Perdaman Urea Project

Environmental Management Plan

Air Quality

Final

Version PCF 2

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Perdaman Chemicals and Fertilisers Pty Ltd

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PCF 2	Revised – DAWE Consultation Feedback	25-Mar-2021	Cardno	Cardno

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1 Overview

Perdaman Chemicals and Fertilisers Pty Ltd (Perdaman) plans to construct and operate a modern urea plant with a production capacity of approximately 2 million tonnes per annum (Mtpa). The plant would be located within the Burrup Strategic Industrial Area (Burrup SIA), on the Burrup Peninsula, approximately 10 kilometres (km) from Dampier and 20km north-west of Karratha in the north west region of Western Australia.

The project would source natural gas from the nearby Woodside operated gas facility. The natural gas would be converted to urea via a series of processing stages involving autothermal reforming (to produce syngas), gas treatment to adjust the syngas to hydrogen (H_2) and carbon dioxide (CO_2) followed by ammonia synthesis and conversion into urea in a granulated form. This final granulated product would be transported to local and international markets via Dampier Port.

Urea is a commonly used fertiliser, containing 46% nitrogen. Nitrogen is essential for crop growth as it is an element used by plants to produce protein as well as it being a component of their DNA. Urea is one of the most economical sources of nitrogen fertiliser, and globally, is the most popular nitrogen-based fertiliser in use. It is also used throughout Australia and is available from rural produce stores and nursery suppliers. In recent years, Australia has imported on average approximately 2 Mtpa of urea, mostly from the Middle East with smaller volumes imported from China and other countries. Urea imported from the Middle East is typically sourced from older plants (10 to 25 years old) and urea imported from China is primarily produced using coal as feedstock (SNC-Lavalin, 2019).

The economic and social benefits of the project are discussed at length in the Environmental Review Document (ERD) documentation (Cardno, 2020). It is expected to include capital investment in Western Australia leading to company and government taxation revenue, more than 2000 construction phase linked jobs and subsequent direct and indirect employment opportunities during the long term operation of the project. The production and supply of urea to the global agricultural sector is expected to improve crop production where it is in use. Urea has a number of other uses, including being an additive in fuels with Selective Catalytic Reduction (SCR) to reduce NOx emissions (Cardno, 2020).

This Air Quality Management Plan (AQMP)[1] has been prepared in accordance with relevant environmental impact assessment guidelines, including those relevant to the preparation of environmental management plans (EPA, 2020). This current version of the AQMP has been prepared taking into account feedback received during the public consultation process associated with the ERD. The AQMP therefore details the measures that Perdaman will implement to manage air emissions from the project. This is summarised in Table 1-1.

[1] Note: As the EPA advises that, in accordance with it's Greenhouse Gas Guidelines issued in April 2020, Greenhouse Gas is considered a separate key environmental factor, a separate project Greenhouse Gas Management Plan has been prepared for that key environmental factor.

Table 1-1: Summary of AQMP

Title of proposal	**Perdaman Urea Project**
Proponent name	Perdaman Chemicals and Fertilisers Pty Ltd (Perdaman)
Purpose of the Environmental Management Plan – Air Quality (AQMP)	Environmental Scoping Document (ESD) requirement – outlines work requirements for the ERD to show how Project emissions to air will be monitored and managed so that the relevant environmental values are protected, including development of an AQMP.
Key environmental factors[2]	Air Quality
Key environmental objectives	Air Quality - To maintain air quality and minimise emissions so that environmental values are protected (EPA, 2016; EPA, 2020). Environmental values' is defined under the *Environmental Protection Act 1986* as a beneficial use, or an ecosystem health condition. The ecosystem health values related to air quality as applied in Environmental Impact Assessment (EIA) are human health and amenity (EPA, 2020). The cultural value of the Burrup Peninsula and the Murujuga Airshed is also acknowledged.
Key provisions in the plan	Outlined in Table 5-2, and summarised here including: • Incorporate Project design features and key pollution control equipment to minimise emissions, including but not limited to – ○ ammonia scrubber (Urea Absorber vent) ○ particulate/ammonia scrubber (Urea Granulation) ○ Dry Low-NOx burners (Power Generation) ○ Stack emission sampling ports and associated safe stack sampling access platforms • Confirm Project emissions of key pollutants through stack emission testing and reporting of other process control indicators. • Verify the air quality impacts of the Project predicted in the Air Quality Impact Assessment by comparison to ambient air quality measurement results. • Support the implementation of, and participate in, the Murujuga Rock Art Strategy.[3] • Implement an ambient air quality monitoring program to establish baseline conditions for ammonia and urea

[2] At the commencement of the assessment process, (2018) the Environmental Review Document (ERD) approved in 2019 was reflective of the EPA guidelines of the time (EPA, 2016). That "Air Quality" guideline addressed both air emissions and greenhouse gas emissions. The assessment documentation made available for Public Environmental Review (March 2020) was also consistent with this. In April 2020, EPA published a revised environmental factor guideline for greenhouse gas emissions. The Greenhouse Gas Management Plan (GHGMP) has now been separated from the Air Quality Management Plan (AQMP) which originally was included in Appendix K of the ERD. This separated AQMP is based on feedback received during the consultation period including the consideration of public submissions.

[3] In February 2020, Puliyapang Pty Ltd was appointed by the WA government to develop and implement the monitoring program, which will be overseen by the DWER and MAC, in consultation with national and international subject-matter experts and stakeholders. Puliyapang is a registered Aboriginal business and is a joint venture between Tocomwall and Calibre, and has partnered with subject matter experts from Curtin University, Artcare and ChemCentre to deliver the monitoring program.

Title of proposal	Perdaman Urea Project
	deposition to augment and inform future co-ordinated monitoring pursuant to MRAS.

2 Scope

2.1 Proposal assessed

Perdaman proposes to construct and operate a Urea Production Plant on the Burrup Peninsula, Western Australia. The Project will be located within the Burrup SIA approximately 10 km from Dampier and 20 km north-west of Karratha. The Urea Production Plant would be the sole urea production facility in Western Australia. The planned production capacity is approximately 2 Mtpa. Natural gas for feedstock to the urea plant will be sourced from a nearby domestic gas plant. The urea product will be transported via closed conveyor to the nearby Dampier Port for export. The life of the project is estimated to be 40-years (based on site access lease), with a possible extension of a further 40-years, making the possible life of project up to 80 years (i.e. decommissioning in 2100).

The Project is described in its entirety in the ERD (Cardno, 2020). Emission estimation is described in full in the ERD (Cardno, 2020) and the associated emission assessment, as summarised in Section 4.2. This revision of the AQMP includes more recent updates and revisions based on feedback received during the ERD public consultation period.

This AQMP will be implemented following receipt of approval under the provisions of the *Environmental Protection Act 1986* (WA) (EP Act), both Part IV and Part V approvals as well as under the provisions of the *Environment Protection Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act).

This AQMP will be reviewed periodically and updated as the Project proceeds.

2.2 Purpose and scope of the AQMP

This AQMP outlines how project emissions to air will be monitored, avoided and managed so that the relevant environmental values are protected.

2.3 Key environmental factors

Air quality is identified as a key environmental factor for the Project. As outlined in the EPA guideline (EPA, 2020) the objective recognises the "fundamental link between good air quality and the environmental values it supports. It also recognises the principle of waste minimisation as set out in the *Environmental Protection Act 1986",* and that "maintaining good air quality and minimising emissions protects human health and amenity, as well as the broader environment."

2.3.1 Potential Impacts

A review of the potential for project impacts to the key environmental factor Air Quality was undertaken as part of the development of the Environmental Scoping Document (ESD) (Cardno, 2019) which was approved by the EPA on 19th July, 2019 following a period of circulation for public comment. Based on the review undertaken as part of the EPA approved ESD, the Potential Impacts, Mitigation and Outcomes are shown in Table ES3 of the ERD (Cardno, 2020). The relevant Air Quality key environmental factor portion of ERD Table ES3 forms Appendix A of this plan.

ERD Scoping Checklist Air Quality key environmental factor section (reproduced below), summarises the relevant ERD sections addressing the work requirements identified in the EPA approved ESD for this key environmental factor. This AQMP should be read in conjunction with the relevant ERD sections identified in the Scoping Checklist for greater context.

ERD Scoping Checklist

Task No.	Scope of Work	Section No.
Air Quality		4.8
7.1	Characterise existing (baseline) air quality and meteorology within the Murujuga airshed, drawing on the findings of relevant studies and publicly available monitoring datasets. This would be undertaken either separately by the Proponent, or collaboratively with other industry data custodians.	4.8.3.3
7.2	Identify the key air pollutants of potential concern and characterise the emissions from the Project and other existing and proposed future industrial emission sources and both existing and proposed future shipping activities within the Murujuga airshed, within the context of the current air emissions inventory for the region.	4.8.4, Appendix D
7.3	Identify the key sensitive receptors in terms of potential health and amenity impacts and heritage values within the Murujuga airshed.	4.8.4
7.4	Evaluate the potential incremental impact of air emissions from the Project on key receptors in the vicinity of the project area. a. Undertake air dispersion modelling. The objective of this modelling is to predict the potential ambient air quality impacts of the Project. This will include scenarios considering the emissions from the Project (in isolation), the increased emissions that would be generated during start-up, upset conditions, and shutdown; and the incremental cumulative impact of the Project considering other industry currently operating (or approved to operate but yet to be built) and proposed future industrial facilities such as Wesfarmers Downstream Chemical Production Facility[4] in the project area. Emissions from existing and proposed future shipping activities will also be included in the cumulative air quality modelling scenarios[5]. Contour plots and tables listing the modelled ambient ground level concentrations for the air pollutants of concern for the relevant modelling scenarios will be included. b. Evaluate the potential incremental human health and amenity impact of the Project by assessing predicted pollutant concentrations in the ambient air at key receptors against relevant ambient air quality standards. c. Evaluate the potential incremental risk of impact upon rock art by assessing predicted pollutant deposition rates at key sensitive receptors. This assessment will be done within the context of the	4.8.5

[4]In relation to proposed future industrial facilities it is noted that as these facilities are only proposals and not yet approved, relevant primary emissions data may not be accessible in the public domain. While best endeavours will be used to access relevant primary data, where this cannot be sourced the modelling will include generic surrogate information for a comparable plant and sited in the proposed development location.

[5] In relation to emissions from shipping it is noted that primary data recording emissions from actual individual or aggregate shipping movements in the Port of Dampier is not available. Therefore, an appropriate surrogate dataset as agreed with the Air Quality Branch and WA EPA will be incorporated in the model to account for this source of emissions into the Murujuga airshed.

Task No.	Scope of Work	Section No.
	Murujuga Rock Art Strategy (released on 15 February 2019), which provides a monitoring, analysis and decision-making framework to protect Aboriginal rock art located on the Dampier Archipelago and Burrup Peninsula listed National Heritage Place.	
7.5	Identify and justify all reasonable and practicable emission reduction equipment and proposed technologies, and demonstrate the use of industry best practice pollution control technology and plant processes including benchmarking against world's best practice for urea production plants.	4.8.6, Appendix L
7.8	Include information on the development of an Air Quality Management Plan and the objectives, management and mitigation measures, trigger and contingency actions, and monitoring of air emissions and ambient air quality, that will be employed to ensure that residual impacts are not greater than predicted. Potential credible opportunities to achieve a long-term reduction in air emissions of concern using best practice measures will be identified and evaluated in the ERD.	Appendix K
7.9	Demonstrate and document how the EPA's objective for this factor can be met.	4.8.7

As indicated in the Scoping Checklist above, Section 4.8 of the Project ERD (Cardno, 2020) provides detailed description and assessment of the Project's potential impacts on air quality and the potential consequential impacts of that may potentially result from changes to regional air quality attributable to the Project.

A number of public submissions on the ERD included issues relating to the Air Quality key environmental factor. The issues raised were reviewed and a response provided in Perdaman's Response to Submissions (RtS) (Cardno, 2021), specifically in:

Appendix	Response to Submission by
D	Pilbara Ports Authority
E, H, J	Public Unidentified
F	Horizon Power
J	Murujuga Aboriginal Corporation
L	Hon. Robin Chapple, MLC
M	City of Karratha
N	Friends of Australian Rock Art (FARA)
P	Department of Water and Environmental Regulation (DWER)
Q	Department of Agriculture, Water and the Environment (DAWE)
R	Department of Biodiversity, Conservation and Attractions
S	DWER (Air Quality Services Branch

For greater context, this AQMP should be read in conjunction with the relevant RtS Appendices shown above.

To summarise the ESD (Cardno, 2019), ERD (Cardno, 2020) and RtS (Cardno, 2021) review and discussion, the Project is a source of atmospheric emissions comprised of NOx, ammonia and urea particulate matter (as PM_{10} and $PM_{2.5}$) of primary concern with respect to air quality on both the local and regional scale.

As described in Section 4.2 of ERD Appendix D – Air Quality Modelling (Jacobs, 2020) a risk assessment was undertaken to identify Perdaman's most important air emissions sources and substances for more detailed assessment. The computational part of the risk assessment was based on comparisons of air emissions estimates from various sources e.g. NPI, Woodside, Perdaman, etc., with a consistent set of ambient air quality standards. The risk assessment also drew on other results of analysis e.g. for Woodside, in a qualitative manner.

In summary, the quantitative risk assessment comprised:

- Analysis of air emissions data provided by Perdaman in relation to the project; i.e., NO_x, SO_2, ammonia, particulate matter, VOCs, formaldehyde, and methanol (Jul-Nov 2019).
- 'Risk values' were calculated by ratios between the mass emissions estimates for each substance and air quality standards. Note the calculated risk values can be considered as proportional to 'dispersion volumes' required for each substance – the larger the dispersion volume required for a particular substance, the higher the risk.
    - The Victorian air quality policy 'design criteria' were used for calculations. Intercomparisons were made with NSW and SA impact assessment criteria to check consistency, which was satisfactory.
    - Conservative (high) estimates of 50% were used for NO_2/NO_x and $PM_{2.5}$/PM_{10} ratios.
    - Background concentrations were excluded from the risk calculations, but assessed qualitatively with the calculated results.

The Project is located within the Murujuga (the Dampier Archipelago and Burrup Peninsula) Airshed. Murujuga is recognised as a unique ecological and archaeological area containing one of the largest collections of Aboriginal engraved rock art (petroglyphs) in the world. Industrial air emissions are of importance within the context of regional air quality (human health and amenity) and concern over the potential risk of impacts to rock art integrity and the National Heritage Place values that are inextricably linked to rock art in the identified listing criteria.

The key issue of concern for the rock art is the potential for colour changes to occur due to natural weathering of the rock art being accelerated by industrial air emissions. An understanding of the weathering processes that are naturally affecting the rock art, and how anthropogenic emissions may alter these processes, is not yet clearly established. The ERD (Cardno, 2020) and RtS (Cardno, 2021) include reviews of the current available relevant information, studies, monitoring and strategies to better understand potential risks to the integrity of rock art at Murujuga, to mitigate risk of future detriment impacts and an appropriate risk weighted application of the precautionary Principle in this regard.

In this context, it should be recognised that ammonia and urea particulates are not acid forming pollutants. Further, urea dust can decompose rapidly to volatile gas phases in a hot, dry ambient terrestrial environment with little or no potential for regular rain, such that losses through volatilisation may be potentially significant (Cardno, 2020).

In order to address the risks associated with this uncertainty, the Perdaman commits, as part of the implementation of the approved project, to be a contributing participant in the MRAS.

Further, in relation to managing risks associated with this uncertainty the Perdaman notes:

- the work and conclusions of Dr Ian MacLeod in the 2005 paper quoted by Black at the Senate inquiry as cited in the ERD and again quoted in a number of submissions on the ERD, were based on the analytical concentration of nitrate ions recovered from the washed surfaces of rocks in the Burrup (Dr Ian MacLeod pers comm)
- the 2005 report by MacLeod only discussed soluble nitrates found on the rock surfaces and made no comment on ammonia or ammonium ions or urea (Dr Ian MacLeod pers comm)
- the material presented to the Senate Committee specifically sought to demonstrate acidic emissions, and used the term "acidic", as an area of concern for rock art integrity
- the Perdaman is not aware of submissions to the Senate Committee or elsewhere demonstrating that urea deposition was a specific contributor source to the concerns
- scientific data confirms that urea is alkaline, not acidic
- as biological ecosystem responses in the nitrogen cycle have been suggested to be an underlying concern being raised, it is relevant for the current understanding to review and consider the relevant

risk weighting to apply to the quoted evidence relates to urea in the nitrogen cycle or solely to other specific constituents i.e. nitrates, of the nitrogen cycle.

- knowledge/data on variable biological responses in ecosystems to different elements of the nitrogen cycle as cited in the ERD (Section 4.8.4.1 P154), are potentially relevant, with appropriate risk weighting, to current and future considerations, whether at the microflora or macrofloral scale.

Notwithstanding the above, the Perdaman acknowledges that there are possibilities of the urea providing some form of stimulation of the combined biological response associated with the natural microflora living on Murujuga rocks. Being part of the complete nitrogen cycle, it is possible that specific microorganisms on the rocks may utilise this additional source of nitrogen reservoir. However, the normal chemical reaction of urea undergoing hydrolysis (reaction with moisture, water) is shown below, with the intermediate step of carbamic acid being only stable at -23^{o}C, before hydrolysis releases the second ammonia molecule and releases the carbon dioxide, from which the process began. It should be noted in this hydrolytic breakdown the oxidation state of the nitrogen is still (-III) in the urea and in the ammonia gas.

$CO(NH_2)_2 + H_2O \rightarrow CO(NH_2)OH + NH_3$ and then $CO(NH_2)OH + H_2O \rightarrow CO_2 + NH_3$

With ambient temperatures of the rocks at Murujuga being at least 50^{o}C above the decomposition point of the carbamic acid the second reaction would be spontaneous. It is very unlikely that sufficient urea will become biologically available to facilitate biological interaction and so become oxidized to the (+III) state of nitrite or the (+V) state of nitrate ions.

The above is relevant to an appropriately risk weighted consideration of the precautionary principle.

Perdaman considers it is appropriate to recognise that if an emission does not leave site as a saleable or useable product, it must leave or be managed as a waste, either as a long-term legacy onsite or as a discharge (emission) offsite. Perdaman reaffirms the application of BAT in design and operation to reduce emission risks to ALARP.

In terms of the EP Act "Polluter Pays" principle, Perdaman reaffirms that the site will be a Prescribed Premise subject to approvals including emission related fees pursuant to Part V of the EP Act.

The reduction of residual NO_x emissions is at diminishing returns – lower NO_x numbers in one process area, and;

- can result in greater use of resources to manufacture and install any necessary equipment;
- with greater power and water draw demands in operation;
- both of which results in increased NO_x and other product of combustion emissions; and
- that can be disproportionate to the initial reduction being sought.

Notwithstanding the considerable work to date on identifying and implementing vendor solutions that deliver BAT performance, especially in relation to air emission, as part of its approach to the Precautionary Principle and to continuous environmental improvement, during the Detailed Design phase, Perdaman commits to continuing to explore BAT opportunities where the application of alternative vendor solutions for urea production can practicably deliver equal or better environmental performance, including air emissions. Where such is achievable, Perdaman will include in its application for Part IV Works Approval a third party reviewed report demonstrating equal or better environmental performance.

2.4 Plan Rationale and approach

This AQMP describes how emissions to air from the project will be monitored and managed with the intent of minimising the project's environmental impact.

The relevant studies conducted by Perdaman in association with the environmental approvals for the Project have been used to inform the development of this AQMP. This includes the following:

- *Perdaman Urea Project Air Quality Impact Assessment, Final Revision 7, 15 March 2020* (Jacobs, 2020).
- *Perdaman Project Destiny Benchmarking of Technology BAT and Emissions* (SNC Lavalin, 2019)
- *Perdaman Project Destiny Review of the Technology Selections* (SNC-Lavalin, 2019).

The Air Quality Impact Assessment (Jacobs, 2020) applied air dispersion modelling to predict the potential ambient air quality impacts of the Project. The assessment considered the potential impacts of the Project (in-isolation) and the incremental cumulative impact of the Project based upon existing and possible future industrial emissions in the region. The air quality impacts are assessed in terms of potential human health and amenity, and in terms of the relative change in air quality as a result of Project emission.

The overall conclusions of the assessment with respect to human health are that, based on modelling which showed compliance with the relevant air quality criteria, there is a low risk of material air quality impact on human health from the Project. The modelling indicated the key pollutants of concern (i.e. those with predicted impacts most closely approaching the relevant air quality criteria) to be dust (comprised of PM_{10} and $PM_{2.5}$ size fractions) and ammonia emitted under normal plant operations from the urea production process primarily.

3 Management Framework

3.1 Relevant internal management mechanisms

Perdaman maintains an environmental management system (EMS) that addresses activities with a potential to affect the environment. As described in the ERD, a key element of the EMS includes assessing risk to identify potential impacts early in the risk assessment process to enable sufficient planning for avoidance and/or mitigation (Cardno, 2020).

The overarching Project Environmental Management Plan (PEMP) documents the strategic environmental controls and Project specific procedures, management plans and protocols that will be used for the Project. It aims to provide an instrument to:

- Comply with permit and approval requirements for the Project granted under Part IV of the *Environmental Protection Act 1986* (WA) (EP Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) and any other ancillary approvals;
- Address applicable legislative and regulatory requirements; and
- Provide a framework for continual improvement and application of best industry practice.

The PEMP outlines the requirements for identifying obligations, planning, auditing, monitoring, reviewing, reporting and managing environmental performance. This AQMP is a sub-plan of the PEMP.

The company's Environmental Policy is the foundation for all of Perdaman's environmental management processes and includes a statement signed by the Chairman / Managing Director. This policy is communicated to all Project personnel and is freely available for all interested parties.

Perdaman's environmental management approach is risk-based, systematic and responsive to change. This is achieved by undertaking comprehensive risk assessments to ensure all hazards are identified, assessed and evaluated to effectively eliminate or control risk levels to an acceptable level. This includes:

- All work environments containing hazards will be assessed.
- Perdaman's risk assessment tools being utilised and associated documentation being retained.
- Risk assessments will be performed regularly and in a timely manner by qualified personnel and with sufficient management representation.
- Risk assessments will be conducted whenever changes occur to the scope of work, equipment or materials used, or in the organisation of the work team.
- Risk assessments will be reviewed at specified intervals with management involvement.
- Following the risk assessment, corrective actions will be taken to ensure that hazards are appropriately evaluated and controlled to levels as low as reasonably practicable (ALARP).
- A follow-up of the risk assessment action items will be performed to ensure corrective measures are effective and sustainable.

Perdaman is responsible for the preparation of overall Project related environment reports including compiling data from monitoring programs. Perdaman will compile monitoring data and relevant environmental information on a regular basis. Reporting to external stakeholders and regulators will be in strict accordance with the Project's approval conditions. In terms of emissions to air, this reporting will include:

- Part IV, Part V and EPBC Act annual environmental compliance reports,

- 5-yearly report on technology innovations findings/update, noting this will consider both air emissions and greenhouse gas emissions. (Refer to Greenhouse Gas Management Plan (GHGMP) for further information on greenhouse gas (GHG) management).

3.2 Relevant statutory and regulatory management mechanisms

The following policies and guidance are relevant in the assessment air quality and emissions to air:

- EPA (2018) Statement of Environmental Principles, Factors and Objectives
- EPA (2018) Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual
- EPA (2016) Environmental Factor Guideline: Air Quality
- EPA (2016) Environmental Factor Guideline: Social Surroundings
- Commonwealth of Australia (1999). Environment Protection and Biodiversity Conservation Act
- Commonwealth of Australia (2007). National Greenhouse and Energy Reporting Act
- DEC (2010) A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated site remediation and other related activities
- DEC (2006) Guidance Notes: Air Quality and Air Pollution Modelling
- DWER (2019) Murujuga Rock Art Strategy
- NEPC (2015, 2019) National Environmental Protection Measure (NEPM) for Ambient Air Quality.

The assessment of potential impacts was determined through a dispersion modelling study, which incorporated meteorological data, emissions information, source characteristics, and included sensitive receptor locations to represent the environmental values to be protected. The assessment considered:

- particulates in two particle size ranges as an indicator for potential health impacts -
    - Particulate matter with an aerodynamic diameter of less than 10 microns (µm) (PM_{10})
    - Particulate matter with an aerodynamic diameter of less than 2.5 µm ($PM_{2.5}$)
- nitrogen dioxide (NO_2), ozone (O_3) and sulphur dioxide (SO_2) for potential health impacts
- ammonia (NH_3), NO_2 and SO_2 deposition (and the relative change) at select locations of Murujuga rock art on the Burrup Peninsula.

The comparison of modelled results, for defined scenarios, to assessment criteria was used as the basis for interpreting or assessing potential impact, and therefore the protection of environmental values. The assessment criteria used is summarised in Table 3-1.

Table 3-1: Ambient air quality assessment criteria for Perdaman Urea Project Air Quality Impact Assessment

Environmental Value Protected	Pollutant	Assessment Criteria[6]	Averaging period	Reference
Protection of human health	Nitrogen Dioxide (NO_2)	120 ppb	1-hour	NEPM [7]
		30 ppb	1-year	
	Photochemical oxidants (as ozone (O_3))	100 ppb	1-hour	
		80 ppb	4-hour	
	Oxides of sulphur (SOx) as sulphur dioxide (SO_2)	200 ppb	1-hour	
		80 ppb	24-hour	
		20 ppb	1-year	
	Particles as PM_{10}	50 µg/m^3	24-hour	
		25 µg/m^3	1-year	
	Particles as $PM_{2.5}$	25 µg/m^3	24-hour	
		8 µg/m^3	1-year	
	Carbon monoxide (CO)	9.0 ppm	8-hour	
	Ammonia (NH_3)	330 µg/m^3	1-hour	NSW EPA
	Formaldehyde (CH_2O) [8]	20 µg/m^3		
	Methanol	3,000 µg/m^3		
	Benzene	9 ppb	1-hour	
	Toluene	90 ppb		
	Xylene	40 ppb		
Protection of Vegetation	Oxides of sulphur (SOx) as sulphur dioxide (SO_2) [9]	7.8 ppb	1-year	EU
	Dry deposition (of NH_3, NO_2, SO_2)	No numerical value[10]		-

[6] Maximum concentrations.

[7] National Environment Protection (Ambient Air Quality) Measure (NEPC, 2015).

[8] Indicator of highest risk VOC.

[9] Indicator.

[10] No numerical value was established, the relative change in modelled air quality is reported as an indicator of potential contribution to impact. The WA government is co-ordinating work that is being undertaken as part of the Murujuga Rock Art Strategy (MRAS) on this aspect. Section 4.0 of the MRAS is the Environmental Quality Management Framework (EQMF) which includes development of Environmental Quality Criteria which relates to scientifically-based limits of 'acceptable' change to rock art.

Environmental Value Protected	Pollutant	Assessment Criteria[6]	Averaging period	Reference
Protection of cultural heritage values	Dry deposition (of NH_3, NO_2, SO_2)			

4 Air Quality and Emissions to Air

The key information associated with air quality (i.e. emissions estimation, modelling outcomes and impact assessment, and associate management and monitoring of emissions) including revisions since the publication of the ERD, is summarised in this section.

4.1 Process and emissions overview

Urea is an organic compound with the chemical formula $CO(NH_2)_2$, manufactured via the reaction of ammonia (NH_3) and carbon dioxide (CO_2) at high pressure and temperature. As outlined in the ERD (Cardno, 2020) Perdaman will use the latest commercially available technology packages to maximise urea production from natural gas feedstock. Natural gas from the nearby Woodside gas plant will be used as feedstock to the process. The stages involved in ammonia synthesis and urea production are outlined below and depicted in the block flow diagram (Figure 4-1). Support utilities include onsite power generation and an air separation plant. The principal sources of air emissions from the process arise from each stage of the production cycle, and are summarised below:

Gas reforming: Natural gas is catalytically reformed with oxygen and steam to form ‘syngas’, which is purified to a hydrogen rich and CO_2 stream. Catalytic reforming occurs at a high efficiency under pressure.

Ammonia synthesis: The hydrogen and nitrogen mixture are compressed and reacted (with help of a catalyst) to form ammonia. This chemical reaction releases heat (exothermic reaction) and is recovered as steam which improves the overall process thermal efficiency, and consequently lowers emissions. All ammonia requirements are produced at the plant and no excess ammonia disposed offsite.

Urea synthesis: Ammonia and CO_2 are reacted to form urea (solution) in a two-stage process which involves an ammonium carbamate (NH_2COONH_4) intermediate. The urea solution is concentrated to over 95 per cent. In normal operations, purification and recycling of CO_2 in the syngas is used during Urea synthesis. Water is recovered and cleaned by a stripping process for internal re-use.

Urea granulation: The concentrated urea solution is dried and granulated, suitable for storage before being conveyed to Dampier Port for export.

Power generation: Process power requirements will be met with a high efficiency combined cycle gas turbine (CCGT) that includes cogeneration of steam, and a steam turbine for excess steam. The gas turbine will be operated on natural gas under normal conditions. The gas turbine will achieve low nitrogen oxides (NOx) emissions by using a DLN (dry-low NOx) burner. Power supply demand will be supplemented with solar power generation, there is no grid connection for third party power supply to the project.

Air separation: Air is compressed and separated into nitrogen (N_2) and oxygen (O_2) in a conventional cryogenic air separation unit.

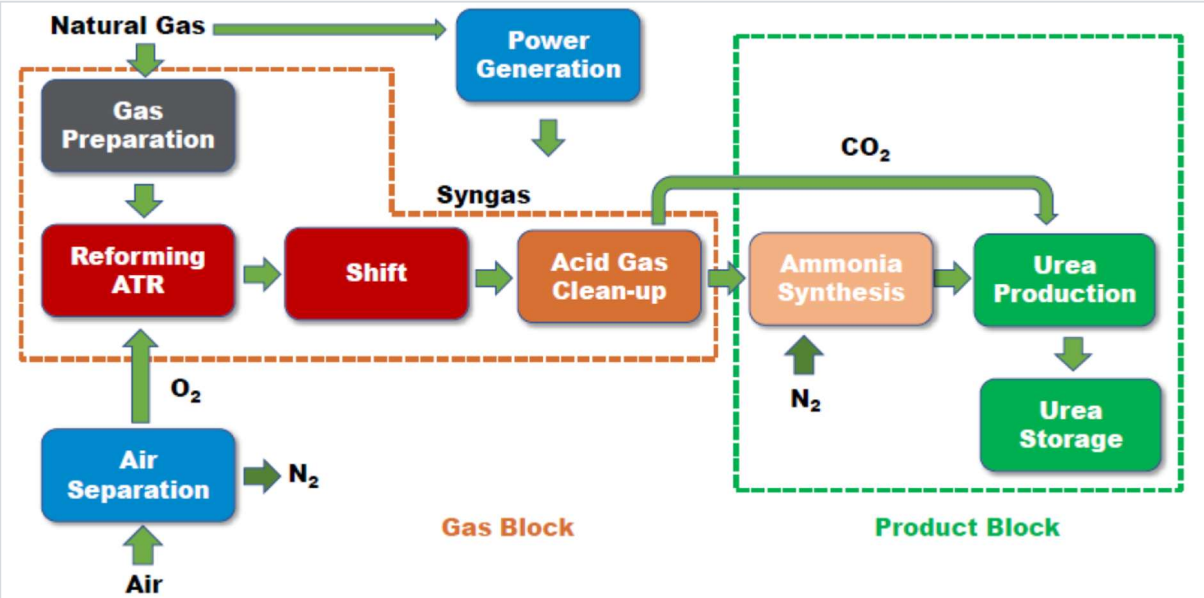

Figure 4-1: Block flow diagram of urea production (Cardno, 2020)

During detailed design, Perdaman will continue to explore opportunities for technology, or vendor substitution that can demonstrably achieve environmental performance of an equal or better standard, to avoid or minimise emissions, to those that are shown in the ERD.

4.2 Estimation of Emissions to Air

The atmospheric emissions from the Project are primarily derived from ammonia synthesis and urea production, and the combustion of natural gas for onsite power generation. Of primary concern with respect to air quality, for both the local and regional scale are:

Oxides of Nitrogen (NOx): Consisting of nitric oxide (NO) and nitrogen dioxide (NO_2), these emissions come from combustion, both from the high temperature combustion where nitrogen in the air is oxidised and from nitrogen in the fuel, and from the production of urea. Of relevance from an air quality perspective, no nitrous oxide (N_2O) is produced or emitted by the Project.

Urea Particulates: Particulate Matter (PM) comprised of urea dust within the PM_{10} (particulate matter with an aerodynamic diameter of less than 10 microns) and $PM_{2.5}$ (particulate matter with an aerodynamic diameter of less than 2.5 microns) size ranges, is released to atmosphere from the urea manufacturing process. Particulate scrubbing equipment is incorporated into the Project design to collect urea particulate present in exhaust gases prior to discharge to atmosphere. The final product is granulated where the physical properties reduce the propensity for dust formation and release of fugitive dust during conveying and product handling compared to the alternative of prills.

Ammonia (NH_3): Traces of ammonia are released from the urea manufacturing process. Acid gas scrubbing equipment is incorporated into the Project design to reduce ammonia present in exhaust gases prior to discharge to atmosphere.

Sulphur dioxide (SO_2), carbon monoxide (CO) and Volatile Organic Compounds (VOCs) (including methanol and formaldehyde) are also present in emissions, but at relatively lower levels in comparison to the pollutants of primary concern listed above. The natural gas feed is a light (clean burning) gas with >85% desulphurized before dispatch to downstream users. Thus, the emission of SO_2 as a product of combustion is minimised.

Ozone (O_3) while not a direct emission from the Project, is formed through atmospheric photochemical reactions involving emissions of NOx and photochemically reactive organic compounds. Given the complex nature of the reactions and the many variables, it is assumed that any project on the Burrup Peninsula emitting photochemically reactive pollutants will contribute to the process of ozone formation. The Project is estimated to contribute less than 5% of the estimated NOx emissions in the regional airshed, based on current approved projects operations.

4.3 Benchmarking of Emissions to Air

A benchmarking review was carried out to compare the expected emissions (from the Project), to a number of references:

- European Commission BAT Reference Document for Large Volume Inorganic Chemicals - Ammonia, Acids and Fertilisers (2007)
- European Commission Best Available Techniques (BAT) Reference Document for Large Combustion Plants (2010/75/EU)
- Yara Ammonia plant (EPA assessment 1036) – a neighbouring project
- Dampier Nitrogen proposed urea plant (EPA assessment 1065) – a proposed project in the area

The outcome of the benchmarking review is summarised in Table 4-1.

Table 4-1: Summary of emissions to air benchmark comparison (Table 4-31, Cardno, 2020)

Source and Emission (mg/Nm^3)	Perdaman	Best Available Technology (BAT)	Yara Ammonia	Dampier Nitrogen	Comment
Natural Gas feed - Fired Heater (dry at 3% oxygen) BAT from EFMA Book 1 Ammonia					
NOx	<150	<150	<180		Conventional plant has reformer
SOx	<1	<1	<1		Northwest Shelf (NWS) gas (feedstock) is low sulphur content
PM	3	<5	<5	<5	Low expected
CO	<100	<100	<110		
NH_3	0	0	0	0	Not present
Natural Gas Feed - Gas Turbine 1 & 2 (each) (dry at 15% oxygen) BAT from EU medium combustion plant 1-540 MW 380-476 2013					
NOx	15	<50	<90	<75	Yara has steam turbine power
SOx	0.5	<1	<1	1	Northwest Shelf (NWS) gas (feedstock) is low sulphur content
PM	1.6	<5	<5		
CO	<10	<20	<50		Yara has boiler
NH_3	0	0	0	0	Not present
Vents - Urea Absorber Vents (2) (each)					
PM (kg/tonne)	0	0	-	0	EFMA 2000, Book 5 Table 8.1.1
NH_3 (kg/tonne)	0.05	0.06	-	<10	EFMA 2000, Book 5 Table 8.1.1
Air – Urea Granulator (2) (each)					
PM	25 (20 design target)	≤30	-	35	EFMA 2000, 8.1.1 (with lower value from 2007 update)
NH_3 (with acid gas scrubbing)	20 (15 design target)	20-30	-		EFMA 2000, 8.1.1 (with lower value from 2007 update)
Other – formaldehyde / methanol	<0.1	<0.2	-	<0.3	Stamicarbon technology uses less formaldehyde

Source and Emission (mg/Nm^3)	Perdaman	Best Available Technology (BAT)	Yara Ammonia	Dampier Nitrogen	Comment
Notes:					
1. Based on average annual design conditions (32ºC) 2. Burrup average ambient temperature has approximately 3% de-rating compared to BAT 3. Non harmful/inert trace fugitive emissions not listed 4. EU Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals - Ammonia, Acid and Fertilisers, August 2007.					

4.4 Predicted Impacts of Air Emissions

A series of modelling scenarios were defined and simulations run for the suite of key pollutants of potential concern. These modelled scenarios support the evaluation of the potential impacts (direct, indirect and cumulative) under the current level of industrial activity on the Burrup Peninsula (as approved) as well as a future expanded level that accounts for the development of a proposed Methanol plant.

Air quality modelling indicates that direct and cumulative:

- NO_x and SO_2 emissions associated with the Perdaman project are not likely to result in unacceptable air quality impacts to human health, with respect to the NEPM standards.
- PM (as PM_{10} and $PM_{2.5}$) emissions associated with the Perdaman project are not likely to result in unacceptable air quality impacts to human health, with respect to the NEPM standards.
- ammonia emissions associated with the project are not likely to result in unacceptable air quality impacts to human health and amenity (odour nuisance).

Modelling indicates that ozone production in the region (as an indicator of photochemical smog) is unlikely to be influenced by the emissions from the Perdaman project.

The potential impact on vegetation from increases in pollutant concentrations is not well understood for the plant communities found in the Burrup region. The maximum point of impact is expected to occur in close proximity to the project area. The NO_x and SO_2 emissions associated with the Perdaman project are proportionally smaller than the existing emissions from the airshed. With respect to urea dust, given the use of best practice pollution control technology within the plant (i.e. the scrubbing system in the plant will remove approximately 99.5% of the entrained urea dust, and approximately 80% of the ammonia) and the use of an enclosed conveyor system, it is unlikely that the vegetation in areas surrounding the plant would be significantly impacted (Cardno. 2020).

Modelling indicates that there may be increases in the ground level concentrations of pollutants at culturally important heritage locations. These increases are relatively small in terms of concentration change.

5 Environmental Management Measures

This section describes the management-based measures that, when implemented are intended to achieve the environmental objective of maintaining air quality and minimising emissions so that environmental values are protected. The management measures have been developed in alignment with the EPA guidelines (EPA, 2020).

5.1 Air Quality Management Measures Adopted

The Project incorporates various design features and pollution control equipment to minimise emissions from the Project on the Murujuga airshed as far as reasonably practicable, such that the potential air quality impact on human health from the Project has been assessed as being low risk. Perdaman commits to confirm vendor specifications for key pollution control equipment are achieved, and Project emissions are consistent with estimates used as the basis for the modelling assessment. The Project will be subject to the Works Approval provisions of Part V of the *Environmental Protection Act 1986*.

The Project will also be subject to the operating Licence provisions of Part V of the *Environmental Protection Act 1986*. Pursuant the EP Act "polluter pays" principle, Part V licences include fees based on pollutant discharges. Perdaman understands that the DWER, during the process of determining the conditions of licensing for the Project, will give due consideration to the operational monitoring requirements and applicable monitoring standards for the Project, including those for urea emissions, ammonia and NO_2.

As a key element of the application for Works Approval, that is required pursuant to Part V to allow construction of the approved Part IV and EPBC Act Project, Perdaman will include an Emissions Verification Plan and Program covering;

- Verification of construction incorporating pollution control equipment relevant to air quality with performance to as approved standards,
- Verification that point source emissions are consistent with, or better than, estimates used as the basis for the modelling assessment, and
- Verification that the air quality impacts of the Project are as predicted in the Air Quality Impact Assessment.

The proximity of existing and possible future industry on the Burrup Peninsula and the potential for cumulative impacts necessitates a regional approach to the management of ambient air quality in the region. Perdaman commits to participate and contribute to monitoring and analysis and other relevant aspects of the Murujuga Rock Art Strategy (DWER, 2019). Perdaman also commits to consult with DWER (Executive Director, Strategic Policy) regarding the Project's emissions monitoring program to ensure that collected data can be made available to inform the implementation of the MRAS.

5.1.1 Avoidance of emissions and emission reductions through design

Details of air emissions from the Project are summarised in Table 5-1, alongside the pollution controls incorporated into the plant and process design. The applied Autothermal Reforming (ATR) technology materially reduces the emissions compared to conventional steam reforming. This is principally a result of the fired heater being significantly smaller than the conventional steam reforming fuel gas requirement. This leads to the NOx per tonne of ammonia (and urea) being lower than other leading ammonia-urea plants around the world. Most of these plants also use a steam boiler (required for starting the steam reformer) and steam turbine power generation, which again is inferior in environmental performance to the combined cycle power plant (typically around 33-35% efficiency for steam to power compared to 52% for CCGT) as adopted by the project.

The Perdaman urea train sizes are comparable to the best around the world, and the Stamicarbon model adopted is recognised as a leader in this field, with a high efficiency melt process, and leading granulation technology performance leading to reduced particulate and ammonia emissions in comparison to other technologies. The sprayer design increases the on-spec granulation production and reduces dust formation from undersize of crushing less oversize granules. Stamicarbon has guaranteed 0.1kg/t ammonia emission for urea product, which again is considered industry leading compared to typically 0.11-0.15 kg/t for modern (competing) urea plants.

With the additional acid scrubbing, the granulator ammonia emission is further reduced to guaranteed less than 20mg/Nm^3, with normal operations expected to achieve around 15mg/Nm^3. There are several other plants around the world which also use acid washing to reduce the ammonia emission. It is noted that many large plants do not apply acid scrubbing. Perdaman will apply acid scrubbing. As such the overall Perdaman Urea granulator ammonia emissions will be comparable to the best in the world (accounting for ambient conditions).

In terms of sulphur emissions, the natural gas supply available in Western Australia has a very low sulphur content in comparison to international sources. This leads to relatively low sulphur emissions to air.

During detailed design, Perdaman will continue to explore opportunities for technology, or vendor substitution that can demonstrably achieve environmental performance of an equal or better standard, to avoid or minimise emissions, to those that are shown in Table 5-1.

The key air quality management measures that will be implemented for the Project are presented in Table 5-2.

Table 5-1: Summary of project emissions and incorporated design controls to avoid and minimise emissions[11]

Process component	Emission source	Controls	Emission characteristics
Power generation	Gas turbine (GE 4211)	Modern industrial gas turbine combined cycle to generate the Plants power requirements. DLN (dry low NOx)	Energy to power efficiency approximately 52%LHV (compared to open cycle gas turbines of around 35%LHV) - substantially reducing the NOx/MWh. 15ppmv NOx (NO + NO_2 at 15% oxygen dry gas) at all normal operating conditions
Autothermal reforming	Fired Heater	Autothermal Reforming (ATR) adopted rather than steam reforming	NOx - 80mg/Nm^3 as specified by the Process Licensor design.
Urea granulator	Urea granulator fluidising exhaust air flow	Water scrubber and recycled to process	PM ≤25mg/Nm^3.
Ammonia Plant	Flare gas	The syngas and refrigeration compressors have high integrity sealing to minimise any ammonia loss (most is internal), with a nitrogen barrier seal to ambient. The Ammonia plant uses a cryogenic wash unit to reduce inerts to very low levels thereby minimising purging to fuel gas.	The Ammonia plant has no detectable ammonia emissions during normal operation. There is normally no flared gas. The flare with a permanent pilot, is required in design to meet safety requirements, not for routine waste disposal by emission to atmosphere.
Urea production	Urea plant, and Granulator fluidising exhaust	Acid scrubbing system	Traces of ammonia are released by the Urea plant, and specifically the Granulator fluidising exhaust air flow

[11] As part of continuous improvement and application of BAT, Perdaman will continue, during detailed design, to evaluate and, as appropriate adopt, alternative technologies where they demonstrably deliver overall performance outcomes as good as or better than described in the ERD and this AQMP.

Process component	Emission source	Controls	Emission characteristics
			(ca. 87% of the total ammonia emissions). Ammonia maximum 0.1kg/t urea product, with the granulator stack ≤110mg/Nm^3 (upstream of acid scrubbing). Acid scrubbing removes most ammonia in the exhaust air, and recovers the ammonia as a fertiliser salt (approx. 70% reduction). Granulator stack emission ≤20mg/Nm^3

Table 5-2: Air Quality Management Measures

EPA factor and objective: Air Quality – To maintain air quality and minimise emissions so that environmental values are protected.			
Outcome: To minimise emissions as far as reasonably practicable over the project life and avoid contributing to adverse cumulative air quality impacts in the region.			
Key environmental values: Human health and amenity			
Key impacts and risks: Adverse impacts to human health and amenity			
Management-based provisions			
Management actions	**Management targets**	**Monitoring**	**Reporting**
Management Action 1 Prepare an application for Works Approval pursuant to Part V of *Environmental Protection Act* that includes an Emissions Verification Plan and Program covering; • Verification of construction incorporating pollution control equipment relevant to air quality with performance to as approved standards • Verification that point source emissions are consistent with, or better than, estimates used as the basis for the modelling assessment • Verification that the attributable regional ambient air quality impacts of the Project are as predicted in the Air Quality Impact Assessment.	Verification that all key pollution control equipment relevant to air quality, performs to the standards indicated in the ERD. Verification that point source air emissions are consistent with, or better than, estimates used as basis for the ERD Air Quality Impact Assessment modelling. Verification that ambient air quality impacts are consistent with, or better than, predicted in the Air Quality Impact Assessment.	To be identified in Emissions Verification Plan and Program	1. Emissions Verification Plan and Program Application for Works Approval pursuant to Part V of *Environmental Protection Act* contains an acceptable Emissions Verification Plan and Program to be lodged for approval with DWER before construction. Report will be made available to the DWER (Executive Director, Strategic Policy) for information.

EPA factor and objective: Air Quality – To maintain air quality and minimise emissions so that environmental values are protected.			
Management Action 2 Implement approved Emissions Verification Plan and Program to incorporate Project design features and key pollution control equipment to minimise emissions, including (but not limited to) the following: • ammonia scrubber (Urea Absorber vent) • particulate/ammonia scrubber (Urea Granulation) • Dry Low-NOx burners (Power Generation)	Vendor specifications to be achieved on all key pollution control equipment. Stack emission sampling ports designed and installed during project construction, to Australian Standard. Stack sampling platforms designed and installed during project construction to ensure safe access. Stack emission sampling ports and sampling access platforms maintained throughout the life of the project to Australian Standard.	Confirmation through stack emissions testing and monitoring of other process control indicators.	2. Compliance Certificate: Verification of construction as approved. Report submitted to DWER consistent with the provision of Work Approval pursuant to Part V of the *Environmental Protection Act.* 3. Commissioning Report: Report outlining results of monitoring completed during commissioning or to confirm completion of commissioning. Report submitted to DWER consistent with the provision of Part V of the *Environmental Protection Act*. Submitted within three months of commencement of Project operations (completion of commissioning). Report will be made available to the DWER (Executive Director, Strategic Policy) for information.
Management actions	**Management targets**	**Monitoring**	**Reporting**
Management Action 3 Implement approved Emissions Verification Plan and Program to	Consistent with, or better than, estimates used as basis for the modelling assessment.	Confirmation through stack emissions testing and monitoring of other process control indicators.	4. Model Emissions Verification Report (EVR) EVR submitted to DWER consistent

EPA factor and objective: Air Quality – To maintain air quality and minimise emissions so that environmental values are protected.			
confirm Project emissions of key pollutants: • oxides of nitrogen (NOx) • particulate matter (as PM_{10} and $PM_{2.5}$) • ammonia		Monitoring undertaken at quarterly intervals (as a minimum) over a 12-month monitoring period. Sampling to be conducted to appropriate AS or a recognised alternative. Analysis by a NATA accredited laboratory and using appropriate USEPA or equivalent test methods.	with the requirements of Works Approval, Commissioning Commitments pursuant to Part V of the *Environmental Protection Act*. To be submitted within three months of completion of the 12-month monitoring period. Report will be made available to the DWER (Executive Director, Strategic Policy) for information.
Management actions	**Management targets**	**Monitoring**	**Reporting**
Management Action 4 Implement approved Emissions Verification Plan and Program to verify the attributable regional ambient air quality impacts of the Project predicted in the Air Quality Impact Assessment by comparison to regional ambient air quality measurement results.	Relevant standards used in the Air Quality Impact Assessment, adopted from: • National Environment Protection (Ambient Air Quality) Measure (NEPC, 2015) • New South Wales Environment Protection Authority (NSW EPA) impact assessment criteria (NSW EPA, 2016).	Confirmation through ambient air quality monitoring at locations agreed with EPA and DAWE for this verification purpose. Ambient monitoring to be conducted to appropriate AS or a recognised alternative. Analysis by a NATA accredited laboratory and using appropriate USEPA or equivalent test methods.	5. Model Emissions Verification Report (EVR) EVR submitted to DWER consistent with the requirements of Works Approval, Commissioning Commitments pursuant to Part V of the *Environmental Protection Act*. To be submitted within three months of completion of the 12-month monitoring period. Report will be made available to the DWER (Executive Director, Strategic Policy) for information.

EPA factor and objective: Air Quality – To maintain air quality and minimise emissions so that environmental values are protected.			
Management actions	**Management targets**	**Monitoring**	**Reporting**
Management Action 5 Support the implementation of, and participate in, the MRAS	As outline in the MRAS	Support and contribute to the State government's coordinated ambient air quality monitoring network that may be established under the MRAS (DWER, 2019). In this regard, Perdaman notes that in February 2020, Puliyapang Pty Ltd was appointed by the WA government to develop and implement the monitoring program, which will be overseen by the DWER and MAC, in consultation with national and international subject-matter experts and stakeholders. Puliyapang is a registered Aboriginal business and is a joint venture between Tocomwall and Calibre, and has partnered with subject matter experts from Curtin University, Artcare and ChemCentre to deliver the monitoring program. DWER indicates that the monitoring program will be implemented over five years, in a staged approach, and includes capacity building and training for Murujuga Rangers on the monitoring and analysis techniques. It is expected that the field work and laboratory monitoring studies element of this initial five year program will	6. Obtain from DWER (Executive Director, Strategic Policy), as the state government nominated co-ordinator of the MRAS, a certification of participation in and agreed support for, the MRAS and its EQMF collaborative air quality and rock art monitoring programmes.

EPA factor and objective: Air Quality – To maintain air quality and minimise emissions so that environmental values are protected.			
		commence before Project construction commences.	
Management actions	**Management targets**	**Monitoring**	**Reporting**
Management Action 6 To augment and inform MRAS co-ordinated programmes under Management Action 5 Implement an ambient air quality monitoring program to establish baseline conditions for ammonia and urea deposition.	No later than 6 months of receiving the later of Part IV or EPBC Act approval Perdaman will develop a Baseline/Background Ambient Monitoring and Management Program in consultation with DWER and MAC then implement an independent ambient air quality monitoring program to establish a relevant baseline (i.e. pre-Perdaman Urea project operations) of background air quality relevant to ammonia and urea deposition, for integration to future MRAS co-ordinated monitoring programmes.	• Monitoring during construction and before commissioning of Project and to establish pre-existing ammonia and urea deposition • Monitoring during operations for 12-month period at a representative site for ammonia and urea deposition, developed in consultation with DWER and MAC.	7. Baseline/Background Ambient Monitoring and Management Program developed in consultation with DWER and MAC. Program to be submitted for approval to the EPA and the Department of Agriculture, Water and the Environment for approval no later than 6 months of receiving the later of Part IV or *EPBC Act* approval. Report will be made available to the DWER (Executive Director, Strategic Policy) for information. 8. Background monitoring results submitted to DWER and DAWE, to inform future MRAS co-ordinated monitoring. programmes. Made available to the DWER (Executive Director, Strategic Policy) for information.

6 Review of this Plan

This AQMP will be progressively reviewed and developed to provide the framework for air quality management requirements as the Project proceeds through the design, construction, commissioning and operational phases.

Once operational, Perdaman commits to developing a periodic audit and review process to identify necessary amendments and improvements to the AQMP based on progress in achieving stated environmental performance objectives, changes in Project operations and knowledge of associated environmental risk, and overall effectiveness of the Project's Environmental Management Plan (EMP) of which this AQMP is a part.

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8 Acronyms

Acronym	Definition
AGR	Acid Gas Recovery
ALARP	As low as reasonably practicable
AQMP	Air quality management plan
AS	Australian Standard
ATR	Autothermal reform
BAT	Best Available Techniques
BPT	Best Practice Technology
CCGT	Combined cycle gas turbine
CH_2O	Formaldehyde
CH_3	Methane
CO	Carbon monoxide
$CO(NH_2)_2$	Urea
CO_2	Carbon Dioxide
DLN	Dry low NOx
EFMA	European Fertiliser Manufacturers Association
EMP	Environmental Management Plan
EMS	Environmental Management System
EP Act	*Environmental Protection Act 1986* (Western Australia)
EPA	Environmental Protection Authority
ERD	Environmental Review Document
EU	European Union
IFIA	International Fertiliser Industry Association
IFS	International Fertiliser Society
GHG	Greenhouse Gas
GHGMP	Greenhouse Gas Management Plan
H_2	Hydrogen
kg	kilograms
kg/t	Kilograms per tonne
km	Kilometres
LHV	Lower heating value
MAC	Murujuga Aboriginal Corporation
mg	milligrams
Mtpa	Million tonnes per annum
MW	Mega Watt
MWh	Mega Watt hour
N_2	Nitrogen
N_2O	nitrous oxide
NEPM	National Environment Protection Measure
NGER Act	National Greenhouse and Energy Reporting Act
NH_2COONH_4	Ammonium carbamate
NH_3	Ammonia

Acronym	Definition
NATA	National Association of Testing Authorities
Nm^3	Normal metres cubed
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
NSW	New South Wales
O_2	Oxygen
O_3	Ozone
PEMP	Project Environmental Management Plan
Perdaman	Perdaman Chemicals and Fertilisers Pty Ltd
ppb	Parts per billion
ppm	Parts per million volume

Acronym	Definition
SIA	Strategic Industrial Area
SO_2	Sulphur dioxide
T	Tonnes
tpd	Tonnes per day
$\mu g/m^3$	Micrograms per cubic metre
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WRI	World Resources Institute
Y	Year

Appendix A: ERD Table ES3

Table ES3 – Summary of environmental impact assessment of key environmental factors (Air Quality Factor)

<table>
<tr><th colspan="2">Air Quality</th></tr>
<tr><td>EPA objective</td><td>To maintain air quality and minimise emissions so that environmental values are protected.</td></tr>
<tr><td>Potential Impacts</td><td>Air emissions from the proposed urea plant have the potential to impact on air quality, nearby rock art, and NHL values in the region.
Air emissions from the proposed urea plant have the potential to contribute to climate change.
Air emissions from the urea plant have the potential to stimulate vegetation growth, which could potentially increase the risk of fires.</td></tr>
<tr><td>Mitigation</td><td>Avoid
The use of natural gas ensures the Project will achieve the highest energy efficiency and lowest GHG emissions compared to coal.
The co-location of ammonia-urea production allows for the CO_2 generated as a by-product of gas reforming to be used as a reagent in the urea synthesis process, and hence avoiding approximately 1.5 Mtpa of GHG emissions from the Project.
Minimise:
Basis of Design has incorporated requirements for emissions avoidance, reduction and minimization.
Emissions will be minimized using contemporary best practice pollution control technology within the plant.
Operational practices will be developed and implemented to optimize plant performance including minimizing emissions.
Continuous improvement will be evaluated and where practicable adopted to reduce emissions over the Project life.
Monitoring and adaptive management will be implemented to practicably align with future Murujuga Rock Art Strategy baseline data and emissions thresholds</td></tr>
<tr><td>Outcomes</td><td>Residual Impact:
Modelling indicates that there may be increases in the ground level concentrations of pollutants beyond the Project footprint, including at culturally important heritage locations.
Other than for urea dust and ammonia, these increases are relatively small in terms of concentration change.
It is noted that increased emission of acid forming pollutants and potential for increase of nitrate enhanced microbial activity have intrinsically been suggested to be prime causes of potential impacts to the integrity of rock art and associated NHL values and amenity at Murujuga.
Against this background, it is noted that urea is
mildly alkaline;
not a nitrate; and
decomposes relatively rapidly in dry hot terrestrial conditions, such as those typical of Murujuga.
It is further noted that ammonia is also alkaline and therefore does not contribute to potential impacts associated with acidic and acid forming emissions,
Therefore, any relatively low level of emitted urea dust is not an acidic pollutant and urea dust does not contribute to nitrate enhancement of microbial activity in any stand-alone analysis of the project emissions.</td></tr>
</table>

	Further, given the differences in its activity in the nitrogen cycle to NOx and ammonium nitrate, urea dust emissions could be considered not to contribute to cumulative impacts in these two aspects of potential concern. It is further noted that ammonia is also alkaline and therefore does not contribute to potential impacts associated with acidic and acid forming emissions, In addition, monitoring results and other scientific work presented in 2019 at the DoEE convened Murujuga Annual Strategic Meeting, provide an enhanced scientific basis for understanding and evaluating the impact of anthropogenic emissions in the region (Warren Fish pers comm) Residual impacts to the integrity of rock art and associated NHL values/amenity at Murujuga, if any, as a result of limited urea dust emissions are not considered to be significant. The net reduction in GHG emissions from the Project by CO_2 reuse in the urea synthesis process is estimated to avoid 1.5 Mtpa CO_2-e (approximately 70% of the total Project GHG) The Project has the capacity to displace all Australian imports of urea, which would have a net benefit (~ 1.1 Mtpa CO_2-e) as GHG emissions from the Project represent international best practice and a significant improvement upon global CO_2 emissions attributable to urea imported from the Middle East and China. This net benefit from displacing imported urea far outweighs the total GHG emissions estimated for the Project (0.65 Mtpa CO_2-e.) **Offset:** The Proponent has committed to MAC to participate and contribute to the development of an Environmental Quality Management Framework as detailed in the Murujuga Rock Art Strategy (DWER, 2019)

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