Air Dispersion Modelling Study and Screening Human Health Risk Assessment Anglesea Power Station and Coal Mine

Prepared for:
Alcoa Australia Limited

Prepared by:
ENVIRON Australia Pty Ltd

Date:
July 2013

Project Number:
AS140151

ENVIRON

July 2013 Our Ref: AS140151

Nicci Marris
Alcoa of Australia Limited
Anglesea Power Station
Camp Road
Anglesea Victoria 3230

Dear Nicci

Re: Air Emissions Study – Alcoa Screening HHRA, Anglesea Power Station and Coal Mine, Victoria

We are pleased to present our final report of the Air Dispersion Modelling and Screening Human Health Risk Assessment (HHRA) Study for the Anglesea Power Station and Coal Mine. This report provides details of the emission inventory, dispersion modelling and a screening HHRA based on the approach recommended by the Victorian EPA.

Should you require any additional information, please contact the undersigned directly.

Yours sincerely
ENVIRON Australia Pty Ltd

Brian Bell
Principal, Australia

Executive Summary

An air dispersion modelling and screening Human Health Risk Assessment (HHRA) of the atmospheric emissions from Alcoa's Anglesea Power Station and Coal Mine have been completed to investigate the potential health risks arising from the atmospheric emissions from these facilities. The screening HHRA considered the potential health risks associated with the current power station emissions and coal mine operations.

The Victorian Environment Protection Authority (EPAV) specified that only those compounds that did not meet the State Environmental Protection Policy (Air Quality Management) (SEPP (AQM)) design criteria be included in the HHRA.

A comprehensive emission inventory identified 39 compounds that are likely to be associated with the atmospheric emissions from the power station and coal mine. The Air Pollution Model (TAPM) was used to predict the meteorology and dispersion of the power station emissions. The CALPUFF air dispersion model was used to model the particulate emissions from the coal mine operations using TAPM predicted meteorology. The predicted ground level concentrations of the compounds modelled were compared against the design ground level concentration (dglc) criteria presented in the Victorian SEPP (AQM).

Three compounds (sulphur dioxide [SO_2], particulate matter with an equivalent aerodynamic diameter of less than 10 μm [PM_{10}] and particulate matter with an equivalent aerodynamic diameter of less than 2.5 μm [$PM_{2.5}$]) were predicted to exceed the SEPP (AQM) dglc criteria in the modelled domain and these compounds were therefore included in the screening HHRA.

The screening HHRA has been confined to the inhalation pathway as this is expected to represent the most significant exposure route to the atmospheric emissions from Alcoa's Anglesea operations. It therefore does not take into account the alternative exposure pathways (e.g. ingestion, dermal absorption). The study considered background concentration data for compounds where this could be determined. The following quantitative health risk indicators were calculated across the model domain and for key receptors located in the vicinity of the Anglesea Power Station and Coal Mine:

- Composite (i.e. based on 1-hour SO_2, and 24-hour PM_{10} and $PM_{2.5}$ Hazard Quotients [HQs]) and 24-hour (i.e. based on 24-hour SO_2, PM_{10} and $PM_{2.5}$ HQs) acute (i.e. short term) Hazard Index (HI); and
- chronic (i.e. long term) HI.

The acute and chronic HQs and HIs were calculated for each model grid point based on the predicted ground level concentrations and the ambient air quality standards developed by the National Environment Protection Council (NEPC) in the National Environment Protection Measure (NEPM). Discrete receptor locations were identified to represent populations or individual residences that could be potentially exposed to atmospheric emissions from the Power Station and coal mine.

Based upon the results of the screening HHRA it can be concluded that:

- The emissions from the power station and coal mine when considered in combination with the background concentrations are predicted to result in a composite acute HI of greater than one at all but two of the nominated receptor locations.
- The 24-hour acute HI was less than one at all locations other than Camp Wilkin and Fraser Avenue.
- An analysis of the predicted concentrations associated with the maximum composite HIs indicated that the 99.5th percentile 24-hour PM_{10} concentrations occurred at different times to when the 99.9th percentile 1-hour SO_2 concentration occurred.
- For all receptors other than Fraser Avenue, the individual PM_{10} and SO_2 acute HQs were less than one indicating that the predicted PM_{10} and SO_2 percentile concentrations considered in the screening HHRA were below the relevant NEPM ambient standards.
- For Fraser Avenue the acute HQ was predicted to be in excess of one for PM_{10}. Of this, Alcoa's operations were predicted to have contributed approximately 70% of the 24-hour concentration. The NEPM goal for PM_{10} is to have no more than five days where the NEPM standard is exceeded. Further analysis of the modelling data indicates that the sixth highest 24-hour average concentrations predicted at Fraser Avenue are well below the NEPM standard for each of the five years modelled. While no exceedances of the NEPM standard have been recorded at the ambient particulate monitoring sites, the air dispersion modelling indicates the potential for this to occur albeit infrequently.
- The acute HIs marginally greater than one are not considered to present cause for concern in terms of possible health risks due to the inherent conservatism embedded in the exposure assessment applied to screening health risk assessment.
- The emissions from the power station and coal mine are predicted to result in a chronic HI and HQ of less than one at all of the nominated receptor locations.
- The potential for emissions from the power station and the coal mine to cause chronic health effects is therefore considered to be low.

The NEPM ambient air quality standards represent the currently accepted standards in Australia, and have therefore been used in this screening HHRA. Any changes to the NEPM ambient air quality standards may affect the outcome of the screening HHRA.

As with any risk evaluation, there are areas of uncertainty in this assessment. To ensure that potential risks are not underestimated, uniformly conservative assumptions have been used to characterise exposure and toxicity.

Alcoa has implemented an Air Quality Control System to manage the impacts of SO_2 on the Anglesea township which has reduced the occurrence of 1-hour average concentrations of SO_2 that exceed the NEPM 1-hour standard in the community. Only one exceedance of the NEPM standard has been recorded in the last four years.

Further, Alcoa commenced ambient PM_{10} and $PM_{2.5}$ monitoring in July 2012 to assess the potential impacts associated with fugitive particulate emissions from its operations. The monitoring results from July to December 2012 indicate that the NEPM standards were being met at all three monitoring locations during this period.

ENVIRON recommends that management/mitigation measures are regularly reviewed to ensure control of the acute (short-term exposure) risk posed by SO_2 from the power station and dust emissions from the coal mine.

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AQCS	Air Quality Control System
AQM	Air Quality Management
BoM	Bureau of Meteorology
BPIP	Building Profile Input Program
CO	Carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DGLC	Design ground level concentration
EPAV	Environment Protection Authority (Victorian)
FB	Fractional Bias
GASP	Global Analysis and Prediction
GDA	Geocentric Datum of Australia
GLC	Ground level concentrations
GM	Geometric Mean Bias
HHRA	Human Health Risk Assessment
IOA	Index of Agreement
N	North
NEPM	National Environment Protection Measures
NMSE	Normalised Mean Square Error
NO_x	Oxides of nitrogen
NO_2	Nitrogen Dioxide
NPI	National Pollution Inventory
OLM	USEPA's Ozone Limiting Method
PAH	Polycyclic Aromatic Hydrocarbons
$PM_{2.5}$	Particulate matter with an equivalent aerodynamic diameter of less than 2.5 µm
PM_{10}	Particulate matter with an equivalent aerodynamic diameter of less than 10 µm
RHC	Robust Highest Concentration
RMSE	Root Mean Square Error
RMSE_S	Systematic Root Mean Square Error
RMSE_U	Unsystematic Root Mean Square Error
S	South
SE	Southeast
SEPP	State Environmental Protection Policy
SD	Standard Deviation
SO_2	Sulphur Dioxide
STP	Standard Temperature and Pressure - is defined by IUPAC (International Union of Pure and Applied Chemistry) as air at 0°C (273.15 K, 32 °F) and 10^5 Pascals
TAPM	The Air Pollution Model. A meteorological and dispersion model developed by CSIRO.
USEPA	United States Environmental Protection Agency
VG	Geometric Variance
VOC	Volatile Organic Compounds
WHO	World Health Organisation

UNITS OF MEASUREMENT

°C	Degree Celsius
d	Day
kg	Kilogram
K	Kelvin
kPa	Kilo Pascals
km	Kilometre
m	Metre
m^3	Cubic metre
Mg	Milligram
MW	Megawatt (or 1 x 10^6 watts)
ppb	Parts per billion
ppm	Parts per million
µg	Microgram
µg/m^3	Microgram per cubic metre expressed at STP
t	Tonnes

1 Introduction

1.1 Background

Alcoa of Australia (Alcoa) operates the 160 megawatt (MW) Anglesea Power Station (power station) and the Anglesea Coal Mine (coal mine) near Anglesea, in Victoria, Australia (Figure 1). The Power Station supplies approximately 40% of the power required by Alcoa's Point Henry aluminium smelter.

Alcoa contracted ENVIRON Australia Pty Ltd (ENVIRON) to conduct an air dispersion modelling study and screening Human Health Risk Assessment (HHRA) of the potential health risks arising from atmospheric emissions from the Anglesea Power Station and Coal Mine. The screening HHRA has considered the potential health risks associated with air emissions from the existing operations.

This report details the air dispersion modelling study, the screening HHRA approach and methodology, and the results of potential acute and chronic risks arising from atmospheric emissions from the power station and the coal mine.

1.2 Project Overview

The study includes the identification of atmospheric emissions that may result from the power station and coal mine based on National Pollutant Inventory (NPI) reports, stack monitoring reports, raw materials handling and process conditions. The identified emissions were included in the air dispersion modelling study to predict ground level concentrations across the model domain and at discrete receptors.

This HHRA is considered to be a screening-level assessment in that it makes generally conservative assumptions regarding the potential magnitude of exposure. The Victorian Environment Protection Authority (EPAV) specified that only those compounds that do not meet the State Environmental Protection Policy (Air Quality Management) (SEPP (AQM)) (EPAV, 2001a) design criteria be included in the HHRA (see Appendix A for EPAV correspondence). This assessment assumed an additive approach to the calculation of health risks, which is generally considered to be conservative (i.e. health protective). Potential antagonistic or synergistic effects were not considered as these cannot readily be quantified. The results of the screening HHRA are able to be used to identify the individual sources and compounds exhibiting the highest contribution to potential health risks in order to help define atmospheric emission management strategies.

1.3 Coal Mine And Power Station Site Description And Process Summary

The Anglesea Coal Mine is an open pit mine located approximately 0.5 km north, northwest of the town of Anglesea and 1.2 km south, southwest of the Anglesea Power Station (Figure 1). The power station is located approximately 1.5 km north of the town of Anglesea. The coal mine and the power station are both located within a 7,221 hectare (ha) mining lease known as the Anglesea Heath.

The coal mine typically operates between 7am and 7pm, seven days per week to produce 1.1 Mtpa of coal for the power station. Alcoa moves overburden to the waste dumps and extracts the brown coal using excavators (mechanical diggers) and 60 t dump trucks. The coal is delivered to the primary crusher and from the crusher to the live stockpiles.

Coal is recovered from the live stockpiles and sent to the pulverisers that reduce the coal to a fine material that is dried and injected into the boiler. The hot combustion gases in the boiler are used to generate steam to drive a two-cylinder 160 MW condensing turbine producing electricity.

Electrostatic precipitators collect more than 98% of the fly ash before the gas passes through induced draft fans to the stack for discharge. The majority of the sulphur that is present in the brown coal is oxidised in the boiler and is emitted to the atmosphere via the power station stack in the form of sulphur dioxide (SO_2).

In 2009 Alcoa developed and implemented and Air Quality Control System (AQCS) to manage the emissions of SO_2 under conditions were the emissions are being dispersed over the town of Anglesea. The AQCS has been integrated into the power station operations. It has resulted in a reduction in the number of exceedances of the National Environment Protection Measure (NEPM) standard of 200 ppb for SO_2 recorded at the ambient monitoring sites located in the town of Anglesea since its inception. The NEPM goal has been met at all of the Anglesea monitoring stations since 2009.

2 Air Dispersion Modelling

2.1 Background

Air dispersion modelling of the Anglesea Power Station and Coal Mine was undertaken using The Air Pollution Model (TAPM, V4.05) and CALPUFF (V6.26). TAPM was used to predict the meteorology and the dispersion of the atmospheric emissions from the Anglesea Power Station. CALPUFF was used to model the particulate emissions from the Anglesea Coal Mine using the TAPM predicted meteorology. The air dispersion modelling results were evaluated against the ambient monitoring data for SO_2 and particulates to evaluate the reliability of the model predictions. The predicted ground level concentrations were compared to the SEPP (AQM) design ground level concentration criteria to select the emissions that were considered in the screening HHRA. This section provides details on the air quality criteria used, emission inventory derivation, model set-up and parameterisation, model validation and the model results.

2.2 Air Quality Criteria

The predicted ground level concentrations resulting from the coal mine and power station's atmospheric emissions have been assessed against the design criteria described in the SEPP (AQM) as presented in Table 1.

The design ground level concentration criteria are typically employed in the assessment of new or expanded sources of emissions. The design ground level concentration criteria for air quality indicators based on toxicity apply everywhere, except inside buildings.

In addition to the pollutants listed above, Boron was included in the assessment as Alcoa has emissions data. As there are no EPAV SEPP Guideline values for Boron, the Texas Commission Environmental Quality (TCEQ) Levels were applied as listed in Table 2.

Table 1: SEPP (AQM) Design Criteria for Individual Compounds		
Substance	**Averaging period**	**EPAV (SEPP)[4] design ground level criteria**
		(µg/m^3)
Class 1		
CO	1-hour	29,000
NO_2	1-hour	190
SO_2	1-hour	450
PM_{10}[1]	1-hour	80
Lead	1-hour	3
Class 2		
$PM_{2.5}$	1-hour	50
Chromium (III) and compounds	3-min	17
Copper dusts and mists	3-min	33
Manganese and compounds	3-min	33
Mercury - Organic	3-min	0.33
Mercury - Inorganic		3.3
Fluoride[2]	24-hour	2.9
	7 days	1.7
	90 days	0.5
Antimony	3-min	17
Chlorine	3-min	100
Hydrogen Chloride	3-min	250
Class 3		
Arsenic and compounds	3-min	0.17
Cadmium and compounds	3-min	0.033
Nickel and compounds	3-min	0.33
Dioxins and Furans[3]	3-min	0.0000037
PAH (as BaP)	3-min	0.73
Benzene	3-min	53
Beryllium	3-min	0.007
Chromium VI Compounds	3-min	0.17

Notes:

1. Applies to point sources only. For area-based sources and roads, applicable criteria are specified in the relevant industry Protocol for Environment Management (PEM).
2. Fluoride content is calculated by dry weight and expressed as fluoride (F-) µg/m^3.
3. TCDD 1-TEQ means 2, 3, 7, 8-Tetrachloro-dibenzodioxan as international equivalents.
4. Gas volumes are expressed at 25°C and at an absolute pressure of one atmosphere (101.325 KPa).

Table 2: Air Quality Criteria - Boron	
Averaging period	**Texas Commission on Environmental Quality (TCEQ) Effects Screening Levels (2009) – Air Quality Objective (µg/m^3)**
1-hour	50
Annual	5
Notes Texas Commission on Environmental Quality -Effects Screening Levels (ESL) Lists Used in the Review of Air Permitting Data - http://www.tceq.texas.gov/toxicology/esl/list_main.html#esl_1	

2.3 Power Station Emission Inventory

The nature and quantity of atmospheric emissions released from the Power Station and coal mine have been characterised through the development of an emissions inventory. The emissions inventory details key compounds and the emission rates from the Power Station and coal mine. These emissions data have been sourced from emission monitoring campaigns for the power station, and an understanding of the process, and National Pollution Inventory (NPI) reporting, and NPI emission estimation methods. The key compounds in the atmospheric emissions from the power station and coal mine include the following:

1 **Sulphur Dioxide (SO_2):** SO_2 is primarily generated by the oxidation of sulphur in the coal burnt in the power station.

2 **Nitrogen Dioxide (NO_2):** During coal combustion, nitrogen present in both the coal and the combustion air is converted to nitrogen dioxide (NO_2) and other oxides of nitrogen (NO_x).

3 **Particulates** particulate are primarily emitted as a result of the mining activities and from the power station stack in the form of uncaptured coal ash.

4 **Metals:** metal emissions are primarily contained in the particulates emitted from the coal mine and power station operations.

5 **Carbon Monoxide:** Carbon monoxide is formed by the incomplete combustion in the Power Station.

6 **Polycyclic Aromatic Hydrocarbons (PAHs):** PAHs originate from the combustion of coal in the Power Station.

7 **Volatile Organic Compounds:** VOC's originate either by the volatilisation from, or combustion of, the coal in the power station.

An overview of the emission inventory process is presented as Figure 2 and includes the substance selection, source selection and an uncertainty analysis. The following sections provide information on the development of the power station emissions inventory while Section 3 presents details on the emissions inventory development for the coal mine.

2.3.1 Anglesea Power Station - Source Characteristics

The characteristics of the power station stack and emissions used in the modelling are presented in Table 3. The discharge characteristics and stack coordinates were provided by Alcoa (N. Marris *pers. comms.* 18 July 2011).

Table 3: Stack Discharge Characteristics

Description	GDA Coordinates		Stack Height	Stack Characteristics at Discharge		
				Diameter	Average Velocity	Average Temp
	X	Y	(m)	(m)	(m/s)	(K)
Stack	253764	5747349	107	3.88	36.8	465.5

2.3.2 Emission Estimates

The compounds considered in this study represent Alcoa's best available knowledge of the emissions released to air from the power station stack and coal mine. This knowledge has been gathered primarily from source emission monitoring campaigns and coal analysis conducted at the Power Station and coal mine. The key processes undertaken to identify and prioritise compounds of interest included:

1 Compounds likely to be present in the air emissions based on process knowledge.

2 Priority compounds covered in the Ambient Air NEPM (NEPC, 1998) and the Ambient Air Toxics NEPM (NEPC, 2004).

3 Compounds known to be present in the coal due to the comprehensive monitoring program.

4 Compounds known to be emitted by similar facilities, nationally and internationally.

5 Compounds that triggered NPI thresholds.

6 Compounds specified in the environmental license.

A total of 39 individual compounds were identified and included into the emission inventory. These compounds included NO_x, carbon monoxide, SO_2, PM_{10} (particulate matter with an equivalent aerodynamic diameter of less than 10 µm), $PM_{2.5}$ (particulate matter with an equivalent aerodynamic diameter of less than 2.5 µm), fluorides, metals, PAH's and dioxins and furans. The inventory data for the Power Station stack emissions were primarily sourced from stack testing reports prepared by external NATA accredited consultants. The results of stack emissions testing reports provided by Alcoa from 2008 to 2012 (N Marris, *pers. comms*. 30 January 2013) were used in the development of the emission inventory. Quarterly trace analysis results for coal samples provided by Alcoa were used in conjunction with estimated PM_{10} emission rates to calculate the trace element emissions contained in particulate emissions from the coal mine.

For this study the emissions profile considered the normal worst case (i.e. maximum) emissions from the Power Station and coal mine unless there were continuous emissions data available. For SO_2, measured hourly average emission rates were used in the dispersion model to predict ground level concentrations. The continuous SO_2 emissions monitoring data were used in the assessment as they reflect the actual operating regime of the power station including the impact of the AQCS.

A summary of the sampling methods used to measure the stack emissions at the Power Station are summarised in Appendix B. Table 4 presents the power station stack emission rates used in the air quality assessment. The coal mine emission estimates are presented in Section 3.

Table 4: Summary of Power Station Emission Rates

No.	Compound	Emission Rate (g/s)	No.	Compound	Emission Rate (g/s)
1	Nitrogen Dioxide[1]	103	21	2, 3, 7, 8 - TCDF	1.47×10^{-9}
2	Sulphur Dioxide[2]	1,148[3]	22	2, 3, 7, 8 - TCDD	4.83×10^{-10}
3	Carbon Monoxide	2.8	23	1,2,3,7,8 - PeCDF	8.50×10^{-10}
4	$PM_{2.5}$	1.0	24	2,3,4,7,8 - PeCDF	2.17×10^{-9}
5	PM_{10}	4.3	25	1,2,3,7,8 - PeCDD	6.67×10^{-10}
6	Total Fluoride	0.5	26	1,2,3,4,7,8 - HxCDF	1.65×10^{-9}
7	Chlorides	4.2	27	1,2,3,6,7,8 - HxCDF	1.52×10^{-9}
8	Mercury	0.0009	28	2,3,4,6,7,8 - HxCDF	2.83×10^{-9}
9	Arsenic	0.002	29	1,2,3,7,8,9 - HxCDF	8.33×10^{-10}
10	Cadmium	0.0001	30	1,2,3,4,7,8 - HxCDD	8.33×10^{-10}
11	Chromium (III)	0.0137	31	1,2,3,6,7,8 - HxCDD	8.33×10^{-10}
12	Copper	0.0022	32	1,2,3,7,8,9 - HxCDD	8.33×10^{-10}
13	Lead	0.0007	33	1,2,3,4,6,7,8 - HpCDF	6.33×10^{-9}
14	Manganese	0.0042	34	1,2,3,4,7,8,9 - HpCDF	3.33×10^{-9}
15	Nickel	0.0183	35	1,2,3,4,6,7,8 - HpCDD	3.33×10^{-9}
16	Benzo(a)pyrene[4]	0.02	36	OCDF	1.67×10^{-8}
17	Beryllium	0.0002	37	OCDD	1.67×10^{-8}
18	Benzene	0.0033	38	Antimony	0.0002
19	Chlorine	0.0067	39	Boron	1.1
20	Chromium (VI)	0.015			

Notes:
[1] Oxides of Nitrogen expressed as Nitrogen Dioxide (NO_2)
[2] Variable hourly emission rates of SO_2 were provided by Alcoa for the year 2008-2012. These actual values were used for modelling and validation.
[3] Average of emission rates of SO_2 for 2008-2012 based on hourly emission rates provided by Alcoa.
[4] The determination of PAH's is based on TEQ values that have been calculated using the toxicity equivalence factors (TEF's) relative to Benzo(a)pyrene, as reported by Larsen and Larsen (1998) in WHO (2003)

With the exception of SO_2 where hourly emissions rates were used, the emission rates presented in Table 4 were used in the modelling. Trace element composition data for the particulate emissions were used to assess the concentrations of metals resulting from the Coal Mine operations. The maximum trace element concentrations measured during 2010 for the coal operations used in the air quality assessment, are presented as Table 5.

Table 5: Summary of Trace Elements present in Coal

No.	Trace Element	Maximum (mg/kg dry coal basis)	No.	Trace Element	Maximum (mg/kg dry coal basis)
1	Beryllium	0.9	6	Mercury	0.19
2	Chloride	400	7	Nickel	19
3	Chromium (total)	7	8	Lead	3
4	Copper	80	9	Antimony	0.2
5	Fluoride	41			

Notes:

Trace element analysis conducted quarterly on coal samples in 2010 and the results were provided by Alcoa (N.Marris *pers. comms*. 18 July 2011)

2.3.3 Treatment of Non-Detect Data

There are four approaches that are typically used to manage non-detect data in the formation of an Emission Inventory (USEPA 1991). These include:

Approach 1: The use of detection limit (DL) data for all non-detects. All non-detects are assigned the value of DL (i.e. the largest concentration of analyte that can be present but not detected).

Approach 2: The reporting of Non-detects as Zero. In which all non-detect chemicals are assumed to be absent.

Approach 3: Non-detects reported as half the DL. This assumes that on average all values between DL and zero could be present, and that the average value of non-detects could be as high as half the detection limit.

Approach 4: Statistical estimate of concentrations below the DL: Use of statistical methods to estimate concentrations below the DL. This approach is more suited for datasets that have a high proportion of detects (> 50%). Therefore statistical predictions of concentrations below the DL are recommended only for compounds which significantly impact the risk assessment and for which data are adequate.

The choice of the appropriate method depends on a number of factors including the severity of the data screened, the size of the data set, and what distributional assumptions are reasonable. ENVIRON's approach to defining the non-detects within this report are as follows:

- **Approach 2**: Non-detects are reported as zero when all analysis returns values below the minimum detect for the emission source in question.
- **Approach 3**: Applied if the analyte is known to be present in the raw materials or generated during the process but not detected in the sampling and analysis undertaken and/or detected in at least one sample.

3 Coal-Mine Operations

3.1 Production and Throughput

The Anglesea Coal Mine is an open pit mine located near the Anglesea Power Station. The mine has a crusher with a capacity of 500 tph (dry) and the coal typically has a moisture content of approximately 44.8%. The coal mine plant typically operates between 7am and 7pm, seven days per week for around 4,380 hours per year to produce 1.1 Mtpa of coal for the Power Station.

3.2 Coal Mining Operations

Alcoa extracts brown coal and moves overburden within the open cut mine using excavators (mechanical diggers) and 60t dump trucks. The excavators load the coal onto trucks for delivery to the primary crusher. Coal is dropped in a 70t hopper at the primary crusher area and is then fed to the crusher via a vibrating feeder. No screening takes place. From the crusher the coal is fed to the live stockpiles. Coal is reclaimed from live stockpile by apron feeder and transferred to the power station via feed conveyor. The operation of the feed conveyor is automated and the coal feed operates continuously.

3.3 Potential Dust Sources

The main potential sources of dust emissions and the proposed dust control measures that will be utilised at the coal mine are described in the following sections. The efficiency of the proposed dust control measures are also described. The control efficiencies are primarily based on the National Pollutant Inventory (NPI)'s estimated control factors for mining activities (NPI, 2012). Potential sources of dust include:

- coal/waste excavation;
- movement of material in pits (i.e. loading of haul trucks).coal/waste dumping onto stockpiles;
- coal crushing;
- conveyor transfer points;
- wheel generated dust from truck movements; and
- wind erosion from ore/waste stockpiles and cleared areas.

3.3.1 Coal/Waste Loading of Trucks

Removal of coal and waste material at the mine has been modelled as the material being lifted and loaded in haul trucks. The emission factors from the NPI Emission Estimation Technique Manual (EETM) for Mining v3.1 (NPI, 2012) were used in conjunction with the total material movements.

3.3.2 Coal/Waste Material Dumping

Coal from the pits is transported to the primary crusher and stockpiled near the primary crusher while overburden is taken to the waste dumps. Dust suppression is provided by water truck which is used to wet down near the digging area. Emissions from loading and unloading of overburden from haul-trucks were calculated by using the emission factor from the NPI EETM for Mining v3.1 (NPI, 2012) based on the total amount of material moved.

3.3.3 Coal Crushing

Coal from the mine is considered to be high moisture content for emission estimation purposes (i.e. greater than 4% by weight). The NPI EETM for Mining v3.1 (NPI, 2012) provides emission factors for crushing based on the moisture content and throughput. For primary crushing of high moisture content ores, the PM_{10} default emission factor is given as 0.004 kg/t. Primary crushing occurs for approximately 2,400 hours per year. Wetting sprays are included at the crusher to minimize dust emissions even though the coal moisture content is very high.

3.3.4 Conveyor Transfer

Conveyor transfer points are potentially a large source of dust emissions. Emissions from transfer points can arise following the initial start-up, where material which has dried out on the conveyor falls off at the belt return, or can occur as material falls off at the belt idlers on the return belt, or via winnowing.

At the coal mine, coal will be conveyed from the primary crusher to the live stockpiles and from these stockpiles to the Power Station. Two transfer stations are used.

Alcoa has committed to enclosing the transfer points and the control efficiency adopted for these sources for modelling purposes is 75%. This is less than the 100% recommended by the NPI (2012) for a totally enclosed system to allow for dust emissions which may escape through the conveyor entry and exit openings and to ensure that the emissions estimates remain conservative.

3.3.5 Conveyor Belts

When exposed to high winds, material on conveyor belts can be lifted off creating nuisance impacts. This is particularly true if there are high conveyors exposed to strong winds or the material being conveyed is prone to dusting.

The European Commission has published a series of publications on Integrated Pollution Prevention and Control, including “Reference Document on Best Available Techniques on Emissions from Storage” (European Commission, 2006). This document addresses the control of dust from conveying systems and states that “a main source of dust emissions from belts is when the returning part of the belt comes into contact with the support pulleys.”

The European Commission’s Best Available Techniques (BAT) document defines BAT for conveyors and transfer chutes as follows:

> “For all types of substances, BAT is to design conveyor to conveyor transfer chutes in such a way that spillage is reduced to a minimum. A modelling process is available to generate detail designs for new and existing transfer points.
>
> For non or very slightly drift sensitive products (S5) and moderately drift sensitive, wettable products (S4), BAT is to apply an open belt conveyor and additionally, depending on the local circumstances, one or a proper combination of the following techniques:

– lateral wind protection;

– spraying water and jet spraying at the transfer points; and/or

– belt cleaning."

The European BAT document defines the dispersiveness of bulk material as follows:

> "The following classification, based on the susceptibility of a material to be dispersed and the possibility of dealing with the problem by wetting, is used for non-reactive products:
>
> – S1: highly drift sensitive, not wettable;
>
> – S2: highly drift sensitive, wettable;
>
> – S3: moderately drift sensitive, not wettable;
>
> – S4: moderately drift sensitive, wettable; and
>
> – S5: not or very slightly drift sensitive."

The European BAT document provides information on dispersiveness classes of solid bulk materials and categorises brown coal within the S4 dispersive class. Therefore, based on the European Best Available Practice documentation the management of transfer points (use of sprays or enclosing), return conveyor dust (belt scrapers/washing), and maintaining moisture in the coal are key to minimising dust from conveyor operations. With these controls in place, the amount of dust expected to be generated from uncovered conveyors would be negligible from a modelling perspective.

As such, the current modelling has only considered particulate emissions from the conveyor transfer points.

3.3.6 Stockyards

The majority of coal from the mine is dumped directly into the crusher. However it is assumed that up to 2% of the coal will be dumped at a permanent stockpile that is in addition to the two live product stockpiles that are used to provide coal to the Power Station.

3.3.7 Stacking

The coal from the crusher is conveyed to the live stockpiles by a conveyor and is placed onto the stockpile from a controlled drop height.

3.3.8 Vehicles and Wheel Generated Dust

Emissions from vehicles travelling along the haul roads have been estimated using the equation developed by the USEPA and provided in the NPI EETM for Mining v3.1 (NPI 2012).

The total vehicle kilometres travelled (VKTs) for haul trucks was calculated based on the estimated distance for the round trip between the mine and the primary crusher and the number of trips per year travelled by the haul trucks.

Alcoa uses a fleet of five haul trucks (60 tonnes each), one dozer and two excavators to produce 1.1 Mtpa of coal. Alcoa has also indicated that water trucks are used for dust suppression on unsealed roads. A summary of the emission estimates from the coal mine and the controls is listed in Section 3.4, Table 6.

3.4 Coal Mine Operations - Particulate Emission Estimates

To enable the prediction of ground level dust concentrations generated from the coal mine operations, hourly dust emission rates are required to be estimated from all major sources. Factors which are important for dust generation include:

- the coal type being handled;
- moisture content;
- operational activities;
- quantity of coal being moved and the number of movements;
- size of stockpiles and level of activity;
- level of vehicle traffic, average speed and load;
- rainfall;
- evaporation; and
- wind speed.

The throughput rates, emission factors, control factors and resultant particulate emission estimates for the 1.1 Mtpa of coal production based on the methodology presented in Section 3.3 are presented in Table 6. A conservative approach has been adopted in setting emission estimates for stockpiling and reclaiming activities.

The emission factors are primarily based on the default emission factors recommended by the NPI (2012) for ‘high’ moisture coal. The control efficiencies adopted for each emission source are based on the recommended NPI (2012) control factors.

In should be noted that dust emission estimates for fugitive dust sources contain a high degree of uncertainty due to the complexity of characterising emission rates, the control efficiencies, and the effectiveness of management measures.

Table 6: Emission Factors, Control Factors and Average Particulate Emission Rate Estimates

Source	No. of Operational Hours	Tonnage Throughput (Mtpa)	PM_{10} Emission Factor (kg/h)	PM_{10} Emission Factor (kg/t)	Control Factor (%)	PM_{10} Emission Estimate (g/s)
Dozer on Coal	597	-	0.3	-	-	0.1
Dozer on Overburden	2389	-	0.7	-	-	0.2
Excavator	2986	3.4		0.014	75	1.1
Coal Rehandle Permanent Stockpile	2986	0.02	-	0.0017	50	0.002
Coal Loading to Haul Trucks	2986	1.1	-	0.0144	-	1.4
Unloading from Truck to Crusher	2986	1.1	-	0.003	-	0.3
Waste Loading to Haul Trucks	2986	2.3	-	0.0003	-	0.06
Waste unloading to waste dump	2986	2.3	-	0.0036	-	0.8
Primary Crusher on Coal	2400	1.1	-	0.002	70	0.06
Haul Road 1[1]	5706	-	-	-	75	0.5
Haul Road 2[1]	6536	-	-	-	75	1.6
Transfer Station 1	8760	0.55	-	0.002	70	0.02
Transfer Station 2	8760	0.55	-	0.002	70	0.02
Stacking	8760	1.1	-	0.0017	0	0.06
TOTAL						6.2

Notes
[1] Details calculations for Haul Road emission rates listed in Appendix D.

An annual hourly variable emission file for PM_{10} was created for this assessment based on the factors presented in Table 6 and the methodology presented in Section 3.3. The variable emissions file, particle size distribution data and a particle size density of 1 g/cm^3 (on which the USEPA particle size diameters are based) were used in the modelling to generate the predicted TSP and $PM_{2.5}$ emissions and subsequent ground level concentrations.

The USEPA's particle size distributions for batch drop, wind erosion and vehicle emissions (USEPA, 2004a and b; USEPA, 2006b) are presented in Table 7. The distribution data for batch drop and wind erosion are similar, while the particle size distribution for vehicle

emissions contains a lower percentage of $PM_{2.5}$. In the absence of particle size distribution data for the TSP, PM_{10} and $PM_{2.5}$ fractions, a composite distribution was derived from the USEPA's three emissions categories (Table 7). It is noted that adoption of a composite distribution represents a simplification as different particulate emission sources will have different particle size distributions (e.g. wind erosion versus vehicular dust) and there may also be differences between particle size distributions between the different material types.

Table 7: Particle Size Distributions

Particle Size Range (µm)	Representative Particle Size (µm)	Percentage of Particulate (%) in Various Size Ranges					
		USEPA Batch Drop	USEPA Wind Erosion	USEPA Unpaved Road	This Study		
					TSP	PM_{10}	$PM_{2.5}$
<2.5	1.3	11	14.8	3.3	9	30	100
2.5 - 5.0	3.8	9	22.2	18.7	8	27	-
5.0 - 7.5	6.3	15			7	23	-
7.5 – 10	8.7				6	20	-
10 – 15	12.5	13	7	52	14	-	-
15 – 23	19	26	30		15	-	-
23 – 30	26				15	-	-
30 – 40	35	26	26	26	15	-	-
40 – 50	45				11	-	-

Notes:

1. Particle sizes are equivalent aerodynamic size and not the physical size. The equivalent aerodynamic size relates to the aerodynamic properties of the particle. For example PM_{10} samplers measure the dust below 10 µm equivalent aerodynamic size and not the physical size.
2. Wind erosion and vehicle emission size distributions are given for below 30 µm only, but have been adjusted here to less than 50 µm based on assuming 74% of the particulate is less than 30 µm as per the batch drop distribution.
3. The distribution of $PM_{2.5}$ has been modelled assuming a single representative particle size of1.3µm.

The USEPA particle size diameters are associated with the equivalent aerodynamic particle diameters which assume a particle density of 1 g/cm^3. Brown coal has a density of around 1.05 g/cm^3.

Generation of the hourly variable emission file requires specific hours of the day to be nominated during which emissions from each potential dust source may be released. It was assumed for modelling purposes that operations will occur at regular intervals across the operational hours (i.e. 7am to 7pm on a daily basis).

3.4.1 Wind Erosion

Dust emissions generated by wind erosion are generally negligible below a wind speed threshold, but increase rapidly when wind speeds exceed the threshold. Dust emissions from wind erosion are also dependent on the erodibility of the material which in turn is dependent on the size distribution of the material and whether a crust has developed. In general, material with a large (>50%) fraction of non-erodible particles (generally particles greater than 1 mm to 2 mm) will not erode as the erodible fraction is protected by these particles. As such, lump coal is not erodible by wind erosion although it is often dusty during material handling where the small fines fraction can be liberated. Fine coal is generally much more susceptible to wind erosion, particularly if there is a large fraction of particles in the range from 0.1 mm to 0.25 mm which can be dislodged by wind and then rolled and skipped along the surface (saltation). These larger particles can then dislodge the smaller (<50 µm) dust fraction which can remain suspended in the air. The AP42 Industrial Wind Erosion Predictive Emission Factor was used to calculate wind erosion of open aggregate storage piles and exposed areas within the facility.

The USEPA (2006a) provides the following formula to estimate wind-generated particulate emissions in units of grams per square meter (g/m^2) per year from mixtures of erodible and non-erodible surface material subject to disturbance as:

$$\textit{Emission factor} = k \sum_{i=1}^{N} P_i \qquad \textit{(Equation 1)}$$

Where: k= particle size multiplier

N= number of disturbances per year

P_i= erosion potential corresponding to the observed fastest speed of wind for the ith period between disturbances, g/m^2

The particle size multiplier (k) for Equation 1 varies with aerodynamic particle size and is 0.5 for PM_{10} and 0.075 for $PM_{2.5}$.

For the coal stockpile areas, wind erosion was assumed to be negligible based on the high moisture content present in brown coal (44.8%). . At equilibrium, the coal moisture content results in an adsorbed multilayer of water which is 3-4 molecules thick (i.e. the micro-pores are completely water filled). The higher the moisture content of the coal, the greater the threshold wind velocity required to cause erosion. At 44.8% moisture content, the threshold friction velocity is higher than the wind gusts typically experienced on site and as such wind erosion of the coal stockpiles is rare.

4 Existing Environment

This section summarises the meteorology of the study area, the surrounding land use, ambient concentrations and background sources within the study area.

4.1 Meteorology

Anglesea experiences a temperate climate characterised by seasonal temperature changes, moderate humidity and moderate rainfall. Table 8 presents a summary of the meteorological conditions recorded at Anglesea during the 2008-2012 period.

Table 8: Summary of Meteorological Parameters for 2008-2012

Period	Wind Speed (m/s)[1]	Predominant Wind direction	Temperature (°C)[1]	Rainfall (mm)[2]
	Average			
Annual	3.9	north-west	18.3	671[2]
Summer	4.5	south-west	22.6	143
Autumn	3.2	north-west	19.0	144
Winter	3.7	north-west	13.8	214
Spring	4.3	north-west	18.5	170

Notes:
[1] Data from the Anglesea Power Station were used to summarise wind speed and wind direction while the BoM, AWS Aireys Inlet 2008-2012 were used to summarise temperature and rainfall.
[2] Average (2008-2012)

Predominant winds are from the north-west and south-west during the year. In the autumn, winter and spring months the prevailing winds are from the north-west; whereas the predominant summer winds are generally from the south-west. The annual average wind speed for the five year period was 3.9 m/s with the spring and summer months having stronger average winds.

Annual wind roses derived from Alcoa's Anglesea meteorological station for 2008-2012 are presented as Figures 3 to 7. A comparison of the intra-annual variability in wind profiles at Anglesea for the years 2008 to 2012 is presented in Figures 8 and 9. The comparison indicates that the winds experienced at the site are fairly consistent between years.

4.1.1 Surrounding Land Use

The Power Station and coal mine sit near a break in the side of a sloping 8,500 ha basin mostly surrounded by elevated terrain. The area surrounding the Power Station (and in the modelled domain) contains urban areas to the south-east, and farmland and vegetated areas ranging from low coastal scrub to forest to the south, west and north of the site. Topography rises unevenly to 200 m above sea level, with flat to undulating farmland in the north and the Otway Ranges to the west. Site specific land use and topographical information used in the dispersion modelling is presented in Figures 10 and 11.

4.2 Ambient Air Quality Monitoring

A summary of the ambient meteorological and air quality monitoring undertaken by Alcoa at its six ambient monitoring stations located in Anglesea for 2008-2012 are presented in this section. Ambient SO_2 monitoring is undertaken at the CFA Hut, Camp Wilkin, Community Centre, Primary School, Camp Rd and Scout Camp. The locations of the monitoring stations are presented in Figure 12.

A summary of the ambient concentrations of SO_2 measured at the six monitoring stations for 2008-2012 are presented as Table 9.

Table 9: 2008-2012 Summary of Ambient SO_2 Concentrations (µg/m^3)[1], 1-Hour Average

Statistics	Community Centre Site	Primary School Site	Scout Camp Site	Camp Wilkin Site	CFA Hut Site	Camp Rd Site
Maximum	511	516	606	547	583	585
99.9th Percentile	249	342	386	309	263	348
99.0th Percentile	63	134	219	63	50	166
95.0th Percentile	9	19	53	8	10	14
Number of Concentrations above NEPM Levels (571 µg/m^3 [200ppb])	0	0	1	0	1	1
Data Recovery Rate (%)	89	76[2]	91	92	93	93

Notes
[1]Concentrations are expressed at STP: 0^{o}C and 101.325 kilopascals (kPa)

[2]Reduced data recovery associated with station shutdown due to change of location – Station offline from 7 April 2011- 20 February 2012

The CFA Hut, Primary School and Scout Camp have each recorded one individual hourly concentration above the NEPM 1-hour standard (i.e. 571 µg/m^3) over the five year period between 2008 and 2012 inclusive. The NEPM goal (i.e. no more than one day where the NEPM 1-hour standard was exceeded) was met at all monitoring sites. The data recovery at the stations over the five years was good, generally being greater than 89% with the exception of the Primary School site where a lower data recovery rate occurred as a result of the relocation of the monitoring site.

4.2.1 Ambient Dust Monitoring

Alcoa commenced monitoring ambient PM_{10} and $PM_{2.5}$ concentrations at three sites located around the coal mine in July 2012. A summary of the monitoring results for the period 23 July-31 December 2012 are presented as Table 10. The locations of the monitoring stations are presented in Figure 13.

Table 10: 23 July 2012- 31 December 2012 - Summary of Ambient Dust Concentrations (µg/m^3), 1-Hour and 24-Hour averages

Statistics	Camp Rd Site (PM_{10})	Camp Rd Site ($PM_{2.5}$)	Camp Wilkin Site (PM_{10})	Camp Wilkin Site ($PM_{2.5}$)	Barwon Water (PM_{10})	Barwon Water ($PM_{2.5}$)
1-Hour Averages						
Maximum	205	31	112	89	137	26
99.9th Percentile	85	24	69	39	114	23
95.0th Percentile	52	16	59	28	43	19
Hourly Data Recovery Rate (%)	97	97	79[1]	97	91	87
24-Hour Averages						
Maximum	41.8	9.0	40.8	19.5	32.7	13.2
99.9th Percentile	40.8	8.8	40.3	18.4	32.6	12.8
95.0th Percentile	24.3	6.0	28.8	9.6	23.0	8.4

Notes
[1]Reduced data recovery associated with equipment malfunction
Concentrations are expressed at STP: 0°C and 101.325 kPa

Recorded data recovery at the stations over the 6 months was high, with capture rates generally above 90%. 1-hour average PM_{10} concentrations of greater than 100 µg/m^3 were observed at all sites and 1-hour average $PM_{2.5}$ concentrations over 50 µg/m^3 were observed at Camp Wilkin over the monitoring period. Dust pollution roses for all three sites are presented in Figures 14 to 19.

These pollution roses show that the peak concentrations are associated from wind sectors that were not associated with Alcoa's Anglesea operations, with Barwon Water recording PM_{10} 1-hour average concentrations over 100 µg/m^3 when the winds were from the north-west, north-east and south-east. 1-hour average PM_{10} concentrations less that 50 µg/m^3 and $PM_{2.5}$ 1-hour average concentrations less than 20 µg/m^3 are observed from all wind directions.

The maximum 24-hour average PM_{10} concentration observed was 41.8 µg/m^3 at Camp Rd. All 24-hour average concentrations recorded over the observed monitoring period were below the NEPM 24-hour standard of 50 µg/m^3 for PM_{10} and 25 µg/m^3 (Advisory Reporting Standard) for $PM_{2.5}$.

5 Model Methodology

Air dispersion modelling was undertaken using TAPM to predict the meteorology and the dispersion of the Power Station's stack emissions. CALPUFF was used to predict the ambient particulate concentrations resulting from the coal mine operations as it is better suited to modelling these low level fugitive sources than TAPM. TAPM was chosen to generate the three dimensional meteorological data as there is a lack of surface and upper air meteorological data available in the Anglesea area. The complex terrain of the region, and the impact of this on wind conditions mean that having temporally and spatially varying three dimensional meteorological conditions is important to the reliable prediction of the dispersion of the emissions.

Site specific meteorological files for the model domain were generated using TAPM, Version 4.05. TAPM is a prognostic model that predicts local three-dimensional meteorological data using synoptic, terrain, vegetation, soil type, and sea surface temperature data. The synoptic meteorological data are provided by the CSIRO and were derived from the GASP (Global Analysis and Prediction) data set which was generated by the Bureau of Meteorology (BoM) as part of its weather forecasting until 15 August 2010. After this date, the US NCEP (National Centers for Environmental Prediction) reanalysis product is used to provide the synoptic data due to the discontinuation of the GASP modelling. TAPM predicts a wide range of meteorological data including wind speed and direction, temperature, pressure, solar radiation, cloud cover and rain over the modelling domain. The CALTAPM program was used to extract the meteorological data from TAPM in the form that CALMET (used to generate the meteorological input file for CALPUFF) could use directly.

A summary of TAPM and CALPUFF parameterisation files is presented in the following sections with samples of the input files presented in Appendix C.

5.1 Model Parameterisation

5.1.1 TAPM

The meteorological simulations were completed using four nested grids (each 42 x 42 x 25 grid points) with grid spacing of 20, 8, 2 and 0.5 km respectively. The TAPM default setting was used to define the vertical grid levels. All of the model grids were centred at latitude 38°23.5′ S and longitude 144°10.5′ E, corresponding to 253,877 mE, 5,747,534 mN in GDA94 coordinates. TAPM supplied soil and terrain height databases were used as input into TAPM.

A user defined landuse database was incorporated into TAPM for the inner model grid to better represent the landuse surrounding Alcoa's Anglesea operations. A high resolution digital image was used to categorise the landuse in the study area. TAPM was run for the 2008 to 2012 calendar years and was configured to use three spin up days.

The ground level pollutant concentrations resulting from the Power Station's atmospheric emissions were predicted over the innermost TAPM model domain (i.e. 21 km by 21 km) with a grid resolution of 250 m.

5.1.2 CALPUFF

The CALPUFF modelling system was used for the air dispersion modelling of the particulate emissions from the coal mine and associated coal handling and storage operations.

CALPUFF is a transport and dispersion model that models “puffs” of material emitted from the sources, simulating dispersion and transformation processes along the transport pathway. Temporal and spatial variations in the meteorological fields are explicitly incorporated into the model. The model was configured to predict the particulate concentrations over the same model domain as used by TAPM (i.e. 21 km by 21 km with a grid resolution of 250 m). The meteorology predicted by TAPM was converted to a gridded three dimensional data file suitable for use by CALMET using the CALTAPM tool developed by TRC. CALMET (Version 6.326) used the CALTAPM output to produce a meteorological file suitable for use with CALPUFF thereby ensuring that the meteorological data used for both models was essentially the same.

5.1.3 Discrete Receptors

Fourteen receptor locations were identified for inclusion into the air dispersion modelling report and the screening HHRA as presented in Table 11. Eleven of the identified receptors were within the Anglesea town with the remaining three being located to the west (Bald Hills) and north (Forest Road and Water Basin) of Anglesea. These receptor locations were selected to represent a range of community facilities, residential areas, and sensitive receptors (e.g. Primary School). The receptor locations are considered to represent the range of potential public exposure to atmospheric emissions from the Power Station.

The locations of the receptors in relation to the Alcoa site are presented in Figure 20, overlain on a map of the local area. For purposes of this assessment all receptors are assumed to be residents, including potentially sensitive subpopulations such as children and the elderly.

Table 11: Summary of Discrete Receptors

Receptor		Distance/Direction from Alcoa Site	GDA Coordinates	
			East (m)	North (m)
1	Mt Ingoldsby / CFA Hut	3.1 km south	252,313	5,744,535
2	Bald Hills Road	5.7 km south-west	248,373	5,748,356
3	Water Basin	3.7 km north	254,613	5,751,195
4	Forest Road	2.7 km north-east	255,693	5,749,546
5	Scout Camp	2.6 km east	256,643	5,746,326
6	Primary School[1]	1.2 km south-east	254,635	5,746,129
7	Camp Road	1 km south-east	254,862	5,746,465
8	Community Centre	2.2 km south-east	254,266	5,745,210
9	Camp Wilkin	2.5 km south-east	253,548	5,745,288
10	Anglesea Surf Club	3.2 km south-west	254,334	5,744,588
11	Waste Treatment Plant	2.4 km south-east	255,413	5,745,616
12	Anglesea Caravan Park	3 km south-east	255,059	5,745,378
13	Fraser Avenue	1.8 km south-west	253,501	5,745,984
14	Pt Road Knight Carpark	4.2 km south	253,906	5,743,102

Notes:
[1] In May 2011 the Primary School SO_2 monitoring station was moved to Anglesea Bowling Club – GDA94 Coordinates 254,985 mE, 5745,299 mN, 0.9km south of the original location. For the purposes of this report the old location is used as validation is conducted using 2008-2011 data.
[2] Receptors 1,5,6,7,8 and 9 are the continuous ambient SO_2 monitoring sites.

5.1.4 Cumulative Impacts

To provide an indication of the cumulative impact that the Anglesea Power Station and coal mine emissions have on the regional air shed, the background ambient concentration of compounds were considered in the assessment. Background concentrations can arise from anthropogenic and non-anthropogenic activities in the study area.

Background concentrations were calculated based the SEPP (AQM) approach of using the 70th percentile concentrations.

The background concentrations adopted for this assessment have been presented in Table 12. The 70th percentile of all 1-hour and 24-hour average concentrations recorded at the monitoring stations has been adopted as the background concentration.

Table 12: Background Concentrations

Air Quality Parameter	Averaging Period	Background Level ($\mu g/m^3$)	Source
SO_2	1-hour	2	70^{th} percentile of observed data
PM_{10}	1-hour	18	
$PM_{2.5}$	1-hour	5	
PM_{10}	24-hour	17	
$PM_{2.5}$	24-hour	5	
Note: Background concentrations expressed at STP (0^oC and 101.325 kPa)			

Background concentrations could not be estimated for NO_2, carbon monoxide or other Class 2 and 3 indicators due to the absence of ambient monitoring data.

5.2 Model Validation

In order to obtain a measure of performance of the air dispersion model, the predicted meteorology and ambient SO_2 and particulate concentrations were compared to the ambient monitoring data collected by Alcoa. Air dispersion modelling has some inherent uncertainties and the USEPA (2001) indicates that modelling typically has inaccuracies of $\pm$10% to $\pm$40%. Ambient monitoring is also associated with a number of inaccuracies, which increase as the monitored values approach the threshold of detection. Typically measurement uncertainty ranges between $\pm$5% and $\pm$10%.

The model evaluation included comparison of wind speed and wind direction probability density function plots of observed vs. predicted data and a statistical evaluation. The statistical measures and the performance evaluation criteria were sourced from the following publications:

1 USEPA-454/R-92-025, Protocol for Determining the Best Performing Model. This document presents a statistical method for comparing the performance of models using classical statistical techniques.

2 ASTM D 6589, Standard Guide for Statistical Evaluation of Atmospheric Dispersion Model Performance. This documents methods and provides a program to evaluate model performance.

The statistical measures used to evaluate the predicted wind speeds were:

1 **Index of Agreement (IOA):** IOA reflects how well the predicted data estimates the observed mean are represented. Hurley (2000) suggests that an IOA of 0.5 or greater represents a good correlation. An IOA of 1 means a perfect correlation between predicted and observed.

2 **Root mean square error (RMSE):** This is an acceptable average measure of the difference or error between predicted and observed values. Low RMSE values in a model indicate that the model is explaining most of the variation in the observations.

3 **Systematic (RMSE_S) and Unsystematic RMSE (RMSE_U):** If the model is unbiased rmse_s should approach 0 and rmse_u should be close to rmse.

In addition, model acceptability criteria summarized by Chang and Hanna (2004) based on extensive experience concluded that for comparison of predicted and observed values (unpaired in space) “acceptable” performing models have the following typical performance measures.

1 **Fractional Bias (FB):** The fraction of predictions within a factor of two of observations is about 50% or greater (i.e. FAC2>0.5).

2 **Geometric mean bias (GM):** The mean bias is within +30% of the mean (i.e. roughly $|FB| < 0.3$ or $0.7 < GM < 1.3$).

3 **Random Scatter as Normalized mean square error (NMSE) and Geometric Variance (VG):** The random scatter is about a factor of two to three of the mean (i.e., roughly NMSE <1.5 or VG<4).

4 **Standard Deviation (Predicted and Observed).** A model is predicting with skill if the standard deviations of the predictions and observations are approximately the same (Piekle 1984).

A summary of the statistical measures used to assess the performance of TAPM with respect to wind speed are presented in Table 13 together with the results of the valuation.

Table 13: Performance Evaluation Summary – Wind Speed (2008-2012)

Statistical Method	Performance Evaluation Criteria	Result
		Anglesea Meteorological Site
RMSE	<2	1.75
IOA	>60%	83%
Fractional Bias	>-0.3 and <0.3	-0.04
NMSE	<1.5	0.19
SD Observed	n/a	2.43
SD Predicted	n/a	1.99
Max Observed	n/a	19.3
Max Predicted	n/a	15.3
Avg Observed	n/a	3.9
Avg Predicted	n/a	4.1

The model evaluation results indicate that TAPM's skill level in predicting the wind speed is acceptable based on the comparison with the Anglesea monitoring data. The performance of TAPM at Anglesea is comparable to its performance observed at other sites in Australia based on ENVIRON's experience.

Plots of predicted and observed wind speed and wind direction are presented in Figures 21 and 22. These figures indicate that the winds are generally well predicted by the model. TAPM over predicts the frequency of winds between 2 and 4 m/s at the Anglesea meteorological station and under predicts the lighter winds. Wind direction is generally well predicted by the model with a marginal under prediction of the southerly component of winds and an over prediction of the south westerly component.

5.2.1 Model Validation –Sulphur Dioxide

The performance of TAPM was validated against the measured ambient SO_2 concentrations. The predicted SO_2 concentrations were compared to the observed SO_2 concentrations at the six ambient monitoring sites (i.e. CFA Hut, Primary School, Camp Rd, Scout Camp, Camp Wilkin and Community Centre). Figures 23 to 28 and Table 14 present the results of the evaluation of TAPM's performance for ambient SO_2 concentrations.

Table 14: Predicted and Observed Ground Level Concentration SO_2 – 2008-2012

	Comm Centre ($\mu g/m^3$)	Primary School ($\mu g/m^3$)	Scout Camp ($\mu g/m^3$)	Camp Wilkin ($\mu g/m^3$)	CFA Hut ($\mu g/m^3$)	Camp Rd ($\mu g/m^3$)
Average Observed	3	5	10	3	3	6
Average Predicted	3	2	5	2	2	2
1-Hour Average Concentrations						
Max Observed	511	516	606	547	583	585
Max Predicted	1291	692	538	1303	1036	1375
99.9th Percentile Observed	249	342	386	309	263	348
99.9th Percentile Predicted	255	208	385	294	270	263
99.0th Percentile Observed	63	134	219	63	50	166
99.0th Percentile Predicted	88	47	198	59	36	65
95.0th Percentile Observed	9	19	53	8	10	14
95.0th Percentile Predicted	7	2	14	2	1	3
RHC[1] Observed	452	488	495	470	452	472
RHC Predicted	570	417	497	613	691	580

Notes
All statistics based on hourly timeframe
Concentrations are expressed at 0°C and 101.325 kPa
[1] RHC - Robust highest concentration

The SO_2 model validation results indicate that the maximum 1-hour averaged concentration predicted over the five year period is over-predicted by the model at five of the monitoring locations with only the predicted concentrations at the Scout Camp being less than those measured. The 99.9th percentile concentration is well predicted at four of the monitoring sites and is under-predicted at the Primary School and Camp Road sites. As the compared percentile concentrations decreases, there is general under prediction of the predicted concentrations based on the observed data. It is considered that these under-predictions are likely to be associated with changes in the emission characteristics (i.e. emission volume, temperature, and emission rate) over the conditions modelled, changes in the wind direction over the modelled hour and differences between the predicted and observed meteorological conditions.

An important test for pollution management and regulatory applications is whether the model can correctly predict the extreme (or high) end of the concentration frequency distribution constructed using data collected over a year. The robust highest concentration (RHC) (Cox and Tikvart, 1990) as expressed by Equation 2 can be used for quantitative evaluation.

$$RHC = C(R) + (C - C(R)) \ln\left(\frac{3R-1}{2}\right) \qquad \textit{Equation 2}$$

Where: C(R) is the Rth highest concentration; and

C is the mean of the top R − 1 concentrations.

The RHC is based on an exponential fit to the highest R – 1 values of the cumulative frequency distribution. A value of R = 11 has been used in this analysis so that C is the average of the top ten concentrations, which is an accepted statistic for evaluation of model performance (Hanna, 1988). The RHC is preferred to the maximum value because it mitigates the undesirable influence of unusual (stochastic) events, while still representing the magnitude of the maximum concentration (unlike percentiles). Based on the results in Table 14, the RHC is over-predicted at four of the six monitoring sites (i.e. Community Centre, Camp Wilkin, CFA Hut and Camp Rd) by between 23% and 56%. The RHC is under-predicted at Primary School by 15% and is well predicted at the Scout Camp.

The comparison between predictions and observed data shows that the model performance for estimating the SO_2 concentrations is satisfactory given assumptions made (i.e. constant emission volume and temperature) in the modelling.

5.2.2 Model Validation – Fugitive Dust

The performance of CALPUFF was validated against the observed ambient dust concentrations for the six months of available ambient monitoring data for the three monitoring sites (i.e. Camp Rd, Camp Wilkin and Barwon Water). Figures 29 to 31 and Table 15 present the results of the evaluation of CALPUFF's performance for ambient dust concentrations.

Table 15: Predicted and Observed Ground Level Concentration PM_{10} and $PM_{2.5}$ – July to December 2012

Statistics	Camp Rd Site (PM_{10}) ($\mu g/m^3$)	Camp Rd Site ($PM_{2.5}$) ($\mu g/m^3$)	Camp Wilkin Site (PM_{10}) ($\mu g/m^3$)	Camp Wilkin Site ($PM_{2.5}$) ($\mu g/m^3$)	Barwon Water (PM_{10}) ($\mu g/m^3$)	Barwon Water ($PM_{2.5}$) ($\mu g/m^3$)
Average Observed	14	2	17	5	13	5
Average Predicted	17.9	5.3	18.3	5.5	17.2	5.1
1-Hour Average Concentrations						
Max Observed	205	31	112	89	137	26
Max Predicted	110	54	170	66	80	37
99.9th Percentile Observed	85	24	69	39	114	23
99.9th Percentile Predicted	71	27	86	37	45	18
99.0th Percentile Observed	46	14	51	22	38	17
99.0th Percentile Predicted	32	10	41	14	24	8
95.0th Percentile Observed	32	9	37	13	28	11
95.0th Percentile Predicted	23	7	24	8	18	5
RHC Observed	95	23	73	47	91	23
RHC Predicted	77	30	98	39	49	19
24-Hour Average Concentrations						
Max Observed	41.8	9	40.8	19.5	32.7	13.2
Max Predicted	36.2	11.3	36.0	13.1	25.3	8.9
99.9th Percentile Observed	40.8	8.8	40.3	18.4	32.6	12.8
99.9th Percentile Predicted	34.9	11.1	35.7	12.6	24.9	8.7
99.0th Percentile Observed	33.2	7.7	36.6	11.2	31.9	10.3
99.0th Percentile Predicted	27.6	9.3	32.8	10.2	21.3	7.0
95.0th Percentile Observed	24.3	6	28.8	9.6	23	8.4
95.0th Percentile Predicted	24.8	7.8	24.4	7.7	19.2	5.8
RHC Observed	29	7	31.6	11.1	26.2	9.5
RHC Predicted	26.7	8.6	28.4	9.1	20.5	6.4

Notes
Background concentrations as listed in Table 12 are included in the concentrations.
Concentrations are expressed at 0°C and 101.325 kPa

The dust modelling validation results indicate that the maximum and RHC predicted 1-hour average concentrations of PM_{10} for the six month period is under predicted by the model at Camp Rd and Barwon Water sites and over predicted at the Camp Wilkin site. The Barwon Water site is situated well over 3 km from the coal mine and power station and therefore the measured ambient particulate concentrations are not expected to be significantly influenced by Alcoa's Anglesea operations. The higher measured concentrations at the Barwon Water are likely to be due to periodic local or regional (e.g. smoke from bushfires) that are not captured within the background concentrations included in the modelling.

The dust modelling validation results indicate that the maximum and RHC predicted 24-hour average concentrations of PM_{10} in the six months are under-predicted by small margins at all sites. As for the 1-hour concentrations, the predicted concentrations at the Barwon Water site were under-predicted by the most significant margin which indicates that other local or regional sources not considered in the modelling are contributing to the measured concentrations.

The annual average PM_{10} concentrations at all of the monitoring sites are predicted to be slightly higher than those recorded. It should be noted that the background concentration (17 $\mu g/m^3$) was the major contributing factor to the predicted annual average concentrations for PM_{10}. Therefore, any change to the background concentration used in the modelling will impact on the model comparisons.

The comparison between the measured and predicted $PM_{2.5}$ concentrations shows similar outcomes to those found for PM_{10} with over- and under-predictions at the different monitoring sites.

Overall, the results of the model validation study indicate that the air dispersion modelling is predicting the ground level concentrations, particularly the 24-hour average concentrations RHC, at a satisfactory level of accuracy.

5.3 Model Results

The predicted 99.9th 1-hour (i.e. 44th highest) and 99.5th 24-hour (i.e. 9th highest) ground level concentrations for the modelled years (2008-2012) are presented in Table 16 and compared against the SEPP (AQM) criteria.

Concentration isopleths for selected compounds and predicted concentrations at discrete receptors are presented as Appendix E. The predicted concentrations presented in Table 16 represent those predicted for the Anglesea power station and the coal mine emissions considered in isolation due to the absence of any background concentration data for all compounds other than SO_2 and particulates.

Table 16: Predicted Concentration of Compounds in the Modelled Domain[1]

Pollutant	Averaging Period	Alcoa Only[2] Concentration in Modelled Domain outside Plant Boundary	SEPP (AQM) design ground level concentration
		µg/m^3	µg/m^3
SO_2	1h	**859**	450 (170 ppb)
$PM_{2.5}$	1h	**168**	50
PM_{10}	1h	**475**	80
NO_2	1h	71	190
CO	1h	1.9	29,000
Total Fluoride	24h	0.1	3
Antimony	3 min	0.003	17
HCl	3 min	5.2	250
Chlorine	3 min	0.008	100
Arsenic	3 min	0.0025	0.17
Cadmium	3 min	0.0002	0.03
Chromium (III)	3 min	0.02	17
Chromium (VI)	3 min	0.02	0.17
Copper	3 min	0.07	6.7
Benzene	3 min	0.004	53
Beryllium	3 min	0.002	0.007
Lead	1h	0.02	3
Manganese	3 min	0.005	33
Mercury	3 min	0.001	0.33
Nickel	3 min	0.02	0.33
Benzo[a]pyrene	3 min	0.03	0.73
Dioxins and Furans[3]	3 min	3.8×10^{-9}	3.7×10^{-6}
		Alcoa Only[2] Concentration in Modelled Domain outside Plant Boundary (µg/m^3)	Texas Commission on Environmental Quality (TCEQ) Effects Screening Levels (2009) – Air Quality Objective (µg/m^3)
Boron	1h	0.8	50
	Annual	0.02	5

Notes:

1. 99.9th percentile values were used for compounds with an averaging periods of 1hr or less and 99.5th percentile concentrations were used for compounds with averaging periods greater than 1hr.

2. Background Concentrations not included.

3. The Toxic Equivalent (TEQ) values have been calculated using the toxicity equivalence factors (TEF) according to the Van den Berg *et al* (2006). The toxicity is assessed by multiplying a congener's concentration with its TEF and summing the resulting values to derive the TEQ emission. The most toxic congener is 2,3,7,8-Tetracholorodibenzodioxin (TCDD) which has a factor of one, with all other 2,3,7,and 8 congeners failing between 0.0001 and one.

Concentrations are expressed at 25°C and 101.325 kPa

The modelling results indicate that PM_{10}, $PM_{2.5}$ and SO_2 are predicted to exceed the SEPP (AQM) design ground level concentration criteria within the model domain. The contours of the predicted 1-hour average concentrations of SO_2, PM_{10} and $PM_{2.5}$ are presented as Figures E1, E6 and E7 respectively in Appendix E.

5.4 Air Dispersion Modelling Key Findings and Conclusions

The key findings of the air dispersion modelling assessment are:

1 The model validation indicated that both the meteorology and dispersion of compounds from the power station and coal mine are well predicted in the modelled domain.

2 The 99.9th percentile 1-hour average concentrations of SO_2 are predicted to exceed the SEPP (AQM) (450 µg/m^3) design criteria to the west and north of the power station. Therefore SO_2 has been included in the screening HHRA.

3 The 99.9th percentile 1-hour average concentrations of PM_{10} are predicted to exceed the SEPP (AQM) design criteria (80 µg/m^3) in the areas near the coal mine crusher and permanent stockpile and to the north-west of the power station. Therefore PM_{10} has been included in the screening HHRA.

4 The 99.9th percentile 1-hour concentrations of $PM_{2.5}$ are predicted to exceed the SEPP (AQM) design criteria (50 µg/m^3) in the areas of near the coal mine crusher and permanent stockpile. Therefore $PM_{2.5}$ has been included in the screening HHRA.

5 The predicted concentrations for all other compounds considered in this assessment were below the SEPP (AQM) design criteria guidelines and are therefore were not included in the screening HHRA.

6 Screening Human Health Risk Assessment

6.1 Background

Risk assessment provides a systematic approach for characterising the nature and magnitude of the risks associated with environmental health hazards, and is an important tool for decision-making. enHealth (2012) describe the five stages of a health risk assessment as being:

1. **Issue identification**. Defines the reasons for the risk assessment being conducted including identifying the existing environmental conditions, potential populations that may be exposed, exposure pathways and exposure mitigation options.

2. **Hazard identification**. Identifies the guideline values for each chemical considered within the risk assessment where these are available. Where the risk assessment is associated with the establishment of such guidelines, the hazard identification will generally include detailed literature reviews on toxicity and dose-response relationships.

3. **Dose response assessment**. Identifies the quantitative relationship between exposure and effects of concern including the response from different population sub-groups.

4. **Exposure assessment**. Defines the magnitude, frequency, duration and routes of exposure to compounds present in the environment. In this assessment, exposure is estimated as the concentration of a compound that a person may be exposed to over both short-term (i.e. acute) and long-term (i.e. chronic) exposure periods. The results of the air dispersion modelling presented in Section 5 have been used to provide the data used in the exposure assessment.

5. **Risk Characterisation**. Determines if exposures to the chemicals of potential concern comply with the health based guideline values. It also identifies potential sources of uncertainty and the extent to which the outcomes of the risk assessment may be affected.

6.1.1 Issue Identification

The Anglesea Power Station and Coal Mine are located to the north and north-west of the town of Anglesea. Alcoa commenced ambient SO_2 monitoring in Anglesea in 1999 at the CFA Hut site. In 2009 Alcoa developed and implemented an AQCS with the objective of ensuring that the power station operations were managed such that the NEPM 1-hour average ambient standard for SO_2 was not exceeded in the town of Anglesea.

In 2012, an ambient PM_{10} and $PM_{2.5}$ monitoring program was commenced in the vicinity of the coal mine and the power station to gather data on ambient particulate concentrations that occur in the Anglesea area.

The atmospheric emissions from the Anglesea Power Station and coal mine contain a number of compounds in addition to SO_2 and particulates. The air dispersion modelling study and screening HHRA has been undertaken in order to assess the potential health risks that may arise from the atmospheric emissions impacting upon the Anglesea community.

As part of the air dispersion modelling study a comprehensive emission inventory was developed (see Section 2.3 and Section 3.4). This inventory identified 39 individual compounds or groups of compounds that were included in the air dispersion modelling study (Section 5). The predicted ground level concentrations were compared to the design criteria specified in the SEPP (AQM). Of the compounds modelled, only SO_2, PM_{10} and $PM_{2.5}$ did not meet the SEPP (AQM) design criteria. The SEPP (AQM) states that where the design criteria are not met, a health risk assessment may be undertaken and therefore SO_2, PM_{10} and $PM_{2.5}$ were considered in the screening HHRA.

6.1.2 Hazard Identification and Dose Response

SO_2, PM_{10} and $PM_{2.5}$ have been considered in the screening HHRA. Information relating to each of these compounds and the current NEPM air quality standards is presented in the following sections.

Sulphur Dioxide

SO_2 is a colourless, irritating and reactive gas with a strong odour. SO_2 is highly soluble and is quickly absorbed in the moist environment of the upper or lower airways of the respiratory tract, where it exerts its adverse effect.

Exposure to SO_2 can create an acute response including coughing, wheezing, aggravation of asthma, and irritation eyes.

Many organisations including the World Health Organisation (WHO) (2006), USEPA (2008 and 2009), RAT (2010) and NEPC (2011) have documented the potential health effects associated with exposure to SO_2 based on the available research. In general these studies have found that asthmatics in particular, and to a lesser extent the young and the elderly, are more susceptible to short term health impacts arising from exposure to SO_2. The studies have also found that exercising asthmatics are generally more susceptible than resting asthmatics, but that the response is very variable within this sub-population.

Asthmatics have been shown to respond very quickly (within minutes) and respond to a wide range of exposure concentrations which means that a threshold concentration cannot be readily determined. Epidemiological studies have also shown an association between short-term exposures and increases in daily mortality from respiratory and cardiovascular effects (NEPC, 2011).

The WHO (2006) concluded that the minimum concentration that evoked changes in the lung function in exercising asthmatics was in the order of 0.4 ppm (or 1,144 $\mu g/m^3$). The WHO (2006) recommended that its existing 10-minute average guideline of 500 $\mu g/m^3$ be retained to provide health protection to exercising asthmatics. The derivation of this guideline included a safety factor of two over that concentration observed to evoke changes in lung function in sensitive exercising asthmatics. The health effects arising from short term

exposure to SO_2 are themselves short-term. The WHO (2006) also recommended a 24-hour average guideline of 20 µg/m^3 based on epidemiological studies conducted for cities including Hong Kong and London. The WHO (2006) indicated that there was considerable uncertainty as to whether SO_2 was the pollutant responsible for the observed effect noting that SO_2 was not considered to be causal to reduced mortality in Germany and the Netherlands.

The USEPA (2008) concluded that a greater portion of exercising asthmatics would experience an increase in the respiratory effects with increasing SO_2 exposure concentrations between 0.2 ppm and 1 ppm with exposure times of 5 to 10 minutes.

The findings of the NEPC (2011) review of the SO_2 health evidence indicated that health effects are observed at current levels of SO_2 in Australian cities which are well below the NEPM standard. The effects are greatest in people with asthma.

Particulates

Particulate matter can consist of a single compound but is more often comprised of a mixture of many different compounds each of which can have different chemical and physical characteristics. Research findings on exposure and risks are complicated by these variable characteristics and different particle sizes. Particulate matter is classified as a function of its aerodynamic diameter as this is important in determining its penetration into the respiratory tract. The USEPA promulgated standards for PM_{10} and $PM_{2.5}$ in 1987 and 1997 respectively (USEPA, 1987, 1997). PM_{10} includes those inhalable particles that are sufficiently small to penetrate to the thoracic region. $PM_{2.5}$, the fine fraction of PM_{10}, is considered to have a high probability of deposition in the smaller conducting airways and alveoli (WHO, 2006).

The toxicity of particulate matter may result from one or more factors, including the actions of the particulate composition, and its presence in the body. The WHO (2006) reported that the US National Research Council (2004) provided a summary table of particle characteristics that may be important to health responses, including size mode, mass concentration, number concentration, acidity, particle surface chemistry, particle core chemistry, metals, carbon (organic carbon and black or elemental carbon), biogenic origin, secondary inorganic aerosols, and material associated with the earth's crust. Other characteristics that have been recognised as potentially playing a role in toxicity are particle surface area, chemical reactivity, water solubility of constituent chemicals and the geometric form of the particles.

The NEPC (2011) found that there is substantial evidence that both short-term and long-term effects for PM_{10} and $PM_{2.5}$ exposure are associated with increases in mortality and morbidity. Particulate exposure can result in cardiovascular and respiratory effects, particularly respiratory disease, asthma and chronic obstructive pulmonary disease, while there are strong associations with ischemic heart disease and congestive heart failure (NEPC, 2011).

Sulphur Dioxide and Particulate Matter

Ambient air quality guidelines are generally associated with single compounds but exposure to a specific compound in the absence of other compounds is rare. Exposure to mixtures of chemicals could result in additive, synergistic or antagonistic effects being observed. The WHO (2006) state the observational studies have not resolved the issue of confounding

between SO_2 and particulate matter or other pollutants, nor have they systematically examined the synergistic effects. Generally, when multiple pollutants were evaluated, particulate matter tended to be more strongly associated with mortality or morbidity outcomes than SO_2 (WHO, 2006). In the absence of definitive studies additive, synergistic or antagonistic effects have not been considered in this screening HHRA.

Ambient Air Quality Guidelines

In 2008 the NEPC made the Ambient Air NEPM that set uniform national ambient air quality standards. The desired outcome of the NEPM "is ambient air quality that allows for the adequate protection of human health and well-being." (Australian Government, 2003). In 2003 the Ambient Air NEPM was revised to include $PM_{2.5}$.

A review of the NEPM commenced in 2007 with the release of a discussion paper (NEPC, 2007) and in May 2011 the NEPC produced a review report (NEPC, 2011) that makes a number of recommendations regarding the future of the NEPM including a shift in focus. One such shift is the acknowledgement that many compounds do not have a recognised threshold for adverse health impacts and therefore includes a recommendation to incorporate exposure reduction targets for priority pollutants. The implementation of the AQCS is an example of a program aimed at reducing population exposure to SO_2.

The Victorian State Environment Protection Policy (Ambient Air Quality) (EPAV, 2001b) (SEPP (AAQ)) specifically adopts the requirements of the Ambient Air NEPM. While they are currently under review, the NEPM ambient air quality standards represent the currently accepted standards in Australia and have therefore been used in this screening HHRA.

Table 17 presents a summary of the NEPM standards for SO_2, PM_{10} and $PM_{2.5}$.

Table 17: Summary of the NEPM Standards Used

Compound	Guideline	Units	Averaging Period	Reference
Acute Health Effects				
Sulphur dioxide	524	$\mu g/m^3$	1 h	NEPC
	209	$\mu g/m^3$	24 h	NEPC
PM_{10}	46	$\mu g/m^3$	24 h	NEPC
$PM_{2.5}$	23	$\mu g/m^3$	24 h	NEPC[1]
Chronic Health Effects				
Sulphur dioxide	52	$\mu g/m^3$	Annual	NEPC
$PM_{2.5}$	7	$\mu g/m^3$	Annual	NEPC

Notes:

1. NEPM Advisory Reporting Standard
2. Concentrations are expressed at 25°C and 1 atm pressure.

TAPM or CALPUFF do not correct the predicted concentrations for temperature. ENVIRON has assumed that the predicted concentrations are associated with an ambient temperature of 25°C.

6.1.3 Exposed Population

As discussed in Section 5.1.3, 14 receptor locations were identified for inclusion into the screening HHRA. The receptor locations were selected to represent a range of community facilities, residential areas, and sensitive receptors (e.g. Primary School). The receptor locations are considered to represent the range of potential public exposure to atmospheric emissions from the Power Station.

The locations of the receptors are presented as Figure 20, overlain on a map of the area. For purposes of this screening assessment, all receptor locations are assumed to be residential in nature, and therefore include potentially sensitive subpopulations such as children and the elderly. The potential health risks associated with the power station and coal mine atmospheric emissions for locations other than the 14 discrete receptors identified above can be estimated from the contours.

6.1.4 Exposure Pathways

Inhalation is expected to represent the most significant exposure pathway for the atmospheric emission from the power station and coal mine.

Whilst particulates and associated compounds such as metals (e.g. arsenic, cadmium and nickel) and hydrogen fluoride are likely to contribute to multi-pathway exposures (i.e. indirect exposure pathways such as soil ingestion, dermal, vegetable ingestion and water ingestion), these other exposure pathways are expected to be a minor contributor to the cumulative human health risks from Alcoa's Anglesea operations as the predicted concentrations at the nearby discrete receptors are relatively low. Therefore, multi-pathway exposure has not been assessed in this screening HHRA.

6.1.5 Estimated Concentrations in Air

The ambient concentrations of the nominated contaminants have been derived from the results of the air dispersion modelling presented in Section 5.

The predicted 99.9^{th} percentile 1-hour average, 99.5^{th} percentile 24-hour average, and average concentrations predicted over the five years modelled have been used in the screening HHRA. These percentile concentrations have been used to represent the actual exposure concentration that is expected to occur across the model domain.

The comparison between the predicted and measured SO_2 and particulate concentrations indicated that this was within reasonable margin of accuracy of actual exposure concentrations over 5 years. Variable background concentrations and changes in emission characteristics which are not accounted for in the model may contribute to the difference between observed and predicted results.

6.2 Exposure Assessment

6.2.1 Quantitative Risk Indicators

The Hazard Index (HI) is calculated to evaluate the potential for adverse health effects from simultaneous exposure to multiple compounds by summing the ratio of the estimated exposure concentration in air to the health protective guidelines for individual compounds. The HI is calculated for acute (Equation 3) and chronic (Equation 4) exposures.

$$HI_{Acute} = \sum^{i} \frac{C_{\leq 24h}}{Gdl_{Acute}} \qquad \textit{Equation 3}$$

$$HI_{Chronic} = \sum^{i} \frac{C_{Annual}}{Gdl_{Chronic}} \qquad \textit{Equation 4}$$

Where:

HI_{Acute} = acute Hazard Index

$C_{\leq 24h}$ = ground level concentration predicted over an averaging period of typically ≤ 24 hours, matching the averaging time of the health protective guideline for each compound (µg/m^3)

Gdl_{Acute} = acute health protective guideline for each compound (µg/m^3)

$HI_{Chronic}$ = chronic Hazard Index

C_{Annual} = long term (annual) average ground level concentration predicted for each compound (µg/m^3)

$Gdl_{Chronic}$ = chronic health protective guideline for each compound (µg/m^3)

For the screening HHRA the acute HI has been determined from the predicted 99.9th percentile 1-hour and 99.5th percentile 24-hour average ground level concentrations predicted by the air dispersion modelling over the 2008 to 2012 period. The chronic HI was calculated from the predicted average concentrations over the same five year period.

Only the three compounds that did not meet the SEPP (AQM) design criteria (i.e. SO_2, PM_{10} and $PM_{2.5}$) were included in the screening HHRA. As such, the individual Hazard Quotients (HQs) for each compound (i.e. the ratio of the predicted compound concentration to the health protective guideline) have also been calculated and considered in this assessment.

6.2.2 Acute Effects

Tables 18 and 19 present the acute HIs calculated for the predicted ground level concentrations resulting from the power station and coal mine atmospheric emissions in combination with the background concentrations. Figures 32 to 35 present contours of the calculated HIs for the model domain. Separate HIs have been calculated for combining PM_{10} and $PM_{2.5}$ with SO_2 to prevent the "double accounting" of $PM_{2.5}$ that is already included as part of the PM_{10} concentrations. The HIs have been calculated as composite acute HI which is calculated on the basis of the SO_2 1-hour and PM_{10} (or $PM_{2.5}$) 24-hour HQs and a 24hr acute HI which is based on the HQs for the SO_2 and PM_{10} (or $PM_{2.5}$) 24-hour concentrations.

Table 18 and Figure 32 present the calculated acute HIs for SO_2 and PM_{10}. The maximum acute HI for SO_2 and PM_{10} is predicted to occur at the coal mine and is above the threshold of one. The composite acute HI was predicted to be greater than one at the majority of the receptors. These composite acute HIs were primarily associated with the emissions of PM_{10} from the coal mine in combination with the background concentrations for those receptors closer to the mine site. SO_2 was the primary contributor to the composite HI at the Water Basin receptor while for the other receptors both SO_2 and PM_{10} (including background) contributed.

An analysis of the predicted concentrations associated with the maximum composite HIs as can be seen in Table 20 for Fraser Avenue indicated that the 99.5th percentile 24-hour PM_{10} concentrations occurred at different times to when the 99.9th percentile 1-hour SO_2 concentration occurred. The data in Table 20 also indicate that the predicted 1-hour average SO_2 concentrations were zero on the day associated with the predicted 99.5th percentile 24-hour PM_{10} and $PM_{2.5}$ concentrations. Appendix F presents an analysis of the predicted concentrations or SO_2 PM_{10} and $PM_{2.5}$ associated with the maximum HQ for each monitoring site.

For all receptors other than Fraser Avenue, the individual PM_{10} and SO_2 HQs were less than one indicating that the predicted PM_{10} and SO_2 percentile concentrations considered in the screening HHRA were below the relevant NEPM ambient standards. For Fraser Avenue the 99.5th percentile 24-hour average PM_{10} concentration (i.e. Alcoa's predicted concentration plus the background concentration) was predicted to be in excess of the relevant NEPM standard. Of this Alcoa's operations were predicted to have contributed approximately 70% of the 24-hour concentration. The NEPM goal for PM_{10} is to have no more than five days where the NEPM standard is exceeded. Further analysis of the modelling data indicates that the sixth highest 24-hour average concentrations predicted at Fraser Avenue are well below the NEPM standard for each of the five years modelled. The Fraser Avenue receptor is located between the Camp Wilkin and Camp Road ambient particulate monitoring sites and these sites have not yet recorded any exceedances of the NEPM standard. While no exceedances of the NEPM standard have been recorded, the air dispersion modelling indicates the potential for this to occur albeit infrequently.

The calculated 24Hr acute HIs presented in Table 18 and Figure 33 are generally lower than the composite HIs as a result of the fact that the HQ for the 24-hour average SO_2 concentration is less than that for the 1-hour average SO_2 concentration.

Table 19 and Figure 34 presents the calculated acute HIs considering SO_2 and $PM_{2.5}$. Figure 34 shows that the acute HI was predicted to be greater than one in the vicinity of the coal mine (due to $PM_{2.5}$), and also to the north and north-west of the power station (due to SO_2). Table 19 shows that the composite acute HI is predicted to be less than one at all receptors except the Water Basin, Camp Wilkin, and Fraser Avenue. At the Water Basin, the composite HI greater than one is primarily attributable with SO_2 whereas at Fraser Avenue it is primarily attributable to $PM_{2.5}$. At Camp Wilkin, SO_2 and $PM_{2.5}$ contribute a similar percentage to the composite HI. In all cases the HQs for both SO_2 and $PM_{2.5}$ are less than one and the 99.5th percentile 24-hour $PM_{2.5}$ concentrations occurred at different times to when the 99.9th percentile 1-hour SO_2 concentration occurred.

Table 18: Calculated Acute Hazard Indices (SO_2 and PM_{10})

Receptor No.	Description	Concentration (µg/m^3)			Hazard Quotient			Acute HI	
		SO_2 1-Hr	SO_2 24-Hr	PM_{10} 24-Hr	SO_2 1-Hr	SO_2 24-Hr	PM_{10} 24-Hr	Composite Acute HI	24Hr Acute HI
1	CFA Hut	248	37.6	33.4	0.47	0.18	0.73	1.20	0.91
2	Bald Hills Road	307	63.7	19.9	0.58	0.30	0.43	1.01	0.73
3	Water Basin	454	114.4	18.8	0.87	0.55	0.41	1.28	0.96
4	Forest Road	284	52.8	18.4	0.54	0.25	0.40	0.94	0.65
5	Scout Camp	354	93.1	20.6	0.68	0.45	0.45	1.13	0.90
6	Primary School	247	42.5	28.9	0.47	0.20	0.63	1.10	0.83
7	Camp Road	235	53.3	25.6	0.45	0.26	0.56	1.01	0.82
8	Community Centre	271	45.7	24.2	0.52	0.22	0.53	1.05	0.75
9	Camp Wilkin	266	47.5	38.2	0.51	0.23	0.83	1.34	1.06
10	Anglesea Surf Club	275	47.0	22.0	0.53	0.22	0.48	1.01	0.70
11	Waste Treatment Plant	322	65.5	23.0	0.61	0.31	0.50	1.11	0.81
12	Anglesea Caravan Park	299	49.4	22.7	0.57	0.24	0.49	1.06	0.73
13	Fraser Avenue	214	32.0	51.7	0.41	0.15	1.12	1.53	1.27
14	Pt Road Knight Carpark	218	41.2	20.6	0.42	0.20	0.45	0.87	0.65

Notes:

1. Composite Acute HI is based on the Acute HQ of SO_2 1-hour and PM_{10} 24-hour.
2. 24hr Acute HI is based on the Acute HQ of SO_2 24-hour and PM_{10} 24-hour.
3. Concentrations expressed at 25°C and 101.325 kPa.

Table 19: Calculated Acute Hazard Indices (SO_2 and $PM_{2.5}$)

Receptor No.	Description	Concentration (µg/m^3)			Hazard Quotient			Acute HI	
		SO_2 1-Hr	SO_2 24-Hr	$PM_{2.5}$ 24-Hr	SO_2 1-Hr	SO_2 24-Hr	$PM_{2.5}$ 24-Hr	Composite Acute HI	24hr Acute HI
1	CFA Hut	248	37.6	10.4	0.47	0.18	0.45	0.92	0.63
2	Bald Hills Road	307	63.7	6.2	0.58	0.30	0.27	0.85	0.57
3	Water Basin	454	114.4	5.8	0.87	0.55	0.25	1.12	0.80
4	Forest Road	284	52.8	5.6	0.54	0.25	0.24	0.78	0.49
5	Scout Camp	354	93.1	6.5	0.68	0.45	0.28	0.96	0.73
6	Primary School	247	42.5	10.3	0.47	0.20	0.45	0.92	0.65
7	Camp Road	235	53.3	9.2	0.45	0.26	0.40	0.85	0.66
8	Community Centre	271	45.7	8	0.52	0.22	0.35	0.87	0.57
9	Camp Wilkin	266	47.5	14.1	0.51	0.23	0.61	1.12	0.84
10	Anglesea Surf Club	275	47.0	7.1	0.53	0.22	0.31	0.84	0.53
11	Waste Treatment Plant	322	65.5	7.4	0.61	0.31	0.32	0.93	0.63
12	Anglesea Caravan Park	299	49.4	7.6	0.57	0.24	0.33	0.90	0.57
13	Fraser Avenue	214	32.0	17.2	0.41	0.15	0.75	1.16	0.90
14	Pt Road Knight Carpark	218	41.2	6.8	0.42	0.20	0.30	0.72	0.50

Notes:

1. Composite Acute HI is based on the Acute HQ of SO_2 1-hour and PM_{10} 24-hour.
2. 24hr Acute HI is based on the Acute HQ of SO_2 24-hour and PM_{10} 24-hour.
3. Concentrations expressed at 25°C and 101.325 kPa.

Table 20: Summary of Predicted Concentrations at Fraser Avenue[1]			
	Averaging time	**Concentration (µg/m^3)**	**HQ**
99.9th Percentile 1-Hour Sulphur Dioxide Concentration predicted on 5 July 2010			
Sulphur dioxide	1-hour	214	0.41
PM_{10}	24-hour	12.5	0.27
$PM_{2.5}$	24-hour	3.9	0.17
99.5th Percentile 24-Hour Average PM_{10} and $PM_{2.5}$ Concentrations both predicted on 10 April 2011			
Sulphur dioxide (Maximum on 10 April 2011	1-hour	0	0.00
PM_{10}	24-hour	36.1	0.78
$PM_{2.5}$	24-hour	12.6	0.55
Notes 1 Background concentrations not included			

6.2.3 Chronic Effects

The chronic HIs including the background concentrations are presented in Table 21 and Figure 36.

Table 21: Calculated Chronic Hazard Indices				
No.	**Receptor**	**Hazard Quotient**		**Chronic HI**
		SO_2	**$PM_{2.5}$**	
1	CFA Hut	0.07	0.69	0.76
2	Bald Hills Road	0.01	0.71	0.72
3	Water Basin	0.01	0.77	0.78
4	Forest Road	0.01	0.71	0.72
5	Scout Camp	0.01	0.76	0.77
6	Primary School	0.05	0.70	0.75
7	Camp Road	0.04	0.71	0.75
8	Community Centre	0.03	0.70	0.73
9	Camp Wilkin	0.08	0.69	0.77
10	Anglesea Surf Club	0.02	0.69	0.71
11	Waste Treatment Plant	0.02	0.73	0.75
12	Anglesea Caravan Park	0.03	0.71	0.74
13	Fraser Avenue	0.15	0.68	0.83
14	Pt Road Knight Carpark	0.01	0.69	0.70

Figure 36 indicates that the maximum chronic HIs are predicted to occur in the immediate vicinity of the coal mine and are associated with the emissions of $PM_{2.5}$ from the mine. The chronic HIs are dominated by the contribution of $PM_{2.5}$ which is primarily associated with the background concentration assumed in the study. The chronic HIs are less than one indicating no cause for concern in terms of potential chronic health risk at all of the nominated receptors.

6.2.4 Irritancy

For the purposes of this screening assessment irritancy refers to a direct physiological response arising from short-term exposure to a compound that may result in mild, transient adverse health effects that are reversible upon cessation of exposure. The health reference values used in the health risk assessment are generally derived from information on the most sensitive toxicological endpoint and in some cases this end point is irritancy. In cases where the most sensitive, critical end point is not irritancy, the reference value derived is also protective of irritancy. However, the NEPC (2011) concluded that many compounds do not have a recognised threshold concentration below which no adverse health effects will be observed. Where there is no threshold concentration, adverse impacts, including irritancy, may occur in a small percentage of the population at concentrations below the ambient air quality criteria.

The HQ for the individual acute effects of SO_2, PM_{10} and $PM_{2.5}$ are all less than one (with the exception of PM_{10} at Fraser Avenue that is marginally over one) and the peak short-term concentrations for SO_2 occur at different times to those for PM_{10} and $PM_{2.5}$. Therefore the risk that the emissions from the power station and coal mine will cause irritation in the wider population is considered to be low.

6.3 Uncertainties Associated With Screening HHRA

The risk assessment process relies on a set of assumptions and estimates with varying degrees of uncertainty. The major sources of uncertainty associated with the risk assessment are associated with:

1. Predicted ground level concentrations which can be affected a number of factors including:
    a. Variability of the atmospheric dispersion conditions.
    b. Assumptions in the models used to estimate key inputs (e.g. emission estimates).
    c. Background concentrations.
2. Ambient air quality guidelines used within the assessment.
3. Exposure uncertainty.

Each of these aspects is discussed in the following sections.

6.3.1 Predicted Ground Level Concentrations

As is the case with any air dispersion modelling assessment, there is uncertainty associated with the predicted ground level concentrations. The key areas of uncertainty associated with the predicted ground level concentrations used for this assessment are outlined in this section.

TAPM predicted meteorology was used in both the TAPM and CALPUFF air dispersion models. The predicted wind speed and direction has been compared to the measured meteorology for the Anglesea Power Station monitoring site and shown to agree well statistically. However, TAPM was shown to under-predict the frequency of light winds that could result in an under-prediction of the maximum ground level concentrations of particulate from the coal mine. The reliability of the predicted meteorological data across the model domain cannot be verified.

The identification and quantification of atmospheric emissions from the power station include the following uncertainties:

- Measurement and analytical uncertainty associated with the stack sampling methods used at the power station. Alcoa have used NATA accredited testing laboratories to undertake the stack sampling program at the power station. However, uncertainty associated with test method interferences, repeatability and reproducibility tests typically range from ±20% to ±30% (could be higher for some compounds).
- Uncertainty arising from variability in discharge characteristics (e.g. emission volume and temperature) and emissions rates (e.g. process variability at time periods shorter than one hour, and the accuracy of continuous emissions monitoring systems).
- Uncertainty arising from the sample size (i.e. number of stack samples) and averaging periods used for compounds not measured on a continuous basis.

The identification and quantification of atmospheric emissions from the coal mine include the following uncertainties:

- The emission factors/equations used to estimate the emission rates are based on research associated with emissions from a range of different operations around the world. Therefore, emissions associated with a particular mine may be different to those calculated from the emission estimation techniques.
- Variability in the actual particulate size distributions compared to those included in the model.
- Variability in the operational areas at the coal mine will affect the actual source of the emissions at any point in time.
- The effectiveness of the management practices (e.g. use of water carts, maintenance of infrastructure) can impact upon the magnitude of the emissions at any point in time.

Background concentrations (i.e. not Anglesea power station and coal mine related) were adopted for the assessment in accordance with the SEPP (AQM) (refer to Section 5). As the power station represents the primary regional source of SO_2 emissions, the background concentrations of SO_2 across the modelling domain are expected to be small and this is supported by the long term ambient SO_2 monitoring database. Limited ambient monitoring data are currently available to characterise background PM_{10} and $PM_{2.5}$ concentrations in the Anglesea area. There are many sources of particulate emissions that occur in the Anglesea area including both natural (e.g. wind-blown dust, sea salt during on-shore air flows, bushfires) and anthropogenic sources (e.g. clearing, fires, vehicles)), and therefore the background PM_{10} and $PM_{2.5}$ concentrations applied in this assessment are considered to be a source of uncertainty.

In completing the air dispersion modelling study, conservative assumptions were applied wherever practical. The available ambient monitoring data indicate that over the five year period between 2008 and 2012, the ambient SO_2 concentrations have marginally exceeded the NEPM 1-hour standard for one hour at three monitoring sites. However in general, the ambient SO_2 concentrations monitored at these sites were well below the NEPM 1-hour standard (e.g. the maximum 99.9^{th} percentile concentration at any monitoring site was 386 $\mu g/m^3$). The available PM_{10} and $PM_{2.5}$ monitoring data indicate compliance with the NEPM standard.

Validation of the model performance showed that the air dispersion models performed well when statistics of the predicted and measured concentrations were compared.

6.3.2 Ambient Air Quality Guidelines

Section 6.1 presented a brief summary of the potential effects associated with exposure to SO_2, PM_{10} and $PM_{2.5}$ in the ambient environment and the NEPM ambient air quality standards applied in this assessment. The NEPM standards were established in 1998 (with a review to add $PM_{2.5}$ in 2003) and were based on the information available at that time. The setting of ambient air quality standards is also subject to policy judgments (e.g. the absolute level of protection provided by the standards) of the regulatory organisations and by legislative influences. The NEPM standards are therefore considered to be appropriate for use in this screening HHRA as recommended by enHealth (2012) which states that "the hazard identification component may simply identify the relevant national or international guideline values for each chemical that may be present".

The NEPC commenced a review of the Ambient Air NEPM in 2007 and in 2011 reported (NEPC, 2011) that the SO_2 health evidence indicated that health effects are observed at current levels of SO_2 in Australian cities which are well below the NEPM standard. The effects are greatest in people with asthma. It also recommended that compliance standards be introduced for $PM_{2.5}$ and that an annual average standard be introduced for PM_{10}. Any changes to the NEPM ambient air quality standards may affect the outcome of the screening HHRA.

The NEPC (2011) found that many compounds do not have a recognised threshold for adverse health impacts and therefore there is no concentration below which all of the population will be protected. It therefore includes a recommendation to incorporate exposure reduction targets for priority pollutants within the NEPM. Alcoa is committed to reducing population exposure to the emissions from its operations. The AQCS that was implemented in 2009 has been designed to reduce the magnitude and duration of elevated SO_2 concentrations within the town of Anglesea. Alcoa also has management measures in place to reduce the emissions of fugitive dust from its coal mining operations.

6.3.3 Exposure Uncertainty

The screening HHRA has only considered exposure via the inhalation pathway. There is therefore a potential that total exposure to specific compounds, particularly for PM_{10} and $PM_{2.5}$ may be underestimated. Ingestion of particulate matter through mechanism such as crops (e.g. vegetable gardens) and water (e.g. suspended or dissolved particulates from rainwater tanks) may result in increased exposure. This is considered to represent a small risk beyond the immediate vicinity of the coal mine.

The screening HHRA has also assumed that an individual is at the same location for the exposure times used in the assessment (i.e. 1-hour, 24-hour and annual) which is considered to be unlikely particularly for times of more than 1-hour.

The calculated HIs have also assumed that the SO_2 and particulate matter (PM_{10} and $PM_{2.5}$) concentrations occur at the same time. An assessment of the predicted percentile concentrations indicates that this does not occur due to the different source characteristics (i.e. stack source for SO_2 and fugitive low level sources for the majority of the particulate emissions).

6.4 Screening HHRA Conclusions

ENVIRON has conducted a screening level HHRA of the potential health risks arising from atmospheric emissions from the Anglesea Power Station and coal mine. The air dispersion modelling study considered 39 compounds that may be emitted from Alcoa's operations. SO_2, PM_{10} and $PM_{2.5}$ were predicted to result in ground level concentrations that were greater than the SEPP (AQM) design criteria. Therefore only SO_2, PM_{10} and $PM_{2.5}$ were carried through to the screening HHRA as required by the EPAV.

Quantitative health risk indicators were calculated for exposure via the inhalation pathway to the emissions of SO_2, PM_{10} and $PM_{2.5}$. The acute and chronic HIs were calculated across the model domain and for key receptors located in the vicinity of the power station and coal mine.

Based upon the results of the screening HHRA it can be concluded that:

- The emissions from the power station and coal mine when considered in combination with the background concentrations are predicted to result in a composite acute HI of greater than one at all but two of the nominated receptor locations.
- The 24-hour acute HI was less than one at all locations other than Camp Wilkin and Fraser Avenue.
- An analysis of the predicted concentrations associated with the maximum composite HIs indicated that the 99.5th percentile 24-hour PM_{10} concentrations occurred at different times to when the 99.9th percentile 1-hour SO_2 concentration occurred.
- For all receptors other than Fraser Avenue, the individual PM_{10} and SO_2 acute HQs were less than one indicating that the predicted PM_{10} and SO_2 percentile concentrations considered in the screening HHRA were below the relevant NEPM ambient standards.
- For Fraser Avenue the acute HQ was predicted to be in excess of one for PM_{10}. Of this, Alcoa's operations were predicted to have contributed approximately 70% of the 24-hour concentration. The NEPM goal for PM_{10} is to have no more than five days where the NEPM standard is exceeded. Further analysis of the modelling data indicates that the sixth highest 24-hour average concentrations predicted at Fraser Avenue are well below the NEPM standard for each of the five years modelled. While no exceedances of the NEPM standard have been recorded at the ambient particulate monitoring sites, the air dispersion modelling indicates the potential for this to occur albeit infrequently.

- The acute HIs marginally greater than one are not considered to present cause for concern in terms of possible health risks due to the inherent conservatism embedded in the exposure assessment applied to screening health risk assessment.
- The emissions from the power station and coal mine are predicted to result in a chronic HI and HQ of less than one at all of the nominated receptor locations.
- The potential for emissions from the power station and the coal mine to cause chronic health effects is therefore considered to be low.

The NEPM ambient air quality standards represent the currently accepted standards in Australia, and have therefore been used in this screening HHRA. Any changes to the NEPM ambient air quality standards may affect the outcome of the screening HHRA.

As with any risk evaluation, there are areas of uncertainty in this assessment. To ensure that potential risks are not underestimated, uniformly conservative assumptions have been used to characterise exposure and toxicity.

Alcoa has implemented an AQCS to manage the impacts of SO_2 on the Anglesea township which has reduced the occurrence of 1-hour average concentrations of SO_2 that exceed the NEPM 1-hour standard in the community. Only one exceedance of the NEPM standard has been recorded in the last four years.

Further, Alcoa commenced ambient PM_{10} and $PM_{2.5}$ monitoring in July 2012 to assess the potential impacts associated with fugitive particulate emissions from its operations. The monitoring results from July to December 2012 indicate that the NEPM standards were being met at all three monitoring locations during this period.

ENVIRON recommends that management/mitigation measures are regularly reviewed to ensure control of the acute (short-term exposure) risk posed by SO_2 from the power station and dust emissions from the coal mine.

7 References

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8 Limitations Of Study

We have prepared this report for the use of Alcoa's Anglesea operations in accordance with generally accepted consulting practice. No other warranty, expressed or implied, is made as to the professional advice included in this report. This report has not been prepared for the use by parties other than the client, the owner and their respective consulting advisors. It may not contain sufficient information for purposes of other parties or for other uses.

Figure 1: Location Map
(Source Image : Google Earth)

Client: Alcoa Anglesea	ENVIRON		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 10/7/13	

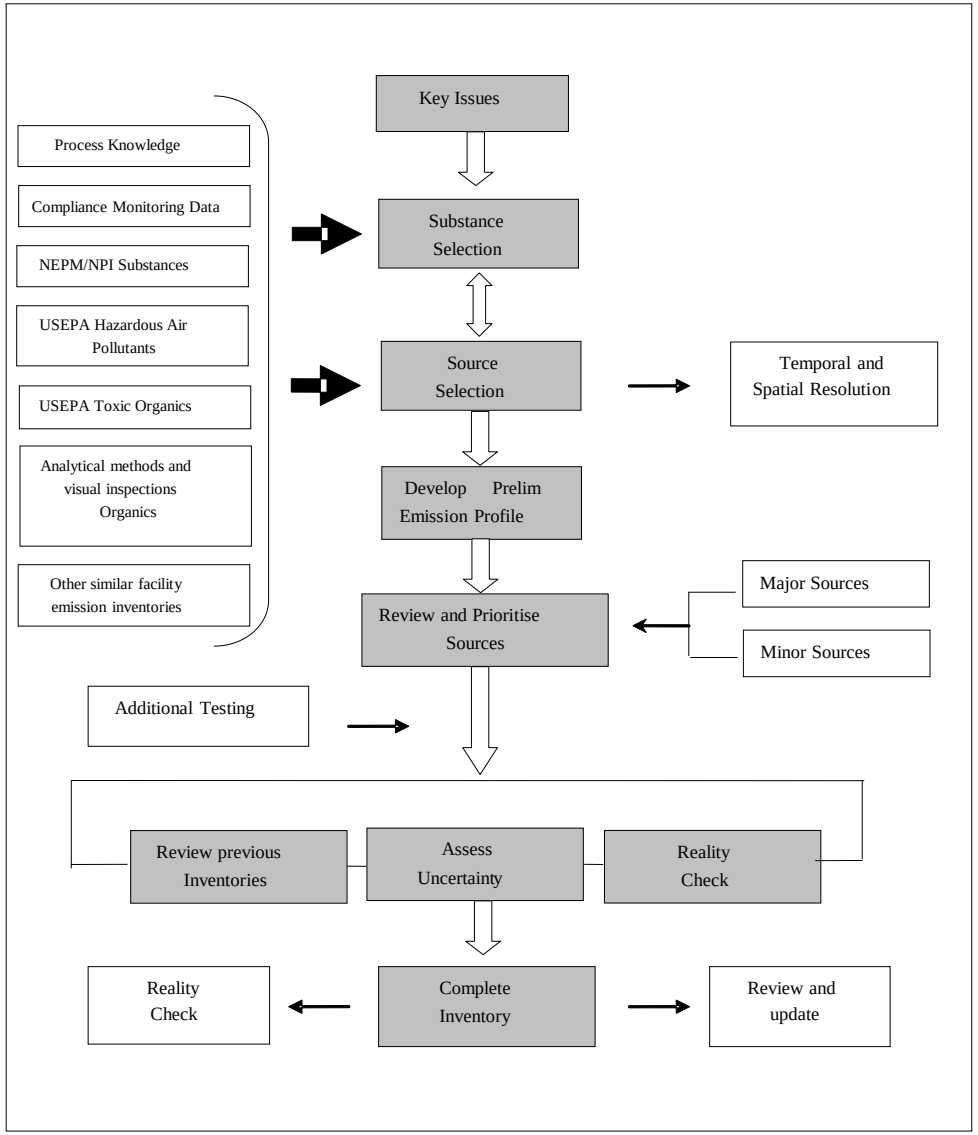


Figure 2: Inventory Selection Process

	Client: Alcoa Anglesea	ENVIRON	
	Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

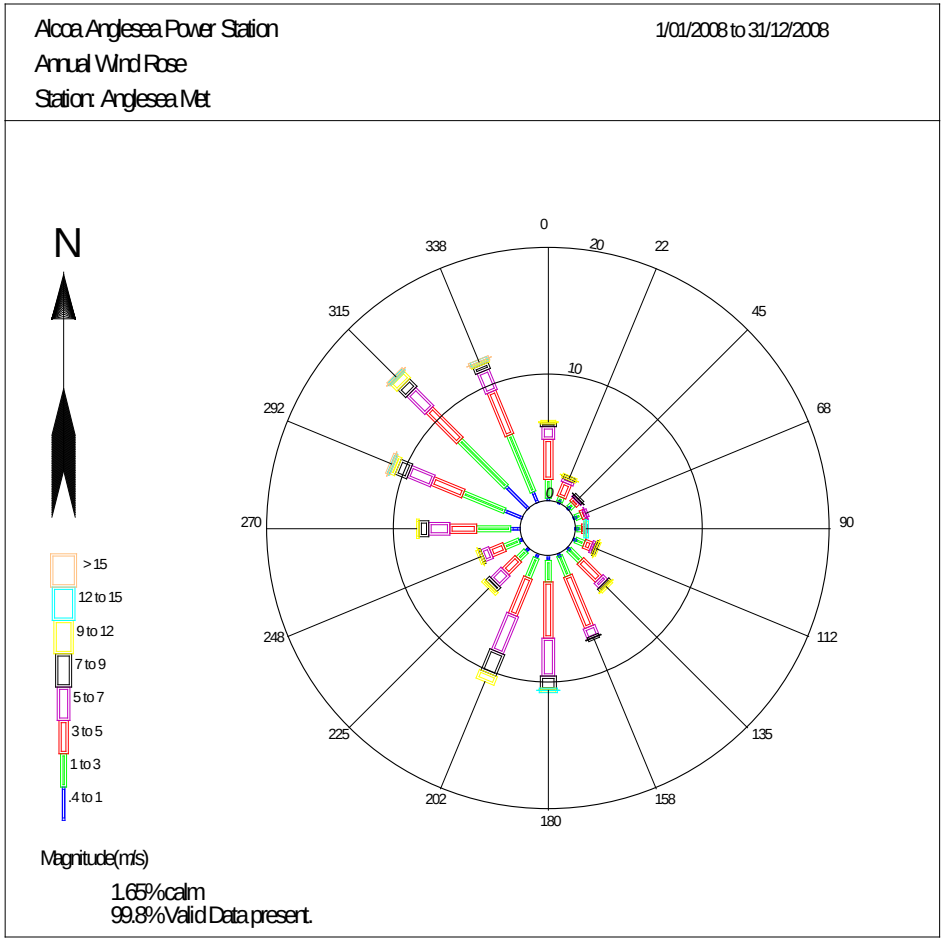


Figure 3: 2008 Annual Wind Rose

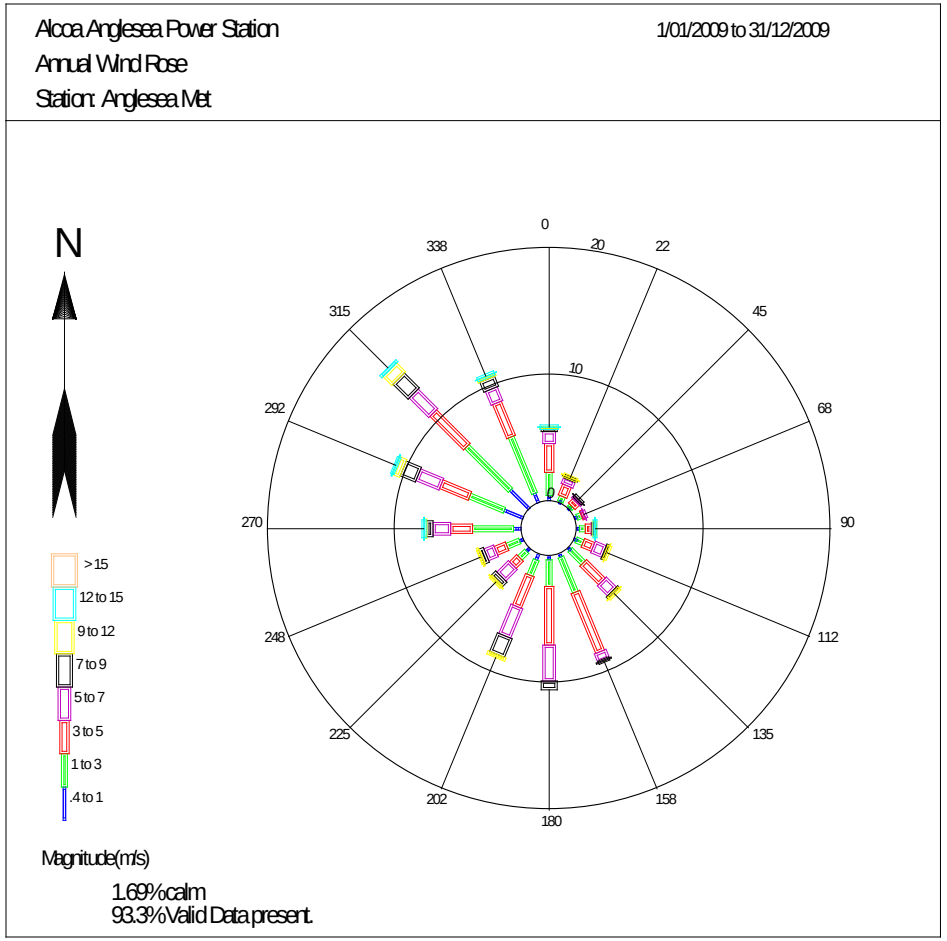


Figure 4: 2009 Annual Wind Rose

Client: Alcoa Anglesea	ENVIRON		Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13	Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

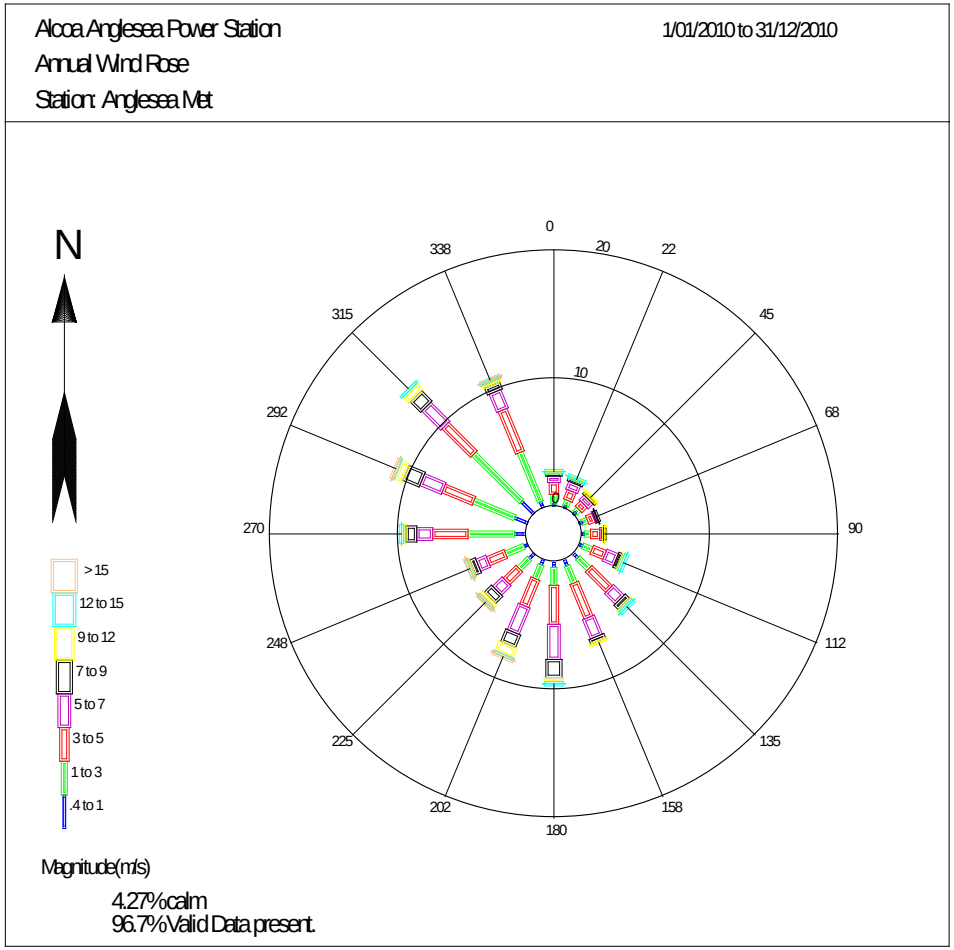


Figure 5: 2010 Annual Wind Rose

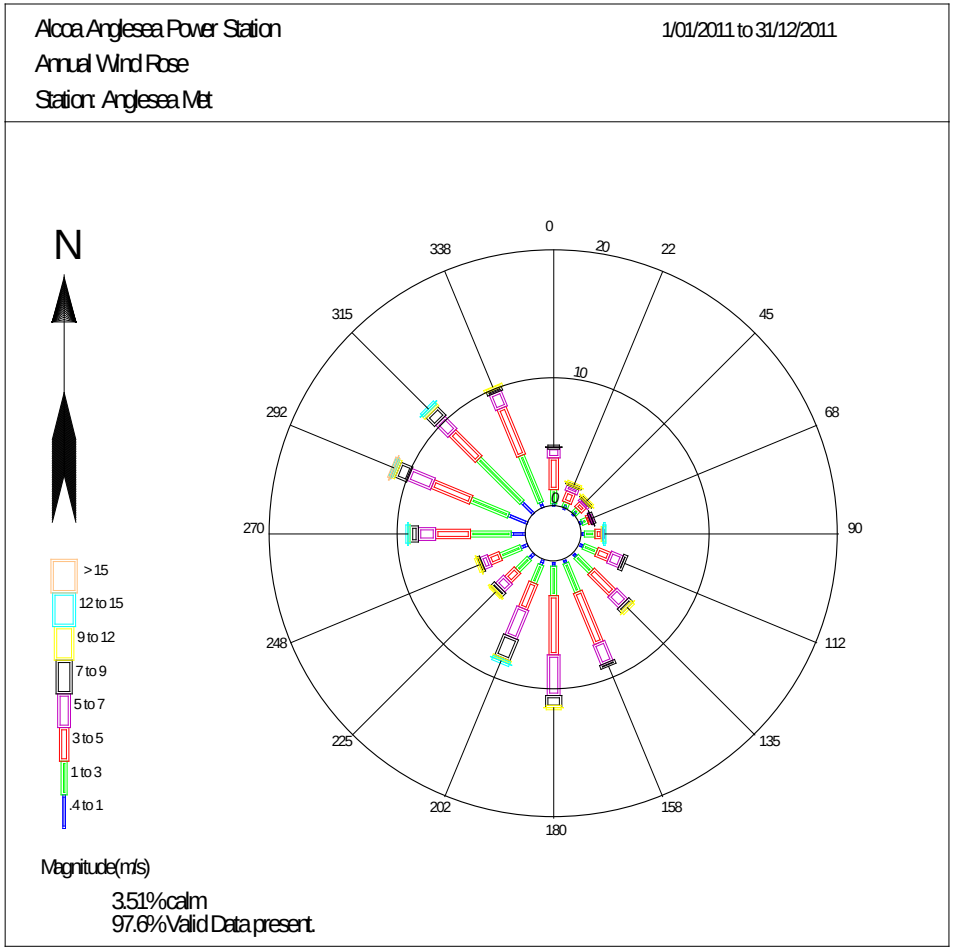


Figure 6: 2011 Annual Wind Rose

Client: Alcoa Anglesea	ENVIRON		Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13	Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

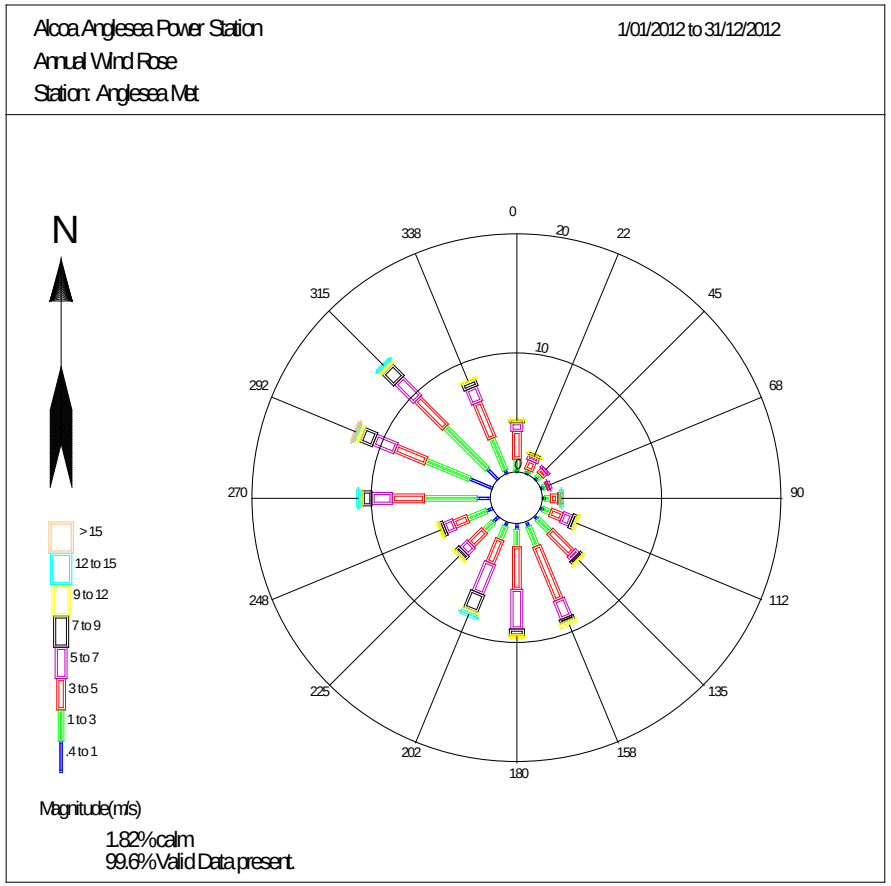


Figure 7: 2012 Annual Wind Rose

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

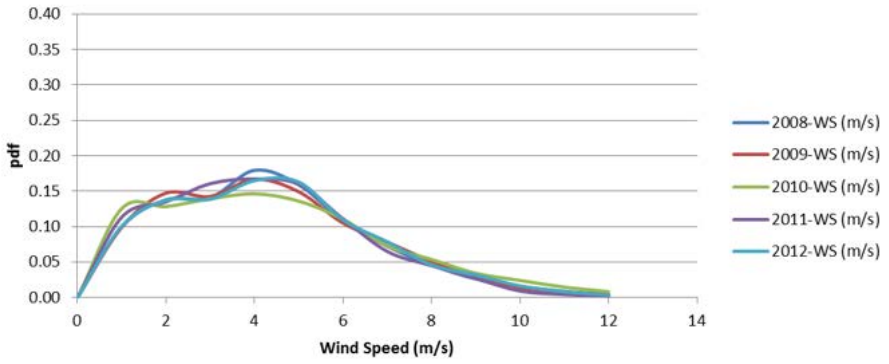


Figure 8: Summary of Observed Wind Speed at Anglesea (2008-2012)

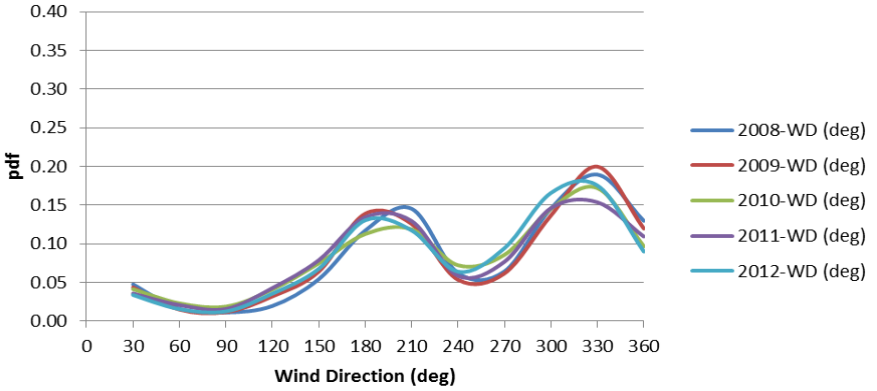


Figure 9: Summary of Observed Wind Direction at Anglesea (2008-2012)

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

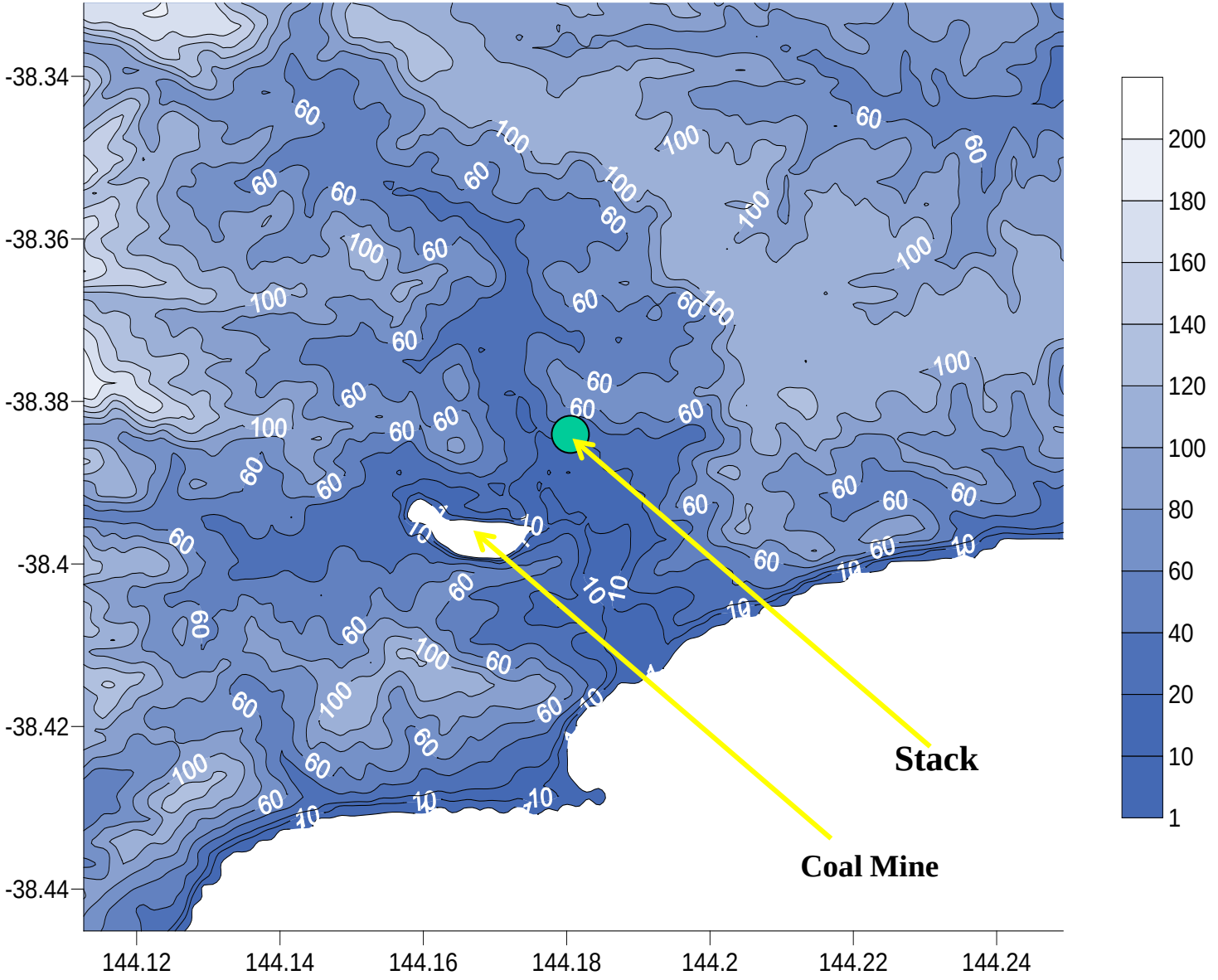
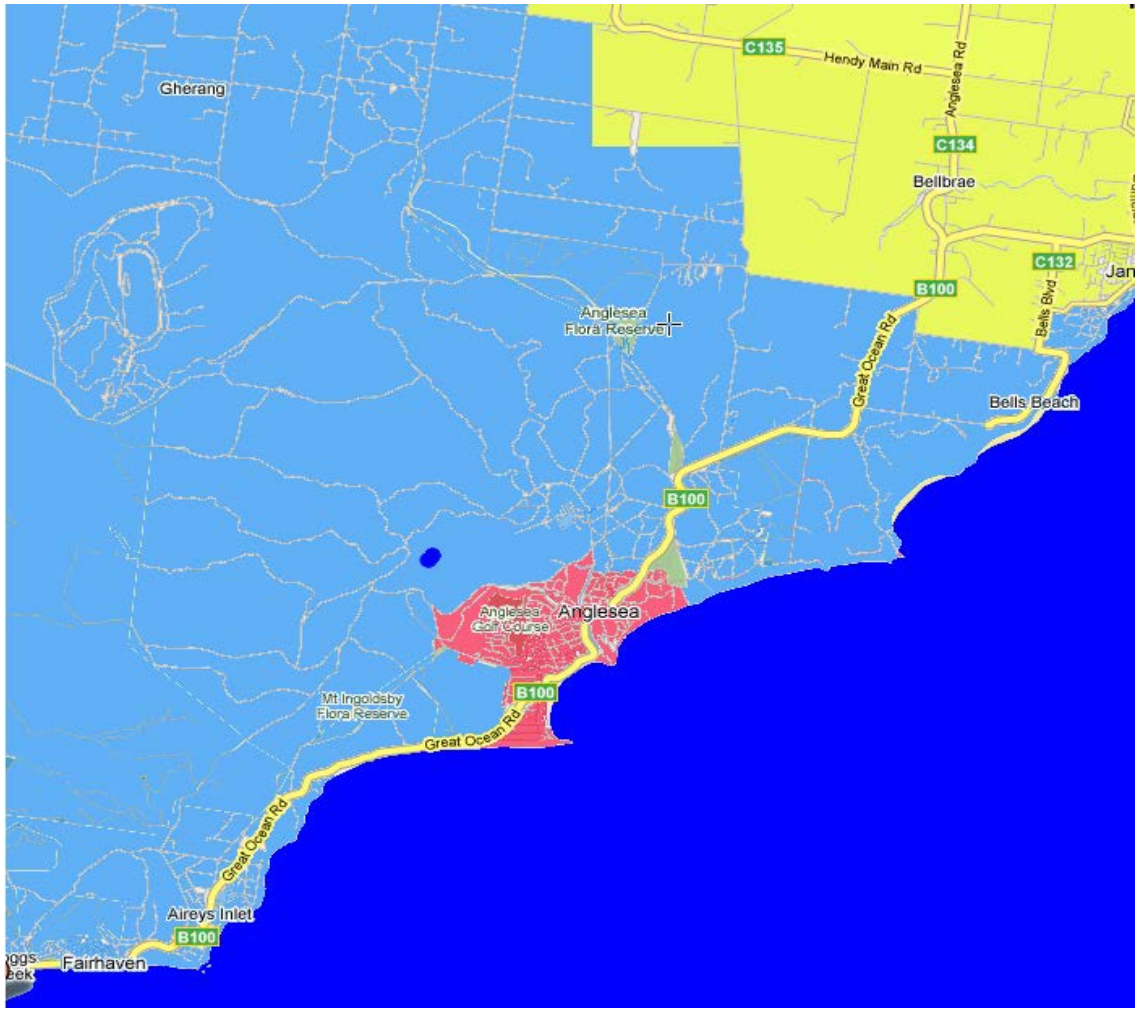


Figure 10: Site Topography

Client: Alcoa Anglesea	ENVIRON		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13	



Land-use Legend:

- Water
- Forest Sparse Woodland
- Pasture – Mid Dense
- Urban - Low

Figure 11: Surrounding Land Use

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

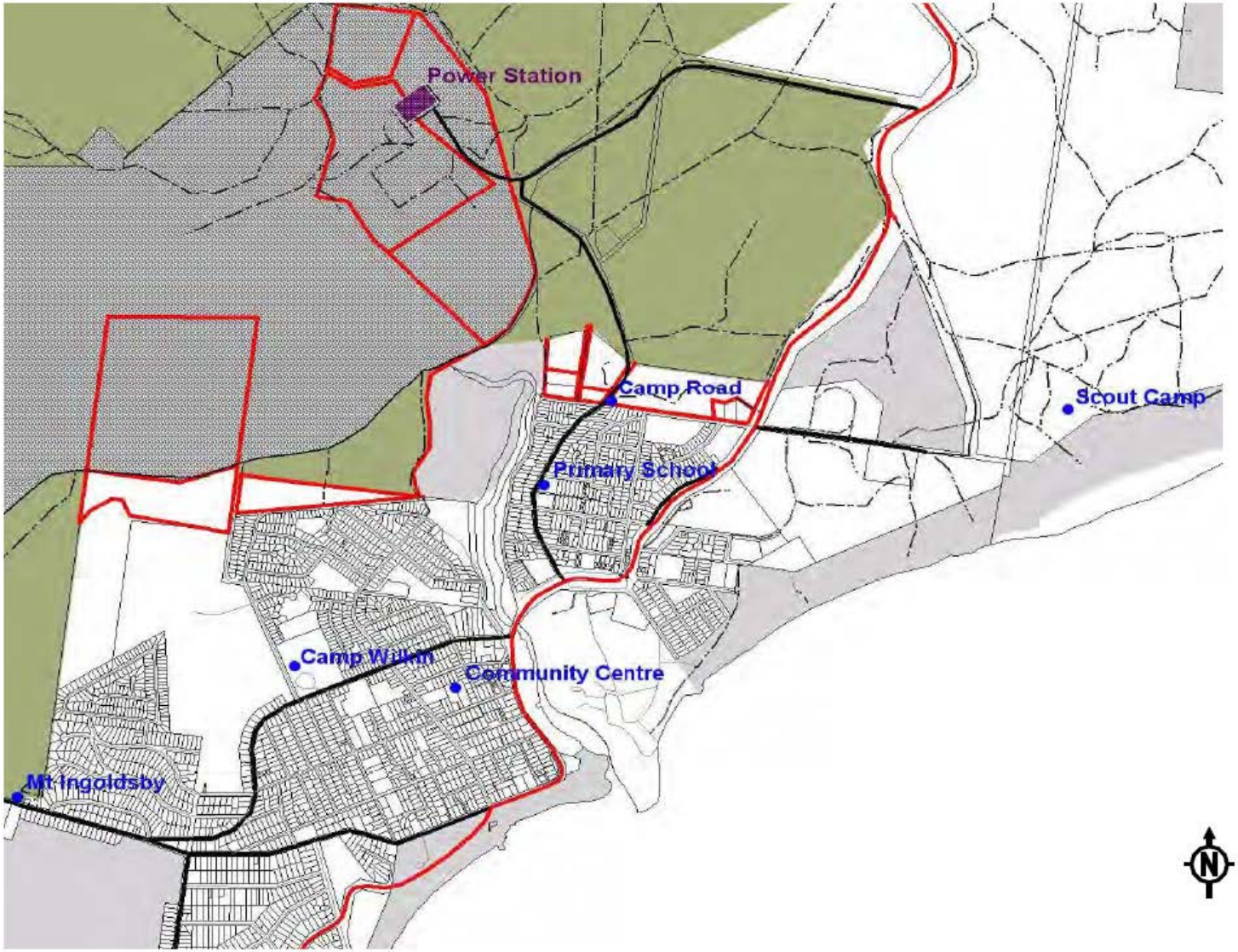


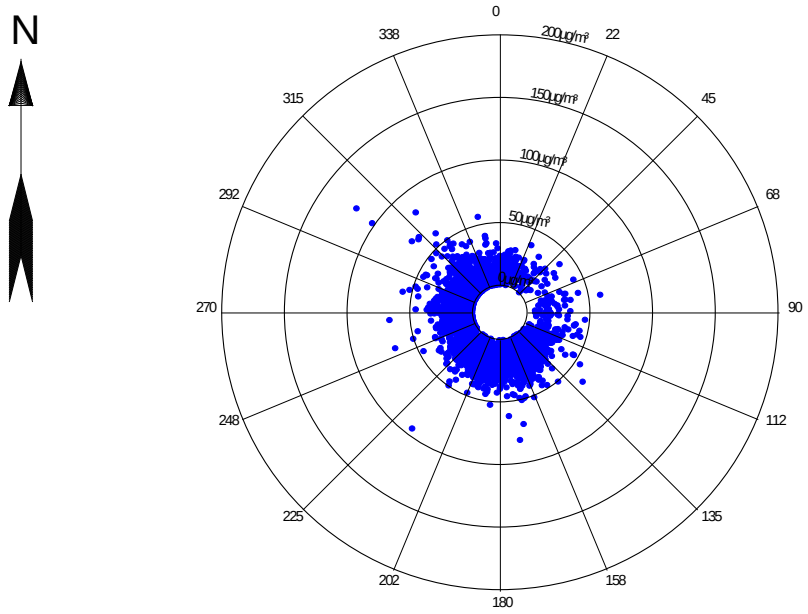
Figure 12: Location of SO_2 Monitoring Stations (Source Image : Alcoa)

Client: Alcoa Anglesea	ENVIRON		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13	

Figure 13: Location of the Dust Monitoring Stations (Source Image: Google Earth)

Client: Alcoa Anglesea	ENVIRON		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13	

Alcoa Australia 24/07/2012 to 31/12/2012
1 Hour Camp Rd PM10
Station: Anglesea Power Station Parameter: Camp Rd Particulate PM10



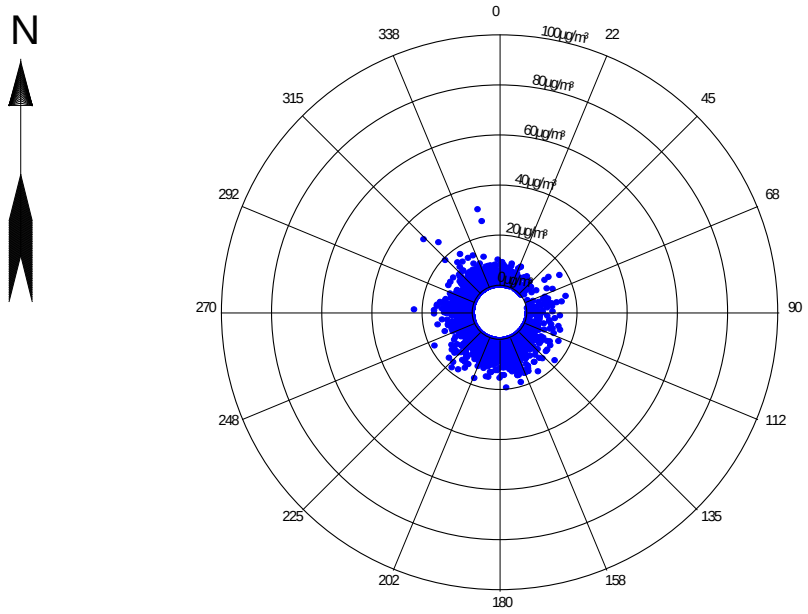
PM10 concentrations for wind speed between .4 and 20 m/s

97.7% Valid Data present.

Figure 14: Pollution Rose Camp Rd – PM_{10}

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Alcoa Australia 24/07/2012 to 31/12/2012
1 Hour Camp Rd PM2.5
Station: Anglesea Power Station Parameter: Camp Rd Particulate PM2.5

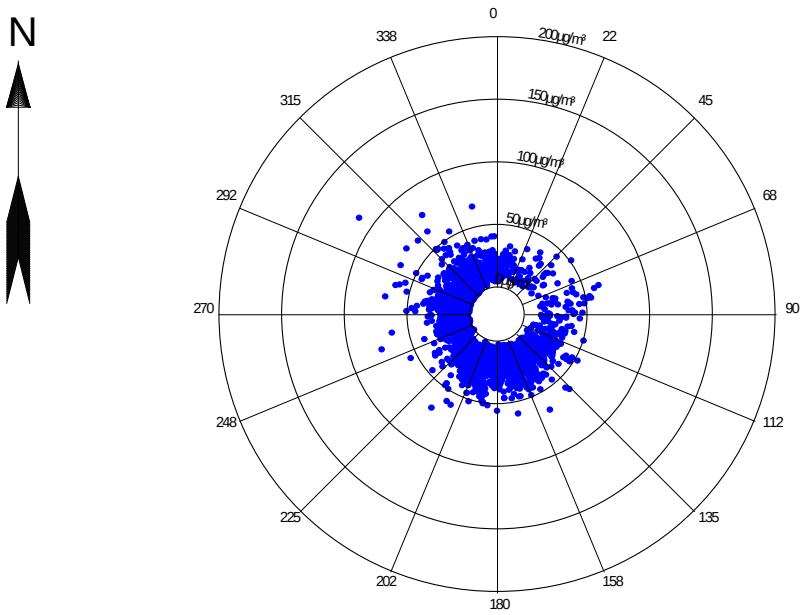


PM25 concentrations for wind speed between .4 and 20 m/s
21.1% of data Negative (plotted as 0).
97.9% Valid Data present.

Figure 15: Pollution Rose Camp Rd – $PM_{2.5}$

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Alcoa Australia 24/07/2012 to 31/12/2012
1 Hour Camp Wilkin PM10
Station: Anglesea Power Station Parameter: Camp Wilkin Particulate PM10

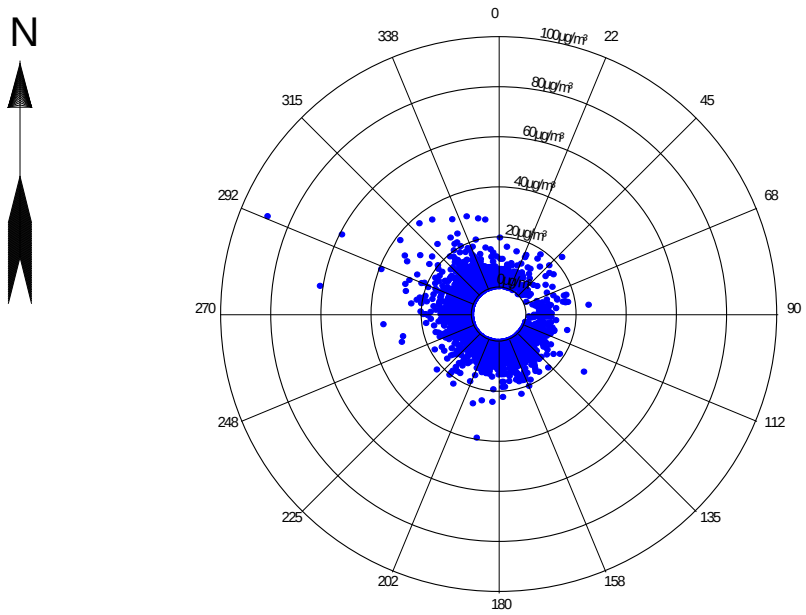


PM10 concentrations for wind speed between .4 and 20 m/s

79.4% Valid Data present.

Figure 16: Pollution Rose Camp Wilkin – PM_{10}

Alcoa Australia 24/07/2012 to 31/12/2012
1 Hour Camp Wilkin PM2.5
Station: Anglesea Power Station Parameter: Camp Wilkin Particulate PM2.5

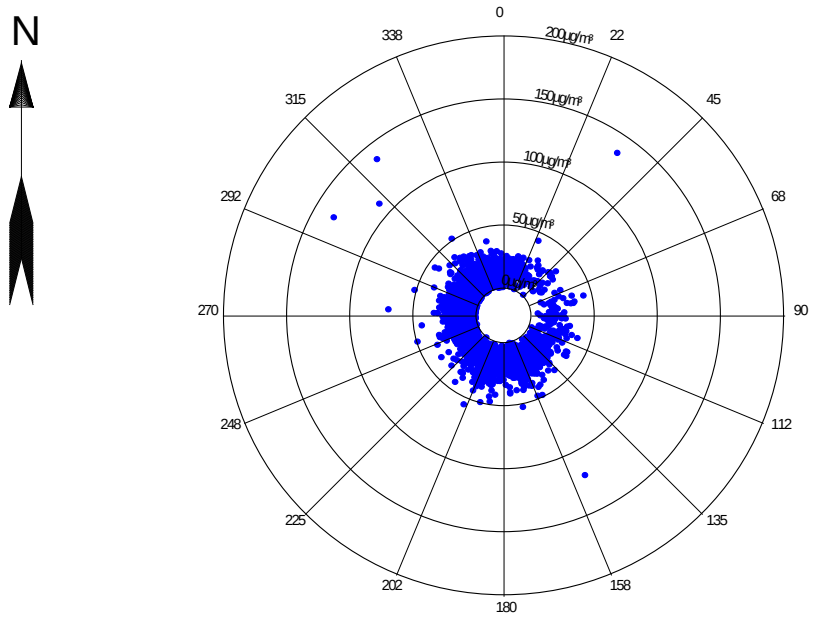


PM25 concentrations for wind speed between .4 and 20 m/s

97.7% Valid Data present.

Figure 17: Pollution Rose Camp Wilkin – $PM_{2.5}$

Alcoa Australia 24/07/2012 to 31/12/2012
1 Hour Barwon Water PM10
Station: Anglesea Power Station Parameter: Barwon Water Particulate PM10



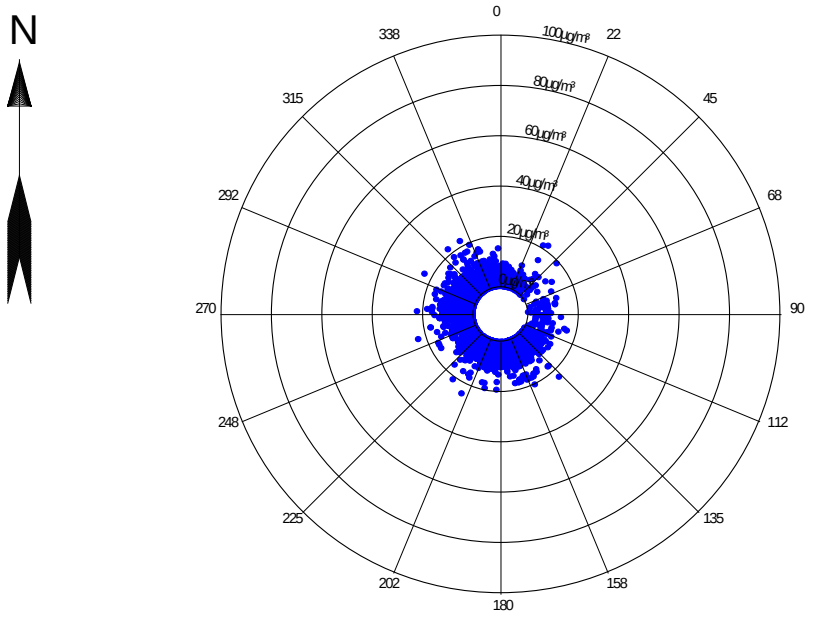
PM10 concentrations for wind speed between .4 and 20 m/s

91.4% Valid Data present.

Figure 18: Pollution Rose – Barwon Water – PM_{10}

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Alcoa Australia 24/07/2012 to 31/12/2012
1 Hour Barwon Water PM2.5
Station: Anglesea Power Station Parameter: Barwon Water Particulate PM2.5



PM25 concentrations for wind speed between .4 and 20 m/s

87.0% Valid Data present.

Figure 19: Pollution Rose – Barwon Water – $PM_{2.5}$

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

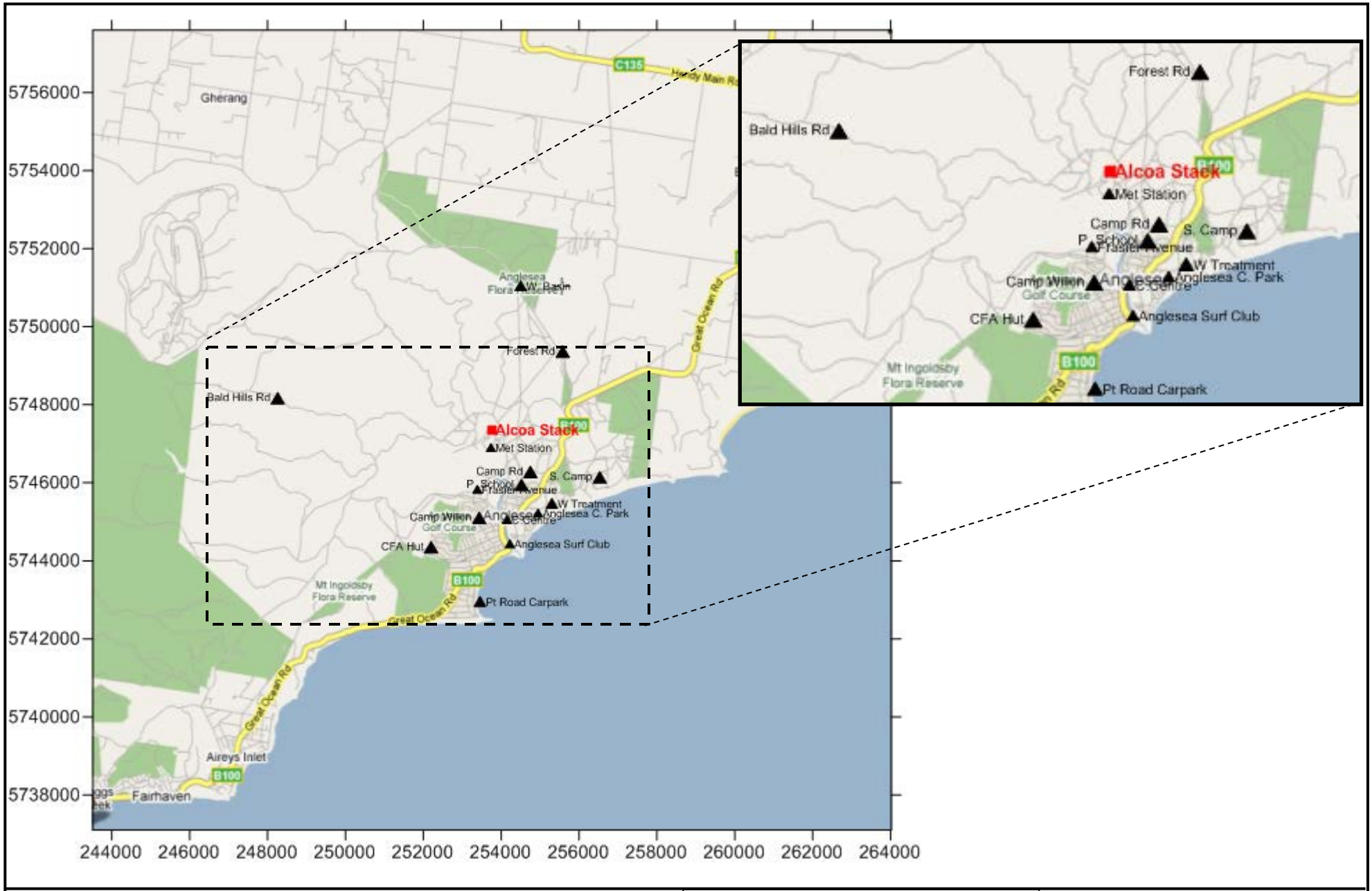


Figure 20: Location of Discrete Receptors (Source Base Map: Google Maps)

Client: Alcoa Anglesea		ENVIRON	
Project: Anglesea HHRA		Drawing Ref: AL	Date: 11/7/13

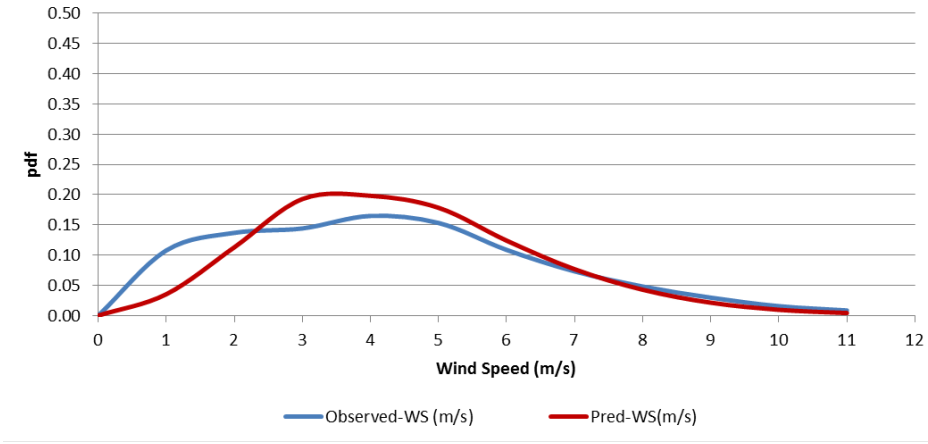


Figure 21: Pdf Plots of Wind Speed – Observed vs Predicted (2008-2012)

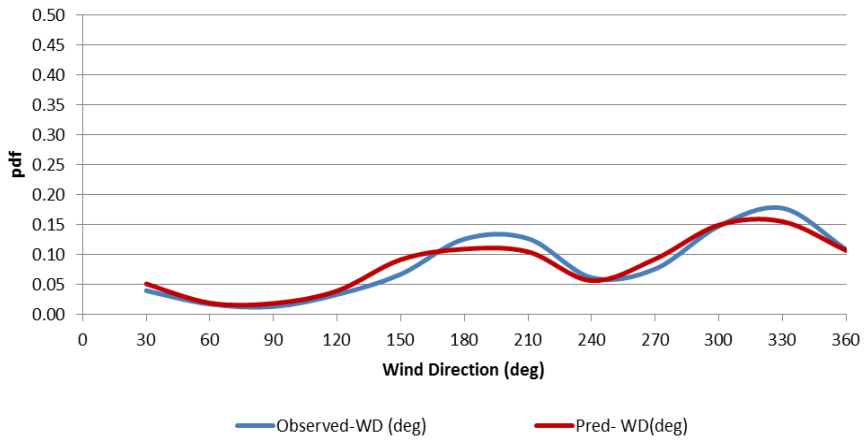
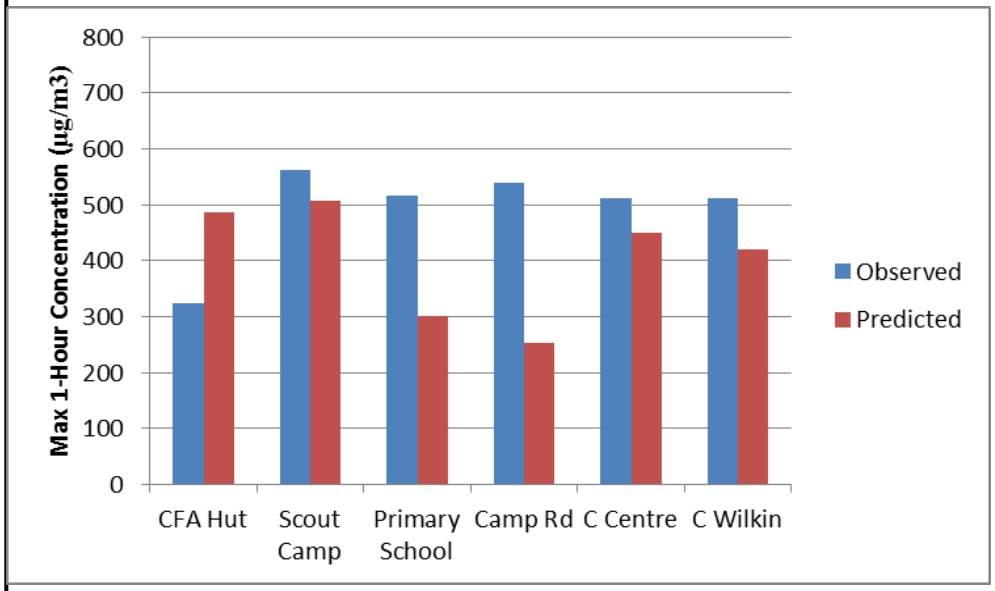
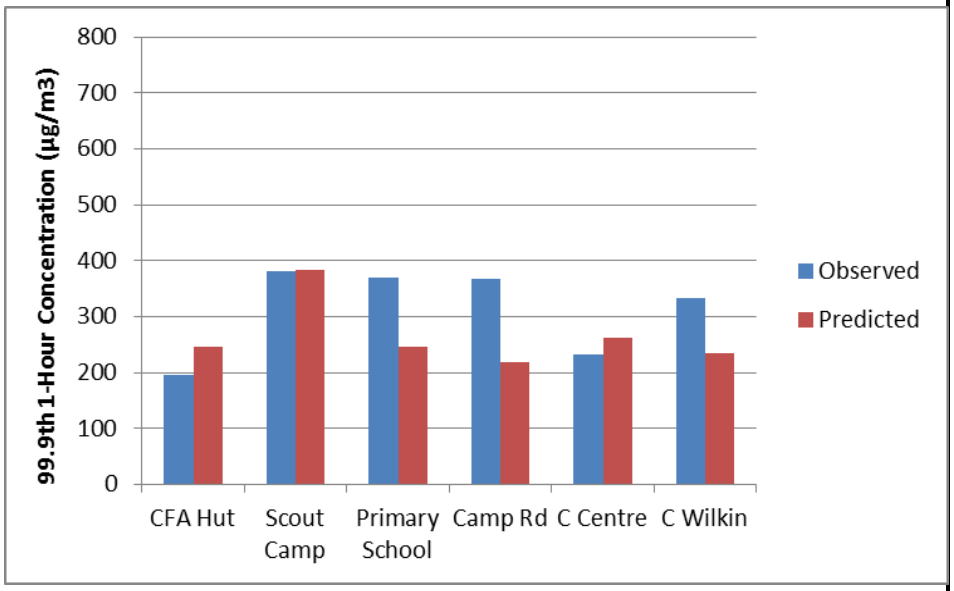


Figure 22: Pdf Plots of Wind Direction – Observed vs Predicted (2008-2012)





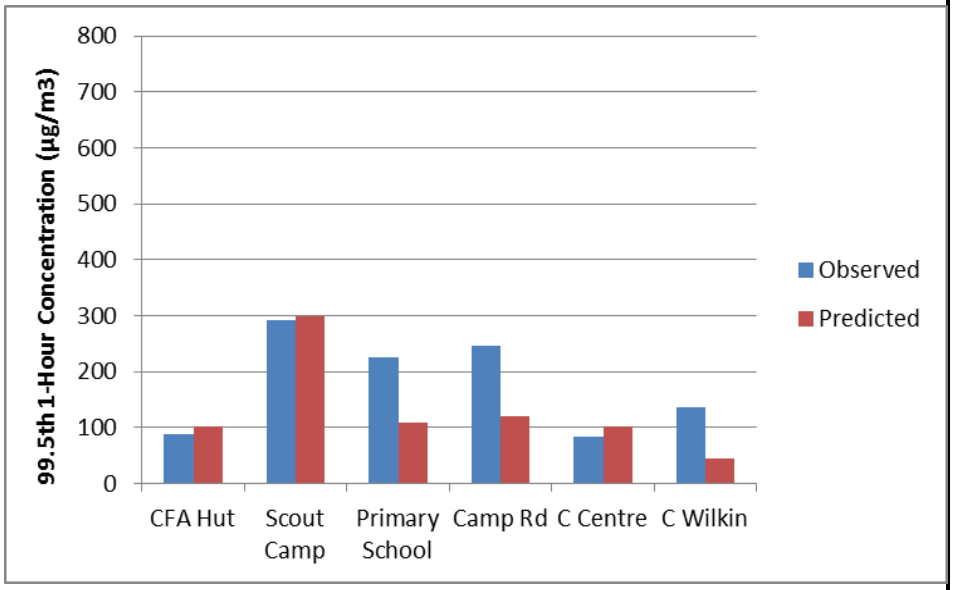
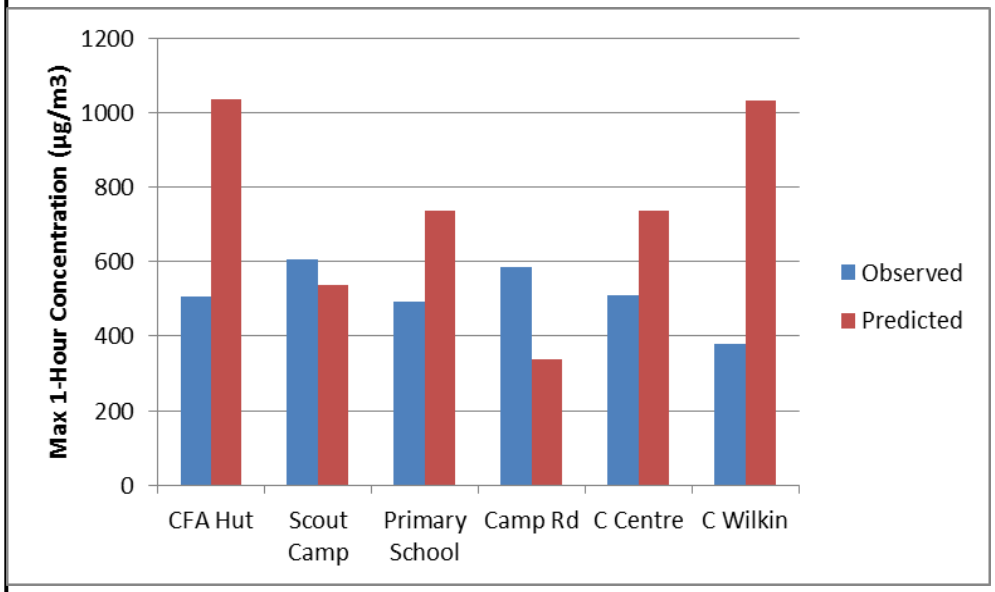
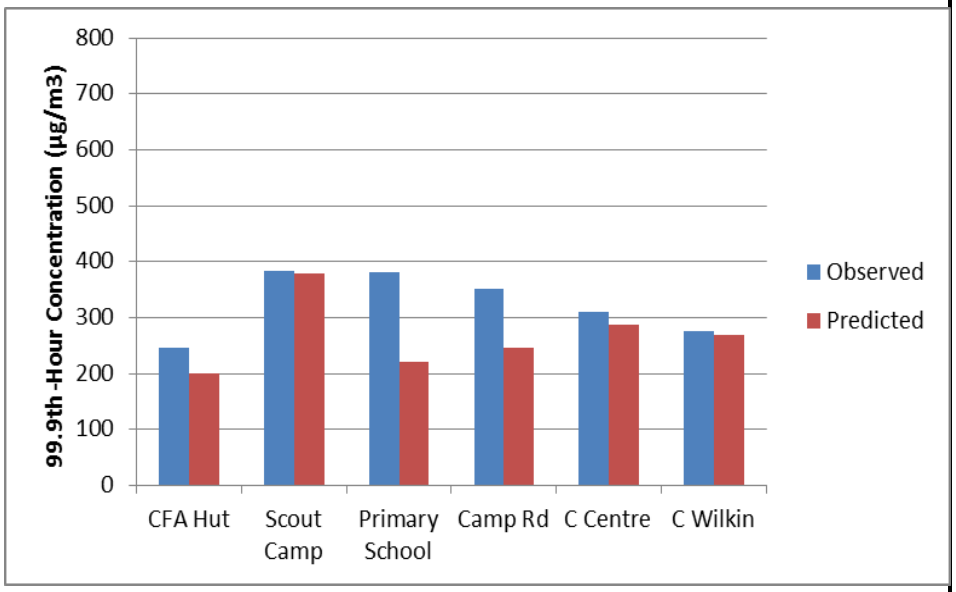


Figure 23: SO_2 Validation - Year 2008 – 1-Hour Maximum, 99.9th and 99.5th Percentiles

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13





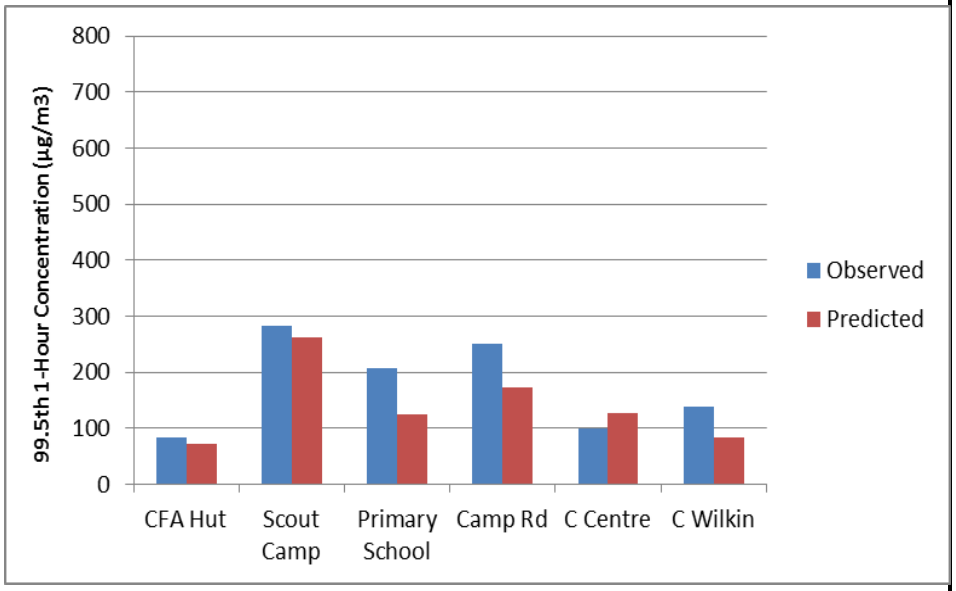
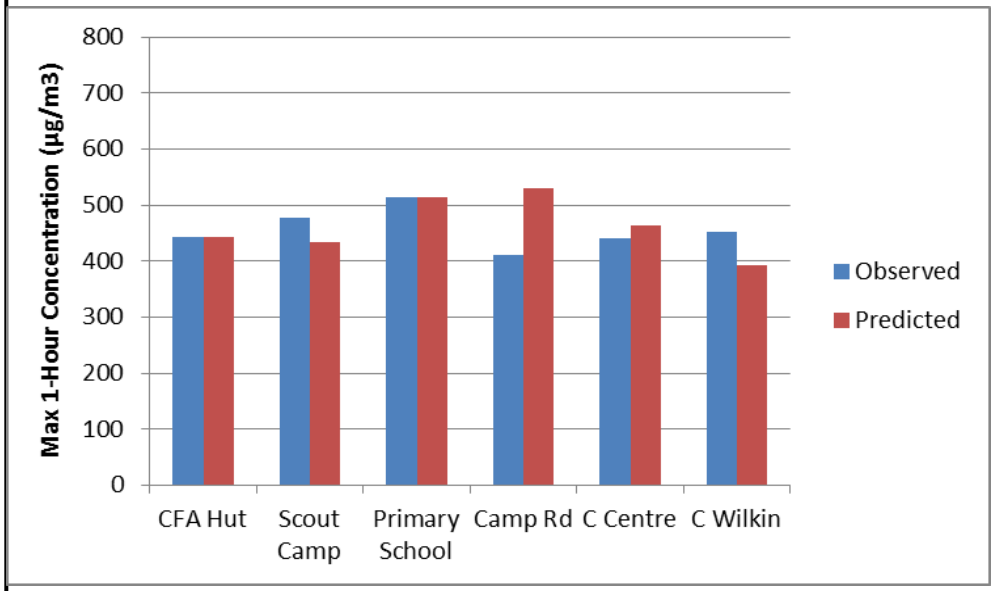
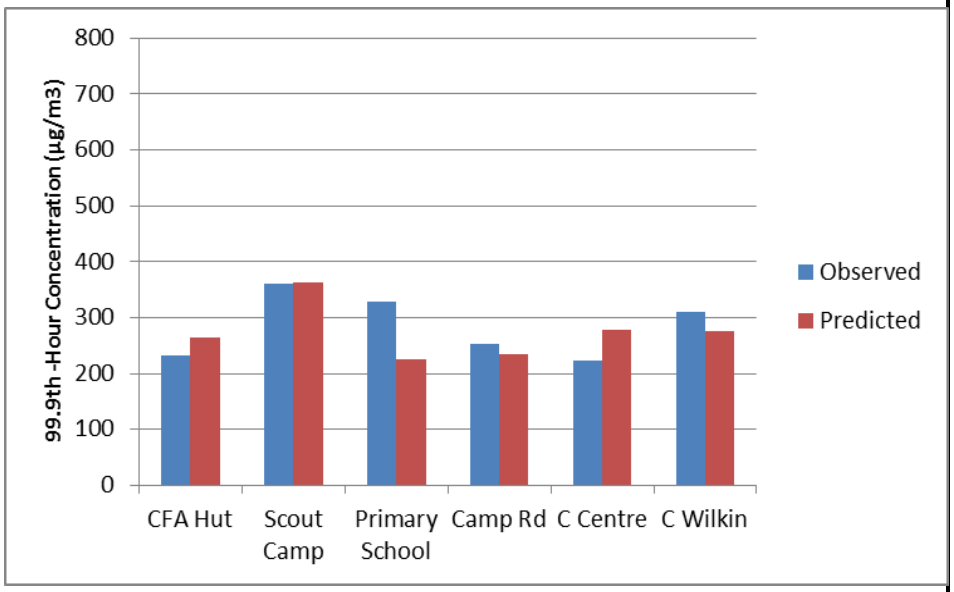


Figure 24: SO_2 Validation - Year 2009 – 1-Hour Maximum, 99.9th and 99.5th Percentiles

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13





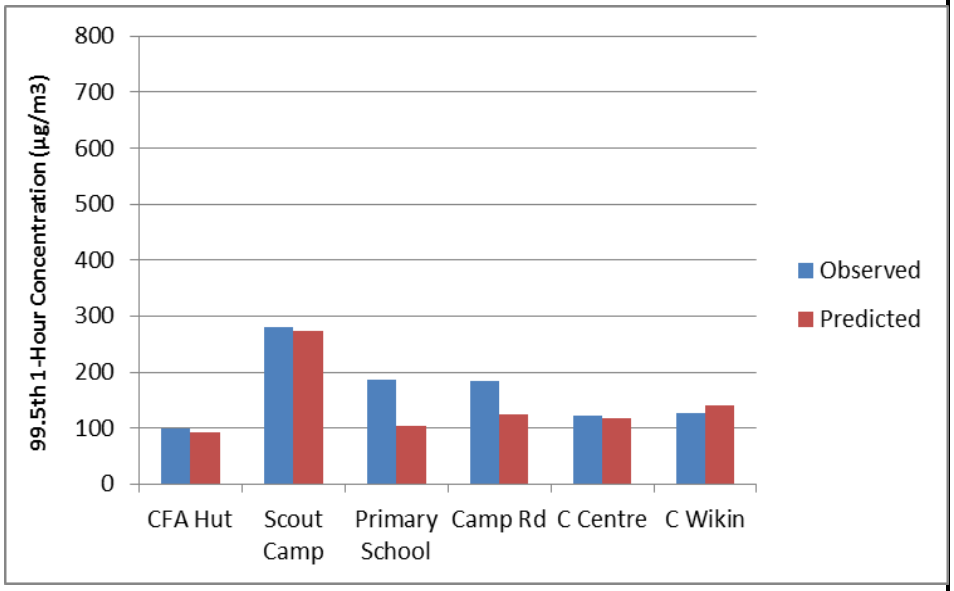
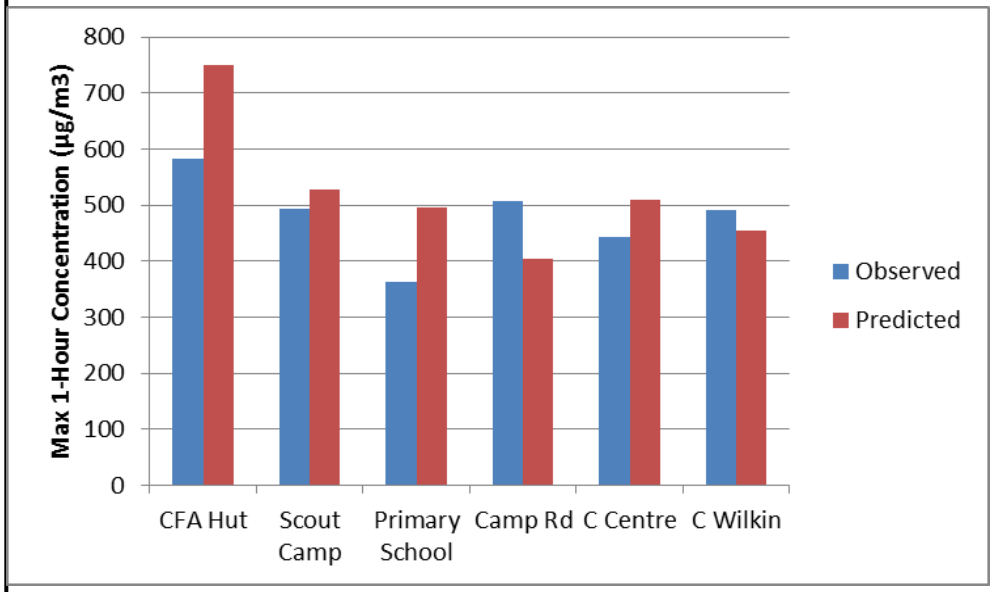
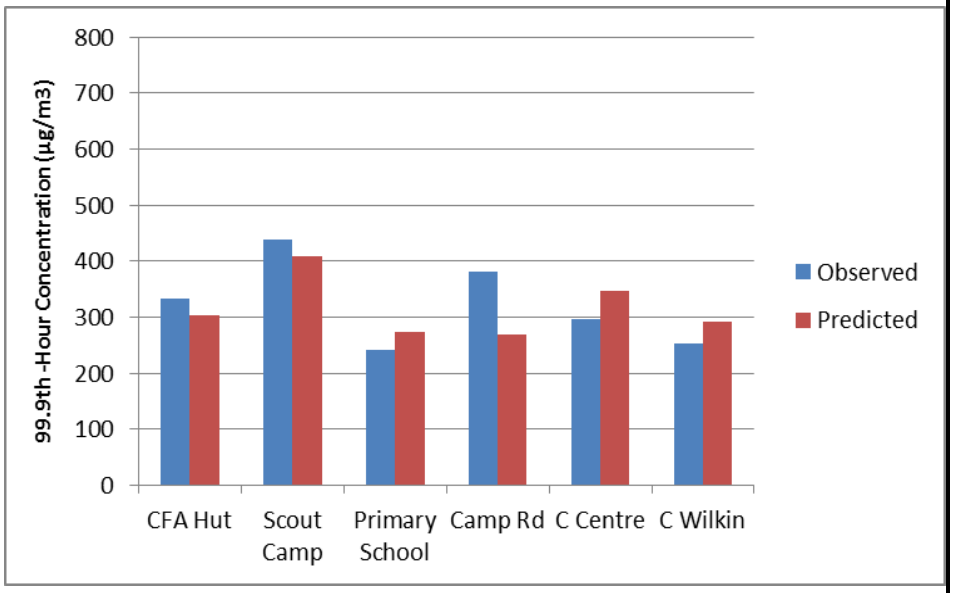


Figure 25: SO_2 Validation - Year 2010 – 1-Hour Maximum, 99.9th and 99.5th Percentiles

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13





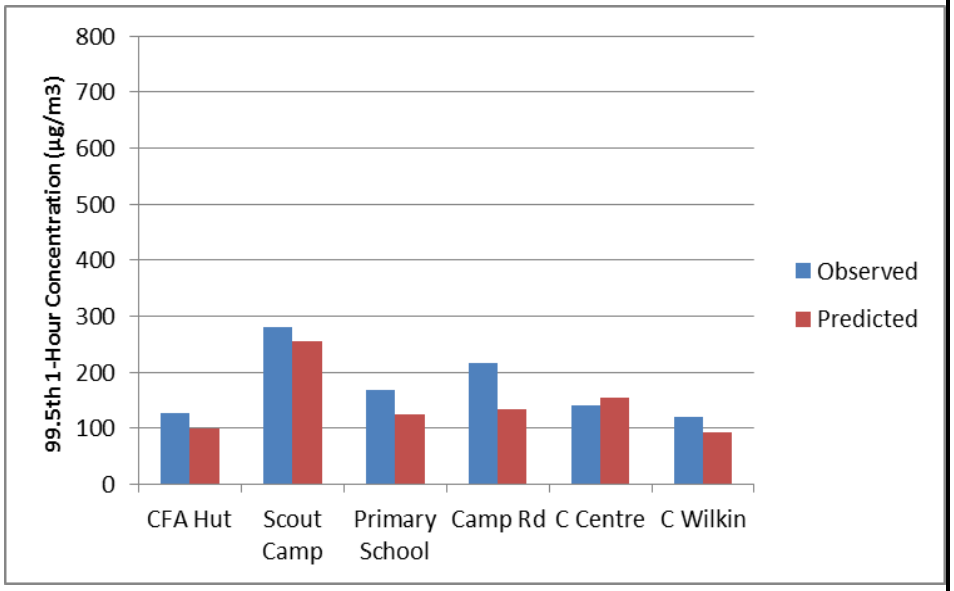
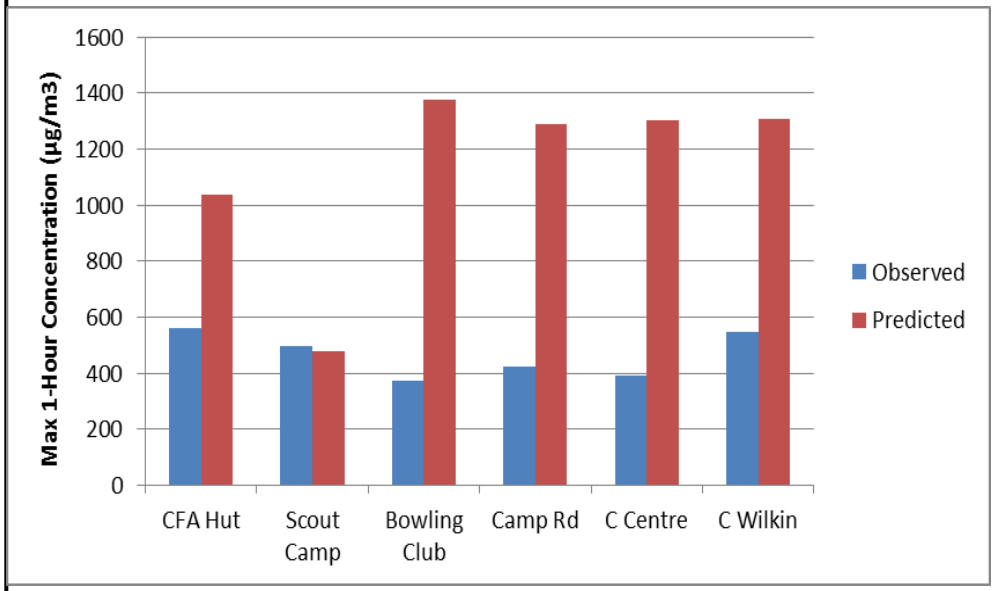
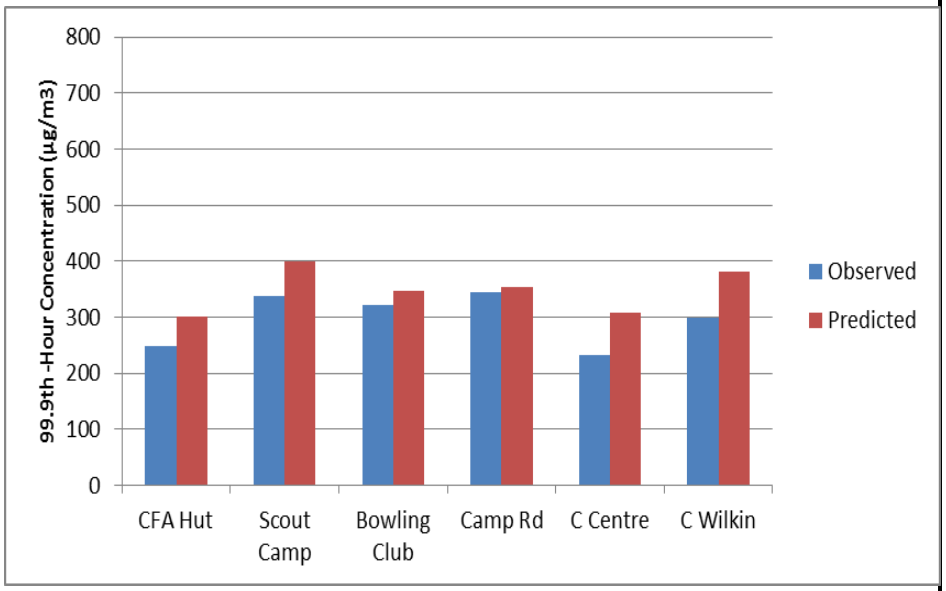


Figure 26: SO_2 Validation - Year 2011 – 1-Hour Maximum, 99.9th and 99.5th Percentiles

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13





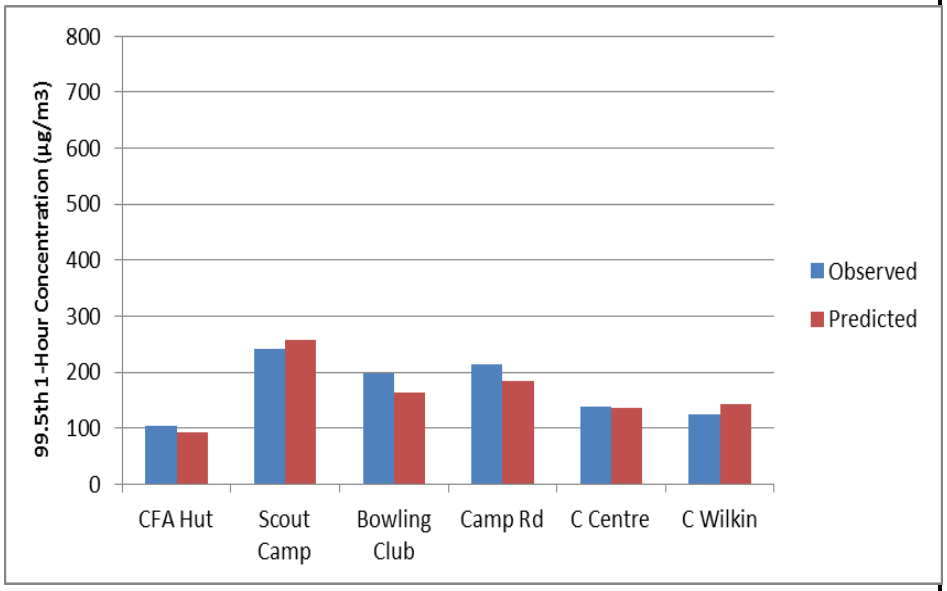
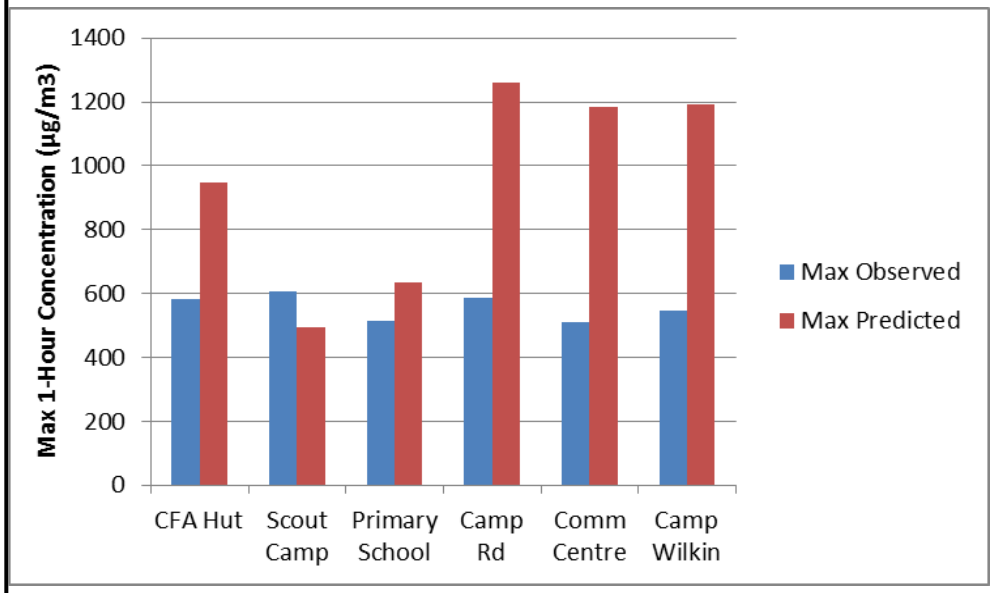
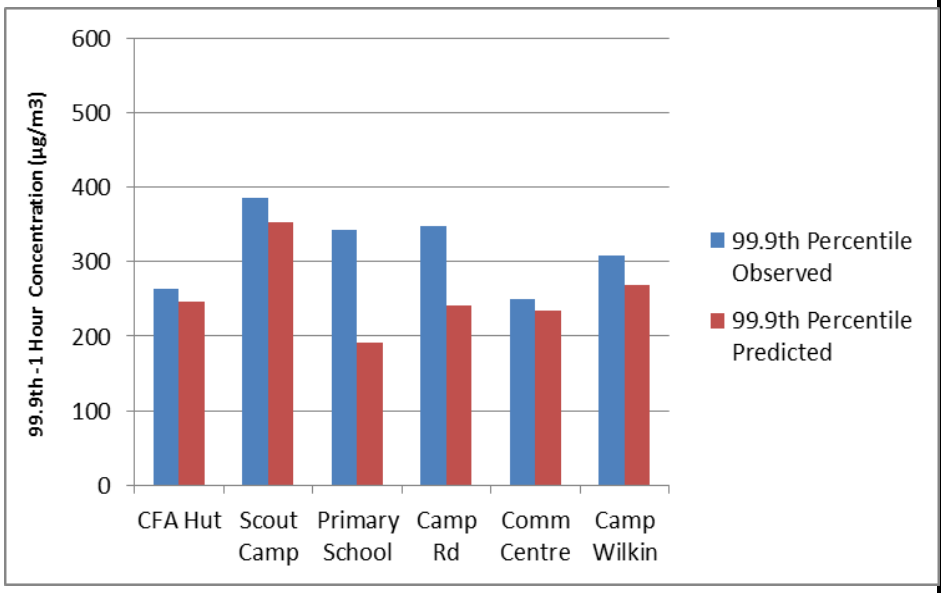


Figure 27: SO_2 Validation - Year 2012 – 1-Hour Maximum, 99.9th and 99.5th Percentiles

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13





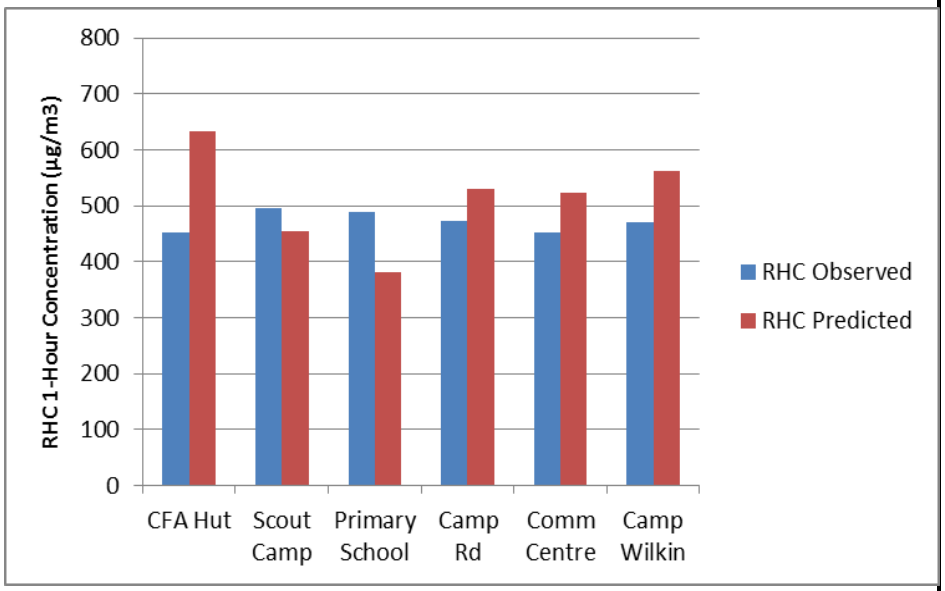
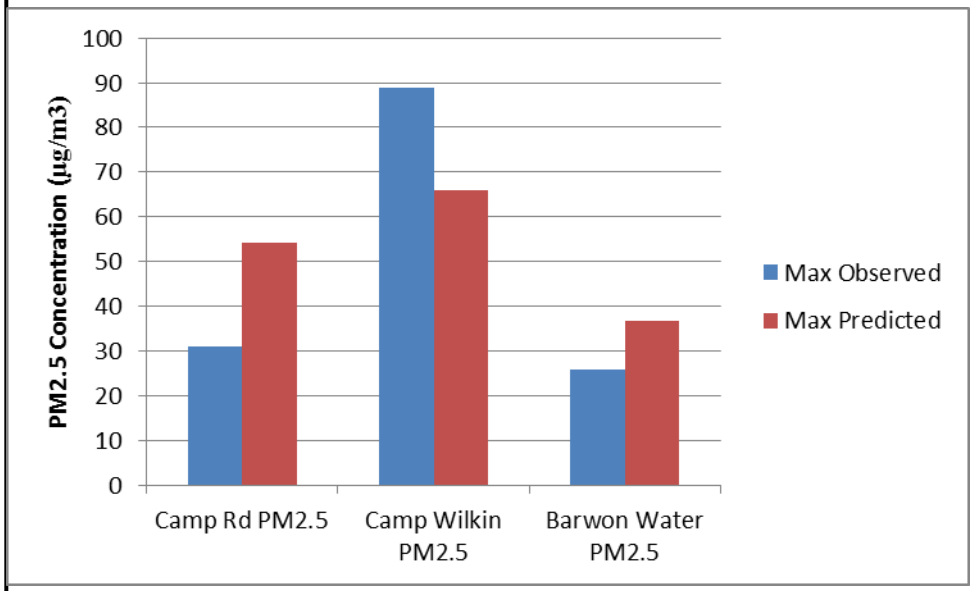
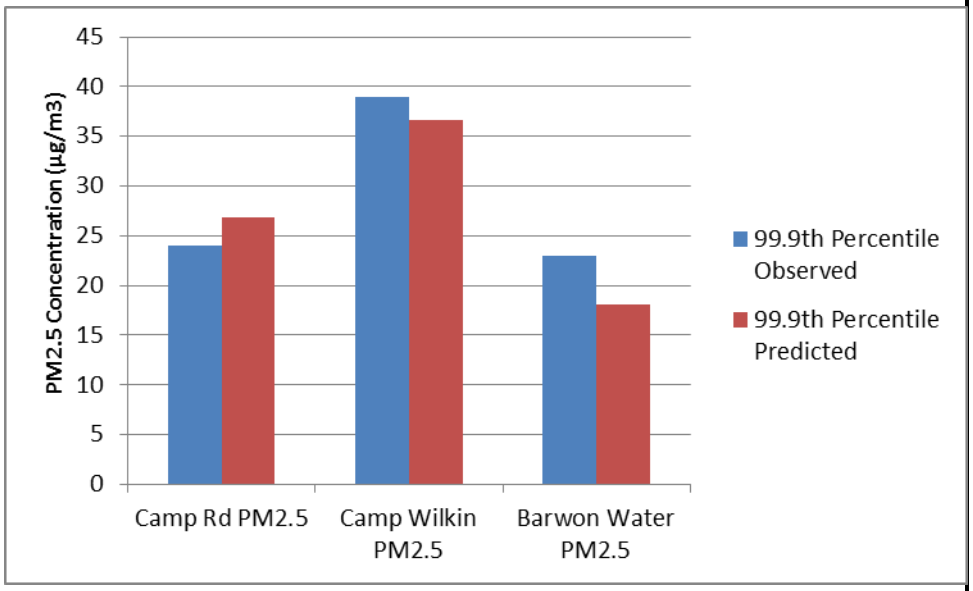


Figure 28: SO_2 Validation – All Years 2008-2012 – 1-Hour Maximum, 99.9th Percentile and RHC

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13





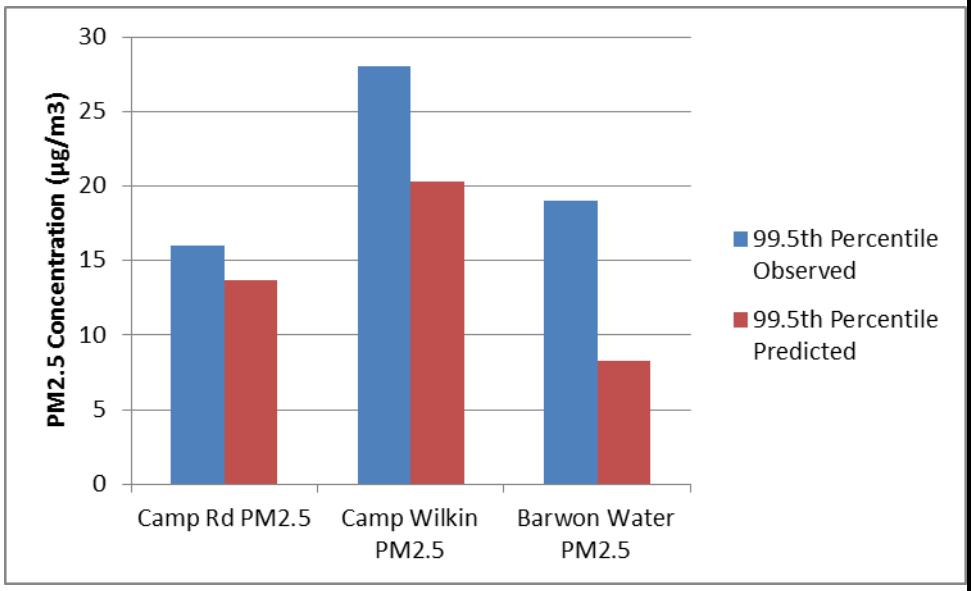
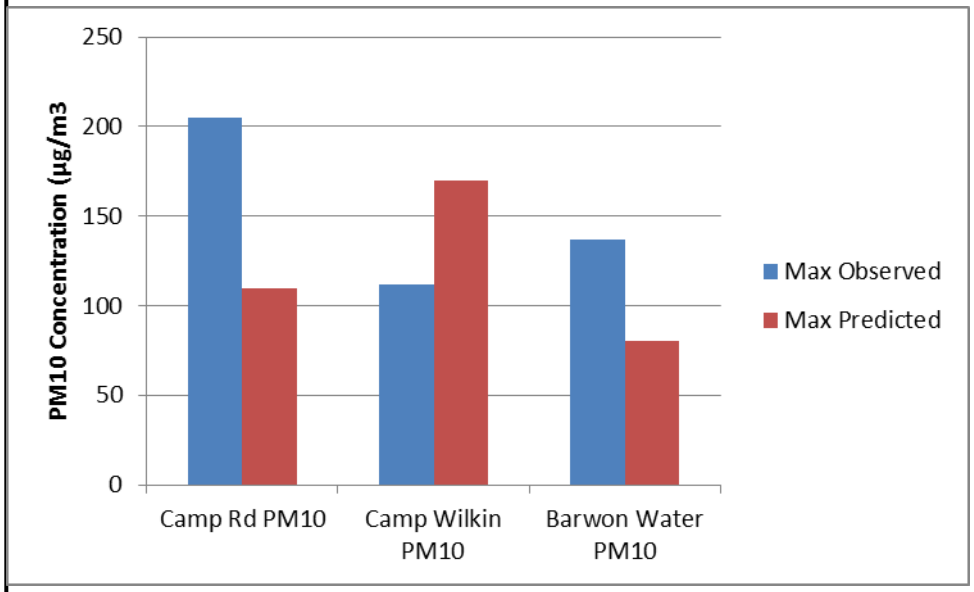
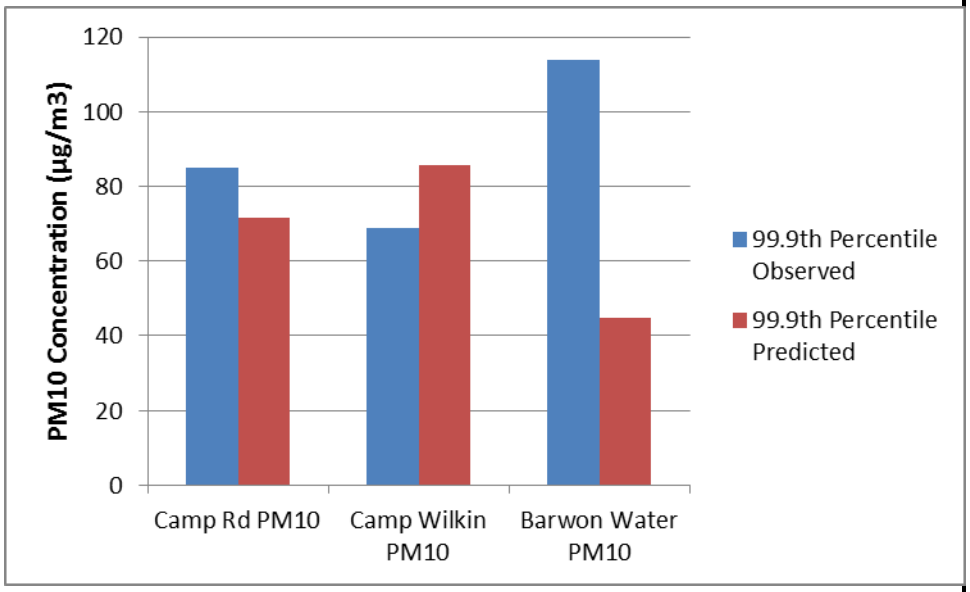


Figure 29: $PM_{2.5}$ Validation – July- December 2012 – 1-Hour Maximum, 99.9th and 99.5th Percentiles (Includes Background Concentration)

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13





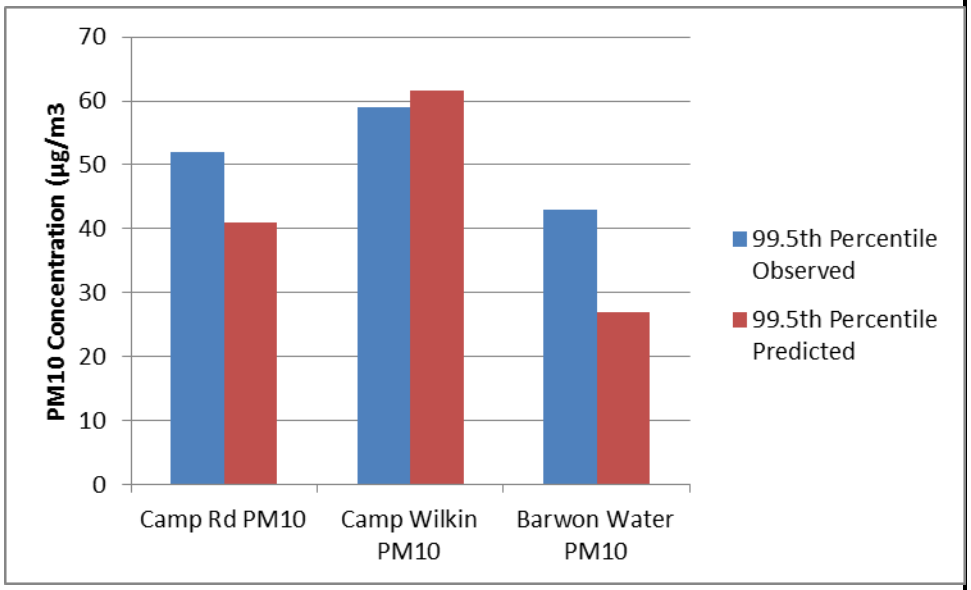


Figure 30: PM_{10} Validation – July- December 2012 – 1-Hour Maximum, 99.9th and 99.5th Percentiles (Includes Background Concentration)

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

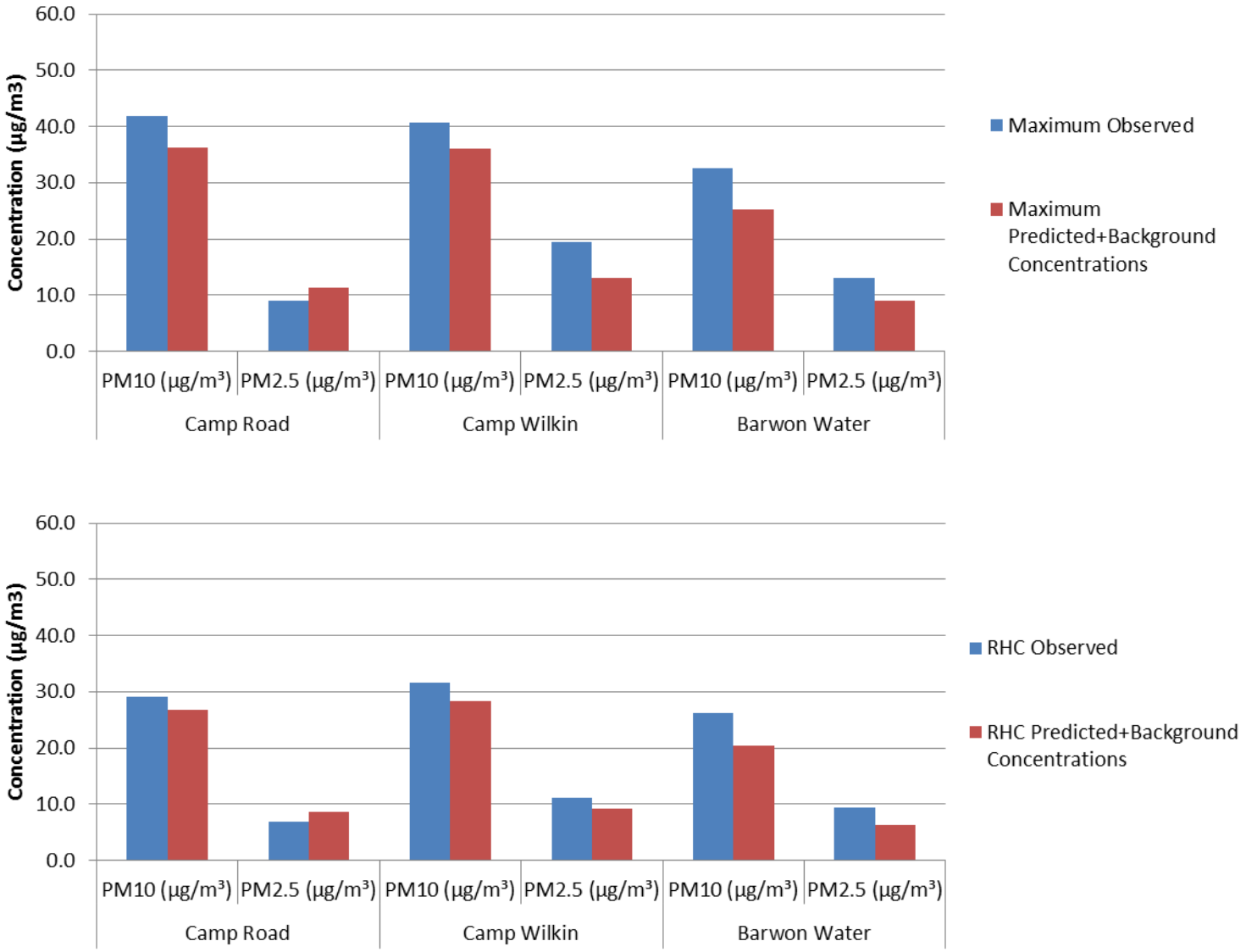


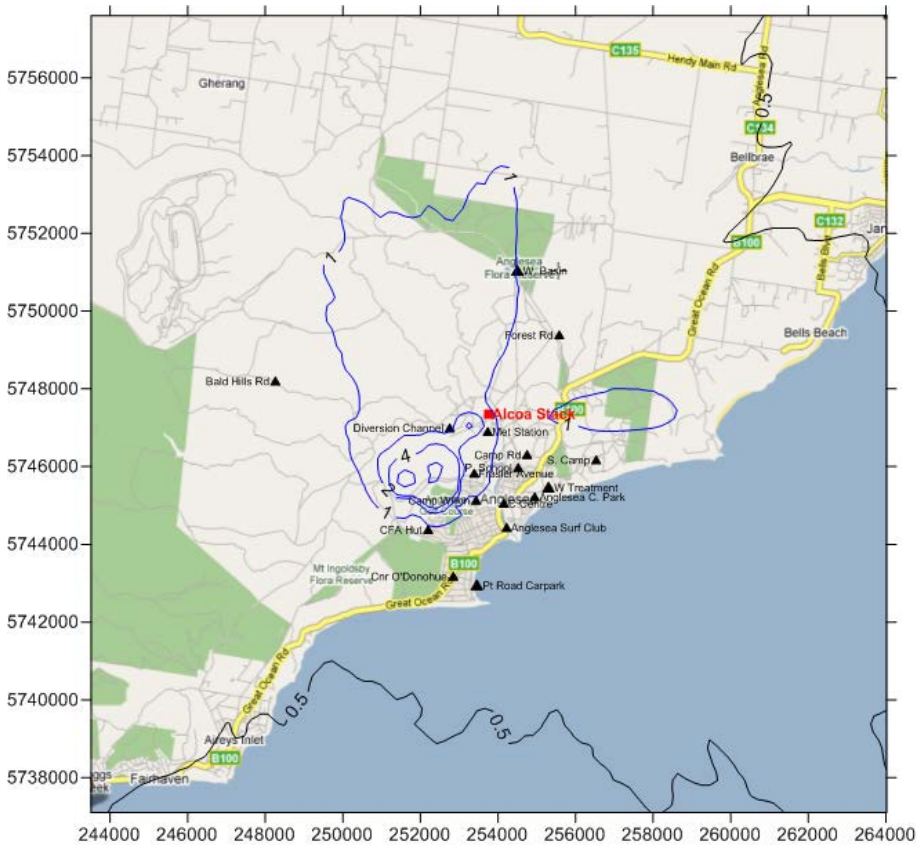
Figure 31: Ambient Dust 24 Hour Validation – July- December 2012 – Maximum and RHC

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level - Composite Acute HI (SO_2 and PM_{10})		
	Background	Predicted HI (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)
Max Composite Acute HI in Modelled Domain	0.34	38.2	38.5
1	0.34	0.86	1.20
2	0.34	0.68	1.02
3	0.34	0.94	1.28
4	0.34	0.60	0.94
5	0.34	0.79	1.13
6	0.34	0.76	1.10
7	0.34	0.67	1.01
8	0.34	0.71	1.05
9	0.34	1.00	1.34
10	0.34	0.66	1.00
11	0.34	0.77	1.11
12	0.34	0.72	1.06
13	0.34	1.19	1.53
14	0.34	0.53	0.87

Figure 32: Composite Acute HI (SO_2 and PM_{10}) (Source Base Map: Google Maps)

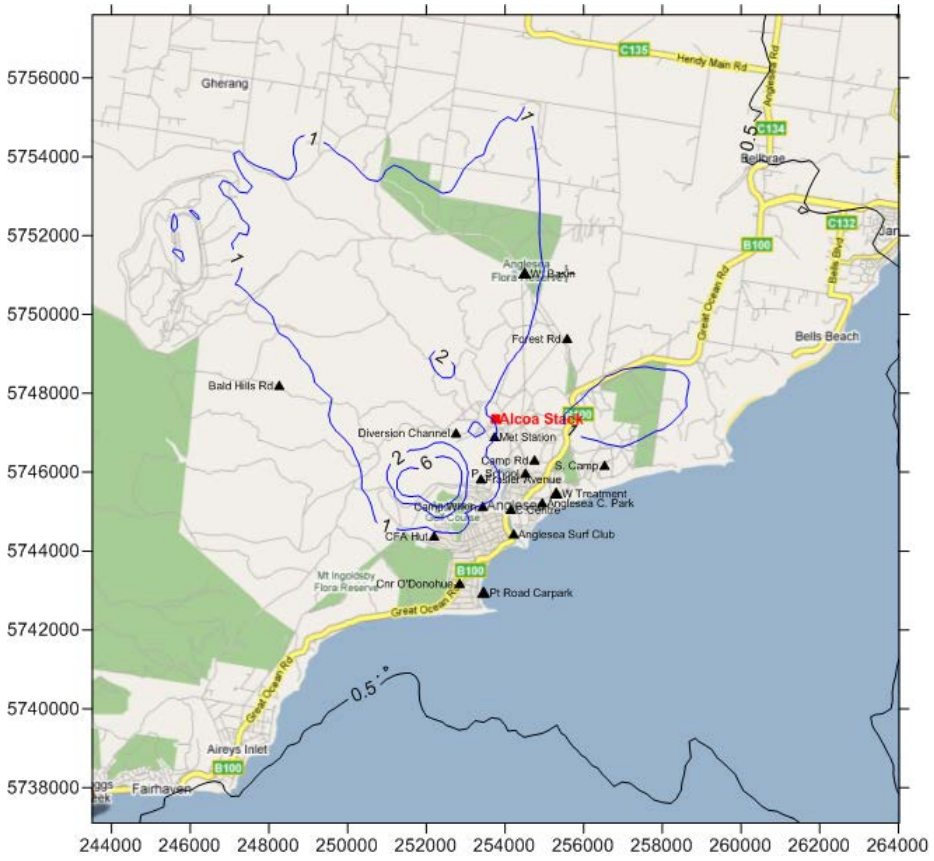
Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13



Receptor	Predicted Ground Level - 24-Hour Acute HI (SO_2 and PM_{10})		
	Background	Predicted HI (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)
Max Composite Acute HI in Modelled Domain	0.34	37.8	38.1
1	0.34	0.57	0.91
2	0.34	0.39	0.73
3	0.34	0.62	0.96
4	0.34	0.31	0.65
5	0.34	0.56	0.90
6	0.34	0.49	0.83
7	0.34	0.48	0.82
8	0.34	0.41	0.75
9	0.34	0.72	1.06
10	0.34	0.36	0.70
11	0.34	0.47	0.81
12	0.34	0.39	0.73
13	0.34	0.93	1.27
14	0.34	0.31	0.65

Figure 33: 24-Hour Acute HI (SO_2 and PM_{10}) (Source Base Map: Google Maps)

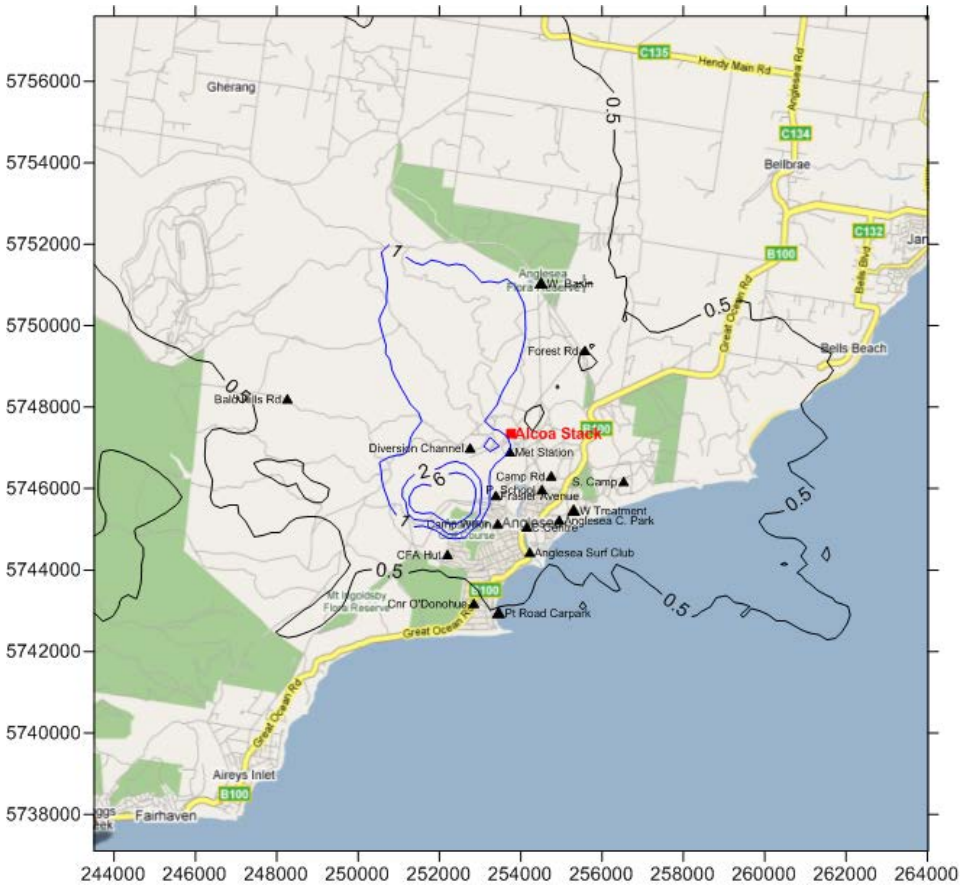
Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13



Receptor	Predicted Ground Level - Composite Acute HI (SO_2 and $PM_{2.5}$)		
	Background	Predicted HI (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)
Max Composite Acute HI in Modelled Domain	0.20	24.0	24.2
1	0.20	0.70	0.90
2	0.20	0.65	0.85
3	0.20	0.91	1.11
4	0.20	0.57	0.77
5	0.20	0.75	0.95
6	0.20	0.70	0.90
7	0.20	0.63	0.83
8	0.20	0.65	0.85
9	0.20	0.90	1.10
10	0.20	0.62	0.82
11	0.20	0.72	0.92
12	0.20	0.69	0.89
13	0.20	0.93	1.13
14	0.20	0.50	0.70

Figure 34: Composite Acute HI (SO_2 and $PM_{2.5}$)

(Source Base Map: Google Maps)



Receptor	Predicted Ground Level - 24-Hour Acute HI (SO_2 and $PM_{2.5}$)		
	Background	Predicted HI (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)
Max Composite Acute HI in Modelled Domain	0.20	23.6	23.8
1	0.20	0.41	0.61
2	0.20	0.36	0.56
3	0.20	0.59	0.79
4	0.20	0.28	0.48
5	0.20	0.52	0.72
6	0.20	0.43	0.63
7	0.20	0.44	0.64
8	0.20	0.35	0.55
9	0.20	0.62	0.82
10	0.20	0.32	0.52
11	0.20	0.42	0.62
12	0.20	0.36	0.56
13	0.20	0.67	0.87
14	0.20	0.28	0.48

Figure 35: 24 Hour Acute HI (SO_2 and $PM_{2.5}$) (Source Base Map: Google Maps)

Client: Alcoa Anglesea	ENVIRON	
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level - Chronic HI (SO_2 and $PM_{2.5}$)		
	Background	Predicted HI (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)
Max Annual Ave in modelled domain	0.63	7.8	8.4
1	0.63	0.13	0.76
2	0.63	0.09	0.72
3	0.63	0.15	0.78
4	0.63	0.09	0.72
5	0.63	0.14	0.77
6	0.63	0.12	0.75
7	0.63	0.12	0.75
8	0.63	0.10	0.73
9	0.63	0.14	0.77
10	0.63	0.08	0.71
11	0.63	0.12	0.75
12	0.63	0.11	0.74
13	0.63	0.20	0.83
14	0.63	0.07	0.70

Figure 36: Chronic HI – (SO_2 and $PM_{2.5}$) (Source Base Map: Google Maps)

DRAFT

Appendix A
EPA Correspondence

30 October 2007

Neil Salisbury
Manager
Environ Australia
Suite 5, 651 Victoria St
ABBOTSFORD VIC 3067

Our Ref: 32313

Dear Neil

PORTLAND ALUMINIUM QHRA

Thank you for your letter regarding additional information on the air dispersion modelling and Quantitative Health Risk Assessment for Portland Aluminium.

EPA has the following comments in response to the questions you have raised.

- If there is evidence that a substance will be present or will be generated through the process then it should be included in the inventory. EPA agrees with the method of using half the limit of detection, but does not support the approach of converting the non-detects to zero if it is expected that a substance will be present.

- The cumulative carcinogenic risk should not exceed 1 in 100,000. This includes the contribution from background levels, and should be considered as the upper bound of risk, not the acceptable risk target. Emission controls should be aimed at reducing the risk to 1 in a million. The contribution from the facility alone (i.e. without background) should not exceed 1 in a million.

- The *State environment protection policy (Air Quality Management)* [SEPP (AQM)] and the *State environment protection policy (Ambient Air Quality)* [SEPP (AAQ)] objectives must be used where available. If other standards/guidelines are to be used they must be justified, and as far as possible guidelines from only one agency should be used.

  The intervention levels in the SEPP (AQM) for air toxics were adopted from the Texas Centre for Environmental Quality Effect Screening Levels (ESL). To be consistent with SEPP (AQM) it would be appropriate to use these values. The Californian EPA also has a set of Acute and Chronic Reference Exposure Levels (REL) from which the derivation is available on their website.

  EPA recommends the following hierarchy for using the standards/guidleines

1. SEPP (AQM)
2. Texas ESL
3. Californian EPA REL

- The SEPP (AQM) requires background data to be included, unless it can be demonstrated that there are no other sources of the pollutant in the region. Background data must be included for all criteria pollutants.

  EPA has data available on PM_{10} for Warrnambool. Please contact EPA for advice on other data that may be appropriate to your assessment.

- EPA agrees with the approach for comparing the predicted ground level concentrations against the SEPP (AQM). Only substances that do not meet the design criteria (including background) need to undergo a quantitative risk assessment.

- EPA agrees the approach for reviewing the sensitive receptors.

- Modelling should be conducted for the worst-case normal operations (e.g. maximum emissions), and should be done using the maximum hourly emissions rates.

- EPA agrees with the use for the Mt Gambier data for the preliminary evaluation of model predications.

- $PM_{2.5}$ emissions should be modelled for all cases where particles (PM_{10} and TSP) are being modelled.

- The time series plots should show background, contribution from the smelter and combine concentration separately on the graph so that the contribution from the smelter to the total concentrations can be clearly identified.

- In schedule A of SEPP (AQM), the design criteria for PAHs refer to PAH measured as benzo-a-pyrene.

  For the intervention levels specified in Schedule B the definition of PAHs are all particles bound PAHs with a vapour pressure below that of Pyrene (at STP).

For the standard 16 PAHs measured the particle bound PAHs is considered the sum of the following compounds:

- benz(a)anthracene
- Chrysene
- benzo(b&k) fluoranthene,
- benzo(a)pyrene
- benzo(e)pyrene
- perylene
- indeno (1,2,3-cd)pyrene
- dibenzo(a.h)anthrancene
- benzo(ghi)perylene.

If you have any queries please contact me on 5226 4825.

Yours sincerely

ERICA KUHLE
SOUTH WEST REGION

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Appendix B
Sampling Methods

Contractor Company Name: SGS

Analyte	Sampling Methodology/ SGS Method ID	Analytical Methodology/ SGS Method ID	Analysis Performed by/NATA Accreditation Number:	Analytical Limit of Detection	QC Method (Spiking/Ref. Std etc)
Carbon Monoxide	Online analyser / SGS Method VAMTR-PEMS	Non-dispersive infrared CO analyser	SGS (onsite)/ NATA Acc no: 14601	0.5ppm	On-use calibration with NATA certified gas standard
Oxides of Nitrogen	Online analyser / SGS Method VAMTR-PEMS	Chemiluminescence NOx analyser/ USEPA Method 7E	SGS (onsite)/ NATA Acc no: 14601	0.5ppm	On-use calibration with NATA certified gas standard
Sulphur Dioxide	Online analyser / SGS Method VAMTR-PEMS	Fluorescence SO2 analyser.	SGS (onsite)/ NATA Acc no: 14601	-	On-use calibration with NATA certified gas standard
Polycyclic Aromatic Hydrocarbons	Isokinetic sampling into a train consisting of a filter, resin trap and impinger train/ California Air Resources Board Method 429,	Gas chromatography with mass selective detection (GCMS)/ CARB 429	SGS Belgium (reported by SGS Australia)/ NATA Acc no: 2562	0.25µg	Field spike (pre-sampling) and laboratory(post-sampling) spike
Chloride as hydrogen chloride	Impinger train sampling USEPA Method No 26A.	USEPA Method No 26A. analysis by ION chromatography.	SGS Sydney, report no.51894	-	-
Total Fluorides	Isokinetic sampling using method MEA-238	Soluble fluoride fraction analysed using fluoride specific electrode	SGS Gippsland (reported by SGS Australia)	-	Field spike (pre-sampling) and laboratory(post-sampling) spike
Volatile Organic Compounds	Single-point sampling onto a activated charcoal tube/ Vic EPA Method 4230.	Gas chromatography with mass selective detection (GCMS)/ Vic EPA Method 440.1	SGS Coburg (reported by SGS Australia)/ NATA Acc no: 2562	10µg	Duplicate samples

Analyte	Sampling Methodology/ SGS Method ID	Analytical Methodology/ SGS Method ID	Analysis Performed by/NATA Accreditation Number:	Analytical Limit of Detection	QC Method (Spiking/Ref. Std etc)
Dioxins and furans	Isokinetic sampling into a train consisting of a filter, resin trap and impinger train/ USEPA Method 23	Gas chromatography with mass selective detection (GCMS)/ CARB 429	SGS Belgium (reported by SGS Australia)/ NATA Acc no: 2562	0.25 – 130 µg (depending on dioxin/furan species)	Field spike (pre-sampling) and laboratory (post-sampling) spike
Carbon Dioxide	Online Analyser / SGS method VAMTR-PEMS	Non-dispersive infrared CO analyser	SGS (onsite)/ NATA Acc no: 14601	0.5ppm	On-use calibration with NATA certified gas standard
Total (Gaseous and Particulate) Metals and Metallic compounds	Isokinetic sampling into a train consisting of a filter and impingers/ USEPA Method 29	Inductively coupled plasma (ICP) or atomic absorption (AA) spectroscopy/ USEPA Method 29	SGS Australia/ NATA Acc no: 2562	0.1 – 10 µg (depending on metal species)	Matrix spike Duplicate samples
Particulate Matter	Isokinetic sampling into an in-line filter holder, (in-stack)/ AS 4323.2 1995	Gravimetric analysis/ AS 4323.2 1995.	SGS (laboratory)/ NATA Acc no: 14601	0.5mg	Acetone blank
Particulate Matter 10	Sampling using Malvern Mastersizer M20 laser particle size analyser	Gravimetric analysis/ USEPA Method 201A	Herman Research Laboratories	-	-
Moisture Content	Gravimetry, MEA-105/ SGS method MEA-107	USEPA method 23,29, 26A	NA	NA	NA
Flow rate and Velocity	MEA-100, using a pitot tube and differential manometer.	NA	SGS (onsite)/ NATA Acc no:	NA	NA
Sampling plane criteria	AS 4323.1 -1995	NA	NA	NA	NA

D R A F T

Appendix C
TAPM Input File

```
|----------------------------------------|
| THE AIR POLLUTION MODEL (TAPM V4.0.4). |
| Copyright (C) CSIRO Australia. |
| All Rights Reserved. |
|----------------------------------------|

----------------
RUN INFORMATION:
----------------
NUMBER OF GRIDS=           4
GRID CENTRE (longitude,latitude)=(   144.1750     , -38.39167     )
GRID CENTRE (cx,cy)=(      253764 ,     5747349 ) (m)
GRID DIMENSIONS (nx,ny,nz)=(         42 ,         42 ,         25 )
NUMBER OF VERTICAL LEVELS OUTPUT =         17
DATES (START,END)=(    20091229 ,    20101231 )
DATE FROM WHICH OUTPUT BEGINS =    20100101
LOCAL HOUR IS GMT+   9.600000
TIMESTEP SCALING FACTOR =   1.000000
VARY SYNOPTIC WITH 3-D SPACE AND TIME
V4 LAND SURFACE SCHEME
EXCLUDE NON-HYDROSTATIC EFFECTS
INCLUDE PROGNOSTIC RAIN EQUATION
EXCLUDE PROGNOSTIC SNOW EQUATION
TKE-EPS TURBULENCE (PROGNOSTIC TKE + EPS, EDMF)
POLLUTION : 1 TRACER (TR1)
INCLUDE POLLUTANT VARIANCE EQUATION
INCLUDE 3-D POLLUTION OUTPUT (*.C3D)
POLLUTANT GRID DIMENSIONS (nxf,nyf)=(         83 ,         83 )
TR1 POLLUTANT SPECIES : GENERIC
TR1 BACKGROUND =  0.0000000E+00 (ug/m3)
TR1 DECAY RATE =  0.0000000E+00 (per second)
---------------------------------

START GRID          1 angle01
GRID SPACING (delx,dely)=(       20000 ,       20000 ) (m)
POLLUTANT GRID SPACING (delxf,delyf)=(       10000 ,       10000 ) (m)
NO MET. DATA ASSIMILATION FILE AVAILABLE
NO CONCENTRATION BACKGROUND FILE AVAILABLE
NO BUILDING FILE AVAILABLE
NUMBER OF pse SOURCES=           1
NO lse EMISSION FILE AVAILABLE
NO ase EMISSION FILE AVAILABLE
NO gse EMISSION FILE AVAILABLE
NO bse EMISSION FILE AVAILABLE
NO whe EMISSION FILE AVAILABLE
NO vpx EMISSION FILE AVAILABLE
NO vdx EMISSION FILE AVAILABLE
NO vlx EMISSION FILE AVAILABLE
NO vpv EMISSION FILE AVAILABLE

INITIALISE
```

LARGE TIMESTEP = 300.0000
METEOROLOGICAL ADVECTION TIMESTEP = 150.0000 (s)
POLLUTION ADVECTION TIMESTEP = 300.0000 (s)
pse KEY :
is = Source Number
ls = Source Switch (-1=Off,0=EGM,1=EGM+LPM)
xs,ys = Source Position (m)
hs = Source Height (m)
rs = Source Radius (m)
es = Buoyancy Enhancement Factor
fs_no = Fraction of NOX Emitted as NO
fs_fpm= Fraction of APM Emitted as FPM
INIT_pse
is, ls, xs, ys, hs, rs, es, fs_no, fs_fpm
1, 1, 253764., 5747349., 107.00, 1.94, 1.00, 1.00, 0.50,

LAGRANGIAN (LPM) MODE IS OFF FOR THIS GRID

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Appendix D
Haul Road Emission Rates

Haul Road Generated Dust

Average Wind Speed	4.2	m/s	
Moisture Content	44.8	%	

Total vehicle kilometres travelled (VKTs) for haulpacks were based on each truck driving over a haul road to either a waste dump or the primary crusher

PM10 Wheel Generated Dust from Unpaved Roads

EK=	0.4536/1.6093*1.5*(s/12)^0.9*((W*1.1023)/3)^0.45	kg/VKT	
VKT (vehicle kilometres travelled)			
Moisture Content of Coal	44.8	%	
S=Silt Content (%)	5	%	
W= Vehicle Gross mass in tonnes	70	tonnes	*(Assuming haul truck leaves full and arrives empty)*
Average speed light vehicles	30	km/h	
Average speed haul trucks	15	km/h	
PM10 - Wheel generated Dust from unpaved roads	0.8	kg/VKT	(VKT= vehicle kilometres travelled)
Total vehicle kilometers travelled over hours			
Total no. of trips of 60 ton Haul Truck to Crusher and back (5706 hours)	16651	trips	*45.62 Trips per day * 365 days*
Total no. of trips of 60 ton Haul Truck to waste dump (6536 hours)	51246	trips	*140.4 Trips per day * 365 days - by three overburden hau*
Kilometers travelled from coal pit to crusher	3.2	km	
Kilometers travelled from coal pit to waste dump	3.6	km	
			(Per Year)
Emissions from coal pit to crusher (PM10) - Haul Truck (5706 Hours)	2.2	g/s	
Emissions from coal pit to waste dump (PM10) - Haul Truck (6536 Hours)	6.5	g/s	
Movement on haul road (75% Control) - application of level 2 watering			
Emissions from coal pit to crusher (PM10) - Haul Truck	**0.54**	g/s	(75% Dust Control - Level 2 Watering)
Emissions from coal pit to waste dump (PM10) - Haul Truck	**1.62**	g/s	(75% Dust Control - Level 2 Watering)

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Appendix E
Concentration Isopleths for Compounds

NB: Background values represent the regional background levels

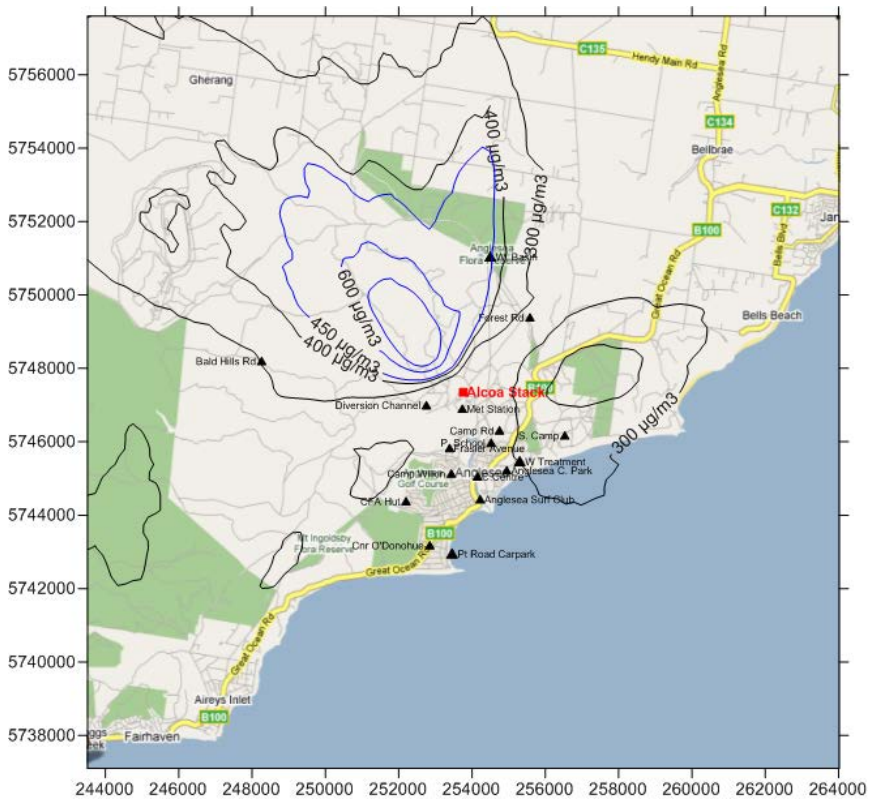

Figure E1: Predicted Ground Level Concentrations SO_2- 99.9th 1 Hour Average (µg/m³) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level SO_2 Concentration – 99.9th 1 Hour Average (µg/m³)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 1hr Ave for modelled domain outside plant boundary	1.8	**859**	**861**	450
1	1.8	248	250	450
2	1.8	307	309	450
3	1.8	**454**	**456**	450
4	1.8	284	286	450
5	1.8	354	356	450
6	1.8	247	249	450
7	1.8	235	237	450
8	1.8	271	273	450
9	1.8	266	268	450
10	1.8	275	277	450
11	1.8	322	324	450
12	1.8	299	301	450
13	1.8	214	216	450
14	1.8	218	220	450

Table E1: SO_2 – 99.9th 1 Hour Average Predicted Ground Level Concentrations (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Figure E2: Predicted Ground Level Concentrations CO- 99.9th 1 Hour Average (µg/m3) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level CO Concentration – 99.9th 1 Hour Average (µg/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 1hr Ave for modelled domain outside plant boundary	NA	1.9	1.9	29000
1	NA	0.6	0.6	29000
2	NA	0.7	0.7	29000
3	NA	1.0	1.0	29000
4	NA	0.7	0.7	29000
5	NA	0.7	0.7	29000
6	NA	0.6	0.6	29000
7	NA	0.6	0.6	29000
8	NA	0.7	0.7	29000
9	NA	0.6	0.6	29000
10	NA	0.7	0.7	29000
11	NA	0.8	0.8	29000
12	NA	0.7	0.7	29000
13	NA	0.5	0.5	29000
14	NA	0.6	0.6	29000

Table E2: CO- 99.9th 1 Hour Average Predicted Ground Level Concentrations (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

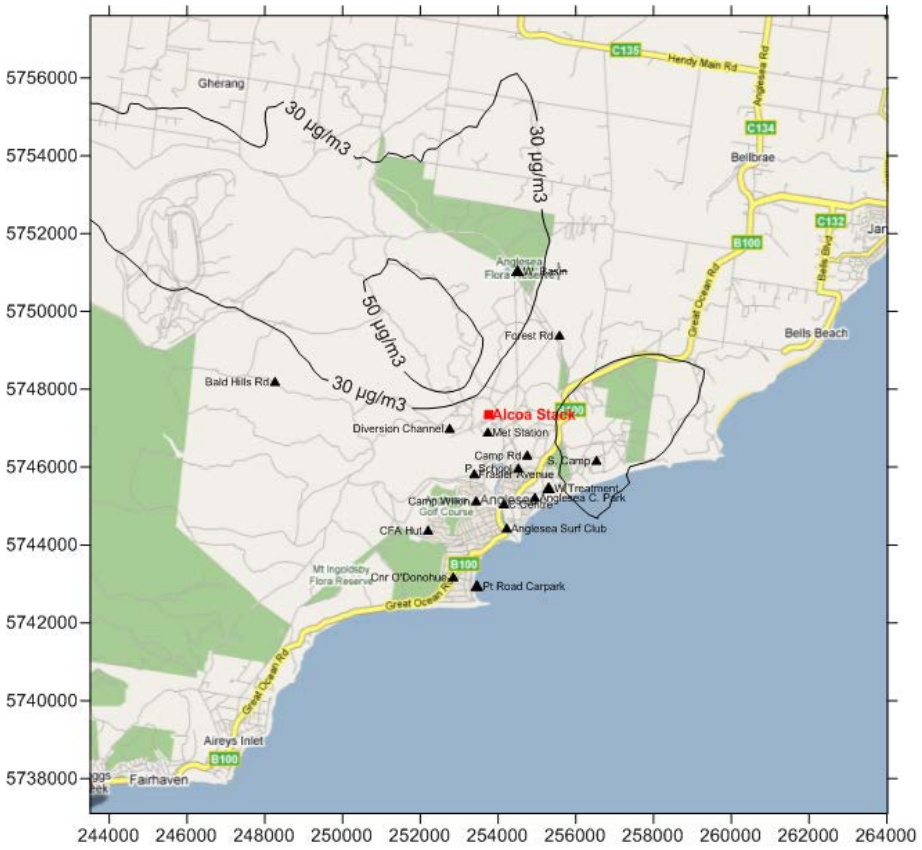

Figure E3: Predicted Ground Level Concentrations NO_2 – 99.9th 1 Hour Average (µg/m³) - Alcoa Only (2008-2012)

Receptor	Predicted Ground Level NO_2 Concentration – 99.9th 1Hour Avg (ug/m³)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 1hr Ave for modelled domain outside plant boundary	NA	71	71	190
1	NA	21	21	190
2	NA	25	25	190
3	NA	37	37	190
4	NA	24	24	190
5	NA	24	24	190
6	NA	22	22	190
7	NA	24	24	190
8	NA	26	26	190
9	NA	23	23	190
10	NA	25	25	190
11	NA	29	29	190
12	NA	27	27	190
13	NA	18	18	190
14	NA	22	22	190

Table E3: NO_2– 99.9th 1 Hour Average Predicted Ground Level Concentrations (2008-2012)

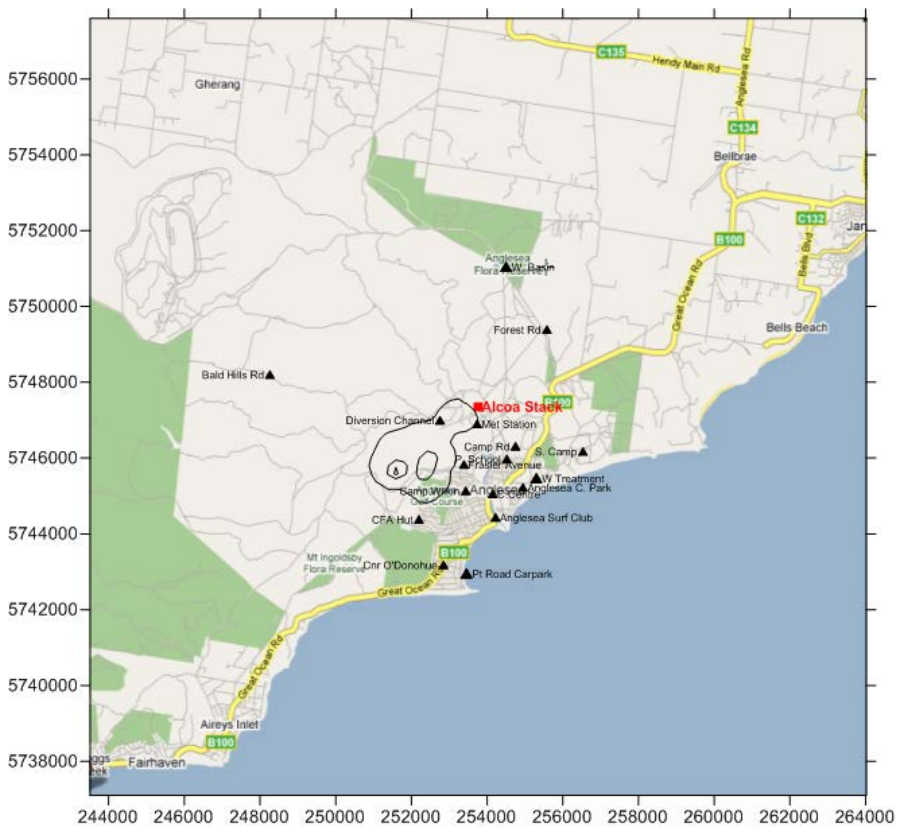

Figure E4: Predicted Ground Level Concentrations Lead- 99.9th 1Hr Average (µg/m3) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Lead Concentration – 99.9th 1Hour Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 1hr Ave for modelled domain outside plant boundary	NA	0.022	0.022	3
1	NA	0.0004	0.0004	3
2	NA	0.0003	0.0003	3
3	NA	0.0003	0.0003	3
4	NA	0.0002	0.0002	3
5	NA	0.0003	0.0003	3
6	NA	0.0004	0.0004	3
7	NA	0.0004	0.0004	3
8	NA	0.0003	0.0003	3
9	NA	0.0004	0.0004	3
10	NA	0.0003	0.0003	3
11	NA	0.0003	0.0003	3
12	NA	0.0003	0.0003	3
13	NA	0.0007	0.0007	3
14	NA	0.0002	0.0002	3

Table E4: Lead- 99.9th 1Hr Average Predicted Ground Level Concentrations – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

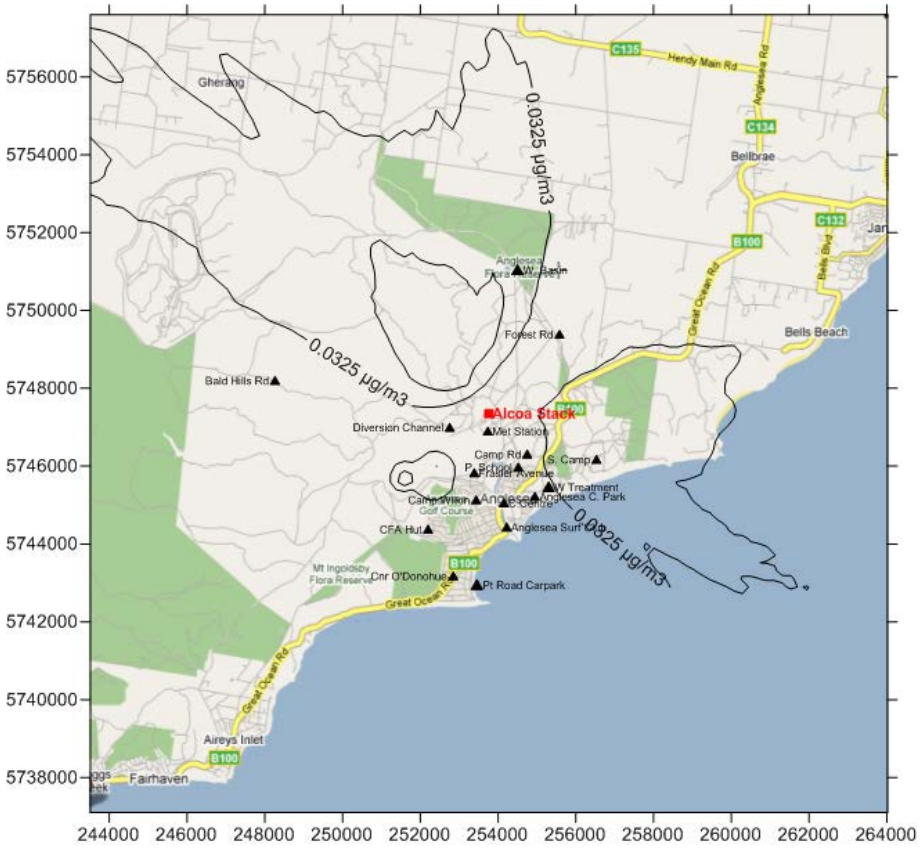

Figure E5: Predicted Ground Level Concentrations Fluoride – 24Hr Average (µg/m^3) – Alcoa Only (2008-2012)

Receptor	Predicted Ground Level Fluoride Concentration – 24Hr (ug/m^3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
99.5th 24hr Ave for modelled domain outside plant boundary	NA	0.10	0.10	3
1	NA	0.02	0.02	3
2	NA	0.04	0.04	3
3	NA	0.04	0.04	3
4	NA	0.02	0.02	3
5	NA	0.05	0.05	3
6	NA	0.02	0.02	3
7	NA	0.02	0.02	3
8	NA	0.02	0.02	3
9	NA	0.02	0.02	3
10	NA	0.02	0.02	3
11	NA	0.04	0.04	3
12	NA	0.03	0.03	3
13	NA	0.02	0.02	3
14	NA	0.02	0.02	3

Table E5: Fluoride – 24Hr Average Predicted Ground Level Concentrations – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

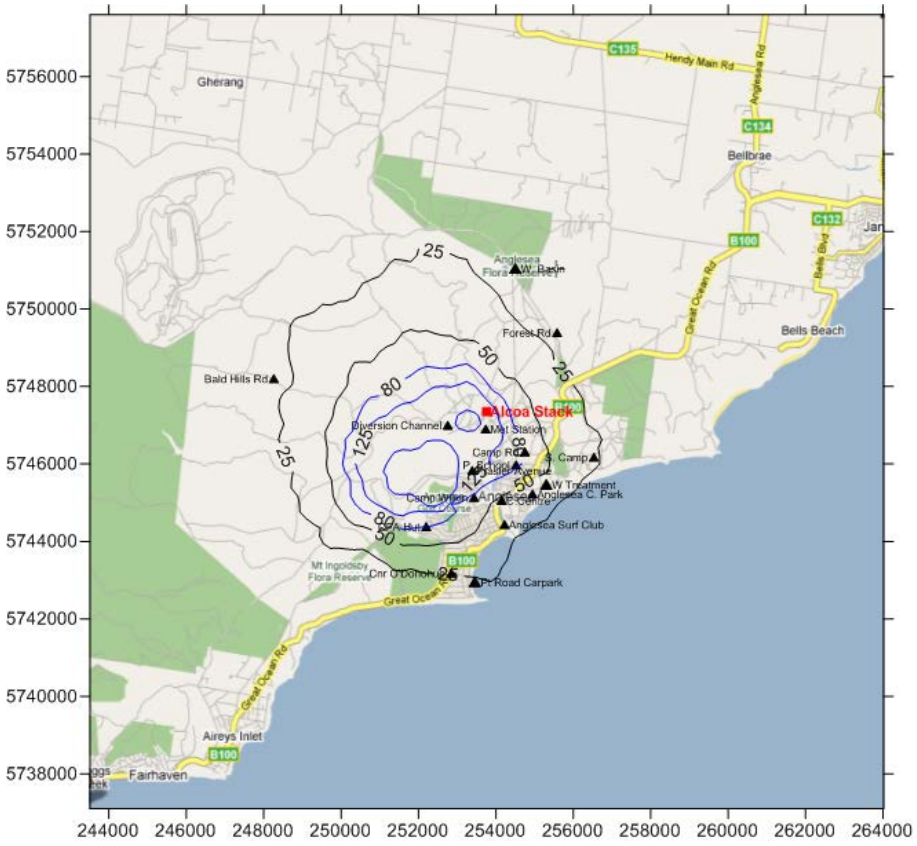

Figure E6: Predicted Ground Level Concentrations PM_{10} – 99.9th 1Hr Average (µg/m³) - Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level PM_{10} – 99.9th 1 Hr Average (ug/m³)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 1hr Ave for modelled domain outside plant boundary	16.5	**475**	**492**	80
1	16.5	79	**96**	80
2	16.5	22	39	80
3	16.5	16	33	80
4	16.5	18	35	80
5	16.5	23	40	80
6	16.5	**87**	**104**	80
7	16.5	71	88	80
8	16.5	45	62	80
9	16.5	**84**	**101**	80
10	16.5	33	50	80
11	16.5	38	55	80
12	16.5	40	57	80
13	16.5	**175**	**192**	80
14	16.5	26	43	80

Table E6: PM_{10} – 99.9th 1 Hr Average Predicted Ground Level Concentrations (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

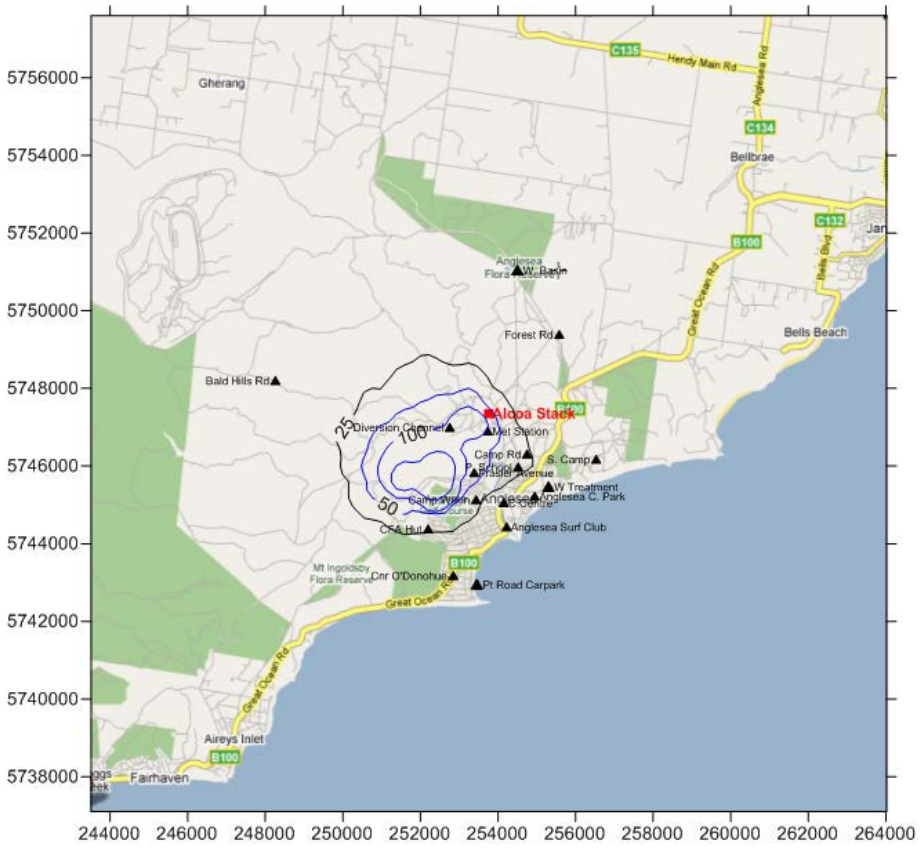

Figure E7: Predicted Ground Level Concentrations $PM_{2.5}$– 99.9th 1 Hour Average (µg/m³) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level $PM_{2.5}$ – 99.9th 1 Hr Average (ug/m³)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 1hr Ave for modelled domain outside plant boundary	4.6	**168**	**173**	50
1	4.6	27	32	50
2	4.6	8.7	14	50
3	4.6	6.1	11	50
4	4.6	6.0	11	50
5	4.6	9.1	14	50
6	4.6	30	35	50
7	4.6	26	31	50
8	4.6	17	22	50
9	4.6	36	41	50
10	4.6	13	18	50
11	4.6	15	20	50
12	4.6	15	20	50
13	4.6	**66**	**71**	50
14	4.6	9.3	14	50

Table E7: $PM_{2.5}$– 99.9th 1 Hour Average Predicted Ground Level Concentrations (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

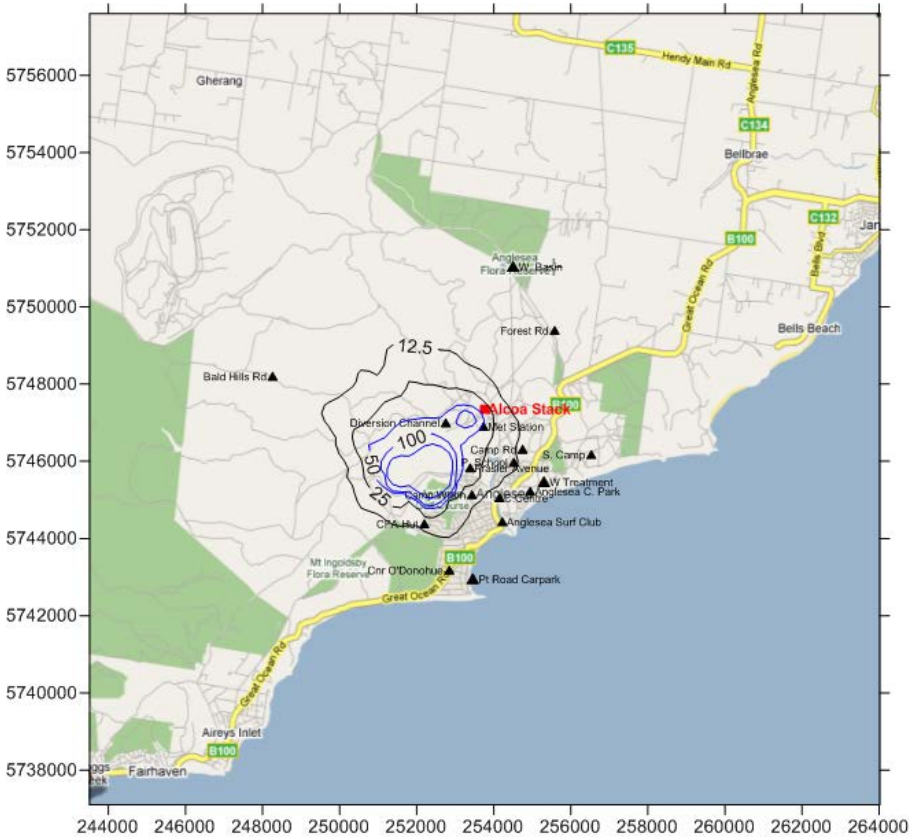

Figure E8: Predicted Ground Level Concentrations PM_{10}– 99.5th 24 Hour Average (µg/m³) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level PM_{10} – 99.5th 24 Hr Average (ug/m³)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	NEPC ground level concentration (glc)
Max 99.5th 24hr Ave for modelled domain outside plant boundary	15.6	**137**	**153**	50
1	15.6	17.8	33	50
2	15.6	4.3	20	50
3	15.6	3.2	19	50
4	15.6	2.8	18	50
5	15.6	5.0	21	50
6	15.6	13.3	29	50
7	15.6	10.0	26	50
8	15.6	8.6	24	50
9	15.6	22.6	38	50
10	15.6	6.4	22	50
11	15.6	7.4	23	50
12	15.6	7.1	23	50
13	15.6	36.1	**52**	50
14	15.6	5.0	21	50

Table E8: PM_{10}– 99.5th 24 Hour Average Predicted Ground Level Concentrations (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

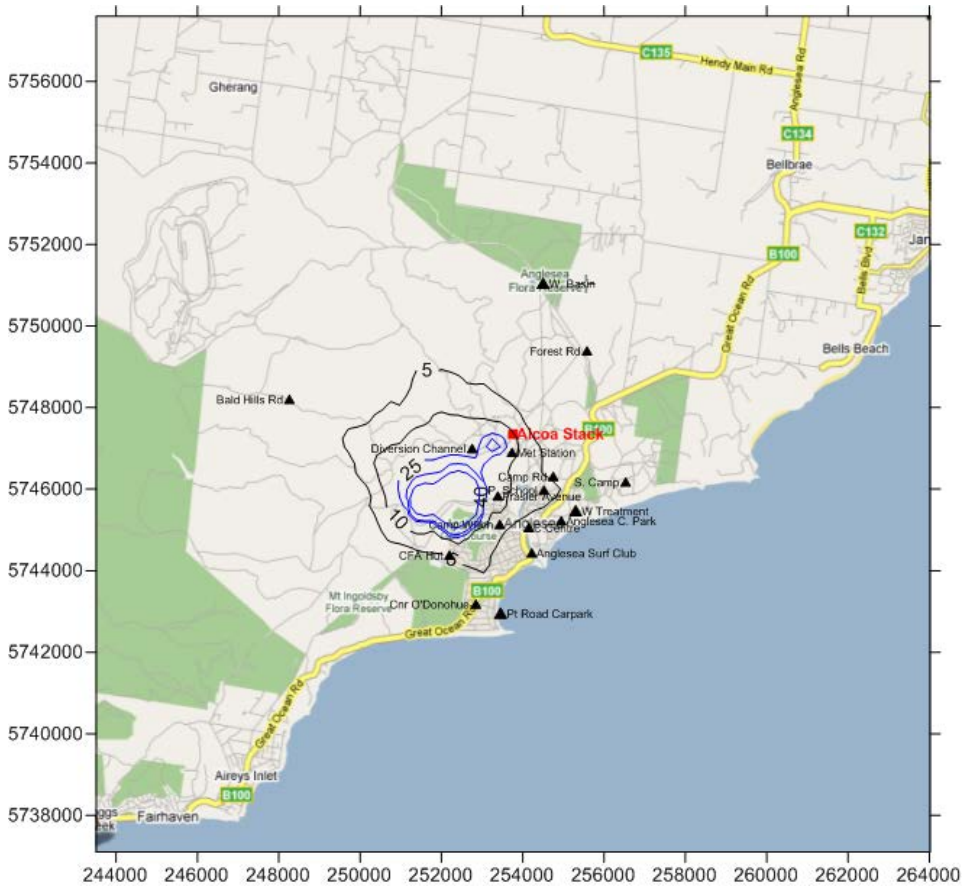

Figure E9: Predicted Ground Level Concentrations $PM_{2.5}$–99.5th 24 Hour Average (µg/m³) – Alcoa Only (2008-2012)

Receptor	Predicted Ground Level $PM_{2.5}$ – 99.5th 24 Hr Average (ug/m³)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
99.5th 24 Hr Ave outside plant boundary	4.6	**46**	**50.6**	25
1	4.6	5.8	10.4	25
2	4.6	1.7	6.3	25
3	4.6	1.2	5.8	25
4	4.6	1.0	5.6	25
5	4.6	1.9	6.5	25
6	4.6	5.7	10.3	25
7	4.6	4.6	9.2	25
8	4.6	3.4	8.0	25
9	4.6	9.5	14.1	25
10	4.6	2.5	7.1	25
11	4.6	2.8	7.4	25
12	4.6	3.0	7.6	25
13	4.6	12.6	17.2	25
14	4.6	2.2	6.8	25

Table E9: $PM_{2.5}$ –99.5th 24 Hour Average Predicted Ground Level Concentrations (2008-2012)

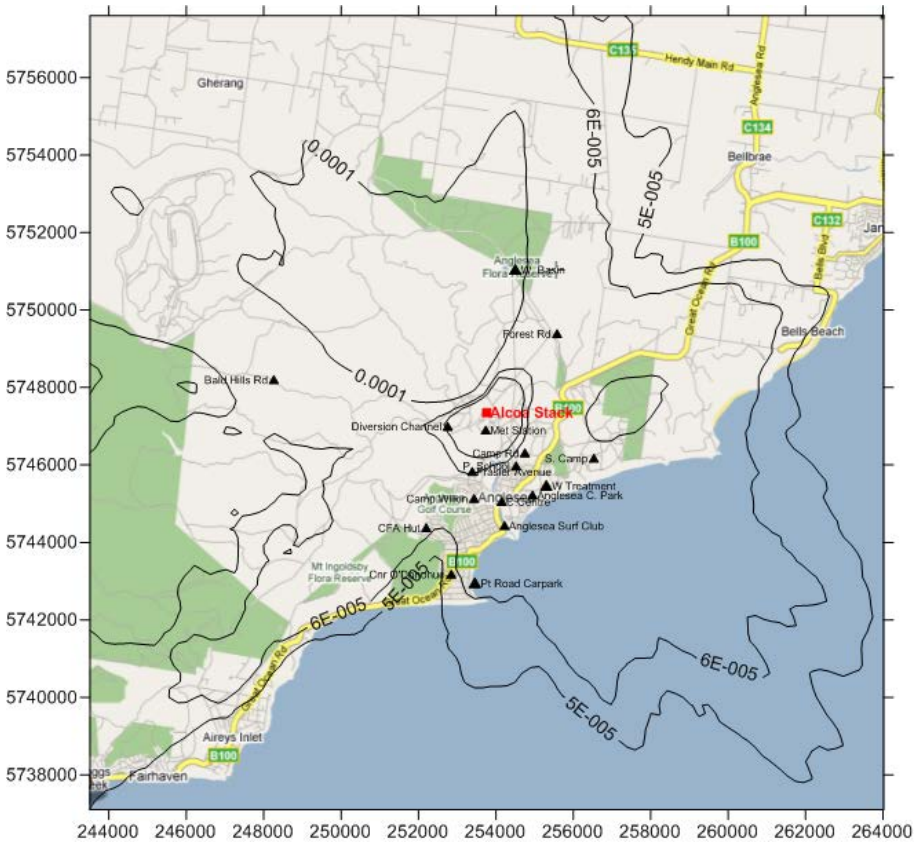

Figure E10: Predicted Ground Level Concentrations Antimony– 99.9th 3-Min Average (µg/m³) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Antimony– 99.9th 3min Average (ug/m³)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.003	0.003	17
1	NA	0.0001	0.0001	17
2	NA	0.0001	0.0001	17
3	NA	0.0001	0.0001	17
4	NA	0.0001	0.0001	17
5	NA	0.0001	0.0001	17
6	NA	0.0001	0.0001	17
7	NA	0.0001	0.0001	17
8	NA	0.0001	0.0001	17
9	NA	0.0001	0.0001	17
10	NA	0.0001	0.0001	17
11	NA	0.0001	0.0001	17
12	NA	0.0001	0.0001	17
13	NA	0.0001	0.0001	17
14	NA	0.0001	0.0001	17

Table E10: Antimony– 99.9th 3-Min Average Predicted Ground Level Concentrations (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

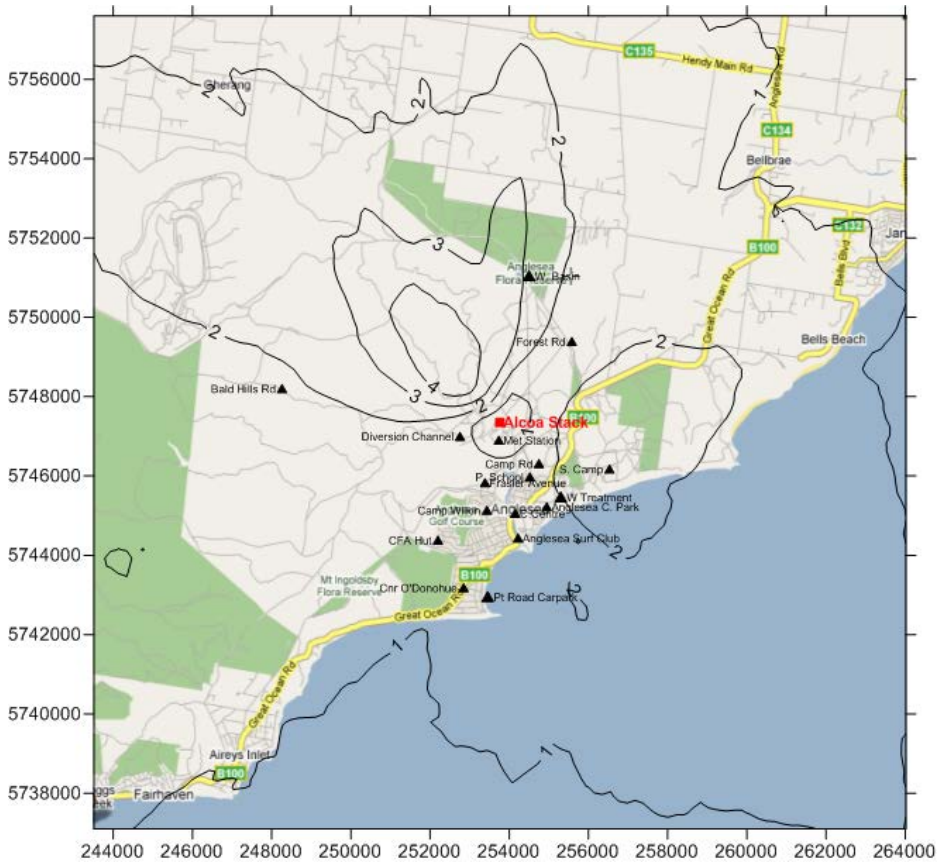

Figure E11: Predicted Ground Level Concentrations HCl– 99.9th 3 Min Average (µg/m^3) – Alcoa Only (2008-2012)

Receptor	Predicted Ground Level HCl– 99.9th 3 Min Average (ug/m^3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	5.2	5.2	250
1	NA	1.6	1.6	250
2	NA	1.8	1.8	250
3	NA	2.7	2.7	250
4	NA	1.7	1.7	250
5	NA	1.7	1.7	250
6	NA	1.6	1.6	250
7	NA	1.7	1.7	250
8	NA	1.9	1.9	250
9	NA	1.7	1.7	250
10	NA	1.8	1.8	250
11	NA	2.2	2.2	250
12	NA	2.0	2.0	250
13	NA	1.3	1.3	250
14	NA	1.6	1.6	250

Table E11: HCl– 99.9th 3 Min Average Predicted Ground Level Concentrations (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

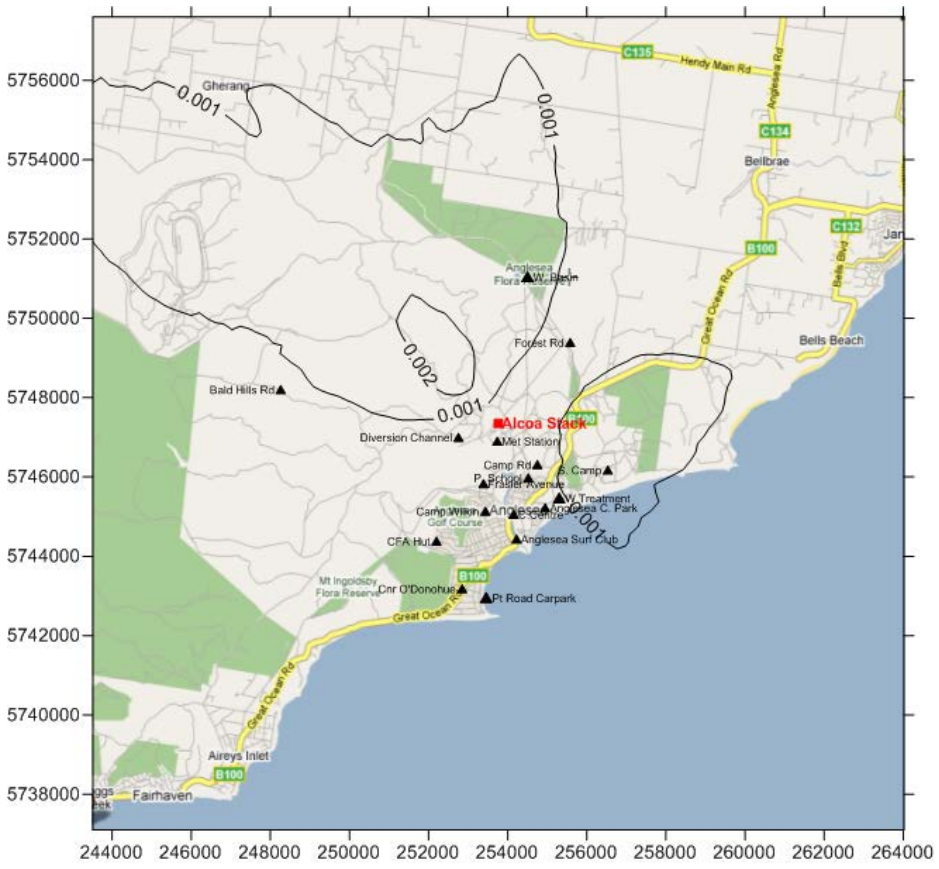

Figure E12: Predicted Ground Level Concentrations Arsenic– 99.9th 3 Min Average (µg/m³) – Alcoa Only (2008-2012)

Receptor	Predicted Ground Level Arsenic – 99.9th 3min Average (ug/m³)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.0025	0.0025	0.17
1	NA	0.0007	0.0007	0.17
2	NA	0.0009	0.0009	0.17
3	NA	0.0013	0.0013	0.17
4	NA	0.0008	0.0008	0.17
5	NA	0.0008	0.0008	0.17
6	NA	0.0008	0.0008	0.17
7	NA	0.0008	0.0008	0.17
8	NA	0.0009	0.0009	0.17
9	NA	0.0008	0.0008	0.17
10	NA	0.0009	0.0009	0.17
11	NA	0.0010	0.0010	0.17
12	NA	0.0009	0.0009	0.17
13	NA	0.0006	0.0006	0.17
14	NA	0.0008	0.0008	0.17

Table E12: Arsenic– 99.9th 3 Min Average Predicted Ground Level Concentrations (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

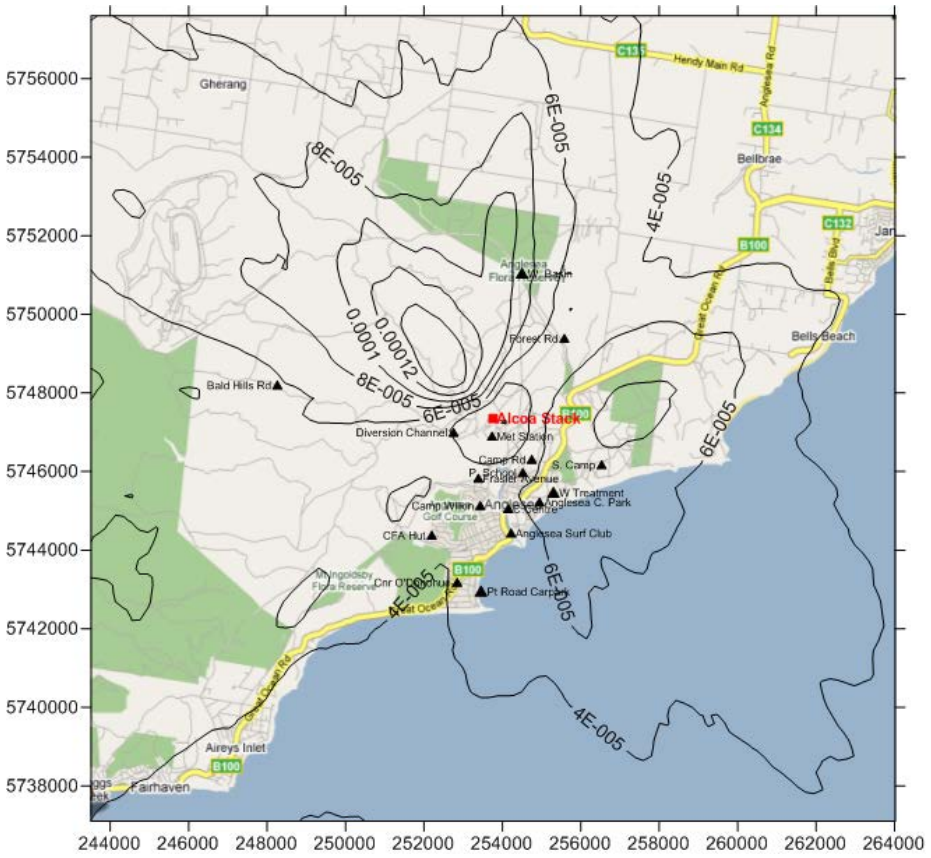

Figure E13: Predicted Ground Level Concentrations Cadmium– 99.9th 3 Min Average (µg/m3)– Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Cadmium– 99.9th 3Min Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.00017	0.00017	0.03
1	NA	0.00005	0.00005	0.03
2	NA	0.00006	0.00006	0.03
3	NA	0.00009	0.00009	0.03
4	NA	0.00006	0.00006	0.03
5	NA	0.00006	0.00006	0.03
6	NA	0.00005	0.00005	0.03
7	NA	0.00006	0.00006	0.03
8	NA	0.00006	0.00006	0.03
9	NA	0.00005	0.00005	0.03
10	NA	0.00006	0.00006	0.03
11	NA	0.00007	0.00007	0.03
12	NA	0.00006	0.00006	0.03
13	NA	0.00004	0.00004	0.03
14	NA	0.00005	0.00005	0.03

Table E13: Cadmium– 99.9th 3 Min Average Predicted Ground Level Concentrations (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

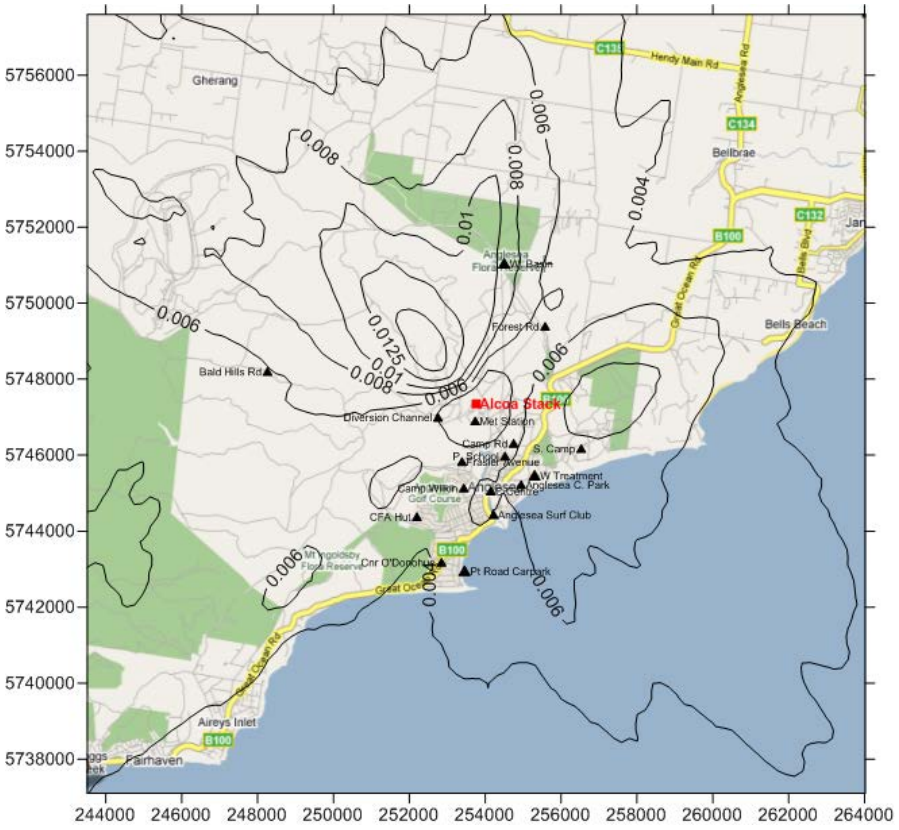

Figure E14: Predicted Ground Level Concentrations Chromium (III) – 99.9th 3 Min Average (µg/m3) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Chromium (III)– 99.9th 3Min Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.0171	0.0171	17
1	NA	0.0051	0.0051	17
2	NA	0.0060	0.0060	17
3	NA	0.0090	0.0090	17
4	NA	0.0057	0.0057	17
5	NA	0.0057	0.0057	17
6	NA	0.0053	0.0053	17
7	NA	0.0057	0.0057	17
8	NA	0.0061	0.0061	17
9	NA	0.0055	0.0055	17
10	NA	0.0060	0.0060	17
11	NA	0.0071	0.0071	17
12	NA	0.0064	0.0064	17
13	NA	0.0044	0.0044	17
14	NA	0.0052	0.0052	17

Table E14: Chromium (III) – 99.9th 3 Min Average Predicted Ground Level Concentrations (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

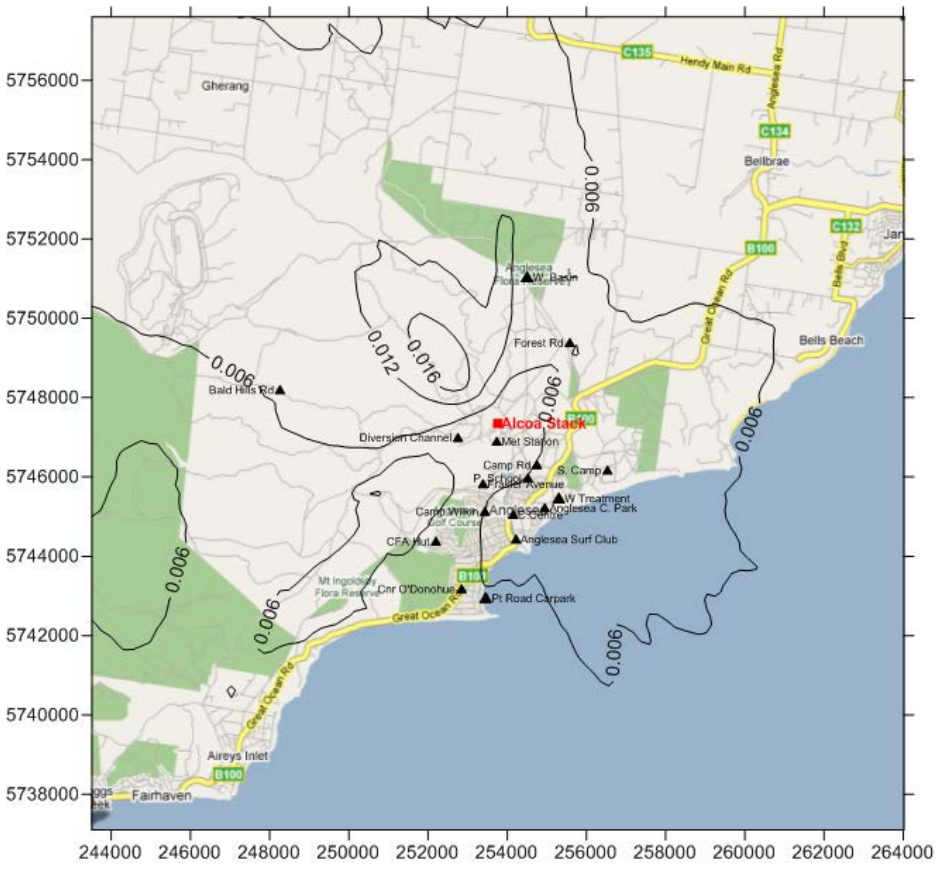

Figure E15: Predicted Ground Level Concentrations Chromium (VI) – 99.9th 3 Min Average (µg/m3) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Chromium (VI)– 99.9th 3Min Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.0187	0.0187	0.17
1	NA	0.0056	0.0056	0.17
2	NA	0.0066	0.0066	0.17
3	NA	0.0099	0.0099	0.17
4	NA	0.0063	0.0063	0.17
5	NA	0.0063	0.0063	0.17
6	NA	0.0059	0.0059	0.17
7	NA	0.0062	0.0062	0.17
8	NA	0.0067	0.0067	0.17
9	NA	0.0061	0.0061	0.17
10	NA	0.0066	0.0066	0.17
11	NA	0.0078	0.0078	0.17
12	NA	0.0071	0.0071	0.17
13	NA	0.0048	0.0048	0.17
14	NA	0.0057	0.0057	0.17

Table E15: Chromium (VI) – 99.9th 3 Min Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

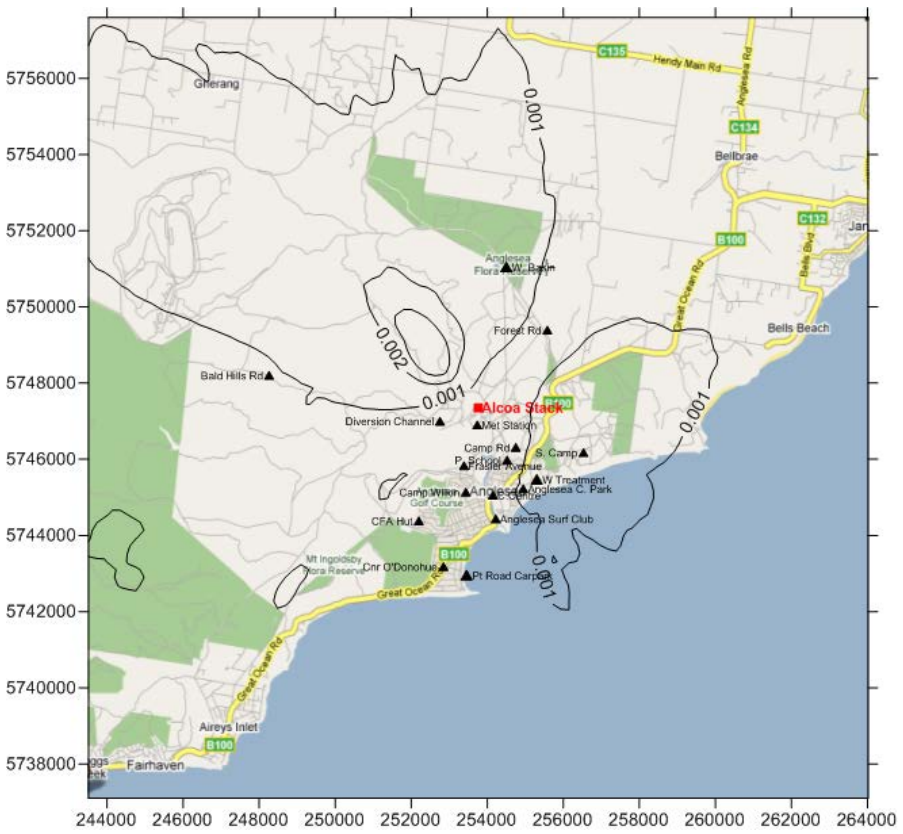

Figure E16: Predicted Ground Level Concentrations Copper – 99.9th 3 Min Average (µg/m³) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Copper– 99.9th 3Min Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.07	0.07	6.7
1	NA	0.0008	0.0008	6.7
2	NA	0.0010	0.0010	6.7
3	NA	0.0014	0.0014	6.7
4	NA	0.0009	0.0009	6.7
5	NA	0.0009	0.0009	6.7
6	NA	0.0008	0.0008	6.7
7	NA	0.0009	0.0009	6.7
8	NA	0.0010	0.0010	6.7
9	NA	0.0009	0.0009	6.7
10	NA	0.0010	0.0010	6.7
11	NA	0.0011	0.0011	6.7
12	NA	0.0010	0.0010	6.7
13	NA	0.0007	0.0007	6.7
14	NA	0.0008	0.0008	6.7

Table E16: Copper – 99.9th 3 Min Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

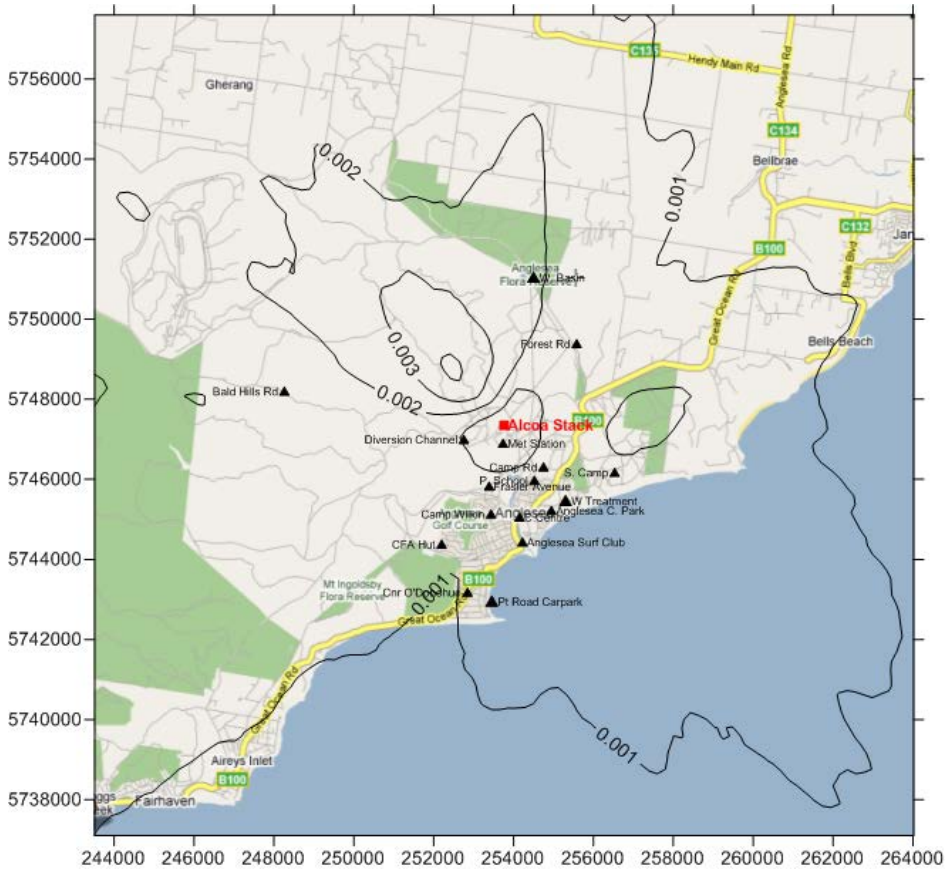

Figure E17: Predicted Ground Level Concentrations Benzene – 99.9th 3 Min Average (µg/m3) – Alcoa Only (2008-2012)

Receptor	Predicted Ground Level Benzene– 99.9th 3Min Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.0042	0.0042	53
1	NA	0.0012	0.0012	53
2	NA	0.0015	0.0015	53
3	NA	0.0022	0.0022	53
4	NA	0.0014	0.0014	53
5	NA	0.0014	0.0014	53
6	NA	0.0013	0.0013	53
7	NA	0.0014	0.0014	53
8	NA	0.0015	0.0015	53
9	NA	0.0014	0.0014	53
10	NA	0.0015	0.0015	53
11	NA	0.0017	0.0017	53
12	NA	0.0016	0.0016	53
13	NA	0.0011	0.0011	53
14	NA	0.0013	0.0013	53

Table E17: Benzene – 99.9th 3 Min Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

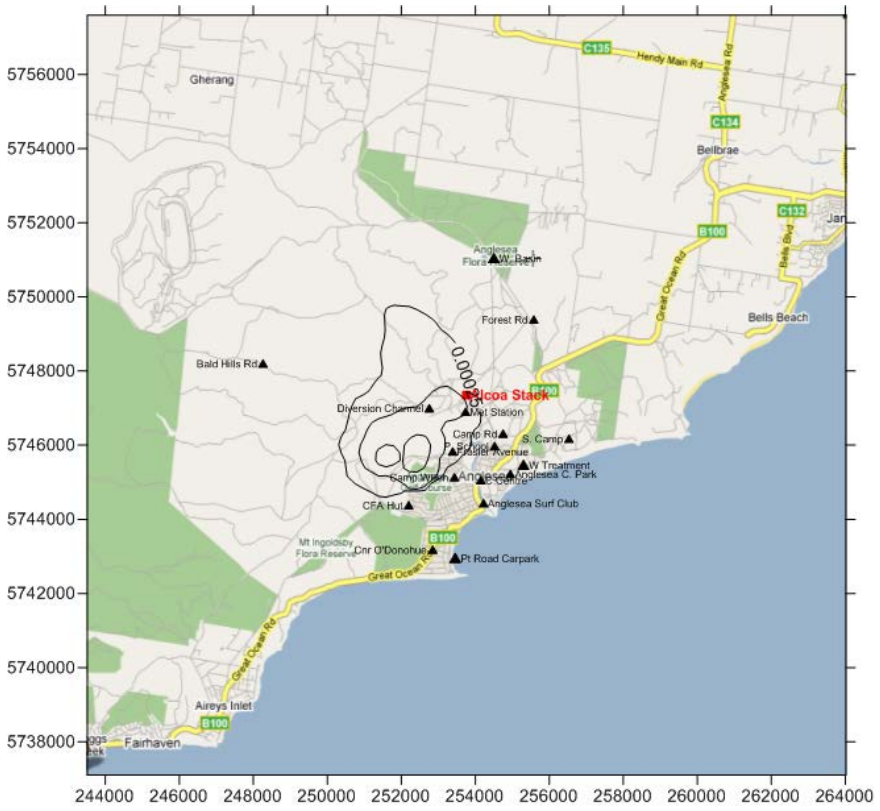

Figure E18: Predicted Ground Level Concentrations Beryllium – 99.9th 3 Min Average (µg/m³) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Beryllium– 99.9th 3Min Average (ug/m³)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.002	0.002	0.007
1	NA	0.0002	0.0002	0.007
2	NA	0.0001	0.0001	0.007
3	NA	0.0001	0.0001	0.007
4	NA	0.0001	0.0001	0.007
5	NA	0.0001	0.0001	0.007
6	NA	0.0002	0.0002	0.007
7	NA	0.0002	0.0002	0.007
8	NA	0.0001	0.0001	0.007
9	NA	0.0002	0.0002	0.007
10	NA	0.0001	0.0001	0.007
11	NA	0.0001	0.0001	0.007
12	NA	0.0001	0.0001	0.007
13	NA	0.0003	0.0003	0.007
14	NA	0.0001	0.0001	0.007

Table E18: Beryllium – 99.9th 3 Min Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

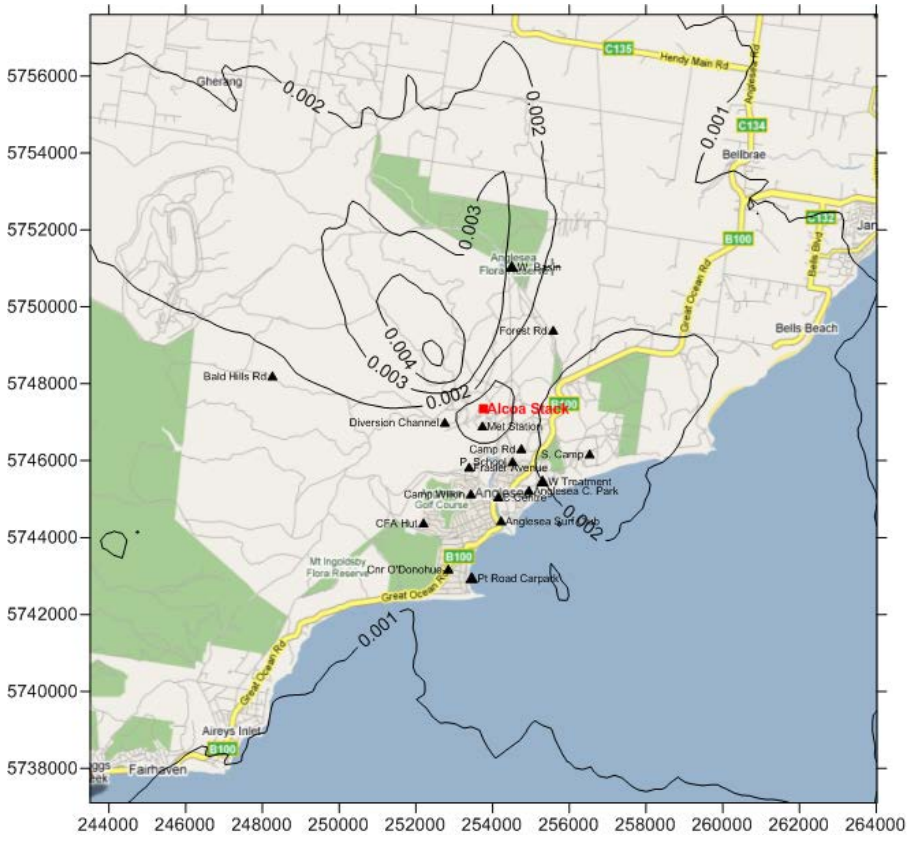

Figure E19: Predicted Ground Level Concentrations Manganese – 99.9th 3 Min Average (µg/m³) – Alcoa Only (2008-2012)

Receptor	Predicted Ground Level Manganese (99.9th 3Min Average (ug/m³)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.0052	0.0052	33
1	NA	0.0016	0.0016	33
2	NA	0.0018	0.0018	33
3	NA	0.0027	0.0027	33
4	NA	0.0017	0.0017	33
5	NA	0.0017	0.0017	33
6	NA	0.0016	0.0016	33
7	NA	0.0017	0.0017	33
8	NA	0.0019	0.0019	33
9	NA	0.0017	0.0017	33
10	NA	0.0018	0.0018	33
11	NA	0.0022	0.0022	33
12	NA	0.0020	0.0020	33
13	NA	0.0013	0.0013	33
14	NA	0.0016	0.0016	33

Table E19: Manganese – 99.9th 3 Min Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

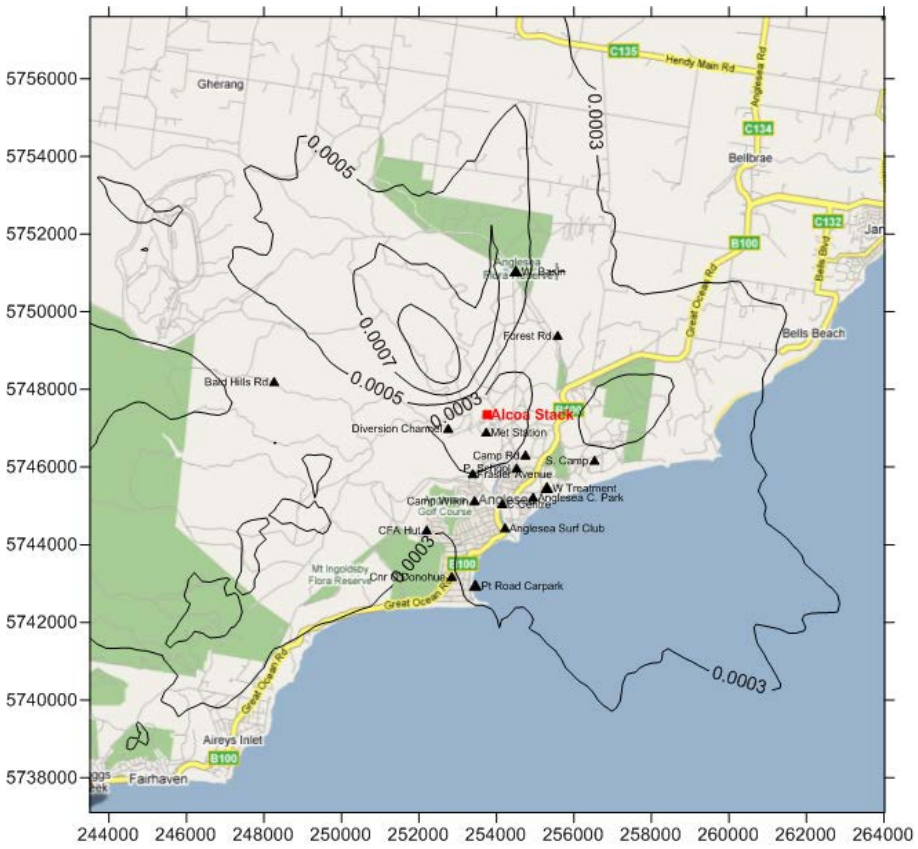

Figure E20: Predicted Ground Level Concentrations Mercury – 99.9th 3 Min Average (µg/m3) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Mercury– 99.9th 3Min Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.0011	0.0011	0.33
1	NA	0.0003	0.0003	0.33
2	NA	0.0004	0.0004	0.33
3	NA	0.0006	0.0006	0.33
4	NA	0.0004	0.0004	0.33
5	NA	0.0004	0.0004	0.33
6	NA	0.0003	0.0003	0.33
7	NA	0.0004	0.0004	0.33
8	NA	0.0004	0.0004	0.33
9	NA	0.0003	0.0003	0.33
10	NA	0.0004	0.0004	0.33
11	NA	0.0004	0.0004	0.33
12	NA	0.0004	0.0004	0.33
13	NA	0.0003	0.0003	0.33
14	NA	0.0003	0.0003	0.33

Table E20: Mercury– 99.9th 3 Min Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

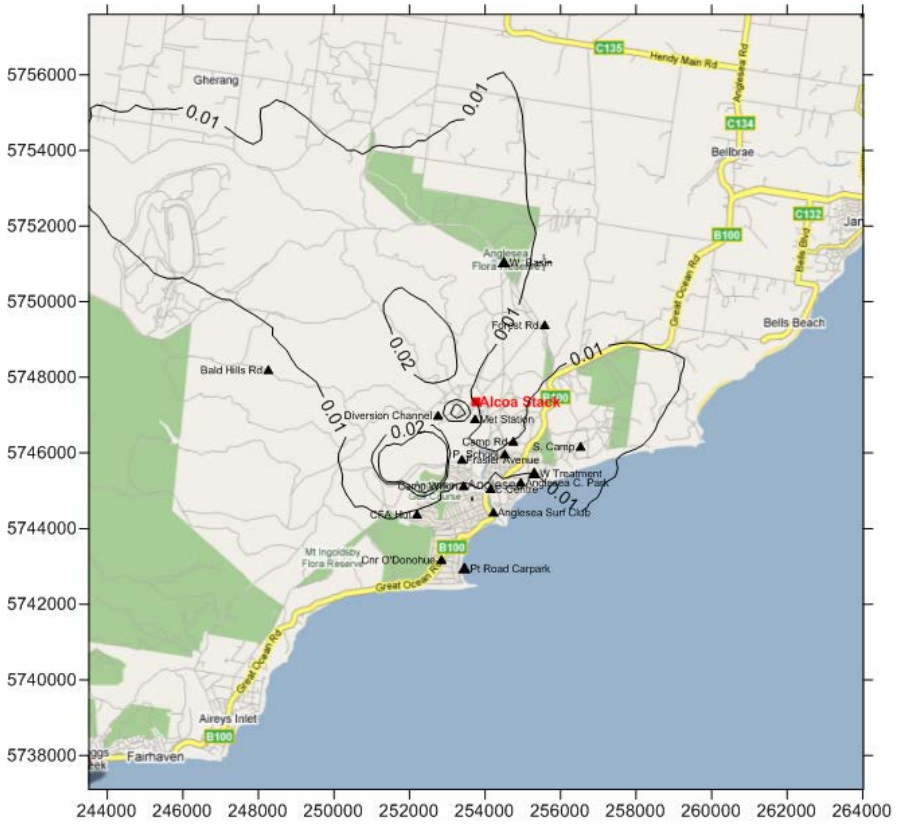

Figure E21: Predicted Ground Level Concentrations Nickel– 99.9th 3 Min Average (µg/m3) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Nickel– 99.9th 3Min Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.02	0.02	0.33
1	NA	0.01	0.01	0.33
2	NA	0.01	0.01	0.33
3	NA	0.01	0.01	0.33
4	NA	0.01	0.01	0.33
5	NA	0.01	0.01	0.33
6	NA	0.01	0.01	0.33
7	NA	0.01	0.01	0.33
8	NA	0.01	0.01	0.33
9	NA	0.01	0.01	0.33
10	NA	0.01	0.01	0.33
11	NA	0.01	0.01	0.33
12	NA	0.01	0.01	0.33
13	NA	0.01	0.01	0.33
14	NA	0.01	0.01	0.33

Table E21: Nickel – 99.9th 3 Min Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

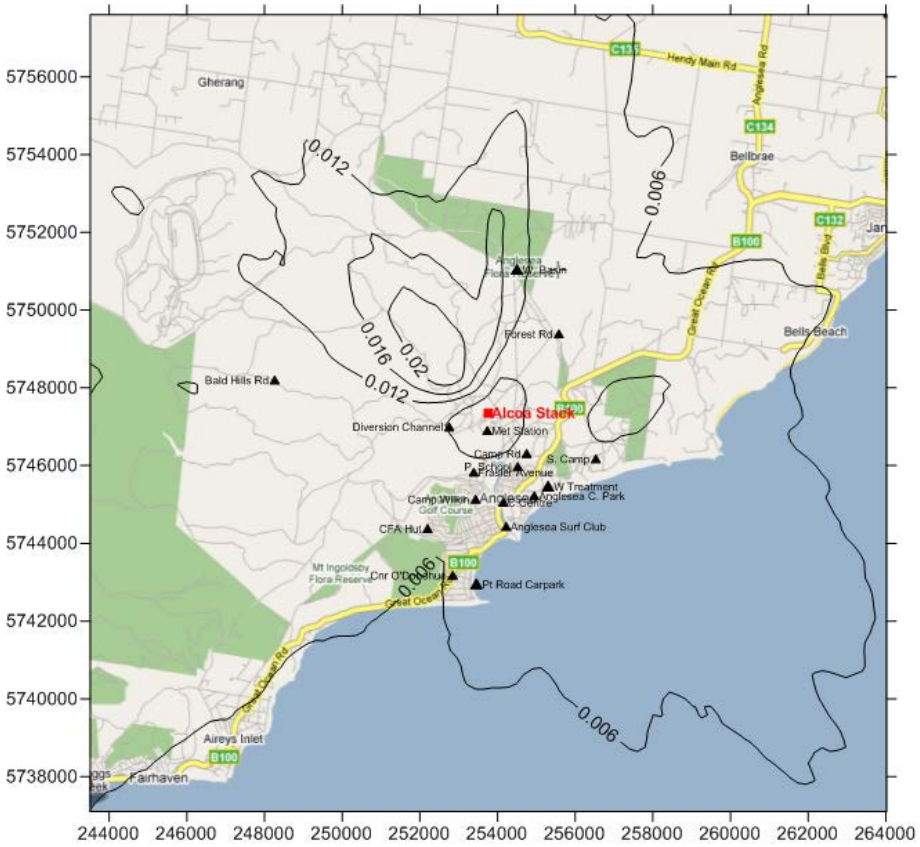

Figure E22: Predicted Ground Level Concentrations Benzo[a]pyrene – 99.9th 3 Min Average (µg/m3) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Benzo[a]pyrene – 99.9th 3Min Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.0250	0.0250	0.73
1	NA	0.0075	0.0075	0.73
2	NA	0.0088	0.0088	0.73
3	NA	0.0131	0.0131	0.73
4	NA	0.0084	0.0084	0.73
5	NA	0.0084	0.0084	0.73
6	NA	0.0078	0.0078	0.73
7	NA	0.0083	0.0083	0.73
8	NA	0.0090	0.0090	0.73
9	NA	0.0081	0.0081	0.73
10	NA	0.0088	0.0088	0.73
11	NA	0.0103	0.0103	0.73
12	NA	0.0094	0.0094	0.73
13	NA	0.0064	0.0064	0.73
14	NA	0.0076	0.0076	0.73

Table E22: Benzo[a]pyrene – 99.9th 3 Min Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

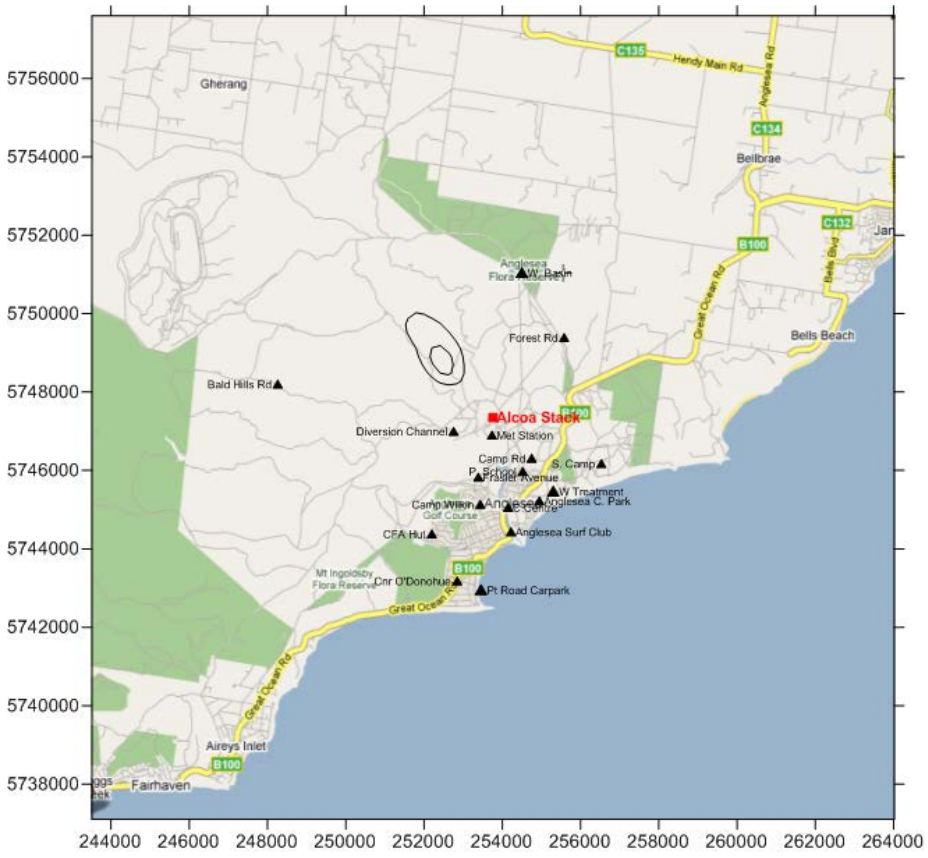

Figure E23: Predicted Ground Level Concentrations Dioxins & Furans – 99.9th 3 Min Average (µg/m3) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Dioxins & Furans– 99.9th 3Min Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	3.8E-09	3.8E-09	3.7E-06
1	NA	1.1E-09	1.1E-09	3.7E-06
2	NA	1.3E-09	1.3E-09	3.7E-06
3	NA	2.0E-09	2.0E-09	3.7E-06
4	NA	1.3E-09	1.3E-09	3.7E-06
5	NA	1.3E-09	1.3E-09	3.7E-06
6	NA	1.2E-09	1.2E-09	3.7E-06
7	NA	1.3E-09	1.3E-09	3.7E-06
8	NA	1.4E-09	1.4E-09	3.7E-06
9	NA	1.2E-09	1.2E-09	3.7E-06
10	NA	1.3E-09	1.3E-09	3.7E-06
11	NA	1.6E-09	1.6E-09	3.7E-06
12	NA	1.4E-09	1.4E-09	3.7E-06
13	NA	9.8E-10	9.8E-10	3.7E-06
14	NA	1.2E-09	1.2E-09	3.7E-06

Table E23: Dioxins & Furans – 99.9th 3 Min Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

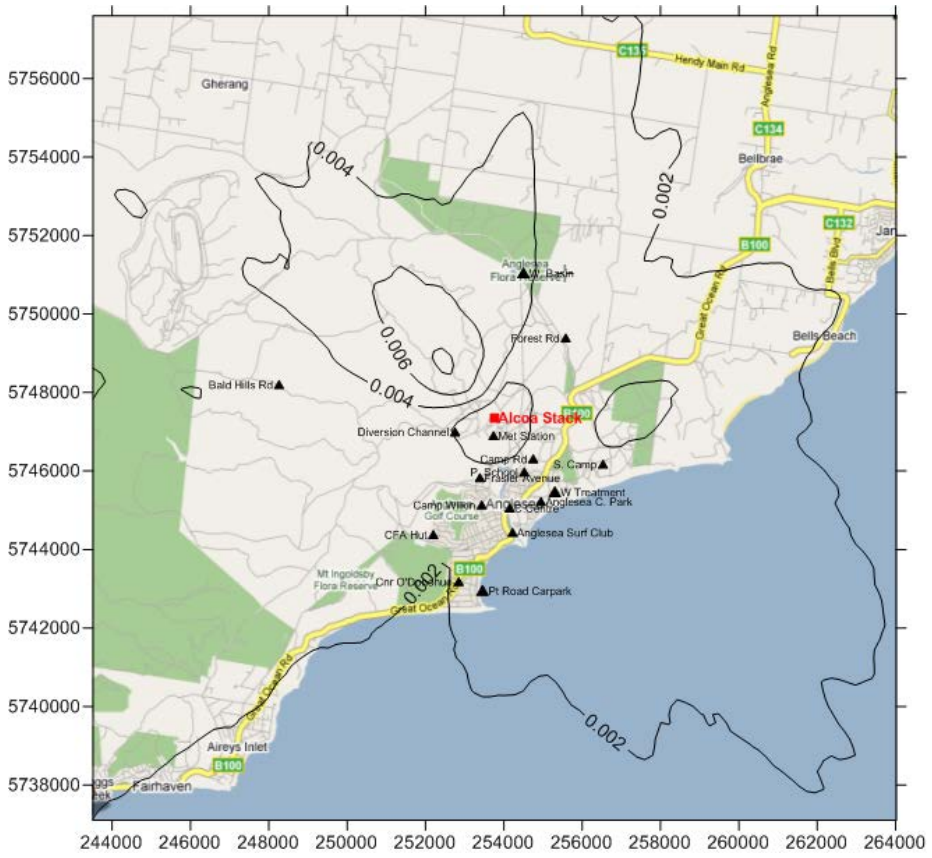

Figure E24: Predicted Ground Level Concentrations Chlorine– 99.9th 3 Min Average (µg/m3) – Alcoa Only (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Receptor	Predicted Ground Level Chlorine– 99.9th 3Min Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	EPAV design ground level concentration (dglc)
Max 99.9th 3min Ave for modelled domain outside plant boundary	NA	0.008	0.008	100
1	NA	0.002	0.002	100
2	NA	0.003	0.003	100
3	NA	0.004	0.004	100
4	NA	0.003	0.003	100
5	NA	0.003	0.003	100
6	NA	0.003	0.003	100
7	NA	0.003	0.003	100
8	NA	0.003	0.003	100
9	NA	0.003	0.003	100
10	NA	0.003	0.003	100
11	NA	0.003	0.003	100
12	NA	0.003	0.003	100
13	NA	0.002	0.002	100
14	NA	0.003	0.003	100

Table E24: Chlorine– 99.9th 3 Min Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

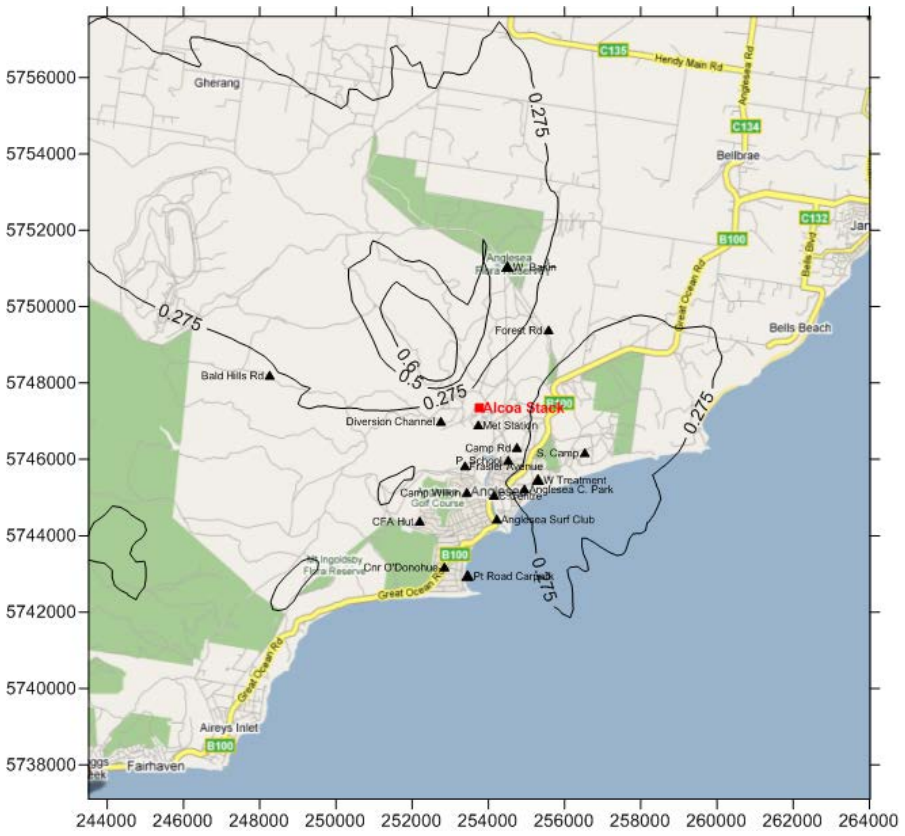

Figure E25: Predicted Ground Level Concentrations Boron– 99.9th 1 Hour Average (µg/m3) – Alcoa Only (2008-2012)

Receptor	Predicted Ground Level Boron– 99.9th 1 Hour Average (ug/m3)			
	Background	Predicted Concentrations (Alcoa Only)	Background + Predicted Concentrations (Alcoa Only)	Texas Commission on Environmental Quality (TCEQ) (µg/m3)
Max 99.9th 1 hr Ave for modelled domain outside plant boundary	NA	0.8	0.8	50
1	NA	0.2	0.2	50
2	NA	0.4	0.4	50
3	NA	0.4	0.4	50
4	NA	0.3	0.3	50
5	NA	0.3	0.3	50
6	NA	0.2	0.2	50
7	NA	0.3	0.3	50
8	NA	0.3	0.3	50
9	NA	0.2	0.2	50
10	NA	0.3	0.3	50
11	NA	0.3	0.3	50
12	NA	0.3	0.3	50
13	NA	0.2	0.2	50
14	NA	0.2	0.2	50

Table E25: Boron – 99.9th 1 Hour Average Predicted Ground Level Concentration (2008-2012)

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Client: Alcoa Anglesea		
Project: Anglesea HHRA	Drawing Ref: AL	Date: 11/7/13

Appendix F
Analysis of Concentrations Associated with the Peak HQs

Table F1 Predicted Concentrations when 99.9th Percentile 1-Hour Average Ground Level Concentrations of Sulphur Dioxide is Predicted to Occur

Without Background

Receptor	Date	Predicted Concentrations (µg/m^3)			Hazard Quotient		
		SO_2	PM_{10}	$PM_{2.5}$	SO_2	PM_{10}	$PM_{2.5}$
		1-hour	24-hour	24-hour	1-hour	24-hour	24-hour
CFA Hut	23/01/2012	248	0.3	0.1	0.47	0.01	0.00
Bald Hills	11/08/2009	307	1.0	0.4	0.58	0.02	0.02
Water Basin	27/01/2011	454	0.5	0.2	0.87	0.01	0.01
Forest Road	8/10/2012	284	0.7	0.2	0.54	0.01	0.01
Scout Camp	23/04/2011	354	0.9	0.3	0.68	0.02	0.01
Primary School	5/01/2008	247	0.1	0.0	0.47	0.00	0.00
Camp Road	13/04/2012	235	0.4	0.1	0.45	0.01	0.01
Community Centre	7/11/2012	271	0.0	0.0	0.52	0.00	0.00
Camp Wilkin	23/03/2008	266	0.0	0.0	0.51	0.00	0.00
Anglesea Surf	7/01/2011	275	0.2	0.1	0.53	0.00	0.00
Waste Treatment	25/09/2012	322	0.7	0.3	0.61	0.02	0.01
Anglesea Caravan	17/05/2011	299	0.7	0.2	0.57	0.02	0.01
Fraser Avenue	5/07/2010	214	12.5	3.9	0.41	0.27	0.17
Pt Road	7/04/2011	218	0.2	0.1	0.42	0.00	0.00

Table F2 Predicted Concentrations when 99.9th Percentile 1-Hour Average Ground Level Concentrations of Sulphur Dioxide is Predicted to Occur

With Background

Receptor	Date	Predicted Concentrations (µg/m^3)			Hazard Quotient		
		SO_2	PM_{10}	$PM_{2.5}$	SO_2	PM_{10}	$PM_{2.5}$
		1-hour	24-hour	24-hour	1-hour	24-hour	24-hour
CFA Hut	23/01/2012	248	15.9	4.7	0.47	0.35	0.20
Bald Hills	11/08/2009	307	16.6	5.0	0.58	0.36	0.22
Water Basin	27/01/2011	454	16.1	4.8	0.87	0.35	0.21
Forest Road	8/10/2012	284	16.3	4.8	0.54	0.35	0.21
Scout Camp	23/04/2011	354	16.5	4.9	0.68	0.36	0.21
Primary School	5/01/2008	247	15.7	4.6	0.47	0.34	0.20
Camp Road	13/04/2012	235	16.0	4.7	0.45	0.35	0.21
Community Centre	7/11/2012	271	15.6	4.6	0.52	0.34	0.20
Camp Wilkin	23/03/2008	266	15.6	4.6	0.51	0.34	0.20
Anglesea Surf	7/01/2011	275	15.8	4.7	0.53	0.34	0.20
Waste Treatment	25/09/2012	322	16.3	4.9	0.61	0.35	0.21
Anglesea Caravan	17/05/2011	299	16.3	4.8	0.57	0.35	0.21
Fraser Avenue	5/07/2010	214	28.1	8.5	0.41	0.61	0.37
Pt Road	7/04/2011	218	15.8	4.7	0.42	0.34	0.20

Table F3 Predicted Concentrations when 99.5th Percentile 24-Hour Average Ground Level Concentrations of PM_{10} is Predicted to Occur

Without Background

Receptor	Date	Predicted Concentrations (µg/m³)			Hazard Quotient		
		SO_2	PM_{10}	$PM_{2.5}$	SO_2	PM_{10}	$PM_{2.5}$
		1-hour	24-hour	24-hour	1-hour	24-hour	24-hour
CFA Hut	26/10/2008	0	17.8	5.8	0.00	0.39	0.25
Bald Hills	3/03/2010	145	4.3	1.6	0.28	0.09	0.07
Water Basin	10/02/2011	30	3.2	1.2	0.06	0.07	0.05
Forest Road	1/11/2010	183	2.8	1.0	0.35	0.06	0.04
Scout Camp	24/03/2012	0	5.0	1.9	0.00	0.11	0.08
Primary School	5/02/2011	4	13.3	5.7	0.01	0.29	0.25
Camp Road	29/04/2010	0	10.0	4.6	0.00	0.22	0.20
Community Centre	3/03/2009	2	8.6	3.4	0.00	0.19	0.15
Camp Wilkin	30/01/2010	2	22.6	9.5	0.00	0.49	0.41
Anglesea Surf	26/04/2008	0	6.4	2.5	0.00	0.14	0.11
Waste Treatment	1/07/2010	0	7.4	2.8	0.00	0.16	0.12
Anglesea Caravan	9/01/2012	0	7.1	3.0	0.00	0.15	0.13
Fraser Avenue	10/04/2011	0	36.1	12.6	0.00	0.78	0.55
Pt Road	18/06/2009	0	5.0	2.2	0.00	0.11	0.10

Note: Sulphur dioxide is the maximum 1-hour concentration predicted on the specific date.

Table F4 Predicted Concentrations when 99.5th Percentile 24-Hour Average Ground Level Concentrations of PM_{10} is Predicted to Occur

With Background

Receptor	Date	Predicted Concentrations (µg/m³)			Hazard Quotient		
		SO_2	PM_{10}	$PM_{2.5}$	SO_2	PM_{10}	$PM_{2.5}$
		1-hour	24-hour	24-hour	1-hour	24-hour	24-hour
CFA Hut	26/10/2008	0	33.4	10.4	0.00	0.73	0.45
Bald Hills	3/03/2010	145	19.9	6.2	0.28	0.43	0.27
Water Basin	10/02/2011	30	18.8	5.8	0.06	0.41	0.25
Forest Road	1/11/2010	183	18.4	5.6	0.35	0.40	0.24
Scout Camp	24/03/2012	0	20.6	6.5	0.00	0.45	0.28
Primary School	5/02/2011	4	28.9	10.3	0.01	0.63	0.45
Camp Road	29/04/2010	0	25.6	9.2	0.00	0.56	0.40
Community Centre	3/03/2009	2	24.2	8.0	0.00	0.53	0.35
Camp Wilkin	30/01/2010	2	38.2	14.1	0.00	0.83	0.61
Anglesea Surf	26/04/2008	0	22.0	7.1	0.00	0.48	0.31
Waste Treatment	1/07/2010	0	23.0	7.4	0.00	0.50	0.32
Anglesea Caravan	9/01/2012	0	22.7	7.6	0.00	0.49	0.33
Fraser Avenue	10/04/2011	0	51.7	17.2	0.00	1.12	0.75
Pt Road	18/06/2009	0	20.6	6.8	0.00	0.45	0.30

Note: Sulphur dioxide is the maximum 1-hour concentration predicted on the specific date.