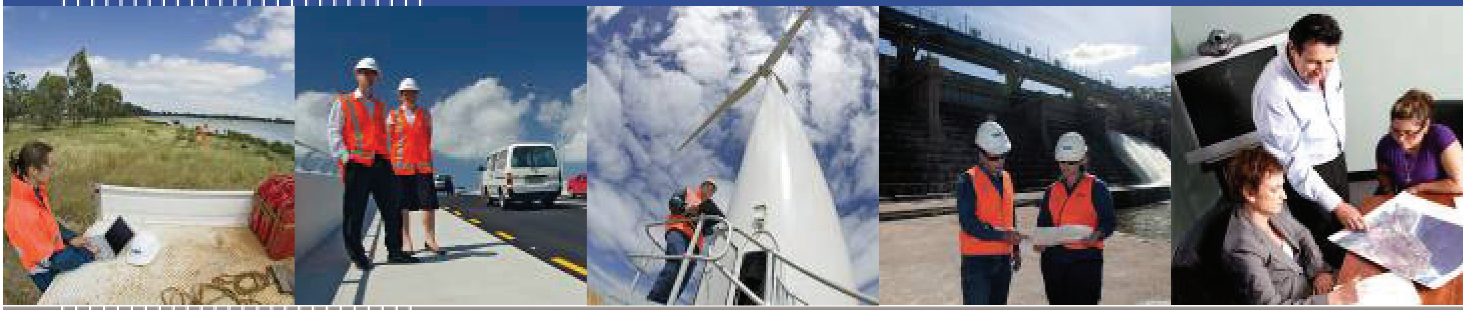
Air Quality

Appendix E



Air Quality Impact Assessment

5 MW Biomass Power Plant

5 NOVEMBER 2009

Prepared for

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Table of Contents

Tables

Figures

Appendices

Abbreviations

Abbreviation	Description
CO	Carbon monoxide
DEC	Department of Environment and Conservation
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
ESP	Electrostatic Precipitator
GWh	GigaWatt hour
HAP	Hazardous Air Pollutant
OU	Odour Unit
NEPM	National Environmental Pollution Measure
NO_2	Nitrogen dioxide
PAHs	Poly Aromatic Hydrocarbons
PM_{10}	Particulate matter 10 microns or less in aerodynamic diameter
SEFE	South East Fibre Exports
SO_2	Sulphur dioxide
TEQ	Toxic Equivalents
TAPM	The Air Pollution Model
VOCs	Volatile Organic Compounds

Executive Summary

An air quality assessment was undertaken for the proposed development of a 5MW Biomass Power Plant to be fuelled by wood waste. The air quality assessment focused on the combustion gases arising from the boiler and comprised two primary components, namely a comparison to regulatory limits of in-stack concentrations and ground level concentrations of air emissions derived from the proposed Power Plant.

The stack emissions were compared against regulatory limits and found to be below the regulatory limits specified in the *Protection of the Environment Operations (Clean Air) Amendment (Industrial and Commercial Activities and Plant) Regulation 2005*.

The ground level concentrations were assessed using the Calpuff dispersion model, incorporating meteorological data generated using TAPM and Calmet. The modelled species included oxides of nitrogen (NO_x), particulate matter (PM_{10}), carbon monoxide (CO), sulphur dioxide (SO_2), lead and Hazardous Air Pollutants (HAPs). The assessment has used a conservative approach applied in accordance with the *Approved Methods* (DEC, 2005). Where appropriate, the assessment of the cumulative impacts against regulatory criteria used the aggregate of the worst case predicted plant impacts and peak background concentrations derived from DECC and other relevant monitoring stations. The dispersion modelling assessment has concluded that the predicted impacts of ground level concentrations of NO_2, PM_{10}, CO, SO_2 and lead when added to background concentrations, are within the regulatory criteria. As per the *Approved Methods*, HAPs were assessed for incremental impact and were below regulatory criteria.

A screening Plume Rise Assessment was also undertaken. When modelled for all hours of the year (2007), plume velocities were predicted to depreciate below 4.3 m/s by 46 metres above ground level (mAGL), thus being below 110 mAGL required by Civil Aviation Safety Authority (CASA) for further consideration.

Introduction

1.1 General

South East Fibre Exports (SEFE) propose to build a 5 MW Wood Waste to Energy (Biomass) facility (Power Plant) at their existing woodchip mill and export facility located in Munganno Point, near Eden NSW, approximately 400 km south of Sydney. The Munganno Point mill site is located on the southern shoreline of Twofold Bay and has been in operation for approximately 40 years. The existing facility includes log receival and storage, debarking, chipping and an associated process plant and wharf / ship-loading facility for the export of woodchips.

SEFE generates approximately 35,100 tonnes of wood waste each year, which at present is being transported off site as mulch or disposed (incinerated) in the existing burner. SEFE propose to use the wood waste as fuel for the proposed Biomass Power Plant. A further 22,600 tonnes of wood waste would also be available from local timber processing operations.

The Biomass Power Plant would have a capacity of around 5 MW and would burn around 57,700 tonnes of wood waste to produce around 31 GWh of electricity per annum. Electricity generated will be used at the mill site with excess provided to the grid.

1.2 Scope of Assessment

As with all major developments in NSW, the air emissions were assessed against *The Protection of the Environment Operations (Clean Air) Amendment (Industrial and Commercial Activities and Plant) Regulation 2005* and the local air quality impact assessment was undertaken in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005). The scope of the assessment includes the following:

- Analysis and summary of existing local climate and meteorological characteristics;
- Analysis and summary of existing air quality in the region, with a focus on existing pollutant concentrations for use in assessing cumulative impacts associated with the proposal;
- Meteorological modelling using TAPM and CALMET, for dispersion modelling predictions;
- Preparing an emissions inventory detailing stack parameter and key pollutant emission rates;
- Dispersion modelling using CALPUFF to predict ground level concentrations (GLC) associated with the operational phase of the proposed development; and
- Comparison of predicted GLCs and in stack concentrations against regulatory criteria and guidelines.

A quantitative assessment of emissions such as dust during construction has not been included in this assessment however, mitigation measures to minimise adverse air quality impacts during the construction process have been included. The assessment of air quality during construction is to be addressed in the Construction Environmental Management Plan.

For the operational phase of the project, a quantitative review of air quality impacts was undertaken using dispersion modelling. The modelling investigated a range of air pollutants likely to be emitted from the plant including oxides of nitrogen (NO_x), particulate matter (PM_{10}), carbon monoxide (CO), sulphur dioxide (SO_2), lead and Hazardous Air Pollutants (HAPs). This assessment includes the methods used to undertake the air quality assessment of the plant and a discussion of the local air quality impact of the proposed development.

Project Overview

2.1 Project Description

2.1.1 Construction

The proposed Power Plant will be located within SEFE's existing mill site, at the current location of the wood waste burner. Construction of the plant is expected to take 15 months.

2.1.2 Operation

The Power Plant would involve a number of key components including:

- An existing uncovered area for the storage of biomass fuel (wood waste);
- Weatherproof fuel storage bunker with 1000 m^3 capacity;
- Fuel reclaim bunker and feed conveyor to supply around 6 tonnes/hr of wood waste (fuel) to the Power Plant.
- 90 tonne fuel storage bin;
- Steam boiler to provide 485^0C, high pressure (65 bar) superheated steam at a rate of 22 tonnes per hour;
- Ash handling systems;
- 5 MW multi-stage steam turbine for power generation; and
- A flue gas exhaust stack (35 m high) with an electrostatic precipitator (ESP) to remove fly ash from the flue gas stream.

Unmixed wood waste fuel would be stored in piles in the existing wood-waste storage area according to fuel source. Sufficient dry mixed fuel to fire the furnace for three days would be stored in a covered 1000 m^3 capacity bunker to provide a source of dry fuel during wet weather events. Fuel would be mixed to a consistent size and moisture content using a front end loader as it is loaded onto a drag chain conveyor for transfer to the 90 tonne capacity fuel bin. The fuel bin is able to discharge, through a bottom discharge system, 6 tonnes per hour of fuel, and is capable of storing up to 15 hours of fuel for the furnace.

The fuel would be funnelled into the power plant (a watertube steam generator) whereby it will be combusted. The heated air from the combustion process will be directed to the tubes containing water and steam whereby superheated steam will be generated. The superheated steam (485^0C and 65 bar) will then enter the turbine where it expands in volume, thus driving the turbine and producing electricity.

Combusted air (flue gas) from the system would be directed to an ESP to remove particulate matter prior to the discharge to atmosphere. The following description of the ESP process at removing particulate matter has been adapted from Vyncke (2009 p.21):

> *"Dust-laden flue gas will enter the ESP casing horizontally and is evenly distributed over several "ducts" which are formed by the walls of the grounded collecting electrodes. In the centre of each duct there are several spray electrodes that are distributed over the whole length. High negative voltages are applied to the spray electrodes, which ionize the gases in their vicinity, by a corona discharge. During their passage through the duct the dust particles are negatively charged by the impact of the gas ions and then deflected towards the positively charged collecting electrodes, where they are deposited temporarily. The dust layer collected on the collecting electrode is continuously removed by a beater mechanism. It falls into a dust collecting trough and is carried off by a conveying mechanism."*

2 Project Overview

Discharge of the flue gas to atmosphere would be from a 35 m high exhaust stack, with a diameter of approximately 1.6 m. A discharge velocity of 18 m/s at a flow rate of 37,000 Nm^3/hour would be typical operating parameters.

Fuel Analysis

The type of fuel being combusted can have a significant influence on the composition of the gaseous emissions generated. The facility will consume approximately 57,700 tonnes of wood waste per annum. Fuel would be drawn primarily from SEFE's current operations with around 22,600 tonnes being obtained from local and regional saw mills. **Table 2-1** provides a description of the available wood waste fuel types. SEFE propose to use only wood waste generated on their own site supplemented with wood waste generated by sawmilling processes. No fuel would be sought from municipal landfill or other sources in which wood waste would potentially contain low levels of contamination. The proposed fuel is therefore considered as a *Standard Fuel* (as defined in *The Protection of the Environment Operations (Clean Air) Amendment (Industrial and Commercial Activities and Plant) Regulation 2005*) for assessing air quality impacts.

Table 2-1 Wood Waste Fuel Types

Fuel Type	Tonnes per annum	Description
Hardwood fines	21,250	This fuel is waste from on-site chipping / screening of hardwood logs which is currently sold to various customers in bulk and generally used for landscaping purposes i.e. gardening mulch.
Pine bark	9,525	This fuel is waste from on-site contract chipping / screening of plantation softwood logs which is currently sold to a single customer and used for landscaping purposes.
Pine fines	3,300	This waste is generated on-site during the chipping / screening of plantation softwood logs and is currently sold to customers for such purposes as lining hens' cages on poultry farms.
SEFE mill waste (hardwood)	1,060	This fuel is waste from on-site chipping of hardwood logs and is currently disposed of on site in the tepee burner for no energy recovery.
Hardwood sawmill waste	17,600	This is hardwood sawmilling and screening waste which will be imported from local and regional sawmills with which SEFE already has commercial relationships.
Softwood sawmill waste	5,000	This is waste which will be purchased from plantation softwood sawmills.

2.2 Emissions Inventory

2.2.1 Sources Assessed

The primary source included in this assessment was the emission from the main (flue gas) stack. The emissions would comprise combustion air that has particulate matter removed through soot removers and an ESP.

2.2.2 Sources Excluded

Ash and soot are generated from several sections in the power plant, namely from the watercooled stepgrate, economisers and superheaters, which are equipped with soot blowers. The ash and soot generated from these sources will be directed to a bottom ash transport system and conveyed to the Ash Silo. It is understood the sources will be covered and minimal particulate matter (the primary air emission for this source) will be generated. Consequently, these sources were excluded.

Particulate matter from the processing of wood was also investigated. Particulate matter would be generated from log crosscutting, debarking, sawing and chipping (Department of the Environment Water Heritage and the Arts 2002), however these emissions are considered to be localised and not a significant contributor to particulate matter emissions from the proposed operation. Consequently, these sources were excluded.

Other sources onsite where emissions were considered to be negligible, and therefore excluded, include:

- Ships (used to freight wood chips);
- All vehicles used on site;
- Clarifiers; and
- Fugitive emissions from buildings and general processes on site.

URS is not aware of any other sources on site or in the local area that require incorporation into modelling to assess the potential air quality impacts of the proposed development.

2.3 Compounds Assessed

Based on the proposed process to be undertaken, the source emissions estimates were obtained from:

- Vyncke (Watertube steam generator supplier) guarantees (Vyncke 1999);
- AP 42 Emission Factors for Wood Residue Combustion in Boilers (US EPA 2003);
- *National Pollutant Inventory Emission Estimation Technique Manual for Timber and Wood Product Manufacturing* (Department of the Environment, Water, Heritage and the Arts 2002); and
- *National Pollutant Inventory Emission Estimation Technique Manual for Combustion in Boilers* (Department of the Environment, Water, Heritage and the Arts 2008).

Subsequently, an emission inventory was prepared and is presented in **Appendix A**. The main stack emission source would be the only source with the potential to significantly affect local air quality. A brief description of the air pollutants found to be of significance, and considered in this assessment, is presented in the following paragraphs.

2.3.1 Criteria Pollutants

Oxides of Nitrogen

Oxides of nitrogen (NO_X) are the sum of nitric oxide (NO) and nitrogen dioxide (NO_2). NO and NO_2 are linked in a circular reaction with oxidants such as ozone which generates NO_2 from NO and sunlight which breaks down NO_2 to NO. Due to this reaction sequence, the exact amount of NO and NO_2 within emissions is often difficult to quantify, consequently the sum of emission of both species is quoted. For the purposes of this assessment, it has been conservatively assumed that all NO_X emissions are emitted as NO_2.

In combustion sources, the high temperatures allow the dissociation of atmospheric nitrogen (N_2), after which the nitrogen may combine with excess oxygen found in the combustion air. In biomass boilers, NO_X emissions from wet bark and wood boilers are typically lower (approximately one-half) in comparison to NO_X emissions from dry wood-fire boilers (US EPA 2003).

Ozone

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 NMHCs 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 Eden and similar rural locations is therefore considered to be low. Photochemical smog is unlikely to occur due to operations of the proposed development, consequently ozone has not been assessed.

Particulate Matter

The major emission of concern from wood boilers is particulate matter (PM). These emissions depend primarily on the composition of the residue fuel burned, and the particle control device (US EPA 2003). It is anticipated that the majority of the particles generated from the wood fired boiler will be controlled using an ESP and comprise particulate matter less than 10 microns in diameter (PM_{10}). ESPs remove larger sized particles and collection efficiencies of 90 to 99 percent for PM have been observed for ESPs operating on wood-fired boilers (US EPA 2003).

As the emissions of PM from the main stack would comprise principally PM_{10}, other larger forms of PM, namely Total Suspended Particulates and Deposited Dust have been excluded from the assessment.

Carbon Monoxide

Carbon monoxide (CO) would be produced as a result of the combustion process and emitted within the exhaust flue gas stream. Nearly all of the fuel carbon (99 percent) in wood residue is converted to

CO_2 during the combustion process. The majority of the fuel carbon not converted to CO_2, due to incomplete combustion, is entrained in the bottom ash (US EPA 2003). Consequently, CO is not considered to be a significant pollutant, although it has been included for thoroughness.

Sulphur Dioxide

Sulphur dioxide (SO_2) when released into the atmosphere can combine with water to generate acid rain. SO_2 is generated through the combustion of sulphur containing fuels such as coal, petrol and diesel. The potential emission of SO_2 is proportional to the amount of sulphur or sulphur compounds within the combustion fuel. Given the relatively low percentage content of sulphur within the proposed biomass fuel, sulphur dioxide emissions are not expected in large quantities, however it has been included for thoroughness.

Hydrogen Fluoride

Whilst several Hazardous Air Pollutants (HAPs) are known to be generated by the combustion of wood, hydrogen fluoride (HF) is not considered a significant pollutant and is associated more with coal combustion than with wood combustion. Investigation of Vyncke (2009), US EPA (2003), and Department of the Environment, Water, Heritage and the Arts (2008) and a literature search did not highlight HF as being in measureable concentrations in the flue gas. Additionally, compounds containing fluorine were not identified in the biomass analysis (HRL 2009). This suggests the sources of fluorine and the process are not likely to generate appreciable concentrations of HF, consequently, HF has not been further assessed.

Lead

A range of metals are known to be present in wood waste combustion products, including lead and associated compounds (Department of the Environment, Water, Heritage and the Arts, 2008). Lead has been considered along with other metallic HAPs in this assessment.

Odour

Odour emissions were not found as part of a literature search to pose adverse air quality issues with the type of plant being proposed, consequently it is not discussed further.

2.3.2 Hazardous Air Pollutants

Hazardous Air Pollutants (HAPs) such as dioxins and furans can be formed in combustion environments under certain conditions. The formation of such compounds often is heavily dependent on combustion temperature and residence time. SEFE proposes to only use waste wood from saw mill and wood chipping operations, with no fuel being sourced from municipal landfills or other potentially contaminated sources. This would limit the formation and emission of hazardous pollutants. For the purposes of this assessment, HAPs have been further defined into:

- Dioxins and Furans;
- Poly Aromatic Hydrocarbons (PAHs),
- Volatile Organic Compounds (VOCs), specifically formaldehyde; and
- Metals, specifically cadmium.

The background for assessment of these compounds is further discussed in **Appendix A**.

Regulatory Framework

3.1 Overview

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 plant 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.

3.1.1 Emissions Standards

The *NSW Protection of the Environment Operations (Clean Air) Amendment (Industrial and Commercial Activities and Plant) Regulation 2005* (Clean Air Regulation) sets emission limits (as in-stack concentrations) for air impurities from stationary plant and equipment. The current standards, taken from Schedule 3 (Electricity Generation) of the Clean Air Regulation, relevant to the proposed Power Plant are presented in **Table 3-1**.

Table 3-1 Emission Standards for Electricity Generation (from Schedule 3, Protection of the Environment Operation (Clean Air) Amendment (Industrial and Commercial Activities and Plant) Regulation 2005

Pollutant	Applicability	Reference Conditions	Limit (Group 6 sources)
Solid Particulates (Total)	Any activity or plant using a liquid or solid standard fuel or a non-standard fuel	Dry, 273 K, 101.3 kPa, 7 % O_2	50 mg/m^3
NO_2 or NO or both as NO_2 equivalent [A]	Any boiler operating on a fuel other than gas, including a boiler used in connection with an electricity generator that forms part of an electricity generating system with a capacity of less than 30 MW	Dry, 273 K, 101.3 kPa, 7 % O_2	500 mg/m^3 as NO_2
Fluorine (F_2) and any compounds containing fluorine, as total fluoride (HF) equivalent.	Any activity or plant using a liquid or solid standard fuel or a non-standard fuel	Dry, 273 K, 101.3 kPa, 7 % O_2	50 mg/m^3
Smoke	Any activity or plant using a liquid or solid standard fuel or a non-standard fuel	Gas stream temperature above dew point. Path length corrected to stack exit diameter as per CEM-1	Ringelmann 1 or 20% opacity

Notes:

[A]: Concentration Standard referenced from Schedule 4 (Standards of concentration for scheduled premises: general activities and plant) as capacity of Biomass Power Plant (5 MW) is less than 30 MW described within Schedule 3. All other Concentration Standards referenced from Schedule 3.

-Reference conditions taken from Schedule 5 Part 3 of the Clean Air Regulation (2005).

-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.

-Standard Fuel, as defined by the regulation, means any unused and uncontaminated soil, liquid or gaseous fuel that is:

(a) a coal or coal-derived fuel (other than any tar or tar residues), or

(b) a liquid or gaseous petroleum-derived fuel, or

(c) a wood or wood-derived fuel, or

(d) bagasse

3.1.2 DECC Air Quality Impact Assessment Criteria

The air quality impact assessment criteria are provided in *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (DEC 2005). 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 plant are shown in **Table 3-2.**

3 Regulatory Framework

Table 3-2 DECC Impact Assessment Criteria for Modelled Pollutants (DEC 2005)

Pollutant	Averaging Period	Frequency	Cumulative / Incremental impact A	Concentration	
Criteria Pollutants				(ppm)	(µg/m^3)
NO_2	1 hour	100%	cumulative	0.12	246
	Annual	100%	cumulative	0.03	62
PM_{10}	24 hour	100%	cumulative	-	50
	Annual	100%	cumulative	-	30
SO_2	10 minutes	100%	cumulative	0.25	712
	1 hour	100%	cumulative	0.20	570
	24 hours	100%	cumulative	0.08	228
	Annual	100%	cumulative	0.02	60
CO	15 minutes	100%	cumulative	87	100,000
	1 hour	100%	cumulative	25	30,000
	8 hours	100%	cumulative	9	10,000
Lead	Annual	100%	cumulative	-	0.5
Hazardous Air Pollutants				(ppm)	(mg/m^3)
Formaldehyde	1 hour	99.9 %	incremental	0.02	0.018
Cadmium	1 hour	99.9 %	Incremental	N/A	0.000018
Dioxins and Furans B	1 hour	99.9%	incremental	-	2.0×10^{-9}
PAH (as benzo[a]pyrene) C	1 hour	99.9%	incremental	-	0.0004

Notes:

- = not applicable

Gas volumes expressed at 25^{0}C and 101.3 kPa (DEC 2005);

A: Cumulative impact refers to the addition of an ambient air background concentration when assessing plant impact, whilst incremental refers only to predicted concentration derived from the plant.

B: Dioxins and furans reported as toxic equivalent using toxic equivalence factors listed in clause 29 of the Clean Air Regulation.

C: Polycyclic Aromatic Hydrocarbons (PAH) as benzo[a]pyrene (BaP) reported using potency equivalency factors, as defined in DEC (2005).

3.1.3 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) (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} and an advisory standard for $PM_{2.5}$ is also included. 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, the 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 concentrations are identical to the DEC (2005) criteria, as shown in **Table 3-2.**

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 (NEPC, 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*." (NEPC, 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.

Existing Environment

4.1 Climate

Two Bureau of Meteorology weather stations are located in proximity to Eden, namely Green Cape Lighthouse and Merimbula Airport. For the purposes of this assessment, Green Cape Lighthouse (Station 069055) was chosen to represent the climate at the proposed development location. Monthly climatic data for Green Cape Lighthouse is presented in **Table 4-1**.

The area experiences warm summers and mild winters as expected on coastal regions, where the water has a moderating influence on temperature. As shown in **Table 4-1**, the mean daily maximum temperature is approximately 21^{0}C during summer and 15^{0}C during winter. Sub-zero temperatures have not been recorded, with the lowest temperature reading being 2^{0}C. The area receives moderate rainfall having a mean annual rainfall of 747 mm over an average of 109.5 rain days per year.

4.2 Meteorology

The meteorology for the site was prepared using the meteorological model TAPM (v4). Output files and parameters from TAPM were used as input into CALMET. An assessment of the meteorological data generated is provided in **Appendix B**. It is considered that the meteorological data prepared is suitable for incorporation into dispersion modelling.

4.3 Ambient Air Quality

Background concentrations of air pollutants in this area may be derived from a range of sources. Short-term elevated concentrations of PM_{10}, NO_x, CO and other products of combustion may occur in the event of bush-fires or fuel reduction burns. DEC (2005) requires the use of the maximum measured ambient concentration, measured over at least a 12 month period, to be used as the background concentration within the modelling assessment. The 12 month period allows for seasonal variation in background concentrations as well as a range of atmospheric conditions to be assessed, however, the method is considered to be conservative.

As the meteorology used in the dispersion modelling was for 2007, URS also attempted to obtain background concentrations for 2007 from Department of Environment, Climate Change and Water (DECCW) or other relevant background monitoring stations. It should be noted that no monitoring stations (DECCW), or other monitoring data, is currently available for the local region. In order to quantify cumulative air quality impacts, URS adopted background concentrations in 2007 from the DECC monitoring station located at Wollongong (DECC 2008). These data are likely to present more elevated concentrations than would be apparent within Eden, given the lack of emission sources in the area. The Eden local area consists of a more rural environment, with fewer combustion and industrial sources while Wollongong is highly urbanised with a multitude of combustion and industrial sources all of which would contribute to increase pollutant concentrations in the local air shed.

4 Existing Environment

Table 4-1 Monthly Climate Data for Green Cape Lighthouse (Bureau of Meteorology, 2009)

Statistic Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Start Year	End Year
Mean maximum temperature (^{O}C)	21.6	22.1	21.3	19.7	17.3	15.1	14.4	14.8	15.9	17.3	18.6	20.1	18.2	1966	1992
Highest temperature (^{O}C)	37.2	33.5	28.2	28.3	24.8	20.3	22.1	21.7	32.6	33.9	34.4	30.1	37.2	1966	1992
Lowest maximum temperature (^{O}C)	16	16.5	14.3	13.2	11.7	10.4	7.5	9.6	10.3	11.8	12.4	14.4	7.5	1966	1992
Mean minimum temperature (^{O}C)	16.2	16.7	16	14	11.8	9.7	8.4	8.7	9.6	11.5	13	14.7	12.5	1966	1992
Lowest temperature (^{O}C)	9	6	9.4	7.6	2.1	2.6	2	2.6	3.3	3.8	5.3	5.6	2	1966	1992
Highest minimum temperature (^{O}C)	21	21.1	21.2	20.5	18.2	16.2	14.5	13.6	16.8	17.5	18	20.1	21.2	1966	1992
Mean rainfall (mm)	77.2	57	71.5	61.8	68.1	69.1	57	44.1	55.1	59.6	67.2	59.1	747.2	1904	2007
Highest rainfall (mm)	456.5	248.8	275.8	383.4	246.3	329.4	178.6	144.7	125.6	184.2	211.8	177.4	1222	1904	2007
Lowest rainfall (mm)	0	0.3	5.4	2.3	3.6	4.3	1	2.8	3.8	5.8	0	3.3	335.4	1904	2007
Highest daily rainfall (mm)	370.1	197	111	101.1	110	121.4	84	96.5	79	108	129	110.8	370.1	1904	2007
Mean number of days of rain	8	7.4	9.6	8.1	9.3	9.8	9	9.1	9.6	10.3	10.1	9.2	109.5	1904	2007
Mean number of clear days	6.2	6	5.4	6.2	5	5.1	7.1	6.2	6.2	5.2	4.5	4.8	67.9	1966	1992
Mean number of cloudy days	12.8	11.6	13.2	11.2	14.3	12.7	10	10.7	11.2	12.4	13.5	13.8	147.4	1966	1992
Mean 9am temperature (^{O}C)	18.6	19.1	18.4	16.5	13.9	11.7	10.5	11.2	12.8	14.6	15.8	17.4	15	1966	1992
Mean 9am wet bulb temperature (^{O}C)	17	17.5	16.9	14.8	12.4	10.3	9	9.6	11.1	12.7	14.2	15.7	13.4	1966	1992
Mean 9am dew point temperature (^{O}C)	15.6	16.4	15.7	13.3	11	8.8	7.2	7.8	9.2	10.9	12.9	14.4	11.9	1967	1992
Mean 9am relative humidity (%)	84	85	84	82	83	83	81	80	80	80	84	83	82	1967	1992
Mean 9am cloud cover (oktas)	4.9	5	5	4.5	4.9	4.8	4.2	4.3	4.5	4.8	5	5.3	4.8	1966	1992
Mean 3pm temperature (^{O}C)	20.1	20.8	20	18.3	16.1	14.1	13.3	13.5	14.2	15.5	17	18.5	16.8	1966	1992
Mean 3pm wet bulb temperature (^{O}C)	17.9	18.6	17.9	15.9	14.1	12	10.9	11.4	12.1	13.6	15.2	16.6	14.7	1966	1992
Mean 3pm dew point temperature (^{O}C)	16.4	17.3	16.5	14.1	12	10	8.5	9.1	10	11.6	13.7	15.2	12.9	1967	1992
Mean 3pm relative humidity (%)	80	81	81	78	78	77	74	76	77	79	82	82	79	1967	1992
Mean 3pm cloud cover (oktas)	4.8	4.8	4.9	4.8	5.1	5	4.5	4.8	4.8	5	5	5	4.9	1966	1992

4 Existing Environment

Table 4-1 Summary of Background Data Used in Air Quality Modelling

Species	Averaging Time	Monitoring Station	Maximum Background Concentration (µg/m³)C	Air Quality Criteria (µg/m³)
NO_2	1 hour	Wollongong	81	246
	Annual	Wollongong	17	62
PM_{10}	24 hour	Wollongong	47.6A	50
	Annual	Wollongong	19.5	30
SO_2	10 minutes	Wollongong	B	712
	1 hour	Wollongong	84	570
	24 hour	Wollongong	21	228
	Annual	Wollongong	3	60
CO	15 minute	Wollongong	B	100,000
	1 hour	Wollongong	3	30,000
	8 hour	Wollongong	2	10,000
Lead D	Annual	Wallsend	0.09	0.5

Notes:

A: PM_{10} 24 hour average reported as 99th percentile. The maximum for the reported year (58.8 ug/m³) is above air quality guidelines due to bushfires (DECC 2008) and thus the 99th percentile has been adopted.

B: Concentrations with an averaging time of less than 1 hour have been determined from 1 hour concentrations using the equation outlined in 4.3.1 below.

C: Values taken from DECC (2008).

D: Lead concentration conservatively assumed to be 0.09 µg/m³, being the highest measured value in NSW over the past several years. The value of 0.09 µg/m³, was measured in Wallsend in 2003 (DECC 2008).

4.3.1 Estimation of Pollutant Concentrations for Averaging Periods Less Than One Hour

Where pollutant concentrations were required to be assessed for averaging time less than one hour, namely for SO_2 and CO, **Equation 1** was used (Victoria EPA, 2005).

$$C_t = C_{60}\left[\frac{60}{t}\right]^{0.2} \qquad \text{[Equation 1]}$$

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).

URS

Assessment Method

5.1 Approach to Modelling

The site is situated in a coastal region, where coastal wind regimes are likely to heavily influence local dispersion parameters and local air quality. For this reason, CALPUFF has been chosen as the appropriate model for use in conducting predictive plume dispersion. Other parameters and model inputs are discussed in the remainder of this section.

5.2 Meteorology

The CALPUFF modelling incorporated modelling the meteorology using CALMET, to produce a three dimension wind field of the modelling domain. Given the lack of real meteorological data in the area, TAPM (v4) was used to produce surface and upper air files for input into CALMET. The meteorological data used in the assessment is discussed in **Appendix B**.

5.3 Emission sources

A single point source was included in the modelling (boiler flue gas stack), and stack parameters and emission rates are further outlined below and detailed in **Appendix A**.

5.3.1 Normal Plant Operation

The manufacturers' design specifications were obtained for the key pollutants of concern from the main stack, which are Nitrogen Oxides (NO_x, assumed to be present as NO_2), particulate matter (assumed to be PM_{10}) and Carbon Monoxide (CO). Emission rates for other pollutants assessed (sulphur dioxide, lead and HAP) have been estimated using emission factors derived from other sources. It should be noted that emission factors were developed from a number of different wood waste boilers, likely to have used a multitude of wood waste including municipal landfill waste that could potentially be contaminated. Given that the proposed Power Plant would only use uncontaminated wood waste, these emission factors are deemed conservative.

Unlike the other compounds assessment, numerous different types of dioxins, furans and PAH occur in a variety of forms. The toxic equivalents (TEQs), otherwise known as Toxic Equivalent Factors (TEFs) were developed to "weight" the various forms of dioxins to allow the toxicity of a complex mixture to be expressed as a single number. This is further discussed in **Appendix A**.

A summary of the stack emissions is provided in **Table 5-1.**

Table 5-1 Summary of Main Stack Parameters and Emissions

Stack Parameter	Units	Value
Stack Height (above ground level)	m	35
Stack Diameter	m	1.6
Exit Temperature	°C	180
Oxygen	Vol %	5.15
Exit Velocity	m/s	11.2
Mass Flow Rate	Nm^3/hr (wet)	49,000
Mass Flow Rate	Nm^3/hr (dry)	35,770
Stack Emissions	**Units**	
Criteria Pollutants		
NO_x (as NO_2)	g/s	5.62
CO	g/s	1.97
SO_2	g/s	1.38
PM_{10}	g/s	0.56
Lead	g/s	2.26×10^{-3}
Hazardous Air Pollutants		
Formaldehyde	g/s	0.57
Cadmium	g/s	7.02×10^{-5}
Dioxins and Furans		
Total Dioxins and Furans	g/s	4.95×10^{-9}
PAH		
Total PAH as Benzo[a]pyrene	g/s	2.82×10^{-7}

Notes:

The TEQ used to estimate dioxin, furan and PAH concentrations and emission are detailed in **Appendix A**.

All NO_X has conservatively been assumed to be present as NO_2.

5.3.2 Plant Start Up and ESP Maintenance Emissions

Emissions from power plant facilities are prone to varying pollutant emissions during plant start-up and maintenance scenarios. During plant start-up, emissions may be at levels lower or higher than emissions predicted during steady state operation. Emissions may also be outside normal operating scenarios when maintenance is being carried out on air pollution control devices (i.e. ESP). Emissions during such scenarios have been investigated.

SEFE has indicated that operation of the facility would not occur during maintenance on the ESP. As a result, no assessment of elevated emissions from a scenario where the ESP is offline has been included.

Maintenance of the facility would entail a 'hot shutdown' (i.e. where the combustion chamber remains at temperature) every three months and a 'cold shutdown' every six months. SEFE has indicated that emission limits as dictated by the Clean Air Regulation would not be exceeded during 'hot shutdown' periods. SEFE has also indicated that emissions during start-up after a 'cold shutdown' should not be exceeded provided the start-up is done gradually and well controlled. Control of emissions during 'start-up' are to be controlled through an Air Quality Management Plan for the facility. Therefore, no further assessment of emissions during 'start-up' or shut-down periods are considered warranted.

5.4 Receptors

A 10 km by 10 km gridded receptor domain, with a 500 m grid spacing was modelled. A large domain range was used in order to predict any impacts within the Eden urban area, across the bay from the site. Four discrete receptors were also represented in the modelling inputs. The sensitive receptors were as follows:

- Receptor 1 - Edrom Lodge (760398 mE, 5889072 mN, MGA)
- Receptor 2 - Boydtown (756273 mE, 5889474 mB, MGA)
- Receptor 3 - Eden (South) (758982 mE, 5892994 mN, MGA)
- Receptor 4 - Eden (Town Centre) (758156 mE, 5894126 mN,MGA)

The locations of the sensitive receptors are shown in each of the contour plots presented in the **Figures** Section.

5.5 Building Wake Effects

Building wake effects were incorporated into CALPUFF using the Building Profile Input Program (BPIP). The most significant building that would influence building wakes is considered to be the boiler housing which encompasses the wood waste boiler. The flue gas stack was positioned at the centre of the boiler housing, with a height of 21 m, a width of 16 m and a length of 30 m. The flue gas exhaust stack would be 35 m.

5.6 Scenarios Assessed

A single dispersion modelling scenario has been completed for normal plant operation with discharge parameters and emission rates outlined above. The modelling scenario considered constant emissions over a single year (2007).

5.7 Plume Rise Assessment

To ensure the buoyant plumes from the main stack do not present a hazard to aircraft, a screening level plume rise assessment is contained in **Appendix C**.

Dispersion Modelling Results

6.1 Air Quality

Results predicted from the single dispersion modelling scenario have been summated in **Table 6-1**. Incremental concentrations predicted at each discrete receptor have been tabulated, in conjunction with the maximum predicted concentration over the entire modelling domain. The results show that none of the modelled pollutants are present at concentrations that exceed the DEC (2005) guidelines.

The contour plots for the criteria pollutants (NO_2, CO, SO_2, PM_{10} and lead) are presented in the **Figures** Section. The contour plots show that the peak ground level concentrations are generally restricted to regions within 1km of the plant.

6.2 Plume Rise Assessment

The screening Plume Rise Assessment is detailed in **Appendix C**. The screening assessment was based on the method provided in CASA (2004) *Advisory Circular AC 139-05(0) Guidelines for Conducting Plume Rise Assessments*.

When modelled for all hours of the year (2007), plume velocities were predicted to depreciate below 4.3 m/s by 46 mAGL, and below 110 mAGL required by CASA for further consideration.

6 Dispersion Modelling Results

Table 6-1 Summary of dispersion modelling results with comparison against regulatory criteria (All results are in µg/m³)

Pollutant	Averaging Time	Frequency	Maximum Concentration (ug/m^3)	Concentration at Receptors (ug/m^3)				Background (ug/m^3)	Cumulative (ug/m^3)	Criteria (ug/m^3)	Conformance to Criteria
				Receptor 1: Edrom Lodge	Receptor 2: Boydtown	Receptor 3: Eden South	Receptor 4: Eden Town				
NO_x (as NO_2)	1 hour	100%	87.6	29.9	17.9	27.4	42.2	81	168.6	246	Yes
	Annual	100%	0.8	0.4	0.1	0.1	0.1	17	17.8	62	Yes
SO_x (as SO_2)	10 minutes	100%	30.8	10.5	6.3	9.6	14.8	120	151.0	712	Yes
	1 hour	100%	21.5	7.3	4.4	6.7	10.4	84	105.5	570	Yes
	24 hours	100%	2.5	1.3	0.6	0.6	0.8	21	23.5	228	Yes
	Annual	100%	0.2	0.1	0.0	0.0	0.0	3	3.2	60	Yes
Solid Particles (as PM_{10})	24 hours	100%	1.0	0.5	0.2	0.3	0.3	47.6	48.6	50	Yes
	Annual	100%	0.1	0.0	0.0	0.0	0.0	19.5	19.6	30	Yes
CO	15 minutes	100%	40.5	13.8	8.3	12.7	19.5	3,959	3,999	100,000	Yes
	1 hour	100%	30.7	10.5	6.3	9.6	14.8	3,000	3,031	30,000	Yes
	8 hours	100%	7.3	3.5	1.8	2.3	3.5	2,000	2,007	10,000	Yes
Lead	Annual	100%	3.79E-04	1.80E-04	1.80E-04	1.80E-04	1.80E-04	0.09	0.09	0.5	Yes
Dioxins and Furans	1 hour	99.9%	3.97E-11	1.7E-11	7.7E-12	1.1E-11	1.1E-11	-	-	2.00E-09	Yes
PAHs	1 hour	99.9%	2.30E-09	9.7E-10	4.4E-10	6.1E-10	6.2E-10	-	-	4.00E-04	Yes
Formaldehyde	1 hour	99.9%	4.57E-03	1.9E-03	8.8E-04	1.2E-03	1.2E-03	-	-	2.00E-02	Yes
Cadmium	1 hour	99.9%	5.63E-07	2.4E-07	1.1E-07	1.5E-07	1.5E-07	-	-	1.80E-05	Yes

Notes:

The TEQ or PEF used to estimate dioxin, furan and PAH concentrations and emission are detailed in **Appendix A**.

All NO_X has conservatively been assumed to be present as NO_2.

Discussion

7.1 Comparison to Emissions Standards

As presented in **Table 7-1** The ESP emissions proposed for the facility comply with the relevant emission limits specified in the Clean Air Regulation.

Table 7-1 Proposed in-stack concentration compared to regulatory criteria

Pollutant	Reference Conditions	Limit (Group 6 sources)	Proposed Concentration	Conformance to regulatory criteria
Solid Particulates (Total)	Dry, 273 K, 101.3 kPa, 7 % O_2	50 mg/m^3	50 mg/m^3	Yes
NO_2 or NO or both as NO_2 equivalent [A]	Dry, 273 K, 101.3 kPa, 7 % O_2	500 mg/m^3 as NO_2	500 mg/m^3	Yes
Fluorine (F_2) and any compounds containing fluorine, as total fluoride (HF) equivalent.	Dry, 273 K, 101.3 kPa, 7 % O_2	50 mg/m^3	< 50 mg/m^3	Yes
Smoke	Gas stream temperature above dew point. Path length corrected to stack exit diameter as per CEM-1	Ringelmann 1 or 20% opacity	< 20% opacity [A]	Yes

Notes

[A]: Opacity of the emissions has not been provided, however, emissions from the Electrostatic Precipitator are expected to meet regulatory criteria.

7.2 Comparison to DECC Air Impact Assessment Criteria

The predicted impact of NO_X (as NO_2), CO, SO_2, PM_{10}, lead and HAP emissions from the Facility were shown to be below regulatory criteria, hence on the basis of these predictions, no adverse impacts on local air quality are expected as a result of the discharge of these pollutants from the proposed Facility.

The intent of this document is to investigate the compliance of the proposal with air quality criteria. Whilst assessment methods such as adding the 100th percentile background (e.g. the highest hourly background reading recorded for the year) to the peak impact concentration will lead to overestimation of actual impacts, this is appropriate for the purpose of investigating compliance with regulatory criteria (DEC 2005).

Mitigation Measures

8.1 Construction

Key mitigation measures to be employed during construction are provided below. The primary emissions during construction would be confined to dust, which would be controlled by the following mitigation measures:

- Before works begin, a Construction Environmental Management Plan (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;
- Vehicles would only be loaded to less than the height of the side and tailboards and loads of 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 would be stabilised using fast-seeding grass or synthetic cover spray; and
- All major access roads are sealed and vehicle speeds on unsealed site areas would be controlled to minimise dust.

8.2 Operation

The primary emissions from the development will those emanating from the ESP. Based on an analysis of the wood waste fuel to be used, the emissions will comply with regulatory criteria and will have the following concentrations:

- NO_X (calculated as NO_2 with a maximum of 1% N in the fuel) concentration of ≤ 500 mg/Nm^3; and
- Particulates matter (maximum of 1.5% ash in the fuel and calculated on an O_2 content of 11% by volume and dry flue gas) concentration of ≤ 50 mg/Nm^3.

In addition, other emissions from the ESP will comply with the regulations stipulated in the Clean Air Regulation.

SEFE has indicated that operation of the facility would not occur during maintenance on the ESP. Maintenance of the Power Plant will include a 'hot shutdown' every three months and a 'cold shutdown' every six months. SEFE has indicated that emission limits as dictated by the Clean Air Regulation would not be exceeded during 'hot shutdown' periods. SEFE has also indicated that emissions during start-up after a 'cold shutdown' should not be exceeded provided the start-up is done gradually and well controlled. Control of emissions during 'start-up' will be via a Air Quality Management Plan for the facility.

Conclusion

An air quality assessment was undertaken for the proposed development of a 5MW Biomass Power Plant to be fuelled by wood waste. The assessment comprised two primary components, namely a comparison of in-stack concentrations to the limits specified in the *NSW Protection of the Environment Operations (Clean Air) Amendment (Industrial and Commercial Activities and Plant) Regulation 2005* (Clean Air Regulation) and a comparison of ground level concentrations against criteria contained in the *Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW* (DEC 2005).

The stack emissions were found to be below regulatory limits specified in the *Clean Air Regulation 2005*.

The ground level concentrations were assessed using the Calpuff dispersion model, incorporating meteorological data generated using TAPM and Calmet. The modelled species included oxides of nitrogen (NO_x), particulate matter (PM_{10}), carbon monoxide (CO), sulphur dioxide (SO_2), lead and Hazardous Air Pollutants (HAPs), including dioxins, furans, PAHs, VOCs and metals.

The assessment has used a conservative approach applied in accordance with the *Approved Methods* (DEC, 2005). Where appropriate, the assessment of the cumulative impacts against regulatory criteria has used the aggregate of the worst case predicted plant impacts and peak background concentrations from DECC and other relevant monitoring stations.

The air dispersion modelling assessment has concluded that the predicted impacts on ground level concentrations of NO_2, PM_{10}, CO, SO_2, and lead when added to background concentrations, are within the regulatory criteria. As per the *Approved Methods*, HAPs were assessed for incremental impact and were below regulatory criteria. The results generally show peak impacts occurring within 1km of the plant.

A screening Plume Rise Assessment was also undertaken. When modelled for all hours of the year (2007), plume velocities were predicted to depreciate below 4.3 m/s by 46 mAGL, and below 110 mAGL required by CASA for further consideration.

Given the generally conservative nature of the air quality assessment, it is considered that the potential for adverse air quality impacts of the proposed plant will be low.

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Limitations

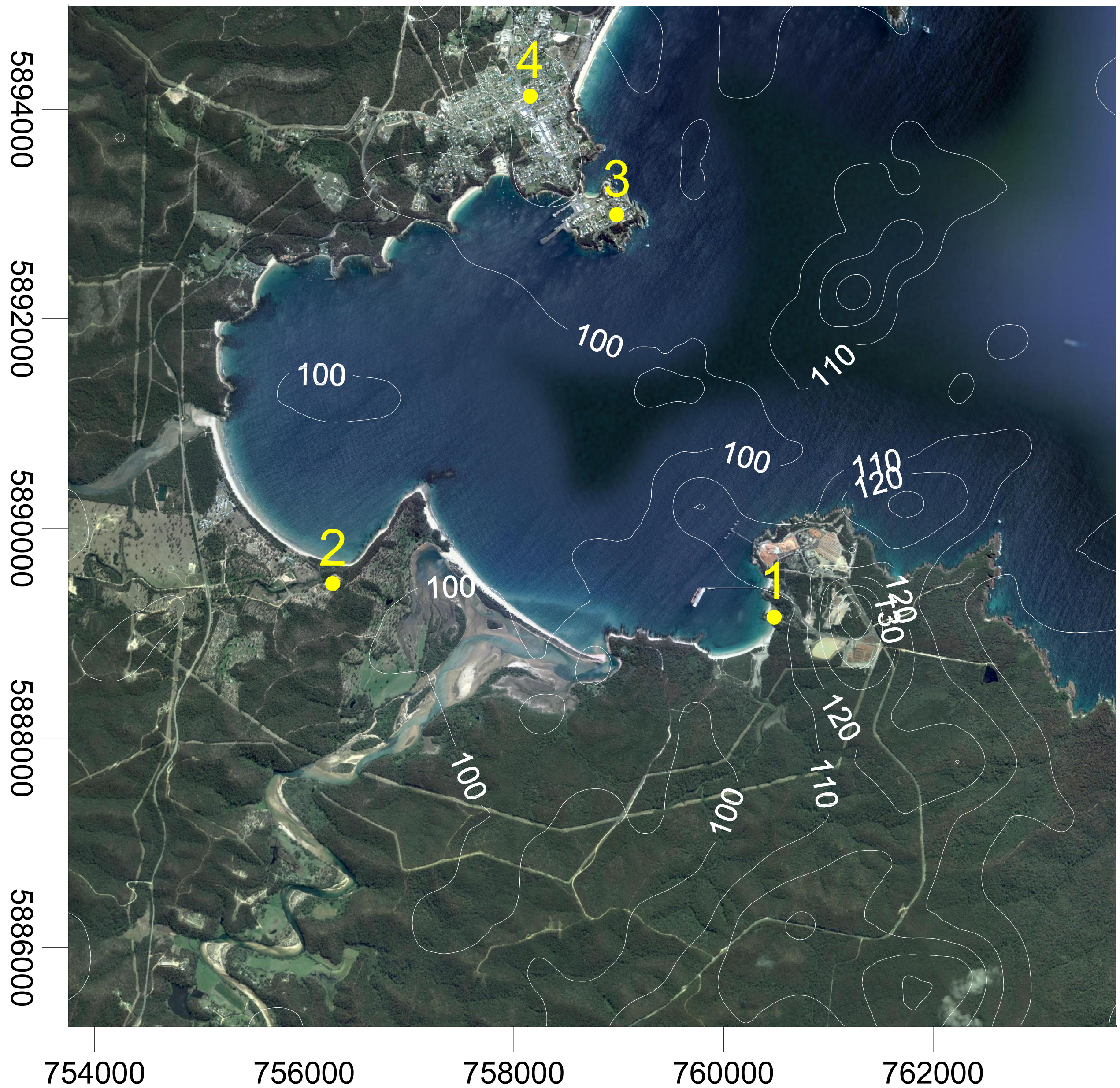
URS Australia Pty Ltd (URS) has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of South East Fibres Export Pty Limited and only those third parties who have been authorised in writing by URS to rely on the report. It is based on generally 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 1 May 2009.

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 between July and November 2009 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.

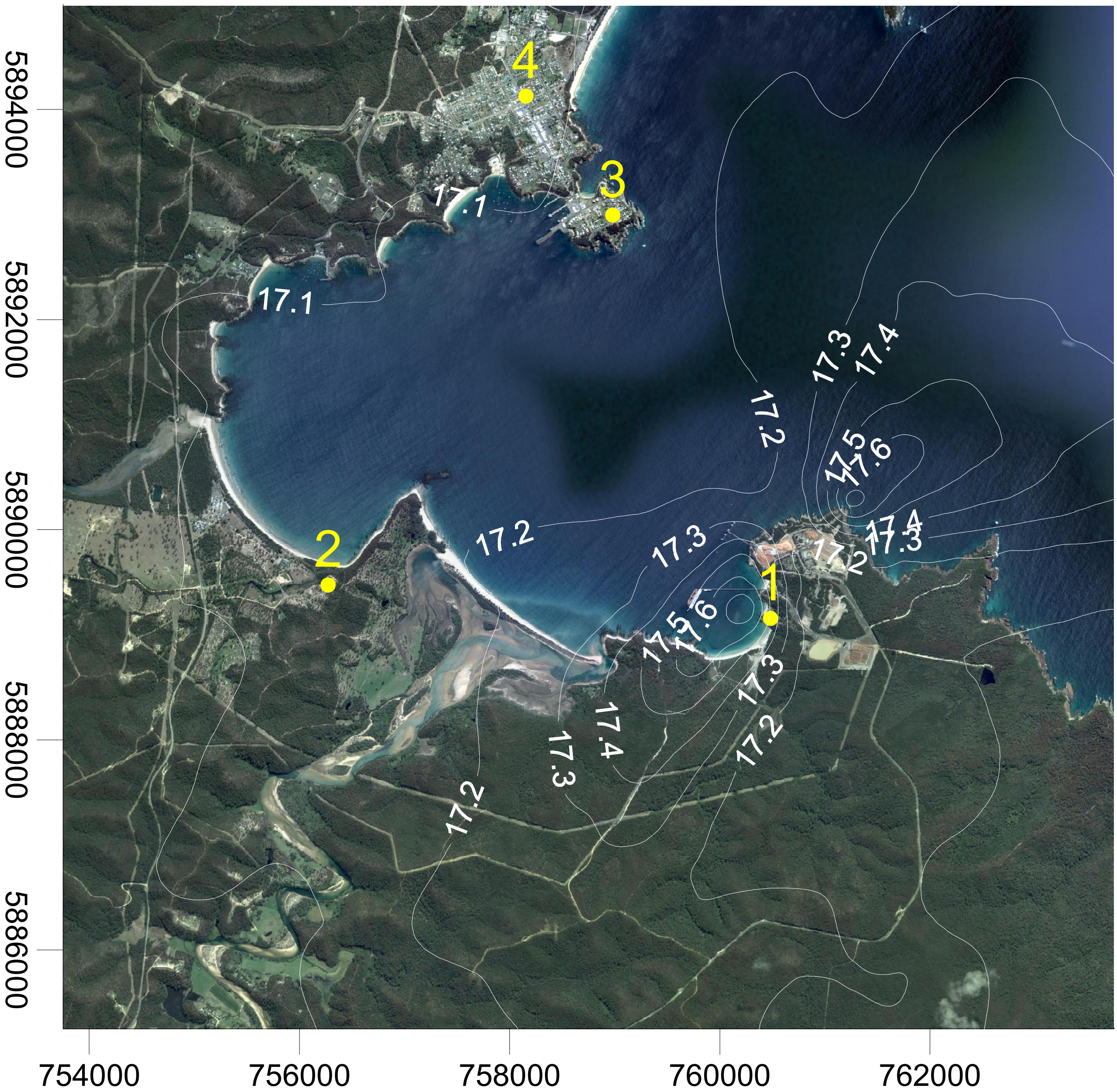
Figures



(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

N

Client: South East Fibre Exports (SEFE)	Project: 5 MW Biomass Power Station Air Quality Assessment			Title: Nitrogen Oxides (NOx) Concentration 1 hour averaging period (ug/m3)	
URS	Drawn: RW	Approved: DRAFT	Date: 3/11/2009	Figure: 1	Rev: A
	Job No: 43177675	File: 43177675 Figure 1			A4



(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

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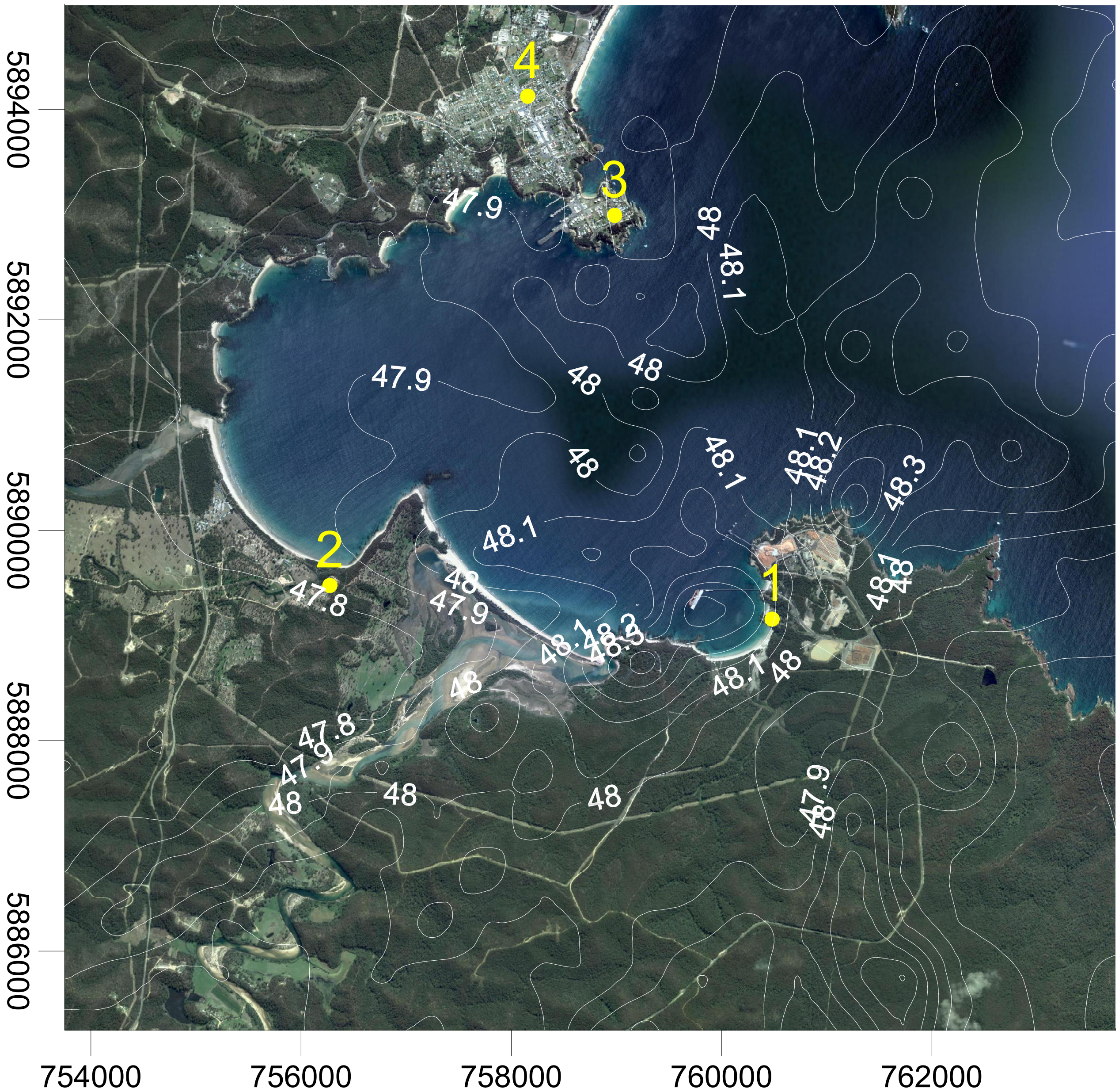
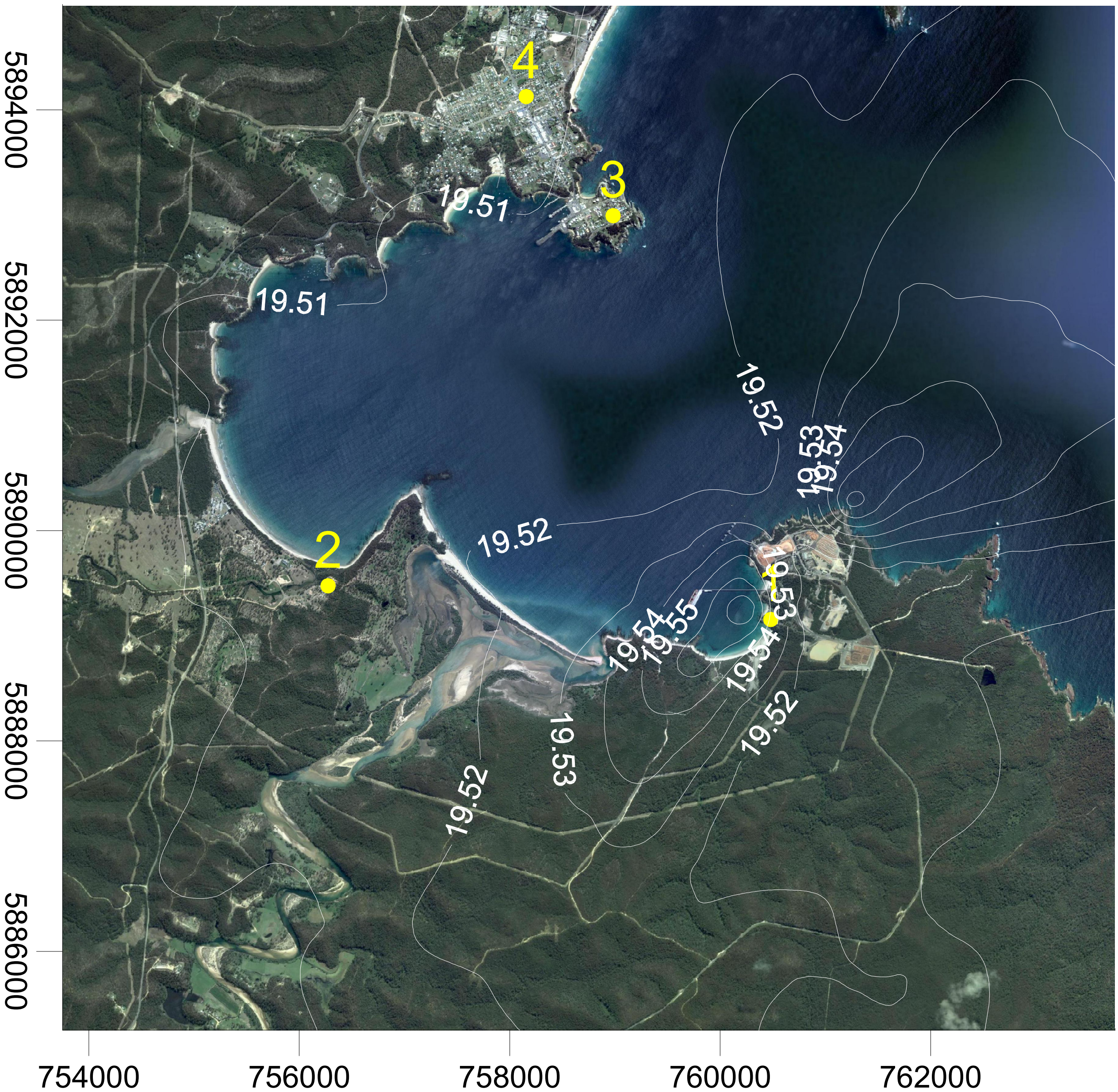
URS	Drawn: RW / Approved: DRAFT / Date: 3/11/2009	Figure: 2 / Rev: A
	Job No: 43177675 / File: 43177675 Figure 2	A4



(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

Client: **South East Fibre Exports (SEFE)**	Project: **5 MW Biomass Power Station Air Quality Assessment**	Title: Particulate Matter (PM10) Concentration 24 hour averaging period (ug/m3)
URS	Drawn: RW / Approved: DRAFT / Date: 3/11/2009	Figure: 3 / Rev: A
	Job No: 43177675 / File: 43177675 Figure 3	A4



(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

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Client: South East Fibre Exports (SEFE)	Project: 5 MW Biomass Power Station Air Quality Assessment	Title: Particulate Matter (PM10) Concentration Annual average (ug/m3)
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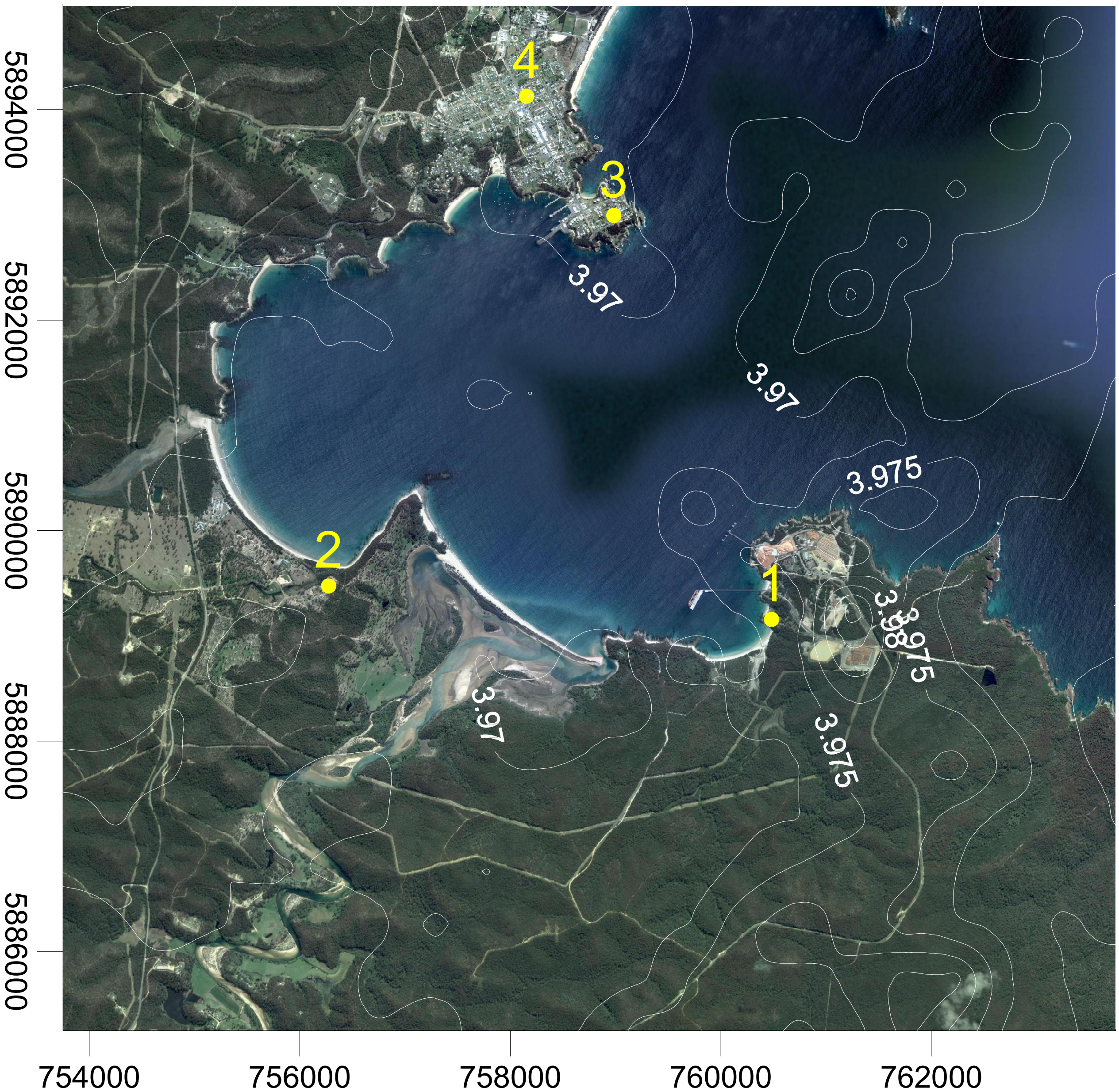
	Job No: 43177675; File: 43177675 Figure 4	Rev: A; A4



(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

Client: South East Fibre Exports (SEFE)	Project: 5 MW Biomass Power Station Air Quality Assessment			Title: Carbon Monoxide (CO) Concentration 15 minute averaging period (mg/m3)	
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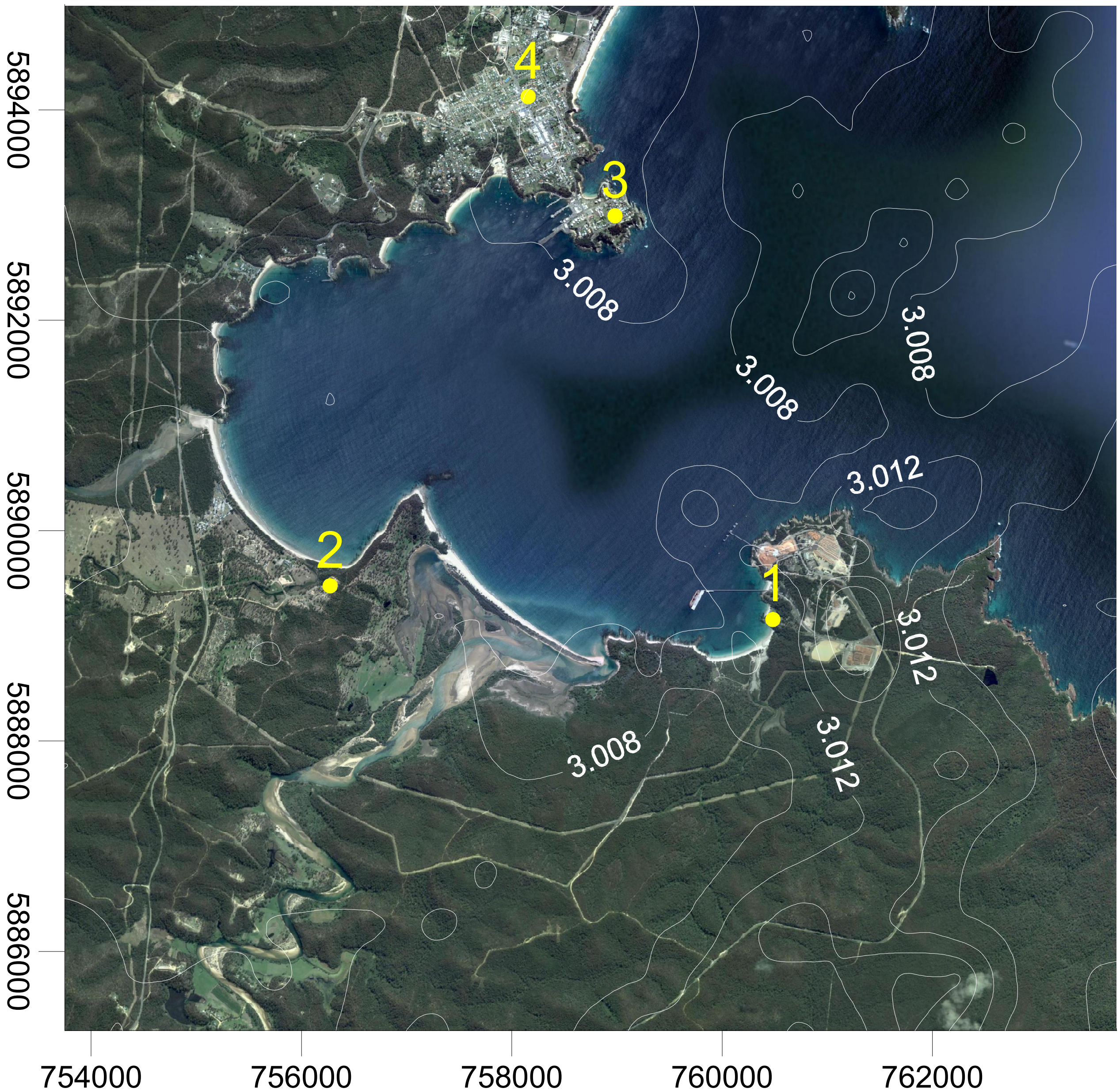
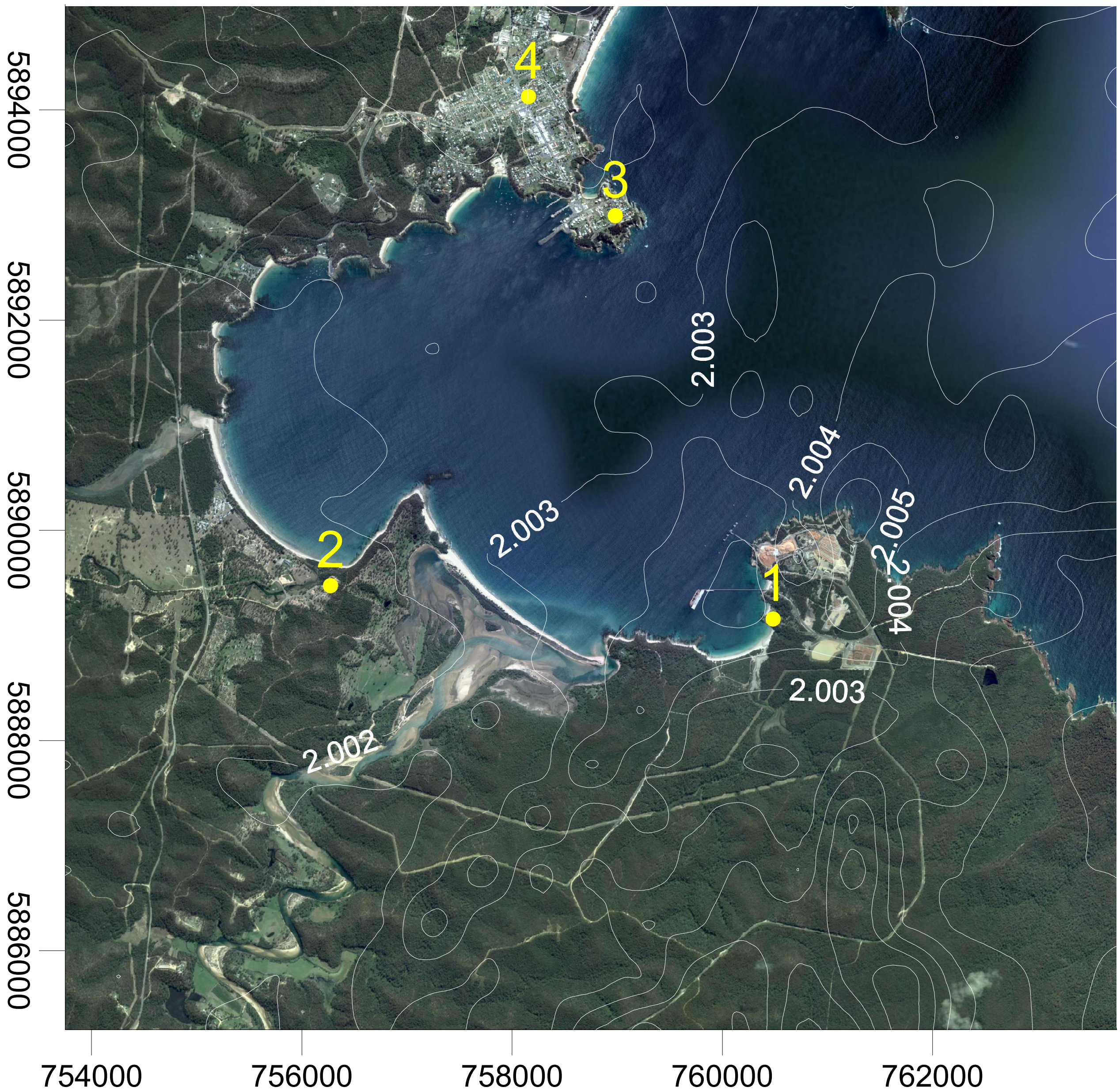
	Job No: 43177675	File: 43177675 Figure 5			A4



(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

N

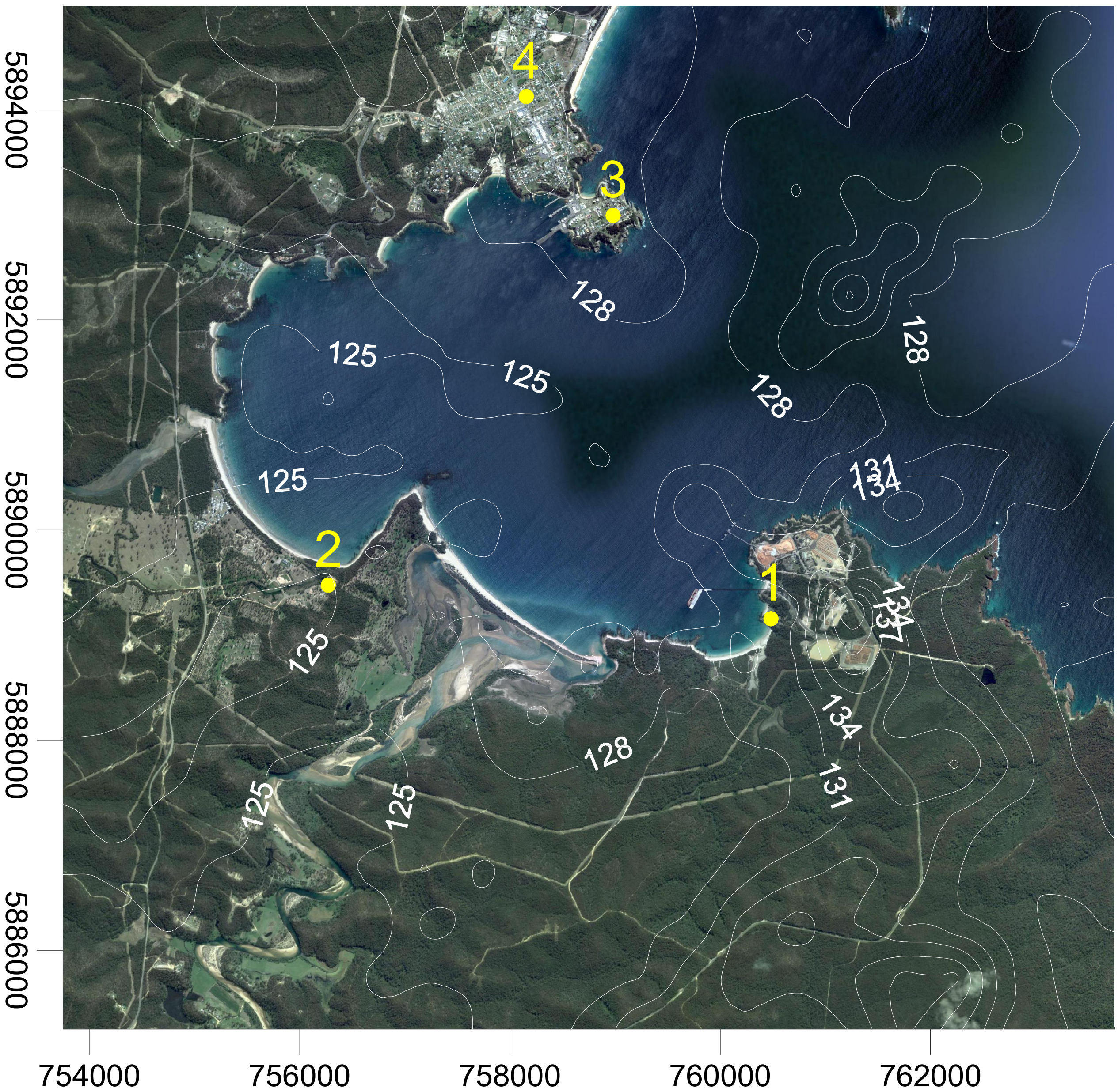
Client: South East Fibre Exports (SEFE)	Project: 5 MW Biomass Power Station Air Quality Assessment	Title: Carbon Monoxide (CO) Concentration 1 hour averaging period (mg/m3)
URS	Drawn: RW / Approved: DRAFT / Date: 3/11/2009 / Job No: 43177675 / File: 43177675 Figure 6	Figure: 6 / Rev: A / A4



(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

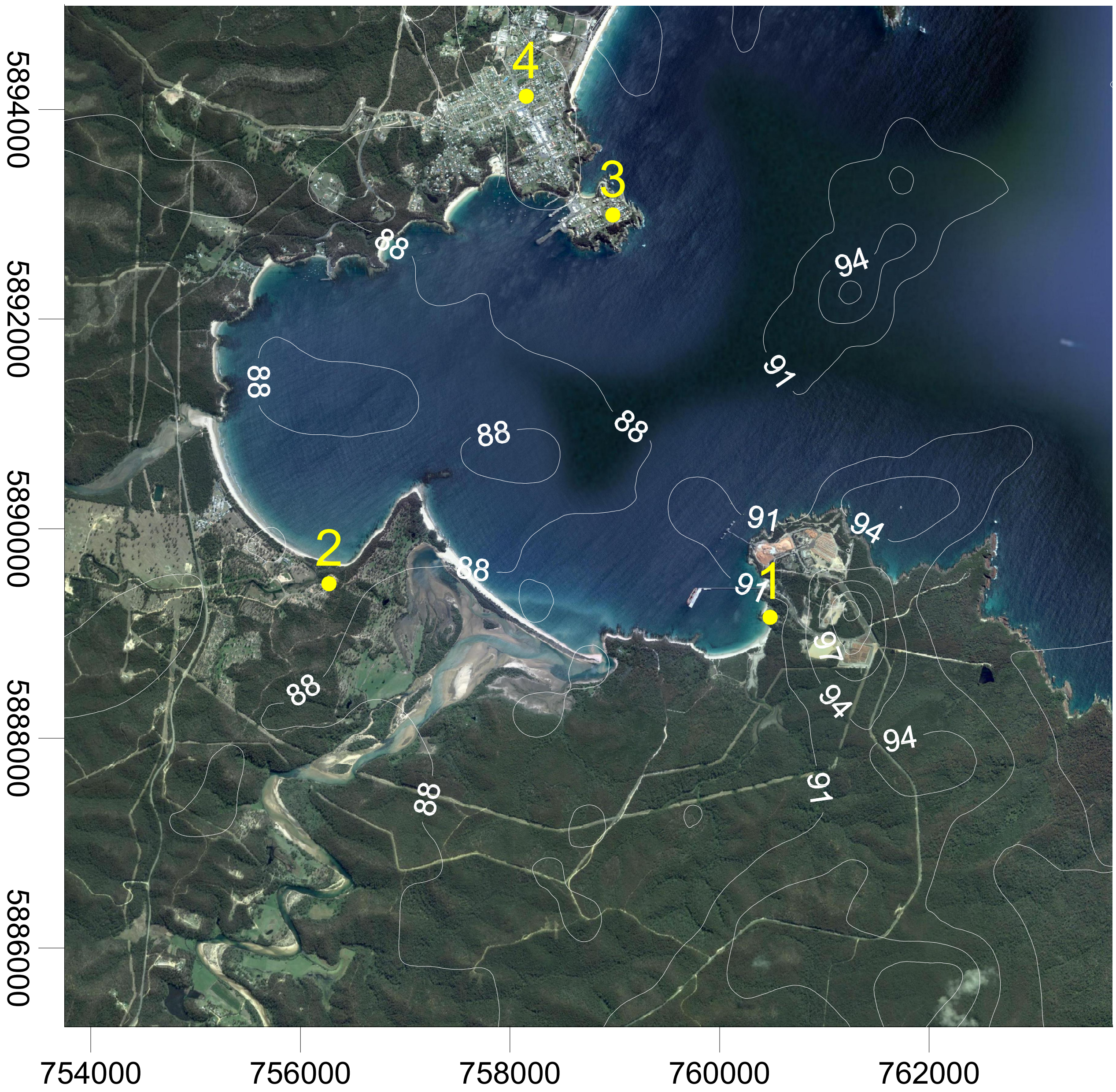
N

Client: South East Fibre Exports (SEFE)	Project: 5 MW Biomass Power Station Air Quality Assessment			Title: Carbon Monoxide (CO) Concentration 8 hour averaging period (mg/m3)	
URS	Drawn: RW	Approved: DRAFT	Date: 3/11/2009	Figure: 7	Rev: A
	Job No: 43177675	File: 43177675 Figure 7			A4



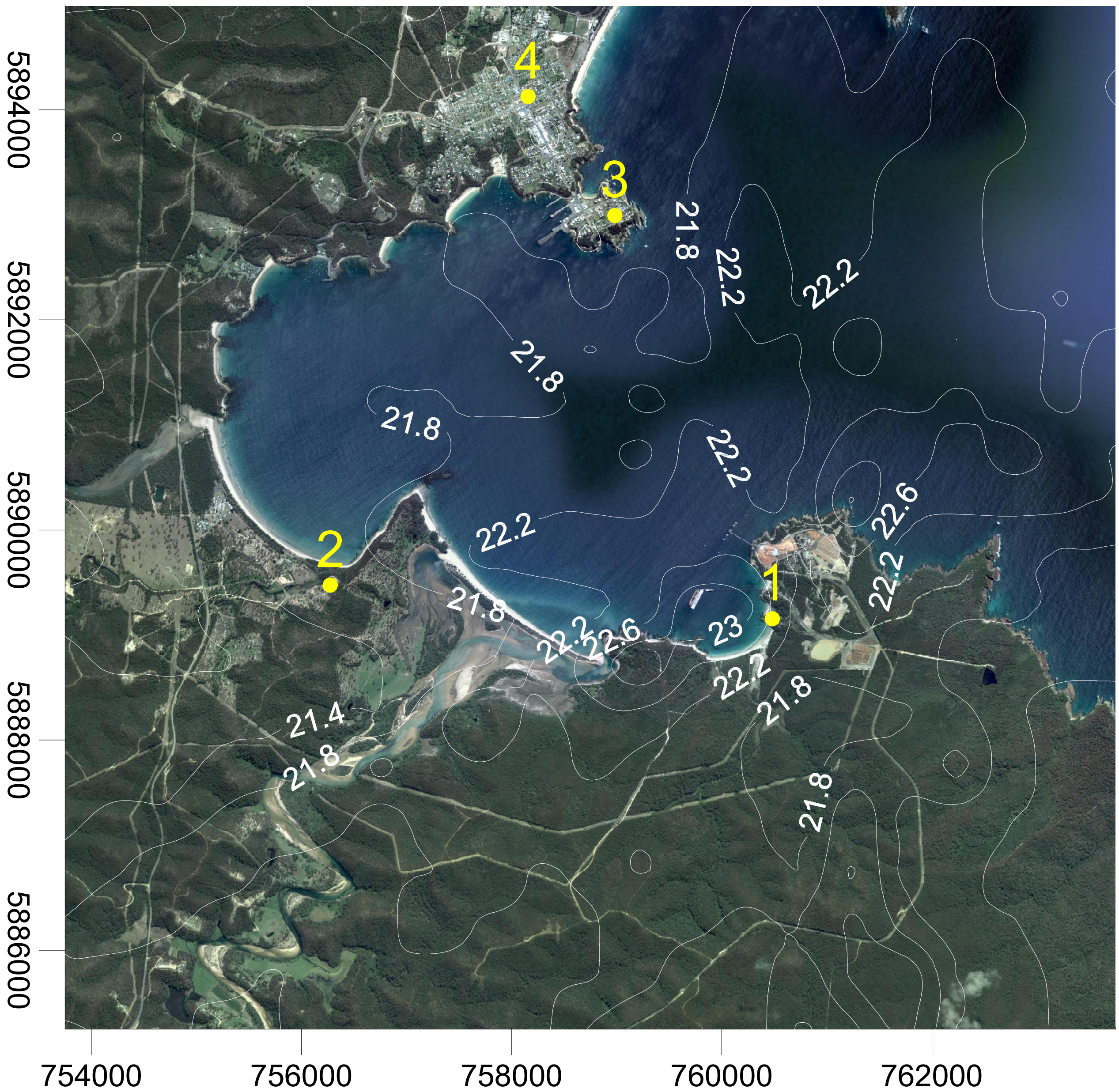
(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

Client: **South East Fibre Exports (SEFE)**	Project: **5 MW Biomass Power Station Air Quality Assessment**	Title: Sulphur Dioxide (SO2) Concentration 10 minute averaging period (ug/m3)
URS	Drawn: RW · Approved: DRAFT · Date: 3/11/2009 · Job No: 43177675 · File: 43177675 Figure 8	Figure: 8 · Rev: A · A4



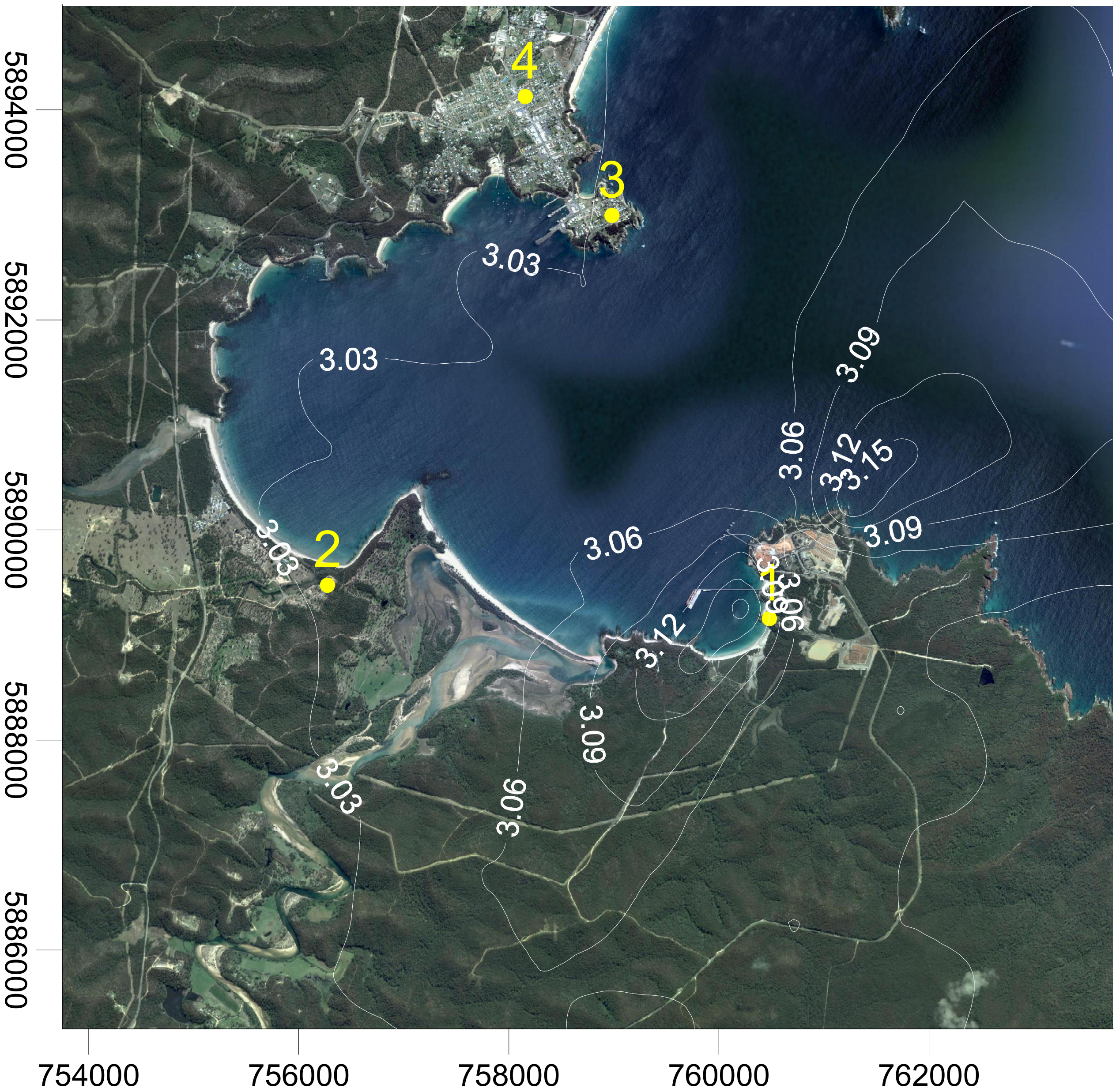
(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

Client: South East Fibre Exports (SEFE)	Project: 5 MW Biomass Power Station Air Quality Assessment		Title: Sulphur Dioxide (SO2) Concentration 1 hour averaging period (ug/m3)
URS	Drawn: RW	Approved: DRAFT	Date: 3/11/2009
	Job No: 43177675	File: 43177675 Figure 9	Figure: 9 Rev: A A4



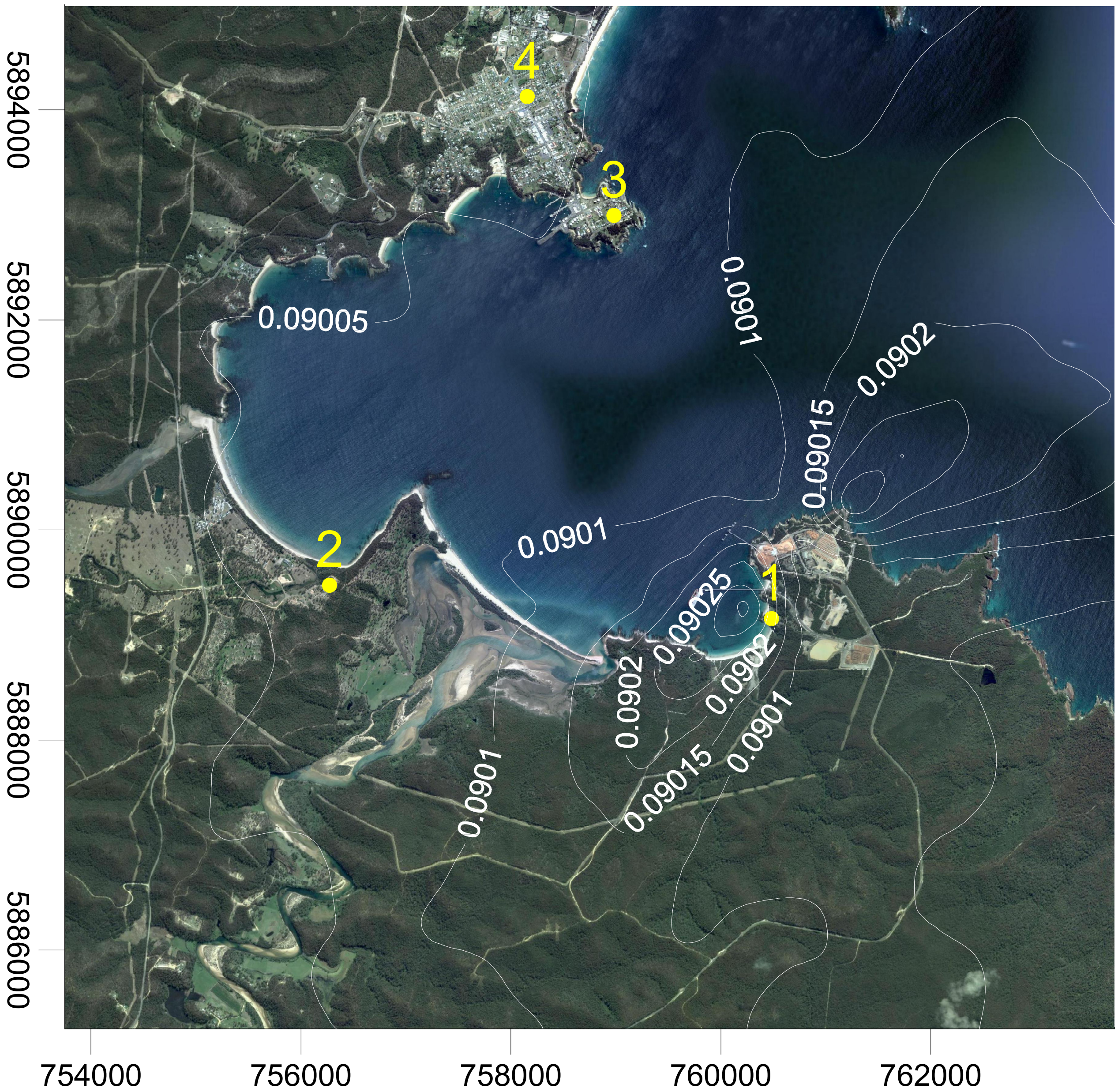
(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

Client: South East Fibre Exports (SEFE)	Project: 5 MW Biomass Power Station Air Quality Assessment			Title: Sulphur Dioxide (SO2) Concentration 24 hour averaging period (ug/m3)	
URS	Drawn: RW	Approved: DRAFT	Date: 3/11/2009	Figure: 10	Rev: A
	Job No: 43177675	File: 43177675 Figure 10			A4



(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

Client: South East Fibre Exports (SEFE)	Project: 5 MW Biomass Power Station Air Quality Assessment			Title: Sulphur Dioxide (SO2) Concentration Annual average (ug/m3)	
URS	Drawn: RW	Approved: DRAFT	Date: 3/11/2009	Figure: 11	Rev: A
	Job No: 43177675	File: 43177675 Figure 11			A4



(Image sourced from GoogleEarth)
GDA 94 Co-ordinates
Cumulative concentrations shown
Four sensitive receptor locations shown in yellow

N

Client: South East Fibre Exports (SEFE)	Project: 5 MW Biomass Power Station Air Quality Assessment	Title: Lead Concentration Annual average (ug/m3)
URS	Drawn: RW / Approved: DRAFT / Date: 3/11/2009 / Job No: 43177675 / File: 43177675 Figure 1	Figure: 12 / Rev: A / A4

Appendix A Emissions Inventory

Appendix A

A.1 Stack Emissions

A.1.1 Stack Parameters

The stack parameters used in the dispersion modelling and stack concentration calculations provided in **Table A1**.

Table A1 Stack Parameters

Stack Parameter	Units	Boiler Stack
Stack Height (above ground level)	m	35
Stack Diameter	m	1.6
Cross Sectional Area	m^2	2.01
Exit Temperature	ºC	180
O_2	vol	5.15%
H_20	vol	27%
Exit Velocity	m/s	11.2
Volumetric Flowrate	Nm^3/h (dry)	35770
	Nm^3/h (wet)	49000
	Am^3/h	81290
	Am^3/s	22.6

A.1.2 Criteria Pollutants and HAPs

The manufacturers' design specifications were obtained for the key pollutants of concern from the main stack, which are Carbon Monoxide (CO), Nitrogen Oxides (NO_x, assumed to be present as NO_2) and particulate matter (assumed as PM_{10}). Emissions rates for these compounds were estimated using these design concentrations. Stack concentrations for the single source associated with the proposal (flue gas stack) is provided in **Table A2** below.

The hazardous air pollutants chosen comprised volatile HAPs, metallic HAPs and semi volatile HAPs. For both the volatile and metallic HAPs, the emission factors of the HAPs[A] listed in Department of the Environment Water Heritage and the Arts (2008), were compared against the impact assessment criteria contained in DEC (2005). The pollutants with the greatest relative impact were considered to be formaldehyde as the volatile HAP and chromium for the metallic HAP. These compounds were chosen as the most conservative pollutants, consequently ground level impacts of other volatile and metallic HAP are expected to be below those predicted for formaldehyde and chromium.

[A] The emission factors in Department of the Environment Water Heritage and the Arts (2008) for Dry electrostatic granular filter (presumed to be similar in efficiency to the proposed ESP, did not present emissions for any VOC. Consequently, formaldehyde was chosen as a suitable VOC, given it has comparatively low criteria in DEC (2005) compared with other gaseous combustion products and is often emitted in relatively high concentrations.

Appendix A

Table A2 Stack emission concentrations

Stack Concentrations	mg/Nm³	mg/Am³	Source
Reference Condition	Dry, 273K, 7% O_2	Wet, 453K, 5.15% O_2	-
Criteria Pollutants			
NO_x (as NO_2)	500	249	Clean Air Regulations
CO	175	87	Vyncke (2009)
Solid Particles (as PM_{10})	50	25	Clean Air Regulations
SO_2	123	61	US EPA (2003)
Lead	2.34E-01	0.12	US EPA (2003)
Hazardous Air Pollutants			
Formaldehyde	51	25	US EPA (2003)
Cadmium & compounds	6.24E-03	3.11E-03	US EPA (2003)
Dioxins and Furans	4.40E-07	2.19E-07	US EPA (2003)
PAH's	2.51E-05	1.25E-05	US EPA (2003)

Dioxins, furans and PAHs comprise a range of compounds, each with varying toxicity, consequently must be assessed more rigorously. This has been undertaken in the following section.

A.1.3 Dioxins, Furans and PAH

Gras *et al* 2004 state that this set of weighting factors, expresses the toxicity of a specific congener relative to an equivalent mass of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), which is the most studied and most toxic PCDD. Multiplication of the mass of the congener by its weighting factor (or toxic equivalents factor, TEF) yields the corresponding toxic equivalent for a given congener (TEQ) in a mixture. The formula for calculating TEQ is as follows:

$$TEQ = ([PCDD_i \times TEF_i]_n) + ([PCDF_i \times TEF_i]_n) + ([PCB_i \times TEF_i]_n) \qquad \text{(Equation 2)}$$

The Toxic Equivalent Factors for a range of dioxins, furans and PCBs vary slightly depending on the agency producing the factors, but the generally accepted TEFs are provided in **Table A3**. **Table A3** shows TEFs from DEC (2005) which are designed to provide regulatory criteria for currently operating premises. The other TEFs listed in **Table A3** are the WHO_{98} TEF. The WHO_{98} TEFs are the most widely used TEFs and were adopted for this investigation.

As can be seen in **Table A3**, toxicity equivalency factors are provided for a range of dioxins, furans known to be present in biomass combustion gas. As discussed, these factors are used to calculate a single toxicity equivalent value, known as the TEQ . The measured concentrations of dioxins furans and PCBs are multiplied by the TEFs to give the TEQ, which allows direct comparison of “toxicity” between samples having different composition.

For example, a sample with a concentration of 2 picograms (pg) of 2,3,7,8 TetraCDD has an equivalent TEQ to another sample with a concentration of 20 picograms (pg)of 2,3,7,8, TetraCDF. This is due to the latter sample having a TEF one tenth of the former sample. This is expressed in the following calculation:

Appendix A

(2 pg of 2,3,7,8 TetraCDD) x (TEF of 1) = TEQ of 2

has the same TEQ as

(20 pg of 2,3,7,8, TetraCDF) x (TEF of 0.1) = TEQ of 2

This would also apply for the PAH emission factors adopted, outlined in **Table A4**.

Table A3 Emission Factors - Dioxins & Furans

Compound	Average Emission Factor (lb/MMBtu)	Average Emission Factor (kg/J)	TEF*
Dioxins			
2,3,7,8 tetrachlorodibenzodioxin	8.60E-12	3.70E-21	1
1,2,3,7,8 pentachlorodibenzodioxin	1.50E-09	6.45E-19	1
1,2,3,4,7,8 hexachlorodibenzodioxin	1.60E-06	6.88E-16	0.1
1,2,3,4,6,7,8 heptachlorodibenzodioxin	2.00E-09	8.60E-19	0.01
octachlorodibenzodioxin	6.60E-08	2.84E-17	0.0001
Furans			
2,3,7,8 tetrachlorodibenzofuran	9.10E-11	3.91E-20	0.1
1,2,3,7,8 pentachlorodibenzofuran	4.20E-10	1.81E-19	0.05
1,2,3,4,7,8 hexachlorodibenzofuran	2.80E-10	1.20E-19	0.1
1,2,3,4,6,7,8 heptachlorodibenzofuran	2.40E-10	1.03E-19	0.01
octachlorodibenzofuran	8.80E-11	3.78E-20	0.0001

Notes: * = Toxic Equivalence Factor, as presented in the Regulation.

Table A4 Adopted Emission Factors - PAHs

Compound	Average Emission Factor (lb/MMBtu)	Average Emission Factor (kg/J)	PEF*
Benzo[a]pyrene	2.60E-06	1.12E-15	1
Benzo[a]anthracene	6.50E-08	2.80E-17	0.1
Benzo[b]fluoranthene	1.00E-07	4.30E-17	0.1
Benzo[j]fluoranthene	1.60E-07	6.88E-17	0.1
Benzo[k]fluoranthene	3.60E-08	1.55E-17	0.1
Indeno[1,2,3-cd]pyrene	8.70E-08	3.74E-17	0.1
Chrysene	3.80E-08	1.63E-17	0.01
Dibenz[a,h]anthracene	9.10E-09	3.91E-18	0.4

Notes: * = PAHs expressed as benzo[a]pyrene using the Potency Equivalency Factors (PEFs)

Appendix B Meteorological Data Discussion

Appendix B

B.1 Assessment of Meteorological Data

The meteorological data needed for dispersion modelling is required to be site representative. The nearest weather stations were found to be located at Merimbula Airport Automatic Weather Station (AWS), and the Green Cape Lighthouse AWS, both operated by the Bureau of Meteorology (BoM) and both located approximately 20 km from the Site. Meteorological data from BoM weather stations is typically not viable for use in dispersion analysis, given the type of instrumentation often used at airport monitoring sites especially in reporting of calm (i.e. low wind speed) conditions. Given this and the distance from the Site, local meteorological data was not sought for modelling purposes. Rather, URS adopted the approach of using The Air Pollution Model (TAPM) to conduct meteorological predictions for the local area, and to provide meteorological inputs into the meteorological model CALMET for use in atmospheric dispersion modelling. Meteorological data for 2007 was compiled, to coincide with the most recently available information of background pollutant concentrations, in order to provide a complete contemporaneous assessment. The method for determining meteorological parameters and model input and output parameters is further discussed in the following sections.

B.2 Meteorological Modelling

B.2.1 The Air Pollution Model (TAPM)

TAPM (v4) 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 to simulate meteorological fields in a number of situations[2].

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.

TAPM, with the use of the input databases provided by CSIRO, was used to generate a meteorological dataset for the year 2007 based on actual synoptic data. The following TAPM settings and input files were used to generate the meteorological file for the site for the year 2007.

Default options were selected, except where noted otherwise below:

- Grid centre coordinates –37°07’00’’ latitude, 149°56’00’’ longitude (MGA94: 760628 mE, 5888157 mN);
- Meteorological grid consisting of four nests of 25 x 25 grid points at 30, 10, 3 and 1 km, with 25 vertical grid levels from 10 to 8000 m;
- Terrain at 9 arc-second (approximately 270 m) 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); and
- 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.

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

B.2.2 CALMET

CALMET is a three dimensional meteorological simulation package included within the CALPUFF suite of program. CALMET predicts three dimensional wind profiles and atmospheric parameters for use in predicting dispersion conditions through CALPUFF. Surface and upper air files generated by TAPM were used in predicting wind profiles over the modelling domain with CALMET. Two surface and two upper air files (at the site, and at Eden) were used as inputs into CALMET to adequately capture any variance in meteorological conditions from emission points to receptors. An overwater met station (in the form of a SEA.dat file) was also incorporated into the model from TAPM outputs, to adequately capture varying coastal meteorological conditions, and their influence on local dispersion effects. Other CALMET parameters used in the meteorological modelling were as follows:

- 42 x 42 grid points at 500 m resolution (Total grid dimension of 21 km x 21 km) using user specified land use, and terrain information generated from TAPM terrain data bases;
- TAPM generated surface and upper air meteorological stations for a point located on the site, and for a point located at Eden;
- Overwater station position at a point along the coast. The SEA.dat file for use in CALMET was developed using meteorological information outputted from TAPM in an effort to adequately model coast meteorological conditions;
- CSUMM formatted TAPM output for use in the ‘initial guess’ stage of wind field generation; and
- 12 vertical levels ranging from 20 m to 3000 m (cell face height).

The annual and seasonal wind roses for the TAPM generated meteorological data are provided in **Figure B1**. These wind roses show the dominance of winds from the south west and north east. Summer shows winds to be primarily from the north east, with autumn showing a distinct south westerly component. Similarly, Winter shows the presence of a high proportion of winds from the south west with Spring showing a more uniformly spread of winds with a slight dominance of winds from the north east and south west quadrants.

Appendix B

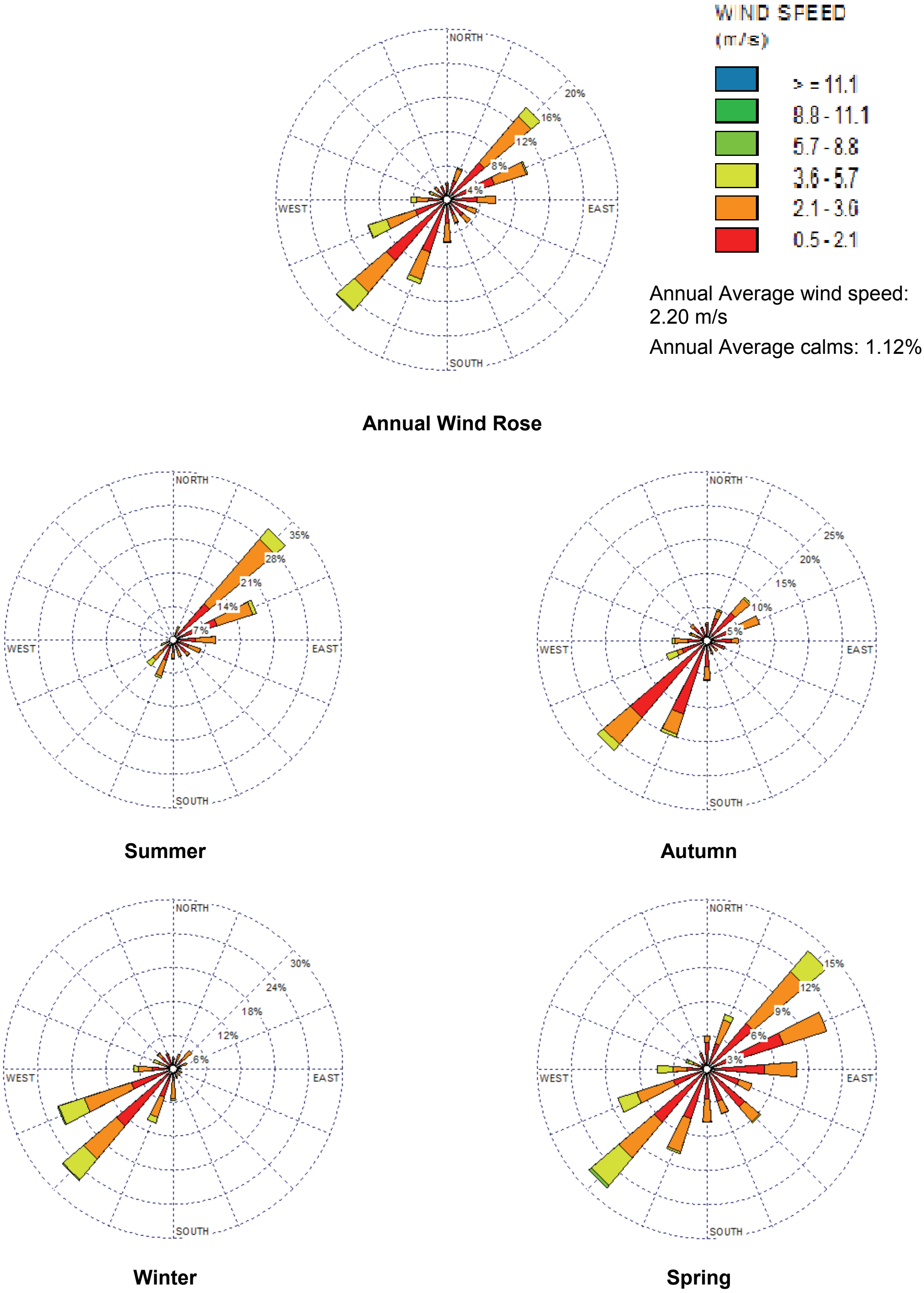


Figure B1 Annual and Seasonal Windrows generated for the Site using TAPM & Calmet

B.3 Mixing Height

Figure B2 shows the Mixing Height (m) vs Time of Day (Hour) generated from TAPM data at the development site for 2007. 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.

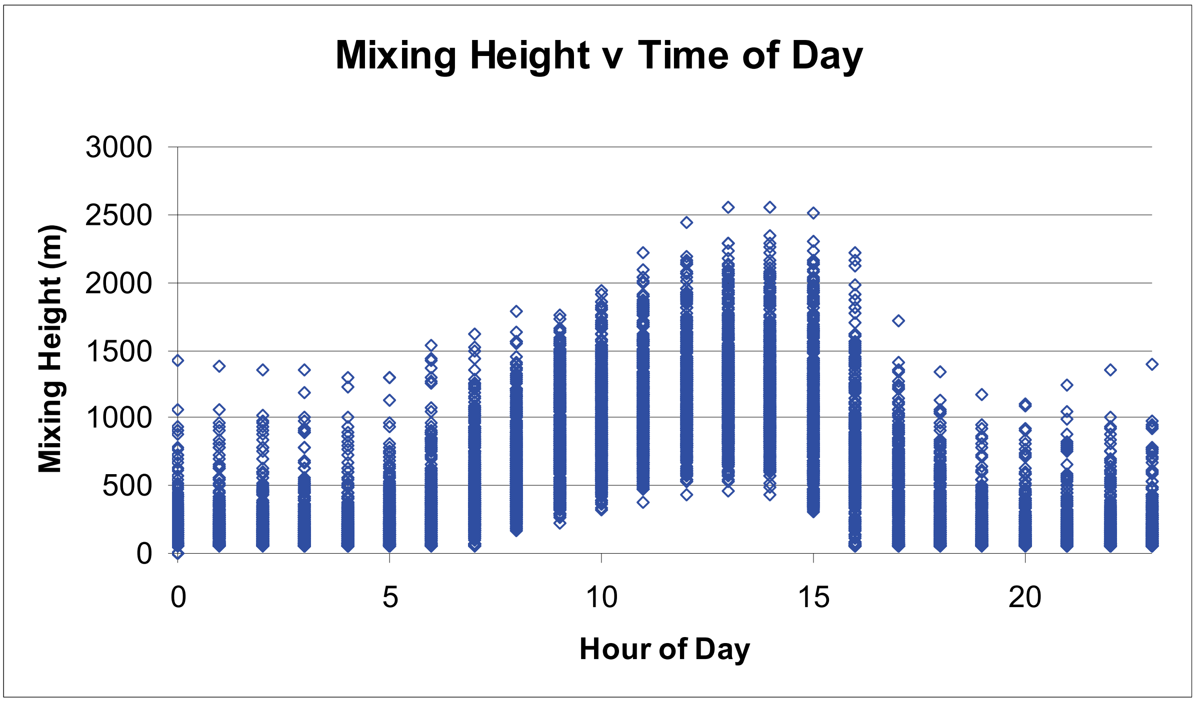


Figure B2 Mixing Height (m) vs Time of Day (Hour of Day)

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 B1**.

The stability classes for the site have been extracted from a TAPM generated meteorological file and are shown in **Table B2**.

Appendix B

Table B1 Modified Pasquill-Gifford Stability Classes (adapted from Turner, 1994[3])

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 A2** 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 B2 Site Representative Pasquill-Gifford Stability Classes

Stability Class	% of year
A (Extremely Unstable)	2.6%
B (Moderately Unstable)	19.7%
C (Slightly Unstable)	18.8%
D (neutral)	9.9%
E (Slightly Stable)	4.5%
F (Moderately Stable)	44.6%

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 B2**. 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 B1**.

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

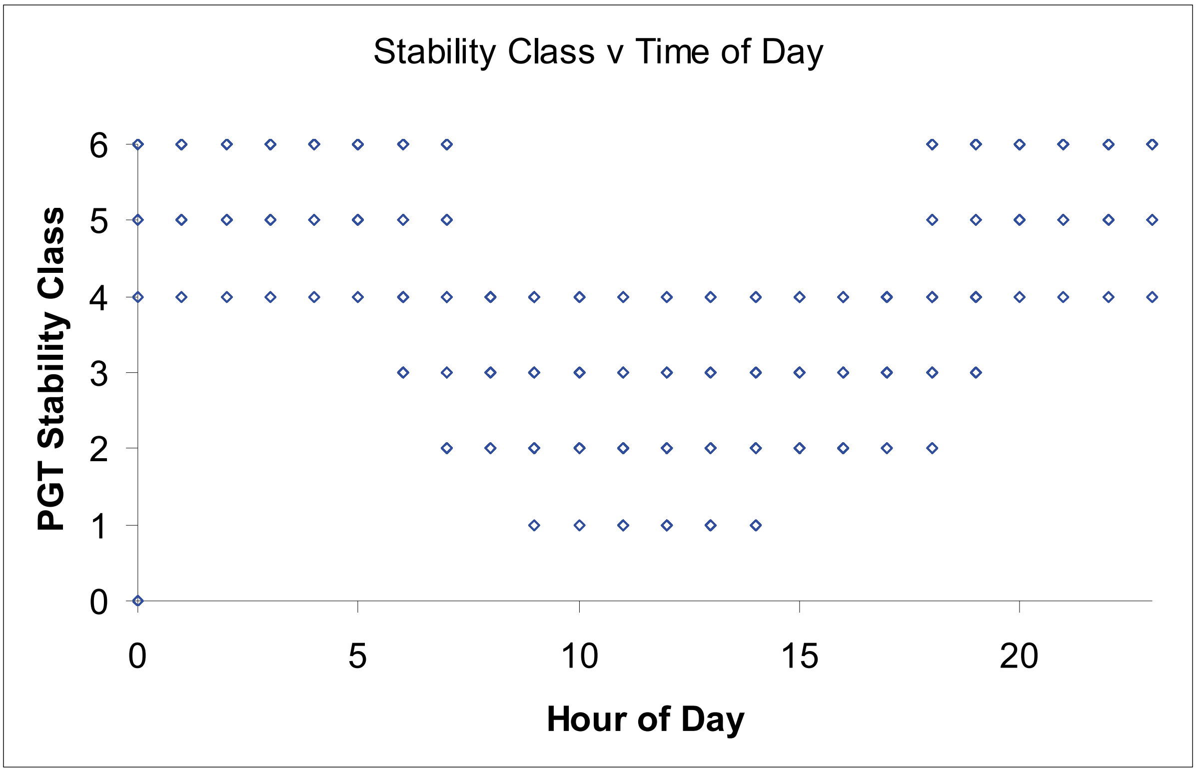


Figure B2 Stability Class vs Time of Day
(Pasquill Gifford Turner Stability Classes 1 – 6 refer to A to F respectively)

Stability Classes were also measured against wind speed, as shown in **Figure B3.** As expected, the highest wind speeds are associated with Stability Classes C and D. The more unstable conditions (Stability Classes A and B) are associated with lower wind speeds, as it is under low winds (coupled with stronger solar insolation) where thermal turbulence is able to dominate. The more stable conditions (Stability Classes E and F) are also associated with low wind speeds. These data are consistent with the values contained in **Table B1.**

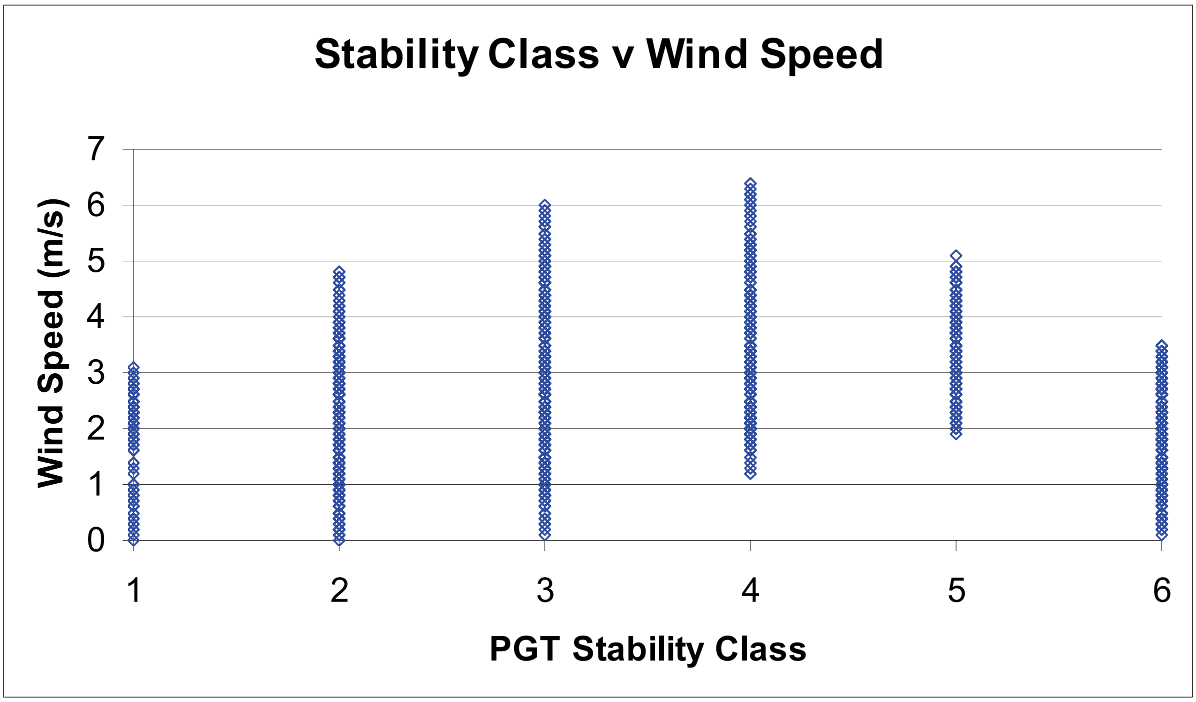


Figure B3 Stability Class vs Wind Speed
(Pasquill Gifford Turner Stability Classes 1 – 6 refer to A to F respectively)

B.5 Conclusion

Where site specific dispersion meteorological data may not be site representative, as is the case for the proposed 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, TAPM generated meteorological data was incorporated into CALMET to predict local meteorology.

The assessment of the predicted meteorology at the proposed 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 Screening Level Plume Rise Assessment

Appendix C

C.1 Background and Methodology

The Civil Aviation Safety Authority (CASA) considers an exhaust plume with a (critical) vertical velocity component of greater than 4.3 m/s to be a potential hazard to aircraft. In areas remote from an aerodrome, CASA require proponents of industrial facilities to notify them if any proposed exhaust plumes are likely to exceed the critical velocity at a height greater than 110 metres Above Ground Level (mAGL). This screening assessment has used the CSIRO's TAPM model to predict a single year of hourly meteorological cases and plume velocity profiles such that potential plume impacts can be identified. The assessment has followed the CASA Advisory Circular *"Guidelines for Conducting Plume Rise Assessments"* (June, 2004) with the exception that a single year has been modelled, and only basic statistics have been presented. Given the small scale of thermal emissions, this approach is considered acceptable.

C.2 Emission Parameters

The stack will serve a boiler which will generate steam at a rate of approximately 20MW, and at a thermal efficiency of approximately 86% (LHV). The use of sea water for cooling purposes means that only a small portion of energy from the power cycle (around 3 MW) is emitted to the air. This means that a relatively small amount of energy is available to contribute to plume buoyancy. Plume buoyancy is the dominant mechanism by which plumes rise through the atmosphere. **Table C1** below shows the stack parameters that were modelled for this screening assessment.

Table C1 – Stack Parameters

Stack Parameter	Value
Approximate Location (MGA94)	760665 mE, 5889863 mN, Zone 55
Base Elevation	39 mAHD
Height	35 mAGL / 74 mAHD
Diameter	1.6 m
Exit Temperature	180°C
Exit Velocity	11.2 m/s

C.3 Results

Table C2 presents the results from the TAPM modelling, where critical vertical extent is the height of the plume at which the plume depreciates to the critical vertical velocity of 4.3m m/s. As expected, for all hours of the year modelled, plume velocities were predicted to depreciate below 4.3 m/s within metres of the stack top, and well below 110 mAGL.

Table C2 – Modelling Results

Stack Parameter	Critical Vertical Plume Extent (mAGL)
Maximum	43
Average	38
Minimum	36

C.4 Conclusion

The modelling has predicted that plume emissions from the proposed facility will not reach 110 mAGL at a velocity greater than 4.3m/s.

C.5 References

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

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

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