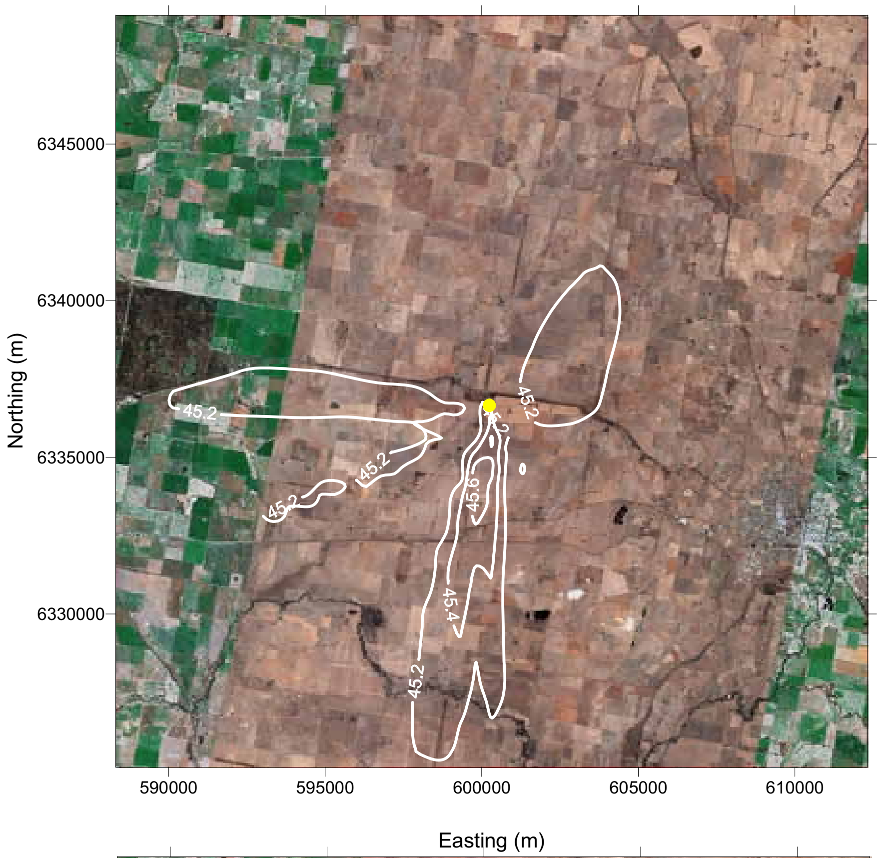
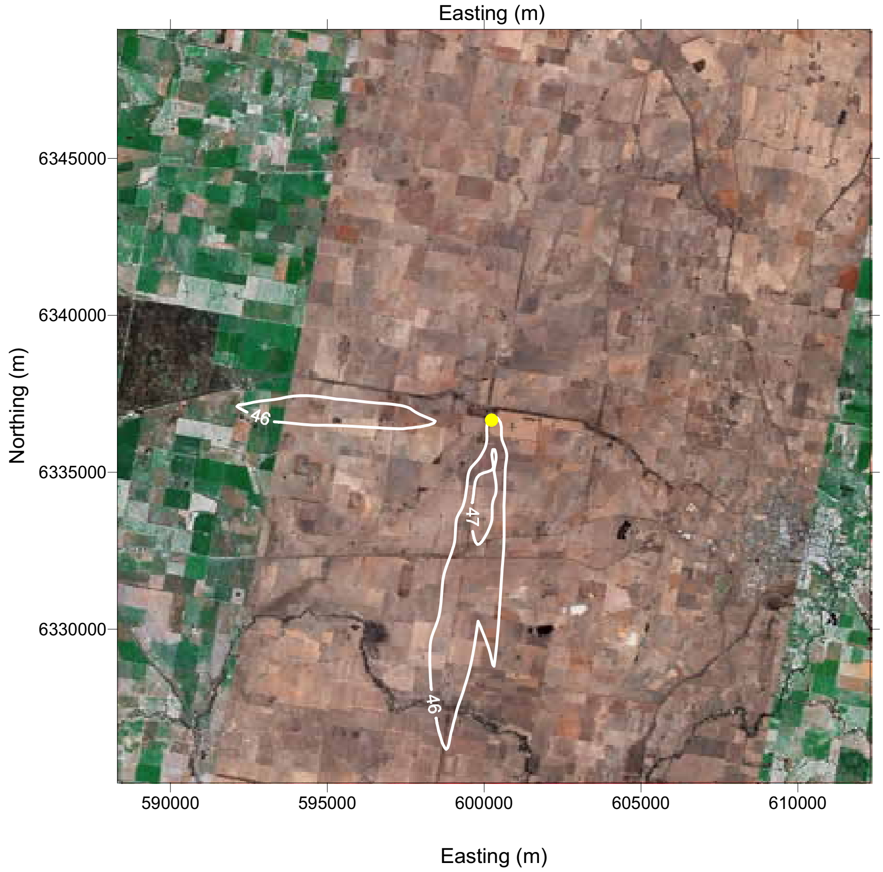
NATURAL GAS



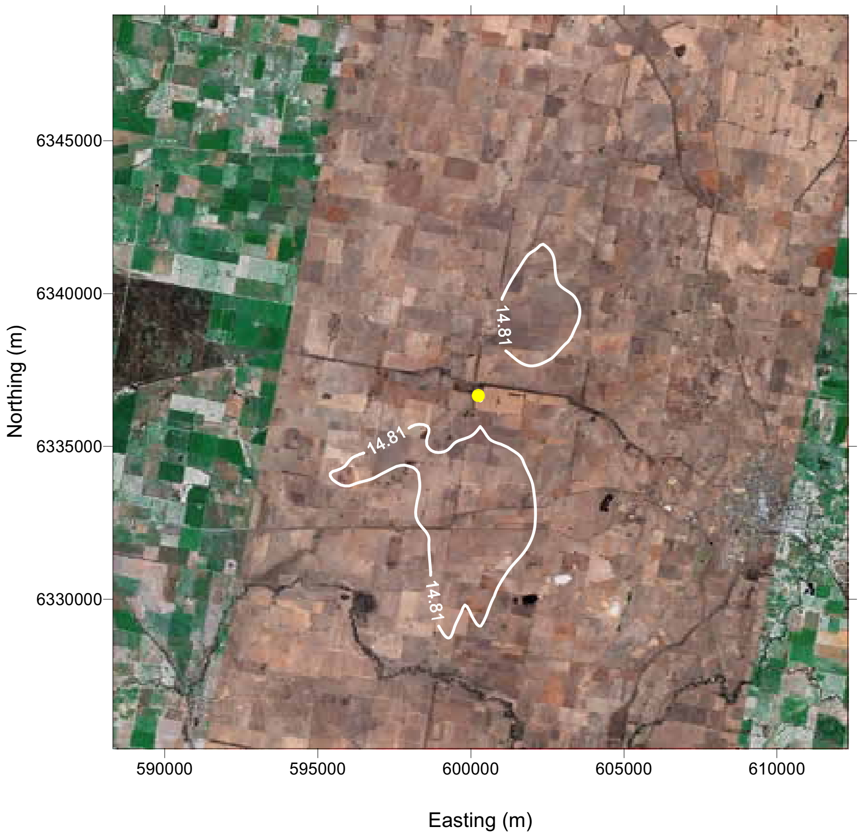
DISTILLATE



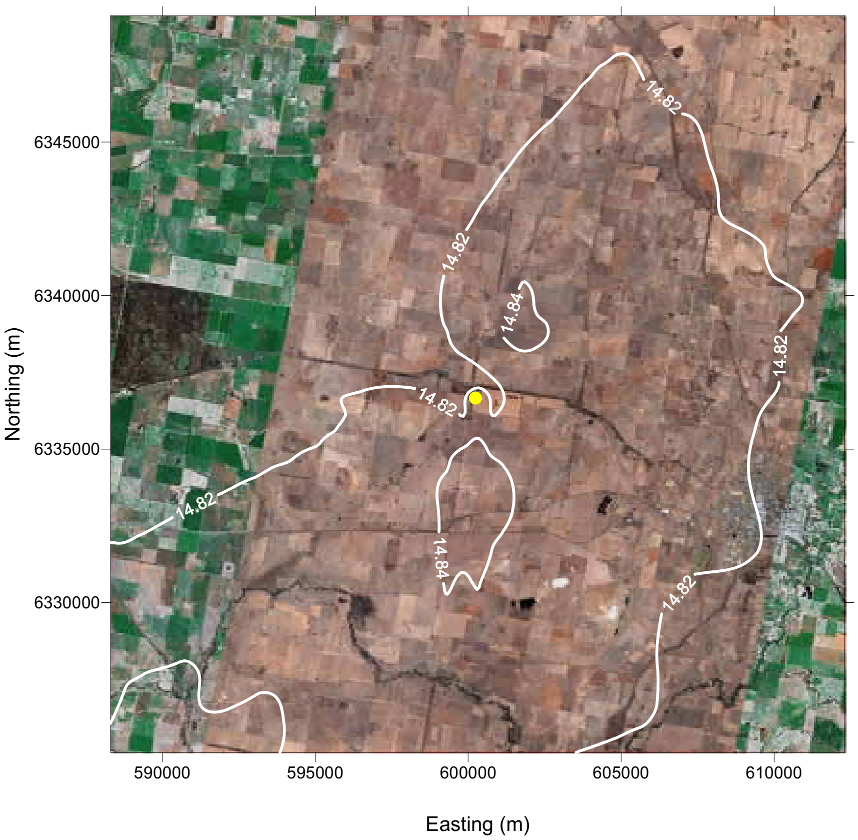
Contours in μg/m^3
Background Concentration: 45μg/m^3
DECC Assessment Criteria: 50μg/m^3
Proposed stack locations

Client: INTERNATIONAL POWER (AUSTRALIA) PTY LTD	Project: ENVIRONMENTAL ASSESSMENT PARKES PEAKING POWER STATION			Title: PM_{10} 24 Hour Averaging Maximum Cumulative Concentration	
URS	Drawn: MDT	Approved: DRAFT	Date: August 2007	Figure: 8	Rev: A
	Job No: 43177456	File: 43177456 Figure A8.srf			A4

NATURAL GAS



DISTILLATE



Contours in µg/m^3
Background Concentration: 14.8µg/m^3
DECC Assessment Criteria: 30µg/m^3
● Proposed stack locations

Client: INTERNATIONAL POWER (AUSTRALIA) PTY LTD	Project: ENVIRONMENTAL ASSESSMENT PARKES PEAKING POWER STATION			Title: PM_{10} Annual Averaging Cumulative Concentration	
URS	Drawn: MDT	Approved: DRAFT	Date: August 2007	Figure: 9	Rev: A
	Job No: 43177456	File: 43177456 Figure A9.srf			A4

Appendix A Greenhouse Gas Assessment

Appendix A Greenhouse Gas Assessment

A.1 Summary

A greenhouse gas assessment has been undertaken for the Parkes Peaking Power Plant project, which is planned to operate primarily as natural-gas fired peaking power plant with up to 200 hours operation per turbine per year proposed using distillate as a back-up fuel in the event of interruption to natural gas supplies. The power station will generate up to 115 GWh per annum and (except for extraordinary circumstances identified in its environmental license) normally operate for up to 10% of the year.

The principal greenhouse gas emission from the 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 quantified in this report.

Due to the nature of the efficient combustion process inherent in modern gas turbine plant and the limited period of actual operations, greenhouse gas emissions from the Parkes Peaking Power Plant relative to the emissions from intermediate and base load power plants are low.

Based on the upper limit of proposed operation, total greenhouse gas emissions from the Parkes Peaking Power Plant are estimated to be 0.109 Mt CO_2-e per year, which will contribute 0.07% of all existing greenhouse gas sources in NSW, and up to 0.019% of the Australian emissions of greenhouse gases for all sectors.

Although there are currently no regulated limits on greenhouse emissions, there are a number of recent developments at the state, national and international levels to manage greenhouse gas emissions. The Parkes Peaking Power Plant will participate in the relevant programs to manage greenhouse gas emissions, including the Generator Efficiency Standards, the Greenhouse Challenge Plus program and International Power (Australia) Pty Ltd (IPRA) will develop an Environmental Management System for the facility.

The Parkes Peaking Power Plant will contribute to the reduction of greenhouse gas emissions at the State level by displacing alternative generation by more carbon-intensive fossil fuelled power plant. Also, by injecting power at a regional level when high local demand requires it, electrical line loss inefficiencies associated with the long distance high voltage transmission network are minimised.

Appendix A Greenhouse Gas Assessment

A.2 Introduction

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 Global Warming Potential 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[1]. Because of this, the accounting and management of greenhouse gases 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 each greenhouse gas produced by the Parkes Peaking Power Plant, which is expressed as a percentage of the total estimated annual national greenhouse gases produced over the life of the project.

A.3 Greenhouse Gas Policy Issues

Global and national greenhouse gas policy is complex and despite the Kyoto protocol coming into force in 2005, remains uncertain. This section briefly summarises the policy issues.

A.3.1 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.
- Joint Implementation.
- 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.

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[1] 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.

A.3.2 Australian Policy

The Australian policy on climate change was released in July 2007[2] 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.

In addition to this policy, the Commonwealth Department of the Environment and Water Resources, through the Australian Greenhouse Office, manages programs that directly affect Australia's greenhouse gas inventory, including:

- Compiling and validating the National Greenhouse Gas Inventory;
- Delivery of the voluntary based Greenhouse Challenge Plus program, a vehicle for companies to report their greenhouse gas emissions annually; and
- Guiding a range of greenhouse gas mitigation initiatives.

Generator Efficiency Standards (GES)

The greenhouse gas initiative that is relevant to the stationary energy sector in Australia is the Generator Efficiency Standards (GES), launched in 2000 (see http://www.greenhouse.gov.au/ges/index.html for more information). The GES aims to work towards the best practice in the efficiency of fossil-fuelled electricity generation, and deliver reductions in the greenhouse gas intensity of energy supply. Generators are included in GES if they meet all of the specified criteria due to their use of fossil fuels:

- 30 MW electrical capacity or above; and
- 50 GWh per annum electrical output; and
- A capacity factor of 5% or more in each of the last three years.

The proposed Parkes Project satisfies the criteria for participation in the GES program.

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.

Since the Parkes Peaking Power Plant is a minor consumer of energy, and is instead is an electricity generator, it is not required to be a mandatory participant in the EEO program under the current EEO rules that exempt electricity generators.

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

National Emissions Trading Scheme

The recently released report of the Prime Ministerial Task Group on Emissions Trading[3] 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 2012.

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;
- 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;
- 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.

A.3.3 State-based Initiatives

The NSW Greenhouse Gas Abatement Scheme (GGAS)

The NSW Greenhouse Gas Abatement Scheme (GGAS) 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.

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

A.4 Greenhouse Gas Assessment Methodology

The greenhouse gas emission inventory for the Parkes Peaking Power Plant is based on the methodology detailed in the Greenhouse Gas Protocol[4], and the relevant emission factors in the *Factors and Methods Workbook* 2006 [5] and the *Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2005 – Energy (Stationary Sources)*[6]. 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 company. 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 facility where electricity is generated.
- 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 of purchased fuels; and use of sold products and services.

The Director-General's Environmental Assessment Requirements specify that both direct and indirect emissions from the project should be assessed. This greenhouse gas assessment has been conducted using the Australian Greenhouse Office's quantitative methodology.

Individual contributions to the total site emissions were estimated from the use of natural gas and distillate fuel for stationary energy generation. These were compared to the estimated annual power output from the Parkes Peaking Power Plant to assess the greenhouse gas contribution to the NSW and the Australian greenhouse gas emissions annually based on generation of power for up to 10% of the year.

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[4] World Business Council For Sustainable Development & World Resources Institute (2004) The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard.

[5] Australian Greenhouse Office (2007) AGO Factors and Methods Workbook, December 2006.

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

A.5 Greenhouse Gas Inventory

The greenhouse gas inventory for the Parkes Peaking Power Plant reports Scope 1 and Scope 3 emissions to account for the direct (Scope 1) and indirect (Scope 3) emissions from the project. The operational boundary is defined as the site boundary of the power station facility. Scope 3 emissions are limited to upstream emissions from the production of natural gas and distillate fuel used for electricity generation.

The Parkes Peaking Power Plant will have three gas turbine units with a total installed capacity in the range of 120MW to 150 MW. The plant will operate as a peaking plant, with an expected operating time of up to 10% of the year (10% capacity factor). Plant operation will mainly be on natural gas, with up to 6,000 tonnes of distillate consumed per year as a backup fuel (in the event of natural gas supply interruption) representing 200 hours of operation per unit on distillate. The estimated fuel consumption and power generated per year (power sent out) are presented in **Table 1**.

Table 1 Estimated Gas and Distillate Consumption and Electricity Sent Out

Parameter	Value	Units
Amount Gas Combusted	1,240,000	GJ/yr
Amount Distillate Combusted	6,000	tonne/yr
Electricity Sent Out	115,000	MWh/yr

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

- Liquid fuel combusted by off-site vehicles
- Liquid refrigerant losses; and
- Electricity purchased from the grid;

Table 2 shows the GHG inventory for the Parkes Project for direct greenhouse gas emissions from the project, while **Table 3** shows the indirect greenhouse gas emissions (including fuel extraction emissions).

Appendix A Greenhouse Gas Assessment

Table 2 Greenhouse Gas Inventory for Parkes Project - Direct Emissions

Scope	Emission Type	Parameter	Value	Emission Factor	Greenhouse gas emissions				% of total CO_2-e	Notes
					t CO_2	t CH_4	t N_2O	t CO_2-e		
1	Direct stationary combustion emissions	Amount Distillate combusted	7,059 kL	69.9 kg CO_2/GJ 0.004 kg CH_4/GJ 0.0006 kg N_2O/GJ	19,046	1.1	0.2	19,119	0.02	1, 3
1	Direct stationary combustion emissions	Amount Natural Gas combusted	1.24 PJ/yr	50.8 kg CO_2/GJ 0.008 kgCH_4/GJ 0.0001 kg N_2O/GJ	62,992	10	0.1	63,239	72.3	2, 4
Total Direct Greenhouse Gas Emissions					**t CO_2-e per year**			**82,358**		
					Mt CO_2-e per year			**0.082**		

Table Notes:

1) Amount of distillate combusted. Distillate energy content of 38.6 GJ/kL taken from Table 1 of "AGO Factors and Methods Workbook", Australian Greenhouse Office, December 2006.

2) Amount of natural gas combusted

3) Emission factors for diesel combustion from Table 3 and Table 102 of "Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks: Energy (Stationary Sources), National Greenhouse Gas Inventory Committee", 2005.

4) Emission factors for natural gas combustion from Table 98 and Table 102 of "Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks: Energy (Stationary Sources), National Greenhouse Gas Inventory Committee", 2005.

Appendix A Greenhouse Gas Assessment

Table 3 Greenhouse Gas Inventory for Parkes Project - Indirect Emissions

Scope	Emission Type	Parameter	Value	Emission Factor	Greenhouse gas emissions				% of total CO_2-e	Notes
					t CO_2	t CH_4	t N_2O	t CO_2-e		
3	Indirect stationary combustion emissions	Amount Distillate combusted	7,059 kL	7.8 kg CO_2-e/GJ	2,125	-	-	2,125	0.002	1, 3
3	Indirect stationary combustion emissions	Amount Natural Gas combusted	1.24 PJ/yr	19.5 kg CO_2-e/GJ	24,180	-	-	24,180	27.7	2, 3
Total Indirect Greenhouse Gas Emissions					**t CO_2-e per year**			**26,305**		
					Mt CO_2-e per year			**0.026**		

Table Notes:

1) Amount of distillate combusted. Distillate energy content of 38.6 GJ/kL taken from Table 1 of “AGO Factors and Methods Workbook”, Australian Greenhouse Office, December 2006.

2) Amount of natural gas combusted

3) Emission factors for indirect emissions from Table 2 of “AGO Factors and Methods Workbook”, Australian Greenhouse Office, December 2006. This only provides total CO_2-e emissions, hence emissions due to other greenhouse gases are unavailable.

A.6 Management of Greenhouse Gases

A.6.1 GHG Emissions for Power Generation

Generation of electricity by gas power stations currently represents the most efficient fossil-fuel based method of generating base load electricity. Base-load open-cycle gas-fired electricity generation results in roughly two thirds of the greenhouse gas intensity of coal-fired generation while combined cycle gas-fired electricity generation results in roughly third to half of the greenhouse gas intensity of coal-fired generation

The proposed Parkes facility will operate as a peaking plant and run for up to 10% of the year.

The Parkes Peaking Power Plant will contribute to the reduction of greenhouse gas emissions at the State level by displacing alternative generation by more carbon-intensive fossil-fuelled power plant rather than the transmission of power generated in the Hunter Valley and adjoining States into the NSW Central West districts.

Also, by injecting power at a regional level when high local demand requires it, electrical line loss inefficiencies - associated with the long distance high voltage transmission network and generally of the order of 5% to 10% - will be minimised.

A.6.2 Comparison to Australian and NSW GHG Inventories

Total greenhouse gas emissions in Australia for 2005 were estimated to be 559.1 million tonnes of CO_2-e[7] while NSW was estimated to emit 158.2 million tonnes CO_2-e from all sources (28% of national emissions). Most of the greenhouse gas emissions in NSW come from stationary energy sources (48% of NSW emissions).

Based on the upper limit of proposed operation the Parkes Project is estimated to release 0.109 million tonnes of CO_2-e (includes full fuel cycle emissions) per year as a peak load station, representing 0.19% of the emissions associated with electricity generation in NSW, or 0.07% of all sources of greenhouse gas in NSW in 2005.

The greenhouse gas production from the Parkes Peaking Plant represents 0.06% of emissions associated with electricity generation in Australia, and 0.019% of all sources of greenhouse gas in Australia, based on the 2005 inventory.

Quantitative greenhouse gas emissions from Parkes Peaking Plant and comparison with greenhouse gas generated from the Electricity sector in NSW and Australia are provided in Table 4.

Table 4 Comparison of Greenhouse Gas Inventory for power generation

Greenhouse gas inventory sector	CO_2-e emissions ($Mt\ CO_2$-e)	% Contribution represented by the Parkes Peaking Plant
Parkes Peaking Power Plant	0.109	-
NSW - Electricity generation sector	57.8	0.19
NSW - Total greenhouse gas emissions	158.2	0.07
Australia - Electricity generation sector	194.3	0.06
Australia -Total greenhouse gas emissions	559.1	0.019

[7] *Australia's National Greenhouse Accounts, State and Territory Greenhouse Gas Inventories 2005,* Australian Greenhouse Office 2007.

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 Parkes facility cannot be meaningfully compared to future emissions from other sources of greenhouse gases in Australia over the operational life of the plant.

A.6.3 Greenhouse Gas Programs

International Power (Australia) Pty Ltd (IPRA) has committed to meeting the State and Federal greenhouse gas programs that are applicable to the site.

All IPRA assets operating in Australia are participants in the Greenhouse Challenge Plus program, and all have either committed or are in process of committing to the legally binding targets under the Commonwealth Government's Generator Efficiency Standards.

As part of these programs, IPRA monitors GHG emissions, thermal efficiency and heat rate at each of its power plant sites, and implements programs to improve operational performance and reduce emissions.

The Parkes Peaking Power Plant will also become a participant in these programs.

- Generator Efficiency Standard (GES),
- Greenhouse Gas Challenge Plus Program,
- Environmental Management System ISO 14001:2004 standard,

In addition to the above, IPRA is working with the Commonwealth and the Victorian Governments to trial carbon dioxide capture and storage in Victoria.

Given the small GHG contribution from the Parkes Peaking Plant, IPRA is not proposing to implement any additional greenhouse gas offsets for this project.

Appendix B Meteorological Data Discussion

Appendix B Meteorological Data Discussion

B.1 Assessment of Meteorological Data – 2000 - 2005

The meteorological data needed for dispersion modelling is required to be site representative. In order to obtain site representative meteorological data, URS located the closest known Bureau of Meteorology (BoM) weather stations to the site. The closest weather stations were found to be located at Parkes Airport (Station 065068) and Parkes (Macarthur Street, Station 065026) which are understood to conform to relevant Australian Standards. However, the Parkes (Macarthur Street) weather station only measures key parameters twice per day, thus rendering it unsuitable for use in hourly averaged modelling. The Parkes Airport weather station, which produces hourly averaged data, is located approximately 16km east of the proposed development site.

In order to assess the representativeness of the meteorological data collected at the Parkes Airport weather station, URS examined six years: 2000 through to 2005, inclusive. This methodology is consistent with the requirements contained in DEC (2005) *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.* It should be noted that at the start of the assessment, data for 2006 was not available, hence was not assessed.

The Parkes Airport windroses for 2000 – 2005 are shown in **Figure B.1**. The examination of the six years of meteorological data was summarised with the “All years” windrose and wind speed plot shown in **Figure B.1**.

The wind roses for the individual years appear to be consistent, showing winds from the north east quadrant to be dominant with slightly less dominant winds from the south western quadrant. The average wind speed for the years showed little difference from year to year, with a range between 3.8 m/s in 2000 to 4.38 m/s in 2003, the average being 4.06. m/s. Similarly, the calms showed some variation with the calm periods ranging from 3.28% in 2002 to 4.33% in 2000. The most recent year, 2005, appears to be consistent with other years and does not show anomalous results in terms of wind directions or average wind speeds. As it is also the most recent wind data for the area that was assessed, the data for 2005 was considered suitable for use within this assessment.

In order to ensure local meteorological conditions were represented in the dispersion modelling, The Air Pollution Model (TAPM) was used to generate local wind fields. Parkes Airport meteorological data for 2005 was assimilated into TAPM at the project site. Thus TAPM-generated wind fields at the proposed development site are essentially equal to those measured by at Parkes Airport. The relocation of the BoM meteorological data to the proposed development site was performed as a preliminary comparison of modelling results (where the BoM data was left at the Parkes Airport site) showed the ground level concentration results were less conservative than relocating the meteorological data to the project site (in TAPM). Thus the relocation represents a conservative measure.

B.2 Meteorological modelling

TAPM was run to calculate meteorological fields for the modelling domain. Through a number of verification studies (e.g. CSIRO 2005), TAPM has been identified as a suitable model of choice to simulate meteorological fields in a number of situations[1].

TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical co-ordinate for three-dimensional simulations. It includes parameterisations for cloud/rain micro-physical processes, turbulence closure, urban/vegetative canopy and soil, and radiative fluxes.

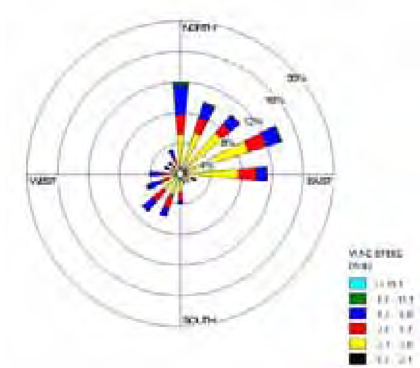
[1] CSIRO, 2005. The Air Pollution Model (TAPM) Version 3. Part 2: Summary of Some Verification Studies. CSIRO Atmospheric Research Technical Paper 72, 2005.

Appendix B Meteorological Data Discussion

- TAPM, with the use of the input databases provided by CSIRO, was used to generate a meteorological dataset for the year 2005 based on actual synoptic data. The following TAPM settings and input files were used to generate the meteorological file for the Parkes site for the year 2005., default options were selected, except where noted otherwise below:
- Grid centre coordinates –33° 6 min latitude, 148° 4'30'' min longitude (600310 mE, 6337113 mN);
- Meteorological grid consisting of four nests of 25 x 25 grid points at 30, 10, 3 and 1 km spacing, with 25 vertical grid levels from 10 to 8000 m;
- Terrain at 9 arc-second (approximately 270m) resolution from the Geoscience Australia terrain database. Land characterisation data at approximately 1km resolution, sourced from the US geological Survey, Earth Resources Observation System (EROS) Data Centre Distributed Active Archive Centre (EDC DAAC). Sea surface temperature data at 100 km grid intervals from the US National Centre for Atmospheric Research (NCAR);
- Six hourly synoptic scale meteorology from the BoM on a 75 to 100 km grid. This data is derived from the BoM LAPS (Limited Area Prediction System) output;
- The Parkes Airport meteorological data was used on a radius of influence of 35km. The centre of influence was also relocated to the project site and configured to affect the lowest two levels of TAPM generated wind fields (9.8 and 24.8m).

The annual and seasonal windroses for the TAPM generated meteorological data are provided in **Figure B.2**. These wind roses show the dominance of winds from the north east and south west quadrant for the majority of the year. Winter, however, shows the presence of a high proportion of winds from the north and north east quadrant.

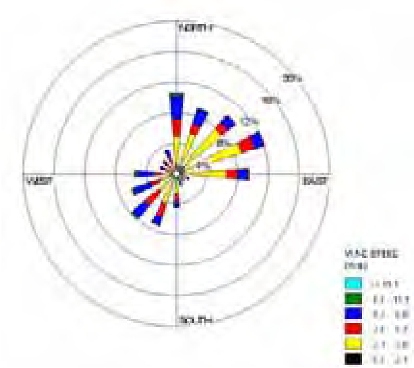
Appendix B Meteorological Data Discussion



2000

Average wind speed: 3.80 m/s

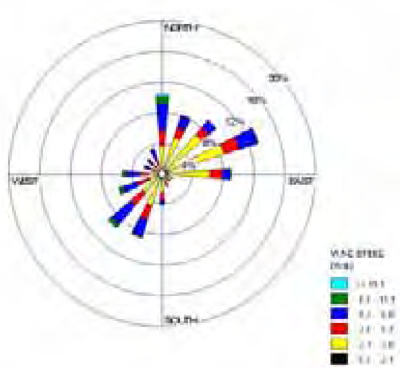
Calms: 4.33 %



2001

Average wind speed: 3.89 m/s

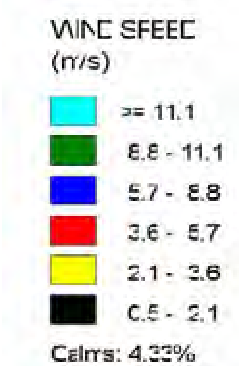
Calms: 4.08 %



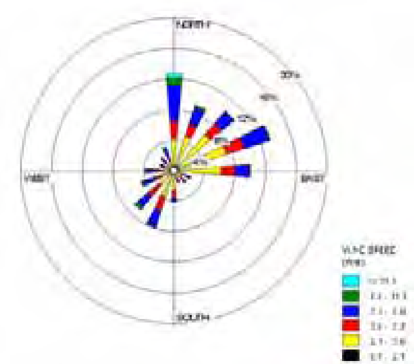
2002

Average wind speed: 4.17 m/s

Calms: 3.28 %



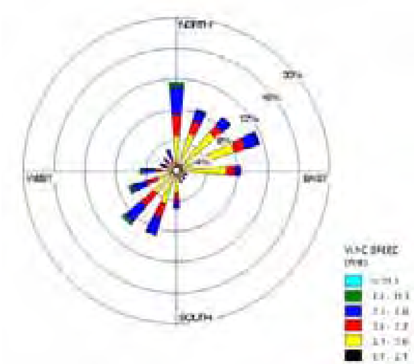
Wind Speed Legend



2003

Average wind speed: 4.38 m/s

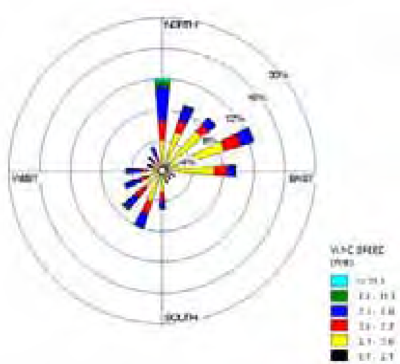
Calms: 3.31 %



2004

Average wind speed: 4.03 m/s

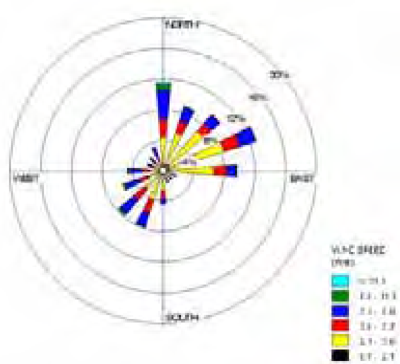
Calms: 3.62 %



2005

Average wind speed: 4.03 m/s

Calms: 4.03 %



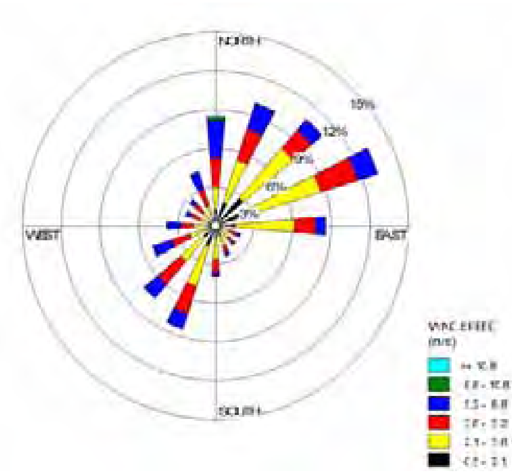
All years

Average wind speed: 4.06 m/s

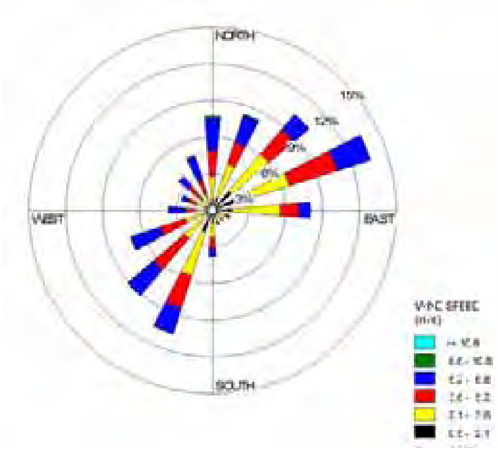
Calms: 3.75 %

Figure B.1: Parkes Airport Wind Roses 2000 – 2005

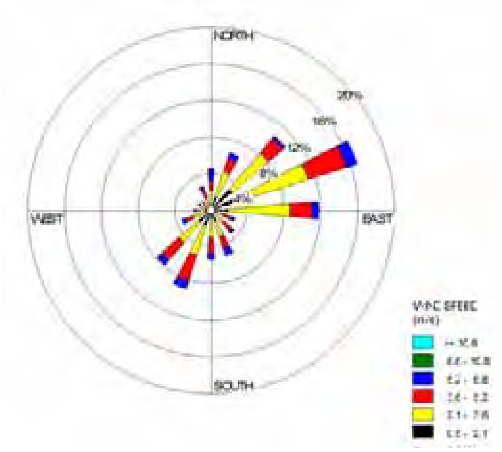
Appendix B Meteorological Data Discussion



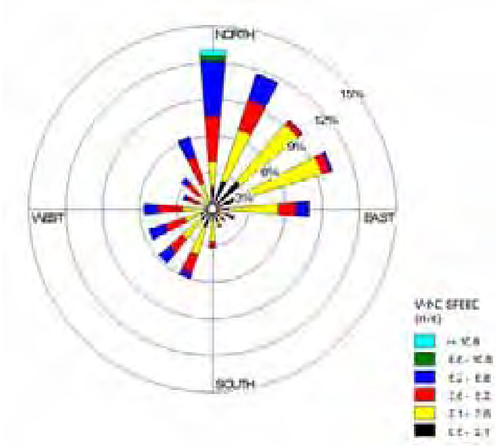
Annual Wind Rose



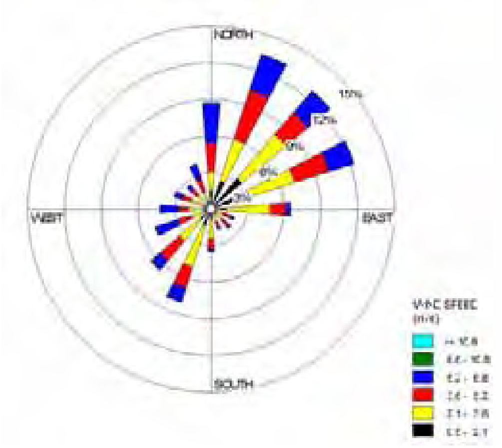
Summer



Autumn



Winter



Spring

Figure B.2: Seasonal TAPM generated wind roses for the proposed development site

Appendix B Meteorological Data Discussion

B.3 Mixing Height

Figure B.3 shows the Mixing Height (m) vs Time of Day (Hour) generated from TAPM data at the development site for 2005. The figure shows that the TAPM predicted mixing height increases with increasing solar radiation as a function of time of day. This is consistent with general atmospheric processes that show increased vertical mixing during the daytime associated with the increasing thermal radiation. Nightime conditions are cooler, more stable and, as expected, winds are generally lighter thus vertical mixing is reduced leading to a lower mixing height.

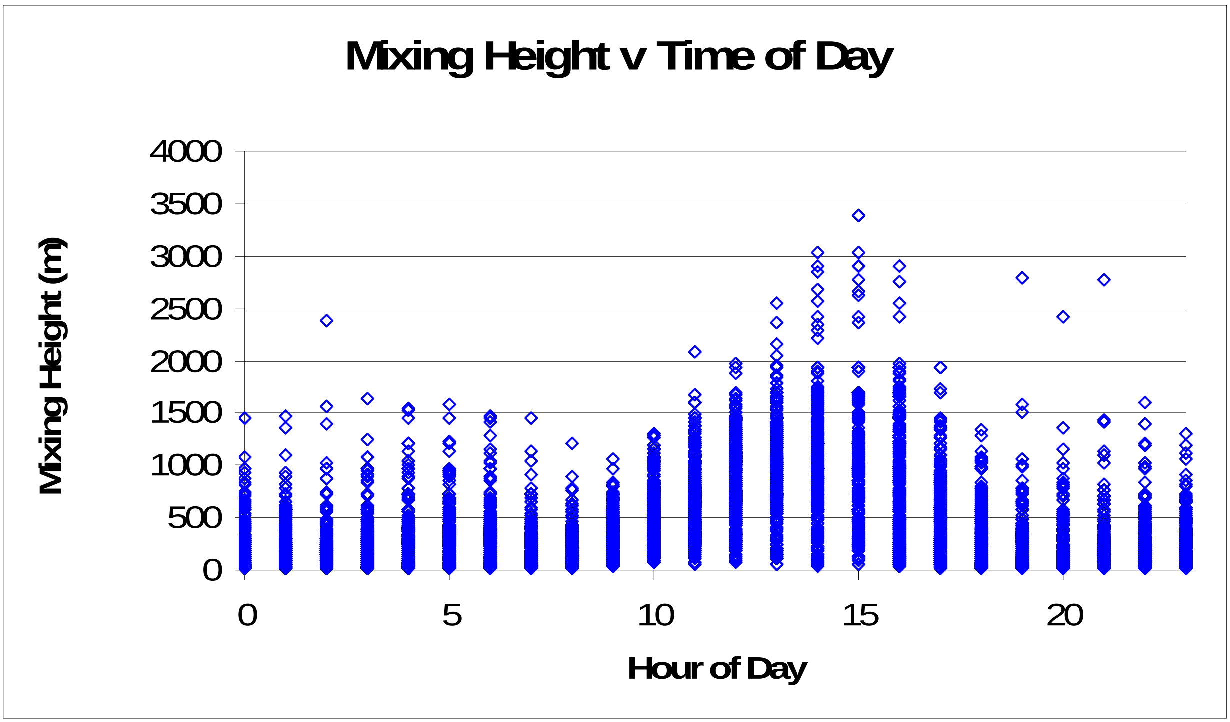


Figure B.3 Mixing Height (m) vs Time of Day (Hour of Day) – TAPM predicted, Parkes Site 2005

B.4 Atmospheric Stability

Stability class is used as an indicator of atmospheric turbulence for use in meteorological models. The class of atmospheric stability generally used in these types of assessments is based on the Pasquill-Gifford-Turner scheme where six categories are used (A to F) which represent atmospheric stability from extremely unstable to moderately stable conditions. The stability class of the atmosphere is based on three main characteristics, these being:

- Static stability (vertical temperature profile/structure);
- Convective turbulence (caused by radiative heating of the ground);and
- Mechanical turbulence (caused by surface roughness).

The Pasquill Gifford Stability classes are provided in **Table B.1**.

The stability classes for the site have been extracted from a TAPM generated meteorological file and are shown in **Table B.2**.

Appendix B Meteorological Data Discussion

Table B.2: Modified Pasquill-Gifford Stability Classes (adapted from Turner, 1994[2])

Surface Wind Speed at 10m (m/s)	Insolation			Night-time cloud (Oktas)	
	Strong	Moderate	Slight	Thinly overcast of > 4/8 low cloud	< 3/8 Cloud
≤ 2	A	A-B	B	-	-
2 - 3	A-B	B	C	E	F
3 - 5	B	B-C	C	D	E
5 - 6	C	C-D	D	D	D
> 6	C	D	D	D	D

Notes:
- = Generally referred to as strongly stable conditions.

The Pasquill Gifford Stability Classes, shown in **Table B.2** shows neutral atmospheric conditions (Stability Class D) is the most prevalent Stability Class of the area, with the extreme stability classes, namely Extremely Unstable (Stability Class A) being the least prevalent.

Table B.2: Site Representative Pasquill-Gifford Stability Classes

Stability Class	% of year
A (Extremely Unstable)	0.6%
B (Moderately Unstable)	8.4%
C (Slightly Unstable)	15.5%
D (neutral)	37.9%
E (Slightly Stable)	14.0%
F (Moderately Stable)	23.5%

2 Turner B 1994 *Workbook of Atmospheric Dispersion Estimates: An Introduction to Dispersion Modelling*. 2nd Edition. CRC Press Inc

Appendix B Meteorological Data Discussion

In addition to their composition, Stability Classes were also predicted by TAPM for the site as a function of time of day, as shown in **Figure B.4**. The Stability Classes in **Figure B.4** are labelled 1 through 6 and refer to Stability Classes A (Extremely Unstable) through F (Very Stable) respectively. As expected, the Stability Classes show a tendency for the unstable classes (Stability Classes A, B and C) to occur during daytime, whilst the more stable conditions (Stability Classes D,E and F) are shown to occur primarily during night time. This is consistent with the values contained in **Table B.2**.

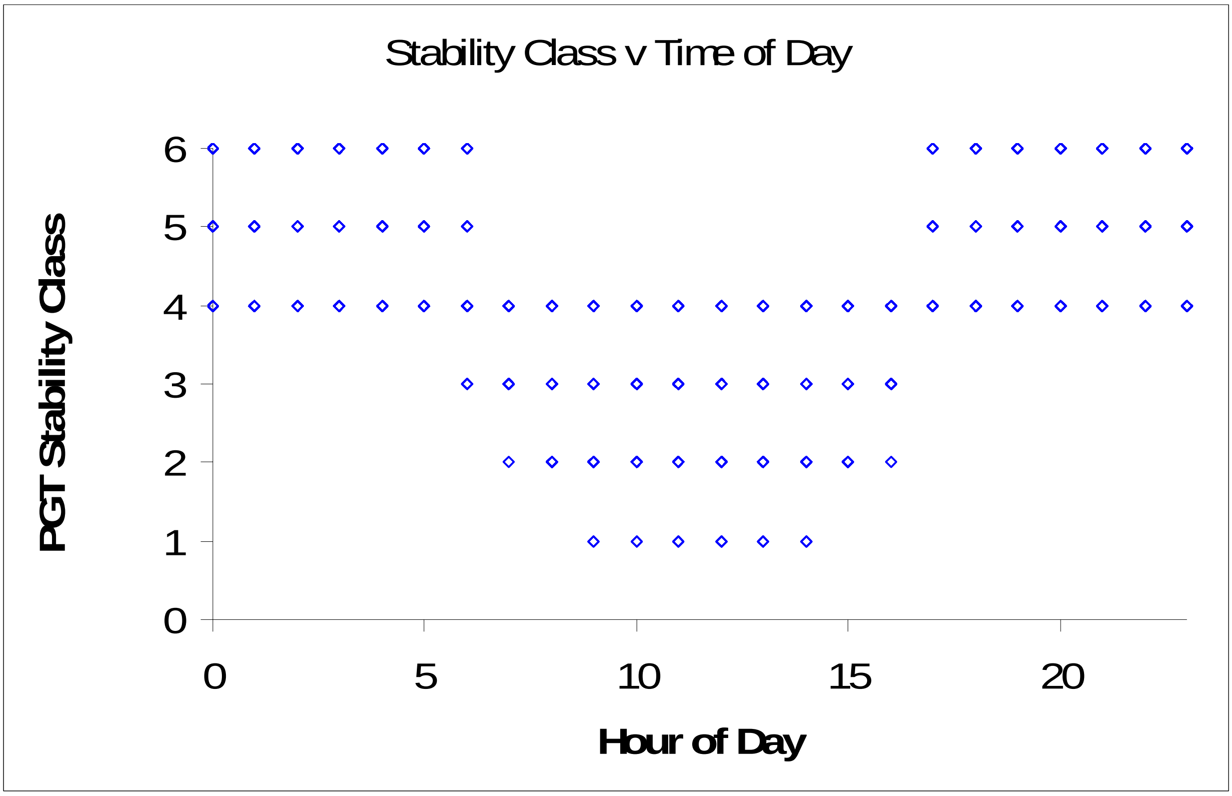


Figure B.4: Stability Class vs Time of Day – TAPM predicted, Parkes Site 2005

Appendix B Meteorological Data Discussion

Stability Classes were also measured against wind speed, as shown in **Figure B.5**. The Stability Classes in **Figure B.5** are labelled 1 through 6 and refer to Stability Classes A through F respectively. As expected, the highest wind speeds are associated with stable or neutral stability classes (Stability Classes C and D). The more unstable conditions (Stability Classes A and B) have lower wind speeds due to vertical mixing, and the more stable conditions (Stability Classes E and F) also have low wind speeds as a result of stable night time atmospheric conditions. These data are consistent with the values contained in **Table B.2.**

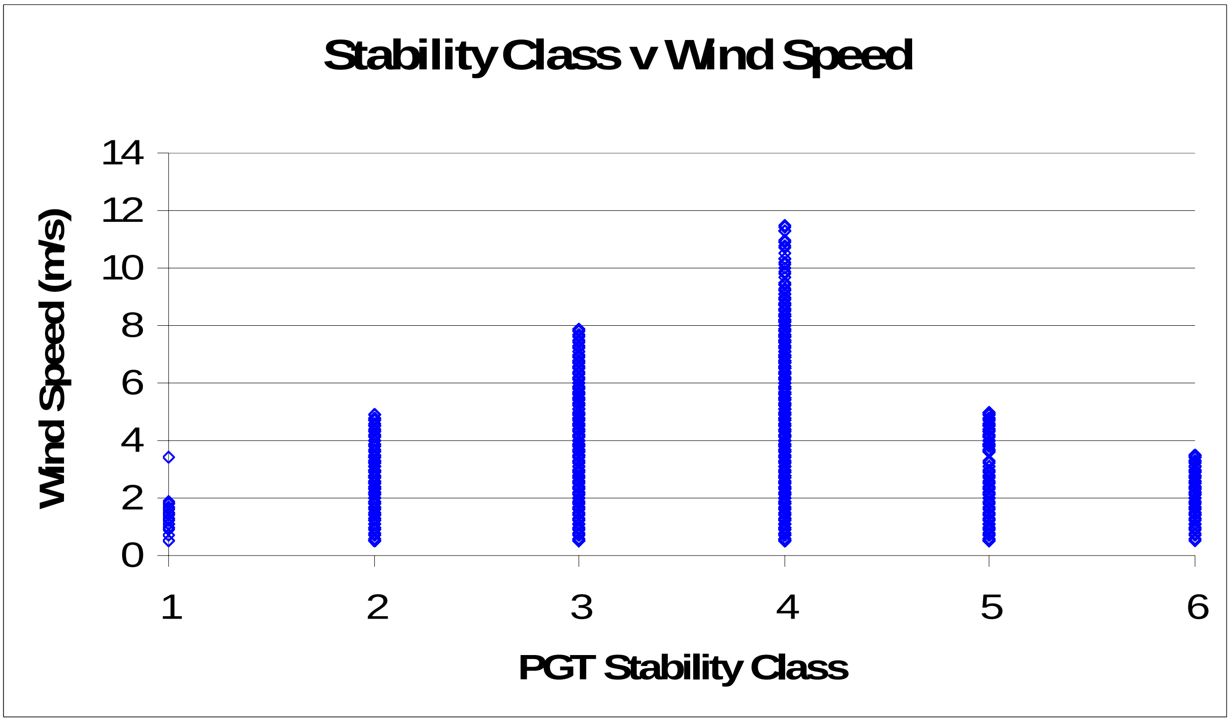


Figure B.5: Stability Class vs Wind Speed – TAPM predicted, Parkes Site 2005

B.5 Conclusion

Where site specific meteorological data does not exist, as is the case for the proposed Parkes development site, the predicted meteorological data used in the dispersion modelling is required to be representative of the surrounding area. It is accepted standard Australian practice, that in situations where adequate site-specific meteorological data does not exist, TAPM is used to synthetically generate meteorological data. TAPM is a sophisticated, 3D meteorological model that has been extensively validated. In order to better represent the meteorology of the proposed development site, Parkes airport data was incorporated into the predicted TAPM meteorology.

The assessment of the predicted meteorology at the proposed Parkes development site was discussed and was shown to be consistent with general atmospheric parameters. It is therefore considered that the meteorological data used in dispersion modelling is appropriate.

Appendix C Plume Rise Assessment

R E P O R T

Appendix C

Plume Rise Assessment for the Proposed Parkes Peaking Power Plant

Prepared for

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Contents

Executive Summary

The proposed Parkes Peaking Power Plant has been assessed for its potential impact on aviation safety. As operational times for peaking plants cannot be predicted, the assessment was performed on the basis that the plant would be operating continuously at full load (3 turbines operating). The actual operation of the plant is expected occur for between up to 10% of the year.

Based on the assessment for one year of modelled data using TAPM, the OLS is exceeded during approximately 5% of the year, with an average vertical velocity of 4.3m/s at 50m above ground level.

Whilst this assessment is considered conservative with respect to the modelled operating times and operating conditions, consideration should be given for the plant to be designated a hazard to aircraft operators in the area.

Section 1 Introduction

International Power (Australia) Pty Ltd (IPRA) proposes to build an open cycle gas turbine power plant for peaking operation, with a capacity in the range of 120MW to 150MW.

The proposed facility is to be located approximately 10km west of Parkes and will comprise three gas turbines - each of nominal 40MW to 50MW depending upon final plant selection - fuelled primarily by natural gas from the Central West Gas Pipeline, with the capability to operate on distillate fuel should the gas supply be interrupted.

Operating duty of the plant would be determined by daily fluctuations in market demand, however IPRA estimates that the operating duty will consist of short run periods totalling up to 10% of any one year.

This plume rise assessment is based upon information provided by IPRA as being typical of the types of gas turbine plant under consideration.

Given the quantity, velocity and temperature of the exhaust gases emitted from the exhaust stacks, open cycle gas turbine plumes can travel at high velocities through the atmosphere. Exhaust temperatures upwards of 500 degrees Celsius, and exit velocities of around 25 metres per second enhance the dispersion characteristics of the plume and reduce the ground level impacts of pollutants. However, this factor presents issues for aviation safety, where the high velocity of the exhaust gases can potentially affect the handling characteristics of aircraft, with the risk of airframe damage in extreme cases.

The purpose of this report is to present the information required to perform an aviation hazard analysis based on the predicted impacts of the proposed facility. The statistics have been compiled in coordination with the Civil Aviation Safety Authority's (CASA) Advisory Circular "Guidelines for Conducting Plume Rise Assessments" (June, 2004). This involved use of the CSIRO's The Air Pollution Model (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.

CASA consider an exhaust plume with a vertical velocity component of greater than 4.3m/s to be a potential hazard to aircraft stability during approach, landing, take-off and for low level manoeuvring in general. At these stages of flight the stability of the aircraft is critical, especially in situations where visibility is extremely poor, such that potentially hazardous areas cannot be identified visually, and pilots are reliant on instruments for navigation.

Such plumes also potentially create risks to the structure of the aircraft, where the transient nature of the plume has the potential to overstress the frame.

Therefore, industrial sources that may release exhaust plumes with a vertical velocity greater than 4.3m/s at the Obstacle Limitation Surface (OLS) of 110m, must undergo a hazard analysis, such that suitable measures can be taken to prevent the hazards described above.

Section 2 Background

2.1 Proposed Plant Location

The proposed facility is located approximately 15km WNW from Parkes Airport. The three exhaust stacks are located in a single line in an east-west direction with 40m spacing between each stack. **Table 2.1** presents the locations of the three stacks.

Table 2.1: Gas Turbine Stack locations

Stack	Location (GDA94)		Base Elevation (mAHD)
Stack 1	600200mE	6336666mN	272
Stack 2	600240mE	6336660mN	272
Stack 3	600280mE	6336654mN	272

2.2 Operating Scenario

The operating scenario in this assessment considers the three gas turbines running for every hour of the year at full operating load and temperature.

Given the expected total operating time of the plant is for up to 10% per year, this represents a conservative scenario, whilst still remaining relevant to the needs of the aviation safety assessment, recognising that the plant may operated for extended periods and during any hour of the day.

2.3 Exit parameters

As the power plant is configured in an open cycle arrangement, the exhaust gases exit the turbine with considerable amounts of energy, relative to the ambient air. Exit parameters are shown in **Table 2-2**.

Table 2.2: Stack Exit Parameters

Exit Parameter	Units	
Stack Height (above ground level)	(m)	20
Stack Diameter	(m)	4
Nominal Capacity	(MW)	40
Exit Temperature	(°C)	541
Exit Velocity	(m/s)	26

The analysis performed in this report was conducted using The Air Pollution Model (TAPM). TAPM was used to generate site-specific meteorology for the proposed plant. The model was also set to produce an output of the plume rise from the exhaust stacks. This output consists of vertical velocity, plume centreline elevation and radius of the plume. The plume elevation and radius are measured from the plume's point of release, until it stabilises in the atmosphere. TAPM produces this output in intervals ranging from 1 to 5 seconds, for each source (exhaust stack), for every hour of the modelling period. This allows the elevation of the plume at the point at which it reaches 4.3m/s to be interpolated.

Section 3 Modelling Methodology

3.1 Model Setup

3.1.1 TAPM Configuration

The configuration of TAPM used in this assessment was based on the guidelines included in Attachment A of the Advisory Circular “Guidelines for Conducting Plume Rise Assessments” (CASA – AC139-05(0) – June 2004). This is with the exception of the specified modelling period of 5 years. The year 2005 was used in this assessment.

- Grid centre coordinates –33°6’ latitude, 148° 4’30’’ longitude (600310 mE, 6337113 mN);
- Four nested grid domains (25 x 25): 30 km, 10 km, 3 km and 1 km;
- Meteorological grid consisting of four nests of 25 x 25 grid points at 30, 10, 3 and 1 km spacing, with 25 vertical grid levels from 10 to 8000 m;
- Eulerian dispersion was used on the outer nests, whilst Lagrangian dispersion was used on the innermost nest;
- Buoyancy enhancement from multiple stacks was calculated according to the method described in Manins et al. 1992;
- The Parkes Airport meteorological data was used on a radius of influence of 35km. The centre of influence was also relocated to the project site and configured to affect the lowest two levels of TAPM generated wind fields (9.8 and 24.8m);
- Terrain at 9 arc-second (approximately 270m) resolution from the Geoscience Australia terrain database. Land characterisation data at approximately 1km resolution, sourced from the US geological Survey, Earth Resources Observation System (EROS) Data Centre Distributed Active Archive Centre (EDC DAAC). Sea surface temperature data at 100 km grid intervals from the US National Centre for Atmospheric Research (NCAR);
- Six hourly synoptic scale meteorology from the BoM on a 75 to 100 km grid. This data is derived from the BoM LAPS (Limited Area Prediction System) output;

3.1.2 Meteorological Data Assimilation

The TAPM generated wind fields were influenced by Bureau of Meteorology data for 2005, from the Parkes Airport Automatic Weather Station (AWS). The Parkes Airport AWS is located 15km east of the site (6333825mE, 615933mN). The data was used with the centre of influence moved to the proposed site, with a radius of influence of 35km, and configured to affect the lowest two levels of TAPM generated wind fields (9.8 and 24.8m). The results using this methodology were found to be more conservative than when no data assimilation was used, or than when the centre of influence of the AWS was located at the actual AWS site, although the difference in impact between the two latter scenarios was only minor.

3.1.3 Plume Merging

TAPM does not account for interaction between sources with regards to plume dynamics. Every source is treated separately, with its trajectory defined by its individual exit parameters and the surrounding meteorology. This is an inadequate representation for cases where, due to the presence of multiple exhaust stacks, the plumes merge and experience enhanced buoyancy. Contact between plumes results in a reduction of the entrainment of cooler static air, thus increasing the extent and rate of plume rise.

Section 3 Modelling Methodology

In this assessment, the 'Buoyancy Enhancement Factor' parameter in TAPM has been used in accordance with the methodology of Manins (1992) and Hurley (2005) to account for the additional plume rise due to the merging of the plumes. This methodology takes into account the number of exhaust stacks present, their separation, as well as the exit parameters of the exhaust gas, thus arriving at a buoyancy enhancement factor for use in TAPM.

In TAPM this enhancement factor is used to scale the initial condition for buoyancy flux, thus increasing the magnitude of the plume velocity throughout its rise. A buoyancy enhancement factor of 1.43 was used in this assessment.

3.2 Statistical Analysis

Plume rise statistics were developed using the TAPM gradual plume rise output in accompaniment with the upper air data derived from TAPM (at heights of 9.8 to1468 m above ground level). This data was processed to give the statistical representation of the plume's vertical and horizontal plume extent required for the assessment.

The height at which the plume velocity decreases to 4.3m/s was calculated through linear interpolation of the TAPM gradual plume rise output. This gives the critical vertical extent of the plume for each hour of the modelling period (i.e. the height at which the vertical velocity reaches 4.3m/s).

The critical horizontal plume extent was calculated using the TAPM gradual plume rise output, in conjunction with the TAPM generated upper air data. The plume is assumed to adopt the ambient horizontal wind velocity immediately (Hurley, 2005).

i.e. $$\frac{dx_p}{dt} = u$$

where x_p = horizontal plume velocity;

t = time

u = horizontal component of wind speed.

For each time step of the gradual plume rise file that is output from TAPM, the upper air data was linearly interpolated to give the horizontal wind speed at that point. The horizontal translation of the plume during this time step was calculated as a product of the interpolated wind speed, and the length of the time step. These were summed for each time step until the critical vertical velocity of 4.3m/s was reached. The plume radius (Ry) at this height was then added to the total to give the horizontal distance from the source to the extremity of the plume boundary, at the point at which a vertical velocity of 4.3 m/s was reached (i.e. critical horizontal extent).

Statistics for wind speed at specific elevations were calculated through linear interpolation of the upper air data, which was given at 15 heights (between 9.8, 24.5, 48.9, 97.9, 146.8, 195.8, 244.7, 293.6, 391.5, 489.4, 587.3, 734.1, 978.8, 1223.5 and 1468.2 m). Whilst this profile follows a power-law trend, the error of linear interpolation is considered to be negligible, considering that the intervals between lower levels are smaller where change in wind speed with elevation is greatest. These results were then manipulated to give the various statistical representations required for the hazard assessment.

Section 4 Results

4.1 Local meteorology

Bureau of meteorology data from the Parkes Airport Automatic Weather Station indicates that the region experiences fairly high wind speeds, with an average wind speed of 4.06m/s in the period from 2000-2005 inclusive.

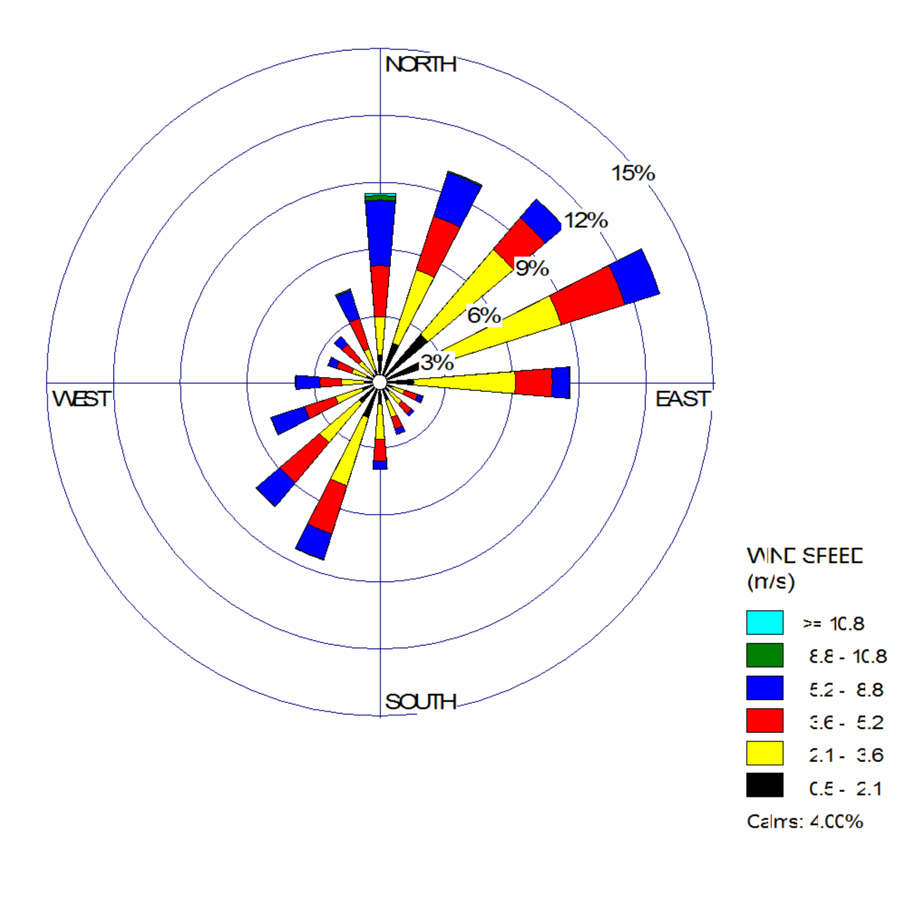


Figure 4.1 – TAPM generated wind rose for Parkes 2005, all hours, 10 m elevation

Figure 4.2 shows the relative cumulative frequency for wind speeds at various elevations. This figure represents the probability (at various elevations) of experiencing a wind speed less than or equal to a given value, based on the TAPM results for 2005. For example, at 100m elevation, there is approximately 55% probability that the wind speed for a given hour is less than or equal to 5m/s. The decreasing probability of low wind speeds with increasing elevation is indicated by rightward trend as elevation increases.

Section 4 Results

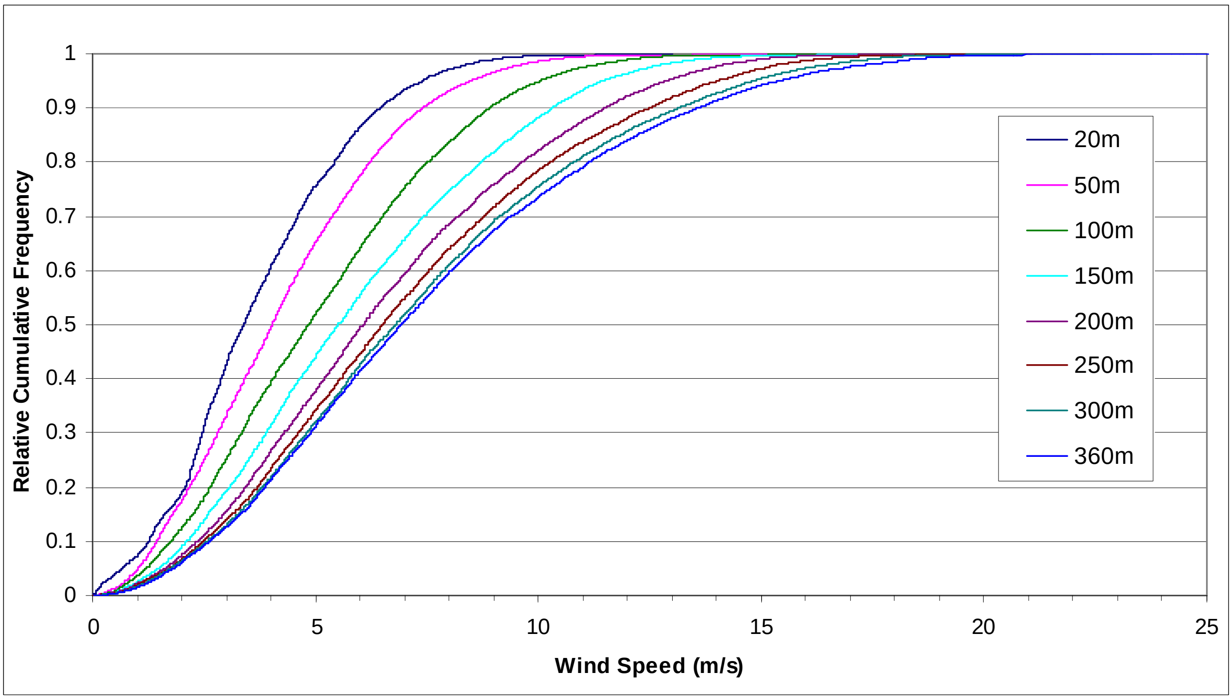


Figure 4.2: TAPM upper air wind speed relative cumulative frequency

Each row of **Table 4.1** displays the percentage of the year for which winds are less than the wind speed noted at the left of the row. The heights included range from the point of release (top of exhaust stack), to the highest point during the modelling period at which the plume velocity depreciates below 4.3m/s.

Table 4.1: TAPM upper air wind speeds by percentage

Elevation	20m	50m	100m	150m	200m	250m	300m	360m
Wind Speed								
<=0.1m/s	0.81%	0.00%	0.01%	0.02%	0.03%	0.03%	0.03%	0.02%
<=0.2m/s	2.12%	0.18%	0.13%	0.07%	0.13%	0.14%	0.13%	0.03%
<=0.3m/s	2.61%	0.48%	0.25%	0.16%	0.24%	0.26%	0.21%	0.13%
<=0.4m/s	3.14%	0.90%	0.54%	0.34%	0.35%	0.29%	0.26%	0.21%
<=0.5m/s	3.72%	1.20%	0.84%	0.59%	0.55%	0.47%	0.43%	0.33%
<=1.0m/s	7.21%	4.70%	3.57%	2.36%	2.13%	1.88%	1.59%	1.47%
<=1.5m/s	13.46%	10.90%	7.58%	5.06%	4.26%	3.90%	3.68%	3.38%
<=3.0m/s	42.56%	32.95%	25.01%	19.14%	15.37%	13.90%	12.85%	12.58%
<=5.0m/s	75.71%	65.14%	51.75%	43.89%	37.73%	34.06%	31.88%	31.19%

4.2 Plume Rise Statistics

The modelling results show that, as expected for an open cycle gas turbine facility, the plant will produce exhaust plumes with vertical velocities that exceed 4.3m/s above the OLS. **Table 4.2** displays the maximum, minimum and average critical plume extents. The critical vertical plume extent is the height (for a given hour modelled) at and below which, the vertical velocity (w) of the plume exceeds 4.3m/s. The maximum critical vertical plume extent (based on the 2005 meteorology) was 360m, which occurred during extremely calm conditions, where low wind speeds resulted in minimal entrainment of cooler ambient air into the plume. This allowed the plume to conserve its buoyancy to a greater degree, causing it to rise at a greater velocity, and to a greater extent.

The critical horizontal plume extent is the total downwind translation of the plume centreline at the point at which the vertical velocity decreases to 4.3m/s. The maximum critical horizontal plume extent of 96m occurs at a height of approximately 310m (see outermost contour of **Figure 4.6** for detail of variation of maximum critical horizontal plume extent with altitude).

Table 4.2: Maximum, Minimum and Average Critical Plume Extents

	Critical Vertical Plume Extent (m)	Critical Horizontal Plume Extent (m)
Maximum	360	96
Minimum	28	13
Average	50	26

Table 4.3 shows the critical vertical plume extent by percentage of time, for the year 2005. The result of 301m for 0.05% indicates that for 1 in every 2000 hours, the plume velocity exceeds 4.3m/s at a height greater than or equal to 301m. The OLS of 110 m is achieved for 5% of the year, assuming that the power station operates full time and under all possible meteorological conditions.

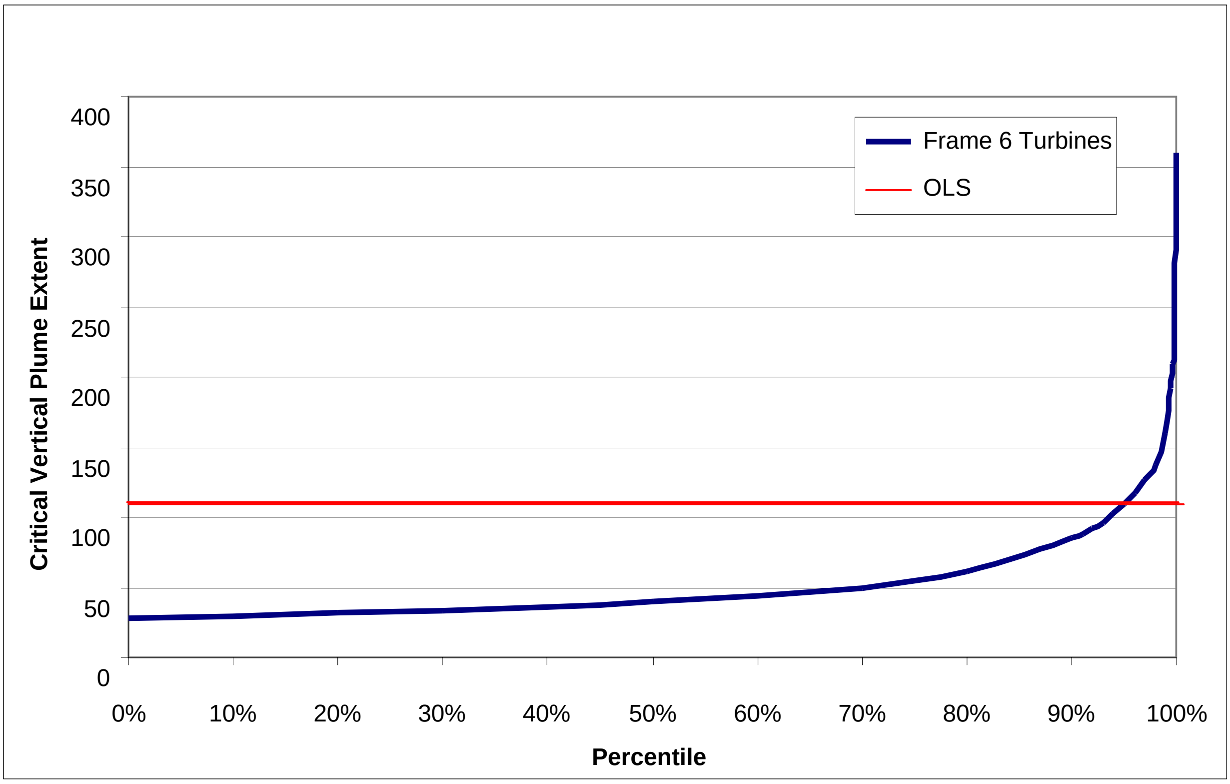
Table 4.3: Heights below which the vertical velocity exceeds 4.3m/s by percentage of 2005

Percentage of time, 2005	Height below which *w* >4.3m/s: (m)
100%	28
90%	30
80%	32
70%	34
60%	36
50%	40
40%	44
30%	49
20%	62
10%	85
9%	88
8%	92
7%	96
6%	102
5%	109
4%	117
3%	126
2%	138
1%	160
0.5%	193
0.3%	209
0.2%	218
0.1%	262
0.05%	301

Section 4 Results

Figure 4.3 is another representation of the data contained in Table 4.3 and provides the critical vertical plume extent by percentile. For example, this figure indicates that for approximately 95% of the time, the vertical velocity of the plume decreases to 4.3m/s at or below 110m elevation.

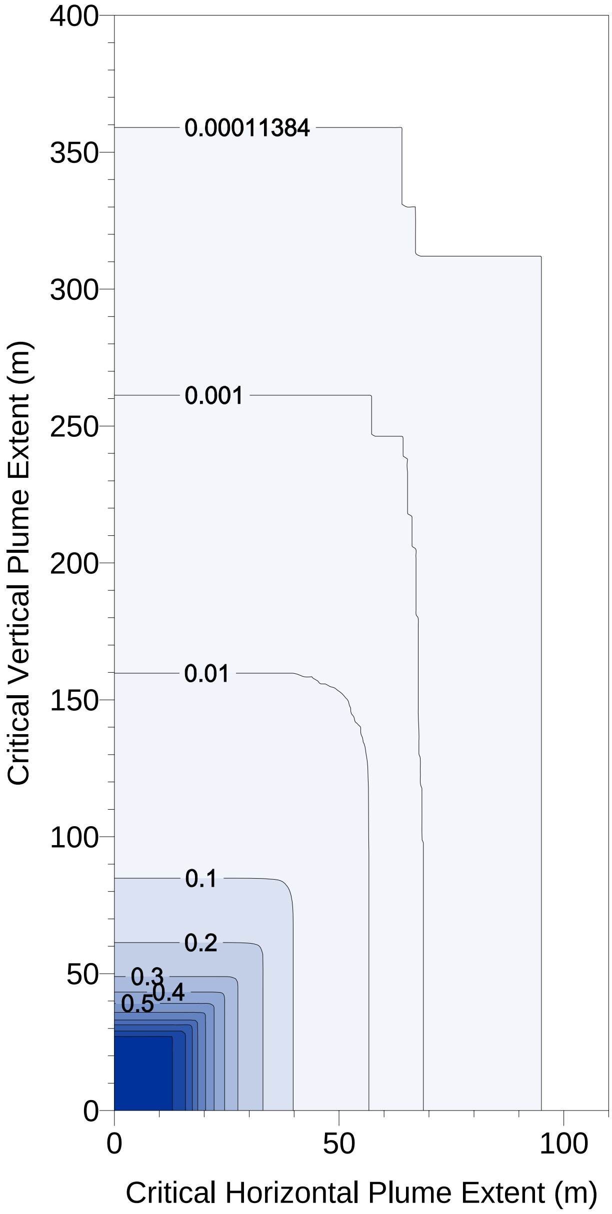
Figure 4.3: Critical vertical plume extent by percentile



Section 4 Results

Figure 4.4 illustrates the vertical and horizontal extent of the critical plume, giving the fraction of time that the plume vertical velocity exceeds 4.3 m/s. For example, for contour level 0.01 (1% of the time, or 87 hours per year), the plume height is approximately 155 m and the corresponding total horizontal extent is 57m. It should be noted that the contour of 0.00011384 is representative of the worst hour (1/8784 = 0.00011384) and thus indicates entire region of space at which the vertical velocity was greater than 4.3m/s for any instance during the year of 2005.

Figure 4.4: Probability density plot representing the region of space for which the plume velocity exceeds the critical velocity of 4.3m/s.



Section 5 Conclusion

The proposed Parkes Peaking Power Plant has been assessed for its impact on aviation safety. As operational times for peaking plants cannot be predicted, the assessment was performed on the basis that the plant would be operating continuously at full load (3 turbines operating). The actual operation of the plant is expected occur for up to of the year.

Based on the assessment for one year of modelled data using TAPM, the OLS is exceeded during approximately 5% of the year, with an average vertical velocity of 4.3 m/s at 50m above ground level. Whilst this assessment is considered conservative with respect to the modelled operating times and operating conditions, consideration should be given for the plant to be designated a hazard to aircraft operators in the area.

Section 6 References

Hurley, Peter J, CSIRO (2005) *The Air Pollution Model (TAPM) Version 3: Technical Description;*

Manins, P C, (1992) *Plume Rise from Multiple stacks*, *Clean Air* (Australia) May 1992 Vol 26 Part2 pp 65-68;

CASA (2004) *Advisory Circular AC 139-05(0) Guidelines for conducting Plume Rise Assessments.*

Section 7 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 International Power (Australia) Pty Ltd 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. 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 August 2007 and is based on the 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.

Appendix D Worst Case Ausplume Assessment

Appendix D Worst Case Ausplume Assessment

D.1 Evaluation of Worst Case Impacts using Ausplume

A screening study of potential impacts from the proposed Parkes Peaking Power Plant was performed using the Victorian EPA's (EPAV) regulatory dispersion model Ausplume. This was performed in order to evaluate the scale of the TAPM predictions against Ausplume predictions when running worst case synthetic meteorology.

Given that ground level concentrations associated with emissions of oxides of nitrogen were of interest, the assessment looked at plant operation on distillate fuel with all three turbines running at full load. This constitutes the scenario during which the highest NO_x impacts could occur. It should be noted however, that occurrence of worst case impacts during these conditions is unlikely, given that operation on distillate fuel will be limited to around 2% of the year (up to 200 hours) which includes operation at lower loads, and without simultaneous operation of all three turbines.

D.2 The Metsamp Meteorological Data File

Ausplume was run using the Metsamp screening meteorological data file. This file contains a range of combinations of meteorological parameters. With reference to Metsamp, the guidance material states:

"Licence applications may only require that predicted pollution levels be less than some threshold under all conceivable meteorological conditions. Because of the conservative assumptions involved, the use of an artificial screening file is often sufficient to ensure that regulatory requirements are met."

(EPAV,2004[1])

In this case however, the Ausplume screening procedure has been used to augment the comprehensive TAPM study documented in the main report.

As the Metsamp screening file only contains meteorological data for a single wind direction, the file was configured (optimised) to contain the standard Metsamp data at intervals in wind direction of 5°. This in turn allows terrain effects to be incorporated into the model, resulting in over 19,000 hour cases of synthetic meteorology.

Once worst case parameters were identified (using Metsamp in this form), the file was further refined to investigate sensitivity to other parameters, beyond the range and resolution of the standard Metsamp file. The parameters investigated were wind speed, ambient temperature and wind direction.

D.3 Model Configuration

Ausplume was run using the following settings. Default parameters were used elsewhere:

- 81 x 81 gridded receptors, at 200m resolution
- Terrain Effects were incorporated using the 'Egan Half Height' option with terrain data sourced from the TAPM database;
- Pasquill Gifford dispersion coefficients were used for both horizontal and vertical dispersion;
- Irwin Rural wind profile exponents were used;

[1] EPA Victoria, June 2004, *AUSPLUME Gaussian Dispersion Model – Technical User Manual*

Appendix D Worst Case Ausplume Assessment

- The 'Adjust PG curves for roughness' option was selected;
- A roughness height of 0.2m was used;
- The 'Enhance Plume for Buoyancy' option was selected;
- Both the 'Gradual Plume Rise' and 'Partial Penetration of Elevated inversions' options were trialled;
- Stack parameters, emission rates and locations were input as detailed in the main report, with the exception of neglecting buoyancy enhancement due to plume merging.

These details are also contained in the Ausplume output file which is included in Attachment A.

D.4 Worst Case Impacts

Ausplume using worst-case optimised synthetic meteorological data has produced a lower peak impact than that predicted by TAPM.

Table 1 – Worst Case Impacts

Model	Predicted Worst Case Impact (µg/m³)	Percent of Maximum Prediction
TAPM (as presented in main report)	93.2	100
AUSPLUME using standard Metsamp (at 230°)	63.6	72
AUSPLUME using optimised Metsamp	66.9	68

D.5 Worst Case Model Meteorology

This section details the influence of various meteorological parameters in producing the worst case impact.

Table 2 – Worst Case Model Meteorology

Parameter	Value
Temperature	-5°C
Wind Speed	1.0m/s
Wind Direction	230°
Stability Class	F
Mixing Height	-

Temperature

The worst case impact was largely insensitive to changes in ambient temperature. The model was run using Metsamp at 10°C increments across the temperature range experienced for the region. An increase from 61.8 µg/m³ to 66.9 µg/m³ over the 48°C to -5°C temperature range recorded in the area, with the peak being recorded at an ambient temperature of -5°C.

Appendix D Worst Case Ausplume Assessment

Wind Speed

Metsamp was configured at 0.1m/s increments which showed a peak maximum concentration for a wind speed of 1.0m/s, where the associated entrainment can reduce the extent of the plume rise without adding too much additional dilution. Theoretically, under this condition the plume would take around two hours to reach the peak impact 7.5km away.

Stability Class

The worst case impacts occurred under the Pasquill Gifford stability class F, which is representative of "extremely stable" conditions. This is represented in Ausplume as an endless ground based inversion with a uniform lapse rate of -3.5K per 100m increase in altitude. In this condition, the ability of the plume to continue rising is restricted, as the plume buoyancy decreases through both the entrainment of ambient air, and continuously increasing ambient air temperature as the plume rises.

Mixing Height

The worst case impact occurs irrespective of mixing height. This is due to the assumptions Ausplume makes for stability classes E and F, in which the inversion is ground based and continues endlessly up throughout the atmosphere.

Plume Rise Option

The worst case impact occurs irrespective of whether or not the *'Partial Penetration of Elevated Inversions option'* is selected, due to the assumptions Ausplume makes for stability classes E and F (listed above). The plume settling height during the worst case conditions is around 190m, where the potential temperature is around 7°C higher than at the ground (as per the -3.5K/100m lapse rate).

D.6 Conclusion

The results of this screening study indicate that the TAPM methodology is conservative against worst-case Ausplume predictions.

In conjunction with the extremely conservative nature of the main assessment (peak background / peak impact / operation all hours / all NO_x as NO_2), this implies with an extremely high level of confidence that air quality guidelines will not be breached by the proposed plant.

Appendix D Worst Case Ausplume Assessment

Attachment A: Ausplume Output File

1

Ausplume with Metsamp: 3 Turbines, Full Load, Distillate Fuel

Concentration or deposition	Concentration
Emission rate units	grams/second
Concentration units	microgram/m3
Units conversion factor	1.00E+06
Constant background concentration	0.00E+00
Terrain effects	Egan method
Smooth stability class changes?	No
Other stability class adjustments ("urban modes")	None
Ignore building wake effects?	No
Decay coefficient (unless overridden by met. file)	0.000
Anemometer height	10 m
Roughness height at the wind vane site	0.300 m

DISPERSION CURVES

Horizontal dispersion curves for sources <100m high	Pasquill-Gifford
Vertical dispersion curves for sources <100m high	Pasquill-Gifford
Horizontal dispersion curves for sources >100m high	Briggs Rural
Vertical dispersion curves for sources >100m high	Briggs Rural
Enhance horizontal plume spreads for buoyancy?	Yes
Enhance vertical plume spreads for buoyancy?	Yes
Adjust horizontal P-G formulae for roughness height?	Yes
Adjust vertical P-G formulae for roughness height?	Yes
Roughness height	0.200m
Adjustment for wind directional shear	None

PLUME RISE OPTIONS

Gradual plume rise?	Yes
Stack-tip downwash included?	Yes
Building downwash algorithm:	PRIME method.
Entrainment coeff. for neutral & stable lapse rates	0.60,0.60
Partial penetration of elevated inversions?	No
Disregard temp. gradients in the hourly met. file?	No

and in the absence of boundary-layer potential temperature gradients given by the hourly met. file, a value from the following table (in K/m) is used:

Wind Speed Category	Stability Class A	B	C	D	E	F
1	0.000	0.000	0.000	0.000	0.020	0.035
2	0.000	0.000	0.000	0.000	0.020	0.035
3	0.000	0.000	0.000	0.000	0.020	0.035
4	0.000	0.000	0.000	0.000	0.020	0.035
5	0.000	0.000	0.000	0.000	0.020	0.035
6	0.000	0.000	0.000	0.000	0.020	0.035

WIND SPEED CATEGORIES
Boundaries between categories (in m/s) are: 1.54, 3.09, 5.14, 8.23, 10.80

WIND PROFILE EXPONENTS: "Irwin Rural" values (unless overridden by met. file)

AVERAGING TIMES
1 hour

1

Ausplume with Metsamp: 3 Turbines, Full Load, Distillate Fuel

SOURCE CHARACTERISTICS

STACK SOURCE: GT1NOX

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
600200	6336666	272m	20m	4.00m	541C	26.0m/s

No building wake effects.
(Constant) emission rate = 1.50E+01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GT2NOX

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
600240	6336660	272m	20m	4.00m	541C	26.0m/s

No building wake effects.
(Constant) emission rate = 1.50E+01 grams/second
No gravitational settling or scavenging.

STACK SOURCE: GT3NOX

X(m)	Y(m)	Ground Elev.	Stack Height	Diameter	Temperature	Speed
600280	6336654	272m	20m	4.00m	541C	26.0m/s

No building wake effects.
(Constant) emission rate = 1.50E+01 grams/second
No gravitational settling or scavenging.

1

Ausplume with Metsamp: 3 Turbines, Full Load, Distillate Fuel

RECEPTOR LOCATIONS

The Cartesian receptor grid has the following x-values (or eastings):

592310.m	592510.m	592710.m	592910.m	593110.m	593310.m	593510.m
593710.m	593910.m	594110.m	594310.m	594510.m	594710.m	594910.m
595110.m	595310.m	595510.m	595710.m	595910.m	596110.m	596310.m
596510.m	596710.m	596910.m	597110.m	597310.m	597510.m	597710.m
597910.m	598110.m	598310.m	598510.m	598710.m	598910.m	599110.m
599310.m	599510.m	599710.m	599910.m	600110.m	600310.m	600510.m
600710.m	600910.m	601110.m	601310.m	601510.m	601710.m	601910.m
602110.m	602310.m	602510.m	602710.m	602910.m	603110.m	603310.m
603510.m	603710.m	603910.m	604110.m	604310.m	604510.m	604710.m
604910.m	605110.m	605310.m	605510.m	605710.m	605910.m	606110.m
606310.m	606510.m	606710.m	606910.m	607110.m	607310.m	607510.m
607710.m	607910.m	608110.m	608310.m			

and these y-values (or northings):

6329113.m	6329313.m	6329513.m	6329713.m	6329913.m	6330113.m	6330313.m
6330513.m	6330713.m	6330913.m	6331113.m	6331313.m	6331513.m	6331713.m
6331913.m	6332113.m	6332313.m	6332513.m	6332713.m	6332913.m	6333113.m
6333313.m	6333513.m	6333713.m	6333913.m	6334113.m	6334313.m	6334513.m
6334713.m	6334913.m	6335113.m	6335313.m	6335513.m	6335713.m	6335913.m
6336113.m	6336313.m	6336513.m	6336713.m	6336913.m	6337113.m	6337313.m
6337513.m	6337713.m	6337913.m	6338113.m	6338313.m	6338513.m	6338713.m
6338913.m	6339113.m	6339313.m	6339513.m	6339713.m	6339913.m	6340113.m
6340313.m	6340513.m	6340713.m	6340913.m	6341113.m	6341313.m	6341513.m
6341713.m	6341913.m	6342113.m	6342313.m	6342513.m	6342713.m	6342913.m
6343113.m	6343313.m	6343513.m	6343713.m	6343913.m	6344113.m	6344313.m
6344513.m	6344713.m	6344913.m	6345113.m			

DISCRETE RECEPTOR LOCATIONS (in metres)

No.	X	Y	ELEVN	HEIGHT	No.	X	Y	ELEVN	HEIGHT
1	599139	6337834	280.0	0.0	5	601082	6336026	280.0	0.0
2	602388	6337514	290.0	0.0	6	599218	6335598	275.0	0.0
3	603304	6335673	320.0	0.0	7	603315	6337950	295.0	0.0

```
  4  602449 6335157   295.0    0.0         8  605629 6341568   360.0    0.0
```

METEOROLOGICAL DATA : "METSAMP" test meteorological file

1 Peak values for the 100 worst cases (in microgram/m3)
Averaging time = 1 hour

Rank	Value	Time Recorded hour,date	Coordinates (* denotes polar)
1	6.69E+01	20,02/01/00	(605710, 6341313, 0.0)
2	6.68E+01	19,02/01/00	(605710, 6341313, 0.0)
3	6.68E+01	21,02/01/00	(605710, 6341313, 0.0)
4	6.31E+01	22,02/01/00	(605710, 6341313, 0.0)
5	6.02E+01	23,02/01/00	(605710, 6341313, 0.0)
6	5.72E+01	24,02/01/00	(605710, 6341313, 0.0)
7	3.90E+01	11,02/01/00	(605710, 6341313, 0.0)
8	3.81E+01	12,02/01/00	(605710, 6341313, 0.0)
9	3.58E+01	13,02/01/00	(605710, 6341313, 0.0)
10	3.34E+01	14,02/01/00	(605710, 6341313, 0.0)
11	3.10E+01	15,02/01/00	(605710, 6341313, 0.0)
12	2.89E+01	16,02/01/00	(605710, 6341313, 0.0)
13	2.55E+01	11,07/01/00	(600910, 6337113, 0.0)
14	2.53E+01	17,02/01/00	(605710, 6341313, 0.0)
15	2.24E+01	18,02/01/00	(605710, 6341313, 0.0)
16	2.17E+01	12,07/01/00	(600910, 6337113, 0.0)
17	1.95E+01	10,02/01/00	(600710, 6337113, 0.0)
18	1.95E+01	10,04/01/00	(600710, 6337113, 0.0)
19	1.95E+01	20,05/01/00	(600710, 6337113, 0.0)
20	1.95E+01	06,07/01/00	(600710, 6337113, 0.0)
21	1.95E+01	16,08/01/00	(600710, 6337113, 0.0)
22	1.95E+01	02,10/01/00	(600710, 6337113, 0.0)
23	1.95E+01	12,11/01/00	(600710, 6337113, 0.0)
24	1.95E+01	24,11/01/00	(600710, 6337113, 0.0)
25	1.84E+01	09,02/01/00	(601110, 6337313, 0.0)
26	1.76E+01	20,08/01/00	(601110, 6337313, 0.0)
27	1.66E+01	22,08/01/00	(600710, 6337113, 0.0)
28	1.66E+01	08,10/01/00	(600710, 6337113, 0.0)
29	1.50E+01	05,10/01/00	(601110, 6337313, 0.0)
30	1.48E+01	21,08/01/00	(600910, 6337313, 0.0)
31	1.35E+01	07,10/01/00	(600710, 6337113, 0.0)
32	1.26E+01	09,04/01/00	(600710, 6337113, 0.0)
33	1.26E+01	19,05/01/00	(600710, 6337113, 0.0)
34	1.26E+01	05,07/01/00	(600710, 6337113, 0.0)
35	1.26E+01	15,08/01/00	(600710, 6337113, 0.0)
36	1.26E+01	01,10/01/00	(600710, 6337113, 0.0)
37	1.26E+01	11,11/01/00	(600710, 6337113, 0.0)
38	1.26E+01	23,11/01/00	(600710, 6337113, 0.0)
39	1.21E+01	06,10/01/00	(601110, 6337313, 0.0)
40	1.21E+01	09,06/01/00	(600910, 6337313, 0.0)
41	1.18E+01	08,02/01/00	(600910, 6337113, 0.0)
42	1.12E+01	07,04/01/00	(603510, 6339313, 0.0)
43	1.04E+01	08,04/01/00	(602510, 6338513, 0.0)
44	1.01E+01	06,04/01/00	(605510, 6341113, 0.0)
45	9.40E+00	15,06/01/00	(602310, 6338313, 0.0)
46	8.47E+00	18,07/01/00	(601910, 6338113, 0.0)
47	8.44E+00	15,05/01/00	(605310, 6340913, 0.0)
48	8.29E+00	23,04/01/00	(600510, 6337113, 0.0)
49	8.25E+00	14,06/01/00	(603910, 6339513, 0.0)
50	8.21E+00	19,07/01/00	(600710, 6337113, 0.0)
51	8.21E+00	05,09/01/00	(600710, 6337113, 0.0)
52	8.21E+00	15,10/01/00	(600710, 6337113, 0.0)
53	7.88E+00	05,05/01/00	(600910, 6337113, 0.0)
54	7.36E+00	16,05/01/00	(603910, 6339713, 0.0)
55	7.14E+00	18,05/01/00	(600910, 6337313, 0.0)
56	7.14E+00	04,07/01/00	(600910, 6337313, 0.0)
57	7.14E+00	14,08/01/00	(600910, 6337313, 0.0)
58	7.14E+00	24,09/01/00	(600910, 6337313, 0.0)

59	7.14E+00	10,11/01/00	(600910, 6337313, 0.0)
60	7.14E+00	22,11/01/00	(600910, 6337313, 0.0)
61	6.87E+00	17,05/01/00	(604110, 6339713, 0.0)
62	6.66E+00	02,06/01/00	(600510, 6336913, 0.0)
63	6.27E+00	19,03/01/00	(600710, 6336913, 0.0)
64	6.24E+00	19,08/01/00	(600910, 6336913, 0.0)
65	6.06E+00	01,08/01/00	(600910, 6337313, 0.0)
66	6.06E+00	11,09/01/00	(600910, 6337313, 0.0)
67	6.06E+00	21,10/01/00	(600910, 6337313, 0.0)
68	6.03E+00	03,07/01/00	(604110, 6339713, 0.0)
69	6.03E+00	13,08/01/00	(604110, 6339713, 0.0)
70	6.03E+00	23,09/01/00	(604110, 6339713, 0.0)
71	6.03E+00	09,11/01/00	(604110, 6339713, 0.0)
72	6.03E+00	21,11/01/00	(604110, 6339713, 0.0)
73	5.92E+00	22,07/01/00	(603910, 6339713, 0.0)
74	5.50E+00	10,07/01/00	(600710, 6336913, 0.0)
75	5.43E+00	02,07/01/00	(604310, 6339713, 0.0)
76	5.41E+00	12,08/01/00	(604310, 6339713, 0.0)
77	5.41E+00	22,09/01/00	(604310, 6339713, 0.0)
78	5.41E+00	08,11/01/00	(604310, 6339713, 0.0)
79	5.41E+00	20,11/01/00	(604310, 6339713, 0.0)
80	5.41E+00	03,09/01/00	(602710, 6338713, 0.0)
81	5.32E+00	08,06/01/00	(600710, 6337113, 0.0)
82	5.12E+00	24,07/01/00	(602510, 6338513, 0.0)
83	5.07E+00	23,07/01/00	(603510, 6339313, 0.0)
84	5.00E+00	10,09/01/00	(602510, 6338513, 0.0)
85	5.00E+00	20,10/01/00	(602510, 6338513, 0.0)
86	4.92E+00	01,07/01/00	(605710, 6341313, 0.0)
87	4.89E+00	04,09/01/00	(601110, 6337313, 0.0)
88	4.89E+00	14,10/01/00	(601110, 6337313, 0.0)
89	4.74E+00	12,10/01/00	(603510, 6339313, 0.0)
90	4.73E+00	11,08/01/00	(605710, 6341313, 0.0)
91	4.73E+00	21,09/01/00	(605710, 6341313, 0.0)
92	4.73E+00	07,11/01/00	(605710, 6341313, 0.0)
93	4.73E+00	19,11/01/00	(605710, 6341313, 0.0)
94	4.70E+00	23,06/01/00	(605710, 6341313, 0.0)
95	4.66E+00	24,06/01/00	(605710, 6341313, 0.0)
96	4.57E+00	07,02/01/00	(600710, 6337113, 0.0)
97	4.48E+00	04,05/01/00	(600710, 6337113, 0.0)
98	4.31E+00	09,09/01/00	(602910, 6338913, 0.0)
99	4.31E+00	19,10/01/00	(602910, 6338913, 0.0)
100	4.20E+00	18,11/01/00	(605710, 6341313, 0.0)

Appendix E Exhaust Stack Emission Calculations

Appendix E Stack Emission Calculations

E.1 Oxides of Nitrogen

Exhaust mass flow rate[1]	141	kg/s		
Exhaust oxygen content	14	% vol		
Exhaust moisture content	12	% vol		
Exhaust volumetric flow rate[2]	109.0	Nm^3/sec		
	96.0	Nm^3/sec (dry)		
	Natural Gas		Distillate	
Manufacturer's guarantee[3]	42		65	ppm,dry,15%O2
In-stack concentration	86.1		133.3	mg/Nm^3,dry,15%O2
	100.7		155.8	mg/Nm^3,dry,stackO2
Emission rate	**9.7**		**15.0**	g/s

[1]GE Energy Brochure, *"Gas Turbine and Combined Cycle Products"*
[2]Assuming exhaust M.W. is equal to that of dry air which has a density of 1.293kg/m^3 at NTP
[3]Supplied by IPRA

Appendix E Stack Emission Calculations

E.2 Sulphur Dioxide

	Natural Gas	Distillate	
Fuel Consumption[1]	9.9	15.3	Tonne/hr
	2.75	4.25	kg/sec
Fuel-bound Sulphur Content[2]	50	-	mg/m³ (15°C, 1atm)
	66[3]	50*	mg/kg
Sulphur emission rate	0.18	0.21	g/s
Sulphur dioxide emission rate**	**0.36**	**0.42**	g/s

[1]Supplied by IPRA
[2]Limit as specified by Australian Standard AS4564-2005
[3]Assuming density of natural gas of 0.755kg/m³ at 15°C and 1atm
*Limit as specified in Standard (Automotive Diesel) Determination 2001
**Assuming all fuel bound sulphur is oxidised to sulphur dioxide

Appendix E Stack Emission Calculations

E.3 Hazardous Air Pollutants

	Natural Gas	Distillate	
Fuel Consumption[1]	9.9	15.3	Tonne/hr
	2.75	4.25	kg/sec
Energy density of fuel[2]	51.4	45.6	MJ/kg (HHV)
Energy Input	141.35	193.8	MW (HHV)
	0.134	**0.184**	MMBtu/sec (HHV)
Emission Factors[3]			
Acetaldehyde	4.00E-05	-	lb/MMBtu (HHV)
Acrolein	6.40E-06	-	lb/MMBtu (HHV)
Benzene	1.20E-05	5.50E-05	lb/MMBtu (HHV)
Ethylbenzene	3.20E-05		lb/MMBtu (HHV)
Formaldehyde	7.10E-04	2.80E-04	lb/MMBtu (HHV)
PAH	2.20E-06	4.00E-05	lb/MMBtu (HHV)
Toluene	1.30E-04	-	lb/MMBtu (HHV)
Xylenes	6.40E-05	-	lb/MMBtu (HHV)

Appendix E Stack Emission Calculations

Emission Rates	Natural Gas	Distillate	
Acetaldehyde	0.002	-	g/s
Acrolein	0.000	-	g/s
Benzene	0.001	0.005	g/s
Ethylbenzene	0.002	-	g/s
Formaldehyde	0.043	0.023	g/s
PAH	0.000	0.003	g/s
Toluene	0.008	-	g/s
Xylenes	0.004	-	g/s

[1]Supplied by IPRA
[2](Natural Gas): AGL, 1995, *Natural Gas Technical Data Handbook*
(Distillate): ABARE/ Australia Government Department of Industry Tourism and Resources, *energy in australia 2006*
[3]USEPA, 1995, AP 42, Fifth Edition, Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources