Delta electricity

Appendix D
Air Quality Assessment

Marulan Gas Turbine Facility

Environmental Assessment

PROJECT APPLICATION

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URS

R E P O R T

Delta Electricity - Marulan Gas Turbine Facility - AIR QUALITY ASSESSMENT

Prepared for

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Executive Summary

Delta Electricity proposes to construct and operate a gas turbine facility at Marulan, 35km north east of Goulburn, NSW. Subject to final facility selection, the Facility will comprise two gas turbines and will operate in two Stages.

Stage 1: Two open cycle gas turbines with a total capacity in the range of 250 to 350 MW. Each turbine could have a capacity in the order of 125 to 175 MW depending on final equipment selected.

Stage 2: Conversion to combined cycle facility to generate electricity for intermediate/base load electricity demand. The proposed capacity of the Stage 2 combined cycle facility is in the range of 400 to 450 MW.

EnergyAustralia are also proposing to construct a similar gas turbine facility adjacent to the Delta Electricity Stage 1 facility. The EnergyAustralia facility is to comprise two turbines in the 175 MW range operating in the open cycle mode only producing a total nominal facility output of 350 MW.

The assessment was undertaken in accordance with the NSW EPA (2005) *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW*. To ensure the potential impacts from the Delta Electricity facility were adequately addressed, the air quality assessment was conducted assessing the standalone Delta Electricity project as well as the combined Delta Electricity and EnergyAustralia projects.

A greenhouse gas assessment was performed for the Delta Electricity Facility and cumulatively with the EnergyAustralia Facility. The assessment estimated, during Stage 1, the Facility would release approximately 0.13 million tonnes of CO_2-e per year, representing 0.23% of emissions from electricity generation in NSW, or 0.02% of all sources of greenhouse gas in Australia. Based on the Stage 2 operation, total greenhouse gas emissions from the Facility are estimated to be approximately 2.1 million tonnes CO_2-e per year, representing 3.63% of emissions from electricity generation in NSW, or 0.37% of all sources of greenhouse gas in Australia. For the combined Delta Electricity (Stage 2) and EnergyAustralia Facilities, based on the upper limits of proposed operation, the assessment estimated the release of approximately 2.3 million tonnes of CO_2-e, representing 3.96% of the emissions from electricity generation in NSW, or 0.41% of all sources of greenhouse gas in Australia.

The air dispersion modelling assessment for Delta Electricity Stage 1 and Stage 2 concluded that under worst case meteorological conditions (with all units operating all hours), the predicted impacts on ground level concentrations of NO_2, PM_{10}, CO, SO_2 and Hazardous Air Pollutants were within the DECC requirements.

The air dispersion modelling assessment for the combined facilities showed the combined Start Up scenarios (Delta Electricity Stage 1 Start Up and EnergyAustralia Start Up) to be the worst case scenario for the majority of modelled compounds, however the modelled compounds were still shown to be below DECC regulatory criteria. The worst case scenario for NO_2 was calculated using the Janssen equation to have a maximum ground level concentration of 229.9 $\mu g/m^3$, which included a maximum background NO_2 concentration of 116.9 $\mu g/m^3$. This maximum predicted NO_2 concentration is below the criteria of 246 $\mu g/m^3$. For all Scenarios modelled, including combined scenarios, PM_{10}, CO, and SO_2 reported only minor impacts. As per the approved methods, HAPs were assessed for incremental impact and were well below regulatory criteria.

The operation of the Facilities could have the potential to impact on aircraft operation. A plume rise assessment was undertaken, the findings of which is contained in **Appendix C** of this report. During the detailed design consideration will be given for the Facilities to be designated a potential hazard to aircraft operation in the area. The implementation of such designation would be at the discretion of Civil Aviation Safety Authority (CASA).

With the implementation of the proposed mitigation measures, it is considered that the potential for adverse air quality impacts as a result of the Delta Electricity and EnergyAustralia Facilities, both individually and combined, will be minor and within regulatory criteria.

Section 1 Introduction

1.1 Overview

Delta Electricity is proposing a Gas Turbine Facility to be located at site on Canyonleigh Road, Brayton, approximately 12km northeast of the village of Marulan referred to herein as the Marulan Site.

The implementation of the Delta Electricity Gas Turbine Facility would be carried out in two stages:

Stage 1: Two open cycle gas turbines with a total capacity in the range of 250 to 350 MW. Each turbine could have a capacity in the order of 125 to 175 MW depending on final equipment selected.

Stage 2: Conversion to combined cycle facility to generate electricity for intermediate/base load electricity demand. The proposed capacity of the Stage 2 combined cycle facility is in the range of 400 to 450 MW.

The facility type will be determined during the tender process, however; a conservative assessment has been conducted based on two E class[1] gas turbines, featuring dry low-NO_x (DLN) burners. The development is planned to occur in two stages, Stage 1 and Stage 2. Stage 1 of the development involves the construction of the Facility to operate in an open cycle gas turbine (OCGT) arrangement as a 'peaking' facility, with the turbines having a combined capacity between 250 and 350 MW. Stage 2 of the development involves the conversion of the open cycle facility to a combined cycle gas turbine (CCGT) arrangement. The Stage 2 turbines will have a combined capacity between 400 and 450 MW during combined cycle.

In addition, EnergyAustralia are also proposing to construct a similar gas fired turbine facility adjacent to the Delta Electricity Stage 1 Facility also on the Marulan Site. The EnergyAustralia Facility would comprise two open cycle gas turbines each of approximately 175 MW capacity, producing a total nominal facility output of 350 MW designed to supply power to the main electricity grid during times of peak electricity demand. In order to ensure the potential impacts from the Delta Electricity facility are adequately assessed, the air quality assessment investigated the emissions from the standalone Delta Electricity facility as well as the combined impact of the emissions from both the Delta Electricity and EnergyAustralia facilities.

1.1.1 Greenhouse Gas

An evaluation of Greenhouse gas emissions, and relevant Greenhouse gas programs was undertaken as part of this assessment. This air quality assessment includes a comprehensive greenhouse gas assessment incorporating a quantitative model showing the tonnages of each produced (directly and indirectly from the development) per year.

1.1.2 Air Quality

The proposed Facility is situated in a rural area and emissions from surrounding industrial sources are negligible. Consequently, the impact of the Delta Electricity Facility on local air quality is expected to be minor. Similarly, given the distance of the Delta Electricity Facility from the greater metropolitan regions of Sydney and Wollongong, a detailed regional air quality assessment was not considered warranted.

1.1.3 Aviation Safety

Stack emissions (plumes) from power plants have the potential to adversely affect aircraft flying through the plumes. The Civil Aviation Safety Authority (CASA) provides guidelines for evaluating the potential

[1] E class refers to gas turbines with an open cycle capacity of 100-199MW.

extent of plume influence from the plant. An aviation safety assessment has also been undertaken for the project, to establish compliance with the CASA guidelines.

1.2 Overview of Approach to Air Quality Impact Assessment

The Environmental Assessment Requirements require the air quality assessment to be prepared in accordance with the NSW EPA (2005) *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (the *Approved Methods*). The *Approved Methods* identify a number of stages in an air quality impact assessment:

1) Input data collection.
2) Dispersion modelling.
3) Processing dispersion model output data.
4) Interpretation of dispersion modelling results.
5) Preparation of an impact assessment report.

The first step in the impact assessment is the collection of information required to complete the dispersion modelling. This includes development of an air emissions inventory, compilation of meteorological data, background air quality data and terrain data. This step is addressed in detail in **Sections 3,6** and **7**.

For Step 2 of the assessment it is noted that three dispersion models are generally endorsed by DECC for development approvals, namely AUSPLUME, TAPM and CALPUFF. The TAPM and CALPUFF models both incorporate site-specific factors such as terrain influences, regional-scale winds and inversions to predict ground-level concentrations. Given the significance of this assessment, it was considered that the use of two models provided greater reliability in the prediction of the potential impacts. The CALPUFF model better handles calm atmospheric conditions and was used to generate the majority of results, with TAPM providing validation of the CALPUFF model concentrations. **Section 8** presents the results from the CALPUFF modelling. A discussion of the validation of these results using TAPM modelling is presented in **Appendix D**.

Due to the different operational scenarios for each of the Delta Electricity (both stages) and EnergyAustralia Facilities and the varying emission characteristics, several scenarios were required to be modelled. The modelling scenarios are discussed further in **Section 7**. Additional "combined Facility" scenarios were modelled and the results are provided in **Appendix D**, however only the worst case Combined Facilities results have been presented in the main report.

Step 4 of the impact assessment is the interpretation of dispersion modelling results. The outputs of the dispersion modelling are added to existing maximum background concentrations of pollutants to determine the predicted ground level concentrations. These ground level concentrations are compared with the DECC's impact assessment criteria. DECC states in the *Approved Methods* that *"…compliance indicates the proposal is unlikely to result in adverse air quality impacts"*. (NSW EPA, 2005 p-3)

1.3 Definitions

AWS – Automatic Weather Station

BoM – Bureau of Meteorology.

Calmet – a 3-D meteorological model designed to provide data for use in Calpuff.

Calpuff – an air quality dispersion model.

CCGT – Combined Cycle Gas Turbine.

Section 1 Introduction

CO_2-e – Carbon dioxide equivalent. Relates to the greenhouse warming potential (GWP) of a certain gas compared to that of carbon dioxide, where carbon dioxide has a GWP of 1. For example, methane (CH_4) has a GWP of 21, meaning that a release of 100 tonnes of CH_4 would be the equivalent to releasing 2100 tonnes of CO_2, in terms of global warming.

CSIRO – Commonwealth Scientific and Industrial Research Organisation

Delta Electricity Facility - The proposed Delta Electricity Facility (Stage 1 and Stage 2) and the portion of the Site that the Delta Electricity Facility would be located within the Marulan Site.

EnergyAustralia Facility - **T**he proposed EnergyAustralia facility and the area portion of the Site that the EnergyAustralia Facility would be located within the Marulan Site.

Facilities: Collective reference to the Delta Electricity and EnergyAustralia facilities.

Greenhouse Gas Protocol – a globally accepted procedure for companies to quantify, report and reduce their greenhouse gas emissions.

Greenhouse Challenge Plus - The programme integrates the Generator Efficiency Standards and the Greenhouse Friendly™ initiative into a single industry programme, focused on reducing greenhouse gas, promoting energy efficiency, integrating greenhouse issues into decision making and allowing for a consistent manner for reporting greenhouse gas emissions.

GGAS - The Greenhouse Gas Reduction Scheme (GGAS) commenced on 1 January 2003. It is one of the first mandatory GHG emissions trading schemes in the world and is specifically associated with the electricity generation sector. GGAS aims to reduce GHG emissions in NSW by 5% per capita below 1989/90 levels by 2007, by encouraging project based activities to offset the production of GHG emissions.

GWP – Global Warming Potential – compares the heat absorbing ability of a greenhouse gas to that of the same mass of carbon dioxide over a given timeframe.

OCGT – Open Cycle Gas Turbine**.**

Operation – The gas turbine running during normal operation i.e. after Start Up. For the purposes of this assessment, normal operation was considered to be 100% load.

Scenarios – Due to the varying conditions of operation, such as Start Up and Operational and the difference in emissions during Stage 1 and Stage 2, for the Delta Electricity Facility, several dispersion modelling scenarios were investigated. However, only the five most relevant scenarios were included in this assessment, namely Scenario 1 – Delta, Scenario 2 – Delta, Scenario 3 – Delta, Scenario 1 – Combined and Scenario 2 – Combined.

Scenario 1 – Delta Electricity. Dispersion model scenario of the gas turbine emissions during the Start Up period of the Delta Electricity facility during Stage 1.

Scenario 2 – Delta Electricity. Dispersion model scenario of the gas turbine emissions during the Operation period of the Delta Electricity facility during Stage 1.

Scenario 3 – Delta Electricity. Dispersion model scenario of the gas turbine emissions during the Operation period of the Delta Electricity facility during Stage 2.

Scenario 1 – Combined. Dispersion model scenario of the gas turbine emissions during which the EnergyAustralia Facility is operating in Start Up mode and the Delta Electricity Facility is also operating in Start Up mode.

Scenario 2 – Combined. Dispersion model scenario of the gas turbine emissions during which the EnergyAustralia Facility is operating in Start Up mode and the Delta Electricity Facility is operating in Stage 2 Operational mode.

Stage 1 – Refers to the Delta Electricity Facility operating in peaking (open cycle) mode.

Section 1 Introduction

Stage 2 – Refers to the Delta Electricity Facility operating in combined cycle mode.

Start Up – The Start Up period for the gas turbine. The duration of Start Up is turbine specific, however, for gas turbines being considered, Start Up would generally take less than 30 minutes.

TAPM – **T**he **A**ir **P**ollution **M**odel. An air quality dispersion model developed by CSIRO.

Section 2 Project Description

2.1 Proposed Development and Turbine Operation

The site location and site layout of both the Delta Electricity and EnergyAustralia Facilities are presented in **Figures 1** and **2**. The Delta Electricity Facility could be developed in two main stages, which are briefly discussed below.

Stage 1 of the development involves the construction of the Facility to operate in an open cycle gas turbine (OCGT) arrangement as a 'peaking' facility. In this configuration, the facility is able to reach full generating capacity in around fifteen minutes from start-up. The Facility in this configuration would operate approximately 500 hours (~5%) of the year.

In each gas turbine generator, air is drawn in through filters to remove particulate matter and passed into the compressor section of the gas turbine. In each compressor, multiple rows of rotating blades raise the temperature and pressure of the air. Following compression of the air to pressures of 15 - 30 atm (depending on the gas turbine model selected), the air flows into combustion chambers (combustors) arranged around each gas turbine. In these combustors, natural gas is injected and oxidised, increasing the temperature to approximately 1,100 - 1,200°C.

The combustion products from the combustion chambers enter the turbine section of the gas turbines and expand to atmospheric pressure, reducing in temperature to around 550°C. As the gas expands, the gases drive the turbine, which in turn, drives the compressor and an electrical generator. From the turbine, the hot exhaust gases are discharged directly to the stack (Stage 1) or to a stack via the Heat Recovery Steam Generators (HRSGs) in combined cycle operation (Stage 2).

Stage 2 of the development involves the conversion of the open cycle facility to a combined cycle arrangement. This involves reclaiming excess heat from the exhaust via heat HRSG units, which utilise heat from the combustion process to generate steam that is then subsequently used to drive a steam turbine/generator arrangement. The thermal inertia of this system means that unlike OCGT configurations, the steam driven component of the Facility takes several hours to reach full operation. The additional start-up time required for the steam component, coupled with the improved efficiency once running, means that it is viable to run for extended periods thus generating an intermediate/base load capacity as opposed to the peaking style of the open cycle gas turbine facility. The Facility would operate at around 90% capacity in combined cycle mode.

The Facility will have no black start capacity[2], which negates the requirement of diesel motors to start the turbines in the absence of power on the electricity grid. There is also no plan for dual fuel operation[3]. Thus the higher emissions associated with the products of combustion of distillate oil will not occur.

The assessment investigated the air quality impacts of both Stage 1 and 2 as well as the combined impact from the EnergyAustralia facility.

2.2 Turbine Emissions

The primary gaseous emissions from the turbines and the formation source are listed in **Table 2-1**.

[2] "Black Start" refers to the start up of the plant using diesel fuel.

[3] Dual Fuel operation refers to the capability of the turbine to operate on both gaseous and liquid fuel. This capability is generally intended to allow plant operation during a failure in the gas supply system.

Section 2 Project Description

Table 2-1 Exhaust components and their sources

Species	Source
N_2, O_2, H_2O	Inlet Air
NO_x	Oxidation of primarily atmospheric and also fuel-bound nitrogen
SO_x	Oxidation of fuel-bound sulphur
CO_2	Oxidisation of carbon in fuel
CO	Incomplete oxidation of carbon in fuel
Particulate Matter	Incomplete oxidation of fuel/impurities in fuel
Hazardous Air Pollutants	Impurities in fuel and incomplete oxidation of fuel

The primary atmospheric emissions from the Facility would be the same as those from most combustion sources, namely: nitrogen (N_2), oxygen (O_2), carbon dioxide (CO_2), water vapour (H_2O), oxides of nitrogen (NO_x) and carbon monoxide (CO). Other gaseous emissions are likely to include oxides of sulphur (SO_x), and low concentrations of particulates and Hazardous Air Pollutants (HAP[4]). N_2 and O_2 will not be assessed and CO_2 is to be addressed as part of the greenhouse gas assessment. HAP are known to occur in small amounts from this type of source. There are, however, some HAP such as formaldehyde, which are known to be emitted from gas combustion, however, for the purposes of this assessment, the primary gaseous species listed, namely NO_x, CO, SO_x, and particulates (PM_{10}) are considered to be the pollutants of greatest concern and have been the focus of this air quality study.

[4] For the purpose of this assessment, HAP includes Volatile Organic Compounds (VOC).

Section 3 Discharges to Air

3.1 Construction Emissions

Bulk earthworks for the two Facilities, should they occur at the same time, are anticipated to take approximately 6 months to complete. The Delta Electricity Facility would be constructed in two stages with the first stage being assumed to take 12 months and 18 months for Stage 2. The EnergyAustralia Facility would be constructed entirely in one stage and has been assumed to take 12 months to complete. These construction periods may or may not overlap.

There is a potential for dust to be generated during the construction events. Dust emissions are to be controlled through mechanisms contained in the Construction Environment Management Plan (CEMP).

3.2 Operation Emissions

3.2.1 Greenhouse Gas Emissions

Greenhouse gas emissions from gas fired turbines will comprise primarily carbon dioxide (CO_2) with small amounts of methane (CH_4) and nitrous oxide (N_2O). The discussion of likely Greenhouse gas emissions and programs relevant to this Project is provided in **Section 4** to this report.

3.2.2 Oxides of Nitrogen

Oxides of nitrogen (NO_X) is the sum of nitric oxide (NO) and nitrogen dioxide (NO_2). In gas turbines the primary mechanism for NO_X formation is termed “thermal NO_X”. This occurs in the burners, where high temperatures allow the dissociation of atmospheric nitrogen (N_2), after which the nitrogen may combine with excess oxygen. Generally the NO_x emissions from a combustion source comprise approximately 90% NO and 10% NO_2.

In the atmosphere NO and NO_2 are linked in a circular reaction with oxidants such as ozone, which generate NO_2 from NO and sunlight which breaks NO_2 down to NO. Due to this reaction sequence, the exact amount of NO and NO_2 within emissions is often unknown, and consequently the sum emission of both species (i.e. NO_x) is quoted. The ambient concentration of NO_2 near to a NO_X source is dependent on the amount of oxidant and sunlight at the time.

In ambient concentrations usually found within the atmosphere, NO has no impact on either human health or the environment. Conversely, it is known that short term concentrations of NO_2 greater than 200ppb (411µg/m^3) (NEPC, 1998a), have the potential to cause irritation in certain individuals. To ensure that individuals are protected from potential health impacts of short term concentrations, maximum short term exposure is set within NSW at 246 µg/m^3 (120ppb). The long term effects of NO_2 are less well known although some evidence suggests poor lung function of inhabitants of areas with high NO_2 concentrations. To address the potential long term effects of NO_2, an annual average limit of 62 µg/m^3 has been set by the Department of Climate Change & Environment (DECC), now incorporating the New South Wales Environment Protection Authority (NSW EPA).

3.2.3 Particulate Matter

Particulate matter is generally divided into two broad fractions - deposited and suspended. Deposited particulate matter is dust that, because of its aerodynamic diameter and density, rapidly falls from the air. In general terms, deposited particulate has a diameter of greater than about 20 µm. However, there is no distinct dividing line between these particles and the smaller particles of suspended matter that fall more slowly out of the air. Because of the size of the particulate matter, most of this material will not enter the human body thorough inhalation. Hence the effects of deposited particulate are primarily nuisance, and may only affect health via annoyance reactions.

Major natural sources of background particulate levels include forest fires, pollen and wind-blown dust from exposed areas. Anthropogenic sources include stationary and mobile combustion sources, road dust, agriculture, mining, major fires and emissions from industrial processes. Background levels vary widely depending on location, meteorology and proximity of major point or area sources.

Particulate matter, with an aerodynamic diameter of 10 µm or less (PM_{10}) js acknowledged as a pollutant of concern due to its ability to be inhaled into the lungs. PM_{10} has been considered as part of this assessment.

Gas turbine emissions operating on natural gas generally contain very low concentrations of particulate matter due to the fuel type and combustion process (US EPA 2000).

3.2.4 Sulphur Dioxide

Emissions of sulphur dioxide are defined by the sulphur content of the fuel. Given that sulfides are removed from natural gas as part of the “desulphurisation” process at the natural gas processing plant, sulphur dioxide emissions are likely to be low to negligible.

3.2.5 Carbon Monoxide

Carbon monoxide (CO) is produced due to the incomplete combustion of any fuel containing carbon, where there is too little oxygen within the mix or the fuel. In gas turbines this occurs primarily during the Start Up phase of operation.

3.2.6 Hazardous Air Pollutants

Hazardous Air Pollutants (HAPs) emissions from gas turbines are lower than for other combustion sources e.g. internal combustion engines (US EPA, 2000). This is due to the combustion environment present, where high temperatures and high amounts of excess air promote more complete combustion of the fuel. The HAPs produced from gas-fired gas turbines include HAPs such as benzene and Polycyclic Aromatic Hydrocarbons (PAHs). Metallic HAPs, such as lead, are not generally considered to be present in significant concentrations in natural gas (US EPA 2000), consequently shall not be assessed.

A review of US EPA (2000) and DEH (2005) suggest the primary HAPs from gas turbines are:

- Acetaldehyde;
- Acrolein
- Benzene;
- Ethylbenzene;
- Formaldehyde;
- Toluene;
- Total PAHs; and
- Xylenes.

The listed HAPs were investigated as part of this assessment.

3.3 Emissions from Other Operational Sources

For the purposes of this report, it has been assumed that the stack emissions represent the primary emission source on site. Other air emission sources on Site include:

- drainage collection pond;
- waste water pond;

- evaporative cooler;
- oil separator pit;
- grey water tank; and
- sanitary/foul water treatment.

These sources are not considered significant and were not included in the modelling.

Section 4 Greenhouse Gas Assessment

4.1 Background

The principal greenhouse gas emission from the proposed Delta Electricity Facility is carbon dioxide (CO_2), which is the main product of fuel combustion. Minor quantities of other greenhouse gases may be emitted and have been represented in this assessment, as carbon dioxide equivalent (CO_2-e).

Greenhouse gases absorb the infrared radiation reflected from the earth's surface and trap the heat in the atmosphere. The most abundant of these gases are carbon dioxide (CO_2) and water vapour (H_2O). Other greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O) are present in much smaller amounts in the atmosphere. Naturally occurring greenhouse gases raise the Earth's global average temperature to approximately 15°C, approximately 33°C higher than without their presence.

The less abundant greenhouse gases (e.g. CH_4 and N_2O) are much more efficient in trapping infrared radiation than CO_2. The measure of how "efficient" a greenhouse gas in trapping heat is called the Global Warming Potential (GWP). GWP compares the heat absorbing ability of a greenhouse gas to that of the same mass of carbon dioxide over a given time frame. For example, over a 100 year time-frame, methane traps approximately 21 times as much infrared radiation from the earth as CO_2 and nitrous oxide approximately 310 times as much infrared radiation as CO_2. When compiling greenhouse gas inventories, this difference in Global Warming Potential is accounted for by converting one tonne of non-CO_2 greenhouse gas into a CO_2 equivalent (CO_2-e) amount using the GWP for that particular non-CO_2 gas.

Since greenhouse gases trap heat in the atmosphere, scientists have suggested that there is a causal link between the rapid increases in the concentrations of greenhouse gases and the possibility of increased global temperatures. The best available scientific evidence suggests that the global average temperature has increased by approximately 0.76 ± 0.19 °C from 1850-1988 to 2001-2005[5]. Because of this, the accounting and management of greenhouse gas emissions resulting from human activities are increasingly seen as an important issue by some governments and industrial companies. Furthermore, efficiencies in greenhouse gas emissions are often related to efficiencies in energy consumption.

This assessment includes a quantitative model of the tonnages of greenhouse gas produced by the propose Delta Electricity Facility, which is compared to state and national greenhouse gas inventories for both the energy sector, and the sum of all sectors. Also included is an estimation of greenhouse gas emissions over the life of the project.

4.2 Greenhouse Gas Policy

Global and national greenhouse gas policy is complex and despite the Kyoto protocol coming into force internationally in 2005 and in Australia in March 2008, the practical implications are still being finalised. This section briefly summarises the policy issues.

4.2.1 International Policy

The Kyoto Protocol to the United Nations Framework Convention on Climate Change was signed in 1997 and entered into force in 2005. Its aim is to limit greenhouse gas emissions of countries that ratified the protocol by setting individual mandatory greenhouse gas emission targets in relation to those countries' 1990 greenhouse gas emissions. It sets out three "flexibility mechanisms" to allow greenhouse gas targets to be met:

- The Clean Development Mechanism;

[5] Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis, Summary for Policymakers,* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, http://www.ipcc.ch.

- Joint Implementation; and
- International Emissions Trading.

The definitions of the three mechanisms above are complex but effectively they allow greenhouse gas reductions to be made at the point where the marginal cost of that reduction is lowest. Essentially, an industrialised country sponsoring a greenhouse gas reduction project in a developing country can claim that reduction towards its Kyoto Protocol target and those greenhouse gas reductions can be traded.

4.2.2 Australian Policy

In December 2007, the Australian Government ratified the Kyoto Protocol which effectively states that greenhouse gas emissions not be more than 8% above 1990 levels. This came into force in Australia in March 2008.

Australia's Climate Change Policy

Australia's Climate Change Policy was released in July 2007[6] and sets out the Commonwealth Government's focus on reducing emissions, encouraging the development of low emissions and emission reduction technology, climate change adaptation, and setting Australia's policies and response to climate change within a global context.

Existing monitoring and reporting programs at a national level include the following:

- National Greenhouse Gas Inventory (NGGI);
- Greenhouse Challenge Plus, including the Generator Efficiency Standards;
- National Pollutant Inventory;
- ABARE Fuel and Energy Survey;
- Energy Efficiency Opportunity Assessment subset of the NFEE;
- Mandatory Renewable Energy Trust (MRET); and
- Greenhouse Friendly.

National Emissions Trading Scheme

The recently released report of the Prime Ministerial Task Group on Emissions Trading[7] has foreshadowed a national emissions trading scheme to help Australia address the global issues of climate change. The initial information is that this will be a "cap-and-trade" scheme, and will be developed by 2010.

Key features of the proposed scheme are:

- Setting of a long-term emissions abatement goal;
- Setting of an initial low target to establish a low starting price for carbon;

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6 Department of the Prime Minister and Cabinet 2007 Australian Government *Australia's Climate Change Policy* , July 2007.

7 Department of the Prime Minister and Cabinet, 2007, *Report of the Task Group on Emissions Trading*, http://www.pmc.gov.au/climate_change/emissionstrading/.

- Implementing progressively more stringent targets, to help drive deeper emission reductions and longer-term technology development;
- Establishing maximum practical coverage of all emission sources and sinks and of all Greenhouse gases;
- Permit liability placed on direct emissions from large facilities and on upstream fuel suppliers for other energy emissions;
- Practical considerations include initial exclusion of agriculture and land use emissions;
- Allocates permits for trade-exposed emission-intensive industries to reduce short-term impacts while encouraging abatement and energy efficiency;
- Recognition of a wide range of credible domestic and international carbon offset regimes; and
- Capacity, over time, to link to other national and regional schemes in order to provide the building blocks of a truly global emissions trading scheme.

National Greenhouse and Energy Reporting Act 2007

The *National Greenhouse and Energy Reporting Act 2007* establishes a single, national system for reporting greenhouse gas emissions, abatement actions, and energy consumption and production by corporations from 1 July 2008. Data reported through the system will underpin the Australian Emissions Trading Scheme (AETS). The ability to monitor, report and verify businesses' emissions data will be essential for maintaining the environmental and financial integrity of the trading system.

AETS requires “controlling corporations” to register and report if its “corporate group” or “facilities” under its “operational control” emit greenhouse gases, produce energy or consume energy above specific thresholds. AETS commences in July 2008 and will facilitate collection of data for an emissions trading scheme.

The Delta Electricity Facility will be subject to mandatory reporting under the National Greenhouse and Energy Reporting Act 2007 as per the requirements outlined in the Greenhouse Gas Emissions and Energy Reporting Policy Paper issued for comment in February 2008.

Greenhouse Challenge Plus

The Greenhouse Challenge Plus program, run by the Australian Greenhouse Office, encompasses reducing emissions from electricity infrastructure, buildings, fleet, manufacturing operations and end-use waste. Delta Electricity has been a member of the Greenhouse Challenge Plus program since 1997.

Energy Efficiency Opportunities (EEO)

The Energy Efficiency Opportunities legislation came into effect in 2006, and requires large energy users (over 0.5PJ of energy consumption per year) to participate in the program (see http://energyefficiencyopportunities.gov.au for program details). The objective of this program is to drive ongoing improvements in energy consumption amongst large users, and businesses are required to identify, evaluate and report publicly on cost effective energy savings opportunities.

Energy Efficiency Opportunities is designed to lead to:

- improved identification and uptake of cost-effective energy efficiency opportunities;
- improved productivity and reduced greenhouse gas emissions; and
- greater scrutiny of energy use by large energy consumers.

Generators and distribution companies are currently exempt for 3 years (to March 2010) from EEO whilst a policy framework is established. This framework will allow the EEO to effectively integrate with existing policy measures (e.g GES) that aim to ensure efficiency in the stationary energy sector. Accordingly it is currently not mandatory for Delta to participate in the program.

4.2.3 State-based Policy

NSW Greenhouse Plan (2005)

The NSW Government Greenhouse Plan[8] was released in November 2005. The plan provides a strategic approach to combating climate change in NSW. The NSW Greenhouse Plan outlines new and ongoing actions to limit greenhouse emissions in NSW, and achieve key emission reduction targets announced by the NSW Government. Key principles and goals of the Greenhouse Plan are to:

- Raise awareness of climate issues within the broader community;
- Recognise that climate change is a global, long term and complex issue with no easy solution;
- Promote understanding of the likely impacts on NSW, and identify strategies for adaptation to the environmental, social and economic impacts of climate change;
- Limit the growth of greenhouse gas emissions and reduce these emissions in NSW. The Plan outlines targets, strategies and actions to achieve significant emission reductions;
- Promote climate change partnerships through co-operative approaches by Government, individuals, industry, business and community groups;
- Reduce business uncertainties by establishing carbon constraints in order to promote new investment and innovation; and
- Identify key strategic areas for cooperative work with other Australian jurisdictions including the development and establishment of a Kyoto compliant national emissions trading scheme.

The NSW Greenhouse Gas Reduction Scheme

The NSW Greenhouse Gas Reduction Scheme (GGAS) (formally known as the NSW Greenhouse Gas Abatement Scheme) commenced on 1 January 2003 with the aim of reducing greenhouse gas emissions from the production and use of electricity. It uses a "baseline and credit" approach to abatement, where project-based activities generate offsets that can be used to abate greenhouse gas emissions.

The tradable unit in the GGAS is a New South Wales Greenhouse Abatement Credit (NGAC), equivalent to one tonne of abated CO_2-e. A more generic name for these credits in GGAS is Abatement Certificate. Retailers are liable for a certain number of NGACs calculated on the basis of their share of the NSW electricity market. Therefore, retailers provide the demand for NGACs, and other parties supply NGACs into the market.

NSW Energy Savings Plan and Fund

High energy users in NSW are required to prepare Energy Savings Action Plans. The Government introduced new legislation in May 2005 to encourage a better understanding of energy use by business, government agencies and local councils and establish detailed plans of action for savings. Currently, no Delta site has been identified to require and Energy Savings Action Plan.

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[8]NSW Government 2005 *NSW Greenhouse Plan* (available at):
http://www.greenhouse.nsw.gov.au/climate_change_in_nsw/greenhouse_plan/nsw_gh_plan_links/nsw_greenhouse_plan

The NSW Energy Efficiency Strategy

This initiative was announced in early December 2007 by the NSW Premier, however functional details are as yet to be developed and announced.

4.3 Greenhouse Gas Assessment Methodology

The greenhouse gas emission inventory for the Delta Electricity Facility is based on the methodology detailed in the Greenhouse Gas Protocol[9], and the relevant emission factors in the *National Greenhouse Accounting (NGA) Factors*[10]. The Protocol was first established in 1998 to develop internationally-accepted accounting and reporting standards for greenhouse gas emissions from companies.

The Greenhouse Gas Protocol is based on the concept of emission “scopes”:

- Scope 1: Direct greenhouse gas emissions. Direct greenhouse gas emissions occur from sources that are owned or controlled by a company. For example:
  - Emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc.;
  - Emissions from chemical production in owned or controlled process equipment.
- Scope 2: Electricity indirect greenhouse gas emissions. This accounts for greenhouse gas emissions from the generation of purchased electricity consumed by the Facility. Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the company. Scope 2 emissions physically occur at the various generators which provide power to the transmission network when the proponent’s electricity consumption (purchase) occurs.
- Scope 3: Other indirect greenhouse gas emissions. This is an optional reporting class that accounts for all other indirect greenhouse gas emissions resulting from a company’s activities, but occurring from sources not owned or controlled by the company. Examples include extraction and production of purchased materials; transportation and extraction of purchased fuels; and use of sold products and services.

This greenhouse gas assessment has been conducted using the Australian Greenhouse Office’s quantitative methodology. Based on estimated plant operation, total emissions (CO_2-e) have been calculated and compared to state and national greenhouse gas inventories for both the energy sector, and the sum of all sectors.

4.4 Greenhouse Gas Inventory

The Delta Electricity Marulan Gas Turbine Facility will have two gas turbines with a total installed capacity in the range of 250MW to 450MW. The plant will operate approximately 500 hours of the year (per turbine) during Stage 1 and 90% during Stage 2. Plant operation will be on natural gas and estimated fuel consumption and power generated per year (power sent out) for both Stage 1 and Stage 2 are presented in **Table 4-1**.

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[9] World Business Council For Sustainable Development & World Resources Institute (2004), *The greenhouse gas Protocol: A Corporate Accounting and Reporting Standard*.

[10] Department of Climate Change, NSW Government 2008, *National Greenhouse Accounting (NGA) Factors*, January 2008

Section 4 Greenhouse Gas Assessment

This assessment encompasses the operational stage of the proposed Delta Electricity Marulan Gas Turbine Facility. The construction and decommissioning phases have not been included. Due to the small size of the project and relatively short construction duration of 18 months, greenhouse gas emissions during construction and decommissioning are considered insignificant (as compared to plant operation) in the calculation of emissions over the lifetime of the project.

The greenhouse gas inventory for the Delta Electricity Facility has included Scope 1 and Scope 3 emissions in order to account for the direct (Scope 1) and indirect (Scope 3) emissions from the project. The operational boundary is defined as the boundary of the power station site. Scope 3 emissions are as defined in the National Greenhouse Factors, the indirect emissions from the extraction, production and transport of the natural gas used for electricity generation.

Given that the proposed Delta Electricity Facility is a generator of electricity, where the power generated has been quantified as net power sent out (i.e. generator output minus electricity required to power auxiliary plant equipment), electricity consumption associated with Scope 2 has been addressed in the forecast of electricity sent out.

Plant operation will be on natural gas and estimated fuel consumption and power generated per year (electricity sent out) are presented in **Table 4-1**. These figures have been based on the maximum proposed operating duty of 500 hours of the year (per turbine) during Stage 1 and 90% of the year during Stage 2.

Table 4-1 Estimated Gas Consumption and Electricity Sent Out

Project Stage	Amount Gas Combusted (PJ/yr)	Electricity Sent Out (GWh/yr)
Stage 1 (Open Cycle)	2	150
Stage 2 (Combined Cycle)	32	3500

The following parameters were not included in the assessment as they contribute negligibly to the site's greenhouse gas inventory:

- Fuel combusted by off-site vehicle use;
- Loss of biomass due to construction;
- Liquid refrigerant losses; and
- Sulphur Hexafluoride (SF_6) emissions from switchgear.

Tables 4-2, 4-3 show the greenhouse gas inventory for the proposed Delta Electricity Facility.

Section 4 Greenhouse Gas Assessment

Table 4-2 Greenhouse Gas Inventory for Delta Electricity Stage 1

Activity[1]	Scope	Emission Type	Emission Factor[2]	Greenhouse Gas Emissions t CO_2-e	Emissions Intensity kg CO_2-e/MWh	% of Total
Gas Consumption: 2 PJ/yr Electricity Generation: 150 GWh/yr	1	Direct stationary combustion	51.3kgCO_2-e/GJ	102,600	684	78
	3	Indirect stationary combustion	14.2kgCO_2-e/GJ	28,400	189	22
	1 + 3	**Total**	**65.5kgCO_2-e/GJ**	**131,000**	**873**	**(100)**

Table 4-3 Greenhouse Gas Inventory for Delta Electricity Stage 2

Activity[1]	Scope	Emission Type	Emission Factor[2]	Greenhouse Gas Emissions t CO_2-e	Emissions Intensity kg CO_2-e/MWh	% of Total
Gas Consumption: 32 PJ/yr Electricity Generation: 3500 GWh/yr	1	Direct stationary combustion	51.3kgCO_2-e/GJ	1,641,600	469	78
	3	Indirect stationary combustion	14.2kgCO_2-e/GJ	454,400	130	22
	1 + 3	**Total**	**65.5kgCO_2-e/GJ**	**2,096,000**	**599**	**(100)**

Notes:

1) Estimates of gas consumption and electricity generation have taken from Burns & Roe Worley (2006)

2) Emission factors for gas combustion sourced from Table 2 of *"National Greenhouse Accounting (NGA) Factors"*, Department of Climate Change, January 2008. These factors incorporate the quantities of CO_2, N_2O and CH_4.emitted from gas combustion.

4.4.1 Project Lifetime Emissions

Table 4-4 shows greenhouse gas emissions for the proposed plant on a project lifetime on the basis that only Stage 2 operates, as the operating period for the Stage 1 development is currently uncertain. Long term market trends define the operating duty, and ultimately the commercial life of the plant, hence there exist large uncertainties in potential emissions over the project lifetime.

Table 4-4 Estimated Greenhouse Gas Emissions on a Project Lifetime Basis

Plant Life (years)	Project Lifetime Emissions ($Mt\ CO_2$-e)		
	Direct	Indirect	Total
30	49.2	13.6	62.9

4.5 Generator Performance

The use of natural gas at the Marulan facility results in electricity production at a lower greenhouse intensity than the NSW average. Progression of the Delta Electricity Facility to combined cycle operation further improves greenhouse efficiency to approximately half that of conventional coal-fired generation. For this reason, natural gas fired, combined cycle generation is widely considered to be an important transitional mode of generation, for the achievement of long-term greenhouse reduction targets.

Detailed plant selection for the proposed facility is yet to be made. The technology employed will be typical of current best practice, both in terms of both technology type (OCGT/CCGT), and detailed equipment selection.

This assessment has incorporated relatively coarse estimations of annual fuel consumption and net electricity sent out. As these are annualised figures, they also incorporate fuel consumption associated with start up, shut down, testing and operation at lower loads (the plant's turbines will operate between around 60-100% load). This means that the annualised intensities presented in **Tables 4-2** and **4-3**, are indicative of the scale of annual greenhouse emissions from the Delta Electricity Facility. However, the coarser resolution of the annualised intensities means that they are not suitable for marginal comparisons of generator greenhouse intensity when considering the type of generating technology employed.

Table 4-5 presents the greenhouse intensities for the styles of proposed plant, as sourced from the *NSW Government Energy Directions Green Paper (2004).* The greenhouse intensity for base load coal-fired generation has been included, for comparison against Stage 2 operations, where the plant will operate in a base load capacity.

Table 4-5 Greenhouse Intensity - Full Fuel Cycle Emissions[11] (NSW Government, 2004[12])

Scenario	Emissions Intensity ($kgCO_2$-e/MWh)
Open Cycle Gas Fired Turbine (Stage 1 - proposed)	600 – 700 [12]
Combined Cycle (Stage 2 – proposed)	400 – 500 [12]
Coal-Fired - Best Existing NSW Plant (included for comparison)	870 [13] – 970 [12]
Coal-Fired - World's Best Practice (included for comparison)	800 – 810 [12]

4.6 Comparison to National and NSW Greenhouse Gas Inventories

Total greenhouse gas emissions in Australia for 2005 (the most recent available at the time of this assessment) were estimated to be 559.1 million tonnes of CO_2-e (Australian Greenhouse Office 2005[14]), while NSW was estimated to emit 158.2 million tonnes CO_2-e from all sources (28.3% of emissions from all states). Most of the greenhouse gas emissions in NSW come from stationary energy sources (48% of NSW emissions).

4.6.1 Delta Electricity Facility

Based on the Stage 1 scenario, the Delta Electricity Facility is estimated to release 0.131 million tonnes of CO_2-e (includes direct and indirect emissions) per year as a peak load station, representing 0.23% of the emissions from electricity generation in NSW, or 0.07% of all sources of greenhouse gas in Australia in 2005.

Based on the Stage 2 scenario, the Delta Electricity Facility is estimated to release 2.096 million tonnes of CO_2-e (includes direct and emissions) per year as a combined cycle station, representing 3.63% of the emissions from electricity generation in NSW, or 0.37% of all sources of greenhouse gas in Australia in 2005.

Quantitative greenhouse gas emissions from Delta Electricity Facility and comparison with greenhouse gas generated from the electricity sector in NSW and Australia are provided in **Table 4-6.**

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[11] Full fuel cycle emissions include Scope 1 (direct) as emitted from the facility, and Scope 3 (indirect) emissions, which account for off-site emissions associated with production and distribution of the fuel.

[12] Adapted from Appendix 5 in NSW Government 2004 *Energy Directions Green Paper*, December 2004.

[13] Data supplied by Delta Electricity for Mt Piper Power Plant.

[14]Australian Greenhouse Office 2007 *Australia's National Greenhouse Accounts, State and Territory greenhouse gas Inventories 2005*, Australian Greenhouse Office, 2007

Table 4-6 Comparison of Proposal to State and National Greenhouse Gas Inventories

Greenhouse Gas Inventory Sector	Greenhouse Gas Emissions	% Contribution represented by the Delta Marulan Gas Turbine Facility	
	(Mt CO_2-e)	Stage 1	Stage 2
Delta Electricity Marulan Gas Turbine Facility	Stage 1: 0.131 Stage 2: 2.096	-	-
NSW Electricity generation sector	57.8	0.23%	3.63%
Total NSW GHG emissions	158.2	0.08%	1.32%
Australia Electricity generation sector	194.3	0.07%	0.81%
Total Australian GHG emissions	559.1	0.02%	0.37%

Australia's future greenhouse gas inventory data are not possible to forecast with certainty. The 2005 inventory data shows that national emissions across all sectors rose by 2.2% from 1990 to 2005. The largest sector increase was the stationary energy sector, followed by transport, showing a rise due to population growth and electricity demand for resources. The land use sector showed a decrease in emissions over this period, largely due to a reduction in vegetation clearing. Since future trends are unknown, the greenhouse gas emissions from the Delta Electricity Facility cannot be meaningfully compared to future emissions from other sources of greenhouse gases in Australia over the operational life of the plant.

4.6.2 Combined Emissions from both the Delta Electricity and EnergyAustralia Facilities

The cumulative greenhouse gas emissions from the Facilities have been estimated as the sum of each Facility's emissions, as included in this, and the neighbouring Facility's individual greenhouse inventories. Stage 2 (CCGT) baseload operation has been assumed for the Delta Electricity Facility. Based on the proposed upper limits of operation, the combined emissions from the Facilities are estimated to be 2.29 million tonnes of CO_2-e per annum. A comparison of these emissions to the state and national inventories is contained in **Table 4-7**.

Table 4-7 Comparison of the Facilities to State and National Inventories

Greenhouse Gas Inventory Sector	CO_2-e emissions (Mt CO_2-e)	% Contribution represented by the combined Facilities
Proposed Delta Electricity and EnergyAustralia Facilities	2.29	-
NSW Electricity Generation Sector	57.8	3.96%
Total NSW Greenhouse gas Emissions	158.2	1.45%
Australian Electricity Generation Sector	194.3	1.18%
Total Australian Greenhouse Gas Emissions	559.1	0.41%

4.7 Participation in Greenhouse Gas Programs

Delta Electricity has long recognised the growing concern by communities and governments of the issues of global warming and emissions of greenhouse gases from the combustion of fossil fuels. Delta Electricity monitors GHG emissions and thermal efficiency at each power station site and implements programs to improve operational performance and reduce emissions.

These programs include:

- Development of renewable energy generation sources including two 30MW biomass fired co-generation facilities on the north coast of NSW, biomass co-firing in existing power stations and mini hydro generators.
- Development of gas fired power stations to provide a lower greenhouse alternative for future electricity demand
- Participation in the Greenhouse Challenge Program since 1997.
- Participation in the Generator Efficiency Standards (GES). Delta Electricity was the first generator to agree to legally binding targets under the Australian Government's Generator Efficiency Standards (GES).
- Participation in the NSW Greenhouse Gas Abatement Scheme and creation of 200,000 to 300,000 NGACs/year.
- Implementation of Environmental Management System ISO 14001:2004 standard.

Delta Electricity is not proposing to implement any greenhouse gas offsets specifically to this project.

Section 5 Regulatory Framework

5.1 General

5.2 Air Quality Criteria

There are three main types of air quality criteria relevant to the Project.

- ***Emission Standards*** – which are maximum allowable pollutant emission concentrations (stack concentrations) specified for particular types of equipment;
- ***Air Impact Assessment Criteria*** – which are designed for use in air dispersion modelling studies and air quality impact assessments for new or modified emission sources; and
- ***Ambient Air Quality Standards*** – which set standards against which ambient air quality monitoring results may be assessed.

In general, Emission Standards and Air Impact Assessment Criteria are used to evaluate the expected impact of air emissions on air quality and the effectiveness of facility design and any associated mitigation measures. The main objective of these criteria is to ensure that the resulting local and regional ambient air quality meets the relevant Ambient Air Quality Standards.

The guidelines also state that cumulative impacts from the Facilities must be taken into consideration. Thus **Section 8** of this report has separately discussed the impacts from the Delta Electricity Facility and the combined Facilities. It should be noted that a comparison of turbine emissions from the EnergyAustralia Facility compared against Emission Standards is considered outside the scope of works for this Project and will not be discussed further.

5.2.1 Emission Standards

The Protection of the Environment Operations (Clean Air) Regulation 2002 sets emission limits for air impurities from stationary plant and equipment. The current standards, taken from Schedule 3 (Electricity Generation) of the Regulation, relevant to the Delta Electricity Marulan Gas Turbine Facility are presented in **Table 5-1** for solid particles, and oxides of nitrogen. The Facility is classified as a Group 6 source, as it will commence operation after 1 September 2005.

Table 5.1: Emission Standards for Electricity Generation (from Schedule 3, Protection of the Environment Operation (Clean Air) Regulation 2002)

Pollutant	Applicability	Limit
Solid Particulates (Total)	-	50 mg/m^3
NO_2 or NO or both as NO_2 equivalent	Any turbine operating on gas, being a turbine used in connection with an electricity generating system with a capacity of 30 MW or more	70 mg/m^3 as NO_2

Note: An activity is designated to "Group 6"if it commenced to be carried on, or to operate, on or after 1 September 2005, as a result of an environment protection licence granted under the Protection of the Environment Operations Act 1997 pursuant to an application made on or after 1 September 2005.

5.2.2 Air Impact Assessment Criteria

In August 2005, NSW Department of Conversation and Climate Change (DECC) updated the *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW*. This document specifies a range of impact assessment criteria for toxic and odorous air pollutants. The impact assessment criteria for those pollutants associated with the proposed Facility are shown in **Table 5-2**.

Table 5.2: NSW EPA Impact Assessment Criteria for Modelled Pollutants

Pollutant	Concentration		Averaging Period
	(ppm)	(µg/m^3)	
Criteria Pollutants			
NO_2	0.12	246	1 hour
	0.03	62	Annual
PM_{10}	-	50	24 hour
	-	30	Annual
SO_2	0.25	712	10 minutes
	0.20	570	1 hour
	0.08	228	24 hours
	0.02	60	Annual
CO	87	100,000	15 minutes
	25	30,000	1 hour
	9	10,000	8 hours
Hazardous Air Pollutants			
Acetaldehyde	0.023	42	1 hour
Acrolein	0.00018	0.42	1 hour
Benzene	0.009	290	1 hour
Ethylbenzene	1.8	8000	1 hour
Formaldehyde	0.018	20	1 hour
Total PAH	-	0.4	1 hour
Toluene	0.09	360	1 hour
Xylenes	0.04	190	1 hour

5.2.3 Ambient Air Quality Criteria

The ambient air quality criteria adopted by NSW are provided by the *National Environment Protection Measure (NEPM) for Ambient Air Quality* (referred to herein as 'NEPM for Ambient Air Quality'), published by the National Environment Protection Council (NEPC) (1998). The NEPM for Ambient Air Quality, sets out national standards and goals for six common ambient air pollutants (NEPC, 1998), namely nitrogen dioxide (NO_2), carbon monoxide (CO), photochemical oxidants (as ozone), sulphur dioxide (SO_2), lead and particulates as PM_{10}[15]. When reviewing the standards and goals set out in the NEPM for Ambient Air Quality, it should be noted that they are designed for use in assessing regional air quality and are not intended for use as site boundary or atmospheric dispersion modelling criteria. Consequently, proposed facility emissions have not been assessed directly against NEPM guidelines, however it should be noted that the NEPM guidelines for NO_2, PM_{10}, SO_2 and CO are identical to the NSW EPA (2005) criteria, as shown in **Table 5-2**.

The NSW Government has also published an Air Quality Management Plan (DEC, 2006) for the Greater Metropolitan Region (GMR) of NSW. In August 2006, the NSW EPA updated and re-issued '*Action for Air*' - the NSW Government's 25-year Air Quality Management Plan, which was originally published in 1998. The proposed development site is situated slightly outside the GMR, thus the management plan does not strictly apply to this development. However, the National Standards and Goals provided in

[15] PM_{10} refers to particulate matter less than 10 microns in diameter.

Section 5 Regulatory Framework

'*Action for Air*' acknowledge the NEPM criteria, which are considered to be identical to the values adopted for this assessment.

In 2004 the NEPC released the *Air Toxics NEPM* (NEPC, 2004) that presented a number of monitoring investigation levels for some key VOCs. The air investigation levels were derived on the basis of the long term protection of human health within regional areas. The purpose of the Air Toxics NEPM (NEPM, 2004) is the collection ambient air concentration of VOC "…*at locations where elevated levels are expected to occur and there is a likelihood that significant population exposure could occur*." (NEPM, 2004 p 2). Similarly to the Ambient Air Quality NEPM, the Air Toxics NEPM is designed for use in assessing regional air quality and not intended for use as site boundary or atmospheric dispersion modelling criteria. Thus, the predicted concentrations of HAP will be compared against the NSW EPA (2005) criteria.

Section 6 Site Description

6.1 Climate and Meteorology

The climate of an environment is described using long term averages of parameters, such as annual temperature and rainfall variation. Conversely, meteorology describes the environment with shorter term parameters such as seasonal wind speed and direction and includes micro-scale weather phenomenon such as katabatic flow.

6.1.1 Climate

Climate data was taken from the closest Bureau of Meteorology (BoM) Automatic Weather Station (AWS) located at Goulburn airport, which is considered to be representative of the region, including the proposed development site. The data has been recorded between 1991 and 2007. Climate data is provided in **Table 6-1**.

Being situated approximately 100km inland, the area experiences hot summers and cold winters. The mean maximum summer temperature is approximately 27^0C, with temperatures as high as 40^0C being recorded. Sub zero temperatures have been recorded between March and November and are regularly recorded during winter with temperatures lower than -10^0C having been recorded. The area receives moderate rainfall having a mean annual rainfall of 513.8mm.

6.1.2 Meteorological Modelling

Meteorological data is primarily needed for use in the dispersion modelling and is required to be site representative. As URS is not aware of meteorological data being collected on site or within close proximity to the site, a search was conducted on the meteorological stations operating in the area and the data were further examined. The nearest Automatic Weather Stations (AWSs) were found to be:

1) Goulburn Airport AWS, operated by the Bureau of Meteorology (located approximately 37km south west of the site);
2) Lynwood AWS, operated by ReadyMix Holdings Pty Limited, located approximately 12km south south west of the site;
3) Berrima AWS, operated by Blue Circle Southern Cement Limited, located approximately 28km east north east of the site; and
4) Moss Vale AWS, operated by the Bureau of Meteorology, located approximately 36km east north east of the site; and
5) South Marulan AWS, operated by Boral Resources (NSW), located approximately 19km south of the site.

Data from the first three sites was reviewed and considered appropriate for use in the assessment. Both Berrima and Lynwood AWS's have been commissioned for air quality purposes, and provide wind data at a resolution beyond that reported by Bureau of Meteorology stations.

Both Moss Vale and South Marulan AWS's were omitted from the meteorological modelling, given that both stations are located near to, yet beyond the Berrima and Lynwood AWS's respectively, Hence these stations have limited ability to contribute significantly to those winds predicted in the region. In particular, the presence of strong local terrain features surrounding the South Marulan AWS means that wind records from the site are most likely dominated by highly localised terrain effects. Meteorological models are not able to resolve these effects with meaningful implications for broader scale meteorology.

A map showing the location of the meteorological stations in relation to the site is provided in **Figure 4**.

Section 6 Site Description

In order to provide a greater understanding into the likely meteorology at the site, the meteorological data obtained at Goulburn, Lynwood and Berrima were used with meteorological processing programs, TAPM and CALMET to generate site representative meteorology. The method and discussion of meteorology is provided in **Appendix A**.

Table 6-1 Climate Data for Goulburn, BoM Station 070330 (BoM 2007)

Statistic Element	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Mean maximum temperature (Degrees C)	27.6	26.6	23.7	20	16	12.4	11.6	13.5	16.2	19.3	22.2	25.7	19.6
Highest temperature (Degrees C)	40.4	38.9	35.9	30.7	24.4	20.7	18.4	24.1	27.1	31.3	38.5	38.6	40.4
Lowest maximum temperature (Degrees C)	15.8	14.2	13.9	10.2	5.1	5.5	4.2	5.5	8	9.1	9.6	11.5	4.2
Mean number of days >= 30 Degrees C	9.9	7.1	2.4	0.1	0	0	0	0	0	0.5	2.4	6.3	28.7
Mean number of days >= 35 Degrees C	2.9	0.9	0.1	0	0	0	0	0	0	0	0.5	1.1	5.5
Mean number of days >= 40 Degrees C	0.3	0	0	0	0	0	0	0	0	0	0	0	0.3
Mean minimum temperature (Degrees C)	12.4	12.7	9.9	5.4	2.9	1	0.4	0.5	3.3	5.1	7.8	10.5	6
Lowest temperature (Degrees C)	1.4	0.7	-0.1	-6.3	-8.1	-10.2	-9.1	-10.9	-6.8	-5.6	-4.4	0.6	-10.9
Mean number of days <= 2 Degrees C	0.1	0.1	0.8	6.6	12.7	16.4	19.1	18.8	11.5	7.5	3.3	0.6	97.5
Mean number of days <= 0 Degrees C	0	0	0.1	2.8	8.9	11.6	14.6	14.2	6.8	4.1	1.3	0	64.4
Mean rainfall (mm)	48.7	40.6	29.2	18.5	37.1	64	38.3	35.8	48.4	56.9	54.2	37.6	513.8
Highest rainfall (mm)	172.6	94.2	57.6	79.8	101.6	190.4	84.2	108.6	112.4	164.6	102.8	79	688.6
Lowest rainfall (mm)	0.4	2	3.2	0.6	2.8	10.6	11.2	5.4	6.4	0.2	4.2	8.2	317.2
Decile 1 monthly rainfall (mm) for years 1994 to 2007	3.7	6.5	4.5	1.1	3.2	24.3	14.2	8	14.4	8.7	12.8	17.6	395
Decile 9 monthly rainfall (mm) for years 1994 to 2007	73.2	81.5	56.1	32.4	87.1	169.4	63.4	80	77.9	92.7	95.9	67.2	626.2
Highest daily rainfall (mm)	126.4	38	25	37	50	123	54.2	38	32	65	53	45.4	126.4
Mean number of days of rain	7.8	6.9	8.7	7.3	11.7	14.6	15.1	11.7	11.1	8.9	9	6.3	119.1
Mean number of days of rain >= 1 mm	5.2	3.8	3.8	2.4	4.8	7.3	6.9	6	7.3	6	6.2	4.5	64.2
Mean number of days of rain >= 10 mm	1.3	1.8	1.3	0.5	1.1	1.6	1.2	0.8	1.9	1.9	2.2	1.2	16.8
Mean number of days of rain >= 25 mm	0.3	0.4	0.1	0.2	0.4	0.5	0.1	0.2	0.1	0.4	0.5	0.5	3.7
Mean 9am temperature (Degrees C)	18.9	17.9	15.2	12.8	9	5.7	5.1	6.7	10.8	14	15	17.7	12.4
Mean 9am relative humidity (%)	70	78	81	78	85	88	87	82	72	66	69	66	77
Mean 9am wind speed (km/h) for years 1991 to 2007	15.2	13.8	12.5	12.4	12.8	13.2	13.7	16.3	19.7	19.5	17.7	16.6	15.3
Mean 3pm temperature (Degrees C)	25.9	25.2	22.4	19	14.8	11.2	10.5	12.4	15.1	17.9	20.7	24.3	18.3
Mean 3pm relative humidity (%)	41	44	46	45	55	63	61	52	50	47	46	38	49
Mean 3pm wind speed (km/h) for years 1991 to 2007	22	21.4	20.6	19.8	20.9	22.4	23	25.9	26.3	25.3	24	22.8	22.9

6.2 Ambient Air Quality

The Approved Methods (NSW EPA, 2005) requires the peak concentration of a criteria pollutant measured by an appropriate ambient air quality monitoring station be used to represent the background concentration of that pollutant for a region. This results in a conservative assessment as concentrations of an individual pollutant may vary over different time scales. While the maximum concentration of a pollutant may be elevated due to unusual events (for example, PM_{10} is elevated during dust storms and bushfires), the concentrations for the remainder of the year may remain low, hence the use of the maximum background value provides a conservative measure of impact.

The background data for NO_2 and SO_2 was taken from the DECC air monitoring site at Bargo (2006), however, background PM_{10} and CO are not measured at Bargo, consequently, the background PM_{10} and CO data were taken from the closest available DECC monitoring stations, namely Oakdale and Macarthur.

The PM_{10} data for Bargo showed one exceedance of criteria during 2006, on 1st November. This 24 hour averaged result of 57.3 µg/m^3 was due to a local bushfire at Lake Burragorang (DECC 2007). As per the guidelines contained in NSW EPA (2005) this value was excluded from the assessment. The next highest 24 hour averaged concentration was found to be 40.0 µg/m^3, which occurred on the 22nd of November 2006. This elevated value is likely to be a result of bushfires occurring in the Blue Mountains (DECC 2007), but has been used in this assessment on the basis of conservativeness.

It should also be noted that the Macarthur monitoring station is located adjacent to the Hume Highway and between the heavily trafficked Narellan and Menangle Roads, consequently the background CO concentrations used in this assessment are considered conservative as the proposed development site is situated away from heavily trafficked roads and industrial areas

A summary of the background air quality concentrations used in this assessment, as measured by DECC / NSW EPA, is provided in **Table 6-2** and a map showing the location of the ambient air quality stations is provided in **Figure 3**.

Table 6-2 Summary of Background data used in Air Quality Modelling - 2006

Species	Averaging Time	DECC Monitoring Station Data	Maximum Background Concentration (µg/m^3)	Air Quality Criteria (µg/m^3)
NO_2	1 hour	Bargo	116.9	246
	Annual average	Bargo	13.7	62
PM_{10}	24 hour	Oakdale	40.0	50
	Annual	Oakdale	14.0	30
SO_2	10 minute	Bargo	36.8^A	712
	1 hour	Bargo	25.7	570
	24 hour	Bargo	5.7	228
	Annual average	Bargo	1.2	60
CO	15 minute	Macarthur	3299^A	100,000
	1 hour	Macarthur	2500	30,000
	8 hour	Macarthur	2250	10,000

A: Sub hourly concentration estimated from peak hourly concentration based on power law discussed in **Section 7.4.6**.

Section 7 Assessment Methodology

7.1 Approach to Assessment

The assessment methodology considered the following:

- emissions during construction;
- emissions during turbine start up;
- emissions during normal turbine operation, during both Stage 1 and Stage 2 for the Delta Electricity project and open cycle for the EnergyAustralia project; and
- cumulative emissions both the facilities at various stages of operation.

The following sections elaborate on the points listed above.

7.2 Construction Emissions

7.2.1 Delta Electricity Facility

Bulk earthworks for the two Facilities should they occur at the same time, are anticipated to take approximately 6 months to complete. The Delta Electricity Facility would be constructed in two stages with the first stage being assumed to take 12 months and 18 months for Stage 2. The EnergyAustralia Facility would be constructed entirely in Stage 1 and is assumed to take 12 months to complete. These construction periods may or may not overlap.

The construction phase would involve earthworks: the construction of concrete footings for the generator units; the formation of unsealed site roads; installation of the units; construction of a switchyard and transmission connection; installation of the gas lateral and gas receiving station; commissioning and other minor works.

During the construction phase, there is the potential for dust to be generated due to the excavation and handling of soils, site grading activities and vehicles movements, however, these emissions will be minimised through the implementation of a construction environment management plan (CEMP). Given the undeveloped nature of the site, there is considered to be no significant potential for dust emissions from construction activities to contain contaminants, or for the works to give rise to odorous emissions. The distance to the nearest residential dwellings (approximately 1.5 km) provides a sufficient buffer zone between the main work area and neighbouring land uses to prevent nuisance dust impacts.

7.2.2 Combined Facilities

It is likely that construction for the EnergyAustralia Facility would commence first however, the Delta Electricity & EnergyAustralia construction periods may overlap. As the potential for dust generation would be managed for each Facility (or together if bulk earthworks progress at the same time for both Facilities), the assumptions presented in **Section 7.2.1** remain valid and cumulative impact from the construction of the two facilities is not considered to be greater than the impact from each individual facility.

7.3 Operational Emissions

The stack emissions were the only sources assessed for the Project. The “E Class” gas turbine would be procured for the Delta Facility. The E Class gas turbine is considered to have emissions representative of the range of turbines currently being considered.

Where supplier emission data existed, those values were used, however, for other emission data, especially for Start Up conditions, data was primarily adopted from Table 11.5 of Parsons Brinckerhoff (2005) (presented in **Appendix B**), which assessed a similar Gas Turbine facility. Due to the potential frequency of starts for open cycle arrangement, Start Up emissions are generally assessed, however, the infrequent nature of combined cycle (Stage 2) Start Up typically precludes further assessment.

For this assessment, Stage 2 emission rates (in g/s) were taken to be identical to Stage 1 emission rates, however, Stage 2 stack exhaust temperature and velocity were lowered to reflect Stage 2 stack characteristics.

The NO_x (as NO_2), and CO emission data for the E Class (Operational Scenario) are based on gas turbine performance data provided in URS (2006). The NO_x and CO emissions during start up for the E Class gas turbine was taken from Table 11.5 of Parsons Brinckerhoff (2005) which proposed a start up emission rate of 117.8 g/s and 895.6 g/s for NO_x and CO respectively.

A conservative approach was taken for SO_2 and emission data has been sourced from Table 11.5 of Parsons Brinckerhoff (2005), which showed an emission rate of 2.2 and 4.9 g/s for Start Up and Operational Scenarios respectively. It should be noted that sulphur does exist in natural gas, however, it exists in trace concentrations.

As supplier data was not available for PM_{10}, emission data has been sourced Table 11.5 of Parsons Brinckerhoff (2005), which showed an emission rate of 4.4 g/s for both Start Up and Operational Scenarios respectively. Particulate matter is generally not considered a significant issue with gas turbines, given the high efficiency of the process and the gaseous fuel, which generally does not give rise to high concentrations of particulates (US EPA, 2000).

The method used to calculate HAP emissions during Operation was based on the relationship between fuel consumption and HAP provided in the US EPA (2000), commonly known as the AP-42 Emissions Factors. The ratio of HAP to fuel consumption was applied to the fuel consumption for each turbine under normal Operation conditions in order to estimate the individual HAP concentrations.

Due to the different operating conditions during Start Up, fuel consumption was not deemed to be an appropriate factor to estimate HAP emissions. The method used to calculate HAP emissions during Start Up was based on the relationship between HAP produced during Start Up and normal Operation for a similar E Class turbine operating on natural gas, as documented in El Segundo Power (ESP II LLC, 2007). Table A.1.6 of ESP II LLC (2007) states that Start Up emissions of VOC to be 13.0 lbs per 12 minute event, equating to 65.0 lbs/hr (8.19 g/s). The normal operation VOC emission rate was stated to be 5.4 lbs/hr (0.68 g/s), thus giving a surrogate VOC scaling factor of 12.04. This scaling factor of 12.04 was applied to the HAP emission rates calculated for the normal operation scenario to generate HAP emission rates during Start Up.

The HAP emission calculations for both normal Operation and Start Up are shown in **Appendix B**.

7.3.1 Scenarios Modelled

Due to the different operational phases for each of the Delta Electricity and EnergyAustralia sites and the varying emission characteristics, several scenarios were required to be modelled. The modelling scenarios undertaken are provided in **Table 7-1**. Additional “combined facility” scenarios were modelled and the results are provided in **Appendix D**, however only the worst case results have been presented and discussed in this main report.

Section 7 Assessment Methodology

Table 7-1 Scenarios Modelled

	Delta Electricity – Stage 1		Delta Electricity – Stage 2	Energy Australia	
	Start Up	General Operation	General Operation	Start Up	General Operation
Scenario 1 - Delta	✓	-	-	-	-
Scenario 2 - Delta	-	✓	-	-	-
Scenario 3 - Delta	-	-	✓	-	-
Scenario 1 - Combined	✓	-	-	✓	-
Scenario 2 - Combined	-	-	✓	✓	-

7.3.2 Delta Electricity Project – Start Up

The start up parameters for the stacks are provided in **Table 7-2**.

Table 7-2 Delta Electricity Start Up - Stack Parameters and Emissions

Stack Parameter [A]	Units	Stage 1 – open cycle Start up
Stack Height (above ground level)	(m)	40
Stack Diameter	(m)	6
Nominal Plant Capacity	(MW)	350
Exit Temperature	(°C)	398
Exit Velocity	(m/s)	27
Stack Emissions (per stack) [B]		
Criteria Pollutants		
NO_X Emission	(g/s)	117.8
CO Emission	(g/s)	895.6
SO_2 Emission	(g/s)	2.2
PM_{10} Emission	(g/s)	4.4
Hazardous Air Pollutants		
Acetaldehyde	(g/s)	0.101
Acrolein	(g/s)	0.016
Benzene	(g/s)	0.030
Ethylbenzene	(g/s)	0.081
Formaldehyde	(g/s)	1.793
Total PAH	(g/s)	0.006
Toluene	(g/s)	0.328
Xylene	(g/s)	0.162

Notes:
A: Stack parameters have been taken from Burns and Roe Worley (2006). Temperature and velocity have been taken from URS (2006).
B: Stack Emissions have been taken from URS (2006).

7.3.3 Delta Electricity Project – General Operation

The start up emissions for the operational Stages of the Delta Electricity Facility are provided in **Table 7-3** and assumed stack locations are provided in **Table 7-4**. It is noted that these stack locations are based on indicative layouts for the Facility.

Table 7-3 Delta Electricity General Operation - Stack Parameters and Emissions

Stack Parameter [A]	Units	Stage 1 – open cycle Operational	Stage 2 – combined cycle Operational
Stack Height (above ground level)	(m)	40	40
Stack Diameter	(m)	6	6
Nominal Plant Capacity	(MW)	350	450
Exit Temperature	(°C)	532	125
Exit Velocity	(m/s)	40	20
Stack Emissions (per stack) [B]			
Criteria Pollutants			
NO_X Emission	(g/s)	19.3	19.3
CO Emission	(g/s)	4.6	4.6
SO_2 Emission	(g/s)	4.9	4.9
PM_{10} Emission	(g/s)	4.4	4.4
Hazardous Air Pollutants [C]			
Acetaldehyde	(g/s)	0.008	0.008
Acrolein	(g/s)	0.001	0.001
Benzene	(g/s)	0.003	0.003
Ethylbenzene	(g/s)	0.007	0.007
Formaldehyde	(g/s)	0.149	0.149
Total PAH	(g/s)	0.0005	0.0005
Toluene	(g/s)	0.027	0.027
Xylene	(g/s)	0.013	0.013

Notes:
A: Stack parameters have been taken from Burns and Roe Worley (2006) and URS (2006). Exit temperature and velocities taken from Table 9, GHD (2006).

B: Criteria pollutant emissions have been taken from URS (2006).

C: HAP Emission rate calculations are provided in **Appendix B**.

Table 7-4 Stack Locations - Delta Electricity Facility

Stack	Location (MGA94)		Base Elevation (mAHD)
Stack 1	229384 mE	6166522 mN	605
Stack 2	229424 mE	6166482 mN	605

7.3.4 EnergyAustralia Turbine Emissions – Start Up

The start up turbine emissions for Energy Australia are provided in **Table 7-5** and assumed stack locations are provided in **Table 7-6**. It is noted that these stack locations are based on indicative layouts for the Facility.

Table 7-5 EnergyAustralia Start Up- Stack Parameters and Emissions

Stack Parameter [A]	Units	Start Up	Operation
Stack Height (above ground level)	(m)	30	30
Stack Diameter	(m)	6.5	6.5
Nominal Plant Capacity	(MW)	350	350
Exit Temperature	(°C)	398	532
Exit Velocity	(m/s)	23	34
Stack Emissions (per stack)[B]			
Criteria Pollutants			
NO_X Emission	(g/s)	117.8	19.3
CO Emission	(g/s)	895.6	4.6
SO_2 Emission	(g/s)	2.2	4.9
PM_{10} Emission	(g/s)	4.4	4.4
Hazardous Air Pollutants [C]			
Acetaldehyde	(g/s)	0.101	0.008
Acrolein	(g/s)	0.016	0.001
Benzene	(g/s)	0.030	0.003
Ethylbenzene	(g/s)	0.081	0.007
Formaldehyde	(g/s)	1.793	0.149
Total PAH	(g/s)	0.006	0.0005
Toluene	(g/s)	0.328	0.027
Xylene	(g/s)	0.162	0.013

Notes:
A: Stack parameters have been supplied by EnergyAustralia. Exit temperatures and velocities adapted from URS (2006) for Start Up and Table 9, GHD (2006) for Operation.

B: Criteria pollutant stack emissions have been taken from URS (2006).

C: HAP Emission rate calculations are provided in **Appendix B**.

Table 7-6 Stack Locations - Energy Australia Facility

Stack	Location (MGA94)		Base Elevation (mAHD)
Stack 1	229144 mE	6166659 mN	605
Stack 2	229141 mE	6166633 mN	605

7.4 Atmospheric Dispersion Modelling

The following sections discuss the modelling options used in the modelling. As previously noted, the meteorological data used in this assessment are discussed in **Appendix A** and the stack emission data are provided in **Tables 7-2** through **7-6**.

7.4.1 Choice of Model

Three dispersion models are generally endorsed by NSW EPA for development approvals, namely AUSPLUME, TAPM and CALPUFF[16]. Steady-state models such as AUSPLUME do not capture the effects of time-varying meteorological conditions over short time periods and may not accurately model maximum ground level concentrations resulting from large buoyant stack emissions. More realistic predictions are generally made with the non-steady-state models, which incorporate more sophisticated treatment of dispersion in convective and complex flow conditions.

The TAPM and CALPUFF models both incorporate site-specific factors such as terrain influences, regional-scale winds and inversions to predict ground-level concentrations. Given the significance of this assessment, it was considered that the use of two models provided greater reliability in the prediction of the potential impacts. However, given that CALPUFF model is understood to better handle calm atmospheric conditions, the CALPUFF model was used to generate the majority of results, with TAPM providing validation of the CALPUFF model concentrations. The results presented in **Section 8** therefore present the results from the CALPUFF modelling. A discussion of the validation of these results using TAPM modelling is presented in **Appendix D**.

7.4.2 Modelling Frequency

All ground level concentrations for criteria pollutants are provided as 100% and HAP are provided as 99.9%. This is consistent with the guidelines provided in NSW EPA (2005).

7.4.3 Building Wake Effects

Due to the buoyant nature of the stack and the lack of buildings within proximity to the development, building wake effects were considered to be negligible.

7.4.4 Gridded Receptor Locations

Due to the large domain of the modelling, a grid spacing was of 500m was used, which was considered appropriate for this assessment given the domain size of 30km. A visualisation of the dispersion modelling grid is shown in **Figure 4**.

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[16] CALPUFF is used for the dispersion modelling component, whilst CALMET is used for the meteorological calculations.

7.4.5 NO/NO_2 Conversion Calculations

The emission rates of oxides of nitrogen from the generators are modelled as total NO_X, which includes nitrogen dioxide (NO_2), nitric oxide (NO) and traces of nitrous oxide (N_2O). The principal species of concern, in terms of human health effects, is NO_2 and it is this compound which has relevant ground level guidelines. While NO_2 will only make up a small proportion of the total NO_X emitted by the generators at the point of discharge, the NO_2/NO_x ratio will increase as the plume travels downwind as NO in the plume is oxidised to form additional NO_2.

NSW EPA (2005) proposes three methods for assessing NO_x impacts, which are listed in order of increasing complexity. A summary of the methods is discussed below.

6) ***Method 1: 100% Conversion of NO to NO_2.*** This method assumes all NOx emissions are emitted as NO_2 and that the highest recorded background NO_2 level is constant;

7) ***Method 2: NO to NO_2 conversion limited by ambient ozone concentration (OLM)***. This method presumes ambient ozone will react with NO to form NO_2.

8) ***Method 3: NO to NO_2 conversion using empirical relationship. (The Janssen Method)***. This method relies on the use of various atmospheric parameters and is discussed below.

In their paper "*A Classification of NO Oxidation Rates in Power Plant Plumes Based on Atmospheric Conditions*", Janssen *et al.* (1988) state that more than 95% of the NO_X from plant emissions will be in the form of NO and less than 5% is in the form of NO_2. They also present the following relationship, shown as Equation 1, for estimating NO_2/NO_x ratios in the plume based on the distance downwind from the source.

$$NO_2/NO_x = A(1-\exp(-\alpha x)) \qquad \text{…[Equation 1]}$$

Where:

x = distance downwind of plant (km)

α and A are dependent on the season, wind speed and background ozone concentrations.

This relationship has been used to convert the maximum downwind NO_2/NO_x concentrations predicted by the modelling to enable comparison with ambient air quality guidelines.

The three methods were investigated in relation to the modelling scenarios. Method 1 is considered the most conservative of the methods and was used on the Single Facility Scenarios (Scenarios 1,2 and 3). Given the conservative nature of the emissions used in the combined scenarios, a more detailed assessment was required, consequently Method 3 (the Janssen Method) was selected in this investigation to estimate NO_2 ground level concentrations for the Scenario 1 - Combined and Scenario 2 - Combined. The Janssen Method was applied using hourly ozone concentrations as measured at the NSW EPA Bargo monitoring stations and the wind speed at plume height (presumed to be 250m above ground level for this analysis) was interpolated from the meteorological file generated.

7.4.6 Estimation of pollutant concentrations for averaging periods less than 1 hour

Where pollutant concentrations were required to be assessed for averaging times less than one hour, namely for sulphur dioxide and carbon monoxide, Equation 2 was used (Victoria EPA, 2005).

$$C_t = C_{60}\left[\frac{60}{t}\right]^{0.2} \qquad \text{…[Equation 2]}$$

Where:

C_t = concentration of pollutant at time t

C_{60} = concentration of pollutant based on averaging time of 60 minutes;

t = time (in minutes)

Section 8 Assessment of Potential Air Quality Impacts

8.1 Summary of Air Quality Impacts

A summary of the potential worst case air quality impacts within the modelling domain from both the Delta Electricity Facility and combined Facilities is provided in **Tables 8-1** and under these conditions, the modelled species do not show an exceedance of criteria.

Sensitive receptor locations are shown in **Figures 5 and 6** and selected worst case dispersion model contour plots for criteria pollutants are provided in the **Figures** Section.

Section 8 Assessment of Potential Air Quality Impacts

Table 8-1 Summary of predicted Ground Level Concentrations

Column 1	Column 2	Column 3	Column 4	Column 5					Column 6	Column 7
Species	**Averaging Period**	**Frequency**	**Background Concentration**	**Scenario Modelled**					**Maximum Cumulative Impact**	**Air Quality Criteria**
Startup			µg/m³	1 – Delta Electricity	2 – Delta Electricity	3 – Delta Electricity	1 - Combined	2 - Combined	µg/m³	µg/m³
NO_X (as NO_2)	1 hour	100% (Maximum)	116.9	105.1	28.2	97.8	113.0 (182)[A]	71.2 (162)[A]	229.9[A]	246
	Annual	100% (Maximum)	13.7	0.33	0.059	0.264	0.67	0.60	14.4	62
PM_{10}	24 hour	100% (Maximum)	40.0	0.47	0.46	1.10	0.93	1.29	41.3	50
	Annual	100% (Maximum)	14.0	0.02	0.013	0.060	0.04	0.08	14.1	30
SO_2	10 minute	100% (Maximum)	36.8	6.46	10.25	35.54	12.7	36.0	72.8	712
	1 hour	100% (Maximum)	25.7	4.51	7.16	24.84	8.85	25.14	50.8	570
	24 hour	100% (Maximum)	5.7	0.38	0.510	1.221	0.740	1.304	7.0	228
	Annual	100% (Maximum)	1.2	0.01	0.015	0.067	0.0256	0.080	1.3	60
CO	15 minute	100% (Maximum)	3299	1054	8.9	30.8	1795.2	1218	5094	100,000
	1 hour	100% (Maximum)	2500	798.7	6.72	23.32	1360.5	923.1	3861	30,000
	8 hour	100% (Maximum)	2250	181.2	1.44	3.43	329.5	166.2	2580	10,000
Acetaldehyde	1 hour	99.9%	-	0.026	0.012	0.043	0.563	0.034	0.563	42
Acrolein	1 hour	99.9%	-	0.004	0.002	0.007	0.090	0.006	0.090	0.42
Benzene	1 hour	99.9%	-	0.008	0.004	0.013	0.169	0.010	0.169	290
Ethylbenzene	1 hour	99.9%	-	0.021	0.010	0.034	0.450	0.028	0.450	8000
Formaldehyde	1 hour	99.9%	-	0.464	0.218	0.755	9.990	0.610	9.990	20
Toluene	1 hour	99.9%	-	0.085	0.040	0.138	1.829	0.112	1.829	360
Total (PAH)	1 hour	99.9%	-	0.001	0.001	0.002	0.031	0.002	0.031	0.4
Xylenes	1 hour	99.9%	-	0.042	0.020	0.068	0.901	0.055	0.901	190

Notes:
[A:] For Scenario 1 - Combined and Scenario 2 - Combined, peak NO_2 impacts from the facility were estimated using the Janssen Equation, as discussed in NSW EPA (2005). Values in brackets assume all NO_X is present as NO_2.
Shaded Cells indicate worst case impact.

Section 8 Assessment of Potential Air Quality Impacts

8.2 Delta Electricity Facility

The following **Sections, 8.2.1 to 8.2.6** discuss Modelling Scenarios 1 – Delta Electricity, 2 - Delta Electricity and 3 – Delta Electricity. The maximum predicted concentrations generally occurred in Scenarios 1 - Combined and 2 - Combined, however, it should be noted that PM_{10} and sulphur dioxide concentrations were found to be elevated during Scenario 3 – Delta Electricity, under combined cycle operation. The elevated results for Scenario 3 - Delta Electricity are likely to be due to lower stack temperatures, resulting in plume grounding closer to the stack, compared with the other scenarios. Scenarios 1 – Combined and 2 – Combined are discussed in **Section 8.3**.

8.2.1 Oxides of Nitrogen

The ground level guidelines for oxides of nitrogen are limited to NO_2, the principal species of concern in terms of health effects. As oxides of nitrogen undergo complex interaction after emissions from the facility, the assumption that all emitted NO_X is present as NO_2, is considered conservative. For the modelled Scenarios (Scenario 1 – Delta Electricity, Scenario 2 – Delta Electricity, Scenario 3 – Delta Electricity), it was presumed that all NO_X emitted from the facility was in the form of NO_2. The results presented in **Table 8-1** showed the 1 hour averages to have cumulative concentrations of NO_2 below regulatory guidelines.

The maximum 1 hour averaged NO_2 result of Scenarios 1,2 and 3 was shown to be Scenario 1 – Delta Electricity, with a concentration of 105.1 $\mu g/m^3$. When added to the maximum background concentration of 116.9 $\mu g/m^3$, the cumulative concentration equates to 222 $\mu g/m^3$, which is below the regulatory criteria of 246 $\mu g/m^3$.

It should again be further noted that the facility is expected to operate for approximately 500 hours of the year, and that the modelling results shown in **Table 8-1** represents the worst case short-term (1 hour) predictions based on the facility operating for every hour of the year, consequently the impacts are likely to be significantly less than modelled.

In addition, the maximum annual average NO_2 result, assuming the facilities were running every hour of the year, was shown to occur in Scenario 1 – Delta Electricity, with a concentration of 0.33 $\mu g/m^3$. When added to the annual averaged NO_2 background concentration of 13.7 $\mu g/m^3$, the cumulative concentration of 14.0 $\mu g/m^3$, is below the criteria of 62 $\mu g/m^3$. Consequently, long term impacts are considered negligible.

8.2.2 Photochemical Smog

Photochemical smog is produced during extended periods of light winds (several hours to several days) accompanied by strong sunlight, as a result of reactions involving the precursor pollutants NO_x and non-methane hydrocarbons (NMHCs). These reactions produce O_3, NO_2, peroxyacetyl nitrate and aldehydes. Aerosols are also formed, which result in visible orange-brown hazes.

While there is NO_x available, the formation of photochemical smog is said to be in a “light-limiting” regime. When NO_x is limiting the formation of smog, it is called “NO_x limited”. Fresh NO_x emissions, or the reaction of nitrogen oxide with partially oxidised NMHCs, may restart these photochemical reactions.

There are few major industrial sources of hydrocarbons in the area and emissions of NO_x and VOCs from vehicles would be significantly lower than the levels experienced in major metropolitan air sheds such and Sydney and Melbourne. The potential for smog generation in Marulan is therefore considered to be low and photochemical smog is unlikely to occur due to operations of the gas turbine facility.

The atmospheric dispersion modelling study has indicated that NO_2 emissions from the proposed Delta Electricity Gas Turbine Facility would not result in exceedances of relevant ambient air quality criteria under normal operating conditions. It is therefore concluded that further quantitative investigations of any likely increases in the potential for smog generation as a result of the proposed Facility emissions are not warranted. No further investigations into smog generation have therefore been undertaken.

8.2.3 Particulate Matter

The maximum measured 24 hour average background concentration of PM_{10} was shown to be 40.0 µg/m³, which is approaching the regulatory limit of 50 µg/m³. Given the maximum 24 hour averaged impact from Scenarios 1 through 3 is 1.1 µg/m³, PM_{10} impacts from the Delta Electricity Facility are considered minor. Similarly, the annual averaged PM_{10} impact was shown to be minor with a maximum predicted cumulative concentration 14.1 µg/m³, being less than the annual criteria of 30 µg/m³,

8.2.4 Sulphur Dioxide

All sulphur dioxide results were shown to be significantly below the regulatory criteria. Consequently, no adverse impacts on air quality are expected as a result of the discharge of sulphur dioxide from the Delta Electricity Facility.

8.2.5 Carbon Monoxide

All carbon monoxide results were shown to be significantly below the regulatory criteria. Consequently, no adverse impacts on air quality are expected as a result of the discharge of CO from the Delta Electricity Facility.

8.2.6 Hazardous Air Pollutants

Following approved methods, HAP were assessed for incremental impact and were below regulatory criteria. The most significant incremental impact was formaldehyde, for which the worst case 1 hour average concentration of 0.755 µg/m^3 constituted 4% of DECC criteria of 20 µg/m^3.

8.3 Summary of Air Quality Impacts – Combined Facilities

The following **Sections,8.3.1** to **8.3.6**, discuss modelling Scenario 1 - Combined and Scenario 2 - Combined.

8.3.1 Oxides of Nitrogen

Modelling of the combined sources used the Janssen Method to estimate NO_2 concentrations. For results presented in **Table 8-1,** the 1 hour average was shown to have cumulative concentrations of NO_2 below regulatory guidelines. Scenario 1 – Combined showed the highest impact for NO_2 with a predicted maximum modelled concentration of 113.0 µg/m^3. When added to the maximum background NO_2 concentration, a cumulative concentration was calculated to be 229.9 µg/m^3 which is below the NSW EPA regulatory criteria of 246 µg/m^3.

The annual average NO_2 concentrations were estimated on the conservative basis that NO_X existed as NO_2, and assuming the facilities were operating every hour of the year. The results provided in **Table 8-1** showed all scenarios were below the criteria of 62 µg/m^3. Given the background concentration of 14.0 µg/m³, and the predicted worst case impact of concentrations at or less than 0.67 µg/m³, long term impacts are considered negligible.

8.3.2 Photochemical Smog

The potential for photochemical smog generation is discussed in **Section 8.2.2** and not considered to warrant further investigation.

8.3.3 Particulate Matter

The maximum measured 24 hour average background concentration of PM_{10} was shown to be 40.0 µg/m³, which is approaching the regulatory limit of 50 µg/m³. Given the maximum 24 hour averaged impact from Scenario 1 – Combined or Scenario 2 - Combined is 1.29 µg/m³, PM_{10} impacts from the

Facilities are considered minor. Similarly, the annual averaged PM_{10} impact was shown to be minor with a maximum predicted concentration 14.1 µg/m³, being less than the annual criteria of 30 µg/m³,

8.3.4 Sulphur Dioxide

All sulphur dioxide results were shown to be significantly below the regulatory criteria. Consequently, no adverse impacts on air quality are expected as a result of the discharge of sulphur dioxide from the Facilities.

8.3.5 Carbon Monoxide

All carbon monoxide results were shown to be significantly below the regulatory criteria. Consequently, no adverse impacts on air quality are expected as a result of the discharge of carbon monoxide from the Facilities.

8.3.6 Hazardous Air Pollutants

Following approved methods, HAP were assessed for incremental impact and were below regulatory criteria. The most significant incremental impact was formaldehyde, for which the worst case 1-hour concentration of 9.990 µg/m^3 constituted 50% of NSW EPA criteria.

8.4 Modelling Verification

In order to verify the modelling results generated using CALPUFF, several scenarios were also run using the TAPM dispersion model and results between the models were compared. The discussion of the modelling verification study is provided in **Appendix D**. Given that NO_2 was shown to be the primary compound approaching criteria, NO_2 was chosen as the preferred pollutant to be assessed for the comparison undertaken.

The comparison of the TAPM and Calpuff models showed that overall, the TAPM results indicated broadly higher concentrations. The predicted ground level concentrations from the different dispersion models were expected to show varying results. However, the maximum cumulative NO_2 results were shown to be below regulatory criteria from both models and were generally comparable. Thus the results did not suggest that the Calpuff predictions were anomalous or erroneous, hence the use of Calpuff in this assessment was considered valid.

8.5 Emission Limits

The *Protection of the Environment Operations (Clean Air) Regulation 2002* sets emission limits for air impurities from stationary plant and equipment, during normal operational conditions, excluding Start Up conditions. The proposed stack emissions for solid particles (PM_{10}) and oxides of nitrogen (NO_X) from an E Class gas turbine (adapted from URS (2006)) are presented in **Table 8-3**. The emissions meet the current standards, taken from Schedule 3 (Electricity Generation) of the Regulation. The emissions of NO_X and PM_{10} presented in **Table 8-3** are based on a NO_X emission limit of 25ppm and typical particulate emissions respectively. Whilst these emission concentrations are considered representative of an E Class gas turbine, it should be noted that at the time of preparing this assessment, the turbine had not yet been selected. Whilst the chosen gas turbine emission concentrations of NO_X and PM_{10} are not expected to vary significantly from the values presented in **Table 8-3**, the performance specifications provided by the gas turbine supplier will need to be confirmed to ensure emission concentrations of NO_X and PM_{10} meet the stated regulatory limits.

Table 8.3 Comparison of Turbine Emissions to POEO (Clear Air) Regulatory Limits

Stack Emissions	Units	"E Class" gas turbine	POEO (Clean Air) Regulatory Limit
NO_X (all NO_x as NO_2)	(mg/m^3)	51	70
Particulates (as PM_{10})	(mg/m^3)	9	50

Note:
Concentrations reported at reference conditions.
Results taken from URS (2006) for an "E Class" gas turbine.

8.6 Aviation Safety

Due to the plume rise from the stack emissions, an aviation hazard analysis was performed based on the predicted impacts of the proposed facility and is discussed in detail in **Appendix C**. Due to the various development scenarios possible, the most conservative plume rise scenario was chosen, namely Delta Electricity Stage 1 (Operation) and EnergyAustralia (Operation) operating for all hours of 2006. This scenario was chosen as this presents the most buoyant (worst case) plume rise conditions.

The statistics have been compiled in accordance with the Civil Aviation Safety Authority's (CASA) Advisory Circular *"Guidelines for Conducting Plume Rise Assessments"* (June, 2004). Where there is potential for an exhaust plume with a vertical velocity greater than 4.3m/s at the Obstacle Limitation Surface (OLS) of 110m, a hazard analysis is required.

This assessment involved use of the TAPM model which was used to create site-specific meteorological data, including meteorology for the upper atmosphere. TAPM was also used to calculate plume rise trajectories for the turbine emissions.

The modelling results show that the combined facilities would produce exhaust plumes with vertical velocities that exceed 4.3m/s above the OLS for approximately 60% of the year, assuming both Delta Electricity and EnergyAustralia facilities were running at full load for all hours of the modelled year, 2006. The maximum, minimum and average heights at which the plume velocity is greater than 4.3 m/s are provided in **Table 8-4**.

Table 8.4 Maximum, Minimum and Average Critical Plume Extents

	Critical Vertical Plume Extent (m)	Critical Horizontal Plume Extent (m)
Maximum	852	262
Minimum	58	37
Average	133	92

Section 9 Environmental Safeguards

9.1 Dust Control During Construction

Environmental safeguards that would be implemented during the construction phases of the expansion are listed below. Emissions of particulates (dust) would be specifically controlled through the implementation of these mitigation measures, which would be incorporated into a Construction Environment Management Plan (CEMP) for the works:

- Before works begin, a CEMP will be prepared which addresses air monitoring and management issues.
- In dry, windy conditions, water sprays would be used to dampen down soils prior to excavation and handling. Exposed surfaces and stockpiles would also be watered, sprayed or covered where required.
- Where practical, particularly dusty works would be scheduled under favourable meteorological conditions only. Earth-moving activities would be stopped when wind speeds exceed 30 km/hr.
- Vehicles would only be loaded to less than the height of the side and tailboards and loads of contaminated fill would be covered during transport. Any soil adhering to the undercarriage and wheels of trucks would be removed prior to departure from the site.
- Any long-term stockpiles or cleared areas would be stabilised using measures such as fast-seeding grass or synthetic cover spray.
- Where relevant, dust suppression measures will be implemented on access roads. Specifically, Canyonleigh Road will have suitable dust suppression measures implemented, such as the use of water sprays, during periods of high vehicle use and vehicle speeds will be controlled to minimise dust.

Section 10 Proposed Monitoring Program

10.1 During Construction

Given the environmental safeguards proposed, dust monitoring programs are not proposed.

10.2 During Operation

The primary emission from the operating facility will be the stacks. The pollutants to be measured from the stack will be determined by the DECC (NSW EPA). The frequency and averaging times of the measured pollutants are yet to be determined and will form part of the Environmental Protection Licence.

Section 11 Conclusion

11.1 Air Quality

11.1.1 Delta Electricity Project

The assessment of background data showed that NO_2, PM_{10}, CO, and SO_2 were not in exceedance of regulatory criteria. The dispersion modelling predicted the impact of the facility emissions on air quality based on the facility operating all hours of the year. Whilst it is proposed that the facility will operate approximately 500 hours of the year during Stage 1 and approximately 90% of the year during Stage 2, this conservative approach was taken to assess the impacts under worst case operating and atmospheric conditions.

The results of the worst case dispersion modelling showed the following:

- Ground level concentrations of NO_2, PM_{10}, CO and SO_2 were shown to be below the NSW EPA regulatory criteria;
- HAP including acetaldehyde, acrolein, benzene, ethylbenzene, formaldehyde, Total PAHs, toluene, xylenes, were found to below the NSW EPA regulatory criteria.

In conclusion, no exceedances of DECC/NSW EPA regulatory criteria were observed and it is considered that the impacts on air quality from this development would be minor and adverse impacts are unlikely.

11.1.2 Cumulative Delta Electricity & EnergyAustralia Facilities

The assessment of background data showed that NO_2, PM_{10}, CO, and SO_2 were not in exceedance of regulatory criteria. The dispersion modelling predicted the impact of the facility emissions on air quality based on both facilities operating all hours of the year. Whilst the facilities assessed, when operating in peaking mode, are likely to operate less than 10% of the year, this conservative approach was taken to assess the impacts under worst case operating and atmospheric conditions.

The results of the worst case dispersion modelling showed the following:

- Ground level concentrations of NO_2, PM_{10}, CO and SO_2 were shown to be below the NSW EPA regulatory criteria;
- HAP including acetaldehyde, acrolein, benzene, ethylbenzene, formaldehyde, Total PAHs, toluene, xylenes, were found to below the NSW EPA regulatory criteria.

In conclusion, no exceedances of DECC/NSW EPA regulatory criteria were observed and it is considered that the impacts on air quality from this development would be minor and adverse impacts are unlikely.

11.2 Aviation Safety

A plume rise assessment / aviation safety study was also performed on the emissions from both Facilities operating as peaking facilities (being the worst case scenario). The peaking Facilities are expected to operate approximately 10% of the year; however, for the purposes of modelling, a conservative plume rise assessment study was completed for an entire year operation under full load. The assessment showed that if the Facilities were to operate continuously under these operating conditions the Facilities would produce exhaust plumes with vertical velocities that exceed 4.3 m/s above the Obstacle Limitation Surface for approximately 60% of the year. Whilst this assessment is conservative with respect to the modelled operating times and operating conditions, consideration would be given for the Facility to be designated a potential hazard to aircraft operators in the area. The implementation of such designation would be at the discretion of the Civil Aviation Safety Authority.

11.3 Greenhouse Gas

Finally, the greenhouse gas assessment indicated that, based on the upper limit of proposed operation, total greenhouse gas emissions from the Delta Electricity Marulan Gas Turbine Facility are estimated to be 0.13 Mt CO_2-e per year during Stage 1 and 2.1 Mt CO_2-e per year during Stage 2.

The greenhouse gas production from Stage 1 would represent 0.02% of emissions associated with electricity generation in NSW, and 0.02% of all sources of greenhouse gas in Australia, based on the 2005 inventory. The greenhouse gas production from Stage 2 would represent 3.63% of emissions associated with electricity generation in NSW, and 0.37% of all sources of greenhouse gas in Australia, based on the 2005 inventory.

Delta Electricity monitors GHG emissions and thermal efficiency at its currently operating power stations and implements programs to improve operational performance and reduce emissions. Programs include:

- Development of renewable energy generation sources;
- Participation in the Greenhouse Challenge Program since 1997;
- Participation in the Generator Efficiency Standards (GES); and
- Environmental Management System ISO 14001:2004 standard.

Delta Electricity is committed to reducing Greenhouse Gas Emissions as part of its Greenhouse Challenge agreement.

Section 12 References

Australian Greenhouse Office 2006 *AGO Factors and Methods Workbook*.

Australian Greenhouse Office 2006 *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2005: Energy (Stationary Sources)*.

Department of the Prime Minister and Cabinet, Australian Government 2007 *Australia's Climate Change Policy*, July 2007.

Department of the Prime Minister and Cabinet, 2007, *Report of the Task Group on Emissions Trading*, http://www.pmc.gov.au/climate_change/emissionstrading/.

BoM 2007 http://www.bom.gov.au/climate/averages/tables/cw_070330.shtml

Burns and Roe Worley 2006 *Delta Electricity Big Hill Functional Design Report – Rev. K.* November 2006.

DEC 2006 *Action for Air 2006 Update*. Department of Environment & Conservation 2006. August 2006.

DECC 2007 *National Environment Protection (Ambient Air Quality) Measure. New South Wales Annual Compliance Report 2006*.

DEH 2005 *National Pollutant Inventory. Emission Estimation Technique Manual for Fossil Fuel Electric Power Generation Version 2.4*. 15 March 2005. Australian Government.

Department of Climate Change, Australian Government 2008, *National Greenhouse Accounting (NGA) Factors*, January 2008

ESP II LLC 2007 *Petition to Amend Final Commission Decision for the El Segundo Power Redevelopment Project. CEC-800-2005-001-CMF*. June 18, 2007. Prepared by Shaw Environmental Inc.

GHD 2006 *Proposed Gas Turbine Power Facility Bamarang, NSW. Air Quality Impact Assessment.* Prepared by Heggies Australia Pty Limited on behalf of GHD Pty Ltd.

Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis, Summary for Policymakers,* Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, http://www.ipcc.ch.

Janssen L.H.J.M, van Wakeren J.H.A, van Dureen H, Elshout A.J (1988) A Classification of NO Oxidation Rates in Power Plant Plumes Based on Atmospheric Conditions; in *Atmospheric Environment*, Vol 32, No.1, pp43-53, 1988

National Greenhouse Gas Inventory Committee 2007 *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Energy (Stationary sources)*. Department of Climate Change

NEPC 1998 *National Environment Protection Measure – Ambient Air Quality*.

NEPC 1998a *National Environment Protection (Ambient Air Quality) Measure – Revised Impact Statement.*

NEPC 2004 *National Environment Protection (Air Toxics) Measure*. December 2004.

NSW EPA 2005 *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW. NSW Government*.

NSW Government 2004 *Energy Directions Green Paper*, December 2004.

NSW Government 2005 *NSW Greenhouse Plan* (available at):
http://www.greenhouse.nsw.gov.au/climate_change_in_nsw/greenhouse_plan/nsw_gh_plan_links/nsw_greenhouse_plan

Parsons Brinckerhoff (2005) *Munmorah Gas Turbine Facility Environmental Impact Statement*.

Section 12 References

US EPA 2000 *AP-42, 5th Ed, Volume 1: Chapter 3 Stationary Internal Combustion Sources*. US Government.

URS 2006 *Local Air Quality Assessment for Proposed Gas Turbine Power Station, Appin NSW*, prepared for AGL Power Generation NSW P/L

Victoria EPA 2005 *AUSPLUME Dispersion Model, Version 6.0*.

World Business Council For Sustainable Development & World Resources Institute (2004), The greenhouse gas Protocol: A Corporate Accounting and Reporting Standard.

Section 13 Limitations

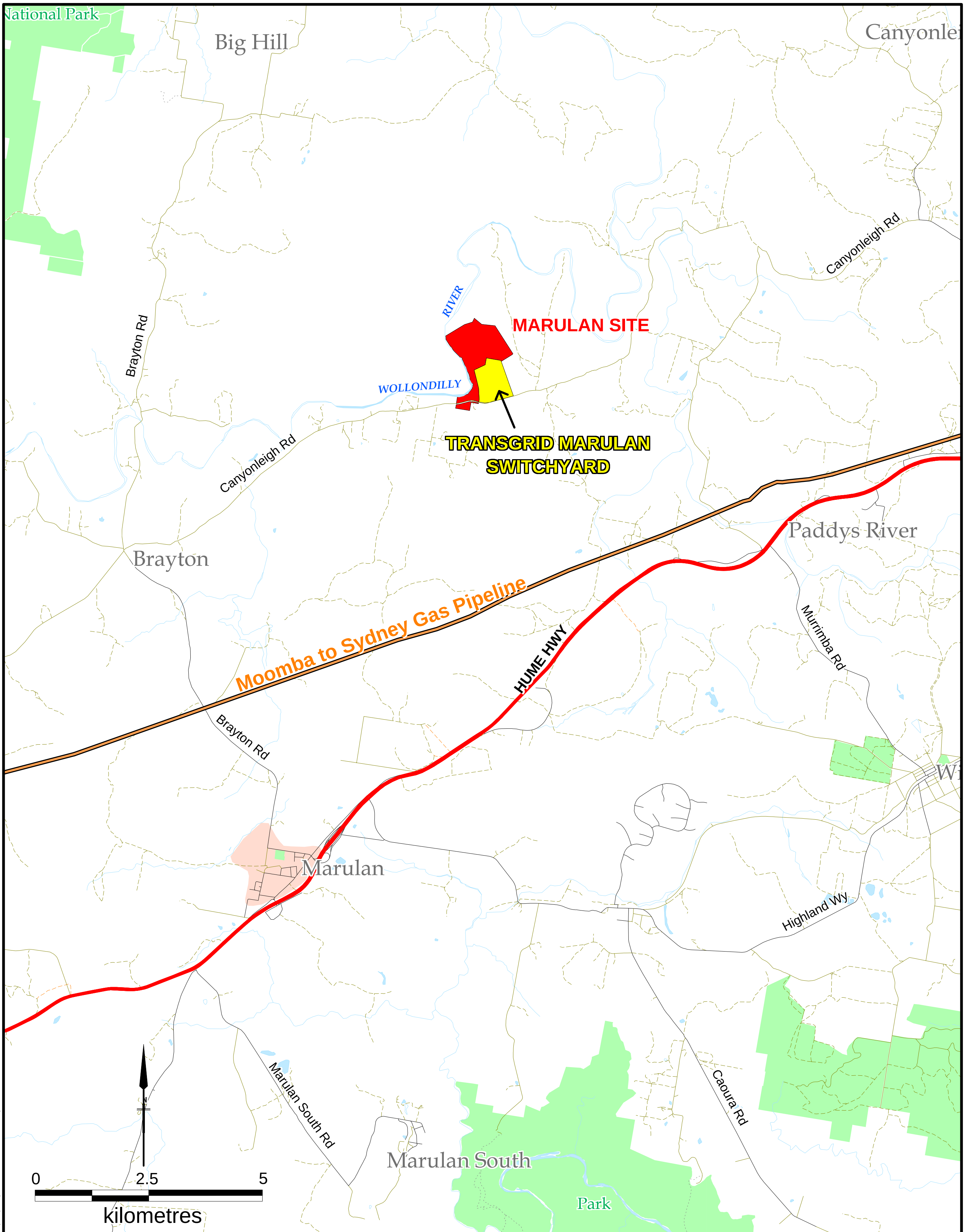
URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Delta Electricity and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 14 February 2008.

The methodology adopted and sources of information used by URS are outlined in this report. URS has made no independent verification of this information beyond the agreed scope of works and URS assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to URS was false.

This report was prepared in January- April 2008 and is based on the conditions encountered and information reviewed at the time of preparation. URS disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Figures



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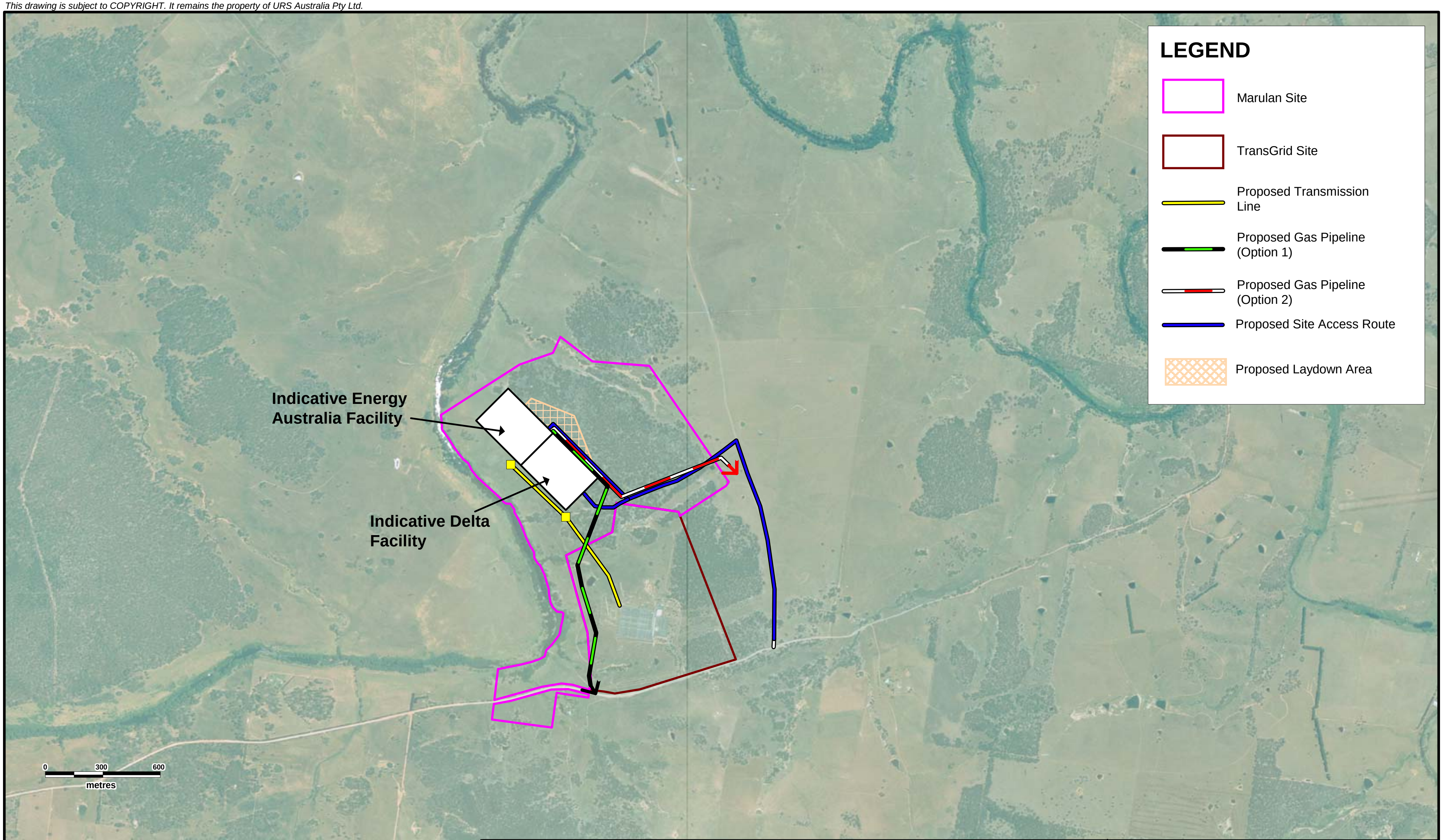
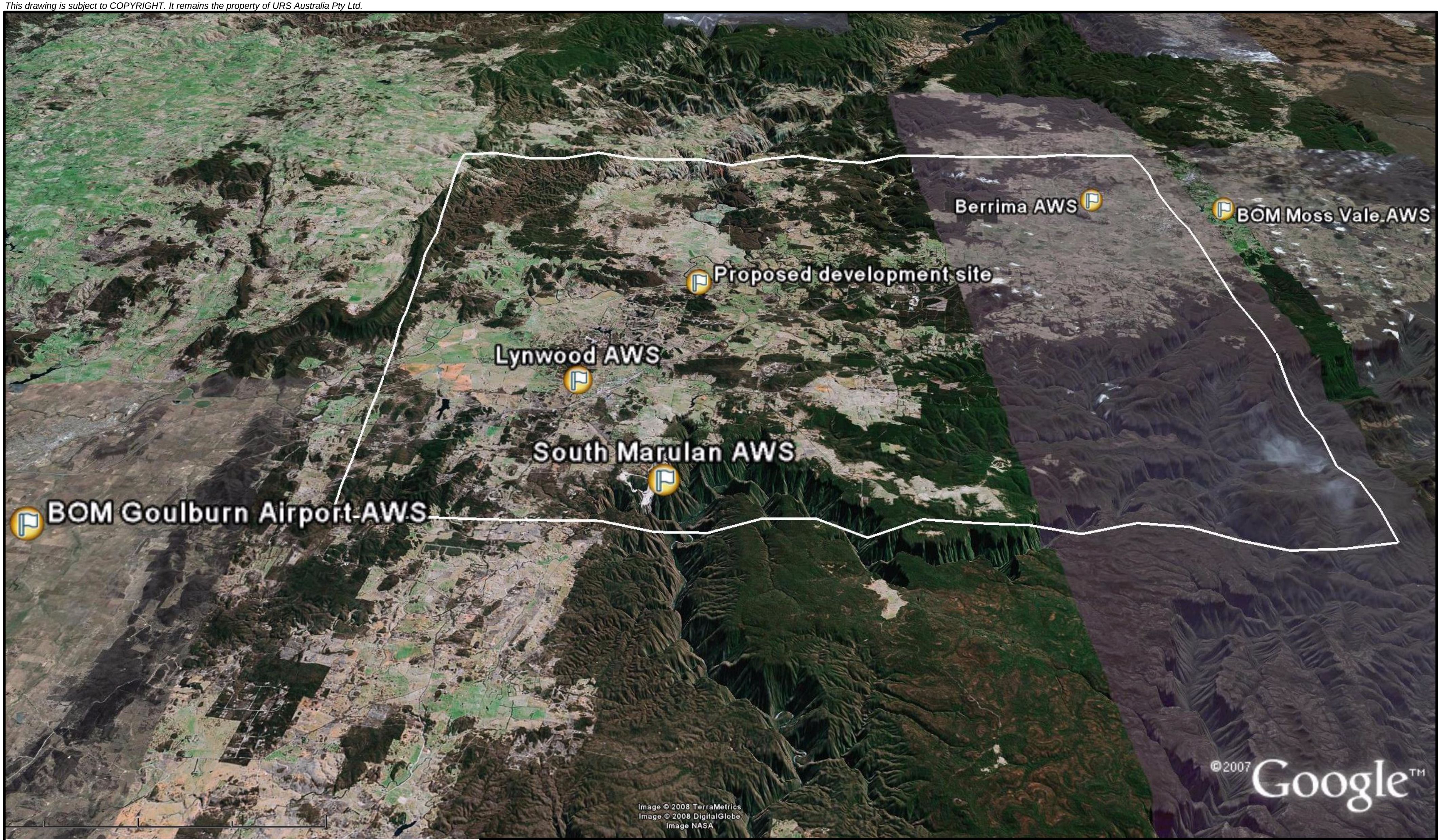
Client	Project	Title
DELTA ELECTRICITY AND ENERGYAUSTRALIA	MARULAN GAS TURBINE FACILITIES	**SITE LOCATION**
URS	Drawn: AJW · Approved: SB · Date: 11/01/2008	Figure: **1**
	Job No: **43217475** · File No: 43217475-005.wor	



Source: Delta Electricity, EnergyAustralia, Southern Cross Consulting Surveyors

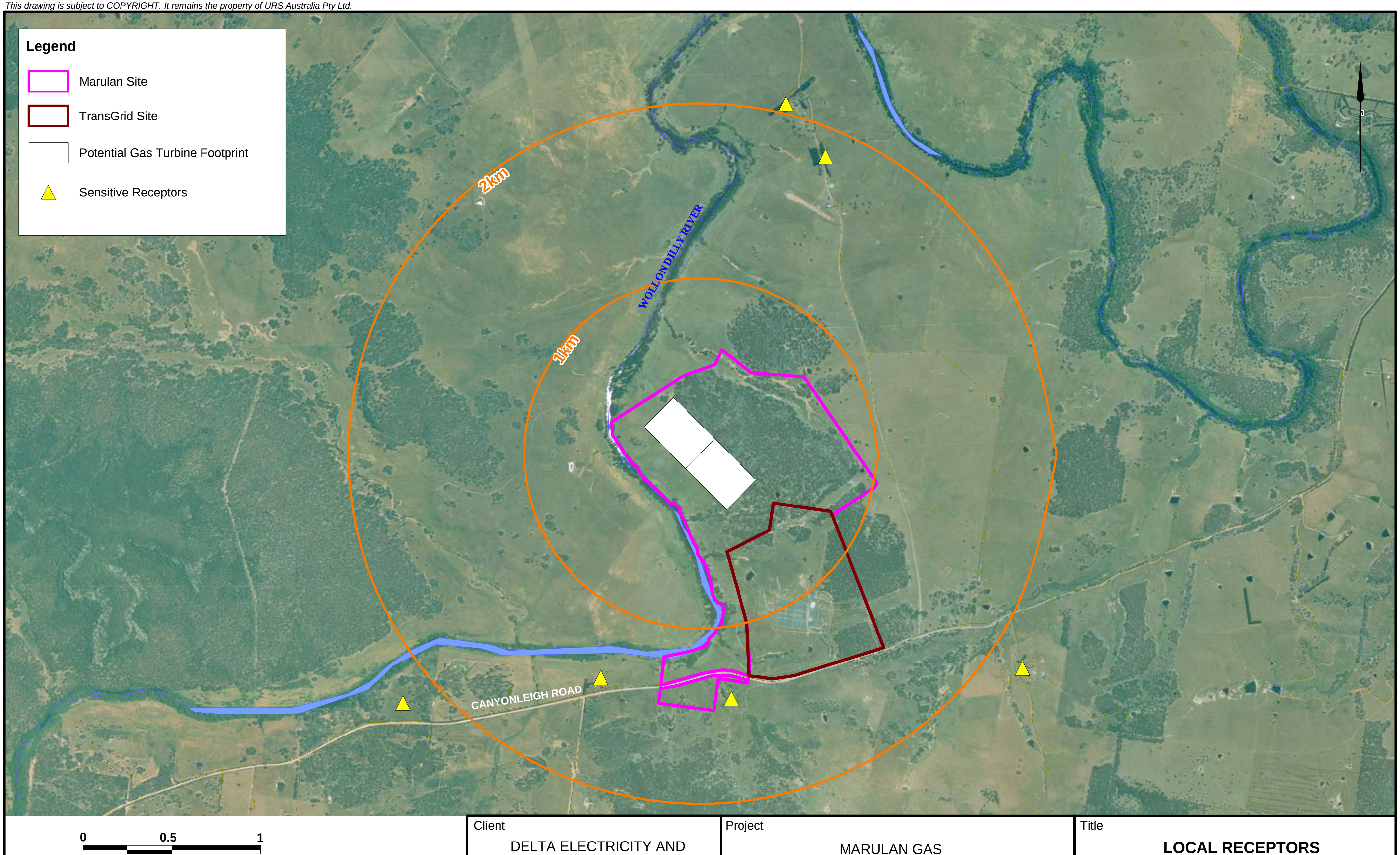
Client	Project	Title
DELTA ELECTRICITY AND ENERGYAUSTRALIA	MARULAN GAS TURBINE FACILITIES	**SITE LAYOUT**
URS	Drawn: AJW · Approved: SB · Date: 11/01/2008 · Job No: **43217475** · File No: 43217475-006.wor	Figure: **2**

Client	Project	Title
DELTA ELECTRICITY AND ENERGYAUSTRALIA	MARULAN GAS TURBINE FACILITIES	**NSW EPA MONITORING STATIONS**
URS	Drawn: AJW / Approved: SB / Date: 16/01/2008	Figure: **3**
	Job No: **43217475** / File No: 43217475-009.wor	



Source: Imagery from Google Earth

Client	Project	Title
DELTA ELECTRICITY AND ENERGYAUSTRALIA	MARULAN GAS TURBINE FACILITIES	**METEOROLOGICAL STATIONS AND DISPERSION MODELLING DOMAIN**
URS	Drawn: AJW · Approved: SB · Date: 16/01/2008	Figure: **4**
	Job No: **43217475** · File No: 43217475-007.wor	



Source: Delta Electricity

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Drawn: AJW | Approved: SB | Date: 11/01/2008

Job No: **43217475** | File No: 43217475-003.wor

Title: **LOCAL RECEPTORS**

Figure: **5**

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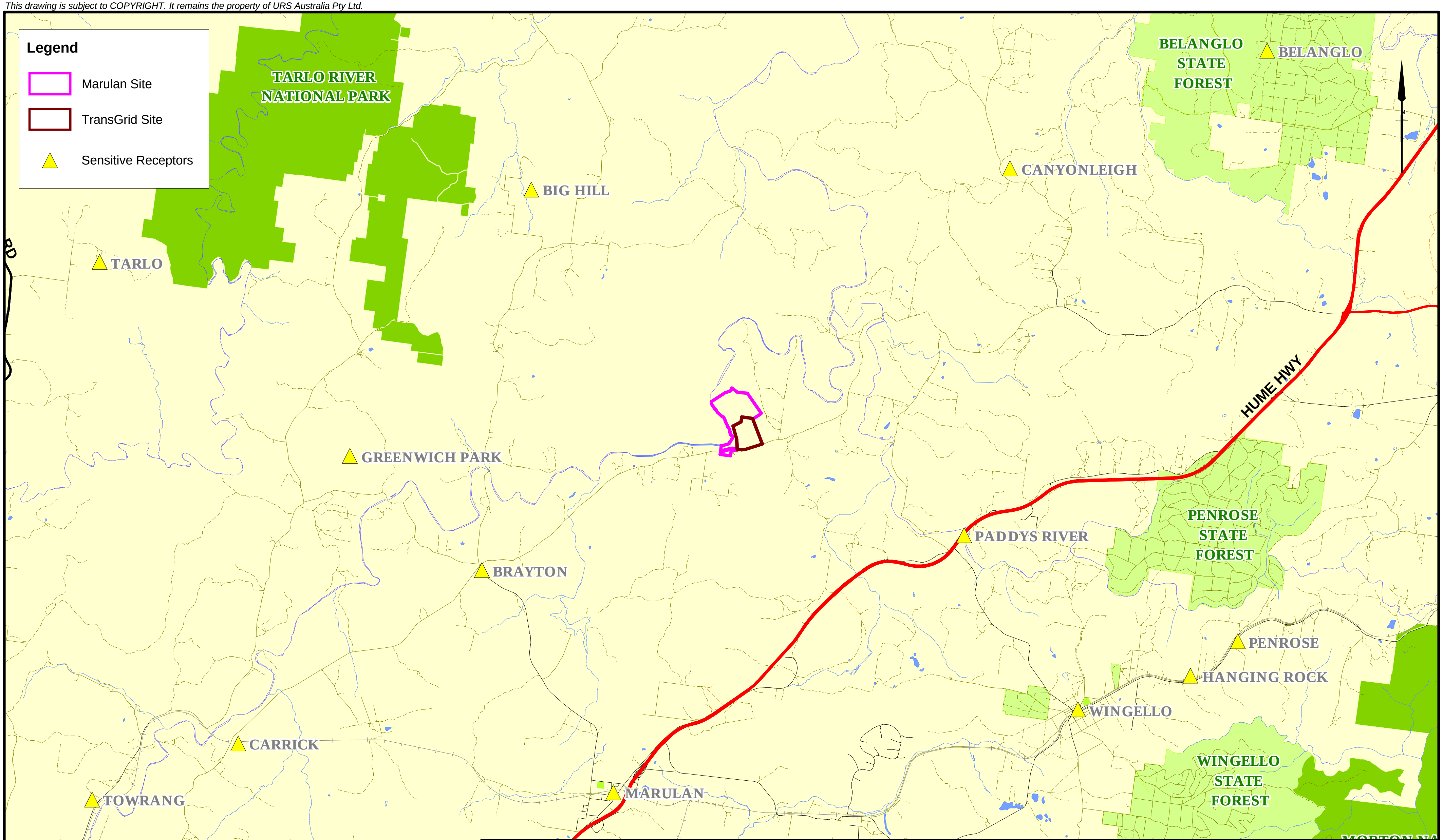

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Client	Project	Title
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URS	Drawn: AJW; Approved: SB; Date 11/01/2008	Figure: **6**
	Job No: **43217475**; File No: 43217475-004.wor	