts globally” of climate change.[5] Policies to mitigate climate change therefore need to be given great priority worldwide, including in Australia.

We are very concerned about Australia’s poor progress towards mitigation of, and adaptation to climate change. Many Australian climate experts believe that Australia’s 2030 goals are an insufficient contribution towards the Paris agreement’s global goal of constraining global warming to 1.5 - 2 degrees centigrade.[6] On current trends, experts believe Australia’s progress is insufficient to meet even these insufficient targets.[7,8] We need much greater ambition and action across many sectors of Australian society to make better progress towards a safer future world.

Essentially, we believe that global emissions reduction should occur as quickly as possible.

To achieve this, we not only need robust mitigation strategies within Australia, but we also need to leave most fossil fuels in the ground so that they are not burned anywhere on the planet. We believe that environmental assessments of proposed new fossil fuel extraction projects must consider the contribution of the extracted fuels when burned to global climate change. Continued expansion of Australia’s fossil fuel industry is fundamentally incompatible with limiting global climate change. It is therefore disastrous for public health.

Gas extraction in Western Australia

Gas industry advocates like to paint gas as being cleaner than coal. We concede that gas-fired electricity is less carbon intensive at the point of combustion than coal.[9] However, gas is still a significant source of carbon dioxide when burnt, and methane when leaked is a particularly potent greenhouse gas when leaked – 86 times as potent as carbon dioxide over a 20 year window, and 34 times as potent over a 100 year window.[10] There is growing concern that even modest fugitive emissions from gas extraction may more than offset the supposed environmental benefits of gas, due to the warming effect of the leaked methane.[11] In the United States, satellite and surface observations suggest a significant increase in methane emissions during recent years in which gas extraction has been vigorous.[12]

It is not feasible for WA to develop its gas resources and also meet our international climate obligations. A recent report from Climate Analytics makes the numbers clear: of the global "carbon budget" of 570 $GtCO_2e$, Australia gets a share of 5.5 $GtCO_2e$, with Western Australia attributed 1 $GtCO_2e$ of this. WA's conventional gas resources would contribute 7.5 $GtCO_2e$. Clearly the vast majority of this gas needs to remain in the ground.[13] Further expansion of gas extraction in Western Australia simply does not fit within WA's obligations to a reasonably safe climate for current and future generations.

Some claim that gas may have a transitional role as we progress to a renewably-generated electricity system, to deal with intermittency of power supply from renewables. This claim is probably overstated due to the complementarity of wind and solar generation, improvements in smart grid technology including ancillary services, use of storage technologies (pumped hydro, thermal solar/molten salt, batteries), the reliability afforded by renewable energy generation which is widely geographically distributed, and opportunities for reductions in demand via efficiency improvements.[14] Modelling by several independent groups (including the Universities of Melbourne and NSW, the Australian National University and the Australian Energy Market Operator) has found that a transition to 100% renewable electricity production is feasible and affordable for Australia.[15–18]

Consequently, we see great potential climate and health hazards in expanding WA's gas industry.

Conclusion

We believe, as does the World Health Organisation, in "health in all policies" – that health impacts should be considered in all policy-making processes.[19] With regards to the expansion of Western Australia's gas industry, we believe policy-making must consider the public health consequences of gas use in both the near and long term.

For the health of much of our living world, including humanity, we appeal to the EPA not to approve the proposed North West Shelf developments.

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Woodside Energy

APPENDIX D SUBMISSIONS

APPENDIX D.29 ANON - 57NR-WV7K-U

Browse to North West Shelf – Commonwealth waters

Hello, I urge you to not approve any of the proposed Burrup Hub LNG proposals.

There are many environmental and social reasons that all 3 proposals must be rejected. The most important of these is the massive increase in Greenhouse gases (GHG), CO2 and methane, that these projects will emit during exploration, drilling, venting, transportation, processing and venting. These emissions will be equal to as much as four times the amount that Adani would produce and will be responsible for 47% of WA emissions, at a time when, according to the IPCC and many other scientific bodies, the world should be taking steps to dramatically and urgently cutting and stopping all GHG emissions. Australia is a signatory to the Paris Agreement and this Burrup Hub proposal will not allow us to meet our commitment to reduce emissions and cooperate with other nations to prevent temperature rising above 1.5 degrees. Average temperatures have already risen more than 1 degree and increased temperature rises are already locked in due to existing GHG in our atmosphere. We must do all we can to abate the GHG already the atmosphere and must not drastically increase the GHG as these proposals would. Already, the LNG exploitation in WA is responsible for Australia's emissions rising – Australia's attempts at carbon abatement are largely neutralised the use of this fossil fuel.

Furthermore, these projects would damage sensitive wetlands areas. Wetlands should be protected in their own right for the multitude of important ecological values they have, and are especially important in today's environment as they are such an important natural carbon sink.

It does not make any sense to pursue these highly environmentally destructive forms of energy when WA has so much potential to become a world leader in renewable energy. Allowing these projects to go ahead will deter investment in clean renewable and a fair transition for workers to energy production that will not result in increased climate change that is already causing millions of deaths and much hardship globally, and will only increase in the magnitude of suffering caused ifwe don't stop using fossil fuels.

In addition, the LNG exploitation in this area is damaging for our precious petroglyphs on the Burrup Peninsular – some of the oldest, largest and most diverse collections of rock art in the world, for which local First Nations groups are seeking World Heritage recognition. This important cultural heritage must be protected from further damage.

Also, the waters around the proposed site of the works are home to a myriad of species that are critically endangered, endangered or vulnerable. A new species of siphonophore has just been discovered in the Kimberley Marine Park, and has not been included in Woodside's Environmental Review Document (ERD), so there is no management plan and extreme uncertainty regarding the impact on this extremely rare marine creature .

Some more detail and points regarding the The NWS proposal in Commonwealth waters particular:

Wetlands:

- jeopardize several Ramsar wetlands and contradict Australia's long-standing and international commitment to the preservation ofwetlands of international importance under The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat.

● The proposal has the potential to wreak havoc on both Marine & Coastal Zone wetlands, and Inland wetlands.

● Sites including Roebuck Bay, Eightymile Beach, Ord river floodplain/estuary and Ashmore Reef Nature Reserves stand to be affected by potential ecological disasters such as oil spills and facility structure damage. While sites around Christmas Island, and the Cocos/Keeling Islands may also be impacted by way of the South Equatorial Current.

● Additionally, ecological disturbances offshore in our north could pose further threats to the mangrove forests of Northern WA, and the Northern Territory (home to 39% of all coastal mangroves in Australia) through increased industrial pollutants, trace nutrients, sediment and pH fluctuations.

Listed threatened species and ecological communities:

The waters around WA, including around the proposed site of the works, are home to myriad mammal, reptile, fish and invertebrate species

● The Department of Parks & Wildlife list the three WA species of sea snake as 'critically endangered', three species of whale listed as 'endangered', three species of endangered turtles in WA; and it lists several more aquatic mammals -- such as the Australian Sea Lion – as 'vulnerable', alongside fish, invertebrate, and bird species. (https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/fauna_notice.pdf)

● The warmer currents surrounding the area in question, play host to cetacean who migrate along the west coast to give birth and nurse their young

● While a series of bottle-necks between Australia, Timor-Leste, Papua New Guinea and Indonesia have created a channel for migratory aquatic organisms to travel directly through the site of the proposed offshore structures.- This proposal will not only directly interrupt the migratory path of cetaceans, marine teleosts, and their predator but also any local, small-scale dependants on these natural movements are at risk.

This risks the total collapse of our marine ecology – not just locally but across an international area.

In terms of Commonwealth Marine area:

This proposal sits adjacent to several Commonwealth Marine Reserves and the NWS threatens the ecological resilience of those marine reserves.

● As it is impossible to "contain" the potential impacts from the commission and operation of two Floating Production Storage and Offloading facilities (connected to existing NWS infrastructure via a 900-kilometre trunk line), the impact on surrounding commonwealth reserves and state reserve must also be considered.

● There are Commonwealth obligations to protect the intricate ecology of Benthic sediments and the Euphotic zones within Its jurisdiction, which serve to further severely discredit this proposal on ecological grounds.

APPENDIX D SUBMISSIONS

APPENDIX D.30 ANON - 57NR-WV7Y-9

Browse to North West Shelf Project: Commonwealth Waters - Environmental Impact Statement

Any proposal for new fossil fuel exploration and exploitation undermines Inter-Governmental Panel on Climate Change (IPCC) aspirations to keep global temperature rise from pre-industrial times below 1.5°C, in order to avert catastrophic climate change[1]. This requires net global greenhouse gas (GHG) emissions to reach zero by 2050 at the latest, which necessarily requires a rapid phase out of fossil fuel emissions from now, not an increase in these.

Already, extraction, processing and export of gas from the North West Shelf (NWS) adds 190-200 million tonnes of CO_2-e to the atmosphere each year.[2] This comes from emissions both in WA (about 55 $MtCO_2$-e) and from export of LNG (about 140 $MtCO_2$-e). WA's internal annual gas-related emissions comprise around 10% of Australia's total internal emissions and WA is the only state where emissions are annually increasing, primarily due to expansion of LNG activities (they are also increasing in the Northern Territory, again primarily due to gas extraction). Australia has recently passed Qatar as the world's biggest exporter of LNG[3], with 57% of Australia's export coming from the NWS. The NWS gas industry, as it now operates, is a major reason why Australia is not on target to reach its modest Paris agreement target of 26-28% emissions reduction by 2030 – a target only consistent with 3-4°C global warming.

It is widely argued that Australia's fossil fuel exports are not a problem as they are accounted for in other countries' emissions. Nevertheless, such emissions all go into the same global atmosphere and the consequent global climate change is already affecting Australia proportionally more than most other nations (e.g. drought, bushfires, aberrant weather events, species extinction, etc). That is, emissions resulting from gas extraction in WA affect global warming in the same way, no matter where that gas is finally used.

Australia's contribution to GHG emissions comprises only 1.3% of total global emissions, if only within-country emissions are considered, but rises to total of 3.6% if Australia's exports of coal and LNG are included[4]. This is indeed a significant contribution to global GHG emissions and it is increasing and planned to increase further. If Australia, a country disproportionately adversely affected by climate change, is serious about convincing other countries to reduce their emissions then it must set an example, primarily by reducing fossil fuel exports. Any expansion of LNG exports, as proposed here, is completely counter to the life support system of this planet that we are used to.

It has been misleadingly argued (Section 7.4.5.2) that export of LNG contributes to reduced global emissions as it allows other countries to replace coal-fired electricity generation with gas-fired electricity generation. This is because it is argued that gas is around 50% less emissions intense than coal. If full life cycle emissions are accounted for then gas ranks with coal in emissions[5], and fugitive emissions from gas extraction, processing and transport are usually underestimated[6,7]. Further, there is no evidence that imported gas is replacing coal for electricity generation. In most countries where coal-fired power is being replaced it is being replaced by renewable energy. Therefore, production and use of LNG is simply adding to the serious GHG emissions problem that we already have and further increases in LNG production only further exacerbates this problem.

Although it is recognized that estimation of GHG emissions of new developments is imprecise, because it depends on estimations of eventual LNG production, which itself is imprecise, the annual values given in Section 7.4.4 seem extraordinarily low (7.6 $MtCO_2$-e) when compared to other estimates (17.2 $MtCO_2$-e)[2]. It is of course in the interests of the proponent to have as low estimates as plausible. Thus there it is essential that there be an independent assessment of emissions before any conclusions are reached about GHG emissions in this proposal.

Of particular concern is estimation of direct methane leakage to the atmosphere, considering that this is >80 times more potent as a greenhouse gas than CO_2 on a 20-year time scale. In Australia it is left to the fossil fuel companies themselves to report fugitive emissions. Detailed studies have concluded that fugitive methane emissions are likely to be much higher than those generally reported[7].

In Section 7.7 there is discussion of emissions reduction aspirations and offsetting emissions. Aspirations are likely to remain as such because geosequestration of CO_2 mixed with methane was supposed to have been a component of already established gas extraction operations. It was not implemented and indeed not enforced by any regulatory authorities. Offsetting of emissions is also mentioned as just an aspiration, rather than a commitment. In any case using revegetation as an offset has many shortcomings (e.g. time taken to compensate emissions, long-term accounting and monitoring, etc.). The bottom line is that any new extraction of gas is simply adding to the already parlous total global emissions.

Table 7.13 attempts to show that new project emissions will be negligible in relation to total global emissions. Firstly, it is not clear how column 2 is derived. Secondly, as mentioned above, there would be major doubts about the emissions values used in columns 3 and 4. These emissions are still additions to an unsatisfactory global level of emissions. Claiming that adding just a little bit more won't make any difference is simply disingenuous. The challenge before humanity is to reduce fossil fuel emissions, not make excuses for increasing them. And if they are to be increased then that must be at the expense of others' attempts to reduce them in other sectors.

The proposed projects are intended to continue operation out to 2070, in defiance of the IPCC consideration that the planet would need to have net zero emissions by 2050 to avoid catastrophic climate change.

Chapter 6 goes into considerable detail in describing the multitude of environmental damage risks to the local marine and terrestrial environment. This review submission does not assess these individually, due to lack of time, but expresses surprise that the proposed preventive and mitigatory measures to avoid these are all "acceptable". Historical weather conditions in estimating risks and responses are assumed but climate change analyses predict that intensity of tropical storms will increase with global warming[1]. This increases the likelihood of damage to infrastructure and consequent environmental damage.

However, even if all of the risks to local environmental damage are averted the ultimate contribution of the proposed projects to global warming will eventually lead to the decimation of this particular environment, along with the entire global environment.

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APPENDIX D SUBMISSIONS

APPENDIX D.31 CLEAN STATE PETITION

Sign a submission to the Environmental Protection Authority

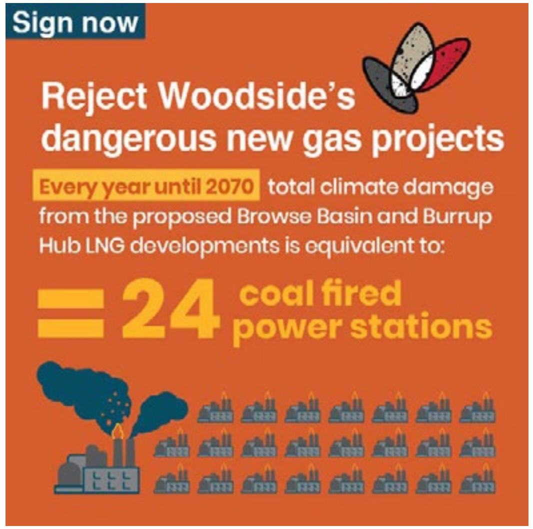
I reject the proposed Browse Basin and North West Shelf gas projects

Dear Dr Tom Hatton (Chairperson EPA WA)

Western Australia must tackle its emissions through the creation of clean jobs and investment in renewable technologies. We must rapidly move away from all types of fossil fuels, including LNG.

We cannot allow the Burrup Hub to become the most polluting fossil fuel project in Australia. Every year until 2070, these projects will emit 95mtpa of carbon pollution which is equivalent to 24 of the largest, dirtiest coal fired power station in WA. This will have devastating impacts on our climate for generations.

I strongly urge you to reject Woodside's proposal as we should be pursuing the cheap and abundant renewable resources we have available right here in WA.



I reject the proposed Browse Basin and North West Shelf gas projects

Clean State

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I reject the proposed Browse Basin and North West Shelf gas projects

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I reject the proposed Browse Basin and North West Shelf gas projects

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I reject the proposed Browse Basin and North West Shelf gas projects

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[redacted]	[redacted]	yourname@email.com	01234 567 890	####	Y/N	Y/N
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I reject the proposed Browse Basin and North West Shelf gas projects

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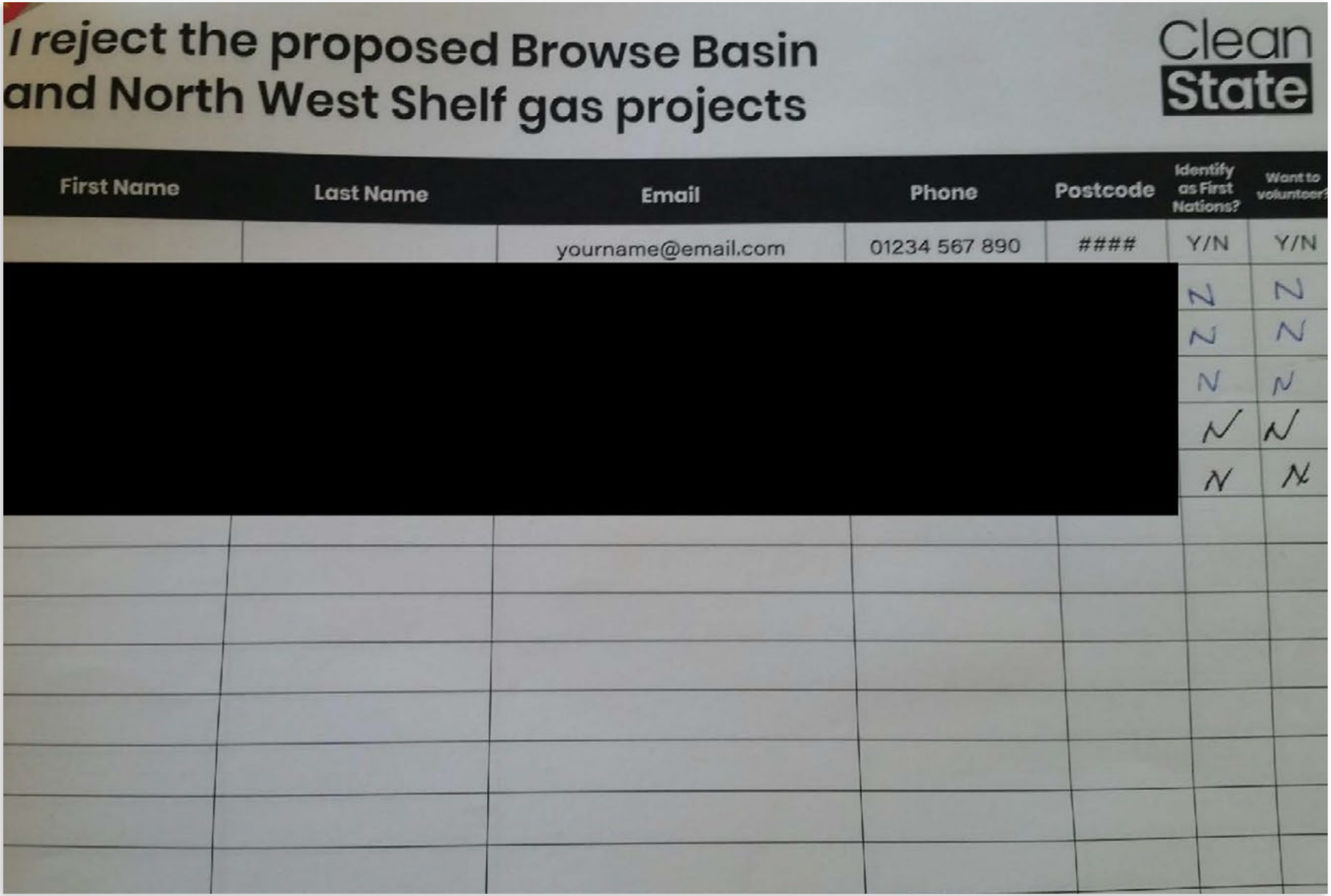

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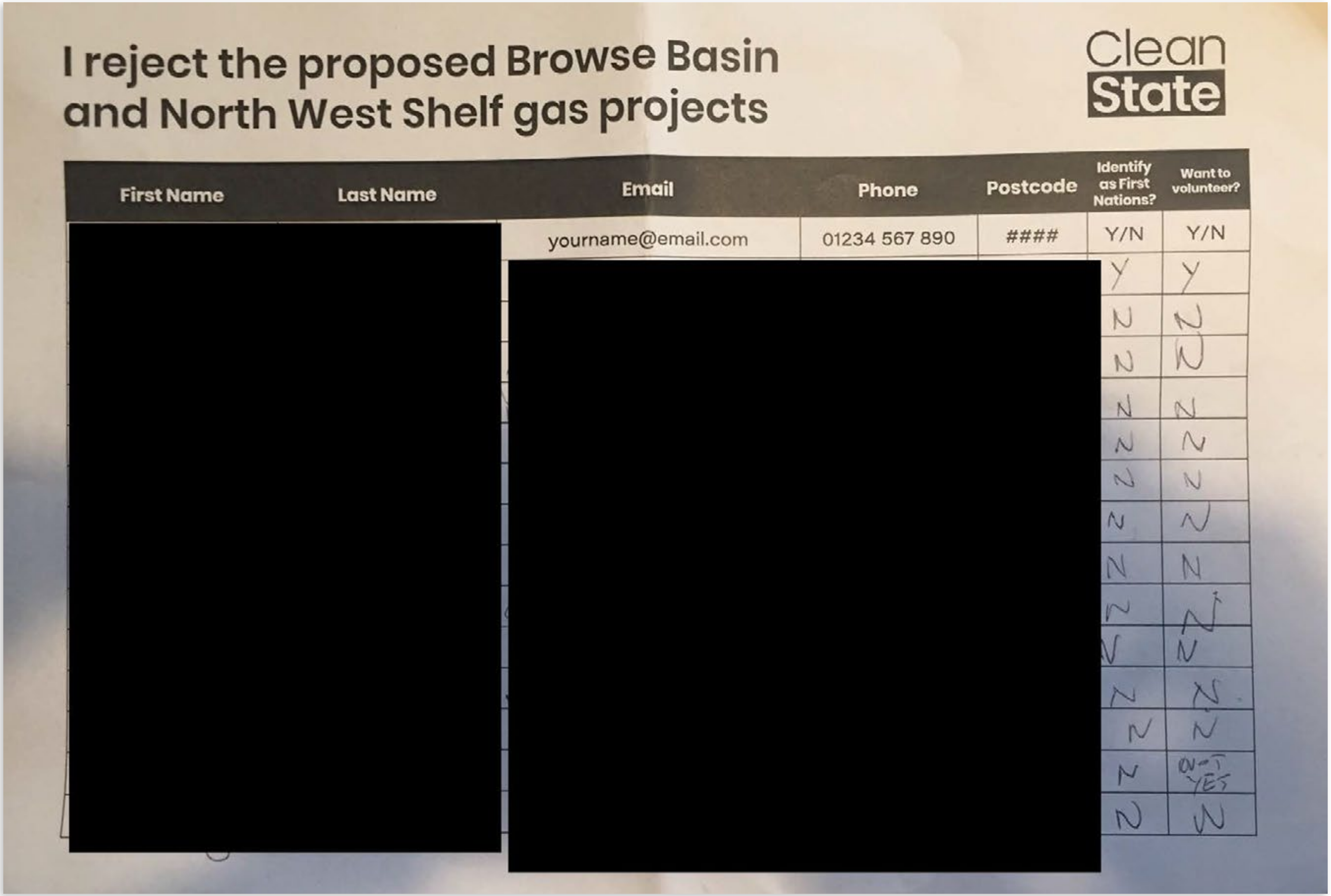

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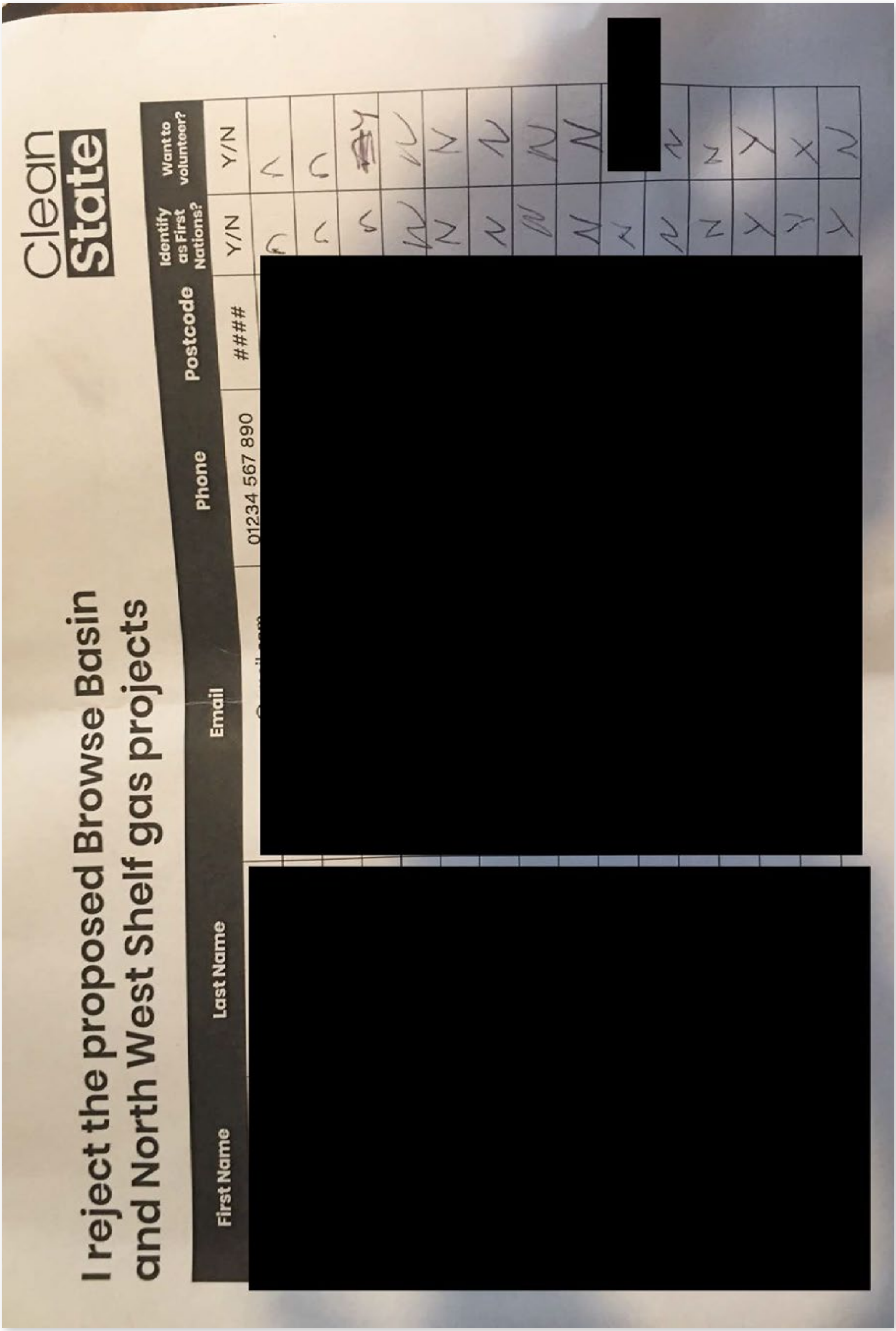

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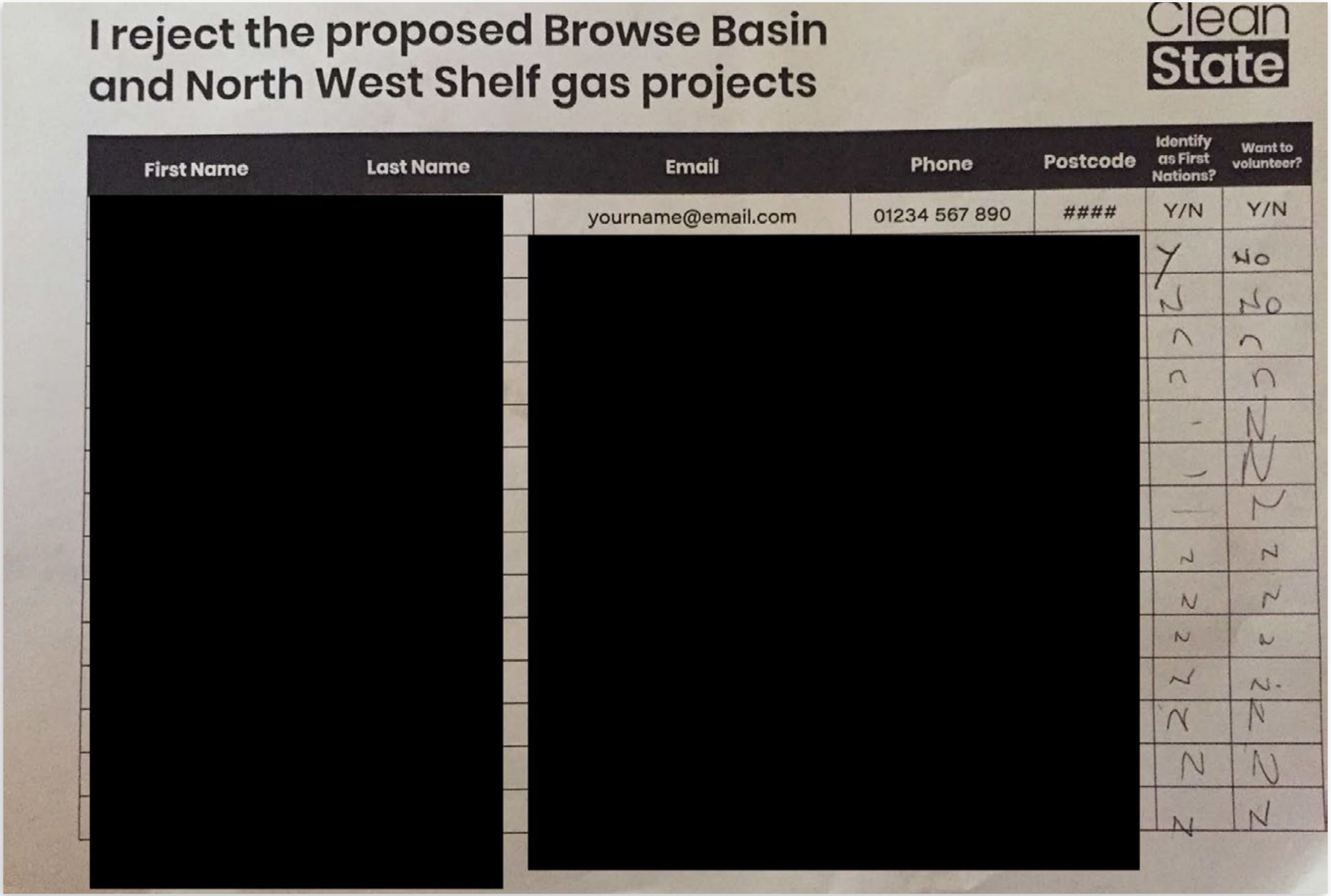

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I reject the proposed Browse Basin and North West Shelf gas projects

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First Name	Last Name	Email	Phone	Postcode	Identify as First Nations?	Want to volunteer?
[redacted]	[redacted]	yourname@email.com	01234 567 890	####	Y/N	Y/N
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APPENDIX D SUBMISSIONS

APPENDIX D.32 ANN-TCUY-7GH9-4

2020

Proposed Browse to North West Shelf Project-Commonweatlth & State Waters-Public Environmental Review

Public Submission

[redacted] | 11 February, 2020.

9 February, 2020

To:
Dr Tom Hatton (Chairperson Environmental Protection Authority WA);
Mr David Fredericks, Secretary Department of Environment and Energy.

SUBJECT: PROPOSED BROWSE TO NWS PROJECT
DRAFT EIS/ERD EPA Assessment No. 2191
EPBC 2018/8319
December 2019

Please find attached my submission to the EIS process for Woodside's proposed Browse to North West Shelf Project. The submission is a public submission and deals with Greenhouse Gas Emissions (GHGe) implications of the proposed project.

2/9/2020

X [redacted]

[redacted]
Dr
Signed by: [redacted]

1

1.0 Background

This submission is a personal submission written by [redacted], retired [redacted] and [redacted] of community programs in sustainability. The submission has been written in response to EPA's Public Environmental Review process for Woodside Energy Ltd's EIS proposal to develop the Browse Development Area located approximately 425km north of Broome in the offshore Browse Basin.

The Browse to North West Shelf (NWS) proposal (in State & Commonwealth waters) surrounding Scott Reef involves drilling and completion, installation, commissioning, operation, well repair and workover, and decommissioning of up to 24 subsea wells and associated infrastructure located in Western Australian State waters.

The submission deals specifically with Greenhouse Gas Emissions (GHG) and provides and explanation in these terms for why development approval should be declined for the Browse project on the basis of EIS data. This submission includes detail particular to WA, as well as some data applicable to both Commonwealth and State waters.

2.0 Background – Expansion of WA and Australia's GHG emissions- Implications of the Paris Agreement

With each new conventional or unconventional gas project approved for production in WA, direct and indirect[1] GHG emissions are rising, increasing the likelihood that:

- Australia will not meet its Paris commitment to reducing emissions to between 26-28% before 2005 levels by 2030; and
- The IPCC's goal of holding the global mean temperature increase to a manageable 1.5 degrees will not be achieved. This threshold of 1.5 degrees describes the figure above which severe climate change related outcomes (e.g. extreme weather events, catastrophic sea level rise, species extinctions) have high probability. The target has been interpreted as requiring net -zero GHGe emissions by 2050.[2]

In 2018, industry analysts, Climate Analytics estimated that domestic emissions expected from all WA *conventional* gas reserves are about 40-75% above what Western Australia's energy sector could emit in order to comply with the Paris Agreement. The concept of a WA carbon budget, representing total WA economy allowable Scope 1 & 2 GHG emissions within the Paris goal of restricting global mean temperature rise to 1.5 degrees, is the appropriate measure for evaluating the nature and significance of GHGe arising from Woodside's BJV.

3.0 Discussion – Woodside's proposed Browse to Northwest Shelf LNG project.

3.1. Contribution to Australia's Greenhouse Gas Inventory & Climate Change

This project will substantially increase WA and Australia's GHG emissions. - The Browse Basin is set to become State's most emissions intensive LNG facility with CHG emissions for NWS increasing under this proposal from 7.6 MtCO2 per annum[3] to 14.4 MtCO2 per annum. If the Browse Burrup Hub expansion proceeds, Woodside will supplant Chevron as WA leading LNG GHG polluter accounting for almost 46% of all LNG pollution in WA.

2

In Chapter 7 of its EIS, Woodside acknowledges implications of its GHG emissions for Australia's commitment to the Paris agreement, including the following targets:

- Keeping "global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit temperature increase to 1.5°C" (Article 2.1(a)).
- Reaching "global peaking of GHG emissions as soon as possible···achieve a balance between anthropogenic emissions by sources and removals by sinks in the second half of this century" (Article 4.1).[4]

But increases in emissions from this project will make it difficult for the State to meet its carbon budget responsibilities as part of a national GHG inventory profile consistent with a Paris Agreement-compatible carbon budget. Research by Climate Analytics (2018) shows the dilemma Australia, Western Australia and the world faces from increasing exploitation of WA's conventional and unconventional gas reserves:[5]

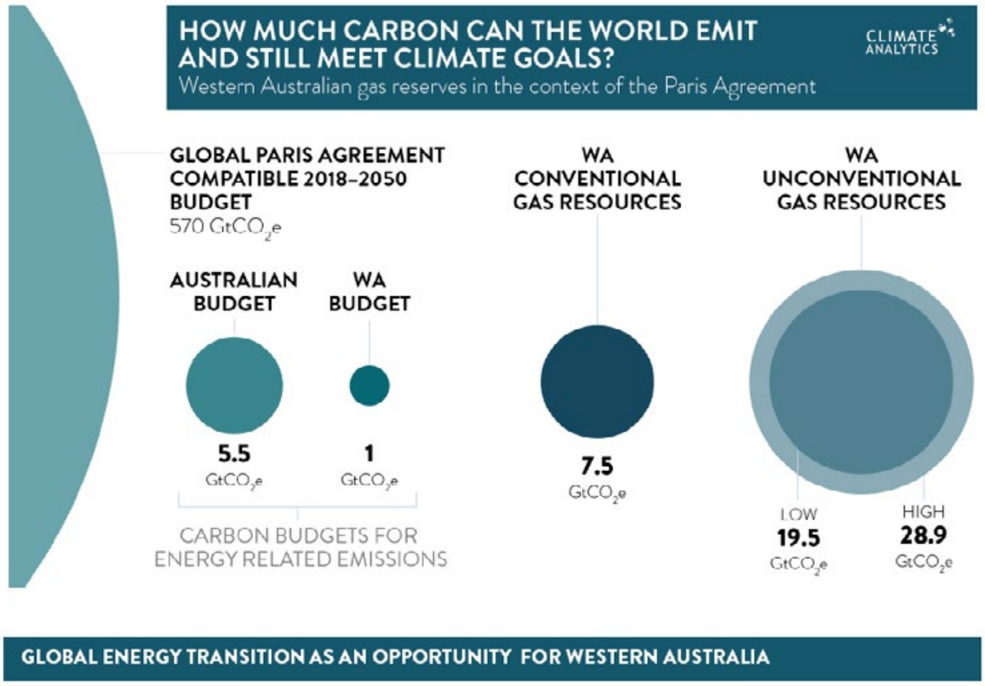

Figure 1- How much carbon can the world emit and still meet climate goals?

1

Within an Australian budget of 5.5 $GtCO_2e$, WA's budget is 1 $GtCO_2e$. Full exploitation of Browse and WA's other LNG resources describes emissions of 7.5 $GtCO_2e$. When emissions are modelled inclusive of unconventional gas this figure rises to 27 $GtCO_2e$. Browse's contribution is claimed at an average 6.8 $MtCO_2e$[6] per year with an expected life (31 year) gross emissions of 211 $MtCO_2e$ and extended life (44 year) emissions of 285 $MtCO_2e$ i.e. nearly 0.3$GtCO_2e$ or one third of the entire WA permissible GHG budget under the Paris Agreement goals.

Even without Browse, there is a huge gap between GHG emissions in a business as usual operating environment and what Australia and WA can afford as a climate budget if we are to meet Paris Agreement goals. In reviewing prospects for new gas projects under the Paris Agreement, consultants Climate Analytics have concluded:

The market for natural gas in the power and heat sectors will likely decline rapidly from the 2030s, as the world meets the Paris agreement goals. In other words, there is a transitional role for gas, but it is limited and does not require further expansion of gas production capacity. This implies that the exploration for additional reserves that Australia is planning in response to their expected large scale demand beyond the late 2020s will very likely become a stranded asset under Paris Agreement implementation.

In this context, the expansion in the exploitation of fossil fuel resources that Australia is planning goes against the global efforts to combat climate change and is not consistent with the global energy transition required to meet the Paris Agreement goals. The majority of the existing global fossil fuel reserves should remain on the ground.[7]

The WA Government might attempt to mitigate the effects of carbon pollution from gas through rapid decarbonisation in other industries such as energy and transport. If the WA Government elects to go down this path, which seems inevitable since it has endorsed the goal of net zero emissions by 2050, then the people of Western Australian will bear the costs of mitigation, not Woodside. Given the problematic nature of massive mitigation compared with emissions reduction required for the Paris Agreement, costs will be high and not borne by the polluter. WA also has no official renewable energy target, suggesting that progress in de-carbonising of the WA energy sector will be sporadic.

3.2 LNG as a transition fuel displacing coal and reducing GHGe
As part of its justification for Browse, on p.24 of its draft EIS, Woodside claims that LNG is a cleaner fuel than coal and

Gas has the potential to contribute significantly to the reduction in global GHG emissions by displacing higher carbon intensive power generation (e.g. coal burning).[8]

In Chapter 7, it is further claimed that:

Numerous independent energy and climate bodies agree that natural gas has a significant role to play in achieving both a reduction in net global emissions and an increased access to a *reliable modern energy supply that supports a progressive transition to renewable energy sources.*[9]

Unfortunately, current research only acknowledges a limited transitionary role for LNG to 2030 and not beyond, posing a fundamental problem for a project predicated on a 31 to 44-year life span:

The market for natural gas in the power and heat sectors will likely decline rapidly from the 2030s, as the world meets the Paris agreement goals. In other words, there is a transitional role for gas, but it is limited and does not require further expansion of gas production capacity. This implies that the exploration for additional reserves that Australia is planning in response to their expected large-scale demand beyond the late 2020s will very likely become a stranded asset under Paris Agreement implementation.

In this context, the expansion in the exploitation of fossil fuel resources that Australia is planning goes against the global efforts to combat climate change and is not consistent with the global energy transition required to meet the Paris Agreement goals. The majority of the existing global fossil fuel reserves should remain on the ground.[10]

This finding is supported by AEMO which sees no substantial increase in gas consumption over the coming decades.[11] Further, the UN Environment Program in its landmark *2019 Report on The Production Gap: The discrepancy between countries' planned fossil fuel production and global production levels consistent with limiting warming to 1.5 or 2 degrees* found that:

Governments are planning to produce about 50% more fossil fuels by 2030 than would be consistent with a 2°C pathway and 120% more than would be consistent with a 1.5°C pathway.[12]

With its GHGe intensity, Browse is not the kind of project that can be built responsibly in circumstances of escalating climate risk.

3.3 Issues with GHG accounting and methodology
Woodside's EIS consistently understates the nature and significance of GHG emissions with its selection of benchmarks, the most glaring of which is the global footprint statement for Browse on p.24 where it says:

it is estimated that Scope 1 and Scope 3 emissions from the proposed Browse to NWS Project could contribute in the range of 0.06% to 0.15% global GHG emissions, depending on the Nationally Determined Contributions (NDC) scenario considered.

Independent research by Climate Analytics, places emissions from this project in the context of Paris Agreement goals by measuring Browse's global footprint as a fraction of the global emissions budget (570GtCO_2) permitted by the 1.5°C 2050 scenario. Using this benchmark, Browse is estimated to produce 2.49 GtCO_2 *representing 0.4% of global emissions compatible with the budget.*[13]

Accounting and methodological issues also exist in EIS reporting of methane emissions. Methane retains 86 times more heat than CO_2 over a 20-year period and is considered responsible for 25% of global warming to date. Table 7.6 which describes emissions by gas type puts total CH_4 emissions at 1.0%.[14] The IEA [International Energy Agency'] estimates a global average methane leakage rate of 1.7%. Total fugitive methane emissions of methane from conventional gas were estimated by Howarth et al. in 2011 as in the range of 1.7%-6.0%.[15] Methane emissions, as a proportion of total emissions, are likely understated in the EIS.

3.4 Failure to provide detail of investment plans, inadequate CO2 abatement from offsets.
It is clear from the EIS, that only 50 $MtCO_2$ are proposed for offsetting over the life of the project i.e. between 1.6 and 1.13 $MtCO_2$ per year. Taking into account the scope of Woodside existing and planned operations to 2030, this figure is plainly inadequate:

- As a result of favoured treatment, existing Woodside projects have not required emissions reduction or abatement. Conservation Council WA estimates that:

  Over the next twelve years, the total cumulative emissions from WA's five current LNG facilities (384Mt) will cancel out the entire amount of abatement expected to be delivered under the ERF (375Mt). At a total cost of $4.55 billion the ERF is effectively an Australian taxpayer-funded offset program for Chevron and Woodside's operations to 2031.[16]

- The same report citing research by Reputex estimates the potential for 80 $MtCO_2$ to be offset per year in WA and that offsetting 30 $MtCO_2$ an amount, just short of the total emissions from current WA LNG production - would create around 4,000 jobs.[17]

4.0 Conclusion
This submission has critically analysed Woodside's EIS claims on GHG emissions from the proposed Browse to NWS LNG project. In an evidence-based manner, it concludes that GHG emissions from this project and emissions reduction and mitigation measures are **unacceptable** for the following reasons:

1. GHG emissions from this project are not consistent with a WA carbon budget of 1 $GtCO_2$ consistent with WA playing its part in achievement of Paris Agreement goals
2. That the proposed offset of 50$MtCO_2$ over the life of the project amounts to 2% of the global carbon footprint of this project and is unacceptable. No actual data or significant detail is provided of how offsets will work to mitigate GHG pollution outcomes.
3. The claim that LNG provides a valid transition pathway is problematic since the UN Environment Program has estimated that current government production plans involve a 120% overshoot relative to the Paris 1.5°C pathway. There is no available carbon budget for new fossil fuel carbon polluting projects.
4. The methodology of comparative comparison in which emissions from the project are trivialized is flawed, misleading and does not represent good practice.

4

ENDNOTES

[1] The following definitions are used:
Scope 1 - emissions directly due to activities within the company during production of CSG and LNG;
Scope 2 - all indirect emissions associated with generation and transmission of electricity used by the company to produce CSG and LNG; and
Scope 3 - emissions are also indirect and external to the company, and they refer to emissions associated with production of goods and services that the company has purchased.
[2] IPCC Special Report on Global Warming of 1.5°C, p 95.
[3] North West Shelf. Approved for 7.7-9.4MtCO2-e http://www.epa.wa.gov.au/sites/default/files/EPA_Report/924_B962.pdf
[4] Woodside. (2019). Proposed Browse to NWS Project Draft EIS/ERD. EPA Assessment No. 2191. p.678. Retrieved from http://www.epa.wa.gov.au/sites/default/files/PER_documentation2/Draft%20EIS%20ERD%20Part%202%20-Chapters%206-9.pdf
[5] Climate Analytics. (2018). *Western Australia's Gas Gamble. Implications of exploiting Canning Basin and other unconventional gas resources for achieving climate targets.* p.6 Retrieved from: https://climateanalytics.org/publications/2018/western-australias-gas-gamble/
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