



**APPENDIX B NORTH WEST SHELF
PROJECT EXTENSION
AIR QUALITY
MANAGEMENT
PLAN**

REVISION 2
G2000RF1401194398

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I. SUMMARY

Woodside Energy Ltd (Woodside), as operator for and on behalf of the North West Shelf (NWS) Joint Venture (NWSJV), is the proponent for the North West Shelf Project Extension Proposal (the Proposal).

In summary, the Proposal is for 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 Proposal is described in its entirety in Section 2 of the NWS Project Extension Environmental Review Document (Woodside, 2019) and is duplicated into **Section 2.1.1** of this Air Quality Management Plan (AQMP) for ease of reference.

This AQMP was prepared in accordance with the 'Instructions on how to prepare *Environmental Protection Act 1986* Part IV Environmental Management Plans' published by the Western Australian (WA) Environment Protection Authority (EPA) (EPA, 2018).

This AQMP details the measures required to manage the potential impacts to air quality from the Proposal. **Table 1-1** summarises the information contained in this AQMP. It should be noted that emissions of greenhouse gases are dealt with separately through the NWS Project Extension Greenhouse Gas Management Plan (Woodside ID G2000RF1401194400).

Table 1-1: AQMP Summary Table

Title of Proposal	North West Shelf Project Extension
Proponent Name	Woodside Energy Ltd., as operator for and on behalf of the NWSJV
Purpose of the AQMP	This Air Quality Management Plan identifies management and mitigation measures to ensure impacts to air quality from the Proposal are not greater than predicted.
Key Environmental Factor/s and Objective/s	Key Environmental Factor: Air Quality EPA Objective: To maintain air quality and minimise emissions so that environmental values are protected (EPA, 2016)
Key Provisions in the AQMP	Management of: <ul style="list-style-type: none"> • 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 Through the implementation of the following key provisions: <ul style="list-style-type: none"> • Implementation of a facility emissions testing and verification program • Undertaking emissions performance monitoring and reporting • Monitoring ambient air concentrations of relevant emissions, that contribute to human health risks • Adoption of practicable and efficient technologies to reduce air emissions • Implementation of an adaptive management plan addressing the potential impact to rock art from industrial emissions • Support the implementation of, and participate in, the DWER Murujuga Rock Art Strategy

2. CONTEXT, SCOPE, AND RATIONALE

2.1 Introduction

The 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 WA's largest producer of domestic gas.

Woodside 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, the Proposal will include processing third-party gas and fluids and any remaining or new NWSJV field resources.

The Proposal is described in its entirety in Section 2 of the NWS Project Extension Environmental Review Document (Woodside, 2019) and is duplicated in **Section 2.1.1** of this AQMP for ease of reference.

This AQMP will be implemented following receipt of approval under the Environmental Protection Act 1986 (WA) (EP Act) and Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth) (EPBC Act). In the interim, the NWS Project will continue to operate under current licence conditions and management practices.

2.1.1 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 in line with current levels
 - modifications to the Karratha Gas Plant (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.
 - Ongoing, additional (and cumulative to existing approvals) emissions and discharges to the environment)
 - Monitoring and management of environmental impacts

2.2 Scope of the AQMP

Purpose of Management Plan

This AQMP outlines how air emissions will be monitored and managed for the Proposal so that the relevant environmental values are protected. Where the Proposal has potential impacts to environmental values, but those impacts are managed under other regulatory instruments, then those impacts and environmental values have not been considered in this AQMP. To determine the impacts from the Proposal that are within the scope of this AQMP these criteria were applied:

- if mitigation is implemented under other regulatory instruments, the impact was determined to be sufficiently managed.
- if an activity required management through design controls and those controls are already in place at the Proposal, the impact was determined to be sufficiently managed.

After applying these criteria, the following potential impacts were determined to be within the scope of this AQMP:

- Gaseous emissions causing a reduction in ambient air quality impacting human health; and
- Changes in air quality causing deposition on nearby heritage features, including National Heritage Places.

Scope

This AQMP applies to operational activities of the Proposal that generate atmospheric emissions and provides a framework for managing them. The key atmospheric emissions managed under this AQMP are described and assessed in the NWS Project Extension Environment Review Document (Woodside, 2019) and are summarised as:

- oxides of nitrogen (NO_x);
- ozone (O₃);
- volatile organic compounds (VOCs); and
- minor contribution of sulphur dioxide (SO₂).

Dark smoke, which has potential to cause impacts to amenity; is managed through monitoring and reporting in accordance with Part V of the EP Act Operational Licence requirements and therefore management of dark smoke is not within the scope of this management plan.

All other atmospheric emissions are outside the scope of this AQMP. Emissions of greenhouse gases are addressed in the NWS Project Extension Greenhouse Gas Management Plan (GHGMP) (Woodside ID G2000RF1401194400).

2.3 Key Environmental Factors

This AQMP specifically relates to the 'Air Quality' environmental factor, as defined by the EPA. The objective for this factor is:

To maintain air quality and minimise emissions so that environmental values are protected.

'Environmental values' are defined under the EP Act as 'a beneficial use, or an ecosystem health condition'. The ecosystem health values related to air quality are defined by the EPA as being human health and amenity (EPA, 2016). In addition to this, this AQMP recognises the value of the Burrup Peninsula from an Aboriginal cultural perspective, particularly from the presence of rock art. Therefore, this AQMP also considers Aboriginal cultural heritage as an environmental value.

2.3.1 Proposal Activities Potentially Affecting Key Environmental Factors

The principal emissions from the Proposal in terms of potential air quality impacts 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 CO₂ removal from reservoir gas).

The most significant by-products of gas combustion and facility emissions include: oxides of nitrogen (NO_x), carbon monoxide (CO), methane, and unburnt volatile organic compounds (VOCs).

An air quality study and risk assessment was undertaken based on a broad survey of Burrup Peninsula air quality studies, historical ambient monitoring records, emission inventories and other information. The NWS Project Extension Environment Review Document (ERD) (Woodside, 2019), together with the air quality impact assessment and modelling (ERD Appendix E) was undertaken for key parameters applicable to contribution by the Proposal to understand cumulative potential air quality impacts. Further detail is available in the ERD with supporting Appendix E.

NO_x was determined to be the predominant risk emission from the facility associated with air quality potentially impacting human health with applicable nitrogen dioxide (NO₂) and ozone (O₃) 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 emissions such as VOCs and CO in the presence of ultraviolet light.

There may also be traces of particulate matter (PM) and sulphur dioxide (SO₂) but such emissions are generally considered negligible associated with the Proposal due to the firing of very low sulphur content natural gas in a controlled environment. Emissions of PM from the Proposal are negligible in relation to background and other industrial sources. Ventilation readily disperses methane and CO emissions, with benzene, toluene, ethylbenzene and xylene (BTEX) as a health indicator for VOCs determined to have insignificant air quality effects at sensitive receptors.

Potential for nuisance odours are assessed as posing low risk of loss of public amenity or reduced amenity to heritage features in the NWS Project Extension Environment Review Document (Woodside, 2019) as are not expected, with a long operational history without reports of nuisance odours. Impacts to vegetation of conservation or heritage significance are not expected, and of low risk, with ambient levels assessed consistently below applicable thresholds.

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. These concerns centre on the issue that deposition of NO_x, SO_x and NH₃ 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 therefore are summarised as: NO_x, secondary formation of O₃, VOCs (pertaining to photochemical intensity of NO/NO₂ and Ozone formation), and very minor contribution of SO₂.

2.4 Rationale and Approach

This AQMP outlines how air emissions from the Proposal will be managed and monitored so that the environmental values of the Burrup Peninsula are protected.

The objective of this AQMP is to manage air emissions from the Proposal to minimise the Proposal's contribution to ambient air quality. This objective acknowledges that planned, continuous emissions to air from the Proposal will occur and that associated risk (potential impacts) can be minimised to acceptable levels through the implementation of this AQMP.

In developing this AQMP, the following points were assessed:

- results of ambient air quality monitoring (including the WA Government's Pilbara Air Quality Study, and Woodside's Burrup Ambient Air Monitoring Program (BAAMP)) to understand the existing air quality on the Burrup Peninsula
- outcomes of ambient air quality modelling for the Proposal and the Burrup Peninsula
- uncertainties as to the potential for accelerated weathering of Aboriginal rock art on the Burrup Peninsula due to industrial emissions.

Based on this assessment, this plan leverages facility technical emissions control technologies, and sets out a suite of operational management practices and contains provisions for measuring, monitoring and reporting emissions from the Proposal. The approach to managing the Proposal's atmospheric emissions combines impact assessment, early response indicators, adaptive management and implementation of the principle of waste minimisation.

Additionally, some potential impacts managed under this AQMP are the subject of ongoing scientific research; therefore, the understanding of how these impacts are best managed may change during implementation of the Proposal. To address the uncertainty associated with these potential impacts, an adaptive management approach will be implemented, together with the Proposal providing for opportunities to substantially reduce NO_x and VOC emissions.

The management approach for this AQMP also identifies several existing statutory mechanisms for managing emissions to air (**Section 3.2**). Where appropriate, this AQMP will refer to these existing mechanisms rather than propose new mechanisms.

3. INTERNAL AND REGULATORY FRAMEWORK

3.1 Internal Management Mechanisms Relevant to this AQMP

3.1.1 Woodside Management System

The Woodside Management System (WMS) defines how Woodside delivers 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 (HSEQ) Policy. The policy provides a public statement of Woodside's commitment to minimising adverse effects on the environment from its activities and to improving environmental performance. It sets out the principles for achieving the objectives for the environment and how these are to be applied. The policy is applied to all Woodside's activities, and employees, contractors and Joint Venture partners engaging in activities under Woodside operational control.

3.1.2 Environmental Performance

The following environmental performance requirements are applicable to all Woodside developments and production assets, including the KGP.

- All existing and future production and support facilities must measure, monitor or estimate air emission streams.
- Air emissions must not unreasonably interfere with the health, welfare, convenience, comfort or amenity of nearby persons/communities.

3.1.3 Opportunity Management Process

Each potential new third-party gas source to be introduced to KGP is assessed under Woodside's Opportunity Management Process (OMP) which aims to find the best way to develop an identified opportunity, present a compelling business case for execution and then realise the value. The OMP applies a structured decision making, planning, governance and delivery approach to ensure opportunities are matured based on good decisions, and that those decisions are knowledge based and account for uncertainty and residual risk. An opportunity lifecycle typically consists of:

- Assess whether there is commercial merit in progressing the opportunity.
- Select the optimum development solution in line with project objectives and define the concept for development of the opportunity.
- Develop a design, an execution plan, and mobilise a team ready to deliver the project to the promised outcomes.
- Execute the plan, and handover the assets and operations organisation ready for start-up at the execute phase.

Under the OMP appropriate to the nature and scale of the opportunity, the process may consider the following activities in relation to air emissions:

- Risk assessment which identifies any changes (e.g. processing of varied gas compositions) which may impact the character of an existing emission and/or discharge.
- Review of existing approvals to identify any additional requirements. This contemplates the impact of an opportunity on existing environmental approvals and relevant regulatory limits.
- Studies, such as modelling which may assist with predicting likely or possible outcomes which can then be interpreted in the context of the existing environment to quantify potential impacts and risks. Modelling may also be used to evaluate alternative designs.
- Engineering assessment which consider requirements for emission monitoring requirements.

3.2 Regulatory Management Mechanisms Relevant to this AQMP

3.2.1 National Environmental Protection (Ambient Air Quality) Measure

The National Environment Protection Council (NEPC), comprising Commonwealth, State, and Territory Ministers, finalised the NEPM (Ambient Air Quality), on 26 June 1998. *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, 2019).

Table 3-1 lists the NEPM (Ambient Air Quality) criteria relevant to the emissions in scope of this AQEMP for human health.

Table 3-1: Relevant NEPM (Ambient Air Quality) Standards

Pollutant	Averaging Period	Maximum Concentration Standard	Maximum Allowable Exceedances
Photochemical oxidants (as O ₃)	1 hour	0.10 ppm	1 day a year
	4 hours	0.08 ppm	1 day a year
Nitrogen dioxide (NO ₂)	1 hour	0.12 ppm	1 day a year
	1 year	0.03 ppm	None

3.2.2 National Environment Protection (Air Toxics) Measure

The NEPM (Air Toxics) sets monitoring investigation levels for particular air toxics. If the levels set by NEPM (Air Toxics) is exceeded, an investigation into the exceedance must be undertaken. Air toxics potentially relevant to the Proposal include BTX as trigger indicators for potential VOC ambient levels.

For this reason, the NEPM (Air Toxics) is relevant and the standards listed in **Table 3-2** are considered when managing emissions to air from the Proposal.

Table 3-2: Relevant NEPM (Air Toxics) Standards

Air Toxics	Averaging Period	Monitoring Investigation Levels (ppm)
Benzene	1 year ¹	0.003
Toluene	1 day ²	1.0
	1 year ¹	0.1
Xylene (as a total or ortho-, meta-, and para-isomers)	1 day ²	0.25
	1 year ¹	0.2

Note 1: For this measure, the annual average concentrations are the arithmetic mean concentrations of 24-hour monitoring results.

Note 2: For this measure, monitoring over a 24-hour period is to be conducted from midnight to midnight.

3.2.3 National Pollutant Inventory

The National Pollutant Inventory (NPI) is a public database that provides information on 93 selected air pollutants and their emissions, produced as a result of industry, transport, commercial premise, and household activities, and emitted to air, land, and water in Australia. The NPI is a Commonwealth Government initiative and each state and territory is responsible for implementing the program.

The objective of the NPI is to inform the community about emissions to water, air, and land and acceptable emissions levels. It also provides information for policy and decision making, environmental planning and management, and minimising waste.

Woodside have been reporting emission data from the NWS Project to the NPI annually since the 1998/1999 reporting period. For the purpose of NPI reporting the NWS Project is referred to as the “Karratha Onshore Gas Treatment Plant”.

3.3 Other Management Mechanisms Relevant to this AQMP

3.3.1 Murujuga Rock Art Strategy and Murujuga Rock Art Stakeholder Reference Group

The Murujuga Rock Art Strategy (the Strategy) provides a long-term framework to guide the protection of rock art on the Burrup Peninsula and surrounding islands of the Dampier Archipelago. The strategy aims to 'build on previous work on the Burrup Peninsula to deliver a scientifically rigorous, world's best practice monitoring program and risk-based approach to the management of impacts to the rock art, consistent with legislative responsibilities under the EP Act' (DWER, 2019a). The WA Department of Water and Environmental Regulation (DWER) and Murujuga Aboriginal Corporation (MAC) are responsible for the day-to-day implementation of the strategy, including ongoing consultation with key stakeholders (DWER, 2019a).

The scope of the strategy is to:

- establish an Environmental Quality Management Framework (EQMF), including the derivation and implementation of environmental quality criteria
- develop and implement a robust program of monitoring and analysis to determine whether change is occurring to the rock art on Murujuga
- identify and commission scientific studies to support the implementation of the monitoring and analysis program and management
- establish governance arrangements to ensure that:
 - monitoring, analysis and reporting are undertaken in such a way as to provide confidence to the Traditional Owner, the community, industry, scientists and other stakeholders about the integrity, robustness, repeatability and reliability of the monitoring data and results
 - government is provided with accurate and appropriate recommendations regarding the protection of the rock art, consistent with legislative responsibilities
- develop and implement a communication strategy in consultation with stakeholders.

DWER plans to use the EQMF to provide a risk-based and robust framework for implementing the monitoring and management that is required to protect rock art from anthropogenic emissions. The EQMF comprises of:

- environmental values – ecosystem conditions that require protection from environmental harm
- environmental quality objectives – specific management goals that must be achieved to protect the environmental values
- environmental quality criteria – scientifically determined limits of reasonable change. These criteria are the standards against which environmental monitoring data are compared to determine the extent to which environmental quality objectives have been met (DWER 2019a)

DWER, in partnership with MAC, plan to implement a revised Murujuga Rock Art Monitoring Program, based on the results from the past 15 years of scientific studies and monitoring of the petroglyphs. This monitoring program potentially includes, but is not limited to, the parameters of colour change, pH/acidity, microbiology, and sources of pollutants (DWER, 2019b). The program should be able to distinguish between changes in condition of the petroglyphs attributed to anthropogenic emissions versus other unrelated causes. The program comprises cost-efficient, best-practice technologies and methods.

Monitoring and analysis results will be published on DWER's website (<https://www.der.wa.gov.au/our-work/programs/36-murujuga-rock-art-monitoring-program>). The strategy will be reviewed every five years or when significant new information becomes available to ensure that the strategy and governance procedures remain relevant and reflect the most recent scientific knowledge and management practices.

The Murujuga Rock Art Stakeholder Reference Group (Stakeholder Reference Group) was established in 2018 to facilitate engagement between key government, industry and community representatives as the Strategy is developed. Woodside is a member of the Stakeholder Reference Group and as such will participate in the following activities, as per the terms of reference (DWER, ND):

- contribute constructively to the monitoring and protection of rock art, being considerate of the views of all stakeholders. This includes the provision of advice to DWER and the Minister for Environment on the design, implementation and analysis of the scientific monitoring and analysis program.
- consult, inform and educate other stakeholders on other matters referred by DWER for input or comment, including further development of the Strategy, implementation of the Strategy and 5 year reviews
- inform the Government's broader consideration of other strategic issues relating to the protection of the rock art on Murujuga.

Where key emissions from the Proposal have potential to impact the Murujuga rock art, management measures have been proposed in line with the work that Woodside is participating in through the Strategy and the Stakeholder Reference Group.

4. EMP PROVISIONS

This section describes the provisions of this AQMP, which when implemented, will achieve the objectives of the air quality environment factor and this AQMP, uphold the relevant environmental values and manage impact to air quality from the NWS Project. **Table 4-1** summarises the provisions that will be implemented. These are based on the approach described in **Section 2.4** and are described in full in **Section 5.2**. Existing air quality management measures for the NWS Project have been included in this AQMP.

Each of the provisions follow a management-based approach. This is on the basis that those aspects of the environment that can be objectively managed through the implementation of trigger values are currently managed through other mechanisms (for example the EP Act Part V Operational Licence) with the remaining aspects are better suited to a management-based approach.

4.1 Management Based Provisions Summary

Table 4-1: Management-based Provisions

Management Actions	Targets	Monitoring	Reporting
MA1: Implement a facility emissions testing and verification program	<p>Quarterly point source emission testing and review program undertaken on applicable and representative equipment to complement and verify routine maintenance and operational surveillance of equipment.</p> <p>Emissions performance will meet limits specified in the Part V Licence, currently L5491/1984/18.</p>	Every three months in accordance with the method specified in the operating licence.	<p>Results of emissions performance reported in the Annual Environment Report (AER).</p> <p>Quarterly results reviewed, and any exceedances reported to DWER as per the operating licence requirement.</p> <p>All exceedances of licence criteria reported in the AER, internal investigation undertaken to determine the root cause and any corrective actions required.</p>
MA2: Undertake emissions performance monitoring and reporting	Monitor, estimate and report air emissions (in accordance with NPI) to inform management practices and minimise potential environmental impacts of emissions.	Monitor, estimate and report air emissions (in accordance with NPI).	Annual reporting in accordance with the NPI.
MA3: Monitor ambient air concentrations of relevant emissions, that contribute to human health risks	No exceedance of relevant NEPM (Ambient Air Quality) and NEPM (Air Toxics) criteria attributable to Proposal emissions.	Implementation of a monitoring program to monitor ambient air quality against NEPM (Ambient Air Quality) and NEPM (Air Toxics) assessment criteria.	<p>Ambient air quality monitoring results will be summarised in the AER, including any observed exceedances of ambient air quality standards and the results of any investigation into exceedance cause.</p> <p>A summary of monitoring results will be made publicly available on the Woodside website annually.</p>

Management Actions	Targets	Monitoring	Reporting
MA4: Adopt practicable and efficient technologies to reduce air emissions	40% reduction of NOx achieved by 31 December 2030. Substantially reduce VOC emissions by 31 December 2030.	Monitor, estimate and report facility emissions after installation of technologies to verify achievement of emission reduction targets.	Performance against emission reduction targets summarised in the AER
MA5: Implement an adaptive management plan addressing the potential impact to rock art from industrial emissions	See Section 5 .		
MA6: Support the implementation of, and participate in, the DWER Murujuga Rock Art Strategy ¹			

Note 1: DWER is responsible for awarding monitoring studies in support of the Murujuga Rock Art Strategy.

4.2 Management Actions

4.2.1 MA1 – Implement a facility emissions testing and verification program

Woodside applies a range of air emissions management practices, consistent with industry standards, internal management system requirements, environmental regulations and the operating licence requirements.

The following table outlines the regular sampling, analysis and monitoring undertaken to manage air emissions from KGP equipment. The results are used for a variety of internal and external purposes, including environment licence and regulatory compliance purposes.

Table 4-2: KGP Equipment Monitoring Activities

Equipment	Sampling [#]	Frequency	Use
Gas turbine stacks <ul style="list-style-type: none"> • 6x Frame 5 • 1x Frame 3 • 4x Frame 7 • 4x LM6000s 	Emissions testing for: <ul style="list-style-type: none"> • Oxides of Nitrogen (NOx) as NO₂, 15% O₂ reference level for gas turbines. 7% O₂ reference level for stabiliser furnaces. • Carbon Monoxide (CO) • Sulphur dioxide (SO₂) 	Once per calendar quarter, at least 45 days apart	Environment Licence compliance Equipment monitoring and optimisation
Stabiliser furnace stacks (x4)*			
Acid Gas Removal Unit (AGRU) vents	Emissions testing for: <ul style="list-style-type: none"> • Carbon dioxide (CO₂) • Hydrocarbon fractions, C1-10 • Most cyclic hydrocarbons, e.g. BTEX, cyclohexane • Hydrogen Sulphide (H₂S) 	Monthly	Equipment monitoring and optimisation National Greenhouse and Energy Reporting National Pollutant Inventory Reporting

Equipment	Sampling [#]	Frequency	Use
Flares <ul style="list-style-type: none"> • Domgas Emergency • LNG Emergency • Operational • Liquid disposal • LNG Storage and Loading • LPG Storage and Loading • LPG Operational 	Dark smoke according to the Ringelmann scale	As required; for dark smoke greater than Ringelmann 1 for more than 30mins	Environment Licence compliance Equipment performance monitoring

* Stabiliser furnace 3 was monitored, but is retired, as it is no longer required.

Sampling is conducted by accredited laboratories and testing methods.

Routine maintenance is conducted as recommended by equipment vendors. For gas turbines, regular maintenance to ensure air quality includes Dry-Low NOx mapping and tuning of the combustion systems. These activities aim to maintain the machines, control NOx emissions and manage efficiency.

Any exceedances of licence criteria will be investigated and reported using Woodside’s incident reporting procedure. The investigation may consider:

- identifying the root cause of the exceedance and the circumstances surrounding the exceedance event;
- implementing remedial controls to control or eliminate the source of the exceedance;
- identifying appropriate corrective and preventive controls to prevent any future such exceedances;
- implementing controls; and
- monitoring the situation thereafter.

All exceedances of licence criteria, including analysis of the cause, and contingency actions implemented by Woodside, will be presented with the Annual Environment Report.

In 2021, Woodside will conduct an investigation into the feasibility of the installation of best practice emissions monitoring technology, including Predictive Emissions Monitoring System (PEMS) or Continuous Emissions Monitoring System (CEMS).

4.2.2 MA2 – Undertake emissions performance monitoring and reporting

In accordance with the requirements of NPI, emissions from the NWS Extension will be monitored and reported annually. Monitoring and reporting will be practicable for field implementation and of an appropriate methodology and duration. Estimation methods include a combination of default emissions factors, engineering calculations, point source monitoring, estimation and/or package combustion monitoring data. Results obtained through this monitoring will be used to demonstrate compliance with proposed air emission reductions outlined in the NWS Extension ERD (specified in MA4).

In calculating key emission sources, sufficient stack emissions test concentrations and turbine operating mode data is obtained to reflect a range of operating conditions thus ensuring emissions estimation and reporting is representative, repeatable and of reasonable accuracy.

The monitoring of emissions after emission-reduction opportunities are implemented will be conducted to verify that the reduction opportunities have been realised.

4.2.3 MA3 – Monitor ambient air concentrations of relevant emissions, that contribute to human health risks

The NWS Project voluntarily established BAAMP in 2008, which continued until 2011. The intent of the program was to gain a better understanding of how operations on the Burrup Peninsula may affect local air quality. Aspects of the program continued to support the Woodside operated Pluto LNG Development from 2011 through to the end of 2015.

The BAAMP allowed for the comparison of observed ground level concentration air emissions to that of the Proposal air quality modelling and validation of approval process risk assessments. Monitoring was undertaken by specialist consultants in line with relevant monitoring and analysis standards. A number of reviews have occurred throughout the program, including an independent review process which was coordinated by Woodside using an independent peer reviewer and review methodology endorsed by the OEPA (now DWER - EPA Services). Reviewer reports accompanied Pluto LNG program compliance reporting to the OEPA.

Review of the BAAMP confirmed that nitrogen dioxide levels were below Australian standard levels currently set to protect human health and well-being and are also below the World Health Organisation and United States EPA levels designated for protection of vegetation (Golder, 2014).

In advance of potential changes to industrial air emissions on the Burrup Peninsula, Woodside voluntarily recommenced ambient air monitoring in 2019 to further understand ambient air quality in the region. The program is expected to extend the historical dataset and complement ambient air quality monitoring proposed under the Murujuga Rock Art Strategy.

It is Woodside’s intention to continue the ambient air monitoring program until its absorption or replacement with the coordinated approach established under the Murujuga Rock Art Strategy.

Woodside’s current ambient air monitoring program uses up to three powered monitoring stations to continuously monitor applicable pollutant gases and meteorological conditions, such as wind speed and direction. The program design draws from historical experience and review outcomes, with consideration of numerous factors when designing the scope and selecting the locations for these monitoring stations (listed in **Table 4-3** and Figure 4-1) including:

- objectives of the monitoring campaign
- logistical and environmental issues (e.g. access to electricity; ease of access for routine and non-routine service visits)
- site security
- applicable standards.
- The program may be updated from time to time in accordance with Section 5.

Table 4-3: Ambient Air Monitoring Locations

Monitoring Station	Location	
	Easting	Northing
Karratha (K)	484,892	7,707,575
Burrup Road (BR)	476,665	7,721,038
Dampier South (DS)	470,239	7,716,142

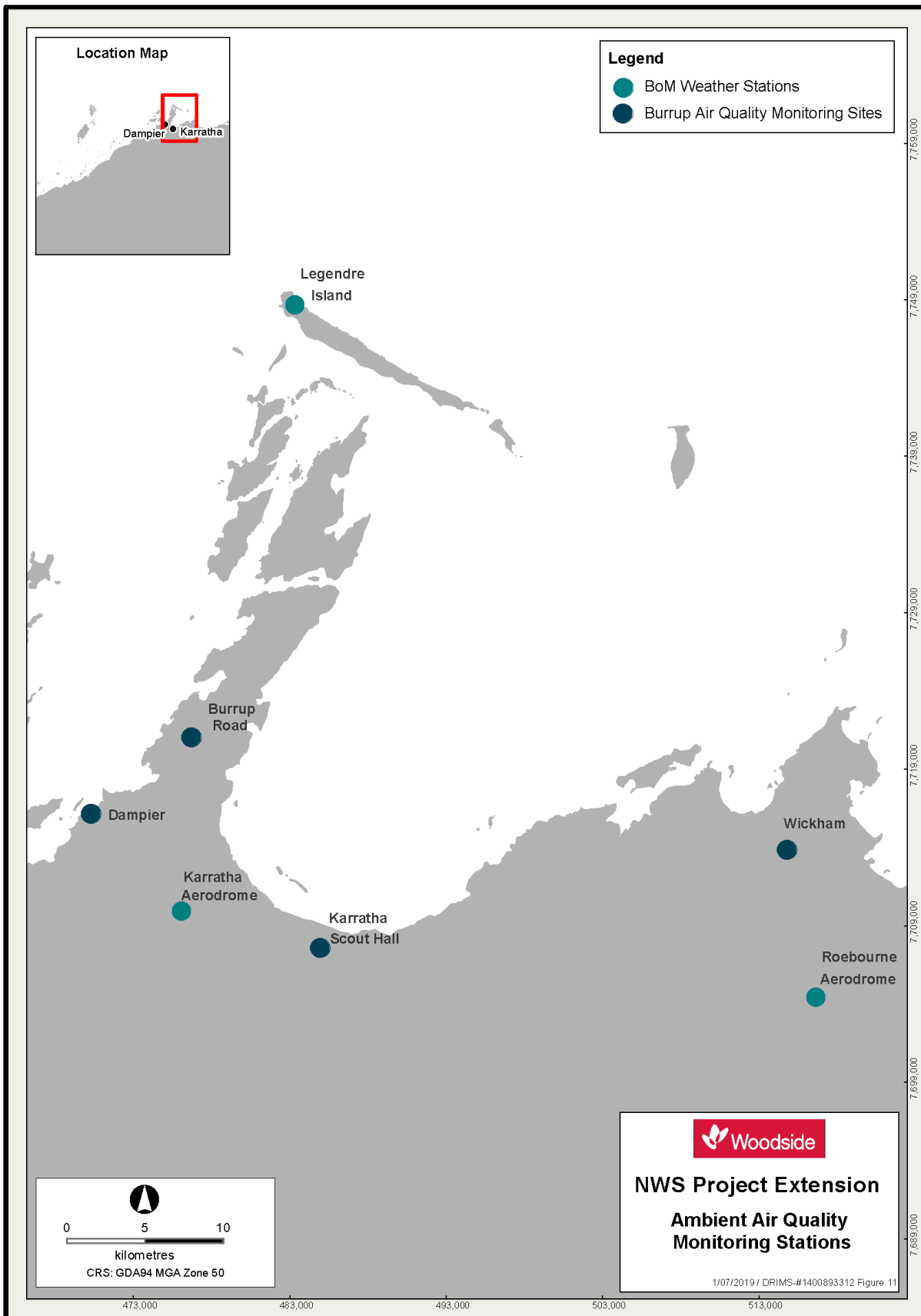


Figure 4-1: Regional BAAMP Ambient (AQ) and Bureau of Meteorology (BoM) monitoring stations

Ambient air quality is monitored based on the details in **Table 4-4** and compared to the assessment criteria in **Table 4-5**.

Table 4-4: Ambient Air Monitoring Parameters

Parameter	5-minute Averaged	15-minute Averaged	1-hour Averaged	24-hour Averaged	Stations
NO _x	✓	-	✓	✓	K, DS, BR
O ₃	✓	-	✓	✓	K, DS
BTX	-	✓	✓	✓	BR
Temperature and relative humidity	✓	-	✓	✓	K, DS, BR
Wind speed and direction	✓	-	✓	✓	K, DS, BR
Global solar radiation	✓	-	✓	✓	K, DS, BR

Table 4-5: Ambient Air Monitoring Criteria

Parameter	Ambient Air Quality Standards and Triggers		
	Concentration (ppb)	Averaging Period	Standard / Source
NO ₂	120 ppb	1 hour	NEPM (Ambient Air Quality)
	30 ppb	Annual	
O ₃	100 ppb	1 hour	NEPM (Ambient Air Quality)
	80 ppb	4 hours	
Benzene	3 ppb	Annual	NEPM (Air Toxics)
	9 ppb (investigation trigger)	1 hour	NSW EPA (2016)
Toluene	1000 ppb	24 hours	NEPM (Air Toxics)
	100 ppb	Annual	
	90 ppb (investigation trigger)	1 hour	NSW EPA (2016)
Xylene	250 ppb	24 hours	NEPM (Air Toxics)
	200 ppb	Annual	
	40 ppb (investigation trigger)	1 hour	NSW EPA (2016)

It is acknowledged that the Commonwealth of Australia has published a Notice of Intention to vary the NEPM (Ambient Air Quality). Implementation of NEPM Standards for the Ambient Air Monitoring Program will duly reflect the most up-to-date in-force NEPM standard.

NSW EPA (2016) guidance is used to assist in interpretation of short-term (1-hour average) BTX monitoring data. It is used for air quality modelling screening purposes, however does not necessarily imply impacts to human health will occur and is not an ambient air quality standard.

All monitoring stations are checked and maintained regularly. During maintenance and outages, a record is kept of equipment downtimes, durations, and causes.

The Annual Environment Report will summarise the results of the ambient air monitoring program. Presentation of results will record the data recovery rate and history, including exception reports, maintenance notes, and statistical representation of captured data. Data statistics will include maximum, 99th, 95th, 90th, and 70th percentiles, median, averages, and a comparison of recorded data to the standards outlined in **Table 4-5**.

Any exceedances of relevant ambient air quality standards will be investigated and reported using Woodside’s incident reporting procedure. A screening analysis (based on the wind direction immediately before and during the exceedance) will be undertaken to identify the possible source of the exceedance, if required. If it is determined that operation of the Proposal is a likely source, then the exceedance will be investigated further, and may consider:

- confirming that the source of the exceedance is likely to be the operation of the Proposal;
- implementing remedial controls to control or eliminate the source of the exceedance;
- identifying the root cause of the exceedance and the circumstances surrounding the exceedance event;

- identifying appropriate corrective and preventive controls to prevent any future such exceedances;
- implementing controls; and
- monitoring the situation thereafter.

All exceedances of ambient air quality standards, including analysis of the cause, and any contingency actions implemented by Woodside, will be presented with the Annual Environment Report.

Air monitoring criteria (Table 4-4) will be updated as relevant standards are updated and monitoring will be performed against the most up to date Air Quality Standards and Triggers.

4.2.4 MA4 – Adopt practicable and efficient technologies to reduce air emissions

NOx and VOC emissions will be managed using the hierarchy of controls. 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 NOx emissions from the Proposal by 40%¹ and substantially reduce VOC emissions by 31 December 2030². Monitoring of performance against this target will be performed annually and progress reported through the Annual Environment Report.

If substantial emissions reductions can be achieved through installation of new equipment (particularly emission reduction equipment), point source emissions will be monitored before and after installation to verify that the equipment operates within the expected parameters.

Woodside will present the results of the point source emissions testing against anticipated emissions reduction performance in the annual environment report.

4.2.5 MA5: Implement an adaptive management plan addressing the potential impact to rock art from industrial emissions

The adaptive management approach adopted in this AQMP (**Section 5**) has been developed cognisant of the Strategy and the EQMF (**Section 3.3.1**). The management actions in this AQMP will be updated once the environmental quality criteria for management of the rock art on the Burrup Peninsula are released. This management plan will be revised in accordance with **Section 5**.

4.2.6 MA6: Support the implementation of, and participate in, the DWER Murujuga Rock Art Strategy

Woodside propose to manage potential impacts to Aboriginal rock art on the Burrup Peninsula in accordance with the Strategy and as a member of the Stakeholder Reference Group.

As described in **Section 3.3.1**, the purpose of the strategy is to protect the Aboriginal rock art on the Burrup Peninsula by providing a long term framework for monitoring and analysing potential changes to the rock art and describing a process by which management responses should be put in place to address adverse impact on the rock art. The monitoring program and associated scientific studies are being designed and implemented by DWER to monitor, evaluate and report on changes and trends in the integrity of the rock art, specifically to determine whether anthropogenic emissions are accelerating the natural weathering/alternation/degradation of Aboriginal rock art.

The implementation of the Strategy, Framework and Monitoring Program (DWER, 2019a)¹² will remove much uncertainty surrounding potential pathways linking industrial emission and accelerated weathering and allow for timely investigation and management where required. The proposed 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.

Historically, Woodside has made a significant financial contribution to a range of scientific studies on the Burrup Peninsula and will continue to contribute to a range of scientific studies on the Burrup Peninsula by providing funds to support the Strategy's implementation. Woodside will also assist with implementing the Strategy through its role on the Stakeholder Reference Group, which has been established by the Minister for Environment to assist with communication and stakeholder engagement.

¹ Woodside is currently 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 NOx emission reductions, Woodside is reviewing current best practice in low NOx technology available for gas turbines. The most recent LNG trains (Trains 4 and 5) constructed at the KGP are already equipped with low NOx 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, as per the AQMP.

² Based on the percentage of reported emissions from KGP over the five-year annual average, covering the 2013/14 to 2017/18 financial years.

5. ADAPTIVE MANAGEMENT AND REVIEW OF THE AQMP

The ability to respond to scientific advances is particularly important for managing potential impacts from air emissions, both in terms of potential impacts to human health and amenity and the Murujuga rock art.

Woodside has not identified any peer-reviewed studies that identify measurable or observable changes to the condition and integrity of the rock art as a result of industrial emissions to date. However, it is acknowledged that there is ongoing scientific research in this area, particularly that being conducted in accordance with the Murujuga Rock Art Strategy and there is need to implement sound adaptive management practices to monitor and respond to new scientific data.

Additionally, emissions from current and forecast future operations will remain well within National Environmental Protection Measure (NEPM) criteria, minimising potential risks to human health. However, it is noted that there may be future changes to Ambient Air NEPM criteria in the future.

In line with the concept of adaptive management and considering the above, the management actions presented in this AQMP shall be monitored, reviewed, evaluated and updated, as required, considering:

- outcomes of any technical review of and evaluation of the emissions and ambient air quality monitoring programs
- new scientific information published, as part of the Murujuga Rock Art Strategy, about the potential impacts of industrial air emissions on Aboriginal rock art of the Burrup Peninsula and that information suggests new or updated provisions should be included in this AQMP.
- new and relevant data/information gained as a result of implementing this AQMP, or from external sources
- effectiveness of proposed emission reduction technologies in achieving proposed targets
- changes in State or Commonwealth legislation or policy.

With relevant updates included in a revised AQMP. In addition, this AQMP may be reviewed:

- based on EPA and decision-making authorities (DMAs) comments during the Environmental Review Document (ERD) approval process
- after any new or revised operating licence is issued under Part V of the *Environmental Protection Act 1986* (WA)
- if a significant environmental incident occurs related to the protection of ambient air quality and human health
- if a new process or activity is proposed to be introduced that has the potential to alter the emissions from the Proposal (and that is not in accordance with this AQMP)

Technical review and evaluation of the management actions outlined in this AQMP will be conducted every five years³ (if not initiated prior to that time) to ensure the management actions are adequately addressing the key risks and meeting EPA objectives. If, as a result of any review, any significant changes are required to be made to the monitoring program or any other aspect of this AQMP, a revised AQMP will be provided to the EPA for approval.

When the five-yearly review cycle is triggered, or if a significant change to either the facility, activity, or risk is identified, a revised AQMP will be submitted to the EPA. When approved, the revised plan will be made publicly available.

³ Frequency no more than annually.

6. STAKEHOLDER CONSULTATION

This AQMP is included as an appendix to the ERD for the Proposal (Woodside, 2019) and therefore is to be reviewed by the EPA, key DMAs, and the general public as part of the assessment process for the ERD. Comments received from the EPA and DMAs during the initial review are incorporated into this AQMP before publication of the ERD (and associated management plans) for public review and comment. All comments received during the public review period that relate to this AQMP are to be considered, and changes made to this AQMP where required.

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8. TERMS

Terms	Definitions
~	Approximately
µg	Microgram
AGRU	Acid Gas Removal Unit
AQMP	Air Quality Management Plan
BR	Burrup Road (monitoring station)
BTX	Benzene, toluene, and xylene compounds
CO	Carbon monoxide
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalent
DMA	Decision-making Authority
DS	Dampier South (monitoring station)
DWER	Western Australian Department of Water and Environmental Regulation
EPA	Western Australian Environmental Protection Authority
ERD	Environmental Review 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.
g/s	Grams per second
GHG	Greenhouse gas
GHGMP	Greenhouse Gas Management Plan
ha	Hectare
K	Karratha (monitoring station)
KGP	Karratha Gas Plant
km	Kilometre
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
m ³	Cubic metre
m ³ /s	Cubic metres per second
mg/m ³	Milligrams per cubic metre
mtpa	Million tonnes per annum
NEPC	National Environment Protection Council
NEPM	National Environmental Protection Measure
NO ₂	Nitrogen dioxide
North West Shelf (NWS) Project	The North West Shelf (NWS) 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.

Terms	Definitions
North West Shelf Joint Venture (NWSJV)	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.
NO _x	Oxides of nitrogen
NPI	National Pollutant Inventory
NWS	North West Shelf
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; and ongoing operation of the NWS Project to enable long-term processing at the NWS Project facilities, currently expected to be until around 2070.
NWSJV	See North West Shelf Joint Venture
O ₃	Ozone
PAQS	Pilbara Air Quality Study
PM	Particulate matter
PM ₁₀	A dust fraction with an aerodynamic diameter of less than 10 microns
PM _{2.5}	A dust fraction with an aerodynamic diameter of less than 2.5 microns
ppb	Parts per billion
ppm	Parts per million
Proposal	See NWS Project Extension Proposal
Section 38 referral	Referral to EPA under the Environmental Protection Act 1986 (WA)
SO ₂	Sulphur dioxide
SO _x	Sulphur oxides
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.
VOC	Volatile organic compound
WA	Western Australia
Woodside	Woodside Energy Ltd. Proponent of the NWS Project Extension Proposal and the Operator of the NWS Project on behalf of the NWS Joint Venture.