Wallarah 2
COAL PROJECT

Wallarah 2 Coal Project

Environmental Impact Statement

April 2013

Appendix L

Air Quality and Greenhouse Gas Assessment

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pae holmes

REPORT

WALLARAH 2 COAL PROJECT – AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

Wyong Areas Coal Joint Venture

Job No: 6514

30 November 2012

A PEL Company

PROJECT TITLE:	**WALLARAH 2 COAL PROJECT – AIR QUALITY AND GREENHOUSE GAS ASSESSMENT**
JOB NUMBER:	**6514**
PREPARED FOR:	Wallarah 2 Coal Project Wyong Areas Coal Joint Venture
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EXECUTIVE SUMMARY

Overview

The Wallarah 2 Coal Project (the Project) is located approximately 4.7 km north-west of central Wyong, NSW. The project involves construction and operation of an underground mining operation extracting up to 5.0 million tonnes per annum (Mtpa) of export quality thermal coal by longwall mining methods. Surface infrastructure at the Tooheys Road Site will include a rail loop and spur, stockpiles, water and gas management facilities, workshop and offices. Surface infrastructure at the Buttonderry Site will include access to the mine, main ventilation facilities, offices and employee amenities.

An Air Quality and Greenhouse Gas Assessment has been prepared for the Project in accordance with the Director-General's Environmental Assessment Requirements (DGRs) for the Project.

Emissions and Existing Environment

Project activities have the potential to generate fugitive dust emissions, particularly from coal handling and stockpiling at the Tooheys Road site. Fugitive dust emissions can also be expected during construction. Emissions at the Buttonderry site will occur from the ventilation shaft, and will include particulate matter and potentially odour. The key pollutant assessed from the flaring of methane is oxides of nitrogen (NOx).

For the purposes of assessing impacts from the Project, discrete receptor locations are selected in close proximity to the surface facilities for the Project.

Local meteorological data have been collected at the Tooheys Road site since 2007 and shows winds to be mainly from the west, west-southwest and west-northwest.

An Environmental Monitoring Program for the Project commenced in 1996 providing monthly averages of dust fallout and 24-hour average TSP and PM_{10} concentrations. The monitoring data collected for the Project provides an indication of background concentrations for TSP, PM_{10} and dust deposition in the region. Annual average concentrations of dust deposition, TSP and PM_{10} are generally below the relevant air quality goals.

Emissions and Modelling Assessment

Dispersion modelling has been used to predict ground level concentrations (glcs) of key pollutants associated with the project. Dust emissions during operations have been estimated by analysing the activities taking place for the Project. Emission estimates are presented for a maximum production scenario of 5 Mtpa product coal. A worst case maximum daily production scenario is also modelled.

The ventilation shaft at the Buttonderry site was also included as a vertically discharging point source and emissions from flaring of methane has also been assessed.

The estimated emissions for construction are less than 35% of the emissions estimated to occur during operation of the Project. Therefore compliance with air quality goals during the operation of the mine would represent compliance during construction.

The results of the dispersion modelling indicate that the predicted incremental glcs for PM_{10}, $PM_{2.5}$, TSP and dust deposition at the closest residential receptors are all below the impact assessment criteria. The highest predicted glcs occur at the closest residence to the north of the site (assessment location P11).

A cumulative assessment, incorporating existing background levels, indicates that the Project is unlikely to result in any additional exceedances of relevant impact assessment criteria at the neighbouring receivers.

Emissions to air associated with the flaring of methane and use in power generation were also assessed. The maximum worst case predicted 1-hour NO_2 glcs from flaring and on-site power generation are approximately 14% of the goal, as a conservative worst case, while the maximum predicted annual average NO_2 glcs from flaring are less than 1% of the goal. Cumulative impacts from NO_2 are minor when added to existing background levels.

The potential for nuisance odour impacts from the ventilation shaft was assessed and found to be small. The modelling indicates that only one privately owned receiver in the vicinity of the Buttonderry site is predicted to experience glcs above the impact assessment criteria of 2 OU. It is important to note that odour impact assessment criteria are related to population density. An odour impact assessment criteria of 7 OU would be acceptable to the average person, but as the number of exposed people increases, the probability of a more sensitive individual being exposed increases. The most stringent criterion of 2 OU is considered to be acceptable for the whole population. On this basis, a predicted odour level of 3 OU at one privately owned receiver would be acceptable to the average person.

Greenhouse Gas Assessment

An assessment of the GHG emissions associated with the Project indicates that average annual scope 1 emissions would represent approximately 0.04% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions.

The capture and flaring of methane (pre and post mining) will have significant benefits in terms of GHG emission reductions, resulting in savings of approximately 8 Mt CO_2-e or 54% of Scope 1 emissions, over the project life.

Air Quality & Greenhouse Gas Management and Monitoring

The proposed dust management measures for the Project are based on recommendations outlined in the EPA's Best Practice Report.

The Project will develop an Energy and Greenhouse Strategy to address interim and long term energy and greenhouse management plans and initiatives, including monitoring, reporting and continuous improvement.

The existing monitoring network will be reviewed and augmented for the operation of the Project and would be outlined in an Air Quality & Greenhouse Gas Management Plan for the Project. It is recommended that post commissioning verification of the ventilation shaft emissions is conducted once operational, to validate the assumptions presented in this report.

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1 INTRODUCTION

The Wyong Areas Coal Joint Venture (WACJV) seeks a Development Consent under Division 4.1 in Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) for the Wallarah 2 Coal Project (the Project). This Air Quality and Greenhouse Gas Impact Assessment supports 'The Wallarah 2 Coal Project Environmental Impact Statement' (Wallarah 2 EIS) prepared by Hansen Bailey Environmental Consultants to support the application.

1.1 Study Requirements

This Air Quality and Greenhouse Gas Assessment has been prepared in accordance with the Director-General's Environmental Assessment Requirements (DGRs) for the Project issued 12 January 2012 in accordance with the requirements in Part 2 in Schedule 2 to the Environmental Planning & Assessment Regulation 2000 (EP&A Regs).

Table 1.1 below outlines the DGRs relevant to air quality and greenhouse gas assessment and where each is addressed within this report.

Detailed agency comments have also been provided for inclusion within the Wallarah 2 EIS. The requirements provided by NSW Environmental Protection Agency (EPA) and are listed in **Table 1.2**. Other agency comments including Transport NSW, Wyong Shire Council and Central Coast Health Network are provided in **Table 1.3**. The Air Quality and Greenhouse Gas Assessment has been prepared in accordance with the DGRs, the NSW OEH "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (Approved Methods) (**DEC, 2005**) and other relevant agency comments.

Table 1.1: Director-General's environmental assessment requirements

Discipline	Requirement	Section
Air	*"including a quantitative assessment of potential:*	
	– *construction and operational impacts, with a particular focus on dust emissions including $PM_{2.5}$ and PM_{10} emissions and the dust generation from coal transport*	*Section 7, 8, 9 and 11.1*
	– *reasonable and feasible mitigation measures to minimise dust emissions, including evidence that there are no such measures available other than those proposed; and*	*Section 7.4*
	– *monitoring and management measures, in particular real-time air quality monitoring*	*Section 11.3*
Greenhouse Gases	*"including:* - *a quantitative assessment of the potential scope 1, 2 and 3 greenhouse gas emissions from the project; including fugitive emissions*	*Section 10*
	- *a qualitative assessment of the potential impacts of these emissions on the environment; and*	*Section 10.4*
	- *an assessment of the reasonable and feasible measures that could be implemented on site to minimise the greenhouse gas emissions of the project"*	*Section 10.6*

Table 1.2: EPA Requirements

Air Quality	Section
Assess the risk associated with potential discharges of fugitive and point source emissions for all stages of the proposal. Assessment of risk relates to environmental harm, risk to human health and amenity.	*Section 7 and 8*
Justify the level of assessment undertaken on the basis of risk factors, including but not limited to: *a. proposal location,* *b. characteristics of the receiving environment,* *c. type and quantity of pollutants emitted.*	*Section 6*
Describe the receiving environment in detail. The proposal must be contextualised within the receiving environment (local, regional and inter-regional as appropriate). The description must include but need not be limited to: *a. Meteorology and climate,* *b. Topography,* *c. Surrounding land use, receptors and* *d. Ambient air quality.*	*Section 3 and 5*
Include a description of the proposal. All processes that could results in air emissions must be identified and described. Sufficient detail to accurately communicate the characteristics and quantify of all emissions must be provided.	*Section 7*
Include a consideration of 'worse case' emission scenarios and impacts at proposed emission limits.	*Section 6*
Account for cumulative impacts associated with existing emission sources as well as any currently approved developments linked to the receiving environment.	*Section 8.8*
Include air dispersion modelling where there is a risk of adverse air quality impacts or where there is sufficient uncertainty to warrant a rigorous numerical impact assessment. Air dispersion modelling must be conducted in accordance with the Approved Methods of the Modelling and Assessment of Air Pollutants in NSW (2005). http://www.environment.nsw.gov.au/resources/air/ammodelling05361.pdf.	*Section 6*
Demonstrate the proposals ability to comply with the relevant regulatory framework specifically the Protection of the Environment Operations (POEO) Act (1997) and the POEO (Clean Air) Regulation (2002).	*Section 4.6.2*
Provide an assessment of the project in terms of the priorities and targets adopted under the NSW State plan 2010 and its implementation plan Action for Air.	*Section 4.6.1*
Detail emission control techniques / practices that will be employed by the proposal.	*Section 7.4*
Greenhouse Gas	
The EIA should include a comprehensive assessment of, and report on, the project's predicted greenhouse gas emissions (tCO2e). Emissions should be reported broken down by: • *direct emissions (scope 1 as defined by the Greenhouse Gas Protocol),* • *indirect emissions from electricity (scope 2), and* • *upstream and downstream emissions (scope 3).* *before and after implementation of the project, including annual emissions for each year of the project (construction, operation and decommissioning).*	*Section 10*
The EIA should include an estimate of the greenhouse emissions intensity (per unit of production). Emissions intensity should be compared with best practice if possible.	*Section 10.5 and 10.1*
The emissions should be estimated using an appropriate methodology, in accordance with NSW, Australian and international guidelines.	*Section 10*
The proponent should also evaluate and report on the feasibility of measures to reduce greenhouse gas emissions associated with the project. This could include a consideration of energy efficiency opportunities or undertaking an energy use audit for the site	*Section 10.6*

Table 1.3: Other Agency Comments

Air Quality	Section
WYONG SHIRE COUNCIL	
Issues: • Potential for significant stack emissions. • Potential for dust generation throughout construction and ongoing operation of the project including along the entire rail corridor. • The potential for the release of methane gas despite programs to extract it in advance of mining operations. **What is needed:** • Baseline data over extended period of time. A green house analysis. • Programs to link methane extraction to that being carried out at Buttonderry Tip. • Long term monitoring throughout the duration of the project. • Detailed study relating to dust impacts (climate/seasonal) and associated amenity on affected residents.	Section 7, 9. 10, 5, and 8 *Note: no proposal to link methane extraction to Buttonderry Tip, however onsite beneficial re-use is considered.*
TRANSPORT FOR NSW - AIR	
Include a quantitative assessment of the potential air quality impacts of the project that explicitly includes consideration of both potential PM_{10}, $PM_{2.5}$ and silica emissions of the project and measures to mitigate dust from loaded wagons.	Section 9
NSW HEALTH CENTRAL COAST LOCAL HEALTH NETWORK	
The scientific evidence clearly demonstrates health effects of particulate pollution at levels below our current NSW guidelines. It is noted that an environmental indicator, dust deposition, has an absolute limit, and also has an incremental limit that should not be exceeded. At times, this can result in a dust deposition level below the absolute level being in excess of the incremental limit, and requiring investigation and action. Over the last several decades, there has been a trend of decreasing guideline levels for particulate air pollution. With this in mind, it is important that the air quality impact assessment addresses current guidelines and assesses the impact of any incremental increases in particulate air pollution. The HHRA should address both construction and operational stages.	Assessed in the Health Risk Assessment Report
It is noted that there has been ongoing air quality monitoring and meteorological data at several locations undertaken by the proponent since the EA was released. $PM_{2.5}$ and PM_{10} have also been monitored by Delta Electricity in the region. These data should be presented with previous data for a comprehensive assessment of air quality and meteorological information. In addition to annual summary measures (including the number of days when data collection occurred for each year, for example), time series graphs of particulate levels (and other relevant indicators) should be presented. Meteorological data including, and not limited to that collected at the proposed Tooheys Road surface facility will be valuable to assess likely environmental and health impacts. The impacts should be assessed in terms of particulate matter (PM2.5 and PM 10) and relevant gases using appropriate air quality models. Assessments of prevailing winds and the predictions of the models may require maps similar to those of the EA, though extending further to the north-east e.g. fig 18 of the EA's Air Quality Assessment Report. The EIS should also quantify operating conditions used in the model - where 24 hour PM 10 predictions are made for a busy day, then the number of expected busy days per year should be stated.	Section 5, 7 and 8.
The air quality impacts of increased truck movements and coal train movements in relation to the surface facility should be assessed.	
A proactive strategy should be outlined stating how any adverse air quality impacts will be managed, and how effective they will be in preventing or reducing air pollution. An ongoing monitoring strategy should be clearly described. Responses to adverse events should also be described, and include how the community will be engaged.	Section 11

2 PROJECT DESCRIPTION

Development Consent is sought to mine coal within the Extraction Area for a period of 28 years. The majority of this resource lies beneath the Wyong State Forest and surrounding ranges (including the Jilliby State Conservation Area (SCA)) while a proportion, to be extracted first, lies beneath a section of the Dooralong Valley and the Hue Hue area.

The Project is located approximately 4.7 km north-west of central Wyong and approximately 45 km south-west of Newcastle within the Wyong Local Government Area (LGA). The location of the Project is shown on **Figure 2.1** and **Figure 2.2**.

Key features of the Project include:

- The construction and operation of an underground mining operation extracting up to 5.0 Mtpa of export quality thermal coal by longwall methods at a depth of between 350 m and 690 m below the surface within the underground Extraction Area;
- Mining and related activities will occur 24 hours a day 7 days a week for a Project period of 28 years;
- Tooheys Road Site surface facilities on company owned and third party land (subject to a mining lease) between the Motorway Link Road and the F3 Freeway which will include (at least) a rail loop and spur, stockpiles, water and gas management facilities, workshop and offices;
- Buttonderry Site Surface Facilities on company owned land at Hue Hue Road between Sparks Road and the Wyong Shire Council's (WSC) Buttonderry Waste Management Facility. This facility will include (at least) the main personnel access to the mine, main ventilation facilities, offices and employee amenities;
- An inclined tunnel (or "drift") constructed from the coal seam beneath the Buttonderry Site to the surface at the Tooheys Road Site;
- Construction and use of various mining related infrastructure including water management structures, water treatment plant (reverse osmosis or similar), generator, second air intake ventilation shaft, boreholes, communications, water discharge point, powerlines, and easements to facilitate connection to the WSC (after July 2013, the Central Coast Water Corporation) water supply and sewerage system;
- Capture of methane for treatment initially involving flaring as practicable for greenhouse emission management and ultimately for beneficial use of methane such as electricity generation at the Tooheys Road Site;
- Transport of coal by rail to either the Newcastle port for export or to domestic power stations;
- A workforce of approximately 300 full-time company employees (plus an additional 30 contractors); and
- Rehabilitation and closure of the site at cessation of mining operations.

The proposed general layout of the Tooheys Road Site and Buttonderry Site are shown in **Figure 2.3** and **Figure 2.4**.

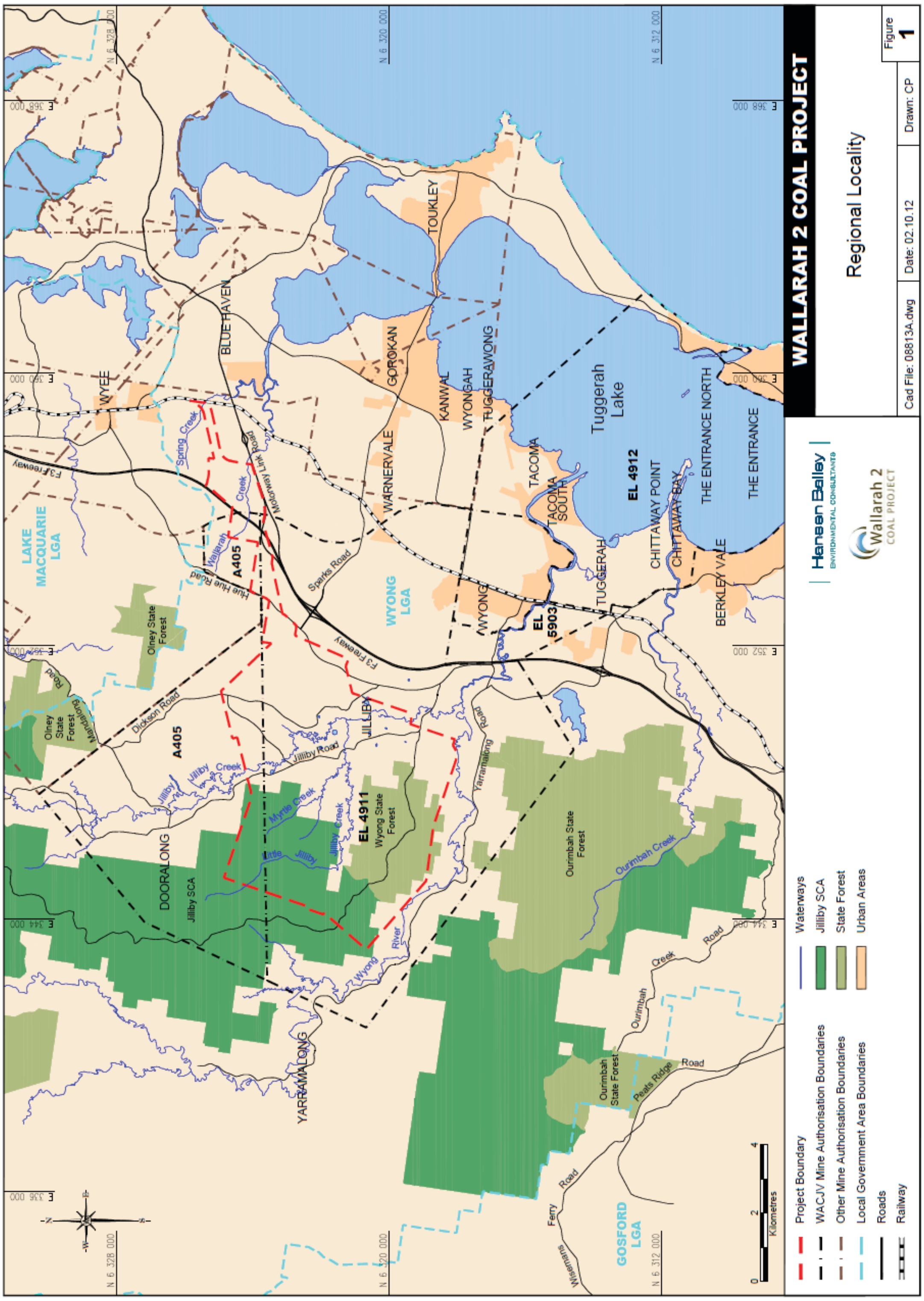


Figure 2.1: Regional Setting

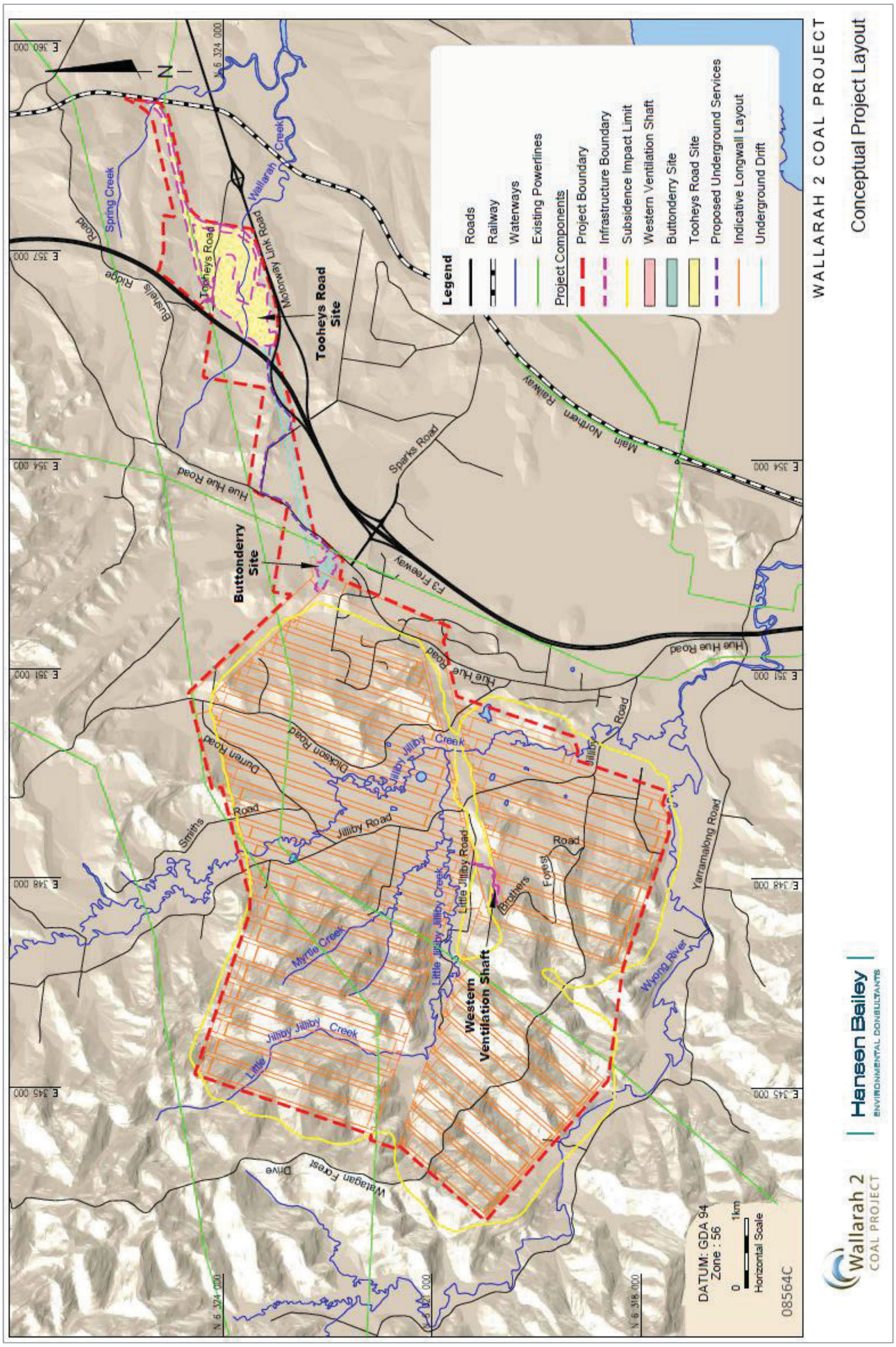


Figure 2.2: Project Layout – Overall

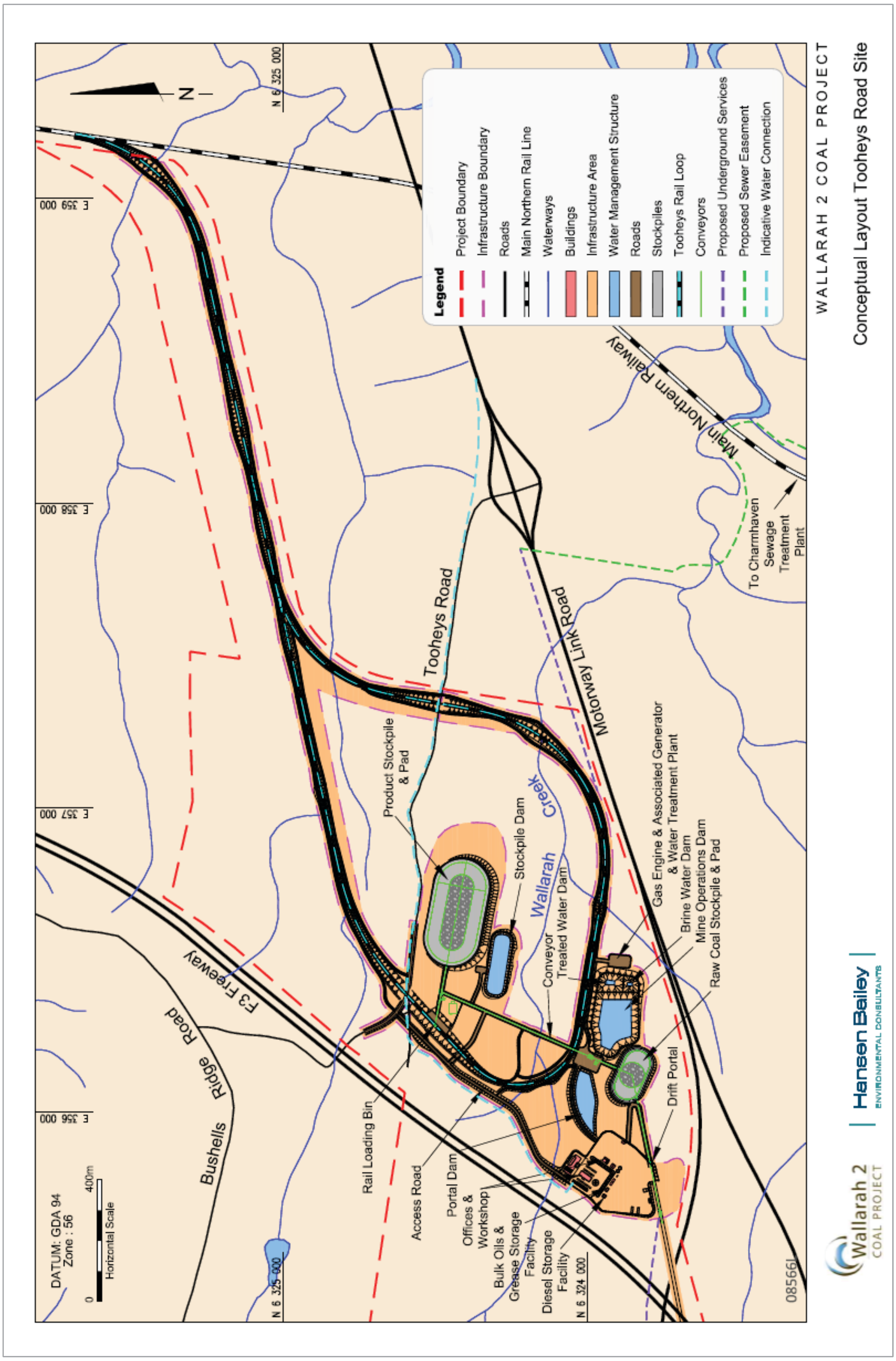


Figure 2.3: Project Layout – Tooheys Road Site

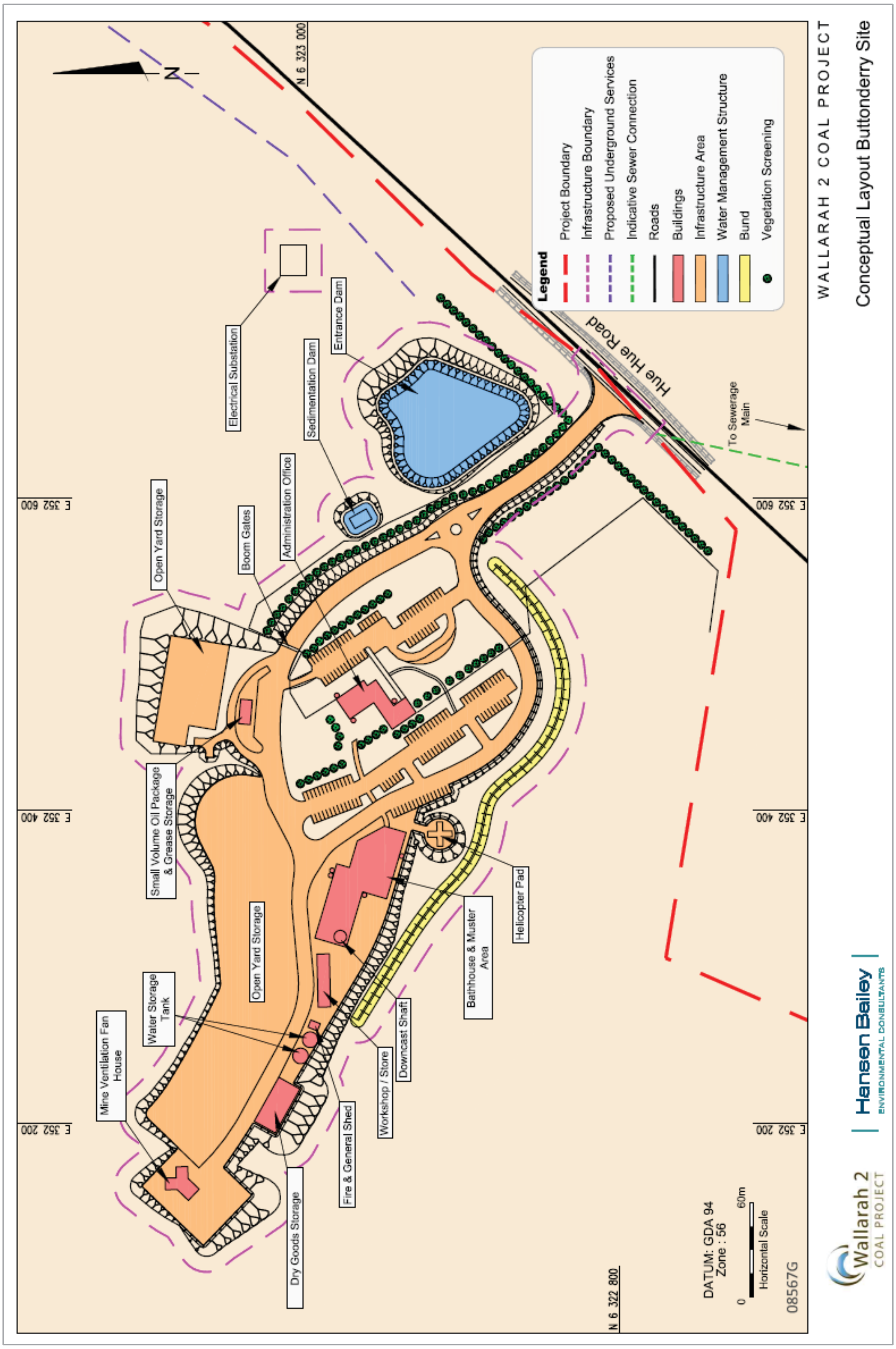


Figure 2.4: Project Layout – Buttondery Site

3 LOCAL SETTING

The closest township to the Project is Wyong which is located approximately 4.7 km to the south-east of the Project Boundary (see **Figure 2.1**). The F3 Freeway and Main Northern Railway Line run north – south, adjacent to the Project Boundary to the east and forms part of the major road and rail network within the region.

The largest proportion of the Project is the underground coal extraction area which is mostly located beneath the Wyong State Forest and adjacent forested hills, including beneath part of the Jilliby SCA which was created in 2003. In the east of the Project Area is Jilliby Jilliby Creek which joins Wyong River further to the south-east. Wyong River which borders the southern part of the underground coal extraction area enters Tuggerah Lake, a large coastal saltwater lagoon on the Central Coast of NSW to the southeast of the Project.

The Project's three surface facilities, namely: Tooheys Road site, Buttonderry Site and the Western Ventilation Shaft site are located generally in the eastern extent of the Project Area. The Tooheys Road site is located on the eastern side of the F3 Freeway and in the vicinity of Wyong's industrial estate.

The Buttonderry Site is located on the western side of the F3 Freeway and within a rural (non-urban constrained land zone) residential area. The Wyong Waste Management Facility is located to the immediate northeast of the Buttonderry Site.

For the purposes of assessing impacts from the Project, discrete assessment locations are selected and presented in **Table 3.1** and **Figure 3.1**. These receptors represent assessment locations in close proximity to the surface facilities for the Project. For some properties, there are no dwellings (or residences) identified on the property. A list of the assessment locations and relevant land owners are presented in **Appendix A**.

Table 3.1: Relevant Receptor Locations

Receptor ID	Easting (m)	Northing (m)	Elevation (m)
P1	357855	6322289	25
P2	357021	6322338	42
P3	356727	6322844	24
P4	354803	6322823	47
P5	353943	6323781	48
P6	355040	6325280	65
P7	355524	6325206	55
P8	355898	6325231	50
P9	356509	6325499	53
P10	357203	6326257	42
P11	356222	6325149	49
P12 (Bluehaven)	359426	6324622	7
P13	351245	6322968	19
P14	351364	6322948	16
P15	351632	6322985	17
P16	351783	6322837	31
P17	351940	6322848	42
P18	351815	6323743	29
P19	351054	6323433	33
P20	351205	6323857	30
P21	351920	6323989	31
P22	351795	6322769	34
P23	351869	6322717	35
P24	352046	6322637	57
P25	352248	6322672	54
P26	352359	6322615	47
P27	352154	6322523	48
P28	352245	6322549	46
P29	352319	6322512	40
P30	352693	6322395	29
P31	352562	6322475	31
P32	352562	6322404	31
P33	352462	6322452	34

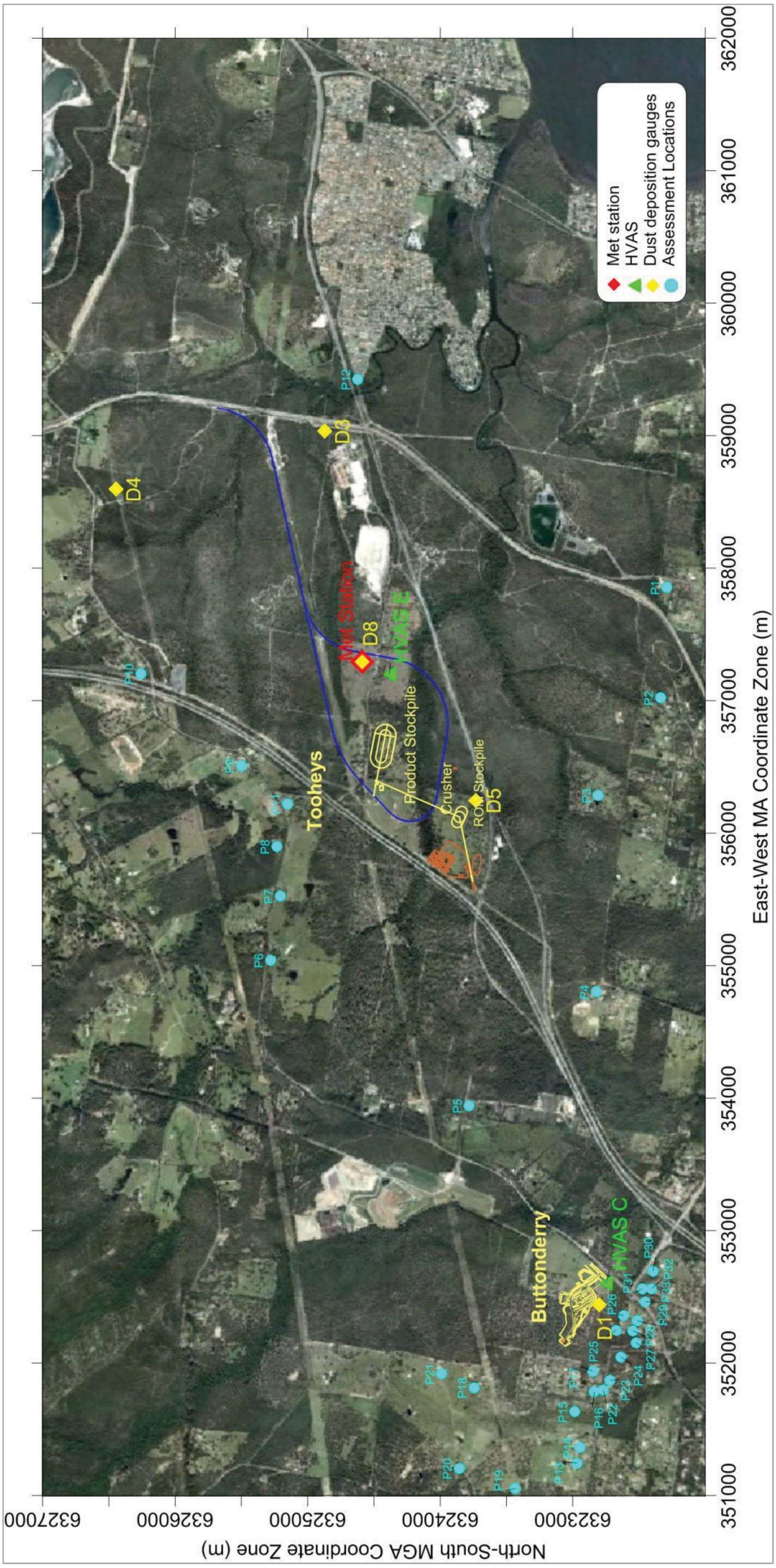


Figure 3.1: Local Setting, Relevant Receptor Locations and Monitoring Sites

Figure 3.2 shows a pseudo three-dimensional (3D) representation of the local topography in the area of the W2CP and surrounds. Vertical exaggeration is applied to emphasise terrain features.

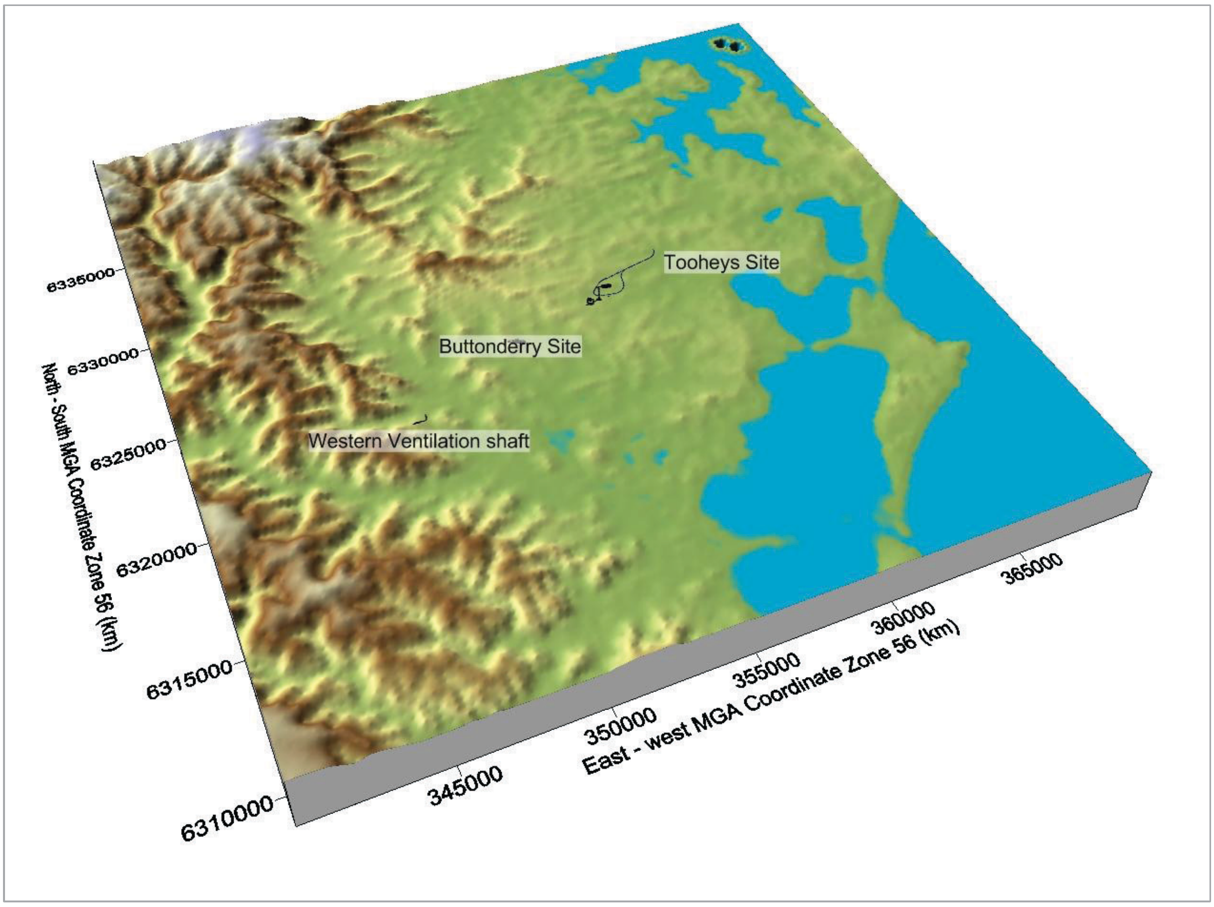


Figure 3.2: Pseudo 3-D representation of regional topography within modelling domain

4 AIR QUALITY CRITERIA

4.1 Emissions to Air

The potential emissions to air from the Project are summarised as follows:

- Project activities described in **Section 2** have the potential to generate fugitive dust emissions, particularly from coal handling and stockpiling at the Tooheys Road site. Fugitive dust emissions can also be expected during construction at the Tooheys Road, Buttonderry and Western Ventilation Shaft site, from bulk earthworks and material handling.
- Emissions from the ventilation shaft at the Buttonderry site (mine ventilation air (MVA) will comprise of particulate matter, dilute methane, combustion emissions (from underground mining equipment) and potentially other hydrocarbons, which may be odorous.
- Combustion of diesel in mining equipment will result in emission of coarse and fine fractions of particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2) and organic compounds. The mining fleet associated with an underground mine is relatively small and emissions from diesel-powered equipment during both construction and operation would not result in significant off-site concentrations. It is noted that emissions of particulate matter from diesel consumption in mining equipment is accounted for in the estimates of fugitive emissions for relevant sources (i.e. dozers).
- The flaring of coal seam methane is a high-temperature oxidation process used to burn waste gases containing methane. Emissions from flaring include unburned hydrocarbons, carbon monoxide (CO) and oxides of nitrogen (NO_x). In combustion, gaseous hydrocarbons react with atmospheric oxygen to form carbon dioxide (CO_2) and water. The quantities of hydrocarbon emissions generated relate to the degree of combustion. Properly operated flares achieve at least 98% combustion efficiency in the flare plume, meaning that hydrocarbon and CO emissions amount to less than 2% of hydrocarbons in the gas stream (**US EPA, 1995**). Similarly, if operated efficiently, the creation of smoke or particles from the flare should be minor. Therefore, the key pollutant from flaring considered in this report is oxides of nitrogen (NOx).
- Options are being considered for the potential beneficial re-use of methane in on-site power generation. Emissions from the gas engines used in on-site power generation would include particulate matter, NO_x, CO and SO_2. The emission rates for CO and SO_2 are are lower than emissions for NO_x, however, the impact assessment criteria for CO and SO_2 are higher than NO_x (NO_2). Therefore, compliance with the NO_2 criteria, demonstrates compliance with these other criteria.
- Greenhouse gases (GHG) such as fugitive methane (CH_4) and carbon dioxide (CO_2) from the combustion of fuel in combustion engines and indirect emissions from the combustion of coal are assessed in **Section 10**.

The following sections provide information on the air quality criteria used to assess the impact of dust and other emissions.

4.2 Particulate Matter and Health Effects

Particulate matter has the capacity to affect health and to cause nuisance effects, and is categorised by size and/or by chemical composition. The potential for harmful effects depends on both. The particulate size ranges are commonly described as:

- Total Suspended Particulate (TSP) –refers to all suspended particles in the air. In practice, the upper size range is typically 30 μm to 50 μm.
- Particulate Matter less than 10 microns (PM_{10}) – refers to all particles with equivalent aerodynamic diameters of less than 10 μm, that is, all particles that behave aerodynamically in the same way as spherical particles with diameters less than 10 μm and with a unit density. PM_{10} are a sub-component of TSP.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5 μm diameter (a subset of PM_{10}). These are often referred to as the fine particles and are a sub-component of $PM_{10.}$
- $PM_{2.5-10}$ – defined as the difference between PM_{10} and $PM_{2.5}$ mass concentrations. These are often referred to as coarse particles.

Evidence suggests that health effects from exposure to airborne particulate matter are predominantly related to the respiratory and cardiovascular systems. The human respiratory system has in-built defensive systems that prevent larger particles from reaching the more sensitive parts of the respiratory system. Particles larger than 10 μm, while less significant in terms of health effects, can soil materials and generally degrade aesthetic elements of the environment. For this reason, air quality goals make reference to measures of the total mass of all particles suspended in the air and is referred to as TSP. In practice particles larger than 30 to 50 μm settle out of the atmosphere too quickly to be regarded as air pollutants. The upper size range for TSP is usually taken to be 30 μm.

Both natural and anthropogenic processes contribute to the atmospheric load of particulate matter. Coarse particles ($PM_{2.5-10}$) are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal[1] materials from roads, farming, mining, dust storms, and so forth. Coarse particles also include sea salts, pollen, mould, spores, and other plant parts. Mining dust is likely to be composed of predominantly coarse particulate matter (and larger).

Fine particles or $PM_{2.5}$ are derived primarily from combustion processes, such as vehicle emissions, wood burning, coal burning for power generation, and natural processes such as bush fires. Emissions of these fine particles from coal mining operations are primarily restricted to emissions from the combustion of diesel and would be relatively minor for this Project, and other underground mining operations, which have a reduced mining fleet.

Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosol from volatile organic compound emissions. $PM_{2.5}$, and in particular the ultrafine sub-micron particles, may penetrate beyond the larynx and into the thoracic respiratory tract and evidence suggests that particles in this size range are more harmful than the coarser component of PM_{10}.

The size of particles determine their behaviour in the respiratory system, including how far the particles are able to penetrate, where they deposit, and how effective the body's clearance mechanisms are in removing them. This is demonstrated in **Figure 4.1**, which shows the relative deposition by particle size within various regions of the respiratory tract. Additionally, particle size is an important parameter in determining the residence time and spatial distribution of particles in ambient air; key considerations in assessing exposure.

1 Crustal dust refers to dust generated from materials derived from the earth's crust.

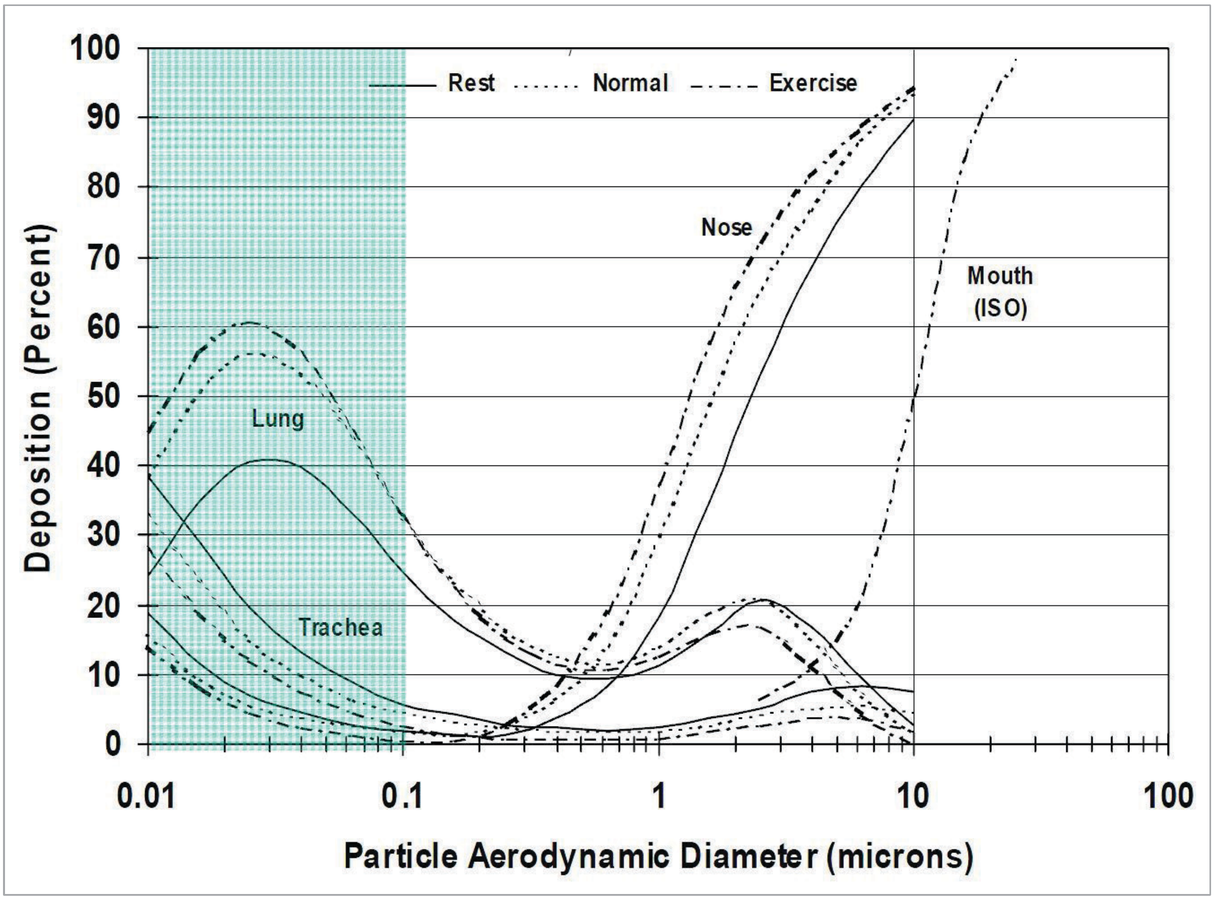


Figure 4.1: Particle Deposition within the Respiratory Track (Source: Chow, 1995)

The health-based assessment criteria used by the EPA have, to a large extent, been developed by reference to epidemiological studies undertaken in urban areas with large populations where the primary pollutants are the products of combustion (**EPA**, **1998**; **National Environment Protection Council** [**NEPC**], **1998a**; **NEPC**, **1998b**). This means that, in contrast to dust of crustal origin, the particulate matter from urban areas would be composed of smaller particles and would generally contain acidic and carcinogenic substances that are associated with combustion.

4.3 Oxides of Nitrogen

The key pollutant released from flaring of methane will be oxides of nitrogen (NO_x). NO_x is comprised of nitric oxide (NO) and nitrogen dioxide (NO_2), however NO is not generally considered harmful to human health and not considered an air pollutant at the concentrations that are typically found in ambient environments. Effects of NO_2 include respiratory infections, asthma and chronic lung disease.

NO_x are produced when fossil fuel is combusted in internal combustion engines (e.g. motor vehicles) and emissions from the existing road network, including the freeway would contribute to ambient levels of NO_x in the local area.

4.4 EPA Criteria

The Approved Methods specifies air quality assessment criteria relevant for assessing impacts from air pollution (**DEC, 2005**). The air quality goals relate to the total dust burden in the air and not just the dust from the Project. In other words, consideration of background dust levels needs to be made when using these goals to assess potential impacts. These criteria are health-based (i.e. they are set at levels to protect against health effects). These criteria are consistent with the *National Environment Protection Measure for Ambient Air Quality* (referred to as the Ambient Air-NEPM) (**NEPC, 1998a**). However, the EPA's criteria include averaging periods, which are not provided in the Ambient Air-NEPM, and also reference other measures of air quality, namely dust deposition and TSP.

In May 2003, the NEPC released a variation to the Ambient Air-NEPM (**NEPC, 2003**) to include advisory reporting standards for particulate matter with an equivalent aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$). The purpose of the variation was to gather sufficient data nationally to facilitate the review of the Ambient Air-NEPM, which is currently underway. The variation includes a protocol setting out monitoring and reporting requirements for $PM_{2.5}$ particles. It is noted that the Ambient Air-NEPM $PM_{2.5}$ advisory reporting standards are not impact assessment criteria.

Notwithstanding the above, in the absence of any other relevant standard/goal, the advisory reporting standards have been used in this report for comparison against dispersion modelling results (**Section 8**). **Table 4.1** summarises the air quality goals for pollutants that are relevant to this study.

Table 4.1: EPA Air Quality Standards/Goals for Particulate Matter Concentrations

Pollutant	Standard	Averaging Period	Source
TSP	90 μg/m^3	Annual	NSW DEC (2005) (assessment criteria)
PM_{10}	50 μg/m^3	24-Hour	NSW DEC (2005) (assessment criteria)
	30 μg/m^3	Annual	NSW DEC (2005) (assessment criteria)
	50 μg/m^3	24-Hour	NEPM (allows five exceedances per year)
$PM_{2.5}$	25 μg/m^3	24-Hour	NEPM Advisory Reporting Standard
	8 μg/m^3	Annual	NEPM Advisory Reporting Standard
Nitrogen Dioxide	246 μg/m^3	1-Hour	NSW DEC (2005) (assessment criteria)
	62 μg/m^3	Annual	NSW DEC (2005) (assessment criteria)

Notes: μg/m^3 – micrograms per cubic metre.

In addition to health impacts, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, including vegetation. Larger particles do not tend to remain suspended in the atmosphere for long periods of time and will fall out relatively close to source. Dust fallout can soil materials and generally degrade aesthetic elements of the environment, and are assessed for nuisance or amenity impacts.

Table 4.2 shows the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust fallout levels are set to protect against nuisance impacts (**DEC, 2005**).

Table 4.2: EPA Criteria for Dust (Insoluble Solids) Fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

Notes: g/m^2/month – grams per square metre per month.

4.5 Odour

Odour criteria have been refined by EPA to take account of population density in the area. **Table 4.3** lists the odour assessment criteria, to be exceeded not more than 1% of the time, for different population densities.

The difference between odour criteria is based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area, there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area.

The criteria assume that 7 odour units at the 99th percentile would be acceptable to the average person, but as the number of exposed people increases there is a chance that sensitive individuals would be exposed. The criterion of 2 odour units at the 99th percentile is considered to be acceptable for the whole population. This most stringent criterion has been considered for the Project as a conservative approach.

Table 4.3. Impact assessment criteria for complex mixtures of odorous air pollutants

Population of affected community	Odour performance criteria (nose response odour certainty units at the 99th percentile)
Single residence (≤~2)	7
~10	6
~30	5
~125	4
~500	3
Urban (>2000) and/ schools and hospitals	2

4.5.1 Peak to Mean Ratios

It is common practice to use dispersion models to determine compliance with odour criteria. This introduces a complication because Gaussian dispersion models are only able to directly predict concentrations over an averaging period of three-minutes or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a three-minute period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source.

To determine more rigorously the ratio between the one-second peak concentrations and three-minute and longer period average concentrations (referred to as the peak-to-mean ratio) that might be predicted by a Gaussian dispersion model, the EPA commissioned a study by Katestone Scientific Pty Ltd (see **Katestone 1995** and **1998**). This study recommended peak-to-mean ratios for a range of source types. The ratio is also dependent on atmospheric stability and the distance from the source. The EPA Technical Framework for odour assessment (**DEC 2006a** and **2006b**) and the Approved Methods (**DEC, 2005**) take account of this peaking factor and the criteria shown in **Table 4.3** are based on nose-response time.

4.6 Other Legislative Requirements

4.6.1 NSW Action for Air

The NSW State Plan identifies cleaner air and progress on GHG reductions as priorities. In 1998, the NSW Government implemented a 25 year air quality management plan, Action for Air, for Sydney, Wollongong and the Lower Hunter (**DECCW, 2009**). Action for Air is a key strategy for implementing the State Plan's cleaner air goals. Action for Air seeks to provide long-term ongoing emission reductions. It does not target acute and extreme exceedances from events such as bushfires. The aim of Action for Air includes:

- meeting the national air quality standards for six pollutants as identified in the Ambient Air-NEPM; and
- reducing the population's exposure to air pollution, and the associated health costs.

The six pollutants in the Ambient Air-NEPM include CO, NO_2, SO_2, lead, ozone and PM_{10}. The main pollutant from the Project that is relevant to the Action for Air is PM_{10} and NO_2. Action for Air aims to reduce air emissions to enable compliance with the Ambient Air-NEPM targets to achieve the aims described above, with a focus on motor vehicle emissions. Whilst the Project is not located within the areas relevant to the Action for Air plan (i.e. Sydney, Wollongong and the Lower Hunter), the Project generally addresses the aims of the Action for Air Plan in the following ways:

- PAEHolmes have reviewed potential mitigation measures, and a range of measures have been adopted for the Project (**Section 7.4**).
- Air quality emissions potentially associated with the Project have been quantified (**Section 7**).
- Dispersion modelling has been conducted to predict the impact of these emissions on nearby receivers, and assess the effect of the emissions on ambient concentrations which can then be compared with the Ambient Air-NEPM goals (**Section 8**).

4.6.2 Protection of the Environment Operations (POEO) Act, 1997

If approved, the Project would operate under an Environmental Protection Licence (EPL) issued by the EPA under the *Protection of the Environment Operations Act 1997* (POEO Act). Relevant to air quality, the EPL would outline the Project's requirements to minimise dust emissions and specifies air quality monitoring requirements. The *Protection of the Environment Operations (Clean Air) Regulations 2010* (POEO (Clean Air) Regulation) (**POEO, 2010**) sets out standards of concentration for emissions to air from scheduled activities. The maximum pollution levels allowed under the regulations for general activities are provided in **Table 4.4**.

Table 4.4: Maximum Allowable Emission Levels

Air Impurity	Activity or Plant	Standard of Concentration
Solid Particles	Any process emitting solid particles	50 mg/m^3

In addition, the NSW *POEO (Clean Air) Regulation* prescribes requirements for domestic solid fuel heaters, control of burning, motor vehicle emissions and industrial emissions. Motor vehicle emissions would be addressed by regular maintenance of all vehicles associated with the Project. In addition, no burning on-site would be conducted to minimise potential for smoke impacts on neighbouring receivers.

5 EXISTING ENVIRONMENT

5.1 Meteorology

5.1.1 Local Climatic Conditions

The Bureau of Meteorology (BoM) collects climatic information in the vicinity of the Project. A range of climatic information collected from the Norah Head Automated Weather Station (Norah Head AWS) which is located approximately 10 km southeast of the Project is presented in **Table 5.1**. Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Monthly daily averages of maximum and minimum temperatures are also provided. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures recorded at the Norah Head AWS are 22.1 °C and 15.1°C respectively. On average, February is the hottest month, with an average maximum temperature of 25.9°C. July is the coldest month, with average minimum temperature of 9.7°C.

The annual average relative humidity reading collected at 9.00 am from the Norah Head station is 71% and at 3.00 pm the annual average is 65%. The month with the highest relative humidity on average is February with 9.00 am and 3.00pm averages of 78% and 72% respectively. The month with the lowest relative humidity is August with 9.00 am and 3.00 pm averages of 63% and 56% respectively.

Rainfall data collected at the Norah Head AWS shows that May is the wettest month, with an average rainfall of 163 mm over 14.3 rain days. The average annual rainfall is 1,153.9 mm with an average of 143.6 rain days.

Table 5.1: **Climate Averages for the Norah Head AWS for 1964-2011**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
9 am Mean Dry-bulb and Wet-bulb Temperatures (ºC)[1] and Relative Humidity (%)													
Dry-bulb	22.3	22.4	21.1	19.3	16.2	13.7	12.8	14.5	17.2	19.3	20	21.6	18.4
Wet-	19.4	19.7	18.2	16.1	13.8	11.4	9.9	11.4	13.5	15.4	17.1	18.5	15.4
Humidity	76	78	76	71	72	72	69	63	64	65	72	72	71
3 pm Mean Dry-bulb and Wet-bulb Temperatures (ºC)[1] and Relative Humidity (%)													
Dry-bulb	24	24.2	23.3	21.2	18.9	16.7	16.1	17.4	19	20.3	21.5	23.1	20.5
	20.2	20.9	19.7	17.1	15.2	13.3	11.9	12.7	14.6	16.2	17.8	19.3	16.6
Humidity	70	72	69	65	64	63	59	56	60	64	68	68	65
Mean Maximum Temperature (ºC) [1]													
Mean	25.7	25.9	24.8	22.8	20	18	17.2	18.8	20.9	22.4	23.5	24.7	22.1
Mean Minimum Temperature (°C) [1]													
Mean	19.6	20	18.7	15.8	13.1	10.9	9.7	10.6	12.8	14.8	16.7	18.3	15.1
Rainfall (mm)[2]													
mean	72.7	101.6	105.2	127.3	163	133.8	98.6	69.6	68.9	56.4	89.5	67.4	1153.9
Raindays (Number)													
mean	12.5	11.4	12.5	13.4	14.3	13.1	11.2	9.2	11.6	10.6	12.9	10.9	143.6

Source: BOM (2012) Climate averages for Station: 061366; Commenced: 1989; Latitude: 33.28 °S; Longitude: 151.58 °E

5.1.2 Local Wind Data

Local meteorological data have been collected at the Tooheys Road site since 2007. The meteorological station was replaced during 2009 and site specific data were not available for 2009. There was also a period from January to March 2010 where the weather station failed and data are not available. The weather station has been operational since March 2010 with no outages.

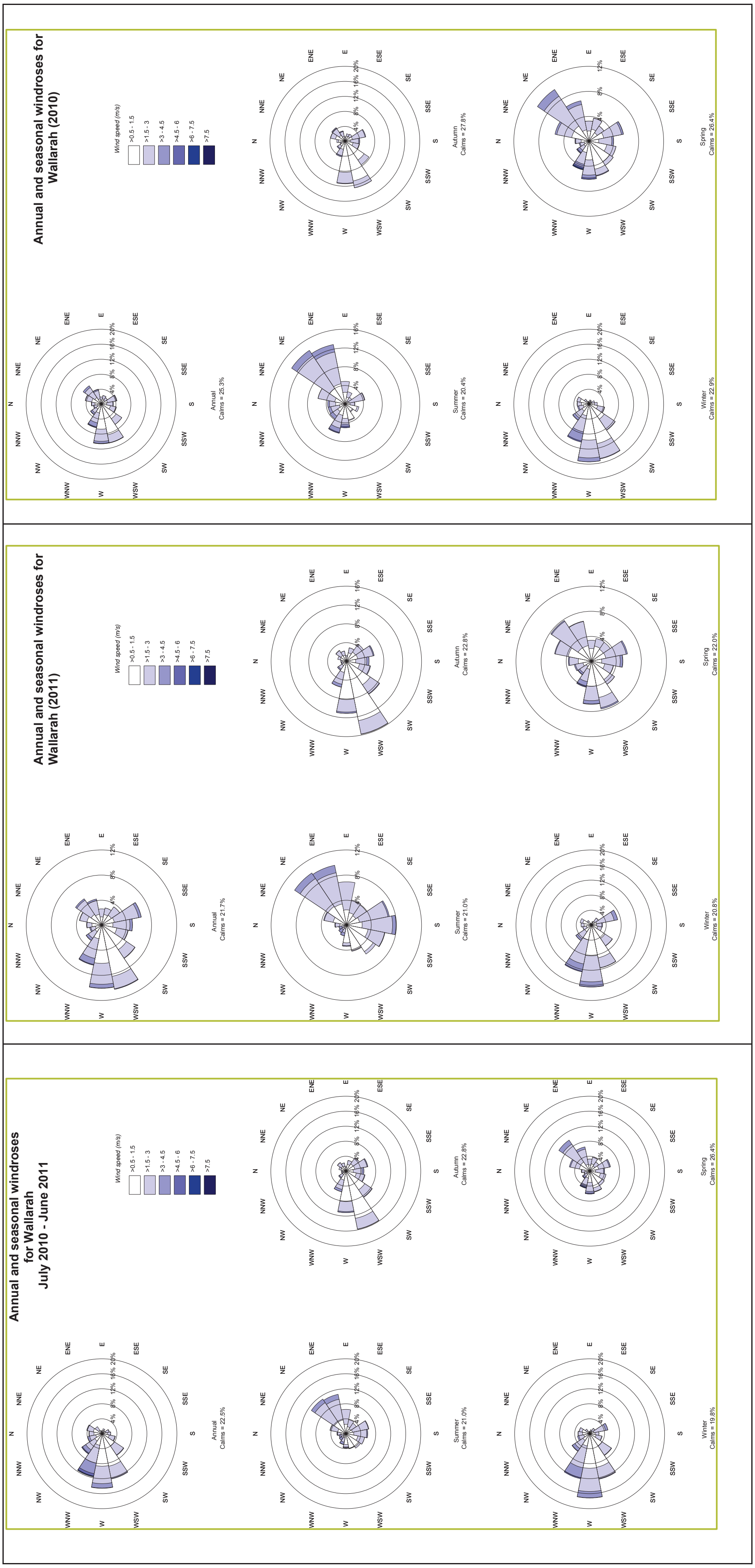
Comparative statistics are shown in **Table 5.2** and windroses for each available year are presented in **Figure 5.1**. Based on an analysis of data availability, a period from July 2010 to June 2011 is chosen for modelling. This period is representative of wind patterns across recent years and seasons and comparable with data collected at the Norah Head AWS.

On an annual basis, **Figure 5.1** shows winds to be mainly from the west, west-southwest and west-northwest. The annual percentage of calms is high (winds less than 0.5 m/s) at 22%. The annual average wind speed is 1.3 m/s.

Table 5.2: Comparative Statistics for Meteorological Data

Period	% Calms	Average Wind Speed (m/s)	% Data Recovery [(a)]
2007	29	1.7	60% – 70%
2008	31	1.6	62%
2009	-	-	0%
2010	25	1.2	80%
2011	22	1.3	86%
July 2010 – June 2011	22	1.3	95%

Note: [(a)] based on wind speed/direction


Annual and seasonal windroses for Wallarah (2010)
Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
Annual
Calms = 25.3%
Summer
Calms = 20.4%
Autumn
Calms = 27.8%
Winter
Calms = 22.9%
Spring
Calms = 26.4%
Annual and seasonal windroses for Wallarah (2011)
Annual
Calms = 21.7%
Summer
Calms = 21.0%
Autumn
Calms = 22.8%
Winter
Calms = 20.8%
Spring
Calms = 22.0%
Annual and seasonal windroses for Wallarah July 2010 - June 2011
Annual
Calms = 22.5%
Summer
Calms = 21.0%
Autumn
Calms = 22.8%
Winter
Calms = 19.8%
Spring
Calms = 26.4%

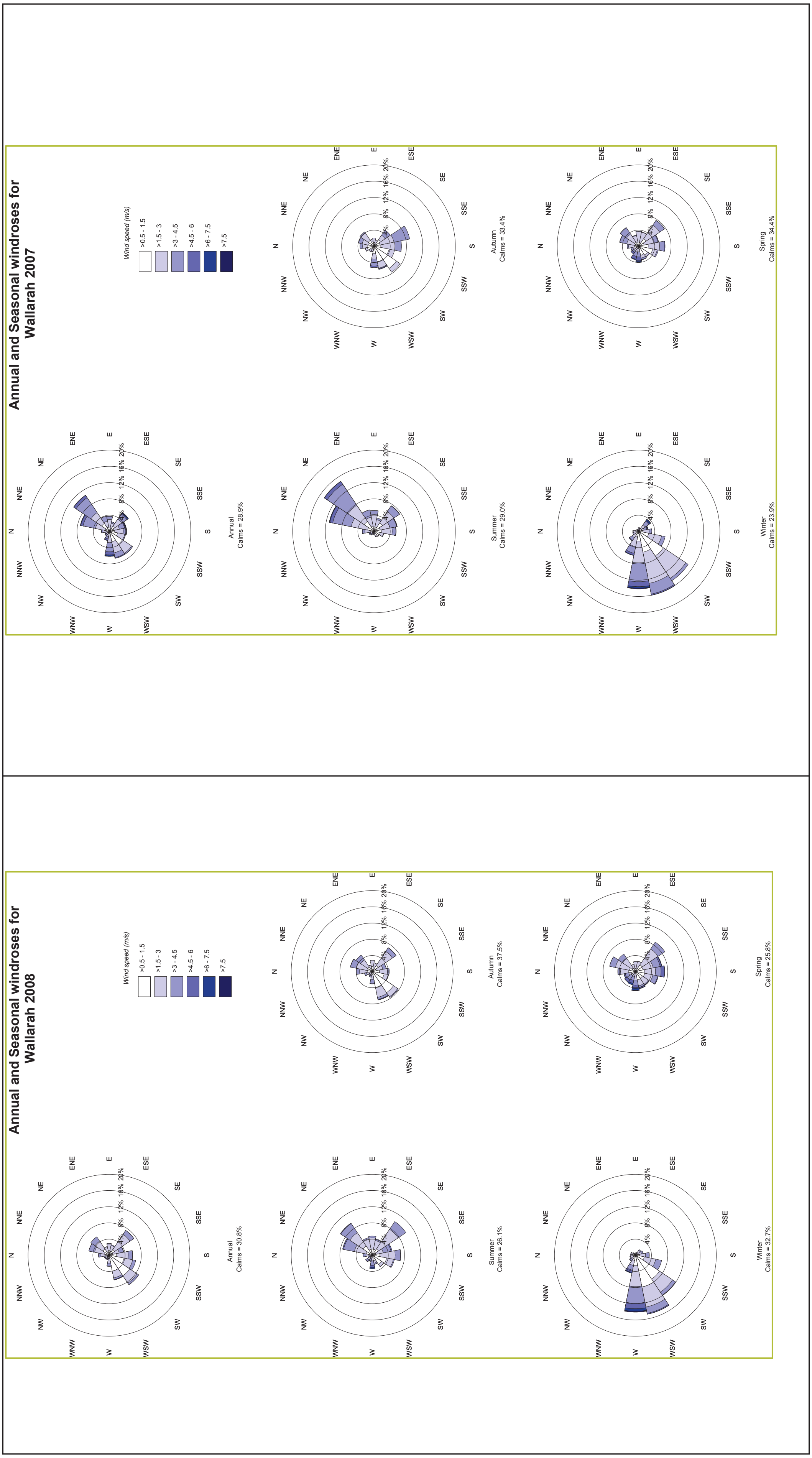


Figure 5.1: Annual and seasonal windroses for Tooheys Road weather station

5.2 Existing Ambient Air Quality

Air quality standards and goals refer to pollutant levels which include the contribution from proposed projects as well as other sources. To fully assess impacts against all the relevant air quality standards and goals it is necessary to have information or estimates on existing dust concentration and deposition levels in the area in which the Project is likely to contribute to these levels.

An Environmental Monitoring Program for the Project commenced in 1996 providing monthly averages of dust fallout levels. Dust concentrations were also measured by high volume air samplers (HVAS). Air monitoring was discontinued in early 2004 and recommenced in late 2006. Recent and historical data are summarised in reports by ERM (**ERM, 2008, 2009, 2010, 2011, 2012**). Available data commencing in 1999 from the two relevant HVAS and eight (later six) dust deposition gauges are provided below.

The locations of the current monitoring sites in place for the mine operations are shown on **Figure 3.1** and include:

- Two HVAS measuring PM_{10} on a one day in six cycle;
- Two HVAS measuring total suspended particles (TSP) on a one day in six cycle; and
- Six dust deposition gauges.

The HVASs are located near each of the Tooheys Road and Buttonderry Road sites. Dust deposition gauges are located near the Tooheys Road and Buttonderry Road sites and also representative of nearby residential areas.

5.2.1 PM_{10} and TSP Concentrations

HVAS C is located at the Buttonderry site and HVAS E at the Tooheys Road site. The HVAS monitoring results will include all background sources relevant to that location, including any contribution which may occur from local activities. Concentrations of 24-hour PM_{10} above the goal of 50 µg/m^3 are measured on occasion, often associated with bushfires, dust storms or dry, hot conditions.

A summary of the monitoring data is presented in **Table 5.2**. There was a gap in data collection between 2003 and 2006. Since the recommencement of monitoring in September 2006 to date (May 2012) these data are 84%-85% complete (HVAS C) and 90% - 93% complete (HVAS E).

Annual average concentrations of PM_{10} are generally below the relevant air quality goals for the monitoring period. Exceedances of annual average PM_{10} goal of 30 µg/m^3 were recorded in 2002 and 2006. In 2002, the annual average PM_{10} concentration are based on data were collected over November and December only, a period impacted by bushfires. The average annual PM_{10} over both monitoring sites for the monitoring period is 18 µg/m^3.

The highest 24-hour average PM_{10} concentration was 156 µg/m^3 at HVAS E (and 154 at HVAS-C for the same period). This reading was taken during dust storms in April 2009. Further elevated readings were recorded in April 2009 and again in September 2009, during another dust storm. These dust storms affected a widespread area of NSW (April 2009) and the eastern coast of Australia (September 2009). Elevated readings in November and December 2006 were due to severe bushfires in the area and across the state.

Table 5.3 also provides a summary of the annual average TSP concentration data collected at these sites. Monitoring results show that from 1999 to 2012 there have been no recorded exceedances of the EPA impact average assessment criterion for TSP of 90 µg/m^3. The highest annual average TSP was 64 µg/m^3 measured in 2002 by HVAS C and 61 µg/m^3 also measured in 2002 by HVAS E.

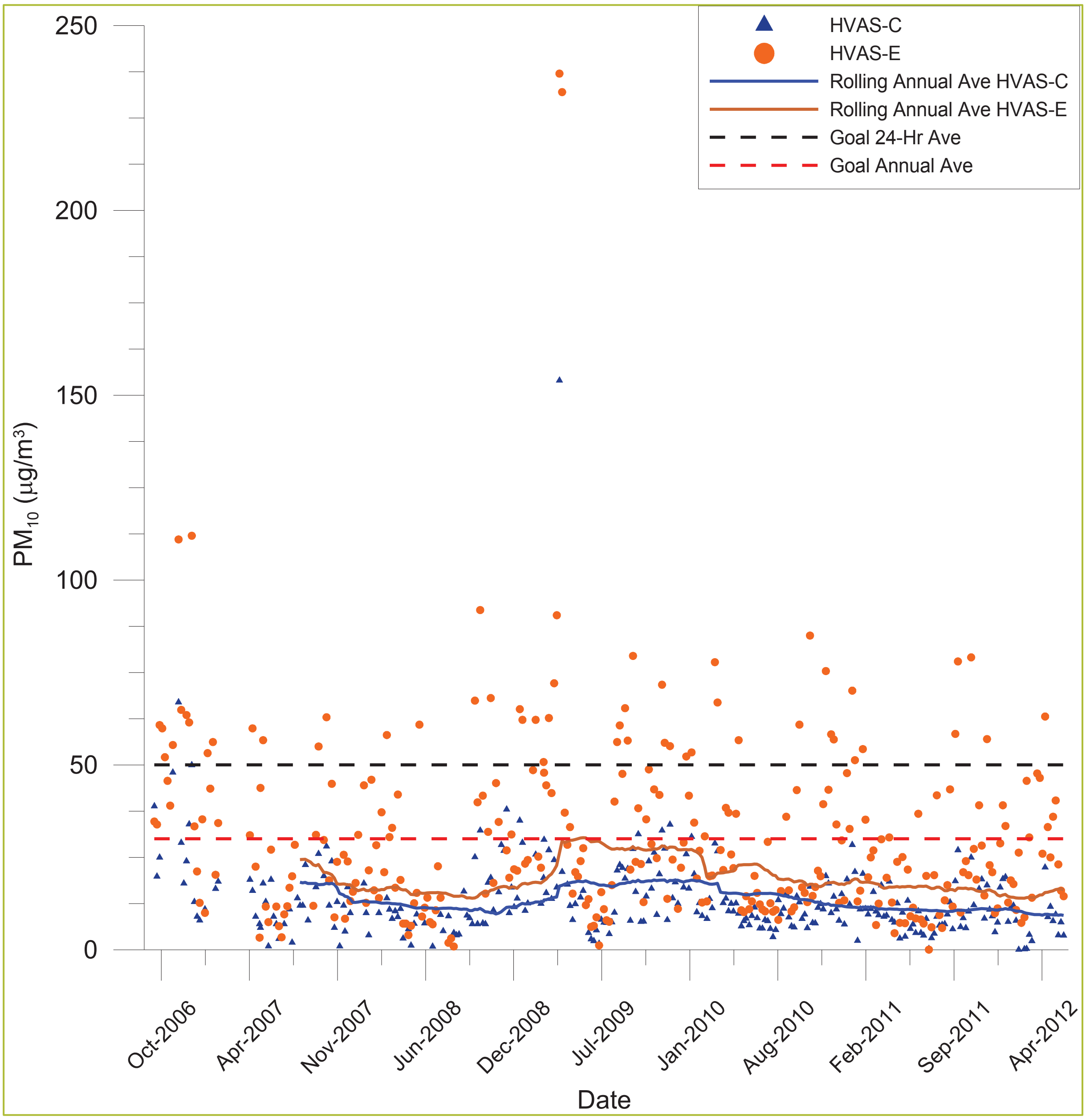


Figure 5.2: 24hr PM_{10} concentrations for November 2006 to May 2012

Table 5.3: Summary of PM_{10} and TSP concentration

Year	HVAS C				HVAS E			
	PM_{10} Annual Ave	PM_{10} 24-Hr Max	Days above criteria [a]	TSP Annual Ave	PM_{10} Annual Ave	PM_{10} 24-Hr Max	Days above criteria [a]	TSP Annual Ave
Goal	*30 (µg/m³)*	*50 (µg/m³)*	*50 (µg/m³)*	*90 (µg/m³)*	*30 (µg/m³)*	*50 (µg/m³)*	*50 (µg/m³)*	*90 (µg/m³)*
1999	10	14	0	24	9	14	0	21
2000	11	30	0	20	12	66	1	26
2001	12	33	0	27	13	32	0	30
2002[b]	38	116	2	64	24	85	6	61
2003[b]	12	44	0	29	21	49	0	42
2006[b]	31	67	1	51	37	73	2	57
2007	13	29	0	19	17	41	0	33
2008	12	38	0	18	17	62	1	33
2009	19	154	1	30	28	156	4	50
2010	12	31	0	19	19	57	3	32
2011	11	28	0	18	16	53	2	29
2012[c]	8	22	0	20	17	39	0	28
Average	**15**	**-**	**-**	**25**	**21**	**-**	**-**	**37**

Note: [a] HVAS monitors only recorded dust levels one day in six, so this does not represent all days above criteria.
[b] 2002 data are for November and December only. Gap in monitoring from 2003 to 2006, recommenced September 2006.
[c] Data to May 2012 available at time of writing

5.2.2 Dust Deposition

Dust deposition data have been collected in the area surrounding the Project since September 1996. The locations of the relevant dust deposition gauges are shown in **Figure 5.3**. Gauges D6, D10 and D20 are no longer in use. These data, from 1997, expressed as insoluble solids, are presented in **Table 5.4**. Monitoring ceased in 2004 and recommenced in September 2006. For most years, less than a full year of data was available, due to contamination of samples or only a part-year of monitoring.

Annual average dust deposition recorded since September 2006 is shown in **Figure 5.3**. In recent years there have been no exceedances of the EPA criterion of 4 g/m^2/month. The average dust deposition rate across all sites for the entire monitoring period is 1.6 g/m^2/month.

Table 5.4: Dust Deposition Yearly Average(insoluble solids)

Year	D1	D3	D4	D5	D6	D8	D10	D11	D20
1997	-	1.2	0.8	1.1	1.5	-	-	-	2.6
1998	-	0.8	0.6	0.5	2.9	-	-	-	0.9
1999	1.6	0.8	0.8	0.6	2.7	0.2	-	-	0.9
2000	1.3	0.9	0.7	0.7	1.9	4.8	1.0	1.4	1.0
2001	1.1	0.8	0.4	0.9	3.0	3.2	2.3	2.3	0.9
2002	2.2	1.6	-	0.8	2.3	1.2	1.9	2.9	5.2
2003	2.4	1.5	-	1.6	1.9	1.8	0.9	-	1.1
2004	3.5	1.6	-	1.5	1.9	2.3	1.7	-	1.1
2006 (from Sept)	2.0	1.5	1.1	1.1	-	1.6	-	1.9	-
2007	3.9	2.6	1.3	1.1	-	3.4	-	3.1	-
2008	1.4	1.0	0.7	0.8	-	3.9	-	2.2	-
2009	1.8	1.7	1.1	1.0	-	1.4	-	2.2	-
2010	2.2	0.7	0.8	0.5	-	0.8	-	2.5	-
2011	2.1	0.6	0.5	0.4	-	0.6	-	3.5	-
2012 [(a)]	2.4	0.7	0.9	0.5		0.7		2.6	
Average	**2.1**	**1.2**	**0.8**	**0.9**	**2.3**	**2.1**	**1.6**	**2.4**	**1.7**
Average over all sites									**1.6**

Note: [(a)] Average based on first 5 months of data for 2012

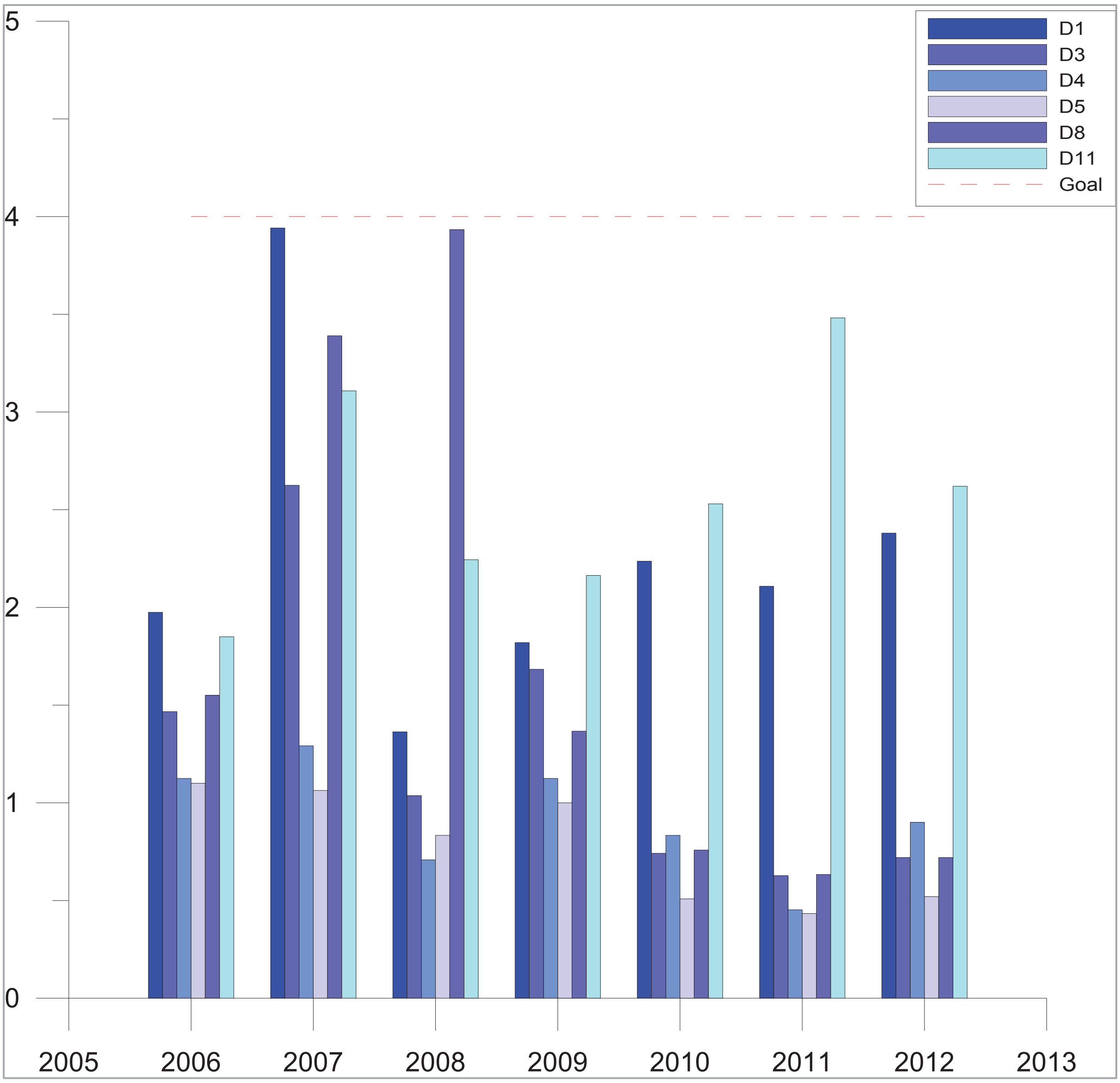


Figure 5.3: Annual Average Dust Deposition

5.2.3 $PM_{2.5}$ Concentrations

No recent $PM_{2.5}$ monitoring data are available in the vicinity of the Project. Historical monitoring for $PM_{2.5}$ has been conducted by Delta Electricity at their Wyee monitoring station (**Wyee Shire Council, 2007**). The Delta monitoring data were presented in Wyong Shire Council's State of the Environment Report for 2006-2007, but not in subsequent monitoring report, which suggests that this monitoring was discontinued. There is currently no requirement for Delta Electricity to monitor PM_{10} or $PM_{2.5}$ in their EPA Environmental Protection Licence (EPL).

$PM_{2.5}$ monitoring data for 2003 to 2007 were presented in Wyong Shire Council's State of the Environment Report for 2006-2007 and shown in **Figure 5.4**. It is not stated in the report what the monitoring method is, however, based on the number of data points presented in in **Figure 5.4** it appears that the monitoring method is High Volume Air Sampling, which is only run every sixth day. This is not an approved method for $PM_{2.5}$ and because the available data is over 5 years old, it is not used in this assessment.

The closest available $PM_{2.5}$ monitoring locations are operated by the EPA at Beresfield and Wallsend, located approximately 40 km – 50 km north of the site. Co-located monitors for PM_{10} and $PM_{2.5}$ are operated at these sites and the average recorded ratio of $PM_{2.5}/PM_{10}$ for these sites during 2011 was 0.3.

Applying this ratio to the annual average PM_{10} concentration recorded at the site (**Table 5.2**), the annual average $PM_{2.5}$ concentration is estimated to be approximately 5 µg/m^3.

It is noted that the ratios of $PM_{2.5}/PM_{10}$ vary across different areas, usually a function of local industrial activity, vehicle traffic, residential density and domestic wood burning. However, in the absence of available recent local data, these ratios are adopted for use in this assessment.

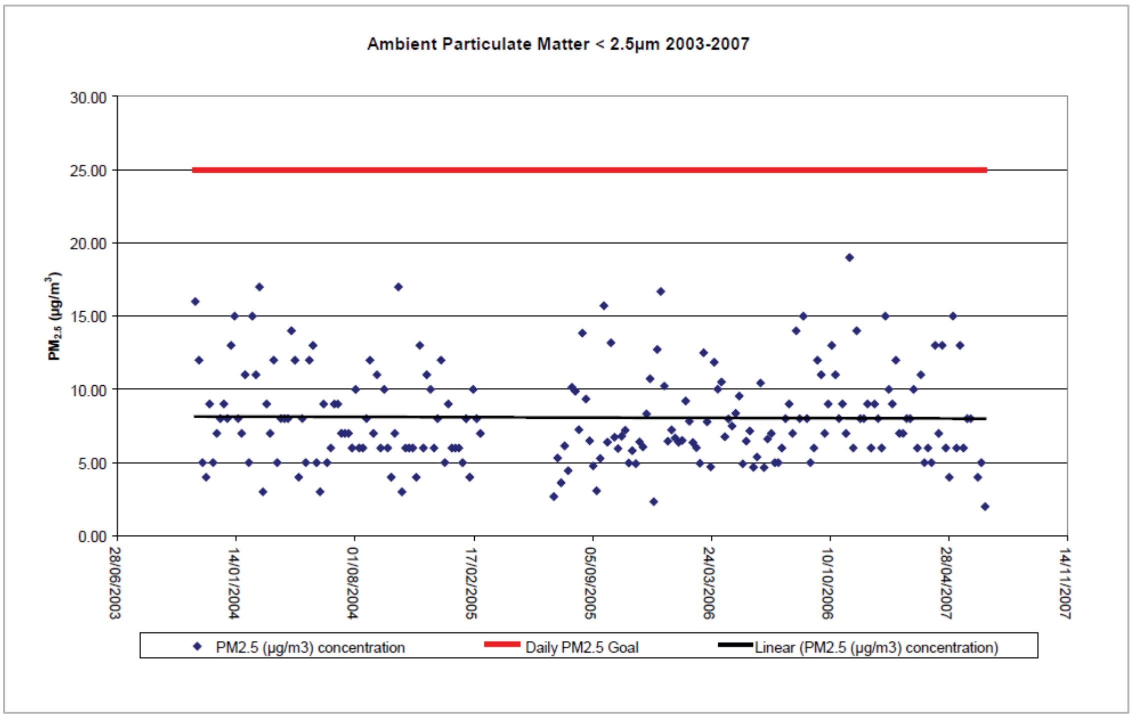


Figure 5.4: Wyee $PM_{2.5}$ Monitoring Data (source: Wyong Shire Council, 2007)

5.2.4 Nitrogen Dioxide (NO_2)

An analysis of ambient NO_2 levels for the area was conducted for the Munmorah Rehabilitation Environmental Assessment (EA) (**Aurecon, 2009**). Monitoring data conducted by Delta Electricity for their Wyee and Lake Munmorah Public School (LMPS) air monitoring stations was analysed for the period 1994 to 2008.

The analysis demonstrates that annual average NO_2 levels for the area are less than one third of the ambient air quality goal of 62 μg/m^3, while maximum 1-hour NO_2 levels are less than one half of the ambient air quality goal of 246 μg/m^3.

The adopted background for the Munmorah Power Rehabilitation (**Aurecon, 2009**) is used to define background NO_2 levels for the area.

5.3 Existing Air Quality for Assessment Purposes

The assessment of air quality impacts for the Project requires consideration of the contributions of from other local sources, including traffic along major transport routes, local power stations, domestic wood fires, local unsealed roads and exposed areas.

The monitoring data collected for the Project provides an indication of background concentrations for TSP, PM_{10} and dust deposition in the region. In the absence of monitoring data for $PM_{2.5}$ an estimate is made based on ratios of $PM_{2.5}$/PM_{10} measured at the closest available EPA monitoring sites.

In summary, for the purposes of assessing potential air quality impacts, the following existing air quality levels are assumed.

- annual average PM_{10} concentration of 18 μg/m^3;
- 24-hour PM_{10} concentrations – daily varying;
- annual average $PM_{2.5}$ concentration of 5 μg/m^3;
- annual average TSP concentration of 31 μg/m^3;
- annual average dust deposition of 1.6 g/m^2/month;
- 1-hour average NO_2 – 77.3 μg/m^3; and
- annual average NO_2 – 17 μg/m^3.

6 MODELLING APPROACH

This Air Quality Assessment has been conducted in accordance with the Approved Methods (**DEC, 2005**) and the approach is described in the following sections.

6.1 Modelling System

The CALMET/CALPUFF modelling system was chosen for this study. CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the 3-D meteorological fields that are utilised in the CALPUFF dispersion model. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region. CALPUFF is a multi-layer, multi-species non-steady state puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal (**Scire *et al*., 2000**). The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer-range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across the puff and takes into account the complex arrangement of emissions from point, area, volume, and line sources. In March 2011 the NSW EPA published generic guidance and optional settings for the CALPUFF modelling system for inclusion in the Approved Methods (**TRC, 2011**). The model set up for this study has been conducted in consideration of these guidelines.

6.2 Model Set Up

CALMET was run for a domain of 30 km x 30 km with a 250 m resolution, centred on the proposed Tooheys Road site. Observed hourly surface data were incorporated into the domain modelling, including the Wallarah site data plus the BoM data from Cooranbong (located 15 km north) and Norah Head (located 14 km southeast). Cloud amount and cloud heights were sourced from observations at Williamtown RAAF base (located 60 km northeast) and included at the Cooranbong site. Any gaps in the data were supplemented with data extracted from TAPM[2]. Further details on model set up are provided in **Appendix B**.

6.3 Dispersion Meteorology

To compare winds predicted by the model with the measured data from the Wallarah AWS (**Figure 5.1**), a CALMET windrose is presented in **Figure 6.1**. The CALMET windrose is extracted for a single point at the approximate location of the Wallarah AWS. The CALMET wind rose displays similar characteristics to the measured data at Wallarah AWS with dominant winds annually from west, west-southwest. The percentage occurrence of calm conditions (defined as wind speeds less than 0.5m/s) are also a similar magnitude between those recorded at Wallarah AWS and those predicted by CALMET.

[2] The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. Detailed description of the TAPM model and its performance is provided in (Hurley 2008; Hurley, Edwards et al. 2009).

Figure 6.1: Windrose extracted from CALMET

7 EMISSIONS TO AIR

7.1 Construction Phase

During construction of the surface infrastructure, fugitive dust emissions can be expected from the activities including:

- Vegetation clearing/stripping;
- Bulk earthworks and material handling;
- Hauling along unsealed surfaces; and
- wind erosion on exposed areas

An estimate of the amount of dust produced during the construction phase is presented in **Table 7.1**.

The total estimated emissions are less than 35% of the emissions estimated to occur during operation of the Project (refer **Section 0**) and therefore further assessment for construction is not considered appropriate. Compliance with air quality goals during the operation of the mine is assumed to represent compliance during mine construction.

Table 7.1: Estimated Dust Emission – Construction

ACTIVITY - Construction	TSP	PM_{10} kg/y	$PM_{2.5}$
Tooheys Road Site			
Dozer clearing vegetation	16,066	3,882	1,687
Loading of excavated material to trucks	331	156	24
Hauling of excavated material to trucks	5,441	932	134
Dumping of excavated material	331	156	24
FEL / Dozer Shaping	6,525	1,471	685
Wind erosion - exposed areas	24,528	12,264	1,840
Buttonderry Site			
Dozer clearing vegetation	4,820	1,165	506
Loading of excavated material to trucks	33	16	2
Hauling of excavated material to trucks	547	94	13
Dumping of excavated material	33	16	2
FEL / Dozer Shaping	6,525	1,471	685
Wind erosion	14,016	7,008	1,051
Total Annual TSP (kg)	**79,195**	**28,632**	**6,653**

Notwithstanding the above, suitable dust mitigation measures would be implemented during the construction phase to ensure that dust emissions are kept to a minimum, especially during adverse meteorological conditions. These mitigation measures are discussed in **Section 11**.

7.2 Operation Phase

During operations, the Project will result in emissions of particulate matter, primarily from coal handling activities at the pit top and the operation of upcast ventilation shafts.

Dust emissions during operations have been estimated by analysing the activities taking place for the Project. The estimated dust emissions during the operational stage of the mine are presented in **Table 7.2** and **Table 7.3**.

Emission estimates are presented for a maximum production scenario of 5 Mtpa product coal. While annual production rates can be used to assess a typical (or average) production day at the site, it is possible that daily production could be higher. A maximum daily production scenario is therefore modelled based on a maximum hourly conveyor capacity of 2000 tonnes per hour (tph) and maximum train loading rates of 4500 tph. It is noted that this represents a very conservative scenario whereby the maximum hourly rates are applied for a 24 hour period, resulting in a daily conveyor production rate of 48 kilotonnes per day (kt/day) and a train loading rate of 108 kt/day. In reality, the busiest day, in terms of train loading would not be greater than 40 kt/day.

These maximum hourly emission rates are applied for each day of the modelled year so that a full range of meteorological conditions can be tested for this scenario.

In estimating dust emissions, consideration has been given to best practice management (BPM) and applicable controls have been applied to significant dust sources. An overview of the BPM is provided in **Section 7.4**.

Table 7.2: Estimated Annual Dust Emission

ACTIVITY	TSP	PM_{10} kg/y	$PM_{2.5}$
Tooheys Road Site			
CL - Conveyor transfer @ Portal	828	392	59
CL - Conveyor transfer to ROM stockpile	828	392	59
CL - Loading ROM stockpile from conveyor	828	392	59
CL - Active ROM Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	13,324	6,662	999
CL - Conveyor transfer to Crushing Station	828	392	59
CL - Processing - Crushing Station	-	-	-
CL - Conveyor transfer between crusher and stockpile	828	392	59
CL - Conveyor transfer to Product stockpile	828	392	59
CL - Loading Product stockpile from conveyor	828	392	59
CL - Active Product Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	48,171	24,086	3,613
CL - Loading Trains	828	392	59
Buttonderry Site			
Ventilation Shaft	23,337	23,337	23,337
Total Annual	**91,458**	**57,218**	**28,423**

Table 7.3: Estimated Daily Emission (Maximum Daily Production Scenario)

ACTIVITY - Max 24 hour	TSP	PM_{10}	$PM_{2.5}$
		kg/day	
Tooheys Road Site			
CL - Conveyor transfer @ Portal	8.0	3.8	0.6
CL - Conveyor transfer to ROM stockpile	8.0	3.8	1.3
CL - Loading ROM stockpile from conveyor	8.0	3.8	0.6
CL - Active ROM Stockpiles (wind erosion and maintenance)	36.5	18.3	2.7
CL - Conveyor to Crushing Station	8.0	3.8	0.6
CL - Processing - Crushing	-	-	-
CL - Conveyor transfer to Product stockpile	8.0	3.8	0.6
CL - Conveyor transfer between crusher and stockpile	8.0	3.8	1.3
CL - Loading Product stockpile from conveyor	8.0	3.8	0.6
CL - Active Product Stockpiles (wind erosion and maintenance)	132.0	66.0	9.9
CL - Loading Trains	17.9	8.5	1.3
Buttonderry Site			
Ventilation Shaft	63.9	63.9	63.9
Total Annual	**306**	**183**	**83**

Dust sources at the Tooheys Road site have been modelled as volume sources, located according to the layouts of the proposed pit top areas. All activities and emissions are assumed to occur 24 hours per day, seven days per week. TSP, PM_{10}, and $PM_{2.5}$ emission rates were calculated using emission factors derived from **US EPA (1995)** and **NERDDC (1988)** work (see **Appendix C**).

7.2.1 Ventilation Shaft

The ventilation shaft at the Buttonderry site was modelled as vertically discharging point sources with the exit velocity reduced to account for non-vertical discharge. The ventilation shaft design assumed that the shaft is at an angle of 30 degrees to the horizontal with a final height of 4 metres at the emission point. The total air flow is 370 m^3/s with an exit velocity of 10 m/s and an effective vertical velocity of 5.1 m/s [sin(30) x 10 m/s].

To provide an indication of potential emissions from the proposed ventilation shaft, reference is made to particulate matter and odour concentration testing, conducted at other underground mines in NSW. A recent assessment undertaken by PAEHolmes reviewed particulate and odour concentrations for a number of underground mines in the southern coal fields (**PAEHolmes, 2010**). Particulate concentrations were in the range 0.4 mg/m^3 to 2 mg/m^3 and the highest value is chosen for the project and conservatively applied to each size fraction. Odour concentrations ranged from 54 OU to 335 OU, with an average of 188 OU. An odour concentration of 200 OU is chosen for this assessment.

Table 7.4: Emissions data reviewed for Particulate Matter and Odour

Source	Pollutant	Concentration
West Cliff Main Vent Duct	TSP	1.5 mg/m^3
		1.1 mg/m^3
Dendrobium Mine Vent Shaft #1	TSP	1.6 mg/m^3
	PM_{10}	1.1 mg/m^3
	$PM_{2.5}$	1.4 mg/m^3
	Odour	54 OU
Metropolitan Colliery	TSP	0.42 mg/m^3
	Odour	175 OU
West Cliff Colliery Ventilation Air (SGS 2009)	TSP	2.0 mg/m^3
Appin Vent Shaft	Odour	335 OU

The adopted in-stack pollutant concentrations were used to derive emission rates for the proposed ventilation shaft based on a design flow rate of 370 cubic metres per second (m^3/s).

Table 7.5: Modelling parameters used for the ventilation shaft

Parameter	Value
Height	4.0 m
Internal Diameter	6 m
Exit Velocity	10 m/s @ 30 degrees from horizontal (adjusted to 5.1 m/s as vertical component)
Assumed Temperature	293 K
Flow Rate	370 m^3/s
Particulate Matter Concentration (TSP, PM_{10}, $PM_{2.5}$)	2 mg/m^3
Particulate Emissions Rate (TSP, PM_{10}, $PM_{2.5}$)	0.74 g/s
In-vent odour concentration	200 OU
Odour emission rate	74,000 ou.m^3/s

7.3 Flare and Gas Engine Emissions

Gas management for the Project will involve pre and post drainage via in-seam and (subject to landholder agreement) surface to in-seam drainage holes and reticulation back to a central gas extraction plant. Initially, methane would be flared, however consideration will be given for beneficial use of methane in electricity generation as actual gas flows are assessed.

Modelling of flare emissions is based on an assumed maximum gas flow rate of 2600 l/s, based on preliminary gas modelling (**GeoGas, 2002**). It is assumed that up to three flares would be installed to treat 2600 l/s and the flare stack parameters assumed for modelling are presented in **Table 7.6**. These parameters are typical for enclosed flares installed at Hunter Valley coal mines.

Emission rates are derived based on Chapter 13.5 (Industrial Flares) of the US EPA AP-42 emission factors (**US EPA, 1995**) and a total gas flow rate of 2600 l/s. It is assumed that gas extraction plant would be electrically powered and would have no associated emissions to air.

Modelling flare emissions differs from conventional plumes in that the buoyancy flux is affected due to radiative heat loses during plume rise. The effective stack height and effective stack diameter have been taken as the actual stack height and diameter. This is due to the fact that the proposed flare is enclosed within a flare stack, and the assumption is made that the flare stack dimensions will reflect, on a reasonable basis, the effective release height and plume diameter. The flare emission source has been modelled using CALPUFF, replacing Briggs plume rise with numerical plume rise to allow for radiative heat loss, vertical wind shear and ambient temperature stratification, with no stack tip downwash chosen (**Robe, 2009**).

Emission rates for gas engines have been derived based on an assumed total power output of 10 MW (2 MW across 5 gas engines) and using emission factors (kg/kWh) for uncontrolled gas turbines on natural gas (**DEWHA, 2008**). The parameters assumed for modelling are based on the gas engines operated at the Mandalong Mine (**HAS, 2008**), and are outlined in **Table 7.6**.

Table 7.6: Flare and Gas Engine Modelling Parameters

	Flare Stacks	Gas Engines
Location (E, N MGA)	356617, 6323862 356618, 6323870 356619, 6323880	356490, 6323881 356491, 6323883 356492, 6323886 356492, 6323889 356493, 6323892
Height (m)	8	10
Diameter (m)	4	0.36
Temperature (k)	1273	482
Gas Flow Rate (L/s)	2,600	N/A
Power Output (MW)	N/A	10 MW (across 5 gas engines)
Exit Velocity (m/s)	5	35
Pollutant Emission Rates (g/s)		
NO_x	0.36 g/s (per flare)	0.28 g/s (per 2 MW gas engine)

7.4 Overview of Best Practice Dust Control

The proposed controls for the Project are based on recommendations of the *NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (**Donnelly *et al.*, 2011**) (the Best Practice Report), a study that was commissioned by the NSW EPA.

Table 7.7 provides an overview of the applicable BPM measures recommended by EPA and those adopted for the assessment. When preparing the emission inventory for modelling the relevant percentage controls for the BPM adopted are shown in **Table 7.7**. Many of the BPM are not relevant for Project as they apply to open cut mining operations.

Table 7.7: Best Practice Dust Management

EPA best practice Section	EPA best practice Table	Mining Activity	Best Practice Control		Applied at site (Y/N/Other)	Comment	Control Applied in Modelling
9.2	66	Hauling on Unsealed Roads	Vehicle restrictions	Speed reduction from 75 km/h to 50 km/h	N/A	Not applicable to underground operations	
				Speed reduction from 65 km/h to 30 km/h	N/A	Not applicable to underground operations	
				Grader speed reduction from 16 km/h to 8 km/h	N/A	Not applicable to underground operations	
			Surface improvements	Pave the surface	N/A	Not applicable to underground operations	
				Low silt aggregate	N/A	Not applicable to underground operations	
				Oil and double chip surface	N/A	Not applicable to underground operations	
			Surface treatments	Watering (standard procedure)	N		
				Watering Level 1 (2 L/m2/h)	N		
				Watering Level 2 (>2 L/m2/h)	Y	Applied during construction. No hauling during operation of the Project	75%
				Watering grader routes	N		
				Watering twice a day for industrial unpaved road	N		
				Dust suppressants (please specify)	N		
			Other	Use of larger vehicles	N/A	Not applicable to underground operations	
				Conveyors	N/A	Not applicable to underground operations	
9.3	71	Wind Erosion on Exposed Areas & Overburden Emplacements	Avoidance	Minimise pre-strip	Y	Applied during construction. Not applicable during operation of the Project	
			Surface stabilisation	Watering	N/A	Not applicable to underground operations	
				Chemical suppressants	N/A	Not applicable to underground operations	
				Paving and cleaning	N/A	Not applicable to underground operations	
				Application of gravel to stabilise disturbed open areas	N/A	Not applicable to underground operations	
				Rehabilitation goals	Y	Applied during construction. Not applicable during operation of the Project	
			Wind speed reduction	Fencing, bunding, shelterbelts or in-pit dump	N/A	Not applicable to underground operations	
				Vegetative ground cover	N/A	Not applicable to underground operations	
9.3	72	Wind Erosion and Maintenance - Coal Stockpiles	Avoidance	Bypassing stockpiles	N/A	Not practical	
			Surface stabilisation	Water sprays	Y	Fixed water sprays on stockpiles	50%
				Chemical wetting agents	N		
				Surface crusting agent	N		
				Carry over wetting from load in	N		
			Enclosure	Silo with bag house	N		
				Cover storage pile with a tarp during high winds	N		
			Wind speed reduction	Vegetative windbreaks	N		
				Reduced pile height	N		
				Wind screens/fences	N		
				Pile shaping/orientation	N		
				Erect 3-sided enclosure around storage piles	N		
9.4	76	Bulldozers on OB	Minimise travel speeds and distance		Y	Applied during construction. Not applicable during operation of the Project	
			Travel routes and material kept moist		Y	Applied during construction. Not applicable during operation of the Project	

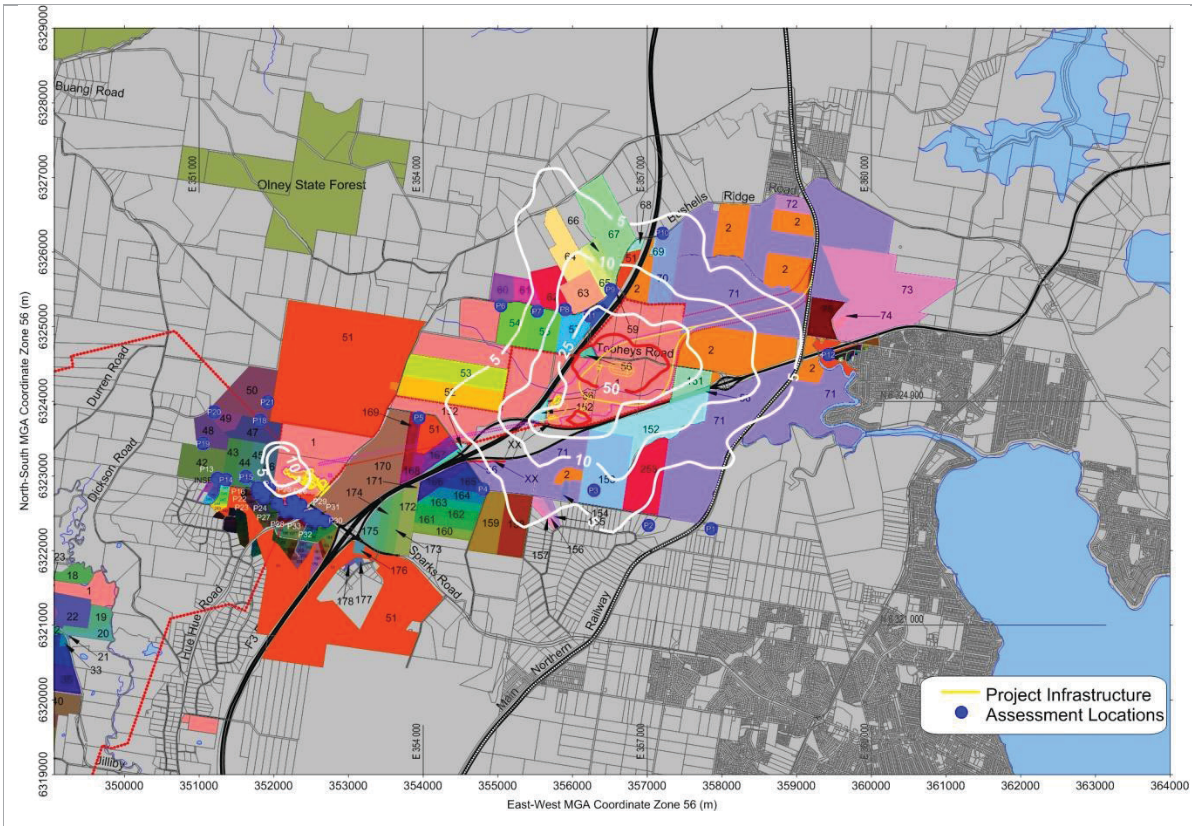
EPA best practice		Mining Activity	Best Practice Control		Applied at site (Y/N/Other)	Comment	Control Applied in Modelling
Section	Table						
9.5	81	Blasting and drilling	Blasting	Delay shot to avoid unfavourable weather conditions	N/A	Not applicable to underground operations	
				Minimise area blasted	N/A	Not applicable to underground operations	
	82		Drilling	Fabric filters	N/A	Not applicable to underground operations	
				Cyclone	N/A	Not applicable to underground operations	
				Water injection while drilling	N/A	Not applicable to underground operations	
9.6	85	Draglines	Minimise drop height		N/A	Not applicable to underground operations	
			Minimising drop height		N/A	Not applicable to underground operations	
			Modify activities in windy conditions		N/A	Not applicable to underground operations	
			Water sprays		N/A	Not applicable to underground operations	
			Minimise side casting		N/A	Not applicable to underground operations	
9.7	90	Loading and dumping overburden	Excavator	Minimise drop height	Y	Applied during construction. Not applicable during operation of the Project	
			Truck dumping	Minimise drop height	Y	Applied during construction. Not applicable during operation of the Project	
				Water application	Y	Applied during construction. Not applicable during operation of the Project	
				Modify activities in windy conditions	Y	Applied during construction. Not applicable during operation of the Project	
9.8	95	Loading and dumping ROM coal	Avoidance	Bypass ROM stockpiles	N		
			Truck or loader dumping coal	Minimise drop height	N/A	Not applicable to underground operations	
				Water sprays on ROM pad	N/A	Not applicable to underground operations	
			Truck or loader dumping to ROM bin	Water sprays on ROM bin or ROM pad	N/A	Not applicable to underground operations	
				Three sided and roofed enclosure of ROM bin	N/A	Not applicable to underground operations	
				Three sided and roofed enclosure of ROM bin + water	N/A	Not applicable to underground operations	
				Enclosure with control device	N/A	Not applicable to underground operations	
9.9	96	Conveyors and transfers	Conveyors	Application of water at transfers	Y		
				Wind shielding - roof OR side wall	Y		40%
				Wind shielding - roof AND side wall	Y	3/4 shielded conveyors proposed	
				Belt cleaning and spillage minimisation	Y	No reduction applied to inventory	
			Transfers	Enclosure	N		
9.10	97	Stacking and reclaiming product coal	Avoidance	Bypass coal stockpiles	N		
			Loading coal stockpiles	Variable height stack	Y		
				Boom tip water sprays	Y		
				Telescopic chute with water sprays	Y		
			Unloading coal	Bucket-wheel, portal or bridge reclaimer with water	N		
9.11	-	Train and truck load out and transportation	Limit load size to ensure coal is below sidewalls		Y	No reduction applied to inventory	
			Maintain a consistent profile		Y	No reduction applied to inventory	
			Use bedliners to minimise seepage		N		
			Cover load with tarpaulin		N/A	Not applicable to underground operations	
			Utilise truck wheel wash		N/A	Not applicable to underground operations	

8 IMPACT ASSESSMENT

The results of the predictions for the Project are presented in the sections below. The contour plots are indicative of the concentrations that could potentially be reached, under the conditions modelled. A summary of the predicted pollutant concentrations at each of the assessment locations is presented in **Table 8.1**. The assessment locations and corresponding lot numbers are presented in **Appendix A**.

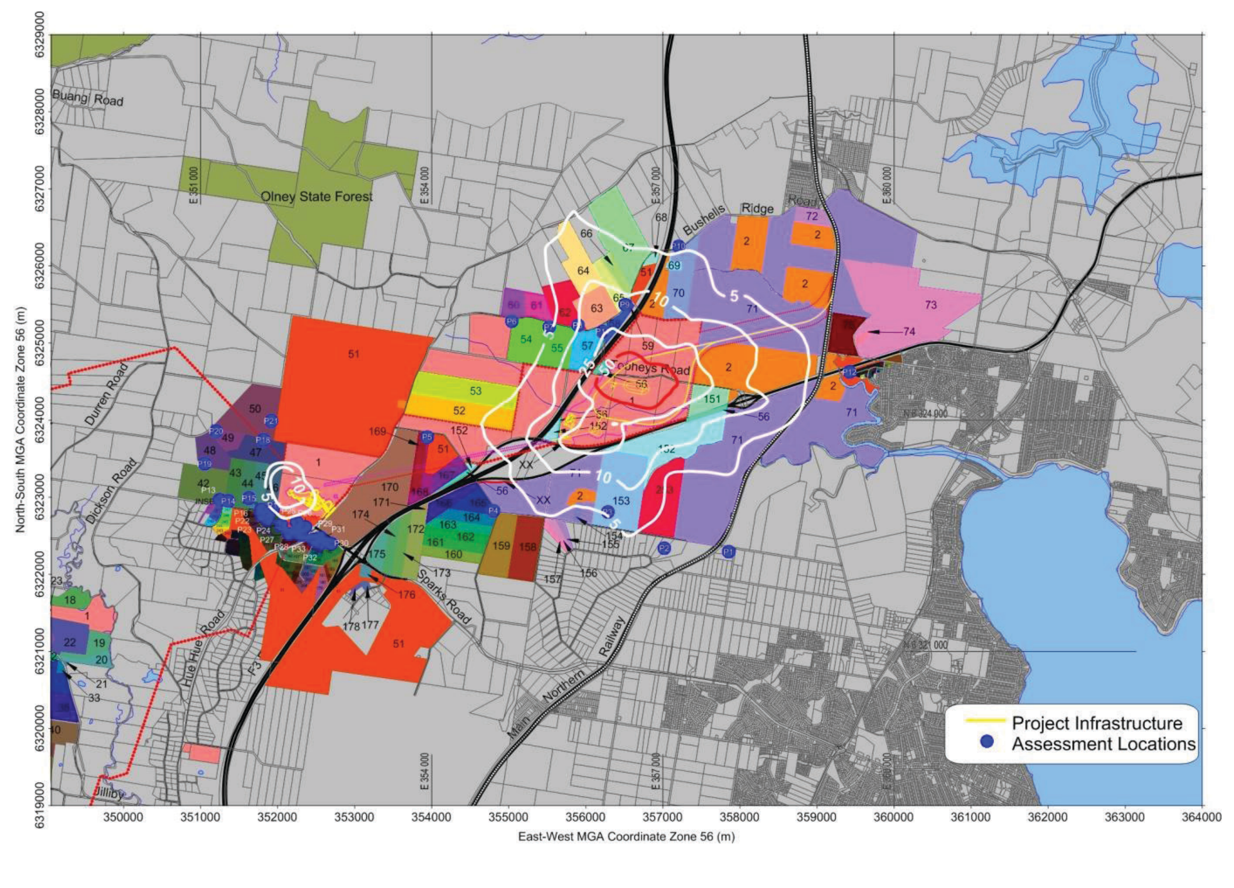
8.1 Incremental Ground Level PM_{10} Concentrations

Contour plots for the predicted ground level concentrations (glcs) of PM_{10} are presented in **Figure 8.1**, **Figure 8.2** and **Figure 8.3**. Predicted 24-hour average PM_{10} are presented for a maximum daily production scenario and a maximum annual production scenario. Annual average PM_{10} predictions are presented for the maximum annual production scenario. The relevant impact assessment criteria are shown by the red contour line. There are no privately owned receivers that are predicted to experience glcs of PM_{10} above the assessment criteria, due to emissions from the Project-only. The highest predicted glcs occur at the closest residence to the north of the site (P11). At this location, the predicted incremental 24-hour PM_{10} concentration is 27 µg/m^3 for the maximum daily scenario and 22 µg/m^3 for the maximum annual production scenario. The predicted annual average PM_{10} concentration is 1.6 µg/m^3.



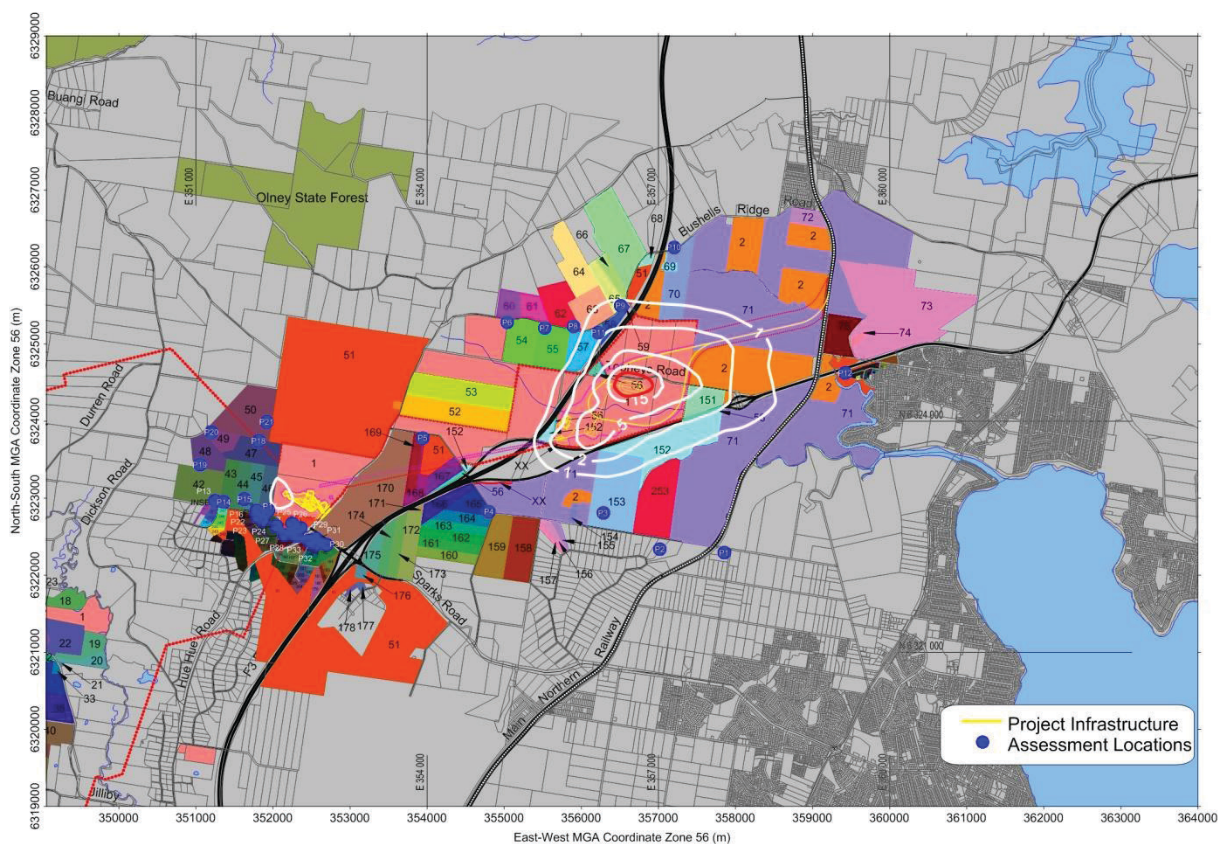
Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Wyong	Maximum Daily Production	Maximum	24-Hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m^3	50 µg/m^3	CALMET	K. Hill

Figure 8.1: Incremental Max 24-Hour PM_{10} Concentration – Maximum Daily Production



Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Wyong	Maximum Annual Production	Maximum	24-Hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m^3	50 µg/m^3	CALMET	K. Hill

Figure 8.2: Incremental Max 24-Hour PM_{10} Concentration - Maximum Annual Production



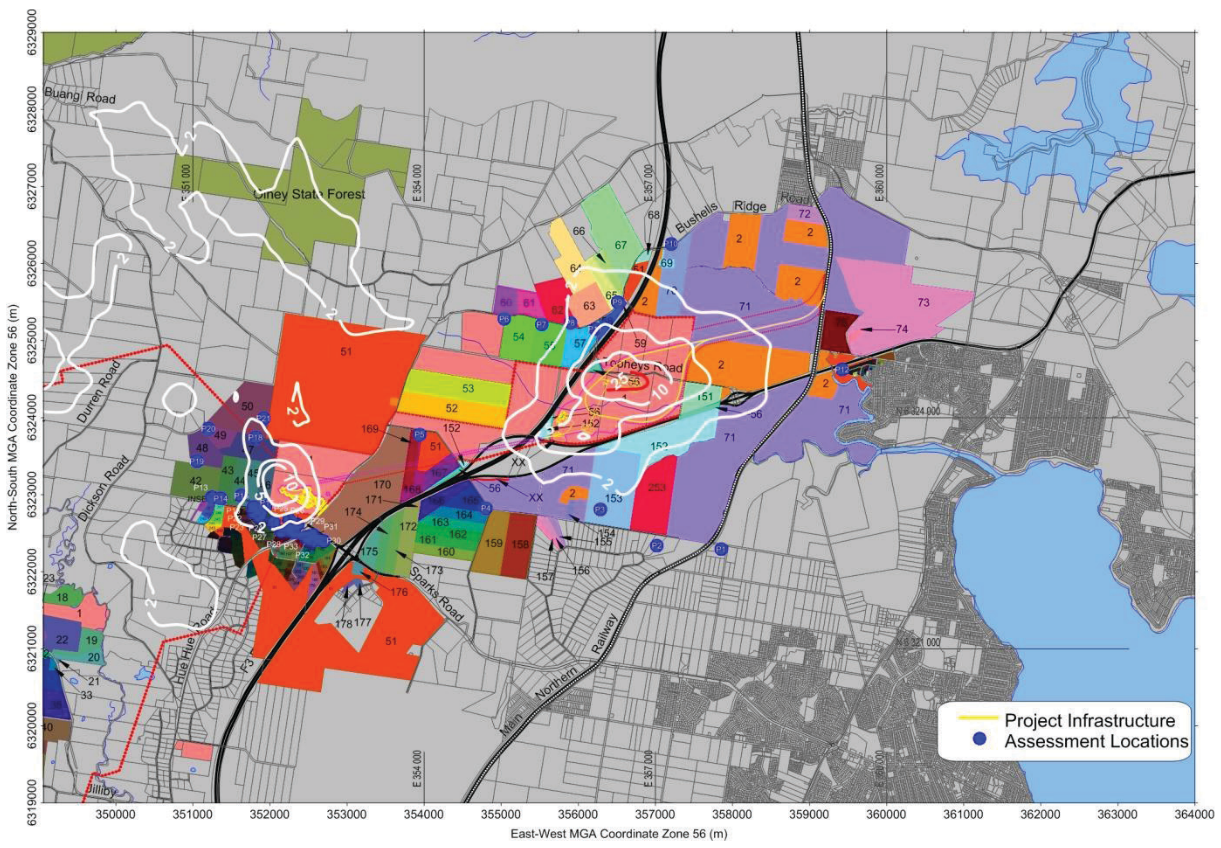
Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Wyong	Maximum Annual Production	N/A	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m^3	30 µg/m^3	CALMET	K. Hill

Figure 8.3: Incremental Annual Average PM_{10} Concentration - Maximum Annual Production

8.2 Incremental Ground Level $PM_{2.5}$ Concentrations

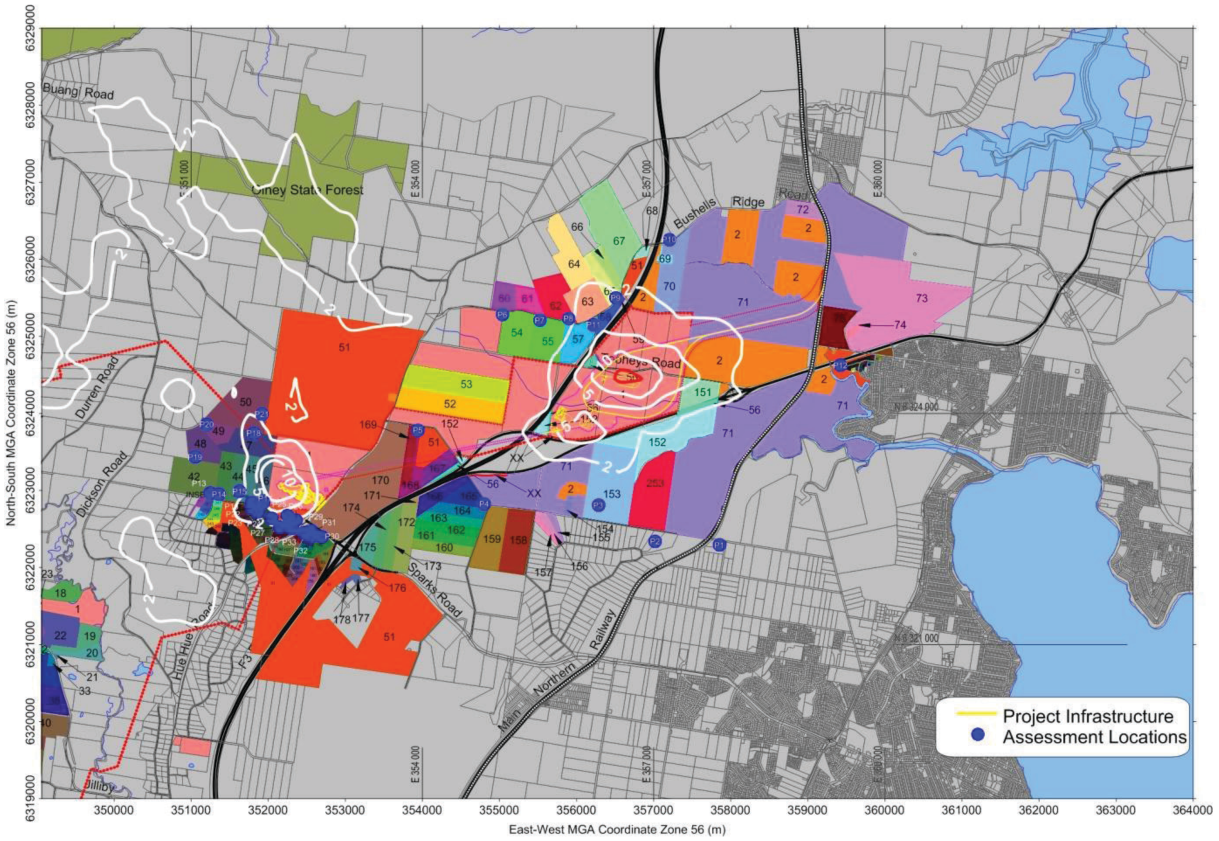
Contour plots for the predicted glcs of $PM_{2.5}$ are presented in **Figure 8.4**, **Figure 8.5** and **Figure 8.6**. Predicted 24-hour average $PM_{2.5}$ glcs are presented for a maximum daily production scenario and a maximum annual production scenario. Annual average $PM_{2.5}$ predictions are presented for the maximum annual production scenario. The relevant impact assessment criteria are shown by the red contour line.

There are no privately owned receivers that are predicted to experience glcs of $PM_{2.5}$ above the assessment criteria, due to emissions from the Project-only. The highest predicted glcs occur at the closest residence to the north of the site (P11). At this location, the predicted incremental 24-hour $PM_{2.5}$ concentration is 5 µg/m^3 for the maximum daily scenario and 3.8 µg/m^3 for the maximum annual production scenario. The predicted annual average $PM_{2.5}$ concentration is 0.3 µg/m^3.



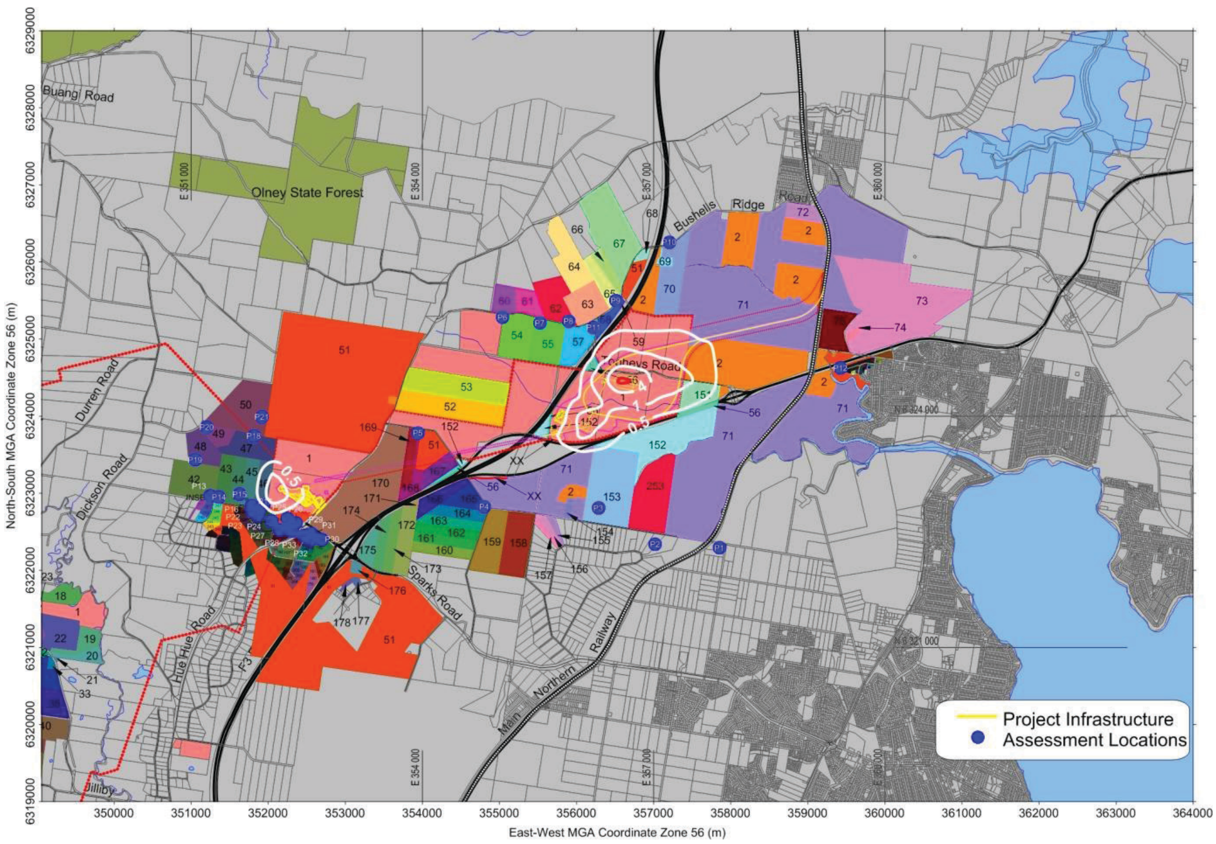
Species: PM$_{2.5}$	Location: Wyong	Scenario: Maximum Daily Production	Percentile: Maximum	Averaging Time: 24-Hour
Model Used: CALPUFF v6.42	**Units:** µg/m^3	**Guideline:** 25 µg/m^3	**Met Data:** CALMET	**Plot:** K. Hill

Figure 8.4: Incremental Max 24-Hour PM$_{2.5}$ Concentration - Maximum Daily Production



Species:	Location:	Scenario:	Percentile:	Averaging Time:
$PM_{2.5}$	Wyong	Maximum Annual Production	Maximum	24-Hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m^3	25 µg/m^3	CALMET	K. Hill

Figure 8.5: Incremental Max 24-Hour $PM_{2.5}$ Concentration – Maximum Annual Production



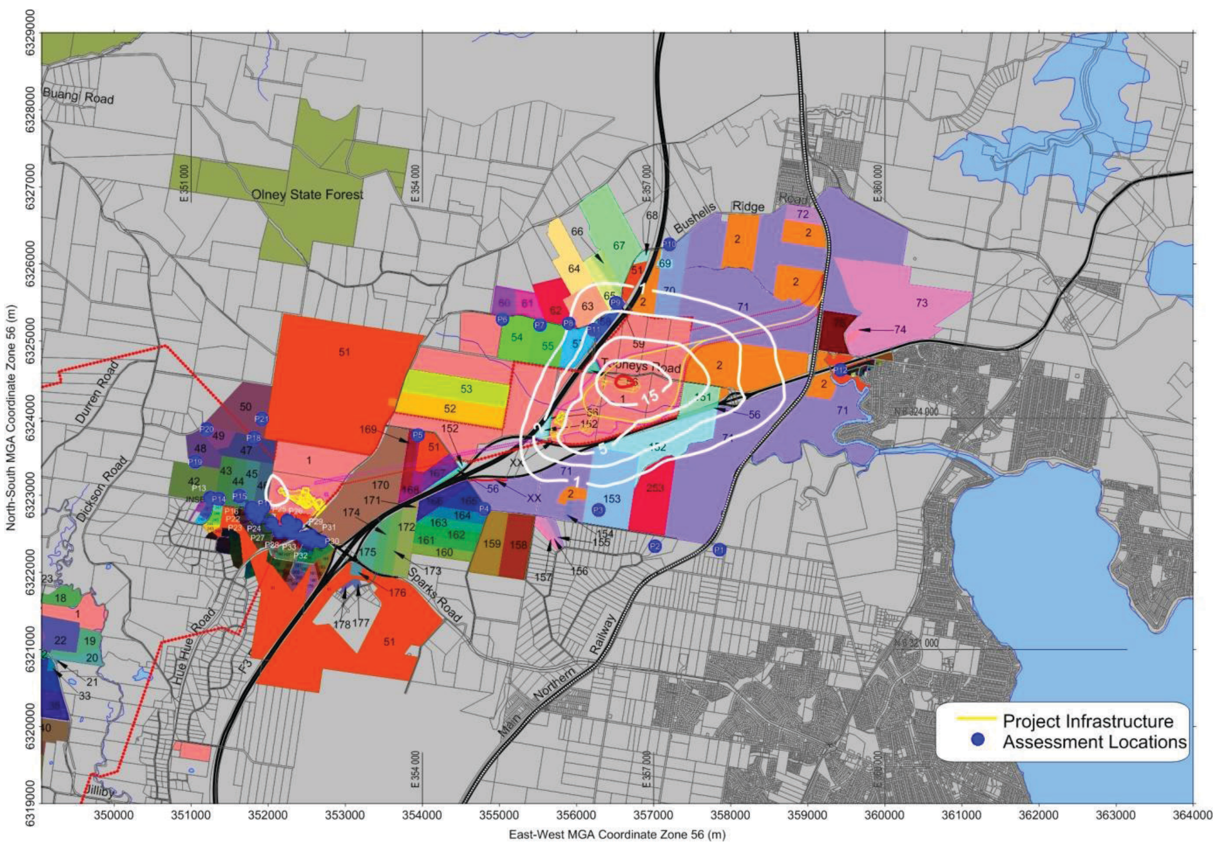
Species: $PM_{2.5}$	**Location:** Wyong	**Scenario:** Maximum Annual Production	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF v6.42	**Units:** µg/m^3	**Guideline:** 8 µg/m^3	**Met Data:** CALMET	**Plot:** K. Hill

Figure 8.6: Incremental Annual Average $PM_{2.5}$ Concentration – Maximum Annual Production

8.3 Incremental Ground Level TSP Concentrations

Contour plots for the predicted glcs of TSP are presented in **Figure 8.7**. Annual average TSP predictions are presented for the maximum annual production scenario. The relevant impact assessment criterion is shown by the red contour line.

There are no privately owned receivers that are predicted to experience glcs of TSP above the assessment criteria, due to emissions from the Project-only. The highest predicted glcs occur at the closest residence to the north of the site (P11). At this location, the predicted incremental annual average TSP concentration is 2.4 µg/m^3.



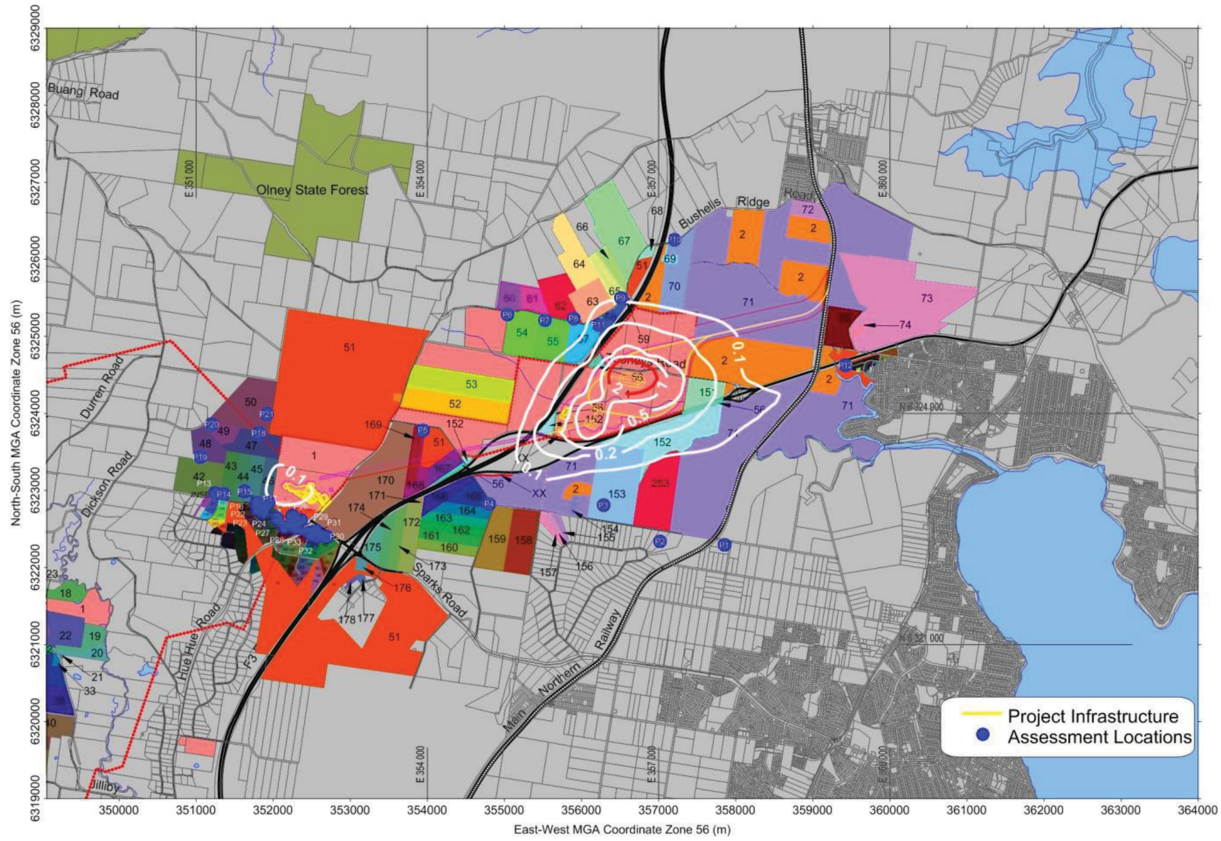
Species:	Location:	Scenario:	Percentile:	Averaging Time:
TSP	Wyong	Maximum Annual Production	N/A	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m³	90 µg/m³	CALMET	K. Hill

Figure 8.7: Incremental Annual Average TSP Concentration – Maximum Annual Production

8.4 Incremental Ground Level Dust Deposition Level

Contour plots for the predicted dust deposition levels are presented in **Figure 8.8**. Annual average dust deposition predictions are presented for the maximum annual production scenario. The relevant impact assessment criterion is shown by the red contour line.

There are no privately owned receivers that are predicted to experience dust deposition above the assessment criteria, due to emissions from the Project-only. The highest predicted levels occur at the closest residence to the north of the site (P11). At this location, the predicted incremental annual average dust deposition is 0.1 g/m^2/month which will be well within the compliance limits.



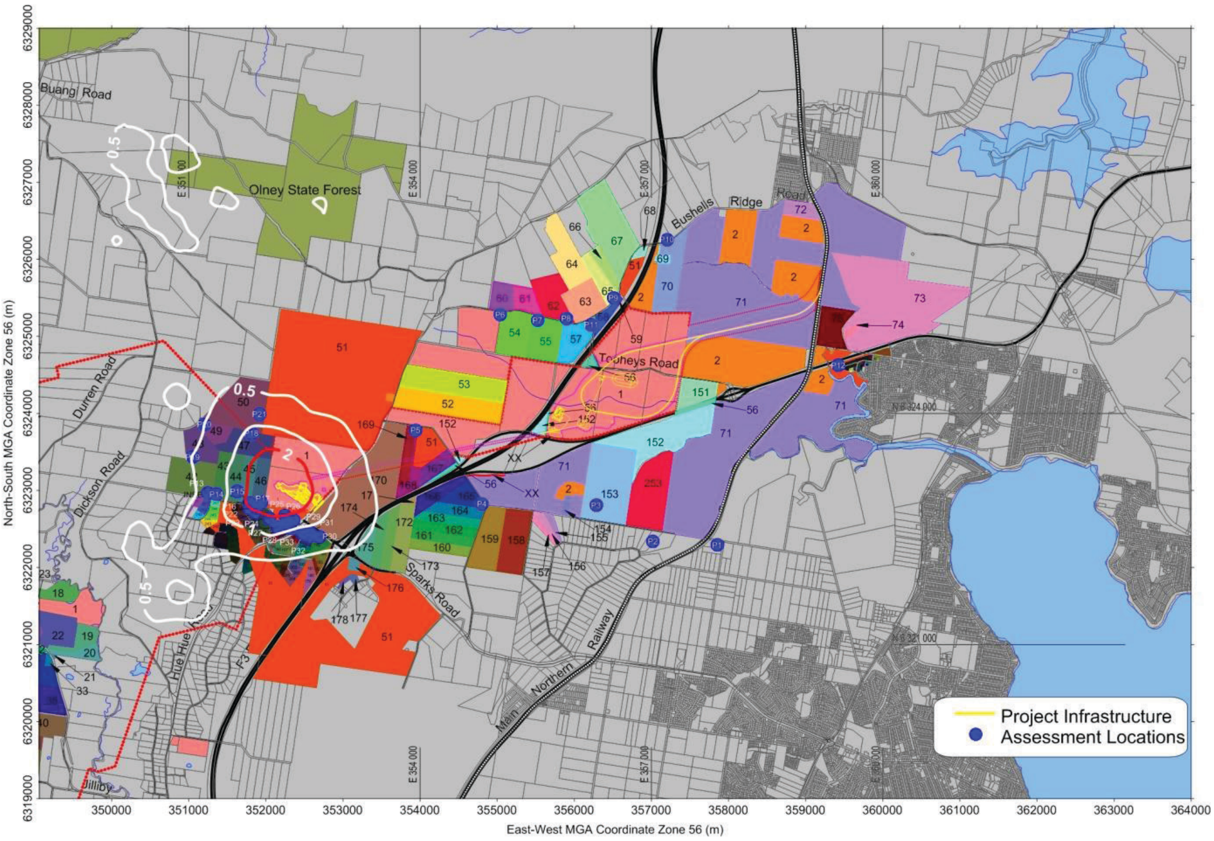
Species:	Location:	Scenario:	Percentile:	Averaging Time:
Dust Deposition	Wyong	Maximum Annual Production	N/A	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	g/m^2/month	2 g/m^2/month	CALMET	K. Hill

Figure 8.8: Incremental Annual Average Dust Deposition – Maximum Annual Production

8.5 Incremental Ground Level Odour Concentration

Contour plots for the predicted glcs of odour are presented in **Figure 8.9**. The relevant impact assessment criterion is shown by the red contour line.

The modelling indicates that five existing privately owned receivers around the Buttonderry vent shaft site that are predicted to experience odour at the impact assessment criteria (2 OU) . There is only one privately owned receiver is predicted to experience odour above the impact assessment criteria (refer **Table 8.1**).



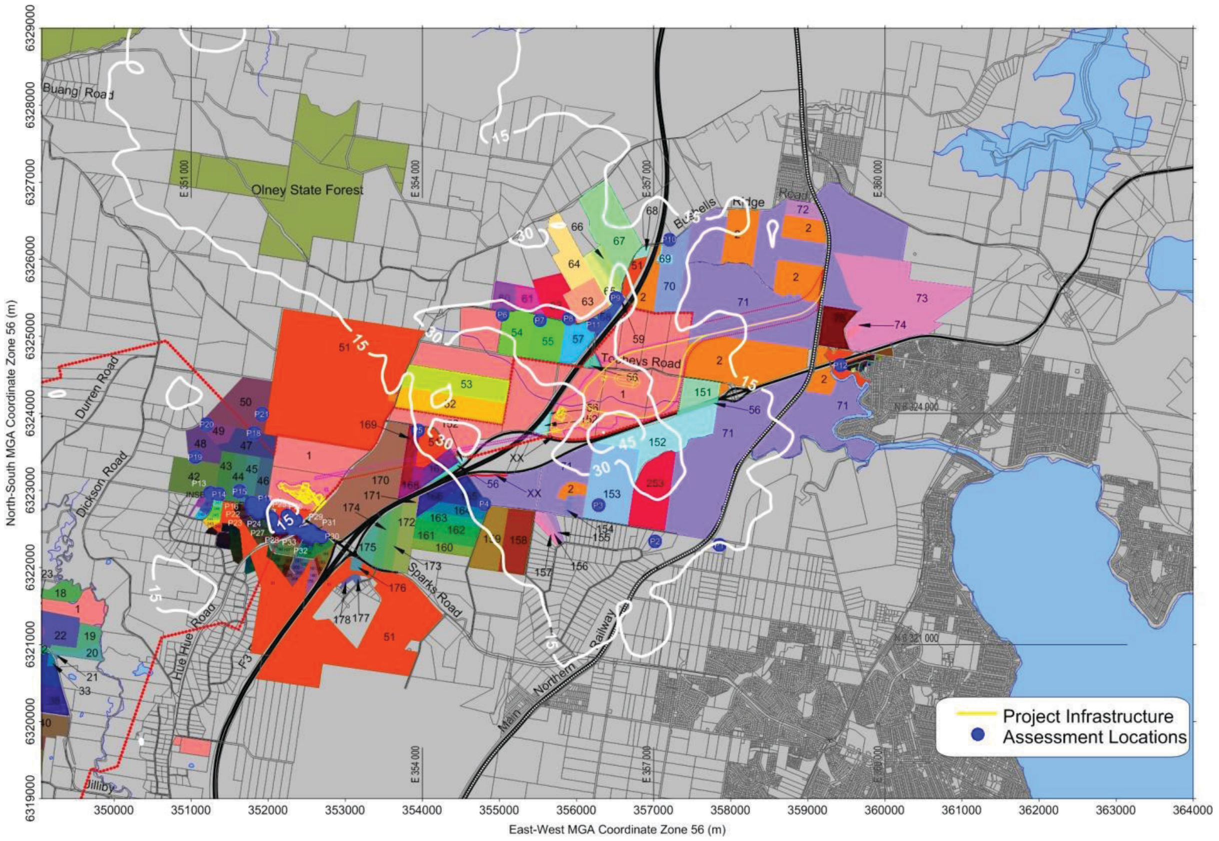
Species:	Location:	Scenario:	Percentile:	Averaging Time:
Odour	Wyong	Maximum Annual Production	99th percentile	Nose response
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	ou	2 ou	CALMET	K. Hill

Figure 8.9: Incremental 99th percentile Odour

8.6 Predicted Ground Level Concentration of NO_2 from Combustion of Methane

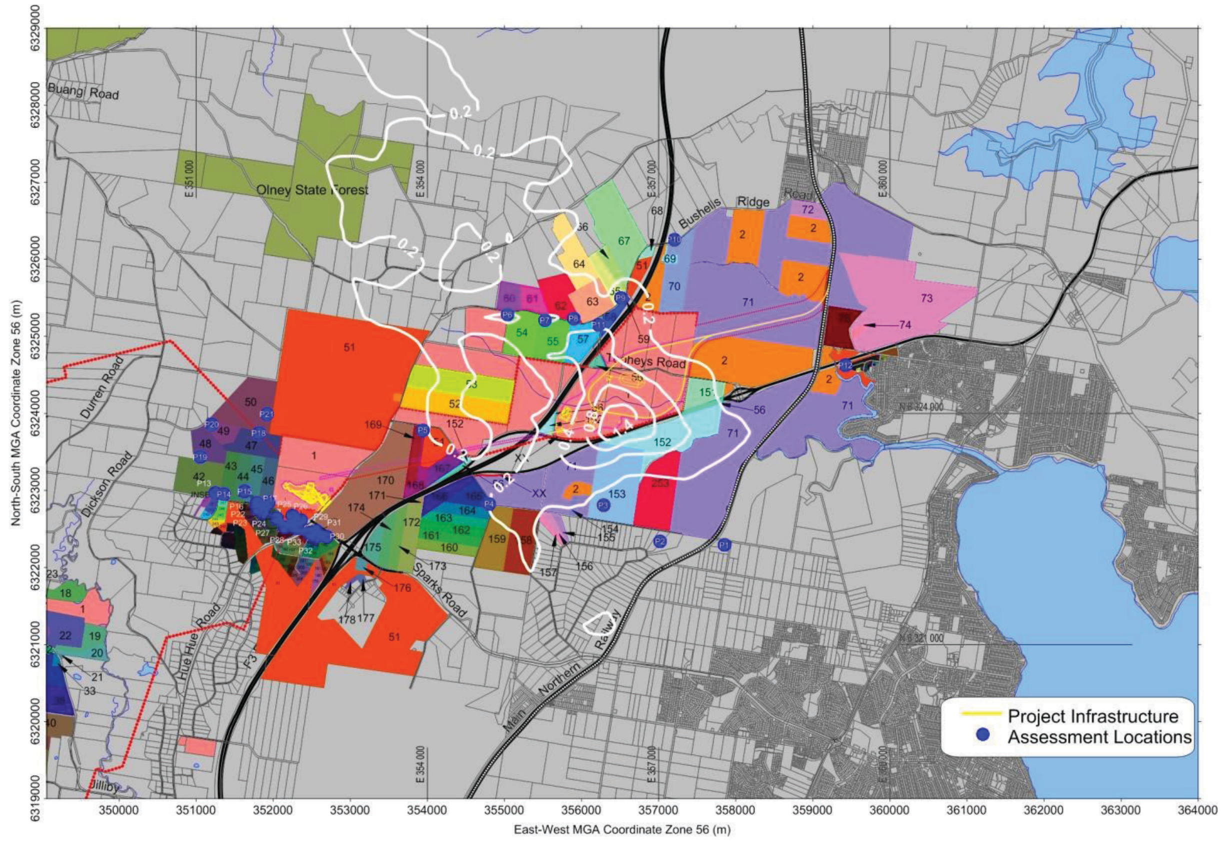
Emissions of NO_x will consist of both nitric oxide (NO) and nitrogen dioxide (NO_2). NO_2 is the regulated oxide of nitrogen and assessed for compliance. While $NO_x \gg NO_2$ transformation rates will vary, for example, with amount of available sunshine, atmospheric ozone concentration and with distance from source, a conservative assumption of 100% conversion is assumed for this assessment. In reality, conversion is more likely to be 10%-20% for shorter averaging periods.

Contour plots for the predicted 1-hour and annual average glcs of NO_2 are presented in **Figure 8.10** and **Figure 8.11**. There are no privately owned receivers that are predicted to experience NO_2 above the assessment criteria, due to emissions from flaring or onsite power generation. The highest predicted 1-hour NO_2 glc (assuming 100% conversion of NOx) is approximately 14% of the impact assessment criteria.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
NO_2	Wyong	Flaring and Onsite Power Generation	Maximum	1-hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	μg/m^3	246 μg/m^3	CALMET	K. Hill

Figure 8.10: Incremental 1-Hour Average Nitrogen Dioxide



Species: NO$_2$	Location: Wyong	Scenario: Flaring and Onsite Power Generation	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF v6.42	**Units:** μg/m^3	**Guideline:** 62 μg/m^3	**Met Data:** CALMET	**Plot:** K. Hill

Figure 8.11: Incremental Annual Average Nitrogen Dioxide

8.7 Potential Impacts on Proposed Jilliby Subdivision

The Jilliby Stage 2 Land Owners Action Group are proposing a rural residential subdivision immediately west of the proposed Buttonderry Ventilation shaft site. The subdivision would involve staged rezoning of approximately 400 hectares north of Sandra St, Jilliby.

Based on the modelling results presented in the sections above, it is not anticipated that the proposed rezoning would result in any significant impact for future residential dwellings as part of the subdivision. The expected air quality impacts on future residential dwellings are expected to be similar to the predictions presented in **Table 8.1** for the assessment locations P13 to P21.

Table 8.1: Predicted Incremental Ground Level Concentrations at Assessment Locations

Receptor ID	Easting	Northing	$PM_{2.5}$			PM_{10}			TSP	Dust deposition	Odour	NO_2	
			24 hour		Annual	24 hour		Annual	Annual	Annual	Nose Response	1 hour	Annual
			Busy day	Average day		Busy day	Average day				99th percentile		
Units			$\mu g/m^3$			$\mu g/m^3$			$\mu g/m^3$	$g/m^2/month$	Ou	$\mu g/m^3$	
Criteria			**25**	**25**	**8**	**50**	**50**	**30**	**90**	**2**	**2**	**246**	**62**
P1	357855	6322289	0.4	0.3	0.03	1.7	1.4	0.1	0.2	0.015	0	14	0.07
P2	357021	6322338	0.8	0.6	0.04	3.8	3.0	0.2	0.2	0.014	0	23	0.10
P3	356284	6322807	1.1	0.8	0.08	6.0	4.8	0.4	0.6	0.034	0	24	0.15
P4	354803	6322823	0.7	0.5	0.07	3.4	2.7	0.2	0.3	0.060	0	19	0.19
P5	353943	6323781	0.7	0.5	0.05	3.3	2.6	0.1	0.2	0.025	0	14	0.11
P6	355040	6325280	0.7	0.7	0.06	3.3	2.6	0.2	0.2	0.020	0	35	0.43
P7	355524	6325206	1.1	0.8	0.09	5.9	4.6	0.4	0.5	0.040	0	32	0.40
P8	355898	6325231	2.3	1.6	0.15	13.0	9.4	0.7	1.0	0.064	0	33	0.34
P9	356509	6325499	2.9	2.1	0.22	13.7	10.9	1.1	1.5	0.088	0	34	0.29
P10	357203	6326257	1.3	1.0	0.08	6.0	4.7	0.4	0.4	0.025	0	20	0.10
P11	356222	6325149	5.0	3.8	0.30	27.2	22.1	1.6	2.4	0.141	0	32	0.36
P12	359426	6324622	0.6	0.5	0.06	2.9	2.3	0.3	0.3	0.044	0	8	0.07
P13	351245	6322968	1.0	0.9	0.08	1.4	1.2	0.1	0.1	0.012	1	9	0.04
P14	351364	6322948	1.0	1.0	0.10	1.7	1.5	0.1	0.1	0.016	1	8	0.04
P15	351632	6322985	1.6	1.5	0.19	2.4	2.1	0.2	0.2	0.026	1	7	0.04
P16	351783	6322837	3.3	3.3	0.32	3.3	3.3	0.3	0.3	0.045	2	8	0.05
P17	351940	6322848	4.9	4.9	0.46	4.9	4.9	0.5	0.5	0.063	3	10	0.07
P18	351815	6323743	3.7	3.7	0.15	3.5	3.5	0.2	0.2	0.019	1	6	0.05
P19	351054	6323433	0.8	0.8	0.07	1.0	0.9	0.1	0.1	0.007	1	13	0.06
P20	351205	6323857	0.8	0.8	0.07	1.2	1.0	0.1	0.1	0.008	1	9	0.05
P21	351920	6323989	0.9	0.9	0.10	1.6	1.3	0.1	0.1	0.013	1	8	0.05
P22	351795	6322769	3.3	3.3	0.28	3.2	3.2	0.3	0.3	0.040	2	9	0.06
P23	351869	6322717	2.3	2.3	0.23	2.3	2.3	0.2	0.2	0.031	2	9	0.06
P24	352046	6322637	2.7	2.7	0.20	2.7	2.7	0.2	0.2	0.022	2	17	0.13
P25	352248	6322672	2.1	2.1	0.16	2.0	2.0	0.2	0.2	0.029	2	17	0.12
P26	352359	6322615	1.8	1.8	0.13	1.8	1.8	0.2	0.2	0.025	1	14	0.10
P27	352154	6322523	1.5	1.5	0.11	1.4	1.4	0.1	0.1	0.016	1	15	0.10
P28	352245	6322549	1.3	1.3	0.11	1.3	1.2	0.1	0.1	0.018	1	14	0.10
P29	352319	6322512	1.2	1.2	0.09	1.2	1.2	0.1	0.1	0.017	1	12	0.08
P30	352693	6322395	0.8	0.8	0.08	1.3	1.0	0.1	0.1	0.015	1	10	0.07
P31	352562	6322475	1.0	1.0	0.09	1.2	0.9	0.1	0.1	0.016	1	10	0.07
P32	352562	6322404	0.9	0.9	0.08	1.2	0.9	0.1	0.1	0.014	1	10	0.07
P33	352462	6322452	1.2	1.2	0.08	1.1	1.1	0.1	0.1	0.015	1	10	0.07

8.8 Cumulative Impact Assessment

8.8.1 24-Hour PM_{10}

There are no available continuous 24-hour PM_{10} data for the area. HVAS data are available every sixth day, however, this is insufficient to provide a representative background for each day of the model simulation.

A statistical approach (using a Monte Carlo Simulation) is presented to investigate the potential for cumulative 24-hour PM_{10} impacts. The approach takes all of the available background monitoring data from HVAS C and HVAS E and randomly generates a daily 24-hour PM_{10}. This random daily background concentration is added to model predictions for each day of the year, at selected receptor locations. The addition of the random background to the model predicted 24-hour PM_{10} is repeated 250,000 times to generate a probability distribution of cumulative 24-hour PM_{10} concentrations. The Monte Carlo Simulation is run using the Oracle Crystal Ball software (version 11.1.1.2).

The process assumes that a randomly selected background value from the real dataset would have a chance equal to that of any other background value from the dataset of occurring on the given future day when the Project is operational. With sufficient repetition, this would yield a good statistical estimate of the combined and independent effects of varying background and Project contributions to total 24-hour PM_{10}.

The results of the simulation are extracted and the predicted number of days that cumulative 24-hour PM_{10} concentration would exceed certain 24-hour PM_{10} concentrations is determined for each residence.

This is shown in **Figure 8.12** for the worst impacted assessment location close to both the Buttonderry site (P17) and the Tooheys Road site (P11). The plots show the cumulative 24-hour PM_{10} concentration compared with the existing background, as discussed in **Section 5**.

As shown in **Figure 8.12** there is a very low probability that cumulative 24-hour PM_{10} concentrations would result in any additional days over 50 µg/m^3 than would occur anyway due to background in the absence of the Project.

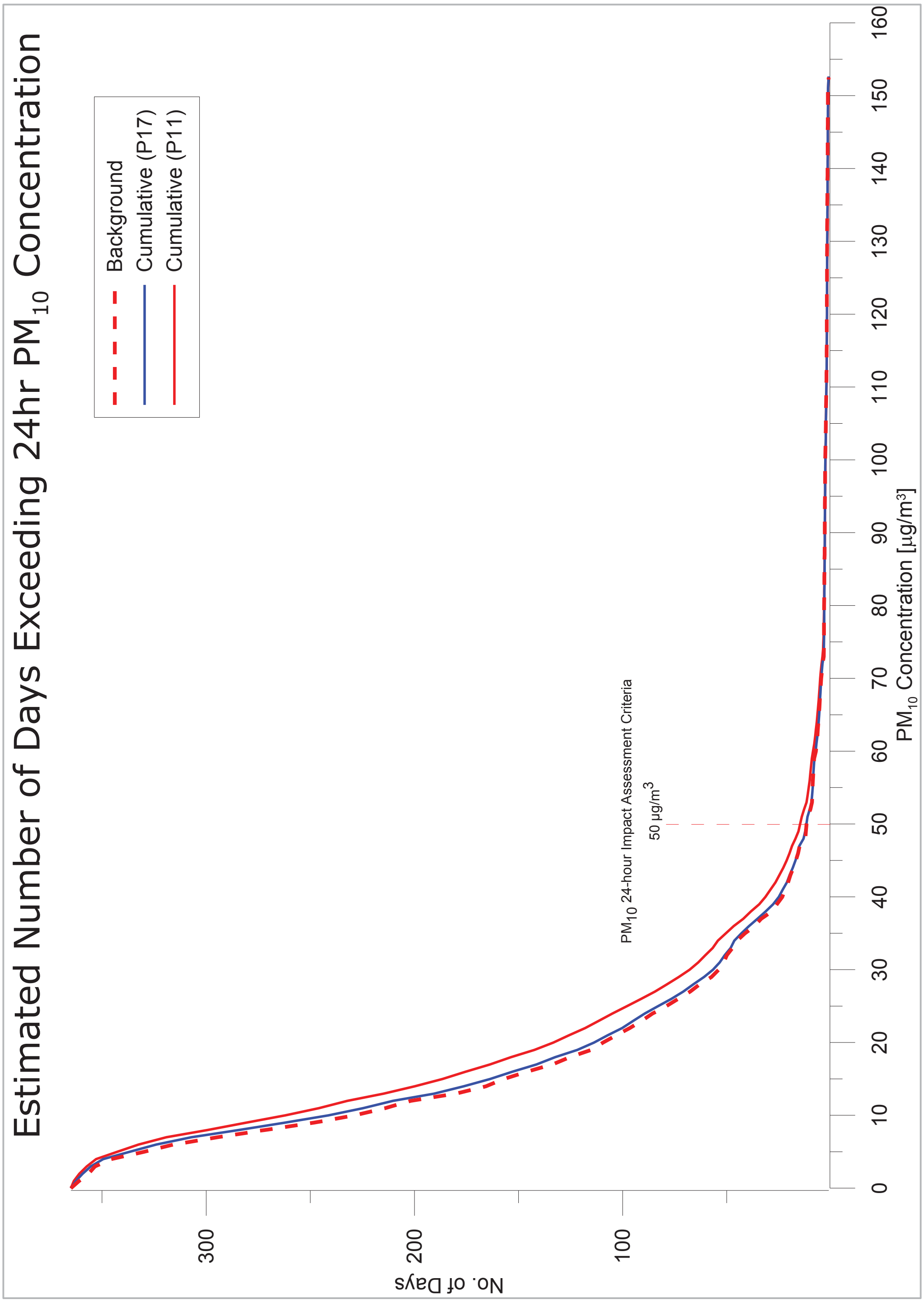


Figure 8.12: Predicted Number of Days Over 24-Hour PM_{10} Concentration at worst impacted residences

8.8.2 Annual Average

The predicted pollutant concentrations at each of the sensitive receptors are added to the adopted background levels presented in **Section 5.2** and presented in **Table 8.2**.

There are no privately owned receivers that are predicted to exceed the annual average assessment criteria when existing background concentrations are included.

Table 8.2: Predicted Cumulative Ground Level Concentrations at Receptor Locations

Receptor ID	Easting	Northing	$PM_{2.5}$	PM_{10}	TSP	Dust deposition
			Annual	Annual	Annual	Annual
Units			µg/m³	µg/m³	µg/m³	g/m²/month
Criteria			**8**	**30**	**90**	**4**
P1	357855	6322289	5.0	18.1	31.2	1.6
P2	357021	6322338	5.0	18.2	31.2	1.6
P3	356284	6322807	5.1	18.4	31.6	3.4
P4	354803	6322823	5.1	18.2	31.3	1.7
P5	353943	6323781	5.0	18.1	31.2	1.6
P6	355040	6325280	5.1	18.2	31.2	1.6
P7	355524	6325206	5.1	18.4	31.5	1.6
P8	355898	6325231	5.1	18.7	32.0	1.7
P9	356509	6325499	5.2	19.1	32.5	1.7
P10	357203	6326257	5.1	18.4	31.4	1.6
P11	356222	6325149	5.3	19.6	33.4	1.7
P12	359426	6324622	5.1	18.3	31.3	1.6
P13	351245	6322968	5.1	18.1	31.1	1.6
P14	351364	6322948	5.1	18.1	31.1	1.6
P15	351632	6322985	5.2	18.2	31.2	1.6
P16	351783	6322837	5.3	18.3	31.3	1.6
P17	351940	6322848	5.5	18.5	31.5	1.7
P18	351815	6323743	5.2	18.2	31.2	1.6
P19	351054	6323433	5.1	18.1	31.1	1.6
P20	351205	6323857	5.1	18.1	31.1	1.6
P21	351920	6323989	5.1	18.1	31.1	1.6
P22	351795	6322769	5.3	18.3	31.3	1.6
P23	351869	6322717	5.2	18.2	31.2	1.6
P24	352046	6322637	5.2	18.2	31.2	1.6
P25	352248	6322672	5.2	18.2	31.2	1.6
P26	352359	6322615	5.1	18.2	31.2	1.6
P27	352154	6322523	5.1	18.1	31.1	1.6
P28	352245	6322549	5.1	18.1	31.1	1.6
P29	352319	6322512	5.1	18.1	31.1	1.6
P30	352693	6322395	5.1	18.1	31.1	1.6
P31	352562	6322475	5.1	18.1	31.1	1.6
P32	352562	6322404	5.1	18.1	31.1	1.6
P33	352462	6322452	5.1	18.1	31.1	1.6

8.8.3 Nitrogen Dioxide

The maximum predicted 1-hour NO_2 ground level concentration (glc) from flaring and onsite power generation is approximately 2% of the goal while the maximum predicted annual average NO_2 glc from flaring is less than 1% of the goal.

Cumulative impacts from NO_2 would therefore be minor when added to existing background levels (refer **Section 5.2.4**).

9 COAL TRANSPORTATION

The Project will involve construction and operation of a rail load out facility and transportation of coal by rail to Newcastle. Dust emissions associated with train loading have been included as part of the modeling assessment of mining operations (refer **Section 7**). Potential impacts from the fugitive dust emissions from coal wagons during rail transportation are discussed below.

The potential for health effects from coal dust emissions from rail transport has been studied extensively in Queensland. Queensland Rail (QR) commissioned an environmental evaluation of coal dust emissions from rolling stock in the Central Queensland Coal Industry (**Connell Hatch, 2008**). The purpose of this study was to determine the extent of the issue and identify any potential environmental harm caused by fugitive dust from coal wagons, in the context of nuisance and health impacts and to identify the potential reasonable and feasible measures that could reduce any environmental harm.

In terms of impacts on human health, the QR study concluded that there appears to be minimal risk of adverse impacts due to fugitive coal emissions from trains throughout the network, based on results of monitoring and modelling predictions (**Connell Hatch, 2008**). In terms of impacts on amenity, the results of monitoring and modelling indicate that fugitive coal dust at the edge of the rail corridor are below levels that are known to cause adverse impacts on amenity (**Connell Hatch, 2008**).

PAEHolmes has reviewed the QR study to determine if the conclusions presented are applicable to NSW based on, for example, differences in coal volumes, loading practices, train speeds, wagon shapes, coal properties, etc., and it was concluded that many of the observations from the QR study can be applied to the NSW network.

To ensure fugitive dust emissions are kept to a minimum during the relatively short journey to port, WACJV will commit to water spraying the coal surface during train loading.

In summary, the rail load out facility will be designed such that:

- Surface spraying of product coal for transportation.
- load size is limited to ensure coal is below wagon sidewalls.
- loading is such that a consistent profile is maintained.

10 GREENHOUSE GAS ASSESSMENT

10.1 Introduction

Greenhouse gas (GHG) emissions have been estimated based on the methods outlined in the following documents:

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) Greenhouse Gas Protocol *The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition* **(WRI/WBCSD, 2004**);
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008*; and
- The Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) *National Greenhouse Accounts* (NGA) *Factors 2011* (**DCCEE, 2011)**.

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Standard Organisation, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes. Three 'scopes' of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes, as described below. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment. The 'scope' of an emission is relative to the reporting entity. Indirect scope 2 and scope 3 emissions will be reportable as direct scope 1 emissions from another facility.

1) Scope 1: Direct Greenhouse Gas Emissions

Direct GHG emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct GHG emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources.
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials (e.g. the manufacture of cement, aluminium, etc.).
- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources (e.g. trucks, trains, ships, aeroplanes, buses and cars).
- Fugitive emissions. These emissions result from intentional or unintentional releases (e.g. equipment leaks from joints, seals, packing and gaskets; methane (CH_4) emissions from coal mines and venting); hydrofluorocarbon (HFC) emissions during the use of refrigeration and air conditioning equipment; and CH_4 leakages from gas transport.

2) Scope 2: Energy Product Use Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that account for GHG emissions from the generation of purchased energy products (principally, electricity, steam/heat and reduction materials used for smelting) by the entity. Scope 2 in relation to coal mines typically covers purchased electricity, defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity.

3) Scope 3: Other Indirect Greenhouse Gas Emissions

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

In the case of the Project, scope 3 emissions will include emissions associated with the rail transportation and combustion of product coal, as well as the minor emissions associated with the extraction, processing and transport of fuel used onsite. The GHG Protocol provides that reporting scope 3 emissions is optional. If an organisation believes that scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with scope 1 and scope 2. However, the GHG Protocol notes that reporting scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult because reporting is voluntary. Double counting needs to be avoided when compiling national (country) inventories under the Kyoto Protocol. The GHG Protocol also recognises that compliance regimes are more likely to focus on the "point of release" of emissions (i.e. direct emissions) and/or indirect emissions from the purchase of electricity.

10.2 Greenhouse Gas Emission Estimates

Emissions of carbon dioxide (CO_2) and CH_4 would be the most significant GHGs for the Project. These gases are formed and released during the combustion of fuels used on site and from fugitive emissions occurring during the mining process, due to the liberation of CH_4 from coal seams.

Inventories of GHG emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as global warming potentials) and emission factors take into account the global warming potentials of the gases created during combustion. The estimated emissions are referred to in terms of carbon dioxide equivalent (CO_2-e) emissions by applying the relevant global warming potential. The GHG assessment has been conducted using the National Greenhouse Account (NGA) Factors, published by the **DCCEE (2011)**.

Project-related GHG sources included in the assessment are as follows:

- fuel consumption (diesel) during mining operations and construction – scope 1;
- release of fugitive CH_4 during mining – scope 1. It is assumed that 35% of the total measured gas content would be emitted via mine ventilation air (MVA);
- emissions associated with the flaring of CH_4 (pre and post drainage). It is assumed that 65% of the total measured gas content would be captured for flaring;
- indirect emissions associated with on-site electricity use – scope 2;
- indirect emissions associated with the production and transport of fuels – scope 3;
- emissions from coal transportation – scope 3; and
- emissions from the use of the product coal – scope 3.

A summary of the annual GHG emissions is provided in **Table 10.1**. Full details of all calculations are provided in **Appendix D**.

10.3 GHG Benefits from Flaring and Beneficial Re-Use

A proportion of the gas (approximately 35%) will be released via the mine ventilation system (as MVA) as described above. However, the capture and flaring of the remaining CH_4 (pre and post mining) will have significant benefits in terms of GHG emission reductions.

When compared to 100% fugitive emissions of CH_4, the flaring scenario results in a GHG saving of approximately 8 Mt CO_2-e or 54% of Scope 1 emissions, over the project life.

Additional GHG savings would be realised through the use of onsite power generation. For example, an installed capacity of 10 MW would provide enough power demand for the site (based on the anticipated electricity demand), thereby eliminating GHG emissions from purchased electricity (~1.5 Mt CO_2-e over the project life). Any additional electricity generated onsite would be distributed back into the grid, thereby offsetting further Scope 1 GHG emissions.

Table 10.1: Summary of Annual Greenhouse Gas Emissions

	Scope 1 Emissions (t CO2-e)				Scope 2 Emissions (t CO2-e)	Scope 3 Emissions (t CO2-e)				
Year	**Diesel**	**Fugitive MVA**	**Flaring**	***Total***	**Electricity**	**Diesel**	**Electricity**	**Energy Production**	**Rail**	***Total***
Year 1	4,775	0	0	*4,775*	0	364	0	0	0	*364*
Year 2	4,775	0	0	*4,775*	0	364	0	0	0	*364*
Year 3	90	6,014	1,844	*7,948*	1,733	7	350	422,607	261	*423,226*
Year 4	293	19,503	5,980	*25,776*	5,619	22	1,137	1,370,488	847	*1,372,494*
Year 5	908	60,514	18,556	*79,978*	17,436	69	3,526	4,252,333	2,629	*4,258,558*
Year 6	1,983	132,172	40,530	*174,685*	38,083	151	7,702	9,287,803	5,742	*9,301,398*
Year 7	1,645	109,645	33,622	*144,912*	31,592	125	6,389	7,704,817	4,763	*7,716,095*
Year 8	1,960	130,677	40,071	*172,709*	37,652	149	7,615	9,182,748	5,677	*9,196,189*
Year 9	2,274	151,607	46,489	*200,371*	43,683	173	8,835	10,653,516	6,586	*10,669,110*
Year 10	2,038	135,876	41,665	*179,579*	39,150	155	7,918	9,548,052	5,903	*9,562,028*
Year 11	2,279	151,947	46,593	*200,820*	43,781	174	8,855	10,677,392	6,601	*10,693,021*
Year 12	2,340	155,956	47,823	*206,119*	44,936	178	9,088	10,959,130	6,775	*10,975,171*
Year 13	2,353	156,840	48,094	*207,286*	45,191	179	9,140	11,021,208	6,813	*11,037,340*
Year 14	2,114	140,904	43,207	*186,225*	40,599	161	8,211	9,901,419	6,121	*9,915,912*
Year 15	2,139	142,603	43,728	*188,471*	41,089	163	8,310	10,020,799	6,195	*10,035,467*
Year 16	2,038	135,876	41,665	*179,579*	39,150	155	7,918	9,548,052	5,903	*9,562,028*
Year 17	2,549	169,887	52,095	*224,530*	48,950	194	9,900	11,938,050	7,380	*11,955,524*
Year 18	2,549	169,887	52,095	*224,530*	48,950	194	9,900	11,938,050	7,380	*11,955,524*
Year 19	2,549	169,887	52,095	*224,530*	48,950	194	9,900	11,938,050	7,380	*11,955,524*
Year 20	2,453	163,499	50,136	*216,088*	47,109	187	9,528	11,489,179	7,103	*11,505,997*
Year 21	2,500	166,625	51,094	*220,219*	48,010	191	9,710	11,708,839	7,238	*11,725,978*
Year 22	2,447	163,092	50,011	*215,549*	46,992	187	9,504	11,460,528	7,085	*11,477,303*
Year 23	2,284	152,219	46,677	*201,179*	43,859	174	8,870	10,696,493	6,612	*10,712,150*
Year 24	2,209	147,258	45,156	*194,623*	42,430	168	8,581	10,347,902	6,397	*10,363,049*
Year 25	2,150	143,317	43,947	*189,414*	41,294	164	8,352	10,070,939	6,226	*10,085,680*
Year 26	2,171	144,744	44,385	*191,300*	41,705	166	8,435	10,171,219	6,288	*10,186,107*
Year 27	2,103	140,191	42,989	*185,282*	40,394	160	8,169	9,851,279	6,090	*9,865,699*
Year 28	2,173	144,846	44,416	*191,434*	41,735	166	8,441	10,178,381	6,292	*10,193,280*
Year 29	2,501	166,727	51,126	*220,354*	48,040	191	9,716	11,716,002	7,243	*11,733,152*
Year 30	2,253	150,214	46,062	*198,530*	43,282	172	8,754	10,555,624	6,525	*10,571,075*
Year 31	2,549	169,887	52,095	*224,530*	48,950	194	9,900	11,938,050	7,380	*11,955,524*
Year 32	2,549	169,887	52,095	*224,530*	48,950	194	9,900	11,938,050	7,380	*11,955,524*
Year 33	2,468	164,519	50,448	*217,435*	47,403	188	9,587	11,560,808	7,147	*11,577,730*
Year 34	2,229	148,617	45,572	*196,419*	42,821	170	8,661	10,443,406	6,456	*10,458,693*
Year 35	2,441	162,684	49,886	*215,010*	46,875	186	9,480	11,431,877	7,067	*11,448,610*
Year 36	2,549	169,887	52,095	*224,530*	48,950	194	9,900	11,938,050	7,380	*11,955,524*
Year 37	2,452	163,431	50,115	*215,998*	47,090	187	9,524	11,484,404	7,100	*11,501,214*
Year 38	2,347	156,432	47,969	*206,747*	45,073	179	9,116	10,992,556	6,796	*11,008,647*
Total	**86,476**	**5,127,869**	**1,572,425**	***6,786,770***	**1,477,507**	**6,595**	**298,822**	**360,338,101**	**222,758**	***360,866,275***

10.4 Impact on the Environment

According to the Intergovernmental Panel of Climate Change's (IPCC) Fourth Assessment Report, global surface temperature has increased 0.74 ± 0.18ºC during the 100 years ending 2005 (**IPCC, 2007a**). The IPCC has determined *"most of the observed increase in globally averaged temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations".* "Very likely" is defined by the IPCC as greater than 90% probability of occurrence (**IPCC, 2007b**).

Climate change projections specific to Australia have been determined by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), based on the following global emissions scenarios predicted by the IPCC (**CSIRO, 2007**):

- A1F1 (high emissions scenario) – assumes very rapid economic growth, a global population that peaks in mid-century and technological change that is fossil fuel intensive.
- A1B (mid emissions scenario) – assumes the same economic and population growth as A1F1, with a balance between fossil and non-fossil fuel intensive technological changes.
- B1 (low emissions scenario) – assumes the same economic and population growth as A1F1, with a rapid change towards clean and resource efficient technologies.

For the global emissions scenarios described above, the projected changes in annual temperature relative to 1990 levels for Australian cities for 2030 and 2070 are presented in **Table 10.2** as determined by the **CSIRO (2007)**.

Table 10.2: Projected changes in annual temperature (relative to 1990)

Location	2030 - A1B (mid-range emissions scenario)	2070 - B1 (low emissions scenario)	2070 - A1F1 (high emissions scenario)
Temperature (°C)			
Brisbane	0.7 - 1.4	1.1 - 2.3	2.1 - 4.4
Dubbo	0.7 - 1.5	1.2 - 2.5	2.2 - 4.8
St George (Queensland)	0.7 - 1.6	1.2 - 2.7	2.4 - 5.2
Sydney	0.6 - 1.3	1.1 - 2.2	2.1 - 4.3

Notes: Range of values represents the 10^{th} and 90^{th} percentile results.
For 2030, only A1B results are shown as there is little variation in projected results for the global emission scenarios A1B, B1 and A1F1 (**CSIRO, 2007**).
Source: **CSIRO (2007)** *Climate Change in Australia – Technical Report 2007*, Commonwealth Scientific and Industrial Research Organisation.

The CSIRO also details projected changes to other meteorological parameters (for example rainfall, potential evaporation, wind speed, relative humidity and solar radiation) and the predicted changes to the prevalence of extreme weather events (for example droughts, bush fires and cyclones).

The potential social and economic impacts of climate change to Australia are detailed in The Garnaut Climate Change Review (**Garnaut, 2008**), which draws on IPCC assessment work and the CSIRO climate projections. The Garnaut review details the negative and positive impacts associated with predicted climate change with respect to:

- agricultural productivity;
- water supply infrastructure;
- urban water supplies;

- buildings in coastal settlements;
- temperature related deaths;
- ecosystems and biodiversity; and
- geopolitical stability and the Asia-Pacific region.

The Project's contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions.

Average annual scope 1 emissions from the Project (0.2 Mt CO_2-e) would represent approximately 0.04% of Australia's annual average commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions, given that Australia contributed approximately 1.5% of global GHG emissions in 2005 **(Commonwealth of Australia, 2011)**.

A comparison of predicted annual GHG emissions from the Project with global, Australian and NSW emissions inventories are presented in **Table 10.3**.

Table 10.3: Comparison of greenhouse gas emissions

Geographic coverage	Source coverage	Timescale	Emission Mt CO_2-e	Reference
Project	Scope 1 only	Average annual	0.2	This report.
Global	Consumption of fossil fuels	Total since industrialisation 1750 - 1994	865,000	IPCC (2007a) Figure 7.3 converted from Carbon unit basis to CO_2 basis. Error is stated greater than ±20%.
Global	CO_2-e emissions	2005	35,000	Based on Australia representing 1.5% of global emissions (Commonwealth of Australia, 2011). Australian National Greenhouse Gas Inventory (2005) taken from http://www.ageis.greenhouse.gov.au/
Global	CO_2-e emission increase 2004 to 2005	2005	733	IPCC (2007a) From tabulated data presented in Table 7.1 on the basis of an additional 733 Mt/a. Data converted from Carbon unit basis to CO_2 basis.
Australia	1990 Base	1990	547.7	Taken from the National Greenhouse Gas Inventory (2009) http://www.ageis.greenhouse.gov.au/
Australia	Kyoto target	Average annual 2008 - 2012	591.5	Based on 1990 net emissions multiplied by 108% Australia's Kyoto emissions target.
Australia	Total	2009	564.5	Taken from the National Greenhouse Gas Inventory (2009) http://www.ageis.greenhouse.gov.au/
NSW	Total	2009	160.5	Taken from the National Greenhouse Gas Inventory (2009) http://www.ageis.greenhouse.gov.au/

GHG from Australian sources will be collectively managed at a national level, through initiatives implemented by the Australian Government. The Australian Government has committed to reduce GHG emissions by between 5-25% below 2000 levels by 2020, with the level of reduction dependent on the extent of reduction actions undertaken internationally **(Commonwealth of Australia, 2011)**. Similarly, the Federal Opposition has committed to a 5% reduction below 1990 levels by 2020 in its Direct Action Plan **(Liberal Party of Australia, 2010)**.

The commitment from the Australian Government to reduce GHG emissions is proposed to be achieved through the introduction of the Australian Government's proposed carbon pricing mechanisms. From 1 July 2012, this will involve a fixed price on GHG emissions from major emitters, with no cap on Australia's GHG emissions, or emissions from individual facilities **(Commonwealth of Australia, 2011)**.

From 1 July 2015 an emissions trading scheme is proposed to be implemented. As such, Australia's GHG emissions, inclusive of emissions associated with the Project, would be capped at a level specified by the Australian Government. Under the emissions trading scheme, there will specifically be no limit on the level of GHG emissions from individual facilities, with the incentive for facilities to reduce their GHG emissions driven by the carbon pricing mechanism **(Commonwealth of Australia, 2011)**.

It is expected that the Project would exceed the facility threshold of 25,000 t CO_2-e per annum for participation in the carbon pricing mechanisms, and as such scope 1 GHG emissions from the Project would be subject to the carbon pricing mechanism. As such, the Project would directly contribute to the revenue generated by the carbon pricing mechanism, which is to be used to fund the following initiatives designed to reduce Australia's GHG emissions **(Commonwealth of Australia, 2011)**:

- $1.2 billion Clean Technology Program to improve energy efficiency in manufacturing industries and support research and development in low-pollution technologies.
- $10 billion Clean Energy Finance Corporation to invest in renewable energy, low-pollution and energy efficiency technologies.
- $946 million Biodiversity Fund (over the first six years) to protect biodiverse carbon stores and secure environmental outcomes from carbon farming.

10.5 Greenhouse Gas Emissions Intensity

The estimated GHG emissions intensity of the Project is approximately 0.045 t CO_2-e/t ROM coal (scope 1 emissions only). The estimated emissions intensity of the Project is similar to the majority of underground coal mines in Australia (0.05 t CO_2-e/t coal) (scope 1 emissions only) (**Deslandes, 1999**).

It is noted that the Project will not have a coal washery and associated reject emplacement, resulting in reduced demand for electricity and diesel.

10.6 Project Greenhouse Gas and Energy Reduction Measures

The Project will develop an Energy and Greenhouse Strategy within 2 years after the commencement of longwall coal extraction. The Strategy will address interim and long term energy and greenhouse management plans and initiatives, including monitoring, reporting and continuous improvement.

The Strategy will incorporate commitments for WACJV to implement the following approaches to improving energy efficiency and reducing greenhouse emissions from the Project:

- Use of minimum 5% bio-diesel or similar in the mining fleet, subject to manufacturer's guidelines;
- Use of low-sulphur diesel fuel for underground mobile equipment;

- Conduct an options study for coal mine methane capture and utilisation within 3 years of the commencement of longwall coal mining production;
- Monitor greenhouse gas emissions and mitigation actions from the commencement of mining operations;
- Prior to the development and implementation of a long term methane utilisation strategy, WACJV will commit to enclosed flaring of the initial production of captured methane to enable a significant reduction in greenhouse emissions;
- Conduct an energy efficiency audit each three years after the commencement of longwall mining operations, and
- Installation of energy efficient appliances, lighting and hot water system (such as gas boosted solar hot water system).

The Project will continue to assess and implement energy and greenhouse management initiatives during the project design, operation and decommissioning.

11 MANAGEMENT AND MONITORING

11.1 Construction Dust Management

The principal emissions from the construction phase of the Project will be dust and particulate matter, occurring from the following activities:

- Vegetation clearing and earthmoving during site preparation and access road construction;
- Excavation of portal and ventilation shafts and stockpiling of excavated material;
- Excavated material handling, shaping, and bund construction;
- Movement of heavy plant and machinery within the site;
- Graders / scrapers working access road construction; and
- Wind erosion from exposed surfaces.

Emissions of carbon monoxide (CO), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2) will occur from diesel-powered plant and equipment used on-site and vehicle movements to site. However these emissions are typically minor for projects of this scale and too widely dispersed to give rise to significant off-site concentrations.

Procedures for controlling dust impacts during construction will include, but not necessarily be limited to the following:

11.1.1 Clearing / Excavation

Emissions from vegetation stripping, topsoil clearing and excavation can occur, particularly during dry and windy conditions. Emissions can be effectively controlled by increasing the moisture content of the soil / surface. Other controls that will be considered are:

- Modify working practices by limiting excavation during periods of high winds.
- Limiting the extent of clearing of vegetation and topsoil to the designated footprint required for construction and appropriate staging of any clearing.

11.1.2 Access Road

The use of earth moving equipment can be significant sources of dust, and emissions should be controlled through the use of water sprays during road construction. Where conditions are excessively dusty and windy, and fugitive dust can be seen leaving the site, work practices should be modified by limiting scraper / grader activity.

11.1.3 Haulage and Heavy Plant and Equipment

Vehicles travelling over paved or unpaved surfaces tend to produce wheel generated dust and can result in dirt track-out on paved surfaces surrounding the work areas.

- All vehicles on-site should be confined to a designated route with speed limits enforced;
- Trips and trip distances should be controlled and reduced where possible, for example by coordinating delivery and removal of materials to avoid unnecessary trips;
- Dirt that has been tracked onto sealed roads should be cleaned as soon as practicable;

- When conditions are excessively dusty and windy, and dust can be seen leaving the works site the use of a water truck (for water spraying of travel routes) should be used;
- Seal the main access roads as soon as practical.

11.1.4 Wind Erosion

Wind erosion from exposed ground should be limited by avoiding unnecessary vegetation clearing and ensure rehabilitation occurs as quickly as possible. Wind erosion from temporary soil stockpiles can be limited by minimising the number of stockpiles on-site and minimising the number of work faces on stockpiles.

11.2 Operational Dust Control

Sources of emissions during operation of the Project are described in **Table 7.2** and **Table 7.3** with the proposed management measures outlined in **Table 7.7**.

Based on the predicted impacts from the Project, the proposed management measures, developed in accordance with the NSW EPA best practice document '*NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining*' (**Donnelly et al., 2011**), are considered feasible and reasonable.

11.3 Monitoring

The air quality emissions from the construction activities will be monitored using the existing environmental monitoring network to ensure compliance with the relevant air quality criteria.

The existing monitoring network should be reviewed and augmented for the operation of the Project. The review of the existing monitoring regime would form part of the Air Quality Management Plan for the Project.

In accordance with best practice dust management at the site, the existing HVAS would be augmented or replaced by a continuous PM_{10}/$PM_{2.5}$ monitoring instrument (such as a TEOM) at a location representative of receivers (for example to the north of the site) who may experience short-term elevated dust concentrations.

A short-term average performance indicator will be set at a level that allows proactive dust management if dust levels are expected to approach the 24-hour PM_{10} impact assessment criteria in the upcoming 24 hours.

12 CONCLUSION

PAEHolmes has completed an Air Quality and Greenhouse Gas Assessment for the Project, in accordance with the DGRs and requirements as identified throughout the planning approvals process.

The key air quality issues assessed are emissions of dust during the operation of the Project. During construction, fugitive dust emissions can also be expected, however the total estimated dust emissions are less than 35% of the emissions estimated to occur during operation of the Project. Therefore compliance with air quality goals during the operation of the mine is assumed to represent compliance during mine construction.

Two operational scenarios were assessed, one based on the maximum annual production rate of 5 Mtpa and a second scenario based on a worst case maximum daily production rate. Dispersion modelling was conducted for each scenario to predict the ground level concentrations for all relevant pollutants.

The results of the modelling indicate that the predicted incremental PM_{10}, $PM_{2.5}$, TSP and dust deposition at the closest residential receptors are all below the impact assessment criteria. The highest predicted glcs occur at the closest residence to the north of the site (P11).

A cumulative assessment, incorporating existing background levels, indicates that the Project is unlikely to result in any additional exceedances of relevant impact assessment criteria at the neighbouring receivers.

Emissions to air associated with the flaring of methane and use in power generation were also assessed. The maximum predicted 1-hour NO_2 glc from flaring is approximately 14% of the goal while the maximum predicted annual average NO_2 glc from flaring is less than 1% of the goal. Cumulative impacts from NO_2 are minor when added to existing background levels.

The potential for nuisance odour impacts from the ventilation shaft was assessed and found to be small. The modelling indicates that only one privately owned receiver in the vicinity of the Buttonderry site is predicted to experience glcs above the impact assessment criteria of 2 OU. It is important to note that odour impact assessment criteria are related to population density. An odour impact assessment criteria of 7 OU would be acceptable to the average person, but as the number of exposed people increases, the probability of a more sensitive individual being exposed increases. The most stringent criterion of 2 OU is considered to be acceptable for the whole population. On this basis, a predicted odour level of 3 OU at one privately owned receiver would be acceptable to the average person. Notwithstanding this, it is recommended that post commissioning verification of the ventilation shaft emissions is conducted once operational, to validate the assumptions presented in this report.

An assessment of the GHG emissions associated with the Project indicates that average annual scope 1 emissions would represent approximately 0.04% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions.

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APPENDIX A

Assessment Locations and Land Ownership

Assessment Location ID	Easting	Northing	Owner ID Number	Owner Name
1	357855	6322289	254	STEVEN BARRY MCKEOGH & SIEW TING MCKEOGH
2	357021	6322338	255	ARTHUR ROBERT MUNROE & SUSAN JOAN MUNRO
3	356284	6322807	153	JT & KE HUTCHINSON
4	354803	6322823	165	STANDARD INDUSTRIES PTY LIMITED
5	353943	6323781	169	DELCARE CONSTRUCTIONS PTY LIMITED
6	355040	6325280	1	WYONG COAL PTY LIMITED
7	355524	6325206	55	BJ & KR DRAKE
8	355898	6325231	62	N & A IORDANIDIS
9	356509	6325499	65	DJC SUAREZ
10	357203	6326257	256	NORMAN JAMES HAWKINS & ADA MARIE HAWKINS
11	356222	6325149	57	KR DRAKE
12	351245	6322968	42	AT ETHELL
13	359426	6324622	N/A	N/A Representative of Bluehaven Residential Area
14	351364	6322948	43	ZS MUSLU
15	351632	6322985	44	C TOHAMY & MUSLIM COMMUNITY CO-OPERATIVE (AUSTRALIA) LTD
16	351783	6322837	45	S WONG & S LIN & PH LEE
17	351940	6322848	46	LA & R ATCHISON
18	351815	6323743	47	EM DUNN
19	351054	6323433	48	KG & KA MACDONALD
20	351205	6323857	49	MJ BAULCH
21	351920	6323989	50	F & EM MERCIECA
22	351795	6322769	224	CJ CAMPBELL & EI HINSON
23	351869	6322717	223	J EDINGTON
24	352046	6322637	222	RW & CP & BW IKIN
25	352248	6322672	1	WYONG COAL PTY LIMITED
26	352359	6322615	1	WYONG COAL PTY LIMITED
27	352154	6322523	213	CJ & L BAUERHUIT
28	352245	6322549	214	JF & AP RITCHIE
29	352319	6322512	215	ME & JE WALTERS
30	352693	6322395	185	HELI-AUST LAND HOLDINGS PTY LTD
31	352562	6322475	191	B & B MITROVIC
32	352562	6322404	190	J & R DIMIS
33	352462	6322452	192	RO & AE HOLLAND

APPENDIX B

Model Set Up

Model Set Up

TAPM (v 4.0.4)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grid points	43 x 43 x 35
Year of analysis	Jul 2010 – Jun 2011
Centre of analysis (local coordinates)	354890, 6323821
CALMET (v. 6.42)	
Meteorological grid domain	30 km x 30 km
Meteorological grid resolution	250 m
Input data	Surface station data from Wallarah, Coorangbong, Norah Head and cloud cover and height from Williamtown. Prognostic 3D.dat extracted from TAPM at 1 km grid

CALMET Model Options used

Flag	Descriptor	Default	Value Used
IEXTRP	Extrapolate surface wind observations to upper layers	Similarity theory	Similarity theory
BIAS (NZ)	Relative weight given to vertically extrapolated surface observations versus upper air data	NZ * 0	-1, -0.5, -0.25, 0, 0, 0, 0
TERRAD	Radius of influence of terrain	No default (typically 5- 15km)	6 km
RMAX1 and RMAX2	Maximum radius of influence over land for observations in layer 1 and aloft	No Default	2.5 km
R1 and R2	Distance from observations in layer 1 and aloft at which observations and Step 1 wind fields are weighted equally	No Default	2.5 km

CALPUFF Model Options used

Flag	Flag Descriptor	Value Used	Value Description
MCHEM	Chemical Transformation	0	Not modelled
MDRY	Dry Deposition	1	Yes for PM
MTRANS	Transitional plume rise allowed?	1	Yes
MTIP	Stack tip downwash?	1	Yes
MRISE	Method to compute plume rise	1	Briggs plume rise
MSHEAR	Vertical wind Shear	0	Vertical wind shear not modelled
MPARTL	Partial plume penetration of elevated inversion?	1	Yes
MSPLIT	Puff Splitting	0	No puff splitting
MSLUG	Near field modelled as slugs	0	Not used
MDISP	Dispersion Coefficients	2	Based on micrometeorology
MPDF	Probability density function used for dispersion under convective conditions	0	No
MROUGH	PG sigma y,z adjusted for z	0	No
MCTADJ	Terrain adjustment method	3	Partial Plume Adjustment
MBDW	Method for building downwash	1	ISC method

APPENDIX C

Estimated Emissions

Wallarah 2 Coal Project

Estimated emissions are presented for all significant dust generating activities associated with the construction and operation of the Project.

Fugitive dust emissions can be expected during construction from the following activities:

- excavation of material for the box cut, ventilation shafts and ROM stockpile area;
- loading of material to trucks and transport within site;
- dozers on excavated material; and
- graders working road construction.

Fugitive dust emissions can be expected during operation from the following activities:

- loading stockpile from conveyor;
- wind erosion and maintenance on stockpiles; and
- upcast ventilation shafts.

Loading / dumping waste rock

Each tonne of material loaded will generate a quantity of particulate matter that will depend on the wind speed and the moisture content according to the US EPA emission factor equation (**US EPA, 1985 and updates**) shown below:

$$E\ (kg/t) = k \times 0.0016 \times \left(\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}} \right)$$

Where:

K = 0.74 for TSP, 0.35 for PM_{10} and 0.053 for $PM_{2.5}$

U – wind speed (m/s)

M – moisture content (%)

The moisture content of waste material is assumed to be 5% and the wind speed is taken from the measured wind at the Wallarah AWS.

Hauling material / coal on unsealed surfaces

The emission estimate of wheel generated dust associated with hauling at the pit top areas (i.e. for hauling of waste rock material during construction is based the US EPA AP42 emission equation for unpaved surfaces at industrial sites (**US EPA, 1985 and updates**) shown below:

$$E\ \ (kg/VKT) = 0.2819 \times k \times [\ \times (s/12)\text{^}0.7 \times ((W \times 1.1023)/3)\text{^}0.45]$$

Where:

k = 4.9 for TSP, 1.5 for PM_{10} and 0.015 for $PM_{2.5}$

s = silt content of road surface

W = mean vehicle weight

The silt content (s) for the haulage routes is assumed to be 4%.

The mean vehicle weight used in the emissions estimates is an average of the loaded and unloaded gross vehicle mass, to account for one empty trip and one loaded trip. Haul trucks carrying waste during construction are assumed to have a payload of 136 t and a tare weight of 181 t.

Dozers working on waste rock

Emissions from dozers on waste have been calculated using the US EPA emission factor equation (**US EPA, 1985 and updates**).

$$E(kg/hr) = k \times \frac{s^{1.2}}{M^{1.3}}$$

Where:

k = 2.6 for TSP, 0.3375 for PM_{10} and 0.0273 for $PM_{2.5}$

s = silt content (assumed to be 10%)

M = moisture content (assumed to be 2%).

Active Stockpiles – Wind Erosion and Maintenance

The following **US EPA (1985 and updates)** emission factor equation has been used for wind erosion.

$$E_{TSP}\ (kg/ha/hr) = 1.8\ x\ U$$

Where:

U= mean wind speed (m/s) and is taken as 1.3 m/s from the Wallarah meteorological site.

For PM_{10} this is multiplied by a factor of 0.5 and for 0.075 for $PM_{2.5.}$

Estimated emissions of TSP during Operations

ACTIVITY - Operations (Annual)	TSP Emission kg/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Assumptions
Tooheys Road Site																		
CL - Conveyor transfer @ Portal	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Conveyor transfer to ROM stockpile	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	
CL - Loading ROM stockpile from conveyor	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA
CL - Active ROM Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	13,324	1.3	ha	2.34	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.
CL - Conveyor transfer to Crushing Station	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Processing - Crushing Station	-	5,000,000	t/y	0.0027	kg/t											100	% control	100% ontrol assumed for full enclosure of crushing station
CL - Conveyor transfer between crusher and stockpile	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Conveyor transfer to Product stockpile	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.4	5	moisture content in %								% control	
CL - Loading Product stockpile from conveyor	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA
CL - Active Product Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	48,171	4.7	ha	2.34	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.
CL - Loading Trains	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. No controls for stockpile loading
Buttonderry Site																		
Ventilation Shaft	55,016	11,668	10^6 m3/yr	4.7150	TSP Conc. (mg/m3)	8760	h/y	3600	s/hour	370	Flow Rate (m3/s)						% control	Flow rate take from 2008 EA. Particulate concentration for Vent Shaft taken from measurements at Tasman Underground Mine (HAS, 2007)
Total Annual TSP (kg)	**123,138**																	

Estimated emissions of PM_{10} during Operations

ACTIVITY - Operations (Annual)	PM10 Emission kg/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Assumptions
Tooheys Road Site																		
CL - Conveyor transfer @ Portal	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.2	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Conveyor transfer to ROM stockpile	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Loading ROM stockpile from conveyor	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA
CL - Active ROM Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	6,662	1.3	ha	1.17	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.
CL - Conveyor transfer to Crushing Station	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Processing - Crushing Station	-	5,000,000	t/y	0.0012	kg/t											100	% control	100% ontrol assumed for full enclosure of crushing station
CL - Conveyor transfer between crusher and stockpile	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.2	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Conveyor transfer to Product stockpile	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Loading Product stockpile from conveyor	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA
CL - Active Product Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	24,086	4.7	ha	1.17	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.
CL - Loading Trains	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. No controls for stockpile loading
Buttonderry Site																		
Ventilation Shaft	55,016	11,668	10^6 m3/yr	4.7150	TSP Conc. (mg/m3)	8760	h/y	3600	s/hour	370	Flow Rate (m3/s)						% control	Flow rate take from 2008 EA. Particulate concentration for Vent Shaft taken from measurements at Tasman Underground Mine (HAS, 2007)
Total Annual PM10 (kg)	**88,506**																	

Estimated emissions of $PM_{2.5}$ during Operations

ACTIVITY - Operations (Annual)	PM2.5 Emission kg/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Assumptions
Tooheys Road Site																		
CL - Conveyor transfer @ Portal	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Conveyor transfer to ROM stockpile	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Loading ROM stockpile from conveyor	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA
CL - Active ROM Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	999	1.3	ha	0.1755	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.
CL - Conveyor to Crushing Station	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Processing - Crushing Station	-	5,000,000	t/y	0	kg/t											100	% control	100% ontrol assumed for full enclosure of crushing station
CL - Conveyor transfer to Product stockpile	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Conveyor transfer between crusher and stockpile	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 40% control assumed for wind shielding
CL - Loading Product stockpile from conveyor	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA
CL - Active Product Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	3,613	4.7	ha	0.1755	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.
CL - Loading Trains	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. No controls for stockpile loading
Buttonderry Site																		
Ventilation Shaft	55,016	11,668	10^6 m3/yr	4.7150	TSP Conc. (mg/m3)	8760	h/y	3600	s/hour	370	Flow Rate (m3/s)						% control	Flow rate take from 2008 EA. Particulate concentration for Vent Shaft taken from measurements at Tasman Underground Mine (HAS, 2007)
Total Annual PM2.5 (kg)	**60,103**																	

Estimated emissions of TSP during Construction

ACTIVITY - Construction	TSP Emission kg/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Assumptions
Tooheys Road Site																		
Dozer clearing vegetation	16,066	960	h/y	16.74	kg/h	10	silt content in %	2	moisture content in %									Generally retained assumption from 2008 EA: - amounts of excavated material - dozer hours - moisture contents - trip distances Updated the following: - hauling emission equation -topsoil silt content - updated truck payload and vehicle gross mass based on CAT785.
Loading of excavated material to trucks	331	1,461,030	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	4	moisture content in %									
Hauling of excavated material to trucks	5,441	1,461,030	t/y	0.015	kg/t	136	t/truck load	181	Vehicle gross mass (t)	0.5	km/return trip	4.1	kg/VKT	4	% silt conten	75	% control	
Dumping of excavated material	331	1,461,030	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	4	moisture content in %									
FEL / Dozer Shaping	6,525	960	t/y	6.8	kg/h	10	silt content in %	4	moisture content in %									
Wind erosion - exposed areas	24,528	7	ha	0	kg/ha/hr													
Buttonderry Site																		
Dozer clearing vegetation	4,820	288	h/y	16.74	kg/h	10	silt content in %	2	moisture content in %									
Loading of excavated material to trucks	33	146,850	t	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	4	moisture content in %									
Hauling of excavated material to trucks	547	146,850	t/y	0.015	kg/t	136	t/truck load	181	Vehicle gross mass (t)	0.5	km/return trip	4.1	kg/VKT	4	% silt conten	75	% control	
Dumping of excavated material	33	146,850	t	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	4	moisture content in %									
FEL / Dozer Shaping	6,525	960	t/y	6.8	kg/h	10	silt content in %	4	moisture content in %									
Wind erosion	14,016	4	ha	0.4	kg/ha/hr													
Total Annual TSP (kg)	**79,195**																	

APPENDIX D

Estimation of Greenhouse Gas Emissions

D.1 FUEL CONSUMPTION

GHG emissions from diesel consumption were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E_{CO2-e}	=	Emissions of GHG from diesel combustion	(t CO_2-e)[1]
Q	=	Estimated combustion of diesel	(GJ)[2]
EF	=	Emission factor (scope 1 or scope 3) for diesel combustion	(kg CO_2-e/GJ)[3]

1 tCO_2-e = tonnes of carbon dioxide equivalent.
2 GJ = gigajoules.
3 kg CO_2-e/GJ = kilograms of carbon dioxide equivalents per gigajoule.

The quantity of diesel consumed (Q) in each year is based on a diesel intensity rate of 0.19 L diesel/t ROM). Diesel consumption during construction (Year 1 and Year 2) is based on the assumption that 1780 kl/year is required. The quantity of diesel consumed in gigajoules (GJ) (Q) is then calculated using an energy content factor for diesel of 38.6 gigajoules per kilolitre (GJ/kL).

GHG emission factors and energy content for diesel were sourced from the NGA Factors (**DCCEE, 2011**). The estimated annual and Project total GHG emissions from diesel usage are presented in **Table C.1**.

Table C.1: Estimated CO2-e (tonnes) for diesel consumption

Year	Diesel (kL)	Emissions (t co2-e)		
		Scope 1	Scope 3	Total
Year 1	1,780	4,775	364	5,139
Year 2	1,780	4,775	364	5,139
Year 3	34	90	7	97
Year 4	109	293	22	315
Year 5	338	908	69	977
Year 6	739	1,983	151	2,134
Year 7	613	1,645	125	1,770
Year 8	731	1,960	149	2,110
Year 9	848	2,274	173	2,448
Year 10	760	2,038	155	2,194
Year 11	850	2,279	174	2,453
Year 12	872	2,340	178	2,518
Year 13	877	2,353	179	2,532
Year 14	788	2,114	161	2,275
Year 15	797	2,139	163	2,302
Year 16	760	2,038	155	2,194
Year 17	950	2,549	194	2,743
Year 18	950	2,549	194	2,743
Year 19	950	2,549	194	2,743
Year 20	914	2,453	187	2,640
Year 21	932	2,500	191	2,690
Year 22	912	2,447	187	2,633
Year 23	851	2,284	174	2,458
Year 24	823	2,209	168	2,378
Year 25	801	2,150	164	2,314
Year 26	809	2,171	166	2,337
Year 27	784	2,103	160	2,263
Year 28	810	2,173	166	2,339
Year 29	932	2,501	191	2,692
Year 30	840	2,253	172	2,425
Year 31	950	2,549	194	2,743
Year 32	950	2,549	194	2,743
Year 33	920	2,468	188	2,656
Year 34	831	2,229	170	2,400
Year 35	910	2,441	186	2,627
Year 36	950	2,549	194	2,743
Year 37	914	2,452	187	2,639
Year 38	875	2,347	179	2,526
Total	**32,235**	**86,476**	**6,595**	**93,071**

D.2 ELECTRICITY

GHG emissions from electricity usage were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E_{CO2-e}	=	Emissions of GHG from electricity usage	(tCO_2-e/annum)
Q	=	Estimated electricity usage	(kWh/annum)[1]
EF	=	Emission factor (Scope 2 or Scope 3) for electricity usage	($kgCO_2$-e/kWh)[2]

[1] kWh/annum = kilowatt hours per annum

[2] $kgCO_2$-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

The quantity of electricity used each year is based on an intensity rate of 11 kWh/tpa ROM. GHG emission factors were sourced from the NGA Factors (**DCCEE, 2011**). The estimated annual and Project total GHG emissions from electricity usage are presented in **Table C.2**.

Table C.2: Estimated CO_2-e (tonnes) for electricity

Year	Electricity (kWhr)	Emissions (t CO2-e)		
		Scope 2	Scope 3	Total
Year 1	0	0	0	0
Year 2	0	0	0	0
Year 3	1,947,000	1,733	350	2,083
Year 4	6,314,000	5,619	1,137	6,756
Year 5	19,591,000	17,436	3,526	20,962
Year 6	42,790,000	38,083	7,702	45,785
Year 7	35,497,000	31,592	6,389	37,982
Year 8	42,306,000	37,652	7,615	45,267
Year 9	49,082,000	43,683	8,835	52,518
Year 10	43,989,000	39,150	7,918	47,068
Year 11	49,192,000	43,781	8,855	52,635
Year 12	50,490,000	44,936	9,088	54,024
Year 13	50,776,000	45,191	9,140	54,330
Year 14	45,617,000	40,599	8,211	48,810
Year 15	46,167,000	41,089	8,310	49,399
Year 16	43,989,000	39,150	7,918	47,068
Year 17	55,000,000	48,950	9,900	58,850
Year 18	55,000,000	48,950	9,900	58,850
Year 19	55,000,000	48,950	9,900	58,850
Year 20	52,932,000	47,109	9,528	56,637
Year 21	53,944,000	48,010	9,710	57,720
Year 22	52,800,000	46,992	9,504	56,496
Year 23	49,280,000	43,859	8,870	52,730
Year 24	47,674,000	42,430	8,581	51,011
Year 25	46,398,000	41,294	8,352	49,646
Year 26	46,860,000	41,705	8,435	50,140
Year 27	45,386,000	40,394	8,169	48,563
Year 28	46,893,000	41,735	8,441	50,176
Year 29	53,977,000	48,040	9,716	57,755
Year 30	48,631,000	43,282	8,754	52,035
Year 31	55,000,000	48,950	9,900	58,850
Year 32	55,000,000	48,950	9,900	58,850
Year 33	53,262,000	47,403	9,587	56,990
Year 34	48,114,000	42,821	8,661	51,482
Year 35	52,668,000	46,875	9,480	56,355
Year 36	55,000,000	48,950	9,900	58,850
Year 37	52,910,000	47,090	9,524	56,614
Year 38	50,644,000	45,073	9,116	54,189
Total	**1,660,120,000**	**1,477,507**	**298,822**	**1,776,328**

D.3 FUGITIVE METHANE

Emissions from fugitive CH_4 were estimated using the following equation:

$$E_{co2-e} = Q \times EF$$

where:

E_{CO2-e}	=	Emissions of GHG from fugitive CH_4	(t CO_2-e/annum)
Q	=	ROM coal extracted during the year	(t)
EF	=	Scope 1 emission factor	(t CO_2-e/tonne)

A site specific emission factor (EF) of 0.1 t CO_2-e/tonne has been determined based on gas content testing (**GeoGas, 2011**). The measured gas content of 7.6 m^3/t (**GeoGas, 2011**) was converted to CO_2-e based on the National Greenhouse and Energy Reporting System (NGERS) methodology (Division 3.2.2, Subdivision 3.2.2.2 Method 4) (**DCC, 2009**).

It is assumed that of the total measured gas content, approximately 35% would be emitted via mine ventilation air. The remaining 65% (pre drainage and post drainage) would be flared. The estimated annual and Project total GHG emissions from fugitive CH_4 are presented in **Table C.3.**

Table C.3: Estimated CO2-e (tonnes) for fugitive methane and flaring

Year	ROM (tpa)	Scope 1 Emissions (t CO2-e)	
	(tpa)	Flaring (Pre and Post Drainage)	Fugitive (MVA)
Year 1	0	0	0
Year 2	0	0	0
Year 3	177,000	1,844	6,014
Year 4	574,000	5,980	19,503
Year 5	1,781,000	18,556	60,514
Year 6	3,890,000	40,530	132,172
Year 7	3,227,000	33,622	109,645
Year 8	3,846,000	40,071	130,677
Year 9	4,462,000	46,489	151,607
Year 10	3,999,000	41,665	135,876
Year 11	4,472,000	46,593	151,947
Year 12	4,590,000	47,823	155,956
Year 13	4,616,000	48,094	156,840
Year 14	4,147,000	43,207	140,904
Year 15	4,197,000	43,728	142,603
Year 16	3,999,000	41,665	135,876
Year 17	5,000,000	52,095	169,887
Year 18	5,000,000	52,095	169,887
Year 19	5,000,000	52,095	169,887
Year 20	4,812,000	50,136	163,499
Year 21	4,904,000	51,094	166,625
Year 22	4,800,000	50,011	163,092
Year 23	4,480,000	46,677	152,219
Year 24	4,334,000	45,156	147,258
Year 25	4,218,000	43,947	143,317
Year 26	4,260,000	44,385	144,744
Year 27	4,126,000	42,989	140,191
Year 28	4,263,000	44,416	144,846
Year 29	4,907,000	51,126	166,727
Year 30	4,421,000	46,062	150,214
Year 31	5,000,000	52,095	169,887
Year 32	5,000,000	52,095	169,887
Year 33	4,842,000	50,448	164,519
Year 34	4,374,000	45,572	148,617
Year 35	4,788,000	49,886	162,684
Year 36	5,000,000	52,095	169,887
Year 37	4,810,000	50,115	163,431
Year 38	4,604,000	47,969	156,432
Total	**150,920,000**	**1,572,425**	**5,127,869**

D.4 VEGETATION CLEARING

There is minimal vegetation stripping required for the Project (restricted to small areas around the surface infrastructure) and there GHG emissions due to vegetation clearance have not been calculated.

D.5 PRODUCT COAL TRANSPORTATION

The scope 3 emissions associated with product coal transportation have been estimated based on all product coal being transported to Newcastle for export by rail. Emissions associated with product coal transportation have been estimated based on an emission factor for loaded trains of 12.3 grams per net tonne per kilometre (**QR Network Access, 2002**). Emission factors were not available for unloaded trains so the factor for loaded trains is conservatively applied for the return trip.

The return rail trip to the port of Newcastle is estimated to be 120 km. The total estimated GHG emissions from rail transport of product coal are provided in **Table C.4.**

Table C.4: Estimated CO_2-e (tonnes) for product coal transportation

Year	Product Coal (tpa)	Scope 3 Emissions (t CO2-e)
Year 1	0	0
Year 2	0	0
Year 3	177,000	261
Year 4	574,000	847
Year 5	1,781,000	2,629
Year 6	3,890,000	5,742
Year 7	3,227,000	4,763
Year 8	3,846,000	5,677
Year 9	4,462,000	6,586
Year 10	3,999,000	5,903
Year 11	4,472,000	6,601
Year 12	4,590,000	6,775
Year 13	4,616,000	6,813
Year 14	4,147,000	6,121
Year 15	4,197,000	6,195
Year 16	3,999,000	5,903
Year 17	5,000,000	7,380
Year 18	5,000,000	7,380
Year 19	5,000,000	7,380
Year 20	4,812,000	7,103
Year 21	4,904,000	7,238
Year 22	4,800,000	7,085
Year 23	4,480,000	6,612
Year 24	4,334,000	6,397
Year 25	4,218,000	6,226
Year 26	4,260,000	6,288
Year 27	4,126,000	6,090
Year 28	4,263,000	6,292
Year 29	4,907,000	7,243
Year 30	4,421,000	6,525
Year 31	5,000,000	7,380
Year 32	5,000,000	7,380
Year 33	4,842,000	7,147
Year 34	4,374,000	6,456
Year 35	4,788,000	7,067
Year 36	5,000,000	7,380
Year 37	4,810,000	7,100
Year 38	4,604,000	6,796
Total	**150,920,000**	**222,758**

Emissions from the shipping of product coal are not included in this assessment due to the difficulties in emission estimates, including uncertainty in export markets and limited data on emission factors and/or fuel consumption for ocean going vessels.

D.6 ENERGY PRODUCTION FROM PRODUCT COAL

The scope 3 emissions associated with the combustion of product coal were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EC \times EF}{1000}$$

Where:

E_{CO2-e}	=	Emissions of GHG from coal combustion	(t CO_2-e)
Q	=	Quantity of product coal burnt	(GJ)
EC	=	Energy Content Factor for black / coking coal	(GJ/t)[1]
EF	=	Emission factor for black / coking coal combustion	(kg CO_2-e/GJ)

[1] GJ/t = gigajoules per tonne

The quantity of thermal saleable coal is based on the production rate in tpa. This is converted to GJ using an energy content factor for black coal of 27 GJ/t. The GHG emission factor and energy content for coal were sourced from the NGA Factors (**DCCEE, 2011**).

The emissions associated with the use of the product coal are presented in **Table C.5**.

Table C.5: Scope 3 emissions for energy production from product coal

Year	Product Coal (tpa)	Scope 3 Emissions (t CO2-e)
Year 1	0	0
Year 2	0	0
Year 3	177,000	422,607
Year 4	574,000	1,370,488
Year 5	1,781,000	4,252,333
Year 6	3,890,000	9,287,803
Year 7	3,227,000	7,704,817
Year 8	3,846,000	9,182,748
Year 9	4,462,000	10,653,516
Year 10	3,999,000	9,548,052
Year 11	4,472,000	10,677,392
Year 12	4,590,000	10,959,130
Year 13	4,616,000	11,021,208
Year 14	4,147,000	9,901,419
Year 15	4,197,000	10,020,799
Year 16	3,999,000	9,548,052
Year 17	5,000,000	11,938,050
Year 18	5,000,000	11,938,050
Year 19	5,000,000	11,938,050
Year 20	4,812,000	11,489,179
Year 21	4,904,000	11,708,839
Year 22	4,800,000	11,460,528
Year 23	4,480,000	10,696,493
Year 24	4,334,000	10,347,902
Year 25	4,218,000	10,070,939
Year 26	4,260,000	10,171,219
Year 27	4,126,000	9,851,279
Year 28	4,263,000	10,178,381
Year 29	4,907,000	11,716,002
Year 30	4,421,000	10,555,624
Year 31	5,000,000	11,938,050
Year 32	5,000,000	11,938,050
Year 33	4,842,000	11,560,808
Year 34	4,374,000	10,443,406
Year 35	4,788,000	11,431,877
Year 36	5,000,000	11,938,050
Year 37	4,810,000	11,484,404
Year 38	4,604,000	10,992,556
Total	**150,920,000**	**360,338,101**