Pluto LNG Project
Air Quality Management Plan

Date: 07/09/11

Revision: 2

Reference No: X0000AH0002

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ABBREVIATIONS

AGRU	Acid Gas Removal Unit
aMDEA	activated Methyl Diethanolamine
BTEX	Benzene, Toluene, Ethylene and Xylene
BTX	Benzene, Toluene, Xylene
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalents
DEC	Department of Environment and Conservation
DLN	Dry Low NO_x
EAR	Environmental Assessment Report
EPA	Environmental Protection Authority
GHG	Greenhouse Gases
GLCs	Ground Level Concentrations
GTC	Gas Turbine Compressors
GTG	Gas Turbine Generators
LNG	Liquid Natural Gas
MEG	Mono Ethylene Glycol
MGA	Map Grid Australia
MS757	Ministerial Statement No.757
N_2	Nitrogen
NEPM	National Environment Protection Measure
NO	Nitrogen Oxide
NO_x	Oxides of Nitrogen
NPI	National Pollutant Inventory
NSW	New South Wales
O_2	Oxygen
O_3	Ozone
PER	Public Environmental Review
PM_{10}	Particulate Matter
RTO	Regenerative Thermal Oxidiser
SKM	Sinclair Knight Merz
SO_x	Oxides of Sulphur
TAPM	"The Air Pollution Model"
TOT	Trunkline Onshore Terminal
VOCs	Volatile Organic Compounds
WA	Western Australia
WBPL	Woodside Burrup Pty Ltd

1. INTRODUCTION

1.1 Purpose

This plan outlines how air emissions will be managed and monitored for the Pluto Liquefied Natural Gas (LNG) Park and provides an Air Quality Management Plan required for the operations phase of the plant.

Woodside was granted approval by the Western Australian (WA) Minister for the Environment to implement the proposed Pluto LNG Development, contingent on meeting the conditions contained in the Ministerial Statement 757 [1]. Condition 11 relates specifically to air quality management during the operations phase of the development, now called the Pluto LNG Project. Construction of the first of two LNG trains permitted by the approval commenced in 2007.

1.2 Scope

This Air Emissions Management Plan has been developed to fulfill the requirements of MS757 Condition 11-2 (Refer to **Box 1**).

This Plan provides a framework for management of emissions to air, founded on a risk based approach. This plan commences from grant of an operating licence for Train 1 of the Pluto LNG Plant, issued by the DEC under Part V of the *Environment Protection Act 1986*.

This Plan includes:

- Outcomes of cumulative air quality modeling and emissions assessments;
- Proposed targets and standards for air emissions from the operating facilities;
- An air emissions monitoring programme;
- An ambient air and nitrogen deposition monitoring programme; and
- An annual reporting regime.

Management of greenhouse gases is outside the scope of this plan and is detailed in the Pluto Greenhouse Gas Abatement Program [6] submitted to fulfill Condition 12 of Ministerial Statement 757 [1] and approved in October 2007.

Revision 1 of the Pluto - Air Quality Management Plan was approved by Office of the EPA on 10 November 2011 to address MS757 Condition 11-2. The letter outlining this approval is attached as an Appendix. Revision 2 of this Plan is provided for information, detailing the Pluto NOx Deposition Programme (Section 9).

1.3 Description of Operator

Woodside Burrup Pty Ltd, a wholly owned subsidiary of Woodside, is operator of the Pluto LNG Project. References in this plan to “Woodside” may be references to Woodside Petroleum Ltd or its applicable subsidiaries.

Based in Perth, Western Australia (WA), Woodside has major operational assets and exploration and development interests in five continents including Australia and the United States. In 58 years Woodside has grown from a pioneer oil and gas explorer to Australia’s largest independent producer of oil and gas and one of the world’s largest producers of Liquefied Natural Gas (LNG).

Woodside operates one of Australia’s largest resources projects, the North West Shelf Project in WA, which produces about 40% of Australia’s oil and gas. In 2012 Woodside will be producing

LNG from the Pluto LNG Project, near Karratha. Woodside is also seeking to progress the Sunrise LNG Development in the Timor Sea and the Browse LNG Development in northern WA.

Woodside Burrup Pty. Ltd. is the proponent for the Pluto LNG Project and is also operator, on behalf of itself and joint venture partners Tokyo Gas and Kansai Electric.

Further information about Woodside and the Pluto LNG Project can be found on http://www.woodside.com.au.

1.4 Project Background

The Pluto gas field was discovered in April 2005 and is located on the North West Shelf of Western Australia, approximately 190 km north-west of Dampier. The associated gas processing plant will be located on the Burrup Peninsula, Western Australia, approximately 6km from Dampier.

Woodside currently operates Production Licence WA-34-L which incorporates the Pluto gas field and has developed the field through an offshore subsea gathering system connected to an offshore riser platform. Gas and liquids will then be exported to shore via a trunkline for processing.

1.5 Context

The sources, characteristics, impacts and management of air emissions generated for the Pluto LNG Project have been discussed in detail in the Public Environmental Review (PER) [2] and Supplement and Response to Submissions [3]. Since the publication of the PER and Response to Submissions, further assessments have been undertaken in order to address recommendations made by the DEC and EPA, as well as meet Ministerial Conditions.

Section 15 of the *Environmental Protection Act 1986* (WA) requires that the EPA shall use its best endeavours to protect the environment and to prevent, control and abate pollution. When a new proposal is designed, there are clearly opportunities to design and incorporate best practice processes and technologies.

Ministerial Statement No.757 [1] (MS757) specifies the following requirements (Refer to **Box 1**) relating to control of air emissions and air quality management from the Pluto LNG Project.

Box 1 – Extract from Ministerial Statement MS757 (2007) [1]

11 Air Emissions

11-1 Prior to submitting a Works Approval application for the plant, the proponent shall submit a detailed Front End Engineering Design Report demonstrating that the proposed works adopt best practice pollution control measures to minimise emissions from the plant, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

This Report shall:

1. *set out the base emission rates for major sources for the plant and the design emission targets; and*
2. *address normal operations, shut-down, and start-up, and equipment failure conditions*

11-2 At least three months prior to commencement of operations, the proponent shall prepare an Air Quality Management Plan to the requirements of the Minister for the Environment.

The objective of this Plan is to ensure that best available practicable and efficient technologies are used to minimise and monitor air emissions from the plant.

This Plan shall include:

1. cumulative air quality modelling which uses data from the Front End Engineering Design Report and includes emissions from approved industrial sources at Cape Preston and Barrow Island;
2. proposed targets and standards;
3. an emissions monitoring programme, which includes nitrogen compounds, butene, toluene, ethylene, xylene, ozone, acrylene and hydrogen sulphide emissions from the plant;
4. an ambient air monitoring programme and a nitrogen deposition monitoring programme; and
5. annual reporting.

11-3 The proponent shall implement the Air Quality Management Plan required by Condition 11-2.

11-4 The proponent shall make the Air Quality Management Plan required by condition 11-2 publicly available in a manner approved by the CEO.

Since MS757 was released, Woodside has prepared and submitted a Best Practice Air Emissions Report [8] (as required by Condition 11-1) which describes a number of design and operational measures taken to mitigate and minimise potential environmental impacts arising from emissions. This report addresses in detail, the expected performance of facility and relates to potential worst case impacts at sensitive receptors, identified through cumulative ambient air modelling. This was accepted by the Minister for the Environment in November 2008.

Air emissions were further assessed as part of the Works Approval for the first LNG train and associated facilities, which was granted in August 2008 (WA4444/2008/1, [5]). This assessment considered additional information available following detailed plant design that had taken place since the issue of the Pluto LNG Development PER in 2006 [2].

To fulfill requirements of Condition 5(ii) of the LNG facilities Works Approval, Woodside has developed a Stack Emission Test Plan [4] to support validation of the performance of the plant once the facility has been built and commissioning completed. The Stack Emission Test Plan has been submitted to DEC. Results obtained through implementation of this plan will be used to demonstrate compliance with proposed air emission discharge specifications and provided to the Department of Environment and Conservation (DEC) within a compliance document required under Condition 2 of the Works Approval prior to plant Licencing.

2. EMISSIONS IDENTIFICATION AND ASSESSMENT

The most significant sources of air emissions for the onshore component of the Project include:

- Gas turbine generators for electrical power and gas turbine compressors;
- A regenerative thermal oxidiser; and
- Flares.

Primary air emissions from these sources include CO_2, CO, NO_x, O_3, particulate matter (as PM_{10}), SO_x, VOCs (benzene, toluene and xylene) and N_2.

Recent assessment of these emissions by DEC was documented within the Environmental Assessment Report (EAR) of the Works Approval. The EAR considered information, risk assessment and modeling outcomes provided by Woodside in support of an application for Works Approval for the Plant. Principal documents included:

- Pluto LNG Processing Plant - Works Approval Supporting Document XA0005RH0023 [7];
- Assessment of Best Practice for Minimising Emissions to Air from Major Plant XA0005RF6023 [8];
- Pluto Works Approval Supporting Study: Air Quality Study of Revised Plant XA0005RH0027 [9];
- Pluto LNG Emissions Schedule;
- Pluto Preliminary Decommissioning Plan; and
- Woodside Environmental Policy and Greenhouse Policy.

The Works Approval EAR concluded that air emissions from the proposal were assessed as a 'medium' (or 'D') risk in relation to NO_x, and 'Low' (or 'E') risk for all other air emissions. This assessment utilizes the DEC Emissions and Discharges Risk Assessment Matrix (contained in Works Approval W4444/2008/1, Appendix B) and takes into account the environmental significance of the emission and socio-political context.

A summary of the air emissions risk assessment outcomes for the Pluto LNG Works Approval is provided in Table 2 of the EAR.

MS757 highlighted a number of potential pollutant species for further management prior to the submission of detailed documentation and studies discussed above. The pollutant species specified in Condition 11 that are emitted from the Pluto LNG plant include nitrogen compounds, benzene, toluene, xylene, ozone (as a secondary pollutant) and hydrogen sulphide.

Further development of Pluto emissions schedules and estimates and subsequent risk assessment has shown that, of these pollutant species only nitrogen compounds are likely to be produced from the Pluto LNG facility which presents as an emission of concern.

Emissions of ozone, benzene, toluene, and xylene (assessed as BTX) have been assessed by DEC to represent a negligible to 'Low' risk (refer EAR). Butene, ethylene and acrylene initially specified in MS757 are not present in the feed gas stream, nor produced or emitted by the Pluto LNG processing system and will not be monitored for as part of this plan.

Thus, management of air pollutants from Project sources focuses on the key emissions of oxides of nitrogen, with monitoring of other pollutants including BTX, carbon monoxide, oxides of sulphur and hydrogen sulphide also occurring. Pollutants which are not produced or emitted from the Pluto LNG processing system (e.g. butane, ethylene, acrylene) will not be monitored. Other pollutants

not discussed in this section, which are considered negligible or low risk, may be monitored for purposes such as NPI reporting and compliance with other requirements as required, however are not included within the scope of this Plan.

3. SUMMARY OF CONTROLS AND MANAGEMENT FOR MINIMISING AIR EMISSIONS

An assessment of best practice has been undertaken by Woodside and is outlined in the report "*Assessment of Best Practice for Minimising Emissions to Air from Major Plant*" (FWW, 2007)

The assessment identified the gas turbines for electrical power and compression drivers, the acid gas removal unit / regenerative thermal oxidiser, and flaring as the most significant sources of air emissions for the onshore component of the Project. The assessment includes an overview of the various definitions of best practice, a review of the best practice techniques for the minimisation of atmospheric emissions (in the context of gas turbines, thermal oxidisers and flares), and a discussion of the rationale behind technology selection for the Project.

Mitigation measures incorporated into the project design, and operational controls, for minimising air emissions are documented in detail in the "Assessment of Best Practice for Minimising Emissions to Air from Major Plant" (previously submitted as required by MS757 Condition 11-1) and "Greenhouse Gas Abatement Program" (Woodside Pluto LNG Project website) . A brief summary of these design and operational controls is provided in the following sections.

3.1 Gas Turbines

Gas turbines are required for power generation (GTGs) and for driving compressors (GTCs). Air emissions from these turbines are minimised via the selection of best practicable technology, combined with dry low-NO_x (DLN) emissions control systems. This combination results in NO_x emissions from turbine stacks at levels that are predicted to be below performance guidance from the WA Environment Protection Authority[1].

The power generation and compressor drive turbines are of an industrial design, selected for high reliability, with low specific NO_x and CO_2 emissions to meet EPA guidance levels for NO_x.

Air emissions are also reduced through the recovery of waste heat from several gas turbine units. Recovered heat will usually supply all of the heat demand of the process, thus enhancing energy efficiency and eliminating the need for further combustion sources (and hence air emissions).

3.2 Acid Gas Removal Unit (AGRU) and Regenerative Thermal Oxidiser

CO_2 is removed from the feed gas in the AGRU by active absorption using aMDEA. Some low levels of hydrocarbons, including BTX, are co-absorbed during the acid gas removal stage. Specification of aMDEA in the acid gas removal system, as opposed to traditional acid gas removal solvents, reduces the co-absorption of BTX and other hydrocarbons by approximately 90%. This has a significant greenhouse saving, as well as occupational health benefits.

[1] Guidance for the Assessment of Environmental Factors (in accordance with the Environmental Protection Act 1986), Guidance Statement for Emissions of Oxides of Nitrogen from Gas Turbines, No 15, May 2000, Environmental Protection Authority, Western Australia. [10]

Rather than vent the waste gas stream from the AGRU (which consists mainly of CO_2, water and a small component of hydrocarbons, including BTX), waste gases are treated through a regenerative thermal oxidiser. The regenerative thermal oxidiser converts the hydrocarbon fractions into oxidised by-products to minimise environmental impact and protect human health. A regenerative thermal oxidiser was selected as the most efficient means of doing this, as in steady-state operations it requires minimal ongoing supply of fuel to maintain functionality (thus minimising greenhouse gas and NO_x emissions). It is predicted that the operating regenerative thermal oxidiser will convert in the order of 99% of already low levels of incoming BTX and other hydrocarbons before discharge.

3.3 Flares

The Onshore Pluto LNG Project has been designed for “no continuous flaring” with flare operation restricted to startup, shutdown, upset, maintenance and emergency conditions only.

The frequency of these occasions (i.e. where flaring is required) is expected to be low due to the inclusion of high integrity valves and control systems, gas recovery where practicable, fuel gas balancing and advanced process control. The need to flare due to maintenance activities has been reduced by developing a plant that is reliable and will incorporate appropriate sparing; hence unplanned maintenance is minimised leading to reduced shutdowns. Flaring during plant start up and shutdown will be reduced through operational controls including established plans and procedures.

The flares have also been designed to minimise dark smoke production, as follows:

- Storage and loading flare system (Site A) - single stage flare with air assist.
- Cold dry flare (Site B) – single stage flare with sonic flare tip.
- Warm wet flare and common spare flare (Site B) – two stage flare with air assist.

Stack heights for the cold dry flare, warm wet flare and spare flare are all located not less than 130 metres above ground level to further limit potential impacts associated with air emissions.

The above smokeless flaring technologies concentrate on improving air-fuel mixing to ensure sufficient oxygen for complete combustion. Air assist systems achieve better mixing via a forced or natural draft air supply to the flare tip. A multi stage flare allows the fuel flow at each flare tip to be optimised to the size and design of the tip, thus promoting better mixing and combustion. Sonic flare tips generate greater energy at sonic velocities which promotes better mixing (however has the disadvantage of greater noise).

Air emissions from operations have also be reduced via the use of nitrogen to maintain the continuous purge of the flare piping. It is common for flare systems to be continuously purged with small quantities of fuel gas, to prevent explosive air/gas mixtures forming in the flare piping systems. Based on the composition of the Pluto gas field, nitrogen from the reservoir will be produced as a by-product of the LNG process; hence nitrogen will be reclaimed and used to purge the flare systems, resulting in reduced GHG and NO_x emissions. The nitrogen system is designed to supply the maximum requirement of nitrogen continuously to purge the four flare systems on site (Site A: storage and loading flare, Site B: cold-dry flare, warm-wet flare and spare flare).

4. CUMULATIVE AIR QUALITY MODELLING

Cumulative air modelling which include likely emissions from the Pluto LNG project has been undertaken and is documented within the following reports:

- PER Additional Information: Pluto LNG Development Cumulative Air Quality Study (SKM, 2006) [11]
- Pluto Works Approval Supporting Study: Air Quality Study of Revised Plant XA0005RH0027 (SKM, 2007) [9]

The cumulative air quality assessment included in the PER was repeated to incorporate revised plant configurations and also address the EPA recommendation (EPA Bulletin 1259) [12] that modelling should include emissions from other significant industrial sources planned for the region. In the revised study, the other significant emission sources modelled include the proposed Gorgon Gas Development at Barrow Island and the proposed Austeel Direct Reduced Iron plant at Cape Preston. The revision focussed on the most significant air emissions identified through the original air modelling. The modelling described above has been submitted to DEC and approved as part of the application for Works Approval to commence construction of the Pluto LNG facility.

Key findings of the above air emissions studies are detailed below in this management plan.

Modelling was conducted based on the referred two-train Pluto development, and as such represent higher emissions than what would be expected from Train 1 only. Modelling also included cumulative sources. The detailed modelling results were previously submitted as part of the Pluto Works Approval submission. The Air Quality Management Branch of DEC reviewed the modelling and advised that the model used (TAPM) was appropriate and that there did not appear to be any significant errors in the model configuration (Refer Works Approval W444/2008/1 - Environmental Assessment Report, 2008)

Data presented in the *Assessment of Best Practice for Minimising Emissions to Air from Major Plant XA0005RF6023* report was utilised in the development of the cumulative air modeling. For the purposes of the risk assessment summarised in the above submissions, the air quality study assessed credible, but worst case cumulative emissions impacts from the two train Development approved under MS757 Comparisons with NEPM air quality guidelines were modelled by assessing the highest ground level concentrations (GLCs) at nearby sensitive receptors represented by residential areas of Dampier and Karratha. These areas were used as human exposure would be expected to be more likely to occur over an extended period of time compared with industrial areas or public recreational areas.

Outcomes of the revised modelling submitted as part of the Works Approval supporting documentation are summarised in Table 4-1 against key emissions. These modelling results are based on the two train Pluto LNG Development and hence are anticipated to be conservative values for the current, single train development which is planned to become operational in 2011.

Table 4-1 Pluto LNG Development – Two Train Cumulative Air Quality Modelling Summary

Emission	Modelling Summary (Based on Two Train Development)
• NO_x (point source)	Maximum modelled (SKM 2007) cumulative NO_2 emissions under normal conditions are within: • 67% (1 hour average), and • 31% (annual average) of ambient standard (NEPM).

Emission	Modelling Summary (Based on Two Train Development)
• Photochemical oxidants - as ozone, O_3 (point source)	Maximum modelled (SKM 2007) cumulative O3 emissions under normal conditions are within: • 78% (1 hour average), and • 82% (max 4 hour average) of ambient standard (NEPM).
• Particulates as PM10 (point source)	None of the model-predicted (SKM 2006) NEPM exceedences for PM10 are due to sources from the Pluto LNG Project. Sources primarily due to iron ore handling activities near Dampier as well as bushfires in the region.
• SO_x (point source)	• Maximum modelled (SKM 2006) cumulative SO_2 emissions under normal conditions were the same for existing sources and for existing sources + Pluto. • Emissions of SO_2 from onshore Pluto Project are expected to be negligible. • Existing SO_2 sources primarily due to shipping emissions.
• CO (point source)	Maximum modelled (SKM 2006) CO emissions under normal conditions are well below standard (<1% of NEPM).
• VOCs (incl. BTX)	Maximum modelled (SKM 2006) emissions under normal conditions are well below applicable standard (<1% of Vic EPA, NSW DEC). Volumes emitted are low / negligible.

Ref [5][9]

Woodside commenced a voluntary ambient air monitoring programme on the Burrup Peninsula in late 2008 as part of an internal environmental improvement initiative to gain a better understanding of how its operations on the Burrup may affect local air quality. Following twelve months of monitoring, a comprehensive review of data from this programme and other historical datasets (e.g. Pilbara Air Quality Study (DEP, 2002)) was undertaken to assess the capacity of the Burrup airshed to accommodate industrial growth.

Woodside concurrently commissioned an independent study to compare and understand ambient air quality trends with modelling conducted to date, and to further develop an appropriate model to predict air emissions associated with Woodside's LNG development in the area.

Part I of the draft *2009 Burrup Ambient Air Quality Study* focuses on historical ambient air monitoring data as well as the first 12 months of data from the ambient air monitoring programme commenced in late 2008. The report presents a summary and analysis of the data and compares this to past modelling assessments undertaken on the Burrup. Key findings from the review of the monitoring programme data to late 2009 relevant to Pluto modelling (SKM, 2006) were that:

- Previous modelling (including the Pluto modelling (SKM, 2006)) was found to significantly over-predict the NO2 and Ozone concentrations compared to 2009 monitoring results at Dampier and Karratha.
- Against the 2009 data, background Ozone concentrations are the closest of the gaseous species to the air quality criteria at about 65% of the 1-hour NEPM standard and 75% of the 4-hour standard. These maxima are due to emissions from large fires in the Pilbara..
- It was also noted that in towns other sources (including motor vehicles) are considered to lead to higher NO2 concentrations than those from industry. Local maxima at some sites were predicted to be the result of small stationary engines located in close proximity to the monitoring site.

These findings further highlight conservatism in the modelled estimates for the referred two-train Pluto development. Emissions for the Pluto LNG Development (initially employing only a single LNG train) are expected to be well within the basis for Works Approval air quality assessment presented in Table 4-2 (which also includes future or proposed industrial emissions sources in the region).

5. VALIDATION OF DESIGN EMISSIONS ESTIMATES

As noted in Section 1.5, Woodside has developed the Stack Emissions Test Plan required under Works Approval W4444/2008/1 during plant commissioning. The objective of the stack emission testing is to assist in optimising the efficiency of the Pluto facilities; to minimise stack emissions of specific environmentally harmful compounds; to ensure compliance with EPA performance guidelines, and for Woodside to confirm that it is satisfied with the performance of vendor supplied equipment and systems.

The Stack Emissions Test Plan describes the process for carrying out tests for NO_x, SO_2 and CO for all gas turbines and the regenerative thermal oxidiser. Additionally, it describes the process for carrying out tests for aromatic hydrocarbons (BTEX) and hydrogen sulphide from the regenerative thermal oxidiser.

Results obtained through implementation of this plan will be provided to the DEC within a compliance document required under Condition 2 of the Works Approval prior to plant Licencing.

Woodside will review the results of stack emissions testing against anticipated emissions performance and compare them with previously completed risk and impact assessments presented in approvals documentation. Upon completion of this assessment, results will be provided to the DEC within a compliance document required under Condition 2 of the Works Approval and a Part V Licence will be sought from DEC.

6. PROPOSED TARGETS AND STANDARDS

Operational targets and performance standards are defined for air emissions of significance (Medium and above) as detailed in Section 2 based on the risk assessment documented in the Works Approval EAR. Significant emissions of oxides of nitrogen will be regularly monitored and performance reported as outlined in Sections 7, 8 and 9).

Emissions assessed as non-significant (or ‘Low’ risk) will be managed internally by Woodside in accordance with good industry practice, to ensure that emissions remain within the predicted range used as the basis for the risk assessment. Management measures include:

- Reliability centered maintenance programmes for equipment and process systems;
- Risk based inspection of equipment and pipework;
- Operational fuel gas composition monitoring;
- Scheduled turbine maintenance (e.g. waterwash, major/minor overhaul);
- Routine inspection of valves and flanges; and
- Energy efficiency opportunity reviews.

Point source emissions monitoring (detailed in Section 7.1) will focus on validating emission performance under normal operation against performance targets and limits specified in Table 6-1.

Table 6-1 Pluto Performance Targets and Air Emission Limits

Performance Criteria	Electrical Power Generation Turbines [GT4001-4004]	MR Compression Gas Turbine [1_KT1410]	PR Compression Gas Turbine [1_KT1430]	Regenerative Thermal Oxidiser [1_A1251]
NO_x	NO_x (mg/Nm^3 @ 15%O_2)			NO_x (mg/Nm^3 @3%O_2)
Target	50	70	70	70 (NO_x as NO_2)
Limit	100	100	100	100 (NO_x as NO_2)

7. MONITORING AND REPORTING

This section details emissions monitoring and reporting for point source emissions, and notification processes in the event of dark smoke or regenerative thermal oxidiser outage.

7.1 Point Source Emissions Monitoring

Regular monitoring via stack emission tests of NO_x, SO_2 and CO will be undertaken for gas turbines and the regenerative thermal oxidiser. Additionally, stack emission testing will be undertaken for aromatic hydrocarbons (BTX) and hydrogen sulphide from the regenerative thermal oxidiser.

Monitoring will initially be undertaken quarterly during the first year of stable operations (following from date of execution of Commissioning Stack Emissions Test), and then annually following review of emissions results.

Ongoing stack emissions testing will follow the same test methodology as defined within the Commissioning Stack Emissions Test Plan.

Stack exhaust sampling ports have been installed in accordance with AS4323.1 -1995 *Stationary source emissions - Selection of sampling points* on the following equipment to enable point source air emissions monitoring and data collection:

- Mixed refrigerant compressor gas turbine stack: 1A-1410;
- Propane compressor gas turbine stacks 1 and 2: 1A-1430;
- Power generation gas turbine stacks: A-4001, A-4002, A-4003, A-4004; and
- Regenerative thermal oxidiser vent stack: 1A-1251-B2.

A report summarising results of point source emissions from stack sampling points above will be provided to the DEC regional office annually. This report will be provided concurrently with a Part V Licence annual audit and compliance reporting outlined in Section 10 of this Plan.

7.2 Smoke Monitoring

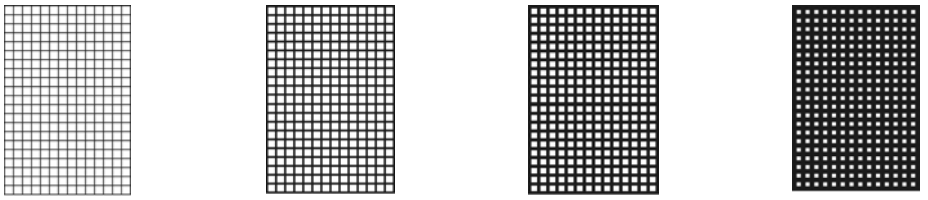
Smoke can be caused during flaring due to incomplete combustion of products. Environmental impacts from smoke emitted from a gas processing plant are considered negligible, however smoke can cause a visual amenity impact. Woodside has focussed on eliminating or significantly reducing the potential for smoke, particularly dark smoke, to be generated from the facility.

The Pluto design is such that no routine flaring is required, other than to maintain a pilot flame, however flaring will occur infrequently during maintenance, shutdowns/restarts and upset conditions. The four flare systems incorporate equipment specifically tailored to minimise the

potential for, and/or duration of, dark smoke events from each system. Incorporated equipment includes: liquid knock-out drums and pumps to intercept and recover heavier hydrocarbons from reaching the flare; air blowers and sonic flare tips to assist in achieving complete combustion; and single and multi-stage flares to better match flare flow ranges to the effective operating range of each tip.

In the event that smoke is produced during operations, the shade (or darkness) of the smoke will be estimated using the Australian Miniature Smoke Chart (AS 3543, 1989) [23]. Events of an intensity greater than Ringelmann 1 that continue for greater than a 4-minute period will be recorded (colour and duration).

Any dark smoke emissions of a shade greater than Ringelmann 3 emitted for a period of 30 minutes or more in any 24 hour period will be reported to the Director (DEC regional office) within 24 hours of Woodside becoming aware of the emission. The report will include the date and time the event occurred, the duration of the dark smoke event, Ringelmann number, location and cause of flared gas. A summary of any recorded and reported smoke events will be provided to the DEC regional office annually. This report will be provided concurrently with a Part V Licence annual audit and compliance reporting outlined in Section 10 of this Plan.



Ringelmann 1 Ringelmann 2 Ringelmann 3 Ringelmann 4

Source: Bureau of Mines Information Circular 8333 Ringelmann Smoke Chart

7.3 Emissions Reduction Equipment – Regenerative Thermal Oxidiser

During planned and unplanned outages of the regenerative thermal oxidiser (e.g. for planned maintenance or repairs) AGRU waste gas will be vented to a safe location via the regenerative thermal oxidiser emergency vent: 1A-1251-B1. This vent location has been designed to ensure adequate dispersion of waste gases to ensure pollutant levels remain well below relevant health levels. As outlined in Section 3.2, the AGRU solvent selected nominally reduces BTX and other hydrocarbon co-absorption by 90% compared to traditional solvents. Therefore, regenerative thermal oxidiser outage presents a low risk of health or environmental impacts.

Woodside will notify the DEC Regional Manager of regenerative thermal oxidiser outages;

- Prior to the regenerative thermal oxidiser being taken offline for planned maintenance, where the planned duration exceeds 7 days;
- Within the next business day following a trip of the system leading to the regenerative thermal oxidiser being down for greater than 7 days ; or
- Within the next business day upon becoming aware that a regenerative thermal oxidiser outage is likely to exceed 7 days.

Notification will include the time, date; and reason for the outage, the anticipated duration of the outage and corrective measures to be taken to reinstate the system.

A summary of any notifiable regenerative thermal oxidiser outages will be provided to the DEC regional office annually. This report will be provided concurrently with a Part V Licence annual audit and compliance reporting outlined in Section 10 of this Plan.

8. AMBIENT AIR MONITORING AND REPORTING

Woodside commenced an ambient air monitoring programme on the Burrup Peninsula in late 2008 as part of an internal environmental improvement initiative to gain a better understanding of how its operations on the Burrup may affect local air quality. Sinclair Knight Merz (SKM) and Ecotech designed and are executing the programme and analysing the results.

This program is complementary to the commitment within this Plan to continue a Pluto ambient air quality monitoring and analysis programme into the operational phase of Pluto, as data gathered will permit comparison of modelled data with observed data and relevant ambient air quality objectives.

The Pluto programme will commence once the plant is operating under a Part V Licence and will continue for a 24 month period, after which the results will be analysed and provided to DEC.

The Pluto programme will utilise three existing powered monitoring stations to monitor pollutant gases continuously and meteorological measurements such as wind speed and direction.

These monitoring stations were progressively installed and commissioned between October and December 2008. Monitoring station locations are listed in Table 8-1. Monitoring locations were selected to be generally representative of local ambient air quality and in line with AS2922-1987: Ambient Air – Guide for the Siting of Sampling Units [14], and AS2923-1987: Ambient Air – Guide for Measurement of Horizontal Wind for Air Quality Applications [15].

Factors which have influenced the location of the monitoring stations include:

- distance from industry;
- distance from human receptors;
- available power;
- accessibility/land tenure;
- security;
- avoid chemical and physical interference;
- unrestricted airflow; and
- open area.

The monitoring station locations are displayed in Figure 8-1. Parameters which will be monitored at each site as part of the Pluto programme are summarised in Table 8-2 along with the duration of monitoring.

Table 8-1 Monitoring station locations for the Pluto programme

Monitoring Station	Location (MGA Zone 50)		Commissioned
	Easting	Northing	
Burrup Road Water Corp Tank	476663 E	7721040 N	12 Oct 2008
Dampier North	470239 E	7716142 N	19 Dec 2008

Karratha Scout Hall	484892 E	7707575 N	24 Sep 2008

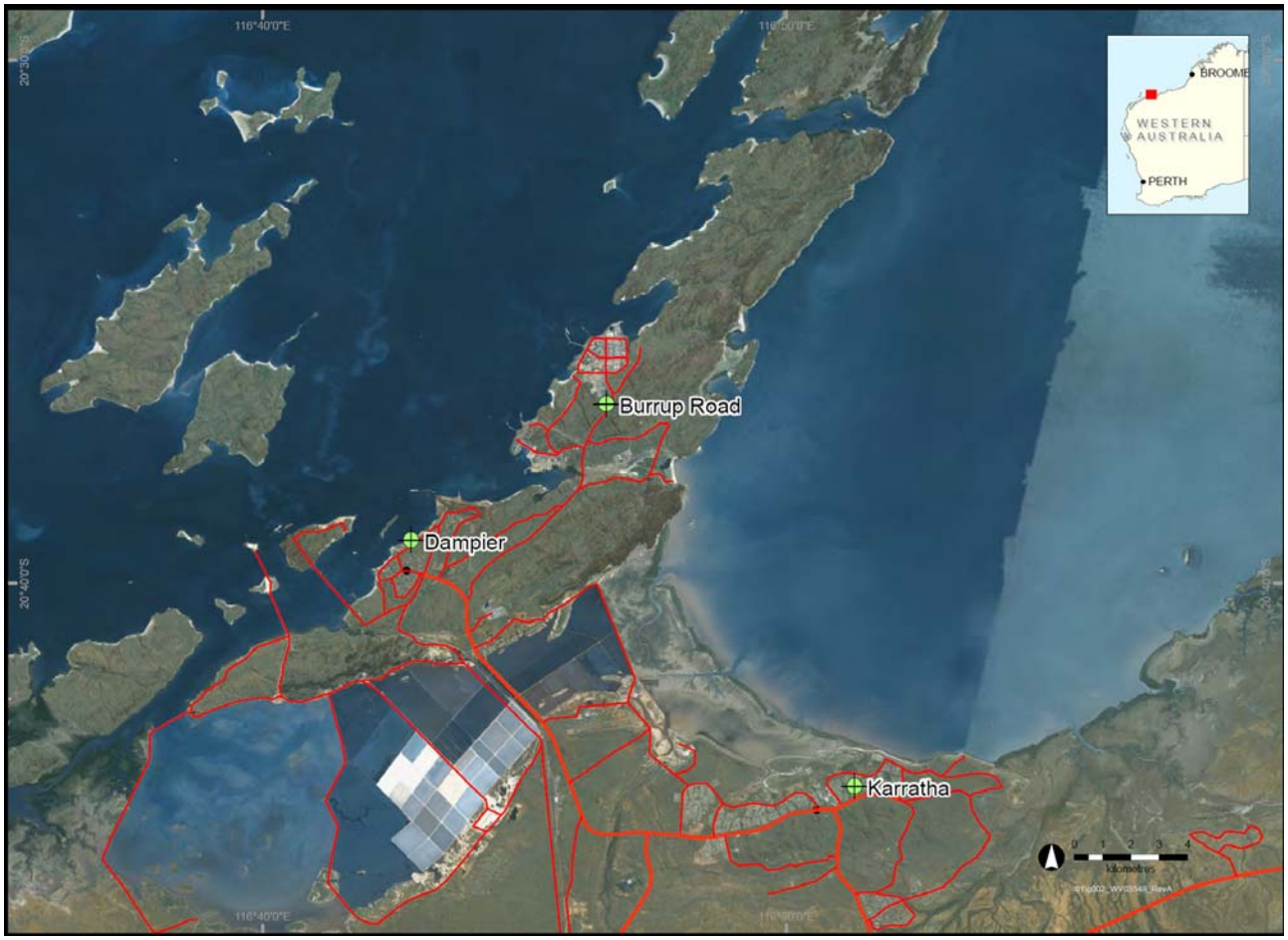


Figure 8-1 Monitoring site locations for the Pluto programme

Table 8-2 Parameters monitored for the Pluto programme

Parameter	5 Minute Averaged	15 Minute Averaged	1 Hour Averaged	24 Hour Averaged	Stations	Monitoring and review period. *(Continuation beyond this timeframe is subject to review outcomes)*
PM2.5			X	X	B, D, K	12 months
NO (ppm)	X		X	X	B, D, K	24 months
NO_2 (ppm)	X		X	X	B, D, K	24 months
NO_X (ppm)	X		X	X	B, D, K	24 months
Ozone (ppb) [1]	X		X	X	D, K	24 months
Benzene (ppb)		X	X	X	B	12 months
Toluene (ppb)		X	X	X	B	12 months
Xylene (ppb)		X	X	X	B	12 months
Air temperature (°C)	X		X	X	B, D, K	24 months
Relative humidity (%)	X		X	X	B, D, K	24 months
Wind speed (m/s)	X		X	X	B, D, K	24 months
Wind direction (degrees)	X		X	X	B, D, K	24 months
Solar radiation (W/m^2)	X		X	X	B, D, K	24 months

B= Burrup, D = Dampier K = Karratha

8.1 Monitoring Standards and Protocols

Air quality monitoring will be conducted in accordance with relevant Australian and other standards, and analysed with reference to ambient air quality criteria as summarised in Table 8-3**.**

Table 8-3 Ambient air quality monitoring parameters and air quality limits

Parameter	Ambient air quality limits		
	Concentration Standard	**Averaging period**	**Standard**
PM2.5[(1)]	25 µg/m³ (advisory reporting standard)	24 hours	NEPM (Ambient Air Quality)
	8 µg/m³ (advisory reporting standard)	Annual	
Oxides of nitrogen (NO_X)	None	None	N/A
Nitrogen dioxide (NO_2)	120 ppb	1 hour	NEPM (Ambient Air Quality)
	30 ppb	1 year	
Nitrogen oxide (NO)	None	None	N/A
Ozone (O_3)	100 ppb	1 hour	NEPM (Ambient Air Quality)
	80 ppb	4 hours	
Benzene[(2)]	3 ppb[(3)]	Annual	NEPM (Air Toxics)
Toluene	1000 ppb	24 hours	NEPM (Air Toxics)
	100 ppb	Annual	
Xylene	250 ppb	24 hours	NEPM (Air Toxics)
	200 ppb	Annual	

[1]The PM2.5 is an advisory reporting standards and goal for particles as PM2.5 outlined as a variation to the Air NEPM. The NEPC goal is to gather sufficient data nationally to facilitate a review of the standard
[2] The Air Toxics NEPM defines a Benzene monitoring investigation level for the purpose of collecting data (NEPC, 2004).
[3] Parts per billion by volume.

8.2 Equipment

The key equipment used to monitor ambient air emissions is detailed in Table 8-4.

Table 8-4 Summary of equipment used

Equipment[2]	**Measures**	**Threshold**	**Monitoring Standard**
BAM Particulate Sampler or equivalent	PM2.5	1 µg/m^3	US EPA standard or equivalent
EC9841 Oxides of Nitrogen Analyser	Oxides of Nitrogen (NO, NO_2, NO_X)	0.5 ppb	AS 3580.5.1-1993
EC9810 Ozone Analyser	Ozone	0.5 ppb	AS 3580.6.1-1990
RM Young Wind Monitor	Wind speed, direction	1.0 m/s (propeller) 1.1 m/s (vane)	AS 2923-1987
Vaisala Relative Humidity/Temp. Sensor	Temperature, relative humidity	Not specified	US EPA 450/4-87 1987
Middleton First Class Solar Radiation Sensor	Solar radiation	Not specified	US EPA 450/4-87 1987
Syntech Spectras GC955 analyser	Benzene, toluene, xylene	0.1 µg/m3 (0.03 ppb for benzene)	Gas chromatography Synspec GC955 series manual

[2] *For operational reasons Woodside may need to change or replace the analyser instruments specified in Table 8.4 with equivalent models. Replacement equipment will meet the monitoring standard stated.*

8.3 Data Recovery, Maintenance and Outages

All monitoring stations will be checked and maintained as per the Ambient Air Monitoring Programme: Maintenance and Breakdown Response Plan [16]. During maintenance and outages, a record will be kept which highlights equipment downtimes, durations and causes. It should be noted that monitoring equipment is shut down upon issue of Cyclone Warnings to protect the equipment.

8.4 Results Analysis and Reporting

A report will be compiled and provided to Office of the EPA at the completion of the programme summarising the results of the Pluto Ambient Air Monitoring Programme. Results will be reviewed and quality controlled. Presentation of results will record the data recovery rate and history including exception reports and maintenance notes, and statistical representation of captured data. Statistics presented for the collected data will include maximum, 99th, 95th, 90th and 70th percentiles, median, averages, and a comparison of recorded data to standards outlined in Table 8-3.

9. NITROGEN DEPOSITION MONITORING

9.1 Background and Context

Western Australian Ministerial Approval of the Pluto LNG Development was received in December 2007. Since this time, extensive studies have been completed which included assessment of anthropogenic air emissions on indigenous rock art on the Burrup Peninsula.

The Western Australian Government established the Burrup Rock Art Monitoring Management Committee in 2002 in response to concerns expressed about possible adverse impacts on rock art by industrial emissions to air. This Committee commissioned a number of environmental investigations to establish whether industrial emissions are having adverse impacts on rock art on the Burrup Peninsula.

These studies included measurements of air quality, microclimate, dust deposition, colour change, mineral spectrometry, microbiological analyses, accelerated weathering studies, and air dispersion modelling studies [18].

The findings of these studies and recommendations were published in April 2009 by the Burrup Rock Art Monitoring Management Committee in the report entitled; Report and Recommendations to the Minister for State Development [18]. Documentation and reports relevant to the Burrup Rock Art Monitoring Programme are publically available, and online at:
http://www.dsd.wa.gov.au/burruprockart

Key points from the Western Australian Government commissioned study pertinent to the design of the Pluto Air Quality Management Plan are summarised below:

Dispersion modelling of emissions to air from a range of sources on the Burrup Peninsula was conducted in 2003 and 2009. Relevant emissions sources include contributions from industry as point sources, shipping represented as small volume sources and area emissions from biogenic and anthropogenic sources. The current and future emissions for each of the two modelling time periods conducted. The future scenario indicates the emission rates and ambient concentrations that would have been experienced over the modelling periods if proposed industrial projects in the Pilbara region were implemented. These current and proposed/potential sources included:

- Apache Devil Creek development;
- Austeell
- Burrup Fertilisersl
- Gorgon LNG Development;
- Hamersley Power Station;
- North West Shelf Venture Karratha Gas Plant (KGP), Trains 1-5;
- KGP Train 6;
- Pluto Two Train Development (based on PER estimates);
- Shipping;
- Biogenic; and
- Area (background).

The predicted concentrations of air pollutants on the Burrup Peninsula were small and the increases due to future emissions were found to be modest [19].

As part of the study, CSIRO conducted an analysis of air pollution, rainwater composition and acid deposition on the Burrup Peninsula to assess the likelihood that air pollution from the industrial area may damage the petroglyphs (rock art). Monitoring was conducted during two distinct periods from August 2004 until September 2005 (2004/2005) and from February 2007 until September 2008 (2007/2008). This study concluded that the absolute deposition fluxes of nitrogen and sulfur are of the magnitude (~ tens of meq m^{-2} yr^{-1}) that would only affect soil or rock that is in the most sensitive class of critical loads. As the Burrup area is in a critical load class that can cope with a deposition flux of about 200 meq m^{-2} yr^{-1}, which is significantly greater than the observed deposition fluxes at the sites, acid deposition to the Burrup area is unlikely to cause any deleterious effects to rock or rock art on the Burrup Peninsula. [20]

The Report and Recommendations to the Minister for State Development [18] summarises the following:

Rock samples were exposed in the laboratory to concentrations of pollutants at current, and up to five to ten times the possible future estimates of air pollution near industry on the Burrup Peninsula. There were no detectable changes to the rock surface colour from exposure to pollutant concentrations at several times the concentrations likely to be experienced at the rock art locations near to industry on the Burrup Peninsula.

Having reviewed all the evidence of the reports and the comments from an international peer review panel, the Burrup Rock Art Monitoring Management Committee reached the conclusion that at March 2009 there is no scientific evidence to indicate that there is any measurable impact of emissions on the rate of deterioration of the Aboriginal rock art in the Burrup.

The report [18] contained the following recommendations to the Minister for State Development:

1. *That monitoring of the colour contrast and spectral mineralogy be continued on an annual basis for ten years and be reviewed after five years.*

2. *That monitoring of ambient air quality and rock microbiology be suspended and only commenced if warranted by a major increase in emissions or if evidence becomes available to require further monitoring. Triggers to consider recommencement of monitoring of ambient air quality would include a major expansion or change in emissions characteristics of any existing emission source, a major new emission source, or if monitoring of rock surfaces suggests the possibility of changes.*

3. *That a small technical working group replace BRAMMC and meet annually to consider the results of monitoring of the colour contrast and spectral mineralogy, air quality monitoring results for the Burrup, modelling and other studies, and to make these results available to the public on an annual basis.*

4. *That no environmental management measures specifically to protect the rock art from air pollution are necessary at this time. If monitoring suggests the possibility of impacts of air pollutants on rock art the technical working group will report to Government so that appropriate action may be initiated.*

In light of these findings and recommendations, the first year of results from the ambient air quality monitoring programme (2009) indicated that ground level NO_x concentrations are well below current modelled concentrations.

9.2 Pluto - Nitrogen Deposition Monitoring Study

Woodside will implement a nitrogen deposition monitoring programme for a period of 24 months of data collection between end 2011 and end 2013. The programme has been developed to determine nitrogen deposition at six locations on and adjacent to the Burrup Peninsula before and during operation of the Pluto LNG Project.

Monthly samples of wet-only rainwater, total suspended particles (TSP) and nitrogen dioxide (NO_2) gas will be collected at each location outlined in Table 9-1. In addition, weekly size resolved particulate samples will be collected at one location (to be determined) for three weeks during the 2012/2013 calendar years.

Table 9-1 Monitoring station locations for the Pluto Nitrogen Deposition Programme

Monitoring Station	Location Coordinates	
	Latitude	Longitude
Woodside East	20.60167	116.78276
Burrup Road	20.62093	116.76928
Water Tank	20.61800	116.78516
King Bay South	20.64416	116.75067
Karratha	20.73575	116.83662
Mardie Station	21.16790	116.12000

At each, site wet–only rainwater samples will be collected using a rainwater sampler; TSP samples will be collected on Teflon filters using a Micro-Vol 110 sampler; NO_2 will be collected using passive samplers (in duplicate). TSP mass will also be determined gravimetrically. Rainwater and TSP soluble ion composition will be determined using ion chromatography. Gravimetric mass and soluble ion composition data will be NATA accredited.

The concentrations of ammonia and nitrate in the rainwater samples will be used to determine nitrogen deposition in the aqueous phase. The dry deposition of particles however is strongly dependent on the size distribution of the particles. Hence, the study will also include the collection of three size-resolved particle samples using a cascade impactor that divides a particle sample into

12 size fractions between 0.056 and 10µm. The soluble ion composition of these size-resolved samples (particularly ammonia and nitrate) will be used to determine the deposition of nitrogen in the particulate phase.

NO_2 concentrations on the passive samplers will be determined by colourimetric spectrophotometry and from this nitrogen deposition in the gas phase will be determined.

Upon completion of the data collection phase, a report will be prepared and provided to EPA by 1 July 2014. The report will present the results of the programme, and findings with consideration of:

- the latest findings and recommendations from the BRAMMC (or replacement group);
- the latest understanding of existing and proposed industrial emissions sources in the region; and
- results obtained from the Pluto ambient air quality monitoring programme.

Further to these commitments, Woodside is actively contributing to managing the recommendations above through its support of the establishment of a Technical Working Group which is to be led by the Department of Environment and Conservation on behalf of the Minister for the Environment.

10. SCHEDULED REPORTING AND REVIEW

Woodside will review results of ongoing emissions monitoring and ambient air monitoring programs outlined in this document on a regular basis. Results will be compared with previously completed sampling and monitoring results and risk and impact assessments presented in approvals documentation. If actual emission levels are found to be significantly higher than predicted risk assessment levels, this difference will be communicated concurrent with a Part V Licence annual audit and compliance report and a way forward will be outlined.

An annual report will be prepared which summarises point source emissions monitoring results and other notifications described in this plan. The annual report will be provided to the DEC Regional Manager concurrent with a Part V Licence annual audit and compliance report.

The plan may require revision at any time if required, for example, as a result of the reviews described in this section, or to reflect a change in any regulatory conditions that apply to the Project, to ensure the plan remains up-to-date. If there are any significant changes required to be made to the monitoring program or any other aspect of this plan, a revised plan will be provided to the EPA for approval. Approval will be obtained before the revised plan is implemented and the revised plan will be made publicly available.

10.1 Ambient Air Monitoring Review

The following review will be undertaken on the ambient air monitoring programme:

- 12 month review of the PM2.5 and BTX monitoring data; and
- 24 month review of NOx and ozone monitoring data.

This review process will be coordinated by Woodside using an independent peer reviewer to be agreed with EPA. The review process methodology will be agreed upon before the first review with the following stakeholders: EPA, Woodside and the independent peer reviewer.

Following the 12 month review a decision will be made on the continuation of the PM2.5 and BTX monitoring requirements. A decision on the continuation of the NOx and ozone monitoring will occur as part of the 24 month review process.

10.2 Nitrogen Deposition Monitoring Review

Following the 24 month nitrogen deposition monitoring period a review of the data will be conducted. This review will be coordinated by Woodside using an independent peer reviewer to be agreed with EPA. The review process methodology will be agreed upon before the review with the following stakeholders: EPA, Woodside and the independent peer reviewer.

A decision on the continuation of the nitrogen depositional monitoring programme will occur as part of the review process.

11. COMMUNITY QUERIES

Woodside is committed to open dealing with the local communities within which it operates. Woodside has in place a process [21] to ensure that any member of the community can easily raise a query or concern with Woodside, which will be addressed promptly.

This process ensures that:

- All interaction, queries, feedback or complaints are efficiently and politely received;
- All necessary information is collected and reported; and
- Appropriate corrective and preventative action is taken, including feedback (if requested or required) to the person raising the query.

Any feedback is logged in a Complaints Query Log Sheet and forwarded to the appropriate area within Woodside for action. [22]

Feedback on the Pluto LNG Project can be lodged with Woodside at any time, via Pluto free call number 1800 634 988 or email pluto.info@woodside.com.au

12. REFERENCES

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APPENDIX – OFFICE OF THE EPA LETTER OF APPROVAL OF THE PLUTO AIR QUALITY MANAGEMENT PLAN

Approved under the provisions of the *Environmental Protection Act 1986*.

GOVERNMENT OF WESTERN AUSTRALIA

Office of the Environmental Protection Authority

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Mr Farid Bogani
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PERTH WA 6840

Dear Mr Bogani

PLUTO LIQUEFIED NATURAL GAS DEVELOPMENT (SITE B OPTION) BURRUP PENINSULA, SHIRE OF ROEBOURNE (MINISTERIAL STATEMENT 757) – PLUTO LNG PROJECT AIR QUALITY MANAGEMENT PLAN

Thank you for your letter of 23 September 2010 and the attached Pluto LNG Project Air Quality Management Plan (28 September 2010, Revision 0), prepared to address Condition 11-2 of Ministerial Statement 757 which initially states that:

11-2 At least three months prior to commencement of operations, the proponent shall prepare an Air Quality Management Plan to the requirements of the Minister for the Environment.

The revised Pluto LNG Project Air Quality Management Plan (September 2011, revision 1) is considered to be complete. It is noted that monitoring review periods are detailed within your plan, it is expected that you will liaise with the OEPA regarding this review, prior to when these time periods will elapse.

If there are any changes to the Pluto LNG Project Air Quality Management Plan (September 2011, revision 1) that would substantially affect the management actions or targets, the amended plan is required to be resubmitted to the OEPA.

Yours sincerely

Kim Taylor
GENERAL MANAGER

10 October 2011

Cc: Department of Environment and Conservation Air Quality Branch
Department of Environment and Conservation Industry Regulation Branch, Pilbara Region
Department of Indigenous Affairs