NORTH WEST SHELF PROJECT EXTENSION

ENVIRONMENTAL REVIEW DOCUMENT

EPA Assessment No. 2186
EPBC 2018/8335
Revision 1 – December 2019

Woodside

TABLE OF CONTENTS

Tables

Figures

Invitation to make a submission

The Western Australian (WA) Environmental Protection Authority (EPA) invites people to make a submission on the environmental review for this Proposal.

Woodside Energy Ltd, as operator for and on behalf of the North West Shelf Joint Venture proposes the ongoing operation of the NWS Project to enable the long-term processing of third-party gas and fluids and NWSJV field resources through the NWS Project facilities until around 2070. The Environmental Review Document (ERD) has been prepared in accordance with the EPA's Procedures Manual (Part IV Divisions 1 and 2). The ERD is the report by the proponent on their environmental review that describes this Proposal and its likely effects on the environment.

The ERD is available for a public review period of **8 weeks** from **18 December 2019**, closing on **12 February 2020.**

Information on the Proposal from the public may assist the EPA to prepare an assessment report in which it will make recommendations on the Proposal to the Minister for Environment.

Why write a submission?

The EPA seeks information that will inform the EPA's consideration of the likely effect of the Proposal, if implemented, on the environment. This may include relevant new information that is not in the ERD, such as alternative courses of action or approaches.

In preparing its assessment report for the Minister for Environment, the EPA will consider the information in submissions, the proponent's responses and other relevant information.

Submissions will be treated as public documents unless provided and received in confidence, subject to the requirements of the *Freedom of Information Act 1992* (WA).

Why not join a group?

It may be worthwhile joining a group or other groups interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on information in the ERD.

When making comments on specific elements in the ERD:

- Clearly state your point of view and give reasons for your conclusions.
- Reference the source of your information, where applicable.
- Suggest alternatives to improve the outcomes on the environment.

What to include in your submission

Include the following in your submission to make it easier for the EPA to consider your submission:

- Your contact details – name and address.
- Date of your submission
- Whether you want your contact details to be confidential.
- Summary of your submission, if your submission is long.
- List points so that issues raised are clear, preferably by environmental factor.
- Refer each point to the page, section, and if possible, paragraph of the ERD.

- Attach any reference material, if applicable. Make sure your information is accurate.

The closing date for public submissions is: **12 February 2020.**

The EPA prefers submissions to be made electronically via the EPA's Consultation Hub at https://consultation.epa.wa.gov.au

Alternatively, submissions can be:

- posted to: Chairman, Environmental Protection Authority, Locked Bag 10, Joondalup DC WA 6919, or
- delivered to: The Environmental Protection Authority, 8 Division Terrace, Joondalup WA 6027.

If you have any questions on how to make a submission, please contact the EPA Services at the Department of Water and Environmental Regulation (DWER) on (08) 6364 7000.

SCOPING CHECKLIST

Task No.	Required Work by Proponent	Section
Air Quality (Health and Amenity)		
1.	Characterise the existing environment, identify sensitive receptors and describe long-term trends for temperature, wind speed, wind direction, humidity and rainfall using local and regional meteorological information.	Section 4.1
2.	Characterise the existing local and regional ambient air quality using existing monitoring data, audit results and observations. Supplement this information with data from publicly available reports and studies, including: + Aggregated Emission Inventory for the Pilbara Airshed: Emissions Inventory Report 1999/2000 (SKM, 2003) + Pilbara Air Quality Summary Report (DoE, 2004) + Burrup Peninsula Air Pollution Study: Final Report – April 2006 (CSIRO, 2006)	Section 4.2
3.	Characterise the proposed emissions to air from the NWS Project Extension Proposal by developing an air emission inventory.	Appendix E: NWS Project Extension Air Quality Impact Assessment
4.	Characterise current and reasonably likely future emissions from other local and regional industrial sources for input into air quality modelling.	Appendix E: NWS Project Extension Air Quality Impact Assessment
5.	Review publicly available modelling studies and compare results with appropriate air quality standards to screen out pollutants and sources that present a low risk to ambient air quality.	Appendix E: NWS Project Extension Air Quality Impact Assessment
6.	Undertake air quality modelling to determine impacts to ambient air quality resulting from the NWS Project Extension Proposal. Modelling will consider the following: + Undertake, and provide information on the results of, a literature review of the past use of advanced models which included the (then) current and expected future emission sources in the region. + Provide information on the selection and justification of an appropriate model for the region. This justification should focus on the model's ability to simulate the dispersion and photochemical transformation of the pollutants of concern and should be able to model those pollutants of concern from all industrial sources in the region. + Provide a review of at least 10 years of meteorology. + Reporting of the modelling outcomes will include a discussion of the limitations of the chosen modelling. + Comparisons with relevant ambient air quality criteria for the protection of human health.	Appendix E: NWS Project Extension Air Quality Impact Assessment

Task No.	Required Work by Proponent	Section
7.	Air quality modelling (item 6) results to include the following: + Contour plots for the pollutants of concern, which describe modelling scenarios, and for the NWS Project Extension Proposal in isolation, as well as current and reasonably likely future emissions identified at item 4 above (i.e. cumulative impacts). + Tables listing the modelled ambient concentrations for the pollutants of concern, including those generated by the NWS Project Extension Proposal in isolation, as well as current and reasonably likely future emissions identified at item 4 above (i.e. cumulative impacts).	Appendix E: NWS Project Extension Air Quality Impact Assessment
8.	Identify and evaluate potential credible opportunities to achieve a long-term reduction in air emissions of concern. Where practicable, use air modelling to quantify reductions that are reasonably achievable for future operations under different scenarios.	Section 6.3.5 Appendix A: NWS Project Extension Air Quality Management Plan
9.	Identify management and mitigation measures that will be implemented to ensure residual impacts are not greater than predicted. This will include: + Developing an Air Quality Management Plan which incorporates an adaptive management program with due consideration of the Murujuga Rock Art Strategy. + Monitoring air emissions and air quality where relevant. + Summarising how the mitigation hierarchy will be addressed. + Identifying existing management and mitigation mechanisms that have been implemented for current NWS Project operations and that are proposed to be continued. + Identifying management and mitigation measures that could be implemented over time to achieve continuous improvement in the long-term reduction in air emissions of concern.	Section 6.3.5 Appendix A: NWS Project Extension Air Quality Management Plan
10.	Predict the extent, severity, and duration of any residual impacts from the NWS Project Extension Proposal that may be expected after implementing management and mitigation measures.	Section 6.3.6
Air Quality (Greenhouse Gas Emissions)		
11.	Characterise greenhouse gas emissions direct and indirect (types and volumes) from the NWS Project Extension Proposal and assess the relative contribution to regional, state, national and international greenhouse gas emissions.	Section 6.4.4.1
12.	Based on the greenhouse gas emission characteristics, benchmark the emissions from the NWS Project Extension Proposal against comparable Australian and International LNG developments.	Section 6.4.4.1 Appendix F: NWS Project Extension Greenhouse Gas Benchmarking Report

Task No.	Required Work by Proponent	Section
13.	Identify and justify contemporary best practice management and mitigation measures that will be implemented to reduce greenhouse gas emissions and improve operational efficiency, including: + Developing a Greenhouse Gas Management Plan. + Summarising how the mitigation hierarchy will be addressed including benchmarking against other facilities where appropriate and where public information is available. + Identifying existing greenhouse gas management and mitigation mechanisms that have been successfully implemented for current operations and that will be continued. + Identifying relevant contemporary best practice management and mitigation measures, including all reasonable and practicable emission reduction equipment and technologies, that can be implemented over time to achieve a long-term reduction in greenhouse gas emissions.	Section 6.4.5 Appendix B: NWS Project Extension Greenhouse Gas Management Plan
14.	Predict the extent, severity, and duration of any residual impacts from the NWS Project Extension Proposal that may be expected after implementing management and mitigation measures.	Section 6.4.6
Social Surroundings (Heritage)		
15.	Describe the existing environment by identifying heritage features, using published sources as well as outcomes from engagement with relevant Aboriginal groups.	Section 4.6.2
16.	Characterise the heritage value and sensitivity of vegetation in and/or adjacent to the development envelope using existing monitoring data and consulting with local Aboriginal groups and corporations with an interest in the area.	Section 4.6.3
17.	Characterise the heritage value and sensitivity of the marine environment in and/or adjacent to the development envelope using existing monitoring data and consulting with local Aboriginal groups and corporations with an interest in the area.	Section 4.6.4
18.	Describe the elements of the Proposal that may affect social surroundings.	Section 6.5.4

19.	Describe the potential impacts of each element of the Proposal on social surroundings, with an emphasis on:
	+ Potential impacts to petroglyphs from air emissions using:
	  + publicly available scientific reports on the effects of atmospheric pollution on petroglyphs.
	  + results from air quality modelling of current and predicted future operations, under different scenarios (Refer to item 6 under Air Quality).
	+ Potential impacts to vegetation with heritage values using publicly available information, air quality modelling and existing Woodside monitoring data.
	+ Potential impacts to aspects of the marine environment that have heritage value using existing Woodside monitoring data and outcomes of consultation with local Indigenous groups and corporations.
	+ Other aspects with heritage value as identified through consultation with local Aboriginal groups and corporations.
		Section 6.5.4
		Appendix H: A synthesis of literature on the potential impact of industrial air emissions on Murujuga Rock Art

Task No.	Required Work by Proponent	Section
20.	Identify management and mitigation measures that will be implemented to ensure residual impacts are not greater than predicted, including: + Developing a Cultural Heritage Management Plan that incorporates an adaptive management program and which will be aligned with the Murujuga Rock Art Strategy. + Summarising how the mitigation hierarchy will be addressed. + Identifying existing management and mitigation mechanisms that have been implemented for current operations and that will be continued. + Identifying management and mitigation measures that will be implemented over time to achieve a long-term reduction in air emissions of concern for petroglyphs. + Identifying management and mitigation measures that will be implemented over time to reduce impacts to heritage features within the development envelope, vegetation with heritage value and aspects of the marine environment with heritage value.	Section 6.5.5 Appendix C: NWS Project Extension Cultural Heritage Management Plan
21.	Consult and incorporate feedback from local Indigenous groups on the management and mitigation measures that could be implemented over time to reduce impacts to heritage features and petroglyphs.	Section 5 and Section 6.5.4 Appendix C: NWS Project Extension Cultural Heritage Management Plan
22.	Predict the extent, severity, and duration of any residual impacts from the NWS Project Extension Proposal that may be expected after implementing management and mitigation measures.	Section 6.5.6
Marine Environmental Quality		
23.	Characterise the existing marine environmental quality (baseline water and sediment quality) in the area potentially affected by the Proposal using existing operational monitoring data and, if required, additional field surveys for those contaminants that are not routinely monitored including fire-fighting foams.	Section 4.4
24.	Characterise the relevant activities from the Proposal that have the potential to affect marine environmental quality.	Section 6.6.4
25.	Characterise the quality of the different wastewater discharges to the marine environment, including through Whole Effluent Toxicity (WET) testing.	Section 6.6.4.1 Appendix D: NWS Project Extension Marine Environmental Quality Management Plan
26.	Predict the spatial extent, temporary variability and concentration (or magnitude) of contaminants in the waste dispersion fields.	Section 6.6.4.1 Appendix G: Karratha Gas Plant Wastewater Discharge Modelling
27.	Spatially define marine discharge mixing zone in relation to key sensitive biological receptors likely to be affected by the discharges.	Section 6.6.4.1 Appendix D: NWS Project Extension Marine Environmental Quality Management Plan

Task No.	Required Work by Proponent	Section
28.	The baseline data acquisition should be adequate for the derivation of environmental quality criteria for indicators relevant to the discharge(s) e.g. water, sediment and/or biological quality indicators.	Appendix D: NWS Project Extension Marine Environmental Quality Management Plan
29.	Characterise cumulative impacts by developing an inventory of marine discharges from other local industrial sources using publicly available monitoring results. Undertake a cumulative impact study if relevant.	Section 6.6.4.1

30.	Identify management and mitigation measures that will be implemented to ensure residual impacts are not greater than predicted, including:
	+ Providing a Marine Environmental Quality Management Plan (MEQMP) that includes the following
	  + An Environmental Quality Plan (EQP) which will be based on the updated Pilbara Coastal Water Quality Consultation Outcomes - Environmental Values and Environmental Quality Objectives (DoE, 2006b). Any departures from the Pilbara Coastal Water Quality Consultation Outcomes will be clearly shown and justified with clear rationale.
	  + Environmental quality criteria for indicators relevant to planned discharges.
	  + Spatial definition of the waste discharge point using numerical modelling outputs and the results of any wastewater discharge toxicity testing.
	  + Definition of the boundaries of low or moderate levels of ecological protection surrounding the discharges, depicted using at a suitable scale.
	  + The EQP will identify environmental values to be protected and spatially define the environmental quality objectives (including the levels of ecological protection) that are relevant to the marine environment surrounding the Proposal.
	  + The key sensitive biological receptors likely to be affected by the discharges, described and mapped as an overlay on the EQP (e.g. seagrass and/or coral).
	  + Information to demonstrate that discharges would adequately protect the environmental values and meet the levels of ecological protection assisted to the discharge areas.
	  + An adaptive management program that applies the environmental quality management framework, including monitoring at appropriate sites, designed to ensure the EQP is achieved.
	+ Providing a revised list of contaminants of concern for on-going monitoring and revised set of environmental quality criteria for the assessment and management of the discharge to ensure all relevant environmental values are protected.
	+ Monitoring of the receiving waters at the boundary of each level of ecological protection and at reference sites to ensure compliance with the EQP.
	+ Monitoring marine discharges as relevant.
	+ Summarising how the mitigation hierarchy will be addressed.
	+ Identifying existing management and mitigation mechanisms that have been implemented for current operations and that will be continued.
		Section 6.6.5
		Appendix D: NWS Project Extension Marine Environmental Quality Management Plan

31.	Identify any additional management or mitigation measures, including monitoring, that could be implemented to minimise as far as reasonably practicable residual impacts to marine environmental quality.	Section 6.6.5 Appendix D: NWS Project Extension Marine Environmental Quality Management Plan

EXECUTIVE SUMMARY

Woodside

1. EXECUTIVE SUMMARY

1.1 Introduction

This executive summary provides an overview of the information presented in the North West Shelf (NWS) Project Extension Environmental Review Document (ERD) prepared by Woodside Energy Ltd (Woodside), as Operator for and on behalf of the North West Shelf Joint Venture (NWSJV).

1.1.1 Background and Context

The NWS Project commenced in 1984 with the commissioning of the Karratha Gas Plant (KGP) in Western Australia (WA). Since then the KGP has undergone several expansions and additional facilities have been installed. At present, and subject to Ministerial Statement 536 (MS 536), the Existing NWS Project processes natural gas and associated fluids from NWSJV field resources to produce up to 18.5 million tonnes per annum (mtpa) of liquefied natural gas (LNG) at the KGP.

Woodside now proposes to operate the NWS Project to around 2070 as an LNG facility that is commercially capable of accepting gas for processing from other resource owners. Therefore, this Proposal (the Proposal) will include processing third-party gas and fluids and any remaining or new NWSJV field resources. The Proposal is described further in **Section 2.4** and the full Proposal is contained in the North West Shelf Project Extension Proposal Section 38 Referral Supporting Information (Woodside, 2018).

The Proposal was referred to the WA Environmental Protection Authority (EPA) under Section 38 of the *Environmental Protection Act 1986* (WA) (EP Act) on 14 November 2018. On 4 December 2018, the EPA determined that the Proposal required assessment under Part IV of the EP Act at the level of Environmental Review – Public Environmental Review with the relevant environmental factors being:

+ Air Quality
+ Social Surroundings (Heritage)
+ Marine Environmental Quality.

In parallel, the Proposal was referred to the Commonwealth (Cth) Department of the Environment and Energy (DoEE) on 22 November 2018 in accordance with the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). On 3 May 2019, the DoEE determined the Proposal to be a controlled action with this controlling provision:

+ National Heritage (EPBC Act Section 15B and 15C), namely the Dampier Archipelago (including Burrup Peninsula).

Assessment of the Proposal is being undertaken by the WA EPA on behalf of the DoEE as an accredited assessment.

1.2 Overview of the Proposal

To enable the future operation of the NWS Project and the ongoing supply of gas and fluids to domestic and international markets, the Proposal seeks approval to transition the Existing NWS Project facilities to a new phase of the NWS Project; which is commercially capable of accepting gas for processing from other resource owners. The NWS Project Extension Proposal is seeking approval for the:

+ Long-term processing of third-party gas and fluids and NWSJV field resources through the NWS Project facilities, including:
  + Changes to feed gas composition including changed content of inerts, hydrocarbons and other components.
  + Changes to the composition of environmental discharges and emissions, although annual volumes of emissions and discharges are expected to be within current levels.
  + Modifications to the KGP onshore receiving facilities (that would not otherwise be undertaken if not for the Proposal) to accommodate third-party gas and fluids, as well as upgrades to metering to facilitate processing of third-party gas and fluids.
  + Potential construction of additional operational equipment to accommodate changes to feed gas composition or management of discharges and emissions.

- Ongoing operation of the NWS Project (from the date of the approval of this Proposal) to enable long-term processing at the NWS Project facilities, currently expected to be until around 2070, including
  - Ongoing use of existing NWS Project facilities to process third-party gas and fluids and NWSJV field resources.
  - Inspection, maintenance, and repair (IMR) and improvement programs for trunklines (TL), 1TL and 2TL
  - Maintenance dredging associated with jetties and berthing pockets.
  - Replacing equipment, plant, and machinery as required that would not otherwise be replaced if not for the Proposal.
  - Continuation of emissions and discharges to the environment (Woodside, as Operator for and on behalf of the NWS Project, will implement emission reduction opportunities [described in **Section 6**] that will result in a staged decrease in key emissions over time).
  - Monitoring and management of environmental impacts.

It is Woodside's intention that once the Proposal is approved, that approval will take the Existing NWS Project outside of the scope of the existing environmental assessment framework and within the ambit of the EPBC Act and EP Act. Woodside is therefore seeking approval for the Proposal to change and operate the KGP so that it is commercially capable of accepting gas for processing from other resource owners. Following assessment of this ERD the NWSJV requests a single new approval under the EPBC Act and a single new approval under the EP Act that will incorporate both the processing of third-party gas and fluids and any remaining or new NWSJV field resources, with all of that occurring under proposed LNG tolling arrangements.

No additions are proposed to the disturbance footprint currently approved under existing approvals, including Ministerial Statements, Commonwealth *Environment Protection (Impact of Proposals) Act 1974* (EPIP Act; superseded by the EPBC Act in 1999) approval, and EPBC Act authorisations.

1.3 Summary of Potential Impacts, Existing and Proposed Mitigations, and Outcomes

A summary of potential impacts and risks, existing and proposed mitigation measures and outcomes described in this ERD are provided in **Table 1-1**.

Table 1-1: Summary of Potential Impacts described in ERD

Air Quality (Health and Amenity)	
EPA Objective	To maintain air quality and minimise emissions so that environmental values are protected.
Policy and Guidance	**EPA policy and guidance:** + Statement of Environmental Principles, Factors and Objectives (EPA, 2018a) + Environmental Factor Guideline: Air Quality (EPA, 2016a) **Other policy and guidance:** + Air Quality Modelling Guidance Notes 2006 (DoE, 2006a) + Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW) (NSW EPA, 2016) + European Union Air Quality Standards for the Protection of Vegetation (EU, 2008) **Relevant legislation:** + *National Environment Protection Council (Western Australia) Act 1996* (WA) + *National Environmental Protection (Ambient Air Quality) Measure 2016* (Cth) + *National Environment Protection (Air Toxics) Measure 2011* (Cth) + *National Environmental Protection (National Pollutant Inventory) Measure 1998* (Cth)

Air Quality (Health and Amenity)	
Potential Impacts and Risks	Gaseous emissions causing a reduction in ambient air quality impacting human health.
	Changes in air quality causing deposition on nearby heritage features, including National Heritage Places.
	Degradation of terrestrial and nearshore vegetation of heritage and conservation value due to deposition of gaseous emissions.
	Emission of odorous substances and dark smoke impacting public amenity.
Mitigation	No significant impacts or risks to Air Quality (Health and Amenity) were identified. No additional management or mitigation measures are required to be implemented to further minimise residual risks. However, the Proposal provides equipment life and operational opportunities to further minimise NO_x and VOC emissions. Woodside will continue emissions monitoring programs during the Proposal through the implementation of the NWS Project Extension Air Quality Management Plan.
Outcomes	No significant air quality impacts to human health and amenity are expected associated with the ongoing operation of the Proposal. The potential introduction of third-party gas and fluids may cause changes to air emission characteristics. However, these emissions are anticipated to remain similar to current emissions. Analysis of seven years of ambient air monitoring data demonstrate long term cumulative ground level emissions rates below NEPM health standards for the existing operation. Environmental monitoring and existing environmental baseline data which include historical operation of the NWS Project, together with robust and conservative modelling predictions provide evidence to support the predicted outcomes of the Proposal. The Proposal is therefore expected to achieve the EPA's objective for Air Quality. The residual risk for air emissions potentially impacting on human health was assessed as *low*. The residual risk of dark smoke emissions potentially impacting public amenity was similarly assessed as *low* while the residual risk of odorous substances potentially impacting public amenity was assessed as *slight*.

Air Quality (Greenhouse Gas Emissions)	
EPA Objective	To maintain air quality and minimise emissions so that environmental values are protected.
Policy and Guidance	**EPA policy and guidance:** + Statement of Environmental Principles, Factors and Objectives (EPA, 2018a) + Environmental Factor Guideline: Air Quality (EPA, 2016a) **Other policy and guidance:** + Climate Solutions Package (DoEE, 2019a) + Greenhouse Gas Emissions for Major Projects (DWER, 2019a) **Relevant legislation:** + *National Greenhouse and Energy Reporting Act 2007* (Cth) + *Carbon Credits (Carbon Farming Initiative) Act 2001* (Cth) + *National Greenhouse and Energy Reporting (Measurement Determination) 2008* (Cth) + *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* (Cth)
Potential Impacts and Risks	Contribution to global greenhouse gas concentrations from the emission of Scope 1, Scope 2 and Scope 3 emissions.
	Climate change influenced by changes to global greenhouse gas emission concentrations
Mitigation	Mitigation measures will be implemented through the NWS Project Extension Greenhouse Gas Management Plan, which includes provisions for identification and implementation of emissions reduction opportunities.

Air Quality (Greenhouse Gas Emissions)	
Outcomes	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. It was not possible to quantitatively assess the impact of the Proposal to any regional, state or global climate changes. 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. In addition to this global context, intensity benchmarking shows the emissions intensity of the Proposal compares favourably with many other Australian LNG facilities. This is in part due to design decisions, but also the continuous reduction in emissions intensity by the NWS Project. There are no planned impacts or risks associated with the Proposal that are considered inconsistent with the EPAs objective for the Air Quality Factor. The Proposal is therefore expected to achieve the EPA's objective for Air Quality.

Social Surroundings (Heritage)	
EPA Objective	To protect social surroundings from significant harm.
Policy and Guidance	**EPA policy and guidance:** + Statement of Principles, Factors and Objectives (EPA, 2018a) + Environmental Factor Guideline – Social Surroundings (EPA, 2016b) + Guidance for the Assessment of Environmental Factors Assessment of Aboriginal Heritage No. 41 (EPA, 2004) **Other policy and guidance:** + Australia's National Heritage – Applying the Principles (DoEE, 2008) + Murujuga National Park Management Plan No. 78 (DEC, 2013) + Due Diligence Guidelines (Version 3.0) (DPLH, 2013) + Engage Early – Guidance for proponents on best practice Indigenous engagement for environmental assessments under the EPBC Act (DoE, 2016) + Murujuga Rock Art Strategy (DWER, 2019b) + European Union Air Quality Standards for the Protection of Vegetation (EU, 2008) **Relevant legislation:** + *Aboriginal Heritage Act 1972* (WA) + *Environmental Protection and Biodiversity Conservation Act 1999* (Cth)
Potential Impacts and Risks	Accelerated weathering of rock art due to industrial emissions. Degradation of terrestrial and nearshore vegetation of heritage and conservation value due to deposition of gaseous emission. Direct, accidental physical damage to heritage features within the development envelope. Continued restricted access to heritage features within the development envelope until around 2070. Reduced amenity to heritage features outside the development envelope as a result of odorous substances (e.g. odour from atmospheric emissions). Harm to marine fauna and flora with heritage value from: + Changes to water quality from planned and unplanned discharges. + Turbidity from maintenance dredging.

Social Surroundings (Heritage)	
Mitigation	The NWS Project Extension Cultural Heritage Management Plan (CHMP) sets the framework for how Woodside will continue to minimise its impact to the heritage environment to an acceptable level. The implementation of this management plan will ensure that representatives of the Indigenous groups of the area continue to be consulted regarding Woodside's heritage management activities, impacts, and influence Woodside's approach to heritage management. In addition, 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).
Outcomes	Woodside's approach to the management of Aboriginal heritage has been developed to ensure the requirements of the *Aboriginal Heritage Act 1972* (WA) and the environmental objectives of the Social Surroundings environmental factor are met. 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. Based on the current environmental performance of the NWS Project, the continued implementation of existing management measures and the commitment to reassess any potential impacts or risks from the introduction of third-party gas, there were no impacts or risks that the objectives the EPA has established for Social Surroundings (Heritage) would not be achieved.

Marine Environment Quality	
EPA Objective	To maintain the quality of water, sediment, and biota so that environmental values are protected.
Policy and Guidance	**EPA policy and guidance:** + Statement of Environmental Principles, Factors and Objectives (EPA, 2018a) + Environmental Factor Guideline – Marine Environmental Quality (EPA, 2016c) + Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016d) **Other policy and guidance:** + Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives (DoE, 2006b) + Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2018)
Potential Impacts and Risks	Reduction in marine environment quality, resulting from planned discharges to the marine environment.
	Direct reduction of water and sediment quality and indirect impacts to marine flora and fauna, resulting from maintenance dredging and shipping.
	Direct reduction of water and sediment quality and indirect impacts to marine flora and fauna, resulting from unplanned discharges from offshore or onshore accidents or emergencies.
	Reduction of water and sediment quality and indirect impacts to marine flora and fauna, resulting from the presence and potential migration of onshore contamination.
Mitigation	Mitigation measures will be implemented through the NWS Project Extension Marine Environment Quality Management Plan. Contemporising of the KGP's waste water treatment system will occur through installation of additional treatment equipment to be installed to further reduce hydrocarbons and heavy metals discharged from the Jetty Outfall. The use of Per- and poly-fluoroalkyl substances (PFAS) containing firefighting foams at the KGP is being phased out.
Outcomes	After implementing the proposed mitigation measures, no planned impacts or risks higher than a *moderate* ranking have been identified. The Proposal is expected to result in planned impacts with the same or lower consequence as those that are presented currently. Three decades of environmental monitoring and existing environmental baseline data provides evidence to support the predicted outcomes of the Proposal. The Proposal is therefore expected to achieve the EPA's objective for Marine Environmental Quality.

INTRODUCTION

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2. INTRODUCTION

2.1 Overview

The North West Shelf (NWS) Project is one of the world's largest liquefied natural gas (LNG) producers, supplying oil and gas to Australian and International markets from offshore gas, oil, and condensate fields in the Carnarvon Basin off the north-west coast of Australia. For more than 30 years, it has been Western Australia's (WA) largest producer of domestic gas.

Woodside Energy Ltd (Woodside), as Operator for and on behalf of the North West Shelf Joint Venture (NWSJV), is (subject to approval of this Proposal) proposing to extend the operating life of the NWS Project through opening the NWS Project facilities for the long-term processing of third-party gas and fluids.

The addition of third-party gas and fluids to NWSJV field resources will see the NWS Project facilities transition to an LNG Facility which is commercially capable of accepting gas for processing from other resource owners. This will allow the NWS Project to operate until around 2070, and will provide an ongoing supply of natural gas, LNG, liquefied petroleum gas (LPG), and condensate to domestic and international markets. The Proposal also provides Woodside with the opportunity to contemporise aspects of the Karratha Gas Plant (KGP) to meet current societal expectations and reducing emissions and discharges.

2.2 Purpose and Scope of the Environmental Review Document

This document presents an environmental impact assessment of the Proposal (as defined in **Section 2.4**) for public review and assessment by the WA Environmental Protection Authority (EPA) and the Commonwealth (Cth) Department of the Environment and Energy (DoEE). This Environmental Review Document (ERD) describes the Proposal in detail, identifies and assesses potential impacts resulting from the Proposal and describes the proposed impact avoidance, mitigation, and management measures that will be implemented.

The scope of this ERD is defined by the NWS Project Extension Environmental Scoping Document (ESD), which was approved by the EPA on 29 August 2019 following public review and comment (Woodside, 2019). Specifically, the ESD confirms:

- The following three key environmental factors are relevant to the Proposal
  - Air Quality
  - Social Surroundings (Heritage)
  - Marine Environmental Quality.
- The Proposal is also subject to this controlling provision under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
  - National Heritage (EPBC Act Section 15B and 15C), namely the Dampier Archipelago (including Burrup Peninsula).

This document has also been prepared to satisfy the requirements of:

- Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016 (EPA, 2016e)
- EPA's Instructions on how to prepare an Environmental Review Document (EPA, 2018b).

2.2.1 Infrastructure in Commonwealth Waters

This Proposal does not include infrastructure within Commonwealth waters (e.g. North Rankin Complex, Goodwyn A facility, 1TL and 2TL) which are operated under accepted Environment Plans in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2006*. The authorisation of the Commonwealth Environment Minister under Section 146B of the EPBC Act[1] provides that Commonwealth petroleum activities undertaken in accordance with the endorsed Program[2] (e.g. activities covered by an accepted Environment Plan and Offshore Project Proposal (where relevant)) do not require further approval under Part 9 of the EPBC Act.

2.3 Proponent

The Proponent for this Proposal is Woodside, as operator for and on behalf of the NWSJV. The Proponent's details are:

Woodside Energy Ltd
11 Mount Street
Perth WA 6000
ABN: 63 005 482 986

The contact person in relation to the environmental approvals process for this Proposal is:

Anthony McMullen
Environment Manager
Phone: 1800 422 977
Email: feedback@woodside.com.au

2.4 Proposal Description (NWS Project Extension Proposal)

To enable the future operation of the NWS Project and the ongoing supply of gas and fluids to domestic and international markets, the Proposal seeks approval to transition the Existing NWS Project facilities to a new phase of the NWS Project which is commercially capable of accepting gas for processing from other resource owners. The NWS Project Extension Proposal is seeking approval for the:

- long-term processing of third-party gas and fluids and NWSJV field resources through the NWS Project facilities, which includes
  - Changes to feed gas composition including changed content of inerts, hydrocarbons and other components.
  - Changes to the composition of environmental discharge and emissions, although annual volumes of emissions and discharges are expected to be in line with current levels.
  - Modifications to the KGP onshore receiving facilities (that would not otherwise be undertaken if not for the Proposal) to accommodate third-party gas and fluids, as well as upgrades to metering to facilitate processing of third-party gas and fluids.
  - Potential construction of additional operational equipment to accommodate changes to feed gas composition or management of environmental discharge and emissions.
- Ongoing operation of the NWS Project (from the date of the approval of this Proposal) to enable long-term processing at the NWS Project facilities, currently expected to be until around 2070, including
  - Ongoing use of existing NWS Project facilities to process third-party gas and fluids and NWSJV field resources; Inspection, maintenance, and repair (IMR) and improvement programs for 1TL and 2TL.
  - Maintenance dredging associated with existing jetties and berthing pockets.
  - Replacement of equipment, plant, and machinery as required that would not otherwise be replaced if not for the Proposal.
  - Continuation of emissions and discharges to the environment (Woodside, as operator for and on behalf of the NWS Project, will implement emission reduction opportunities, including nitrogen oxides (NO_x), and volatile organic compounds (VOCs) (described in **Section 6.3**) that will result in a staged decrease in emissions over time).
  - Monitoring and management of environmental impacts.

As described in the NWS Project Extension Section 38 Referral Supporting Information (Woodside, 2018), the Proposal, if approved, is proposed to operate under new Commonwealth and State environmental approvals, where the new State Ministerial Statement could incorporate the relevant conditions from, and then supersede, existing Ministerial Statements 320, 334, 482 and 536 and equivalent Commonwealth authorisations and approvals. New and consolidated environmental approvals are proposed to regulate the whole of the NWS Project from the date of the approvals to allow for the impacts to be managed in a holistic, site-wide, consolidated and environmentally effective and efficient manner.

The development envelope of the Proposal is shown in **Figure 2-1**. The Proposal will be contained within the same development envelope as that of the existing NWS Project (Refer to **Section 2.5**). No additional areas are proposed to be added to the development envelope.

No additional area is proposed to be added to the disturbance footprint currently approved under existing approvals, including Ministerial Statements, EPIP Act, and EPBC Act authorisations.

The regional location of the Proposal is shown in **Figure 2-2**. The key physical and operational characteristics of the Proposal are listed in **Table 2-1** and **Table 2-2**.

Table 2-1: Summary of the Proposal

Proposal Title	North West Shelf Project Extension
Proponent Name	Woodside Energy Ltd, as Operator for and on behalf of the NWSJV
Short Description	Ongoing operation of the NWS Project to enable the long-term processing of third-party gas and fluids and NWSJV field resources through the NWS Project facilities until around 2070

Table 2-2: Location and Proposed Extent of Physical and Operational Elements

Element	Location	Existing NWS Project	Change	NWS Project Extension Proposal
Physical Elements				
NWS Project (onshore component)	Development envelope	276 ha[1] of disturbance within a 331 ha development envelope	No change	276 ha of disturbance within a 331 ha development envelope
NWS Project (KBSB, Southern Expansion Lease and Access Roads)	Development envelope	104 ha of disturbance within a 193 ha development envelope[2]	No change	104 ha of disturbance within a 193 ha development envelope
NWS Project (offshore component; State waters)	Development envelope	700 ha development envelope (includes 589 ha pipeline exclusion zone and 111 ha jetty lease)	No change	700 ha development envelope (includes 589 ha pipeline exclusion zone and 111 ha jetty lease)
Operational Elements[3]				
Reserve source	Various	North Rankin and Goodwyn gas fields and gas received through onshore receipt points and tie-ins	NWSJV field resources and third-party gas and fluids	NWSJV field resources and third-party gas and fluids
LNG production capacity	Development envelope	18.5 mtpa	No change	18.5 mtpa
CO_2 emissions	Development envelope	2.9 mtpa (Trains 4 and 5) 4.8 mtpa (Trains 1 to 3)[4]	No change	7.7 mtpa
NO_X emissions	Development envelope	Not specified	n/a	8,900 tpa[5]
Project life	n/a	30+ years	Additional 40 years	Up to 2070

Note 1: This existing disturbance footprint is consistent with Schedule 1 of MS536, being comprised of disturbance within the following lots only:
- *Karratha Gas Plant: De Wit Location Lot 199 On Plan 216680 [Crown Lease LGE I123606] (236 ha)*
- *Karratha Gas Plant Buffer Zone: De Wit Location Lot 197 Burrup Road, Burrup [Crown Lease LGE I123606] (95 ha)*

Note 2: The other onshore components of the existing NWS Project as defined in the Referral include the following lease areas:
- *Southern Expansion Lease: De Wit Location Lot 379 and Part Lot 380 Burrup Road, Burrup [Crown Lease LGE I161020] (132 ha)*
- *Plant Access Road (Northern and Southern): De Wit Location Lot 655 and Lot 195 Burrup Road, Burrup [Crown Lease LGE I237587] (3 ha)*
- *King Bay Supply Base: De Wit Location Lot 151 and Lot 204 On Plan [Crown Lease LGE I154282] (58 ha)*

Note 3: Operational elements that are subject to other environmental regulatory frameworks (e.g. Part V of the EP Act) are not included in the operational elements table. However, this does not preclude potential impacts from those elements of the NWS Project Extension Proposal being considered in this ERD.

Note 4: NWSJV Additional LNG Facilities Project Public Environment Review / Public Environment Report (Woodside, 1998), as authorised by Ministerial Statement 536

Note 5: This estimate is based on each turbines' maximum exhaust gas flow rate (from vendor data). It is based on measured exhaust gas concentrations for licence compliance, engineering calculation estimation and NPI Emissions Estimate Techniques.

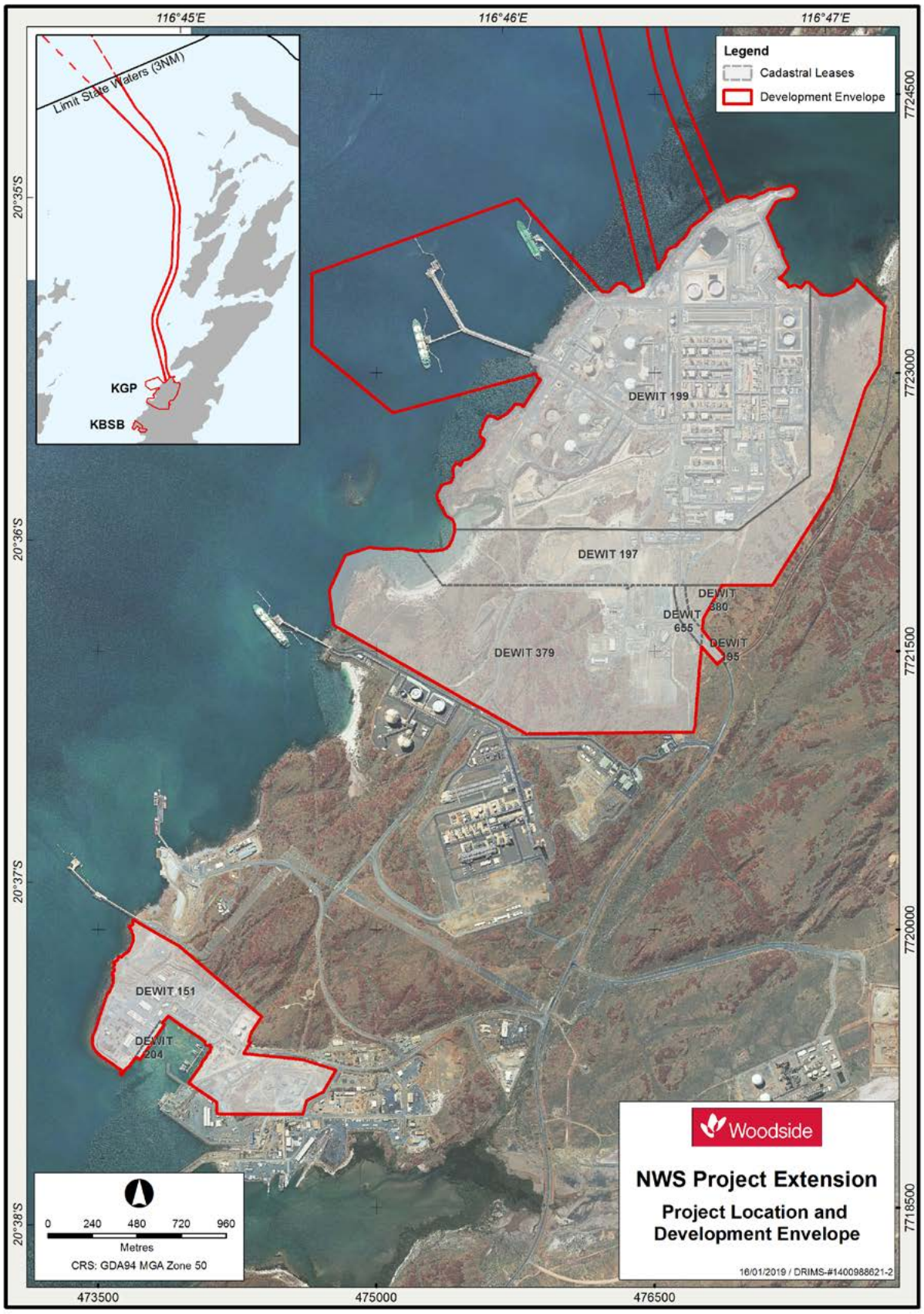


Figure 2-1: NWS Project Extension Proposed Development Envelope

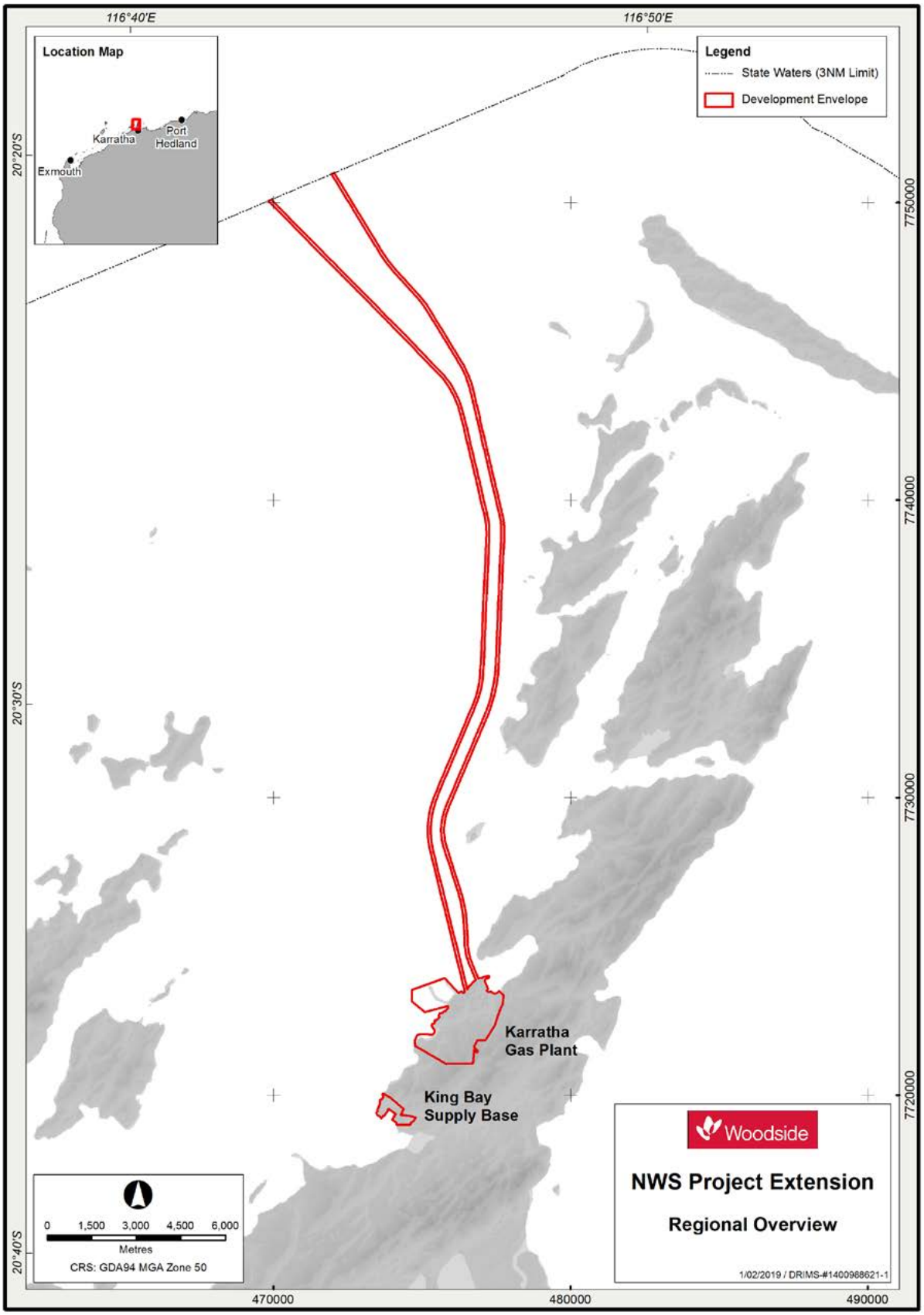


Figure 2-2: Regional Location of the Proposal

2.5 Existing NWS Project

The KGP was originally commissioned in 1984 with feed gas and fluids supplied from the North Rankin platform (now the North Rankin Complex). The KGP has undergone several expansions and additional facilities have been installed since it was first commissioned. At present, and subject to MS 536, the existing NWS Project processes natural gas and associated fluids from NWSJV field resources to produce up to 18.5 mtpa of LNG at the KGP. The onshore and State waters component of the existing NWS Project includes these key processing, storage, and offloading facilities:

- five LNG processing trains
- two domestic gas trains
- six condensate stabilisation units
- three LPG fractionation units
- LPG, LNG, and condensate storage facilities
- two jetties for exporting condensate, LPG, and LNG
- power generation and supporting utilities
- emergency, operational, and storage and loading flares
- two subsea trunklines, described as 1TL and 2TL, within State waters and crossing onshore to the KGP
- an off-site supply base (KBSB), used for activities such as diesel storage, refuelling, pilotage, and logistics
- associated infrastructure necessary and incidental to conducting existing NWS Project activities.

Except for 1TL and 2TL, these key components of the NWS Project are located approximately 18 km from Karratha and are bounded by Withnell Bay to the north, Mermaid Sound to the west, Murujuga National Park to the east, and industrial land to the south, on these leases:

- KGP: De Wit Location Lot 199 on Plan 216680 (Crown Lease LGE I123606).
- KGP Buffer Zone: De Wit Location Lot 197 on Plan 30713, Burrup Road, Burrup (Crown Lease LGE I123606).
- Southern Expansion Lease: De Wit Location Lot 379 and Part Lot 380 Burrup Road, Burrup (Crown Lease LGE I161020).
- Plant Access Road (Northern and Southern): De Wit Location Lot 655 and Lot 195 Burrup Road, Burrup (Crown Lease LGE I237587).
- KBSB: De Wit Location Lot 151 and Lot 204 (Crown Lease LGE I154282).
- KGP Loading Jetties Seabed Lease.
- Pipeline Licences TPL 15 and TPL 16 / PL 58.

Current NWSJV field resources are extracted by offshore facilities in Commonwealth waters. Gas and de-watered liquid hydrocarbons are then transported onshore to the KGP through two trunklines (1TL and 2TL), which run broadly parallel to each other and extend from the North Rankin Complex in Commonwealth waters, through State waters, and onshore to the KGP. In order to ensure the efficient processing of NWSJV field resources and use of NWS Project facilities, the following activities are also undertaken as required as part of the existing NWS Project:

- Inspection, maintenance, repair (IMR) and improvement programs on equipment, plant, machinery and subsea infrastructure identified above as key processing, storage and offloading facilities.
- Modifications to, or replacement upon reaching end of life equipment, plant, machinery and subsea infrastructure identified above as key processing, storage and offloading facilities and power generation/utilities.
- Processing (and associated tie-ins) from approved onshore feed sources as necessary to maintain production levels.

NWSJV field resources are processed at the KGP for export to international and domestic markets. Marine vessels transport LNG, LPG, and condensate to international markets. Natural gas from the KGP is supplied to the domestic market via the Dampier to Bunbury Natural Gas Pipeline (DBNGP).

The Existing NWS Project in its current configuration will operate up until the date of the approval of this Proposal. This includes implementing changes that are already approved or may be approved through separate processes. These existing operations of the Existing NWS Project are outside the scope of this Proposal.

The Existing NWS Project (and any already approved changes) will continue to operate under the current environmental assessment framework during the assessment of the Proposal and until approval of this Proposal.

2.5.1 Existing Environmental Approvals

The existing NWS Project environmental approvals are detailed in **Table 2-3**.

Table 2-3: Summary of Environmental Approvals for the existing NWS Project

Date	Application	Scope
24 August 1993	Section 38	Establish additional facilities for Liquefied Petroleum Gas (LPG) extraction and export within the existing onshore treatment plant at the Burrup Peninsula. Approved under Ministerial Statement 320.
11 January 1994	Section 46	Amendment to Ministerial Statement 320 Condition 1. Approved under Ministerial Statement 324.
14 July 1998	Section 38	Construction and operation of a 2nd gas trunkline (from offshore NWS facilities to the KGP) and the debottlenecking of the Domestic Gas process. Approved under Ministerial Statement 482.
11 February 2000	Section 38	Additional Liquefied Natural Gas Facilities, including installation of 2 additional processing trains, 4 power generation turbines, 2 jetty/berths, 1 LNG tank, utilities upgrade and dredging/blasting works. Approved under Ministerial Statement 536.
25 February 2005	Section 45C	Amendment to Ministerial Statement 536 to increase the amount of additional generating units from an additional two generating units (50 megawatts total) to an additional 4 generating units (120 megawatts total).
7 June 2005	Section 45C	Amendment to Ministerial Statement 536 to increase dredged seabed material for shipping lanes, ship berthing basins, and turning circles from 2.7 Million cubic metres to 2.7 Million cubic metres plus approximately 1 Million cubic metres at Star Rock.
29 August 2006	Section 45C	Amendment to Ministerial Statement 536 to include: + Additional gas powered generation unit (one), 4 additional gas engines, 1 BOG liquefication unit, and 1 inlet air chilling unit. + Additional LNG Production of 11 million tonnes per annum (existing 7.5 mtpa). + Additional Power Supply of approximately 150 megawatts (5 no. gas turbines (GTs)) and approximately 12 megawatts (4 no. gas engines).
18 July 2019	Section 45C	Amendment to Ministerial Statement 536 to include: + Add to the reserve source listed in Table 1 of Schedule 1 to and gas received through onshore receipt points and tie-ins. + Add to the project facilities column listed in Table 1 of Schedule 1; Onshore receipt points and tie-ins.

Note 1: Ministerial Statements 320 and 334 remain in force but the conditions are replicated in Ministerial Statement 536.

2.6 Excluded from the Proposal

The Proposal does not include:

- Infrastructure to tie gas field sources into 1TL or 2TL. Separate approvals will be obtained for developing and using tie-in infrastructure, where required.
- Developing gas fields. Separate approval will be obtained for the developing the fields, where required.

2.7 Woodside's Management System

The Woodside Management System (WMS) defines how Woodside will deliver its 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 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 Joint Venture partners engaging in activities under Woodside operational control. In addition, Woodside Climate Change Policy demonstrates a commitment to be part of a solution to climate change. This includes promoting and pursuing a culture of energy efficiency and improve resources use in designs and operation.

Our environmental management process ensures we understand the potential risks and impacts of our activities and implement appropriate mitigation strategies to minimise our environmental footprint. Robust impact assessment and risk-management underpinned by credible science, strong partnerships and transparency are the key elements to Woodside's approach no matter where we are or what the regulatory regime may require.

Many of our activities in Western Australia are located next to unique environments. We collaborate with some of the world's leading scientific research organisations to understand how these environments function. These partnerships and credible science outcomes enable us to conduct our activities responsibly and verify our environmental performance. The knowledge generated through our partnerships is shared with government, industry and the broader community in many formats including scientific publications and educational outreach programs.

2.7.1 NWS Project Historical Environmental Performance

Woodside, as operator of the NWS Project, is committed to achieving a level of environmental management and performance consistent with national and international standards and statutory obligations. Annual environmental reports for the KGP, submitted to the EPA in accordance with Condition 9 of MS 536, demonstrate that Woodside has achieved environmental performance consistent with our environmental approvals.

Various measures have been successfully implemented to ensure sound management of environmental issues associated with sensitive environmental receptors near the NWS Project facilities. These measures include policies and plans (such as Woodside's Environmental Policy), maintaining hazard registers, auditing environmental performance, inductions, and including environmental management and performance requirements in tenders and contracts. Monitoring results demonstrate that control measures have managed or mitigated potential environmental impacts associated with the NWS Project facilities.

Woodside has progressively implemented initiatives to improve reliability at the NWS Project and deliver the desired level of operational performance.

Key improvements in design, processes, and technology have been incorporated in the NWS Project facilities as the opportunity has arisen; these include but have not been limited to:

- Installation of more efficient gas turbines, dry low NO_X burners, dry gas seals and compressor seal gas recovery on LNG Train 4. Installation dry gas seals on LNG Train 5.
- Installation of lean head end combustion liners on existing gas turbines.
- Alterations to the operating mode to improve efficiency and reliability.
- Replacement of the acid gas removal solvent to reduce emissions from this process.
- Proactively identifying maintenance activities with the potential to cause dark smoke.
- Closer monitoring of dark smoke from the flare to quickly implement dark smoke remedial actions.

These improvements have resulted in overall improvements in emissions, in particular NO_X 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**.

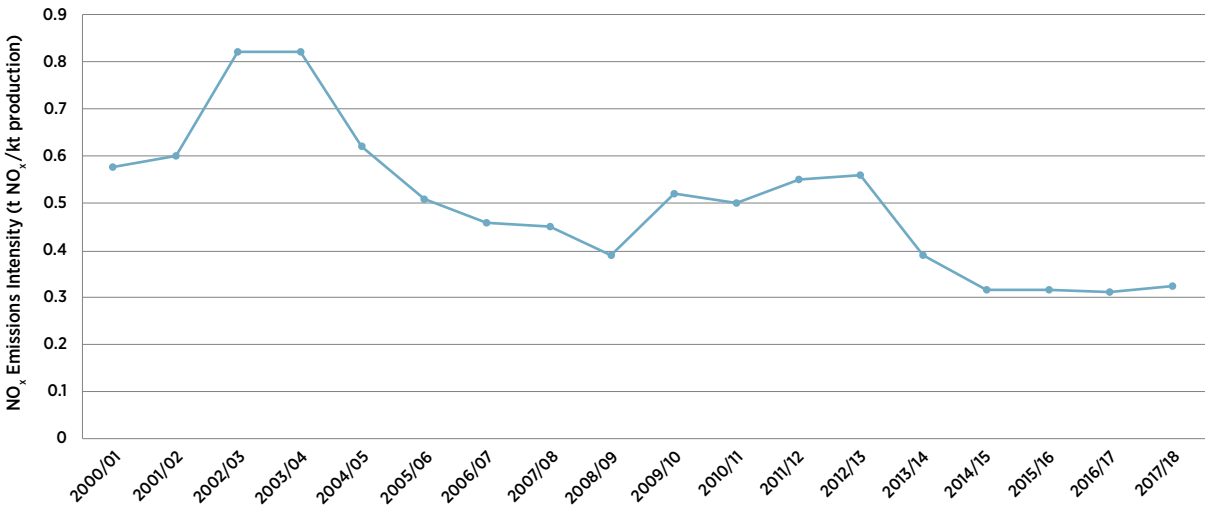


Figure 2-3: NO_x Emissions Intensity 2000-2017

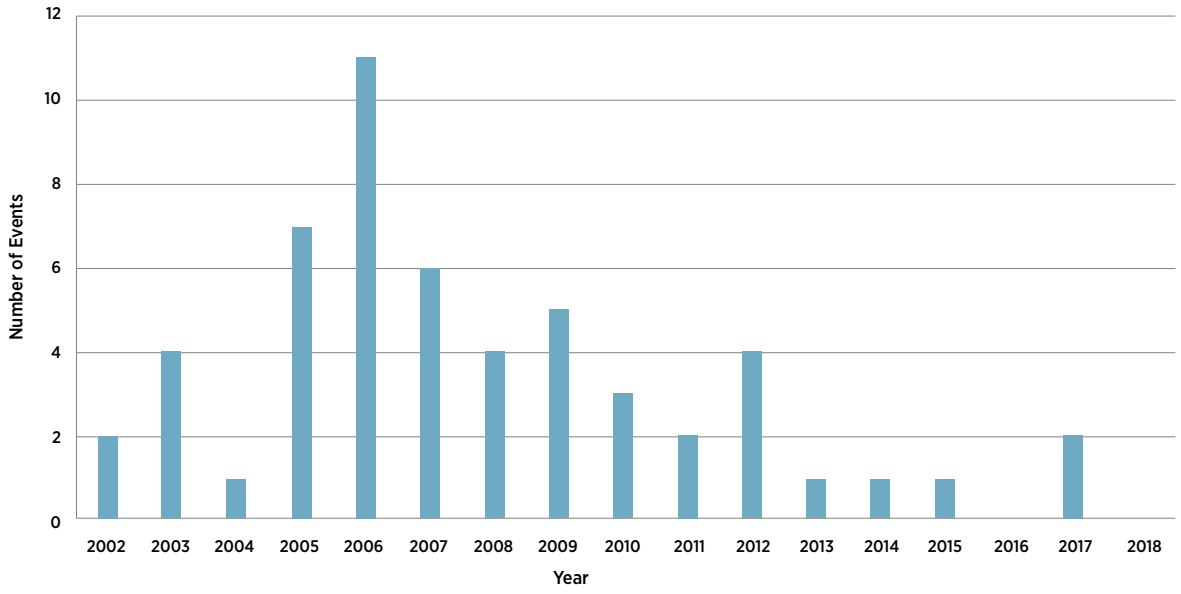


Figure 2-4: Regulatory Reportable Dark Smoke Events 2002-2018

The NWS Project facilities have been through several major development phases and extensive debottlenecking since their initial commissioning in 1984. Improvement projects and initiatives implemented to reduce greenhouse gas (GHG) emissions have improved the GHG efficiency of the existing LNG Trains 1, 2, and 3 from 0.59 t CO_2e/t of LNG to 0.49 t CO_2e/t of LNG (Jacobs, 2019). Furthermore, because of their more recent construction and thus more modern design, LNG Trains 4 and 5 have consistently operated at approximately 30% lower GHG emission intensity than that of LNG Trains 1, 2 and 3.

Woodside also engages proactively in open and transparent communication with the community regarding the NWS Project facilities. Discussions with key stakeholders from government and community groups in the City of Karratha area take place every two months at the Karratha Community Liaison Group Forum. Woodside distributes periodic newsletters to keep the public up to date with NWS Project operations, including current and future issues of potential interest to stakeholders. Woodside actively participates in the Murujuga Rock Art Stakeholder Reference Group and provides funding and support to the Murujuga Rock Art Strategy.

No new environmental issues are expected to be associated with the long-term processing of third-party gas and fluids and NWSJV field resources through the NWS Project facilities. The successful management strategy used for the existing NWS Project will be the basis of ongoing management for the Proposal. Woodside will continue to implement environmental initiatives and review its operations for potential opportunities to reduce its environmental footprint. Woodside is confident that by continuing to implement its current multi-faceted management strategy, long-term operation of the plant (as outlined in this Proposal) can occur in a way that is acceptable to WA and the wider community.

2.8 Proposal Justification

The Proposal presents a number of opportunities for the NWSJV, the community of the City of Karratha, and energy consumers across Australia and internationally. Specifically, the Proposal allows existing gas resources to be developed without the need for constructing new processing facilities, provides ongoing employment and social investment in the region, and supports the transition to a lower carbon future.

Several offshore gas reserves in the North-West of Australia have development potential, however have marginal economics. Allowing NWS Project infrastructure to process new field developments minimises the potential environmental disturbance associated with constructing new trunklines and processing facilities and may enable the development of otherwise sub-economic reserves.

The Proposal provides continued employment opportunities and associated economic and social investment for the City of Karratha. The NWS Project employs approximately 691 people during normal operations with 441 (64%) of these employees living locally in the City of Karratha, contributing to the local economy and community.

The NWS Project also employs more than 1400 contractor and service provider staff across a range of onshore and offshore roles. We are aware of at least 300 contractor roles that are filled by Karratha residents. Contractor numbers increase further during major turnaround campaigns typically undertaken twice per year, which can require up to 1500 short-term contractor positions.

Finally, the ability to develop future gas reserves using existing NWS Project infrastructure will provide increased energy security to energy consumers, including the ongoing supply of domestic gas to WA. Continued use of natural gas as an energy resource also plays an important role in moving towards a lower carbon future as natural gas burns cleaner than most other carbon-based fuels. As an example, the International Energy Agency (IEA) reported that coal-to-gas switching helped avert 95 mt of CO_2 emissions in 2018 (IEA, 2019a). Furthermore, gas plays an important role in the IEA sustainable development scenario (SDS) particularly in terms of providing peaking and balancing power instead of baseload generation and replacing more emissions-intensive fuels in the industry and transport sectors (IEA, 2019b).

REGULATORY, LOCAL AND REGIONAL CONTEXT

Woodside

3. REGULATORY, LOCAL AND REGIONAL CONTEXT

3.1 Regulatory Context

3.1.1 Environmental Impact Assessment Process

The Proposal was referred to the EPA, under Section 38 of the *WA Environmental Protection Act 1986* (EP Act) on 14 November 2018. On 4 December 2018, the EPA determined that the Proposal required assessment under Part IV of the EP Act at the level of Environmental Review – Public Environmental Review.

In parallel, the Proposal was referred to DoEE on 22 November 2018 in accordance with the EPBC Act. On 3 May 2019, DoEE determined the Proposal to be a controlled action, requiring further assessment by accredited assessment under Part IV of the EP Act, at the level of Environmental Review – Public Environmental Review.

The ESD for the Proposal was prepared by Woodside and approved by the EPA on 29 August 2019 following public review and comment (Woodside, 2019). The ESD sets out the work required to address potentially significant impacts to the key environmental factors (air quality, social surroundings [heritage], and marine environmental quality) and the matters of national environmental significance (MNES) (national heritage [EPBC Act Section 15B and 15C], namely the Dampier Archipelago [including Burrup Peninsula]) relevant to the Proposal.

The ERD has been prepared to satisfy the information requirements of the ESD. In developing this ERD Woodside conducted several workshops, commissioned independent studies, and carried out stakeholder consultation. In particular, the following studies were conducted and are appended to this ERD to inform assessment:

+ North West Shelf Project Extension Air Quality Impact Assessment (Jacobs, 2019a). This assessment included air dispersion and deposition modelling of five scenarios to understand the potential impacts to air from the Proposal (**Appendix E**).
+ Greenhouse Gas Benchmarking Assessment (Jacobs, 2019). This assessment benchmarked the GHG emission performance of the Karratha Gas Plant (which is a component of the Proposal) against that of other comparable Australian and International LNG facilities (**Appendix F**).
+ Karratha Gas Plant Wastewater Discharge Modelling (RPC, 2019). This modelling project assessed discharges to the marine environment from the NWS Project to understand the spatial extent of the potential impacts to the marine environment from the Proposal (**Appendix G**).

In addition to these studies, this ERD has been based on operational and environmental data obtained since the commencement of the NWS Project more than 30 years ago. This includes (but is not limited to) heritage surveys (archaeological and ethnographic), marine monitoring and ambient air monitoring programs.

If the EPA is satisfied that the ERD adequately addresses the requirements set out in the ESD (Woodside, 2019), the EPA will approve the release of the ERD for a 6 week public review period. Following the public review period, the EPA will provide Woodside with a copy of all submissions received, which are to be addressed in a 'Response to Submissions' document prepared by Woodside to the satisfaction of the EPA.

The EPA will assess the ERD, the submissions received, and Woodside's response to submissions when preparing its report and recommendations to the WA Minister for the Environment. The EPA report and recommendations will also be provided to the Commonwealth Minister for the Environment for use in making a decision on the Proposal under the EPBC Act and any conditions that should be applied.

3.1.2 Other Approvals and Regulation

The NWS Project operates in accordance with a number of other approvals and regulations. In 1977, the five foundation NWSJV participants entered into an agreement with the WA State Government. The agreement was legislated as the *North West Gas Development (Woodside) Agreement Act 1979* (WA) (State Agreement). The State Agreement requires the NWSJV participants to submit proposals to the current Minister for State Development, Jobs and Trade for developing the project and/or if changes to the original approved proposal are proposed. These proposals must have regard for protecting and managing the environment, including an ongoing program of investigation and monitoring to ascertain the effectiveness of any environmental protection and management measures. The proposals required under the State Agreement do not preclude assessment of the Proposal under the EP Act.

In addition to the State Agreement, the Proposal must also comply with aspects of other relevant state legislation and regulations and is guided by relevant key overarching state policies and strategies. **Table 3-1** summarises the other approvals and regulations that apply to the Proposal.

Table 3-1: Other Approvals and Regulations

Proposal Activites	Land Tenure/ Access	Type of Approval	Legislation Regulating the Activity	Regulatory Body
Physical location of onshore components	+ Crown Lease LGE I123606 + Crown Lease LGE I161020 + Crown Lease LGE I237587 + Crown Lease LGE I154282	Tenure	+ *Land Administration Act 1997* + *Aboriginal Heritage Act 1972*	Department of Planning, Lands and Heritage (DPLH)
Operation of KGP	+ Crown Lease LGE I123606 + Crown Lease LGE I161020 + Crown Lease LGE I237587	Licence for Prescribed Premise	+ *Environmental Protection Act 1986* + *Environmental Protection Regulations 1987*	Department of Water and Environmental Regulation (DWER)
Storage and handling of dangerous goods	+ Crown Lease LGE I123606 + Crown Lease LGE I161020 + Crown Lease LGE I237587 + Crown Lease LGE I154282	Dangerous Good Site Licence Safety Case	+ *Dangerous Goods Safety Act 2004* + *Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007* + *Dangerous Goods Safety (Major Hazard Facility) Regulations 2007*	Department of Mines, Industry Regulation and Safety (DMIRS)
Physical location of the jetties	+ Seabed Lease	Tenure	+ *Land Administration Act 1997* + *Port Authorities Act 1999*	DPLH
Operation of export jetties	+ Seabed Lease	Jetty Licence	+ *Jetties Act 1926*	Department of Transport
Physical location of the subsea trunklines 1TL and 2TL	+ Territorial Sea Pipeline Licence (TPL) 15 (1TL offshore pipeline licence) + TPL 16 (2TL offshore pipeline licence) + PL 58 (2TL onshore pipeline licence) + 1TL does not require an onshore pipeline licence	Pipeline Licence	+ *Petroleum (Submerged Lands) Act 1982* + *Petroleum (Submerged Lands) (Pipelines) Regulations 2007*	DMIRS
Operation and maintenance of 1TL and 2TL	+ TPL 15 (1TL offshore pipeline licence) + TPL 16 (2TL offshore pipeline licence) + PL 58 (2TL onshore pipeline licence) + 1TL does not require an onshore pipeline licence	Environment Plan and Oil Spill Contingency Plan	+ *Petroleum (Submerged Lands) Act 1982* + *Petroleum (Submerged Lands) (Environment) Regulations 2012* + *Pollution of Waters by Oil and Noxious Substances Act 1987*	DMIRS

3.1.3 Decision-making Authorities

In addition to the WA Minister for Environment, the WA EPA, and the Commonwealth Minister for Environment, the key decision-making authorities (DMAs) relevant to the Proposal are listed in **Table 3-2**.

Table 3-2: Decision-making Authorities Relevant to the Proposal

Decision-making Authority	Relevant WA Legislation
Minister for State Development, Jobs and Trade	*North West Gas Development (Woodside) Agreement Act 1979*
Minister for Mines and Petroleum	*Petroleum (Submerged Lands) Act 1982* *Petroleum Pipelines Act 1969*
Chief Executive Officer, DWER	*Environmental Protection Act 1986*
Chief Dangerous Goods Officer, DMIRS	*Dangerous Goods Safety Act 2004*
Chief Executive Officer, City of Karratha	*Planning and Development Act 2005*

3.2 Local and Regional Context

The location of the Proposal is shown in **Figure 2-2**.

3.2.1 Land Use

The land use of the area immediately surrounding the onshore component of the Proposal is zoned as industrial. Land use in the wider area includes conservation, recreation, tourism, and traditional uses by Aboriginal people.

3.2.2 Other Developments in the Region

Existing industrial facilities on the Burrup Peninsula are shown in **Figure 3-1** and include:

+ Pluto LNG Development, which comprises facilities for processing and exporting gas from offshore gas reservoirs, including the planned expansion of the Pluto LNG Development. The Pluto LNG Development and associated infrastructure is not part of the Proposal and is subject to its own, separate, approvals.
+ Yara Pilbara Fertilisers plant, which exports ammonia to domestic and global markets from the Port of Dampier.
+ Yara Pilbara Nitrates Technical Ammonium Nitrate plant, a joint venture with Orica, which converts ammonia into ammonium nitrate and is used by mines throughout the Pilbara region.
+ Burrup Material Facility, at King Bay, which stores spare parts and equipment for offshore facility operations, facilitates logistics and transportation of materials to offshore operations, has a port for offshore vessels (production, drilling, and exploration), and harbours tug boats for oil and gas vessels.
+ Port of Dampier, which comprises private port terminals. Main import/export activities include iron ore, LPG, LNG, diesel, condensate, salt, anhydrous ammonia, bulk cargo, and general cargo.
+ Dampier Salt, which has salt mining operations on the east side of the Burrup Peninsula and export (shipping) facilities on East Mid Intercourse Island and Mistaken Island.
+ Rio Tinto's East Intercourse Island and Parker Point shipping terminals for exporting iron ore.

At the time of writing, two additional third-party developments had been proposed for the Burrup Peninsula industrial estate, with proximity to the region's deep-water port and Western Australia's existing domestic gas pipeline network:

+ Potential methanol plant with a production capacity of approximately 5000 tonnes per day on Site E within the Burrup Strategic Industrial Area (BSIA) on the Burrup Peninsula.
+ Potential urea plant with a production capacity of approximately 2 mtpa on Sites C and F within the BSIA on the Burrup Peninsula.

Figure 3-1: Existing and Proposed Industrial Facilities

RECEIVING ENVIRONMENT

Woodside

4. RECEIVING ENVIRONMENT

4.1 Meteorology

The Burrup Peninsula experiences an arid to tropical climate with two distinct seasons - a hot wet summer with periodic heavy rains, and a mild winter with occasional rainfall. A range of climatic data including temperature, rainfall, and winds, has been collected by the Bureau of Meteorology (BoM) station at Karratha Airport (Karratha Aerodrome, Station ID 4083) since 1971. Specific climatic data relevant to the Proposal is described in the following subsections and has been included in the NWS Project Extension Air Quality Impact Assessment (**Appendix E**).

4.1.1 Temperature

The 1993–2018 monthly mean maximum and minimum temperatures for BoM Karratha Aerodrome are shown in **Figure 4-2**. Over that time, daily maximum and minimum temperatures have ranged from 48 °C in the wet season to 7 °C in the dry season.

4.1.2 Rainfall and Relative Humidity

Monthly rainfall statistics for BoM Karratha Aerodrome (for 1972–2018) are shown in **Figure 4-3**, and monthly mean 9 am and 3 pm relative humidity (RH) statistics for Karratha Aerodrome (for 1993–2010) are shown in **Figure 4-4**. The rainfall observations clearly show the Burrup Peninsula wet season running from approximately January to June, and the dry season from approximately July to December.

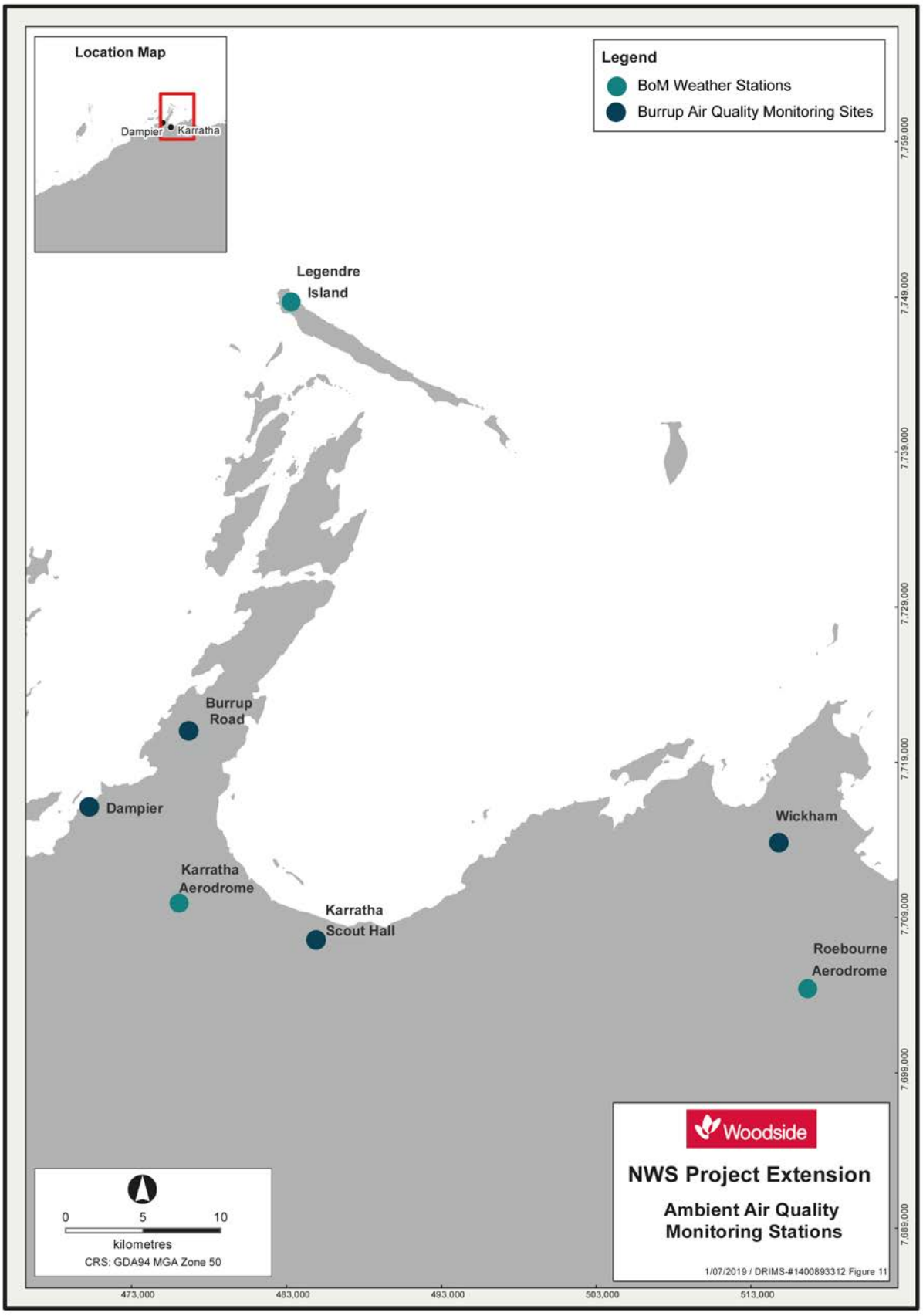


Figure 4-1 Existing Meteorological and Ambient Air Quality Monitoring Stations

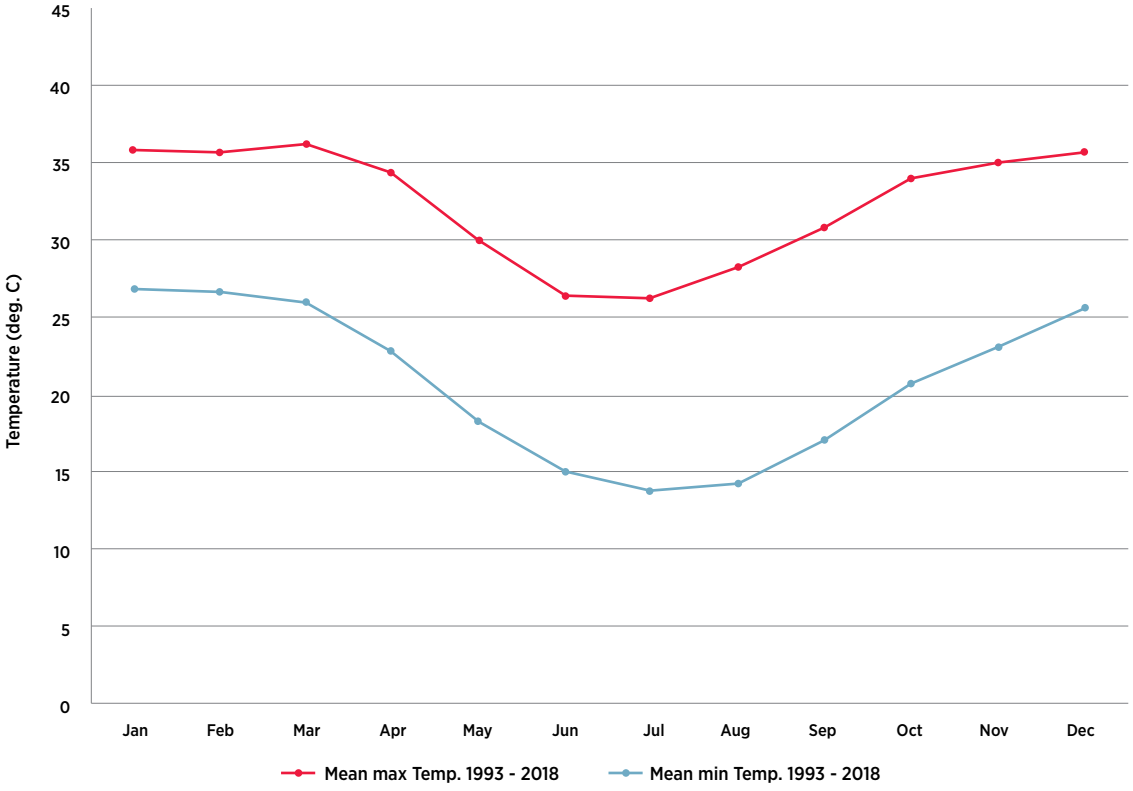


Figure 4-2: Monthly Mean Maximum and Minimum Temperature – Karratha Aerodrome 1993–2018

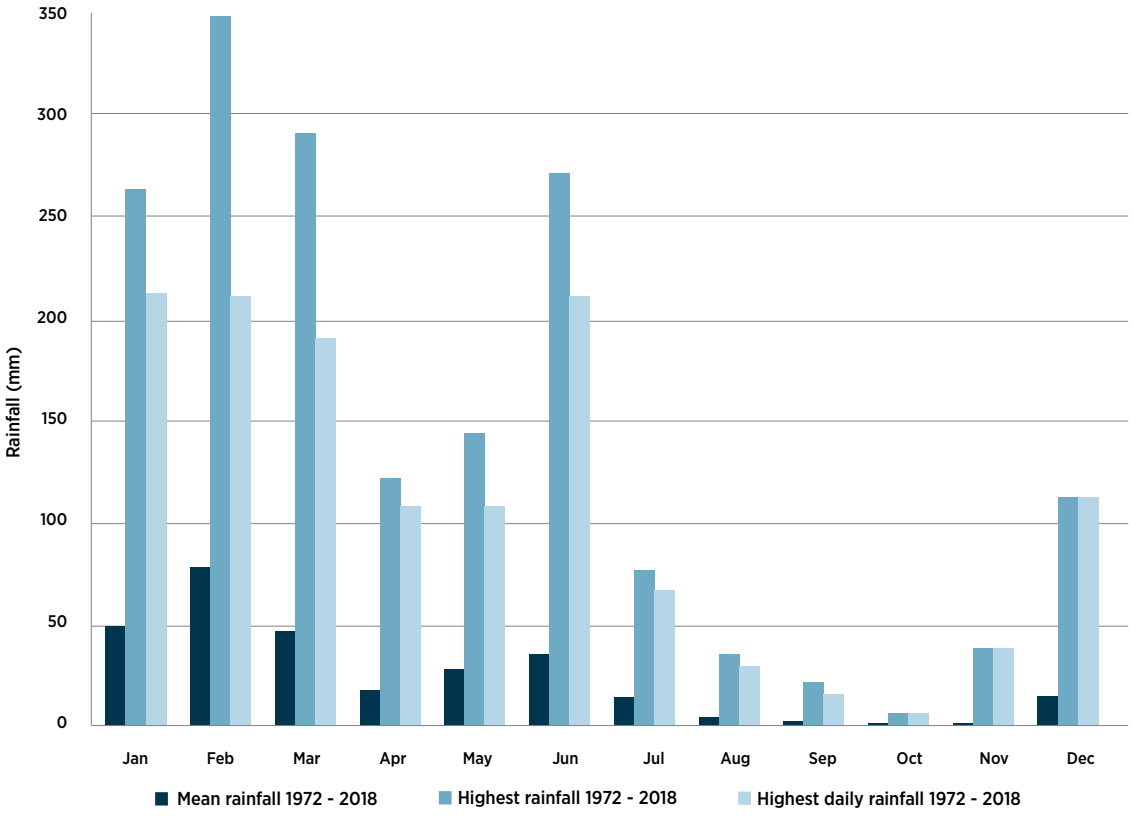


Figure 4-3: Monthly Rainfall – Karratha Aerodrome 1972–2018

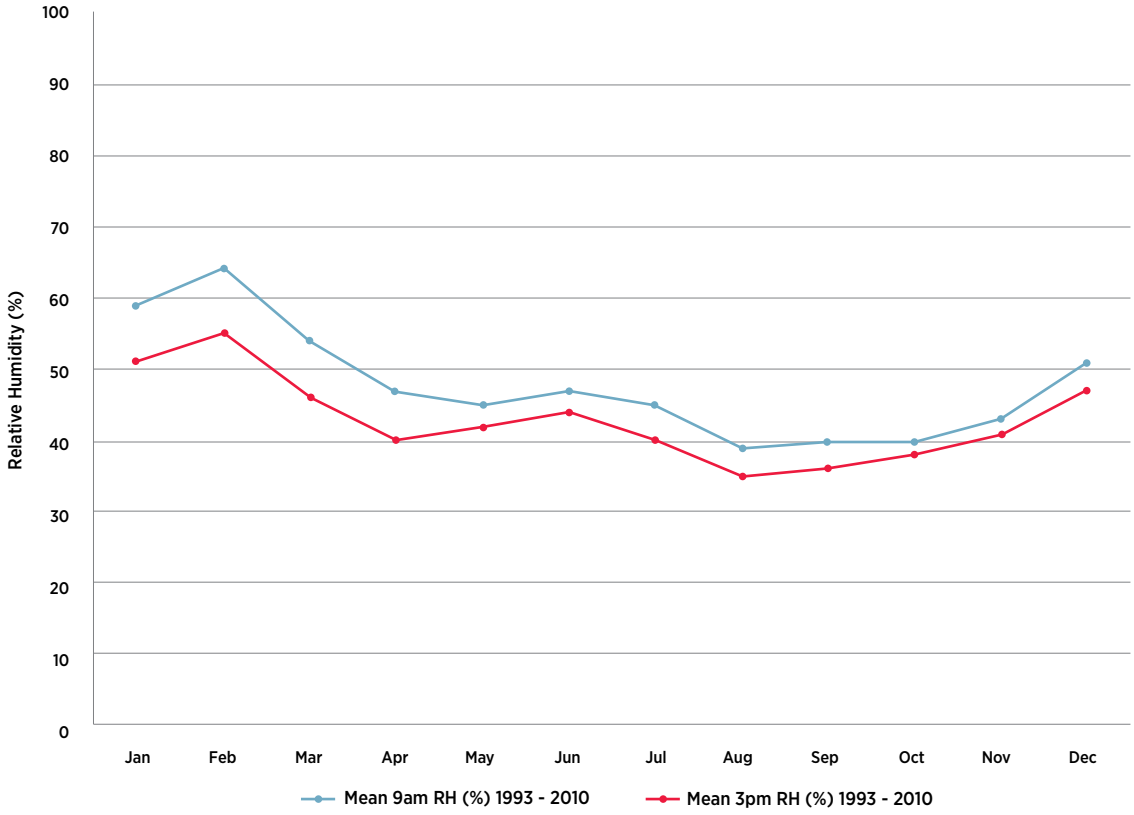


Figure 4-4: Monthly 9 am and 3 pm Relative Humidity – Karratha Aerodrome 1993–2010

4.1.3 Wind Speed and Wind Patterns

Monthly mean daily wind speeds and maximum wind gusts for BoM Karratha Aerodrome for 2003–2018 are shown in **Figure 4-5**.

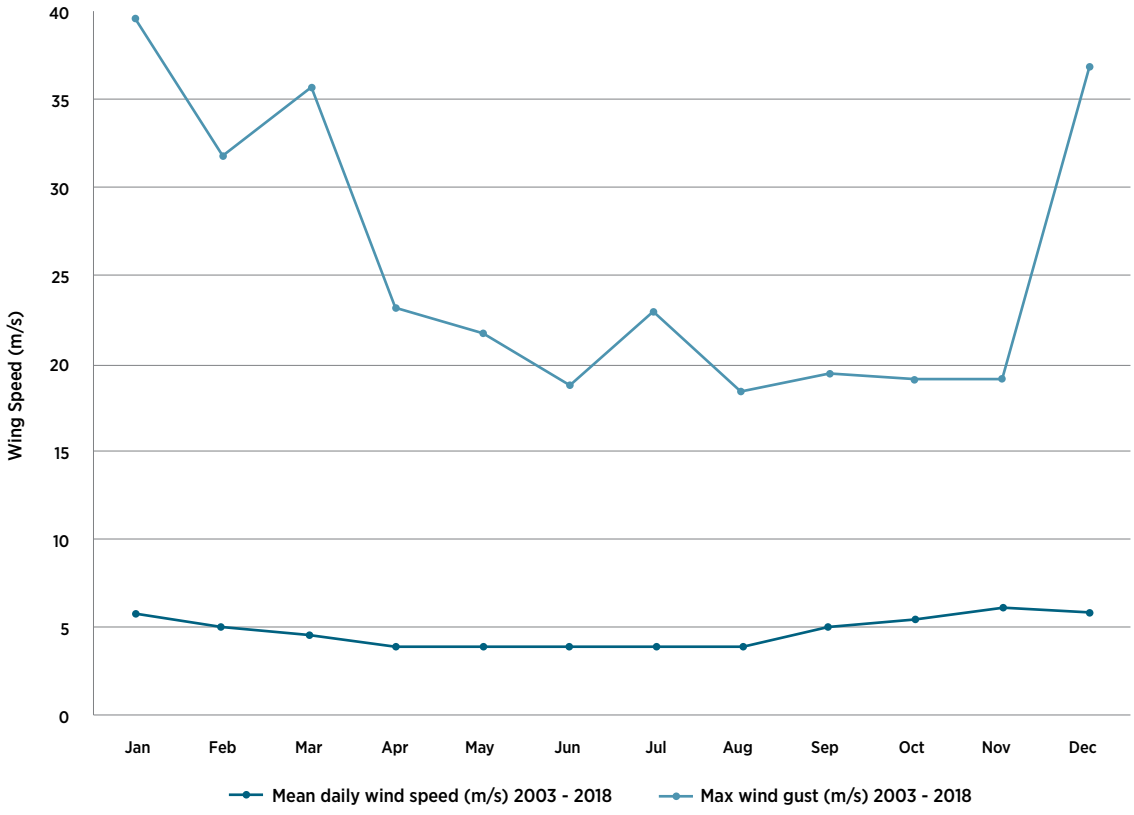


Figure 4-5: Mean Daily Wind Speed and Maximum Wind Gust – Karratha Aerodrome 2003–2018

Hourly average wind speed statistics calculated from measurements at BoM Karratha Aerodrome and two other weather stations in the Burrup region in 2014, are compared in **Table 4-1**.

Table 4-1: Wind Speed Comparisons – Burrup Peninsula 2014

Statistic	BoM Karratha Aerodrome	BoM Roebourne	BoM Legendre Island
Data capture	99.9%	99.9%	99.9%
Maximum (m/s)	13.1	13.4	16.1
90th percentile (m/s)	8.0	7.8	9.7
70th percentile (m/s)	6.2	5.7	7.1
Average (m/s)	5.0	4.5	6.0

Pilbara Cyclones

Cyclones have affected the coastal communities of Port Hedland, Karratha, Dampier, and Onslow, and parts of inland Pilbara. Typically, cyclones form over warm ocean waters to the north, intensify before crossing the Pilbara coast, then track south. (BoM, 2019).

Heavy rainfall and flooding are the main impacts for most cyclonic events in inland Pilbara. The highest rainfall is usually found along or just east of the track for most systems. The flood potential of a cyclonic system is associated with its track, speed, areal extent, and saturation of catchments from prior rainfall. Rainfall totals >100 mm are common with tropical lows that move over land (BoM, 2019).

4.1.4 Climate Predictions in a Changing Climate

Australia has experienced noticeable climate variability and changes in temperature, rainfall, and sea level. To better understand how regional future changes in climate may influence meteorology, the CSIRO has defined likely climate change scenarios for the catchments and bioregions across Australia.

Australia has various climates and terrains so Natural Resource Management (NRM) groupings have been utilised to describe how global climate trends may be experienced nationally. The Proposal is located in the Rangelands cluster (see **Figure 4-6**), which spans a significant portion of Australia. This cluster contains varied landscapes, including the Flinders Ranges, the ranges of the Pilbara and the centre of Australia, Barkly Tableland, and Western Desert (CSIRO, 2019). Small towns, communities, and cattle and sheep grazing are distributed across the cluster. The vegetation also varies, and includes tropical woodlands, shrublands, grasslands, and saltbush (CSIRO, 2019). Water features are intermittent, predominantly comprising coastal rivers in the west and streams that drain into salty lakes (e.g. Kati Thanda–Lake Eyre in South Australia) (CSIRO, 2019). Rainfall systems in this cluster vary seasonally, from monsoonal rainfall events in the north, to low and variable rainfall patterns in the centre and south (CSIRO, 2019). This cluster covers varying landscapes and climate regions, so it is divided into the Rangelands North and Rangelands South sub-clusters (CSIRO, 2019). The NWS Project is in the Rangelands North sub-cluster (**Figure 4-6**).

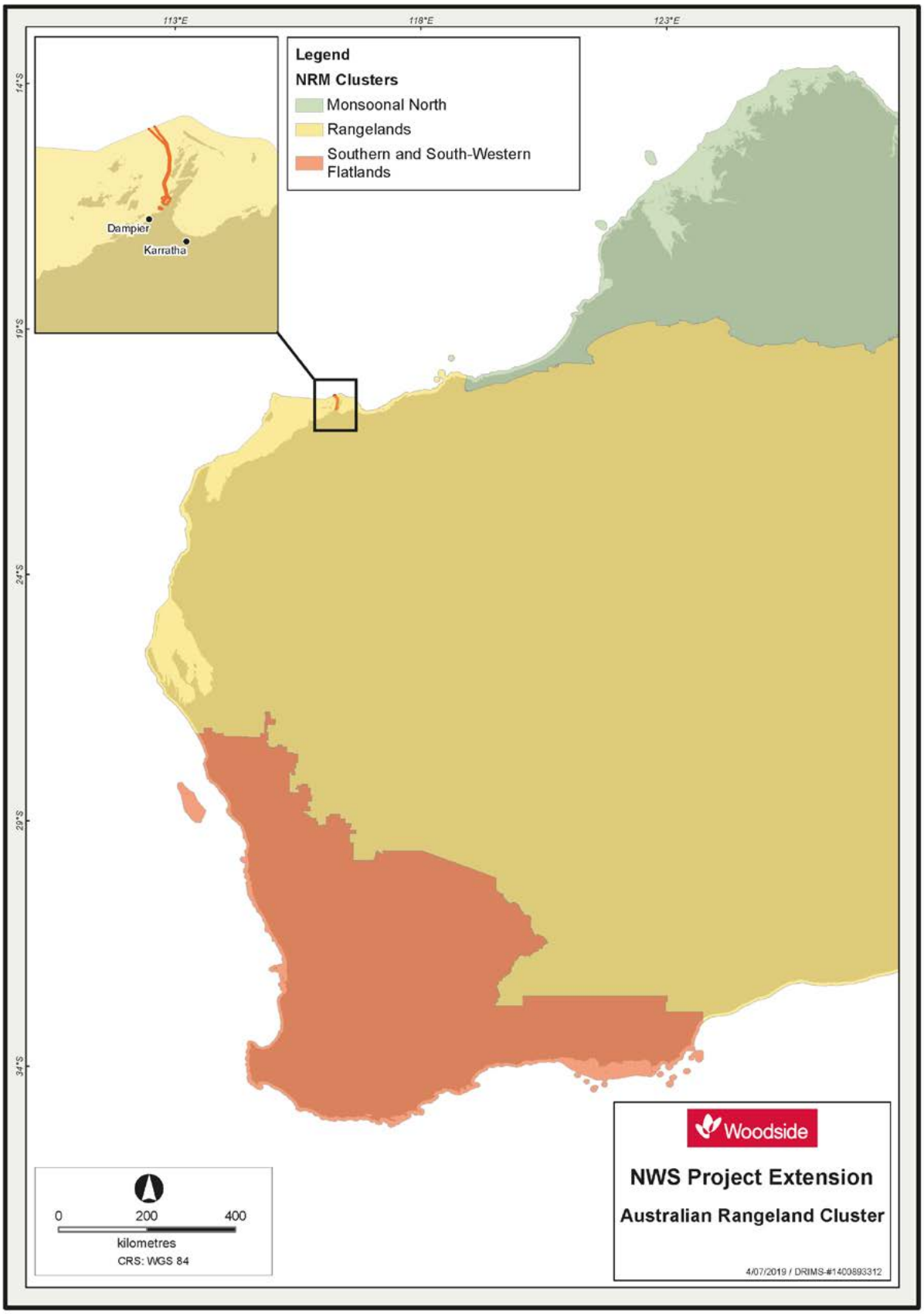


Figure 4-6: Map of the Rangeland Cluster (Source: CSIRO 2019)

CSIRO have reported that the future climate of the Rangelands cluster can be predicted by understanding the climate system, historical trends, and model simulations of the climate response to changes in GHG concentrations (CSIRO, 2019). Significant climate trends including higher temperatures, increased frequency of hot days, decreased rainfall, increased intensity of rainfall events, changes in wind speed, and reduced humidity are predicted across the Rangelands cluster (CSIRO, 2019).

Temperatures in the Rangelands cluster have been monitored by the BoM since national records commenced in 1910. From 1910 to 2013 the mean surface air temperature has increased by 1.0 °C in Rangelands North and 0.9 °C in Rangelands South (CSIRO, 2019). Increases in mean maximum and minimum temperature are predicted, with mean warming predicted to increase by 0.6 °C to 1.4 °C above the 1986–2005 climate data (CSIRO, 2019). Increases in the hottest temperature reached on the hottest days is also predicted. Alice Springs, in the Rangelands North sub-cluster, is predicted to have a 45% increase in the number of days above 35 °C by 2090 (CSIRO, 2019).

A decrease in spring rainfall events is predicted across the Rangelands cluster. Changes to rainfall events across other seasons are predicted by 2090, but due to natural variability an increase or decrease in the frequency of these events is unknown (CSIRO, 2019). Heavy rainfall events are predicted to increase across the Rangelands, but it is also unknown when these intense rainfall events might occur (CSIRO, 2019).

Global and regional studies predict a decrease in tropical cyclone frequency. Changes in the proportion of intense storms and wind speed are uncertain, as little to no change has been observed since observations began (CSIRO, 2019). Similarly, for relative humidity and solar radiation—little to no change is predicted across the Rangelands North sub-cluster. However, a decrease in relative humidity in summer and autumn is predicted across the Rangelands.

Evapotranspiration is where water is transferred from the land to the atmosphere by evaporation. An increase in evapotranspiration across the North and South Rangelands sub-clusters is predicted in all seasons, especially summer (CSIRO, 2019). Further hydrological and environmental modelling is needed to better understand the changes in soil moisture and evapotranspiration across the Rangelands.

Although the Proposal is located within the Rangelands cluster, it is on the extreme north-western edge of it and in a coastal setting. Therefore, although these predictions for Rangelands can be useful for understanding projected broadscale changes to climate, local variations based on the specific location and nature of the Proposal's setting and local climatic conditions may occur. Predicting the datasets required to generate representative meteorological data to confidently embark on modelling a changing climate scenario is impracticable. This would also introduce a high level of uncertainty due to the nature of natural interactions in atmospheric weather patterns, in a unique coastal peninsula environment.

Long running ambient air monitoring in the Burrup Peninsula Region (2008 – 2015) described further in **Section 4.2** provides a strong empirical dataset (ambient air emissions) which includes operation of the Proposal in the region over a broad spectrum of climatic conditions. Inference to potential ambient air trends with varying climate conditions (such as temperature) is preferred from this dataset. Ambient results have co-measured meteorological information, and this dataset is therefore independent of modelling uncertainties in both generating fine-scale meteorological conditions, and subsequent ambient air predictions based on these.

4.2 Air Quality

This section describes existing air quality in the Burrup Peninsula region. Woodside conducted ambient air monitoring programs on the Burrup Peninsula from 2008 to 2015; this data was used to supplement historical studies to understand the existing air quality relevant to the Proposal (Refer to the NWS Project Extension Air Quality Impact Assessment (**Appendix E**). Prior to these monitoring programs, the Pilbara Air Quality Study (PAQS) was undertaken by the Government of Western Australia in the early 2000s (DoE, 2004), which included investigations of monitoring data. CSIRO (2006) reported on monitoring undertaken specifically to assess the potential for air pollutant impacts on petroglyphs, including measurements of gaseous and particulate pollutants, deposited dust, meteorological parameters, rainwater composition, and the deposition of nitrogen and sulphur. The PAQS established a baseline for future assessments such as the Burrup Peninsula air pollution study by CSIRO Marine and Atmospheric Research (Gillet, 2008), and air dispersion modelling studies to investigate the potential for air quality impacts (e.g. SKM (2009), and Air Assessments (2010b)). Other similar air quality studies, and their supporting studies and reports, were completed around the same time (refer **Appendix E** and **Appendix H**).

Ambient levels were compared to the National Environment Protection (Ambient Air Quality) Measure (NEPM [Ambient Air Quality]). The *National Environment Protection Council Act 1994* (Cth), allows the National Environment Protection Council to make National Environment Protection Measures (NEPMs). NEPMs are a special set of national objectives designed to assist in protecting or managing particular aspects of the environment. The NEPM [Ambient Air Quality] outlines (set) ambient air quality monitoring protocol that allows for the adequate protection of human health and well-being (NEPC, 2016).

4.2.1 Air Quality Effects from Fires

Several air quality reports suggest that bushfires noticeably impact the air quality in the Pilbara region. Air pollutant levels typically affected by bushfires are reported to be ozone (O_3), particulate matter (PM_{10}), carbon monoxide (CO) and Oxides of Nitrogen (NO_X). One source suggested that the highest O_3 levels detected at Karratha in 2012 may have been caused by fires rather than industrial sources (Golder Associates, 2014).

4.2.2 Oxides of Nitrogen and Ozone

NO_X and O_3 are key pollutants associated with the Proposal. Although NO_X is emitted from the Proposal, O_3 is a more complex process. In general, the production of O_3 occurs from emissions of NO_X and other emissions such as Volatile Organic Compounds (VOCs) and CO in the presence of ultraviolet light (Seinfeld and Pandis, 2016).

Between 2008 and 2015 SKM, Jacobs and Ecotech conducted ambient air monitoring programs on behalf of Woodside on the Burrup Peninsula. Ambient air monitoring results of hourly averages for nitrogen dioxide (NO_2) and O_3 (acquired from 2008 to 2015) were analysed for this ERD and are provided in **Figure 4-7** to **Figure 4-11**. NO_2 was monitored to allow comparison to the relevant air quality standards. Data from the ambient air monitoring showed that NO_2 is typically observed well below the relevant NEPM (Ambient Air Quality) standard of 120 ppb for NO_2 (Jacobs, 2019a). The monitoring results showed that O_3 is also below the corresponding 1-hr NEPM (Ambient Air Quality) standard of 100 ppb but is proportionately higher than NO_2.

Ambient air monitoring results showed higher concentrations of O_3 than NO_2 in Dampier and Karratha. The opposite was the case for the Burrup Road ('Burrup') station, located closer to the Burrup industrial sources. One interpretation is that NO_2, which is assumed to be emitted primarily by Woodside sources, was dispersed to lower concentrations by the time it reached the townships of Dampier and Karratha. Therefore, there was less NO_2 in the townships to destroy the higher concentrations of O_3 there. A review of ambient air monitoring data between 2010 and 2013 by Golder (2014) identified only four small exceedances of the NEPM (Ambient Air Quality) standard for maximum 4-hourly average O_3 concentration (80 ppb), which all occurred on 24 and 26 October 2012. A detailed analysis by Golder (2014) could not determine the source of this anomaly.

Statistical summaries of the results from ambient air monitoring have been determined from the hourly average NO_2 concentrations for the three monitoring locations are illustrated in **Figure 4-7** (Karratha), **Figure 4-8** (Dampier), and **Figure 4-9** (Burrup). The statistics determined from the hourly averages are: maximum, 99.9th percentile, 99th percentile, 90th percentile, 70th percentile, median and average. The NEPM (Ambient Air Quality) standard for maximum hourly average NO_2 is 120 ppb. Inspection of the maximum hourly average and annual average NO_2 concentrations (ppb) for the years shown in **Figure 4-7** (Karratha), **Figure 4-8** (Dampier), and **Figure 4-9** (Burrup), demonstrate that there have been no exceedances of the NEPM (Ambient Air Quality) NO_2 standards over the monitoring period. This includes the 2014 period when Pluto LNG Development had ramped up to full production and the KGP, a component of the NWS Project was operating at or near capacity.

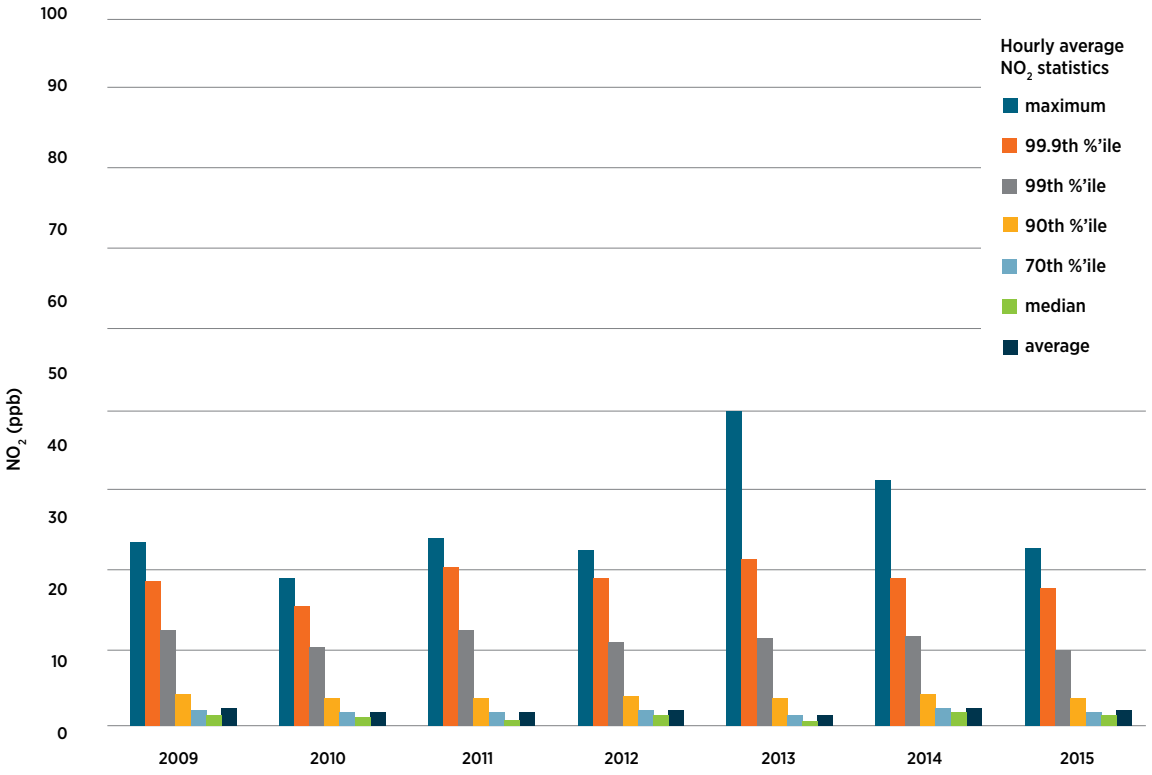


Figure 4-7: Woodside Air Quality Monitoring Results 2009–2015: Karratha NO_2 (NEPM 120 ppb)

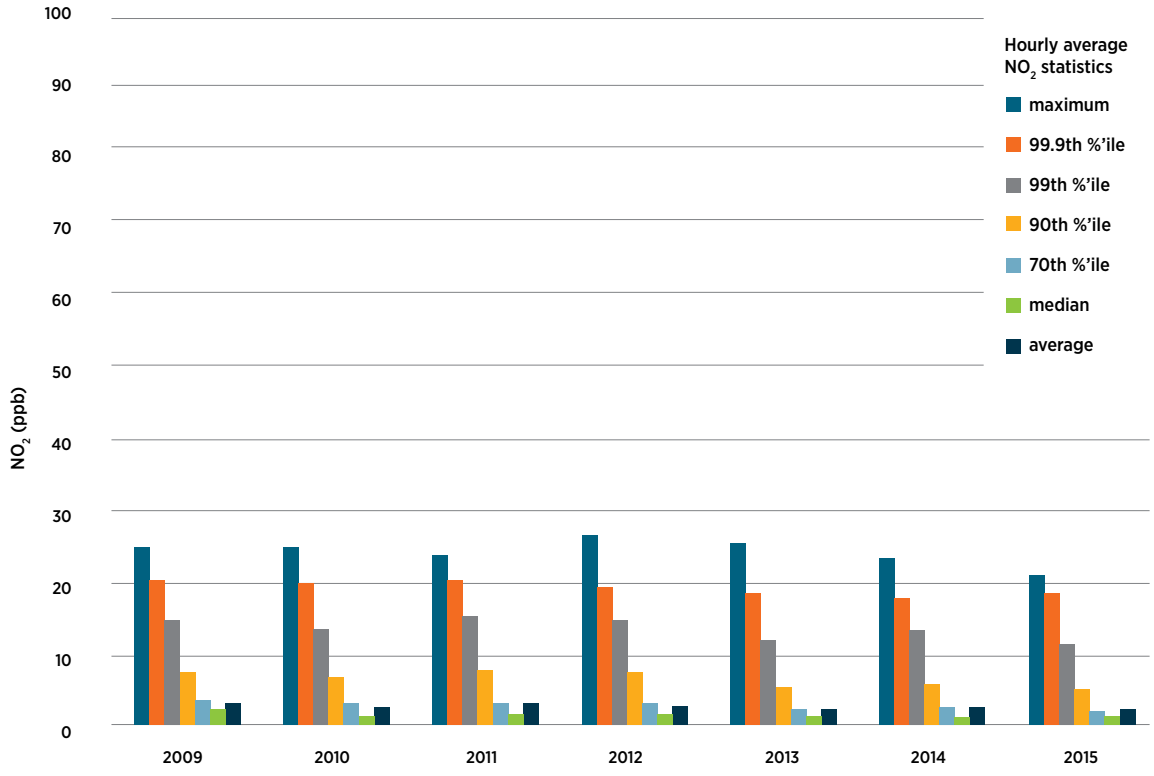


Figure 4-8: Woodside Air Quality Monitoring Results 2009–2015: Dampier NO_2 (NEPM 120 ppb)

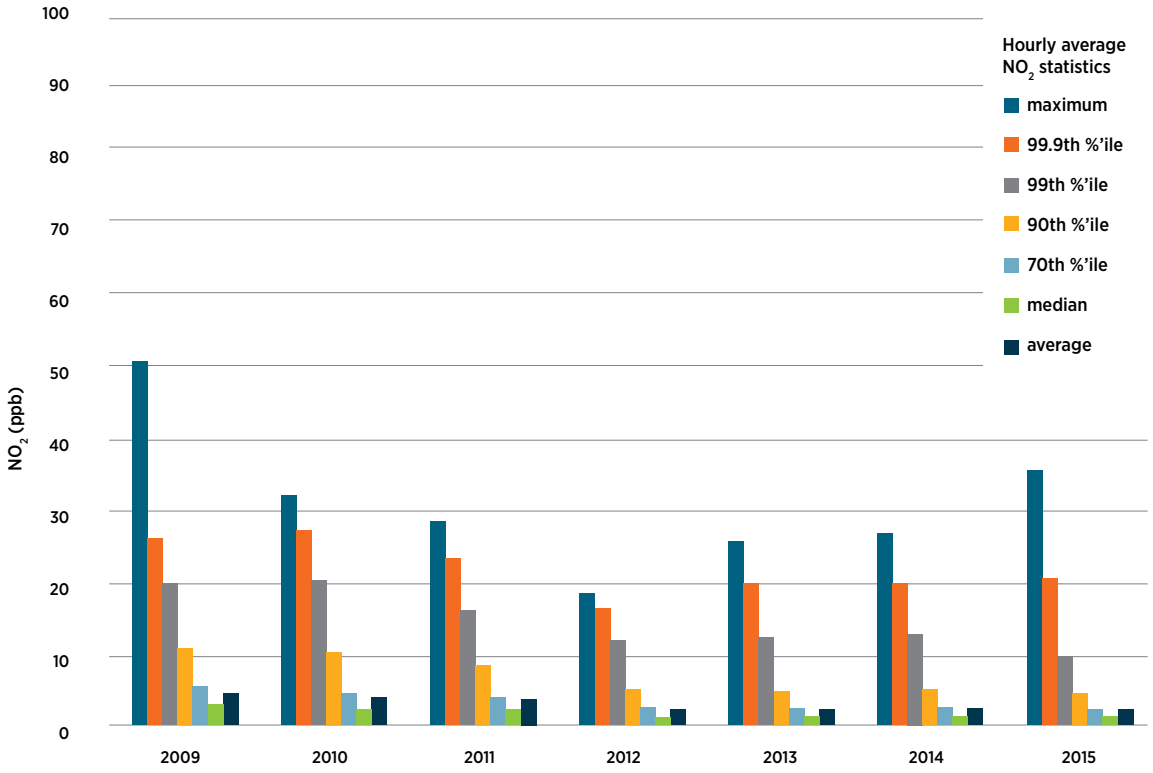


Figure 4-9: Woodside Air Quality Monitoring Results 2009–2015: Burrup NO_2 (NEPM 120 ppb)

Seasonal variation of NO_2 during each of the monitoring years is observable from the ambient data set at all stations, with peaks observed during cooler months (e.g. 1-hr NO_2 during July and August 2014 around 18 ppb (99.9 percentile), and average around 3.5 ppb), whilst hot summer periods are lower (e.g. 1-hr NO_2 during December and January 2014 between 5.8 - 16.8 ppb (99.9 percentile), and average around 2 ppb).

Statistical summaries of results for hourly average O_3 concentrations are shown for the two monitoring locations: Karratha (**Figure 4-10**) and Dampier (**Figure 4-11**). The corresponding NEPM (Ambient Air Quality) standard (maximum hourly average, 100 ppb) was not exceeded in any hour measured over 2009–2015.

Seasonal variation of O_3 during each of the monitoring years is less evident than NO_2 variation, with slight relative increases during September to November at Dampier and Karratha (e.g. 1-hr O_3 during September to November 2014 around 38-49 ppb (99.9 percentile), and average around 23-31 ppb), whilst December to March periods are typically slightly lower (e.g. 1-hr O_3 during December and March 2014 between 32-38 ppb (99.9 percentile), and average around 19-23 ppb).

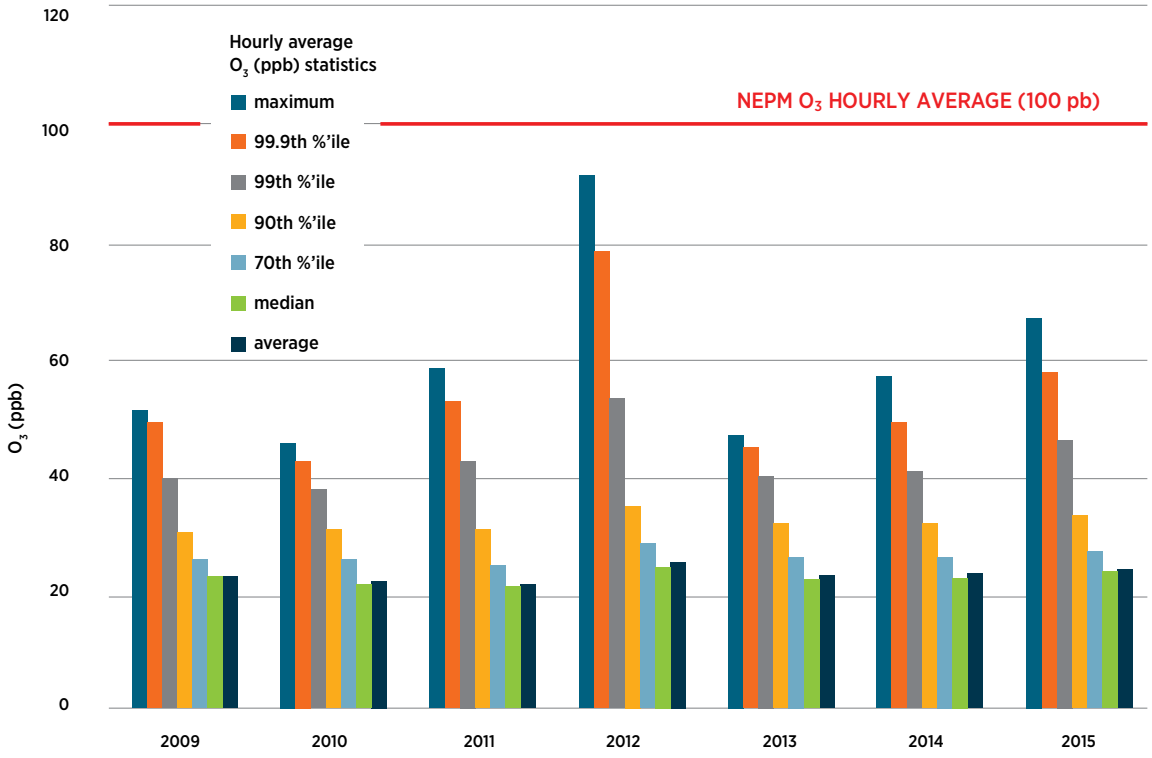


Figure 4-10: Woodside Air Quality Monitoring Results 2009–2015: Karratha O_3

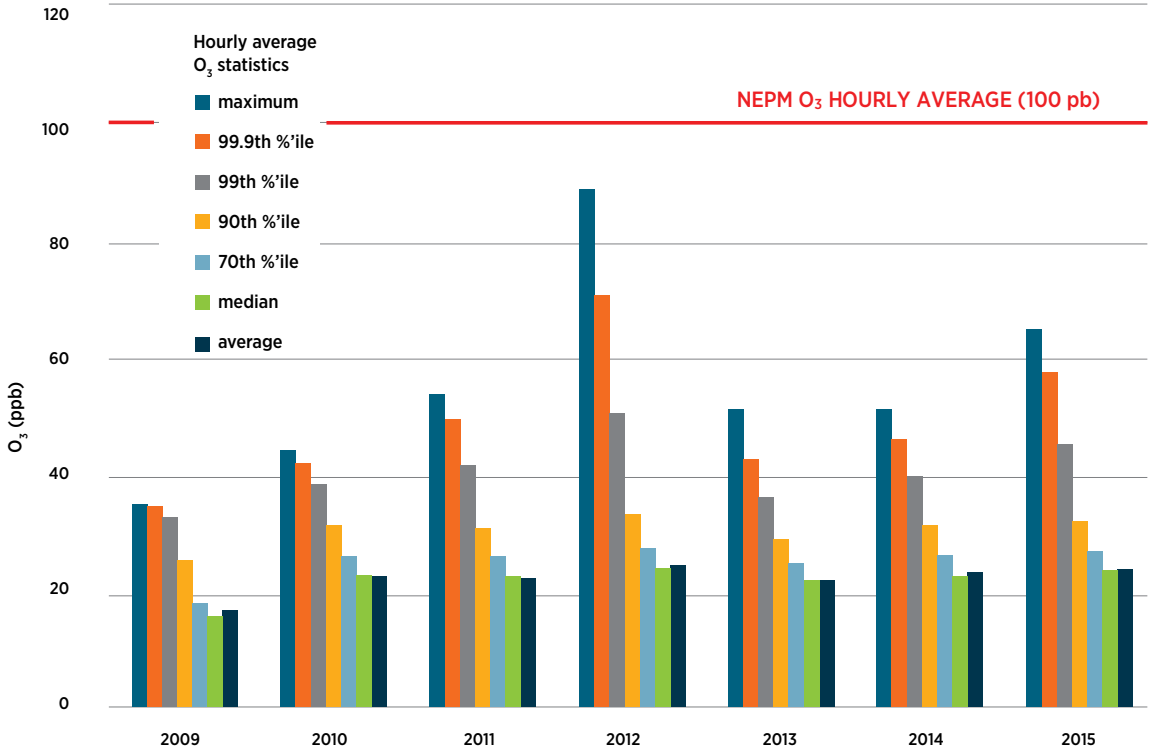


Figure 4-11: Woodside Air Quality Monitoring Results 2009–2015: Dampier O_3

4.2.3 Volatile Organic Compounds (including Benzene, Toluene, Ethylbenzene, and Xylene [BTEX])

Ambient air monitoring data were also assessed to determine the ambient level of benzene, toluene, and xylene compounds (BTX) as an indicator for VOC risk level relevant to the Proposal.[3] Ethylbenzene was not measured as part of historic ambient air monitoring programs, due to technical limitations. A review of historic emissions reports (e.g. NPI) of the Proposal demonstrates that ethylbenzene emissions are significantly lower than either benzene, toluene, or xylene emissions.

The relevant standards when assessing BTX are the 'Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales' (NSW EPA Assessment Criteria) for assessing maximum hourly average concentrations and the 'National Environment Protection (Air Toxics) Measure' (NEPM [Air Toxics]) for assessing daily and annual averages. The NEPM (Air Toxics) sets out standards for long term (annual) averages because these are more readily related to human health effects than shorter term averages. The NSW EPA Assessment Criteria are relevant as they set out hourly average concentration assessment criteria and were used to assist with interpretation of measured hourly average concentrations.

Maximum hourly average concentrations of benzene measured at the local township air quality stations at Dampier and Karratha from 2008 to 2010 never exceeded 3 ppb. For comparison, the corresponding NSW EPA assessment criterion is 9 ppb (NSW Environmental Protection Authority (NSW EPA), 2016). The measured 90th percentile hourly average benzene concentrations at both locations was 0.1 ppb.

During the monitoring brief exceedances of the NSW EPA (2016) assessment criterion for benzene (9 ppb) occurred at the Burrup monitoring station location: 14 hours at Burrup 1 instrument (0.03% of total hours), and 12 hours at Burrup 2 instrument (0.04% of total hours). Possible causes of these localised and short-term elevated levels may include transient emission sources (such as vehicles operating nearby to the monitoring station). Ambient monitoring results indicate the annual average benzene is typically less than 0.1 ppb (at or near level of detection), and less than 4% of the NEPM (Air Toxics) monitoring investigation level for benzene of 3 ppb.

A review of all monitoring results from 2008 to 2015 found that toluene and xylenes were consistently recorded at lower levels than benzene, which correlates with reported emissions of these substances. Given this, benzene is considered a 'trigger pollutant' for the BTEX group of VOCs, meaning that if benzene is lower than the assessment criteria then toluene, ethylbenzene and xylene are also below the assessment criteria.

A statistical summary of the hourly average BTX monitoring results for 2009—the only year where data capture was less than 75% for each ambient monitoring station—showed that BTX concentrations were below the NSW EPA Assessment Criteria for almost all the time (99.9% of hours).

4.2.4 Airborne Particulate Matter as PM_{10} and $PM_{2.5}$

Although Particulate Matter (PM) is not a high emission from the Proposal, the existing environment is characterised by high levels of PM, which is relevant to providing context of the existing air quality.

Rio Tinto conducts PM monitoring at Dampier, Karratha, King Bay, Wickham, Point Samson and Roebourne (Rio Tinto, 2015). Monitoring reports were not available for review at the time of writing. However, recent data published online can be used for assessment (Pilbara Iron, 2019). On 9 May 2019, very high PM_{10} (particulate matter less than 10 µm in diameter) concentrations were observed at Dampier, Karratha, Wickham, Point Samson, and Roebourne. The strong correlation between these measurements, taken by several monitors on this day, suggests a regional dust elevation from natural causes was the probable cause. A review of 30 days of PM_{10} data for Karratha (10 April to 10 May 2019) indicates the 'clean-air background' PM_{10} levels are approximately 10 µg/m^3, with a median or average closer to 20 µg/m^3. These values are typical of PM_{10} concentrations measured in other parts of Australia.

The "Dampier Port Increase in Throughput – 120 mtpa Environment Protection Statement" provides a useful time series plot of daily PM_{10} measured by Hamersley Iron at Dampier from 2001 to 2004 (SKM, 2005). Some broad conclusions about the variations in PM_{10} on the Burrup Peninsula can be drawn from inspecting this record. The record provides information about the clean-air background and air quality impacts, with the latter likely due to local particulate emissions from bushfires, dust storms, and some industry. The PM_{10} concentrations peaked during higher wind speeds in January, with typical daily concentrations ranging between 30 and 40 µg/m^3. Exceedances of the NEPM (Ambient Air Quality) standard of 50 µg/m^3 ranged from ~ 5–10 exceedances per year. Mid-year, during the dry season with corresponding lower wind speeds, typical daily concentrations varied between 10 and 20 µg/m^3.

The Pluto LNG Development Cumulative Air Quality Study (SKM, 2006) reviewed monitoring results for particulate matter as PM_{10}. The study found that existing industrial activity in the Pilbara airshed mainly contributed to

3 *The Burrup Peninsula Air Pollution Study: Final Report – April 2006 (CSIRO, 2006) has been reviewed to assist with risk screening of BTEX and has not been used in the characterisation of the local and regional ambient air quality.*

emissions of $PM_{2.5}$ and PM_{10}, with PM exceeding NEPM (Ambient Air Quality) advisory criteria (SKM, 2006) stated that higher PM_{10} concentrations were observed on days of high wind speeds. On these days the $PM_{2.5}$/PM_{10} fraction was reduced from ~ 50% to ~ 20%, indicating windblown dust caused the high PM_{10} concentrations, as the small particle fraction is higher in smoke emissions.

A review by Air Assessments (Air Assessments, 2010a) indicated that measurements of PM_{10} at Dampier tend to be high, and 'exceed the NEPM (Ambient Air Quality) standard'. (Air Assessments, 2010a) indicated the major sources of PM in the Burrup region are: smoke from fires, dust from natural sources and iron ore stockpiling, and ship-loading operations at the ports of Dampier and Cape Lambert. Emissions of PM from the onshore gas plants were recognised as small and of little relevance in comparison with these other sources.

An independent review of $PM_{2.5}$ monitoring results acquired at Karratha, Dampier and Burrup monitoring stations from December 2011 to December 2012 was conducted by Golder for the Pluto LNG Development (Golder, 2014). Although a number of exceedances of NEPM advisory criteria for $PM_{2.5}$ were recorded at the three locations, based on back-trajectory analysis, flare rate, black smoke and $PM_{2.5}$ concentrations, Golder (2014) concluded there was sufficient evidence to suggest that air emissions from the Pluto LNG Development were not associated with the exceedances. Iron ore handling was stated as a probable cause of exceedances of $PM_{2.5}$ standards detected at Dampier monitoring station.

4.2.5 Sulphur Dioxide

A review of sulphur dioxide (SO_2) ambient air monitoring results on Burrup Peninsula was undertaken by Air Assessments (Air Assessments, 2010b) which has been used to determine levels of SO_2 in the existing air quality. This report was used as SO_2 was not monitored in the ambient air monitoring programs. To understand SO_2 levels, the ambient air monitoring report (Air Assessments, 2010b) applied conservative assumptions to several fixed industrial emissions sources, noting very low sulphur in fuel concentrations. For this reason, estimates for exhaust SO_2 for most sources were assessed as being at or near the limit of detection, thus a reasonable estimate for an annual average was 0.1 ppb (the NEPM (Ambient Air Quality) standard for annual SO_2 is 20 ppb). Maximum hourly average concentrations would not be expected to exceed 10 ppb for most locations away from engine exhausts on ships, the most significant source in the region. The comparable maximum hourly average NEPM (Ambient Air Quality) standard is 200 ppb.

Summary

In summary, the review of air quality monitoring data for the Burrup Peninsula study area showed that NO_2, and O_3 are the health pollutants most relevant to the Proposal, based on assessment of ambient levels and contribution to those emissions by the Proposal.

4.3 Terrestrial Environment

4.3.1 Soils and Geology

The Burrup Peninsula is part of a spine of Archaean igneous rocks that includes granophyres, gabbros, and small granite exposures (Woodside, 2006). The disturbance footprint occupies a granitic land system with heavily weathered, shallow, red sandy soils, comprising a mixture of boulders, cobbles, gravels, and silty sand. Soils reach a depth of up to 2 m in lower alluvial slopes, which may also contain stony clay colluvial infills.

The surface soils within the disturbance footprint have been heavily modified by cutting, filling, and levelling to enable construction of level, sealed areas of hard standing for roads, storage tanks, processing equipment etc, as well as drainage features to contain and direct surface water flows (and consequently reduce rainwater infiltration) in the event of seasonal heavy rainfall. The KGP sits on a raised platform of fill material. The existing topsoil, erosional deposits and in-situ weathering profiles were excavated to expose 'fresh' bedrock. The bedrock surface was subsequently used as the base on which the fill platform was constructed using the excavated material, together with additional material from local sources. Typically, this material consisted of coarse angular gravel, cobbles, and boulders of granophyre debris. Whilst the depth of fill is variable, boreholes drilled within the platform by URS suggest that it ranges from 4 m – 11.5 m depth (Woodside, 2006).

4.3.2 Vegetation and Flora

The Proposal is within the Roebourne subregion of the Pilbara Bioregion as defined by the Interim Biogeographic Regionalisation of Australia (DSEWPC, 2012a). Vegetation of the Roebourne subregion is generally characterised by quaternary alluvial, colluvial coastal, and subcoastal plains that support grass savannah, hummock grasses, and dwarf shrub steppe of *Acacia stellaticeps* or *A. pyrifolia* and *A. inaequilatera* (Astron, 2018). The uplands are dominated by *Triodia* hummock grasslands and *Eucalyptus victrix* or *Corymbia hamersleyana* woodlands that are supported by ephemeral drainage lines (Astron, 2018).

Although some vegetation is located within the Proposal development envelope, online flora and vegetation databases do not identify any threatened ecological communities, threatened flora or priority flora within the development envelope. Five flora species listed as Priority 3 flora by the Department of Biodiversity, Conservation and Attractions (DBCA) and one species listed as Priority 4 are known to occur on the Burrup Peninsula within a 10 km radius of KGP. These are *Eragrostis surreyana*, *Schoenus punctatus*, *Stackhousia clementii*, *Terminalia supranitifolia*, *Vigna triodiophila* and *Rhynchosia bungarensis*. Two

Priority 1 ecological communities are known to occur on the Burrup Peninsula: Burrup Peninsula rock pool communities; and Burrup Peninsula rock pile communities.

The exact vegetation condition is unknown, but it is assumed to range from completely degraded where clearing activities have occurred, to very good or excellent where native vegetation has been retained. The sensitivity of the vegetation has been determined based on its conservation significance and/or heritage value. Vegetation and flora that is listed under State or Federal legislation as threatened or listed on DBCA's Priority flora and ecological community lists is classed as 'sensitive vegetation'. Similarly, vegetation and flora that has been identified as used by Aboriginal groups or that has heritage value is also classed as 'sensitive'. **Table 4-2** details the vegetation considered to be of high or medium sensitivity.

Table 4-2: Vegetation with Medium or High Sensitivity

Vegetation Description	Reason for Sensitivity	Within or Adjacent to Development Envelope
Burrup Peninsula: Burrup Peninsula rock pool communities	Priority Ecological Community	No. No known records within 2 km of the development envelope
Burrup Peninsula: Burrup Peninsula rock pile communities	Priority Ecological Community	No. No known records within 2 km of the development envelope
Vegetation that includes or is habitat for: + *Eragrostis surreyana* + *Schoenus punctatus* + *Stackhousia clementii* + *Terminalia supranitifolia* + *Vigna triodiophila* + *Rhynchosia bungarensis*	Named flora species are listed as Priority 3 or Priority 4 by DBCA	No. No known records within 2 km of the development envelope
Vegetation that contains plants used by Aboriginal people including: + *Acacia coriacea* + *Acacia pyrifolia* + *Avicennia marina Ficus brachypoda* + *Solanum sp.*	This vegetation is considered to have heritage value and provides an ongoing connection to the land for the Aboriginal groups of the Burrup Peninsula	Yes

4.3.3 Hydrology

As with much of the wider Pilbara region, the Burrup Peninsula has limited surface freshwater supplies and relies on inputs during the wet season. Consequently, freshwater flows in the region are variable and are often experienced as high-flow, short-period events. The general topography of the Burrup Peninsula is such that surface water flows are channelled off steep slopes into drainage lines and numerous gullies (**Figure 4-12**). These high-rainfall and short-duration events are followed by dry periods that stop stream flow and the recharge of deeper waterholes and gorges.

Groundwater aquifers on the Burrup Peninsula occur as isolated pockets, located in rock fractures, joints, bedding planes, and cavities of the rock mass. Fractured rock aquifers occur as localised systems with regional flow (Woodside, 2006).

The soils and underlying weathered bedrock on the Burrup Peninsula are highly permeable and allow the recharge of groundwater during rainfall events; however, the presence of granophyre at shallow depths prevents long-term subsurface water storage. The granophyre at depth is expected to be a generally tight, solid rock mass with limited open fractures/joints. Therefore, the orientation, interconnectivity and permeability of these limited open pathways governs the rate and nature of groundwater movement (Woodside, 2006).

Little groundwater flow is expected to occur from the perched water tables. Instead, this water will be ephemeral and subject to gradual drainage and evaporation (Woodside, 2006).

The natural topography of the development envelope was heavily altered by the construction of the KGP. Nevertheless, several remnant creeks and gullies occur across the development envelope, some of which have been truncated or modified and may contain water and/or flow on a seasonal basis. No permanent natural bodies of fresh surface water exist within the development envelope.

4.3.4 Ground Water

There are no environmental values associated with groundwater underlying the NWS Project and there are no coastal aquifers hydraulically connected to the site.

Figure 4-12: Surface Hydrology of the Burrup Peninsula

4.4 Marine Environment

The trunklines (1TL and 2TL) and nearshore marine infrastructure lie within the waters of Mermaid Sound in the broader Dampier Archipelago. The marine and coastal habitats along the Pilbara coast and nearshore islands (including the Dampier Archipelago) are part of the NWS and are contiguous with the NWS province, which is a part of the wider North West Marine Region (NWMR) as defined under the Integrated Marine and Coastal Regionalisation of Australia (DEH, 2006).

To monitor the health and detect changes in the marine environment within and adjacent to the Proposal development envelope, Woodside undertakes chemical and biological monitoring of the intertidal and subtidal environment as part of the Chemical and Ecological Monitoring of Mermaid Sound (ChEMMS) program. This program monitors for environmental changes that may indicate impacts arising from operation of the Proposal. ChEMMS was initiated by the NWSJV in June 1985 and includes an annual surveillance monitoring program of the following parameters:

- Contaminant concentrations (e.g. metals, hydrocarbons) in samples of sediments, oysters and mud whelks.
- Mangrove health.
- Coral health (conducted every five years).

Monitoring for the ChEMMS program is currently undertaken at several sites, including:

- Potential impact sites around the KGP and KBSB (including at the boundary of low or moderate ecological protection zones in the vicinity of planned discharges).
- Reference sites at Conzinc Bay, Withnell Bay, Watering Cove, Cowrie Cove, North Burrup, and Hearson Cove.

Locations of monitoring sites are shown in **Figure 4-13**.

As part of ChEMMS program reviews, the current monitoring sites are reviewed to confirm they are appropriate and continue to meet the requirements of the ChEMMS program. As such, these sites may be subject to change.

ChEMMS results are reported each year in the Annual Environment Report submitted to DWER and the State Agreement report submitted to Department of Jobs, Tourism, Science and Innovation. As a result, the levels of potential contamination in the marine environment surrounding the development envelope is regarded as well understood. Monitoring for changes in the marine environment through the ChEMMS program is ongoing. No significant environmental changes have been observed and no significant changes to the operation of the NWS Project facilities are being initiated. Therefore, additional monitoring or studies beyond the existing ChEMMS program were not considered necessary to inform this ERD. The latest data and information from the ChEMMS program and other relevant sources have been included in this ERD.

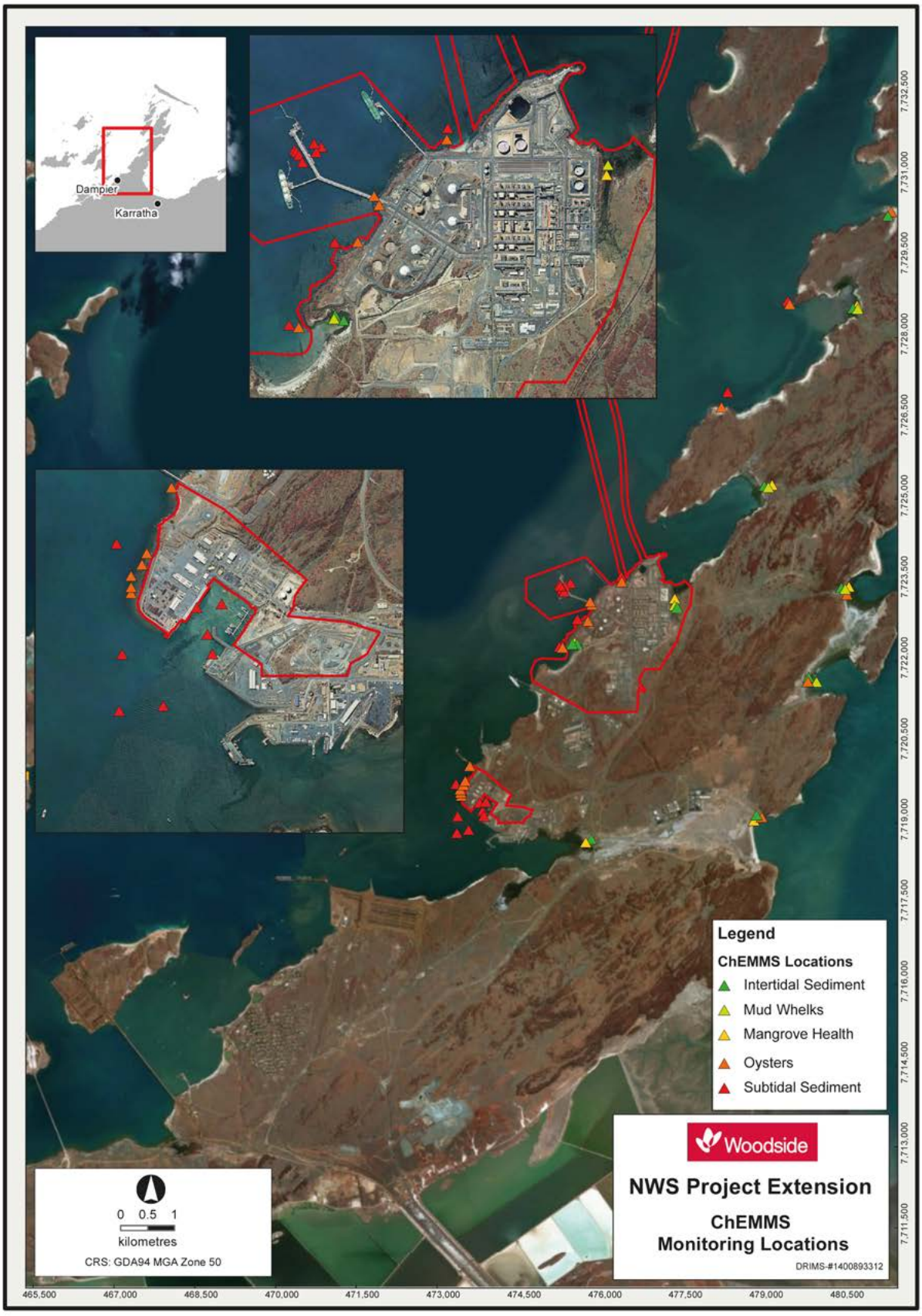


Figure 4-13 ChEMMS Monitoring Locations and Methodology

4.4.1 Coastal Processes

Coastal processes in the vicinity of the development envelope are characterised by waves mainly from a south-west direction with an average swell height of 1 to 2 m, which rises to 3 m during winter (June to August). Storm events form in the lower Indian Ocean during winter, which generates swell and can create a low, consistent, long wave form that reaches to the Dampier Archipelago (Pearce et al, 2003). As waves move down Mermaid Sound from the open ocean, their heights typically reduce by at least 50 % (Pearce et al, 2003). Predominately westerly winds in summer result in increased wave action within the Dampier Archipelago, while the predominantly winter easterlies result in calmer marine conditions due to the western shores of the Burrup Peninsula and the islands to its north. (Woodside, 2015). Intense low-pressure systems and extreme winds are more frequent during cyclone season (December to April), when swell conditions in excess of 8 m height can be produced.

The Dampier Archipelago and the surrounding islands are influenced by semidiurnal tides, which range up to 5.1 m, within a region that has a range of tidal height from less than 2 m south-west of Barrow Island to greater than 6 m north of Broome (Pearce et al, 2003). Sea levels above predicted tidal heights can be significantly raised during storm surges and cyclonic events (Pearce et al, 2003).

Currents in the Dampier Archipelago are influenced by the layout of the islands, tides, local winds, and large-scale ocean circulation (Jones, 2004). On a spring tide, tides flow in a south-easterly direction and are channelled through the islands and along Mermaid Sound and Mermaid Strait, converging near the Intercourse Islands at the south of the archipelago (Pearce et al, 2003). Ebb tides flow in the opposite direction at comparable speeds (Pearce et al, 2003).

The offshore entrances of the Dampier Archipelago and some of the islands experience strong tidal speeds, ranging from 0.4 to 0.5 m/s at the seaward reaches of Mermaid Sound, and 0.3 to 0.4 m/s in the channel between Eaglehawk and Enderby Islands and the channel south of Rosemary Island (Jones, 2004). The channels connecting Mermaid Sound and Nickol Bay between Angel and Dolphin Islands have the strongest currents, exceeding 2 m/s (Woodside, 2015). Further offshore in Mermaid Sound, tidal currents are ~ 0.2 m/s during spring tides and 0.1 m/s during neap tides. However, secondary circulation can occur because flows around the islands are complex (Woodside, 2015).

4.4.2 Benthic Habitats

Intertidal and shallow subtidal habitats are extensive and well developed along the Pilbara coastline and include mangroves, coral and rocky reefs, algae, mudflats and ephemeral seagrass beds (Wells et al, 2003).

The Dampier Archipelago comprises more than 40 major islands and many smaller islands (islets) and rocks, and has a high diversity of nearshore marine habitats, including soft sediments and sandy beaches, reefs, and rocky shores (Pearce et al, 2003).

The habitats surrounding the development envelope comprise of mangroves at No Name Creek, North East Creek and various other beaches; corals, seagrasses, and macroalgae at Mermaid Sound; and silt substrate in the nearshore areas where the jetties, berthing pockets and the shipping channel are located. The NWS Project trunklines (1TL and 2TL) traverse silt and sand substrates and pass through two small areas of subtidal reef platform.

A map of significant benthic habitats in Mermaid Sound is presented in **Figure 4-14**. The habitat map is an amalgamation of a number of previous studies and maps and is used to show with high confidence the significant habitats of Mermaid Sound. In developing the map, an extensive range of existing habitat maps/ data for the region were overlayed. Habitat layers were split into individual habitat types and evaluated for congruence in the extent and placement of habitat features. Based on the data source and agreement of data layers a confidence value for each feature was assigned (ranging from 1 – data should be rejected to 5 - data is highly reliable and the extent of the feature is justified based on the survey methods used to describe it and the feature is corroborated by two data sources) (MScience, 2017). The final habitat file was produced by grouping individual habitat layers into one spatial file. The final shape file was assessed for conflicts in habitat classification between grouped layers and the feature confidence values were modified accordingly. Once all layer conflicts had been resolved, randomly selected features were checked against high-resolution satellite imagery to confirm their validity. In some cases, the boundaries of features were modified based on the available satellite imagery to increase confidence in their validity. A final assessment of the combined spatial data was performed by incorporating advice from an expert in the benthic primary producing habitats within the Dampier Archipelago and surrounding Cape Lambert. The expert advice was generally used to modify the confidence classification of data layers but, in some cases, the spatial extent of features was modified based on expert assessment of the feature (MScience, 2017). Where impacts to localised features are required, Woodside may refer to more detailed habitat maps, acknowledging the confidence of these may be lower.

The following subsections discuss the various benthic communities using the habitats described above, that occur near the development envelope.

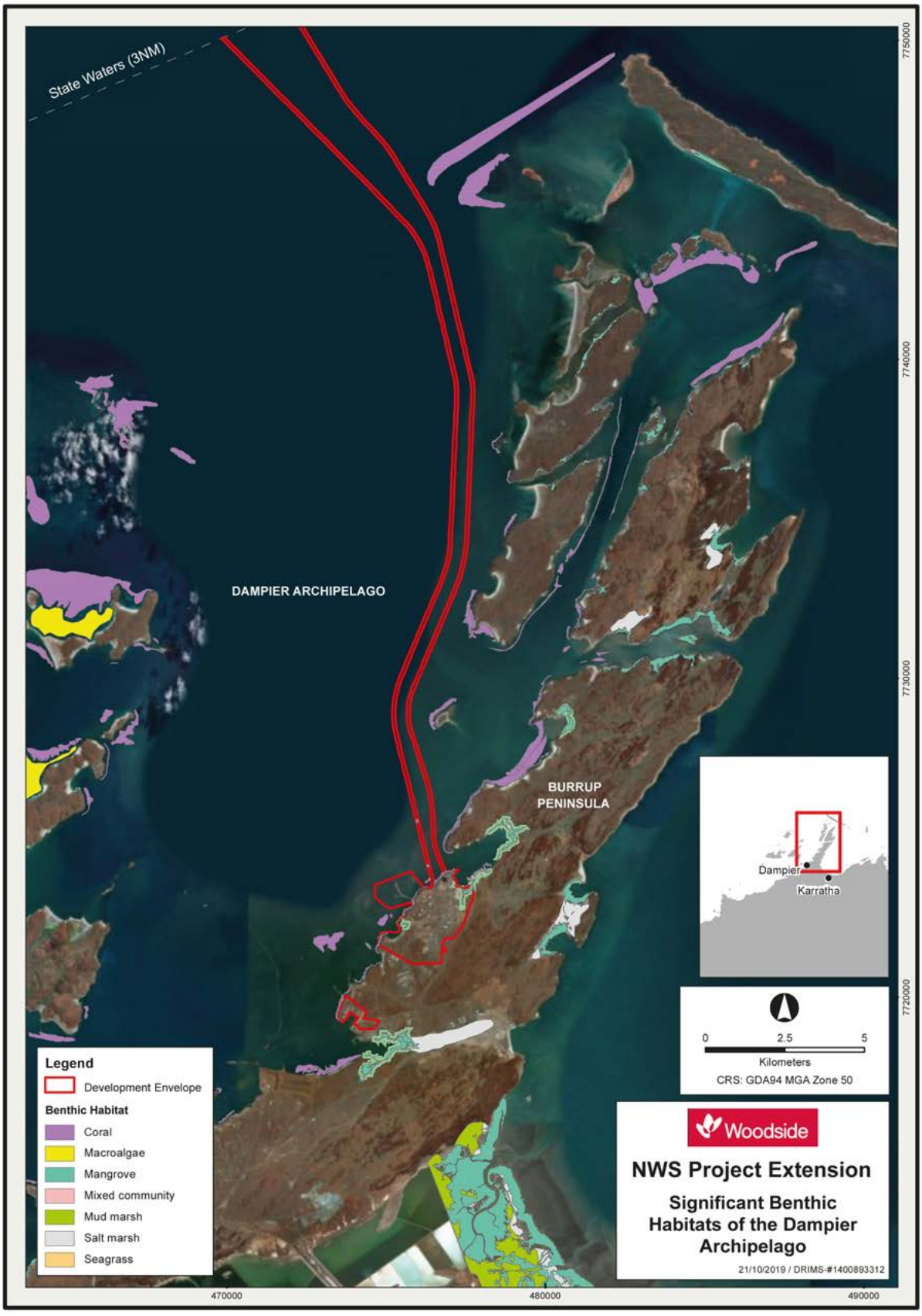


Figure 4-14 Significant Benthic Habitats of the Dampier Archipelago

4.4.2.1 Mangroves

Mangroves are an important part of the coastal ecosystem, contributing to primary productivity and providing habitat for fauna species including fish, sea snakes, turtles, and birds (Wells et al, 2003). The significance of tropical arid zone mangroves along the Pilbara coastline is recognised and specific guidance documentation has been established by the EPA for protecting these communities, habitats, and dependent habitats from development pressures (Woodside, 2006).

The geographic distribution of mangrove habitat is typically restricted to sheltered areas such as estuaries, tidal creeks, and sheltered bays. Mangroves are recognised as being important habitats for fish feeding grounds and nurseries; they also protect coastal areas from erosion by stabilising sediments. Six species of mangrove occur in the Dampier region: *Avicennia marina*, *Aegialitis annulata*, *Aegiceras corniculatum*, *Bruguiera exaristata*, *Ceriops tagal*, and *Rhizophora stylosa*.

The nearest mangrove community to the development envelope area is stands of *Avicennia* and *Rhizophora* that exist adjoining sandy beaches near No Name Bay and at No Name Creek. This stand has been studied as part of the ChEMMS program. A review of the ChEMMS data in 2017 shows no changes in mangrove health that can be attributed to the NWS Project (Advisian, 2017). Although there was a short-term decrease in canopy cover recorded between 2014 and 2015, the canopy cover increased between 2015 and 2017. These changes occurred across all monitoring sites, including reference sites, and therefore are likely to be due to natural variation, responses to climate fluctuations, or other factors outside Woodside's control (Advisian, 2018a).

4.4.2.2 Marine Invertebrates

The wide variety of suitable habitats in the nearshore areas of the Dampier Archipelago support an abundant and diverse group of tropical invertebrate species. More than 2226 species of marine invertebrates have been recorded in the Dampier Archipelago, including 1227 mollusc, 438 crustacean, 275 sponge, and 286 echinoderm species (Woodside, 2006).

The zooplankton in the region includes the larval stages of many organisms (i.e. meroplankton) such as corals and fishes (Sampey et al, 2004). The inshore ichthyoplankton assemblage is characterised by shallow reef fishes such as blennies (family *Blenniidae*), damselfish (family *Pomacentridae*) and north-west snappers (family *Lethrinidae*), while offshore assemblages are dominated by deepwater and pelagic taxa such as tunas (family *Scombridae*) and lanternfish (family *Myctophidae*) (Beckley et al, 2009). Some of these taxa are commercially and recreationally important species in the region.

To understand the health of marine invertebrates near the development envelope Woodside monitors oysters and mud whelks as part of the ChEMMS program. Contaminant levels in oysters for the parameters analysed in 2017 have not shown an increasing trend, with results generally showing slight fluctuation at all sites, following a similar trend to previous years (Advisian, 2018a).

Mud whelks are gastropod snails found abundantly in mangroves. Analysis of contaminant levels in mud whelks in 2017 did not show an increasing trend in any parameters, except for a gradual increase in chromium and nickel concentrations (Advisian, 2018a). This increase has been seen across most sites, including reference sites distant from North East Creek and No Name Creek.

4.4.2.3 Coral

Coral communities of the Dampier Archipelago predominantly occur as narrow linear features fringing the shorelines of islands and the Burrup Peninsula, and are typically found between 2 m and 10 m mean low water. These fringing reefs are not true coral reefs because they establish and grow on existing hard substratum (Woodside, 2006).

The Pilbara region contains an assortment of substrates, which support various coral species, and the nearshore marine environment has a high species count for an inshore reef system (Blakeway et al, 2005). A total of 229 species of both scleractinian (hard) and non-scleractinian (soft) corals are found throughout the Dampier Archipelago, representing a large proportion of the 318 hermatypic species from 70 genera known to occur in WA (URS, 2004). The most diverse coral assemblages of the Dampier Archipelago are on the seaward slopes of Delambre, Legendre, Rosemary, and Kendrew Islands (Woodside, 2015); Rosemary Island is the closest to the development envelope, at a distance of 20 km.

Distribution of coral communities shows a strong gradient in which nearshore or inner harbour reefs are dominated by sediment-tolerant species that shift to wave-tolerant clear water species further offshore in the outer harbour (Woodside, 2006). Corals are sensitive to natural and anthropogenic influences, and can be damaged by weather, predators, dredging, fishing, and anchoring. Coral communities colonising the rocky subtidal slopes that fringe shorelines in Mermaid Sound and the Burrup Peninsula form ecologically important communities, which are sensitive to events such as oil spill, sedimentation, and cyclones (Pearce et al, 2003).

The coral communities along the mainland Burrup Peninsula coast show little evidence of reef development; rather they grow by encrusting solid substrata such as Precambrian rock (Jones, 2004).

A review of the ChEMMS data collected in 2017 indicates that the overall health of the corals monitored across all sites was positive, with a relatively small number of colonies showing signs of anthropogenic damage.

Analysis of the most recent coral monitoring data (Advisian, 2018b) demonstrates little variation in coral cover between this most recent survey and the previous surveys, indicating no significant impact associated with the NWS Project to date.

4.4.2.4 Seagrass

Seagrasses depend on light and suitable sea temperatures and conditions, and are generally found in coastal waters at depths up to 10 m (Woodside, 2006). Seagrasses in the Dampier Archipelago are generally sparse, occurring in low abundance on shallow sandy sediments in sheltered areas and interspersed with other benthic communities and habitats. The predominant species is Halophila, which is typically restricted to a 6 m depth contour (Woodside, 2006) .

Seagrasses are found in the inner harbour of Mermaid Sound, including Withnell Bay, with the closest occurrence about 1.8 km from the development envelope. It is highly unlikely that seagrasses are present in offshore areas of the region beyond ~50 m depth, mainly due to light attenuation.

Sheltered flats and larger bays in the Dampier Archipelago support sparse meadows of seagrass, occurring in low abundance of shallow sandy sediments (McMahon et al, 2017). Seagrass meadows are more abundant between Keast and Legendre Islands north of the Burrup Peninsula, and between West Intercourse Island and Cape Preston. Recorded occurrences of Halophila species in the Dampier Archipelago fluctuate depending on factors such as salinity, success of seed set and colonisation, temperature, and grazing by dugongs (Woodside, 2006).

4.4.2.5 Macroalgae

Macroalgae, or seaweeds, generally require a hard substrate, sufficient sunlight, and water clarity and so are generally limited to shallow water. In nearshore areas, macroalgae are most commonly found on shallow limestone pavements located throughout the Dampier Archipelago and along coastal areas of the Pilbara.

Large expanses of macroalgae are prevalent along the seaward side of West Intercourse Island, approximately 17 km away from NWS Project, extending south-west along the coast to Cape Preston and beyond, and on several shallow reef flats on the western and eastern margins of Mermaid Sound.

The most abundant group of macroalgae in the region is brown algae; in particular, species from the genus *Sargassum*, *Dictyopteris*, and *Padina* are very common. The most common species of green algae in the Dampier Archipelago include Caulerpa species and calcareous *Halimeda* species. Various red algae are also found in the Dampier Archipelago, including corallines, calcified red algae, and algal turf (Woodside, 2006).

4.4.3 Intertidal Mudflats and Sand Flats

The intertidal zone of the Dampier Archipelago is characterised by wide sandflats and mudflats, rocky shores, coral reefs and mangroves, all of which support abundant and diverse invertebrate fauna. Intertidal mudflat and sandflats generally support an abundant and species-rich invertebrate fauna including molluscs, polychaete worms and crustaceans, which are a food source for foraging migratory birds (CALM, 2005).

4.4.4 Shorelines

The shorelines in the Dampier Archipelago include a diverse range of geomorphic units including:

+ intertidal rocky shores
+ subtidal rocky shores
+ intertidal limestone pavements
+ subtidal limestone pavements
+ intertidal flats
+ intertidal beaches
+ subtidal shoals
+ subtidal plains (Jones, 2004).

The habitats immediately surrounding the development envelope comprise rocky shorelines and the sandy beaches at No Name Bay (Woodside, 2015). The area is underlain by granophyre bedrock, which is a fine-grained acid igneous rock with similar mineralogical and chemical properties to granite (Woodside, 2015). Due to the nature of its formation, granophyre is a very hard.

4.4.5 Water and Sediment Quality

4.4.5.1 Water Quality and Characteristics

Mean water temperature of the nearshore waters of the Dampier Archipelago range from 22.5 °C in July/August to 30.4 °C in February. Nearshore waters are typically more saline although dilution of surface water occurs during periods of cyclonic activity and heavy rainfall. Water turbidity increases from the clear, oceanic waters offshore to relatively turbid waters inshore (Pearce et al, 2003). The higher level of turbidity in the nearshore environment is predominantly related to the continual resuspension of fine sediment material through natural inputs such as winds, tidal currents, and wave energy, which is exacerbated in shallow areas where strong tidal flows exist (such as through Flying Foam Passage) or where a high volume of vessel movements occur. Monitoring at 25 sites (outside dredging periods) spread throughout Mermaid Sound for dredging associated with the Pluto LNG Development found that long-term median turbidity (recorded as nephelometric turbidity unit [NTU]) ranged from 2 to 3.2 NTU (Woodside, 2006).

A study measuring dissolved concentrations of cadmium, chromium, copper, lead, and zinc, total mercury, polycyclic aromatic hydrocarbons (PAHs),

phenols, BTEX chemicals, and petroleum hydrocarbons found that water quality in the Dampier Archipelago met the guidelines for a 'high' Level of Ecological Protection (LEP) (99% species protection) based on the recommended guidelines and approaches in ANZECC and ARMCANZ (ANZECC and ARMCANZ, 2018). The study found no detectable levels of organics in the adjacent nearshore waters (Wenziker et al, 2006). Coastal waters are expected to be of high quality given the distance from shore and lack of terrigenous inputs.

Waters in the Dampier Archipelago are considered oligotrophic (deficient in plant nutrients). However, on occasions, blooms of nitrogen-fixing microbes such as *trichodesmium* or mangrove mudflat cyanobacterium may contribute significant amounts of nutrients into the marine environment. High spatial and seasonal variability are evident in nutrient and chlorophyll-a concentrations within the Dampier Archipelago (Woodside, 2006).

4.4.5.2 Sediment Quality

Sediment quality in the Dampier Archipelago has been studied extensively. These studies have rarely found anthropogenic contaminants in sediments of the Dampier Archipelago beyond relevant environmental guideline values. This has been attributed to the lack of riverine inputs and the controls on discharges associated with industrial development (Stoddart and Anstee, 2005). Sediments in Mermaid Sound are considered to be generally clean (i.e. below the screening levels of the National Ocean Disposal Guidelines for Dredged Material (Commonwealth of Australia, 2002), with tributyltin (TBT) the only anthropogenically sourced contaminant of concern) and are acceptable for ocean disposal. TBT paints on ships have been banned since 2008 and TBT concentrations have been declining in the Dampier Archipelago for many years. In 2015, OEPA endorsed a decision to cease monitoring for TBT as part of the annual ChEMMS program.

In 2017, metals within surveyed sediments were predominantly below the ANZECC and ARMCANZ (2000) trigger levels. Exceptions to this include Withnell Bay (for chromium, nickel), North East Creek (for nickel, mercury), Cowrie Cove (for nickel) and King Bay (for nickel). Previous studies of the Dampier region have shown naturally elevated levels of nickel and chromium present (DEC, 2006). Additional dilute acid testing was undertaken on samples exceeding the trigger level (i.e., nickel, chromium and mercury) which indicated that concentrations of these metals in an available state were very low. Mineralised forms of metals are not recognised as bioavailable due to not easily dissolving in the water or during passage through an organism gut. Comparisons between total metal concentrations and dilute acid extractable metals provides information as to what extent metals are mineralised. The low amounts of bioavailable nickel and mercury is a positive outcome, as while there is a notable presence of these metals in the sediment, the amount which is available to be absorbed by benthic biota, including surface-dwelling filter feeders (oysters) and grazers (mudwhelks) as well as rooted plants (mangroves), is well below the ANZECC and ARMCANZ (2000) guideline trigger levels. As such, there is no immediate risk to the receiving environment from these concentrations of metals.

In 2017, a one off investigation was undertaken to detect the presence of per- and poly-fluoroalkyl substances/ perfluorooctanoic acid (PFAS/PFOA) beyond the immediate plant boundary. Sediments were collected and analysed for the full suite of PFAS/PFOA contaminants, in accordance with the Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (DER, 2016). Sediment sampling and analysis at No Name Bay did not detect the presence of PFAS. Samples taken at North East Creek Beach detected PFAS at a maximum value of 0.001 mg/kg, which is significantly below the trigger level (2 mg/kg) in soil for the protection of human health (HEPA, 2018). The use of PFAS/PFOA at the KGP is being phased out and only used in emergency situations, therefore no increase in these values is expected.

4.4.6 Marine Fauna

An EPBC Act Protected Matters Search of the development envelope (with a 2 km buffer) (**Table 4-2**) and a review of other publicly available information has found that a number of protected species of fauna have potential to be near the Proposal.

The marine waters within the NWS Project development envelope are part of the Dampier Archipelago's coastal open water foraging habitat for numerous seabird species, with the coastal fringes of the Burrup Peninsula and Dampier Archipelago containing a range of intertidal habitats suitable for migratory shorebirds and resident wetland birds (See **Section 4.4.6.5**).

Table 4-3: EPBC Act Protected Matters Search Results Relevant to the Proposal

Species	Status EPBC Act
Birds	
Actitis hypoleucos Common Sandpiper	Migratory
Anous stolidus Common Noddy	Migratory
Apus pacificus Fork-tailed Swift	Migratory
Ardenna pacifica Wedge-tailed Shearwater	Migratory
Arenaria interpres Ruddy Turnstone	Migratory
Calidris acuminate Sharp-tailed Sandpiper	Migratory
Calidris alba Sanderling	Migratory
Calidris canutus Red Knot	Endangered, Migratory
Calidris ferruginea Curlew Sandpiper	Critically Endangered, Migratory
Calidris melanotos Pectoral Sandpiper	Migratory
Calidris ruficollis Red-necked Stint	Migratory
Calidris subminuta Long-toed Stint	Migratory
Calidris tenuirostris Great Knot	Critically Endangered, Migratory
Calonectris leucomelas Streaked Shearwater	Migratory
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover	Vulnerable, Migratory
Charadrius mongolus Lesser Sand Plover, Mongolian Plover	Endangered, Migratory
Charadrius veredus Oriental Plover, Oriental Dotterel	Migratory
Fregata ariel Lesser Frigatebird, Least Frigatebird	Migratory
Glareola maldivarum Oriental Pratincole	Migratory
Hydroprogne caspia Caspian Tern	Migratory
Limicola falcinellus Broad-billed Sandpiper	Migratory
Limosa lapponica Bar-tailed Godwit	Migratory
Limosa lapponica bauera Bar-tailed Godwit (bauera), Western Alaskan Bar-tailed Godwit	Vulnerable
Limosa lapponica menzbieri Bar-tailed Godwit (menzbieri), Northern Siberian Bar-tailed Godwit	Critically Endangered
Macronectes giganteus Southern Giant Petrel	Endangered, Migratory
*Numenius madagascariensi*s Eastern Curlew, Far Eastern Curlew	Critically Endangered, Migratory
Numenius phaeopus Whimbrel	Migratory
Onychoprion anaethetus Bridled Tern	Migratory
Pandion haliaetus Osprey	Migratory
Pezoporus occidentalis Night Parrot	Endangered
Phalaropus lobatus Red-necked Phalarope	Migratory
Pluvialis fulva Pacific Golden Plover	Migratory
Pluvialis squatarola Grey Plover	Migratory
Rostratula australis Australian Painted Snipe	Endangered
Sterna dougallii Roseate Tern	Migratory
Sternula nereis nereis Australian Fairy Tern	Vulnerable
Thalasseus bergii Crested Tern	Migratory
Tringa brevipes Grey-tailed Tattler	Migratory

Species	Status EPBC Act
Tringa nebularia Common Greenshank, Greenshank	Migratory
Tringa stagnatilis Marsh Sandpiper, Little Greenshank	Migratory
Tringa totanus Common Redshank, Redshank	Migratory
Xenus cinereus Terek Sandpiper	Migratory
Mammals	
Dugong dugon Dugong	Migratory
Megaptera novaeangliae Humpback Whale	Vulnerable, Migratory
Sousa chinensis Indo-Pacific Humpback Dolphin	Migratory
Tursiops aduncus Spotted Bottlenose Dolphin	Migratory
Reptiles	
Aipysurus apraefrontalis Short-nosed Sea snake	Critically Endangered
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth	Endangered, Migratory
Caretta caretta Loggerhead Turtle	Endangered, Migratory
Chelonia mydas Green Turtle	Vulnerable, Migratory
Eretmochelys coriacea Hawksbill Turtle	Vulnerable, Migratory
Natator depressus Flatback Turtle	Vulnerable, Migratory
Fish	
Anoxypristis cuspidate Narrow Sawfish, Knifetooth Sawfish	Migratory
Carcharias taurus Grey Nurse Shark	Vulnerable
Carcharodon carcharias White Shark, Great White Shark	Vulnerable, Migratory
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray	Migratory
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray	Migratory
Pristis clavate Dwarf Sawfish, Queensland Sawfish	Vulnerable, Migratory
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish	Vulnerable, Migratory
Rhincodon typus Whale Shark	Vulnerable, Migratory

Marine Mammals

An EPBC Act Protected Matters search identified a number of marine mammal species that may occur within the vicinity of the State waters component of the development envelope, including four species that have been identified as having ecologically significant interactions (e.g. through biologically important areas [BIA]) in the area or that are considered 'iconic' including:

+ Humpback whale (Megaptera *novaeangliae*)
+ Indo-Pacific humpback dolphin (*Sousa chinensis*)
+ Indian Ocean bottlenose dolphin (*Tursiops aduncus*)
+ Dugong (*Dugong dugon*).

These four species are described in more detail below.

Humpback Whale

Humpback whales are listed as vulnerable and migratory under the EPBC Act. The west coast population of humpback whales is genetically distinct from the eastern Australian population.

The west coast population of the humpback whale generally migrates along the coast ~20 km from shore (DoEE, 2019b). The southern migration route (peaking in late August/early September) is closer to the mainland and traverses the Dampier Archipelago (DoEE, 2019b). Inshore waters of the Dampier Archipelago are used as resting areas, including a female and calf humpback resting area, which is traversed by 1TL and 2TL (DEH, 2005).
The northern migration during July moves further offshore to breeding and calving grounds, and resting areas.

Some of the Proposal infrastructure is located within a migratory BIA for Humpback Whales (DoEE, 2019c) (**Figure 4-15**).

Indo-Pacific Humpback Dolphin

Indo-Pacific humpback dolphins typically inhabit coastal areas, residing in shallow coastal, estuarine, and occasionally riverine habitats in tropical and subtropical regions, in less than 20 m depth (DoE, 2019) although they have been sighted in depths ranging from 1 to 40 m

in other areas such as Ningaloo Reef and Exmouth Gulf. Indo-Pacific humpback dolphins forage in a range of habitats including coastal lagoons, enclosed bays, around islands and reefs (Woodside, 2015). This species is classified as migratory under the EPBC Act and is known to inhabit the northern Australian coastline, with its distribution appearing to extend as far south as Exmouth Gulf (Woodside, 2015). Although frequently sighted in the Pilbara region, this species occurs in low numbers and is widely spread (Woodside, 2015). Given its affinity for shallow coastal waters, this species has the potential to occur within the development envelope in any season.

Indian Ocean Bottlenose Dolphin

Bottlenose dolphins are distributed continuously around Australia. The Indian Ocean bottlenose dolphin is considered to be a warm water subspecies of the common bottlenose dolphin, and occupies inshore waters, often in depths of less than 10 m (Chevron, 2010). Although it may use a range of habitats (including estuaries and nearshore environments), it mostly frequents open coastal waters (DoE, 2019). This species is classified as migratory under the EPBC Act and is known to occur from Shark Bay north to the western edge of the Gulf of Carpentaria (Woodside, 2015). In the Pilbara region, this species occurs in low numbers and is widely dispersed (Woodside, 2015). Given its affinity for shallow coastal waters, this species has the potential to occur within the development envelope in any season.

Dugongs

Dugongs are associated with tropical and subtropical coastal waters, particularly shallow, protected waters such as sheltered bays, mangrove channels, and in the lee of large inshore islands

The EPBC Act lists dugongs as marine and migratory, and they are specially protected under the *Biodiversity Conservation Act 2016* (WA) (BC Act). Dugongs are large herbivorous marine mammals that feed on seagrass beds and macroalgae in coastal areas, with the availability of food resources thought to drive their migration patterns (DoEE, 2019d). The dugong has a widespread distribution throughout the Pilbara region, which includes the Dampier Archipelago, Barrow Island, the Montebello Islands, Lowendal Island, and Exmouth Gulf (DoEE, 2019d). Inside the Dampier Archipelago, dugongs have been recorded near various islands, including Rosemary, East Lewis, West Lewis, Keast, Legendre, and Little Rocky Islands (Woodside, 2015). Dugongs have also been known to occur in shallow sheltered bays of the Burrup Peninsula and the mainland coast such as Regnard Bay and Nickol Bay, as well as the seaward side of the Hamersley Shoal at the entrance of the Mermaid Sound (Woodside, 2015).

Although the nearshore areas near the development envelope contain seagrass habitats that may represent habitat for dugongs, the area does not constitute critical habitat. The closest dugong BIA is at Exmouth Gulf more than 235 km away from the Proposal. Dugong feeding grounds occur around Angel and Gidley Islands and sightings have occurred in this area, 1TL and 2TL traverse the seabed adjacent (Woodside, 2006). Additional sightings/feeding grounds are located around Malus, East Lewis, and West Lewis Islands, with the closest feeding area on East Lewis Island, approximately 10 km away from the Proposal.

Turtles

An EPBC Act Protected Matters search identified five marine turtle species that may occur within or near the development envelope; the vulnerable and migratory Green Turtle (*Chelonia mydas*), the endangered and migratory Leatherback Turtle (*Dermochelys coriacea*), the endangered and migratory Loggerhead Turtle (*Caretta caretta*), the vulnerable and migratory Hawksbill Turtle (*Eretmochelys coriacea*), and the vulnerable and migratory Flatback Turtle (*Natator depressus*). These five marine turtle species are also classified as threatened under the BC Act.

Of these species, four (Green, Loggerhead, Flatback, and Hawksbill) have significant nesting beaches along the mainland coast and islands in the Pilbara region including the Dampier Archipelago (Woodside, 2015). There are areas known to be important marine turtle aggregation areas within the Dampier Archipelago, in waters surrounding Rosemary, Hauy, Legendre, and Delambre Islands. There are also BIAs within the development envelope for Flatback, Green, and Hawksbill turtles (Woodside, 2006) (**Figure 4-15**). Flatback turtles are known to have major nesting at Delambre Island; and Hawksbill turtles are known to have major nesting areas on Rosemary and Delambre Islands with the largest nesting aggregation recorded at Rosemary Island.

Table 4-4: Key Information on Marine Turtles in the North West Shelf Marine Region

Turtle Species	Key Season	Diet	Key Habitats
Green Turtle	**Breeding:** Approximately September to December. **Nesting:** November to March. Peak period from January to April.	Seagrasses and algae.	**Preferred habitat:** Estuarine, rocky and coral reef, seagrass, and nearshore reef habitats in the photic zone. **Distribution:** North West Shelf Marine Region: Ningaloo coast to Lacepede Islands. **Major nesting sites:** Montebello Islands, Barrow Island, Muiron Islands, some islands of the Dampier Archipelago, Lacepede Islands, and North West Cape.
Loggerhead Turtle	**Breeding:** Approximately September to March **Nesting:** Late October to late March. Peak period from late December to early January.	Carnivorous – feeding mainly on molluscs and crustaceans.	**Preferred habitat:** Rocky and coral reefs, seagrass pastures, and estuaries. **Distribution:** North West Shelf Marine Region: Shark Bay to North West Cape and as far north as Muiron Islands and Dampier Archipelago. **Major nesting sites:** Principally from Dirk Hartog Island, along the Gnaraloo and Ningaloo coast to North West Cape and the Muiron Islands. There have been occasional records from Varanus and Rosemary Islands in the Pilbara. Late summer nesting recorded for Barrow Island, Lowendal Islands, and Dampier Archipelago.
Hawksbill Turtle	**Nesting:** All year round with peak in October to January.	Mainly sponges – also seagrasses, algae, soft corals, and shellfish.	**Preferred habitat:** Rocky and coral reef habitats. **Distribution:** North West Shelf Marine Region: Shark Bay to Dampier Archipelago. **Major nesting sites:** There is a single breeding stock in the region centred around the Dampier Archipelago. The most significant rookery in WA is at Rosemary Island. Other rookeries include Varanus Island in the Lowendal group, and some islands in the Montebello group.
Flatback Turtle	**Nesting:** November to March with peak period in January.	Carnivorous – feeding mainly on soft-bodied prey such as sea cucumbers, soft corals, and jellyfish.	**Preferred habitat:** Nearshore and offshore subtidal and soft-bottomed habitats of offshore islands. **Distribution:** North West Shelf Marine Region: Lacepede Islands to Exmouth. **Major nesting sites:** The largest nesting sites of the Pilbara region are Barrow Island and the mainland coast (Mundabullangana Station near Cape Thouin, and smaller nesting sites at Cemetery Beach in Port Hedland and Bells Beach near Wickham). Other significant rookeries include Thevenard Island, the Montebello Islands, Varanus Island, the Lowendal Islands, and islands of the Dampier Archipelago.
Leatherback Turtle	**Nesting:** No confirmed nesting activity in WA.	Carnivorous – feeding mainly in the open ocean on jellyfish and other soft-bodied invertebrates.	**Preferred habitat:** Nearshore, coastal tropical and temperate waters. **Distribution:** May be encountered in North West Shelf Marine Region but more commonly found in Australian East Coast waters. **Major nesting sites:** No known nesting sites within the North West Shelf Marine Region.

Based on: Recovery Plan for Marine Turtles in Australia 2017–2027 (DoEE, 2017)

Tracking data for post-nesting Green, Hawksbill and Flatback turtles recorded for the Pilbara region show that turtles travelling from nesting sites to foraging grounds would travel through to east or south of Barrow Island and the Dampier Archipelago, and north of Broome to foraging grounds. However, Hawksbill turtles generally travelled south to the coastal island chain south of Barrow Island (Woodside, 2015).

This tracking data also indicates the three marine turtle species recorded for the Pilbara region travel and forage in coastal waters that are relatively shallow:

+ Hawksbill turtles: less than 10 m deep
+ Green turtles: less than 25 m deep
+ Flatback turtles: less than 70 m deep (Woodside, 2015).

There is a potential for turtles to occasionally navigate through the development envelope in any season due to their occurrence in coastal waters and breeding activity within the Dampier Archipelago. Beaches within the development envelope have not been identified as being biologically important nesting beaches, but occasional nesting has been observed.

Sea Snakes

Two families of sea snake are found in Australian waters—the true sea snakes (family *Hydrophidae*) and sea kraits (family *Laticauda*) (Commonwealth of Australia, 2012). Sea snakes show diversity across various habitat types, including coral reefs, deep inter-reef areas, rocky substrates, and muddy substrates (Commonwealth of Australia, 2012). Although sea snakes are air-breathing, they can dive to depths of around 100 m, so may utilise habitat up to 100 m deep (DBCA, 2015).

Sixteen sea snake species were identified as potentially occurring in the Proposal area. One of these species—the short-nosed sea snake (*Aipysurus apraefrontalis*), is classified as critically endangered under the EPBC Act and threatened under the BC Act. The short-nosed sea snake has a widespread distribution and inhabits reef flats and shallow waters up to 10 m depth (DoEE, 2019e).

Sharks and Fish

Shallow water (less than 30 m depth) fish species have been recorded in the waters of the Dampier Archipelago, comprising:

+ 456 coral reef species
+ 116 mangrove species
+ 106 soft-bottom species
+ 67 pelagic species (Hutchins, 2004).

Areas of greater topographic diversity, such as those along the northern edge of the Dampier Archipelago, generally host a greater diversity of fish species (Hutchins, 2004).

A number of teleost fish species have been identified in the EPBC Act Protected Matters search for the Proposal, including 29 species of pipefish, six species of seahorse, and one sea dragon species. These species are commonly found in seagrass and sandy habitats close to islands or reefs and have potential to be found in the development envelope.

Vulnerable marine shark species potentially occurring near the Proposal include the grey nurse shark (*Carcharias taurus*), the great white shark (*Carcharodon carcharias*), the green sawfish (*Pristis zijsron*), the dwarf sawfish (*Pristis clavata*) and manta rays.

Seabirds and Shorebirds

A large number of seabird and shorebird species (or species habitat) may occur near the Proposal; these include species classified as threatened and migratory under the EPBC Act or specially protected under the BC Act (WA). Most species identified are also migratory, so their presence would only be expected during part of the year (Woodside, 2006) .

A search of the DBCA NatureMap database and the EPBC Act Protected Matters search tool indicated that at least 59 bird species could be present at the Burrup Peninsula and the surrounding islands of the Dampier Archipelago. The coastlines in the archipelago include a diverse range of geomorphic units, which provide diverse habitat types attracting a range of migratory shorebirds and resident wetland birds. Furthermore, small islands in the area provide important nesting and refuge sites (DSEWPC, 2012b). Conzinc Island, which is the closest island to the Proposal trunklines is a (predominantly) winter nesting site for a range of seabirds including the wedge-tailed shearwater (*Puffinus pacificus*), roseate tern (*Sterna dougallii*), and fairy tern (*Sterna nereis*) (CALM, 2000).

Several migratory, marine, and conservation significant bird species were identified as potentially occurring near the Proposal area through EPBC Act searches (**Table 4-2**). Due to the high-flow, short-duration freshwater events on the Burrup Peninsula, migratory wetland species identified in the searches are unlikely to occur near the Proposal, other than as occasional visitors.

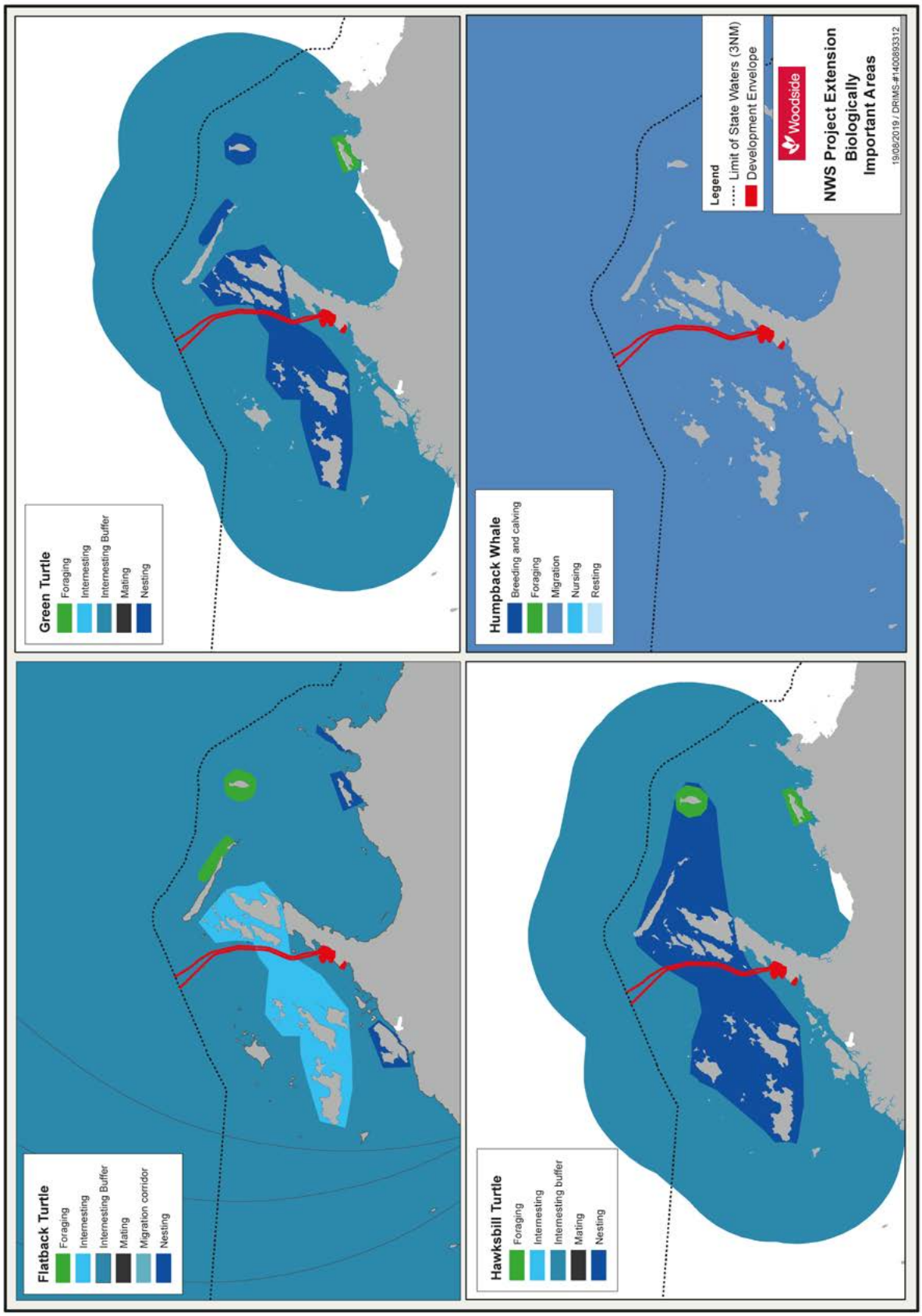


Figure 4-15: Biologically Important Areas that intercept the proposal development envelope (DoEE, 2019c)

4.4.7 Sensitivity of the Marine Environment

The sensitivity of the marine environment has been determined using the environmental values and Levels Of Protection (LEP) identified by the Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives (DoE, 2006b). Areas of maximum ecological protection are considered to have a high sensitivity as they generally incorporate pristine areas with no existing impact. Areas of moderate ecological protection are not considered to be sensitive environments due to the presence of elevated or high levels of contaminants.

Areas that provide habitat for marine species used by or important to the local Aboriginal groups of the Burrup Peninsula are considered to be sensitive. In particular, areas of habitat for dugongs and turtles, nesting areas for turtles and seabirds, and areas used for customary fishing (including fish traps, spearing and line fishing) and gathering are of importance to Aboriginal people. The Flying Foam Edible Oyster Project, a joint venture between the Murujuga Aboriginal Corporation, Maxima Pearling Company, Pilbara Development Commission, Fisheries Research and Development Commission and City of Karratha, has also been assigned a high level of sensitivity.

Table 4-5 details the marine environments considered to be of high or medium sensitivity.

Table 4-5: Marine Environments with Medium or High Sensitivity

Description	Reason for Sensitivity
Areas identified in DoE (2006b) as having the Maximum LEP.	These areas show no detectable change from the natural variation of the environment. Maximum LEP areas are considered pristine and include marine parks. They are considered highly sensitive.
Areas identified in DoE (2006b) as having the High LEP.	These regions typically retain all ecosystem function, however are influenced by anthropogenic influences such as mobilisation of sediments from ship movements or dredging. They are considered to have a moderate sensitivity.
Habitat for marine fauna used by Aboriginal people including: + Dugongs. + Turtles.	Dugongs and turtles are hunted by Aboriginal people as a customary food source. They are considered highly sensitive.
Turtle nesting beaches and seabird nesting areas.	Eggs are collected by Aboriginal people as a customary food source. They are considered highly sensitive.
Customary fishing and gathering areas.	Areas used by Aboriginal people that provide an ongoing connection to the land and traditional ways of life. They are considered highly sensitive.
Flying Foam Oyster Project.	Production of edible oysters for commercial sale. This area is also within a Maximum LEP. They are considered highly sensitive.

4.5 Existing Infrastructure

An important feature of the marine receiving environment in the context of this ERD is the existing NWS Project infrastructure. The following paragraphs describe the infrastructure that interacts with the marine environment and the processes in place to manage discharges to the marine environment.

The existing NWS Project infrastructure that interacts with the marine environment includes, but is not restricted to:

+ Existing offshore infrastructure within State waters, which includes two jetties, two trunklines, jetty outfall, and dredged channels within the Port of Dampier.
+ Existing discharges from onshore infrastructure specifically
  + Licenced discharge of treated stormwater and treated wastewater from the jetty outfall into Mermaid Sound.
  + Stormwater, site run-off, and treated effluent from the sewage treatment plant and demineralisation plant into the administration drain and then into No Name Creek.
+ Sewage discharges and site run off from King Bay Supply Base.

The existing marine environment, which broadly maintains a high level of environmental quality, is

characterised by shipping and industrial activities including the presence of the Proposal. Although unrelated to the Proposal, shipping activity from the Port of Dampier and independent Rio Tinto shipping terminals in the area also define the existing marine environment. The Mermaid Sound and Dampier Archipelago have areas of high environmental quality that sustain significant marine ecosystems and important coastal processes.

The benthic environment has been historically dredged to allow LNG, LPG, condensate vessels and logistical support vessels to transit to and from the NWS Project's onshore infrastructure and is regularly disturbed by frequent vessel movements.

4.6 Social Environment

The NWS Project is located 10 km north-east of Dampier and 18 km north-west of Karratha, within the administrative area of the City of Karratha. Bounded by the Shire of Ashburton to the south, the Town of Port Hedland to the east, and the Indian Ocean to the north and west, the City of Karratha is home to four industrial ports and contributes approximately $8.76 billion to the national economy each year (City of Karratha, 2018).

The City of Karratha is home to approximately 22,200 residents, which represents an increase in population of 31% over the last ten years. Forecasted figures indicate continued growth, and city infrastructure such as power, water, and sewerage have all been upgraded in preparation for this anticipated expansion.

A search of the WA State Heritage Register on 6 May 2019 indicated that the two closest non-Aboriginal registered sites are east of the development envelope. These sites are Watering Cove and Hearson Cove, both on the eastern coastline of the Burrup Peninsula and at least 5 km from the Proposal. Hearson Cove is listed as a historic landing place of the Northwest Exploring Expedition led by F.T. Gregory in 1861 (Heritage Council, 2016); and Watering Cove is also listed as a historic site of importance to the Northwest Exploring Expedition (Heritage Council, 2016).

From an Aboriginal cultural heritage perspective, the wider western Pilbara region and Dampier Archipelago contain a prolific and diverse range of Aboriginal heritage sites and objects. Aboriginal heritage represented in the region includes rock art sites, ethnographic sites, standing stones, shell middens, artefact scatters, quarries, and grinding patches. These heritage features are thought to pre-date sea-level rises that occurred 9,000 – 6,000 years ago and therefore there may also be submerged heritage features in the areas surrounding the Dampier Archipelago (MAC, 2016). However, the Western Australia Maritime Archaeology database did not identify any listed submerged heritage features in or near the development envelope.

It has been estimated that the Dampier Archipelago, including the Burrup Peninsula, may contain up to one million petroglyphs (Vinnicombe, 2002) at a density of between 17 and 76 heritage sites per square kilometre (Bird and Hallam, 2006). The petroglyphs feature a range of motif types including anthropomorphic and zoomorphic figures and geometric and amorphous designs. At a national level, the range of anthropomorphic figures is diverse and the petroglyphs vary considerably in their motif subject content, technique, antiquity, and distribution across the landscape.

State records and the NWSJV's own surveys during the operation of the NWS Project have identified a range of Aboriginal heritage site types, inside and adjacent the development envelope. An audit of Aboriginal heritage sites within the development envelope confirmed the presence of 134 sites currently preserved in situ (Mott et al, 2007). Records have not confirmed the presence of submerged heritage features.

Murujuga National Park and the listed National Heritage Place of the Dampier Archipelago (including Burrup Peninsula; (**Figure 4-16**), are east of the development envelope. The boundary of the National Heritage Place overlaps the onshore NWS Project lease area in the north-east at Withnell Bay, at Mount Wongama Road, and over a section of the Mount Wongama telecommunications lease. Further south, the National Heritage Place is 150 m or more from the edge of the NWS Project lease boundary. **Figure 4-16** shows where the Murujuga National Park and the National Heritage Place are located in relation to the development envelope.

Figure 4-16: Social Environment

4.6.1 The Burrup Peninsula

The Proposal is located on the Burrup Peninsula, traditionally referred to as Murujuga. The Burrup Peninsula has a significant cultural heritage, with evidence of a 30,000 year relationship between Aboriginal people and the Pilbara (City of Karratha, 2019).

In the context of Aboriginal cultural heritage, the Burrup Peninsula is most widely known for its large collection of rock art (in the form of petroglyphs). The Burrup Peninsula and surrounding islands of the Dampier Archipelago have one of the largest and most diverse collections of rock art in the world, which have significant cultural value to Traditional Owner groups and to Aboriginal people more broadly (DWER, 2019b). The Traditional Owners of Murujuga have a deep cultural and spiritual connection to the rock art of the Burrup Peninsula, which provides a record of Aboriginal lore, dreamtime stories, customs, and local knowledge of the land and its resources (MAC, 2019).

In 2003, the Murujuga Aboriginal Corporation (MAC) was formed as a part of the Burrup and Maitland Industrial Estates Agreement with the WA Government. This corporation represents five traditional groups—the Ngarluma People, the Mardudhunera People, the Yaburara People, the Yindjibarndi People, and the Wong-Goo-Tt-Oo People (MAC, 2018). MAC maintains freehold title to the Murujuga National Park, which lies near the development envelope, and co-manages the area with the DBCA (MAC, 2018).

4.6.2 Heritage Places and Features

The Burrup Peninsula has a substantial amount of Aboriginal heritage places and features, which hold significant cultural value to Aboriginal people. These features and sites include petroglyph sites, ethnographic sites, standing stones, shell middens, artefact scatters, quarries, grinding patches, and coastal fishing and foraging activities (Heritage Council, 2017).

To characterise the heritage places and features of the Burrup Peninsula for this ERD, Woodside used government heritage databases, publicly available published sources, outcomes of Woodside-commissioned archaeological and ethnographic surveys, and outcomes from engagement with relevant Aboriginal groups throughout the development of this ERD.

Although the value of the Burrup Peninsula varies between individuals and groups, the richness of the heritage features led to its listing as a National Heritage Place in 2007 as the 'Dampier Archipelago (including Burrup Peninsula) National Heritage Place'. Further information on the status, features, and protection of the National Heritage Place under the EPBC Act is included in **Section 7**. In addition to the National Heritage Place listing, a large area of the Burrup Peninsula is registered on the State Heritage Register as Place Number 08663 (Burrup Peninsula and Hearson Cove).

State records and Woodside's own surveys have identified a range of Aboriginal heritage site types, inside and adjacent to the development envelope. An audit of Aboriginal heritage sites within the development envelope confirmed the presence of 134 Aboriginal heritage sites preserved in situ (Mott et al, 2007). Woodside maintains a database of Aboriginal heritage sites and quarterly heritage update meetings are held with Traditional Owners, and discussions include NWS Project-related activities and ongoing heritage management requirements. Annual Aboriginal heritage site audits are conducted with Traditional Owners and a qualified archaeologist to inspect, monitor, and report on the condition of the sites within the development envelope. Due to the cultural sensitivity of some features, the exact heritage site locations are not published and are not given in detail in this document.

Outside the Proposal development envelope, the Burrup Peninsula, and surrounding islands of the Dampier Archipelago, it has been estimated that the Dampier Archipelago, including the Burrup Peninsula—may contain up to one million petroglyphs (Vinnicombe, 2002) at a density of between 17 and 76 heritage sites per square kilometre (Bird and Hallam, 2006). The petroglyphs depict a range of terrestrial and marine fauna, extinct mammals, snakes, and reptiles, as well as human figures in complex group scenes. Although rock art is difficult to date, the petroglyphs on the Burrup Peninsula are estimated to be up to 30,000 years old (Gregory, 2009; Mulvaney, 2011), and are on a range of rock types. The images depicted by the petroglyphs were created by removing part of a rock surface by hammering (pecking, pounding, bruising) and abrading (rubbing, incising, scraping) (SECRC, 2018). The petroglyphs are found on the weathered rock surfaces of igneous rocks (granophyric rhyodacite, granites, gneissic granites, and gabbro) formed when molten magma cools. The granites and gabbro of the Burrup Peninsula are coarse-grained, while the granophyre is a fine-grained rock. Most of the petroglyphs are found on granophyric rhyodacite (Vinnicombe, 2002). The extensive petroglyph collection on the Burrup Peninsula is of significant cultural heritage value, connecting Aboriginal people today to the traditions of their ancestors. They depict significant social, economic, and spiritual insights into the life of ancient peoples and showcase tens of thousands of years of connection between Aboriginal people and country.

Engagement with relevant Aboriginal groups throughout the preparation of this ERD did not identify any additional heritage features relevant to the Proposal.

4.6.3 Vegetation with Heritage Value

Vegetation with heritage value is also found on the Burrup Peninsula. To characterise the heritage value and sensitivity of vegetation in and adjacent to the development envelope Woodside used publicly available

published sources, results of the ethnographic surveys and audits undertaken in June and October 2018 and reported in November 2018 (IHS, 2018), and outcomes of engagement with relevant Aboriginal groups. As discussed in **Section 4.3.2**, vegetation that contains plants used by Aboriginal people is considered to be 'sensitive' vegetation.

Many plants found on the Burrup Peninsula are used by Aboriginal people, including *Acacia coriacea* (used for spears and boomerangs), *A. pyrifolia* (Kanji Bush, edible seeds and gum), *Avenica marina* (edible seeds), *Ficus brachypoda* (Rock Fig, edible fruit) and various *Solanum* species (Bush Tomato, edible fruit) (City of Karratha, 2013). The Murujuga Cultural Management Plan (MAC, 2016) also emphasises the heritage value of vegetation on the Burrup Peninsula identifying that some trees provide medicine for colds and flus, shade for shelter, and ceremonial tools; examples include Jami bush used to treat aches, pains, and cuts; mangroves used for fishing; and spinifex seeds used to make damper.

The 2018 ethnological surveys and audits conducted by Woodside with Traditional Owners and a qualified archaeologist and anthropologists identified two bush-medicine plants growing at Withnell Bay—one is used as a healing balm for physical injuries and colds, and is also a spiritual protection for people visiting country; the other is used to settle the stomach and is also a source of food (IHS, 2018).

Engagement with relevant Aboriginal groups throughout the preparation of this ERD did not identify any additional vegetation with heritage values.

4.6.4 Heritage Value of the Marine Environment

The Aboriginal groups whose traditional country includes the Burrup Peninsula have connections to and uses for the sea, including coastal areas adjacent to the development envelope. To characterise the heritage value and sensitivity of the marine environment, Woodside used publicly available published sources, results from ethnographic surveys conducted in June and October 2018 and reported in November 2018, and outcomes of engagement with relevant Aboriginal groups.

The relationship Aboriginal peoples have with the marine environment began thousands of years ago and Aboriginal groups continue to rely on the coastal and marine environments of the region for their cultural identity, wellbeing, and their domestic and commercial economies (Smyth, 2007).

As stated in **Section 4.6.2**, the petroglyphs on the Burrup Peninsula contain many depictions of marine fauna, including those hunted for food by the Aboriginal peoples of the area (IHS, 2018). Midden sites have also been found, indicating shellfish foraging (IHS, 2018). Aboriginal peoples have traditionally used and continue to use the marine environment for a diverse range of aquatic and customary fishing activities, including:

+ hunting (dugongs, turtles)
+ egg collecting (turtles, seabirds)
+ capturing fish (spearing, reef trapping, herding, line fishing, collecting in stone fish traps, poisoning)
+ gathering shellfish and other marine resources.

Customary fishing is done in accordance with relevant Aboriginal laws and customs to satisfy personal, domestic, ceremonial, educational, or non-commercial communal needs, using various technologies and practices, including spears, specially designed boomerangs, and traps.

The Murujuga Aboriginal Corporation has entered into a joint venture partnership with Maxima Pearling Company, Pilbara Development Commission, Fisheries Research and Development Commission and City of Karratha for a trial rock oyster farm to determine if safe edible oysters can be produced in the Dampier Archipelago. The trial was established in 2017 in Flying Foam Passage (between Angel and Dolphin Islands) and repurposes the pearl farming licences held by Maxima Pearling Company.

Engagement with relevant Aboriginal groups throughout the preparation of this ERD did not identify any additional heritage values or sensitivities of the marine environment.

STAKEHOLDER ENGAGEMENT

Woodside

5. STAKEHOLDER ENGAGEMENT

5.1 Overview

Woodside has been part of the Australian community for more than 60 years and has been operating on the Burrup Peninsula for more than 30 years. Woodside has well-established relationships with the Pilbara community, and regularly engages with stakeholders through various forums on a broad range of issues, including potential environmental and social impacts associated with its operations.

Key to understanding local issues are mechanisms such as the Karratha Community Liaison Group, which holds quarterly meetings with a range of local government, State Government, and industry representatives. Woodside also has an established office in Karratha, which provides an avenue for locals to discuss any issues in person.

Stakeholder consultation and engagement is an integral component of the environmental impact assessment and environmental approvals process. This section describes Woodside's approach, as Operator for and on behalf of the NWSJV, to stakeholder consultation broadly and for the Proposal specifically.

Woodside's objectives for stakeholder consultation are to:

+ Improve stakeholder awareness and understanding of the Proposal.
+ Provide stakeholders with opportunities to obtain information about the Proposal including the physical, ecological, socio-economic and cultural environment that may be affected, the potential impacts that may occur, and the prevention and mitigation measures proposed to avoid or minimise those impacts.
+ Gain feedback from stakeholders on their concerns in regard to the Proposal and where possible, address stakeholder concerns through further activities, or by implementing additional mitigation measures.

Stakeholder engagement in relation to this Proposal includes engagement with identified stakeholders undertaken as part of a voluntary NWS Project Extension Social Impact Assessment (SIA) (Advisian, 2019).

5.2 Stakeholder Identification

The process for stakeholder consultation as undertaken by Woodside as the Operator of the NWS Project included the identification of stakeholders and their relevance to the Proposal.

Table 5-1 on the next page outlines a summary of stakeholders and stakeholder groups. Stakeholders were identified as a result of Woodside's current and ongoing activities, direct engagements with government agencies and regulators and via community engagements and forums.

Table 5-1: Stakeholders and Stakeholder Groups

Commonwealth Government Agencies	
Department of Industry, Innovation and Science (DoIIS)	National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA)
Department of Environment and Energy (DoEE)	National Offshore Petroleum Titles Administrator (NOPTA)
Australian Industry Participation Authority	Australian Fisheries Management Authority (AFMA)
Department of Agriculture and Water Resources – Biosecurity	Department of Foreign Affairs and Trade (DFAT)
Department of Prime Minister and Cabinet	
WA State / Local Government Agencies	
Environmental Protection Authority (EPA)	Department of Mines, Industry Regulation and Safety (DMIRS)
Department of Jobs, Tourism, Science and Innovation (DJTSI)	Department of Transport (DoT)
Department of Planning, Lands and Heritage (DPLH)	Department of Water and Environmental Regulation (DWER)
Department of Education	Pilbara Development Commission
Regional Development Australia	City of Karratha
Traditional Owner Groups / Indigenous Stakeholders	
Murujuga Aboriginal Corporation (MAC)	Ngarluma Yindjibarndi Foundation Ltd (NYFL)
Ngarluma Aboriginal Corporation (NAC)	Five language groups with interests over the Burrup: Ngarluma, Yindjibarndi, Wong-Goo-Tt-Oo, Yaburara and Mardudhunera
Business / Tourism / Peak Bodies / Education providers / Community Groups	
Karratha Community Liaison Group	Local service providers
Karratha Tourism and Visitor Centre	Local education providers
NGOs	
Australian Conservation Foundation	The Wilderness Society of WA
World Wildlife Fund	Friends of Australian Rock Art (FARA)
Conservation Council of WA	Marketforces
Greenpeace	
Fisheries	
Western Australia Fishing Industries Council (WAFIC)	AFMA (see above)
Commonwealth Fisheries Association	
Industry	
Australian Petroleum Production and Exploration Association (APPEA)	Chamber of Minerals and Energy of Western Australia (CME)
Australian Marine Oil Spill Centre (AMOSC)	Various oil and gas operators

Note: Members of State and Federal Parliament including Ministers and Shadow Ministers were identified and engaged accordingly however are not individually listed above.

5.3 Stakeholder Engagement Process

Woodside, as Operator for and on behalf of the NWSJV, has undertaken a phased stakeholder engagement program for the Proposal, which will continue throughout the environmental impact assessment process. This program is based on utilising existing relationships and engaging more broadly with parties likely to have an interest in the Proposal. Stakeholders include DMAs, other relevant State and Commonwealth government agencies, local government authorities, the local community, environmental non-governmental organisations, academics, and research organisations.

Stakeholder activities to date have included:

+ social impact assessment
+ social impact management planning
+ economic impact assessment
+ one-on-one engagement
+ broad stakeholder forums
+ targeted correspondence
+ hard-copy and electronic communication materials
+ advertising, media and social media.

Table 5-2 summarises the stakeholder consultation relevant to this Proposal.

5.4 Stakeholder Consultation

5.4.1 Voluntary Social Impact Assessment (SIA)

Woodside commissioned a voluntary NWS Project Extension SIA of the Proposal to support internal decision-making. The SIA represents a separate process to the broader stakeholder engagement undertaken by Woodside. The SIA was finalised in 2019 (Advisian, 2019).

Stakeholder engagement as part of the SIA process was undertaken in December 2018 and April 2019 in order to:

+ Provide details of the proposed NWS Project Extension, as part of broader Woodside activities.
+ Better understand stakeholder and community perceptions of the potential impacts and benefits of the proposed NWS Project Extension
+ Verify baseline data, collect further baseline data against some indicators and identify local values, attitudes and aspirations.

Stakeholder groups consulted included:

+ local Chamber of Commerce
+ Indigenous organisations
+ local businesses
+ local government staff and councillors
+ ports
+ regional development
+ service providers including community, education, health.

The overall sentiment from stakeholders who were engaged in 2018 and 2019 for the SIA recognised that Karratha Local Government Area (LGA) had undergone a series of peaks and troughs of economic activity and expressed a desire to leverage the long-term nature of Woodside's activities and operations to ensure the ongoing sustainability of the Karratha region. There was a general interest in understanding local employment and training opportunities, especially for Indigenous stakeholders. Some stakeholders also raised matters of potential impacts to rock art. The key findings of the SIA are outlined below.

5.4.1.1 SIA Key Findings

For existing NWS operations, Woodside has committed to transitioning towards a predominantly residential workforce, based in the Karratha LGA. The operations workforce is anticipated to be a continuation of existing numbers, skill-sets and roles, including operators, maintainers, engineering, logistics, asset management, technical and functional support until around 2070.

Economic Development, Employment and Skills Development

Woodside's proposal to extend the life of the NWS Project to approximately 2070 and their existing policy to implement a predominantly residential workforce stands to provide direct long-term economic development opportunities to the State, regional and local Karratha economies.

There is a real opportunity for the community to continue to benefit from the project in the long-term, including participation by local businesses in the supply chain and continued opportunities for local training and employment.

Population growth

SIA consultations identified a clear desire for long-term sustained population growth in the Karratha LGA. The move to a predominantly residential Karratha based workforce was well-received by stakeholders. There was a recognition that the impact of various factors including fluctuating populations due to resources development needs to be managed better into the future.

Housing and accommodation

Strong stakeholder sentiment exists in the Karratha LGA around FIFO and housing. It is acknowledged that there is a sector of the community that is vulnerable to housing availability and affordability. It is recognised that there will need to be continued planning and transparent

communication with the Karratha LGA on the Woodside residential footprint to support effective regional accommodation planning.

Community amenity and lifestyle

The extended time frame and potential population increase as a result of the implementation of a predominantly residential workforce is expected to positively impact community amenity and lifestyle. This will occur as the long-term residential workforce continues to integrate and participate in local groups and organisations to improve community vibrancy and connectedness. However, SIA consultations revealed that challenges exist for due to construction workforce rosters, that can play a part in a person's ability to participate in community life.

Community safety wellbeing and resilience

Stakeholders raised a concern that the gap between socioeconomic indicators of Indigenous and non-Indigenous communities within the Karratha LGA will continue to widen, specifically in reference to Roebourne. Consultations confirmed that stakeholders want to see a commitment from Woodside to support long term social change and expressed a preference for longer-term investment, rather than continued sponsorship or infrastructure investment. Some stakeholders perceive that there may be community health impacts associated with flaring and emissions. Managing this perception through regular occupational health and monitoring and communications will be important.

Indigenous Cultural Heritage and Relations

The Burrup Peninsula is a highly significant cultural area for Aboriginal communities. This is discussed further in **Section 7.3**.

Impacts, both real or perceived to the cultural heritage of the Burrup Peninsula require careful and ongoing management and stakeholder engagement. Some stakeholders expressed an interest in understanding mitigation measures including cultural heritage management.

Proposed approach to mitigation and management

Mitigation and management measures proposed will be contained within social impact management plans. Further information regarding impacts and risks of the Proposal and mitigation measures are detailed in **Section 6**.

5.4.2 Environmental Scoping Document

From 6 June to 20 June 2019, the EPA held a public comment period for the Proposal's ESD.

Interested parties were encouraged to comment on the ESD, which was made public on the EPA's website and describes the extent of the Proposal, identifies preliminary key environmental factors and outlines the required work to be undertaken.

Via their submissions, stakeholders raised matters related to the potential impacts of industrial emissions on the environment and rock art (cultural heritage), issues of air quality and associated health concerns and cultural heritage management.

Section 6 details the impacts and risks of the Proposal and mitigation measures, with the management plans included as appendices.

5.4.3 Woodside Stakeholder Consultation

Woodside has continued to undertake a broad range of engagements with relevant stakeholders in relation to the Proposal, noting that this is a separate and broader process to that described in 5.4.1. These stakeholders include decision-making authorities, other relevant government agencies and authorities (Local, State and Commonwealth), the local community, local Indigenous groups, academics, research authorities and environmental NGOs.

The approach to consultation has utilised multiple methods of engagement including via face-to-face meetings, community forums, emails, letters or phone calls.

Table 5-2 outlines engagements that been undertaken in relation to the Proposal following the referral in November 2018.

Table 5-2: Stakeholder Consultation Activities to Date

Stakeholder	Date	Issues / topics raised *(by who proponent or stakeholder)*	Proponent response / outcome *(response or outcome undertaken (or proposed) by the proponent (referring to relevant environmental factor/s)*
Murujuga Aboriginal Corporation (MAC)	January 2019	**Proponent:** The Proposal and environmental approvals process.	**Outcome:** Proponent to continue engagement around the Proposal, environmental approvals and specifically to engage on cultural heritage management.
Department of Industry, Innovation and Science	January 2019	**Proponent:** The Proposal and environmental approvals process.	**Outcome:** Ongoing engagement related to the Proposal and status of environmental approvals.
Department of Transport	February 2019	**Proponent:** The Proposal and environmental approvals process.	**Outcome:** Ongoing engagement related to the Proposal and status of environmental approvals.
City of Karratha	February 2019	**Proponent:** The Proposal and environmental approvals process.	**Outcome:** Ongoing engagement related to the Proposal and status of environmental approvals.
Karratha Community Liaison Group including representatives from NYFL, City of Karratha, LandCorp, WA Police, Department of Local Government and Communities, Pilbara Ports, Karratha Districts Chamber of Commerce and Industry, Regional Development Australia, Pilbara Development Commission and Dampier Community Association	March 2019	**Proponent:** The Proposal and environmental approvals process.	**Outcome:** Continued engagement relevant to the Proposal, environmental approvals process and timing of public comment period.
Representatives from Ngarluma, Yindjibarndi, Yaburara/Mardudhunera, Wong-Goo-Tt-Oo	March 2019	**Proponent:** The Proposal and environmental approvals.	**Outcome:** Proponent to continue engagement around the Proposal, environmental approvals and cultural heritage management.
Murujuga Aboriginal Corporation (MAC)	March 2019	**Proponent:** The Proposal and environmental approvals.	**Outcome:** Proponent to continue engagement around the Proposal, environmental approvals and cultural heritage management.
Environmental Protection Authority	March 2019	**Proponent:** The Proposal and environmental approvals.	**Outcome:** Ongoing engagement related to the Proposal and status of environmental approvals.
Department of Environment and Energy	March 2019	**Proponent:** The Proposal and environmental approvals.	**Outcome:** Ongoing engagement related to the Proposal and status of environmental approvals.
Public community engagement - Broad range of community stakeholders	May 2019	**Proponent:** The Proposal and environmental approvals.	**Outcome:** Ongoing engagement related to the Proposal and status of environmental approvals.

Stakeholder	Date	Issues / topics raised *(by who proponent or stakeholder)*	Proponent response / outcome *(response or outcome undertaken (or proposed) by the proponent (referring to relevant environmental factor/s)*
City of Karratha – councillors	May 2019	**Proponent:** The Proposal and environmental approvals.	**Outcome:** Ongoing engagement related to the Proposal and status of environmental approvals.
Representatives from Murujuga Aboriginal Corporation (MAC)	May 2019	**Proponent:** The Proposal and environmental approvals, including matters of national heritage and Indigenous heritage values. **Stakeholder Group:** Raised issue of Submerged Archaeology.	**Outcome:** Proponent to continue engagement related to the Proposal and cultural heritage management. Proponent confirmed that Submerged Archaeology was not impacted / relevant to the Proposal.
Representatives from Ngarluma Yindjibarndi Foundation Ltd NYFL	May 2019	**Proponent:** The Proposal and environmental approvals, including matters of national heritage and Indigenous heritage values. **Stakeholder Group:** Sought clarity on extent of Proposal, with regards to current footprint of Karratha Gas Plant. Raised World Heritage Values.	**Outcome:** Proponent confirmed that there would not be a change to the current Karratha Gas Plant footprint under Proposal. Proponent to continue engagement related to the Proposal, environmental approvals, cultural heritage management and World Heritage Values.
Representatives from Ngarluma, Yaburara/ Mardudhunera, Wong-Goo-Tt-Oo	June 2019	**Proponent:** The Proposal and environmental approvals, including matters of national heritage and Indigenous heritage values. **Stakeholder Group:** Sought clarity on extent of Proposal, with regards to current footprint of Karratha Gas Plant. Raised aspects with heritage values including Rock Art and Middens.	**Outcome:** Proponent confirmed no change to Karratha Gas Plant current footprint under Proposal. Proponent to continue engagement around environmental approvals and cultural heritage management.
Karratha Community Liaison Group including representatives from NYFL, City of Karratha, LandCorp, WA Police, Department of Local Government and Communities, Pilbara Ports, Karratha Districts Chamber of Commerce and Industry, Regional Development Australia, Pilbara Development Commission and Dampier Community Association	June 2019	**Proponent:** The Proposal and environmental approvals process.	**Outcome:** Ongoing engagement related to the Proposal.

Stakeholder	Date	Issues / topics raised *(by who proponent or stakeholder)*	Proponent response / outcome *(response or outcome undertaken (or proposed) by the proponent (referring to relevant environmental factor/s)*
Environmental Protection Authority	August 2019	**Proponent:** Attended Board meeting to discuss NWS Project Extension ESD.	**Outcome:** ESD finalised.
NAC Board meeting	September 2019	**Proponent:** The Proposal, environmental approvals and heritage matters.	**Outcome:** Proponent to continue engagement around Proposal, environmental approvals and cultural heritage management.
Representatives from Ngarluma, Yaburara/Mardudhunera, Wong-Goo-Tt-Oo	September 2019	**Proponent:** The Proposal, environmental approvals and heritage matters.	**Outcome:** Proponent to continue engagement around Proposal, environmental approvals and cultural heritage management.
Karratha Community Liaison Group including representatives from NYFL, City of Karratha, LandCorp, WA Police, Department of Local Government and Communities, Pilbara Ports, Karratha Districts Chamber of Commerce and Industry, Regional Development Australia, Pilbara Development Commission and Dampier Community Association	September 2019	**Proponent:** Update on Woodside's activities, including the Proposal and environmental approvals.	**Outcome:** Ongoing engagement related to the Proposal and status of environmental approvals, noting public comment period timeframes.

5.4.4 Indigenous Stakeholders

Specific engagements were undertaken with Indigenous stakeholders in relation to any potential impacts to national heritage values, including Indigenous heritage values. These engagements provided a detailed overview of the environmental assessment and approval processes, provided the opportunity for questions to be asked, responses provided and any outstanding concerns to be understood.

The process of consultation with Indigenous stakeholders undertaken by Woodside is consistent with the National Heritage provisions and the Engage Early Model of engagement. Woodside recognises interests of Indigenous groups and seeks each group's advice on how to engage and how often, we have regular meetings with our Indigenous stakeholders, invite questions out of session as they arise and we use best endeavours to ensure all stakeholders are provided with all relevant information necessary in order to respond. Woodside also consults more broadly with representatives of community and the language groups.

The following items have been raised in consultations to date regarding the conservation of aspects with heritage value. Please note that the aspects were raised in the context of Traditional Owners seeking to understand how the aspects have been considered by the Proposal:

+ World Heritage Values
+ Rock Art
+ Middens
+ Impacts of expanded footprint (a combination of aspects including rock art, access to sites, flora and other archaeology).

Concerns over Submerged Archaeology have been raised in consultation with Traditional Owners to date, however potential impacts to submerged archaeology are not relevant to the NWS Project Extension Proposal as no additional disturbance areas, either onshore or offshore, are proposed as part of this approval.

The aspects outlined above all fall within social surroundings. Woodside has identified other aspects not raised specifically during stakeholder consultations relevant to the Proposal, particularly from the existing heritage surveys and processes established as part of existing operations. Archaeological and ethnographic surveys have also identified a range of aspects as part of the social surroundings. Ethnographic surveys have identified vegetation with heritage values. No other aspects were identified by Traditional Owners in any consultations. Specific engagements have been held with Indigenous stakeholders in relation to any potential impacts of the North West Shelf Project Extension Proposal on the national heritage values, including Indigenous heritage values, of the listed National Heritage Place on the Dampier Archipelago.

This includes consultation with stakeholders including Traditional Owners and custodians, with discussions focused on cultural heritage management. Discussions to date have reinforced that Indigenous stakeholders would require specific consultation if the existing footprint of the KGP was to increase. It should be noted that an increase of the existing footprint of the KGP is not required under the Proposal.

Noting our approach to continued and regular engagement with Aboriginal stakeholders, Woodside recognises that it may not always be appropriate for Aboriginal people to disclose information about highly culturally significant matters. Therefore, when issues or concerns are raised in broader terms, such as seeking clarification that the Proposal footprint will not be expanded, we take these matters seriously.

Further engagement is planned as part of the public comment period for the ERD, including discussion on the attached NWS Project Extension Cultural Heritage Management Plan (**Appendix C**).

Woodside corporate meetings are also held on an ongoing and regular basis with MAC, NYFL, NAC and the five language groups who have an interest over the Burrup Peninsula including updates on the Proposal, the environmental approvals process and mitigation approach.

5.4.5 Summary of Stakeholder Feedback

The stakeholder consultations to date, including the public comment period on the ESD, regarding the Proposal, have reinforced stakeholders interest in understanding the possible opportunities that may be generated or sustained for local businesses as well as employment and training opportunities in Pilbara, with a specific focus on employment for Karratha locals.

Stakeholders also raised issues of national heritage (with a focus on rock art) and expressed an interest in understanding mitigation measures and management relevant to cultural heritage.

5.5 Ongoing Stakeholder Engagement

This ERD has been released for public review, which offers stakeholders an opportunity to provide formal input into the environmental impact assessment.
In addition to activities undertaken to support the development of the ERD, Woodside, as part of its standard operating practices, will continue to engage with stakeholders throughout all phases of the proposed NWS Project Extension. This includes ongoing engagement to inform and consult:

+ stakeholders about key milestones and activities
+ onshore supply chain and logistics support locations
+ ongoing social investment in relevant communities.

ENVIRONMENTAL PRINCIPLES AND FACTORS

Woodside

6. ENVIRONMENTAL PRINCIPLES AND FACTORS

6.1 Introduction

6.1.1 Identification of Key Environmental Factors

Following referral of the Proposal under Section 38 of the EP Act, the EPA determined the Key Environmental Factors relevant for the assessment of the Proposal are:

+ Air Quality
+ Social Surrounding (Heritage)
+ Marine Environmental Quality.

These environmental factors are described in **Sections 6.3** to **Section 6.6**.

Woodside's impact assessment approach focuses primarily on the above environmental factors but has also had regard for other factors that may be impacted by the Proposal. This approach has led to consideration of impacts to amenity (such as through odorous emissions) and culturally significant vegetation. Woodside's approach to impact assessment for this Proposal is outlined in **Section 6.1.2**.

6.1.2 Impact Assessment Approach

6.1.2.1 Overview

The environmental impact and risk assessment presented in this document was undertaken in accordance with Woodside's Impact Assessment Procedure (Woodside, 2016a), Environment Impact Assessment Guideline (Woodside, 2017a) and Risk Management Procedure (Woodside, 2017b). These documents support the implementation of impact and risk assessment and set out the broad principles and high-level steps for assessing environmental impacts and risks across the lifecycle of Woodside's activities. This process provides the inputs to the assessment of the impact and risks presented in this ERD.

Within this process, a distinction is made between an 'impact' and a 'risk' as follows:

+ **Environmental Impact:** An expected change to the environment, whether adverse or beneficial, wholly or partially resulting from the planned routine and non-routine project activities (e.g. routine liquid discharges).
+ **Environmental Risk:** An unplanned event or incident which has the potential to impact the achievement of the stated environmental objectives.

The impact assessment approach undertaken for this Proposal includes the following steps:

1. Identify aspects (i.e. results of planned or unplanned Proposal activities that have the potential to impact on the environment).
2. Identify the receptors (i.e. physical, biological, cultural or human elements of the environment that may be impacted by Proposal aspects).
3. Assess the receptor sensitivity (i.e. the sensitivity/vulnerability/importance of the receptor) as either high, medium or low value.
4. Assess the magnitude (i.e. no lasting effect, slight, minor, moderate, major or catastrophic) of the credible environmental impacts and risks from each aspect based on the extent, duration, frequency and scale.
5. Assign an impact level to each environmental impact based on the receptor sensitivity and the magnitude of the expected impact.
6. Assign an environment risk rating to each environmental risk based on the receptor sensitivity and magnitude of the potential impact; and the likelihood of occurrence.
7. Use the impact and risk levels to assess the Proposal against the EPBC Act Significant Impact Criteria and the WA EPA Objectives.

6.1.2.2 Receiving Environment

The existing environment of the Proposal was defined in order to identify environmental receptors that have the potential to interact with the Proposal, including:

+ physical characteristics of the environment (e.g. seabed and water quality)
+ ecological characteristics of the environment (e.g. benthic communities, fish, seabirds, marine reptiles and marine mammals)
+ socio-economic and cultural characteristics of the environment (e.g. heritage, fishing, shipping and tourism).

A description of the receiving environment is presented in **Section 4**. Information on the existing environment has been primarily drawn from existing and recent studies completed by Woodside and other relevant references. These studies have enabled Woodside to build a detailed understanding of the receiving environment of the Proposal to enable identification of the potential environmental impacts and assessment and selection of the appropriate measures to mitigate potential impacts.

6.1.2.3 Assessment of Impact and Risks

Relevant impacts and risks identified in the environmental scoping phase and presented in the NWS Project Extension Proposal Environmental Scoping Document (Woodside, 2019) and have been reviewed and refined during the preparation of the ERD.

6.1.2.3.1 Impact Assessment Methodology

The following section outlines definitions used by Woodside to determine the following:

- **Sensitivity of the receptor:** this includes consideration of the quality of the receiving environment, the biodiversity of the receiving environment and the ability for the receiving environment to recover.
- **Magnitude of the risk or impact:** this includes consideration of the temporal and geographical extent of the risk or impact.
- **Impact Level:** This is determined based on a predefined matrix comparing the sensitivity of the receptor and magnitude of the impact.

6.1.2.3.2 Sensitivity of Receptor

The sensitivity of the receptor is described as low, medium or high based on the definitions and example criteria set out in **Table 6-1**. This is then combined with the magnitude of the impact to determine the impact level.

6.1.2.3.3 Magnitude

Magnitude is a measure of the predicted change likely to occur as a result of the impact, rated as being negligible, slight, minor, moderate, major or catastrophic. The key drivers for defining the magnitude of an impact are the expected duration and scale of the predicted change. Where relevant, the magnitude of an impact can also take into account the frequency or repetitiveness of the change and whether it has a local, regional or international 'extent'.

Table 6-1: Receptor Sensitivity definitions

Environmental Aspect	Receptor Sensitivity		
	Low	***Medium***	***High***
	Highly degraded, low biodiversity value ecosystems or those with a high recovery capacity.	Natural ecosystem, species, habitat including ecosystems with slight disturbance/ degradation or those with a moderate recovery capacity.	Highly valued ecosystems, species, habitats or physical or biological attributes or those with a low recovery capacity.
Soil and Groundwater	+ Brackish groundwater + Barren/industrial land + Non-aquifer	+ Natural state + Agricultural land + Springs and wells	+ Drinking/domestic water + Supports area/species of ecological importance (including baseflow to a watercourse)
Marine Sediment	+ Existing Port + Contaminated sediment	+ Natural state	+ Supports area/species of ecological importance (BPPH)
Water Quality	+ Existing Port + Polluted watercourse	+ Natural state + Industrial water source (power station)	+ Drinking water/ domestic water + Supports area/ species of ecological importance + Supports unique industry (fishery, aquaculture)
Air Quality (including odour)	+ Existing pollution (industrial air shed) + Areas where people might be expected to pass through, but exposure for any extended period is unlikely	+ Flora/Fauna of moderate susceptibility/ moderate tolerance of air emissions (crops) + Areas or buildings where occasional longer periods of exposure may occur	+ Ecological sites (rock art) designated at national/international level + Flora/Fauna of very high susceptibility/very low tolerance of air emissions (mangroves) + Residential buildings where near-constant presence of people is possible and long-term exposure is likely
Ecosystems/ habitats	+ Commonly occurring habitats (abyssal plain), not subject to significant decline + Pre-disturbed/ degraded habitats (existing infrastructure/ development)	+ Sites of local biodiversity value but not intact, fragile or unique (open water, nearshore)	+ Habitats recognised as intact or unique (wetlands) or areas recognised as having high environmental value (Coral reef, mangroves) + Protected area designation
Species	+ Widespread common species (Plankton, seagulls)	+ Regionally important population of a species, either because of population size or distributional context (Pelagic/ demersal fish, reptiles)	+ Species listed at a national/international level (Blue whale, migratory birds, significant part of life cycle, critical species)
Ecosystem Services	+ No third-party use	+ Other users (shared, routine use, tourism)	+ Multiple dependent/subsistence users, high cultural value

Table 6-2: Magnitude definitions

Environmental Aspect	Magnitude					
	No lasting effect	***Slight***	***Minor***	***Moderate***	***Major***	***Catastrophic***
	Typical parameters / criteria Extent: Localised Temporal Recovery: Temporary (<1 month for recovery)	Typical parameters / criteria Extent: Near-field Temporal Recovery: Short term (<1 year for recovery)	Typical parameters / criteria Extent: Near-field Temporal Recovery: Short term (1-2 years for recovery)	Typical parameters / criteria Extent: Far-field Temporal Recovery: Medium term (2-10 years for recovery)	Typical parameters / criteria Extent: Regional Temporal Recovery: Long term (10-50 years for recovery)	Typical parameters / criteria Extent: Regional Temporal Recovery: Permanent (>50 years for recovery)
Water Quality	Temporary contamination that is localised	Short-term contamination (levels above relevant standards &/or background) on a near-field scale	Short-term contamination (levels above relevant standards &/or background) on a near-field scale	Medium-term contamination (levels significantly above relevant standards) on a far-field scale	Long-term contamination (levels significantly above relevant standards) on a regional scale	Permanent contamination (levels significantly above relevant standards) on a regional scale
Air Quality	Temporary impact to environment that is localised	Slight, short-term impact to the environment on a near-field scale	Air quality significantly above relevant standards causing Short-term impact to local ecosystem function or human health on a near-field scale	Air quality significantly above relevant standards causing medium term impact to local ecosystem function or human health on a far-field scale	Air quality significantly above relevant standards causing long-term impact to local ecosystem function or human health on a regional scale	Air quality significantly above relevant standards causing permanent impact to local ecosystem function or human health on a regional scale
Ecosystems/ habitats	Temporary impact (hours to a 1 month) to ecosystem or habitat that is localised	Slight, short-term localised effect on ecosystem/habitat service on a near-field scale	Short-term impact to ecosystem/habitat service on a near-field scale	Medium-term impacts to ecosystem/habitat service on a far-field scale	Long-term impacts to ecosystem/habitat service on a regional scale	Permanent impact to ecosystem/habitat service on a regional scale
Species	Temporary impact (<1 month) to species that is localised	Slight, short-term localised impact on species on a near-field scale	Short-term impact to population on a near-field scale	Medium-term impact to population on a far-field scale	Long-term impact of population on a regional scale	Permanent impact or eradication of population on a regional scale

6.1.2.3.4 Impact Level

An impact level is applied to each environmental impact based on the magnitude (extent, nature, scale) of the impact and the receptor sensitivity, assigning the fields in the matrix shown in **Figure 6-1**. The impact levels used for evaluating impacts aligns with the consequence levels used for evaluating risks and ranges from catastrophic, major, moderate, minor, slight and negligible.

	Receptor Sensitivity			Impact Level
Magnitude	***Low***	***Medium***	***High***	
Catastrophic	**B**	**A**	**A**	**Catastrophic (A)**
Major	**C**	**B**	**A**	**Major (B)**
Moderate	**D**	**C**	**B**	**Moderate (C)**
Minor	**E**	**D**	**C**	**Minor (D)**
Slight	**F**	**E**	**D**	**Slight (E)**
No lasting effect	**F**	**F**	**E**	**Negligible (F)**

Note: The following impact levels may be assigned for the environmental impacts: Catastrophic (A), Major (B), Moderate (C), Minor (D), Slight (E), Negligible (F).

Figure 6-1: Matrix used to determine impact level, based on impact magnitude and receptor sensitivity.

6.1.2.3.5 Risk Assessment Methodology

Where an impact is not planned to occur and relies on failure of one or more mitigative barriers to eventuate, the event is considered a risk. The methodology used to evaluate the rating of an environmental risk is slightly differently than the methodology used for planned impacts, due to the requirement to consider the likelihood that the unplanned event or incident occurs. In this case, a likelihood of the most credible worst-case outcome is taken into account to determine the risk ranking.

Depending on the nature of the risk, the likelihood will be determined using either experience, published industry quantitative data or using modelled probabilities. The likelihood of a risk event occurring can be considered remote (0), highly unlikely (1), unlikely (2), possible (3), likely (4) or highly likely (5). The risk consequence is determined using the same methodology as for a planned impact, considering the magnitude of the potential impact and sensitivity of the receiving environment. The likelihood of the impact occurring, and the consequence of the impact are then used to assign a risk ranking.

The following risk categories may be assigned for unplanned events, as per the risk bands shown on the Woodside risk matrix, shown in **Figure 6-2:** severe; very high; high; moderate; and low.

Figure 6-2: Risk Matrix

Consequence

	Health & Safety	Environment	Financial	Reputation & Brand	Legal & Compliance	Social & Cultural
A	> 30 fatalities and / or permanent total disabilities	Catastrophic, long-term impact (> 50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	> $5B	Catastrophic, long-term impact (> 20 years) to reputation and brand. International concern and / or persistent national concern in significant area of operation. Company operations, major ventures, significant or multiple asset operations severely restricted or terminated, and may extend to company at stake	Loss of licence to operate. Potential jail terms for executives, directors or officers. Prolonged litigation / prosecution. Fines (> $100M) and / or civil liability (> $1B)	Catastrophic, long-term impact (> 20 years) to a community, social infrastructure or highly valued areas / items of international cultural significance
B	Multiple fatalities and / or permanent total disabilities	Major, long-term impact (10-50 years) on highly valued ecosystems, species, habitat or physical or biological attributes	> $500M - $5B	National concern and / or international interest. Medium to long-term impact (5-20 years) to reputation and brand. Venture and / or asset operations restricted	Significant restriction on licence to operate. Prolonged litigation / prosecution. Fines (< $100M) and / or civil liability (< $1B)	Major, long-term impact (5-20 years) to a community, social infrastructure or highly valued areas / items of national cultural significance
C	Single fatality and / or permanent total disability	Moderate, medium-term impact (2-10 years) on ecosystems, species, habitat or physical or biological attributes	> $50M - $500M	National concern. Moderate, medium-term impact (2-5 years) to reputation and brand. Venture and / or asset operations restricted or curtailed	Material breach of legislation, regulation, contract or licence condition. Major litigation / prosecution. Fines (< $15M) and / or civil liability (< $150M)	Moderate, medium-term impact (2-5 years) to a community, social infrastructure or highly valued areas / items of national cultural significance
D	Major injury or occupational illness or permanent partial disability	Minor, short-term impact (1-2 years) on species, habitat (but not affecting ecosystems function), physical or biological attributes	> $5M - $50M	Minor, short-term impact (1-2 years) to reputation and brand. Close scrutiny of asset level operations or future proposals	Breach of legislation, regulation, contract or licence condition with investigation and / or report to authority. Litigation / prosecution. Fines (< $5M) and / or civil liability (< $50M)	Minor, short-term impact (1-2 years) to a community or highly valued areas / items of cultural significance
E	Moderate injury or occupational illness or temporary partial disability	Slight, short-term impact (< 1 year) on species, habitat (but not affecting ecosystems function), physical or biological attributes	> $500K - $5M	Slight, short-term local impact (< 1 year) to reputation and brand. Some impact on asset level non-production activities	Breach of legislation, regulation, contract or licence condition. Regulatory action and / or sanction	Slight, short-term impact (< 1 year) to a community or areas / items of cultural significance
F	Minor injury or occupational illness	No lasting effect (< 1 month). Localised impact not significant to environmental receptors	≤ $500K	No lasting effect (< 1 month). Isolated and short-term local concern	Breach of internal standard	No lasting effect (< 1 month). Localised impact not significant to areas / items of cultural significance

Likelihood

	Remote	Highly Unlikely	Unlikely	Possible	Likely	Highly Likely
Experience	Unheard of in the industry	Has occurred once or twice in the industry	Has occurred many times in the industry but not at Woodside	Has occurred once or twice in Woodside or may possibly occur	Has occurred frequently at Woodside or is likely to occur	Has occurred frequently at the location or is expected to occur
Frequency	1 in 100,000 - 1,000,000 years	1 in 10,000 - 100,000 years	1 in 1,000 - 10,000 years	1 in 100 - 1,000 years	1 in 10 - 100 years	> 1 in 10 years
Modelled distribution %* (Probability of event occurrence)	< 1%	1% - 5%	6% - 20%	21% – 50%	51% - 80%	> 80%
LEVEL	0	1	2	3	4	5

** Not to be used for operational Health & Safety or Environment risk assessments.*

LEVEL	0	1	2	3	4	5
A	A0	A1	A2	A3	A4	A5
B	B0	B1	B2	B3	B4	B5
C	C0	C1	C2	C3	C4	C5
D	D0	D1	D2	D3	D4	D5
E	E0	E1	E2	E3	E4	E5
F	F0	F1	F2	F3	F4	F5

Risk endorsement table

Current Risk

SEVERE	Risk at this level requires **immediate (no more than 12 hours)** communication to the **CEO & divisional EVP / SVP** via VP Risk & Compliance
VERY HIGH	Risk at this level requires **immediate (no more than 12 hours)** communication to **divisional EVP / SVP** with concurrent communication to VP Risk & Compliance
HIGH	Risk at this level requires timely communication to **SVP / VP of business unit or function**
MODERATE	Risk at this level requires timely communication to **line manager** (i.e. relevant Asset or Project Manager)
LOW	Risk at this level requires timely communication to the relevant **line manager**

Note: All currency stated in $US. The consequence and likelihood categories are not necessarily equal to each other. For example, the financial column is not equal to the remediation costs or consequences described in other columns.

6.1.2.4 Existing and Proposed Mitigation Measures

In order to ensure the Proposal is implemented in a manner that meets the EPA's environmental objectives, existing and proposed mitigation measures have been identified for each potential impact and risk to the relevant environmental factors. As defined by Woodside's Health, Safety and Environment Risk Assessment Guideline (Woodside, 2017c), mitigation measures have been categorised in accordance with the hierarchy of controls:

+ **Avoid** - elimination of the risk by removing the hazard.
+ **Minimise** – reduction of a hazard or substitution of a hazard with a less hazardous one. Also considers procedural aspects such as management systems and work instructions used to mitigate environmental exposure to hazards.
+ **Rehabilitate** - includes methods to enable recovery from the impact of an event.

6.1.2.5 Predicted Outcome

In accordance with the EPA Administrative Procedures (2016e), this ERD seeks to conclude each impact assessment by summarising the identified impacts and residual risks that may remain after applying the mitigation hierarchy. The significance of these is then summarised in the context of the EPBC Act Significant Impacts Criteria (in relation to MNES) and/or the Western Australian EPA Objectives.

Environmental Management Plans have been prepared for each environmental factor to demonstrate how existing and proposed mitigation measures will manage environmental impacts and risks to a level that presents no significant residual risk.

6.2 Principles

Section 4A of the EP Act sets out the environmental protection principles of an environmental impact assessment. These are:

+ the precautionary principle
+ the principle of intergenerational equity
+ principles relating to improved valuation, pricing, and incentive mechanisms
+ the principle of the conservation of biological diversity and ecological integrity
+ the principle of waste minimisation.

Table 6-3 lists these environmental protection principles, which were considered throughout the preparation of this ERD.

Table 6-3: Consideration of Environmental Protection Principles

Principle	Consideration
The precautionary principle *Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.* *In application of this precautionary principle, decisions should be guided by:* a. *Careful evaluation to avoid, where practicable, serious or irreversible damage to the environment.* b. *An assessment of the risk-weighted consequences of various options.*	The NWS Project has been operating for more than three decades and over this time Woodside has developed a robust understanding of how the NWS Project interacts with the environment. Significant operational and environmental monitoring data collected in this time provides a scientific basis for how the Proposal interacts with the existing environment. In addition, Woodside commissioned air dispersion and deposition modelling, and marine dispersion modelling for the Proposal to further understand discharges and emissions from the Proposal. In relation to impacts on the Burrup Peninsula rock art from industrial emissions, the past 15 years has seen numerous studies being conducted to investigate the potential for industrial emissions to impact on the Burrup Peninsula rock art. During this period, the NWS Project has operated within the same emissions profile as presented in this Proposal. No published peer reviewed studies identified measurable or observable changes to condition and the integrity of the rock art as a result of industrial emissions. As such, significant accelerated weathering impacting on the distinguishability of petroglyphs across the region is not expected to occur as a result of the Proposal. As part of the implementation of the NWS Project Extension Air Quality Management Plan (**Appendix A**), Woodside will continue to evaluate new information as it emerges and ensure an adaptive approach to the management of emissions and discharges as required to avoid significant impacts.
The principle of intergenerational equity *The present generation should ensure that the health, diversity, and productivity of the environment is maintained and enhanced for the benefit of future generations.*	The principle of intergenerational equity is upheld by the Proposal from two perspectives. Firstly, the Proposal will be implemented with mitigation measures that ensure the environment is maintained for future generations. Management plans have been development for each key environmental factor to demonstrate how existing and proposed mitigation measures will manage environmental impacts and risks to an acceptable level. Secondly, developing natural gas as an energy resource plays an important role in moving towards a lower carbon future and mitigating 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.

Principle	Consideration
Principles relating to improved valuation, pricing, and incentive mechanisms 1. *Environmental factors should be included in the valuation of assets and services.* 2. *The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance, and abatement.* 3. *The users of goods and services should pay prices based on the full lifecycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.* 4. *Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.*	Woodside is committed to preventing pollution by reducing emissions and discharges as well as efficiently using resources. Woodside proposes to reduce NO_x emissions by 40%[4] and substantially reduce VOC emissions by 31 December 2030. In addition, Woodside will also install additional water polishing equipment to reduce the discharge of environmental contaminants. In addition to the above, Woodside is also required to pay for emissions to air and discharges to the marine environment under Part V of the EP Act through annual licence fees. Where emissions and discharges are planned to occur, Woodside bears the cost of containment, avoidance, and abatement.
The principle of the conservation of biological diversity and ecological integrity *Conservation of biological diversity and ecological integrity should be a fundamental consideration.*	The NWS Project has operated for more than three decades with no ongoing impact to biological diversity or ecological integrity. The successful environmental management strategy used for the NWS Project will be the basis of ongoing management of the Proposal.
The principle of waste minimisation *All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.*	All reasonable and practicable measures have been and will continue to be undertaken by Woodside during the operation of the NWS Project to ensure waste is minimised. Generated waste will be disposed of appropriately and in accordance with the applicable waste regulations. Woodside also has, and will continue to operate under, an Operational Licence (issued under Part V of the EP Act) to manage emissions and discharges from the Proposal. Woodside will continue to take reasonable and practicable measures to minimise emissions to air and therefore reduce the risk of significant impacts to the rock art. Woodside has proposed to reduce NO_x emissions by 40%[5] and substantially reduce VOC emissions by 31 December 2030 to maintain environment quality and protect rock art. Furthermore, Woodside will continue to implement environmental initiatives and review operations for potential opportunities to improve efficiency and reduce emissions and discharges.

4 *Based on the percentage of reported emissions from KGP over the five-year average, covering the 2013/14 to 2017/18 financial years.*

5 *Based on the percentage of reported emissions from KGP over the five-year average, covering the 2013/14 to 2017/18 financial years.*

6.3 Key Environmental Factor – Air Quality (Health & Amenity)

6.3.1 EPA Objective

To maintain air quality and minimise emissions so that environmental values are protected (EPA, 2016a).

6.3.2 Policy and Guidance

EPA Policy and Guidance

+ Statement of Environmental Principles, Factors and Objectives (EPA, 2018a)
+ Environmental Factor Guideline – Air Quality (EPA, 2016a)

Other Policy and Guidance

+ Air Quality Modelling Guidance Notes 2006 (DoE, 2006a)
+ Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW) (NSW EPA, 2016)
+ European Union Air Quality Standards for the Protection of Vegetation (EU, 2008)

Relevant Legislation

+ *National Environment Protection Council (Western Australia) Act 1996* (WA)
+ *National Environmental Protection (Ambient Air Quality) Measure* (Cth).
+ *National Environment Protection (Air Toxics) Measure* (Cth).
+ *National Environmental Protection (National Pollutant Inventory) Measure 1998* (Cth)

Section 10 details how this legislation, policy and guidance relates to the Proposal.

6.3.3 Receiving Environment

This section identifies the elements of the receiving environment that are directly and indirectly related to the Air Quality (Health and Amenity) environmental factor. Refer to **Section 4** for detailed description of each relevant receptor of the receiving environment.

Table 6-4: Air Quality Receiving Environment

	Activity	Ongoing emissions to air from the NWS Project Extension Proposal until around 2070.	Introduction of third-party gas and fluids, which may cause changes to air emission characteristics.
Receving Envrionment	*National Heritage Place*	✓	✓
	Shorelines		
	Seabirds and Shorebirds		
	Sharks and Fish		
	Sea Snakes		
	Turtles		
	Marine Mammals		
	Sediment Quality		
	Water Quality		
	Macroalgae		
	Seagrass		
	Coral		
	Marine Invertebrates		
	Mangroves	✓	✓
	Marine Fauna with Heritage Value		
	Vegetation with Heritage Value	✓	✓
	Heritage Features	✓	✓
	Terrestrial Vegetation	✓	✓
	Contribution to GHG Concentrations		
	Air Quality (Relevant to Amenity)	✓	✓
	Air Quality (Relevant to Human Health)	✓	✓

6.3.4 Potential Impacts and Risks

These activities associated with the Proposal have the potential to affect air quality:

- Ongoing emissions to air from the NWS Project Extension Proposal until around 2070.
- Introduction of third-party gas and fluids, which may cause changes to air emission characteristics.

The potential impacts to air quality include:

- Gaseous emissions causing a reduction in ambient air quality impacting human health.
- Changes in air quality causing deposition on nearby heritage features, including national heritage places.
- Degradation of terrestrial and nearshore vegetation of heritage and conservation value due to deposition of gaseous emissions.
- Emission of odorous substances and dark smoke impacting public amenity.

6.3.4.1 Gaseous Emissions Causing a Reduction in Ambient Air Quality Impacting Human Health

Description of Potential Impact

The principal emissions from the Proposal in terms of potential air quality impacts will arise from the combustion of fuel gas in gas turbines for power generation, flaring associated with the gas processing plant, and gas conditioning process vents (such as for CO_2 removal from reservoir gas Acid Gas Removal Unit [AGRU]). The most significant products of gas combustion and facility emissions include: carbon dioxide (CO_2), oxides of nitrogen (NO_X), carbon monoxide (CO), methane, and unburnt volatile organic compounds (VOCs). Ventilation readily disperses CO emissions relative to criteria. There may also be traces of particulate and sulphur dioxide (SO_2) associated with the Proposal, but such emissions are generally considered negligible due to the firing of very low sulphur content natural gas in a controlled environment. NO_X will be the predominant emission from the facility associated with air quality potentially impacting human health with applicable nitrogen dioxide (NO_2) and ozone (O_3) health criteria. Ozone is not emitted directly from the Proposal but is formed through anthropogenic sources via chemical reactions between oxides of nitrogen and other pollutants such as VOCs and CO in the presence of ultraviolet light.

Health effects of elevated NO_2, SO_2 and O_3 are well documented. High concentration of NO_2 can irritate airways in the human respiratory system. Such exposures over short periods can aggravate respiratory diseases (e.g. asthma) leading to respiratory symptoms (such as coughing, wheezing or difficulty breathing) (USEPA, 2016). Longer exposures to elevated concentrations of NO_2 may contribute to the development of asthma and potentially increase susceptibility to respiratory infections (USEPA, 2016). NO_2 has been demonstrated to increase the effects of exposure to other pollutants such as O_3, and small (inhalable) particles (USEPA, 2016). Short-term exposures to SO_2 can harm the human respiratory system and make breathing difficult. People with asthma, particularly children, are sensitive to these effects of SO_2 (USEPA, 2019a). The health effects of exposure to ozone include irritation of eyes and air passages, decreased lung function and development, adverse effects on pulmonary function and aggravation of asthmatic conditions (USEPA, 2019b).

Air Dispersion Modelling

An air quality study and risk assessment was undertaken based on a broad survey of Burrup Peninsula air quality studies, historical ambient monitoring records, estimates of cumulative emission inventories and other information. An air quality impact assessment (**Appendix E**) was undertaken for key parameters applicable to contribution by the Proposal to understand cumulative potential air quality impacts to human health.

Air dispersion models combine simulations of regional and local meteorology with complex physics and chemistry of air pollution processes to provide the best predictions of the dispersion of air emission. The air quality impact assessment for the Proposal utilised the CSIRO Atmospheric Research Air Dispersion Model 'TAPM-GRS' (The Air Pollution Model – Generic Reaction Set), (Hurley et al, 2008), using a 2014 meteorological dataset. Further information regarding modelling methodologies are included in the NWS Project Extension Air Quality Impact Assessment (**Appendix E**).

The air quality impact assessment modelled the following pollutants that have potential to impact human health in the region relevant to the Proposal:

- NO_X (modelled as NO_2 to enable assessment against relevant health standards)
- Ozone (O_3)
- SO_2.

Based on the risk assessment (Refer to **Section 4.2** and **Appendix E**), VOCs (including BTEX) were excluded from the modelling for the Proposal. Ambient air monitoring undertaken during 2009-2015 showed that emissions of BTX (monitored as indicators of VOCs with associated health criteria) had insignificant air quality effects at the sensitive receptor locations of Dampier, Karratha and Burrup Road. For the great majority of the time, BTX concentrations were much lower than heath thresholds. Therefore, modelling BTX ground concentrations was not warranted as part of the air quality impact assessment. Estimates for total VOC emissions were included in the modelling for their influence on photochemistry.

Airborne particulate matter (PM) as PM_{10} and $PM_{2.5}$ from the Proposal was not modelled. Although exceedances of ambient air quality standards for these air quality

pollutants occur on the Burrup Peninsula, they are primarily due to smoke from bushfires and controlled burns, raised dust, and other industrial sources. Emissions of particulate matter from the Proposal are negligible in relation to these sources (refer to **Section 4.2**).

The air quality impact assessment considered the emissions from several operational scenarios representing current and potential future industrial facilities on the Burrup Peninsula. All scenarios include shipping activities on the Burrup Peninsula. The scenarios listed in **Table 6-5** were included in the modelling.

Table 6-5: Scenarios used for Cumulative Air Dispersion Modelling

Scenario	Description
Current Baseline (CBM)	This is the near-term, most likely scenario. It predicts the contribution to ambient air quality from industry currently operating on and around the Burrup Peninsula. It considers cumulative emissions from the current NWS Project and the existing, built, industrial facilities and emissions most applicable to the BSIA and the nearby region to use as a baseline for assessment. These include: + NWS Project; KGP + Woodside Pluto LNG Development (Train 1) + Yara Technical Ammonium Nitrate and Liquid Ammonium Plant + Pilbara Iron Yurralyi Maya Power Station + Santos Devil Creek Power Station + ATCO Karratha Power Station + EDL West Kimberley Power Plant + All shipping berths on the Burrup Peninsula + All shipping berths at Cape Lambert.
Current Baseline with proposed emission reductions in place (KIO)	This is the medium-term, best-case scenario. It demonstrates the benefits gained in ambient air quality from proposed NO_X reductions outlined in **Section 6.3.5**. It considers cumulative emissions from the Proposal operating with a significant reduction in NO_X for KGP sources, and the existing, built, industrial facilities and emissions most applicable to the BSIA and the nearby region. The KGP data for modelling were modified to conservatively reflect likely improvement opportunity concepts representing feasible and significant NO_X reduction.
Future Burrup Strategic Industrial Area with existing and approved facilities operating, with proposed emission reductions in place (FBSIA E&A)	This is the medium-term, most likely scenario. It considers cumulative emissions from the Proposal operating with a significant reduction in NO_X emissions, existing operating facilities, and future BSIA development approved at the time of writing this ERD (Pluto LNG Development [Train 2]).

Scenario	Description
Future Burrup Strategic Industrial Area State (FBSIA), with existing, approved and referred facilities operating	This is the long-term, worst-case scenario. It considers cumulative emissions from the Proposal operating with no reduction in NO_X emissions, existing operating facilities, and reasonably foreseeable future BSIA; approved development (Pluto LNG Development [Train 2]) and, referred developments (but not assessed or approved) at the time of writing this ERD. The latter developments are represented by indicative Urea and Methanol Plants.
Future Burrup Strategic Industrial Area state (existing, approved and referred) with proposed emission reductions in place (FBSIA-KIO)	This is a long-term, possible case scenario. It considers cumulative emissions from the Proposal operating with a significant reduction in NO_X emissions, existing operating facilities, and future developments approved at the time of writing this ERD (Pluto LNG Development [Train 2]) and BSIA developments referred (but not assessed or approved) at the time of writing this ERD. The latter reasonably foreseeable future developments are represented by indicative Urea and Methanol Plants.

Model input emissions inventories were developed based on reasonable and conservative emissions estimates, considering available datasets, design data, monitoring data and for proposed developments and modifications; preliminary design data based on concept and early 'front end engineering design' (FEED) assumptions. Third party emissions were represented based on consideration of publicly available literature and input following consultation with some parties.

To confirm that TAPM-GRS performance was fit for purpose, modelled baseline (CBM) results were compared to measured results from Woodside ambient air monitoring programs. When compared to ambient air monitoring results for NO_2 and O_3 from 2014, when the NWS Project and Pluto LNG Development began operating together at or near capacity, model results were found to support actual results and the TAPM-GRS model was therefore deemed suitable and with an accuracy appropriate for the assessment of the Proposal.

All scenarios assumed the Proposal operating with a feed gas of a similar composition to the NWS Project. The majority of air emissions of relevance to the Proposal are emitted directly (NO_X, SO_2) or indirectly (O_3) from the combustion of natural gas.

Although, changes to feed gas composition have the potential to vary the make-up of fuel gas, and gas conditioning process performance, the subsequent impacts on associated air emissions is limited, or controlled through engineering and operational controls. In the case of NO_X, the emission of these products from combustion does not materially vary based on feed gas composition within the NWS Project system design and operational envelope. Potential variations in combustion and gas conditioning process performance, which has the potential to impact emissions performance (such as for CO_2, CO, SO_2, hydrogen sulphide (H_2S), methane and VOC (including BTEX)) is inherently limited through integrated facility design envelope (i.e. there are engineering limitations regarding the range to which the facility design margins can accept and/or process feed gas composition variations).

Potential air emission characteristic changes from the introduction of third-party gas will be managed in line with the Woodside management system to ensure that the environmental objectives and legislative requirements are met. This assessment will include the identification of appropriate management and mitigation controls to ensure impacts and risks are minimised. Therefore, the likelihood of any impact on the receiving environment due to the introduction of third-party gas is negligible and residual impacts after the application of stated mitigations are not significant.

Air Dispersion Assessment Criteria

The WA EPA provides guidance for assessing the potential impacts of a proposal on air quality in the Environmental Factor Guideline: Air Quality (EPA, 2016a); although this guideline does not specify air quality standards for assessment, it does provide the following considerations:

+ Whether numerical modelling and other analyses to predict potential impacts have been undertaken using recognised standards with accepted inputs and assumptions.
+ Whether existing background air quality, including natural variations, has been established through monitoring and accepted proxy data.
+ Whether analysis of potential health and amenity impacts has been undertaken using recognised criteria and standards, where relevant, informed by Australian and international standards.

In the absence of specific air quality standards from the EPA, the NEPM (Ambient Air Quality) is typically accepted for air quality impact assessments in WA. The desired environmental outcome of the NEPM (Ambient Air Quality) is ambient air quality that allows for the adequate protection of human health and wellbeing.

Measurement and concentration averaging periods are based on critical exposure times for health impacts and are thus different for various pollutants. Therefore, to assess potential ground-level concentrations (GLCs) for the Proposal, modelled predictions were assessed against the relevant NEPM (Ambient Air Quality) standards shown in **Table 6-6**.

Table 6-6: NEPM (Ambient Air) Standards Relevant to the Proposal[1]

Air Emission	Averaging period	Maximum concentration standard	Maximum allowable exceedances
Nitrogen dioxide (NO_2)	1 hour	120 ppb	1 day a year
	1 year	30 ppb	None
Photochemical oxidants as Ozone (O_3)	1 hour	100 ppb	1 day a year
	4 hours	80 ppb	1 day a year
Sulphur dioxide (SO_2)	1 hour	200 ppb	1 day a year
	1 day	80 ppb	1 day a year
	1 year	20 ppb	None

Note 1: It is noted that the Commonwealth of Australia has published a Notice of Intention to vary the NEPM (Ambient Air Quality). However, as that amendment has not been formalised this ERD has only considered the 2015 standards, which were in force at the time of writing this ERD.

Air Dispersion Modelling Results

Cumulative atmospheric modelling for the Proposal was conducted for all the scenarios listed in **Table 6-5**. Contour plots of the maximum 1-hour and annual average NO_2 predicted concentrations for the near-term most likely (CBM) and medium-term best case (KIO) scenarios are presented in **Figure 6-3** to **Figure 6-6**. Similarly, plots of the maximum 1-hour and maximum 4-hour O_3 predicted concentrations for the two scenarios are presented in **Figure 6-7** and **Figure 6-8**. Finally, plots of the maximum 1-hour, maximum 24-hour and annual average SO_2 concentrations for the two scenarios are presented in **Figure 6-9** to **Figure 6-11**.

The near-term, most likely scenario (CBM) represents the continuation of the current emissions situation. The medium-term, best case scenario (KIO) presents the benefits gained in ambient air quality from the proposed NO_X reductions. It considers cumulative emissions from the Proposal operating with a conservative representation of feasible and significant NO_X reduction concepts, together with the existing, built, industrial facilities within the BSIA and the nearby region. At all locations on the grid, NO_2 and O_3 concentrations are lower in the KIO model. SO_2 remains consistent, as is expected as SO_2 is primarily associated with regional shipping activities and is not a significant emission from Proposal combustion or processing equipment.

Results from air dispersion modelling show that predicted levels of NO_2, O_3, and SO_2 are below NEPM (Ambient Air Quality) standards for all current and future cumulative emissions scenarios. Predicted model results received at the residential areas of Dampier and Karratha are summarised in **Table 6-7** whilst single point grid receptor maxima (any location within the study area) are outlined in **Table 6-8**.

Table 6-7: Summary of TAPM-GRS Results: Discrete Receptor Locations

Monitoring Station	CBM	KIO	FBSIA-E&A	FBSIA	FBSIA-KIO	NEPM (Ambient Air Quality) Standards
Maximum 1-hour average NO_2 (ppb)						
AQ Karratha	24.8	16.1	17.5	28.3	20.9	120
AQ Dampier	24.8	18.2	19.0	25.8	19.5	120
Annual average NO_2 (ppb)						
AQ Karratha	0.9	0.8	0.8	1.0	0.9	30
AQ Dampier	1.7	1.6	1.6	1.8	1.7	30
Maximum 1-hour average O_3 (ppb)						
AQ Karratha	57.9	55.0	55.2	61.2	55.8	100
AQ Dampier	55.4	53.2	53.7	56.5	54.4	100
Maximum 4-hour (stepwise) average O_3 (ppb)						
AQ Karratha	56.3	51.2	51.8	59.1	53.8	80 (moving average)
AQ Dampier	52.5	50.5	51.0	53.6	51.8	80 (moving average)
Maximum 1-hour average SO^2 (ppb)						
AQ Karratha	3.6	3.6	3.6	3.6	3.6	200
AQ Dampier	12.9	13.3	13.3	12.9	13.3	200
Maximum 24-hour average SO_2 (ppb)						
AQ Karratha	1.7	1.7	1.7	1.7	1.7	80
AQ Dampier	4.6	4.5	4.5	4.6	4.5	80
Annual average SO_2 (ppb)						
AQ Karratha	0.9	0.9	0.9	0.9	0.9	20
AQ Dampier	1.6	1.6	1.6	1.6	1.6	20

Table 6-8: Summary of TAPM-GRS Results: Grid Receptor Maxima and NEPM (Ambient Air Quality) Standards

Assessment Parameter (units)	CBM	KIO	FBSIA-E&A	FBSIA	FBSIA-KIO	NEPM (Ambient Air Quality) Standard
Max. 1-hour NO_2 (ppb)	42.6	29.1	30.7	43.9	32.4	120
Annual NO_2 (ppb)	5.0	4.9	5.0	5.6	5.7	30
Max. 1-hour O_3 (ppb)	61.8	59.2	60.0	63.0	61.0	100
Max. 4-hour (stepwise avg) O_3 (ppb)	58.2	55.3	56.1	59.7	57.4	80 (moving average)
Max. 1-hour SO^2 (ppb)	18.1	18.2	18.2	18.1	18.2	200
Max. 24-hour SO_2 (ppb)	7.0	7.0	7.0	7.0	7.0	80
Annual SO_2 (ppb)	4.5	4.5	4.5	4.5	4.5	20

Assessment of Potential Impacts (including Cumulative Impacts)

Interpretation of Modelling Results

Results for the near-term, most likely operational scenario (CBM) show that industrial emissions from industry operating on the Burrup Peninsula now and in the short-term will not generate exceedances of NEPM (Ambient Air Quality) standards. Predicted ambient concentrations of O_3 have the highest percentage of the criteria, with maxima (1-hour and 4-hour) at residential areas of Dampier and Karratha between 55 and 70% of the NEPM. Maximum percentages of approximately 20% of the NEPM criteria are predicted for the 1-hour NO_2 concentrations at Karratha and Dampier. Maximum percentage of 1-hour SO_2 concentrations are very low, being between 2 and 5% of the NEPM (Ambient Air Quality) standards at Karratha and Dampier.

The reduction in NO_X emissions (KIO) is reflected in a 35% reduction of the maximum NO_2 concentration at Karratha and a 27% reduction at Dampier.

When considering medium-term operational scenarios, it is appropriate to also consider emissions from developments currently approved (under the EP Act (WA)) but not implemented, as it is reasonably possible that such developments will be implemented in the medium term. The modelling scenario FBSIA E&A considers cumulative emissions from the Proposal operating with a significant reduction in NO_X from NWS Project sources, existing operating facilities, and future developments approved at the time of writing this ERD (i.e. Pluto LNG Development [Train 2]). Inclusion of Pluto LNG Development (Train 2) has a small effect (between 4% - 9% increase for single point maximum 1-hour NO_2 concentrations from KIO), with the FBSIA E&A scenario predicting an overall 29% reduction of the maximum 1-hour NO_2 concentration at Karratha and a 23% reduction at Dampier compared to baseline. There is a slight reduction compared to baseline in O_3 against NEPM (Ambient Air Quality) standards, and no change in SO_2 indicators.

The modelling study considered two long term emission scenarios (FBSIA and FBSIA-KIO) to test potential future cumulative outcomes which include reasonably foreseeable BSIA third party developments. Both scenarios considered the Proposal, existing operating facilities, future developments currently approved (i.e. Pluto LNG Development [Train 2]) and developments currently referred but not assessed or approved. The latter developments are represented by an indicative Urea Plant and Methanol Plant. The only difference between the two scenarios is the projected emissions from the Scenario FBSIA scenario is that emissions rates are aligned with current emissions (CBM), while FBSIA-KIO applies a significant reduction in NO_X from KGP sources.

The results from the FBSIA scenario (considered to represent the long-term, worst-case) demonstrate that in all instances the ambient air quality is below the relevant NEPM (Ambient Air Quality) standards. There is a slight increase over concentrations predicted for current operations (CBM). However, the predicted NEPM indicators for the FBSIA-KIO scenario are either less than, or very similar to, those predicted for current operations (CBM). Based on this, it is expected that the proposed emission reduction measures will achieve a net reduction in ambient air levels of NO_2 and O_3.

Values of the SO_2 NEPM (Ambient Air Quality) standards are similar across all modelled scenarios, with a conservative (over-estimate) assumption for both industrial emissions points (with very low sulphur in fuel), and shipping. The largest contributor of SO_2 to ambient air near the Proposal is shipping activities. All models included conservative shipping emissions estimates, with emissions modelled for all (13) berths on the Burrup Peninsula, and five berths at Cape Lambert. A ship was assumed to be docked at all these berths with ancillary engines running continuously; i.e. 24 hours per day, every day of the year. Even with this conservative assumption, SO_2 remained well below the relevant NEPM (Ambient Air Quality) standards. It should also be noted that SO_2 emissions are expected to significantly reduce from 1 January 2020 due to the implementation of low sulphur fuel legislation. In accordance with the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983* (Cth), all ships and vessels operating anywhere in Australia will be required to use fuel that contains a maximum sulphur content of 0.5% m/m (measured by mass). This emissions reduction was not factored into the modelling scenarios.

The modelled levels of NO_2, O_3, and SO_2 are below the relevant health standards (NEPM [Ambient Air Quality]) for the short-term, medium term and long-term modelled scenarios. Of particular importance, is that the predicted NEPM indicators at the residential areas of Karratha and Dampier are all well below the relevant standards. The predicted maximum 1-hour average NO_2 at Karratha is 23.6% of the relevant standard and 21.5% at Dampier, with maximum annual averages between 3% and 6% of the annual NEPM at respective locations. The predicted maximum 4-hour average O_3 at Karratha is 74% of the relevant standard and 67% at Dampier.

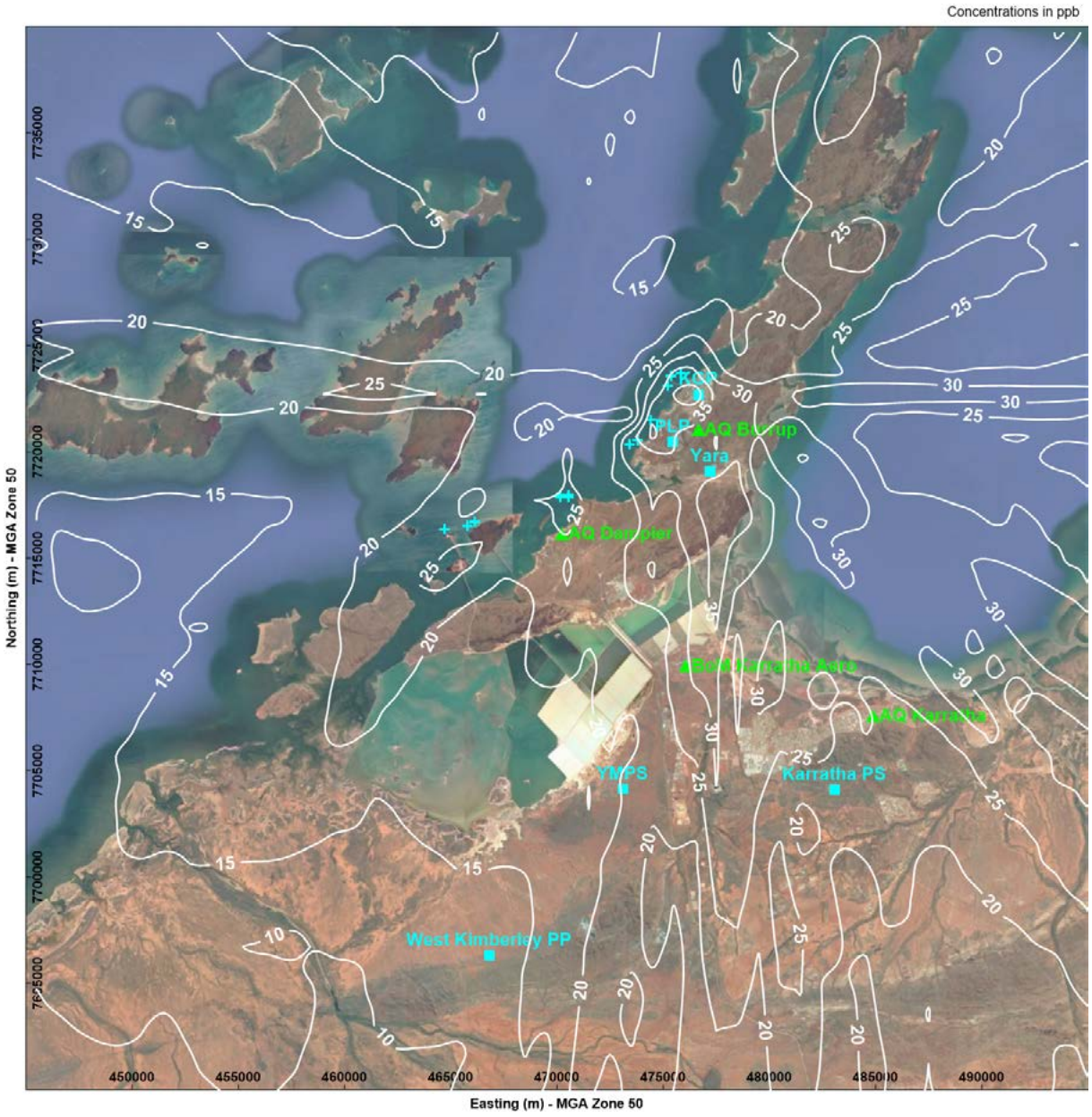


Figure 6-3: CBM – Maximum 1h NO_2 concentrations (ppb) (Near Term, Most Likely Scenario)

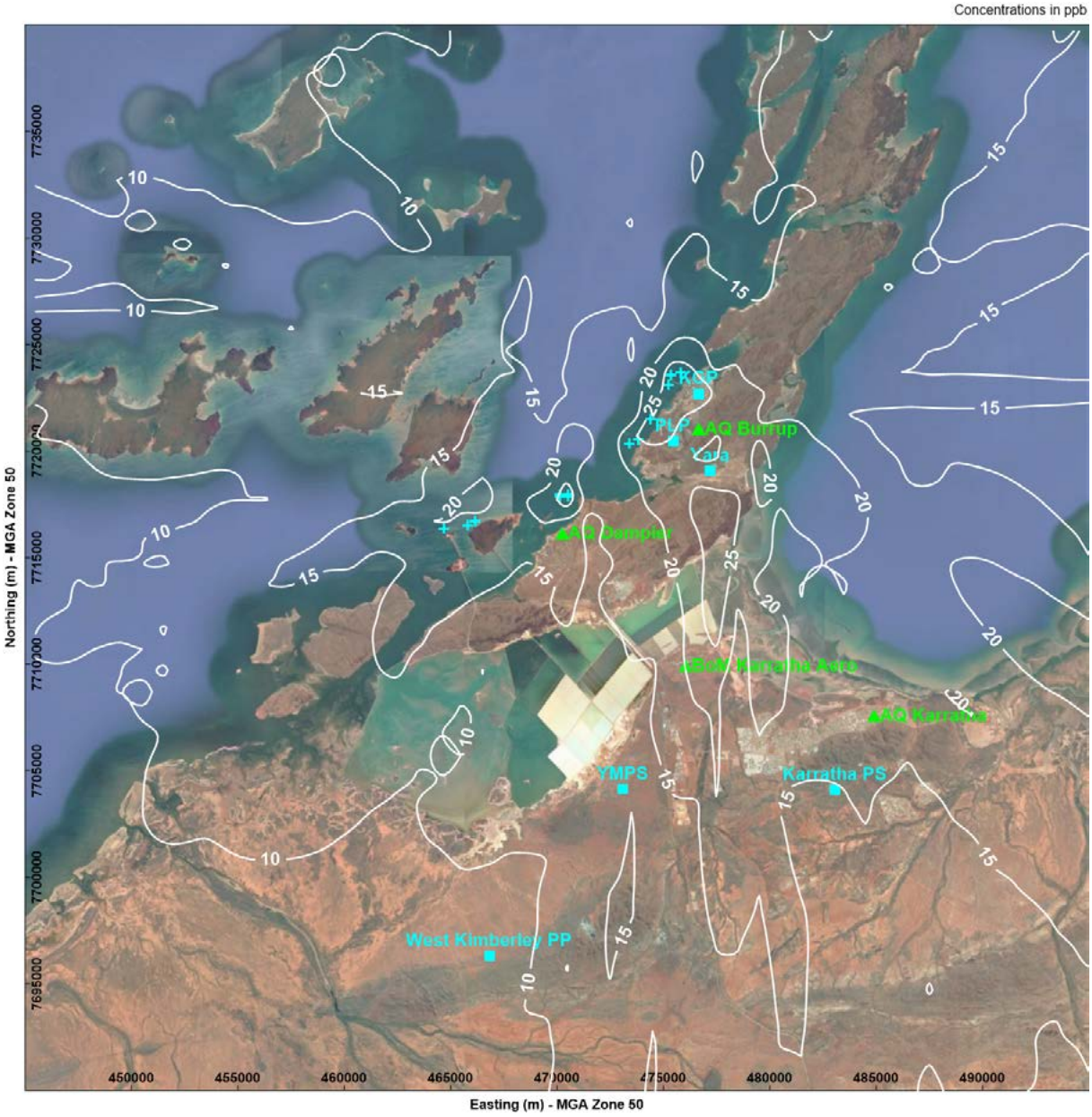


Figure 6-4: KIO – Maximum 1h NO_2 concentrations (ppb) (Medium-Term, Best Case Scenario)

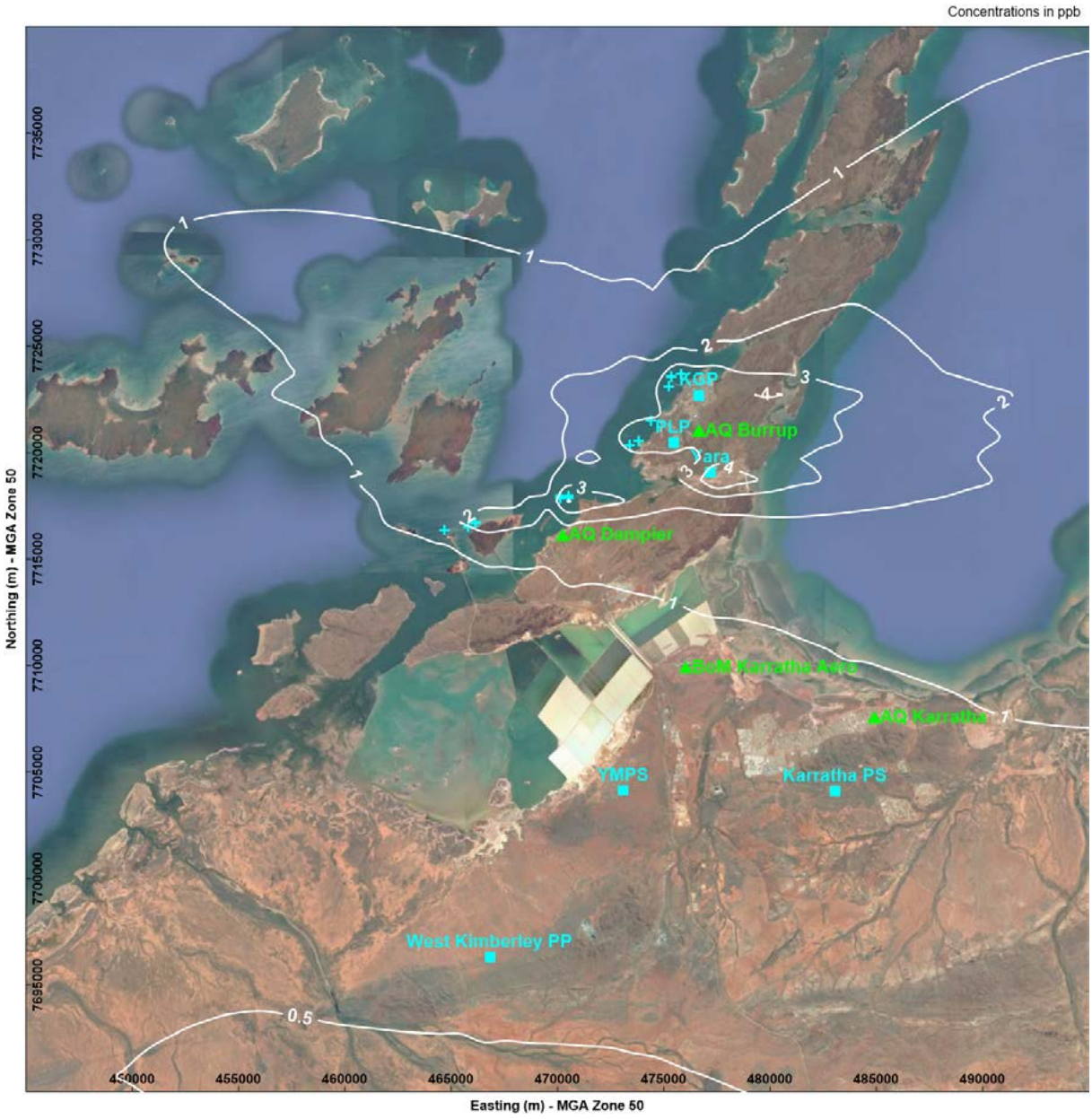


Figure 6-5: CBM – Annual Average NO_2 concentrations (ppb) (Near-Term, Most Likely Scenario)

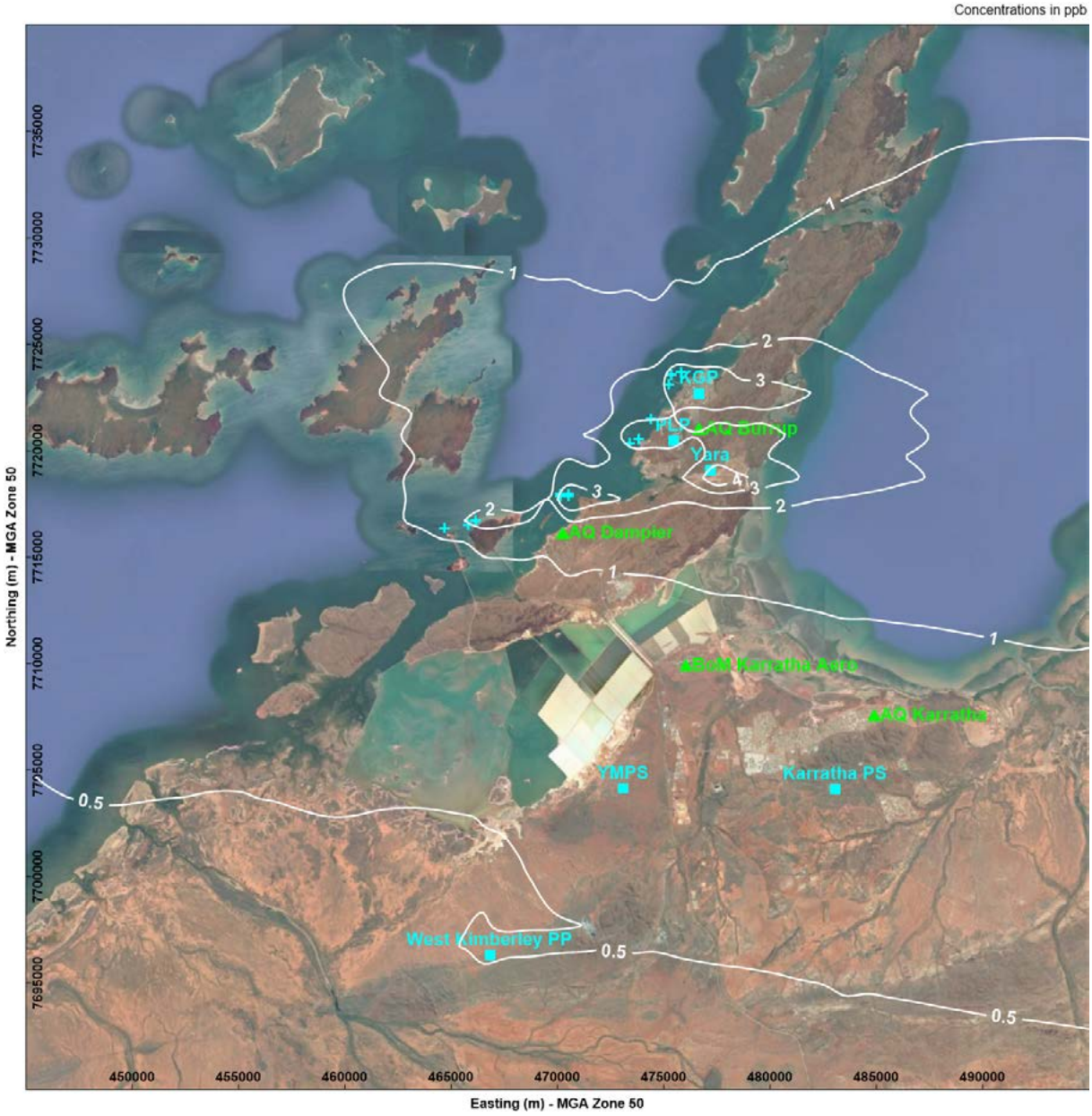


Figure 6-6: KIO – Annual Average NO_2 concentrations (ppb) (Medium-Term, Best Case Scenario)

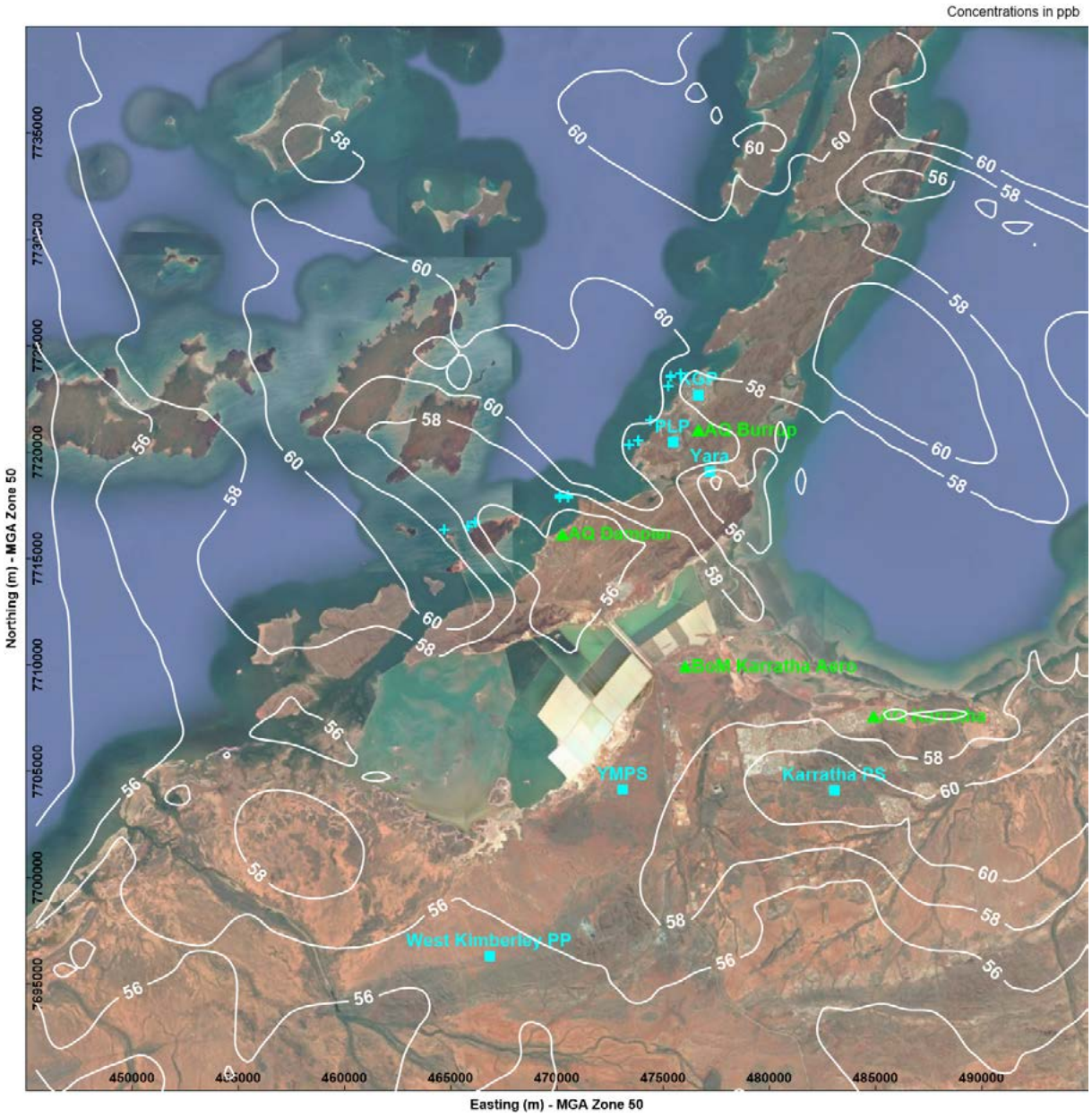


Figure 6-7: CBM – Maximum 1-hour Average O_3 Concentrations (ppb) (Near-Term, Most Likely Scenario)

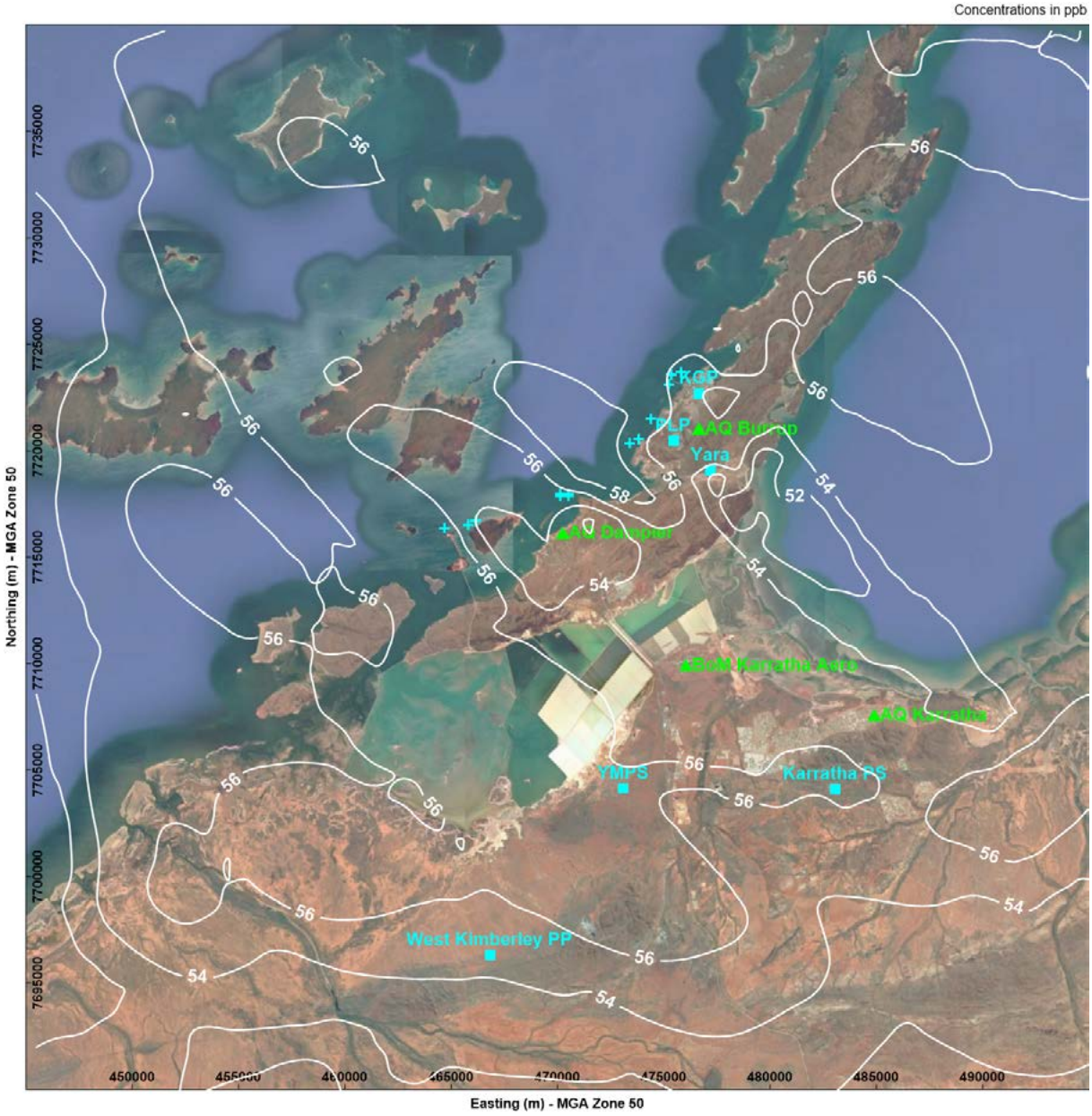


Figure 6-8: KIO – Maximum 1-hour Average O_3 Concentrations (ppb) (Medium-Term, Best Case Scenario)

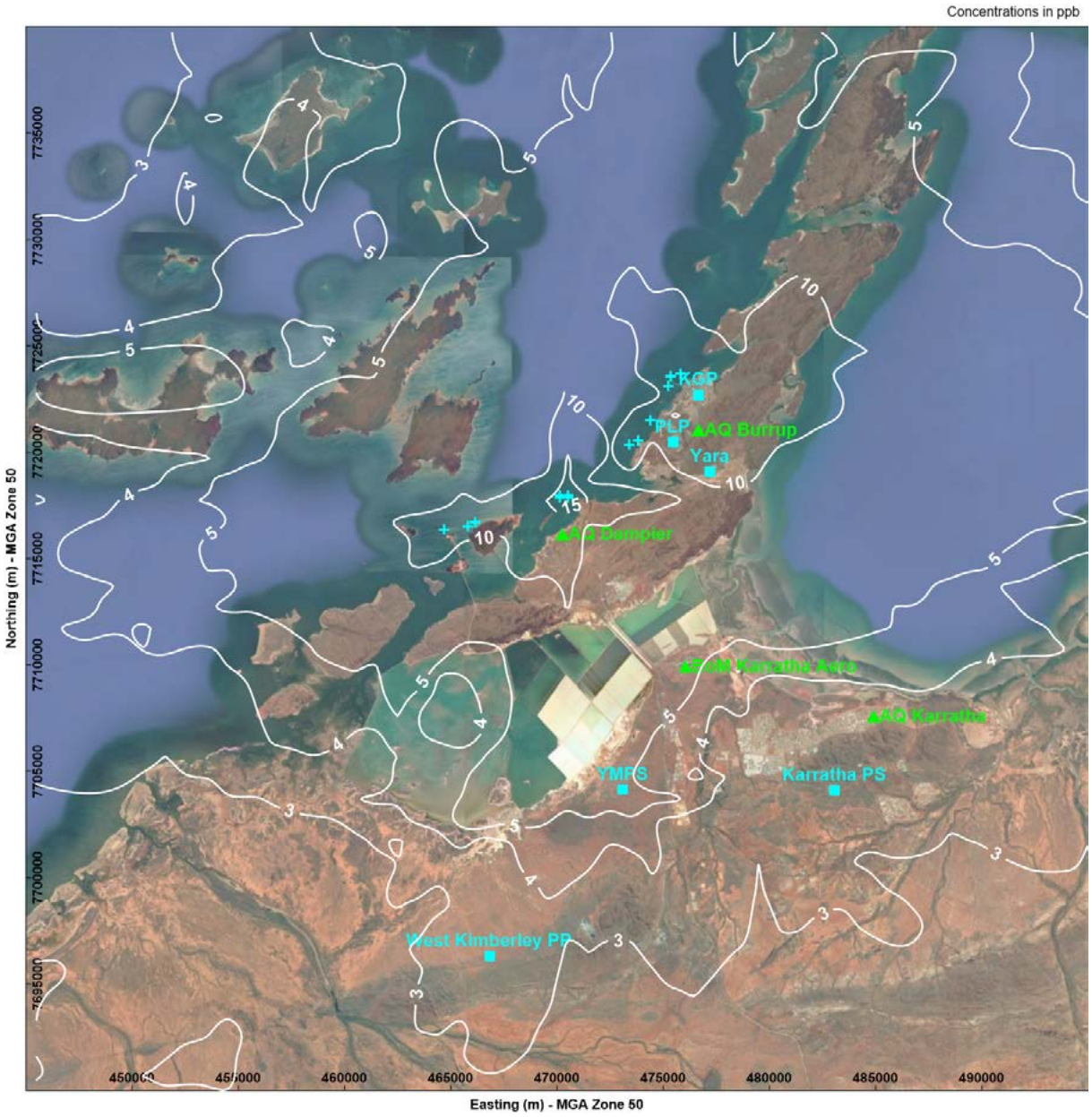


Figure 6-9: CBM – Maximum 1-hour Average SO_2 Concentrations (ppb) (Near Term, Most Likely Scenario)

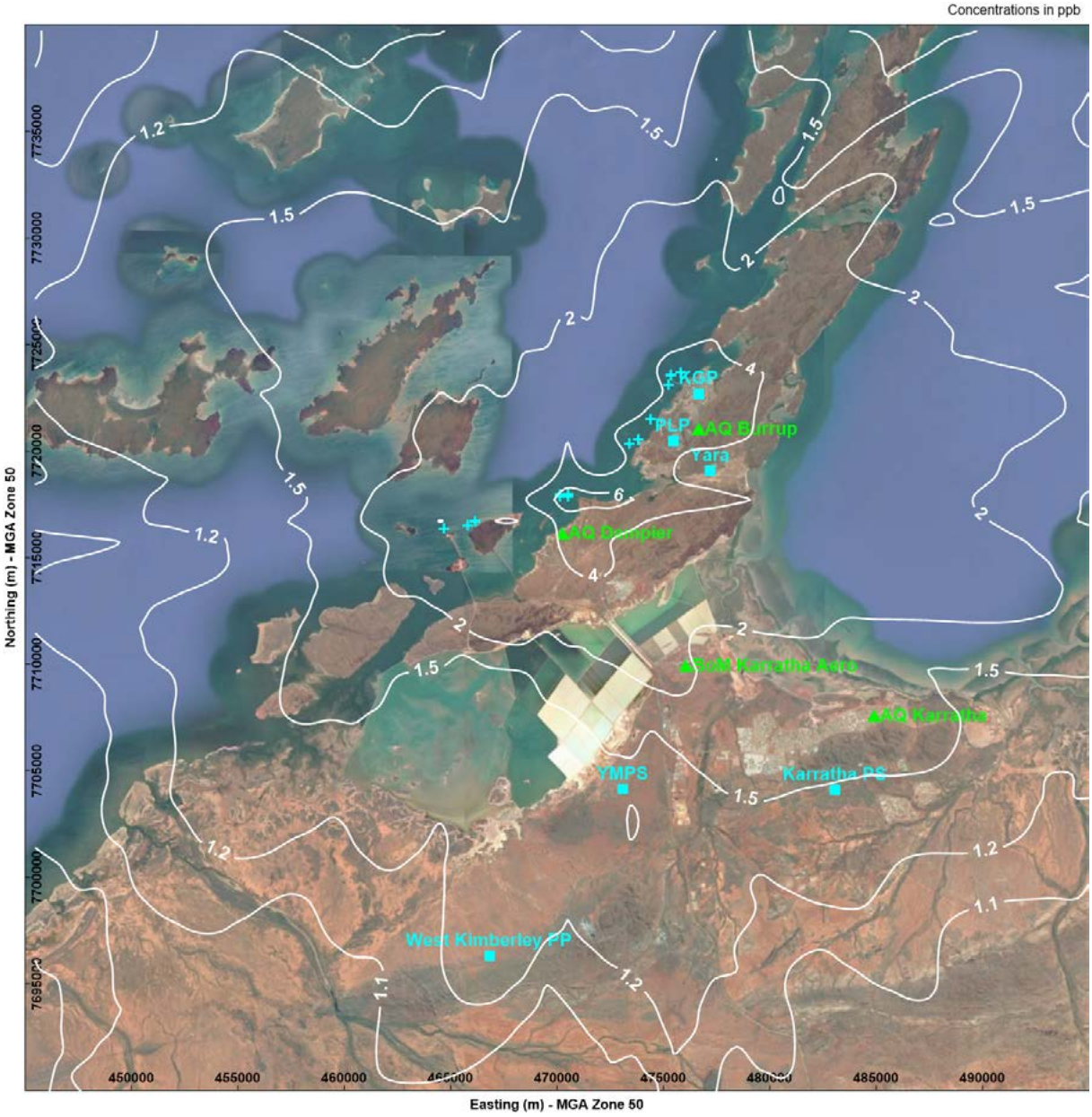


Figure 6 10: CBM – Maximum 24-hour Average SO_2 Concentrations (ppb) (Near Term, Most Likely Scenario)

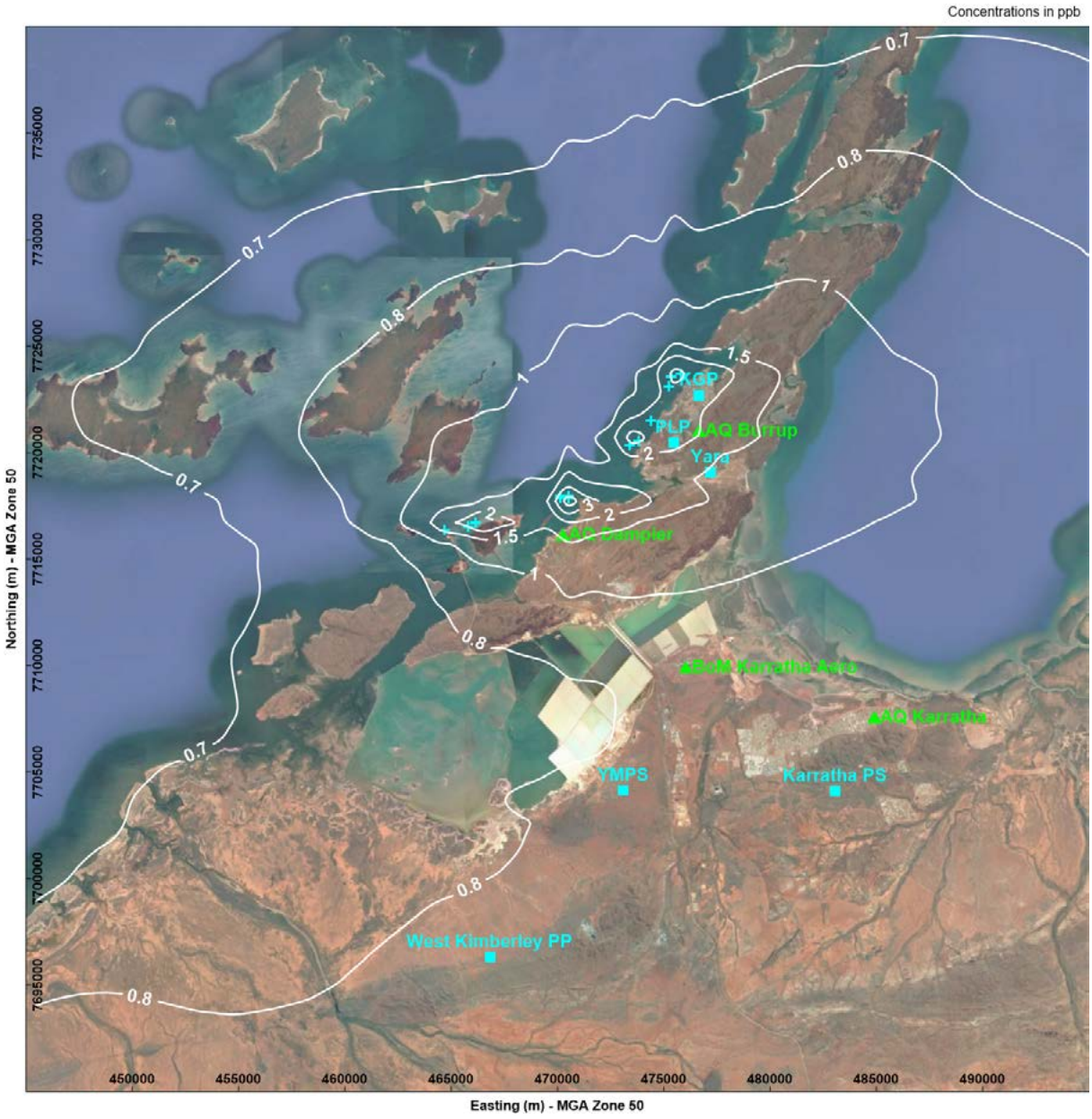


Figure 6-11: CBM – Annual Average SO_2 Concentrations (ppb) (Near Term, Most Likely Scenario)

Assessment of Potential Impacts

Based on existing air quality monitoring data and a comparison of a range of air dispersion modelling scenarios against relevant health assessment criteria, the potential impact from the Proposal to ambient Air Quality (human health) was assessed as having no lasting effect. The likelihood of this impact arising considering the existing mitigations was assessed as being *highly unlikely*. The receptor sensitivity is assessed as *medium*. While there is existing industry in the area and emissions occur a significant distance from residential areas, tourism and other recreational activities are frequently conducted in the region, but any exposure duration is limited. Therefore, it is assessed that there is a *low risk* of emissions from the Proposal reducing air quality to a level causing impacts the human health. This assessment considers potential cumulative impacts resulting from the interaction with the Proposal and other sources of reduction in ambient air quality.

6.3.4.2 Changes in Air Quality Causing Deposition on Nearby Heritage Features, Including National Heritage Places

A description and assessment of the potential impacts and risks from changes to air quality causing deposition of nitrogen and sulphur on heritage features in and around the development envelope is discussed in **Section 6.5.4.1**.

6.3.4.3 Degradation of Terrestrial and Nearshore Vegetation of Heritage and Conservation Value due to Deposition of Gaseous Emissions

A description and assessment of the potential impacts and risks from degradation of terrestrial and nearshore vegetation of heritage and conservation value due to deposition of gaseous emissions is discussed in **Section 6.5.4.2**.

6.3.4.4 Emission of Odorous Substances and Dark Smoke Impacting Public Amenity

Description of Potential Impact

Odorous Substances

Unreasonable emissions of odorous substances have the potential to cause nuisance or public amenity concerns. Potential trace levels of odorous substances associated with the Proposal can include VOCs (including BTEX) and sulphurous compounds (such H_2S).

VOCs (including BTEX) emissions are key air emissions in terms of risk to human health. These emissions are summarised in **Section 4.2** and **Section 6.3.4.1** with Burrup ambient monitoring results well below odour thresholds (e.g. odour threshold for benzene of around 61,000 ppb (USDoHHS, 2007). The sulphur content of the NWS Project gas reserve sources is very low, with emissions points designed to ensure adequate dispersion of potential trace odorants. Due to these low sulphur levels, odour emissions of sulphurous compounds (H_2S) are not expected to be of the magnitude sufficient to cause nuisance or amenity concerns.

There is a risk that third-party feed gas may alter the levels of trace sulphur compounds in gas to be processed through the NWS Project or increase concentrations of odorous substances released from the NWS Project. Potential air emission characteristic changes from the introduction of third-party gas will be managed in line with the Woodside management system to ensure that the environmental objectives and legislative requirements are met. This assessment will include the identification of appropriate management and mitigation controls to potential odour and amenity risk outside of the NWS Project development envelope remains at an acceptable level.

Dark Smoke

Dark smoke can be caused by the incomplete or low temperature combustion of flared gas. While dark smoke can release particulate matter that may cause impacts to health or vegetation due to the release of particulate matter, the impact is primarily to visual amenity. Dark smoke events are infrequent and particulate matter is released at low concentrations for short durations. Potential impacts to human health and nearby vegetation are described in **Section 6.3.4.1** and **Section 6.3.4.3** respectively. The likelihood of dark smoke causing impacts to human health is considered *remote*, with the consequence having *no lasting event*.

Assessment of Potential Impacts and Risks

For both odorous substances and dark smoke, the sensitivity of the receptor is assessed as *medium* due to the presence of the Murujuga National Park close to the Proposal and the use of the Burrup Peninsula for both recreation and tourism.

Odorous Substances

The NWS Project has experienced a long operational history without reports of nuisance odours. Potential for odour is inherently managed through facility design, such low sulphurous feed gas composition specification, process controls and design of emissions exhaust equipment. Hence, unreasonable or nuisance odour emissions are not expected, nor do they pose a significant risk to public or heritage values in the region. It is considered *highly unlikely* that the residents of Dampier (10 km from KGP) and Karratha (18 km from KGP) or the visitors to the Burrup Peninsula would experience any odour from the Proposal and any potential exposure would have *no lasting effect*. Therefore, there is only a *low risk* of loss of public amenity or reduced amenity to heritage features outside the development envelope as a result of air emissions from the Proposal.

Dark Smoke

All reasonably practical measures are taken to minimise or eliminate dark smoke events, but a small number of events are predicted to occur each year at the NWS Project due to unavoidable activities, such as safely disposing of hydrocarbons in plant upset conditions or to conduct preventative maintenance. The occurrence

of these events is minimised and controlled through maintenance planning and operational practices. Dark smoke events are monitored and reported in accordance with the Part V Operating Licence conditions. The planned impacts from dark smoke events would result in a loss of amenity to residents of Karratha and Dampier and visitors to the Burrup Peninsula and impact level of this loss of amenity is assessed as *slight*, given its infrequent short term nature. The risk to human health arising from dark smoke is *low*. It is unlikely that unplanned potentially larger or more frequent dark smoke events would cause impact levels to visual amenity greater than *slight*.

6.3.5 Existing and Proposed Mitigation

The existing and proposed avoidance, mitigation and contingency measures applicable to the management of impacts to Air Quality (Health and Amenity) arising from the Proposal are summarised in **Table 6-9**. Detailed description of measures is provided in the NWS Project Extension Air Quality Management Plan (**Appendix A**).

Table 6-9: Existing and Proposed Additional Mitigation Measures: Air Quality (Health and Amenity)

Impact	Existing Mitigation Measures	Proposed Mitigation Measures
Gaseous emissions causing a reduction in ambient air quality impacting human health	**Avoid** + Design measures implemented to ensure adequate dispersion of odorous emissions from exhausts and vent points. + Buffer zone established around site where no access is permitted. + Condensate tanks installed with sealed rims to avoid loss of VOCs to atmosphere. **Minimise** + Continuation of the facility emissions testing and verification programs as described in the NWS Project Extension Air Quality Management Plan (**Appendix A**). + Continue to implement the Woodside management system which includes procedures to assess changes in feed gas sources. **Rehabilitate** + Not applicable for this impact.	**Avoid** + No additional measures are proposed. **Minimise** + Adopt practicable and efficient technologies to reduce air emissions from the Proposal as described in the NWS Project Extension Air Quality Management Plan (**Appendix A**) + Monitor ambient concentrations of relevant emissions, that contribute to human health risks, from the Proposal as described in the NWS Project Extension Air Quality Management Plan (**Appendix A**) + Woodside has identified and evaluated credible opportunities to achieve a long-term reduction in air emissions and as a result is making a commitment to reduce NO_X emissions from the Proposal by 40%[1] and substantially reduce VOC emissions by 31 December 2030[2]. + Implement the NWS Project Extension Air Quality Management Plan (**Appendix A**) which includes provisions for monitoring ambient air concentrations of relevant emissions that contribute to human health risks and for assessing changes in feed gas composition. **Rehabilitate** + Not applicable for this impact.
Changes in air quality causing deposition on nearby heritage features, including national heritage places	Refer to the mitigation measures in **Section 6.5.4.1**.	
Degradation of terrestrial and nearshore vegetation of heritage and conservation value due to deposition of gaseous emissions	Refer to the mitigation measures in **Section 6.5.4.2**.	

Note 1: Based on the percentage of reported emissions from the KGP over the five-year annual average, covering the 2013/2014 to 2017/2018 financial years.

Note 2: Woodside is undertaking further studies at the KGP to identify and evaluate credible opportunities to achieve a long-term reduction in air emissions, and confirm the selection of improvement options to achieve the percentage emissions reductions. For NO_x emission reductions, Woodside is reviewing current best practice in low NO_x technology available for gas turbines. The most recent LNG trains (Trains 4 and 5) constructed at the KGP are already equipped with low NO_x technology. For VOC emission reductions, opportunities are being reviewed to determine where current best practice technology can be applied within the constraints of an existing plant and brownfield environment. Woodside anticipates that these studies will be completed in 2020, with a status update to be provided in the relevant Annual Environmental Report.

Impact	Existing Mitigation Measures	Proposed Mitigation Measures
Emission of odorous substances and dark smoke impacting public amenity	**Avoid** + Design measures implemented to ensure adequate dispersion of odorous emissions from exhausts and vent points. + Buffer zone established around site where no access is permitted. + Sources of potential odour (e.g. sewage treatment plant) located away from plant boundary. + Condensate tanks installed with sealed rims to avoid loss of VOCs to atmosphere. **Minimise** + Continuation of the facility emissions testing and verification programs as described in the NWS Project Extension Air Quality Management Plan (**Appendix A**). + Continue to implement the Woodside management system which includes procedures to assess changes in feed gas sources. + Public complaints process and incident investigation procedure for reports of odour or dark smoke. + Emissions performance monitoring and reporting. + Regular inspection and maintenance of flare tips to ensure adequate combustion and minimising dark smoke. + Assist gas utilised during periods where dark smoke may be released, to facilitate complete combustion of heavy hydrocarbons. **Rehabilitate** + Not applicable for this impact	**Avoid** + No additional measures are proposed. **Minimise** + Implement the NWS Project Extension Air Quality Management Plan (**Appendix A**) which contains procedures for assessing changes in feed gas composition that may change nuisance-causing emissions. + Support implementation of the Murujuga Rock Art Strategy (DWER, 2019b) as a member of the Murujuga Rock Art Stakeholder Reference Group. **Rehabilitate** + Not applicable for this impact

6.3.6 Predicted Outcome

After implementing the proposed mitigation measures, the planned impacts and risks associated with the ongoing emissions to air from the Proposal until around 2070 and the potential introduction of third-party gas and fluids (which may cause changes to air emission characteristics) are assessed as having an residual environment impact rating not greater than slight, or residual risks greater than *low*. Woodside considers that this indicates the residual impacts and risks associated with the proposal are broadly aligned with the EPA's objective for Air Quality. There were no impacts or risks identified that would mean that the EPA Objectives for Air Quality are not achieved.

Potential air emission characteristic changes from the introduction of third-party gas will be managed in line with the Woodside management system to ensure that the environmental objectives and legislative requirements are met. This assessment will include the identification of appropriate management and mitigation controls to ensure impacts and risks remains below levels considered to be significant. Therefore, Woodside has a high level of confidence in these residual risk rankings. The implementation of the NWS Project Extension Air Quality Management Plan (**Appendix A**) and other management measures (summarised in **Table 6-9**) will continue to reduce any residual impacts on human health and amenity within and outside the NWS Project development envelope.

No additional management or mitigation measures are required to be implemented to further minimise residual risks. However, the Proposal provides equipment life and operational opportunities to further minimise NO_X and VOC emissions. As such, Woodside is committed to reducing NO_X emissions by 40%[6], and substantially reduce VOCs by 31 December 2030. These opportunities to further reduce air emissions are illustrated to predict a net reduction in ambient air ground level concentrations of the key pollutants of NO_2 and O_3 for future cumulative emissions scenarios in and around the BSIA.

No significant air quality impacts to human health and amenity are expected associated with the ongoing operation of the Proposal. Analysis of seven years of ambient air monitoring data demonstrate long term cumulative ground level emissions rates below NEPM health standards.

Woodside will continue emissions monitoring programs during the Proposal through the implementation of the NWS Project Extension Air Quality Management Plan (**Appendix A**). This management plan leverages facility technical emissions control technologies and sets out a suite of operational management practices and contains provisions for measuring and managing emissions from the Proposal (such as point source emissions verification and ambient air monitoring).

Environmental monitoring and existing environmental baseline data—which include historical operation of the NWS Project—together with robust and conservative modelling predictions, provide evidence to support the predicted outcomes of the Proposal.

There were no identified changes to existing NWS infrastructure from the Proposal that would increase the planned impacts to Air Quality beyond those from existing operations.

Refer to **Section 6.5.4.1** for potential impacts associated with accelerated weathering to rock art from industrial emissions.

A summary of the impact assessment outcomes used to derive this outcome is provided in **Table 6-10**.

Table 6-10: Air Quality (Health and Amenity) Impact Assessment Summary

Impact	Receptor Sensitivity	Magnitude	Likelihood (unplanned impacts only)	Impact Level/ Environment Risk Rating
Emission of odorous substances and dark smoke impacting public amenity	Medium	Planned – Slight Unplanned - Minor	N/A Highly Unlikely	Impact level - Slight Risk rating - Low
Gaseous emissions causing a reduction in ambient air quality impacting human health	Medium	No lasting effect	Unlikely	Risk rating - Low
Changes in air quality causing deposition on nearby heritage features, including national heritage places	Refer to **Section 6.5**			
Degradation of terrestrial and nearshore vegetation of heritage and conservation value due to deposition of gaseous emissions	Refer to **Section 6.5**			

6 *Based on the percentage of reported emissions from KGP over the five year average, covering the 2013/14 to 2017/18 financial years.*

6.4 Key Environmental Factor – Air Quality (Greenhouse Gas Emissions)

6.4.1 EPA Objective

To maintain air quality and minimise emissions so that environmental values are protected (EPA, 2016a).

6.4.2 Policy and Guidance

EPA Policy and Guidance

+ Statement of Environmental Principles, Factors and Objectives (EPA, 2018a)
+ Environmental Factor Guideline: Air Quality (EPA, 2016a)

Other Policy and Guidance

+ Climate Solutions Package (DoEE, 2019a)
+ Greenhouse Gas Emissions for Major Projects (DWER, 2019a)

6.4.2.4.1 Relevant Legislation

+ *National Greenhouse and Energy Reporting Act 2007* (Cth)
+ *Carbon Credits (Carbon Farming Initiative) Act 2001* (Cth)
+ *National Greenhouse and Energy Reporting (Measurement Determination) 2008* (Cth)
+ *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015* (Cth)

Section 10 details how this legislation, policy and guidance relates to the Proposal.

6.4.3 Receiving Environment

This section identifies the elements of the receiving environment that are directly and indirectly related to the Air Quality (Greenhouse Gas Emissions) environmental factor. Refer to **Section 4** for detailed description of each relevant receptor of the receiving environment.

Table 6-11 Air Quality (Greenhouse Gas Emissions) Receiving Environment

	Activity	Ongoing emissions to air from the NWS Project Extension Proposal until around 2070.	Introduction of third-party gas and fluids, which may cause changes to air emission characteristics
Receving Envrionment	*National Heritage Place*		
	Shorelines		
	Seabirds and Shorebirds		
	Sharks and Fish		
	Sea Snakes		
	Turtles		
	Marine Mammals		
	Sediment Quality		
	Water Quality		
	Macroalgae		
	Seagrass		
	Coral		
	Marine Invertebrates		
	Mangroves		
	Marine Fauna with Heritage Value		
	Vegetation with Heritage Value		
	Heritage Features		
	Terrestrial Vegetation		
	Contribution to GHG Concentrations	✓	✓
	Air Quality (Relevant to Amenity)		
	Air Quality (Relevant to Human Health)		

6.4.4 Potential Impacts and Risks

The components of the Proposal that may result in GHG emissions include:

- Ongoing emissions to air from the NWS Project Extension Proposal until around 2070.
- Introduction of third-party gas and fluids, which may cause changes to air emission characteristics.

Potential impacts from GHG emissions may include:

- Contribution to global GHG concentrations from Scope 1, Scope 2 and Scope 3 emissions.
- Climate change influenced by changes to Global GHG emission concentrations.

6.4.4.1 Contribution to global GHG concentrations from Scope 1, Scope 2 and Scope 3 emissions

Description of Potential Impacts

The Proposal contributes to global GHG concentrations from:

- Direct emissions from the production of LNG and other products (Scope 1[7] emissions) .
- Indirect emissions from the consumption of electricity (Scope 2[8] emissions).
- Indirect emissions from activities such as transport and customer use of products sold by the Proposal (Scope 3[9] emissions).

Based on LNG production of 18.5 mtpa, the Scope 1 and Scope 2 GHG emissions from the Proposal will be up to 7.7 mtpa CO_2e. Details on the Scope 1, 2 and 3 emission sources are described further below and are summarised in **Table 6-12** and **Table 6-15**.

For the purpose of this document, Scope 1 emissions include emissions generated between the trunkline onshore terminal at the KGP to the fiscal metering point for each product. Scope 1 emissions described in this section cover all potential future emissions from the introduction of third party gas and fluids.

Scope 1 Emissions

Scope 1 emissions associated with the Proposal include:

- Gas turbine compressors: operating gas turbine compressors used to compress refrigerant to liquefy natural gas.
- Acid gas removal: removing and venting of CO_2 from the gas stream through the AGRUs, including venting some residual methane, VOCs and other incidental substances associated with gas processing.
- Electricity generation: operating gas turbine generators that use gas from the Proposal to generate electricity to run the Proposal.
- Flaring: burning hydrocarbons through the flare.
- Fugitive emissions: small emissions of gas to the atmosphere from various areas throughout the Proposal, such as flanges, valves, and process safety vents.

Scope 2 Emissions

Scope 2 emissions associated with the Proposal are from electricity consumed at KBSB. This accounts for approximately 0.002 mtpa, as reported in the 2017 - 2018 NGERS report.

All electricity consumed at the KGP is generated on site and therefore GHG emissions associated with this electricity generation is considered in the Scope 1 emissions detailed above.

There are currently no other Scope 2 emissions associated with the Proposal.

Table 6-12: Estimated Summary of Maximum Scope 1 and 2 Emissions for NWS Project Extension[1]

Annual Scope 1 and Scope 3 Emissions	Annual GHG Emissions (mtpa)	GHG Emissions over 50 year life of project[2] (mt)
Scope 1 and 2 Emissions		
CO_2e Emissions[3]	7.70	385.00

Note 1: Average emissions have not been forecasted due to potential changes to future gas sources to be processed by the NWS Project. Woodside proposes to operate the NWS Project as an LNG facility that is commercially capable of accepting gas for processing from other resource owners. Therefore it is more accurate to refer to maximum annual and life of the project emissions.

Note 2: Maximum Scope 1 and 2 emissions are based on 50 years of operation at full capacity for the KGP. It is expected that GHG emissions would decline towards the end of project life.

Note 3: Maximum direct (Scope 1 and 2) GHG emissions are based on current limits described in previous environmental assessment documentation submitted for the NWS Project under the EP Act (Woodside, 1998).

7 *Scope 1 GHG emissions are the emissions released to the atmosphere as a direct result of an activity, or series of activities at a facility level (Clean Energy Regulator, 2019)*

8 *Scope 2 GHG emissions are the emissions released to the atmosphere from the indirect consumption of an energy commodity (Clean Energy Regulator, 2019)*

9 *Scope 3 GHG emissions are indirect GHG emissions other than Scope 2 emissions that are generated in the wider economy (Clean Energy Regulator, 2019)*

Emissions from Third Party Consumption

GHG emissions associated with the consumption of LNG is expected to predominately occur internationally and therefore, emissions associated with LNG shipping, regasification, distribution and combustion have been estimated using emissions factors sourced from the Ecoinvent v3.5 database.

For GHG emissions associated with the consumption of Domgas, an emission factor has been developed based on NGER that considers both distribution and final end point fuel combustion of natural gas. Fugitive emissions associated with Domgas during transmission (along the Dampier to Bunbury Natural Gas Pipeline) have been estimated in accordance with the NGER Measurement Determination. NGER end point fuel combustion factors have been used for third-party consumption of LPG and Condensate. The transportation and distribution emissions associated with these products are considered to be negligible when compared to the total Scope 3 emissions estimate and therefore have not been included in the below calculations.

The Scope 3 consumption emissions (**Table 6-14**) of each product have been calculated using the emission factors defined in **Table 6-13** above. Maximum annual production rates for each product (converted to energy content) from the Proposal were assumed when estimating Scope 3 emissions.

Table 6-13: Emission Factors for the Calculation of Scope 3 GHG Emissions

Scope 3 Sources	Emission Factor	Reference
LNG	3.13 kg CO_2e/kg LNG[1]	Ecoinvent v3.5 Database
LPG	60.6 kg CO_2e/GJ	NGER (Determination) Schedule 1 and S3.80
Domgas	57.35 kg CO_2e/GJ[2]	NGER (Determination) Schedule 1
Condensate	61.3 kg CO_2e/GJ	NGER (Determination) Schedule 1

Note 1: Ecoinvent v3.5 emissions factor of 3.13 kg CO_2e/kg LNG represents an increase in 8.6% from the NGERs (Determination) Schedule 1 factor of 2.88 kg CO_2e/kg LNG. The additional emissions account for other emission sources, including transport, regasification and distribution.

Note 2: Emission factor includes end user combustion and distribution losses.

Table 6-14: Estimated Scope 3 Emissions for NWS Project Extension

Scope 3 Sources	Maximum Annual GHG Emissions (mtpa)[1]
LNG	57.91
LPG	1.72
Domgas	10.38
Condensate	10.18

Note 1: Maximum Scope 3 GHG emissions associated with third party consumption of products are based on the LNG nameplate capacity of 18.5 mtpa as set out in Schedule 1 of MS536 (as amended). As condensate, LPG and Domestic Gas products do not have regulated production limits, maximum emissions have been based on the highest reported annual production rate for each product over the past five financial years (2013/14 – 2017/18), as reported under NGERS.

Table 6-15: Estimated Summary of Maximum Scope 3 Emissions for NWS Project Extension[1]

	Annual GHG Emissions (mtpa)	GHG Emissions over 50 year life of project[2] (mt)
CO_2e Emissions	80.19	4009.31

Note 1: Maximum Scope 3 emissions are based on 50 years of operation at full capacity for the KGP. It is expected that GHG emissions would decline towards the end of project life.

Note 2: Average emissions have not been forecasted due to potential changes to future gas sources to be processed by the NWS Project. Woodside proposes to operate the NWS Project as an LNG facility that is commercially capable of accepting gas for processing from other resource owners. Therefore it is more accurate to refer to maximum annual and life of the project emissions.

Upstream Emissions

GHG emissions associated with the upstream extraction and processing of gas and fluids are not under assessment as part of this Proposal. All upstream facilities supplying gas and fluids to the KGP (including existing NWS Project offshore facilities) are required to operate under an accepted Environment Plan in accordance with the *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* (Cth) which requires a demonstration that environmental impacts and risks of the activity will be reduced to as low as reasonably practicable and will be of an acceptable level. In addition, operators are required to report actual GHG emissions for both upstream and downstream processing facilities on an annual basis under the *National Greenhouse and Energy Reporting Act 2007* (Cth).

Contribution to Regional, State, National and Global Emissions

To inform the assessment of the impact of emissions from the Proposal, total direct (Scope 1 and 2) as well as direct and indirect (Scope 1, 2 and 3) emissions are put into context of domestic and global anthropogenic emissions. As future global emissions may vary depending on the success of various measures to reduce emissions, global emissions are shown against 2017 actuals and the four United Nations Environment Program Nationally Determined Contribution (NDC) Scenarios:

+ 2030 (No Policy Baseline)
+ 2030 (Current Policy Baseline)
+ 2030 (2°C Pathway)
+ 2030 (1.5°C Pathway).

Table 6-16: Percentage Contribution of Maximum Proposal Emissions to Regional, State, National and Global GHG Emissions

	Total GHG Emissions (mtpa)	Proposed NWS Project Extension Direct Emissions (Scope 1 & 2) 7.7 mtpa CO_2e	Proposed NWS Project Extension All Emissions (Scope 1, 2 & 3) 87.89 mtpa CO_2e
Regional[1]	25.9	29.75 %	Not Applicable
Western Australia	88.5[2]	8.70 %	Not Applicable
Australia	534.7[3]	1.44 %	Not Applicable
Global (NDC Scenarios)[4]			
2017 Actual	53,500	0.01 %	0.16 %
2030 (No Policy Baseline)	65,000	0.01 %	0.14 %
2030 (Current Policy Baseline)	59,000	0.01 %	0.15 %
2030 (2°C Pathway)	40,000	0.02 %	0.22 %
2030 (1.5°C Pathway)	24,000	0.03 %	0.37 %

Note 1: As there is no definitive public record of GHG emissions in the Pilbara region, quantification of emissions is based on the National Greenhouse and Energy Reporting Safeguard facility reported emissions (2017/2018 FY) for facilities that emit more than 100,000 tonnes of CO_2e per annum. Therefore, this calculation is a subset of GHG emissions in the Pilbara region and only reflects industrial scale emitters. Regional emissions have been defined as emissions occurring within the Pilbara region of Western Australia. Due to the nature of the data available, regional emissions also include integrated upstream offshore facilities that feed into onshore processing plants located in the Pilbara. For the NWS Project, 1 mtpa of CO_2e per annum from the upstream offshore operations has been assumed. This estimatation is inherently uncertain as there is no definitive public record for GHG emissions in the Pilbara region.

Note 2: 2017 Greenhouse Gas Emissions for Western Australia (Commonwealth of Australia, 2019a)

Note 3: 2017 Total Greenhouse Gas Emissions for Australia. Sources from the Australian National Inventory Report 2017 (DoEE, 2019f). Submitted under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (KP).

Note 4: Five United Nations Environment Program NDC Scenarios have been used to represent current and future proposed global greenhouse gas emissions. Emission estimated have been referenced from the UN Environment Emissions Gap Report 2018 (UNEP, 2018). It should be noted that the 2030 emissions forecasts are United Nations Environment Program projections only and total global GHG emissions reflect anthropogenic emissions only.

Contribution to Australia's Emissions

Under the Paris Agreement, Australia has a target of reducing emissions by 26 – 28% below 2005 levels by 2030. Australia stated in its Nationally Determined Contribution that it would develop its target into an emissions budget covering the period of 2021 – 2030. The target trajectory for this period is 4,800 mt in order to reach the 26% reduction target (DoEE, 2018). Scope 1 and 2 GHG emissions from the Proposal are expected to contribute to 1.6% of this cumulative emissions budget.

Australia's emissions projections 2018 (DoEE, 2018) provides an indicative summary of how Australia is tracking to achieve its Nationally Determined Contribution. Projected emissions to 2030 from the LNG sector (direct combustion and fugitive) are included in the methodology used to underpin these projections. The methodology is based on an export capacity of 80 mtpa of LNG in 2020 with the addition of one new LNG train in the mid-2020's (DoEE, 2018).

The emissions reduction task to achieve the 2030 target is currently 328 mtCO_2e. The Australian government has outlined a plan to closing this gap in the Climate Solutions Package (Commonwealth of Australia, 2019b).

Benchmarking Against Other LNG Facilities

The comparison parameter most commonly used to benchmark GHG emissions from LNG facilities is 'GHG intensity' (i.e. the tonnes of GHG emitted per tonne of LNG produced). GHG emissions are expressed in CO_2e, where the CO_2e emissions are an aggregate of GHG emissions including carbon dioxide, methane and nitrous oxide, calculated as an equivalent CO_2 emission by factoring in the global warming potential (GWP) of each constituent gas. GWP is applied in accordance with *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (Cth). GHG intensity has been calculated for emissions associated with gas processing at the LNG facility and does not include emissions associated with the upstream extraction of the natural gas or the downstream combustion of the LNG. The following emissions were excluded from the benchmarking assessment:

- GHG emissions from upstream operations associated with the extraction and compression of raw gas (i.e. upstream of the Trunkline Onshore Terminals ([TOT1 and TOT2]).
- Scope 2 emissions.
- Scope 3 emissions.
- Emissions associated with handling, transport and use of gas product downstream of the fiscal product meter.

The benchmarking has not included proposed future mitigation measures to reduce GHG emissions. Mitigation measures to reduce GHG emissions are assessed annually and will be implemented in accordance with internal decision criteria which takes into account a number of economic and environmental considerations.

The methodology for choosing LNG facilities against which to benchmark the Proposal included assessing the location, age, and capacity of each facility, and whether enough publicly available data about emissions and LNG production was available. Nine Australian and eight international facilities were selected for the benchmarking study, which represents nearly half of the LNG facilities globally. Data has been preferentially extracted from Environmental Impact Statement greenhouse gas information where applicable.

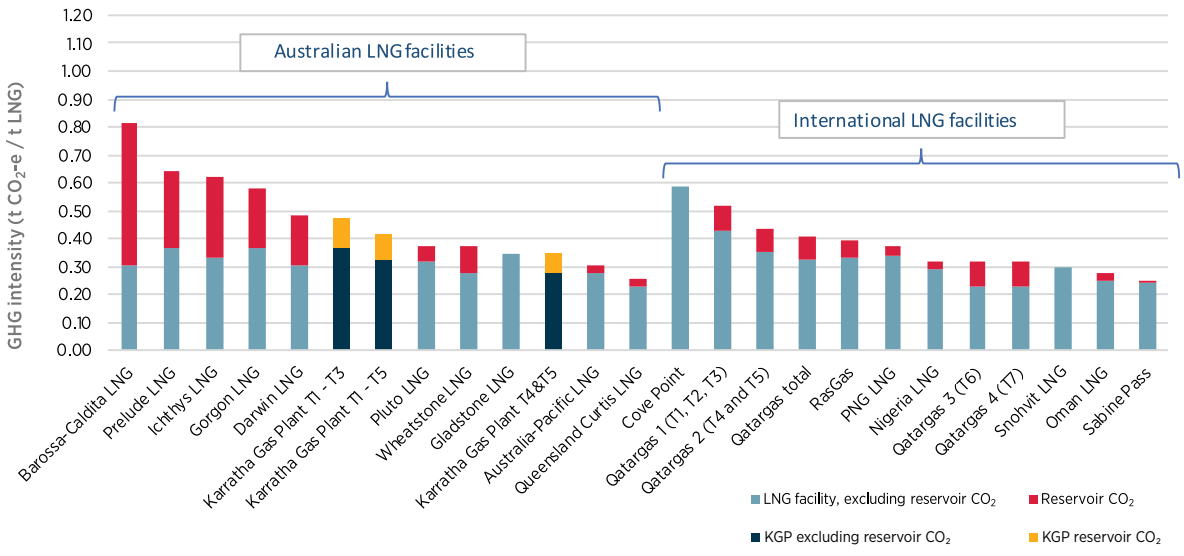


Figure 6-12 GHG Benchmarking Results

Table 6-17: KGP LNG facility GHG intensity data for current operations

LNG Facility	LNG Production Rate 2017 - 2018 mtpa	GHG Intensity (t CO2e / t LNG)		
		Reservoir CO_2	*LNG Facility, Excluding Reservoir CO_2*	*Total LNG Facility*
Karratha Gas Plant T1 - T5	16.6	0.09	0.32	0.41
Karratha Gas Plant T1 - T3	8.22	0.09	0.40	0.49
Karratha Gas Plant T4 -T5	8.40	0.09	0.26	0.35

The benchmarking shown in **Figure 6-12** assesses the Proposal in three parts: KGP Trains 1 to 3; KPG Trains 4 and 5; and KGP Trains 1 to 5. The emissions intensity is shown in **Table 6-17**, separated into these three parts. Assessing the Proposal from this perspective acknowledges that KGP Trains 4 and 5 are newer and were designed with lower emissions intensities than KGP Trains 1 to 3.

The benchmarking shows that the emissions for KGP Trains 4 and 5, and for KGP Trains 1 to 5, are lower than the average (0.44 t CO_2e / t LNG) for the Australian facilities analysed[10]. Facilities with GHG intensities lower than KGP Trains 4 and 5 are Australia-Pacific LNG, and Queensland Curtis LNG, both of which have relatively high LNG production capacities and have been commissioned recently (i.e. in the last five years). When reservoir CO_2 is excluded, the GHG intensity of KGP Trains 4 and 5 is lower than the average for the Australian facilities analysed (0.31 t CO_2-e / t LNG). The GHG intensity, excluding CO_2 reservoir emissions, for KGP Trains 1 to 5 are slightly higher than the average for the Australian facilities.

The GHG intensity of the Proposal, excluding emissions attributable to reservoir CO_2, is slightly higher than Wheatstone. An influencing factor may be the use of aero-derivative turbines for both refrigeration and power generation at Wheatstone LNG; aero-derivative turbines are only used for power generation for KGP Trains 4 and 5.

Of the international LNG facilities, the Qatargas facility is most comparable to KGP Trains 1 to 5 as it is a large facility of similar age and has a similar reservoir CO_2 content. This facility comprises four LNG plants, with a total of seven liquefaction trains (Trains 1 to 7). The GHG intensity for this facility (combined Trains 1 to 7) is 0.41 t CO_2e/t LNG, which is very similar to that of KGP Trains 1 to 5. Like the Proposal, the GHG intensity of the Qatargas facility has decreased progressively over the years as newer liquefaction trains have been added.

Overall, the current and future projected GHG performance of the Proposal is similar to both Australian and international LNG facilities. The GHG intensity for KGP is lower than the average intensity for the nine Australian facilities assessed, even when the high CO_2 proposed Barossa-Caldita LNG facility is excluded. When assessed against international LNG facilities, the GHG performance of the Proposal was found to be very similar to those facilities located in a similar climate and of similar age.

Assessment of Potential Impacts and Risks

Total direct (Scope 1) emissions of 7.7 mtpa CO_2e has previously been described in environmental assessment documentation submitted for the NWS Project under the EP Act (Woodside, 1998). The ongoing operation of the NWS Project or future introduction of third-party gas or fluids and subsequent processing of these hydrocarbons, in accordance with the Proposal, will not increase the existing annual GHG emissions characteristics of the NWS Project. Although the CO2 composition (and other compositional elements) of third-party gas resources could vary from that of the existing NWSJV gas resources, mitigation measures will be put in place to ensure total direct emissions from the Proposal do not exceed 7.7 mtpa. This equates to between 0.01% and 0.03% of annual global GHG emission concentrations, depending on future emissions trends (as illustrated in **Table 6-16**).

The impact associated with the Proposal's GHG emissions contribution needs to be considered in context of global emissions and the receptor relevant to GHG emissions is therefore the global atmosphere. Therefore regional, state and national GHG contributions are not further assessed. The IPCC (2014) notes that GHGs accumulate over time and mix on a global scale and therefore emissions from a single entity (individual, community, company, country, etc) will mix with and affect the emissions of other entities. The sensitivity of

10 *The calculated average excludes the Barossa–Caldita LNG GHG intensity as the data is preliminary estimates only based on early reservoir modelling and early engineering designs. Gorgon LNG emissions intensity represents the facility operating emissions at the time of publication, without Carbon Capture and Storage of reservoir CO_2.*

this receptor (global atmosphere) is assessed as medium given the global nature of the issue and the range of airsheds, of varying air quality and GHG emissions sources, encompassed. Any direct impact associated with the direct emission of GHGs from the Proposal are negligible when assessed in isolation.

The relationship between GHG emission concentrations and their influence on climate change is discussed in **Section 6.4.4.2**.

The NWS Project (current and future projected) GHG performance is similar to both Australian and international LNG facilities. During the implementation of this Proposal, Woodside will continue to identify opportunities to reduce GHG emissions, through measures such as the optimisation of the existing process or implementation of the technological solutions. Woodside has demonstrated continuous improvements in greenhouse emissions from NWS Project, with the emissions intensity of LNG production decreasing 0.60t CO_2e/t LNG in 2000 prior to construction of LNG Train 4, to an intensity of 0.41t CO_2e/t LNG in 2018, equating to a reduction of 30% in emissions intensity over this time.

While the Proposal will contribute directly to global GHG emissions, it should be noted that gas significantly contributes to reducing net emissions and improving access to a reliable modern energy supply (e.g. renewable energy) (IPCC, 2014). According to the IPCC (2014) electricity generated from gas has on average half the GHG emissions of electricity generated from coal. The IEA has calculated that the coal-to-gas switching helped avert 95 mt of CO_2 emissions in 2018. Furthermore, gas plays an important role in the IEA sustainable development scenario (SDS) particularly in terms of providing peaking and balancing power instead of baseload generation and replacing more emissions-intensive fuels in the industry and transport sectors (IEA, 2019b). Woodside estimates of its global GHG emission contribution do not account for the potential benefits that could be attributed to gas. Woodside is actively working to create and expand markets where LNG substantially reduces emissions and where lower emissions alternatives are unlikely to displace LNG.

The potential magnitude of the NWS Project's contribution to global GHG emissions is assessed as *slight* given the above information and the small percentage of the contribution when compared to total global GHG emissions. The Proposal's GHG emissions are managed through the dedicated GHG Management Plan. With the implementation of the GHG Management Plan, which includes identification and implementation of opportunities to reduce emissions, together with the complex interaction of GHG emissions in the atmosphere and the potential for gas to contribute to a reduction in net global GHG emissions, the residual impact is assessed as *low*.

6.4.4.2 Climate Change Influenced by Changes to Global GHG Emission Concentrations

Description of Potential Impacts

GHG emissions from the Proposal are detailed in **Section 6.4.4.1** above.

Woodside acknowledges that groups such as Intergovernmental Panel on Climate Change (IPCC) and CSIRO have established a link between an increase in global GHG emission concentrations and changes in global climatic conditions.

GHG are those gases that, when emitted into the atmosphere, absorb infrared radiation and release this energy as heat (CSIRO, 2015). Increased anthropogenic emissions since the pre-industrial era are considered likely to have been the dominant cause of the observed trend in increasing global average temperatures (IPCC, 2014). This increase in temperature is projected to have an adverse effect on natural ecosystems, as a result of reductions in the bioclimatic range within which a given species or ecological community exists, and human health, due to increased risk of injury and death due to more extreme weather events (intense heatwaves, droughts, fires and storms), increased risk of food, water and vector (e, g, mosquito) borne diseases, changed food security and water scarcity (IPCC, 2014).

Carbon, in the form of CO_2, is commonly recognised as one of the principal agents of global climate change (CSIRO, 2015), with the combustion of fossil fuels most commonly cited as the key contributing factor (IPCC, 2014). The current focus on climate change, its causes and remediation measures, is a global phenomenon.

The IPCC Climate Change 2014 Synthesis Report (IPCC, 2014) states that 'the globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85 C over the period 1880 to 2012' and that with this there have been observable impacts to sea levels, ocean temperatures, and the cryosphere". These changes have been attributed to the increase in concentration of greenhouse gas emissions, mainly carbon dioxide, in the atmosphere.

Regulatory Framework

Owing to the global nature of GHG emissions, a national and global response is required in order to address the potential influence of climate change from changes to GHG emission concentrations. Australia has established the Emissions Reduction Fund (ERF) as part of the Commonwealth Government's Climate Solutions Package (formally Direct Action Plan), which has a primary goal to deliver on Australia's nationally determined contribution under the Paris Agreement, to 'reduce emissions by 26-28 per cent below 2005 levels by 2030'. The ERF has three key elements: crediting, purchasing, and safeguarding emission reductions. The Safeguard Mechanism seeks to impose limits on large

GHG-emitting facilities to ensure that net emissions are kept below a defined baseline. The intent of the Safeguard Mechanism is to "ensure emissions reductions paid for through the Emissions Reduction Fund are not displaced by significant increases in emissions above business-as-usual levels elsewhere in the economy" (Australian Government, 2016).

The NWS Project is subject to the Safeguard Mechanism which provides a framework for Australia's largest emitters of GHG to measure, report and manage their net emissions to below a defined baseline. Under the Safeguard Mechanism, the NWS Project must maintain its net emissions below a current baseline of 7.57 mtpa CO_2e[11]. This baseline represents all emissions from the NWS Project facilities (some of which are not included within the scope of the Proposal, i.e. offshore facilities). Facilities subject to the safeguard mechanism are entitled to apply for a baseline variation in certain circumstances. Woodside anticipates subsequent change to Safeguard Mechanism baselines may be implemented in the future to achieve any additional commitments made under the Paris Climate Agreement (or equivalent future agreements). In August 2019, the Western Australian government announced its GHG emissions policy[12] for major projects being assessed by the EPA. The policy requires proponents that emit significant emissions to develop a greenhouse gas management plan that details the proponent's contribution towards achieving the State Government's aspiration of net zero emissions by 2050. The EPA will make its recommendation on a major proposal involving GHG emissions to the Minister for the Environment who will consider this policy and how the approval is conditioned. Woodside proposes to contribute to the State GHG policy through its compliance with the Safeguard Mechanism, as described above.

Natural gas in the context of global emissions

While it is planned that there will be direct GHG emissions from the Proposal, these emissions are necessary to enable the provision of natural gas to domestic and international markets. The provision of clean and reliable energy is paramount to the lifting of worldwide living standards. As a clean and reliable energy source, gas is expected to play a key role in the future energy mix (as a partner to renewables). In addition, 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).

The IPCC's 2014 Synthesis Report stated 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 IEA, coal-to-gas switching helped avert 95 MT of CO_2 emissions in 2018 (IEA, 2019a).

In addition to directly displacing higher emissions fossil fuels, natural gas supports the enhanced uptake of renewable energy. A key technical challenge associated the widespread deployment of renewables is the low capacity factor, as renewable power such as from wind and solar can be intermittent or inconsistent (Heiligtag et.al., 2019). As a readily dispatchable and reliable power source, gas-fired power is an ideal partner with renewables, as it can be quickly turned on to provide system stability when renewable power generation or electricity demand fluctuates (IEA, 2018). By providing this firming capacity, gas-fired power allows high renewable penetration in the form of a reliable power source to help resolve intermittency issues (IEA, 2018).

Each year the IEA publishes a World Energy Outlook (WEO). Since 2017 the WEO has included a Sustainable Development Scenario (SDS), which describes an energy system that satisfies the three objectives of mitigating climate change, providing universal energy access by 2030 and reducing the severe health impacts of air pollution. GHG emissions projections in the SDS are "lower than most published decarbonisation scenarios based on limiting long-term global average temperature rise to 1.7-1.8 °C" (IEA, 2019a).

The SDS shows that the total global consumption of natural gas continues to increase until at least 2040 which is the end of the modelled period (**Figure 6-13**). The Proposal will supply gas into markets modelled under the SDS and the modelling demonstrates gas consumption in these markets grows by 130% between 2017 and 2040.

11 The baseline established under the Safeguard Mechanism is separate from the key characteristic of the Proposal which will not lead to direct greenhouse gas emissions of more than 7.7 mtpa.

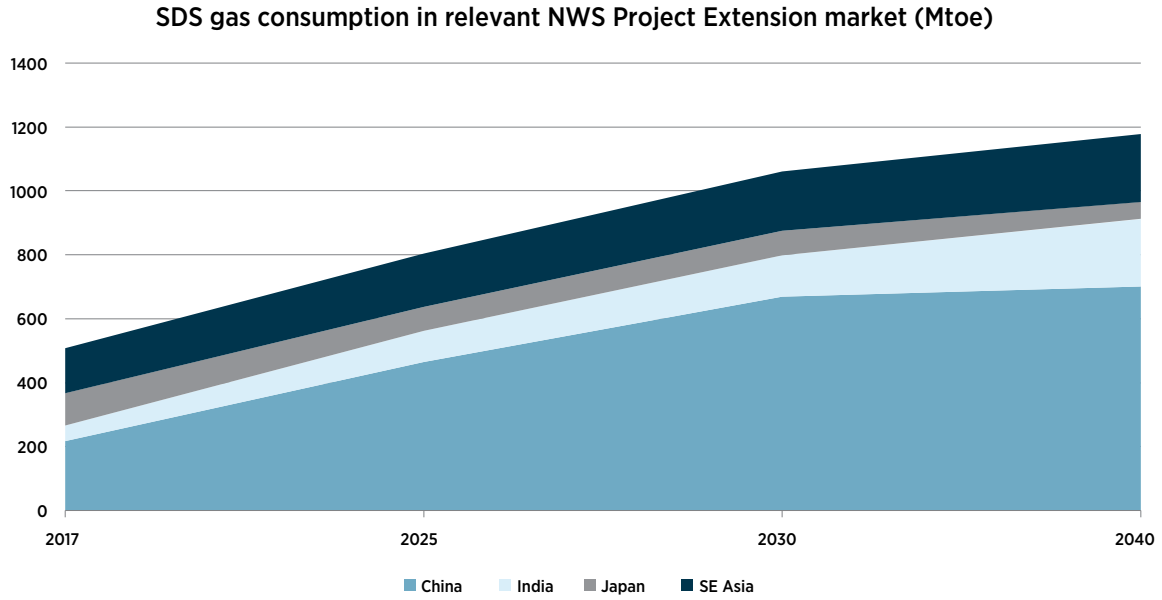


Figure 6-13: Forecast Gas Consumption in the IEA's SDS in Relevant Markets (Mtoe)

6.4.4.2.1 Assessment of Potential Impacts and Risks

As noted in the Climate Change 2014: Synthesis Report (IPCC, 2014) GHGs accumulate over time and mix on a global scale. While greenhouse gas concentrations globally are not homogenous due to local meteorological conditions, the atmospheric concentration of carbon dioxide has been observed as being generally well mixed (IPCC 2014). Woodside has not identified any published, peer reviewed, scientific literature that has identified a link between greenhouse gas emissions from a particular source and a corresponding change in local climatic conditions. For this reason, it is not possible to make an assessment of any impact to climate change arising from the Proposal to the local receiving environment or any individual receptor.

More generally, a report by Australia's Biodiversity and Climate Change Advisory Group (Steffen et al, 2009) in 2009 gives a summary of potential impacts to marine and terrestrial species, habitats and ecosystems across Australia. CSIRO has predicted that global climate change may lead to impacts on the environment of Western Australia. CSIRO has published what this impact may look for each national resource management region with all regions predicted to experience a changing climate and with all regions being vulnerable to the impacts of that changing climate (CSIRO, 2019). Potential climate change predictions relevant to the Pilbara region, in which the Proposal is located, are described in **Section 4.1.4**.

6.4.5 Existing and Proposed Mitigation

The existing and proposed avoidance, mitigation and contingency measures applicable to the management of impacts to Air Quality (Greenhouse Gas Emissions) arising from the Proposal are summarised in **Table 6-18**. 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 Greenhouse Gas emissions will be achieved. A detailed description of measures is provided in the NWS Project Extension Greenhouse Gas Management Plan (**Appendix B**).

Table 6-18: Existing and Proposed Mitigation Measures: Air Quality (GHG Emissions)

Impact	Existing Mitigation Measures	Proposed Mitigation Measures
Contribution to global GHG emission concentrations	**Avoid** + Elements included in the design of the KGP LNG trains to avoid GHG emissions have been discussed in the NWS Project Extension Greenhouse Gas Management Plan (**Appendix B**). **Minimise** + Continue to implement the Optimisation Reference Plan which identifies and implements opportunities to improve production and energy efficiency. + Continue to implement the KGP Energy Management Plan. + Continue to set fuel and flare targets annually. + Continue to implement Woodside Procedures to assess changes in feed gas sources. + Continue to comply with the National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015 which includes requirements to manage net emissions to below relevant baselines. **Rehabilitate** + Not applicable for this impact.	**Avoid** + No additional measures are proposed. **Minimise** + Implement NWS Project Extension Greenhouse Gas Management Plan (**Appendix B**), which contains provisions for managing GHG emissions from the Proposal including identification and implementation of emissions reduction opportunities and monitoring changes in feed gas composition to prevent Scope 1 emissions from the Proposal exceeding 7.7 mtpa. + Woodside has identified all reasonable and practicable emissions reduction equipment and technologies for GHG emissions reductions. + Woodside is making a commitment to avoid, reduce or offset 330,000 tpa of CO_2e from the KGP by 2030. + Undertake 5-yearly assessment of reasonable and practicable emission reduction equipment and technologies, that could be implemented to improve GHG emissions performance. **Rehabilitate** + No additional measures are proposed.
Climate Change Influenced by Changes to Global GHG Emission Concentrations		

6.4.6 Predicted Outcome

After implementing the proposed mitigation measures, no planned impacts or risks with a residual risk higher than a *low* risk rating have been identified. Woodside considers that this indicates the residual impacts and risks associated with the proposal are broadly aligned with the EPA's objective for Air Quality. There were no impacts or risks identified that would mean that the EPA Objectives for Air Quality are not achieved. The Proposal will contribute up to 0.03% of global GHG emissions and this contribution is assessed as contributing to a slight impact (i.e. increase) to global emissions. It was not possible to quantitatively assess the impact of the Proposal to any local, state or global climate changes.

While the Proposal will contribute directly to a slight increase in global greenhouse gas emissions, the provision of natural gas into markets 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). As such, the Proposal may result in a net reduction in global GHG emissions. However, the likelihood of this outcome is considered uncertain, due to the wide range of variables beyond the control of the Proposal.

In addition to this global context, intensity benchmarking shows the emissions intensity of the Proposal compares favourably with many other domestic and international LNG facilities. This is in part due to design decisions, but also the continuous reduction in emissions intensity achieved by the NWS Project. These have been achieved utilising the mitigation measures that are in place relating to GHG emission reduction. These mitigation measures will continue to be implemented through the NWS Project Extension Greenhouse Gas Management Plan (**Appendix B**) and further reductions in emissions intensity are anticipated to be achieved in the future.

Woodside has identified the existing Federal regulations that apply to GHG emissions and will continue to comply with these requirements.

There were no identified changes to existing NWS infrastructure from the Proposal that would increase the planned impacts to global greenhouse gas emissions or to climate change influenced by these emissions.

A summary of the impact assessment outcomes used to derive this outcome are provided in **Table 6-19**.

Table 6-19: Air Quality (Greenhouse Gas Emissions) Impact Assessment Summary

Impact	Receptor Sensitivity	Magnitude	Likelihood (unplanned impacts only)	Impact Level
Contribution to global GHG concentrations from Scope 1, Scope 2 and Scope 3 emissions	Medium	Slight	N/A	Slight
Climate Change Influenced by Changes to Global GHG Emission Concentrations	Not able to be assessed			

6.5 Key Environmental Factor – Social Surroundings (Heritage)

6.5.1 EPA Objective

To protect social surroundings from significant harm (EPA, 2016b).

Note: The Environmental Factor Guideline – Social Surroundings (EPA, 2016b) acknowledges that social surroundings include: Aboriginal heritage and culture; natural and historical heritage; amenity; and economic surroundings. For this ERD the only aspect of the social surroundings environmental factor that is relevant to the Proposal is Aboriginal heritage and culture. This was determined by the EPA and is consistent with the referral decision dated 4 December 2018, and the ESD (Woodside, 2019).

6.5.2 Policy and Guidance

EPA Policy and Guidance

+ Statement of Principles, Factors and Objectives (EPA, 2018a)
+ Environmental Factor Guideline – Social Surroundings (EPA, 2016b)
+ Guidance for the Assessment of Environmental Factors – Assessment of Aboriginal Heritage No. 41 (EPA, 2004)

Other Policy and Guidance

+ Australia's National Heritage – Applying the Principles (DoEE, 2008)
+ Murujuga National Park Management Plan No. 78 (DEC, 2013)
+ Due Diligence Guidelines (Version 3.0) (DPLH, 2013)
+ Engage Early – Guidance for proponents on best practice Indigenous engagement for environmental assessments under the EPBC Act (DoE, 2016)
+ Murujuga Rock Art Strategy (DWER, 2019b)
+ European Union Air Quality Standards for the Protection of Vegetation (EU, 2008)

Relevant Legislation

+ *Aboriginal Heritage Act 1972* (WA)
+ *Environment Protection and Biodiversity Conservation Act 1999* (Cth)

Section 10 details how this legislation, policy and guidance relates to the Proposal.

6.5.3 Environment

This section identifies the elements of the receiving environment that are directly and indirectly related to the Social Surroundings (Heritage) environmental factor. Refer to **Section 4** for detailed description of each relevant receptor of the receiving environment.

Table 6-20: Social Surroundings Receiving Environment

Receving Envrionment	Activity	Ongoing emissions to air from the NWS Project Extension Proposal until around 2070	Continued presence and activity of people, vehicles, vessels, and equipment in the development envelope.	Ongoing marine discharges from the operation of the NWS Project facilities
	National Heritage Place	✓	✓	
	Shorelines			✓
	Seabirds and Shorebirds			
	Sharks and Fish			
	Sea Snakes			
	Turtles			
	Marine Mammals			
	Sediment Quality			
	Water Quality			
	Macroalgae			
	Seagrass			
	Coral			
	Marine Invertebrates			
	Mangroves	✓		
	Marine Fauna with Heritage Value			✓
	Vegetation with Heritage Value	✓	✓	✓
	Heritage Features	✓	✓	
	Terrestrial Vegetation			
	Contribution to GHG Concentrations			
	Air Quality (Relevant to Amenity)			
	Air Quality (Relevant to Human Health)			

6.5.4 Potential Impacts and Risks

The following activities associated with the Proposal have the potential to affect social surroundings (heritage):

- Ongoing emissions to air from the Proposal until around 2070.
- Continued presence and activity of people, vehicles, vessels, and equipment in the development envelope.
- Ongoing marine discharges from the Proposal until around 2070.

The potential impacts to social surroundings (heritage) that are assessed in this ERD are:

- Accelerated weathering of rock art due to industrial emissions.
- Degradation of terrestrial and nearshore vegetation of heritage and conservation value due to deposition of gaseous emission.
- Direct, accidental physical damage to heritage features within the development envelope.
- Continued restricted access to heritage features within the development envelope until around 2070.
- Reduced amenity to heritage features outside the development envelope as a result of odorous substances (e.g. odour from atmospheric emissions).
- Harm to marine fauna and flora with heritage value from:
  - Changes to water quality from planned and unplanned discharges.
  - Turbidity from maintenance dredging.

6.5.4.1 Accelerated Weathering of Rock Art due to Industrial Emissions

Description of Potential Impacts

The presence of heavy industry on the Burrup Peninsula has generated concerns that industrial emissions may lead to an accelerated weathering or deterioration of rock art (petroglyphs). These concerns centre on the issue that deposition of NO_X, SO_X and ammonia (NH_3) from anthropogenic industrial sources have the potential to increase the acidity of the rock surface through chemical and/or biological processes. Key emissions as they relate to this Proposal's power generation and process emissions include NO_X, VOCs (pertaining to photochemical intensity of NO/NO_2 formation), and a very minor contribution of SO_2.

The concerns are that acidic conditions may then alter the natural state of weathering for rock, making colour variations and depth of petroglyphs difficult to distinguish from the rest of the rock surface. A synthesis of literature on the potential impact of industrial air emissions on Murujuga rock art is provided in **Appendix H** and should be read in conjunction with this section.

In addition to its heritage management activities and recognition of the national heritage values, Woodside has also supported appropriate scientific monitoring of air emissions in and around the Burrup Peninsula. Woodside's approach to monitoring and air emissions management practices has also been informed by third-party studies including the work undertaken by the Burrup Rock Art Monitoring Management Committee (BRAMMC) which was established in 2002 to address the uncertainty and lack of available scientific information, and to assess whether there has been any change to the petroglyphs over and above that due to natural weathering.

Over the past 15 years, numerous studies have been conducted to investigate the potential for industrial emissions from new and existing industrial development on the Burrup Peninsula to impact on the Burrup Peninsula rock art, including:

- Air quality monitoring and modelling studies to aid in the assessment of the potential for air pollution from industrial activities on the Burrup Peninsula to impact petroglyphs.
- Studies of microbial diversity on the petroglyphs to investigate whether rock surfaces closer to industrial emissions sources host different microbial communities, which could affect petroglyph weathering.
- Studies analysing colour changes in the petroglyphs and spectral mineralogy analysis to obtain more precise measurements of composition or colour changes (this study compared southern sites near industry with sites further north on the Burrup Peninsula).

No published peer reviewed studies identified measurable or observable changes to the condition and integrity of rock art as a result of industrial emissions. Woodside recognises some anecdotal evidence and stakeholder concerns have been raised regarding observable changes may have occurred to the rock art. It should be noted that there is an absence of readily observed change to rock, and rock art over the 15-year period during which the peer reviewed studies have been undertaken, and that during this time, the NWS Project operated with emissions rates comparable to the Proposal. As such, significant accelerated weathering affecting the distinguishability of petroglyphs across the region is not expected to occur as a result of the Proposal.

It is noted that there have been criticisms of the methodologies used and the interpretation of the findings from some of these research studies and monitoring programs that have been established to detect changes in petroglyphs and potential accelerated weathering. Inadequacies were identified such as in the statistical analysis of the annual colour change and spectral mineralogy monitoring data, and application of critical load thresholds applied to nitrogen and sulphur deposition monitoring results. Uncertainties

therefore exist regarding techniques for monitoring and detecting change (both natural weathering rate, and potential for accelerated weathering) and the determination of a critical load of acid deposition at which impacts to rock art may occur. This complexity is acknowledged in the Murujuga Rock Art Monitoring Program Tender Documentation (DWER, 2019c)[12]. This uncertainty, together with theorised pathways for potential accelerated weathering, result in risk to social Surroundings (Heritage). Additionally, there is a high level of concern from some stakeholders in relation to potential impacts on rock art and the heritage values of the Burrup Peninsula. As such, it is assessed further through this ERD. Preventative and management controls are presented to ensure that such risk is minimised.

Murujuga Rock Art Strategy

In acknowledgement of continuing public concerns and the increased recognition of the cultural and spiritual significance of the rock art on the Burrup Peninsula to Aboriginal people and of its significant state, national and international heritage value, the WA Government is implementing the Murujuga Rock Art Strategy. The Department of Water and Environmental Regulation (DWER) has primary responsibility for the implementation of the Strategy, to be undertaken in partnership with the Murujuga Aboriginal Corporation (MAC), representing the Traditional Owners of Murujuga, and in consultation with stakeholders, including the community and industry. The Strategy outlines a long-term framework to guide the protection of the Aboriginal rock art located on the Dampier Archipelago and the Burrup Peninsula. Key aspects of the Strategy are to:

+ Establish an Environmental Quality Management Framework which includes the development of guidelines and standards, based on sound scientific information, which will provide warning of potential harmful effects and if management actions are required to protect the rock art from harm.
+ Develop and implement a robust program of monitoring and analysis to determine whether change is occurring to the rock art on Murujuga.
+ Commission scientific studies to support the implementation of the monitoring and analysis program and management against environmental quality criteria.
+ Establish governance communication processes which involve key stakeholders.

The Strategy is intended to provide a "transparent, risk-based and adaptive framework for monitoring and managing environmental quality to protect the rock art on Burrup Peninsula from industrial emissions" (DWER, 2019b).

Woodside will actively support the implementation of the Murujuga Rock Art Strategy through membership of the Murujuga Rock Art Reference Group and will provide funding associated with the Murujuga Rock Art Monitoring Program. It is also Woodside's intention to support the coordinated approach for atmospheric deposition monitoring program to be established under the Strategy and is further described in the NWS Project Extension Air Quality Management Plan (**Appendix A**).

Existing and Predicted Air Quality (Deposition)

As presented in **Section 6.3**, an air quality impact assessment (**Appendix E**) was undertaken to consider existing data-sets of monitoring programs, and TAPM modelling undertaken to represent a range of current and potential future emissions scenarios on the Burrup Peninsula. Assessment includes a comparative review of deposition fluxes of nitrogen and sulphur monitoring on the Burrup Peninsula, as well as modelling estimates of NO_2 (as a sub-component of total deposition flux).

To support comparison with predicted (modelled) deposition estimates, the analysis includes a comparison against ground level monitoring result data of NO_2 dry deposition. Deposition of NO_2 in both modelling and monitoring are based on 'velocity' assumptions to deposit from measured or estimated gaseous NO_2.

Deposition Fluxes of Nitrogen and Sulphur Monitoring - Existing

Deposition flux provides an understanding of the deposition of mass in the form of gas, particle or rainwater to an area of ground over a particular period of time (Gillett, 2008). To specifically understand acid deposition, acid deposition fluxes can be measured by calculating the wet and dry deposition of all nitrogen and sulphur species in the gas and aqueous phases.

On the Burrup Peninsula, CSIRO (Gillett, 2008) determined total deposition flux of nitrogen and sulphur at several measurement sites in 2004–2005 and 2007–2008 by calculating the wet and dry deposition of all nitrogen and sulphur species in the gas and aqueous (rainwater) phases (Gillett, 2008). This included NO_2, SO_2, nitric acid, and ammonia gases, and some other species in rainwater. The study showed that the total wet

12 *"The Customer [DWER] acknowledges that the integrity or condition of the rock art on Murujuga is a complex response to interactions between extrinsic (environmental) and intrinsic (characteristics of the rock and rock art, including its weathering history) factors that operate over different temporal and spatial scales. It will be important that the Murujuga site is considered as a 'system' in the broadest sense.*

The Customer also acknowledges that, given the complexities of the system, the interactions between the system variables, and the non-linear, dynamic characteristics of rock weathering where the system response (weathering / alteration / degradation of the rock art) may be not be proportional to changes in the system inputs (increases in anthropogenic emissions and atmospheric deposition), there will be challenges in identifying definitive causal links between change in the integrity or condition of the rock art and an external variable such as anthropogenic emissions."

and dry deposition flux of nitrogen and sulphur ranged from 19.8-31.6 milliequivalents per square metre per year (meq/m^2/year) over the two monitoring periods. Units of 'meq/m^2/year' were used to enable comparisons with previous monitoring results, where a milliequivalent is one thousandth of a chemical equivalent (e.g. equivalent units of a standard neutralising chemical). An 'equivalent' of an ion is the mass in grams of the ion divided by its molecular weight and multiplied by the charge on the ion (Gillett, 2014).

Based on 2004–2005 data, dry deposition of NO_2 was estimated to contribute to between 16% and 36% of total deposition flux in the region (Gillett, 2008), and SO_2 6% to 8%, the rest is contributed to by various other forms of nitrogen and sulphur species (such as is ammonia/ammonium, nitric acid, and nitrate). The 2007–2008 data ranged from 12% to 20% NO_2 contribution to total deposition flux, and 4% to 7% for SO_2 (Gillett, 2008).

Woodside engaged CSIRO to carry out a study to determine the nitrogen deposition flux (between February 2012 and June 2014) on and around the Burrup Peninsula before and after the commissioning of the Pluto LNG Development (Gillett, 2014). A summary of results for the ranges of total measured nitrogen and sulphur fluxes is provided in **Table 6-21**, including relative contribution from dry NO_2 fraction. **Figure 6-14** (from Gillett, 2014) illustrates box plots of total nitrogen deposition observed on and around the Burrup Peninsula between 2004 and 2014.

Inspection of deposition results shows they have been reasonably consistent over a long period of sampling.

Table 6-21: Summary of Results for Burrup Nitrogen and Sulphur Deposition Monitoring Programs

Monitoring Program	Analyte	Range of Deposition (Excluding Background Sites)	Dry Deposition NO_2 Fraction
2004 – 2005 and 2007 – 2008	Total nitrogen and sulphur	19.8 – 31.6 meq/m^2/year	16% - 36% of total N and S
2008 – 2009	Total nitrogen	18.4 – 32.9 meq/m^2/year	19% - 29% of total N only
2012 – 2014	Total nitrogen	17.1 – 28.8 meq/m^2/year	17% - 34% of total N only

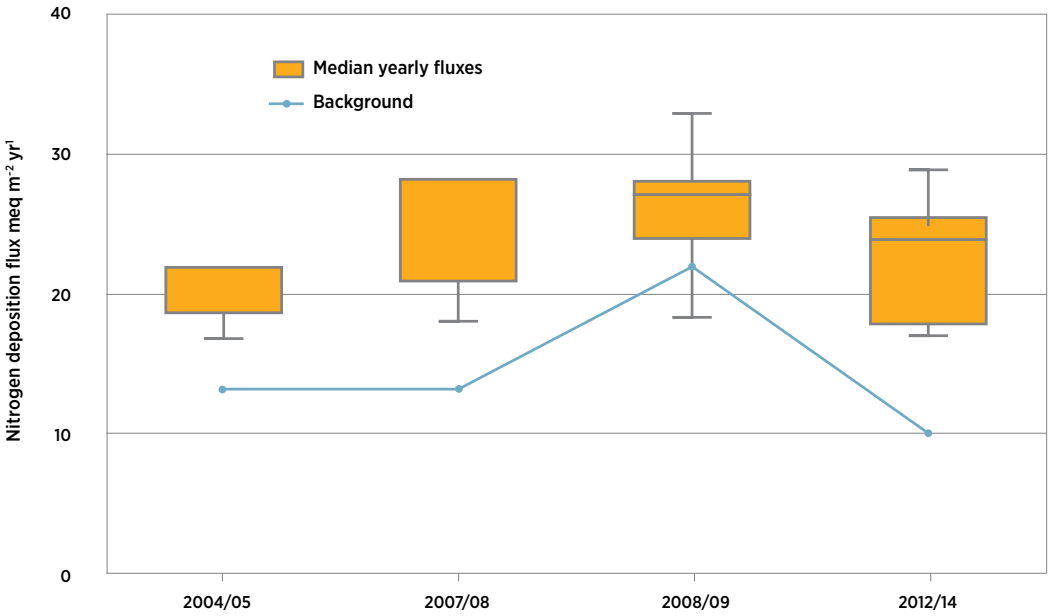


Figure 6-14: Total Nitrogen Deposition Observed on and Around the Burrup Peninsula

Note: The box is defined by the lower and upper quartiles, lines in the boxes are median fluxes and the whiskers are the minimum and maximum fluxes. No upper stems are shown for 2004/05 and 2007/08 as are within the box.

Predicted Deposition of NO_2

Air dispersion models calculate surface deposition for airborne substances using an airborne concentration near ground level, a deposition velocity for the substance of interest, and other parameters (Seinfeld and Pandis, 2016). These parameters are difficult to accurately quantify, and therefore the standards for deposition have greater uncertainties than the standards based on airborne concentrations only. TAPM provides for estimation of NO_2 and SO_2 deposition, with the photochemical model either not able to predict other species, nor suitably approximated for Burrup conditions (e.g. ammonia, nitric acid, and other potential aerosol and rainfall-based mechanisms). The air dispersion modelling undertaken for the Proposal focuses on nitrogen deposition, with SO_2 representing a small fraction of total deposition flux (with the Proposal representing only a minor SO_2 contribution). A comparative approach is taken between existing monitoring data, and a range of scenarios in the absence of an established total (or NO_2) deposition flux potential impact threshold.

The scenarios listed in **Table 6-22** were included in the cumulative air dispersion modelling.

Table 6-22: Scenarios used for Cumulative Air Dispersion Modelling

Scenario	Description
Current Baseline (CBM)	This is the near-term, most likely scenario. It predicts the contribution to ambient air quality from industry currently operating on and around the Burrup Peninsula. It considers cumulative emissions from the current NWS Project and the existing, built, industrial facilities and emissions most applicable to the BSIA and the nearby region to use as a baseline for assessment. These include: + NWS Project; KGP + Woodside Pluto LNG Development (Train 1) + Yara Technical Ammonium Nitrate and Liquid Ammonium Plant + Pilbara Iron Yurralyi Maya Power Station + Santos Devil Creek Power Station + ATCO Karratha Power Station + EDL West Kimberley Power Plant + All shipping berths on the Burrup Peninsula + All shipping berths at Cape Lambert
Current Baseline with proposed emission reductions in place (KIO)	This is the medium-term, best-case scenario. It demonstrates the benefits gained in ambient air quality from proposed NO_X reductions outlined in **Section 6.3.5**. It considers cumulative emissions from the Proposal operating with a significant reduction in NO_X for KGP sources, and the existing, built, industrial facilities and emissions most applicable to the BSIA and the nearby region. The KGP data for modelling were modified to conservatively reflect likely improvement opportunity concepts representing feasible and significant NO_X reduction.
Future Burrup Strategic Industrial Area with existing and approved facilities operating, with proposed emission reductions in place (FBSIA E&A)	This is the medium-term, most likely scenario. It considers cumulative emissions from the Proposal operating with a significant reduction in NO_X emissions, existing operating facilities, and future BSIA development approved at the time of writing this ERD (Pluto LNG Development [Train 2]).
Future Burrup Strategic Industrial Area State (FBSIA), with existing, approved and referred facilities operating	This is the long-term, worst-case scenario. It considers cumulative emissions from the Proposal operating with no reduction in NO_X emissions, existing operating facilities, and reasonably foreseeable future BSIA; approved development BSIA approved development (Pluto LNG Development [Train 2]), and referred developments (but not assessed or approved) at the time of writing this ERD. The latter developments are represented by indicative Urea and Methanol Plants.
Future Burrup Strategic Industrial Area state (existing, approved and referred) with proposed emission reductions in place (FBSIA-KIO)	This is a long-term, possible case scenario. It considers cumulative emissions from the Proposal operating with a significant reduction in NO_X emissions, existing operating facilities, and future developments approved at the time of writing this ERD (Pluto LNG Development [Train 2]) and BSIA developments referred (but not assessed or approved) at the time of writing this ERD. The latter reasonably foreseeable future developments are represented by indicative Urea and Methanol Plants.

Predicted NO_2 deposition rate (as a sub-component of nitrogen and sulphur depositional flux) contour plots are presented from **Figure 6-15** to **Figure 6-18** for CBM and KIO in both units of kg/hectare/year and meq/m^2/year.

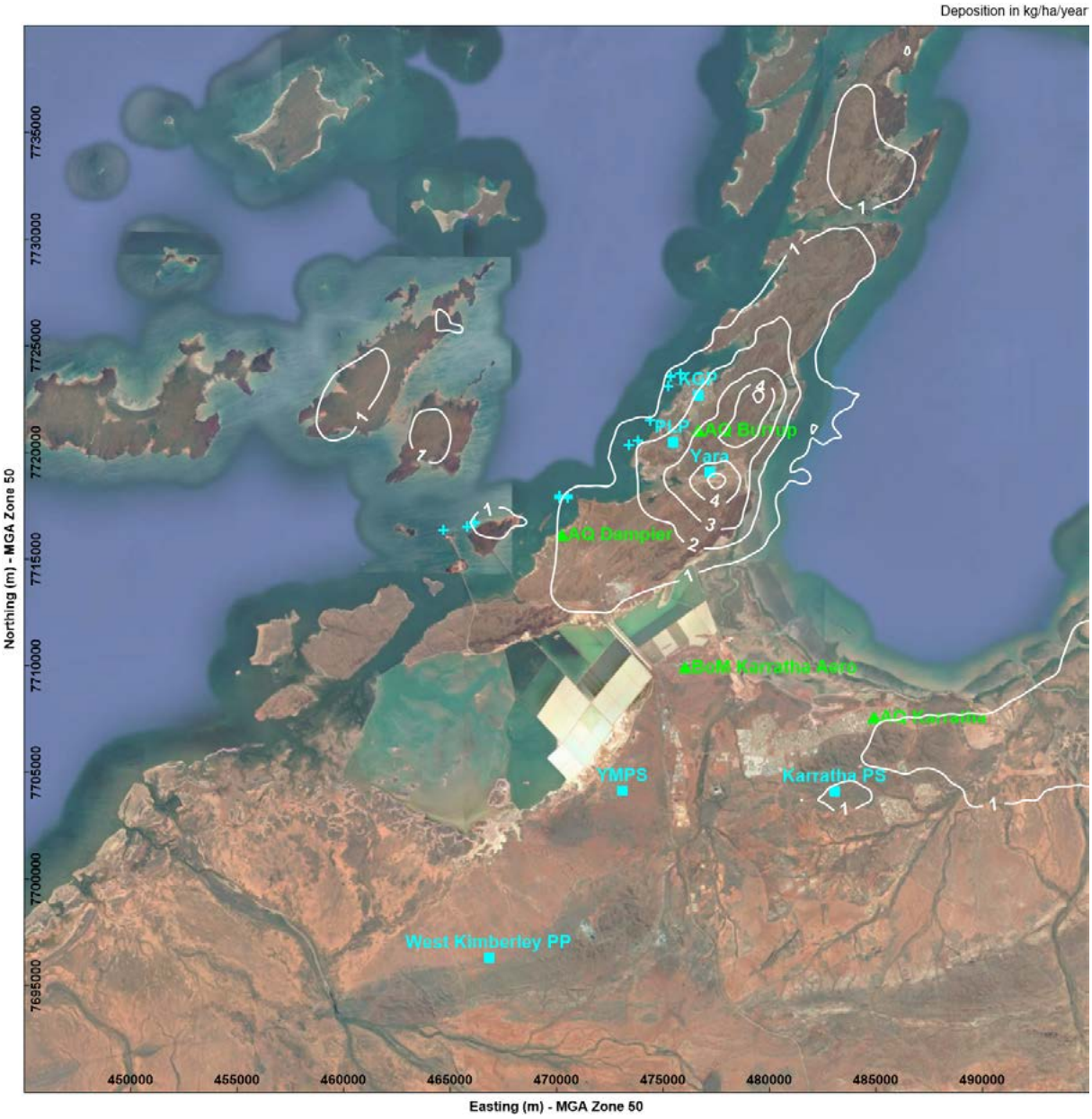


Figure 6-15: CBM – NO_2 Deposition (kg/ha/year)

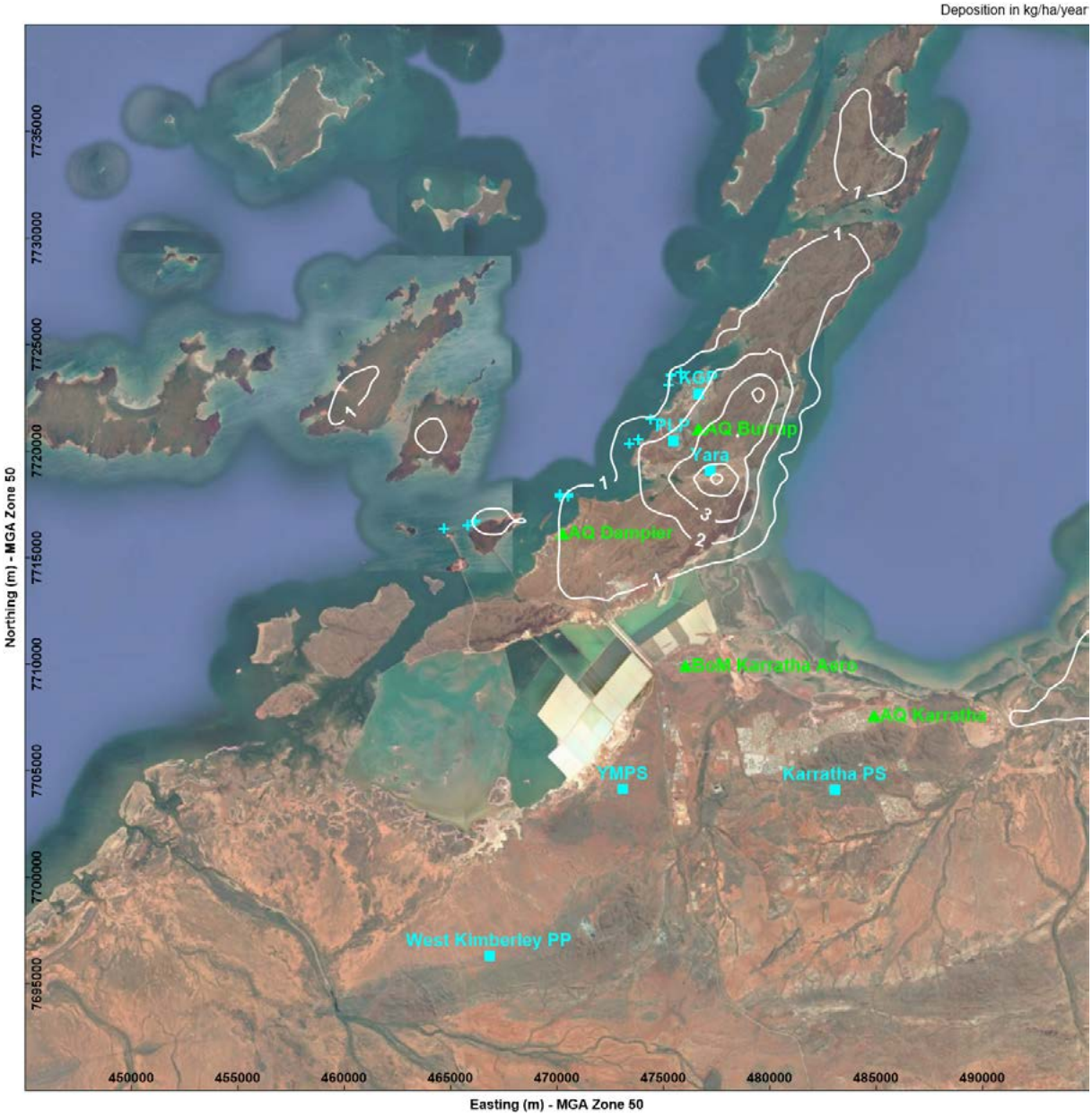


Figure 6-16: KIO – NO_2 Deposition (kg/ha/year)

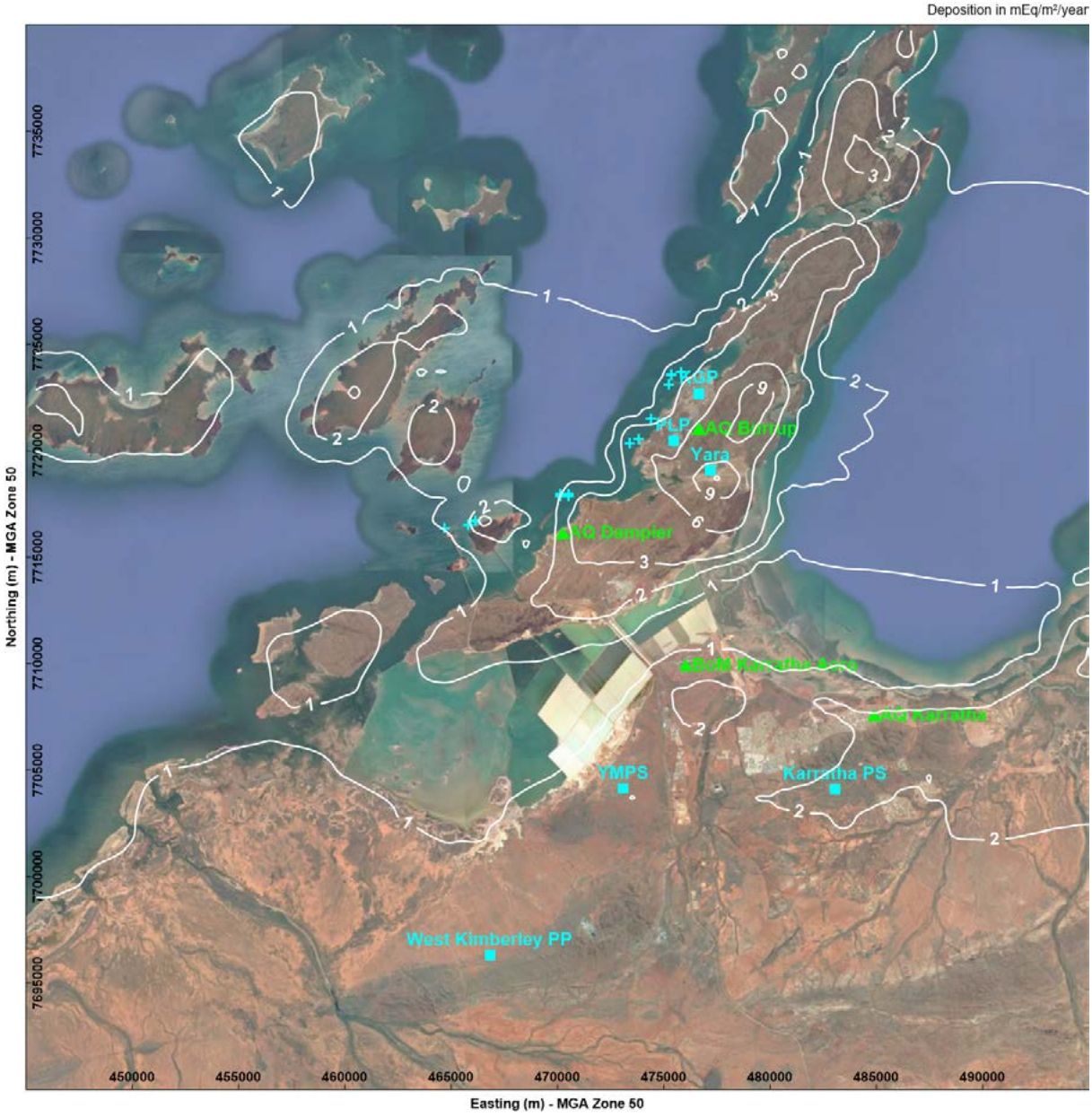


Figure 6-17: CBM – NO_2 Deposition (meq/m²/year)

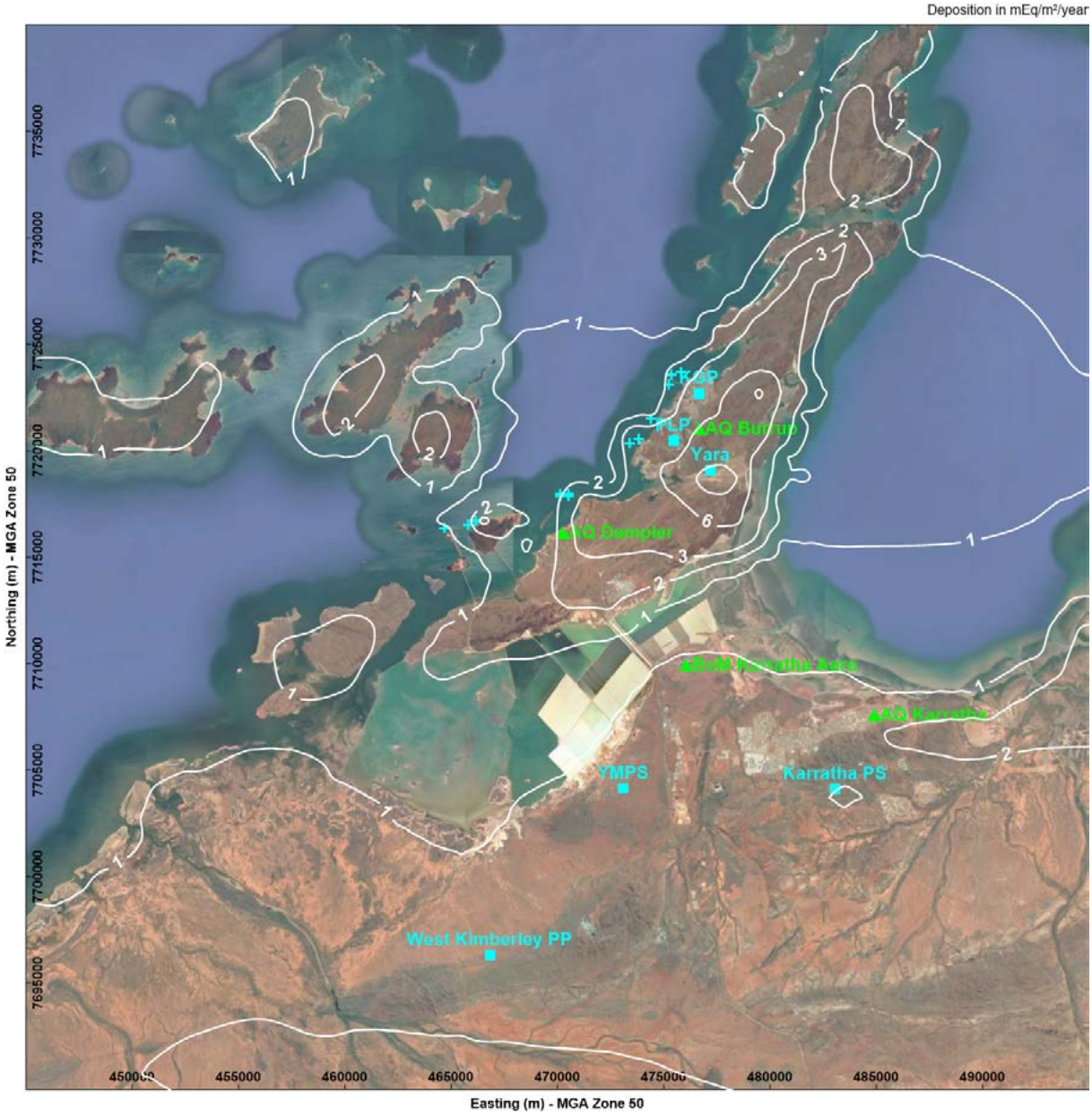


Figure 6-18: KIO – NO_2 Deposition (meq/m²/year)

Modelled outputs for NO_2 deposition were compared against the measured total, and NO_2 component of total nitrogen deposition (2012/2014) as an indicator of alignment of the CBM and potential scenario modelling with the measured baseline (**Table 6-23** and **Figure 6-19**).

Table 6-23: Summary of Monitoring and Model Results for NO_2 Deposition – CBM and Potential Scenarios.

Parameter	1[I] Gap Ridge	2[I] Fertiliser Plant	3[I] BMF	4[I] KGP	5[I] Dom	6[B]Backgnd.
Monitoring 2012/2014 (CSIRO, 2014) – all units are meq/m²/year						
Total nitrogen flux	25.5	23.9	28.8	17.9	17.1	9.8
Dry NO_2 deposition	4.4	4.0	7.7	4.4	5.8	1.3
Scenario Model Results (the Proposal) – all data are NO_2 deposition (meq/m²/year)						
CBM	1.8	8.5	5.0	5.7	6.2	approx. 1.0
KIO	1.6	7.8	4.7	5.2	5.9	approx. 1.0
FBSIA E&A	1.7	8.8	4.9	5.7	7.0	approx. 1.0
FBSIA	2.0	11.6	5.8	6.8	8.8	approx. 1.0
FBSIA-KIO	1.8	10.9	5.6	6.4	8.5	approx. 1.0

Notes:

Superscript 'B' denotes background monitoring site; superscript 'I' indicates monitor in industrial area.

Site 1: Gap Ridge accommodation camp west of Karratha; Site 2 near Yara TAN plant; Site 3 within King Bay Supply Facility, 4 and 5 located near Pluto LNG.

Modelled results for background were from southern-most parts of study grid; it is expected these low, but non-zero values due to modelled biogenic NO_x emissions over land (nil emissions modelled over water).

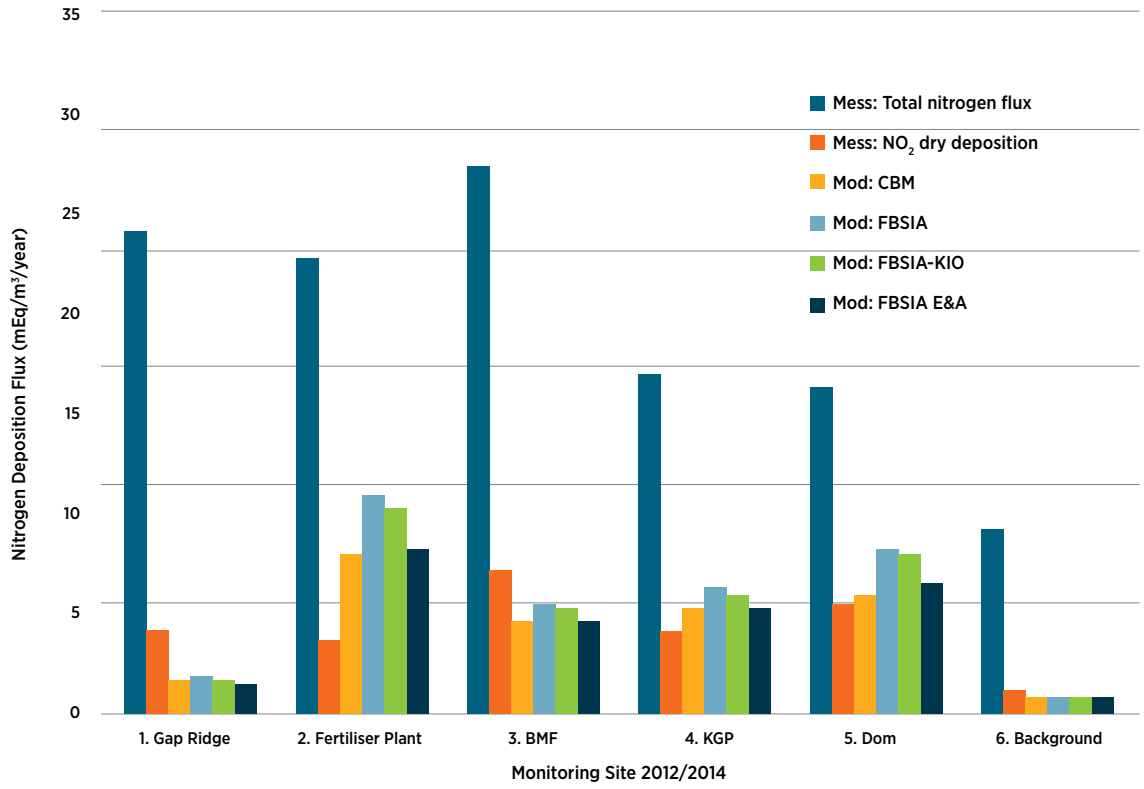


Figure 6-19: Measured and Modelled Nitrogen Fluxes (meq/m²/year) – Comparison at (2012/2014 CSIRO) Monitoring Locations. (Total measured nitrogen deposition flux in brown, with NO_2 contribution shown in all other colours)

As illustrated in **Table 6-23** and **Figure 6-19**, the comparison of modelling versus monitored results at the six locations shows estimated deposition rates for NO_2 are of a similar order to monitored values, indicating that the modelled values are considered to be credible and therefore comparative interpretation of the modelled values is valid for Proposal scenarios.

SO_2 deposition rates were modelled, with all emissions scenarios found to be were almost identical, due to the Proposal's very small effect on the baseline in the region. Model representation of shipping emissions was also found to over-estimate potential SO^2 and deposition (refer to **Appendix E**).

Deposition Scenario Comparative Analysis

To aid visual representation of deposition, a data filter was applied to select model values within the National Heritage Place of the Dampier Archipelago (including Burrup Peninsula) (Commonwealth of Australia, 2019) (e.g. to eliminate interpretation influence of 'over-water' or inland deposition data estimates less applicable to potential rock art receptors). Cumulative modelling scenario outputs for NO_2 deposition associated with the Proposal (CBM representing existing operations, and number of future reasonably foreseeable development scenarios) were analysed to determine potential variance of overall NO_2 depositions values compared to existing emissions represented by CBM.

The modelling study area grid receptor points refined to 310 clipped points within the National Heritage Place are illustrated in **Figure 6-20**. Histograms of the model results for NO_2 deposition (meq/m^2/year) were created for the model grid points within the National Heritage Place boundaries (**Figure 6-20**), to illustrate the differences between CBM and each of the potential cumulative emission scenarios.

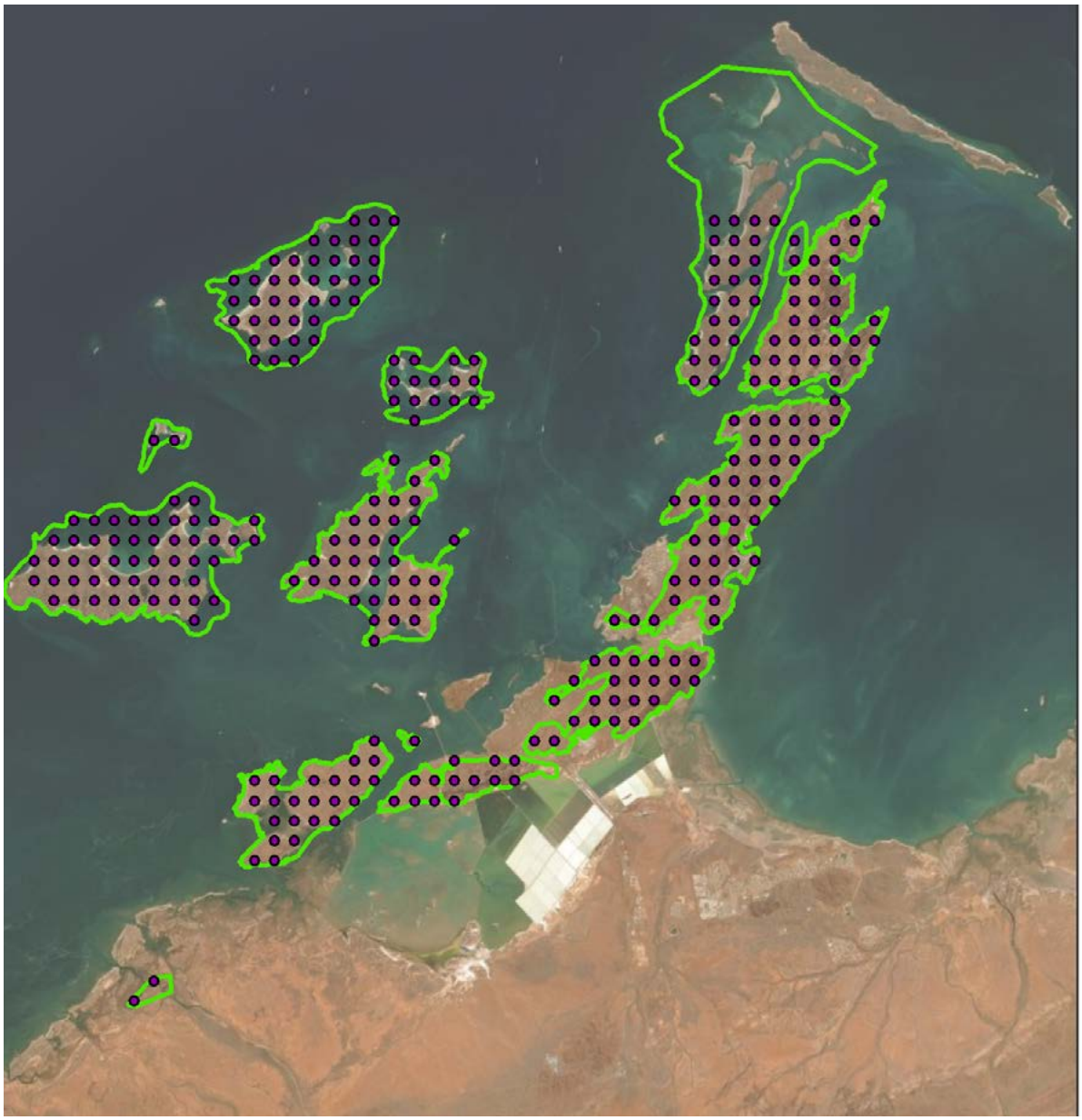


Figure 6-20: Model Grid Points Within the National Heritage Place of the Dampier Archipelago (including Burrup Peninsula)

Model results comparing NO_2 deposition between CBM and each of the other modelled scenarios within the National Heritage Place are provided in the following series of frequency distribution histograms:

- Comparison of current (CBM) and KGP emission reductions (KIO) (**Figure 6-21**).
- Comparison of current (CBM) and future approved developments (Pluto LNG Development) with KGP emission reductions (FBSIA E&A) (**Figure 6-22**).
- Comparison of current (CBM) and future approved and referred developments (FBSIA) (**Figure 6-23**).
- Comparison of current (CBM) and future approved and referred developments with KGP emission reductions (FBSIA-KIO) (**Figure 6-24**).

Histograms have been provided to assist in illustrating relative increase or decrease in deposition rates spatially across the National Heritage Place (i.e. where the frequency of higher deposition rates compared to CBM shift to lower rate frequencies; an overall spatial reduction in deposition rate may be expected across the National Heritage Place).

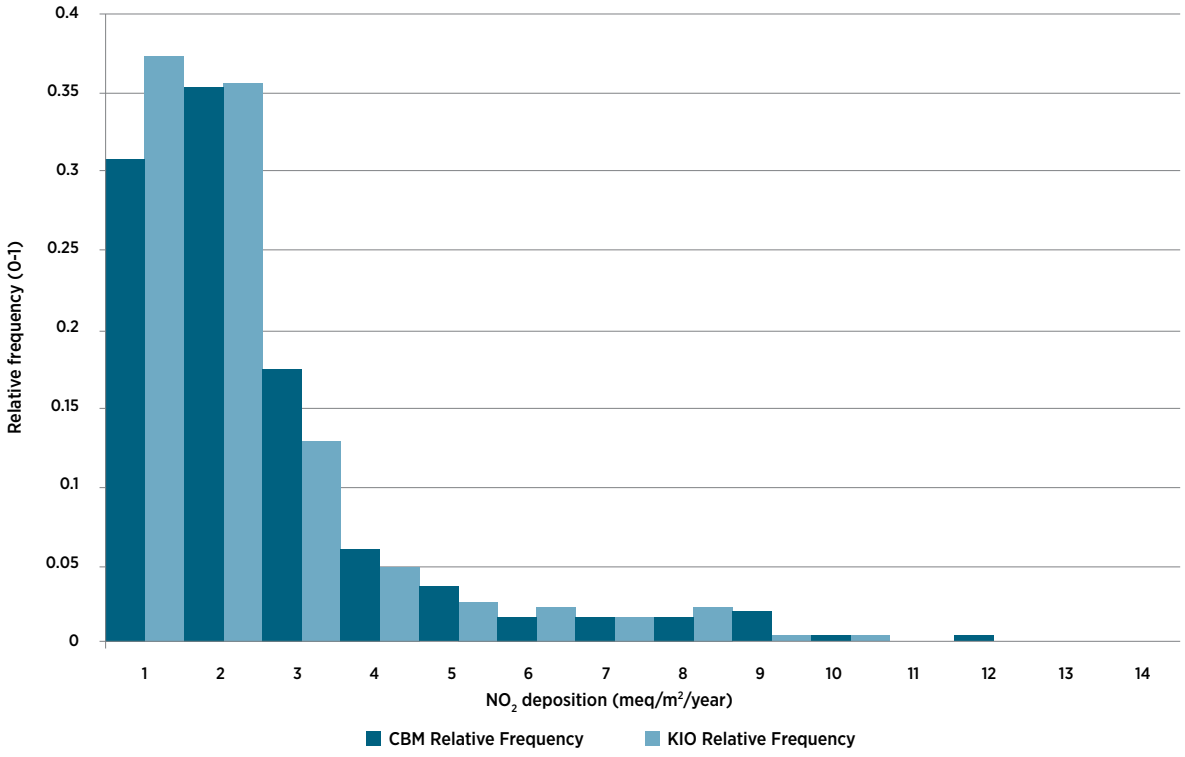


Figure 6-21: Histogram - Comparison of current (CBM) and KGP Emission Reductions (KIO)

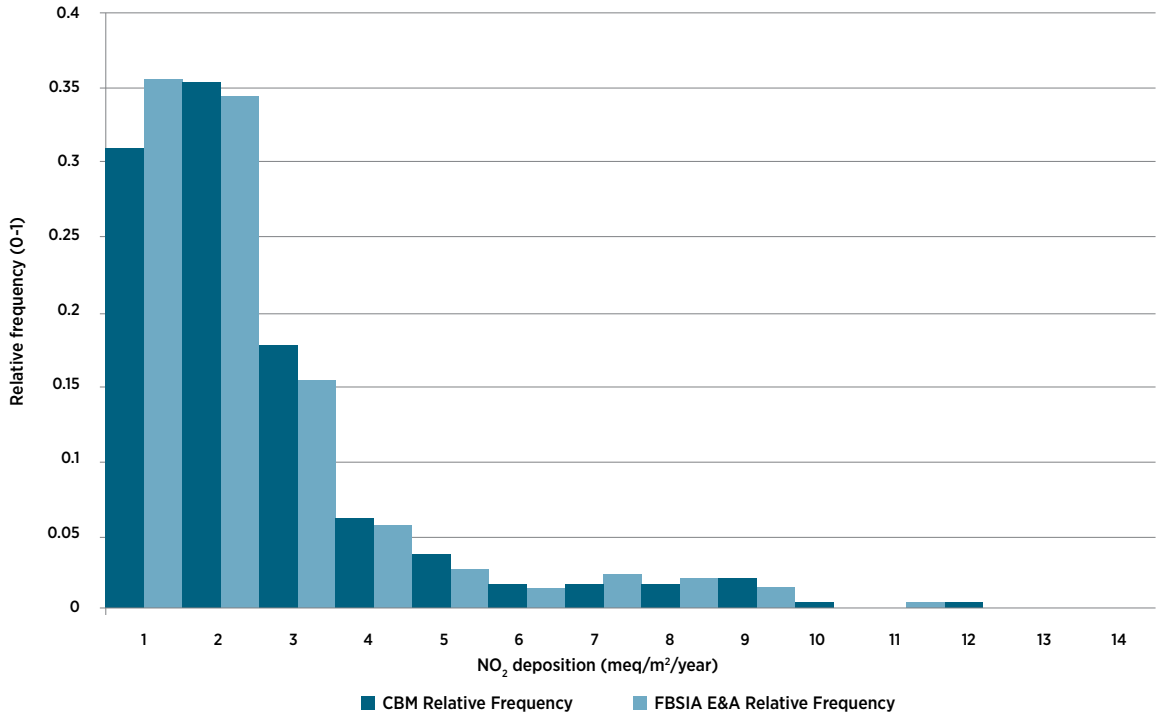


Figure 6-22: Histogram - Comparison of Current (CBM) and Future Approved Developments (Pluto LNG Development [Train 2]) with KGP Emission Reductions (FBSIA E&A)

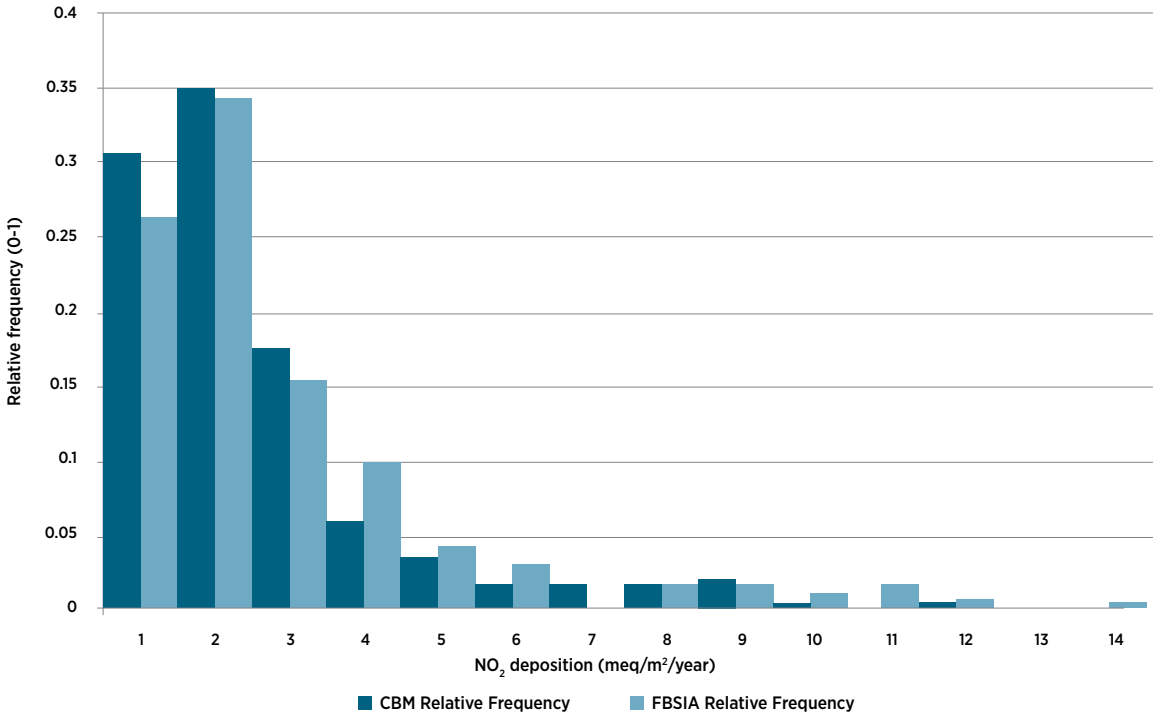


Figure 6-23: Histogram - Comparison of Current (CBM) and Future Approved and Referred Developments (FBSIA)

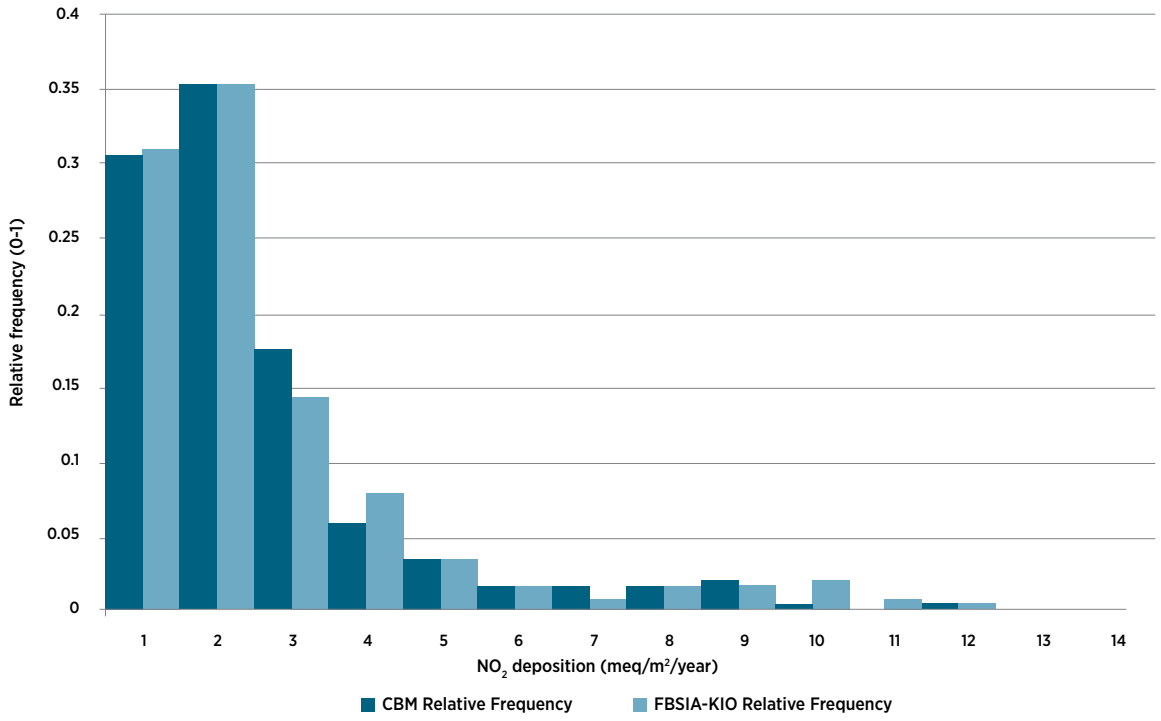


Figure 6-24: Histogram - Comparison of Current (CBM) and Future Approved and Referred Developments with KGP Emission Reductions (FBSIA-KIO)

Comparative analysis of modelled NO_2 deposition values as a sub-component of overall nitrogen and sulphur deposition indicates that:

+ For all scenarios, the majority of the NO_2 deposition results for the grid receptors within the National Heritage Place fall within the range of 1-4 meq/m^2/year.
+ NO_2 deposition in all scenarios as projected at historical monitoring locations broadly align with measured dry NO_2 deposition, indicating likely comparable total nitrogen deposition may be expected to be aligned with historical deposition measurements. Rock art impact assessment studies occurred throughout historical monitoring periods where the range of measured total deposition was broadly consistent.
+ KGP emission reductions (KIO) generally results in an observable reduction of deposition frequencies above 2 meq/m^2/year compared with CBM across the National Heritage Place. Implementation of NO_X reduction opportunities are expected to materially reduce NO_2 maximum concentrations, as well an overall reduction in annual nitrogen deposition across the National Heritage Place.
+ Future approved developments (Pluto LNG Development [Train 2]) with KGP emission reductions (FBSIA E&A) shows a nominally consistent and slightly lower deposition frequencies than CBM above 2 meq/m^2/year. An overall reduction of deposition is expected across the National Heritage Place for this scenario.
+ Reasonably foreseeable future BSIA development scenarios: FBSIA and FBSIA-KIO show relative marginal increases in deposition frequencies above 3 meq/m^2/year compared to current levels. The increase is estimated to be influenced by the addition of potential indicative future point sources in combination with natural topography, and wind direction; whereby spatially distributed point emission sources featuring lower temperature, discharge velocities, height and plume buoyancy may be increasing model ground level estimates.

Assessment of Potential Impacts and Risks

Woodside's approach to the management of Aboriginal heritage has been developed to ensure the requirements of the *Aboriginal Heritage Act 1972* (WA) and the environmental objectives of the Social Surroundings environmental factor are met.

In relation to impacts on the Burrup Peninsula rock art from industrial emissions, the past 15 years has seen numerous studies being conducted to investigate the potential for industrial emissions to impact on the Burrup Peninsula rock art. During this period, the NWS Project has operated within the same emissions profile as presented in this Proposal. No published

peer reviewed studies identified measurable or observable changes to the condition and integrity of the rock art as a result of industrial emissions. As such, significant accelerated weathering impacting on the distinguishability of petroglyphs across the region is not expected to occur as a result of the Proposal.

Preventative and management controls are presented to minimise risk associated with uncertainties and with monitoring and analysis techniques and data-sets to-date, acknowledging theorised pathways for potential accelerated weathering, and stakeholder concern. This ERD commits to provisions for measuring and managing emissions from the Proposal and significant emissions reduction opportunities afforded through facility life extension. 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). This will ensure that risk is minimised and remains at an acceptable level.

The implementation of the Murujuga Rock Art Strategy, Framework and Monitoring Program (DWER, 2019c)[13] will remove much of the uncertainty surrounding potential pathways linking industrial emissions and accelerated weathering and allow for timely investigation and management where required. The proposed robust program of monitoring and analysis will determine whether change is occurring to the rock art and if this change is being accelerated by industrial emissions. Monitoring of rock, and rock art in particular allows for early warning indicators and response mechanisms to ensure that long-term significant impact due to accelerated weathering is avoided. The implementation of the risk-based, adaptive management program using guidelines and standards, derived from sound scientific information, will ensure that the rock art is protected from potentially significant harm associated with industrial emissions.

As the Burrup Peninsula is part of the EPBC Act listed National Heritage Place, is recognised as one of the largest and most diverse, unique and highly valued collections of rock art in the world and has significant cultural value to Traditional Owner groups and to Aboriginal people more broadly, the receptor sensitivity is assessed as *high*. The magnitude of any potential impact to the rock art is assessed as *minor* as there has been no identified measurable or observable changes to the condition and integrity of the rock art as a result of industrial emissions, and air emissions from the NWS Project will remain the same or reduced through identified emissions reductions opportunities. The residual risk to rock art following the implementation of mitigation and management measures, including the Murujuga Rock Art Strategy, Framework and Monitoring Program, is assessed to be *moderate*, which is considered to be not significant.

In accordance with the principle of waste minimisation and application of the hierarchy of controls, Woodside will take reasonable and practicable measures to minimise emissions to air and therefore reduce the risk of significant impacts to the rock art. Woodside proposes to reduce NO_X emissions by 40%[14], and substantially reduce VOCs by 31 December 2030.

Woodside will monitor air emissions during the Proposal through the implementation of the NWS Project Extension Air Quality Management Plan (**Appendix A**). This management plan leverages facility technical emissions control technologies and sets out a suite of operational management practices and contains provisions for measuring and managing emissions from the Proposal. The implementation of this management plan together with the NO_X and VOC reductions will ensure that air emissions will be managed to an acceptable level.

6.5.4.2 Degradation of Terrestrial and Nearshore Vegetation of Heritage and Conservation Value due to Deposition of Gaseous Emissions

Description of Potential Impacts

Degradation and/or health deterioration of terrestrial and nearshore vegetation of heritage and conservation value is assessed as a potential impact associated with gaseous emission arising from the Proposal.

International studies have shown that the emission and increased deposition of NO_X and SO_2 on vegetation can increase susceptibility to stressful conditions such as drought (UK DoETR, 1994).

The vegetation of the Burrup Peninsula includes plants which provide sources of food and bush-medicine for the local Indigenous groups, including Acacia coriacea (used for spears and boomerangs), *A. pyrifolia* (Kanji Bush, edible seeds and gum), *Avicennia marina* (edible seeds), *Ficus brachypoda* (Rock Fig, edible fruit) and various *Solanum* species (Bush Tomato, edible fruit) (City of Karratha, 2013). The 2018 ethnographic surveys and audits identified a bush medicine plant referred to as 'minjari' or 'jami' growing at Withnell Bay. This plant is used as a healing balm for physical injuries and colds, and is also a spiritual protection for people visiting country (IHS, 2018). Bush gum (bush lollies) also grows in Withnell Bay, and is used to settle the stomach (IHS, 2018)

13 *The purpose of the Murujuga Rock Art Monitoring Program is to monitor, evaluate and report on changes and trends in the integrity or condition of the rock art and whether the rock art is being subject to accelerated change; specifically to determine whether anthropogenic emissions are accelerating the natural weathering / alteration / degradation of the rock art. This will enable timely and appropriate management responses by the Western Australian Government and stakeholders to emerging issues and risks (DWER, 2019c).*

14 *Based on the percentage of reported emissions from KGP over the five year average, covering the 2013/14 to 2017/18 financial years.*

The Murujuga Cultural Management Plan (MAC, 2016) describes how the plants of the Murujuga land and sea provide many sources of food and jami. These include examples such as the Bloodwood tree (*Corymbia* opaca) and Coolibah leaves, which can be used to make a decongestant for colds; Corkwood tree flowers for sweet nectar; the Jami bush to treat aches, pains, and cuts; burning mangrove leaves to keep sand flies away; and using spinifex seeds to make damper (MAC, 2016). If the deposition of gaseous emissions adversely impacts this vegetation, Aboriginal cultural associations with the land, such as gathering activities for flora as bush tucker and medicine may be affected.

There is limited information available regarding the impacts of atmospheric deposition on Australia flora and vegetation in arid conditions and very little is known regarding air pollution impacts on vegetation occurring on the Burrup Peninsula. In general, studies overseas have found the low levels of NO_X can be a useful source of nutrient for nitrate dependent plants although if the uptake of NO_2 exceeds the plant's requirements there may be metabolic effects as the plants dispose of surplus nitrogen (Bell and Treshow, 2002).

Air Dispersion Modelling

An air quality impact assessment utilising the CSIRO Atmospheric Research air dispersion model 'TAPM-GRS', was undertaken to understand the contribution that the Proposal is likely to make to ambient air quality with subsequent potential impacts on vegetation of heritage and conservation value.

The setup and operation of the TAPM-GRS for the Proposal, including sensitivity tests undertaken with the model setups, are described in detail in **Appendix E**. The study considered the emissions of NO_X, and SO_2 from several operational scenarios representing current and potential future industrial facilities on the Burrup Peninsula until 2070. All scenarios include shipping activities on the Burrup Peninsula. The scenarios included in the modelling are listed in **Table 6-5** and described in **Section 6-3**.

Air Dispersion Assessment Criteria

Air quality standards for protecting vegetation have been set out by the World Health Organization (WHO, 2000), and the European Union (EU, 2008). Although these standards were developed for protecting vegetation in Europe, they have had wider application and are typically used when assessing proposals in WA. To understand the potential impacts of the Proposal on nearby vegetation, the more-recent EU standards were adopted (**Table 6-24**). The units used in the EU standards were converted to parts per billion (ppb) to allow comparison with the results from the NO_X and SO_2 dispersion modelling conducted for the Proposal. A temperature of 30° C was used for this conversion, which is the typical ambient temperature relevant to the Proposal.

Table 6-24: 2008 EU Air Quality Standards for the Protection of Vegetation

Air Pollutant	EU Air Quality Standard	Standard Adopted for Assessment, Annual Average
NO_X	30 µg/m^3, annual	16 ppb at 30° C (15 ppb as NO_2 at 0° C)
SO_2	20 µg/m^3, annual	8 ppb at 30° C (7 ppb at 0° C)

Source: EU, 2008

Air dispersion models calculate surface deposition for airborne substances using an airborne concentration near ground level, a deposition velocity for the substance of interest, and other parameters (Seinfeld and Pandis, 2016). These parameters are difficult to accurately quantify, and therefore the standards for deposition (e.g. to compare to µg/m^3 values) have greater uncertainties than the standards based on airborne concentrations (ppb) only.

Air Dispersion Modelling Results

Dispersion modelling for the Proposal was conducted for all the scenarios listed in **Table 6-5**. The most relevant scenarios for understanding impact to vegetation are the near-term, most likely scenario (the CBM model) and the medium-term, best-case scenario (the KIO model). Contour plots of the annual average concentration of NO_X for these two operational scenarios are presented in **Figure 6-25** and **Figure 6-26**. Annual average SO_2 concentrations for the CBM scenario are presented in **Figure 6-3** in **Section 6.3** which shows there is no change in the emission of SO_2 between the two scenarios. As such, one contour plot is provided for the annual average SO_2.

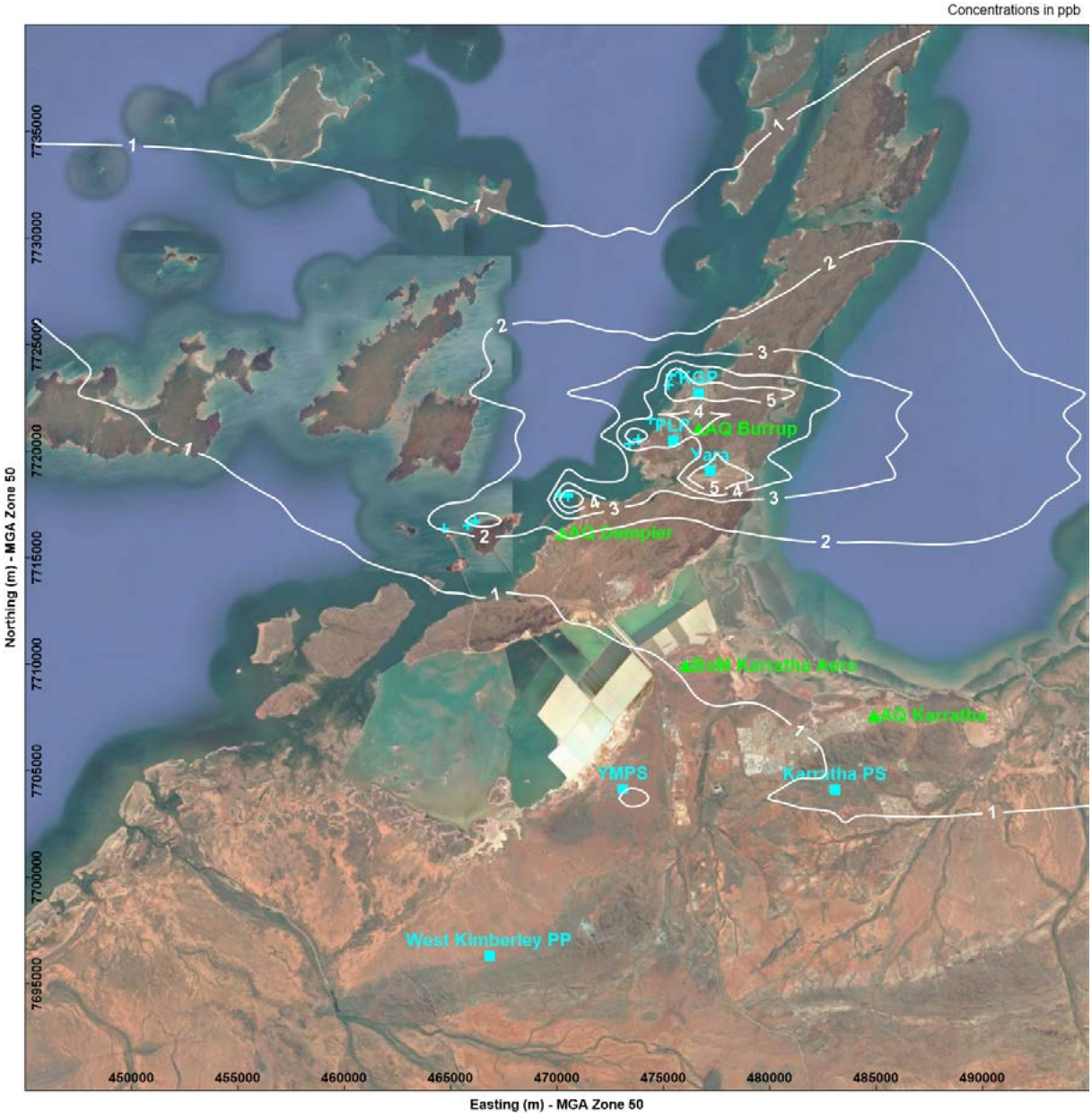


Figure 6-25: CBM- Annual Average NO_x Concentrations (ppb)

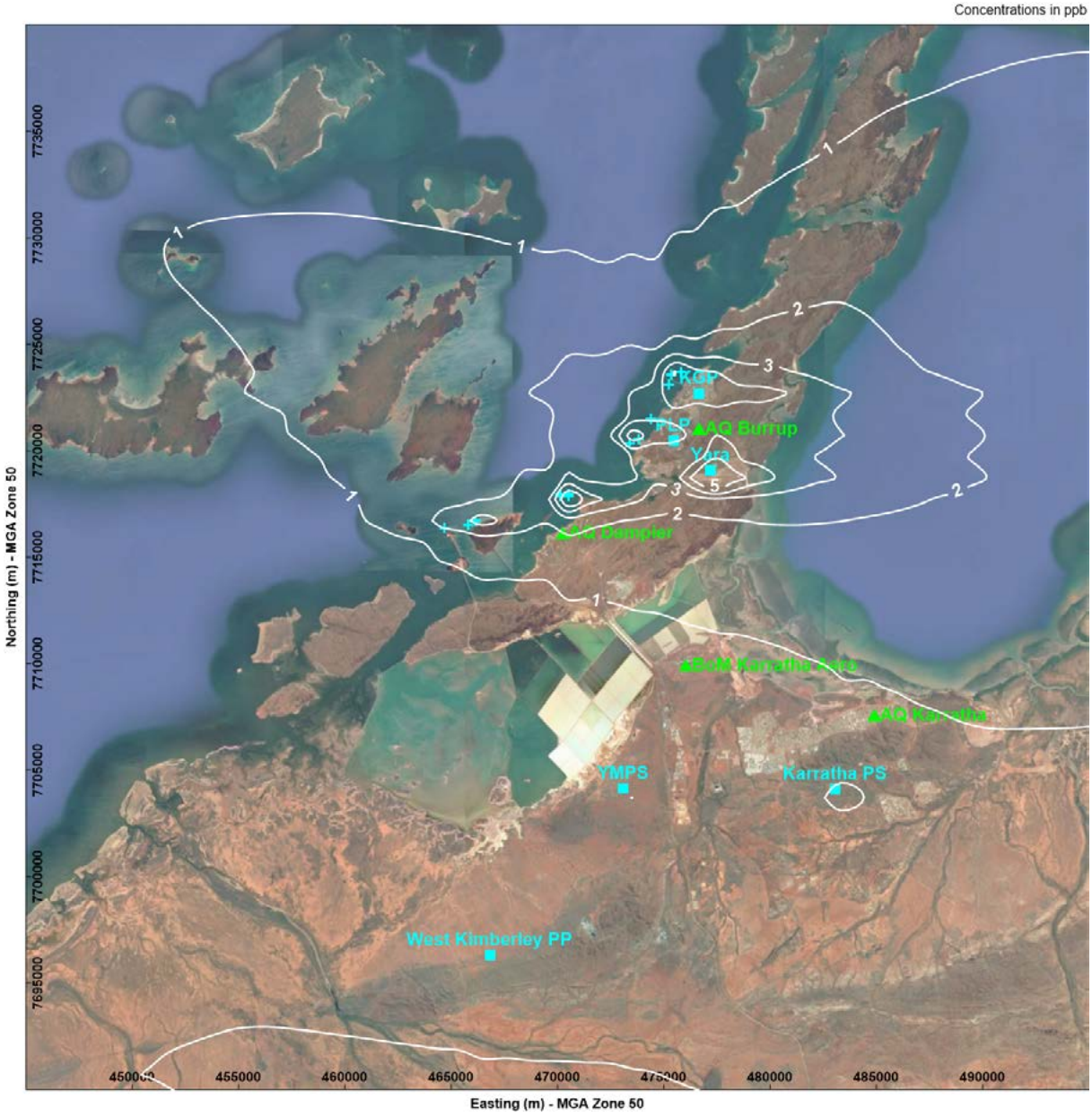


Figure 6-26: KIO - Annual Average NO_X Concentrations (ppb)

Assessment of Potential Impacts and Risks

Interpretation of Modelling Results

The maximum annual average concentrations for NO_X and SO_2 compared with the EU Air Quality Standards or the Protection of Vegetation for modelled cumulative emission scenarios are summarised in **Table 6-25**.

Table 6-25: Summary of TAPM-GRS Results: Grid Receptor Maxima and EU 2008 Standards for Protection of Vegetation

Assessment Parameter	CBM	KIO	FBSIA-E&A	FBSIA	FBSIA-KIO	EU Standard Adopted for Assessment
Annual NO_X (ppb)	7.7	7.4	7.7	9.0	8.8	16 ppb at 30° C (15 ppb as NO_2 at 0° C, or 30 µg/m^3)
Annual SO^2 (ppb)	4.5	4.5	4.5	4.5	4.5	8 ppb at 30° C (7 ppb at 0° C, or 20 µg/m^3)

All predicted values of NO_X are less than 10 ppb and therefore well below the EU (2008) standard of 16 ppb (the EU standard of 20 µg/m^3 has been converted to 16 ppb using the temperature 30° C). Furthermore, ambient concentrations for both the near-term, most likely scenario (CBM) and the medium-term, best-case scenario (KIO) are below 50% of the vegetation criterion everywhere within the calculation grid. All maximum annual average SO_2 values are less than 5 ppb, which is well below the relevant EU (2008) standard of 8 ppb.

Assessment of Potential Impacts and Risks

All predicted concentrations of NO_X and SO_2 are below the EU Air Quality Standards for the Protection of Vegetation (EU, 2008), as such significant impacts to vegetation of heritage or conservation significance are not expected due to emissions contribution from the Proposal. Management and mitigation measures presented in **Section 6.3.5** for air emissions also provide risk reduction for potential impacts to vegetation of heritage or conservation significance. Vegetation of heritage or conservation significance is recognised as having a moderate sensitivity, however the likelihood of an impact occurring is *highly unlikely* and any impact would be *slight* due to the localised nature and high recoverability, resulting in a low residual risk associated with ongoing emissions from the Proposal.

6.5.4.3 Direct, Accidental Physical Damage to Heritage Features within the Development Envelope

Description of Potential Impact

Direct, accidental damage to heritage features could occur through direct interactions with NWS Project workforce (e.g. inappropriate human behaviour [climbing on/over or marking heritage features or leaving rubbish at these sites], driving of vehicles over heritage features, objects accidentally dropped on heritage features, or spills from operational activities). The likely impacts include damage or loss, the significance of which would depend upon the significance of the site.

Woodside maintains a database of known Aboriginal heritage sites that exist within the KGP development site. Implementation of the Proposal does not require a change in the current disturbance envelope, therefore there is no risk of disturbance to heritage features due to clearing or construction activities. Existing operational areas have been designed and constructed so that Project personnel do not need to directly interact with the heritage features to conduct operational activities. Roads within the plant site are clearly marked and personnel must stay on roads unless specifically authorised otherwise. Furthermore, all personnel, contractors and visitors who enter the KGP site undergoes site inductions that include information about the heritage features.

Woodside conducts regular audits of the heritage features within the development envelope to monitor what impacts, if any, may be occurring. These site audits are conducted with Traditional Owners and a qualified archaeologist and inspect, monitor, and report on the condition of the sites within the development envelope. The 2018 Annual Aboriginal Heritage Site Audit identified localised contamination, such as rubbish accumulation, at a number of heritage features and concluded that generally the rock art is in good condition and no permanent damage was detected (IHS, 2018).

Quarterly heritage update meetings are also held with Traditional Owners, and discussions include NWS Project-related activities and ongoing heritage management requirements.

Assessment of Potential Impacts and Risks

A small percentage of the heritage features of the Burrup Peninsula are within the development envelope of the Proposal, which has already been disturbed through construction and operation of the NWS Project.

As a result, the receptor sensitivity of these receptors is assessed as *medium*. Given the continuation of the current, established management measures (**Table 6-26**) and the results of regular site audits conducted to date, it is concluded that significant, permanent, accidental damage to heritage features located within NWS Project development envelope due to the Proposal is *highly unlikely* and the risk of direct, accidental or physical damage to heritage features is considered *low*.

6.5.4.4 Continued Restricted Access to Heritage Features Within the Development Envelope until Around 2070

Description of Potential Impact

Disruption in connection to culturally significant sites within the KGP fenced area may occur due to continued restricted access until around 2070. The significance of the loss of connection would depend upon the significance of the sites and how frequently access is not permitted or is limited.

Heritage features within the fenced area of the Proposal include petroglyph sites, ceremonial/restricted access sites, ethnographic sites, standing stones, shell middens, artefact scatters, quarries, grinding patches, and coastal fishing and foraging opportunities.

There is a process in place to permit Traditional Owners to access culturally significant sites within the KGP fenced area. Woodside has previously received requests from Traditional Owners for ongoing access to the heritage features within the NWS Project leases and welcomes such requests in the future. Access is provided on an 'as requested' basis, although on-site activities occurring at the time of the requested access may influence the areas that can be visited, the number of visitors, and/or the duration of the visit.

Assessment of Potential Impacts and Risks

Woodside will continue to work with the Traditional Owners to provide access to culturally significant sites whenever practicable. It is therefore, *highly unlikely* that significant Aboriginal cultural associations linked to the Heritage features located within the NWS Project development envelope, will be impacted by the Proposal and the residual risk is considered low.

6.5.4.5 Reduced Amenity to Heritage Features Outside the Development Envelope as a Result of Odorous Substances (e.g. Odour from Atmospheric Emissions)

A description and assessment of the potential impacts and risks from odorous substances on heritage features outside the development envelope is discussed in **Section 6.3.4.4**.

6.5.4.6 Harm to Marine Fauna and Flora with Heritage Value

As discussed in **Section 4.6.4**, the Aboriginal groups of the Burrup Peninsula have ongoing connections to the sea and coastal areas adjacent to the development envelope. This includes traditional (customary) fishing, hunting and gathering activities. Marine fauna exploited by Aboriginal groups, and therefore considered to have heritage value, include dugongs (hunting), turtles (hunting and egg collection), seabirds (egg collection), shellfish (collecting) and various marine fish (spearing, line fishing, reef trapping, fish traps).

Seeds of the White Mangrove (*Avicennia marina subsp. marina*) are collected for food and the wood may be used for boomerangs. No other marine flora has been identified as being used by Aboriginal people or as having heritage value.

Changes to marine water quality from both planned and unplanned discharges, or through increased turbidity during maintenance dredging may impact on those marine flora and fauna identified as having heritage value.

Changes to Water Quality from Planned and Unplanned Discharges

A detailed description and assessment of the potential impacts and risks to marine flora and fauna with heritage value from changes to water quality from planned and unplanned discharges is discussed in **Sections 6.6.4.1** and **6.6.4.4** respectively. A summary of this information is provided below.

Planned Discharges

The ongoing discharge of treated wastewater and stormwater to the marine environment from the Proposal has the potential to reduce water and sediment quality through toxicity of physical or chemical stressors present in the discharged water. Indirect impacts to marine flora and fauna may result from decreased water and sediment quality.

Introducing any third-party gas and fluids could change the characteristics of the marine discharges from the Proposal. Third-party gas could have a different chemical composition, thus potentially changing the chemical composition of discharges to the Jetty Outfall. The Proposal will not lead to changes to the quality of water discharged from the Administration Drain, or stormwater runoff.

Planned discharges from the NWS Project to the marine environment have been ongoing continuously for over thirty years without a significant reduction in marine environment quality. Impacts associated with marine discharges are predicted to be highly localised to within specified zones of reduced ecological protection that have been agreed with stakeholders and incorporated into an Environment Quality Plan. No direct or indirect death, or loss of fauna or flora with heritage value, has been predicted to occur as a result of the proposal. This is described in further detail in **Section 6.6.4**.

The magnitude of potential impacts to marine environment quality from ongoing planned discharges, inclusive of potential future changes result from processing of third-party gas and fluids, was assessed as *negligible*. The activity will therefore not have a significant impact on marine flora or fauna with heritage value.

Unplanned Discharges

Activities within state waters associated with the Proposal have the potential to result in unplanned discharges to the marine environment as a result of accidents or emergencies. Causes of unplanned offshore discharges include:

- Spills of hydrocarbons or chemicals from vessels decks to the ocean.
- A loss of containment from the condensate loading system.
- Loss of marine vessel separation (i.e. vessel collision of grounding).
- Loss of containment from a trunkline.

The largest credible impact to the marine environment would arise from a loss of containment from the second NWS Project trunkline (2TL), which contains up to 6,500m^3 of combined gas and condensate. The impacts of this event are described in detail and managed through the implementation of the NWS Trunklines (State Waters) Environment Plan, (State Waters Trunklines EP). Modelling of the subsea loss of containment indicates that surface slicks and entrained oil could be far-reaching, as hydrocarbons have the potential to be transported over long distances via ocean currents.

Operations associated with the Proposal require large volumes of environmentally hazardous materials to be stored onshore. Onshore NWS Project infrastructure (including secondary containment) has been designed to relevant standards and is inspected and maintained, which significantly reduces the likelihood of a spill reaching the environment as this requires a failure of both primary and secondary containment measures.

The worst-case credible event would result in a loss of condensate to the ground from a loss of containment from the slug catcher or condensate loading system. The chemical composition of the spill is the same as that for a trunkline loss of containment, but the volumes reaching the marine environment would be significantly lower and would not be discharged to the marine environment instantaneously. Therefore, impacts are considered to be equivalent to or lower than those that would be associated with a loss of containment from the offshore trunkline.

The environmental impacts resulting from an unplanned discharge very much depend on the nature, size, and characteristics of the discharge, time of year and proximity of the release site in relation to the shoreline.

The likelihood of the worst-case credible hydrocarbon spill (trunkline rupture) occurring is *highly unlikely* as a range of preventative and management measures are in place to prevent this event occurring. If such an accident did occur, *moderate* impacts on marine ecosystems, including flora and fauna with heritage value, may occur.

A range of other possible unplanned events have been assessed and none were assessed as having a higher residual risk than *moderate*. Unplanned discharges will therefore not have a significant impact on marine flora or fauna with heritage value.

Turbidity from Maintenance Dredging

A detailed description and assessment of the potential impacts and risks to marine flora and fauna with heritage value from turbidity from maintenance dredging is discussed in **Section 6.6.4.2**. A summary of this information is provided below.

Maintenance dredging of the shipping channels, turning basins and berthing pockets within the development envelope will continue to be required. This is to maintain sufficient depth for ships to safely traverse the area. Historically, maintenance dredging of NWS shipping channels has occurred at a frequency of between five and 10 years. The frequency of maintenance dredging is not predicted to change as a result of the Proposal. The most recent maintenance dredging was undertaken in 2016, when 350,000 m^3 of material was dredged. No impacts were observed as a result of this maintenance dredging program, the results of which were provided to the DOEE in accordance with conditions of the relevant Sea Dumping Permit.

The most likely impacts associated with maintenance dredging in Mermaid Sound relate to near-field and temporary increases in suspended sediments and turbidity levels from dredging and disposal operations. The quality of sediments likely to be dredged have been studied extensively. The level of contaminants in the dredge spoil have historically been below the screening levels listed in the National Assessment Guidelines for Dredging 2009 (DEWHA, 2009).

The magnitude of potential impacts from maintenance dredging was assessed as *slight*. The activity will therefore not have a significant impact on marine flora or fauna with heritage value.

6.5.5 Existing and Proposed Mitigation

The existing and proposed mitigation measures applicable to the management of impacts to Social Surroundings (Heritage) arising from the Proposal are summarised in **Table 6-26**. Detailed description of measures is provided in the NWS Project Extension Air Quality Management Plan (**Appendix A**) and the NWS Project Extension Cultural Heritage Management Plan (**Appendix C**).

Table 6-26: Existing and Proposed Mitigation Measures: Social Surroundings (Heritage)

Impact	Existing Mitigation Measures	Proposed Mitigation Measures
Accelerated weathering of rock art due to industrial emissions	**Avoid** + Gaseous emissions will result from the proposal and cannot be avoided. **Minimise** + Continuation of the facility emissions testing and verification programs as described in the NWS Project Extension Air Quality Management Plan (**Appendix A**). + Continue to implement the Woodside management system which includes procedures to assess changes in feed gas sources. **Rehabilitate** + Not applicable for this impact.	**Avoid** + No additional measures are proposed. **Minimise** + Adopt practicable and efficient technologies to reduce air emissions from the Proposal as described in the NWS Project Extension Air Quality Management Plan (**Appendix A**). + Monitor ambient concentrations of relevant emissions, that contribute to human health risks, from the Proposal as described in the NWS Project Extension Air Quality Management Plan (**Appendix A**). + Reduce NO_X emissions by 40% of the current emissions baseline[15] by 31 December 2030 and substantially reduce VOCs by 31 December 2030. + Implement the updated NWS Project Extension Cultural Heritage Management Plan (**Appendix C**) which outlines an adaptive management plan addressing the potential impact to rock art from industrial emissions. + Support implementation of the Murujuga Rock Art Strategy (DWER, 2019b) as a member of the Murujuga Rock Art Stakeholder Reference Group. **Rehabilitate** + No additional measures are proposed.

15 Based on the percentage of reported emissions from KGP over the five year average, covering the 2013/14 to 2017/18 financial years.

Impact	Existing Mitigation Measures	Proposed Mitigation Measures
Degradation of terrestrial and nearshore vegetation of heritage and conservation value due to deposition of gaseous emissions	**Avoid** + Gaseous emissions will result from the Proposal and cannot be avoided. Modelling indicates that emission and resultant deposition are below the relevant EU standards for vegetation impacts. + Continuation of the facility emissions testing and verification programs as described in the NWS Project Extension Air Quality Management Plan (**Appendix A**). + Continue to implement the Woodside management system which includes procedures to assess changes in feed gas sources. **Rehabilitate** + Progressively rehabilitate disturbed areas at the end of their operational life, where appropriate.	**Avoid** + No additional measures are proposed. **Minimise** + Adopt practicable and efficient technologies to reduce air emissions from the Proposal as described in the NWS Project Extension Air Quality Management Plan (**Appendix A**). + Reduce NO_x emissions by 40% of the current emissions baseline[16] by 31 December 2030. + Implement the updated NWS Project Extension Cultural Heritage Management Plan (**Appendix C**) which includes provisions for managing air emissions to limit impacts to vegetation. **Rehabilitate** + No additional measures proposed.
Direct, accidental physical damage to heritage features within the development envelope	**Avoid** + Restrict access to the KGP site physically by a fence. + Operational areas are designed so that NWS Project personnel do not need to directly interact with the heritage features to conduct routine activities. **Minimise** + Educate personnel on the sensitivity of the cultural heritage features on the Burrup Peninsula through compulsory site inductions include information about the heritage features. + Maintain a register of known Aboriginal sites. + Independent annual audits of the heritage features. **Rehabilitate** + Evaluate outcomes of independent annual audits and implement corrective actions as required.	**Avoid** + No additional measures are proposed. **Minimise** + Implement the updated NWS Project Extension Cultural Heritage Management Plan (**Appendix C**) which includes provisions for managing physical damage to heritage features equivalent to current, internally required processes. **Rehabilitate** + No additional measures proposed.

16 *Based on the percentage of reported emissions from KGP over the five year average, covering the 2013/14 to 2017/18 financial years.*

Impact	Existing Mitigation Measures	Proposed Mitigation Measures
Continued restricted access to heritage features within the development envelope until around 2070	**Avoid** + As this is a continuation of current practices/situation, avoidance is not applicable for this impact. **Minimise** + Provide access for Traditional Owners to Aboriginal cultural heritage sites within the Proposal development envelope when requested. + Maintain established consultation forums with Traditional Owners and custodians. **Rehabilitate** + Re-establish Traditional Owner access to the development envelope following Decommissioning of the Proposal.	**Avoid** + As this is a continuation of current practices/situation, avoidance is not applicable for this impact. **Minimise** + Implement the updated NWS Project Extension Cultural Heritage Management Plan (**Appendix C**) which includes provisions for managing access to heritage features within the development envelope equivalent to current, internally required processes. **Rehabilitate** + No additional measures proposed.
Reduced amenity to heritage features outside the development envelope as a result of nuisance-causing emissions and discharges (e.g. odour from atmospheric emissions)	Refer to the mitigation measures for odour and dark smoke in **Section 6.3.5**	
Indirect impacts to marine fauna and flora with heritage value	Refer to the mitigation measures in **Section 6.6.5**	

6.5.6 Predicted Outcome

Based on the current environmental performance of the NWS Project (**see Section 2.5**), the continued implementation of existing management measures and the commitment to reassess any potential impacts or risks from the introduction of third-party gas, there were no impacts or risks higher than a moderate ranking identified. Woodside considers that this indicates the residual impacts and risks associated with the Proposal are broadly aligned with the EPA's objective for Social Surroundings. There were no impacts or risks identified that would mean that the EPA objectives for Social Surroundings (Heritage) would not be achieved.

The NWS Project Extension Cultural Heritage Management Plan (**Appendix C**) sets the framework for how Woodside will continue to minimise its impact to the heritage environment. The implementation of this management plan will ensure that representatives of the Indigenous groups of the area continue to be consulted regarding Woodside's heritage management activities and impacts, and influence Woodside's approach to heritage management. Regular heritage update meetings are also held with Traditional Owners, and discussions include NWS Project-related activities and ongoing heritage management requirements.

A summary of the impact assessment outcomes used to derive this outcome are provided in **Table 6-27**.

Table 6-27: Social Surrounds (Heritage) Impact Assessment Summary

Impact	Receptor Sensitivity	Magnitude	Likelihood (unplanned impacts only)	Impact Level/ Environment Risk Rating
Accelerated weathering of rock art due to industrial emissions	High	Minor	Unlikely	Risk Rating - Moderate
Degradation of terrestrial and nearshore vegetation of heritage and conservation value due to deposition of gaseous emission	Moderate	Slight	Highly Unlikely	Risk Rating - Low
Direct, accidental physical damage to heritage features within the development envelope	Medium	Slight	Highly unlikely	Risk Rating - Low
Continued restricted access to heritage features within the development envelope until around 2070	Medium	Slight	N/A	Impact Level - Slight
Reduced amenity to heritage features outside the development envelope as a result of odorous substances (e.g. odour from atmospheric emissions)	Medium (See **Section 6.3**)	Minor	Highly Unlikely	Risk Rating - Low
Harm to marine fauna and flora with heritage value	See **Section 6.6**			

6.6 Key Environmental Factor – Marine Environmental Quality

6.6.1 EPA Objective

To maintain the quality of water, sediment, and biota so that environmental values are protected (EPA, 2016c).

6.6.2 Policy and Guidance

EPA Policy and Guidance

+ Statement of Environmental Principles, Factors and Objectives (EPA, 2018a).
+ Environmental Factor Guideline – Marine Environmental Quality (EPA, 2016c).
+ Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016d).

Other Policy and Guidance

+ Pilbara Coastal Water Quality Consultation Outcomes – Environmental Values and Environmental Quality Objectives (DoE, 2006b).
+ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2018).

Section 10 details how this legislation, policy and guidance relates to the Proposal.

6.6.3 Receiving Environment

Table 6-28 identifies the elements of the receiving environment that are directly and indirectly related to the Marine Environmental Quality environmental factor. Refer to **Section 4** for detailed description of each relevant receptor of the receiving environment.

Table 6-28 Marine Environment Quality Receiving Environment

Receving Envrionment	Activity	Ongoing discharge of treated wastewater to Mermaid Sound and No Name Creek	Ongoing discharge of stormwater to the marine environment	Maintenance dredging of the jetties and berthing pockets at the KGP and KBSB
	National Heritage Place			
	Shorelines			
	Seabirds and Shorebirds			
	Sharks and Fish			✓
	Sea Snakes			✓
	Turtles			✓
	Marine Mammals			✓
	Sediment Quality	✓	✓	
	Water Quality	✓	✓	✓
	Macroalgae			✓
	Seagrass			✓
	Coral			✓
	Marine Invertebrates	✓		✓
	Mangroves	✓	✓	
	Marine Fauna with Heritage Value			✓
	Vegetation with Heritage Value			
	Heritage Features			
	Terrestrial Vegetation			
	Contribution to GHG Concentrations			
	Air Quality (Relevant to Amenity)			
	Air Quality (Relevant to Human Health)			

Receving Envrionment	Activity	Ship loading and ship movements at the KGP and KBSB	Unplanned discharges from offshore accidents or emergencies (e.g. vessel or pipeline hydrocarbon loss of containment)	Unplanned discharges from onshore accidents or emergencies (e.g. hydrocarbon spill)
	National Heritage Place			
	Shorelines		✓	✓
	Seabirds and Shorebirds		✓	✓
	Sharks and Fish		✓	✓
	Sea Snakes		✓	✓
	Turtles	✓	✓	✓
	Marine Mammals	✓	✓	✓
	Sediment Quality	✓	✓	✓
	Water Quality	✓	✓	✓
	Macroalgae		✓	✓
	Seagrass		✓	✓
	Coral		✓	✓
	Marine Invertebrates		✓	✓
	Mangroves		✓	✓
	Marine Fauna with Heritage Value	✓	✓	✓
	Vegetation with Heritage Value			
	Heritage Features			
	Terrestrial Vegetation			
	Contribution to GHG Concentrations			
	Air Quality (Relevant to Amenity)			
	Air Quality (Relevant to Human Health)			

	Activity	Presence and potential migration of onshore contamination
Receving Envrionment	*National Heritage Place*	
	Shorelines	✓
	Seabirds and Shorebirds	✓
	Sharks and Fish	✓
	Sea Snakes	✓
	Turtles	✓
	Marine Mammals	✓
	Sediment Quality	✓
	Water Quality	✓
	Macroalgae	✓
	Seagrass	✓
	Coral	✓
	Marine Invertebrates	✓
	Mangroves	✓
	Marine Fauna with Heritage Value	✓
	Vegetation with Heritage Value	
	Heritage Features	
	Terrestrial Vegetation	
	Contribution to GHG Concentrations	
	Air Quality (Relevant to Amenity)	
	Air Quality (Relevant to Human Health)	

6.6.4 Potential Impacts and Risks

The following activities associated with the Proposal have the potential to affect Marine Environmental Quality:

- Ongoing discharge of treated wastewater to Mermaid Sound via the Jetty Outfall and Administration Drain (including changes to marine discharge characteristics due to the introduction of third-party gas and fluids).
- Ongoing discharge of stormwater to the marine environment.
- Maintenance dredging of jetties and berthing pockets and the KGP and KBSB.
- Ship loading and ship movements at the KGP and KBSB.
- Unplanned discharges from offshore accidents or emergencies (e.g. vessel and pipeline hydrocarbon spills).
- Unplanned discharges from onshore accidents or emergencies (e.g. hydrocarbon spill).
- presence and potential migration of onshore contamination.

The potential impacts to marine environmental quality that are assessed in this ERD are:

- Reduction in Marine Environment Quality, resulting from planned discharges to the marine environment.
- Direct reduction of water and sediment quality and indirect impacts to marine flora and fauna, resulting from maintenance dredging and shipping.
- Direct reduction of water and sediment quality and indirect impacts to marine flora and fauna, resulting from unplanned discharges from offshore or onshore accidents or emergencies.
- Reduction of water and sediment quality and indirect impacts to marine flora and fauna, resulting from the presence and potential migration of onshore contamination.

6.6.4.1 Reduction in Marine Environment Quality, Resulting from Planned Discharges to the Marine Environment

Description of Source of Impact

The ongoing discharge of treated wastewater and stormwater to the marine environment from the Proposal has the potential to reduce water and sediment quality through toxicity of physical or chemical stressors present in the discharged water. Indirect impacts to marine flora and fauna may result from decreased water and sediment quality.

The Proposal has two existing licenced wastewater discharge points—the Jetty Outfall and the Administration Drain, as shown in **Figure 6-27**. Stormwater run-off from the onshore NWS Project infrastructure can enter the marine environment via drains and diversions constructed within the development envelope.

Figure 6-27 Location of Wastewater Discharge Points

Jetty Outfall Discharges & Characteristics

The KGP uses an oil-contaminated water (OCW) system to collect, treat, and discharge contaminated, and potentially contaminated water generated on site. The OCW comprises two networks (LNG and Domgas) of underground pipes for water collection, a series of above-ground holding basins for holding treated collected water, a buffer tank to balance inflows and a final holding basin to facilitate a final treatment step and to allow for the collection of pre-discharge sampling and analysis. Water in this final holding basin is sampled and tested against internal discharge limits before being discharged to a diffuser located on Berth 1 of the KGP LNG jetty, known as the Jetty Outfall (**Figure 6-27**).

Each batch discharge is analysed for the presence of 18 contaminants, in accordance with the KGP Part V Operational Licence, and the last 8 years of results from this sampling is shown in **Table 6-29**. Internal approval to discharge is informed by a subset of the licence parameters identified as potentially driving acute toxicity, with the remaining reviewed on a regular basis. Every year, a representative sample of water discharged via the Jetty Outfall is analysed for an extended suite of potential chemical contaminants. The extensive test suite is informed by a list of contaminants that could be associated with oil and gas operations, to ensure the regularly monitored contaminants are aligned to the actual contaminants present in the waste stream.

In addition to regular chemical characterisation, discharges from the Jetty Outfall undergo regular Whole Effluent Toxicity (WET) testing. The most recent WET testing was conducted on a sample of water collected from the jetty outfall in June 2018. This WET test included eight toxicity tests incorporating a range of tropical and temperate Australian marine species. These species were 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 discharge effluent in marine environments.

Toxicity was observed in all eight tests conducted on the KGP effluent, with EC_{50} values ranging from 12% to 65% concentration of effluent. The sea urchin fertilisation test (EC_{50} value of 12% and EC_{10} value of 1.9%) and the 7-day fish embryo development test (EC_{50} value of 12% and EC_{10} value of 9.6%) were most sensitive to the effluent, while the 5-minute Microtox test was the least sensitive (EC_{50} value of 65% and EC_{10} value of 22%).

The guideline values derived from the species sensitivity distribution in 2018 included a concentration that is protective of 95% of species [(PC95) value of 1.7% wastewater] and a concentration that is protective of 99% of species [(PC99) value of 0.36% wastewater]. This equates to corresponding safe dilution estimates of 1:59 and 1:280 respectively.

Typically expected dilution values expected from discharges to the jetty outfall were modelled using a stochastic model (**Appendix G**). Stochastic models are created by overlaying the result of multiple individual model runs. Each mode run is done utilising sets of wind and weather conditions that are randomly selected from a two year data set of actual weather conditions. In this circumstance, the jetty outfall typical discharge event was modelled 150 separate times with the results from each modelling run overlaid to present the most likely extent of mixing that will be achieved from any given discharge event. The modelled dilution at the boundary of the Jetty Outfall LEPA and MEPA was a minimum of 1:100. The model showed dilution sufficient to achieve the 99% species protection value (PC99 value of 0.36% wastewater, equivalent to 280 dilutions) is consistently achieved within 400 m of the discharge point, although occurring within 300 m in most scenarios (**Figure 6-3**). This is well within the requirement of the EQP to maintain a high level of ecological protection required within a minimum of 600 m of the discharge point. Discharge dilution modelling was also performed to understand the potential impacts if the toxicity of the discharge was to double (PC99 value of 0.18%, equivalent to 560 dilutions). This is shown in **Figure 6-23** and demonstrates that even in this circumstance, the discharge would be within the MEPA boundary for the majority of conditions.

Table 6-29 Average annual concentration of licensed discharge parameters in discharges to the Jetty Outfall

Parameters	Unit	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
a-MDEA	mg/L	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Anionic Surfactant	mg/L	2.6	6.8	18.1	15.8	11.6	6.1	9.1	1.2
COD	mg/L	205.5	411.7	154.9	84.9	75	76.9	605.9	85.8
Conductivity	µS/cm	3,135	4,058	3,302	1,157	2,097	1,269	1,013	676.3
Mercury	µg/L	N/A[1]	N/A[1]	N/A[1]	0.3	0.1	0.4	1.8	0.1
pH	mg/L	8	8	8.3	7.8	8.1	6.9	6.6	8.1
Sulphate	mg/L	934	1,114	947	143	380	86	28	18
Sulphide	mg/L	23	38.5	18.2	0.8	4.9	0.3	2.8	0.2
Cadmium	µg/L	0.1	N/A[1]	0.1	0.1	0.3	0.2	1.8	0.5
Copper	µg/L	2	0	1.9	4.7	14.6	28.2	18.4	6.1
Lead	µg/L	0.8	0	2.2	< LOR	9.9	1.2	9	2.9
Total Nitrogen	mg/L	3.2	3.6	4.5	2.9	4.4	3	4.3	1.9
Total Oil	mg/L	1.8	2.6	1.3	1.3	1	0.6	5	0.7
Total Phosphorous	mg/L	0.6	0.9	1.2	0.6	1.3	1	0.6	0.4
Total Suspended Solids	mg/L	19.5	25.7	14	16.4	14.7	22.5	27	21.2
Zinc	µg/L	45	100	43.8	44.2	31.5	39	194	90.9
Turbidity	NTU	81.5	84.5	50.4	18	18.7	12.3	43.6	18.3
Tri-ethylene glycol	mg/L	12.1	56.3	14	5.5	5.7	0	19.9	5.4
Volume (annual total)	m^3	19,869	26,506	12,430	11,907	6,819	10,352	16,065	21,061

Note 1 – Not measured in this period.

Administration Drain Discharges and Characteristics

The Administration Drain is a concrete-lined open drain that discharges into No Name Creek, an unlined mangrove-fringed watercourse that terminates in a culvert, beyond which water flows into the open ocean at No Name Bay. No Name Bay is within the general exclusion zone that applies to the NWS Project and no public access is permitted within a minimum of 1.5 km of the discharge point. The Administration Drain receives water from these KGP sources:

+ Treated sewage from the sewage treatment plant (STP).
+ Brine discharged from the water demineralisation plant (DWP).
+ Stormwater run-off.

No Name Creek is densely inhabited by mangroves (where there is tidal influence) and a dense reed bed exists between the intertidal region and the concrete-lined Administration Drain. These mangroves and reeds have all naturally re-colonised No Name Creek, which is an artificial waterway constructed as part of the existing NWS Project.

Monthly samples of discharges to the Administration Drain are analysed for the presence of 18 contaminants identified in the KGP Operational Licence (issued under Part V of the EP Act). Toxicity testing of discharges to the Administration Drain has not been conducted as, being primarily a sewage discharge, the nature of contaminants in this discharge are less complex and well understood.

The Administration Drain receives wastewater from the STP, DWP, and site run-off. Cause–effect pathways for potential impacts on marine environmental quality are associated with emissions from nutrients/organic matter in discharge from the STP, and concentration of contaminants by the reverse osmosis process and potentially contaminated stormwater.

Monthly samples of discharges to the Administration Drain are analysed for the presence of 18 contaminants identified in the KGP Part V Operational Licence and the average results of this sampling are shown in **Table 6-30.**

Table 6-30: Average concentration of licensed discharge parameters in the Administration Drain

Parameter	Units	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
COD	mg/L	17.9	50.5	24	17.2	18	16.8	11.9	18.1
Conductivity	µS/cm	1,807	1,849	2,239	1,639	2,380	2,010	1,715	1,485
Total Nitrogen	mg/L	11.3	11.4	7.3	5.2	19.2	29	20.4	5.1
Total Phosphorous	mg/L	0.5	0.8	1	1.4	1.4	1.4	0.4	0.6
pH	mg/L	8.6	8.8	8.8	9.1	8.4	8.5	8.7	8.9
Sulphate	mg/L	224.8	226.8	563.3	296.2	492.9	319.5	252.3	220.7
Sulphide	mg/L	0	0	0.2	0	0	0	0.5	0.1
Surfactants	mg/L	45.7	4	19	17.5	7.8	9.5	8.1	1.1
Total Suspended Solids	mg/L	16.7	11.8	33.4	13	12	39.2	18.2	250.3
Turbidity	NTU	3.9	4.7	8.5	4	5.8	7.5	4.7	68.9
aMDEA	mg/L	<LOR	<LOR	<LOR	30.2	7.5	0	<LOR	<LOR
Copper	µg/L	5	4	3	4.3	3.1	2.8	2	9.3
Zinc	µg/L	100	50	80	32.5	71.3	157.3	60.5	852.2
Cadmium	µg/L	0.1	nd	0.1	0.1	nd	nd	0.6	1
Lead	µg/L	9	nd	1	nd	3.8	0.9	2.8	6.3
Mercury	µg/L	nd	nd	nd	0.1	nd	nd	0.1	0.1
Total Oil	mg/L	1.2	8.4	1.3	0.9	0.5	0.5	0.9	0.3
Discharge Volume (annual total)	m^3	13,901	16,870	28,683	40,509	31,131	29,673	23,874	27,984

nd = no data,

Stormwater collected on the site is discharged to the marine environment via a series of drainage points. Many of the stormwater drains have underflow/overflow sumps, which can collect and trap oily residue and prevent it from being discharged. Stormwater is only collected in this manner from areas of the plant where there is no planned source of contamination, however, operational activities (e.g. driving vehicles, operating machinery) can occur in these areas so stormwater may potentially be contaminated slightly with oil or chemicals. Many stormwater drainage points also have weirs which allow stormwater to be collected and sampled for the presence of contaminants before it is discharged. Prior to any major predicted rainfall event, water within weirs is sampled against internal discharge limits and proactively discharged if within the required specification. Any contaminated water can be manually diverted into the OCW system, for example by utilising vacuum sucker trucks and portable water pumps. The potential impact from the discharge of stormwater are considered to be slight and is not discussed further in this section.

Potential Changes to Discharge Characteristics Resulting from the Introduction of Third party Gas and Fluids

Introducing any third-party gas and fluids could change the characteristics of the marine discharges from the Proposal. Third-party gas could have a different chemical composition, thus potentially changing the chemical composition of discharges to the Jetty Outfall.

No changes to discharges from either the Administration Drain or stormwater runoff are predicted to change as a result the introduction of third-party gas or fluids as they are unrelated to the natural gas processing equipment.

The NWS Project Extension Marine Environmental Quality Management Plan (**Appendix D**) details the routine and periodic sampling regime that is undertaken to ensure that water is suitable to be discharged to the environment. In addition, long-term sampling is conducted to monitor long-term trends in water quality and to confirm adherence to internal and external environmental standards.

Marine discharges that vary in constituent content due to the introduction of any third-party gas and fluids are also constrained by the engineering design of the Proposal equipment. Before accepting any new gas or fluids into the Proposal for processing, a summary of the gas/fluid constituents is provided to Woodside. If a constituent that is not currently processed in the WWTP is present in the third-party gas/fluid and has the potential to remain in the water stream after processing, then this would trigger a management of change process to enable efficient treatment of the changed effluents.

Potential discharge characteristic changes from the introduction of third-party gas and fluids will be managed in line with the Woodside management system to ensure that the existing EQP, environmental objectives and legislative requirements are met. This assessment will include the identification of appropriate management and mitigation controls to ensure impacts and risk remains at an acceptable level. The likelihood of any impact on the receiving marine environment due to the introduction of third-party gas and fluids is negligible and residual impacts after the application of stated mitigations are not significant.

Description of Potential Impacts from Marine Discharges

Direct Impacts to Water Quality

The potential impacts to marine environment quality from planned discharges has been informed by an assessment of the zone of impact of these discharges. The zone of impact for planned discharges is done in accordance with the relevant Environment Quality Plan (EQP). An EQP is 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, 2016d). A Marine Environment Quality Management Plan (**Appendix D**) has been established to ensure the Environment Quality Plan is achieved.

In 2006, the WA Department of Environment (DoE) published the Pilbara Coastal Water Quality Consultation Outcomes Environmental Values and Environmental Quality Objectives, aimed at establishing an Environmental Quality Management Framework (EQMF) for the Pilbara region to help manage and protect the marine environment from the effects of waste inputs and pollution (DoE, 2006b).

Subsequently, the EPA has published Technical Guidance – Protecting the Quality of Western Australia's Marine Environment (EPA, 2016d) that has established the DoE (2006b) EQMF as the approved EQP for the Pilbara coastal waters. **Table 6-31** shows a description of the allowable changes to natural background under certain levels of ecological protection.

Table 6-31: Definition of Allowable Changes to Natural Background Under Levels of Ecological Protection

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.

The EQP establishes required levels of protection for regions immediately surrounding planned discharges from the Proposal. LEPs aren't defined by current condition, however are intended to represent long-term objectives for environmental quality (EPA 2016d). However, these LEPs have been in place at the Proposal for many years and ongoing environmental monitoring has demonstrated they are consistently achieved. For this reason, the LEP zones established in the EQP are considered appropriate to define the zone of impact used in describing potential impacts from planned marine discharges. An exception to this is the definition of a small area around the Administration Drain. Originally assigned a Low LEP within the EQP (DOE, 2006b), the Environment Quality Criteria included within the MEQMP are established to achieve a Moderate Level of Ecological Protection at the Administration Drain release point.

As part of the Proposal, Woodside has developed an NWS Project Extension Marine Environment Quality Management Plan (**Appendix D**) to ensure requirements of the EQP are consistently and reliably achieved by the Proposal. There are no foreseen deviations from the EQP from the implementation of the management plan.

Potential Impacts to Water Quality from Jetty Outfall Discharges

There is a zone of Low Ecological Protection Area (LEPA), an area within which a low level of ecological protection is maintained extending 70 m in all directions from the discharge point. Beyond this, a Moderate Ecological Protection Area (MEPA) has been established that extends 250 m beyond the turning basins and berthing pockets surrounding the KGP LNG loading jetty, excluding areas where this is within 200 m of the shoreline. This shoreline protection has been established to protect the corals that are known to inhabit the rocky coastline of the Pilbara region. While not a uniform shape, the MEPA extends a minimum of 600 m from the jetty diffuser in all directions.

The benthic habitats occurring within both the LEPA and MEPA are all classified as 'silt' (**Figure 6-28**). While certain silty habitats may support biodiverse faunal assemblages in Mermaid Sound, the majority of the seabed within the Jetty Outfall MEPA has previously been dredged to create the shipping channels and turning basins required for LNG tankers to approach the product loading berths.

Typically expected dilution values expected from discharges to the jetty outfall were modelled using a stochastic model (**Appendix G**). The modelled dilution at the boundary of the Jetty Outfall LEPA and MEPA was a minimum of 1:100. The model showed dilution sufficient to achieve the 99% species protection value (PC99 value of 0.36% wastewater, equivalent to 280 dilutions) are consistently achieved within 400 m of the discharge point, although occurring within 300 m in most scenarios (**Figure 6-3**). This is well within the requirement of the EQP to maintain a high level of ecological protection required within a minimum of 600 m of the discharge point. Discharge dilution modelling was also performed to understand the potential impacts if the toxicity of the discharge was to double (PC99 value of 0.18%, equivalent to 560 dilutions). This is shown in **Figure 6-23** and demonstrates that even in this circumstance, the discharge would be within the MEPA boundary for the majority of conditions.

Direct Impacts to Sediment Quality from Jetty Outfall Discharges

Potential impacts to sediments may occur from planned discharges, which contain substances such as hydrocarbons and heavy metals which can deposit and accumulate in sediments. However, the low volume of this discharge and low concentration of contaminants impacting the sediments and frequent monitoring of sediment quality eliminates the potential for any significant impacts occurring.

Sediment quality near the jetty outfall is monitored annually as part of the ChEMMS program. The extensive

data record shows the absence of any sediment contamination likely to cause any impacts above a slight level, with no evidence of long term or potential impacts on ecosystem function. The results from 2018 indicated that all metals, excluding nickel, were below the respective ANZECC/ARMCANZ (ANZECC and ARMCANZ, 2018) trigger levels and were similar to values recorded for previous surveys (Advisian, 2018a). Background concentrations of nickel in the Pilbara are known to exceed guideline values and undisturbed reference sites to the natural presence of this metal.

Total Petroleum Hydrocarbons (TPH) were all below the limits of reporting at most subtidal sediment sites, located within the MEPA boundary, however TPH concentrations were slightly elevated at four locations, with a maximum concentration of 7mg/kg, which is well below guideline values. No Polycyclic Aromatic Hydrocarbons (PAHs) were found in any sediments at impact sites within the Jetty Outfall MEPA boundary.

Figure 6-28 Habitats within the Jetty Outfall MEPA/LEPA

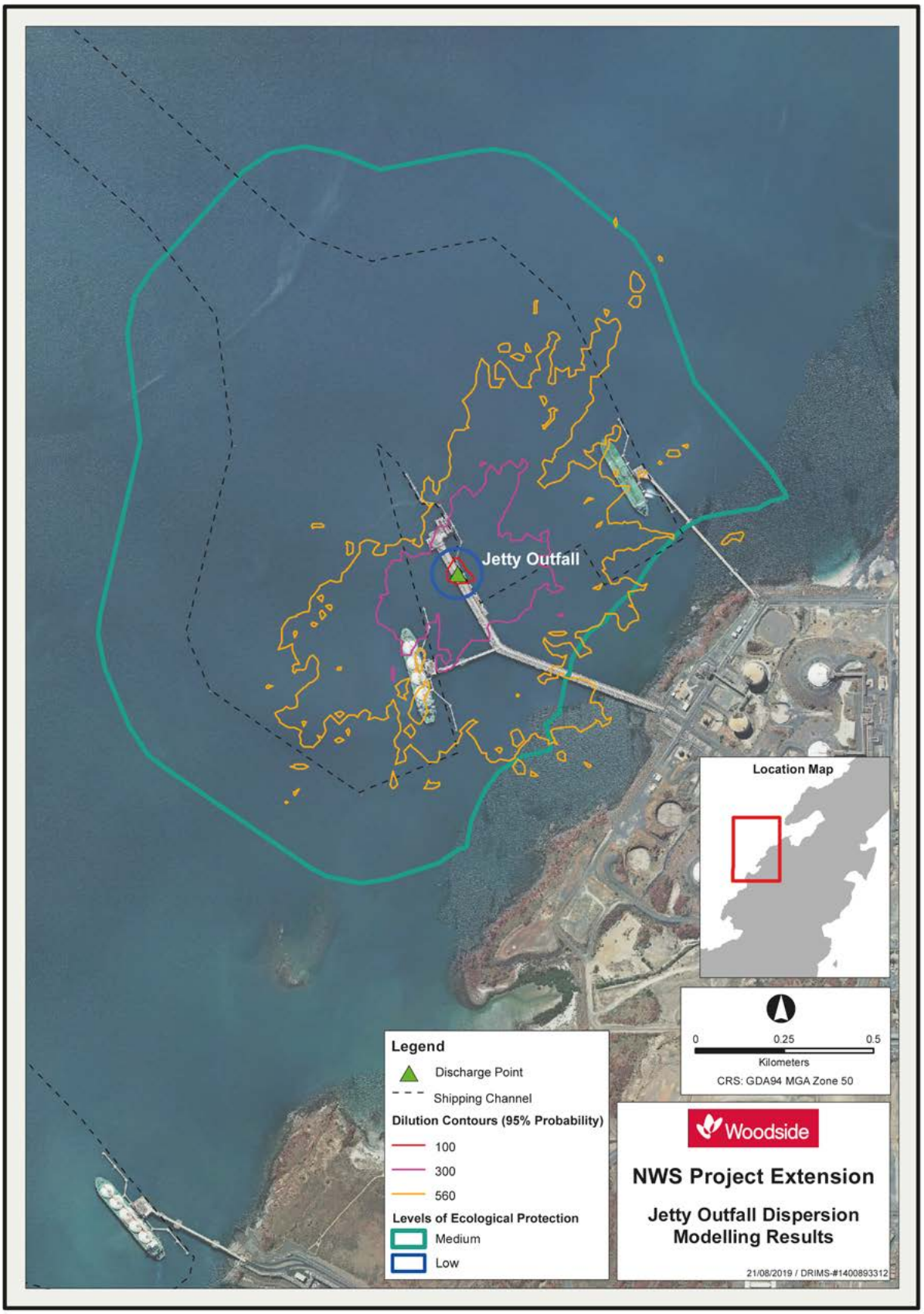


Figure 6 29: Modelled Level of Dilutions from Discharges via the Jetty Outfall (RPC 2019)

Potential Impacts to Water Quality from Administration Drain Discharges

Under the existing EQP (i.e. DOE 2006b), there is a LEPA centred on the location where the Administration Drain discharges into No Name Bay. As part of development of the MEQMP, improvements to treatment systems and results from historic monitoring, it is considered appropriate to assign this region as a MEPA and impacts are assessed on this basis. The MEPA is located within the broader High Ecological Protection Area (HEPA) that extends to most of the Port of Dampier.

The Administration Drain discharges into a 300 m long unlined channel known as No Name Creek (NNC) which is tidally inundated with each high tide. Water in NNC can only flow into the receiving marine environment, No Name Bay (NNB), via a series 10" culverts that pass the boundary road at the western edge of the Karratha Gas Plant.

The Administration Drain discharges into a tidally influenced bay (No Name Bay) consisting of mudflats and sand flats that are typical of the region. There is a stand of mangroves lining the NNB, as well as an artificially constructed rock embankment that has been colonised by intertidal organisms typical of the region.

When water is flowing into NNC (with the incoming tide) discharges from the Administration Drain are prevented by the inflowing tide from entering the marine environment. It is not until the tide begins to recede that the now diluted wastewater can flow into NNB. At low tide, the tidal flat extends at least 100 m from the point where NNC outflows to NNB and ~500 m from the Administration Drain discharge point. The distance between the Administration Drain discharge point and NNB means that there is insufficient water volume to reach the marine environment unless carried with the outgoing tide. It must first mix with the incoming tide, within NNC, for this to occur.

NNC is densely inhabited by mangroves (where there is tidal influence) and a dense reed bed exists between the intertidal region and the concrete-lined Administration Drain. These mangroves and reeds have all naturally re-colonised NNC, which originally existed as an intertidal creek system which was altered as part of the original KGP development.

The modelling results demonstrate discharges from the Administration Drain receive approximately 150 to 830 dilutions (including the 12.5 dilutions received in the Inner Channel) when it first enters the Bay (depending on the tidal discharge rate). Thereafter, it is dispersed by tide and wind towards the west. At 70 m from the discharge location concentrations range from 0% (dilution not applicable) on the flood tide to around 0.08% (1:1,200 dilutions) on the ebb tide (**Appendix G**).

Stochastic modelling was not undertaken for the Administration Drain discharge, as the nature of the receiving environment (into a shallow bay, close to the shoreline) means tidal forcing is the primary factor determining dilution rates. Tidal cycles are predictable and conservative tidal scenario was used to determine the minimum number of expected dilutions at the MEPA boundary. A minimum of 150 dilutions are expected to be achieved at the MEPA boundary in all scenarios.

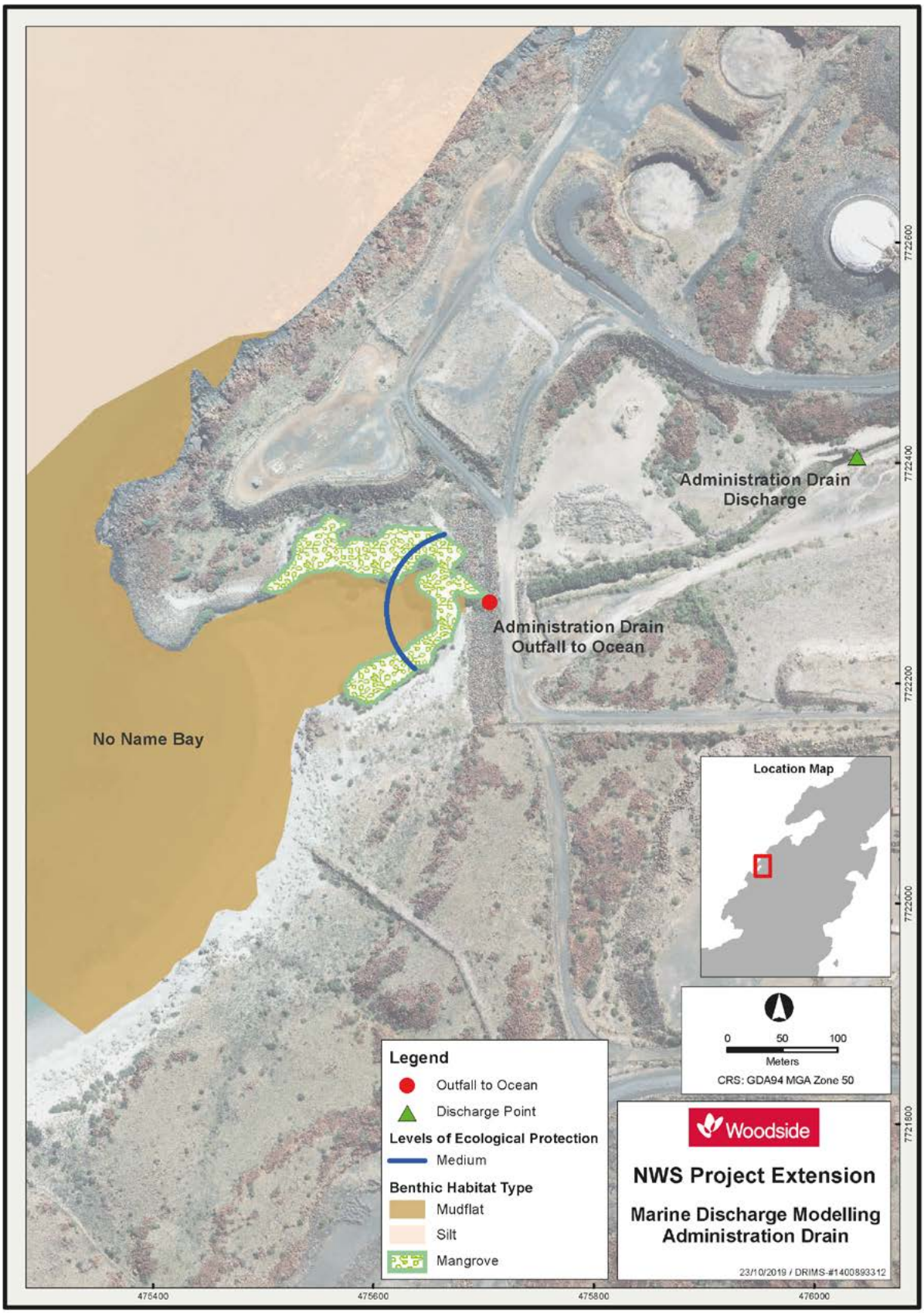


Figure 6-30 Habitats within the Administration Drain MEPA

Direct Impacts to Sediment Quality from Administration Drain discharges.

Potential impacts to sediment quality may arise from planned discharges from the Administration Drain due to the presence of nutrients, heavy metals of residual oil present in the discharge.

Sediment quality monitoring occurs within and immediately beyond the proposed Moderate Ecological Protection Area (MEPA). The MEPA extends 70 m from where the Administration Drain discharges to the ocean. Sediment quality monitoring includes sampling for the presence of contaminants including heavy metals, chemicals and hydrocarbons. At each intertidal sediment monitoring site, sediment samples are taken from the surface layer (1 – 5 cm) of the seabed, for subtidal sediments, samples are taken from a 10 – 15 cm depth using a Van Veen Grab. Oyster health is also monitored beyond the MEPA. This is done by collecting oysters and sampling their tissue for the presence of heavy metals above natural levels.

Sampling locations near the Administration Drain Outfall to Ocean within No Name Bay are shown in **Figure 6-31**.

A summary of the maximum concentrations of sampled parameters within the No Name Bay MEPA boundary are shown in **Table 6-32** and values for beyond No Name Bay MEPA are shown in **Table 6-33**. No contaminant concentration levels above guideline values have been identified through this sampling program, however, some levels are elevated slightly above background levels.

Oysters at this location have been sampled since 1995. There have been no recorded exceedances of Food Standards Australia New Zealand Maximum Safe Eating values for any oysters sampled at the No Name Bay monitoring site (which have been established for relevant substances including mercury, lead and cadmium). These FSANZ values represent levels below which seafood is considered safe for human consumption.

Table 6-32: Results of sediment quality monitoring from within the No Name Bay MEPA

Parameters	Unit	2012	2013	2014	2015	2016	2017	2018	Guideline Value
Cadmium	mg/kg	0.05[1]	0.05[1]	0.05[1]	0.12	0.05	0.05	0.05	1.5
Chromium	mg/kg	7.2	6	9.8	36	19	22.8	23.9	80
Copper	mg/kg	10	11	10	8.8	1.9	2.1	2.4	65
Lead	mg/kg	1.7	6.4	4.1	3.9	2.3	2.6	2.5	50
Mercury	mg/kg	0.005[1]	0.02	0.02	0.02	0.005[1]	0.01	0.005[1]	0.15
TPH	ug/kg	21	<100	<100	68	<100	.89	2.02	280
aMDEA	mg/kg	<.5	<.5	<.5	0.19	<.5	<10	<10	NA

Note 1: Result below detection. Value stated as half limit of detection.

Table 6-33: Results of sediment quality monitoring from beyond the No Name Bay MEPA

Parameters	Unit	2012	2013	2014	2015	2016	2017	2018	Guideline Value
Cadmium	mg/kg	0.05[1]	0.05[1]	0.2	0.05[1]	0.05[1]	0.05[1]	0.05[1]	1.5
Chromium	mg/kg	3.4	8.1	16	20	15	16.4	5.1	80
Copper	mg/kg	8.2	14	7.5	2.3	2.1	1.8	1.8	65
Lead	mg/kg	2.2	9.3	3.3	2	2.3	2.5	2.5	50
Mercury	mg/kg	NA	NA	NA	NA	NA	NA	NA	0.15
TPH	ug/kg	<100	<100	<100	<100	<100	8	4	280
aMDEA	mg/kg	NA	NA	NA	NA	NA	NA	NA	NA

Note 1: Result below detection. Value stated as half limit of detection.

NA: Not sampled in this period.

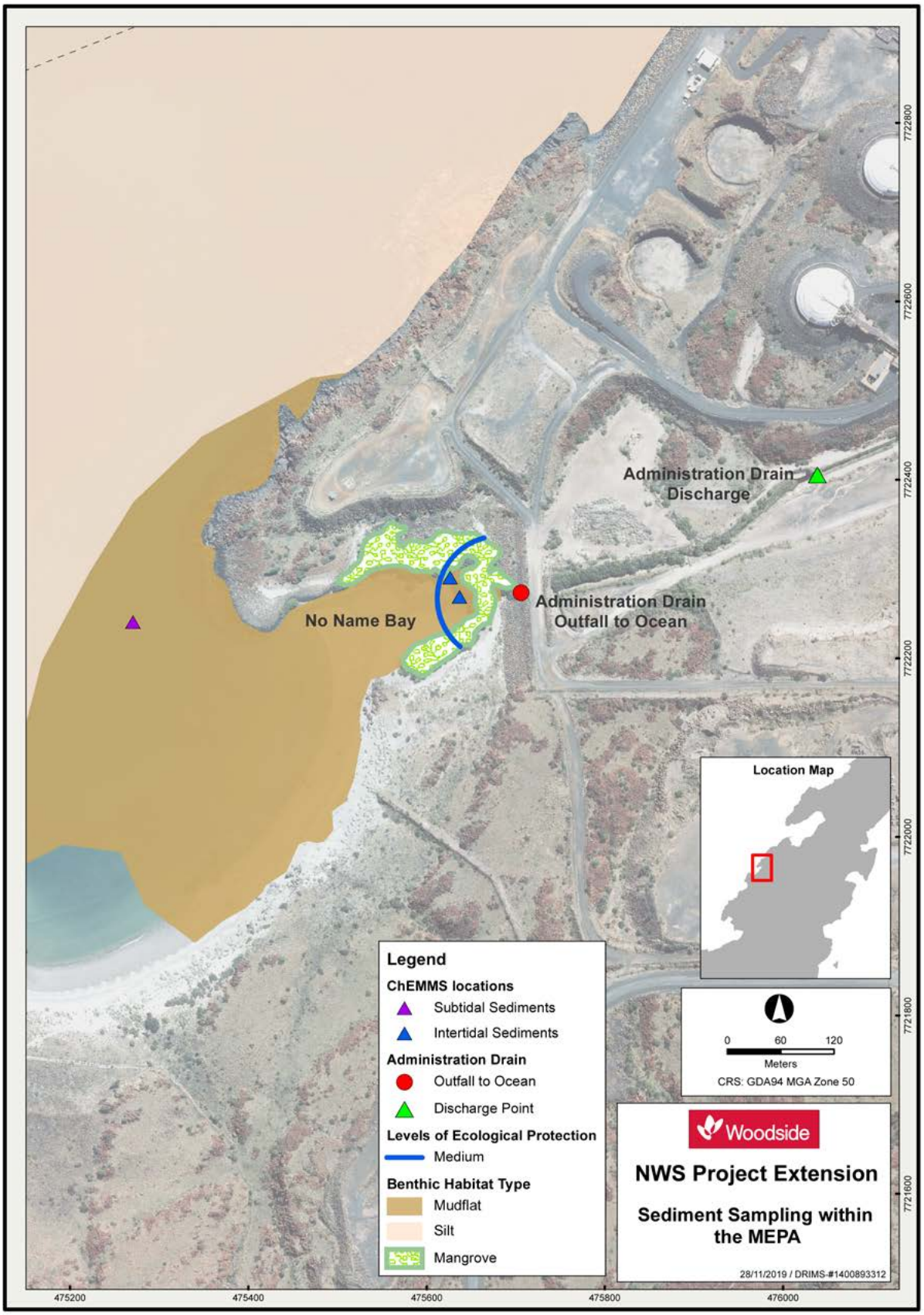


Figure 6-31 ChEMMS Sampling Locations at No Name Bay

Indirect Impacts to Marine Flora and Fauna

Benthic Primary Producer Habitats

No impacts to BPPH (e.g. corals and seagrass) are predicted as a result of ongoing planned discharges into Mermaid Sound from the Proposal. This is because these habitats are not present within the distance below which discharges achieve sufficient dilution to achieve a high level of ecological protection.

The marine habitats potentially impacted (i.e. as they are within the LEPA/MEPA) by discharges from the Jetty Outfall are limited to bare silt in areas that have been previously dredged and are subject to future maintenance dredging.

The marine habitats potentially impacted by discharges from the Administration Drain are tidal mud flats and mangroves within No Name Bay.

Mangroves

Mangrove habitats can be sensitive to changes in water quality, but ongoing discharges from the Administration Drain have not been linked to any impact from previous discharges.

The health of the mangroves has been continually monitored annually for the past 30 years, in accordance with the ChEMMS program. Currently, mangrove health is monitored annually using the Normalised Difference Vegetative Index (NDVI) assessed using images captured from drone imagery. There have been no anthropogenically derived changes to mangrove health in No Name Bay identified through these surveys.

The apparent maintenance of water quality and sediment quality in Mermaid Sound appears to be reflected in the health of the marine biota in the area. During the 2017 survey of mangrove health, none of the parameters monitored indicated any impacts that could be attributed to the NWS Project facilities. When comparing impact and reference sites since 2014, all sites showed variation in canopy cover and these changes are likely due to natural variation rather than related to works occurring near the impact sites (Advisian, 2018b). Similarly, qualitative comparisons of surveyed coral habitats between the 2017 survey and previous surveys shows little variation in habitat composition, indicating an absence of any significant impact.

Marine Fauna

Any potential for toxicity to marine organisms would be expected to be limited to surface waters within the described zones of impact (LEPA/MEPA) assigned to each discharge, and therefore these concentrations will only potentially affect a limited number of marine fauna species and individuals (e.g. cetaceans, turtles and pelagic fish) which are transient through the region, including those with heritage value. Cetaceans are highly unlikely to be present in the vicinity of the discharges, given the presence of daily shipping operations (relevant to jetty outfall) or lack of sufficient depth (relevant to the admin drain).

Furthermore, it should be noted that the threshold concentrations and the subsequent mixing zone have been determined through the application of chronic exposure ecotoxicological tests on marine fauna (over days) and therefore if marine fauna are transient within the receiving environment adjacent to the discharge location, they are unlikely to be exposed to sufficient concentrations or for a sufficient duration to elicit a toxic response. Behavioural responses, such as avoidance, may be exhibited by mobile organisms.

In addition, the predicted toxicity effects on marine fauna within this area of influence is considered conservative as the actual discharge durations (and possible exposure timeframes) are inherently limited given the nature and location of the discharges to considerably less than those used to determine chronic toxicological effects.

Impacts on water quality and marine fauna are assessed as part of the ChEMMS program by analysing oyster tissue. The most recent results showed that potential contaminants, such as TPH levels, Polycyclic Aromatic Hydrocarbons (PAH) concentrations, and heavy metals were all below relevant guideline values (e.g. safe eating levels). This indicates that potential for impacts from ongoing planned marine discharges to occur beyond the low and medium ecological protection areas established under the environment quality plan is very low.

Cumulative Impacts

Cumulative impacts may occur when current or future activities are near each other and their zones of impact have the potential to overlap. The Proposal is within the Port of Dampier, in which other industrial activities occur.

As outlined in the Environment Quality Plan (DoE, 2006b) that applies to all industrial activities in the Port of Dampier, a high level of ecological protection is required to be maintained within the majority of the Port, except within the immediate proximity of shipping activities or industrial discharges.

The nearest other area source of planned industrial impact with the Port of Dampier occurs at the Pluto LNG Loading Facility, where a MEPA is in place immediately around the LNG loading jetty. The nearest planned industrial discharge occurs approximately 6 km away, from Multi User Brine Return Line, operated by the Water Corporation in accordance with Ministerial Statement 594.

All wastewater discharges from the Proposal have undergone dilution modelling, which showed dilution sufficient to achieve a high level of ecological protection is achieved within either 70 m/ 600 m of

the Administration Drain and Jetty Outfall respectively. It was therefore considered highly unlikely that there would be any cumulative impact from these discharges, with the nearest other discharge located 6 km away. It is highly likely that all contaminants would likely be diluted to below limits of detection before any interaction that may lead to cumulative impacts.

Therefore, no cumulative impacts, either from mixing of different wastewater discharges or from overlapping zones of impact are predicted to occur as a result of the Proposal.

Assessment of Potential Impacts

Planned discharges from the NWS Project to the marine environment have been ongoing continuously for over 30 years without a significant reduction in marine environment quality. As the receiving environment is limited to within areas with defined levels of ecological protection, and impacts are predicted to be highly localised to within these zones, the receptor sensitivity relevant to all marine discharges was assessed as *low*.

The magnitude of potential impacts to marine environment quality from ongoing discharges, inclusive of potential future changes result from processing of third-party gas and fluids, was assessed as negligible. These impacts are planned, so likelihood of the outcome was not assessed. The activity will therefore not have a significant impact on Marine Environment Quality.

To further reduce potential impacts to marine environment quality, additional water treatment equipment is to be installed as part of the Proposal, targeting further reductions in the environmental loading of hydrocarbons and heavy metals discharged via the Jetty Outfall.

6.6.4.2 Direct Reduction of Water and Sediment Quality and Indirect Impacts to Marine Flora and Fauna Resulting from Maintenance Dredging and Shipping

Description of Impacts

Maintenance Dredging

Maintenance dredging of the shipping channels, turning basins and berthing pockets within the development envelope will continue to be required. This is done to remove silt that deposits in these areas, in order to maintain sufficient depth for ships to safely traverse the area. Historically, maintenance dredging of NWS shipping channels has historically occurred at a frequency of between five and ten years. The frequency of maintenance dredging is not predicted to change as a result of the Proposal. External factors, such as cyclone frequency, may increase the frequency at which maintenance dredging is required.

Within Mermaid Sound there are various marine habitats and species that are sensitive to disturbance from dredging operations—the most sensitive are Benthic Primary Producer Habitats (BPPHs). To avoid unacceptable losses of BPPH in State waters, the EPA issued Technical Guidance – Protection of Benthic Communities and Habitats (EPA, 2016d). However, there is no dredging required as part of the Proposal that would result in a direct impact or removal of BPPH so this factor was not considered relevant to the Proposal.

The most likely impacts associated with maintenance dredging in Mermaid Sound relate to near-field and temporary increases in suspended sediments and turbidity levels from dredging and disposal operations, which can:

- Result in adverse effects to marine biota by reducing light penetration through the water column, thereby temporarily reducing productivity and growth rates.
- Cause localised and temporary reduction in oxygen levels due to the release of potentially organic-rich sediments into the water column.
- Increase organic matter and nutrient availability to marine organisms, resulting in eutrophic waters with knock-on effects for marine ecosystem productivity.
- Cause toxicological effects to marine organisms associated with the potential resuspension of previously contaminated sediments that were part of dredging or disposal operations.

Turbidity associated with maintenance dredging has the potential to indirectly impact sensitive BPPH, including corals. Depending on the location of spoil disposal, mangroves or seagrass habitats may potentially be impacted.

Maintenance dredging occurs infrequently, generally every five to ten years, with the last occurring in 2016 when approximately 350,000 m^3 of material was dredged. The level of contaminants in the dredge spoil within the development envelope have historically been below the screening levels listed in the National Assessment Guidelines for Dredging 2009 (DEWHA, 2009) and are sampled before disposal. Potential impacts to coral habitats were identified as part of this dredging program and was subject to specific management measures relating to prevention and monitoring of impacts. No impacts were observed as a result of this maintenance dredging program, the results of which were provided to the DOEE in accordance with conditions of the relevant Sea Dumping Permit.

Ship Loading and Ship Movements at the KGP and KBSB

Shipping activities associated with the Proposal include loading LNG, LPG, and condensate onto tankers at the dedicated berths located within the development envelope. This includes arrival, berthing and departure of these vessels. Occasional vessel movements associated with inspection and maintenance of pipelines or wharf infrastructure will also occur. Offshore support vessels, tugs and pilot vessels regularly arrive and depart the KBSB and take on supplies and fuel.

Hydrocarbon products are loaded onto vessels and held onboard as fuel. Unplanned impacts associated with ship loading are covered in **Section 6.6.4.3**.

The Proposal does not include any changes to shipping activity beyond the existing capacity of the existing infrastructure (berths, wharves and jetties). Ongoing shipping activities conducted in support of the Proposal, within the development envelope, will lead to continued generation of produce propeller wash, which will result in sediment resuspension (and deposition) and increased turbidity.

The ChEMMS program is designed to detect any impacts on corals that may occur as a result of ongoing turbidity associated with shipping activity.

Discharges from these vessels may lead to a reduction in marine water quality within the immediate vicinity of the vessel. All discharges are performed in accordance with Australian Marine Orders and any specific requirements implemented by the Dampier Port Authority. Any impacts associated with these discharges are expected to be slight, highly localised and temporary.

The corals along the Burrup coastline are dominated by *Turbinaria*, *Porites*, and *Faviidae* species, which can tolerate high sediment loads (Advisian, 2018b). Any ongoing turbidity impacts generated by export shipping activities are expected to have a negligible effect on coral; sedimentation impacts were more regularly observed at reference sites rather than impact sites (Advisian, 2018b).

No major differences in living hard coral were identified between the impact sites and reference sites during the 2017 ChEMMS surveys. Qualitative comparison between the 2017 ChEMMS survey and the previous survey (2011) shows little variation in habitat composition, indicating the absence of any detectable change resulting from increased turbidity (Advisian, 2018a).

Assessment of Potential Impacts

All maintenance dredging and shipping activities will occur in designated shipping areas that have previously been dredged, or subject to regular ongoing impact from shipping, and as such the sensitivity of the receiving environment is assessed as *low*.

The quality of sediments likely to be dredged have been studied extensively and the level of contaminants in the dredge spoil within the development envelope have historically been below the screening levels listed in the National Assessment Guidelines for Dredging 2009 (DEWHA, 2009) so the magnitude of planned impacts from maintenance dredging is assessed as *slight*. No potential significant future changes to sediment quality (within areas subject to maintenance dredging) as a result of the Proposal or other regional industrial activities were identified. Any impacts that do occur, will occur very infrequently and to areas that are already subject to frequent turbidity (i.e. from shipping). The potential impacts associated with the ongoing requirement to maintenance dredging of NWS shipping channels, etc. and disposal of dredge spoil are therefore assessed as *slight*.

Any future dredging activities will continue to be conducted in accordance with an activity-specific Sea Dumping Permit administered by the DoEE.

Under the Proposal, the nature of shipping activities are not expected to change or lead to an increase in environmental impact compared to existing operations. Impacts from existing shipping activities are considered slight which has been verified through existing environmental monitoring programs which will continue to be implemented as part of the Proposal. The ongoing planned impacts to marine environmental quality from ship loading and ship movements are consistent with those from existing activities and are therefore assessed as slight.

6.6.4.3 Direct Reduction of Water and Sediment Quality and Indirect Impacts to Marine Flora and Fauna, Resulting from Unplanned Discharges from Offshore or Onshore Accidents or Emergencies

Description of Potential Impacts

There are no planned impacts resulting from unplanned discharges from offshore or onshore accidents or emergencies. The risk associated with these events, which accounts for both the potential consequence and likelihood, is assessed below.

Unplanned Discharges from Offshore Infrastructure

Activities within State waters associated with the Proposal have the potential to result in unplanned discharges to the marine environment as a result of accidents or emergencies. No actions associated with the Proposal were identified as having the potential to materially change either the magnitude of the consequence, or likelihood of the occurrence, of any unplanned discharge event. The Proposal will continue to conduct activities that present these risks and associated potential impacts are described and assessed below.

Causes of unplanned offshore discharges include;

+ Spills of hydrocarbons or chemicals from vessels decks to the ocean.
+ A loss of containment from the condensate loading system.
+ Loss of marine vessel separation (i.e. vessel collision of grounding).
+ Loss of containment from a trunkline.

The largest credible impact to the marine environment would arise from a loss of containment from the second NWS Project trunkline (2TL), which contains 6,500 m^3 of combined gas and condensate. The impacts of this event are described in detail and managed through the

implementation of the NWS Trunklines (State Waters) Environment Plan, (State Waters Trunklines EP) which has been prepared in accordance with the *Petroleum (Submerged Lands) (Pipelines) Regulations 2007* and the *Petroleum Pipelines (Environment) Regulations 2012* and is approved by the Department of Mines, Industry, Regulation and Safety (DMIRS).

The State Waters Trunklines EP presents quantitative modelling of the potential impacts from a subsea loss of containment caused by a full release of the inventory within 2TL.

Modelling of the subsea loss of containment indicates that surface slicks and entrained oil could be far-reaching, as hydrocarbons have the potential to be transported over long distances via ocean currents.

In the unlikely event of a major hydrocarbon spill from a NWS Project trunkline, the zone of impact will include the sensitive marine environments of the Dampier Archipelago (and the adjacent Australian Marine Park [AMP]), Barrow and Montebello Islands and the Northern, Middle and Southern Island Group off Onslow (including Serrurier, Thevenard and Great Sandy Islands) and any sensitive receptors in the open waters. In summary, there is unlikely to be a major long-term environmental impact on the offshore deepwater environment. However, long term impacts may occur at sensitive nearshore and shoreline habitats, particularly, the Dampier Archipelago.

Further detail on the potential impacts associated with this event are described in the State Waters Trunklines EP and therefore are not described in further detail here. Despite the significant (major) potential impact of such an event, extensive preventative and mitigative controls are in place that mean the likelihood of such an event is assessed as being highly unlikely and the risk associated with this event is assessed as moderate.

A loss of containment from the condensate loading system is possible if the product-loading infrastructure and emergency intervention (e.g. isolation valves) measures fail. The environmental impact will depend on the volume of the hydrocarbon release, sensitivity of the contacted receiving environment, effectiveness of spill response activities, and the persistence of the hydrocarbon spilled. Due to the lower potential volumes that could be discharged, the impact of this event is less than the impact of the loss of containment scenario described in the NWS Trunklines (State Waters) Environment Plan.

Spills from vessel decks, or due to vessel collision or grounding, have the potential to impact the marine environment. A vessel collision leading to the loss of product inventory (e.g. LPG, condensate) was not considered credible. A vessel collision resulting in the loss of a vessel fuel inventory was assessed as having a potentially major consequence but is assessed as being highly unlikely. The unintentional release of hydrocarbons or chemicals from vessel decks could reduce water quality temporarily in the vicinity of the spill. However, hydrocarbons and chemicals present on vessel decks are either held in low quantities (usually less than 50 L) or likely to have little to no effect on the marine environment if spilled, with the potential for impact reduced by small volumes and rapid dispersion resulting in rapidly dilution to low concentrations. The main effects commonly associated with these spills on marine water quality are chemical (including toxicity). Receptor responses will vary depending on the size and location of the spill event. Spills resulting from vessel collisions could potentially be moderate, but the likelihood of such an event is Highly Unlikely. Shipping within the Port of Dampier is subject to significant existing regulation and no vessel collisions resulting in spills have occurred in the Port since it was established.

Unplanned Discharges from Onshore Infrastructure

Operations associated with the Proposal require large volumes of environmentally hazardous materials to be stored onshore. These materials, if spilt outside secondary containment, have the potential to enter the marine environment directly via surface run-off or indirectly through groundwater flows.

Onshore NWS Project infrastructure (including secondary containment) has been designed to relevant standards and is inspected and maintained, which significantly reduces the likelihood of a spill reaching the environment as this requires a failure of both primary and secondary containment measures. KGP is classified as a Major Hazard Facility and the storage of dangerous or environmentally hazardous goods and complies with Dangerous Good Safety (Major Hazard Facilities) Regulations 2007 (WA). KGP is managed in accordance with a Safety Case, approved by DMIRS.

The worst-case credible event would result in a loss of condensate to the ground from a loss of containment from the slug catcher (where gas and liquids are received onshore at the Proposal) or condensate loading system, resulting in a maximum of 1,000 tonnes of hydrocarbons reaching the marine environment (over a period of between weeks and years). The product is of the same characteristics as that within the trunkline, but the volumes reaching the marine environment would be significantly lower and would not be discharged to the marine environment instantaneously. Therefore, impacts are considered to be equivalent to or lower than those that would be associated with a loss of containment from the offshore trunkline, which have been discussed in the preceding section.

A release of hazardous materials into the onshore environment would be required to be reported and managed in accordance with the *Contaminated Sites Act 2003* (WA) and/or Environmental Protection (Unauthorised Discharges) Regulations 2004.

Assessment of Potential Impacts and Risks

The environmental impacts resulting from an unplanned discharge very much depend on the nature, size, and characteristics of the discharge, time of year and proximity of the release site in relation to the shoreline. The likelihood of the worst-case credible hydrocarbon spill (trunkline rupture) occurring is highly unlikely as a range of preventative and management measures are in place to prevent this event occurring. If such an accident did occur, *moderate* impacts on marine ecosystems may occur. Impacts are limited as the spilled hydrocarbon would be condensate, which has a lower long-term residual impact in the environment when compared to a product such as crude oil. The highest sensitivity environments potentially contacted by the worst-case hydrocarbon release were assessed as being highly sensitive. The magnitude of any impact is mitigated through the implementation extensive oil spill contingency planning arrangements. The residual risk of the worst case credible offshore or onshore accident or emergency loss of containment event is assessed as *moderate*.

Smaller spills from onshore and offshore infrastructure may have a relatively higher likelihood of occurring than a trunkline loss of containment but any associated impact will be significantly lower and are unlikely to extend to areas of high sensitivity. A range of possible unplanned events have been assessed and none were assessed as having a higher residual risk than *moderate*.

6.6.4.4 Reduction of Water and Sediment Quality and Indirect Impacts to Marine Flora and Fauna, Resulting from the Presence and Potential Migration of Existing Onshore Contamination

Description of Potential Impacts

Historic leaks and spills, as well as the use of foams containing PFAS within the development envelope have resulted in contamination of the site and water underlying the site. Contamination is monitored through regular groundwater monitoring of the extensive network of groundwater monitoring bores.

Monitoring of groundwater within the development envelope has detected PFAS in groundwater in the north-east and eastern boundaries of the development envelope. This is likely associated with the historic use of fluorinated firefighting foams on the site. The use of firefighting foams containing PFAS at the KGP is currently being phased out. Site policies now prohibit the testing of firefighting foams containing fluorinated substances on unsealed ground. Any water used in foam testing is collected and disposed of at licenced third-party facilities. There is a potential for foam to contaminate groundwater and sediments only during the release of firefighting foam in an emergency.

Contaminated groundwater may reach the marine environment by seeping into natural surface water courses, including No Name Creek, North East Creek, and North East Creek Beach. There are no identified beneficial users of groundwater below the Proposal, as given its coastal location and specific topography, as all groundwater below the site is expected to flow towards the ocean. The emergence of this groundwater and release into the marine environment may lead to a potential reduction in water or sediment quality.

Contamination has been identified as emerging in the marine environment, with elevated levels of hydrocarbons and heavy metals having been detected within No Name Creek and North East Creek Beach. No bio-available heavy metals above environmental trigger values have been identified at any sampled locations.

PFAS contamination that exceeds the 95% species protection trigger levels has been detected in three groundwater monitoring wells. The use of PFAS at the site is being phased out and no planned release of PFAS containing substances to unsealed surfaces (i.e. for training) is permitted at the site, unless in emergency situations.

There is no planned source of onshore contamination associated with the Proposal and no ongoing contribution to existing contamination. The ongoing presence and operation of the infrastructure associated with the Proposal will continue to present an unlikely risk of new contamination occurring. Remedial actions to address historic contamination have been implemented. The presence of existing onshore contamination is currently being managed in accordance with the *Contaminated Sites Act 2003* (WA).

Assessment of Potential Impacts and Risks

Existing contamination within the development envelope may migrate to the marine environment and it is assessed as likely that this contamination will result in slight impacts to sediment quality in the immediate vicinity of the KGP should that migration occur. The likelihood of existing contamination impacting water quality, or sediments, beyond the immediate plant boundary has a low environmental risk.

Activities associated with the Proposal were not assessed as having any planned interaction (e.g. contributing to or accelerating migration of) with existing contamination. Potential environmental impacts are only associated with the potential migration of existing contamination. With the identified existing and planned mitigation measures, the ongoing use of NWS infrastructure will continue to present an *unlikely* risk of new contamination occurring, with the maximum impact of this potential assessed as *slight*. The residual risk is therefore considered *low*. Remediation of existing contamination is not currently deemed feasible.

6.6.5 Existing and Proposed Mitigation

Existing and proposed mitigation measures that will be implemented so that the Proposal manages its potential to impact marine environmental quality are shown in **Table 6-34**. The Proposal presents a minimal predicted change to existing impacts, so in many cases existing mitigation measures are suitable to minimise residual risks.

Table 6-34: Existing and Proposed Mitigation Measures: Marine Environmental Quality

Impact	Existing Mitigation Measures	Proposed Mitigation Measure
Reduction in marine environment quality, resulting from planned discharges to the marine environment	**Avoid** Marine discharges will result from the Proposal and cannot be avoided. **Minimise** + Bulk dewatering and discharge of produced water occurs offshore with only minor volumes of water discharged. + All sewage is subject to tertiary treatment before discharge. + Stormwater runoff limited to plant areas where hydrocarbon/chemical spill risks have been minimised. + Continue the scientific monitoring program established to detect early warning signs of potential impacts. + Continue to implement existing Operational waste water management plans. + Continue to implement the Woodside management system which includes procedures to assess changes in feed gas sources. **Rehabilitate** + Not applicable for this impact.	**Avoid** + No additional measures are proposed. **Minimise** + Implement the NWS Project Extension Marine Environment Quality Management Plan (**Appendix D**), which contains environmental quality criteria for all licenced wastewater discharges. + Additional treatment equipment to be installed to further reduce hydrocarbons and heavy metals discharged from the Jetty Outfall. **Rehabilitate** + Not applicable for this impact.
Direct reduction of water and sediment quality and indirect impacts to marine flora and fauna, resulting from maintenance dredging and shipping	**Avoid** + Maintenance dredging is required to ensure continuing safe operation of the jetty and export facilities. As such, potential impacts associated with this activity cannot be avoided. **Minimise** + Ship movements are restricted within the development envelope under marine navigation requirements. + Continue the scientific monitoring program (ChEMMS) established to detect early warning signs of potential impacts. + All dredging to be conducted in accordance with a Sea Dumping Permit issued by DoEE and conducted in accordance with permit conditions. **Rehabilitate** + Not applicable for this impact.	+ No additional measures are proposed.

Impact	Existing Mitigation Measures	Proposed Mitigation Measure
Potential direct reduction of water and sediment quality and indirect impacts to marine flora and fauna, resulting from unplanned discharges from offshore or onshore accidents or emergencies	**Avoid** + Monitoring and maintenance of offshore infrastructure in line with the NWS Trunklines State Waters Operations Environment Plan. **Minimise** + Continue the scientific monitoring program (ChEMMS) established to detect early warning signs of potential impacts. + Continue to implement the NWS Trunklines State Waters Operations Environment Plan. **Rehabilitate** + Unplanned incidents are managed through implementation of Woodside's Oil Pollution Emergency Arrangements, the NWS Trunklines State Waters Operations Environment Plan and the KGP Emergency Management Plan.	+ No additional measures are proposed.
Reduction of water and sediment quality and indirect impacts to marine flora and fauna, resulting from the presence and potential migration of onshore contamination	**Avoid** + Management of existing onshore contamination in line with the Groundwater Management Plan to reduce the risk of this contamination migrating into the marine environment. **Minimise** + All hydrocarbons stored in accordance with the requirements of the site Safety Case and required legislation. + Continue the scientific monitoring program established to detect early warning signs of potential impacts. + Planned discharge (i.e. for training) of any firefighting foam onto unsealed ground is not permitted. All waste from training to be collected and disposed of correctly. + Continue to implement the existing Groundwater Management Plan to monitor and detect groundwater contamination. **Rehabilitate** + Comply with the requirements of the *Contaminated Sites Act 2003* and Environmental Protection (Unauthorised Discharge) Regulations 2004.	**Avoid** + The use of firefighting foams containing PFAS to be phased out. **Minimise** + No additional measures are proposed. **Rehabilitate** + No additional measures proposed.

6.6.6 Predicted Outcome

After implementing the proposed mitigation measures, no planned impacts or risks higher than a *moderate* ranking have been identified. Woodside considers that this indicates the residual impacts and risks associated with the proposal are broadly aligned with the EPA's objective for Marine Environmental Quality. There were no impacts or risks identified that would mean that the EPA Objectives for Marine Environment Quality are not achieved.

No additional management or mitigation measures are required to be implemented to further reduce residual risks to below a level that would be considered significant. Contemporising of the KGP's waste water treatment system will occur through installation of treatment equipment to be installed to further reduce hydrocarbons and heavy metals discharged from the Jetty Outfall.

The Proposal is expected to result in planned impacts with the same or lower consequence as those that result from operation of the NWS Project.

Three decades of environmental monitoring and existing environmental baseline data provides evidence to support the predicted outcomes of the Proposal.

A summary of the impact assessment outcomes used to derive this outcome are provided in **Table 6-35**.

Table 6-35: Marine Environment Quality Impact Assessment Summary

Impact	Receptor Sensitivity	Magnitude	Likelihood (unplanned impacts only)	Impact Level/ Environment Risk Rating
Planned discharges to the marine environment from jetty outfall, administration drain and stormwater, including changes to future discharge quality from third party gas/fluids	Low[1]	Slight	N/A	Negligible
Shipping and shipping related activities including maintenance dredging and ship loading	Medium	Slight	N/A	Slight
Unplanned discharges from offshore or onshore accidents or emergencies (e.g. Vessel hydrocarbon spill, pipeline rupture, hydrocarbon spills)	High	Moderate	Highly Unlikely	Risk Rating - Moderate
Presence and potential migration of onshore contamination	Medium	Slight	Unlikely	Risk Rating - Low

Note 1: Within MEPA zones surrounding discharges. High level of ecological protection maintained beyond here so impacts to higher sensitivity receptors are not predicted.

MATTERS OF NATIONAL SIGNIFICANCE

Woodside

7. MATTERS OF NATIONAL SIGNIFICANCE

7.1 Introduction

Woodside referred the NWS Project Extension Proposal to the DoEE (EPBC Reference 2018/8335) in November 2018. In May 2019 the DoEE determined the Proposal to be a controlled action with assessment undertaken by the State of Western Australia as an accredited assessment under the provisions of Section 87 (4) of the EPBC Act. The controlling provision for the Proposal is:

+ National Heritage Places (EPBC Act Sections 15B and 15C), namely the Dampier Archipelago (including Burrup Peninsula).

In addressing the controlling provision, this section has been written in accordance with the EPA 'Instructions on how to Prepare an Environmental Review Document' (EPA, 2018b). There are elements in common between assessing impacts on the National Heritage Place as required under the EPBC Act and impacts on social surroundings as required under the EP Act (see **Section 3.1.1** for the relevant EPA environmental factor). To inform the assessment of impacts of the Proposal on the National Heritage Place, information may be duplicated from **Section 6.5** in this section and cross-referenced to other sections where appropriate.

7.2 Relevant Policy and Guidance

These policy and guidance documents are relevant to assessing the impacts of the Proposal on MNES:

+ Significant Impact Guideline 1.1 – Matters of National Environmental Significance (DoEE, 2013)
+ Australia's National Heritage – Applying the Principles (DoEE, 2008)
+ Murujuga Rock Art Strategy (DWER, 2019b)

7.3 Existing Environmental Values

Description of the National Heritage Place

The Dampier Archipelago (including Burrup Peninsula) was gazetted as a National Heritage Place in July 2007 (Commonwealth of Australia, 2007). The National Heritage Place covers an area of roughly 36,860 ha including areas on the Burrup Peninsula and surrounding islands. The National Heritage Place is directly adjacent to, and in some areas overlaps, the NWS development envelope, as shown in **Figure 7-1**.

The National Heritage Place met five of the eight criteria set for listing as a national heritage place:

+ The place has outstanding heritage value to the nation because of the place's importance in the course, or pattern, of Australia's natural or cultural history.
+ The place has outstanding heritage value to the nation because of the place's possession of uncommon, rare or endangered aspects of Australia's natural or cultural history.
+ The place has outstanding heritage value to the nation because of the place's potential to yield information that will contribute to an understanding of Australia's natural or cultural history.
+ The place has outstanding heritage value to the nation because of the place's importance in demonstrating the principal characteristics of:
  + A class of Australia's natural or cultural places, or
  + A class of Australia's natural or cultural environments.
+ The place has outstanding heritage value to the nation because of the place's importance in demonstrating a high degree of creative or technical achievement at a particular period. (Commonwealth of Australia, 2007).

Gazette Notice No. S127 describes the values of the National Heritage Place, and how those values meet the criteria listed above. This description is weighted towards the heritage value of the rock art (in the form of petroglyphs) in the National Heritage Place, with particular emphasis on the:

+ weathering of the petroglyphs
+ history depicted in the petroglyph illustrations
+ diversity of the petroglyphs
+ unique complexity of the illustrations on the petroglyphs
+ contribution that the illustrations on the petroglyphs have made to understanding Australia's cultural history
+ contribution that the illustrations on the petroglyphs have made to understanding Australia's natural history.

Gazette Notice No. S127 also recognises the high density of standing stones, stone pits, and circular stone arrangements in the National Heritage Place, which contribute to the significance that the National Heritage Place has for Aboriginal cultural heritage (Commonwealth of Australia, 2007).

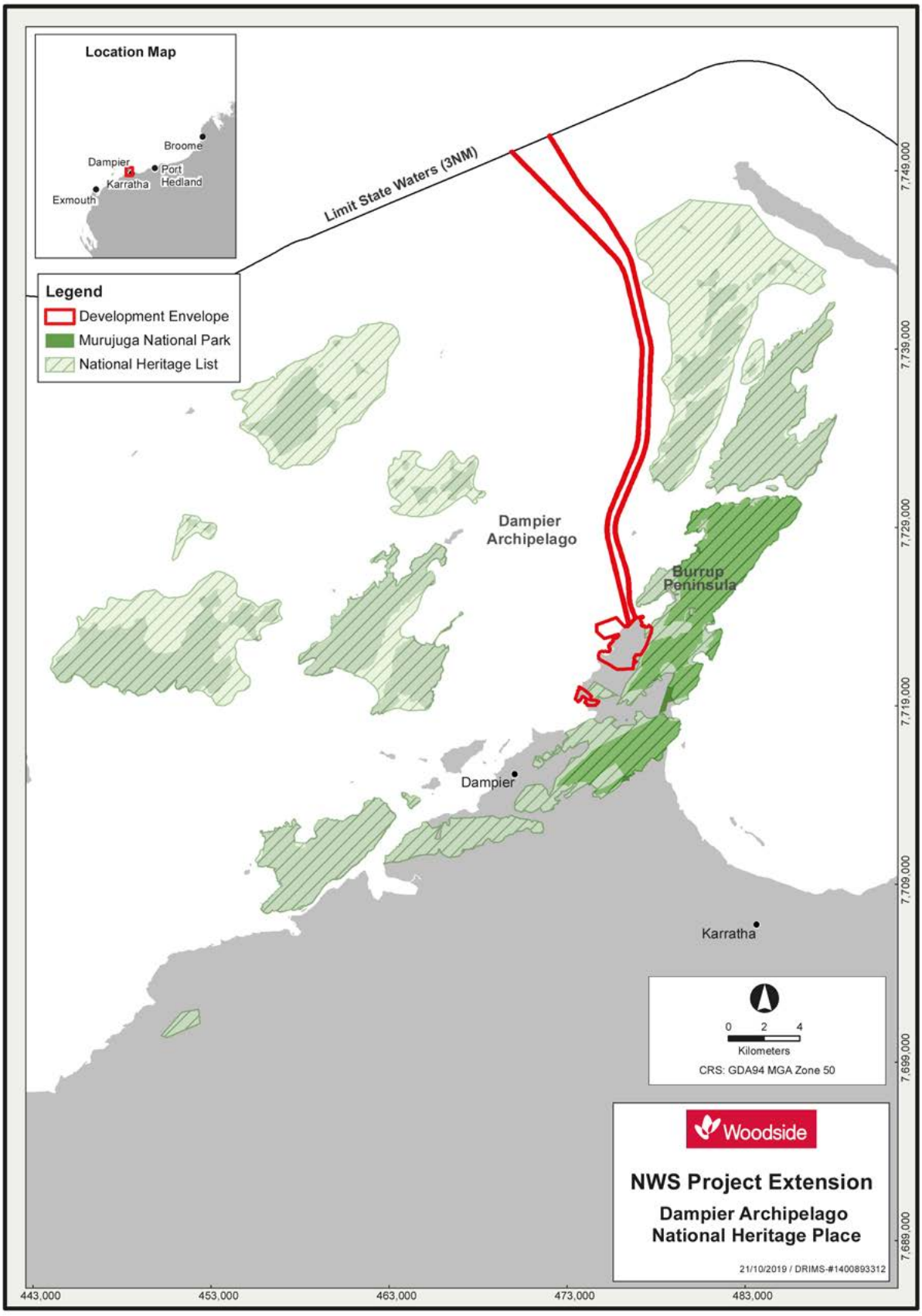


Figure 7-1: National Heritage Place Dampier Archipelago (including Burrup Peninsula)

7.3.1.1.1 Values of the National Heritage Place

The National Heritage Place is located approximately 1,550 km north of Perth, WA, and has significant Aboriginal cultural value. There is evidence of occupation by Aboriginal people for tens of thousands of years (DoEE, 2007). Local Aboriginal groups believe the areas within the National Heritage Place were created by ancestral beings during the Dreamtime and the spirits of Ngkurr, Bardi, and Gardi still live there (DoEE, 2007). **Table 7-1** details the specific values of the National Heritage Place against the listing criteria.

The National Heritage Place is most widely known for its large collection of Aboriginal rock art (in the form of petroglyphs) and contains the largest collection of petroglyphs in Australia. These petroglyphs were created by pecking, pounding, rubbing, and engraving. Traditional Owners describe the petroglyphs as having various purposes—they depict spirit figures, contain images relating to sacred ceremonies, and show aspects of everyday life of the traditional ancestors (DoEE, 2007). The rock art is also significant as it shows connections between Aboriginal peoples across the Pilbara. The quality of the petroglyphs is high and the art is unique (compared to other rock engravings across Australia), particularly because of the creativity demonstrated and the fine details shown in animal and human figure imagery (DoEE, 2007)

Significant stone sites also exist throughout the National Heritage Place, including standing stones, complex stone arrangements, fish traps, stone pits, hunting hides, and stone cairns (DoEE, 2007). Some stone sites are thought to mark areas that were important to everyday life, such as water holes, soaks, and camping areas, while yet others are ancient Aboriginal ceremonial and sacred sites thought to be used for ceremonies, such as rain ceremonies, or 'thalu' sites that increased species' populations (DoEE, 2007).

The National Heritage Place also contains other sites significant to Aboriginal cultural heritage, including quarries, middens, fish traps, rock shelters, ceremonial sites, artefact scatters, and grinding patches (DoEE, 2007).

The development envelope overlaps a small portion of the National Heritage Place. The Proposal does not include any additional disturbance to any part of the National Heritage Place than has already been approved. Any potential impacts from the Proposal will be indirect and the National Heritage Place, as a whole, is the relevant receptor.

Table 7-1: Values of the National Heritage Place

Listing Criteria	Description of Values (Commonwealth of Australia, 2007)
The place has outstanding heritage value to the nation because of the place's importance in the course, or pattern, of Australia's natural or cultural history	The engravings on the Dampier Archipelago include finely executed images of a wide range of terrestrial, avian and marine fauna many of which can be identified to genus or species level. The different degrees of weathering of particular types of faunal engravings on the Dampier Archipelago provide an outstanding visual record of the course of Australia's cultural history through the Aboriginal responses to the rise of sea levels at the end of the last Ice Age.
The place has outstanding heritage value to the nation because of the place's possession of uncommon, rare or endangered aspects of Australia's natural or cultural history.	It is the diversity of representations of the human form (anthropomorphs), many of which are in dynamic attitudes, and the way in which they are sometimes arranged in complex scenes that makes the Aboriginal engravings in the Pilbara exceptional. Although there are a number of distinct regional engraving styles in the Pilbara, the greatest diversity in depictions of the human form, which also include representatives of human figures characteristic of the other Pilbara style provinces, occurs in the Dampier Archipelago.
The place has outstanding heritage value to the nation because of the place's potential to yield information that will contribute to an understanding of Australia's natural or cultural history.	The Dampier Archipelago contains engravings of human figures (anthropomorphs) characteristic of most of the major art provinces in the Pilbara as well as a number of forms unique to the area. It has the potential to become a key site for establishing the sequence of engraved motifs in the Pilbara, an area described as without doubt the richest and most exciting region of rock engravings in Australia.

Listing Criteria	Description of Values (Commonwealth of Australia, 2007)
The place has outstanding heritage value to the nation because of the place's importance in demonstrating the principal characteristics of: (i) a class of Australia's natural or cultural places, or (ii) a class of Australia's natural or cultural environments	The rock engravings on the Dampier Archipelago include an extraordinarily diverse range of animal and human figures which are characteristic of regional styles that occur elsewhere in the Pilbara.
The place has outstanding heritage value to the nation because of the place's importance in demonstrating a high degree of creative or technical achievement at a particular period.	The rock engravings in the Dampier Archipelago show exceptional creative diversity when compared with the other art provinces in the Pilbara or rock engravings elsewhere in Australia.

7.4 Assessment of Potential Impacts of the Action

7.4.1 Relevant Impacts

In accordance with DoEE 'Matters of National Environmental Significance – Significant Impact Guideline 1.1', the Proposal may have a significant impact on the 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" (DoEE, 2013).

The National Heritage values of the National Heritage Place are described in **Section 7.3** above and relate specifically to the petroglyphs, standing stones, stone pits and circular stone arrangements found within the boundary of the National Heritage Place.

In the context of the National Heritage values, the following impacts are considered relevant:

- Industrial air emissions causing accelerated weathering of petroglyphs resulting in degradation, damage, notable alteration, modification, obscuring, or diminishing of the values of the National Heritage Place.
- Direct, accidental physical damage to petroglyphs within the portion of the development envelope that overlaps the National Heritage Place.

7.4.1.1 Industrial Air Emissions Causing Accelerated Weathering of Petroglyphs Resulting in Degradation, Damage, Notable Alteration, Modification, Obscuring, or Diminishing the Values of the National Heritage Place

Description of the Potential Impact

The presence of heavy industry on the Burrup Peninsula has generated concerns that industrial emissions may lead to an accelerated weathering or deterioration of petroglyphs. These concerns centre on the issue that deposition of NO_X, SO_X and NH_3 from anthropogenic industrial sources has the potential to increase the acidity of the rock surface through chemical and biological processes. Key emissions as they relate to this Proposal's power generation and process emissions include NO_X, VOCs (which affect the photochemical intensity of NO/NO_2 formation) and very minor contribution of SO_2.

The concerns are that acidic conditions may then alter the natural state and rate of weathering of the rock, making colour variations and depth of petroglyphs difficult to distinguish from the rest of the rock surface. Over the past 15 years, numerous studies have been conducted to investigate the potential for industrial emissions from new and existing industrial development on the Burrup Peninsula to impact on the Burrup Peninsula rock art, including:

- Air quality monitoring and modelling studies to assess the potential for air pollution from industrial activities on the Burrup Peninsula to impact petroglyphs.
- Studies of microbial diversity on the petroglyphs to investigate whether rock surfaces closer to industrial emissions sources host different microbial communities, which could affect petroglyph weathering.
- Studies analysing colour changes in the petroglyphs and spectral mineralogy analysis to obtain more precise measurements of composition or colour changes (this study compared southern sites near industry with sites further north on the Burrup Peninsula).

No published peer reviewed studies identified measurable or observable changes to the condition and integrity of the rock art as a result of industrial emissions. It is noted that there have been criticisms of the methodologies used and the interpretation of the findings from some of these research studies and monitoring programs that have been established to detect changes in petroglyphs and potential accelerated weathering. Uncertainties therefore

exist regarding techniques for monitoring and detecting change (both natural weathering rate, and potential for accelerated weathering) and the determination of a critical load of acid deposition at which impacts to rock art may occur. This complexity is acknowledged in the Murujuga Rock Art Monitoring Program Tender Documentation (DWER, 2019c).

This uncertainty, together with theorised pathways for potential accelerated weathering presents a possibility that industrial emissions from the Proposal could cause degradation, damage, notable alteration, modification, obscuring, or diminishing of the values of the National Heritage Place. Additionally, it is acknowledged that there is a high level of stakeholder concern surrounding potential impacts to the petroglyphs as a result of industrial air emissions.

Further information on how industrial emissions of NO_X SO_X and NH_3 may influence the deposition of acidic compounds on rock surfaces is provided in **Section 6.5.4.1**.

Assessment of Potential Impacts and Risks

Modelling of five emissions scenarios was undertaken to predict the Proposal's contribution to deposition of acidic compounds in relation to the National Heritage Place. Detailed information in relation to this modelling in presented in **Section 6.5.4.1**. Brief descriptions of the five scenarios modelled are provided in **Table 7-2**.

Table 7-2: Scenarios used for Air Dispersion Modelling

Scenario	Description
Current Cumulative Emissions	
Current Baseline (CBM)	This is the near-term, most likely scenario. It predicts the contribution to ambient air quality from industry currently operating on and around the Burrup Peninsula. It considers cumulative emissions from the current NWS Project and the existing, built, industrial facilities and emissions most applicable to the BSIA and the nearby region to use as a baseline for assessment. These include: + NWS Project; KGP + Woodside Pluto LNG Development (Train 1) + Yara Technical Ammonium Nitrate and Liquid Ammonium Plant + Pilbara Iron Yurralyi Maya Power Station + Santos Devil Creek Power Station + ATCO Karratha Power Station + EDL West Kimberley Power Plant + All shipping berths on the Burrup Peninsula + Main shipping berths at Cape Lambert.
Current Baseline with proposed emission reductions in place (KIO)	This is the medium-term, best-case scenario. It demonstrates the benefits gained in ambient air quality from proposed NO_X reductions outlined in **Section 6.3.5**. It considers cumulative emissions from the Proposal operating with a significant reduction in NO_X for KGP sources, and the existing, built, industrial facilities and emissions most applicable to the BSIA and the nearby region. The KGP data for modelling were modified to conservatively reflect likely improvement opportunity concepts representing feasible and significant NO_X reduction.
Future Cumulative Emissions	
Future Burrup Strategic Industrial Area with existing and approved facilities operating, with proposed emission reductions in place (FBSIA E&A)	This is the medium-term, most likely scenario. It considers cumulative emissions from the Proposal operating with a significant reduction in NO_X emissions, existing operating facilities, and future BSIA development approved at the time of writing this ERD (Pluto LNG Development ([Train 2]).

Scenario	Description
Future Burrup Strategic Industrial Area State (FBSIA), with existing, approved and referred facilities operating	This is the long-term, worst-case scenario. It considers cumulative emissions from the Proposal operating with no reduction in NO_X emissions, existing operating facilities, future BSIA approved development (Pluto LNG Development [Train 2]) and referred developments (but not assessed or approved) at the time of writing this ERD (proposed Perdaman Urea Plant and Wesfarmers Methanol Plant). The later developments are represented by indicative Urea and Methanol Plants. There are no other reasonably foreseeable proposals that can be included in the modelling.
Future Burrup Strategic Industrial Area state (existing, approved and referred) with proposed emission reductions in place (FBSIA-KIO)	This is a long-term, possible case scenario. It considers cumulative emissions from the Proposal operating with a significant reduction in NO_X emissions, existing operating facilities, and future developments approved at the time of writing this ERD (Pluto LNG Development [Train 2]) and BSIA developments referred (but not assessed or approved) at the time of writing this ERD. The latter developments are represented by indicative Urea and Methanol Plants.

Comparative analysis of modelled NO_2 deposition values as a sub-component of overall nitrogen and sulphur deposition indicates that:

- For all scenarios, the majority of the NO_2 deposition results for the grid receptors within the National Heritage Place fall within the range of 1-4 meq/m^2/year.
- NO_2 deposition in all scenarios as projected at historical monitoring locations broadly align with measured dry NO_2 deposition, indicating likely comparable total nitrogen deposition is expected to align with historical deposition measurements. Rock art impact assessment studies occurred throughout historical monitoring periods where the range of measured total deposition was broadly consistent.
- KGP emission reductions (KIO) generally results in an observable reduction of deposition frequencies above 2 meq/m^2/year compared with CBM across the National Heritage Place. Implementation of NO_X reduction opportunities are expected to materially reduce NO_2 maximum concentrations, as well an overall reduction in annual nitrogen deposition across the National Heritage Place.
- Future approved developments (Pluto LNG Development (Train 2)) with KGP emission reductions (FBSIA E&A) shows a nominally consistent and slightly lower deposition frequencies than CBM above 2 meq/m^2/year. An overall reduction of deposition is expected across the National Heritage Place for this scenario.
- FBSIA and FBSIA-KIO show relative marginal increases in deposition frequencies above 3 meq/m^2/year compared to current levels. The increase is estimated to be influenced by the possible addition of future point sources in combination with natural topography, and wind direction; whereby spatially distributed point emission sources featuring lower temperature, discharge velocities, height and plume buoyancy may be increasing model ground level estimates.

Woodside recognises anecdotal evidence and stakeholder concerns that observable changes to the petroglyphs may have occurred. Noting that no published peer reviewed studies identified measurable or observable changes to the condition and integrity of the rock art as a result of industrial emissions, and that during the timeframe of the studies undertaken, the NWS Project operated with emissions rates the same as those proposed for this Proposal, accelerated weathering affecting the distinguishability of petroglyphs across the region is not expected to occur as a result of the Proposal. The Proposal is therefore unlikely to significantly impact the values of the National Heritage Place.

7.4.2 Direct, Accidental Physical Damage to Petroglyphs within the Portion of the Development Envelope that Overlaps the National Heritage Place

Description of Potential Impacts

Direct, accidental damage to the petroglyphs within the portion of the development envelope that is within the boundaries of the National Heritage Place could occur through direct interactions with NWS Project workforce and visitors. This could include obscuring of petroglyphs with paint or other materials (for example during survey activities) or physical damage to the rock (for example, accidental dropped objects damaging the rock).

Assessment of Potential Impacts and Risks

Woodside maintains a database of known Aboriginal heritage sites which exist within the KGP development envelope and operational areas have been designed and

constructed so that Project personnel and site visitors do not need to directly interact with the petroglyphs.

Woodside conducts regular audits of the heritage features within the development envelope to monitor what impacts, if any, may be occurring. In addition, annual Aboriginal heritage site audits are conducted with Traditional Owners and a qualified archaeologist to inspect, monitor, and report on the condition of the sites within the development envelope. The 2018 Annual Aboriginal Heritage Site Audit concluded that generally the rock art is in good condition and no permanent damage was detected (IHS, 2018).

Given the continuation of the current, established management measures and the results of regular site audits conducted to date, it is concluded that permanent damage to petroglyphs within the portion of the development envelope that is within the boundaries of the National Heritage Place, due to the Proposal, is highly unlikely and any risk of impact are considered low.

7.5 Existing and Proposed Mitigation Measures

The existing and proposed mitigation measures applicable to the management of impacts to the National Heritage Place are summarised in **Table 7-3**.

Table 7-3: Existing and Proposed Mitigation Measures: National Heritage Place

Impact	Exiting Mitigation Measures	Proposed Mitigation Measures
Industrial Air Emissions Causing Accelerated Weathering of Petroglyphs Resulting in Degradation, Damage, Notable Alteration, Modification, Obscuring, or Diminishing the Values of the National Heritage Place	Refer to mitigation measures in **Section 6.5.4.1**	
Direct, Accidental Physical Damage to Petroglyphs within the Portion of the Development Envelope that Overlaps the National Heritage Place	Refer to mitigation measures in **Section 6.5.4.3**	

7.6 Conclusion

Over the past 15 years, numerous studies have been conducted to investigate the potential for industrial emissions from new and existing industrial development on the Burrup Peninsula to impact on the values of the National Heritage Place, namely through accelerated weathering of petroglyphs. During this period, the NWS Project operated with emissions rates that are the same as those planned for this Proposal. No published peer reviewed studies identified measurable or observable changes to the condition and the integrity of the rock art as a result of industrial emissions. As such, significant accelerated weathering impacting on the distinguishability of petroglyphs across the region is not expected to occur as a result of the Proposal.

Preventative and management controls are presented to minimise risk associated with uncertainties and with monitoring and analysis techniques and data-sets to-date, acknowledging theorised pathways for potential accelerated weathering, and high level of stakeholder concern. This ERD commits to provisions for measuring and managing emissions from the Proposal and significant emissions reduction opportunities afforded through facility life extension. 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). This will ensure that risk is minimised and remains at an acceptable level.

The implementation of the Murujuga Rock Art Strategy, Framework and Monitoring Program (DWER, 2019c) will remove much of the uncertainty surrounding potential pathways linking industrial emissions and accelerated weathering and allow for timely investigation and management where required. The proposed robust program of monitoring and analysis will determine whether change is occurring to the rock art and if this change is being accelerated by industrial emissions. Monitoring of rock, and rock art in particular allows for early warning indicators and response mechanisms to ensure that damage due to accelerated weathering is avoided. The implementation of the risk-based, adaptive management program using guidelines and standards, derived from sound scientific information, will ensure that the rock art is protected from potentially significant harm associated with industrial emissions.

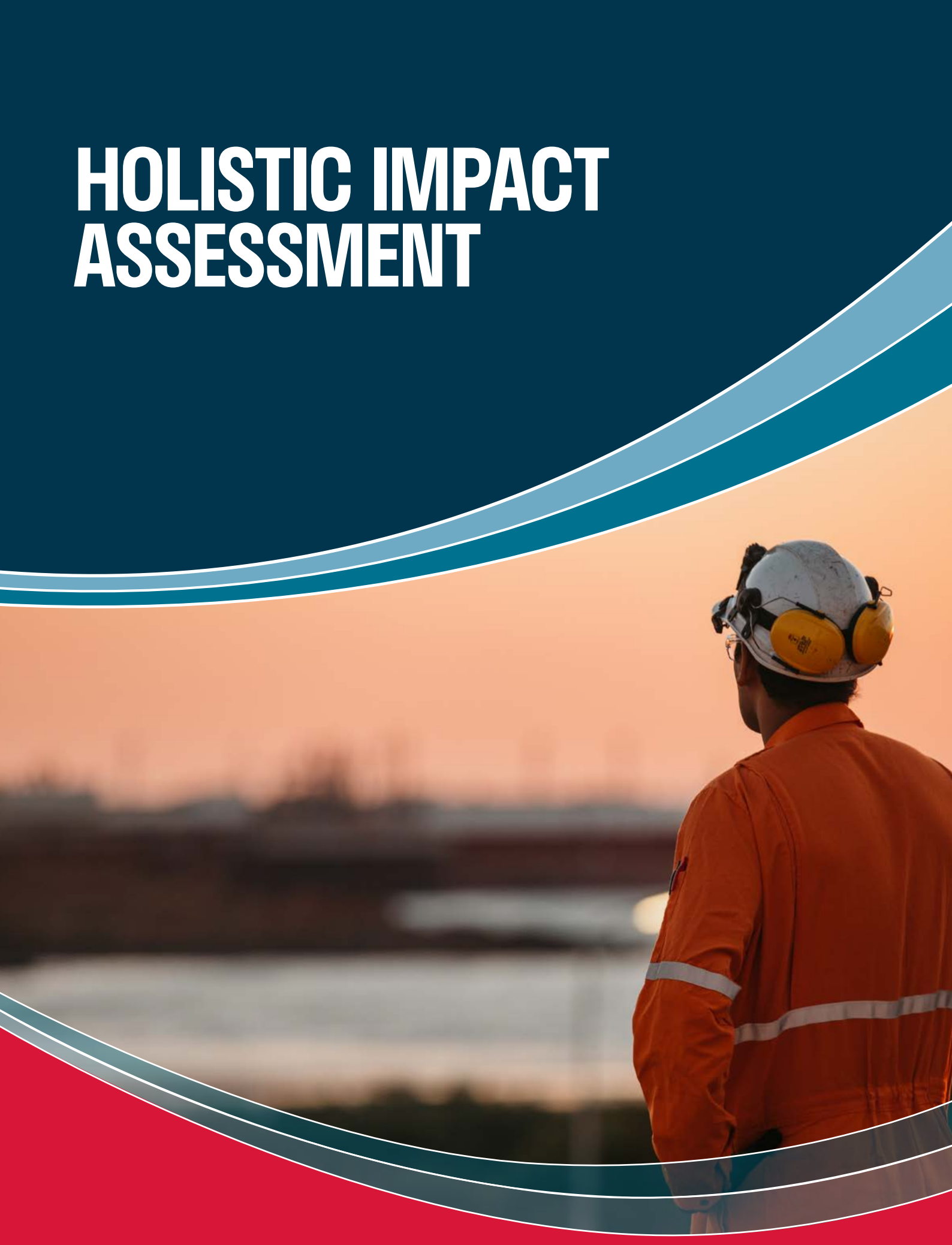
The residual risk to the values of the National Heritage

Place following the implementation of mitigation measures, including the Murujuga Rock Art Strategy, is assessed to be moderate in relation to industrial emissions causing accelerated weathering. The adaptive management approach proposed in the NWS Project Extension Cultural Heritage Management Plan (**Appendix C**) will further ensure that management and mitigation measures are revised as additional scientific knowledge is obtained and the potential impact pathway(s) better understood. As a result, no significant impact to the values of the National Heritage Place is expected.

In relation to impacts from direct, accidental physical damage of Petroglyphs, after implementing the mitigation measures, no significant impact to the values of the National Heritage Place is expected and the residual risk is assessed to be *low*.

As residual impacts to the values of the National Heritage Place are not expected to be significant, as assessed against the criteria defined in Significant Impact Guideline 1.1, no offsets have been proposed.

HOLISTIC IMPACT ASSESSMENT



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8. HOLISTIC IMPACT ASSESSMENT

8.1 Introduction

This section assesses holistically the potential impacts of the Proposal on the whole environment. In accordance with 'Instructions on how to prepare an environmental review document' (EPA, 2018b) this section describes the connections and interactions between the environmental factors relevant to the Proposal and discusses the predicted outcomes of the Proposal in relation to the environmental principles and the EPA's environmental objectives.

8.2 Connections within the Receiving Environment

The key environmental factors relevant to this Proposal have several connections and interactions between each other and other parts of the environment. **Figure 8-1** shows the Proposal's key environmental factors and how these interact.

There are various connections and interactions between the social surroundings and marine environmental quality factors. In particular, these two factors are connected through the cultural relationship that Traditional Owners have with the marine environment and where marine fauna has cultural heritage value. Discharges to the marine environment (both planned and unplanned) therefore have the potential to interact with the environmental values of both factors.

There are also connections between air quality, flora and vegetation, and social surroundings (heritage) with several plant species found on the Burrup known to be utilised by Aboriginal people for a range of uses including food, medicine, tools and weapons. This vegetation may be impacted through deposition caused by air emissions from the Proposal. The potential impacts of air emissions from this Proposal on this vegetation are considered in the social surroundings (heritage) section of this ERD (**Section 6.5.4.2**).

Additional connections and interactions between air quality and social surrounding (heritage) relate to the potential for industrial air emissions to cause deposition of acidic compounds on the rocks of the Burrup Peninsula, resulting in accelerated weathering of rock art. While no published peer reviewed studies identified measurable or observable changes to the condition and integrity of the rock art as a result of industrial emissions, Woodside recognises that some anecdotal evidence and stakeholder concerns have been raised regarding observable changes. This ERD considers the potential for impacts to rock art from industrial emissions in the social surrounding (heritage) section (**Section 6.5.4.1**). In addition, the emission of odorous substances has the potential to impact the amenity of areas outside of the Proposal's development envelope, including the Murujuga National Park, and is addressed in **Section 6.5.4.5**.

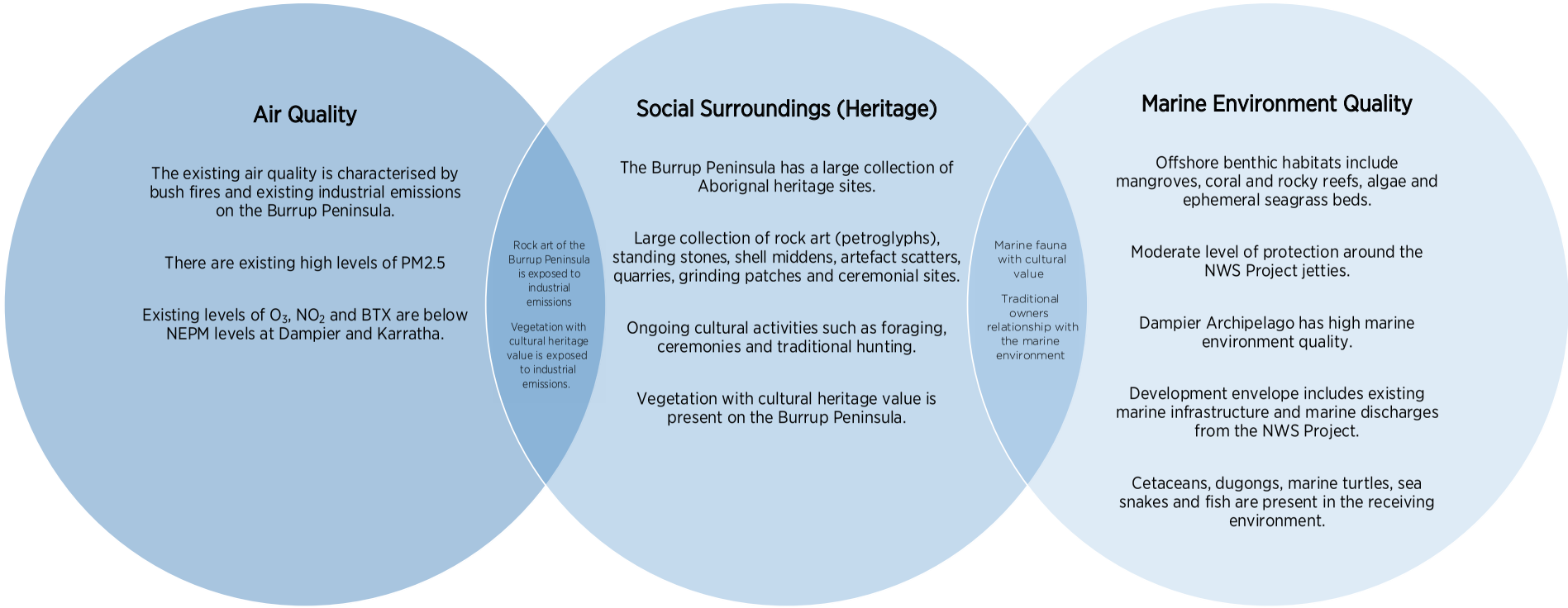

Figure 8-1: Connections with the Receiving Environment

8.3 Environmental Principles

Section 4A of the EP Act sets out environmental protection principles that must be considered during environmental impact assessment. **Section 6-2** of this ERD summarises how each principle relates to the Proposal. **Table 8-1** shows the relationship between each environmental factor and the environmental principles to demonstrate how each principle was applied when assessing the key environmental factors. Not all principles are relevant to each environmental factor, however **Table 8-1** demonstrates that all principles were considered by the assessment.

Table 8-1: How the Proposal Addresses the Environmental Principles

Principle	Air Quality	Marine Environmental Quality	Social Surroundings
The principle of the conservation of biological diversity and ecological integrity: Conservation of biological diversity and ecological integrity should be a fundamental consideration	This ERD acknowledges that air quality is an important factor critical to the conservation of biological and ecological integrity.	Discharges to the marine environment from the Proposal are managed to prevent impact to biological diversity and ecological integrity. Monitoring is undertaken to identify if impacts have occurred.	
Principles relating to improved valuation, pricing, and incentive mechanisms: 1. Environmental factors should be included in the valuation of assets and services. 2. The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance, and abatement. 3. The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste. 4. Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solutions and responses to environmental problems.	The emissions to air from the Proposal are subject to polluter pays principles under Part V of the EP Act through annual licence fees.	The discharges to the marine environment from the Proposal are subject to polluter pays principles under Part V of the EP Act through annual licence fees.	

Principle	Air Quality	Marine Environmental Quality	Social Surroundings
The precautionary principle: Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In application of this precautionary principle, decisions should be guided by: a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and b) an assessment of the risk-weighted consequences of various options.	This ERD recognises that while no published peer reviewed studies identified measurable or observable changes to the condition and integrity of the rock art as a result of industrial emissions, there remains stakeholder concerns that observable changes may have occurred. To address the uncertainty related to the impact of industrial air emission on the rock art, this ERD proposes measures to reduce NO_X, includes management plans for cultural heritage and air quality that include an adaptive management process which enables Woodside to respond to updates in scientific understanding. Further, Woodside commits to supporting the implementation of the Murujuga Rock Art Strategy (DWER, 2019b) as a member of the Murujuga Rock Art Stakeholder Reference Group.	Woodside has undertaken marine dispersion modelling to inform potential impacts to marine environmental quality. Woodside also remains committed to implementing the marine monitoring program, which identifies if changes to the marine environment have occurred.	This ERD recognises that while no published peer reviewed studies identified measurable or observable changes to the condition and integrity of rock art as a result of industrial emissions, there remains stakeholder concerns that observable changes may have occurred. To address the uncertainty related to the impact of industrial air emission on the rock art, this ERD proposes measures to reduce NO_X, and VOCs and management plans for cultural heritage and air quality that include an adaptive management process which enables Woodside to respond to updates in scientific understanding. Further, Woodside commits to supporting the implementation of the Murujuga Rock Art Strategy (DWER, 2019b) as a member of the Murujuga Rock Art Stakeholder Reference Group.

Principle	Air Quality	Marine Environmental Quality	Social Surroundings
The principle of intergenerational equity The present generation should ensure that the health, diversity, and productivity of the environment is maintained and enhanced for the benefit of future generations.	The principles of intergenerational equity and waste minimisation will be implemented through the use of the NWS Project Extension Air Quality Management Plan (**Appendix A**) and the NWS Project Extension Greenhouse Gas Management Plan (**Appendix B**), which contains provisions for measuring and managing emissions from the Proposal. This will safeguard the health, diversity, and productivity of the environment so that it is maintained and enhanced for the benefit of future generations.	This ERD acknowledges the significance of the marine environment for the benefit of future generations. The principle of intergenerational equity will be implemented through continued monitoring of the receiving marine environment.	Woodside is committed to ensuring the principle of intergenerational equity is implemented through the use of the NWS Project Extension Cultural Heritage Management Plan (**Appendix C**) which contains provisions for protecting the Burrup Peninsula's recreation and tourism values and allowing Traditional Owners access to cultural heritage sites. Woodside will continue to work with the Traditional Owners to maintain the existing environment for the benefit of future generations and ensure that potential impacts associated with NO_X and VOC emissions are appropriately managed over time.
The principle of waste minimisation All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	Woodside is committed to reducing emissions to air. This commitment is reinforced throughout this ERD where emission reduction targets have been set for NO_X and VOCs.	Woodside is committed to minimising liquid waste discharged to the marine environment. This is reinforced throughout this ERD where commitments have been made to maintain the quality of liquid wastes discharged.	

8.4 EPA Objectives for the Key Environmental Factors

The environmental objectives relevant to this ERD are:

- **Air Quality:** To maintain air quality and minimise emissions so that environmental values are protected.
- **Marine Environmental Quality:** To maintain the quality of water, sediment, and biota so that environmental values are protected.
- **Social Surroundings:** To protect social surroundings from significant harm.

To determine whether the Proposal meets these objectives, the potential impacts and risks to each of the key factors from the activities associated with the Proposal were identified and assessed. Where significant impacts or risks were identified, current management controls were reviewed to determine if they were sufficient to manage the impact or risk, such that they are no longer considered significant (refer to **Section 6.1.2** for Woodside's impact assessment approach). Where additional management controls were identified or required, these have been proposed in the relevant sections of this ERD.

With the application for the existing and proposed management controls, the predicted outcomes for the key environmental factors are:

- **Air Quality:** All potential impacts were assessed as having a *low* residual risk rating for unplanned risks and *slight* residual impact level for planned impacts, except accelerated weathering of rock art from industrial emissions which has a *moderate* residual risk. There are no residual risks or impacts that are inconsistent with the EPA's objective for this factor. The outcome for impacts to rock art is discussed further below.
- **Social Surrounding (Heritage):** As stated above, the residual risk from accelerated weathering of rock art from industrial emissions has been assessed as *moderate*. The residual risk from all other unplanned risks is assessed as low. For planned impacts the residual impact level is assessed as *slight*. There are no residual risks or impacts that are inconsistent with the EPA's objective for this factor.

  While impacts to rock art from industrial emissions may be significant, Woodside has committed to supporting the implementation of the Murujuga Rock Art Strategy and has included an adaptive management approach in the relevant management plans. This will allow Woodside to respond to new scientific information and understanding, in relation the impacts of industrial emissions, and allow the NWS Project to modify management controls and mitigate potential impacts. Woodside considers this approach will result in the EPA's objective for the environmental factor being met.
- **Marine Environmental Quality:** The residual risk from unplanned discharges is assessed as *moderate* as the credible worst-case scenario is a loss of containment of 1TL or 2TL, however the likelihood of this occurring is *highly unlikely*. The residual risk associated with migration of onshore contamination into the marine environment is assessed as *low*. The residual impact level for impacts related to shipping, ship loading and dredging is assessed as *slight* while the residual impact level for impacts from planned marine discharges is assessed as *negligible*. There are no residual risks or impacts that are inconsistent with the EPA's objective for this factor.

The Proposal is expected to meet the EPA's objectives for the key environmental factors.

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RELEVANT LEGISLATION

Woodside

10.RELEVANT LEGISLATION

Legislation	Legislation Summary
	Commonwealth
Carbon Credits (Carbon Farming Initiative) Act 2011	Gives legislative effect to the Emissions Reduction Fund. It sets up a scheme for the issue of Australian carbon credit units in relation to eligible offsets projects.
Environment Protection (Sea Dumping) Act 1981 + *Environment Protection (Sea Dumping) Regulations 1983*	Addresses Australia's obligations under the London Protocol. The aims of the London Protocol are to protect and preserve the marine environment from all sources of pollution, and to prevent, reduce and eliminate pollution by controlling the dumping of wastes and other materials at sea.
Environment Protection and Biodiversity Conservation Act 1999 + *Environment Protection and Biodiversity Conservation Regulations 2000*	This Act protects matters of national environmental significance (MNES). It streamlines the national environmental assessment and approvals process, protects Australian biodiversity and integrates management of important natural and culturally significant places. Under this Act, actions that may be likely to have a significant impact on matters of NES must be referred to the Commonwealth Environment Minister. The Act also establishes the National Heritage List, which includes natural, Indigenous and historic places that are of outstanding heritage value to the nation. There are penalties for anyone who takes an action that has or will have a significant impact on the heritage values of a place recognised in the National Heritage List. The EPBC Act also establishes the Commonwealth Heritage List, which includes places on Commonwealth lands and waters or under Australian Government control that have Indigenous heritage significance.
Environment Protection (Impact of Proposals) Act 1974	Repealed and replaced by the EPBC Act. An action did not require approval under the EPBC Act if it received all necessary environmental approvals under State, Territory and Commonwealth laws before 16 July 2000.
National Environment Protection Council Act 1994	The Act sets out to ensure that, by means of the establishment and operation of the National Environment Protection Council, people enjoy the benefit of equivalent protection from air, water or soil pollution and from noise, wherever they live in Australia; and decisions of the business community are not distorted, and markets are not fragmented, by variations between participating jurisdictions in relation to the adoption or implementation of major environment protection measures.

Legislation	Legislation Summary
National Environment Protection Measures (Implementation) Act 1998 + *National Environment Protection Measures (Implementation) Regulations 1999* + *National Environmental Protection (Ambient Air Quality) Measure 2016* + *National Environment Protection (Air Toxics) Measure 2011*	This Act and Regulations provide for the implementation of National Environment Protection Measures (NEPMs) to protect, restore and enhance the quality of the environment in Australia and ensure that the community has access to relevant and meaningful information about pollution. The National Environment Protection Council has made NEPMs relating to ambient air quality, the movement of controlled waste between states and territories, the national pollutant inventory, and used packaging materials.
National Greenhouse and Energy Reporting Act 2007 + *National Greenhouse and Energy Reporting (Measurement Determination) 2008* + *National Greenhouse and Energy Reporting (Safeguard Mechanism) Rule 2015*	The Act provides for the reporting and dissemination of information related to greenhouse gas emissions, greenhouse gas projects, energy production and energy consumption, and for other purposes.
Offshore Petroleum and Greenhouse Gas Storage Act 2006 + *Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009* + *Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011* + *Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009*	This Act is the principal Act governing offshore petroleum exploration and production in Commonwealth waters. Specific environmental, resource management and safety obligations are set out in the Regulations listed.
Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 + *Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995*	This Act provides for measures to protect ozone in the atmosphere by controlling and ultimately reducing the manufacture, import and export of ozone depleting substances (ODS) and synthetic greenhouse gases, and replacing them with suitable alternatives. The Act will only apply to Woodside if it manufactures, imports or exports ozone depleting substances.
Protection of the Sea (Prevention of Pollution from Ships) Act 1983 + *Protection of the Sea (Prevention of Pollution from Ships) (Orders) Regulations 1994* + *Marine Orders – Marine Pollution Prevention (Oil orders)* + *Marine Orders – Marine Pollution Prevention (Noxious liquid substances)* + *Marine Orders – Marine Pollution Prevention (Packaged harmful substances) Marine Orders – Marine Pollution Prevention (Garbage)* + *Marine Orders – Marine Pollution Prevention (Sewage)*	This Act gives effect to the International Convention for the Prevention of Pollution from Ships and relates to the protection of the sea from pollution by oil and other harmful substances discharged from ships. Under this Act, discharge of oil or other harmful substances from ships into the sea is an offence. There is also a requirement to keep records of the ships dealing with such substances. The Act applies to all Australian ships, regardless of their location. It applies to foreign ships operating between 3 nautical miles (nm) off the coast out to the end of the Australian Exclusive Economic Zone (200 nm). It also applies within the 3 nm of the coast where the State/Northern Territory does not have complementary legislation.
Aboriginal and Torres Strait Islander Heritage Protection Act 1984	Provides a mechanism for the Commonwealth Environment Minister to make declarations regarding the protection of an Aboriginal site when the Minister is satisfied that, under State or Territory law, there is ineffective protection of the area from a threat of injury or desecration. Declarations made under this Act may involve restricting activities and/or access to an Aboriginal site.

Legislation	Legislation Summary
Native Title Act 1983	Adopts the common law definition of native title, defined as the rights and interests that are possessed under the traditional laws and customs of Aboriginal people in land and waters, and that are recognised by the common law. These rights may exist over Crown Land but do not exist over land held as freehold title. The NT Act recognises the existence of an Indigenous land ownership tradition where connections to country have been maintained and where acts of government have not extinguished this connection.
Underwater Cultural Heritage Act 2018	Prescribes penalties for damage to protected underwater cultural heritage without a permit under Section 30 or in contravention of a permit in Section 28. Under Section 16, protected underwater cultural heritage automatically includes the remains and associated artefacts of any vessel or aircraft that has been in Australian waters for 75 years, whether known or unknown. This protection is also extended to underwater cultural heritage specified by the Commonwealth Minister for Environment under Section 17, which may include Aboriginal or other types of heritage.
Aboriginal Heritage Act 1972	The principle legislation for providing protection and preservation of all Aboriginal cultural heritage places and objects within WA. This Act currently administered by the WA Department of Planning, Lands, and Heritage (DPLH). Under Section 17 of the AH Act it is an offence to excavate, destroy, damage, conceal, or in any way alter any Aboriginal site or artefact. The central legislation to Aboriginal heritage management in the project area is the AH Act as the project area may contain Aboriginal sites, objects or remains covered by this Act.
Biodiversity Conservation Act 2016	The Act provides for the conservation and protection of biodiversity and biodiversity components in Western Australia and the ecologically sustainable use of biodiversity components in Western Australia.
Contaminated Sites Act 2003	The Act provides for the identification, recording, management and remediation of contaminated sites, to consequentially amend certain other Acts and for related purposes.
Dangerous Goods Safety Act 2004 *Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007* *Dangerous Goods Safety (Major Hazard Facility) Regulations 2007*	This Act sets out the requirements for the safe storage, handling and transport of dangerous goods in Western Australia and is supported by six individual regulations, including the Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007. The Dangerous Goods Safety (Major Hazard Facility) Regulations 2007 defines those facilities that are considered 'Major Hazard Facilities' and the specific requirements on these.
Environmental Protection Act 1986 *Environmental Protection Regulations 1987* *Environmental Protection (Unauthorised Discharges) Regulations 2004*	The principle legislation for the prevention, control and abatement of pollution and environmental harm; for the conservation, preservation, protection, enhancement and management of the environment; and for matters incidental to or connected with the above. The Act also establishes the Environmental Protection Authority and processes for Environmental Impact Assessment.

Legislation	Legislation Summary
Jetties Act 1926	The Act makes provision for securing and regulating the use and management of jetties in WA including the construction, maintenance, and preservation of jetties. A jetty is defined under this Act as any jetty, pier, wharf, quay, grid, slip, landing place, stage, platform, or similar structure, whether fixed or floating, erected or placed, wholly or in part, in, on or over any water, and any ramp which is or which may be used for the purpose of launching or landing a vessel.
Land Administration Act 1997	This Act sets out the provisions for disposition and management of State land in Western Australia.
National Environment Protection Council (Western Australia) Act 1996	WA's legislation to enable the National Environmental Protection Council and the development of National Environmental Protection Measures.
North West Gas Development (Woodside) Agreement Act 1979	The Act ratifies the Agreement between the State of Western Australia and the NWSJV partners in relation to the production of natural gas and condensate and the establishment of the KGP. It sets out the rights, obligations, terms and conditions for the development.
Petroleum (Submerged Lands) Act 1982 *Petroleum (Submerged Lands) (Pipelines) Regulations 2007* *Petroleum (Submerged Lands) (Environment) Regulations 2012*	This Act makes provision with respect to the exploration for and the exploitation of the petroleum resources, and certain other resources, of certain submerged lands adjacent to the coast of WA. The supporting regulations include provisions for reporting of safety and environmental incidents, and to prescribe standards for construction and operation, prescribe matters to be contained in Safety Plans and Environment Plans.
Petroleum Pipelines Act 1969 *Petroleum Pipelines Regulations 1970* *Petroleum Pipelines (Environment) Regulations 2012*	An Act relating to the construction, operation and maintenance of pipelines for the conveyance of petroleum and for purposes connected therewith.
Planning and Development Act 2005	The Act sets out the system of land use planning and development in the State. It sets out specific controls over planning at a metropolitan and local level as well as establishing more general controls over the subdivision of land.
Pollution of Waters by Oil and Noxious Substances Act 1987	The Act gives effect to the International Convention for the Prevention of Pollution from Ships and protects the sea and other waters from pollution by oil and other noxious substances.
Port Authorities Act 1999	An Act about port authorities, their functions, the areas that they are to control and manage, the way in which they are to operate, and related matters.

TERMS

Woodside

11. TERMS

Terms	Definitions
~	approximately
<	Less/fewer than
>	More/greater than
µg/m^3	Micrograms per cubic metre. 1 µg/m^3 = one millionth of a gram per cubic metre of air, referenced to a temperature of 0° C and an absolute pressure of 101.325 kPa
µm	Micrometre. 1 µm = 10-^{6} metre = 0.000001 metre or one millionth of a metre
1TL, 2TL	Subsea pipelines (trunklines) 1 and 2, within State waters and crossing onshore to KGP.
ABN	Australian Business Number
AGRU	Acid Gas Removal Unit
Airshed	A volume of air confined to a distinct geographic region, and within which emissions are contained
AMSA	Australian Maritime Safety Authority
AQ	Air Quality (station)
BBPH	Benthic Primary Producer Habitat
BC Act	Western Australian Biodiversity Conservation Act 2016
BIA	Biologically Important Area
BoM	Bureau of Meteorology
BSIA	Burrup Strategic Industrial Area
BTX	Benzene, toluene, and xylene compounds
CB	Air modelling scenario representing the current baseline
ChEMMS	Chemical and Ecological Monitoring of Mermaid Sound (program)
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
Commonwealth waters	Waters stretching from three to 200 nautical miles from the Australian coast
Cryosphere	The frozen water part of Earth, including ice found water and frozen parts of the ocean, such as waters surrounding Antarctica and the Arctic
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cth	Commonwealth of Australia
DBCA	Western Australian Department of Biodiversity, Conservation and Attractions
Development envelope	The boundaries that define the maximum area within which the State onshore and offshore components of the Proposal are located
DMA	Decision-making Authority
DMIRS	Western Australian Department of Mines, Industry Regulation and Safety
DoE	Former Western Australian Department of Environment
DoEE	Commonwealth Department of the Environment and Energy
DPLH	Western Australian Department of Planning, Lands and Heritage
DWER	Western Australian Department of Water and Environmental Regulation

Terms	Definitions
DWP	water demineralisation plant
EMP	Environmental Management Plan
Environmental Review Document	The document prepared to meet the requirements set out in the Environmental Scoping Document and which informs the EPA's assessment of the Proposal
Environmental Scoping Document	The document that the EPA uses to define the form, content, timing and procedure of an environmental review and/or the public review period for the environmental review or other additional assessment information
EP Act	Western Australian Environmental Protection Act 1986
EPA	Western Australian Environmental Protection Authority
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
EPIP Act	*Commonwealth Environment Protection (Impact of Proposals) Act 1974* (EPIP Act). This Act was repealed in 2000 and replaced by the EPBC Act. However, as the NWS Project started in 1984, some of it may be subject to conditions of the EPIP Act.
ERD	*See* Environmental Review Document
ERF	Emissions Reduction Fund
ESD	*See* Environmental Scoping Document
Eutrophic	Having high levels of nutrients, as oxidised nitrogen and inorganic phosphorus, encouraging the growth of algae, etc.
Evapotranspiration	The process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants
EQP	Environment Quality Plan
FBSIA	Air modelling scenario representing the current baseline and future proposed developments in the air modelling study area
FBSIA-KIO	Air modelling scenario representing the FBSIA scenario with emissions reductions in place at the Proposal
Gabbro	Coarse-grained and usually dark-coloured intrusive igneous rock
GHG	Greenhouse Gas
GLC	Ground Level Concentration
Granophyre	Subvolcanic rock that contains quartz and alkali feldspar in characteristic angular intergrowths
H_2S	Hydrogen sulphide
ha	Hectare
HEPA	High Ecological Protection Area
IEA	The International Energy Agency's World Energy Outlook 2018 Scenarios
IMR	Inspection, maintenance, and repair
IPCC	Intergovernmental Panel on Climate Change
ITOPF	International Tanker Owners Pollution Federation Ltd
KBSB	King Bay Supply Base
kg	Kilogram
KGP	Karratha Gas Plant
KIO	Air modelling scenario representing the current baseline and proposed emission reduction opportunities at the Proposal
km	Kilometre
km/h	Kilometres per hour
LEP	Level of Ecological Protection

Terms	Definitions
LEPA	Low Ecological Protection Area
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
m	Metre
m/s	Metres per second
MAC	Murujuga Aboriginal Corporation
meq/m^2/year	Milliequivalents per square metre per year
mg	Milligram
mm	Millimetre
MEPA	Medium Ecological Protection Area
MNES	Matters of National Environmental Significance
MS	Ministerial Statement
mt	Million tonnes
mtpa	Million tonnes per annum
ND	No data
NEPM	National Environment Protection Measure
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
North West Shelf Joint Venture	A joint venture comprising 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 North West Shelf Joint Venture owns the infrastructure used as part of the North West Shelf Project and, together with CNOOC NWS Private Limited, the North West Shelf Joint Venture owns the resources processed as part of the NWS Project.
North West Shelf Project	The North West Shelf Project is one of the world's largest liquefied natural gas producers, supplying oil and gas to Australian and international markets from offshore gas, oil, and condensate fields in the Carnarvon Basin off the north-west coast of Australia. The NWS Project is owned by the NWSJV participants and for more than 30 years, it has been Western Australia's largest producer of domestic gas. The NWS Project currently processes resources owned by the NWSJV and CNOOC NWS Private Limited and is proposed to also process third-party gas and fluids as part of the NWS Project Extension Proposal.
NO_x	Oxides of nitrogen
NRM	Natural Resource Management
NSW	New South Wales
NTU	Nephelometric Turbidity Unit
NWMR	North-west Marine Region
NWS	North West Shelf
NWS Project	See North West Shelf Project
NWS Project Extension Proposal (the Proposal)	The Proposal as described in the NWS Project Extension Section 38 Referral Supporting Information (November 2018) to continue to use the existing NWS Project facilities for the long-term processing of third-party gas and fluids and NWSJV field resources through the NWS Project facilities. Ongoing operation of the NWS Project to enable long-term processing at the NWS Project facilities, currently expected to be until around 2070.

Terms	Definitions
NWSJV	See North West Shelf Joint Venture
O_3	Ozone
OCW	Oil-contaminated water
Offshore facilities	NWS Project infrastructure located offshore up to the State waters boundary and within the development envelope
Oligotrophic	Deficient in plant nutrients
Onshore facilities	NWS Project infrastructure located onshore and within the development envelope
PAH	Polycyclic Aromatic Hydrocarbon
PFAS	Per- and polyfluoroalkyl substance
Photic zone	The depth of the water in a lake or ocean that is exposed to sufficient sunlight for photosynthesis to occur; the depth zone can be greatly affected by turbidity
PL	Pipeline Licence
PM	Particulate Matter
PM_{10}	Particulate matter with a diameter of 10 micrometres or less
$PM_{2.5}$	Particulate matter with a diameter of 2.5 micrometres or less
ppb	Parts per billion
Proposal	See NWS Project Extension Proposal
RH	Relative Humidity
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
State Agreement	Western Australian North West Gas Development (Woodside) Agreement Act 1979
State waters	The marine environment within three nautical miles of the mainland of Western Australia or its islands
STP	sewage treatment plant
t	Tonne
TAPM-GRS	The Air Pollution Model with Generic Reaction Set
TBT	Tributyltin
Teleost	Fish that have a skeleton composed at least in part of bone rather than of cartilage; includes most fish species
Third-party gas and fluids	Gas and associated fluids from sources other than those produced by the NWSJV and CNOOC NWS Private Limited. The processing of third-party gas and fluids is subject to the necessary commercial arrangements being in place between the NWSJV and the relevant third parties as well as all relevant joint venture and regulatory approvals being obtained.
TPH	Total Petroleum Hydrocarbon
TPL	Territorial Sea Pipeline Licence
TRH	Total Recoverable Hydrocarbon
VOC	Volatile Organic Compound
WA	Western Australia
WET	Whole Effluent Toxicity
Woodside	Woodside Energy Ltd; Proponent of the NWS Project Extension Proposal and the Operator of the NWS Project on behalf of the NWSJV.
WWTP	Wastewater Treatment Plant