APPENDIX 6

Air Quality Impact Assessment

Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

AIR QUALITY IMPACT ASSESSMENT – MOUNT OWEN CONTINUED OPERATIONS

Mount Owen Pty Limited c/- Umwelt (Australia)

Job No: 6043C

29 October 2014

PROJECT TITLE:	Air Quality Impact Assessment – Mount Owen Continued Operations
JOB NUMBER:	6043C
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EXECUTIVE SUMMARY

Pacific Environment has been engaged by Umwelt (Australia) Pty Ltd on behalf of Mount Owen Pty Limited to complete the air quality impact assessment for the Mount Owen Continued Operations Project (the Project). The Project involves the continuation of the existing mining operations at Mount Owen North Pit and the Ravensworth East Mine.

Existing Environment

The Mount Owen Complex (Mount Owen, Ravensworth East and Glendell Mines) currently operates an air quality monitoring network which monitors dust deposition, TSP and PM_{10} concentration levels. These data include all emission sources in the vicinity of the Project, including any contribution from existing operations at the Mount Owen Complex, other nearby mining operations and other localised activities. Sources of particulate matter in the area include mining activities, traffic on unsealed roads, local building and construction activities, farming, and animal grazing and to a lesser extent, traffic from the other local roads and other sources such as wood-burning fires.

The monitoring network consists of 25 dust deposition gauges. These are made up of thirteen specifically for Mount Owen and Ravensworth East, and nine for Glendell.

There are also five High Volume Air Samplers (HVAS), all measuring 24-hour average PM_{10} concentrations and four of these measuring Total Suspended Particulates (TSP), as well as five PM_{10} Tapered Element Oscillating Microbalance instruments (TEOMs).

The NSW Office of Environment and Heritage (OEH) manages the Upper Hunter Air Quality Monitoring Network consisting of 14 monitoring sites which measure continuous PM_{10} concentrations. Three of these stations also measure $PM_{2.5}$.

Meteorological Data and Models Used

The air quality assessment is based on the use of a three-dimensional computer-based dispersion model to predict ground-level pollutant concentrations, including dust, diesel and blast fume, in the vicinity of the Project. To assess the effect that emissions would have on existing air quality, the dispersion model predictions have been compared against relevant air quality criteria.

Modelling of local meteorology was undertaken using a combination of the TAPM and CALMET models. CALMET is a meteorological pre-processor endorsed by the US EPA and recommended by the NSW EPA for use in complex terrain and was used to compile a representative meteorological dataset suitable for use in the plume dispersion model CALPUFF.

Assessment Criteria

Predicted pollutant concentrations as a result of the Project have been determined following EPA's guidance document titled "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (**EPA, 2005**), which specifies the impact assessment criteria against which these have been compared. These have been applied in the assessment process following the practices used in contemporary approvals for mining projects in NSW. It also applies to the cumulative impacts resulting from the Project and surrounding approved mines and non-modelled sources.

The assessment criteria are based on considerations of possible nuisance and health effects and provide benchmarks, which are intended to protect the community against the adverse effects of air pollutants.

Best Practice Management

Mount Owen has undergone a rigorous review of its current mitigation measures, particularly in relation to particulates, as part of the Pollution Reduction Program added to its Environmental Protection Licence in 2011 as part of the EPA's Upper Hunter Air Particles Action Plan. Additional measures were identified through that process and will be incorporated into the Best Practice Management procedures as part of the proposed Project.

Impact Assessment

Predictions were made for all private and mine owned residences within the modelling domain. The majority of residences where exceedances are predicted to occur are either mine owned or currently subject to acquisition rights. There is one predicted exceedance of the 24-hour average PM_{10} acquisition criterion (Project only) at one private residence on one day in Year 10.

One privately owned residence without current acquisition rights is predicted to exceed the annual average PM_{10} cumulative criterion of 30 µg/m^3 in Year 1. That particular residence is a significant distance (12 km) from the Project, which is estimated to contribute less than 1 µg/m^3 to the total cumulative concentration. The majority of PM_{10} is due to operations at the adjacent mines, namely Integra and Rixs Creek, as well as existing background levels. Annual average PM_{10} concentrations are predicted to be above the criterion even without the Project contribution. While operations at Integra have been included in the cumulative assessment, Integra has recently been placed in care and maintenance so these predictions will be conservative.

Quantitative assessments of both diesel and blast fume have been carried out for the proposed Project. Worst-case emission scenarios were identified and dispersion modelling completed at the nearest sensitive receptors. Results showed that there may be some theoretical exceedances of the 1-hour average NO_2 criterion at the nearest mine-owned and private residences due to blast fume, when blasting occurs under certain meteorological conditions. The blast assessment is conservative, and assumes that worst-case blast fumes occur at the same time as worst-case meteorological conditions. This is very unlikely to occur in reality as Mount Owen's Blast Management Plan outlines procedures to avoid blasting during these adverse conditions.

In addition, two Glencore-owned residences, in close proximity to the North Pit showed that NO_2 levels may exceed the 1-hour average criterion due to diesel emissions in Year 10.

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1 INTRODUCTION

This report has been prepared by Pacific Environment for Umwelt (Australia) Pty Ltd (Umwelt) on behalf of Mount Owen Pty Limited (Mount Owen), a subsidiary of Glencore Coal Pty Limited, and forms an appendix to the Environmental Impact Statement (EIS) as part of application for Project Approval. The report assesses the likely air quality impacts of the proposed Mount Owen Continued Operations Project (the Project), located in the Upper Hunter Valley, New South Wales (NSW).

The air quality assessment is based on the use of a computer-based dispersion model to predict ground-level pollutant concentrations, including dust, diesel and blast fume, in the vicinity of the Project. To assess the effect that emissions would have on existing air quality, the dispersion model predictions have been compared to relevant air quality criteria, (refer to **Section 4.5**).

The assessment follows the procedures outlined by the NSW Environmental Protection Authority (EPA) in their document titled "*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*" (Approved Methods) (**EPA, 2005**). The Approved Methods specify how assessments based on the use of air dispersion models should be completed. They include guidelines for the preparation of meteorological data, emissions estimation and relevant air quality criteria.

In summary, the report provides information on the following:

- A description of operations at the site, with a focus on describing those aspects that will affect air quality,
- Air quality criteria that need to be met to protect the air quality environment,
- Meteorological and climatic conditions in the area,
- A description of the existing air quality environment including local climate and air quality monitoring data,
- The methods used to estimate emissions to air taking into account the current and proposed control measures to reduce these emissions,
- The expected dispersion patterns due to emissions from the Project and a comparison between the predicted pollutant levels and their relevant air quality criteria, and
- A description of all best practice management measures currently in place and proposed for the Project.

2 PROJECT DESCRIPTION

2.1 Overview

The Mount Owen Complex is located within the Hunter Coalfields in the Upper Hunter Valley of NSW, approximately 20 kilometres northwest of Singleton, 24 kilometres southeast of Muswellbrook and to the north of Camberwell village. The Mount Owen Complex has an approved total processing capacity of 17 Mtpa of ROM coal.

Current mining operations at the Mount Owen Complex include Mount Owen Mine (the North Pit) and associated infrastructure, Ravensworth East (West Pit), and Glendell (Barrett Pit). As part of the Project, no changes are proposed to the approved Glendell Operations. Mount Owen is seeking approval to continue open cut mining operations in the Mount Owen North Pit and to extract additional resources from the Bayswater North Pit (BNP) and the Ravensworth East Resource Recovery (RERR) mining area at Ravensworth East.

Mount Owen has identified significant additional minable coal tonnes to the southeast of the North Pit. As part of the Project, approval is being sought to continue mining of the North Pit to the south of the current approved pit limit, to enable extraction of approximately 74 million tonnes (Mt) ROM. This would extend the life of mine (LOM) from 2016 until approximately 2030. The Ravensworth East Mine's BNP and RERR includes an additional 18 Mt ROM until approximately 2027.

Mount Owen is also seeking to extend the product coal stockpile to assist with managing additional product types. In addition, upgrades to Hebden Road, the Bowmans Creek Bridge and the northern rail loop are also proposed as part of the Project. It should be noted that the maximum approved extraction of 10 Mtpa and 4 Mtpa ROM coal will not change for the Mount Owen and Ravensworth East mining areas respectively.

The Project Area is shown in **Figure 2.1**. This figure shows the various Development Consent areas that currently make up the Mount Owen Complex, as well as the proposed areas as part of the Project. The Project Area is proposed to be a combination of the existing Development Application (DA) boundaries for Mount Owen and Ravensworth East with additional areas included to capture all project aspects, such as the construction at Hebden Road.

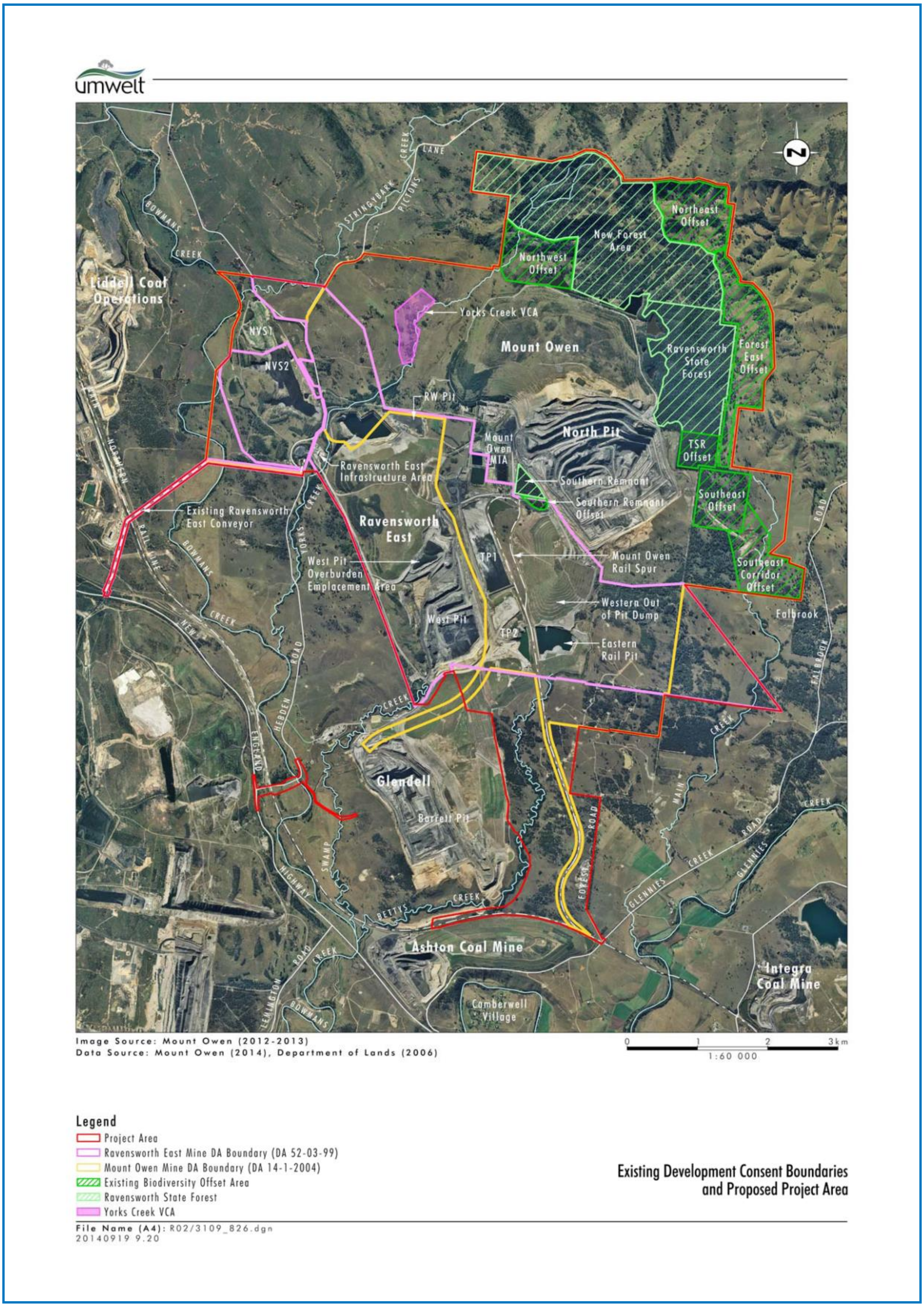


Figure 2.1: Existing Development Consent Boundaries and Proposed Project Area

2.2 Existing Mining Operations

The existing mining methods used are similar across the Mount Owen Complex, which consists of truck and excavators supported by ancillary equipment. All ROM coal mined from the North Pit, and both Ravensworth East and Glendell is processed at the Mount Owen CHPP and transported to the Port of Newcastle via the existing Mount Owen rail spur and the Main Northern Line. Tailings management is currently undertaken in accordance with the existing Mount Owen development consent at four tailings emplacements areas across the Mount Owen Complex, with an additional tailings facility, the West Pit, approved upon cessation of mining in the West Pit (part of the existing Ravensworth East Mine).

2.3 Proposed Mining Operations

Key features of the Project include:

- an approximate 381 hectare extension of the North Pit in a southern direction (from the current approved pit shell),
- mining within the Bayswater North Pit Area and overburden emplacement within the West Pit Overburden Emplacement Area and to the north of the Bayswater North Pit (until 2022),
- mining within the RERR Mining Area and overburden emplacement within the southern end of the West Pit Overburden Emplacement Area (from 2022 to 2027),
- infrastructure upgrades including:
  - provision for a northern rail line turn-out and new rail line,
  - product stockpile extension,
  - Mining Infrastructure Area (MIA) improvements,
  - The CHPP facilities will be upgraded to improve coal recovery and reduce water usage which will be achieved through the installation of flotation treatment at the CHPP;
  - Hebden Road overpass over Main Northern Rail Line,
  - New Hebden Road bridge crossing over Bowmans Creek,
  - continued use of Ravensworth East voids (including West Pit and the RERR Mining Area) for tailings emplacement, and
- an extension of mine life for 21 years (from the date of approval).

The current operating hours are 24-hours per day, seven days per week, with the exception of blasting which occurs between the hours of 9am to 5pm (EST) and 9am to 6pm (DST) Monday to Saturday. In addition, Mount Owen's approval allows for up to 12 blasts per year within the North Pit between 7am and 9am, Monday to Saturday (inclusive). There are no proposed changes to these hours.

An indicative ROM coal and waste production schedule for the Project is provided in **Table 2.1**. The years highlighted were those chosen for modelling. These years are representative of significant stages of the Project as well as worst-case operational and cumulative years.

These stages can be seen clearly in **Figure 2.2**, which presents the same information in graphical form. Year 1 represents the beginning of the Project, while Year 5 represents the year of maximum combined overburden and ROM production. Year 10 represents the last year before a step-change decrease in production. The total material moved in Year 9 is slightly higher than in Year 10, but in Year 10 the pit has progressed further to the southeast and is closer to the residences in the Middle Falbrook area. There is a clear rapid decline in production each year from Year 11 to Year 15.

Table 2.1: Indicative production schedule for the Project

Project Year	Overburden/Waste Mbcm (Mt)*	ROM mined Mt
Year 1	48.3 (114.0)	10.4
Year 2	42.5 (100.3)	10.0
Year 3	44.6 (105.3)	10.1
Year 4	47.1 (11.2)	9.8
Year 5	48.4 (114.2)	11.7
Year 6	41.6 (98.2)	8.1
Year 7	39.4 (93.0)	8.3
Year 8	40.7 (96.1)	5.9
Year 9	42.4 (100.1)	7.3
Year 10	41.1 (97.0)	7.3
Year 11	35.7 (84.3)	6.2
Year 12	27.4 (64.7)	5.9
Year 13	22.8 (53.8)	5.3
Year 14	27.9 (65.8)	4.9
Year 15	14.9 (35.2)	4.5

* The value in brackets is in million tonnes (Mt), converted from million bank cubic metres (Mbcm) by multiplying by an average material density of 2.3 t/bcm

Note: This production schedule is based on the conceptual mine plan, is indicative only and includes mining in North Pit, BNP and RERR. There may be refinements and adjustments to yearly production as the project progresses.

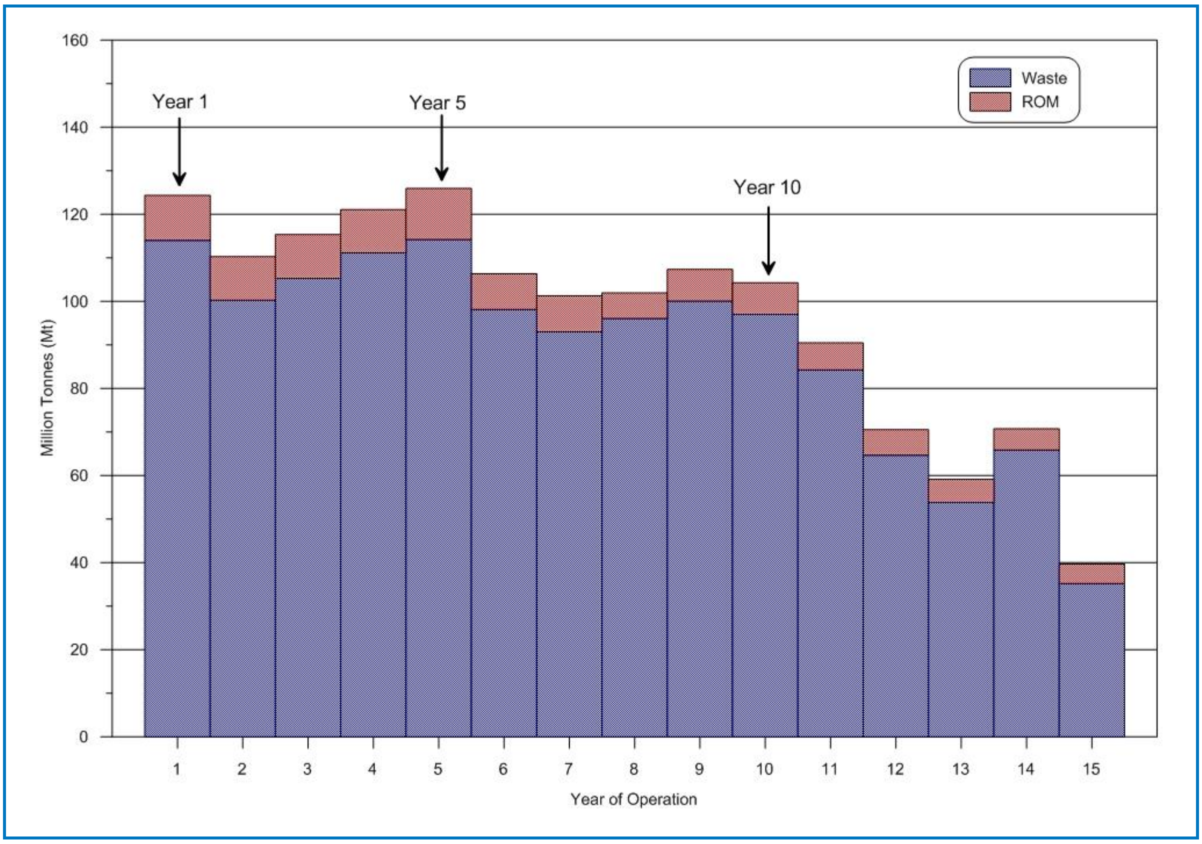


Figure 2.2: Indicative Overburden/Waste and ROM Production rates throughout the Project (combining North Pit, BNP and RERR)

2.4 Coal Handling and Transport

No changes are proposed to the Mount Owen CHPP processing and load out capacity of 17 Mtpa ROM coal, with the CHPP and rail load-out operations to continue to process coal on a 24 hour, 7 days per week basis. However, it is proposed for the CHPP facilities to be upgraded to improve coal recovery and reduce water usage which will be achieved through the installation of flotation treatment at the CHPP.

ROM coal is currently trucked to the ROM coal stockpile and is crushed, screened and then loaded to the CHPP where it is washed. Coarse rejects and fine tailings are generated at the washplant. Product coal is transferred from the CHPP to the product stockpile via a rail mounted stacker and reclaimed for train load-out via coal valves.

Mount Owen will continue to use Ravensworth East voids for tailings emplacement. Coarse reject material from the Mount Owen CHPP is incorporated into the overburden emplacement areas within the Mount Owen Complex, namely the North Pit, West Pit, BNP and RERR Mining Area. Tailings from the Mount Owen CHPP will be pumped to tailings emplacement areas as required to allow sufficient time for dewatering and consolidation. Typically, multiple tailings emplacement areas are required in order to achieve adequate deposition rates that will facilitate stable capping and rehabilitation at cessation. Where possible tailings disposal areas will be compartmentalised to achieve planned rise rates to assist with capping and rehabilitation works.

The Project will continue to utilise the existing Mount Owen Complex rail line that services the Mount Owen Complex. In addition, Mount Owen is seeking approval for the provision of an additional rail line and northern turn-out west of the existing rail line. The existing rail line would be used primarily as a siding for parking of Glencore Rail Fleet when not in service and minor maintenance area.

The Project would involve the transport of the majority of product coal by rail to the Port of Newcastle for sale to the export market. The ability for the transport of some ROM coal to Bayswater and Liddell Power Stations via the Ravensworth East conveyor and M-series conveyor would be maintained. Additionally the Project would provide for the transportation of up to 2 Mtpa ROM coal and crushed gravel on an as required basis via the existing overland conveyor to Liddell Coal Operations and the RCT in addition to maintaining the current approval to transport ROM coal to Bayswater and Liddell power stations.

2.5 Road Diversions and Upgrades

The Project includes the construction of a rail overpass for road traffic adjacent to the existing level crossing where Hebden Road crosses the Main Northern Rail Line. Due to the anticipated increase in future train movements on this line as a result of anticipated western coal expansion, the purpose of the proposed rail overpass construction is to improve traffic flow and reduce traffic hazards by eliminating the potential for traffic to queue back onto the New England Highway.

Further to the east of the Main Northern Rail Line, Hebden Road crosses over Bowmans Creek via the single lane, Bowmans Creek Bridge. As part of the Project, Mount Owen proposes to construct a new bridge to allow for two-way traffic movements. This will provide further improvements to road traffic safety.

3 LOCAL SETTING

The Project is situated in a largely rural area with agriculture and coal mining being the predominant industries in the Hunter Valley. Agricultural activities comprise of viticulture and other cropping, horse breeding and pastoral activities. However, there are no critical industry clusters within the vicinity of the Project. The established mining operations located within 10 kilometres of the Project Area include Glendell Mine, Liddell Coal Operations, Ravensworth Underground, Ravensworth Surface Operations, Integra Mine, Rixs Creek Mine and Ashton Mine.

Topography is variable across the Project area, ranging from below 100 m to the south near Camberwell, to over 500 m along the ridges to the northwest and to the east. **Figure 3.1** shows a pseudo three dimensional representation of the local topography in the Project area and surrounds.

Figure 3.2 shows the land ownership details and the locations of the nearest private residences in the vicinity of the Project.

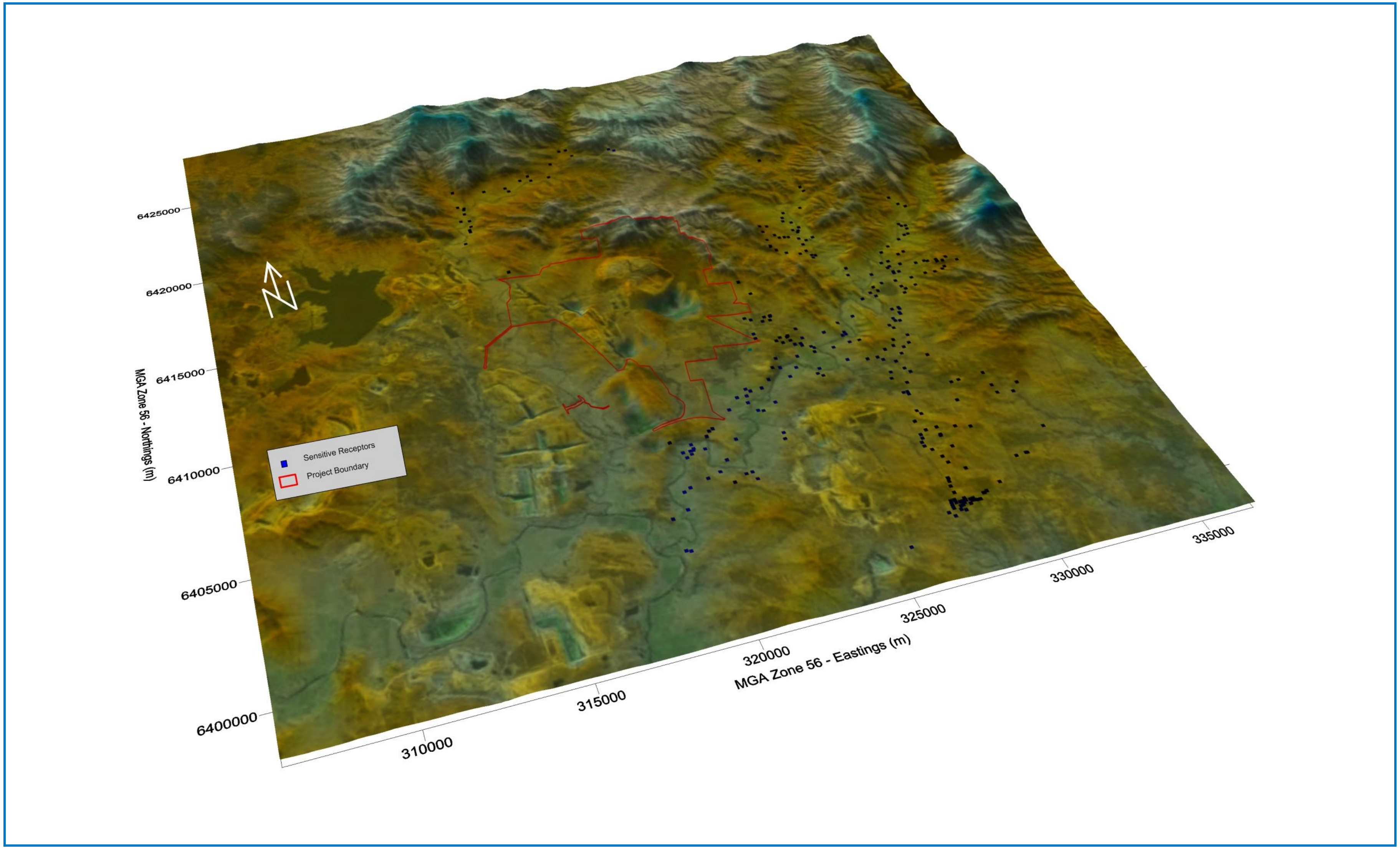


Figure 3.1: Pseudo three-dimensional plot of local topography

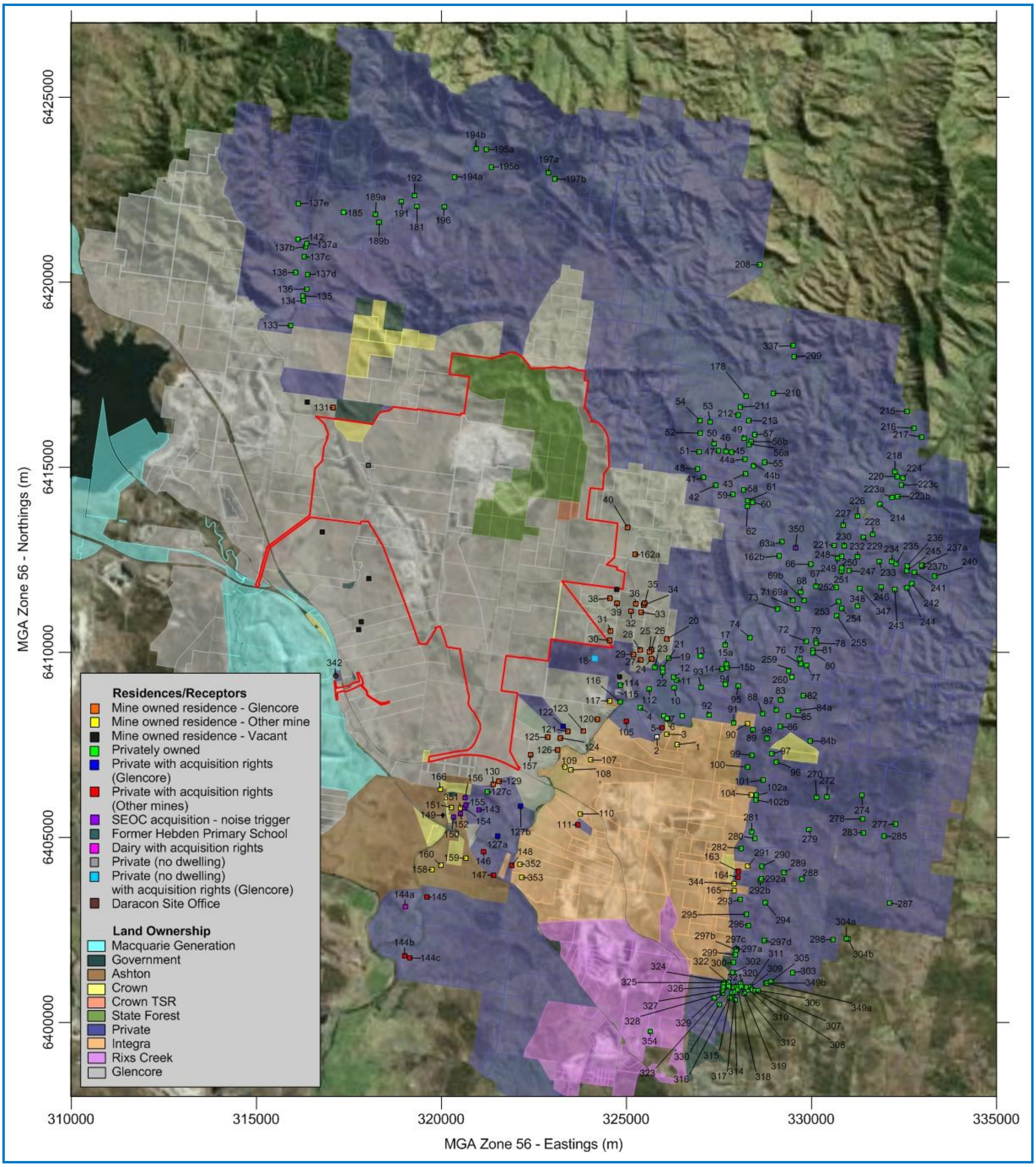


Figure 3.2: Land ownership and receptor locations

4 LEGISLATIVE SETTING

4.1 Introduction

Project mining activities described in **Section 2** have the potential to generate fugitive dust emissions in the form of particulate matter described as total suspended particulate matter (TSP), particulate matter with an equivalent aerodynamic diameter of 10 micrometres (µm) or less (PM_{10}) and deposited dust emissions. In addition, combustion engines of generators and vehicles release emissions through engine exhausts including carbon monoxide (CO), minor quantities of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). Diesel combustion also results in the emission of fine particulate matter and fumes from blasting will result in emissions of oxides of nitrogen.

Other emissions to air from the Project include greenhouse gases (GHG) such as fugitive methane (CH_4) from exposed coal, carbon dioxide (CO_2) from the combustion of fuel in combustion engines, blasting and indirect GHG emissions from the combustion of coal produced off-site. GHG's are not included in this report and are covered in a GHGEA by Umwelt (2014). This assessment is included as a separate Appendix in the EIS.

The following sections provide information on the relevant government requirement guidelines and air quality criteria used to assess the impact of pollutant emissions. To assist in interpreting the significance of predicted pollutant levels some background discussion is also provided.

4.2 Environmental Planning and Assessment Act 1979

The Environmental Planning and Assessment Act 1979 (EP&A Act) requires that consideration be given to environmental impacts as part of the land use planning process. In NSW, environmental impacts are interpreted as including impacts to air quality.

Division 4.1 of the EP&A Act provides for a new planning assessment and determination regime for State Significant Development (SSD). Section 89C of the EP&A Act stipulates that a development will be considered an SSD if it is declared to be such by the State Environmental Planning Policy (State and Regional Development) 2011 (SEPP SRD).

Under Clause 8(1) of SEPP SRD, a development is declared to be State Significant Development if:

a) the development on the land concerned is, by the operation of an environmental planning instrument, permissible with development consent under Part 4 of the EP&A Act.

b) the development is specified in Schedule 1 or 2 of SEPP SRD.

The Project is an SSD as it meets both of these criteria, namely:

- it is permissible with development consent on the land on which it is located, and
- it is a development that is specified in Schedule 1 of SEPP SRD.

This impact assessment has been prepared in accordance with Division 4.1 of Part 4 of the EP&A Act. The EP&A Act requires that environmental impacts including air quality impacts be assessed and mitigated where necessary. The EIS, including this air quality assessment, was prepared in accordance with the Department of Planning and Environment (DP&E), Director General's Requirements (DGRs) for the EIS as outlined in the following section.

4.3 Director-General's Requirements

The Air Quality Assessment has been prepared in accordance with the NSW EPA Approved Methods (**EPA, 2005**) and in consideration of the DGRs for the EIS and EPA agency comments provided to the Director General. The assessment has also been subject to an independent peer review with regard to modelling inputs, methodologies, results and conclusions (refer to **Appendix A**). **Table 4.1** and **Table 4.2** summarise the DGRs and EPA's agency comments, respectively, and the section of the report in which they are addressed.

Table 4.1: Director-General's Requirements

Requirements for Air Quality	Section addressed
… including a detailed quantitative assessment of potential construction, operational and cumulative air quality impacts on all potential receivers including:	
- dust impacts on privately-owned properties, mine-owned properties and properties in the acquisition zone of Mount Owen or any other mine,	Section 10
- 24-hour cumulative PM_{10} emissions using an appropriate probabilistic methodology, project-specific and cumulative $PM_{2.5}$ emissions, and dust generated by the transportation of coal,	Section 10.4, Section 10.2, Section 10.3 and Section 8.1.3
- fumes from diesel, blasting activities and spontaneous combustion,	Section 11, Section 11.3 and Section 12
- reasonable and feasible mitigation measures to minimise dust, diesel and blast fume emissions, including evidence that there are no such measures available other than those proposed, and	Section 6.4 and Section 13
- monitoring and management measures, in particular real-time air quality monitoring and adaptive management protocols.	Section 13

Table 4.2: EPA specific agency comments

Air Quality	Section addressed
Assess the risk associated with the 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.	Throughout report
Justify the level of assessment undertaken on the basis of risk factors, including but not limited to: proposed location, characteristics of the receiving environment and type and quantity of pollutants emitted.	Throughout report
Describe the receiving environment in detail, including but not limited to meteorology and climate, topography, surrounding land-use and receptors and ambient air quality	Section 3 and Section 5
Include a detailed description of the proposal. All processes that could result in air emissions (including blasting) must be identified and described.	Section 2, Section 8 and Section 9
Include a consideration of 'worst case' emission scenarios and impacts at proposed emission limits.	Section 2.3, Section 8, Section 9 and Section 10
Account for cumulative impacts associated with existing emission sources as well as any currently approved developments linked to the receiving environment.	Section 10.3 and Section 10.4
Include air dispersion modelling where there is a risk of adverse air quality impacts. Air dispersion modelling must be conducted in accordance with the Approved Methods. It is noted that the assessment of deposited dust and Total Suspended Particles is not required for coal mines in the Singleton or Muswellbrook LGAs[a], but that cumulative 24-hour PM_{10} emissions are required to be assessed.	Section 10
Demonstrate the proposal's 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 4.9
Provide an assessment of the project in terms of the priorities and target adopted under the NSW State Plan 2010	Section 4.6
Detail emissions control techniques/practices that will be employed by the proposal and demonstrate that there are best management practice, by applying the procedure outlined in Coal Mine Particulate Matter Control Best Practice – Site-specific determination guideline (November 2011).	Section 6.4 and Section 13

[a] It is noted that the assessment of deposited dust and TSP is not required as this Project is in the Singleton LGA. However, this assessment has been carried out for completeness and transparency in the environmental assessment process.

4.4 Air Quality Issues and Effects

From an air quality perspective, it is important to consider the potential emissions that would occur during the operation of the Project. The key pollutants for the Project will be those associated with mining operations, diesel vehicle exhaust and blasting.

Pollutants from mining operations, diesel exhaust and blasting include particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen (NO_x), carbon monoxide (CO) and sulphur dioxide (SO_2). The focus of this assessment will be on the key pollutants of particulate matter (PM) and NO_x. In terms of total emissions, coal mining activities are not significant sources of CO and SO_2, in comparison to pollutants such as particulate matter and NO_x. They are not considered key indicator pollutants for this assessment as is shown in **Section 11.3**.

4.4.1 Particulate Matter

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:

- TSP – refers to all suspended particles in the air. In practice, the upper size range is typically 30 µm.
- 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 (**WHO, 2011**). 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 not able to affect health, 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, 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 materials from roads, farming, mining and dust storms. 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. Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosol from volatile organic compound emissions. $PM_{2.5}$ 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 and is a key consideration in assessing exposure.

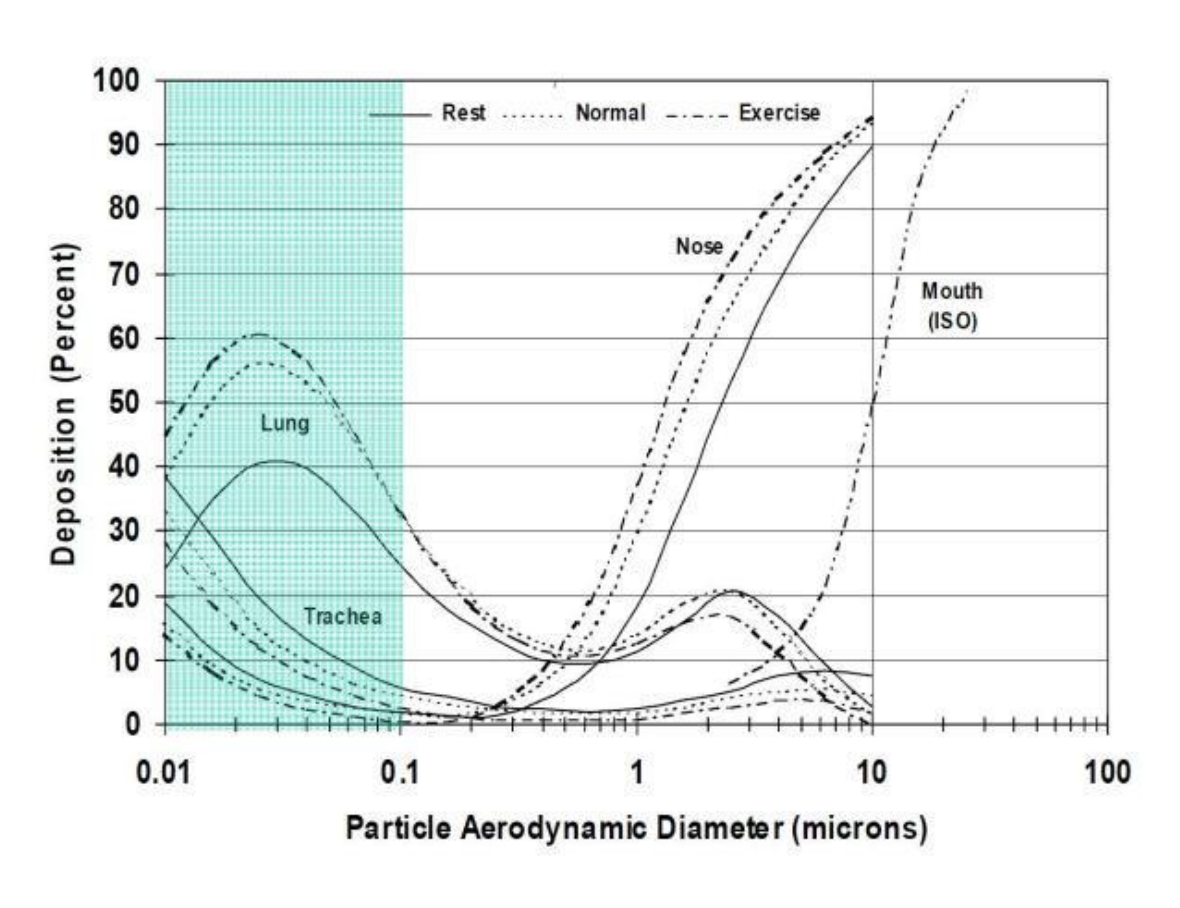


Figure 4.1: Particle Deposition within the Respiratory Tract (*Phalen et al, 1991*)

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 substances that are associated with combustion.

4.4.2 Oxides of Nitrogen (NO_x)

Oxides of nitrogen (NO_x) are produced when fossil fuels are combusted in internal combustion engines (e.g. motor vehicles, mine equipment). NO_x emitted by fossil fuel combustion are comprised mainly of nitric oxide (NO) and nitrogen dioxide (NO_2). NO is much less harmful to humans than NO_2 and is not generally considered a pollutant at the concentrations generally found in urban environments. In open-cut mining there is also potential for NO_2 to form as a result of blasting (see **Section 11**) and diesel emissions from mining machinery (see **Section 11.3**).

NO_2 is the regulated oxide of nitrogen in NSW and effects of exposure to NO_2 include irritation of the lungs and lower resistance to respiratory infections such as influenza. The effects of short-term exposure are still unclear, but continued or frequent exposure to concentrations that are typically much higher than those normally found in the ambient air may cause increased incidence of acute respiratory illness in children. Concern with NO is related to its transformation to NO_2 and its role in the formation of photochemical smog.

Typically, close to the combustion sources (such as trucks and locomotives), NO_2 makes up 5 to 20 per cent by weight of the total oxides of nitrogen. At the point of emission, NO_x would consist of approximately 90-95% of NO and 5-10% of NO_2, the regulated oxide. The dominant short term conversion is NO to NO_2 through oxidation with atmospheric ozone (O_3) as the plume travels from source.

$$NO + O_3 \equiv NO_2 + O_2$$

Therefore, to predict the ground level concentration of NO_2 it is important to account for the transformation of NO_x to NO_2.

The transformation of NO_x to NO_2 in this report is derived using the US EPA's Ozone Limiting Method (OLM) which assumes that all the available ozone in the atmosphere will react with the NO in the plume until either all the O_3 or all the NO is used up.

Using the OLM, NO_2 concentrations are derived as follows:

$$[NO_2]_{total} = \{0.1 \times [NO_x]_{predicted}\} + MIN\{(0.9) \times [NO_x]_{predicted} \; or \; \left({}^{46}\!/_{48}\right) \times [O_3]_{background}\} + [NO_2]_{background}$$

The OLM is generally considered a conservative approach and is therefore appropriate for this assessment (**Tikvart, 1996**).

4.5 NSW EPA Impact Assessment Criteria

The Approved Methods specify impact assessment criteria relevant for assessing impacts from air pollution (**EPA, 2005**). The impact assessment criteria for pollutants relevant to this assessment refer to the total pollutant load in the environment and impacts from new sources of these pollutants must be added to existing background levels for compliance assessment. In other words, consideration of background dust levels needs to be made when using the goals outlined in the Approved Methods to assess potential impacts. These criteria are health-based, that is they are set at levels to protect against health effects, including for the most vulnerable in society.

These criteria are consistent with the National Environment Protection Measures for Ambient Air Quality (referred to as the Ambient Air-NEPM) (**NEPC, 1998a**). However, the EPA's criteria includes averaging periods, which are not included in the Ambient Air-NEPM, and also references other measures of air quality, namely dust deposition and TSP. While the assessment of TSP and dust deposition was not specifically required in the DGRs for this Project, they have been assessed to provide comprehensive information for the community as this provides indicators of amenity rather than health.

In May 2003, the NEPC released a variation to the Ambient Air-NEPM (**NEPC, 2003**) to include advisory reporting standards (ARS) 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 10**).

Table 4.3 summarises the air quality criteria and NEPM standards for concentrations of particulate matter that are relevant to this study. It is important to note that these criteria are applied to the cumulative impacts due to the Project and other sources.

In addition, contemporary project approval and development consent conditions issued by DP&E have also referenced short-term criteria for property acquisition on the basis of predicted air quality, as listed in **Table 4.4**. Applicants have typically been required to acquire land on request when the maximum 24-hour average PM_{10} level exceeds 50 µg/m³ (Project alone) and 150 µg/m³ cumulatively, at any residence on privately-owned land. Long term criteria for property acquisition (annual average PM_{10}, TSP, Dust Deposition) are the same as those listed in **Table 4.3** and **Table 4.5**.

Table 4.3: EPA air quality impact assessment criteria and NEPM advisory reporting standards for particulate matter concentrations

Pollutant	Averaging period	Criteria/ARS	Agency
PM_{10}	24-hour maximum	50 µg/m³	EPA impact assessment criteria (cumulative) Ambient Air-NEPM reporting goal, allows five exceedances per year for bushfires and dust storms
	Annual mean	30 µg/m³	EPA impact assessment criteria (cumulative)
$PM_{2.5}$	24-hour maximum	25 µg/m³	Ambient Air-NEPM Advisory Reporting Standard (cumulative)
	Annual mean	8 µg/m³	
TSP	Annual mean	90 µg/m³	National Health and Medical Research Council (cumulative)

Note: µg/m³ – micrograms per cubic metre

Table 4.4: Recent DP&E short-term acquisition criteria for PM_{10}

Pollutant	Averaging period	Criteria	Project only or cumulative
PM_{10}	24-hour maximum	50 µg/m³	Project only
		150 µg/m³	Cumulative

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 fallout 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 4.5 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.

Table 4.5: EPA criteria for dust deposition (insoluble solids)

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m²/month	4 g/m²/month

Note: g/m²/month – grams per square metre per month

Table 4.6 summarises the air quality criteria for concentrations of nitrogen dioxide (NO_2) that are relevant to this study in the diesel fume and blast assessments.

Table 4.6: EPA criteria for NO_2

Pollutant	Averaging period	Criteria	Agency
Nitrogen dioxide (NO_2)	1-hour	246 µg/m³	EPA Impact Assessment Criteria **EPA (2005)**
	Annual	62 µg/m³	

4.6 NSW State Plan Action for Air

In March 2010, the NSW Government released the NSW State Plan (**DPC, 2010**), its "long term plan to deliver the best possible services to the people of NSW". This document outlines a number of priorities and targets for NSW, identifying improvements in air quality and progress on reducing GHG emissions as priorities. The NSW State Plan sets ambitious goals based largely on community consultation and includes a target to meet the national air quality goals as identified in the Air NEPM.

Coal mining is not identified specifically in the list of areas to be targeted, which includes such things as:

- vapour recovery at petrol stations
- reductions in motor vehicle emissions
- reductions in emissions from other domestic and commercial equipment such as lawn mowers, adhesive and coating products and outboard motors

Industrial emissions are mentioned in the context of "better managing emissions of ozone-forming substances from new and existing industrial sources", rather than reducing particulate emissions. However, as outined in this assessment, this Project aims to implement best management practice and all practical associated mitigation measures in order to reduce particulate emissions. Ozone-forming substances, such as oxides of nitrogen, are also addressed in this report in terms of emissions from blasting and diesel fumes.

In 1998, the NSW Government implemented a 25 year air quality management plan, "Action for Air, for Sydney, Wollongong and the Hunter Valley". This was updated in 2009 (**EPA, 2009**) and is a key strategy for implementing the NSW 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 aims of Action for Air include:

- Meeting the national air quality standards for six pollutants as identified in the Ambient Air NEPM.
- 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}. 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. The main pollutants from the Project that is relevant to the Action for Air are PM_{10} and NO_2 (converted from NO_x).

The Project addresses the aims of the Action for Air Plan in the following ways:

- Pacific Environment has reviewed potential mitigation measures with reference to best practice and a range of measures have been adopted for the Project (**Section 13**).
- Air quality emissions potentially associated with the Project have been quantified (**Section 8** and **Section 9**).
- Dispersion modelling has been conducted by Pacific Environment 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 10**, **Section 11** and **Section 11.3**).

4.7 NSW 2021 and the Upper Hunter Air Particles Action Plan

NSW 2021 (**DPC, 2011**) is a 10-year plan developed by the NSW Government for change in NSW, and replaces the NSW State Plan in setting priorities for action in NSW. It is based around five key strategies, each of which has particular priorities and targets. These strategies are to:

- Rebuild the economy (Goals 1 to 6)
- Return quality services (Goals 7 to 18)
- Renovate infrastructure (Goals 19 to 21)
- Strengthen local environment and communities (Goals 22 to 28)
- Restore accountability to government (Goals 29 to 32)

Goal 22 in NSW 2021, 'to protect our natural environment', includes actions to provide information to local communities on air quality and to reduce particulate emissions from coal mines. The Upper Hunter Region has become a major focus for these actions and to this end, NSW 2021 includes targets to:

- Deliver 14 air quality monitoring sites for the Hunter by December 2011 giving the community local and timely information on air quality (completed)
- Require and support NSW coal mines to reduce dust emissions (continuing progress in the form of Pollution Reduction Programs)

A range of measures either already in place or being developed to improve air quality in the Upper Hunter and achieve these targets, are outlined in the Upper Hunter Air Particles Action Plan (UHAPAP) (**EPA, 2013**). There are five areas which the EPA have identified in the UHAPAP to improve air quality in the Upper Hunter and each of these areas have associated actions which have either been completed or are in the process of being actioned. The five areas and the associated actions, not all of which are related to coal mining, are summarised in **Table 4.7**.

Table 4.7: Actions from the Upper Hunter Air Particles Plan

Target Area	Action
Reducing particle emissions from coal mine operations	Action 1: Develop consent conditions Action 2: Improve links between consent conditions and environmental licences **Action 3: Continued inspection of mining operations and enforcement of conditions** **Action 4: Implement the Dust Stop program** **Action 5: Rehabilitation outcomes** **Action 6: Commence diesel emissions management review of mine sites** Action 7: Further monitoring of dust along the rail corridor
Using strategic planning and guidance	Action 8: Development of guidance material for Director General's requirements Action 9: Implementation of the strategic regional land use plan
Reducing particle emissions from other sources (that is, other than coal mining)	Action 10: Promote the Clean Machine Program in the Upper Hunter Action 11: Promote and support local government participation in the wood smoke program
Engaging and informing communities and industry stakeholders	Action 12: Engage stakeholders Action 13: Report air quality data Action 14: Regulate ongoing industry funding of monitoring network Action 15: Update the NSW Air Emission Inventory
Improving understanding of particles	Action 16: Independent air quality advice to the Government Action 17: Release the results of the Upper Hunter Fine Particle Characterisation Study Action 18: Develop a model of $PM_{2.5}$ in the Upper Hunter airshed

Actions 3 to 6 are those which apply specifically to operations at individual mines. In particular, the Dust Stop program, through PRPs attached to environmental protection licences, has required each NSW coal mine to assess its operations against best practice and identify feasible improvements to reduce dust emissions (Action 4). This was done for the Mount Owen Complex (**Xstrata, 2012**) and the outcomes for Mount Owen are discussed in **Section 6.4**. These outcomes will become part of future operations for the Project. Three new PRPs issued in March 2013, are currently being actioned and any new outcomes will be adopted for the Project.

Action 17 notes the Upper Hunter Fine Particle Characterisation Study (UHFPCS), which was released in September 2013 (**OEH, 2013**). The aim of that study was not to quantify the total contribution of coal dust to the particle loadings, but rather to identify the sources that contribute to $PM_{2.5}$ at Singleton and Muswellbrook.

In summary, the results from the UHFPCS showed that mining is not the main contributor to $PM_{2.5}$ concentrations in the Hunter Valley, but that these emissions are generally in the coarser $PM_{2.5-10}$ fraction. It should be noted that this discussion specifically referred to fugitive dust emissions (crustal) from coal mines.

4.8 The Best Practice Report

The NSW EPA commissioned 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). This report is a review of the coal mining activities in NSW.

The Best Practice Report provides a guidance of controls for reducing emissions and is benchmarked on the international best practice for the following relevant activities:

- Haul roads
- Wind erosion of exposed materials and stockpiles
- Bulldozing
- Blasting
- Drilling
- Loading and dumping overburden
- Loading and dumping ROM coal
- Monitoring, proactive and reactive management

The full set of potential best practice control measures for each of these activities, along with the controls to be adopted by the Project, have been summarised in **Section 6.4**.

4.9 Protection of the Environment Operations Act 1997

Mount Owen currently holds Environment Protection Licence (EPL) 4460 issued by the EPA under the *Protection of the Environment (Operations) Act 1997* (POEO Act). Relevant to air quality, the EPL includes a requirement to minimise dust emissions and specifies dust deposition and PM_{10} sampling requirements. In addition, the *NSW POEO (Clean Air) Regulation 2010* prescribes requirements for domestic solid fuel heaters, control of burning, motor vehicle emissions and industrial emissions (such as Volatile Organic Carbons). Motor vehicle emissions would be addressed by regular maintenance of all vehicles associated with the Project.

5 EXISTING ENVIRONMENT

The Mount Owen air quality monitoring network currently consists of an array of meteorological stations, dust deposition gauges and particulate monitoring sites. The locations of these are shown in **Figure 5.1**, and data collected from each site are described in the following sections.

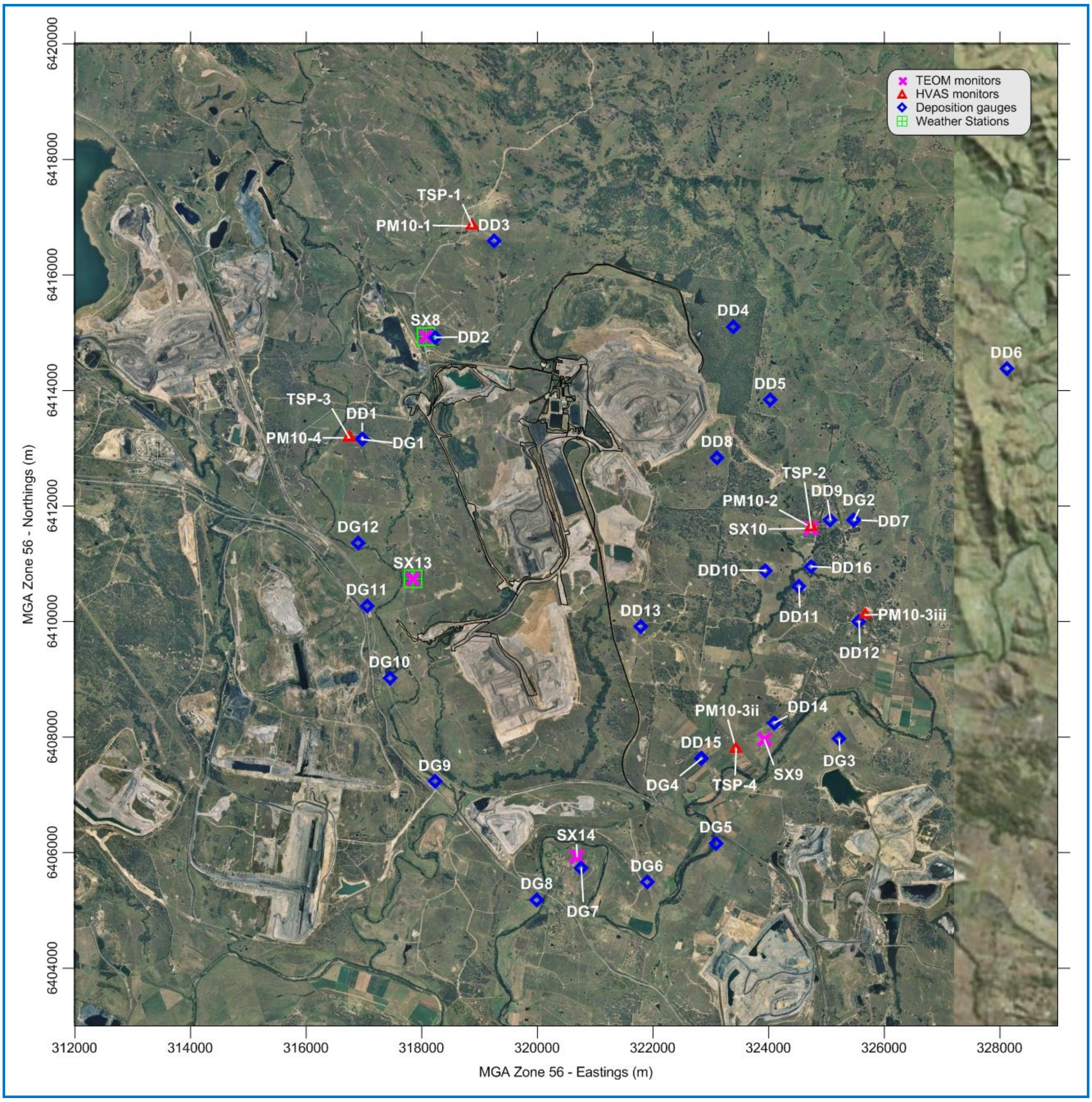


Figure 5.1: Locations of Mount Owen dust monitoring and meteorological stations

5.1 Meteorology

5.1.1 Representative Meteorological Data

An analysis of the meteorological data collected at SX8 and SX13 between January 2009 and August 2012 was competed to determine the most representative 1-year period suitable for air dispersion modelling. The period chosen for modelling was the 12 month period from 1 September 2011 to 31 August 2012 (referred to as 2011/2012 below).

The percentage of calms experienced at SX8 and SX13 are generally consistent from 2009 to 2012. However, there are a significant percentage of calms at the SX13 station in autumn 2009 compared to the other years (refer to **Table 5.1**) which may be the result instrumentation malfunction. Regardless of whether or not this is the case, the data capture rate is very low at SX13 for 2009, and is not used for this assessment.

In accordance with EPA guidelines for air dispersion modelling, the meteorological dataset needs to be >90% complete. The only periods where both SX8 and SX13 are >90% complete in the analysis period, are 2011 and 2011/2012. These two yearly datasets are also very similar to each other at both monitoring sites, in terms of the percentage of calms experienced in each season. That is the percentages of calms in 2011 at SX8, are similar to those measured in the 2011/2012 dataset at the same station.

Table 5.1: Percentage of calm periods in SX8 and SX13 meteorological data

Period	SX8				SX13			
	2009	2010	2011	2011/2012	2009	2010	2011	2011/2012
All	6.5%	8.2%	7.9%	8.3%	20.1%	3.2%	2.9%	4.0%
Summer	4.0%	5.8%	5.7%	7.7%	2.9%	2.3%	2.1%	3.7%
Autumn	10.1%	11.0%	9.9%	11.1%	59.6%	4.0%	3.6%	3.9%
Winter	7.1%	10.0%	8.2%	7.2%	3.0%	4.1%	2.4%	5.4%
Spring	4.3%	6.7%	8.0%	7.3%	1.8%	2.3%	3.2%	3.2%
Percentage complete	**95%**	**87%**	**99%**	**100%**	**77%**	**98%**	**99%**	**100%**

Note: At the time that meteorological data were compiled for modelling purposes the data for 2013 were not yet available.

Annual and seasonal windroses for SX8 and SX13 are shown for the entire data period (2009 – 2012) in **Figure 5.2**, and for the 2011/2012 modelling period in **Figure 5.3**. The patterns are similar for each data period, with no major variations in wind speeds and directions at either monitoring location. There is a slight rotation in predominant wind directions at the SX8 site, particularly in the summer months, but it is not a significant rotation and wind directions remain within the same quadrant.

On the basis of the percentage of calms, the completeness of the data and the predominant wind direction, 2011/2012 was chosen as a suitable and representative modelling year.

5.1.1 Wind speed and direction

The windroses presented in **Figure 5.2** and **Figure 5.3** show that on an annual basis, winds are predominantly from the northwest and southeast quadrants. The predominant wind directions in summer are from the south-southeast and southeast while winter shows more prominent winds from the northwest and north-northwest. Spring and autumn also reflect this pattern. This pattern is typical of that found in the Hunter Valley and is shown in both the complete data set as well as the modelling year.

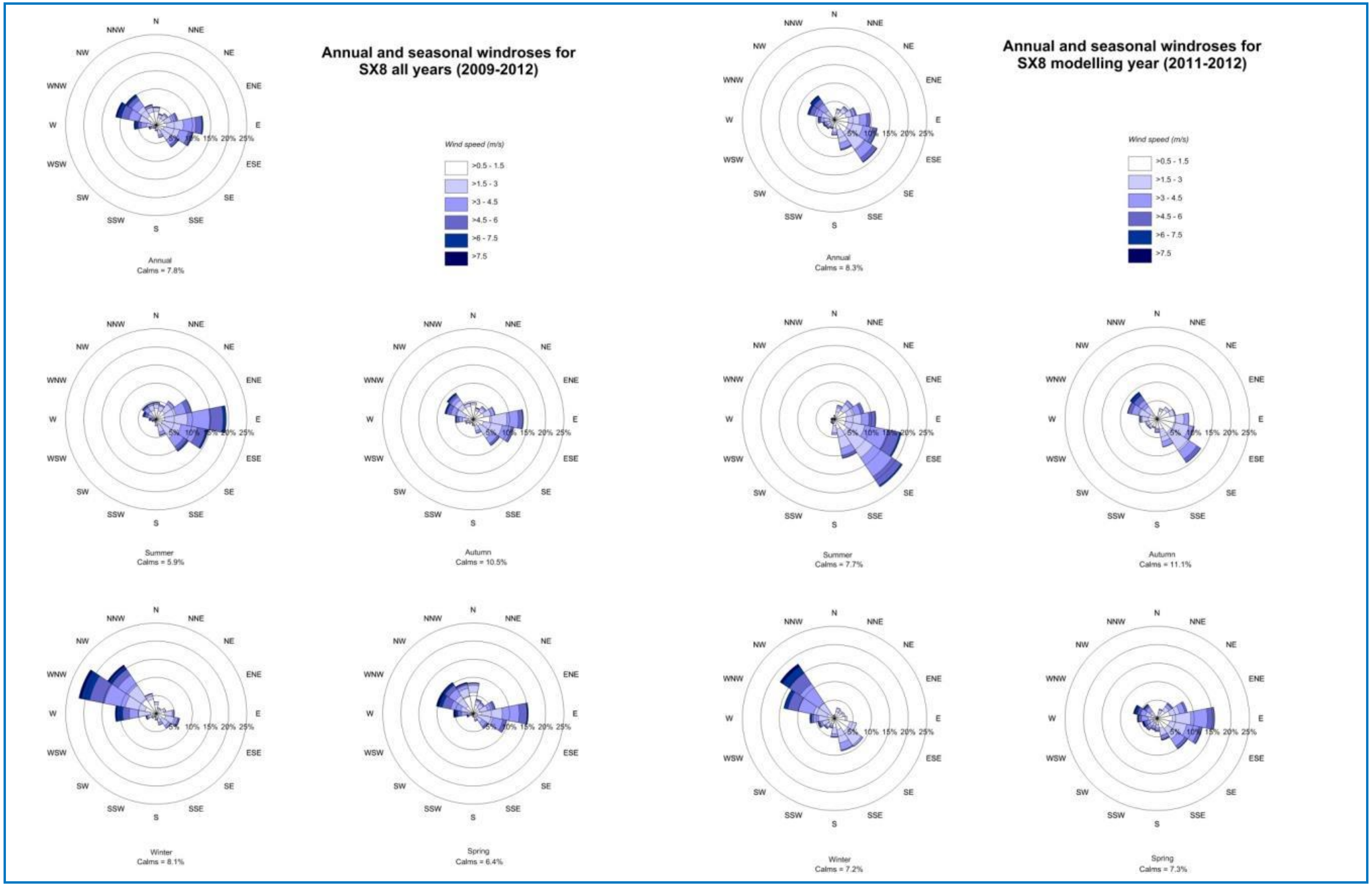


Figure 5.2: Annual and seasonal windroses at SX8 for all data (2009 – 2012) and for the modelling year (2011/2012)

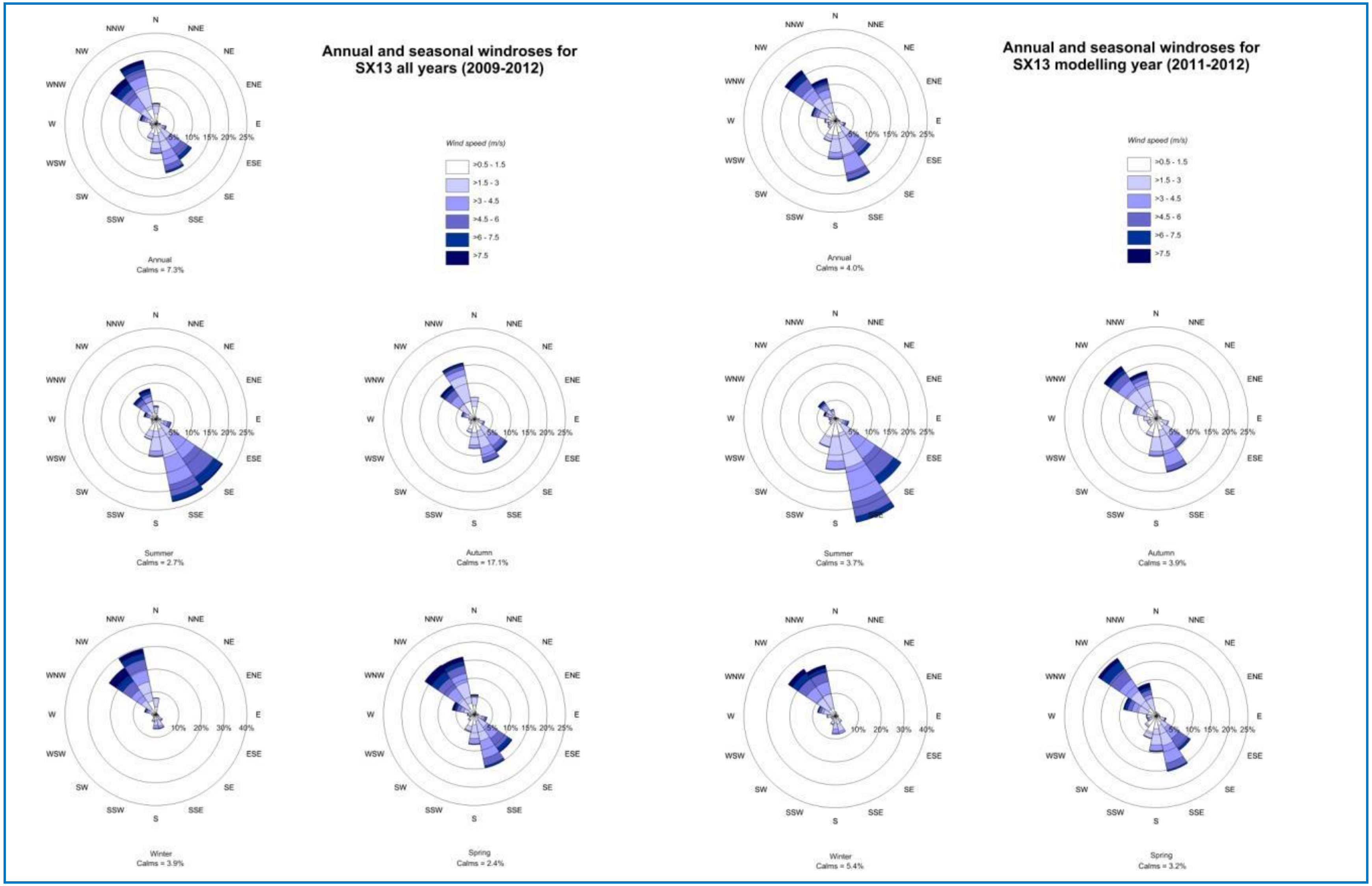


Figure 5.3: Annual and seasonal windroses at SX13 for all data (2009 – 2012) and for the modelling year (2011/2012)

5.2 Local Climate Conditions

The nearest Bureau of Meteorology (BoM) site to collect climatic information in the vicinity of the Project Area is Jerrys Plains. A range of climatic information has been collected from Jerrys Plains (Post Office) since 1884. This station is located approximately 19 km from the Project Area, and the data are presented in **Table 5.2** (**BoM, 2014**). Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures experienced at Jerrys Plains are 25.2°C and 10.6°C respectively. On average January is the hottest month, with an average maximum temperature of 31.7°C. July is the coldest month, with average minimum temperature of 3.8°C.

The annual average relative humidity reading collected at 9 am from the Jerrys Plains site is 70% and at 3 pm the annual average is 47%. The month with the highest relative humidity on average is June with a 9 am average of 80%. The months with the lowest relative humidity are October, November and December with a 3 pm average of 42%.

Rainfall data collected at Jerrys Plains shows that February is the wettest month, with an average rainfall of 73.1 mm over 6 rain days. The average annual rainfall is 646 mm with an average of 67 rain days.

Table 5.2: Climate Information for Jerrys Plains (1884 – 2014)

Statistic Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean maximum temperature (C)	31.7	30.9	28.9	25.3	21.3	18.0	17.4	19.4	22.9	26.2	29.1	31.2	25.2
Mean minimum temperature (C)	17.2	17.1	15.0	11.0	7.4	5.3	3.8	4.4	7.0	10.3	13.2	15.7	10.6
Mean rainfall (mm)	77.1	73.1	59.7	44.0	40.7	48.1	43.4	36.1	41.7	51.9	61.9	67.5	645.9
Mean number of days of rain	6.4	6.0	5.8	4.9	4.9	5.5	5.2	5.2	5.2	5.8	6.3	6.3	67.5
Mean 9am temperature (C)	23.4	22.7	21.2	18.0	13.6	10.6	9.4	11.4	15.3	19.0	21.1	23.0	17.4
Mean 9am relative humidity (%)	67	72	72	72	77	80	78	71	65	59	60	61	70
Mean 3pm temperature (C)	29.8	28.9	27.2	24.1	20.1	17.1	16.4	18.2	21.2	24.2	26.9	29.0	23.6
Mean 3pm relative humidity (%)	47	50	49	49	52	54	51	45	43	42	42	42	47

5.3 Existing Air Quality

5.3.1 Mount Owen Monitoring Network

Air quality standards and goals refer to pollutant levels that include the contribution from specific projects and existing 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 proposed Project is likely to contribute to these levels. It is also important to note that the existing air quality conditions (that is, background conditions) will be influenced to some degree by the existing mining operations and other sources.

Dust deposition and dust concentration (TSP and PM_{10}) are monitored in the vicinity in accordance with the Mount Owen Complex monitoring program. The locations of the monitoring sites are shown in **Figure 5.1**. Airborne dust concentrations can be measured either intermittently or continuously, and both methods have been used in the area of the Mount Owen Complex. A network of High Volume Air Samplers (HVAS) measures both TSP and PM_{10} 24-hour average concentrations on a six day cycle. Five Tapered Element Oscillating Microbalance instruments (TEOMs) measure PM_{10} concentration on a continuous basis. The Mount Owen Complex has a total of 25 dust deposition gauges which measure the monthly average of deposited dust. While monitoring $PM_{2.5}$ is not currently part of the Mount Owen network, there are measurements taken at Camberwell within 8 km of Mount Owen, as well as Singleton and Muswellbrook as part of the Upper Hunter Air Quality Monitoring Network. The following sections discuss the TSP, PM_{10}, $PM_{2.5}$ and dust deposition monitoring results.

The current monitoring results include emission sources in the vicinity of the Project, including any contribution from surrounding mines, traffic on unsealed roads, local building and construction activities, farming, and animal grazing and to a lesser extent traffic from the other local roads and other sources such as wood-burning fires.

5.3.1.1 PM_{10} Concentrations

A summary of the annual average PM_{10} concentration from 2002 to 2013 is shown in **Table 5.3**. The data presented in **Figure 5.4** show the 24 hour PM_{10} averages and the rolling annual average PM_{10} concentrations calculated from these values are shown in **Figure 5.5**.

From **Table 5.3** it can be seen that the majority of the annual average PM_{10} concentrations for each monitoring station do not exceed the EPA annual PM_{10} criterion of 30 $\mu g/m^3$. There were four exceptions to this at PM10-3ii. In 2002, 2003, 2004 and 2012 the annual average PM_{10} concentration at monitor PM10-3ii was 31 $\mu g/m^3$, 38 $\mu g/m^3$, 36 $\mu g/m^3$ and 32 $\mu g/m^3$, respectively. The cause of the high PM_{10} concentrations at monitor PM10-3ii is unknown, however, given that the monitor is downwind of the Mount Complex during the dominant north-westerlies, it is likely that operations at the Mount Owen Complex contributed to the measured PM_{10} concentrations at that location. This monitoring site is also downwind of Integra operations during the summer when south-easterlies dominate the area, and is located on Glencore-owned property.

These monitoring data are also plotted in **Figure 5.4** and **Figure 5.5**. **Figure 5.4** shows a seasonal trend in the 24-hour average PM_{10} concentrations at all PM_{10} monitoring locations. In general, the highest PM_{10} concentrations are experienced during summer and the lowest during winter. The measured 24-hour average PM_{10} concentrations have been above the 50 $\mu g/m^3$ criterion on a number of occasions at all sites, particularly in 2009 when there was a severe and widespread dust storm across eastern Australia and a number of bushfires in NSW. In September 2011, there were also elevated levels across the Hunter Valley area. A preliminary analysis of exceedances that occurred at that time (as part of the Upper Hunter monitoring network), show that high levels in Singleton and Camberwell occurred when wind speeds were high, around 10 m/s and temperatures were around 30 degrees.

The effect of these elevated 24-hour PM_{10} concentrations can be seen in the annual averages presented in **Figure 5.5**, which show a rapid increase at nearly all monitoring sites in late 2009. These data also showed that levels had generally declined between 2010 and mid-2012 across the network, until the latter half of 2012 where levels increased again at nearly all monitoring sites except, SX14 and PM10-1. PM_{10} concentrations at SX14 had a significant drop in 2012/2013, but are now back at the level of most other monitoring locations.

Further discussion of PM_{10} concentrations in the region, as part of the EPA's Upper Hunter Air Quality Monitoring Network, is presented in **Section 5.3.2**.

Table 5.3: Annual average PM_{10} concentrations measured at each HVAS and TEOM site – $\mu g/m^3$

Year	PM10-1[a]	PM10-2[a]	PM10-3iii[b]	PM10-4	PM10-3ii	TEOM1-SX8[e]	TEOM2-SX10[e]	TEOM3-SX9[e]	TEOM4-SX13[f]	TEOM5-SX14[f]
2002	-	-	-	26	**31**	-	-	-	-	-
2003	-	-	-	25	**38**	-	-	-	-	-
2004	16	18	-	23	**36**	-	-	-	-	-
2005	21	19	-	25	30	-	-	-	-	-
2006	17	19	20	22	27[c]	-	-	-	-	-
2007	21	25	24	25	24	-	-	-	-	-
2008	24	26	25	25	22	-	-	-	-	-
2009	28	29	22	28	27	-	-	-	25	30
2010	22	24	21	22	20	-	-	-	18	23
2011	20	24	20	25	21	18	22	20	18	20
2012	18	25	23	29	**32**	21	24	22	23	13
2013	15	26	21	29	21	19	25	23	23	22

Note: Exceedance of the air quality criterion is shown in bold.
[a] Monitoring commenced May 2004
[b] Monitoring commenced May 2006
[c] No monitoring data for the period of April 2006 to August 2006
[d] No monitoring data prior to July 2010
[e] No monitoring data prior to 2011
[f] No monitoring data prior to 2009

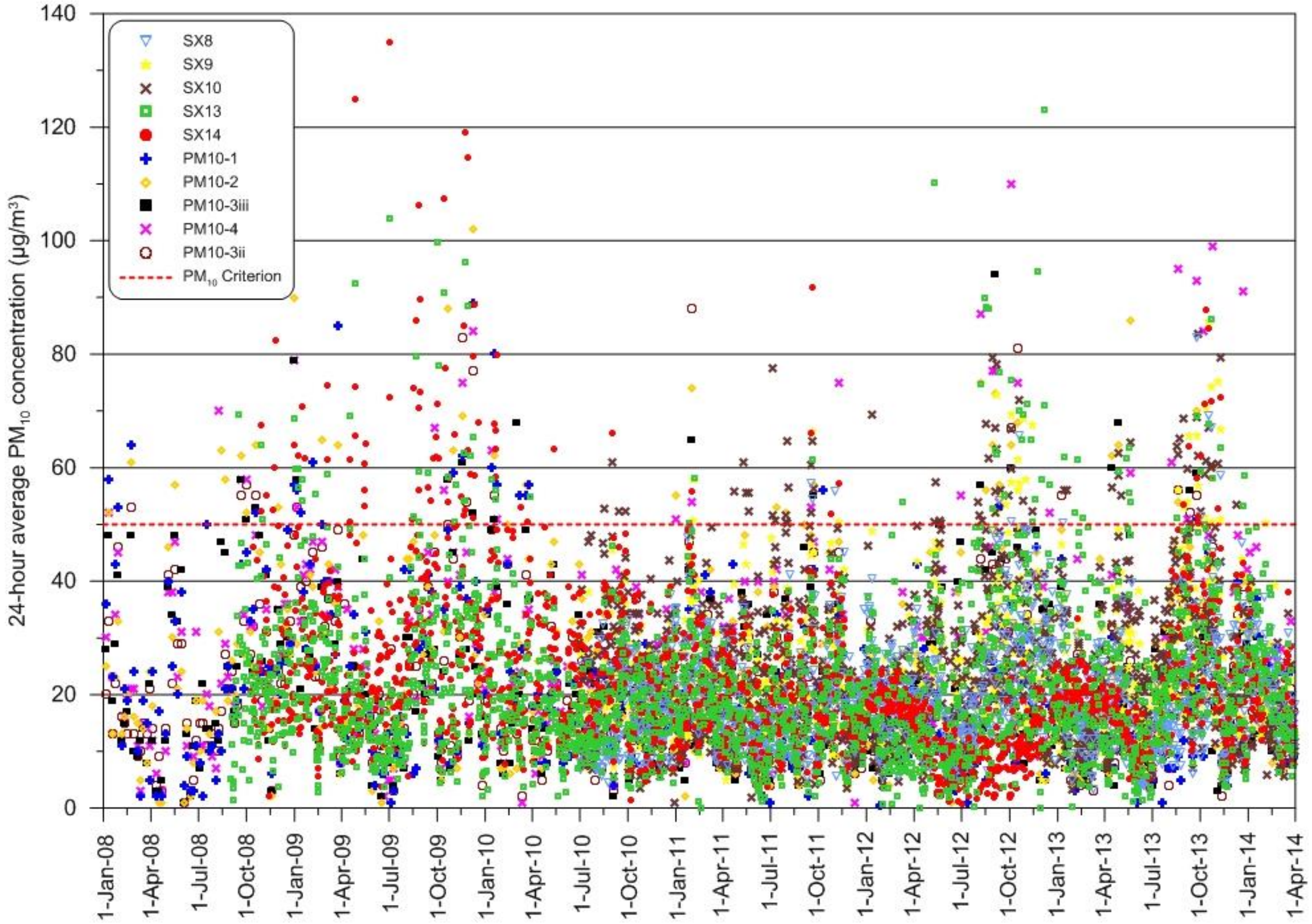


Figure 5.4: 24-hour average PM_{10} concentrations at Mount Owen monitoring sites

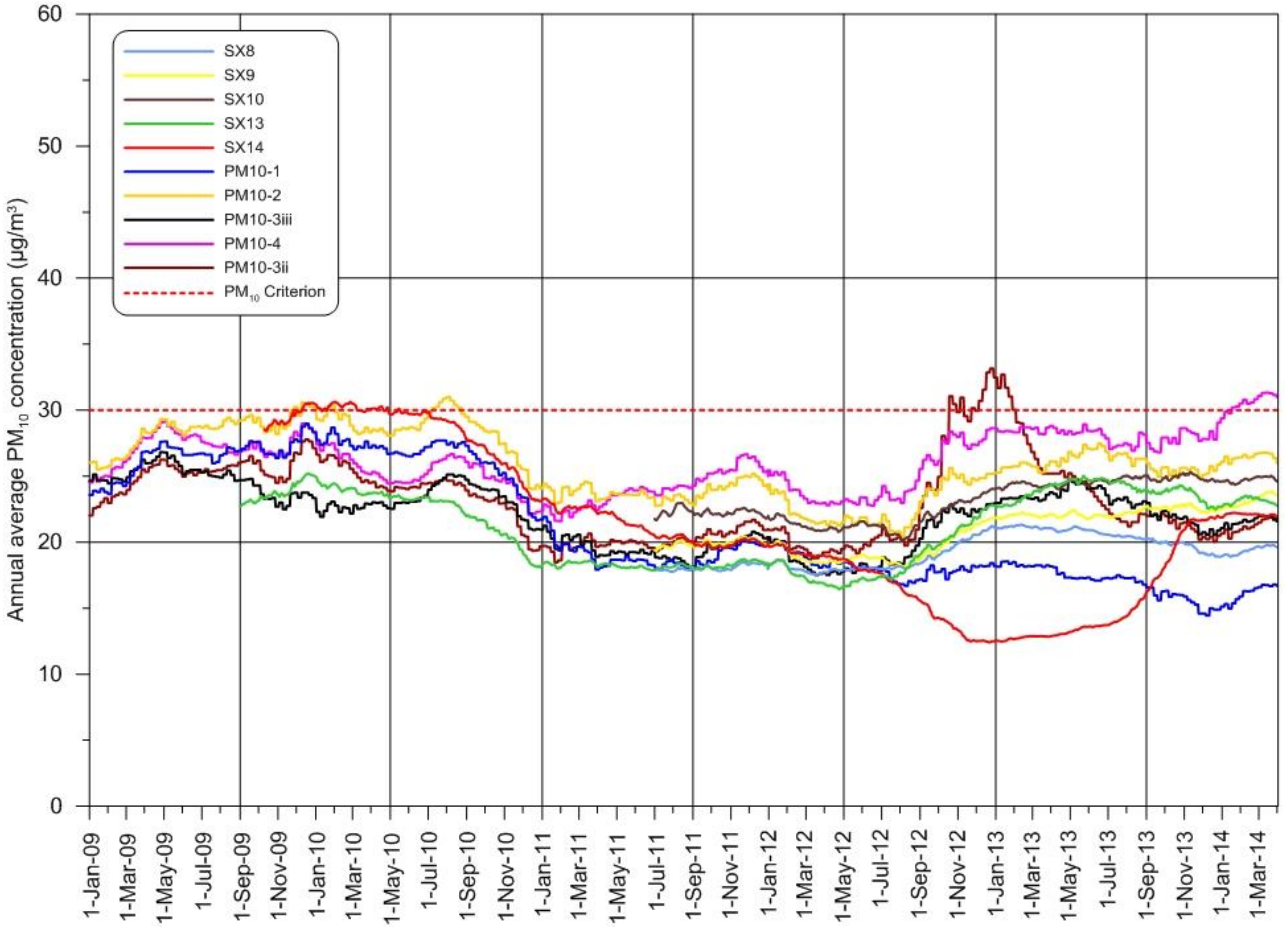


Figure 5.5: Running annual average PM_{10} concentrations at Mount Owen monitoring sites

5.3.1.2 $PM_{2.5}$ Concentrations

The Upper Hunter Air Quality Monitoring Network (UHAQMN) includes three $PM_{2.5}$ monitors which have been in operation since January 2011. These data are presented and discussed in **Section 5.3.2**.

5.3.1.3 TSP Concentrations

A summary of the annual average TSP monitoring results for each of the four TSP HVAS monitors are presented in **Table 5.4**. The annual average TSP concentrations have remained below the EPA criterion of 90 µg/m³ for all years, except at monitor TSP-3 in 2009, 2012 and 2013. TSP-3 is located on Glencore owned land between Liddell Coal and Mount Owen and would be expected to be more elevated than other locations. The highest TSP concentration at monitor TSP-3 in 2009 was 265 µg/m³ on 8 December. Concentrations at all four TSP monitors were elevated on this day. This day corresponds with the start of a period of severe weather conditions and dust storms experienced across NSW from 8 – 13 December (**EPA, 2009** and **RFS, 2009**). The high annual average in 2012 at TSP-3 is the result of elevated 24-hour levels between August and October, peaking at 327 µg/m³ on 5 October 2012. Other monitors all recorded higher than normal TSP measurements on that day, indicating a possible regional event rather than local factors. Temperatures across NSW and the Hunter Valley were of the order of 30 degrees Celcius on that day, and there were a number of hazard reductions burns across the state, including at Newcastle, Dungog, Lake Macquarie and Merriwa, in the preceding days (**RFS, 2012**). These elevated temperatures may have led to increased evaporation rates and potentially increased dust emissions.

Table 5.4: Annual average TSP concentrations measured at HVAS sites – µg/m³

Year	TSP-1	TSP-2[a]	TSP-3[b]	TSP-4[c]
2002	79	-	-	-
2003	70	-	28	-
2004	47	50	64	-
2005	50	45	60	-
2006	50	50	69	66
2007	64	69	79	64
2008	63	76	70	63
2009	80	84	**98**	73
2010	62	79	84	63
2011	62	72	85	65
2012	59	77	**102**	66
2013	47	85	**99**	65

Note: Exceedance of the air quality criterion is shown in bold.
[a] Monitoring commenced May 2004
[b] Monitoring commenced December 2003
[c] Monitoring commenced October 2006

5.3.1.4 Dust Deposition

Figure 5.1 shows the locations of the 25 dust deposition gauges analysed in this assessment. The annual averages are summarised in **Table 5.5**.

From 2004 – 2011, all dust gauges with the exception of DD2, DD5, DD8 and DD11 have recorded annual average deposition levels lower than the EPA annual average assessment criterion of 4 g/m^2/month for insoluble solids. In 2012, two other gauges DG6 and DG11 also recorded above that level. These observations also include the effects of existing operations from other mines in the surrounding area as well as all other sources of particulate matter (for example, traffic, and emissions from industrial and domestic activities).

As shown in **Figure 5.1**, DD8 is very close to Mount Owen operations. Levels have been increasing at DD8 in recent years and the location is no longer representative due to the mine's progression. In March 2013, DD8 was decommissioned and is no longer part of the monitoring network. DD11, lies along the northwest-southeast axis of predominant wind directions in the area and DD2 and DD5 also lie close to existing mining operations. DD2 is adjacent to a tailings dam that was actively being rehabilitated during 2012/2013 and is therefore not representative of sensitive receivers.

There are also a number of monitors that have recorded approximately 2 g/m^2/month or less for almost the entire nine year monitoring period, and are likely to be representative of background conditions not affected significantly by mining. This includes, in particular, DD6 which is more than 5 km away and outside the prevailing wind direction from the Mount Owen Complex. It would be reasonable to use a conservative background level of approximately 2 g/m^2/month across the modelling domain for annual average dust deposition.

Table 5.5: Annual average dust deposition data (insoluble solids) – 2004 to 2013 (g/m^2/month)

Gauge	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Average
DD1/DG1	2.2	1.8	1.8	1.5	1.6	2.7	2.9	3.1	3.8	2.9	2.4
DD2	**6.1**	**5.5**	3.6	3.7	**4.5**	3.6	2.9	3.0	**4.2**	**3.6**	**4.1**
DD3	3.5	2.4	3.1	2.6	3.7	3.3	3.5	3.9	3.4	2.8	3.2
DD4	3.3	2.3	2.4	2.0	1.8	3.2	2.6	2.8	3.0	1.9	2.5
DD5	3.4	**4.5**	3.0	1.8	1.9	3.1	2.8	2.7	3.2	2.5	2.9
DD6	3.3	0.9	1.8	1.6	1.3	1.5	1.2	1.2	1.0	0.9	1.5
DD7/DG2	1.0	1.5	1.6	1.6	1.8	2.8	2.7	2.3	2.6	2.4	2.0
DD8	**4.8**	**4.1**	3.7	3.3	**6.2**	**5.7**	**7.4**	**7.0**	**6.8**	**-**	**5.4**
DD9	3.8	2.5	2.6	2.5	2.5	3.7	3.6	3.9	3.0	3.7	3.2
DD10	-	-	-	2.6	2.3	2.0	-	2.9	3.3	2.9	2.7
DD11	**5.6**	**4.3**	2.8	2.5	3.0	3.3	3.5	**4.3**	3.2	3.1	3.5
DD12	2.0	2.3	2.1	1.8	1.9	2.6	2.1	2.7	3.2	2.3	2.3
DD13	1.7	1.7	2.7	2.5	2.3	3.1	2.6	2.9	3.5	3.1	2.6
DD14	-	-	-	1.1	1.5	2.1	-	1.5	2.4	1.7	1.7
DD15/DG4	2.0	2.1	2.1	1.9	2.6	2.9	4.3	2.8	3.2	2.7	2.7
DD16	-	-	2.0	1.9	1.6	2.2	1.8	1.8	2.6	2.4	2.0
DG3	-	-	-	1.1	1.5	-	-	2.0	2.6	2.1	1.7
DG5	-	-	-	3.0	2.9	-	-	2.5	3.1	2.4	2.8
DG6	-	-	-	2.6	2.6	-	-	3.2	**4.8**	**4.1**	3.5
DG7	-	-	-	2.0	2.2	-	-	2.3	3.5	3.1	2.5
DG8	-	-	-	2.5	2.7	-	-	3.0	3.3	3.0	2.8
DG9	-	-	-	2.8	3.8	-	-	2.5	3.8	3.2	3.2
DG10	-	-	-	2.8	3.2	-	-	3.5	3.4	3.3	3.2
DG11	-	-	-	1.9	2.4	-	-	3.7	**5.9**	**4.4**	3.6
DG12	-	-	-	2.5	2.2	-	-	3.7	4.0	**4.6**	3.5

5.3.2 The Upper Hunter Air Quality Monitoring Network

The Upper Hunter Air Quality Monitoring Network (UHAQMN) is the regional air quality monitoring network in the Upper Hunter managed by the NSW EPA. The network was established in October 2010 to provide reliable, regional air quality monitoring data. By February 2012, fourteen monitoring sites were operational in strategic locations, including the major population centres of Singleton and Muswellbrook. All these monitoring sites measure PM_{10} and three of them (Singleton, Muswellbrook and Camberwell) also measure $PM_{2.5}$. The locations of these monitoring sites are shown in **Figure 5.6**.

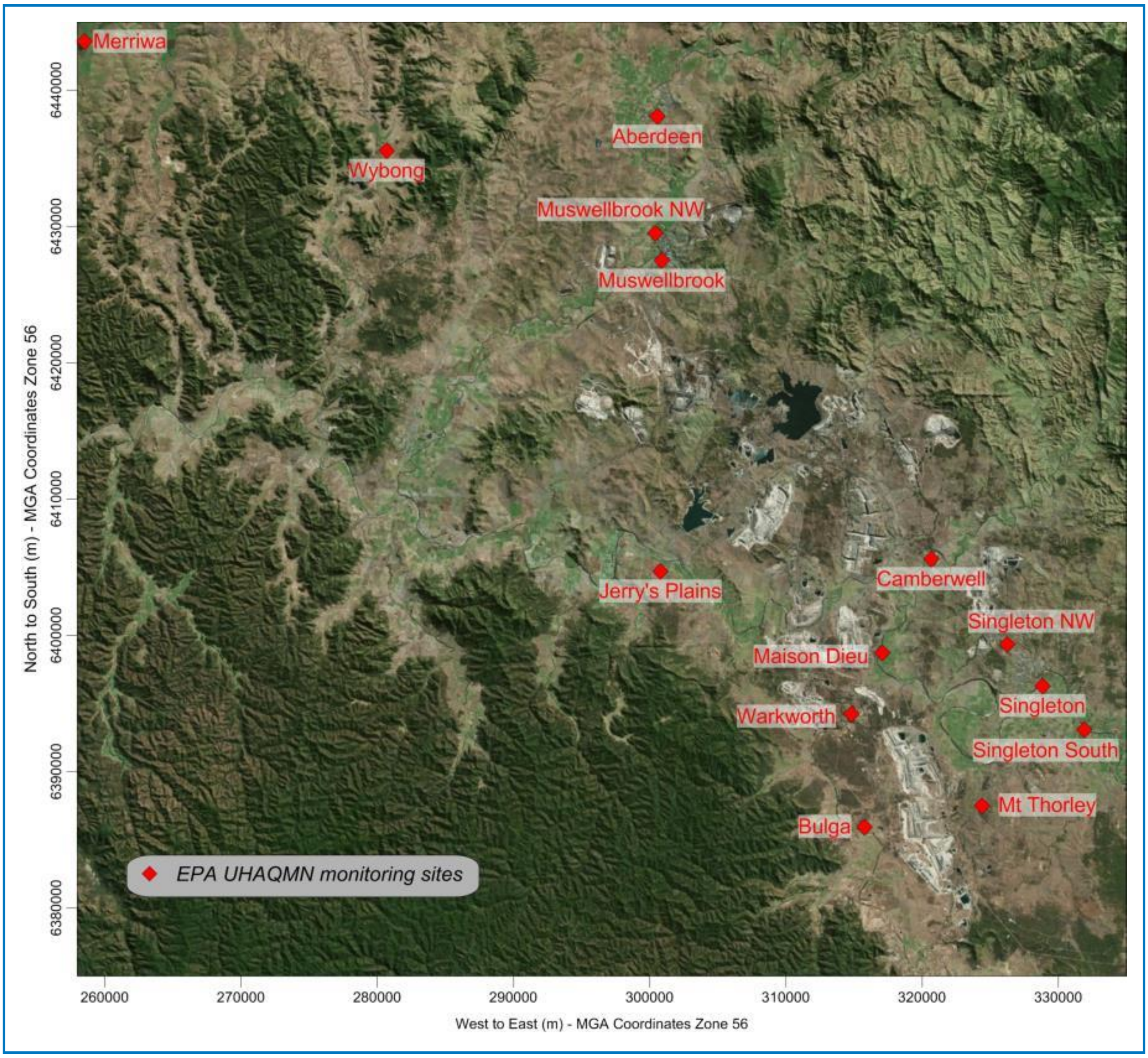


Figure 5.6: Locations of the UHAQMN monitoring sites

Annual average PM_{10} and $PM_{2.5}$ measurements are presented in **Table 5.6** and **Table 5.7**, respectively, and can be compared with the impact assessment criteria for PM_{10} or the Advisory Reporting Standard for $PM_{2.5}$. Median values are also presented and provide an indication of average conditions in the absence of outliers in the data caused by significant events such as bushfires and dust storms. These median values will be used to determine representative background values for both PM10 and PM2.5 to be used in the cumulative assessment presented in **Section 10.3**. The 24-hour PM_{10} and $PM_{2.5}$ data are used to calculate the annual averages, which are shown in **Figure 5.7** and **Figure 5.8**, respectively.

The annual average PM_{10} concentrations at most sites are similar in magnitude to the Mount Owen PM_{10} monitoring network presented in **Table 5.3** and all remain below the PM_{10} criterion of 30 µg/m³. There are three sites in the UHAQMN which show lower annual average PM_{10} values. These sites (Wybong, Merriwa and Jerrys Plains) are representative of the existing background levels without the influence of mining. Merriwa and Wybong are located at significant distances away from the majority of mining activity within the Upper Hunter Valley, as shown in **Figure 5.6**. However, they do lie along the northwest-southeast axis of predominant wind direction through the Hunter Valley and as such may be influenced by finer particles from the southeast, and also some recirculation from the northwest. Jerrys Plains is slightly removed from the northwest-southeast alignment and is less likely to be so directly influenced by mining.

Table 5.6: PM_{10} concentrations measured at the UHAQMN sites (µg/m³)

Monitoring Site	Annual Average			Median		
	2011	2012	2013	2011	2012	2013
Muswellbrook	19.3	21.8	22.6	19.3	20.4	21.0
Singleton	19.8	22.3	23.3	17.7	20.0	20.6
Camberwell	Monitoring commenced in late 2011	26.4	25.8	Monitoring commenced in late 2011	23.4	21.3
Maison Dieu	22.1	25.8	27.8	19.6	23.9	23.8
Singleton NW	Monitoring commenced in late 2011. Annual averages calculated from 2012.	25.9	25.9	Monitoring commenced in late 2011. Annual averages calculated from 2012.	22.6	22.3
Mount Thorley		24.8	24.7		21.4	20.6
Bulga		18.7	19.2		16.7	16.3
Muswellbrook NW		19.1	19.1		17.3	17.7
Wybong		15.4	15.5		13.7	13.5
Aberdeen		17.0	17.3		16.2	16.5
Singleton South		19.0	20.2		17.0	17.2
Jerrys Plains		10.8	18.5		6.5	16.0
Warkworth		21.1	21.4		19.6	19.3
Merriwa		14.2	14.9		12.4	13.9

To determine an appropriate value for background annual average PM_{10}, the Merriwa, Wybong and Jerrys Plains monitors were chosen to be most representative of non-mining sources of particulate matter. The median values at these locations are shown in **Table 5.6**, and is 13.2 µg/m³ across all three sites. As discussed previously, using the median rather than the annual average reduces the influence of significant weather events (which are essentially unpredictable into the future) and thus provides a more representative background value.

For the cumulative assessment in **Section 10.3**, this background value is added to the model predictions from both the Project and other mines within the domain. This value is to represent 'non-mining and other sources' in the area.

Table 5.7: $PM_{2.5}$ concentrations measured at the UHAQMN sites (µg/m³)

Monitoring Site	Annual Average			Median		
	2011	2012	2013	2011	2012	2013
Muswellbrook	9.1	10.1	9.4	7.5	9.0	8.4
Singleton	7.6	8.0	7.8	6.8	7.6	6.6
Camberwell	Monitoring commenced in late 2011	7.5	8.2	Monitoring commenced in late 2011	6.9	7.3

There are three sites which currently measure $PM_{2.5}$ in the UHAQMN, Muswellbrook, Singleton and Camberwell (see **Table 5.7**). **Figure 5.8** shows the 24-hour average data at each of these sites since 2011. There is a clear seasonal trend evident with $PM_{2.5}$ peaks occurring during the cooler months rather than in the warmer months as is usually the case for PM_{10} (as seen in **Figure 5.7**). These $PM_{2.5}$ seasonal trends are more pronounced in the built up areas of Muswellbrook and Singleton, due to the prevalence of wood heaters used during the winter. This is supported by the Upper Hunter Fine Particle Characterisation Study (**OEH, 2013**), which found that wood smoke accounted for an average of approximately 30% of $PM_{2.5}$ in Muswellbrook, peaking at approximately 62% in winter. Similarly, in Singleton, wood smoke accounts for an average of approximately 14% of total $PM_{2.5}$, peaking at around 38% in winter.

To determine a representative background annual average $PM_{2.5}$ for the modelling domain, the Camberwell data have been used. To use measured levels at either Muswellbrook or Singleton would have been overly conservative as they are highly influenced by the $PM_{2.5}$ emissions from wood heaters in winter and not representative of the wider modelling domain. The effect of wood heaters is still seen in the $PM_{2.5}$ data at the Camberwell monitoring site but to a lesser extent. Of the three monitoring sites, it is therefore more appropriate for modelling domain. In addition, Camberwell is also closer to the Project area than either Singleton or Muswellbrook.

The median value is used here again, to reduce the influence of the significant events which can be clearly seen in **Figure 5.8** in November 2012 and October 2013. The median $PM_{2.5}$ value for Camberwell is 7.1 µg/m³ and this value has been used in the cumulative assessment in **Section 10.3**. The 24-hour average $PM_{2.5}$ data for Camberwell has also been used for the cumulative 24-hour assessment in **Section 10.4**.

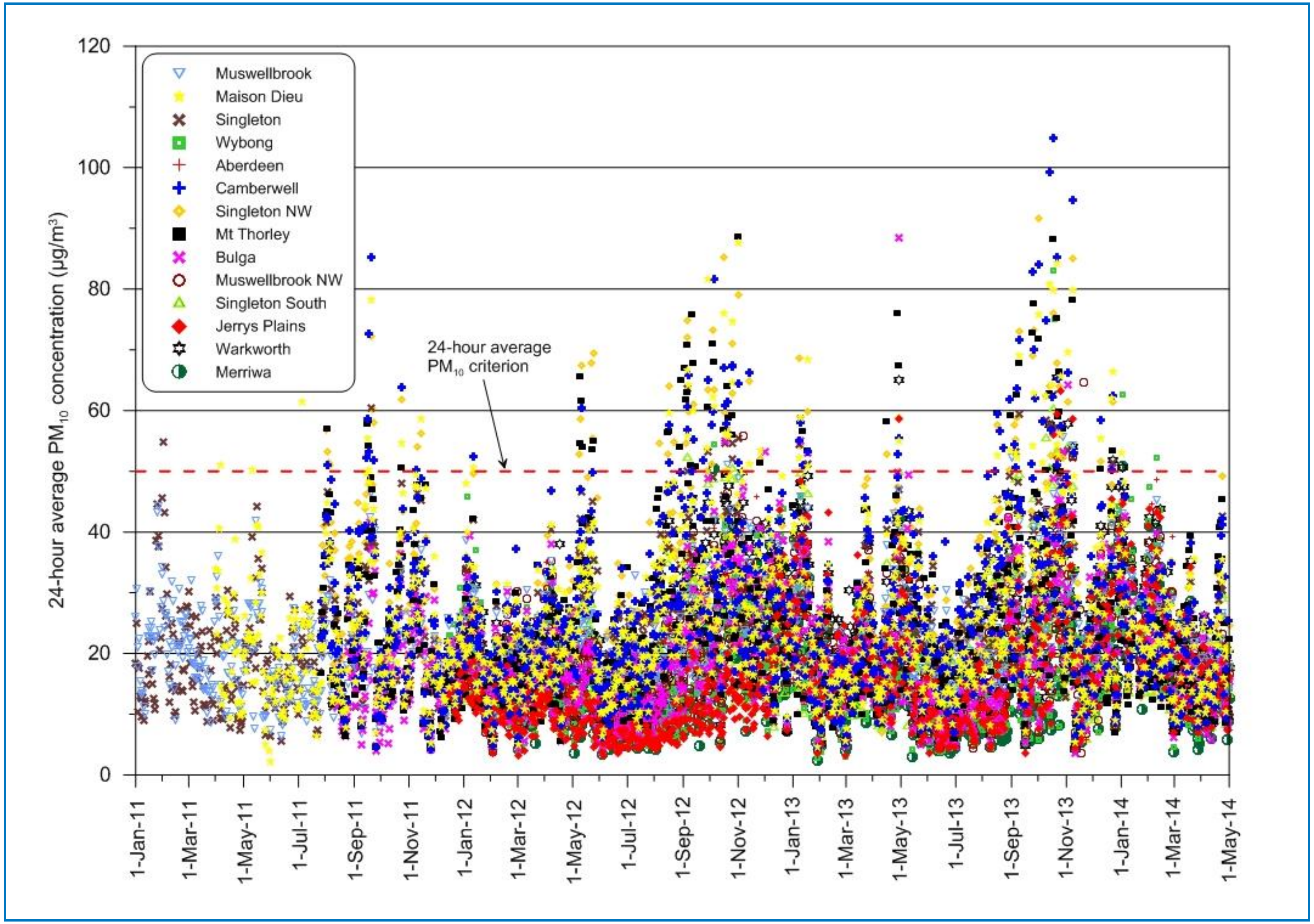


Figure 5.7: 24-hour average PM_{10} concentrations measured at the UHAQMN sites (µg/m³)

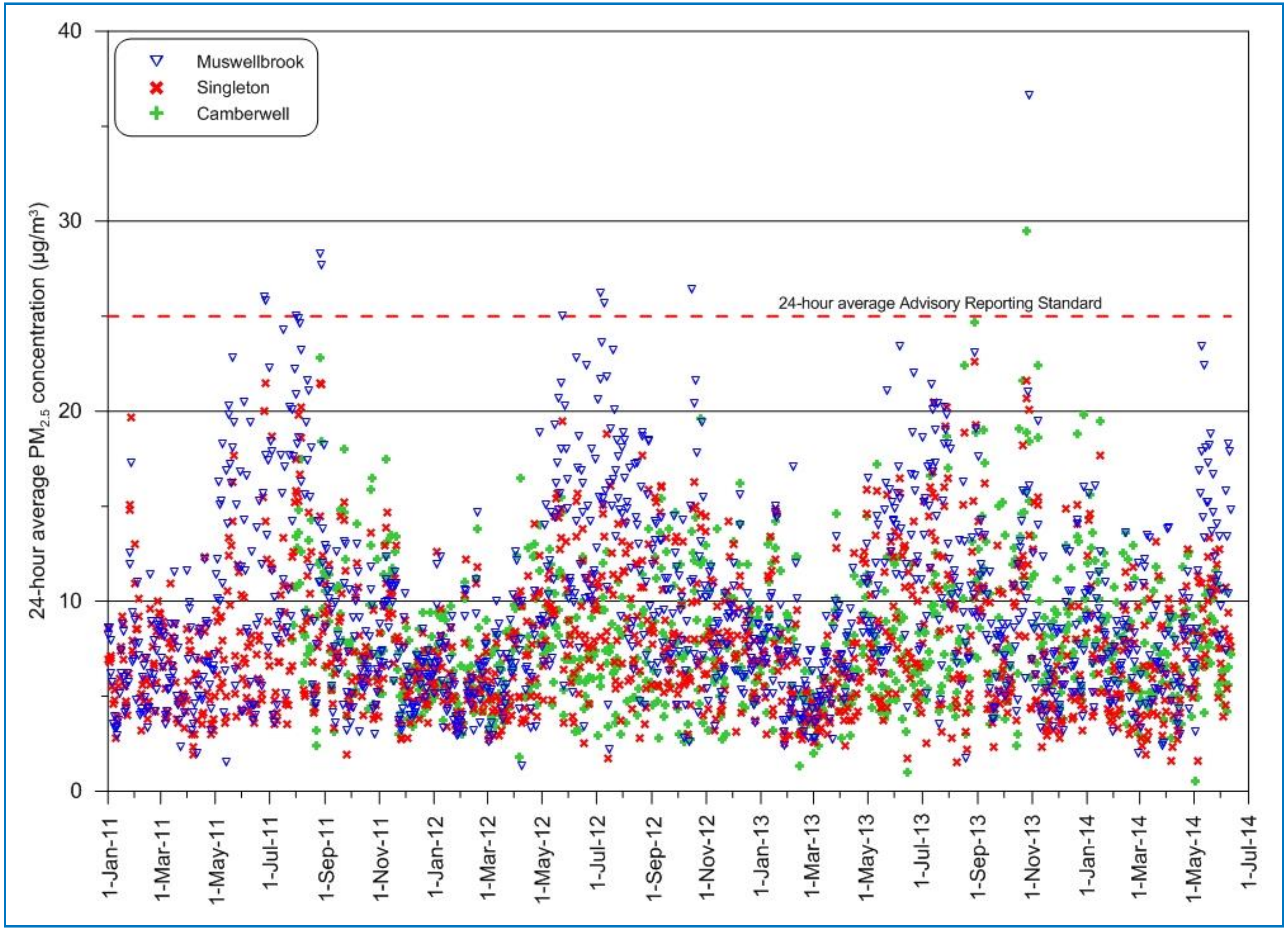


Figure 5.8: 24-hour average $PM_{2.5}$ concentrations measured at the UHAQMN sites (µg/m³)

5.3.3 NO_2 Concentrations

Figure 5.9 presents the maximum hourly NO_2 concentration data collected at five EPA monitoring stations. All five monitoring stations are well below the EPA impact assessment criterion of 246 µg/m³. The maximum hourly concentration recorded at the Muswellbrook site was 94 µg/m³. This value over a period of more than three years represents approximately 38% of the assessment criterion. Levels are slightly lower at Singleton, which is closer to the Project Area. The annual average of the maximum 1-hour average NO_2 data in 2013 was approximately 38 µg/m³, which is well below the EPA criteria of 62 µg/m³.

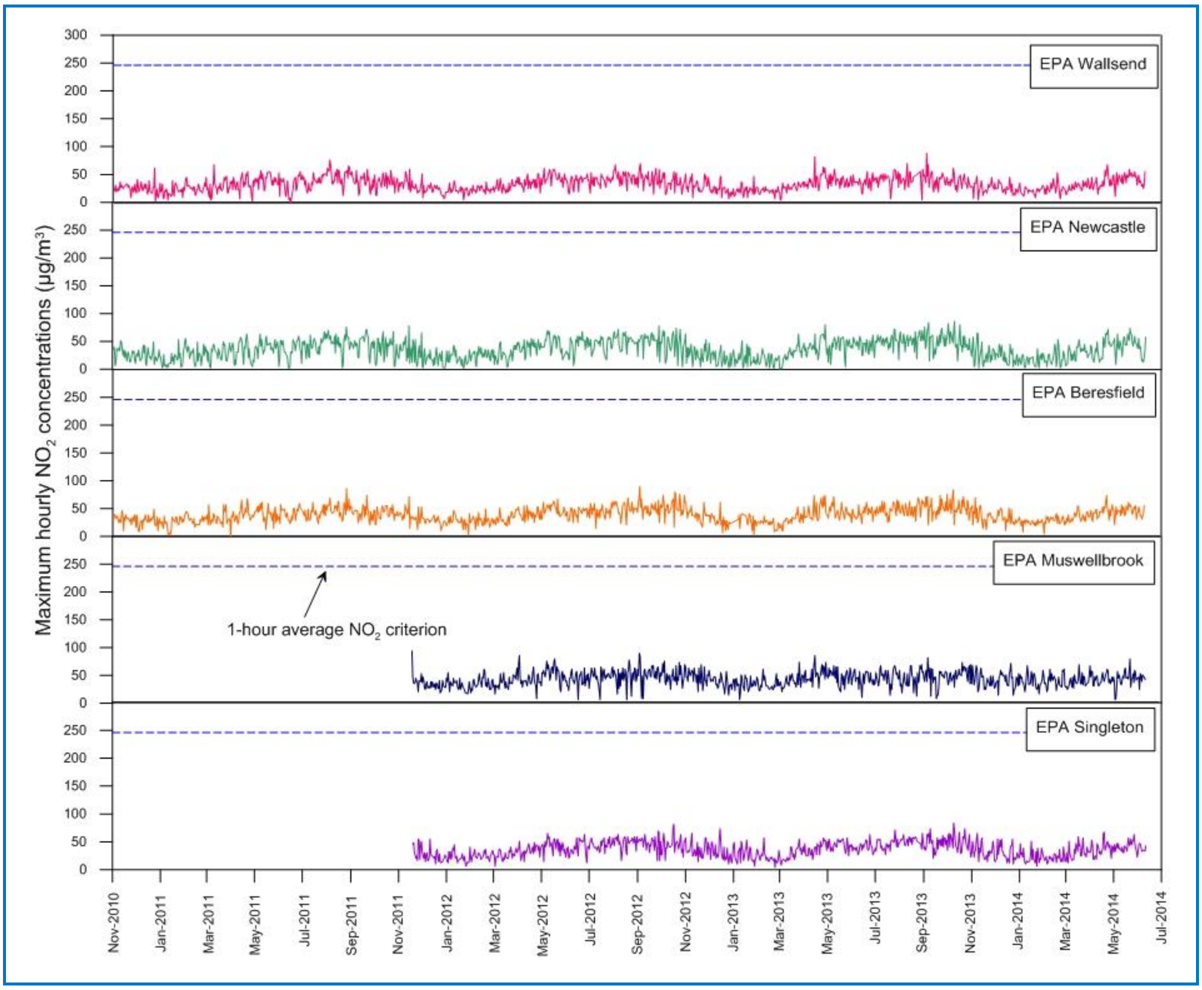


Figure 5.9: NO_2 concentrations measured at EPA monitoring stations

6 METHODOLOGY

6.1 Approach to Assessment

The overall approach to the assessment follows the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**EPA, 2005**) using the Level 2 assessment methodology. The Approved Methods specify how assessments based on the use of air dispersion models should be completed. They include guidelines for the preparation of meteorological data to be used in dispersion models and the relevant air quality criteria for assessing the significance of predicted concentration and deposition rates from the Project.

The air dispersion modelling conducted for this assessment is based on an advanced modelling system using the models TAPM and CALMET/CALPUFF.

The modelling system works as follows:

- TAPM is a prognostic meteorological model that generates gridded three-dimensional meteorological data for each hour of the model run period.
- CALMET, the meteorological pre-processor for the dispersion model CALPUFF, calculates fine resolution three-dimensional meteorological data based upon observed ground and upper level meteorological data, as well as observed or modelled upper air data generated for example by TAPM.
- CALPUFF then calculates the dispersion of plumes within this three-dimensional meteorological field.

Output from TAPM, plus local observational weather station data were entered into CALMET, a meteorological pre-processor endorsed by the US EPA and recommended by the NSW EPA for use in complex terrain and non-steady state conditions (that is, conditions that change in time and space). From this, a 1-year representative meteorological dataset suitable for use in the 3-dimensional plume dispersion model, CALPUFF, was compiled. **Figure 6.1** presents an overview of the modelling system and the details on the model configuration and data inputs are provided in the following sections.

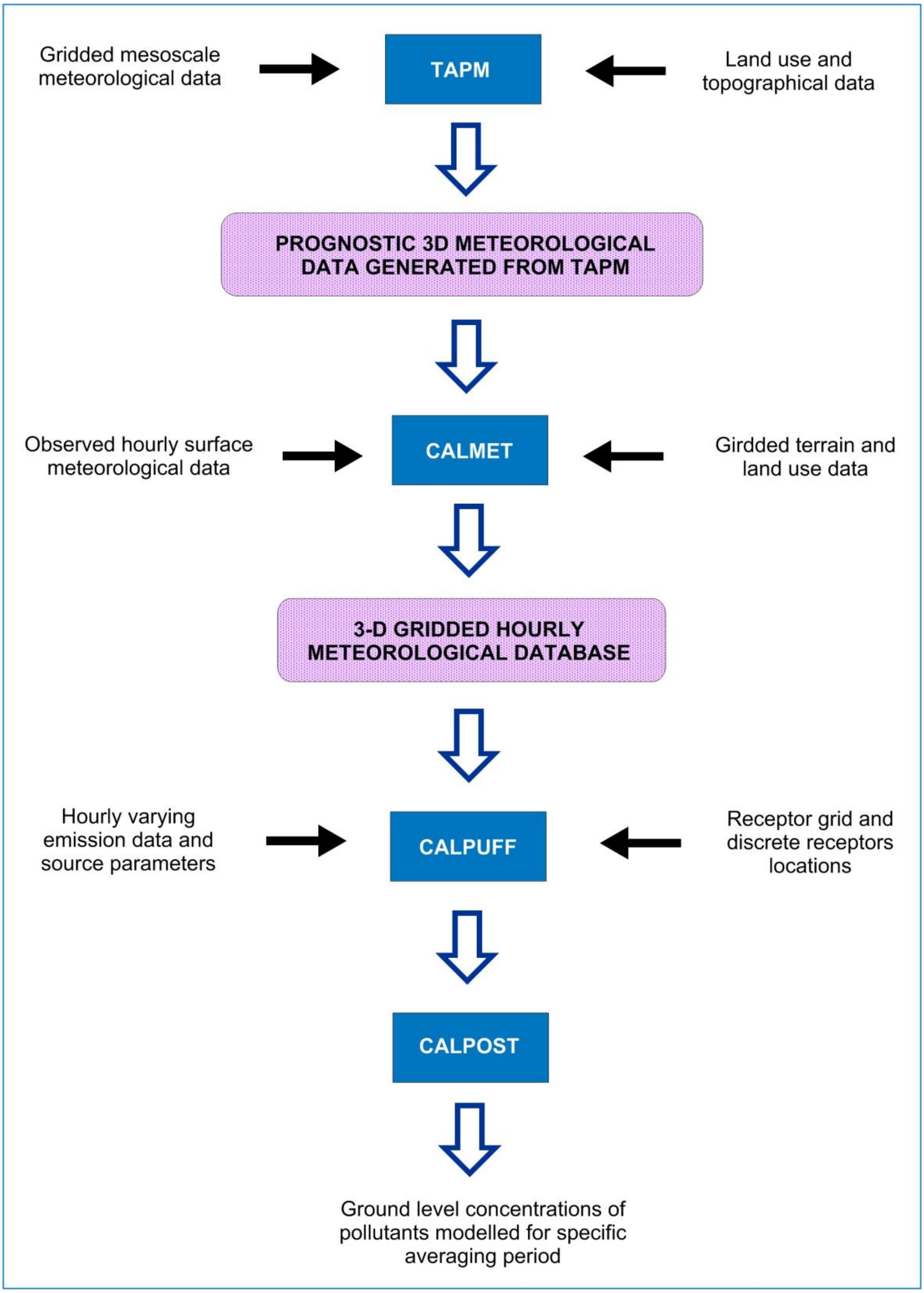


Figure 6.1: Overview of modelling methodology

6.2 TAPM

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)** and **Edwards et al (2008)**.

TAPM solves the fundamental fluid dynamics and scalar transport equations to predict meteorology and pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

For this project, TAPM was set up with 3 domains, composed of 45 grid points along both the x and the y axes, centred on -32˚24.5' Latitude and 151˚16.5' Longitude. Each nested domain had a grid resolution of 30 km, 10 km and 3 km respectively.

6.3 CALMET

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 three-dimensional meteorological fields that are utilised in the CALPUFF dispersion model (i.e. the CALPUFF dispersion model requires meteorological data in three dimensions). 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.

CALMET was initially run for a coarse outer grid domain of 115 km x 115 km, centred near the Project area, with a 1 km grid resolution. This allowed use of measured meteorological parameters (e.g. cloud cover) from the BoM stations, as well as capturing the wider terrain and landuse influences on the local meteorology to be captured. As discussed below, a smaller, finer resolution grid (0.25 km) is used in the vicinity of the Project Area.

Terrain for this area was principally derived from 90 m NASA SRTM data. Finer resolution terrain data from Light Detection and Ranging (LiDAR) was used to represent the Project Area, and combined with the NASA SRTM data to represent the entire modelling domain. Land use for the domain was determined by aerial photography from Google Earth and Glencore aerial photography.

There are five main land uses represented across the modelling domain. The dominant land use is agricultural land, with barren land category used to represent active mining areas. **Figure 6.2** shows the landuse used for modelling Years 1 and 5, which was not anticipated to significantly change between these years. For modelling Year 10 a number of other mines are planned to be either completed or significantly reduced in terms of active mining and dumping areas.

A sensitivity analysis was carried out to investigate the effect of varying the landuse for these changes to active mining areas. The analysis showed that changing the landuse from barren land to agricultural land for these areas results in almost no difference in the predictions at individual receptors. Nevertheless, the varied landuse better represents the Year 10 scenario and was therefore used in the modelling. The landuse used for Year 10 is shown in **Figure 6.3**.

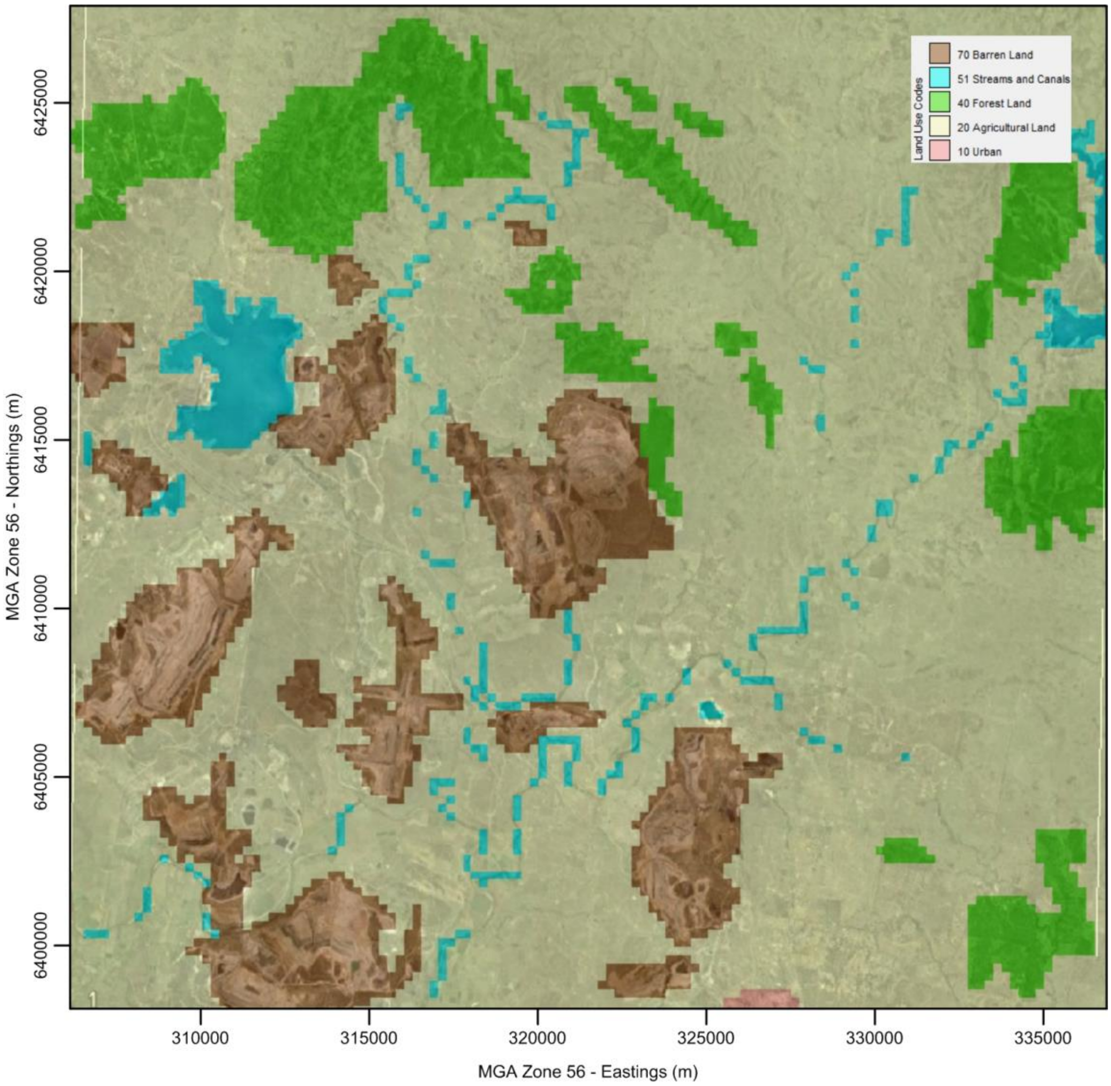


Figure 6.2: Landuse categories used for Year 1 and 5 modelling

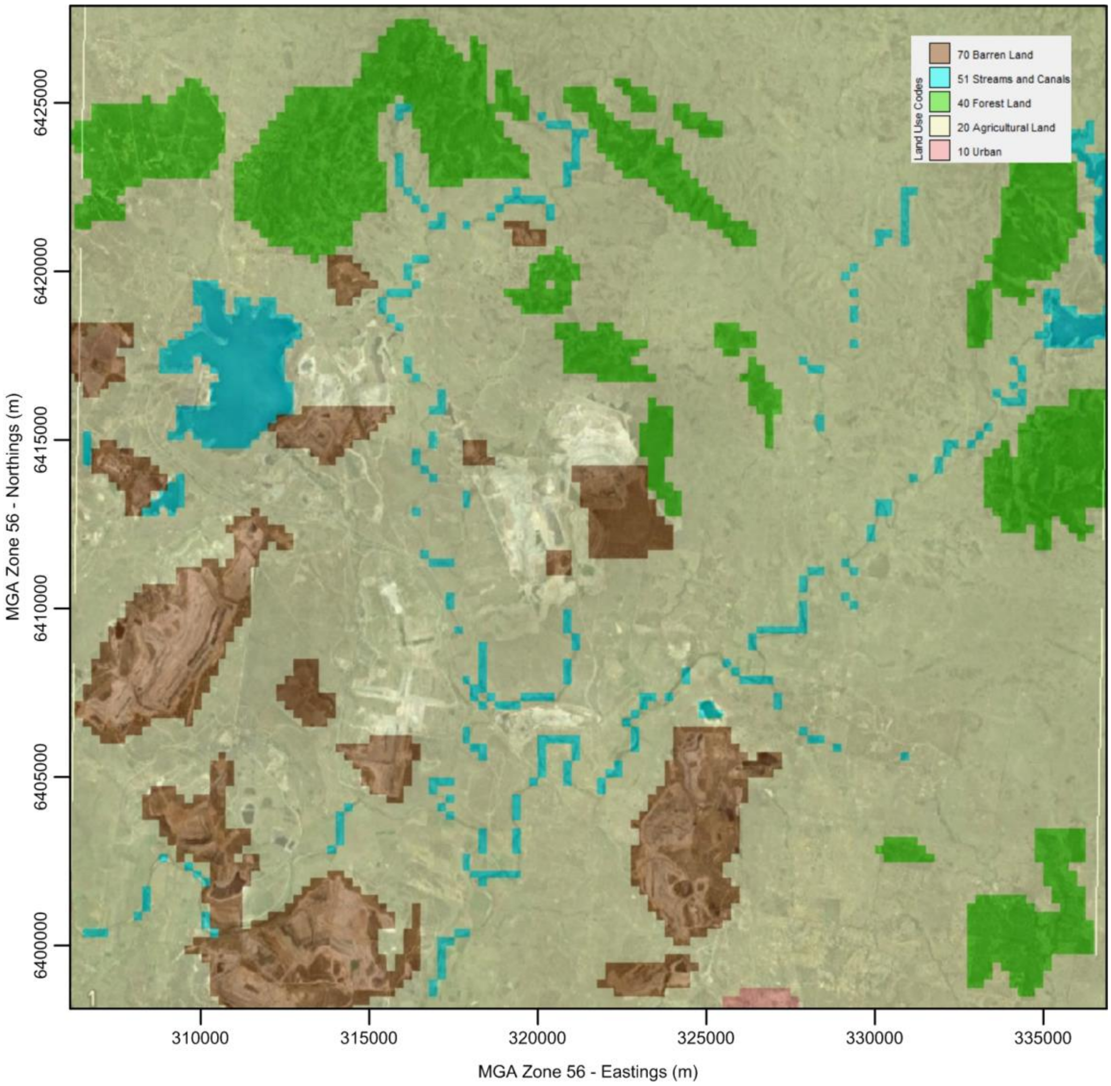


Figure 6.3: Landuse categories used for Year 10 modelling

Observed hourly surface data were incorporated into the modelling from meteorological stations including:

- BoM Williamtown RAAF
- BoM Newcastle (AWS)
- BoM Paterson (TOCAL AWS)
- BoM Cessnock Airport (AWS)
- BoM Scone Airport (AWS)

Meteorological parameters such as wind speed, wind direction, temperature and relative humidity were sourced from all of the above stations. Cloud amount and cloud height data is not measured at most AWS sites so were sourced from the BoM Williamtown station which is the closest station that measures these parameters.

Upper air information was incorporated through the use of prognostic 3-dimensional (3-D) data extracted from TAPM.

The CALMET generated meteorological parameters from the outer grid were then used as input into a finer resolution inner grid domain of 31 km x 30 km with a 250 m resolution, centred on the Project Area. Observed surface data from mine owned monitors including SX8, SX13 and Liddell were incorporated into the inner domain modelling with any gaps in the data supplemented by TAPM. Detailed mine plan terrain data was incorporated into the modelling and a separate CALMET wind field generated for each mine plan scenario.

Table 6.1 summarises the inputs used for both the TAPM and CALMET models and **Figure 6.4** shows the different modelling domains used for both meteorological and dispersion modelling.

Other CALMET model options are listed in **Table 6.2**.

Table 6.1: Meteorological Parameters used for TAPM and CALMET

TAPM (v 4.0.4)	
Number of grids (spacing)	3 (30 km, 10 km, 3 km)
Number of grid points	45 x 45 x 35
Year of analysis	1 September 2011 to 31 August 2012
Centre of analysis	32°24.5' S, 151°16.5' E
Outer CALMET (v. 6.327)	
Meteorological grid domain	115 km x 115 km
Meteorological grid resolution	1 km (coarse resolution)
Vertical levels	0m, 20m, 80m, 120m, 280m, 720m, 1280, 2720, 3000 m
Surface meteorological stations	Williamtown RAAF AWS (Bureau of Meteorology, Station No. 061078) - Wind speed - Wind direction - Temperature - Relative humidity - Cloud Amount - Cloud Height - Sea Level Pressure
	Paterson (Tocal) AWS (Bureau of Meteorology, Station No. 061250) - Wind speed - Wind direction - Temperature - Relative humidity
	Newcastle AWS (Bureau of Meteorology, Station No. 061055) - Wind speed - Wind direction - Temperature - Relative humidity
	Cessnock Airport AWS (Bureau of Meteorology, Station No. 061260) - Wind speed - Wind direction - Temperature - Relative humidity - Sea Level Pressure
	Scone Airport AWS (Bureau of Meteorology, Station No. 061363) - Wind speed - Wind direction - Temperature - Relative humidity - Sea Level Pressure
Upper air	3D.dat TAPM output
Inner CALMET (v. 6.327)	
Meteorological grid domain	30 km x 31 km
Meteorological grid resolution	0.25 km (fine resolution)
Vertical levels	0m, 20m, 80m, 120m, 280m, 720m, 1280, 2720, 3000 m
Surface meteorological stations	SX8 Meteorological Station - Wind speed - Wind direction - Temperature - Relative humidity
	SX13 Meteorological Station - Wind speed - Wind direction - Temperature - Relative humidity
	Liddell Meteorological Station - Wind speed - Wind direction - Temperature
Upper air	Outer CALMET grid

Table 6.2: CALMET Model Options

Flag	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 for all other layers
TERRAD	Radius of influence of terrain	No default (typically 5- 15km)	12 km (outer) and 3 km (inner)
RMAX1 and RMAX2	Maximum radius of influence over land for observations in layer 1 and aloft	No Default	10 km (outer) and 2 km (inner)
R1 and R2	Distance from observations in layer 1 and aloft at which observations and Step 1 wind fields are weighted equally	No Default	5 km (outer) and 1 km (inner)

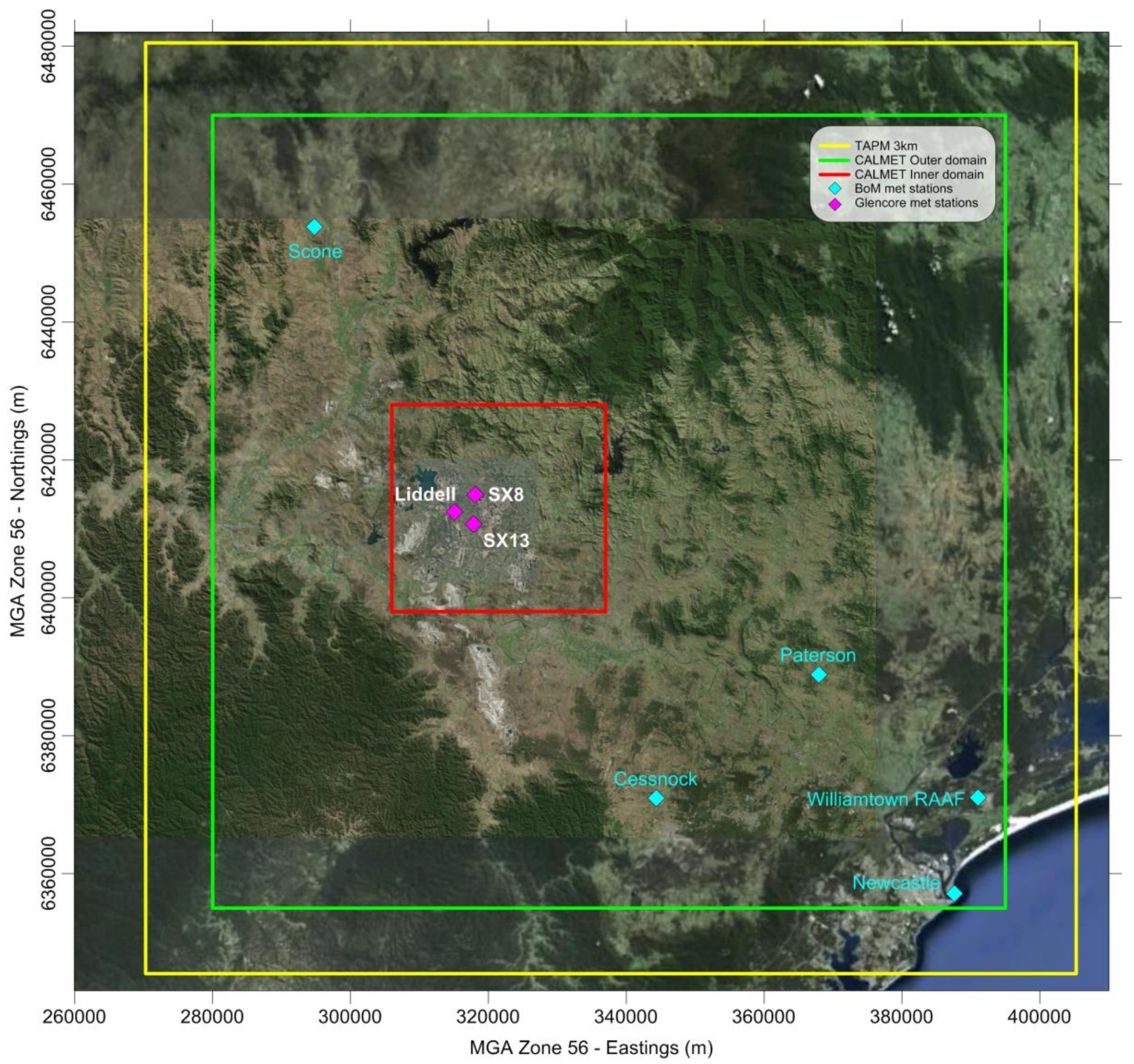


Figure 6.4: Various modelling domains used for meteorological and dispersion modelling

6.3.1 Wind Speed and Direction

The CALMET generated winds are compared with the measured data from the SX8 site and presented in **Figure 6.5**. The CALMET wind rose displays very similar characteristics to the measured data with dominant winds from the southeast and northwest. The average wind speed from CALMET (2.3 m/s) is the same as the measured data at SX8. The percentage occurrence of calm conditions (defined as wind speeds <0.5m/s) are similar, 8.3% recorded at the SX8 station compared with 8.9% predicted by CALMET.

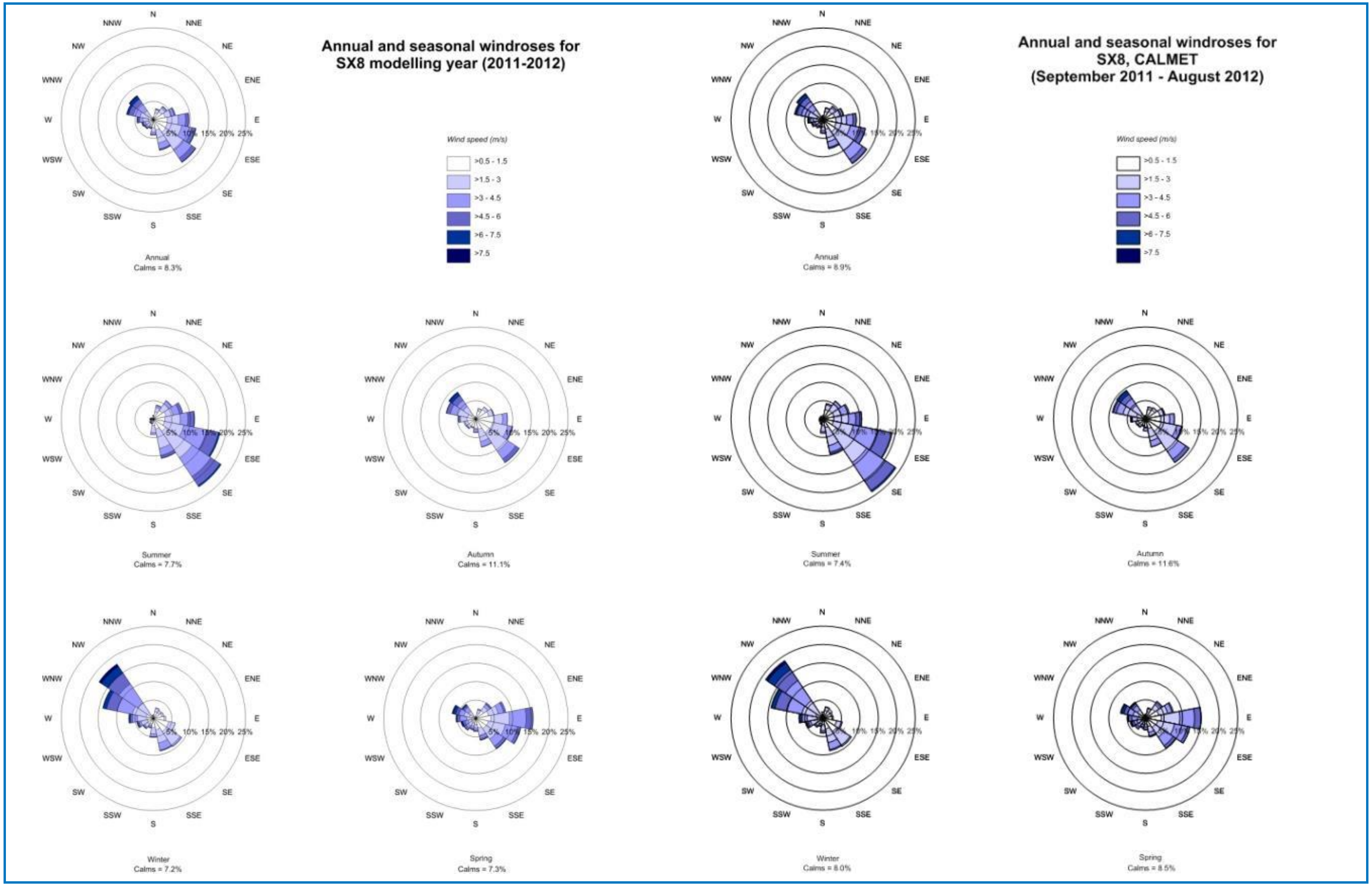


Figure 6.5: Annual and seasonal windroses at SX8 and CALMET

6.4 CALPUFF

CALPUFF is the dispersion module of the CALMET/CALPUFF suite of models. It is a multi-layer, multi species, non-steady-state puff dispersion model[b] that can simulate the effects of time-varying and space-varying meteorological conditions on pollutant transport, transformation and removal. 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 released puffs and takes into account the complex arrangement of emissions from point, area, volume and line sources (**Scire *et al.*, 2000**).

Each dust generating activity was represented by a series of volume sources situated according to their location, as shown in **Section 8.1.1**. The plume dimensions were determined using an initial lateral spread (sigma (σ) y) of 10 m and initial vertical spread (sigma (σ) z) of 2 m. All sources were given a release height of 2 m. Model predictions were made across the domain at gridded receptors at a spacing of 250 m x 250 m, as well as at almost 300 discrete receptors mainly representing privately and mine-owned residences.

A summary of the CALPUFF model options is presented in **Table 6.3**.

Table 6.3: CALPUFF Model Options

Flag	Flag Descriptor	Value Used	Value Description
MCHEM	Chemical transformation	0	Chemical transformation not modelled
MDRY	Dry deposition	1	Yes
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	1	Yes
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

[b] Gaussian plume models are considered steady-state because the plume equation is independent of time, that is, dispersion from the source to receptor is instantaneous for each hour of meteorological data. CALPUFF however, 'remembers' the plume from the previous hour taking into account residual concentrations at each grid point from the hours before and is therefore non-steady-state.

7 BEST PRACTICE MANAGEMENT

7.1 Introduction

In 2010, the NSW EPA commissioned a report to investigate potential best practice measures to either prevent or minimise particulate matter (PM) emissions (**Donnelly et al., 2011**) from open cut coal mines in NSW. The aim of the report was to identify the major sources of particulate matter from coal mines as well as the current emission controls that were being adopted. The report then went on to recommend control measures and estimate the likely emission reductions and feasibility of adopting such measures for the NSW mining industry.

In December 2011, the NSW EPA issued a notice of a variation to Mount Owen EPL 4460. This was part of an EPA initiative for Hunter wide mining operations. The notice required a site-specific review of Best Management Practice (BMP) be conducted to identify the most practicable means to reduce particulate matter, as part of the Pollution Reduction Program (PRP). This was submitted in June 2012 (**Xstrata, 2012**).

The BMP review for Mount Owen followed the process outlined in the OEH's "Coal Mine Particulate Matter Control Best Practice – Site Specific Determination Guideline" (**OEH, 2011**), referred to as the OEH Guideline. The review required Mount Owen to:

- quantify TSP, PM_{10} and $PM_{2.5}$ for all on-site activities,
- rank these to find the top four emission activities for each particle size group,
- identify best management practice control measures that could be applied to these top four activities,
- calculate the reductions that may be achieved by applying these controls, and
- determine which of the control measures are practicable and feasible and a timeframe in which they may be implemented.

The top four sources of PM_{10} emissions for the Mount Owen Mine were identified as:

1. Wheel generated dust from unpaved roads
2. Wind erosion of overburden
3. Loading overburden to trucks
4. Loading coal to trucks

7.2 Current and Proposed BMP Measures

Table 7.1 provides a summary of the applicable best practice management measures recommended by the NSW EPA for the PRP process and identifies current measures and those to be implemented at Mount Owen. Those cells shaded and marked (♦) represent measures that are currently adopted and/or are proposed to be adopted as part of the Project. These controls are drawn from recommendations of the "NSW Coal Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining" (**Donnelly et al., 2011**). The majority of the best practice measures are either currently implemented or will be implemented at the Project.

Control factors for each of the measures identified in **Table 7.1** were applied to the emission estimates calculated in **Section 8**. All reasonable and feasible measures will be undertaken and implemented to reduce dust generated from the Project.

Table 7.1: Best Management Practice measures proposed for the Project

Activity	Best Practice Control		In Place – Mount Owen	In Place – Ravensworth East	Proposed – Mount Owen	Proposed – Ravensworth East	Comments
Scrapers on topsoil	Soil naturally or artificially moist		♦	♦	♦	♦	Soil is naturally moist. Re-handle minimised. Stockpiles seeded with grass as soon as possible.
Hauling (surface treatments)	Vehicle speed restrictions	Reduction from 75 km/hr to 50 km/hr	♦	♦	♦	♦	Main haul roads speed limit 60 km/hr
		Reduction from 65 km/hr to 30 km/hr	♦	♦	♦	♦	Workshop & plant areas between 40-15 km/hr
		Grader speed reduction from 16km/hr to 8 km/hr	♦	♦	♦	♦	No grading in third gear
	Surface improvements	Pave the surface					Not practical as haul roads are temporary and move throughout life of mine.
		Low silt aggregate	♦	♦	♦	♦	Haul roads are surfaced with gravel
		Oil and double chip surface					Not necessary – using gravel
	Surface treatments	Watering (standard procedure)					Applying Level 2 watering to all haul roads.
		Watering Level 1 (2 L/m²/h)					
		Watering Level 2 (>2 L/m²/h)	♦	♦	♦	♦	
		Watering grader routes					
		Watering twice a day for industrial unpaved road					
		Suppressants	♦		♦		Petrotac - suppression emulsion used on light vehicle roads at Mount Owen
		Hygroscopic salts					
		Lignosulphonates					
		Polymer emulsions		♦		♦	
		Tar and bitumen emulsions					
		Sealed or salt-encrusted					
	Other	Use of larger vehicles	♦	♦	♦	♦	Using largest vehicles suitable for mining conditions
		Conveyors					Not feasible as described in Alternatives Section of EIS

Activity	Best Practice Control		In Place: Mount Owen	In Place: Ravensworth East	Proposed: Mount Owen	Proposed: Ravensworth East	Comments
Wind erosion - Exposed areas (active pit/active rehab areas) & Overburden emplacement areas	Avoidance	Minimise pre-strip	♦	♦	♦	♦	Pre-strip operations minimised
	Surface stabilisation	Watering					Prompt and progressive rehabilitation following completion of mining. Temporary rehabilitation of disturbed areas if prompt rehabilitation is not feasible (eg. some topsoil stockpiles). Restricted vehicle access on rehabilitated areas.
		Chemical suppressants					
		Paving and cleaning					
		Application of gravel to stabilise disturbed open areas					
		Rehabilitation goals	♦	♦	♦	♦	
	Wind speed reduction	Fencing, bunding, shelterbelts or in-pit dump	♦	♦	♦	♦	Emplacement of mining waste (including overburden) in pit at Mount Owen and Ravensworth East. No out of pit dumping proposed as part of the Project.
		Vegetative ground cover	♦	♦	♦	♦	Minimising disturbed areas
		Primary rehabilitation	♦	♦	♦	♦	Temporary rehabilitation of disturbed areas if prompt rehabilitation is not feasible, eg. some topsoil stockpiles.
		Vegetation established but not demonstrated to be self-sustaining. Weed control and grazing control	♦	♦	♦	♦	Yes. Early stages of rehabilitation. Intensive monitoring / supplementation is required
Wind erosion - coal stockpiles	Avoidance	Bypassing stockpiles					Not practical
	Surface stabilisation	Water sprays only					Temporarily rehabilitate disturbed areas if prompt rehabilitations is not feasible, for example on some topsoil stockpiles.
		Chemical wetting agents	♦	♦	♦	♦	
		Surface crusting agent					
		Carry over wetting from load in	♦	♦	♦	♦	
	Enclosure	Silo with bag house					
		Cover storage pile with a tarp during high winds					Not practical
	Wind speed reduction	Vegetative windbreaks					Not practical due to location of stockpiles.
		Reduced pile height	♦	♦	♦	♦	ROM stockpile limited to 30m height
		Wind screens/fences					Not practical
		Pile shaping/orientation	♦	♦	♦	♦	Stockpiles are rounded off on the side which faces the main wind direction.
		Erect 3-sided enclosure around storage piles					Not practical
		Rock armour and/or topsoil applied					Not practical

Activity	Best Practice Control		In Place: Mount Owen	In Place: Ravensworth East	Proposed: Mount Owen	Proposed: Ravensworth East	Comments
Bulldozers	Minimise travel speed and distance		♦	♦	♦	♦	Established suitable visual triggers and associated action for dozer operations at exposed locations. Modify dozer operations at exposed locations in accordance with site's air quality control system procedure.
	Keep travel routes and materials moist						
Blasting	Design: delay shot to avoid unfavourable weather conditions		♦	♦	♦	♦	Blasts completed in accordance with Blast Management Plan
	Design: minimise area blasted		♦	♦	♦	♦	
Drilling	Wet	Water injection sprays while drilling	♦	♦	♦	♦	Yes
	Dry collection	Fabric filters					
		Cyclone					
Loading and dumping overburden (Excavators)	Minimising drop height	Reduce from 3m to 1.5m	♦	♦	♦	♦	Equipment designed to limit drop height to 1.5m
Loading and dumping overburden (Trucks)	Minimising drop height	Reduce from 3m to 1.5m	♦	♦	♦	♦	Equipment designed to limit drop height to 1.5m
	Water application						Not practical
	Modify activities in windy conditions		♦	♦	♦	♦	In accordance with the air quality control system procedure or Management Plan
Loading trucks	-		♦	♦	♦	♦	Minimise rehandling. Operations ceased or amended in adverse weather conditions, in accordance with the air quality control system procedure
Unloading trucks	Water sprays						Water sprays on trucks are not feasible. Other management measures such as modifying operations in adverse weather and water cart operations are in place.
Loading and dumping ROM coal	Avoidance	Bypass ROM stockpiles					Not practical.
	Truck or loader dumping ROM coal	Minimise drop height (10m to 5m)	♦	♦	♦	♦	Equipment designed to limit drop height to 10m
		Water sprays on ROM pad					Not required due to inherent moisture content of ROM coal.
	Truck or loader dumping to ROM bin	Water sprays on ROM bin or sprays on ROM pad	♦	♦	♦	♦	Water sprays on ROM coal hoppers at Mount Owen – 3 sided enclosure Stockpile at Ravensworth East does not have an enclosed hopper and not used very often
		Enclosed dump hopper (3 sides and a roof)					
		Enclosed dump hopper (3 sides and a roof) plus water sprays	♦	♦	♦	♦	
		Enclosure with control device					

Activity	Best Practice Control		In Place		Proposed		Comments
			Mount Owen	Ravensworth East	Mount Owen	Ravensworth East	
Conveyor and transfers	Conveyors	Application of water at transfers					All transfer points are fully enclosed and therefore water application is not necessary. All conveyors except for product coal stacker. Underbelt scrapers for cleaning and side skirts to stop spillage
		Wind shielding - roof or side wall or					
		Wind shielding - roof AND side wall	♦	♦	♦	♦	
		Belt cleaning and spillage minimisation	♦	♦	♦	♦	
	Transfers	Enclosure	♦	♦	♦	♦	All transfer points are fully enclosed
		Enclosure and fabric filters					All transfer points are fully enclosed, therefore fabric filters are not required.
Stacking and reclaiming product coal	Avoidance	Bypass coal stockpiles		n/a	♦	n/a	
	Loading coal stockpiles	Variable height stack	♦	n/a	♦	n/a	Sprays in place and used if/when needed.
		Boom tip water sprays	♦	n/a	♦	n/a	
		Telescopic chute with water sprays		n/a		n/a	
		Total enclosure	♦	n/a	♦	n/a	
	Unloading product stockpiles	Bucket wheel, portal or bridge reclaimer with water application		n/a		n/a	Underground reclaimers, therefore further water application is not necessary.
		Water sprays		n/a		n/a	
		Wind breaks		n/a		n/a	
Loading to trains		Enclosure	♦	n/a	♦	n/a	Skirting at bottom of enclosure bin. Sprays in place and used if/when needed. Given full enclosure and use of water sprays, fabric filters are not feasible.
		Enclosure & fabric filters		n/a		n/a	
		Water sprays with chemicals	♦	n/a	♦	n/a	

n/a: not applicable to Ravensworth East as coal from Ravensworth East is processed with Mount Owen coal concurrently. Any controls at this stage that apply to Mount Owen will therefore apply to Ravensworth East

8 EMISSIONS TO AIR – PARTICULATE MATTER

8.1 Emissions from Mount Owen Continued Operations

8.1.1 Source Locations

Estimates of emissions for each source were developed on an hourly time step taking into account the activities that would take place at that location. Thus, for each source, for each hour, an emission rate was determined which depended on the level of activity and the wind speed. Dust generating activities were represented by a series of volume sources situated according to the location of activities for the modelled scenarios. The locations for each modelling year are shown in **Figure 8.1** to **Figure 8.3**.

Not every activity will occur at each source location and some source locations will see significantly more activities than others. For example, in the active pit area a variety of activities will be taking place simultaneously, such as drilling, blasting, loading to trucks, haulage and wind erosion. The source locations in the pit will therefore include a proportion of emissions from some, or all, of these activities.

Table 8.1, **Table 8.2** and **Table 8.3** list all activities that have been modelled for each year together with the source numbers that have been allocated to those activities which are shown in **Figure 8.1**, **Figure 8.2** and **Figure 8.3**, respectively.

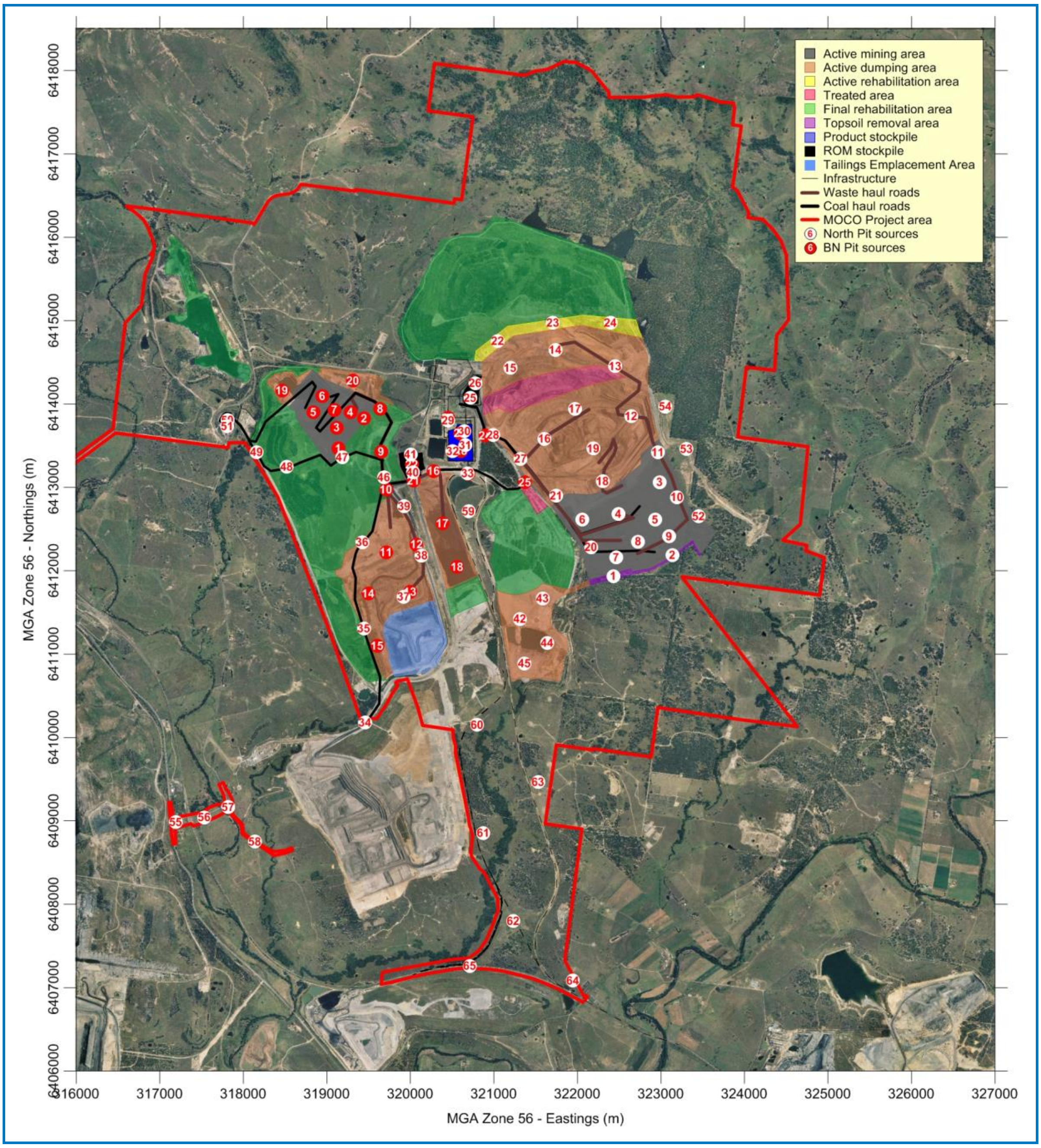


Figure 8.1: Location of sources for Year 1

Table 8.1: Activity and associated source allocation for Year 1

Activity	Source Location Number (see Figure 8.1)
Mount Owen – North Pit	
Topsoil - Scrapers stripping topsoil	1, 2
Topsoil - Scraper hauling topsoil to stockpiles	1, 2, 52, 53, 54
Topsoil - Emplacing topsoil at stockpiles	53, 54
Overburden - Drilling	3, 4, 5, 6, 7, 8, 9, 10
Overburden - Blasting	3, 4, 5, 6, 7, 8, 9, 10
Overburden - Dozers pushing waste	3, 4, 5, 6, 7, 8, 9, 10
Overburden - Excavators loading haul trucks	3, 4, 5, 6, 7, 8, 9, 10
Overburden - Hauling to waste dump with Cat 793	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 27
Overburden - Hauling to waste dump with Cat 785	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 27
Overburden - Unloading at waste dump	12, 13, 14, 15, 16, 17, 18, 19
Overburden - Dozers on waste dumps	12, 13, 14, 15, 16, 17, 18, 19
Rehabilitation - Dozers shaping rehab area	22, 23, 24
Coal - Dozers pushing coal	3, 4, 5, 6, 7, 8, 9, 10
Coal - Excavators loading ROM to trucks	3, 4, 5, 6, 7, 8, 9, 10
Coal - Hauling MTO ROM to ROM pad with Cat 793	3, 4, 5, 6, 7, 8, 20, 21, 27, 28
Coal - Hauling MTO ROM to ROM pad with Cat 785	3, 4, 5, 6, 7, 8, 20, 21, 27, 28
Coal - Hauling Glendell ROM to ROM pad with Cat 789	34, 35, 36, 40
Coal - Unloading MTO ROM at northern ROM pad	25, 26
Coal - Unloading Glendell ROM at southern ROM pad	40, 41
Coal - Primary crushing	29
Coal - Transfer to secondary crusher	29
Coal - Secondary crushing	29
Coal - Transfer to tertiary crusher	29
Coal - Tertiary crushing	29
Coal - FELs feeding North Pit ROM to northern ROM hopper	29
Coal - FELs feeding Glendell ROM to southern ROM hopper	41
Coal - FELs loading northern ROM to trucks for haulage to Rav East conveyer	25, 26
Coal - FELs loading southern ROM to trucks for haulage to Rav East conveyer	40, 41
Coal - Hauling northern ROM to Rav East conveyer with Cat 785	27, 28, 33, 40, 46, 47, 48, 49, 50
Coal - Hauling southern ROM to Rav East conveyer with Cat 785	40, 46, 47, 48, 49, 50
Coal - Unloading ROM at Rav East conveyer	51
Coal - Material transfer of ROM to CHPP (includes Glendell ROM)	32
Coal - Hauling coarse rejects to North Pit waste dump in Cat 789	27, 28, 16, 17
Coal - Hauling coarse rejects to West Pit waste dump in Cat 789	33, 40, 39, 38, 37
Coal - Material transfer of product to stockpiles (includes Glendell)	30, 31
Coal - Dozers on product stockpiles	30, 31
Coal - Material transfer to train loading silo (includes Glendell)	33
Coal - Material transfer to trains (included Glendell product)	33
Grading roads	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 27, 28, 34, 35, 36, 37, 38, 39, 46, 47, 48, 49
Gravel crushing in-pit	3, 4, 5, 6, 7, 8, 9, 10
Wind erosion - Active waste dump area (includes WOOP area 73ha)	12, 13, 14, 15, 16, 17, 18, 19, 42, 43, 44, 45
Wind erosion - Active exposed pit area	3, 4, 5, 6, 7, 8, 9, 10, 11
Wind erosion - Active rehab area	22, 23, 24
Wind erosion - Northern ROM stockpile	25, 26
Wind erosion - Southern ROM stockpile	40, 41
Wind erosion - Product stockpile	30, 31
Wind erosion - Topsoil removal area	1, 2
Wind erosion - Topsoil stockpile/storage area	53, 54
Wind erosion - Construction on Hebden Road	55, 56, 57, 58
Wind erosion - Construction of Rail Loop	59, 60, 61, 62, 63, 64, 65

Activity	Source Location Number (see Figure 8.1)
Mount Owen – Bayswater North Pit	
Topsoil - Scrapers stripping topsoil	1, 2
Topsoil - Scraper hauling topsoil to stockpiles	1, 2
Topsoil - Emplacing topsoil at stockpiles	1, 2
Overburden - Drilling	3, 4, 5, 6
Overburden - Blasting	3, 4, 5, 6
Overburden - Dozers pushing waste	3, 4, 5, 6
Overburden - Excavators loading haul trucks	3, 4, 5, 6
Overburden - Hauling to waste dump with Cat 793	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
Overburden - Hauling to waste dump with Cat 789	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
Overburden - Unloading at waste dump	11, 12, 13, 14, 15, 17, 18, 19, 20
Overburden - Dozers on waste dumps	11, 12, 13, 14, 15, 17, 18, 19, 20
Coal - Dozers pushing coal	3, 4, 5, 6
Coal - Excavators loading ROM to trucks	3, 4, 5, 6
Coal - Hauling ROM to South ROM pad with Cat 789	3, 4, 5, 6, 7, 8, 9, 10, 21
Coal - Unloading ROM at South ROM pad	22
Coal - Primary crushing	23
Coal - Transfer to secondary crusher	23
Coal - Secondary crushing	23
Coal - Transfer to tertiary crusher	23
Coal - Tertiary crushing	23
Coal - FELs feeding ROM to ROM hopper	22
Coal - Material transfer of ROM to CHPP	23
Coal - Hauling coarse rejects to West Pit waste dump in Cat 789	24, 25, 26, 16, 17, 18
Coal - Material transfer of product to stockpiles	27, 28
Coal - Material transfer to train loading silo	26
Coal - Material transfer to trains	26
Grading roads	3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 16, 17, 24, 25, 26
Wind erosion - Active waste dump area (includes areas near West Pit)	11, 12, 13, 14, 15, 17, 18, 19, 20
Wind erosion - Active exposed pit area	3, 4, 5, 6, 7
Wind erosion - Topsoil removal area	1, 2

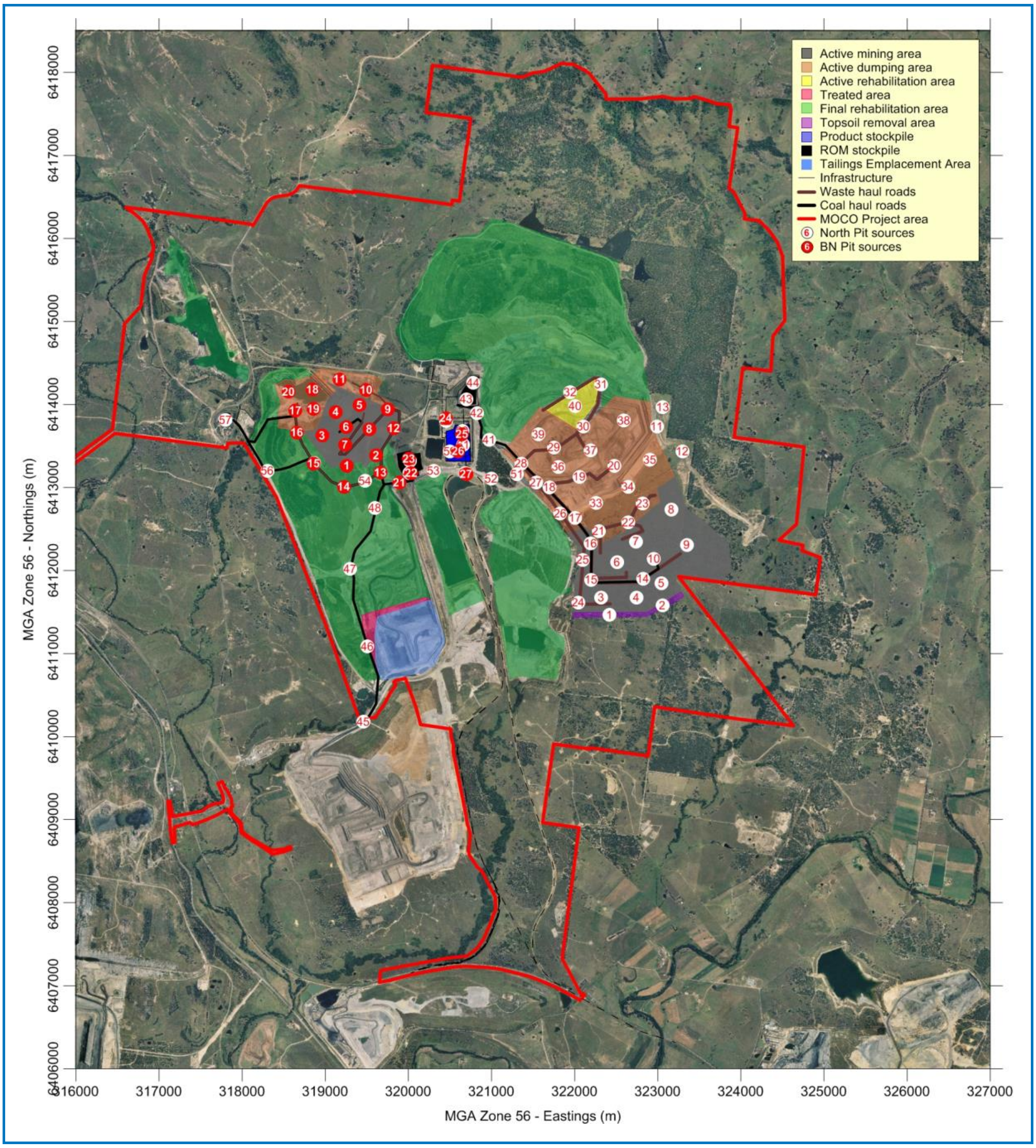


Figure 8.2: Location of sources for Year 5

Table 8.2: Activity and associated source allocation for Year 5

Activity	Source Location Number (see Figure 8.2)
Mount Owen – North Pit	
Topsoil - Scrapers stripping topsoil	1, 2
Topsoil - Scraper hauling topsoil to stockpiles	1, 2, 11, 12, 13
Topsoil - Emplacing topsoil at stockpiles	12, 13
Overburden - Drilling	3, 4, 5, 6, 7, 8, 9, 10
Overburden - Blasting	3, 4, 5, 6, 7, 8, 9, 10
Overburden - Dozers pushing waste	3, 4, 5, 6, 7, 8, 9, 10
Overburden - Excavators loading haul trucks	3, 4, 5, 6, 7, 8, 9, 10
Overburden - Hauling to waste dump with Cat 793	3, 4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39
Overburden - Hauling to waste dump with Cat 785	3, 4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39
Overburden - Unloading at waste dump	19, 20, 29, 33, 34, 35, 36, 37, 38, 39
Overburden - Dozers on waste dumps	19, 20, 29, 33, 34, 35, 36, 37, 38, 39
Rehabilitation - Dozers shaping rehab area	40
Coal - Dozers pushing coal	3, 4, 5, 6, 7, 8, 9, 10
Coal - Excavators loading ROM to trucks	3, 4, 5, 6, 7, 8, 9, 10
Coal - Hauling MTO ROM to ROM pad with Cat 793	3, 4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 17, 18, 28, 41, 42
Coal - Hauling MTO ROM to ROM pad with Cat 785	3, 4, 5, 6, 7, 8, 9, 10, 14, 15, 16, 17, 18, 28, 41, 42
Coal - Hauling Glendell ROM to ROM pad with Cat 789	45, 46, 47, 48, 49
Coal - Unloading ROM at northern ROM pad	43, 44
Coal - Unloading Glendell ROM at southern ROM pad	49, 50
Coal - Primary crushing	58
Coal - Transfer to secondary crusher	58
Coal - Secondary crushing	58
Coal - Transfer to tertiary crusher	58
Coal - Tertiary crushing	58
Coal - FELs feeding North Pit ROM to northern ROM hopper	43
Coal - FELs feeding Glendell ROM to southern ROM hopper	50
Coal - FELs loading northern ROM to trucks for haulage to Rav East conveyer	43, 44
Coal - FELs loading southern ROM to trucks for haulage to Rav East conveyer	49, 50
Coal - Hauling northern ROM to Rav East conveyer with Cat 785	41, 42, 51, 52, 53, 54, 55, 56, 57
Coal - Hauling southern ROM to Rav East conveyer with Cat 785	49, 54, 55, 56
Coal - Unloading ROM at Rav East conveyer	57
Coal - Material transfer of ROM to CHPP (includes Glendell ROM)	58
Coal - Hauling coarse rejects to North Pit waste dump in Cat 789	17, 18, 19, 20, 21, 22, 23, 28, 35, 36, 37, 51, 52
Coal - Material transfer of product to stockpiles (includes Glendell)	60, 61
Coal - Dozers on product stockpiles	59, 60, 61
Coal - Material transfer to train loading silo (includes Glendell)	62
Coal - Material transfer to trains (included Glendell product)	62
Grading roads	9, 10, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 41, 42, 45, 46, 47, 48, 49, 52, 53, 54, 55, 56, 57
Gravel crushing in-pit	3, 4, 5, 6, 7, 8, 9, 10
Wind erosion - Active waste dump area	19, 20, 21, 22, 23, 29, 30, 33, 34, 35, 36, 37, 38, 39
Wind erosion - Active exposed pit area	3, 4, 5, 6, 7, 8, 9, 10, 14, 15
Wind erosion - Active rehab area	40
Wind erosion - Northern ROM stockpile	43, 44
Wind erosion - Southern ROM stockpile	49, 50
Wind erosion - Product stockpile	59, 60, 61
Wind erosion - Topsoil removal area	1, 2
Wind erosion - Topsoil stockpile/storage area	12, 13
Wind erosion - Construction on Hebden Road	No activity in Year 5

Activity	Source Location Number (see Figure 8.2)
Mount Owen – Bayswater North Pit	
Topsoil - Scrapers stripping topsoil	1, 2
Topsoil - Scraper hauling topsoil to stockpiles	1, 2
Topsoil - Emplacing topsoil at stockpiles	1, 2
Overburden - Drilling	3, 4, 5
Overburden - Blasting	3, 4, 5
Overburden - Dozers pushing waste	3, 4, 5
Overburden - Excavators loading haul trucks	3, 4, 5
Overburden - Hauling to waste dump with Cat 793	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
Overburden - Hauling to waste dump with Cat 789	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
Overburden - Unloading at waste dump	10, 11, 16, 17, 18, 19, 20
Overburden - Dozers on waste dumps	10, 11, 16, 17, 18, 19, 20
Coal - Dozers pushing coal	3, 4, 5
Coal - Excavators loading ROM to trucks	3, 4, 5
Coal - Hauling ROM to South ROM pad with Cat 789	3, 4, 5, 6, 7, 8, 9, 12, 13, 21
Coal - Unloading ROM at South ROM pad	22, 23
Coal - Primary crushing	24
Coal - Transfer to secondary crusher	24
Coal - Secondary crushing	24
Coal - Transfer to tertiary crusher	24
Coal - Tertiary crushing	24
Coal - FELs feeding ROM to ROM hopper	23
Coal - Material transfer of ROM to CHPP	24
Coal - Hauling coarse rejects to waste dump in Cat 789	13, 14, 15, 16, 17, 18, 19, 20
Coal - Material transfer of product to stockpiles	25, 26
Coal - Material transfer to train loading silo	27
Coal - Material transfer to trains	27
Grading roads	6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17
Wind erosion - Active waste dump area	10, 11, 16, 17, 18, 19, 20
Wind erosion - Active exposed pit area	3, 4, 5, 6, 7, 8, 9
Wind erosion - Topsoil removal area	1, 2

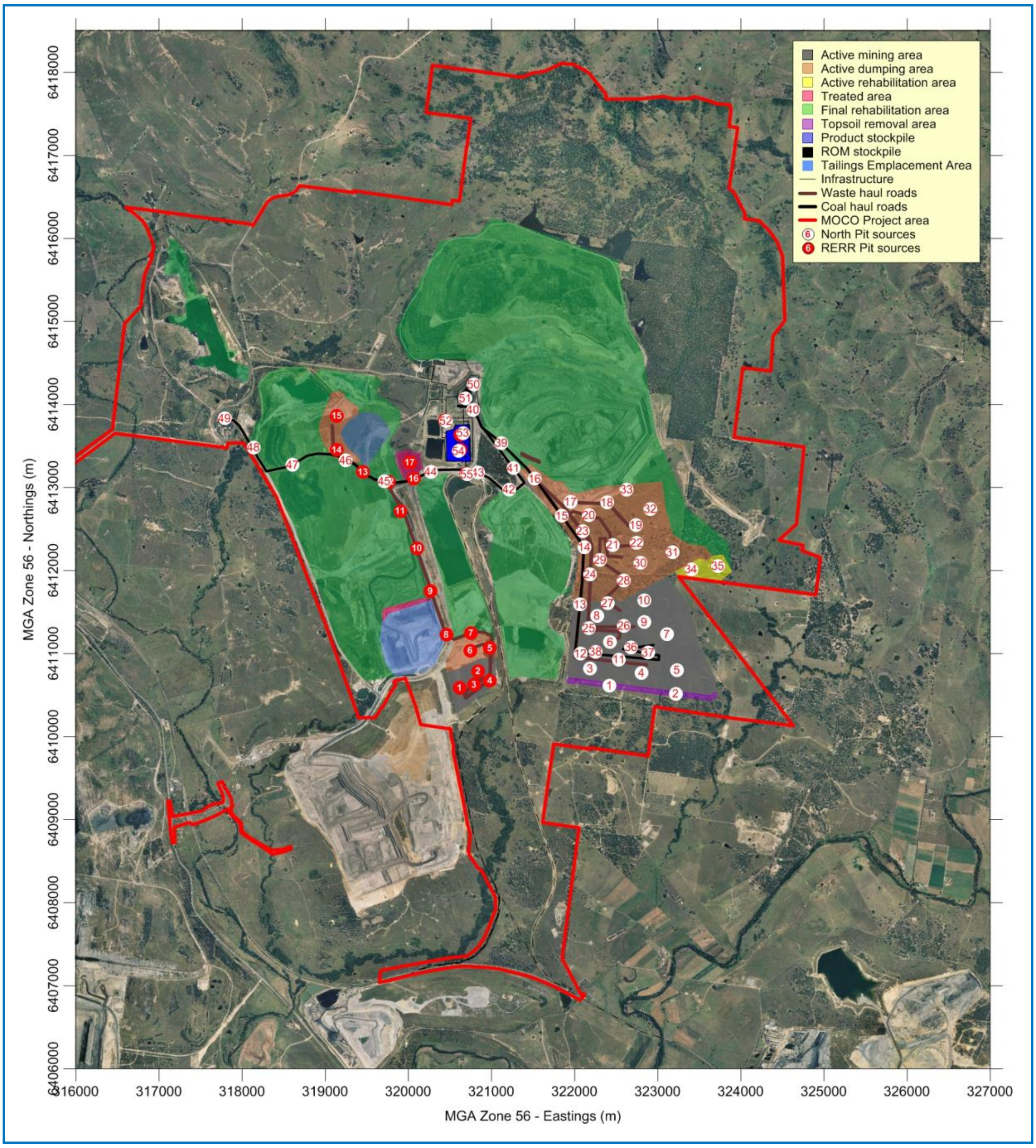


Figure 8.3: Location of sources for Year 10

Table 8.3: Activity and associated source allocation for Year 10

Activity	Source Location Number (see Figure 8.3)
Mount Owen – North Pit	
Topsoil - Scrapers stripping topsoil	1, 2
Topsoil - Scraper hauling topsoil to rehab area	1, 2, 34, 35
Topsoil - Emplacing topsoil at rehab area	34, 35
Overburden - Drilling	3, 4, 6, 7, 8, 9, 10
Overburden - Blasting	3, 4, 6, 7, 8, 9, 10
Overburden - Dozers pushing waste	3, 4, 6, 7, 8, 9, 10
Overburden - Excavators loading haul trucks	6, 7, 8, 9, 10
Overburden - Hauling to waste dump with Cat 793	6, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33
Overburden - Hauling to waste dump with Cat 785	6, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33
Overburden - Unloading at waste dump	17, 18, 19, 20, 21, 22, 28, 29, 30, 31, 32, 33
Overburden - Dozers on waste dumps	17, 18, 19, 20, 21, 22, 28, 29, 30, 31, 32, 33
Rehabilitation - Dozers shaping rehab area	34, 35
Coal - Dozers pushing coal	6, 8, 9, 10
Coal - Excavators loading ROM to trucks	6, 8, 9, 10
Coal - Hauling MTO ROM to North ROM pad with Cat 793	No activity in Year 10
Coal - Hauling MTO ROM to North ROM pad with Cat 785	6, 8, 9, 11, 12, 13, 14, 15, 16, 36, 37, 38, 39 40
Coal - Hauling Glendell ROM to South ROM pad with Cat 789	No activity in Year 10
Coal - Unloading ROM at North ROM pad	50, 51
Coal - Unloading Glendell ROM at South ROM pad	No activity in Year 10
Coal - Primary crushing	52
Coal - Transfer to secondary crusher	52
Coal - Secondary crushing	52
Coal - Transfer to tertiary crusher	52
Coal - Tertiary crushing	52
Coal - FELs feeding North Pit ROM to northern ROM hopper	51
Coal - FELs feeding Glendell ROM to southern ROM hopper	No activity in Year 10
Coal - FELs loading northern ROM to trucks for haulage to Rav East conveyer	50, 51
Coal - FELs loading southern ROM to trucks for haulage to Rav East conveyer	No activity in Year 10
Coal - Hauling northern ROM to Rav East conveyer with Cat 785	39, 40, 41, 42, 43, 44, 45, 46, 47, 48
Coal - Hauling southern ROM to Rav East conveyer with Cat 785	No activity in Year 10
Coal - Unloading ROM at Rav East conveyer	49
Coal - Material transfer of ROM to CHPP (MTO only)	52
Coal - Hauling coarse rejects to North Pit waste dump in Cat 789	14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 28, 29, 30, 31, 32, 33, 39, 40
Coal - Material transfer of product to stockpiles (MTO only)	53, 54
Coal - Dozers on product stockpiles	53, 54
Coal - Material transfer to train loading silo (MTO only)	55
Coal - Material transfer to trains (MTO only)	55
Grading roads	11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48
Gravel crushing in-pit	6, 7, 8, 9, 10
Wind erosion - Active waste dump area	16, 17, 18, 19, 20, 21, 22, 23, 24, 28, 29, 30, 31, 32, 33
Wind erosion - Active exposed pit area	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 25, 26, 36, 37, 38
Wind erosion - Active rehab area	34, 35
Wind erosion - Northern ROM stockpile	50, 51
Wind erosion - Southern ROM stockpile	N/A
Wind erosion - Product stockpile	53, 54
Wind erosion - Topsoil removal area	1, 2
Wind erosion - Topsoil stockpile/storage area	N/A
Wind erosion - Construction on Hebden Road	No activity in Year 10

Activity	Source Location Number (see Figure 8.3)
Mount Owen – RERR	
Overburden - Drilling	1, 2
Overburden - Blasting	1, 2
Overburden - Dozers on waste (in pit)	1, 2
Overburden - Loading to haul trucks	1, 2
Overburden - Hauling to waste dump	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15
Overburden - Unloading at waste dump	6, 14, 15
Overburden - Dozers on waste dumps	6, 14, 15
Coal - Dozers on coal (in pit)	1, 2
Coal - Loading ROM to trucks	1, 2
Coal - Hauling ROM to ROM pad	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 16
Coal - Unloading ROM at ROM pad	17
Coal - FELs Loading ROM to hopper	17
Coal - Material transfer of ROM to CHPP	18
Coal - Primary crushing	18
Coal - Transfer to secondary crusher	18
Coal - Secondary crushing	18
Coal - Transfer to tertiary crusher	18
Coal - Tertiary crushing	18
Coal - Material transfer of product to stockpiles	19, 20
Coal - Material transfer to train loading silo	21
Coal - Material transfer to trains	21
Grading roads	3, 4, 5, 7, 8, 9, 10, 12, 13, 14, 16
Wind erosion - Active waste dump area	5, 6, 14, 15
Wind erosion - Active exposed pit area	1, 2

8.1.2 Mining Operations

The proposed operation of the Project was analysed and estimates of dust emissions for the key dust generating activities were made. Emission factors developed by the US EPA were applied to estimate the amount of dust produced by each activity. The emission factors applied are considered to be the most reliable, contemporary methods for determining dust generation rates.

The mine plans for the Project were analysed and detailed emissions inventories prepared for three key operating scenarios. The operational years chosen were Years 1, 5 and 10, nominally 2016, 2020 and 2025 respectively. These modelled years are considered to be representative of worst-case operations where coal and waste production are highest, where extraction or wind erosion areas are largest or where operations are located closest to sensitive receptors.

Various control factors have also been applied to some activities, based on the information presented in **Section 7**, outlining the current and future commitments to best practice management of dust emissions from Mount Owen operations. Further discussion on controlling dust on haul roads is found in **Section 8.2**. Further detail on the emission factors and calculations is provided in **Appendix B**.

To model the effect of pit retention for emissions for the Project, detailed mine plan terrain data has been incorporated into the modelling. All activities except blasting have been modelled for 24 hours per day.

For each stage of the Project modelled (Year 1, Year 5 and Year 10), a corresponding emissions inventory was developed for TSP, PM_{10} and $PM_{2.5}$. The information used for developing the inventories has been based on the operational descriptions and mine plan drawings to determine haul road distances and routes, stockpile and pit areas, dozer operating hours, truck sizes and other details that are necessary to estimate dust emissions. The site specific parameters described in **Section 8.3**, were used to populate the relevant emission factor equations. **Table 8.4**, **Table 8.5** and **Table 8.6**, summarise the quantities of TSP, PM_{10} and $PM_{2.5}$ estimated to be released by each activity of the Project, and for each modelling year.

Table 8.4: Estimated TSP emissions for Year 1, Year 5 and Year 10 (kg/y)

Activity	Year 1	Year 5	Year 10
Topsoil - Scrapers stripping topsoil	682	992	1,135
Topsoil - Scraper hauling topsoil to stockpiles	263	383	948
Topsoil - Emplacing topsoil at stockpiles	6	8	10
Overburden - Drilling	8,611	8,904	7,440
Overburden - Blasting	72,818	75,308	64,727
Overburden - Dozers pushing waste	88,919	99,440	94,791
Overburden - Excavators loading haul trucks	23,701	24,509	20,973
Overburden - Hauling to waste dump with Cat 793	872,221	1,082,586	931,907
Overburden - Hauling to waste dump with Cat 785	148,669	112,327	176,417
Overburden - Unloading at waste dump	23,701	24,509	20,973
Overburden - Dozers on waste dumps	12,351	12,856	12,320
Rehabilitation - Dozers shaping rehab area	1,181	321	375
Coal - Dozers pushing coal	447,705	494,539	331,965
Coal - Excavators loading ROM to trucks	495,132	569,624	342,068
Coal - Hauling MTO ROM to ROM pad with Cat 793	14,964	26,855	-
Coal - Hauling MTO ROM to ROM pad with Cat 785	138,294	193,057	224,640
Coal - Hauling Glendell ROM to ROM pad with Cat 789	85,500	64,321	-
Coal - Unloading ROM at northern ROM pad	495,132	569,624	342,068
Coal - Unloading Glendell ROM at southern ROM pad	248,720	187,111	-
Coal - Primary crushing	4,464	4,555	1,615
Coal - Transfer to secondary crusher	2,480	2,531	897
Coal - Secondary crushing	4,464	4,555	1,615
Coal - Transfer to tertiary crusher	2,480	2,531	897
Coal - Tertiary crushing	4,464	4,555	1,615
Coal - FELs feeding North Pit ROM to northern ROM hopper	131,403	153,750	68,347
Coal - FELs feeding Glendell ROM to southern ROM hopper	57,479	38,997	-
Coal - FELs loading northern ROM to trucks for haulage to Rav East conveyer	57,123	57,123	114,245
Coal - FELs loading southern ROM to trucks for haulage to Rav East conveyer	57,123	57,123	-
Coal - Hauling northern ROM to Rav East conveyer with Cat 785	31,310	31,310	62,620
Coal - Hauling southern ROM to Rav East conveyer with Cat 785	15,950	15,950	-
Coal - Unloading ROM at Rav East conveyer	114,245	114,245	114,245
Coal - Material transfer of ROM to CHPP (includes Glendell ROM in Years 1 and 5)	876	894	317
Coal - Hauling coarse rejects to North Pit waste dump in Cat 789	11,915	23,223	55,850
Coal - Hauling coarse rejects to West Pit waste dump in Cat 789	5,106	-	-
Coal - Material transfer of product to stockpiles (includes Glendell in Years 1 and 5)	377	357	177
Coal - Dozers on product stockpiles	111,279	102,151	45,374
Coal - Material transfer to train loading silo (includes Glendell in Years 1 and 5)	377	357	177
Coal - Material transfer to trains (includes Glendell product IN Years 1 and 5)	377	357	177
Grading roads	37,234	38,576	39,811
Gravel crushing in-pit	810	810	810
Wind erosion - Active waste dump area (includes WOOP area in Year 1)	324,996	193,596	157,680
Wind erosion - Active exposed pit area	144,540	155,928	153,300
Wind erosion - Active rehab area	24,528	14,796	11,651
Wind erosion - Northern ROM stockpile	4,292	4,292	4,292
Wind erosion - Southern ROM stockpile	6,570	6,570	0
Wind erosion - Product stockpile	2,102	2,102	2,102
Wind erosion - Topsoil removal area	5,344	6,570	8,760
Wind erosion - Topsoil stockpile/storage area	3,942	3,942	-
Wind erosion - Construction on Hebden Road	12,264	-	-
Wind erosion - Construction of Rail Loop	157,680	-	-
Total	**4,516,165**	**4,589,022**	**3,419,335**

Table 8.5: Estimated PM_{10} emissions for Year 1, Year 5 and Year 10 (kg/y)

Activity	Year 1	Year 5	Year 10
Topsoil - Scrapers stripping topsoil	172	250	286
Topsoil - Scraper hauling topsoil to stockpiles	36	53	130
Topsoil - Emplacing topsoil at stockpiles	3	4	5
Overburden - Drilling	4,478	4,630	3,869
Overburden - Blasting	37,865	39,160	33,658
Overburden - Dozers pushing waste	19,808	22,152	21,116
Overburden - Excavators loading haul trucks	11,210	11,592	9,920
Overburden - Hauling to waste dump with Cat 793	186,742	231,781	199,521
Overburden - Hauling to waste dump with Cat 785	31,830	24,049	37,771
Overburden - Unloading at waste dump	11,210	11,592	9,920
Overburden - Dozers on waste dumps	1,865	1,941	1,861
Rehabilitation - Dozers shaping rehab area	178	49	57
Coal - Dozers pushing coal	114,260	126,212	84,721
Coal - Excavators loading ROM to trucks	68,117	78,365	47,059
Coal - Hauling MTO ROM to ROM pad with Cat 793	3,204	5,750	-
Coal - Hauling MTO ROM to ROM pad with Cat 785	29,609	41,333	48,095
Coal - Hauling Glendell ROM to ROM pad with Cat 789	18,305	13,771	-
Coal - Unloading ROM at northern ROM pad	68,117	78,365	47,059
Coal - Unloading Glendell ROM at southern ROM pad	34,217	25,742	-
Coal - Primary crushing	1,984	2,025	718
Coal - Transfer to secondary crusher	909	928	329
Coal - Secondary crushing	1,984	2,025	718
Coal - Transfer to tertiary crusher	909	928	329
Coal - Tertiary crushing	1,984	2,025	718
Coal - FELs feeding North Pit ROM to northern ROM hopper	18,078	21,152	9,403
Coal - FELs feeding Glendell ROM to southern ROM hopper	7,908	5,365	-
Coal - FELs loading northern ROM to trucks for haulage to Rav East conveyer	7,859	7,859	15,717
Coal - FELs loading southern ROM to trucks for haulage to Rav East conveyer	7,859	7,859	-
Coal - Hauling northern ROM to Rav East conveyer with Cat 785	6,703	6,703	13,407
Coal - Hauling southern ROM to Rav East conveyer with Cat 785	3,415	3,415	-
Coal - Unloading ROM at Rav East conveyer	15,717	15,717	15,717
Coal - Material transfer of ROM to CHPP (includes Glendell ROM in Years 1 and 5)	414	423	150
Coal - Hauling coarse rejects to North Pit waste dump in Cat 789	2,551	3,480	11,957
Coal - Hauling coarse rejects to West Pit waste dump in Cat 789	1,093	-	-
Coal - Material transfer of product to stockpiles (includes Glendell in Years 1 and 5)	178	169	84
Coal - Dozers on product stockpiles	24,749	22,719	10,092
Coal - Material transfer to train loading silo (includes Glendell in Years 1 and 5)	178	169	84
Coal - Material transfer to trains (includes Glendell product in Years 1 and 5)	178	169	84
Grading roads	13,009	13,478	13,910
Gravel crushing in-pit	360	360	360
Wind erosion - Active waste dump area (includes WOOP area in Year 1)	162,498	96,798	78,840
Wind erosion - Active exposed pit area	72,270	77,964	76,650
Wind erosion - Active rehab area	12,264	7,398	5,825
Wind erosion - Northern ROM stockpile	2,146	2,146	2,146
Wind erosion - Southern ROM stockpile	3,285	3,285	-
Wind erosion - Product stockpile	1,051	1,051	1,051
Wind erosion - Topsoil removal area	2,672	3,285	4,380
Wind erosion - Topsoil stockpile/storage area	1,971	1,971	-
Wind erosion - Construction on Hebden Road	6,132	-	-
Wind erosion - Construction of Rail Loop	78,840	-	-
Total	**1,102,375**	**1,027,655**	**807,715**

Table 8.6: Estimated $PM_{2.5}$ emissions for Year 1, Year 5 and Year 10 (kg/y)

Activity	Year 1	Year 5	Year 10
Topsoil - Scrapers stripping topsoil	17	25	29
Topsoil - Scraper hauling topsoil to stockpiles	4	5	13
Topsoil - Emplacing topsoil at stockpiles	0	1	1
Overburden - Drilling	258	267	223
Overburden - Blasting	2,185	2,259	1,942
Overburden - Dozers pushing waste	9,337	10,441	9,953
Overburden - Excavators loading haul trucks	1,697	1,755	1,502
Overburden - Hauling to waste dump with Cat 793	18,674	23,178	19,952
Overburden - Hauling to waste dump with Cat 785	3,183	2,405	3,777
Overburden - Unloading at waste dump	1,697	1,755	1,502
Overburden - Dozers on waste dumps	1,297	1,350	1,294
Rehabilitation - Dozers shaping rehab area	124	34	39
Coal - Dozers pushing coal	9,850	10,880	7,303
Coal - Excavators loading ROM to trucks	9,408	10,823	6,499
Coal - Hauling MTO ROM to ROM pad with Cat 793	320	575	-
Coal - Hauling MTO ROM to ROM pad with Cat 785	2,961	4,133	4,810
Coal - Hauling Glendell ROM to ROM pad with Cat 789	1,831	1,377	-
Coal - Unloading ROM at northern ROM pad	9,408	10,823	6,499
Coal - Unloading Glendell ROM at southern ROM pad	4,726	3,555	-
Coal - Primary crushing	1,984	2,025	718
Coal - Transfer to secondary crusher	909	928	329
Coal - Secondary crushing	1,984	2,025	718
Coal - Transfer to tertiary crusher	909	928	329
Coal - Tertiary crushing	1,984	2,025	718
Coal - FELs feeding North Pit ROM to northern ROM hopper	2,497	2,921	1,299
Coal - FELs feeding Glendell ROM to southern ROM hopper	1,092	741	-
Coal - FELs loading northern ROM to trucks for haulage to Rav East conveyer	1,085	1,085	2,171
Coal - FELs loading southern ROM to trucks for haulage to Rav East conveyer	1,085	1,085	-
Coal - Hauling northern ROM to Rav East conveyer with Cat 785	670	670	1,341
Coal - Hauling southern ROM to Rav East conveyer with Cat 785	341	341	-
Coal - Unloading ROM at Rav East conveyer	2,171	2,171	2,171
Coal - Material transfer of ROM to CHPP (includes Glendell ROM in Years 1 and 5)	63	64	23
Coal - Hauling coarse rejects to North Pit waste dump in Cat 789	255	348	1,196
Coal - Hauling coarse rejects to West Pit waste dump in Cat 789	109	-	-
Coal - Material transfer of product to stockpiles (includes Glendell in Years 1 and 5)	27	26	13
Coal - Dozers on product stockpiles	2,448	2,247	998
Coal - Material transfer to train loading silo (includes Glendell in Years 1 and 5)	27	26	13
Coal - Material transfer to trains (includes Glendell product IN Years 1 and 5)	27	26	13
Grading roads	1,154	1,196	1,234
Gravel crushing in-pit	360	360	360
Wind erosion - Active waste dump area (includes WOOP area in Year 1)	24,375	14,520	11,826
Wind erosion - Active exposed pit area	10,841	11,695	11,498
Wind erosion - Active rehab area	1,840	1,110	874
Wind erosion - Northern ROM stockpile	322	322	322
Wind erosion - Southern ROM stockpile	493	493	-
Wind erosion - Product stockpile	158	158	158
Wind erosion - Topsoil removal area	401	493	657
Wind erosion - Topsoil stockpile/storage area	296	296	-
Wind erosion - Construction on Hebden Road	920	-	-
Wind erosion - Construction of Rail Loop	11,826	-	-
Total	**149,628**	**135,963**	**104,313**

In addition to emissions from the North Pit, **Table 8.7**, **Table 8.8** and **Table 8.9** summarise the estimated TSP, PM_{10} and $PM_{2.5}$ emissions from BNP in Years 1 and 5 and the RERR Mining Area in Year 10, for, respectively.

Table 8.7: Estimated emissions for Year 1 – Bayswater North Pit Mining Area (kg/y)

Activity	TSP	PM_{10}	$PM_{2.5}$
Topsoil - Scrapers stripping topsoil	480	121	12
Topsoil - Scraper hauling topsoil to stockpiles	51	7	1
Topsoil - Emplacing topsoil at stockpiles	4	2	0
Overburden - Drilling	1,293	672	39
Overburden - Blasting	4,037	2,099	121
Overburden - Dozers pushing waste	39,943	8,898	4,194
Overburden - Excavators loading haul trucks	8,434	3,989	604
Overburden - Hauling to waste dump with Cat 793	244,050	52,251	5,225
Overburden - Hauling to waste dump with Cat 789	163,288	34,960	3,496
Overburden - Unloading at waste dump	8,434	3,989	604
Overburden - Dozers on waste dumps	2,602	393	273
Coal - Dozers pushing coal	31,672	8,083	697
Coal - Excavators loading ROM to trucks	96,746	13,310	1,838
Coal - Hauling ROM to South ROM pad with Cat 789	26,606	5,696	570
Coal - Unloading ROM at South ROM pad	96,746	13,310	1,838
Coal - Primary crushing	686	305	305
Coal - Transfer to secondary crusher	381	140	140
Coal - Secondary crushing	686	305	305
Coal - Transfer to tertiary crusher	381	140	140
Coal - Tertiary crushing	686	305	305
Coal - FELs feeding ROM to ROM hopper	29,024	3,993	551
Coal - Material transfer of ROM to CHPP	135	64	10
Coal - Hauling coarse rejects to West Pit waste dump in Cat 789	2,795	598	60
Coal - Material transfer of product to stockpiles	55	26	4
Coal - Material transfer to train loading silo	55	26	4
Coal - Material transfer to trains	55	26	4
Grading roads	12,466	4,356	386
Wind erosion - Active waste dump area (includes areas near West Pit)	169,418	84,709	12,706
Wind erosion - Active exposed pit area	54,224	27,112	4,067
Wind erosion - Topsoil removal area	18,396	9,198	1,380
Total	**1,013,827**	**279,081**	**39,878**

Table 8.8: Estimated emissions for Year 5 – Bayswater North Pit Mining Area (kg/y)

Activity	TSP	PM_{10}	$PM_{2.5}$
Topsoil - Scrapers stripping topsoil	352	89	9
Topsoil - Scraper hauling topsoil to stockpiles	38	5	1
Topsoil - Emplacing topsoil at stockpiles	3	1	0
Overburden - Drilling	1,971	1,025	59
Overburden - Blasting	7,600	3,952	228
Overburden - Dozers pushing waste	35,271	7,857	3,703
Overburden - Excavators loading haul trucks	7,694	3,639	551
Overburden - Hauling to waste dump with Cat 793	353,863	75,762	7,576
Overburden - Hauling to waste dump with Cat 789	112,519	24,090	2,409
Overburden - Unloading at waste dump	7,694	3,639	551
Overburden - Dozers on waste dumps	2,602	393	273
Coal - Dozers pushing coal	32,144	8,203	707
Coal - Excavators loading ROM to trucks	98,187	13,508	1,866
Coal - Hauling ROM to South ROM pad with Cat 789	26,158	5,601	560
Coal - Unloading ROM at South ROM pad	98,187	13,508	1,866
Coal - Primary crushing	696	309	309
Coal - Transfer to secondary crusher	387	142	142
Coal - Secondary crushing	696	309	309
Coal - Transfer to tertiary crusher	387	142	142
Coal - Tertiary crushing	696	309	309
Coal - FELs feeding ROM to ROM hopper	29,456	4,052	560
Coal - Material transfer of ROM to CHPP	137	65	10
Coal - Hauling coarse rejects to West Pit waste dump in Cat 789	2,853	611	61
Coal - Material transfer of product to stockpiles	56	26	4
Coal - Material transfer to train loading silo	56	26	4
Coal - Material transfer to trains	56	26	4
Grading roads	10,721	3,746	332
Wind erosion - Active waste dump area	46,078	23,039	3,456
Wind erosion - Active exposed pit area	60,794	30,397	4,560
Wind erosion - Topsoil removal area	13,212	6,606	991
Total	**950,562**	**231,078**	**31,552**

Table 8.9: Estimated emissions for Year 10 – RERR Mining Area (kg/y)

Activity	TSP	PM_{10}	$PM_{2.5}$
Overburden - Drilling	2,993	1,557	90
Overburden - Blasting	34,176	17,771	1,025
Overburden - Dozers on waste (in pit)	6,668	1,485	700
Overburden - Loading to haul trucks	6,390	3,022	458
Overburden - Hauling to waste dump	419,218	89,754	8,975
Overburden - Unloading at waste dump	6,390	3,022	458
Overburden - Dozers on waste dumps	7,029	1,062	738
Coal - Dozers on coal (in pit)	42,926	10,955	944
Coal - Loading ROM to trucks	74,260	10,216	1,411
Coal - Hauling ROM to ROM pad	25,868	5,538	554
Coal - Unloading ROM at ROM pad	74,260	10,216	1,411
Coal - FELs Loading ROM to hopper	22,278	3,065	423
Coal - Material transfer of ROM to CHPP	103	49	7
Coal - Primary crushing	527	234	234
Coal - Transfer to secondary crusher	293	107	107
Coal - Secondary crushing	527	234	234
Coal - Transfer to tertiary crusher	293	107	107
Coal - Tertiary crushing	527	234	234
Coal - Material transfer of product to stockpiles	145	69	10
Coal - Material transfer to train loading silo	44	21	3
Coal - Material transfer to trains	44	21	3
Grading roads	15,113	5,281	469
Wind erosion - Active waste dump area	36,442	18,221	2,733
Wind erosion - Active exposed pit area	20,586	10,293	1,544
Total	**797,096**	**192,534**	**22,873**

A summary of the total TSP, PM_{10} and $PM_{2.5}$ emissions for each year are listed in **Table 8.10**. The estimated emissions for operations 2012 (the meteorological data period) were also calculated and are included in **Table 8.10**. Estimates for 2012 include emissions from both the existing North Pit (Mount Owen Mine) and the West Pit (Ravensworth East Mine). The data shows that while there may be an initial increase in emissions in the early years of the Project, the estimated levels drop back to those which were previously experienced at Mount Owen and Ravensworth East Mines.

Table 8.10: Total TSP, PM_{10} and $PM_{2.5}$ emissions for the Project modelled years (kg)

Modelling year	TSP	PM_{10}	$PM_{2.5}$
(2012)	4,528,534	1,022,631	133,131
Year 1 North Pit and Bayswater North Pit	5,529,992	1,381,456	189,506
Year 5 North Pit and Bayswater North Pit	5,539,584	1,258,733	167,515
Year 10 North Pit and RERR Pit	4,216,430	1,000,249	127,187

It should be noted here that the total PM_{10} emissions calculated for 2012 operations are significantly lower than those calculated for 2010 during the Dust Stop PRP process (2,342,810 kg). There are a number of reasons for this, but the main reasons are the higher haul road control factor and lower measured haul road silt content used for this assessment. In addition to these factors, the assessment for this Project includes haulage and handling of Glendell ROM from the Glendell boundary. The PRP also considered 2010 and this assessment is for 2011/2012 which had different mine plans including differences in such things as haul road lengths and exposed areas.

Table 8.11 summarises the different calculated values. It also includes a total emission recalculated for 2011/2012 using the same haul road control factor and silt content used in the PRP. This recalculated value is similar to the PRP calculation.

Table 8.11: Comparison of emission estimates

Mount Owen PRP (2010)	Current Mount Owen (2011/2012)	Adjusted for PRP silt and haul control (2011/2012)
2,342,810	1,022,631	2,050,859

The silt contents measured for the PRP used the laser diffraction analysis method rather than the dry sieving method required for compliance with the AP-42 emission factor equations. The dry sieving method which supports the AP-42, recognises its potential inaccuracies. However, the equations have been developed using data collected in this way and to use values obtained via a different method would be inappropriate. The 2% value used for the Project was obtained using dry sieving and is appropriate for this assessment.

8.1.3 Coal Transport by Rail

There are no proposed changes to the currently approved train movements. To ensure fugitive dust emissions from coal transportation are kept to a minimum, Mount Owen is committed to water spraying of the coal surface during train loading, as well as best practice load profiling. A study of dust emissions from rail transport at Duralie Coal mine was completed for the approval of the Duralie Extension Project. The study found that the water spray system in place at the train loading facility was very effective in controlling dust emissions from rail transport, achieving 99% control of emissions (**Katestone, 2012**).

Two further studies have also been completed for the Australian Rail Track Corporation (ARTC), assessing particulate emissions from coal trains (**Environ, 2012** and **Katestone, 2013**). Both studies investigated particulate matter (PM) emissions from coal trains (loaded and unloaded) compared with emissions from passenger and freight trains. The Environ study found that at one site there was no statistical difference in concentrations across all particulate size fractions for all train types. At the other site, it was concluded that concentrations coinciding with loaded and unloaded coal train passes are statistically higher for PM_{10}, but not other size fractions, compared with concentrations recorded during passenger train passes. There was no statistical difference between loaded coal train and unloaded coal trains.

The Katestone study concluded that loaded coal trains were not associated with a statistically significant difference in PM_{10} and $PM_{2.5}$ compared with concentrations when no train passed. Unloaded coal trains were associated with a statistically significant difference in PM_{10} and $PM_{2.5}$ compared with concentrations when no train passed.

It is noted that for both studies, PM concentrations were recorded at short distances from the track and for short averaging periods to coincide train passes, therefore no quantification of impact at residential areas can be inferred from the studies.

Glencore has also conducted a series of wind tunnel tests on various coal types across its mines in NSW, to determine the potential for coal dust being emitted from loaded coal wagons. The testing simulated travel times, travel speeds and conditions experienced during rail transport from different mines to ports. The research indicated that the moisture content of the coal types tested makes the potential dust emissions from the surface of loaded coal wagons low during transport from the mine to the port and are likely to be indistinguishable from other local sources.

The research indicates that the emission of coal dust from the surface of loaded coal wagons is unlikely to be a significant source of dust along the rail corridor. Notwithstanding this, Mount Owen is committed to making sure coal in loaded wagons is moistened when loaded to minimise the potential for wind erosion.

To put the potential fugitive emissions from loaded coal trains into context, an estimate has been made as to the levels of PM that may occur. Assuming a loaded train contains a maximum of 91 wagons, each 16.1 m in length and 2 m in width, the total surface area of exposed coal would be just under 3,000 m^2 (0.3 ha). **Katestone (2012)** suggests that if the product is watered as it is loaded to trains, then emissions can be controlled by up to 99%. Assuming a conservative control factor of 50% (allowing time for the coal to dry somewhat en route to the Newcastle port), and an emission factor of 0.1 kg/ha/y (**USEPA, 1985**), then the total fugitive dust emissions from loaded coal trains may be of the order of 131 kg/y. Even if no control factor was taken into account this would be approximately 262 kg/y, which constitutes less than 0.03 % of the total annual emissions calculated in **Section 8.1.2** and would be spread across a large area between Mount Owen and Newcastle. Resultant ground level concentrations would be extremely low and likely to be indistinguishable from background levels.

A recent EPA commissioned review of monitoring data collected next to a rail line investigated whether loaded coal trains produce more particulate matter than other trains. The review, completed by Professor Louise Ryan (University of Technology, Sydney) (**Ryan and Wand, 2014**), found that:

- Both freight trains and coal trains (loaded and unloaded) are associated with a clear and statistically significant increase in particle concentration (approximately 10%) when a train passes.
- There is no evidence that coal trains have a stronger association with increased particle concentrations than freight trains.
- Freight trains and coal trains have similar particulate matter profiles during pass-bys.

Emissions from loaded coal trains are not considered further in this assessment.

8.2 Dust Control on Haul Roads

Preliminary emissions estimations indicated that of the potential dust sources from the Project, emissions from the hauling of overburden and ROM coal contributes more than any other source group to short-term PM_{10} impacts at the closest residential receivers. For this assessment, a level 85% control has been applied to haul road emission estimations.

This 85% control level is supported by **Sinclair Knight Merz (2005)** who derived an equation that shows control benefits for increased watering up to 95%. This finding is confirmed by **Buonicore and Davis (1992)** who state that a level of control of 90% is expected to be achieved by increasing the application rate of water and/or through the use of dust suppressants, such that the moisture content of surface material is approximately 8% (refer to **Figure 8.4**).

The above observations are further reinforced within **US EPA (2006)**. **Figure 8.5** presents the relationship between the instantaneous control efficiency due to watering and the resulting increase in surface moisture. The moisture ratio M (shown on the x-axis) is calculated by dividing the surface moisture content of the watered road by the surface moisture content of the uncontrolled road.

US EPA (2006) states that as the watered surface dries, both the ratio M, and the predicted instantaneous control efficiency (shown on the y-axis), decrease. The figure shows that between the uncontrolled surface moisture content and a value twice as large, a small increase in moisture content results in a large increase in control efficiency. Beyond that, control efficiency grows slowly with increased moisture content. For example, if the uncontrolled surface moisture content was 2%, and the addition of water increased this to 4%, a 75% reduction in emissions could be expected. However, control efficiency increasing the surface moisture content further to 6% would only result in an additional 5% control.

Notwithstanding the above, it is clear from **Figure 8.5**, that while returns diminish between 70 – 100%, theoretical control efficiencies from the application of water alone may reach up to 95%. A conservative assumption of 85% has been made for this assessment. On-going testing at Mount Owen as part of the current NSW coal mine PRPs for haul road dust, is programed to demonstrate that this level is being achieved. On-site testing to date has shown that levels well in excess of 85% are currently being achieved.

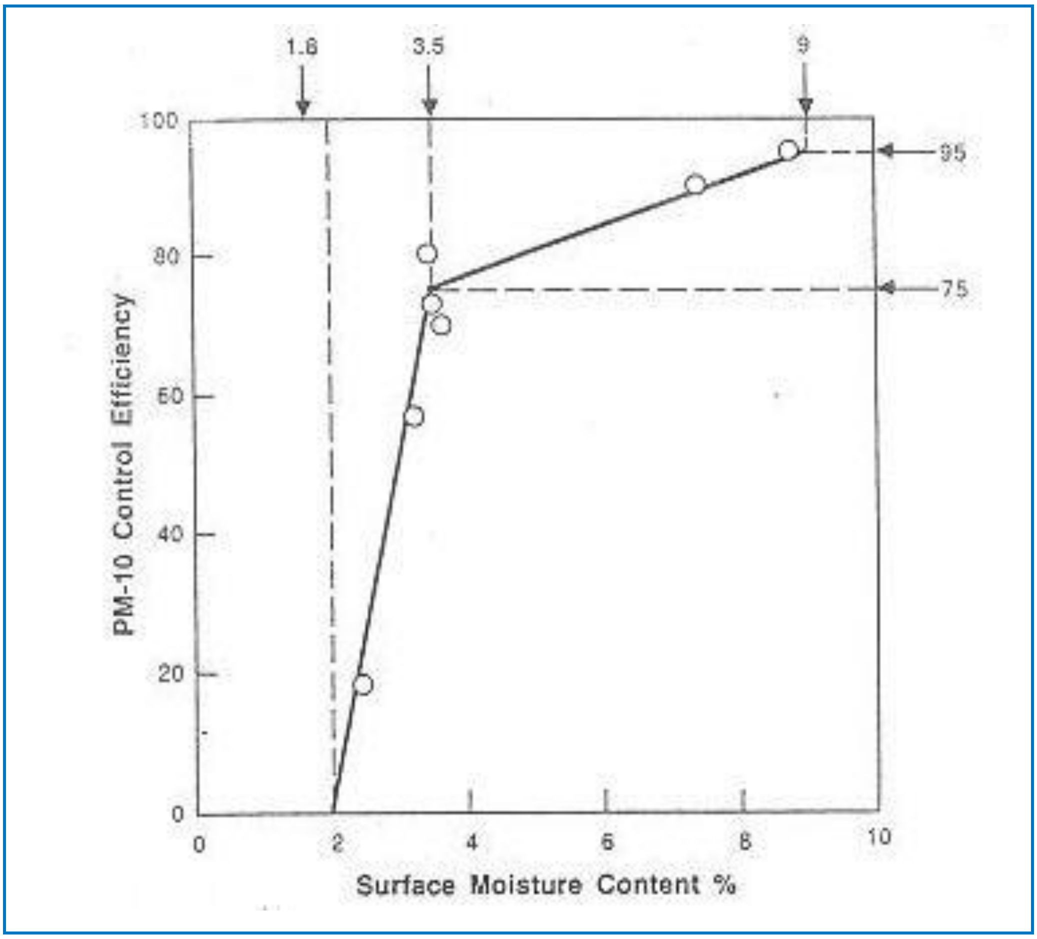


Figure 8.4: Watering Control Effectiveness for Unpaved Roads (Buonicore and Davis, 1992)

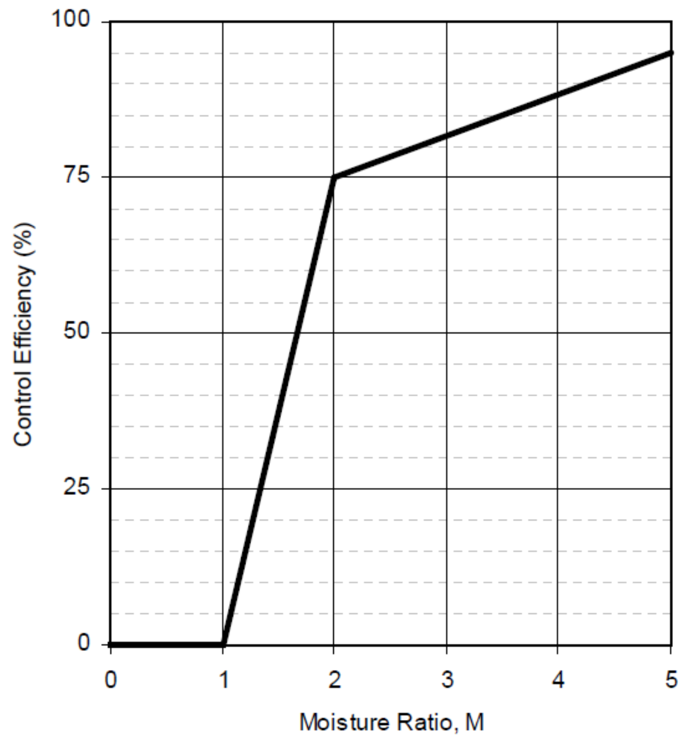


Figure 8.5: Watering Control Effectiveness for Unpaved Travel Surfaces (US EPA, 2006)

8.3 Site Specific Parameter Measurements

Many of the emission factor equations used to determine particulate emissions from operational activities, require values for the silt and moisture content of the various materials handled. In April 2013, a number of samples were taken at Mount Owen. These samples were analysed for silt and moisture content in accordance with the methods outlined in **US EPA (1993)**. **Table 8.12** summarises the results and the full analysis report is shown in **Appendix C**.

All these sampling results were used to inform the emissions inventories, except for silt on haul roads and moisture of product coal. The haul road samples from April 2013, were taken from a currently inactive haul road and as such are not representative of active haul roads. Previous measurements from samples taken on three different active haul roads in March 2011 were used for the emissions calculations in this assessment.

As part of its Pollution Reduction Program under Condition U2 of EPL 4460, Mount Owen is required to demonstrate best practice control of wheel generated dust. Further measurements of haul road silt content were made in February 2014 during this program and the results show levels similar to those made in March 2011. The analysis reports from both the March 2011 and April 2014 testing are both presented in **Appendix C**. It should be noted that during the sampling done in April 2014, measurements were carried out on both controlled and uncontrolled sections of haul road. This was done to fulfil the specific purposes of that particular analysis, to compare controlled and uncontrolled sections of road and determine the relevant control efficiencies. However, the results for the uncontrolled sections (as presented in the analysis report in **Appendix C**) are not relevant for this study as it is concerned with the conditions of the roadway under normal operating conditions, which will be controlled. The average silt content of the controlled sections tested in April 2014 is approximately 1.4% which is lower than the value of 2% used for this assessment.

Analysis of product coal moisture contents has been collected by Mount Owen since 2009. These data show an average moisture content of 9.4% for product coal, and this value has been used.

Table 8.12: Measured silt and moisture contents

Material sampled	Moisture content	Silt content
ROM coal	6.9 %	6.4 %
Overburden (in-pit)	6.6 %	11.4 %
Overburden (waste dumps)	11.2 %	3.7 %
Product coal	9.4 %	N/A
Haul roads	N/A	2 %

8.4 Windblown dust emissions

Windblown dust emissions arise from erosion of exposed areas such as the pit or active dumping or rehabilitation areas. The amount of particle lift-off is dependent on a number of factors which include the threshold friction velocity (the wind velocity necessary to initiate soil erosion).

The current USEPA AP-42 Compilation of Air Pollutant Emission Factors (Fifth Edition) emission factor for industrial wind erosion is outlined in Chapter 13.2.5 **(USEPA, 2006)**. It is also only applicable to dry exposed materials with limited erosion potential. The calculated emissions represent intermittent events, valid for a time period as long as (or longer than) the period between surface disturbances.

Site specific measurements for threshold friction velocity (TFV) were made at Mount Owen on 3 April 2013, and the results are shown in **Table 8.13**.

Table 8.13: Measurements of threshold friction velocity from Mount Owen

Area measured	Threshold friction velocity
ROM coal (stockpiles)	100 cm/s
Overburden (in pit)	100 cm/s
Overburden (waste dumps)	>100 cm/s
Reject Coal	>100 cm/s
Product Coal	100 cm/s

Applying the site-specific measurements (**Table 8.13**) to this emission estimation approach results in almost no wind initiated dust lift-off emissions from exposed areas, which is unrealistic. The USEPA AP-42 Chapter 11.9 (Western Surface Coal Mining) emission factor for wind erosion of exposed areas (0.85 t/ha/y or 0.1 kg/ha/h) has therefore been adopted as it represents a more realistic value for wind erosion and is accepted practice for these assessments.

8.5 Consideration of Cumulative Emissions

8.5.1 Emissions from Neighbouring Mines

In addition to the Project, estimated emissions for each modelling year from other nearby mining operations have been taken from publically available Environmental Assessments (EAs) for those mines.

It should be noted that only those mines which are currently approved to be operating in each of the modelling years have been included in this assessment. Although not formally approved at the time this assessment was done, Liddell have submitted an application for a further modification. At the request of the Department of Planning and Environment, the current emissions for Liddell have therefore been carried forward to this assessment to take this into account and to provide a conservative indication of predicted cumulative levels into the future.

The following mines have been included, although not all are operational for all modelling years.

- Ashton South East Open Cut and Underground (**PAEHolmes, 2009**)
- Glendell Mine (**HAS, 2007**)
- HVO North (**PAEHolmes, 2010a**)
- HVO South (**HAS, 2008**)
- Integra Open Cut and Underground (**HAS, 2009** and **PAEHolmes, 2012**)
- Liddell Colliery (**Pacific Environment, 2013**)
- Ravensworth Surface Operations (**PAEHolmes, 2010b**)
- Ravensworth Underground (**PAEHolmes, 2010c**)
- Rixs Creek (**PAEHolmes, 2009**)

Each mine has been treated as a set number of volume sources located at the points of major emission, as estimated from the locations of pits, dumps and other major dust sources shown in the EAs. Sources have been considered in three classes covering all dust emission sources for which there are emission factor equations for open cut mines. These classes are:

1. Wind erosion sources where emissions vary with the hourly average wind speed according to the cube of the wind speed (**Skidmore, 1998**)
2. Loading/dumping operations where emissions vary with the wind speed raised to the power of 1.3 (**USEPA, 1987**)
3. All other sources where emissions are assumed to be independent of wind speed

The proportion of emissions in each of these categories has been calculated for each individual mine based on the activities occurring at that site. **Table 8.14**, **Table 8.15** and **Table 8.16** present the emission estimates for each of these other mines for TSP, PM_{10} and $PM_{2.5}$ respectively. Where data were not available for the precise years of the Project, the closest modelling year was taken. This is a conservative approach as it does not take into account the locations of individual activities at each site.

Table 8.14: Summary of estimated TSP emissions from other mining operations (kg/y)

Mine	Year 1	Year 5	Year 10
Ashton SEOC and UG	2,118,117	1,095,575	Mining Completed
Glendell Mine	1,887,425	1,054,744	Mining Completed
HVO North	7,980,696	7,980,696	Mining Completed
HVO South	7,402,024	6,020,967	11,286,121
Integra* OC and UG	2,282,856	1,759,338	391,418
Liddell Colliery	4,033,966	4,208,879	Mining Completed
Ravensworth Operations	6,611,937	10,841,960	10,898,176
Ravensworth Underground	27,894	27,894	27,894
Rixs Creek	3,396,251	Mining Completed	Mining Completed

* Conservative estimates as now under care and maintenance

Table 8.15: Summary of estimated PM_{10} emissions from other mining operations (kg/y)

Mine	Year 1	Year 5	Year 10
Ashton SEOC and UG	469,187	263,674	Mining Completed
Glendell Mine	531,117	299,496	Mining Completed
HVO North	2,002,963	2,002,963	Mining Completed
HVO South	1,978,695	1,574,047	2,914,212
Integra OC and UG	608,149	506,287	76,252
Liddell Colliery	1,122,564	1,147,421	Mining Completed
Ravensworth Operations	1,665,527	2,374,182	2,355,621
Ravensworth Underground	10,034	10,034	10,034
Rixs Creek	728,330	Mining Completed	Mining Completed

Table 8.16: Summary of estimated $PM_{2.5}$ emissions from other mining operations (kg/y)

Mine	Year 1	Year 5	Year 10
Ashton SEOC and UG	56,284	30,681	Mining Completed
Glendell Mine	76,713	49,330	Mining Completed
HVO North	255,749	255,749	Mining Completed
HVO South	271,734	213,482	388,105
Integra OC and UG	75,477	69,373	9,093
Liddell Colliery	211,571	216,256	Mining Completed
Ravensworth Operations	216,733	317,593	314,116
Ravensworth Underground	1,262	1,262	1,262
Rixs Creek	118,859	Mining Completed	Mining Completed

8.5.2 Existing Background Levels

In addition to the mines identified in **Section 8.5.1**, distant mines and other sources will contribute to $PM_{2.5}$, PM_{10} and TSP concentrations and to dust deposition in the area surrounding the Project. Estimating the background allowance for distant mines and other sources (collectively referred to as non-modelled sources) is difficult and depends on local land use and the associated emission sources, as well as climate, soil type etc.

Based on the analysis of the UHAQMN data available, as described in **Section 5.3.2**, representative background levels for PM_{10} and $PM_{2.5}$ were determined. There are no TSP monitors in the UHAQMN and the Mount Owen TSP monitors are relatively close to existing mining operations and would therefore provide an overly conservative and unrealistic estimate of non-mining sources of TSP.

However, there are four co-located PM_{10} and TSP monitors within the Mount Owen network, which provide an indication of the PM_{10}:TSP ratio. Comparing these four monitors and the values presented in **Table 5.3** and **Table 5.4**, the average ratio is approximately 0.35 across all four co-located monitors for all years. That is, TSP consists of approximately 35% PM_{10}. Using this ratio, and applying it to the PM_{10} background value of 13.2 µg/m^3 determined in **Section 5.3.2**, an appropriate background value for TSP would therefore be approximately 37.7 µg/m^3. As determined in **Section 5.3.1**, an appropriate background level for dust deposition would be approximately 2 g/m^2/month.

In summary, the following values have been used as background values in the cumulative annual average assessment:

- Annual average $PM_{2.5}$ 7.1 µg/m^3
- Annual average PM_{10} 13.2 µg/m^3
- Annual average TSP 37.7 µg/m^3
- Annual average dust deposition 2 g/m^2/month

8.6 Model Evaluation

Model performance is evaluated by comparing model predictions for existing operations with monitoring data for the same period. Operating mines in 2011-2012 were modelled and annual average PM_{10} predictions were compared to monitoring data from the UHAQMN and mine monitoring sites. However, while the monitoring data will include contributions from all other non-modelled sources (background), the modelling predictions will not.

To account for the non-modelled dust sources, the background annual average PM_{10} concentrations of 13.2 µg/m^3, (see **Section 8.5.2**), was added to model predictions at each monitoring site. The results are shown in **Table 8.17**.

Table 8.17: Comparison of measured and modelled annual average PM_{10} concentrations for 2011/2012

Monitoring Site	Measured	Model + Background	Ratio of measured to modelled
PM10-1	17.2	26.1	0.7
PM10-2	23.1	27.2	0.8
PM10-3iii	20.3	28.1	0.7
PM10-4	25.5	79.6	0.3
PM10-3ii	22.6	51.8	0.4
SX8	18.4	46.4	0.4
SX9	18.7	50.7	0.4
SX10	21.5	27.2	0.8
SX13	19.0	92.8	0.2
SX14	15.6	75.0	0.2
Maison Dieu (UHAQMN)	23.2	83.5	0.3
Camberwell (UHAQMN)	22.6	76.4	0.3
Singleton NW (UHAQMN)	23.1	48.4	0.5

It is clear from the data presented in **Table 8.17**, that the model over predicts at all monitoring locations when background is added. At locations close to mining operations or in prevailing downwind directions, the model significantly over predicts (ratio of measured to modelled of 0.2 – 0.3). At distances further away or out of the prevailing wind directions, the model performs much better (ratios of 0.7 – 0.9).

To account for the model over prediction, this ratio of measured to modelled is used to derive calibration factors to compile a spatially varying calibration gird used for modelling future years. This model calibration grid is presented in **Figure 8.6**, and shows the main areas of over prediction are where there are multiple mines operating in relatively close proximity to each other. In areas to the northeast of the Project, outside the line of predominant wind directions and where there is no monitoring, a maximum calibration of 1 was assumed. The same calibration grid was applied for TSP and $PM_{2.5}$ results.

To calculate the cumulative annual average concentrations, the model was first run for all mines within the modelling domain. The spatially varying calibration grid was applied to the prediction grid for those mines and the relevant background estimate for each particle size group added to these results. The predictions due to the Project were added to provide a final estimate of cumulative ground level concentrations and all gridded and residential receptors.

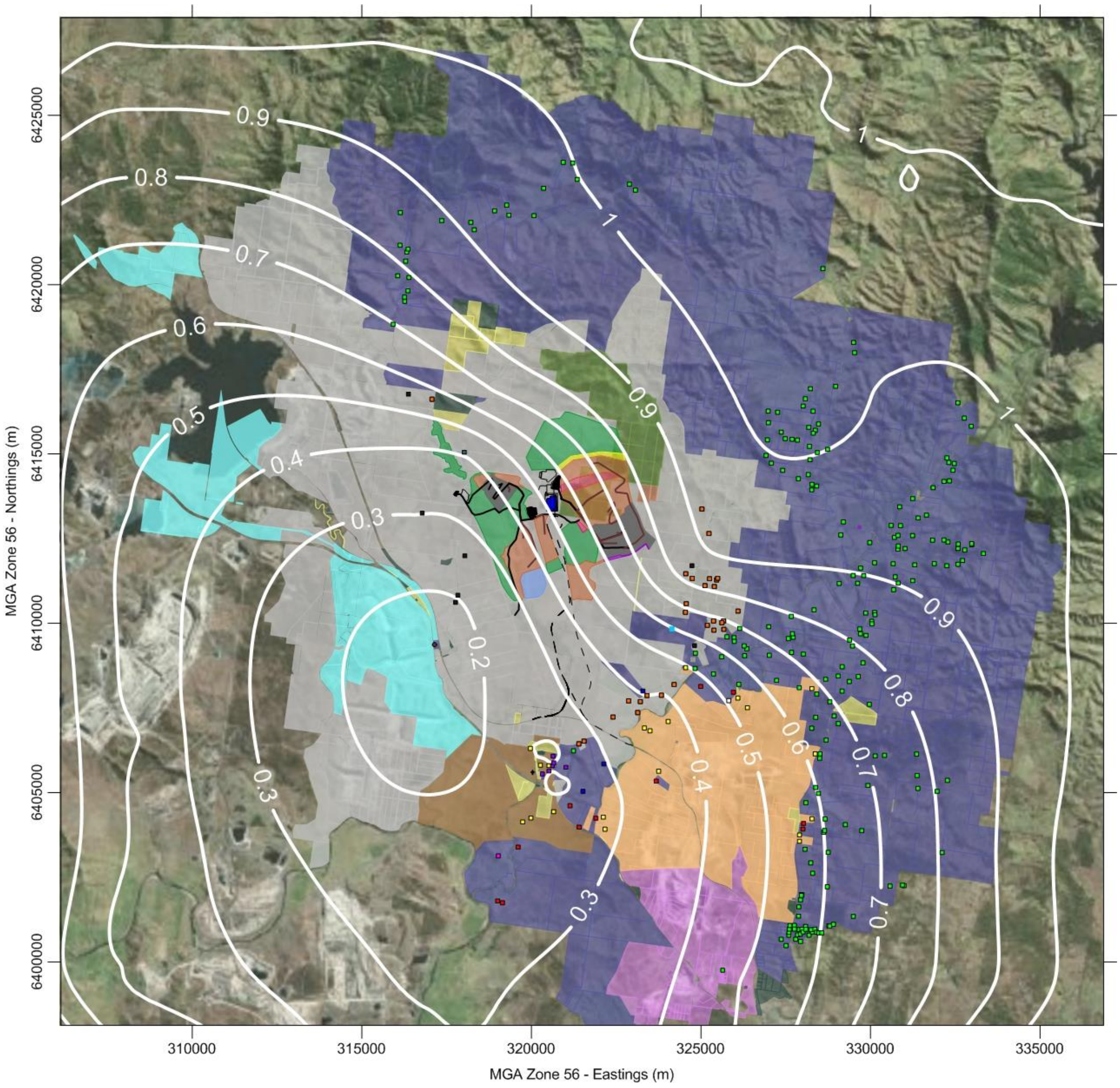


Figure 8.6: Model calibration grid for neighbouring mines

9 EMISSIONS TO AIR – OTHER POLLUTANTS

9.1 Blast Fume Emissions

Blasting activities have the potential to result in fugitive fume and particulate matter emissions. Particulate matter emissions from blasting are included in the dispersion modelling results presented in **Section 10**. There is also potential for blast fume to be generated which predominantly comprise emissions of oxides of nitrogen (NO_x). NO_x includes both nitric oxide (NO) and nitrogen dioxide (NO_2). In terms of impacts on human health, the relevant compound is NO_2 (refer to **Section 4.4.2**).

Ultimately, all nitric oxides emitted into the atmosphere are oxidised to NO_2 and to other higher oxides of nitrogen. The rate at which this oxidation takes place depends on prevailing atmospheric conditions including temperature, humidity and the presence of other substances in the atmosphere such as ozone (O_3). It can vary from a few minutes to many hours. The rate of conversion is quite important because from the point of emission to the point of maximum ground level concentration there will be an interval of time during which some oxidation will take place. If the dispersion is sufficient to have diluted the plume to the point where the concentration is very low, it is less critical that the oxidation has taken place. However, if the oxidation is rapid then high concentrations of NO_2 can occur. Generally, for plumes close to the source the time interval for oxidation is not sufficient to have converted a large proportion of the plume to NO_2.

NSW EPA has not set any air quality goals for nitric oxide, however it has set 1-hour and annual average goals for nitrogen dioxide. It has adopted the NEPM standards of 246 µg/m^3 (1-hour average) and 62 µg/m^3 (annual average).

Blasts predominately use ammonium nitrate/fuel oil (ANFO)-based explosives throughout the open cut coal mining industry. **Attalla et al (2007)** note that there are several variations of the ANFO material but, generally, it is around 94 per cent ammonium nitrate and six per cent fuel oil (i.e. diesel). Under ideal conditions, the only gaseous products from the explosion are carbon dioxide (CO_2), water (H_2O) and nitrogen (N_2), as shown in Equation 1.

$$3NH_4NO_3 + CH_2 \rightarrow 3N_2 + CO_2 + 7H_2O \qquad \text{Equation 1}$$

However, even quite small changes in the stoichiometry (either in the bulk material or caused by localised conditions such as moisture in the blast hole, mineral matter or other factors) can result in a non-ideal explosive reaction and lead to the formation of carbon monoxide (CO) and nitric oxide (NO) as shown in Equation 2 and Equation 3.

$$2NH_4NO_3 + CH_2 \rightarrow 2N_2 + CO + 5H_2O \qquad \text{Equation 2}$$

$$5NH_4NO_3 + CH_2 \rightarrow 4N_2 + 2NO + CO_2 + 7H_2O \qquad \text{Equation 3}$$

In addition, some of the NO formed may oxidise in the presence of oxygen (O_2) and ozone (O_3) to produce NO_2, as shown in Equation 4 and Equation 5.

$$2NO + O_2 \rightarrow 2NO_2 \qquad \text{Equation 4}$$

$$NO + O_3 \rightarrow NO_2 + O_2 \qquad \text{Equation 5}$$

Section 13.3 discusses the management measures that will be implemented to ensure the potential for NO_2 formation is minimised.

At Mount Owen, a large blast size would be of the order of 200 m by 150 m and was modelled as twelve volume sources (50 m by 50 m each), with a release height of 20 m, and an initial vertical spread (σz) of 10 m to give an equivalent plume height of 40 m.

The NO_x emissions from the blast were calculated based on data presented in the Queensland Guidance Note for the management of oxides in open cut blasting **(DEEDI, 2011)**. It was assumed that the initial NO_2 concentration in the plume would be 17 ppm (34.9 mg/m^3) based on the Rating 3 Fume Category in the Queensland Guidance Note. This is a conservative assumption given that Mount Owen has not had a Rating 3 fume since it commenced the capture of this information in 2012.

The initial NO_2 concentration in the plume was converted to a total NO_x emission rate based on a detailed measurement program of NO_x in blast plumes in the Hunter Valley made by **Attalla et al. (2008)** which found that the NO:NO_2 ratio was typically 27:1, giving a NO_x:NO_2 ratio of approximately 18.6 g NO_x/g NO_2.

Based on a total blast volume of 1,200,000 m^3 (200m x 150m x 40m), and an emission release of 10-minutes (600s), the emission rate was calculated to be 108.24 g/s per source (see Equation 6).

Equation 6

$$NO_x\ emission\ rate\ [g/s/source] = volume\ of\ source\ [m^3] \times initial\ NO_2\ concentration\ in\ plume\ \left[\frac{mg}{m^3}\right] \times \frac{1}{1000}\left[\frac{g}{mg}\right] \times \frac{1}{600\ [s]} \times \frac{1}{12\ [sources]} \times 18.6\left(\frac{g\ NO_x}{g\ NO_2}\right)$$

It was assumed that the blast emissions would be present for a 10-minute period and only occur between the hours 9am and 5pm. The current approval allows for 12 blasts per year between 7am – 9am, but the vast majority of blasts will be between 9am – 5pm. No blasting will occur in adverse weather conditions. It is important to note that the modelling assumes blasting could take place on any day of the week, when in reality blasting will only occur Monday to Saturday and not on Sunday or public holidays (as specified in the current Mount Owen Development Consent). The modelling therefore assumes a possible 2,920 hours per year when blasting could occur (8 hours a day, 365 days a year).

The results of the modelling provide predicted NO_x concentrations at the receptors. **Section 11** describes the approach used to determine the NO_2 concentrations for comparison with the relevant criteria.

9.2 Diesel Emissions

Table 9.1 presents a summary of the diesel usage by year of operation. The shaded cells are those for which dispersion modelling was completed to determine the potential impacts from particulate emissions. As presented in **Section 2.3**, operations in Year 10 represent a worst case in terms of production and location of operations, for those residences to the southeast of the proposed pit limit. After Year 10, the projected diesel consumption rate declines rapidly.

The diesel sources were distributed across the mining, dumping, hauling and processing areas assumed for Year 10 and a diesel usage of 53,991 kL was projected to be used for activities in that same year (**Table 9.1**).

Table 9.1: Diesel usage by year of operation

Year of operation	Diesel used (kL)			
	North Pit	Bayswater North Pit	RERR	Project Total
Year 1 (2016)	2,437	16,073	-	**18,510**
Year 2 (2017)	9,173	12,041	-	**21,214**
Year 3 (2018)	19,580	11,464	-	**31,045**
Year 4 (2019)	33,291	14,900	-	**48,191**
Year 5 (2020)	46,081	11,887	-	**57,969**
Year 6 (2021)	43,814	11,464	-	**55,277**
Year 7 (2022)	42,855	9,979	8,752	**61,587**
Year 8 (2023)	41,528	-	10,934	**52,462**
Year 9 (2024)	43,367	-	12,152	**55,519**
Year 10 (2025)	41,776	-	12,215	**53,991**
Year 11 (2026)	34,535	-	12,215	**46,750**
Year 12 (2027)	31,089	-	5,718	**36,807**
Year 13 (2028)	30,810	-	-	**30,810**
Year 14 (2029)	36,135	-	-	**36,135**
Year 15 (2030)	20,811	-	-	**20,811**

Table 9.2 provides a summary of the point source parameters used in the modelling. The source height and diameter were based on mine equipment specification information, the exit temperature from the Bosch Automotive Handbook (**BOSCH, 2007**) and the exit velocity assumed to be 10 m/s. These will vary for different equipment types but these are general values assumed across the site. Emissions are modelled at 'unit' emission rate and then post-processed and scaled using the actual emission rates for each pollutant.

Table 9.2: Point source parameters – diesel emissions

Emission rate	Source Height	Source Diameter	Exit Velocity	Exit Temperature
1 g/s	4 m	0.3 m	10 m/s	673 K

The relevant US EPA Tier 2 emission factors for industrial diesel vehicles are presented in **Table 9.3**. $PM_{2.5}$ and PM_{10} emissions from vehicle movement and equipment have been addressed in **Section 8**.

Table 9.3: USEPA Tier 2 emission factors for industrial diesel vehicles (kg/m^3)

NO_x	SO_2	CO
30.0	0.017	11.4

The results of the dispersion modelling are presented in **Section 11.3**.

10 MODELLING RESULTS – PARTICULATE MATTER

10.1 Introduction

The EPA air quality criteria used for identifying which properties are likely to experience air quality impacts are summarised in **Section 4.5** and have been applied in this assessment. It is important to note that there are currently no impact assessment criteria for $PM_{2.5}$. The predicted concentrations have been compared with the NEPM advisory reporting standards for $PM_{2.5}$. The predictions are focussed on inhabitable dwellings.

Dispersion model predictions have been made for Years 1, 5, and 10 of the Project. These modelled years were selected as representative, worst case years for the life of the Project.

Contour plots of particulate concentrations and deposition levels show the areas that are predicted to be affected by dust at different levels. It is important to note that the contour figures are presented to provide a visual representation of the predicted impacts. To produce the contours it is necessary to make interpolations, and as a result the contours will not always match exactly with predicted impacts at any specific location. The actual predicted particulate concentrations/levels at nearby residences are presented in tabular form in **Appendix D** (Project only) and **Appendix E** (cumulative).

Section 10.2 presents results for the Project alone and **Section 10.3** presents an annual average cumulative assessment. A separate cumulative assessment of 24-hour average PM_{10} and $PM_{2.5}$ is provided in **Section 10.4**.

10.2 Project Only Assessment

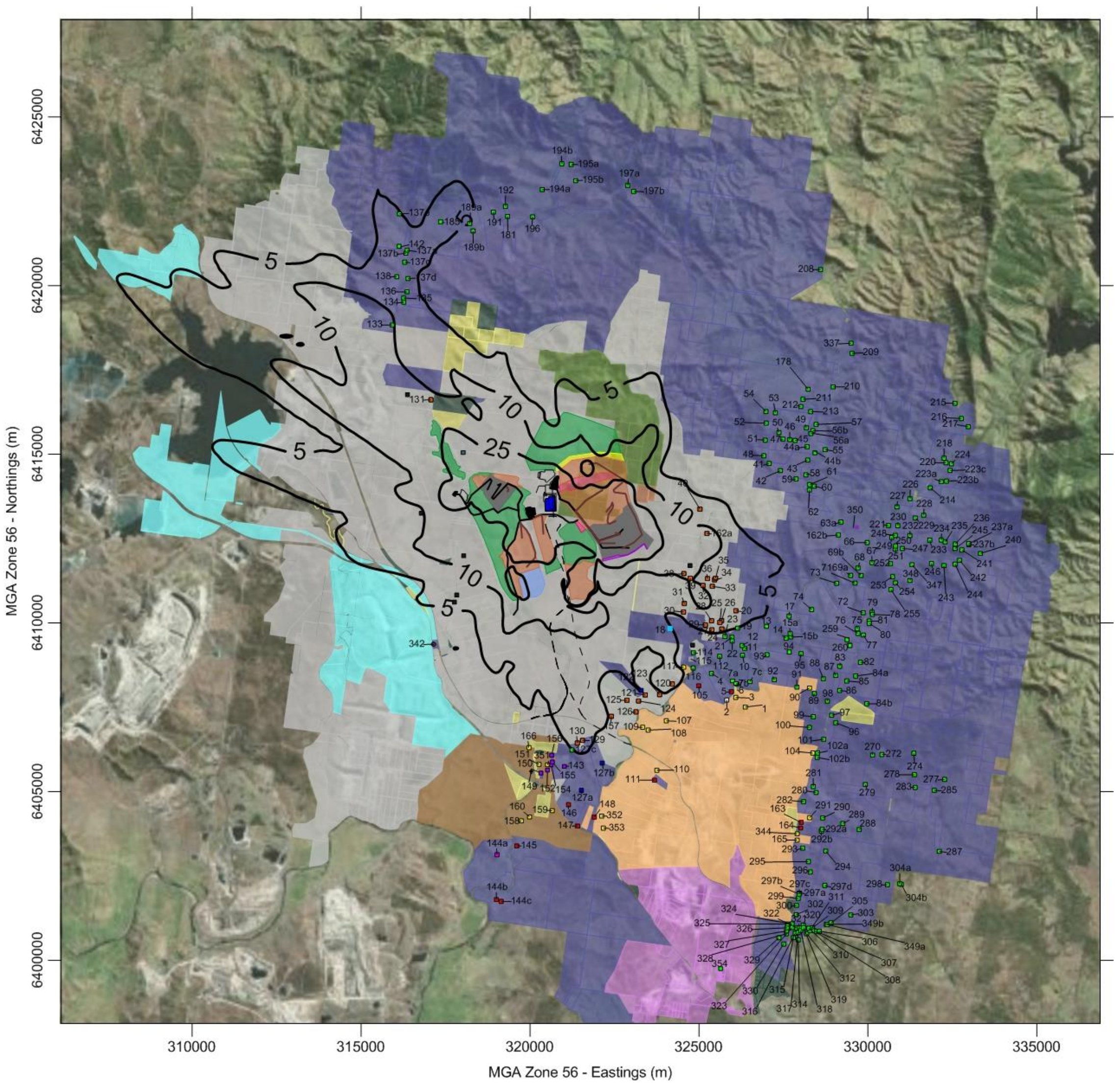
10.2.1 Year 1 (2016)

A summary of the predicted concentration and deposition levels at all sensitive receptors (that is residences both private and mine-owned) due to the operations of the Project alone in Year 1 is presented in **Appendix D**. **Figure 10.1** to **Figure 10.6** show these predictions across the modelling domain.

With the exception of dust deposition, predictions are not compared to EPA impact assessment criteria as these criteria are cumulative. However, for individual residences the maximum 24-hour average PM_{10} predictions can be compared to the DP&E acquisition criterion of 50 µg/m^3 (see **Section 4.5**).

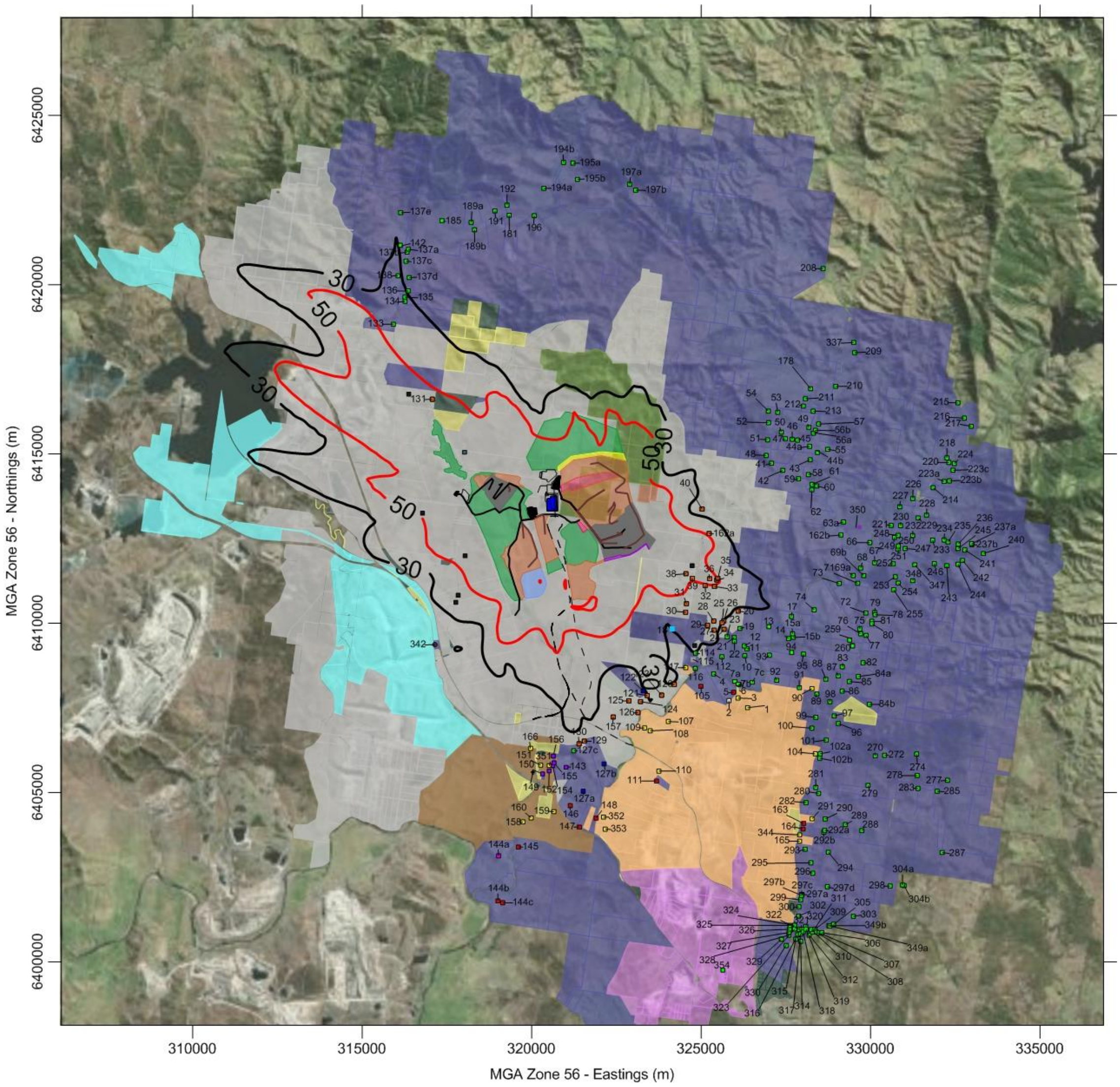
Figure 10.2 shows that there are no privately owned residences that are predicted to exceed the 24-hour average PM_{10} criterion of 50 µg/m^3 in Year 1. The dust deposition levels are also predicted to be well below the EPA incremental criterion of 2 g/m^2/month, at all private residences in Year 1.

Glencore owned residences R34, R36, R38 and R131 are predicted to exceed the 24-hour PM_{10} criterion in Year 1. There are no predicted exceedances of annual average criteria at any residences for the Project alone in Year 1.



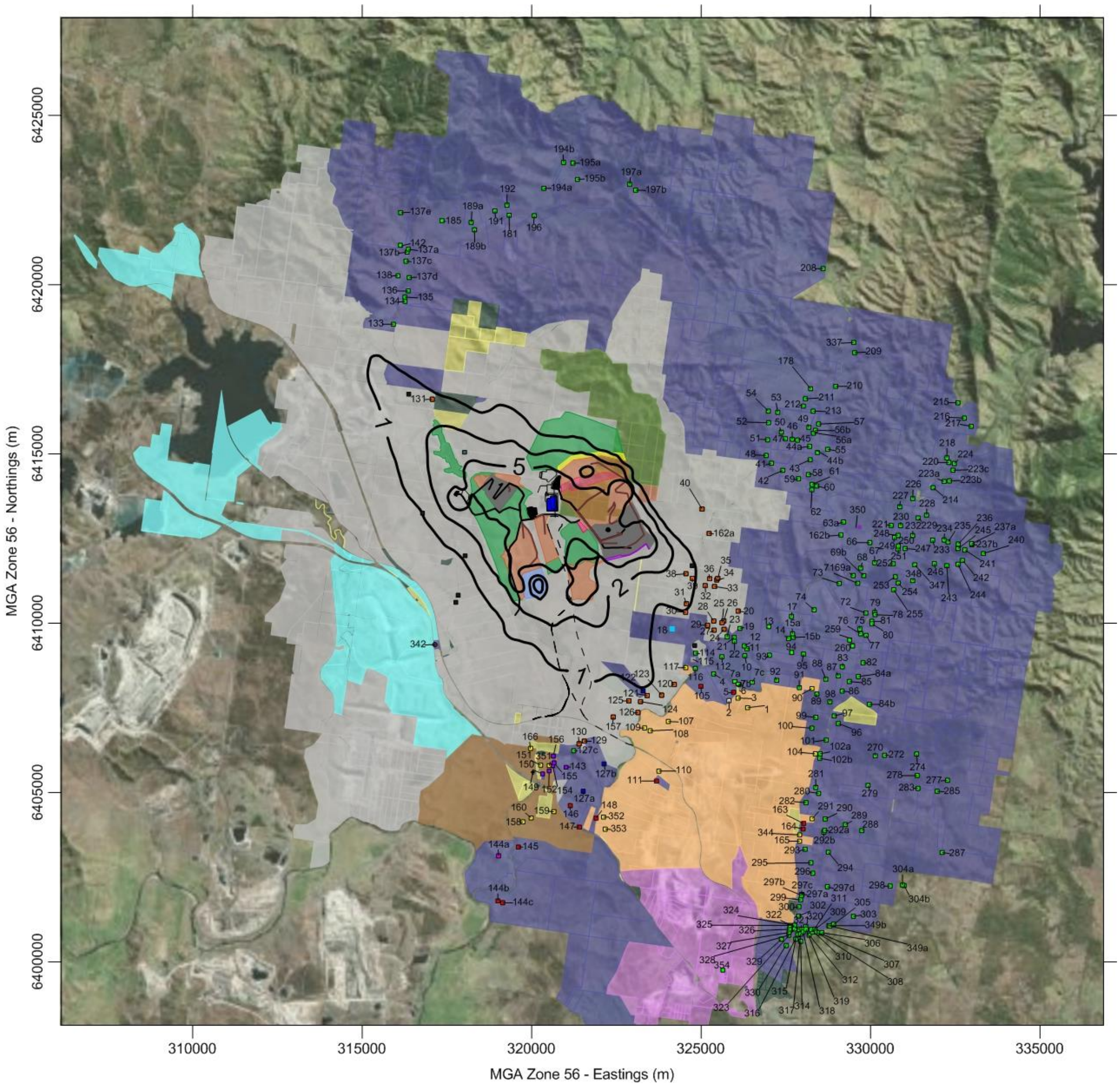
Species: PM2.5	Location: Mount Owen	Scenario: Year 1 – Project Only	Percentile: N/A	Averaging Time: 24-hour
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.1: Predicted maximum 24-hour average $PM_{2.5}$ concentrations in Year 1 – Project Only



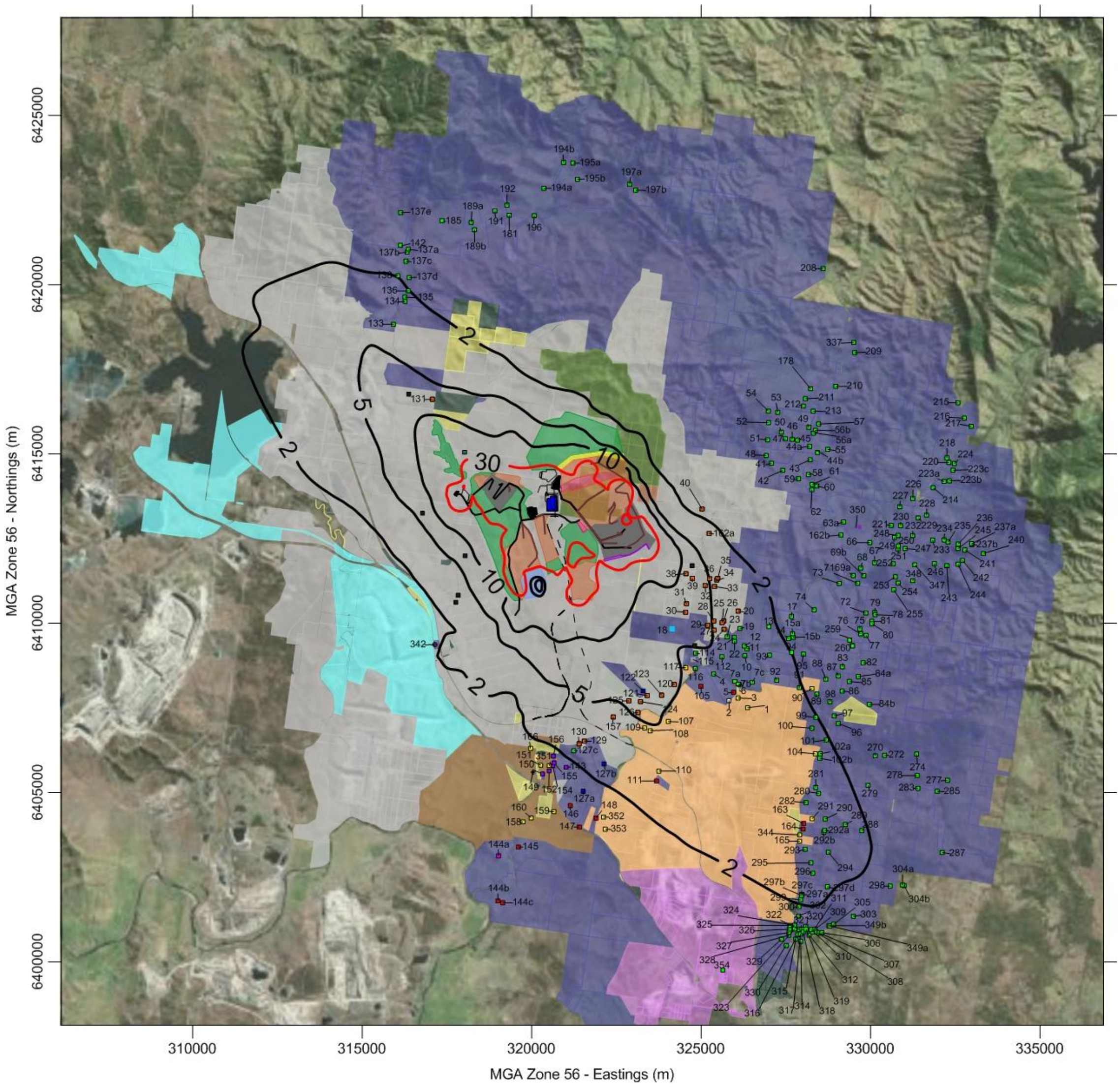
Species: PM10	Location: Mount Owen	Scenario: Year 1 – Project Only	Percentile: N/A	Averaging Time: 24-hour
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.2: Predicted maximum 24-hour average PM_{10} concentrations in Year 1 – Project Only



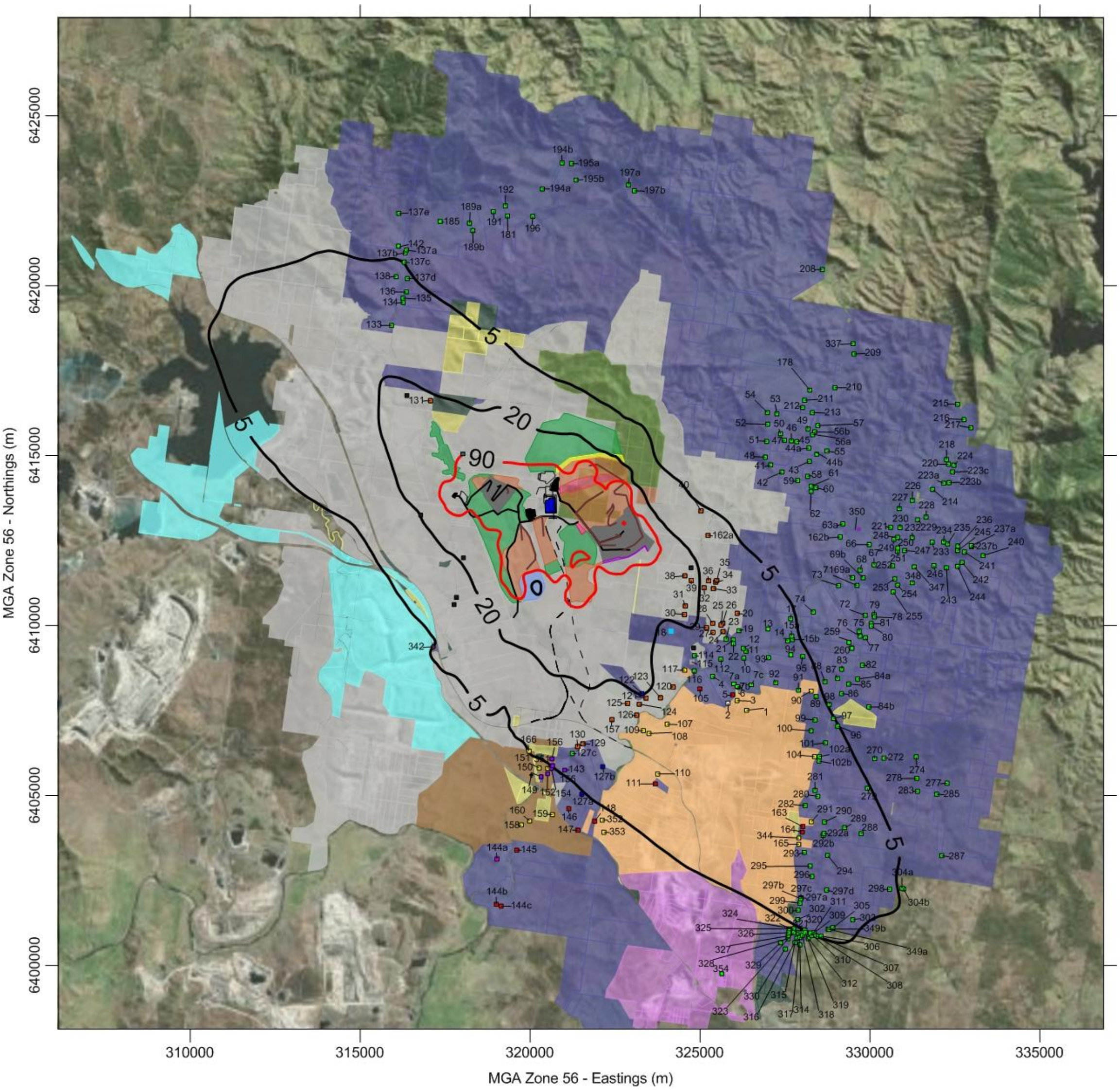
Species: PM2.5	Location: Mount Owen	Scenario: Year 1 – Project Only	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.3: Predicted annual average $PM_{2.5}$ concentrations in Year 1 – Project Only



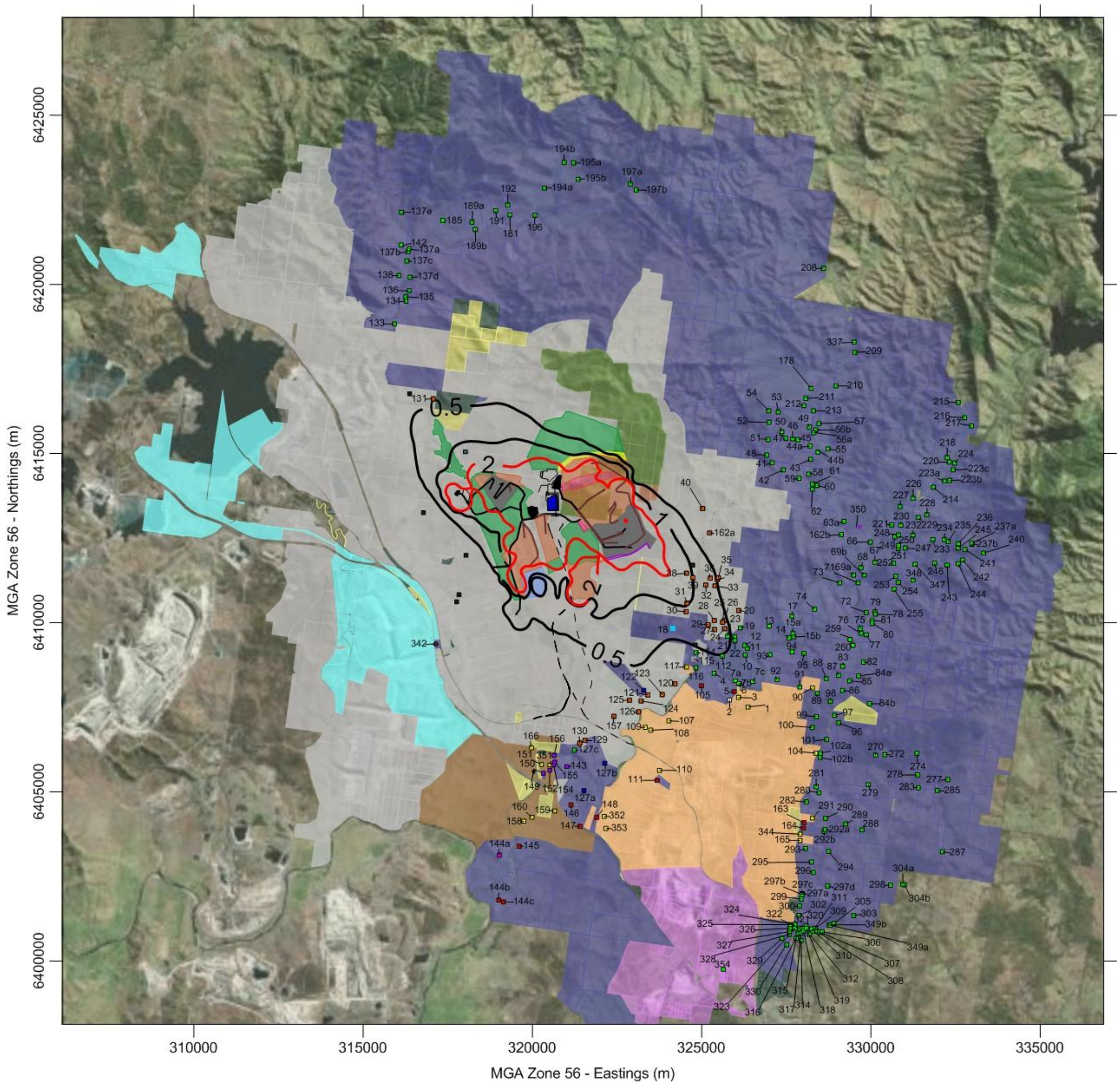
Species: PM10	Location: Mount Owen	Scenario: Year 1 – Project Only	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.4: Predicted annual average PM_{10} concentrations in Year 1 – Project Only



Species: TSP	Location: Mount Owen	Scenario: Year 1 – Project Only	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.5: Predicted annual average TSP concentrations in Year 1 – Project Only



Species: Deposition	**Location:** Mount Owen	**Scenario:** Year 1 – Project Only	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 2	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.6: Predicted annual average dust deposition in Year 1 – Project Only

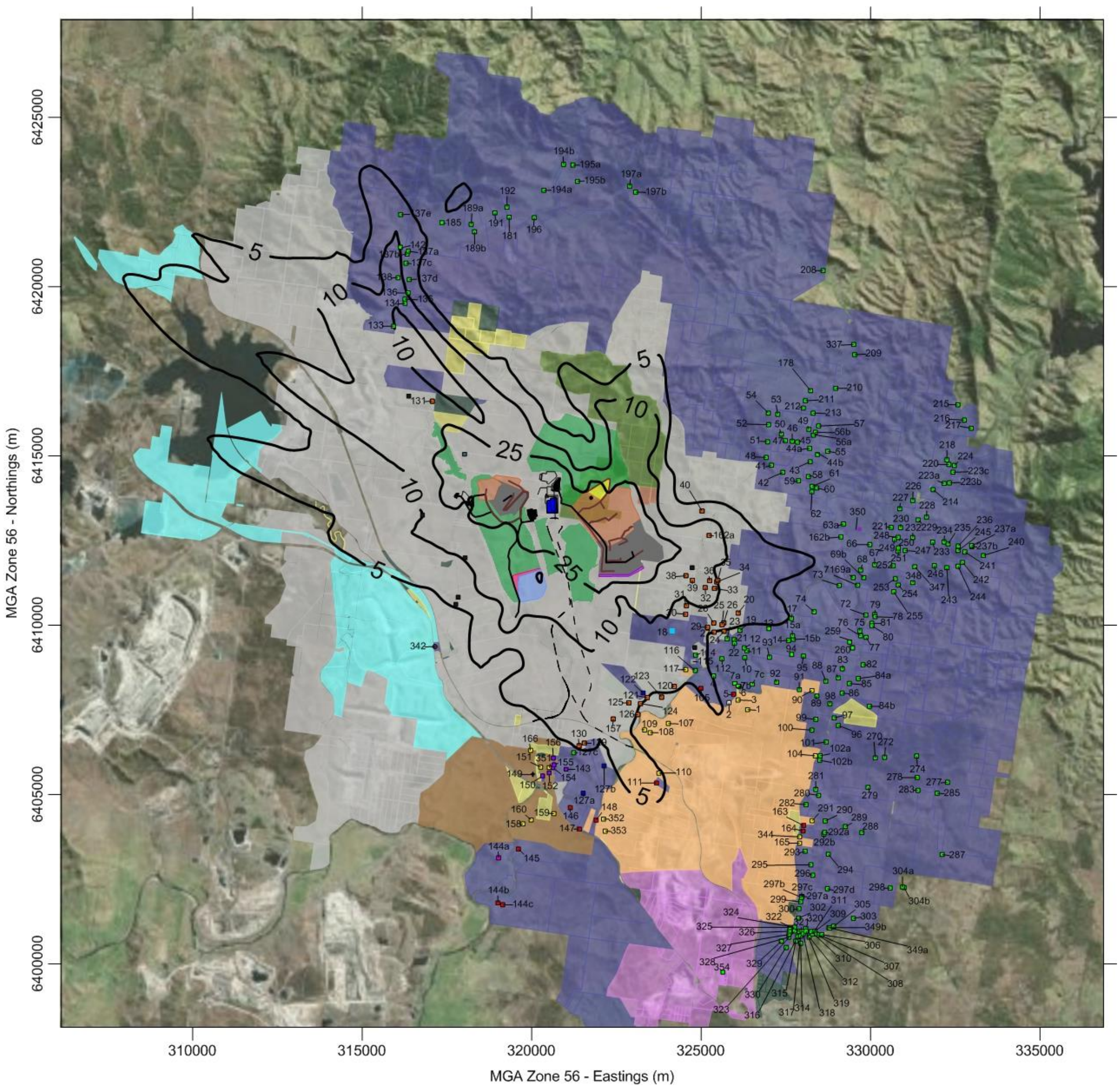
10.2.2 Year 5 (2020)

A summary of the predicted concentration and deposition levels at all sensitive receptors due to the operations of the Project alone in Year 5 is presented in **Appendix D**. Predictions across the modelling domain are shown in **Figure 10.7** to **Figure 10.12**.

With the exception of dust deposition, predictions are not compared to EPA impact assessment criteria as these criteria are cumulative. However, for individual residences the maximum 24-hour average PM_{10} predictions can be compared to the DP&E acquisition criterion of 50 µg/m^3 (see **Section 4.5**).

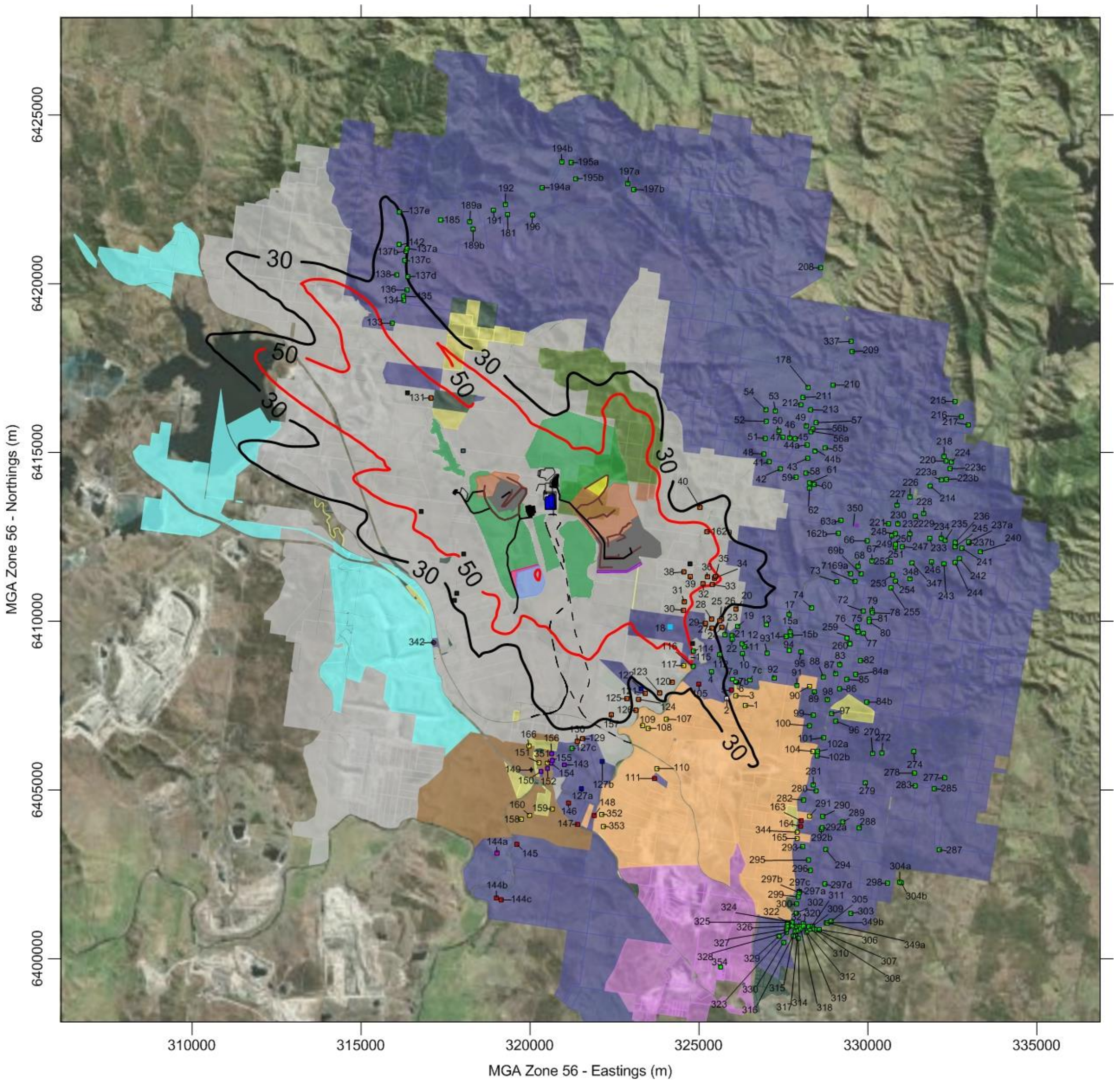
Figure 10.7 shows that there are no privately owned residences that are predicted to exceed the 24-hour average PM_{10} criterion of 50 µg/m^3 in Year 5. Annual average dust deposition levels are also predicted to be well below the EPA incremental criterion of 2 g/m^2/month, at all private residences in Year 5.

Glencore owned residences R30, R31, R32, R34, R35, R36, R38, R39 and R131, are predicted to exceed the 24-hour PM_{10} criterion in Year 5. There are no predicted exceedances of annual average criteria at any residences for the Project alone in Year 5.



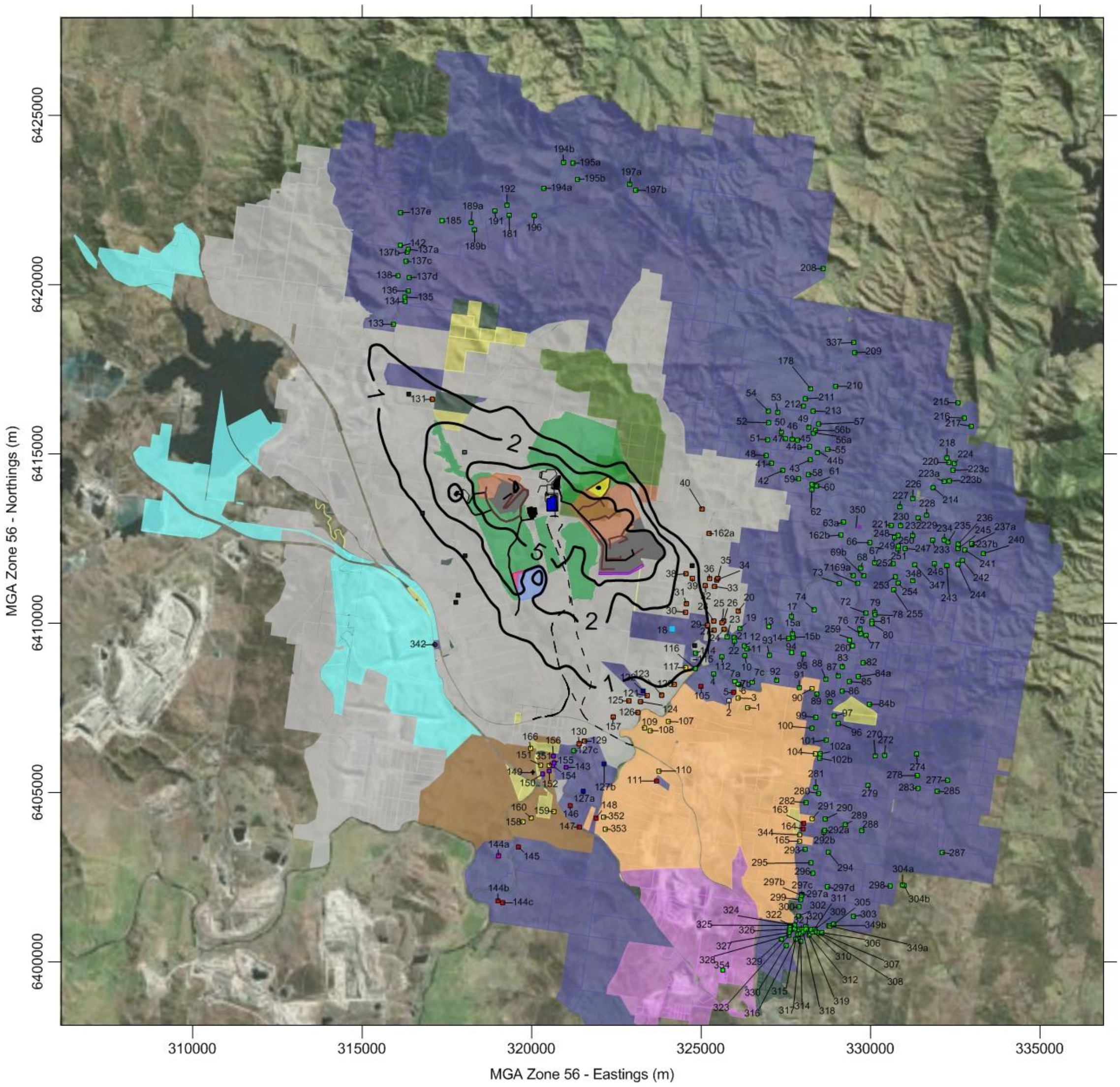
Species: PM2.5	Location: Mount Owen	Scenario: Year 5 – Project Only	Percentile: N/A	Averaging Time: 24-hour
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.7: Predicted maximum 24-hour average $PM_{2.5}$ concentrations in Year 5 – Project Only



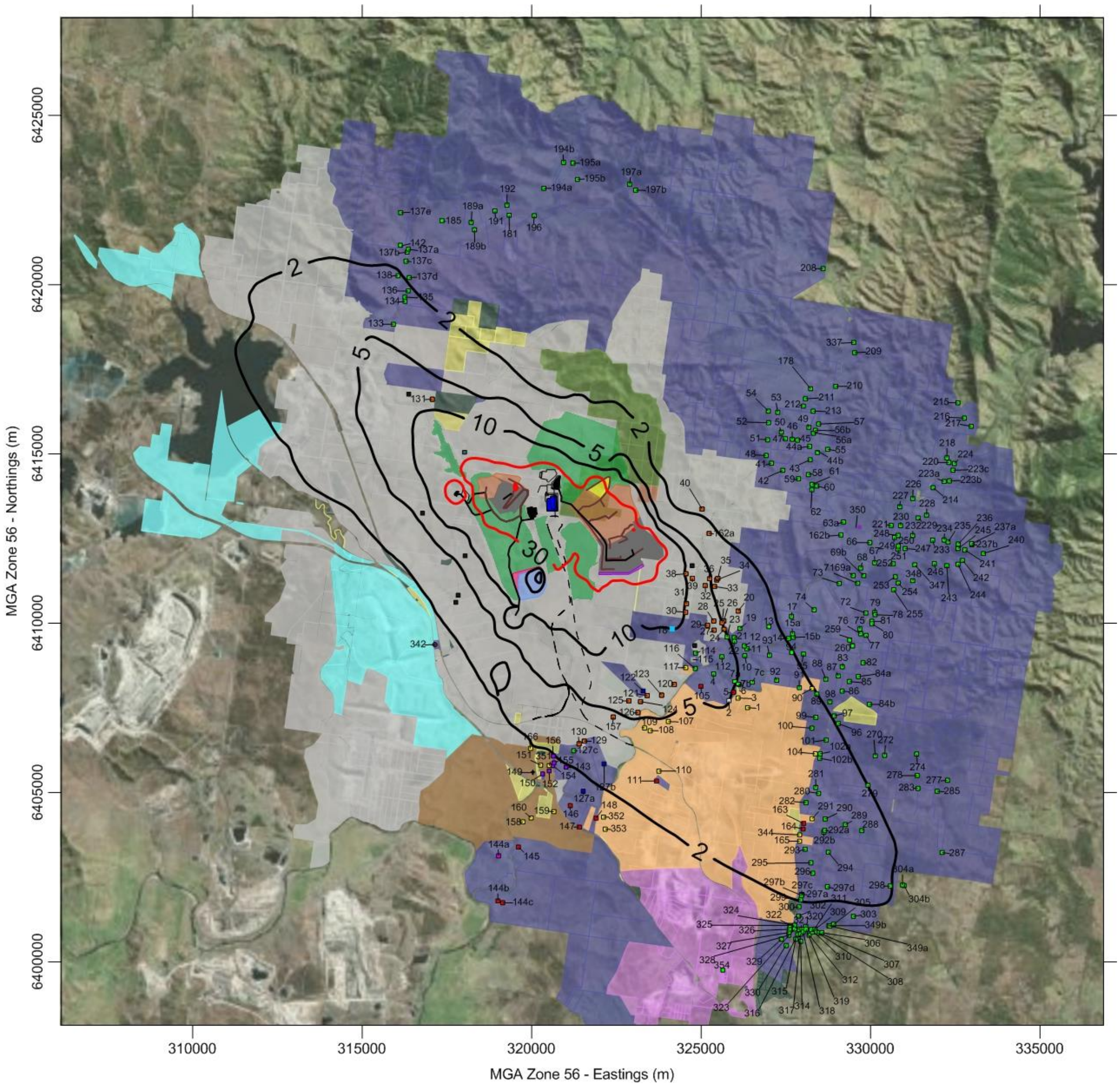
Species: PM10	Location: Mount Owen	Scenario: Year 5 – Project Only	Percentile: N/A	Averaging Time: 24-hour
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.8: Predicted maximum 24-hour average PM_{10} concentrations in Year 5 – Project Only



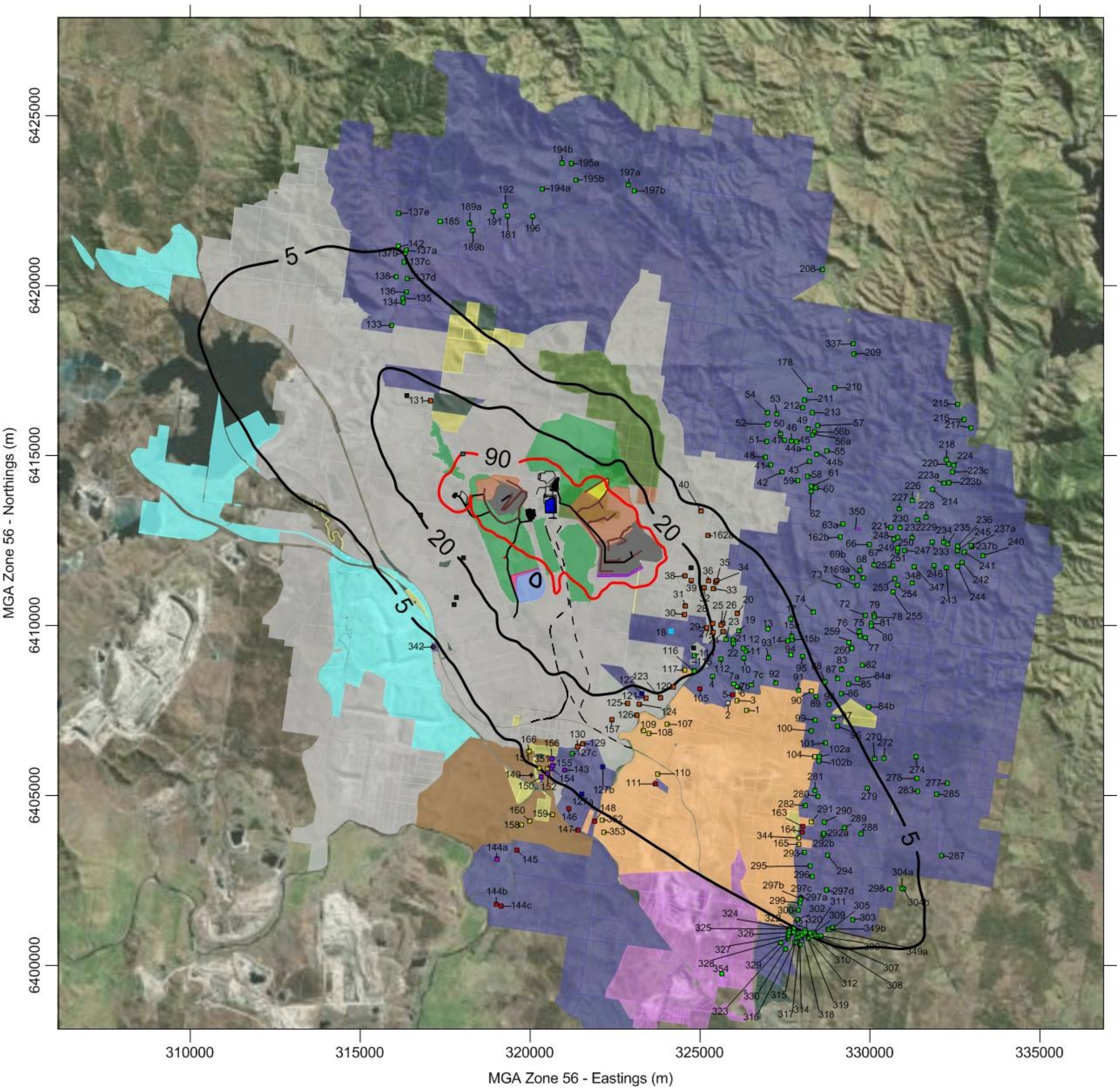
Species: PM2.5	Location: Mount Owen	Scenario: Year 5 – Project Only	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.9: Predicted annual average $PM_{2.5}$ concentrations in Year 5 – Project Only



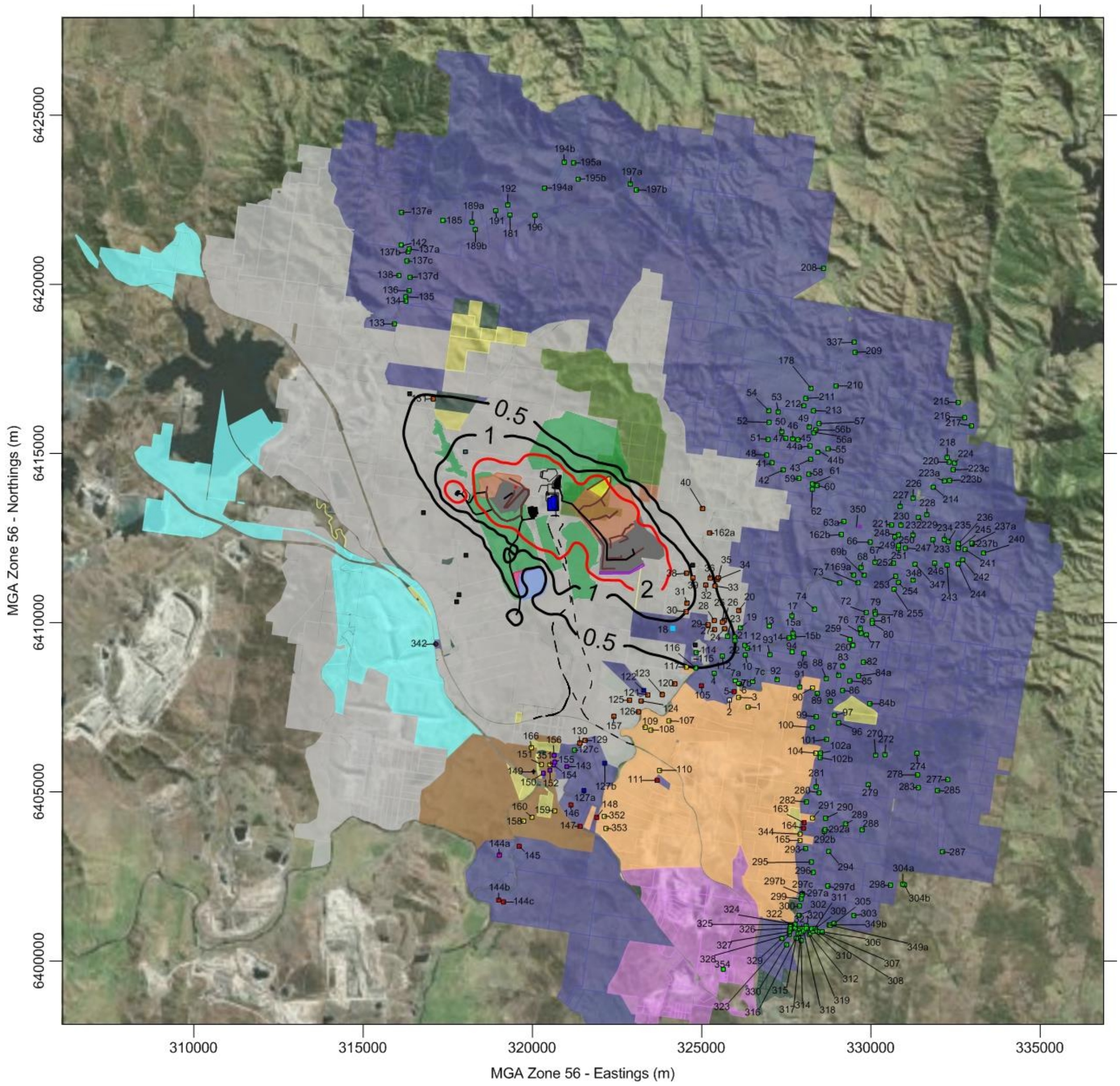
Species: PM10	Location: Mount Owen	Scenario: Year 5 – Project Only	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.10: Predicted annual average PM_{10} concentrations in Year 5 – Project Only



Species: TSP	Location: Mount Owen	Scenario: Year 5 – Project Only	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.11: Predicted annual average TSP concentrations in Year 5 – Project Only



Species: Deposition	**Location:** Mount Owen	**Scenario:** Year 5 – Project Only	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 2	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.12: Predicted annual average dust deposition in Year 5 – Project Only

10.2.3 Year 10 (2025)

A summary of the predicted concentration and deposition levels at all sensitive receptors due to the operations of the Project alone in Year 10 is presented in **Appendix D**. Predictions across the modelling domain are shown in **Figure 10.14** to **Figure 10.19**.

With the exception of dust deposition, predictions are not compared to EPA impact assessment criteria as these criteria are cumulative. However, for individual residences the maximum 24-hour average PM_{10} predictions can be compared to the DP&E acquisition criterion of 50 µg/m³ (see **Section 4.5**).

There is one privately owned residence (R23) predicted to exceed the 24-hour average PM_{10} criterion of 50 µg/m³ in Year 10. The predicted PM_{10} concentration at this residence is estimated to be 51 µg/m³. It should be noted that this is a maximum 24-hour average prediction and will not occur every day of the year. An analysis of the daily predictions at R23 across the modelling year is shown in **Figure 10.13** and indicates that this exceedance is predicted to occur only once. For the majority of the time, levels at R23, due to the Project are predicted to remain below 10 µg/m³.

Dust deposition levels are predicted to remain well below the EPA incremental criterion of 2 g/m²/month, at all private residences in Year 10.

Glencore owned residences R27, R28, R29, R30, R31, R38, R39 and R131 are predicted to exceed the 24-hour PM_{10} criterion in Year 10. Residence R117, owned by Integra, is also predicted to exceed this criterion in Year 10. There are no predicted exceedances of annual average criteria at any residences in Year 10.

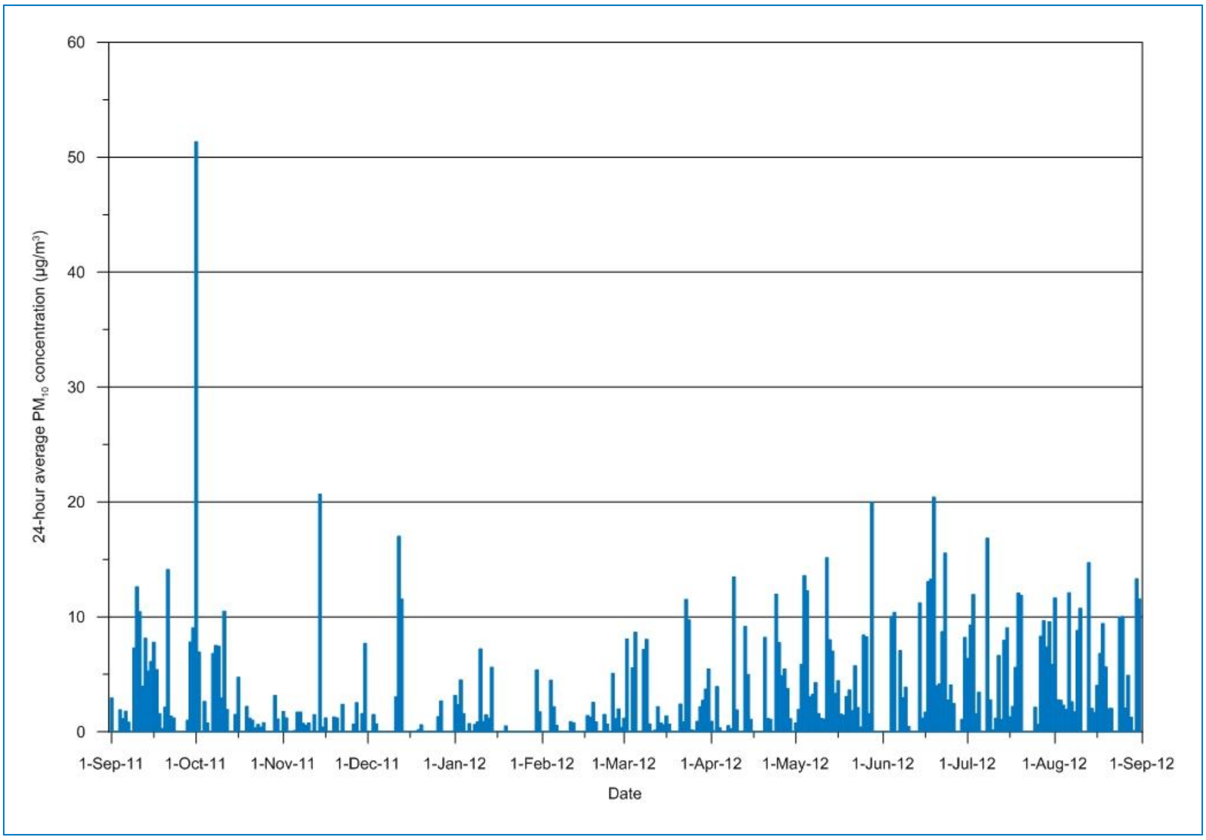
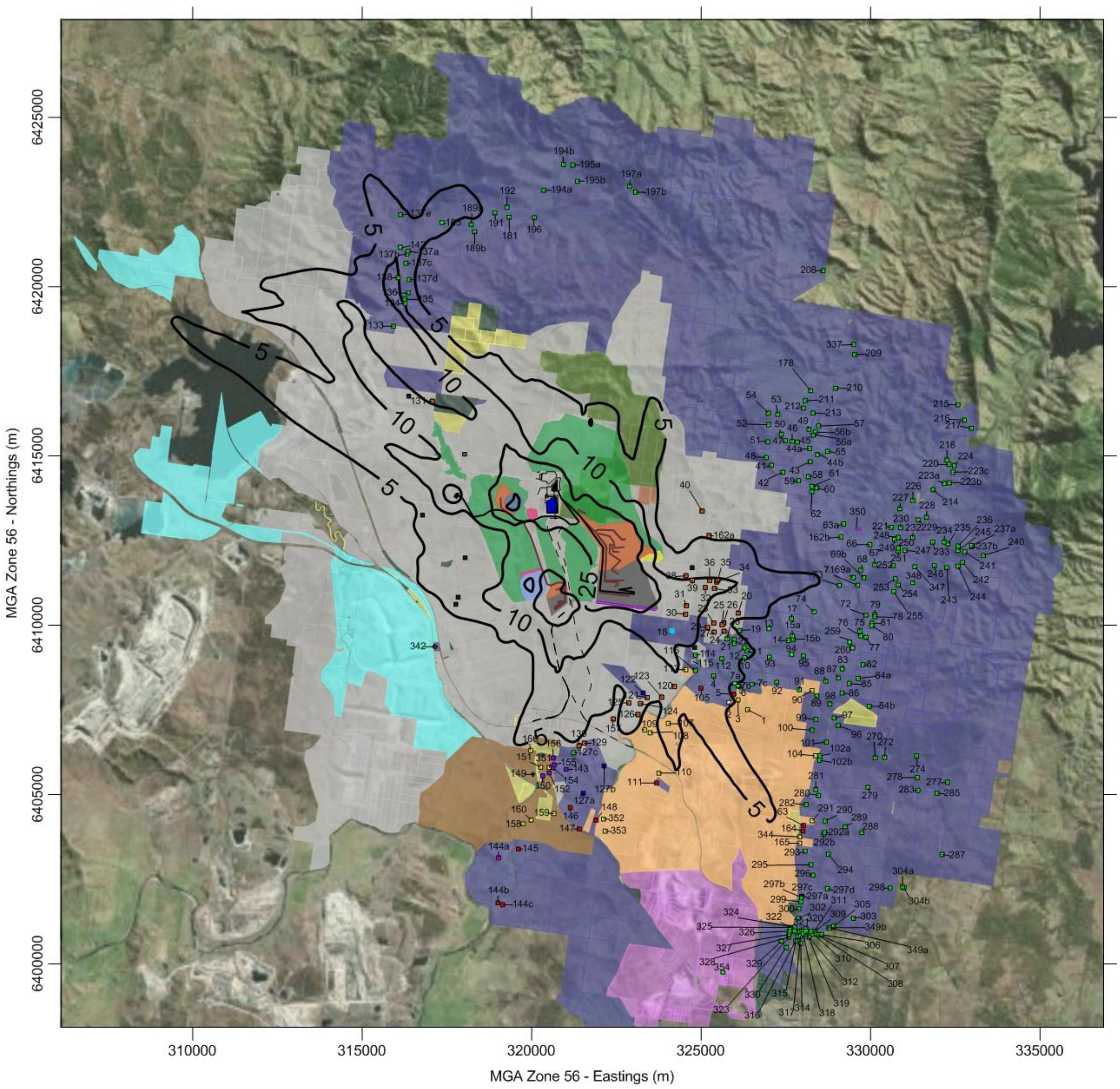
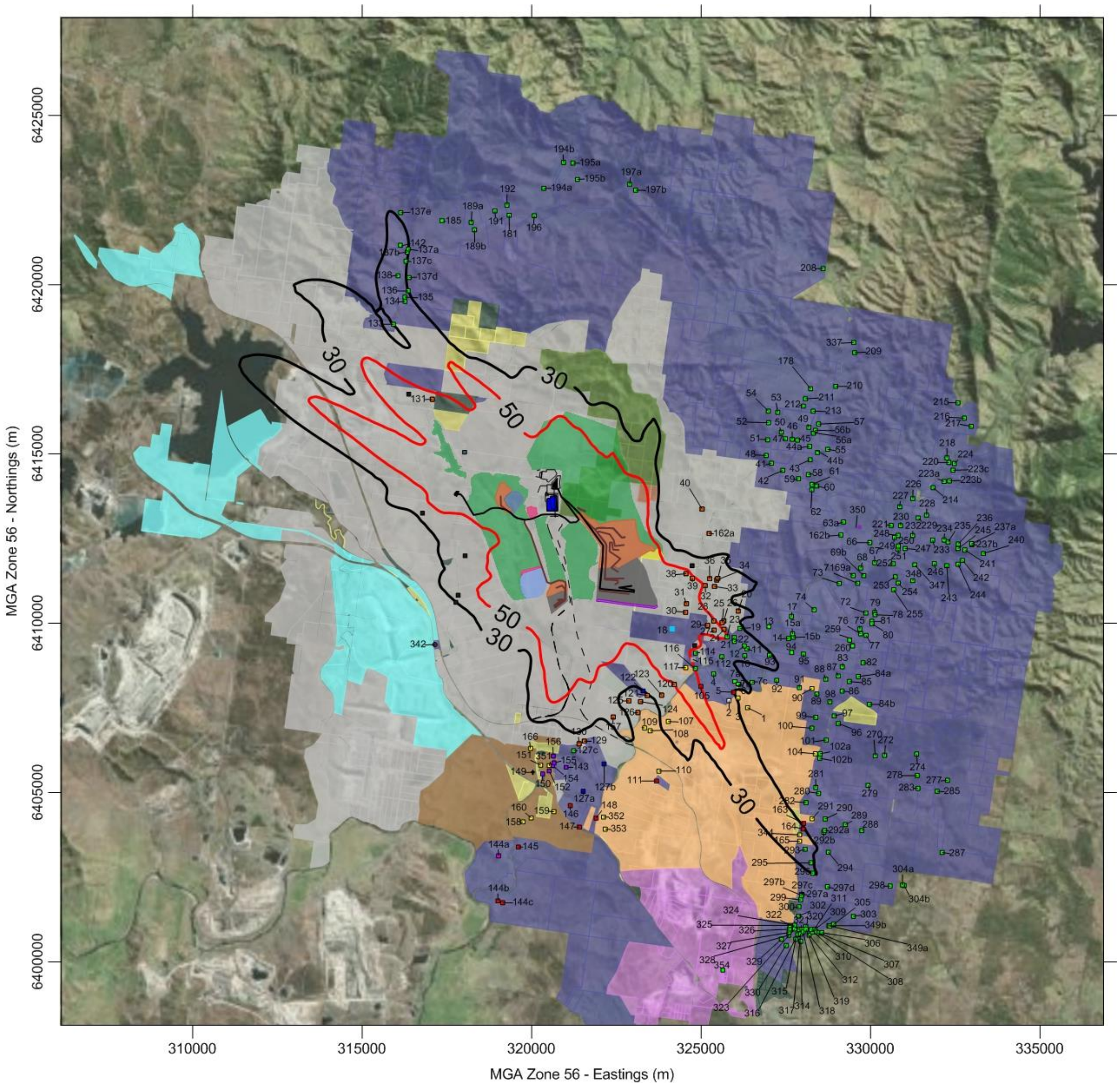


Figure 10.13: Daily predictions of 24-hour average PM_{10} concentrations at R23 due to the Project



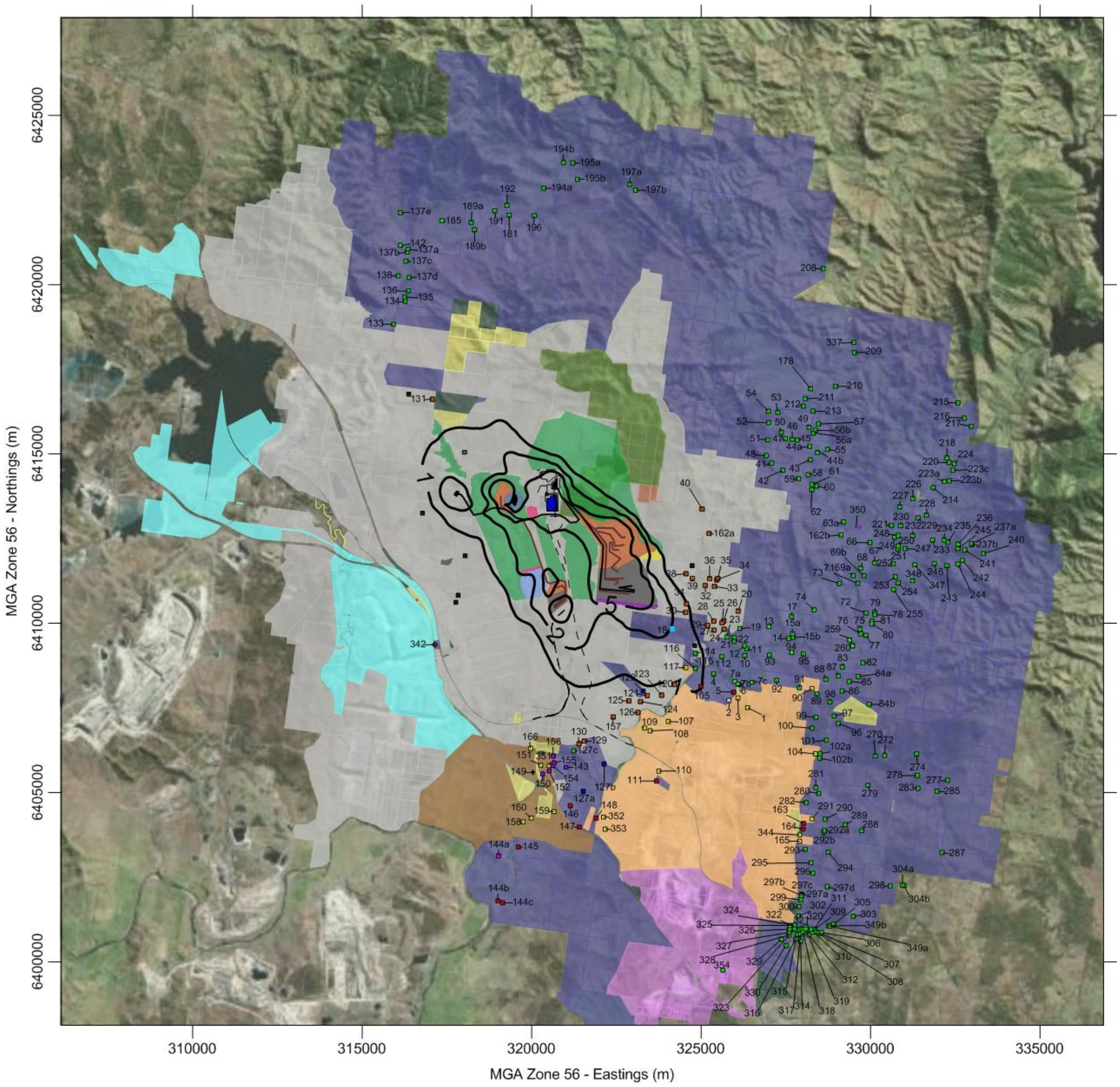
Species: PM2.5	Location: Mount Owen	Scenario: Year 10 – Project Only	Percentile: N/A	Averaging Time: 24-hour
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.14: Predicted maximum 24-hour average $PM_{2.5}$ concentrations in Year 10 – Project Only



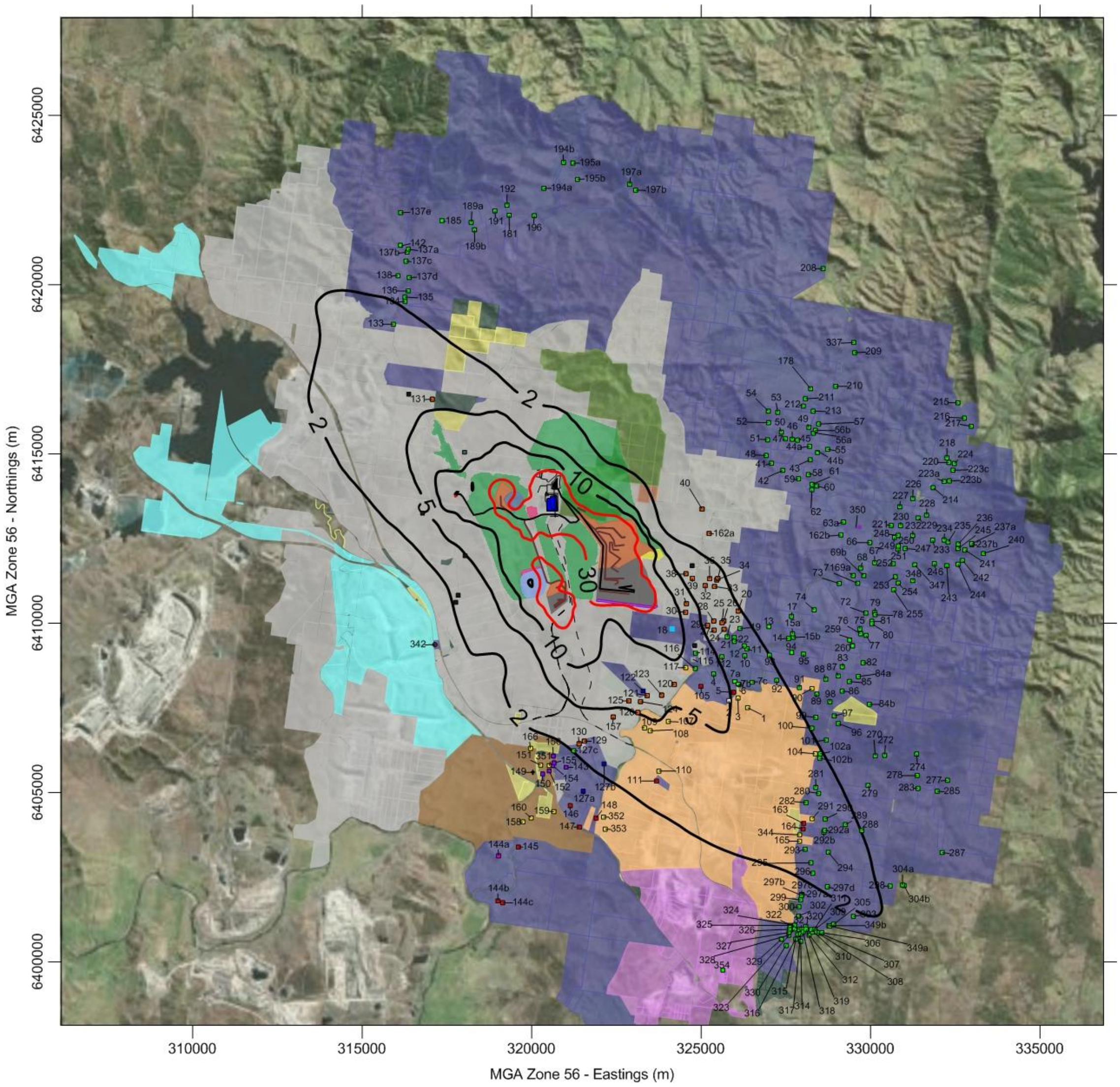
Species: PM10	Location: Mount Owen	Scenario: Year 10 – Project Only	Percentile: N/A	Averaging Time: 24-hour
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.15: Predicted maximum 24-hour average PM_{10} concentrations in Year 10 – Project Only



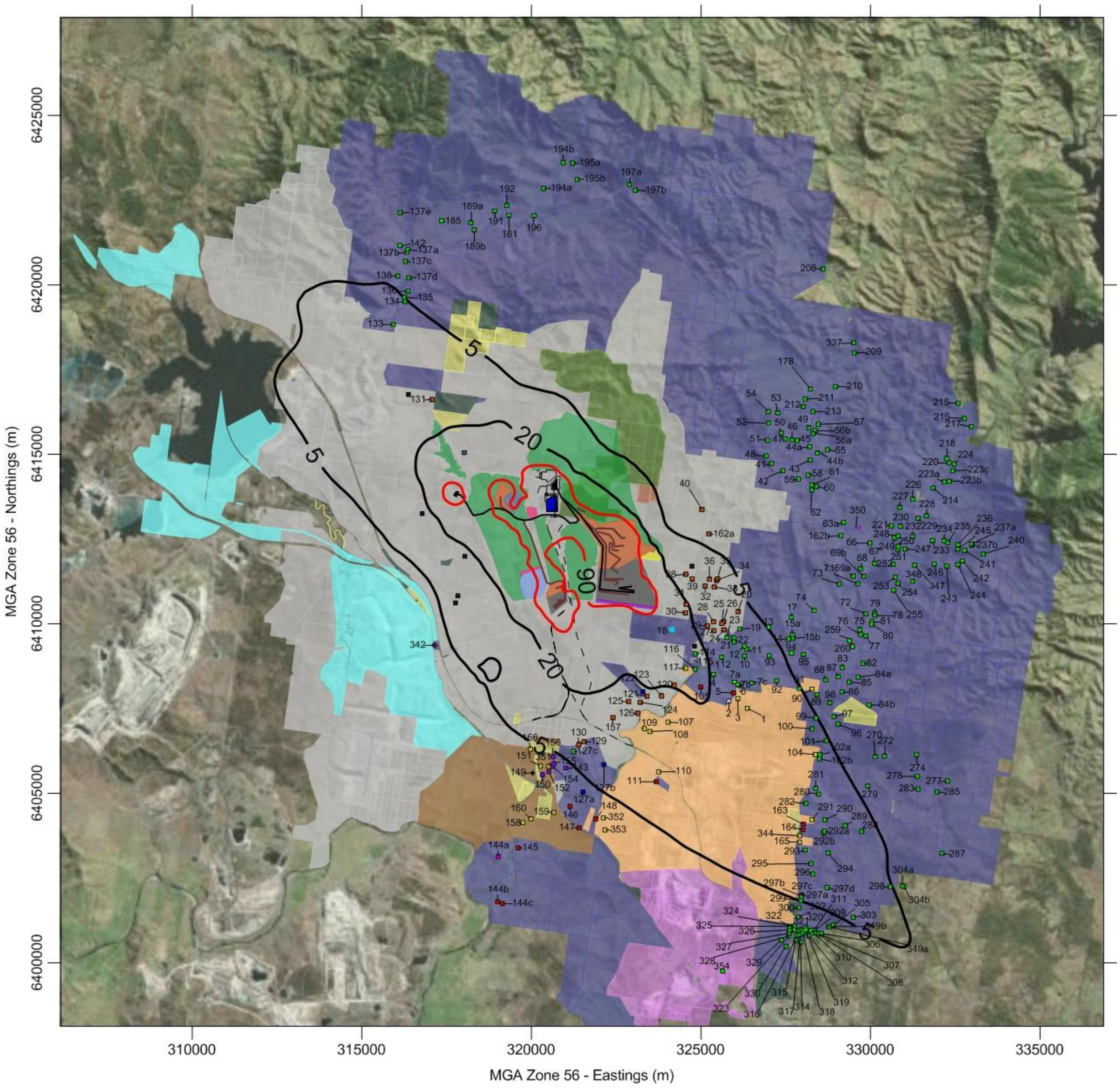
Species: PM2.5	**Location:** Mount Owen	**Scenario:** Year 10 – Project Only	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.16: Predicted annual average $PM_{2.5}$ concentrations in Year 10 – Project Only



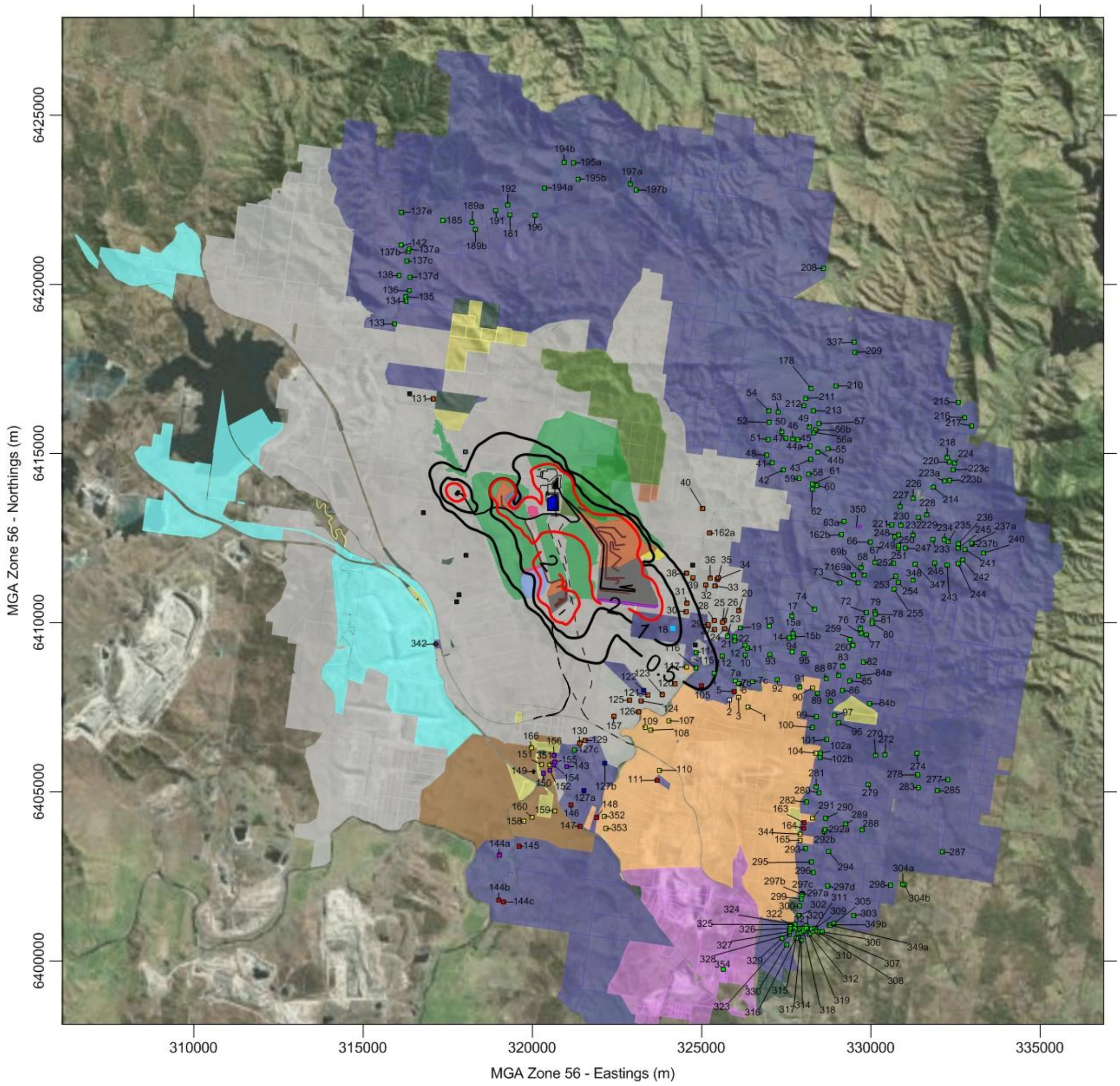
Species: PM10	**Location:** Mount Owen	**Scenario:** Year 10 – Project Only	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.17: Predicted annual average PM_{10} concentrations in Year 10 – Project Only



Species: TSP	**Location:** Mount Owen	**Scenario:** Year 10 – Project Only	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.18: Predicted annual average TSP concentrations in Year 10 – Project Only



Species: Deposition	Location: Mount Owen	Scenario: Year 10 – Project Only	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 2	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.19: Predicted annual average dust deposition in Year 10 – Project Only

10.3 Cumulative Annual Average Assessment

10.3.1 Year 1 (2016)

A summary of the predicted cumulative concentration and deposition levels at all sensitive receptors in Year 1 is presented in **Appendix E**. **Figure 10.20** to **Figure 10.23** show these predictions across the modelling domain for each particle size group. These plots include the emissions from the Project, background levels and neighbouring mines, calibrated according to the model evaluation process described in **Section 8.6**.

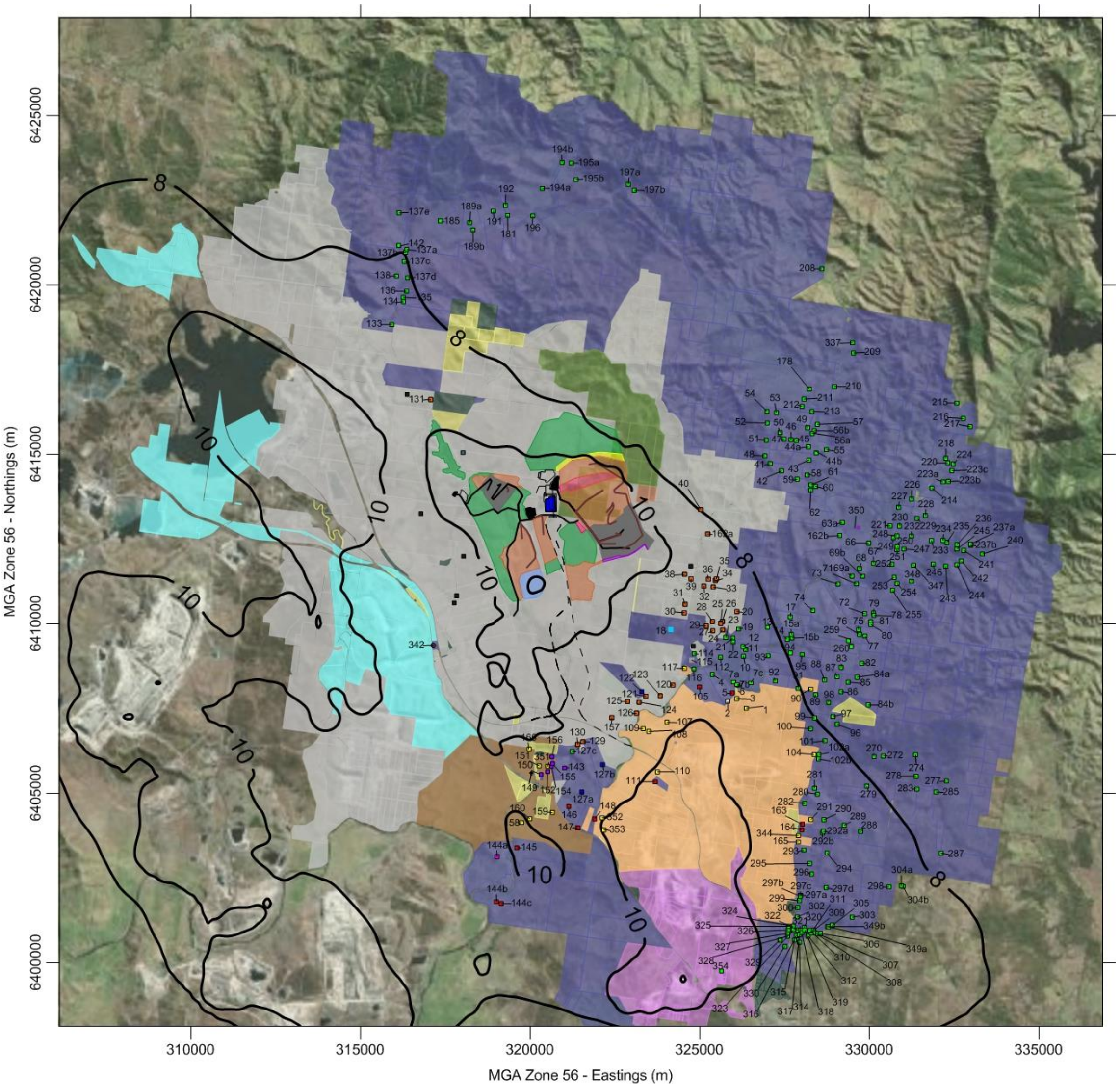
Figure 10.21 shows that there is one privately owned residence, without current acquisition rights, predicted to exceed the annual average PM_{10} criteria of 30 µg/m³ in Year 1. This is Residence 354 south of Integra, on a small parcel of land surrounded by Rixs Creek Mine landholdings. Emissions from Integra and Rixs Creek contribute the bulk of the PM_{10} concentrations in that area. Combined with background levels and contributions from other mines it is likely that levels at R354 would exceed the annual average PM_{10} criterion without emissions from the Project, which contributes less than 1 µg/m³ at that residence.

There are exceedances predicted at other residences in Year 1 but all of these are either mine owned or have current acquisition rights. **Table 10.1** lists the residences predicted to exceed the PM_{10} criteria, and the estimated relative contributions from the Project.

Table 10.1: Residences predicted to exceed annual PM_{10} criteria – Year 1

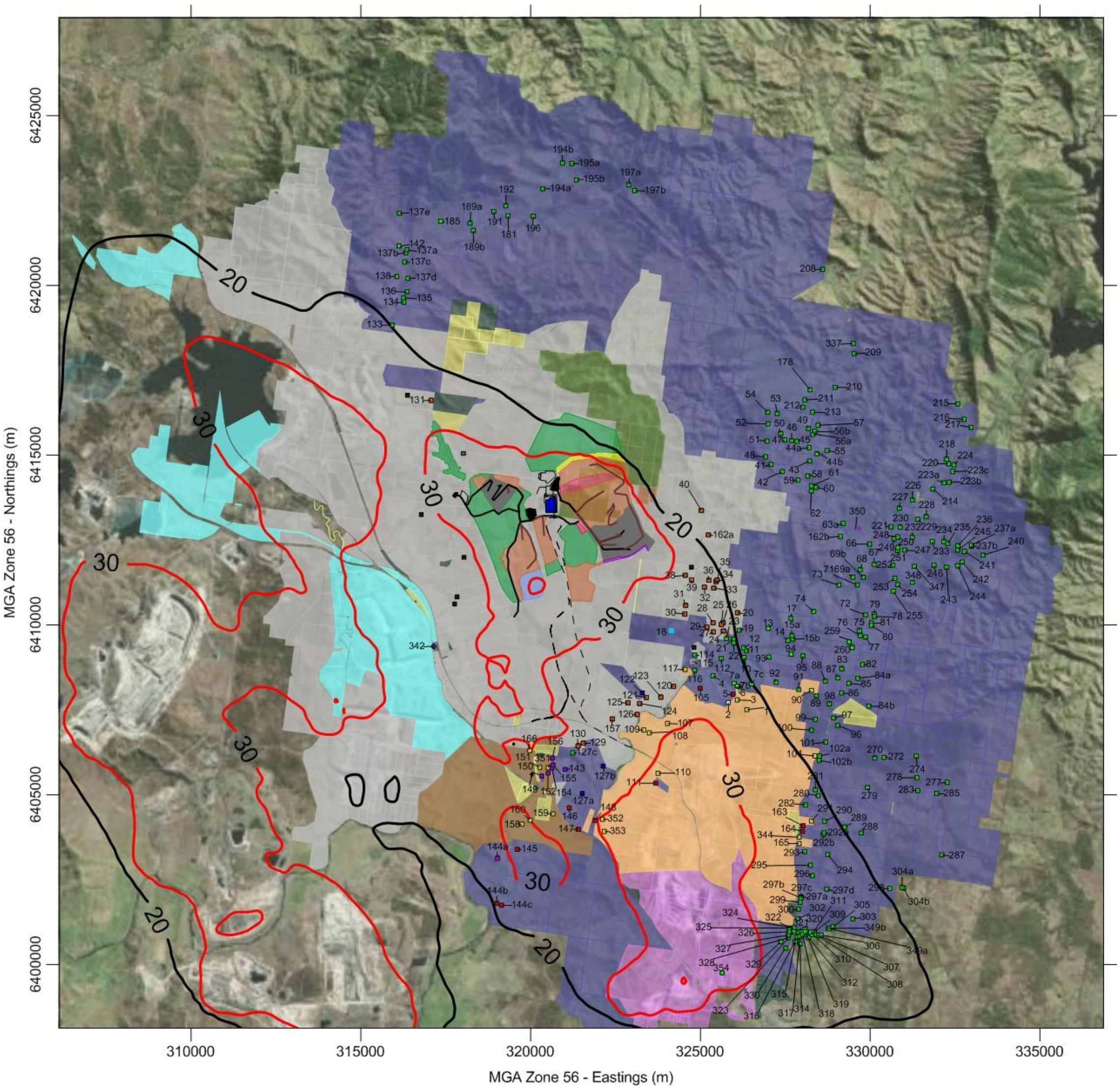
Exceeding Residence ID	Current Ownership Status	Annual Average PM_{10}	
		Total Cumulative (µg/m³)	Project Contribution (µg/m³)
110	Other Mine Owned	33	3
111	Private - Acquisition Rights Other Mines	36	3
145	Private - Acquisition Rights Other Mines	42	1
158	Other Mine Owned	37	1
160	Other Mine Owned	30	1
352	Other Mine Owned	31	1
353	Other Mine Owned	32	1
354	Private	35	<1

Annual average cumulative TSP concentrations are not predicted to exceed 90 µg/m³ at any private residences that are not already subject to acquisition rights. Results are very similar for dust deposition. The only residents predicted to exceed the annual average TSP (R145 and R158) or dust deposition (R38, R145 and R158) criteria, are either mine owned or subject to acquisition rights.



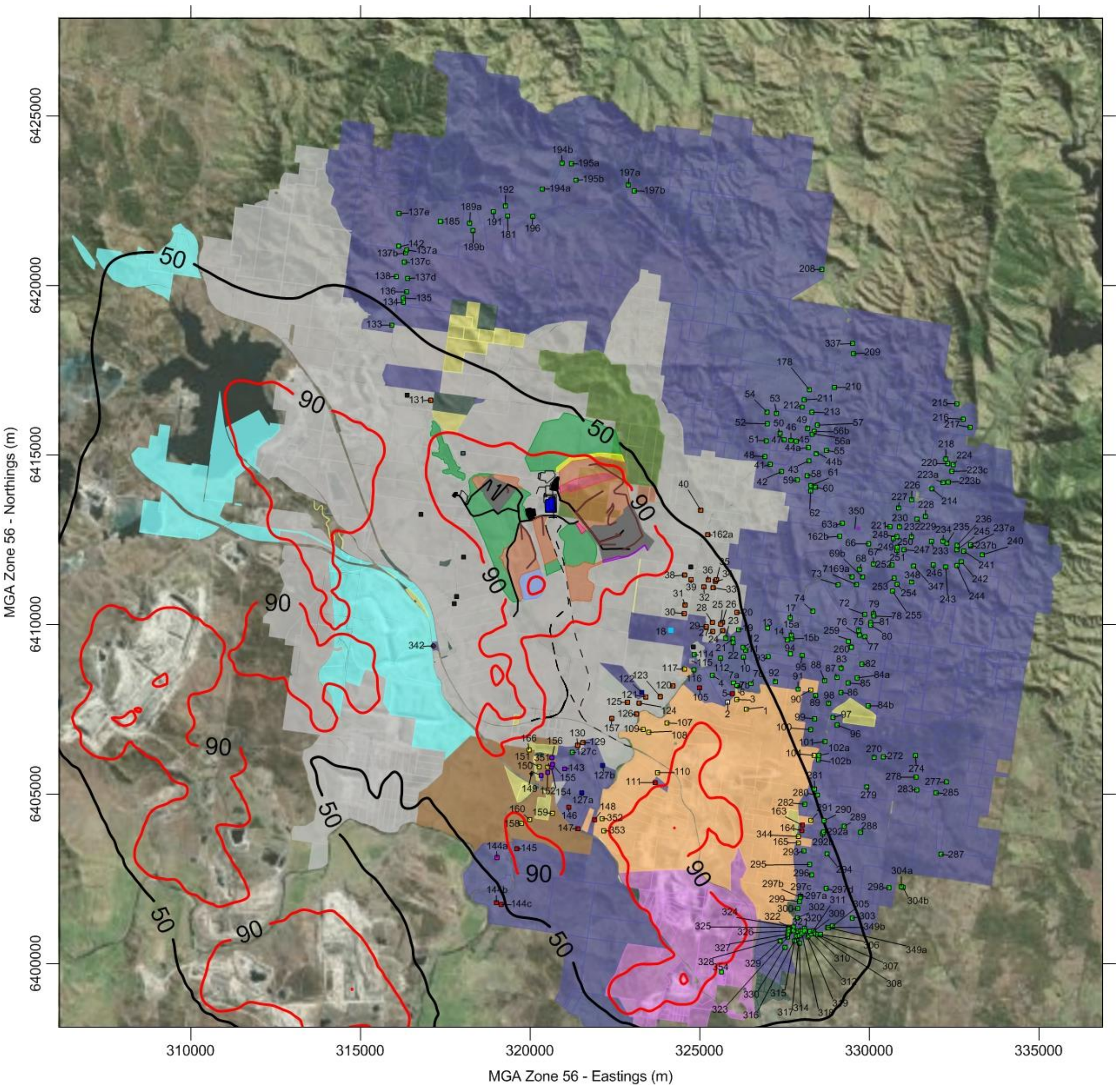
Species: PM2.5	Location: Mount Owen	Scenario: Year 1 – Cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.20: Predicted annual average $PM_{2.5}$ concentrations in Year 1 – Cumulative



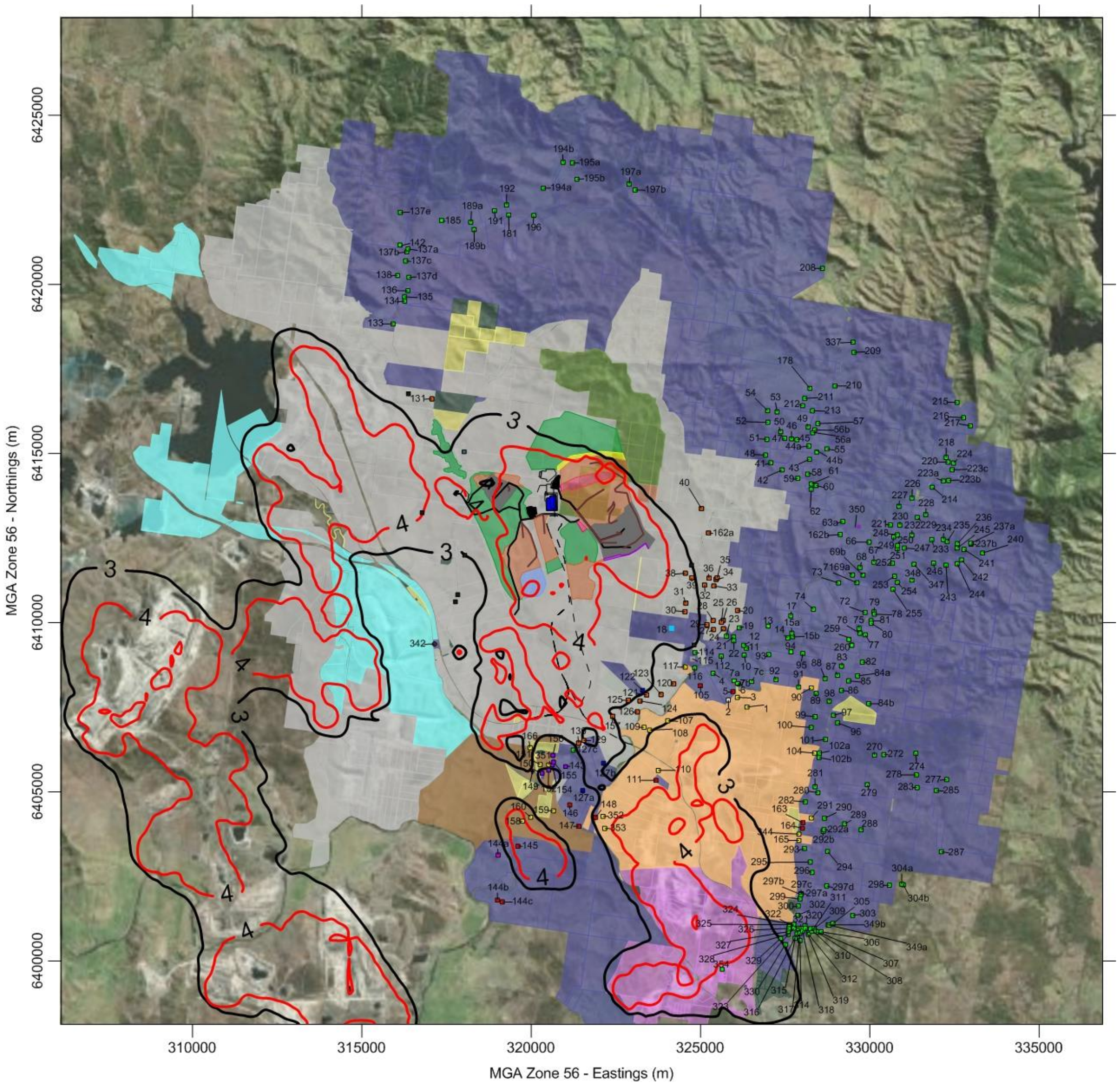
Species: PM10	Location: Mount Owen	Scenario: Year 1 – Cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 30	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.21: Predicted annual average PM_{10} concentrations in Year 1 – Cumulative



Species: TSP	Location: Mount Owen	Scenario: Year 1 – Cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 90	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.22: Predicted annual average TSP concentrations in Year 1 – Cumulative



Species:	Location:	Scenario:	Percentile:	Averaging Time:
Deposition	Mount Owen	Year 1 – Cumulative	N/A	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF	g/m^2/month	4	2011/2012	J. Barnett

Figure 10.23: Predicted annual average dust deposition in Year 1 – Cumulative

10.3.2 Year 5 (2020)

A summary of the predicted cumulative concentration and deposition levels at all sensitive receptors in Year 5 is presented in **Appendix E**. **Figure 10.24** to **Figure 10.27** show these predictions across the modelling domain for each particle size group. These plots include the emissions from the Project, background levels and neighbouring mines, calibrated according to the model evaluation process described in **Section 8.6**.

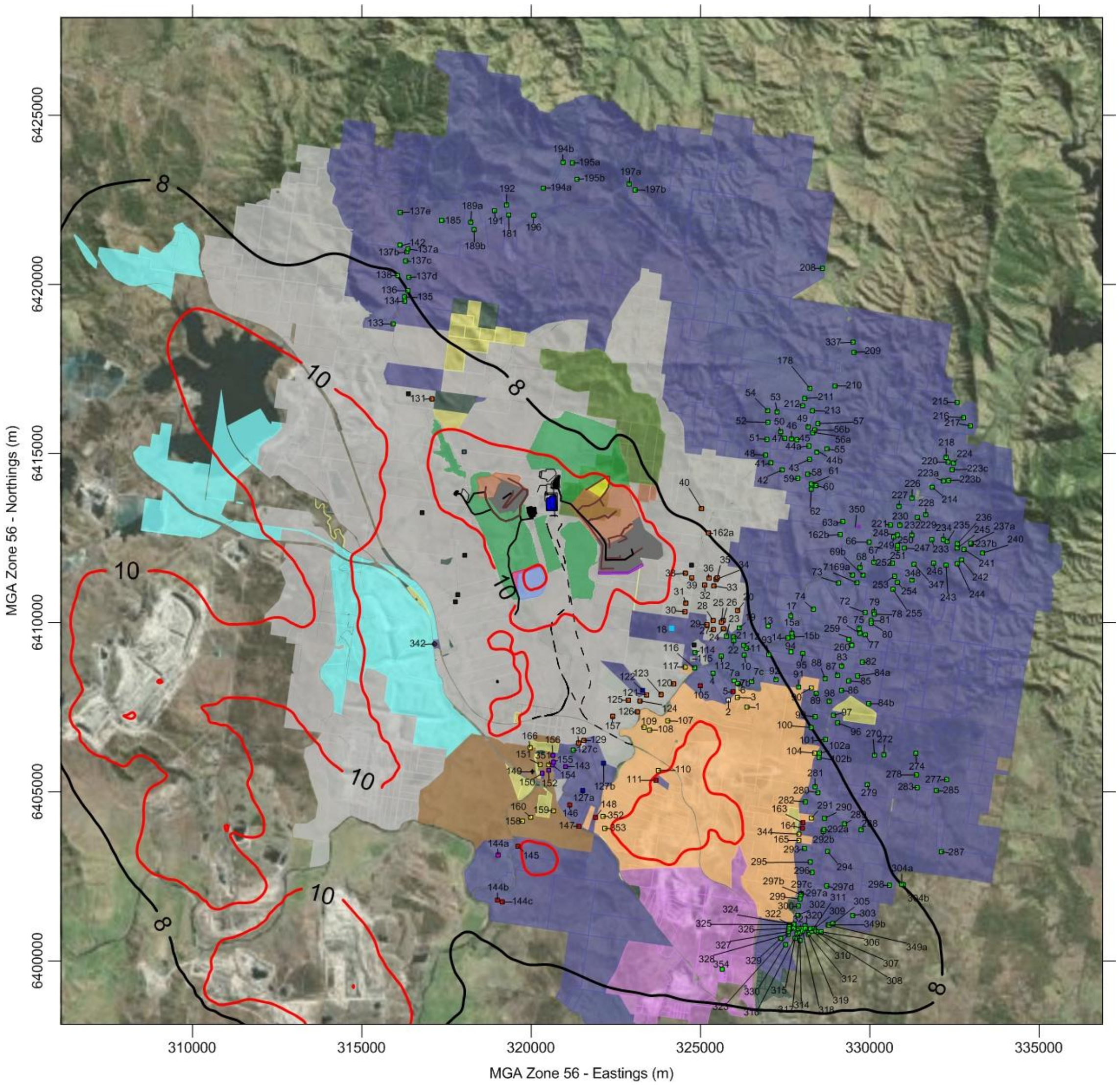
Figure 10.25 shows that there are no privately owned residences, without current acquisition rights, predicted to exceed the annual average PM_{10} criteria of 30 µg/m^3 in Year 5.

Table 10.2 lists the residences predicted to exceed the annual average PM_{10} criteria, and the estimated relative contributions from the Project. R111 is adjacent to Integra is heavily influenced by emissions from those operations. In the same way, R145 is heavily influenced by Ashton's South East Open Cut operations (which may not be approved). In both cases, emissions from the Project are not likely to be the cause of these predicted exceedances.

Table 10.2: Residences predicted to exceed annual PM_{10} criteria – Year 5

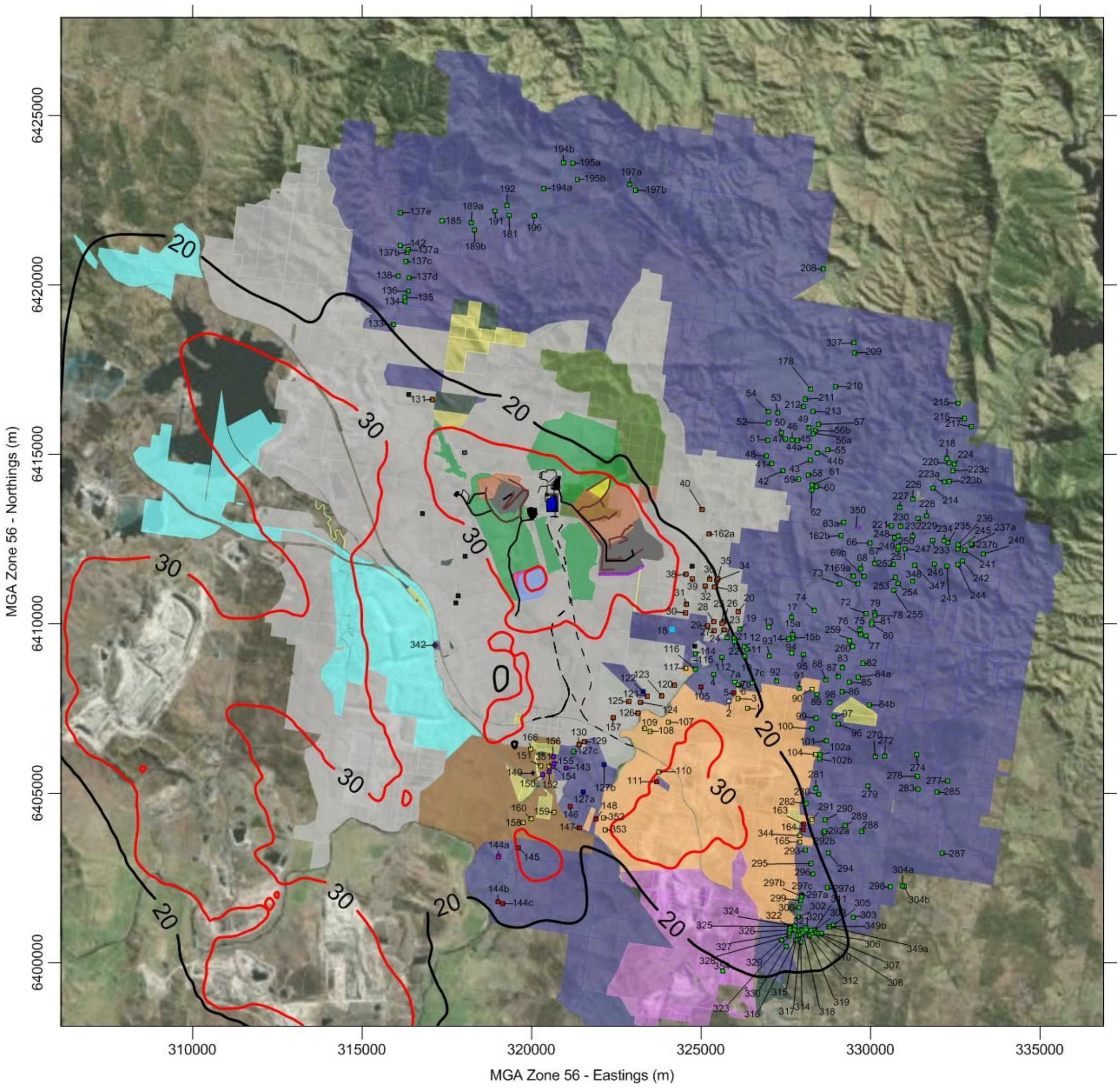
Exceeding Residence ID	Current Ownership Status	Annual Average PM_{10}	
		Total Cumulative (µg/m^3)	Project Contribution (µg/m^3)
111	Private - Acquisition Rights Other Mines	36	3
145	Private - Acquisition Rights Other Mines	31	<1

Annual average cumulative TSP concentrations and dust deposition levels are not predicted to exceed their respective criteria at any private residences without existing acquisition rights in Year 5 (**Figure 10.26** and **Figure 10.27**).



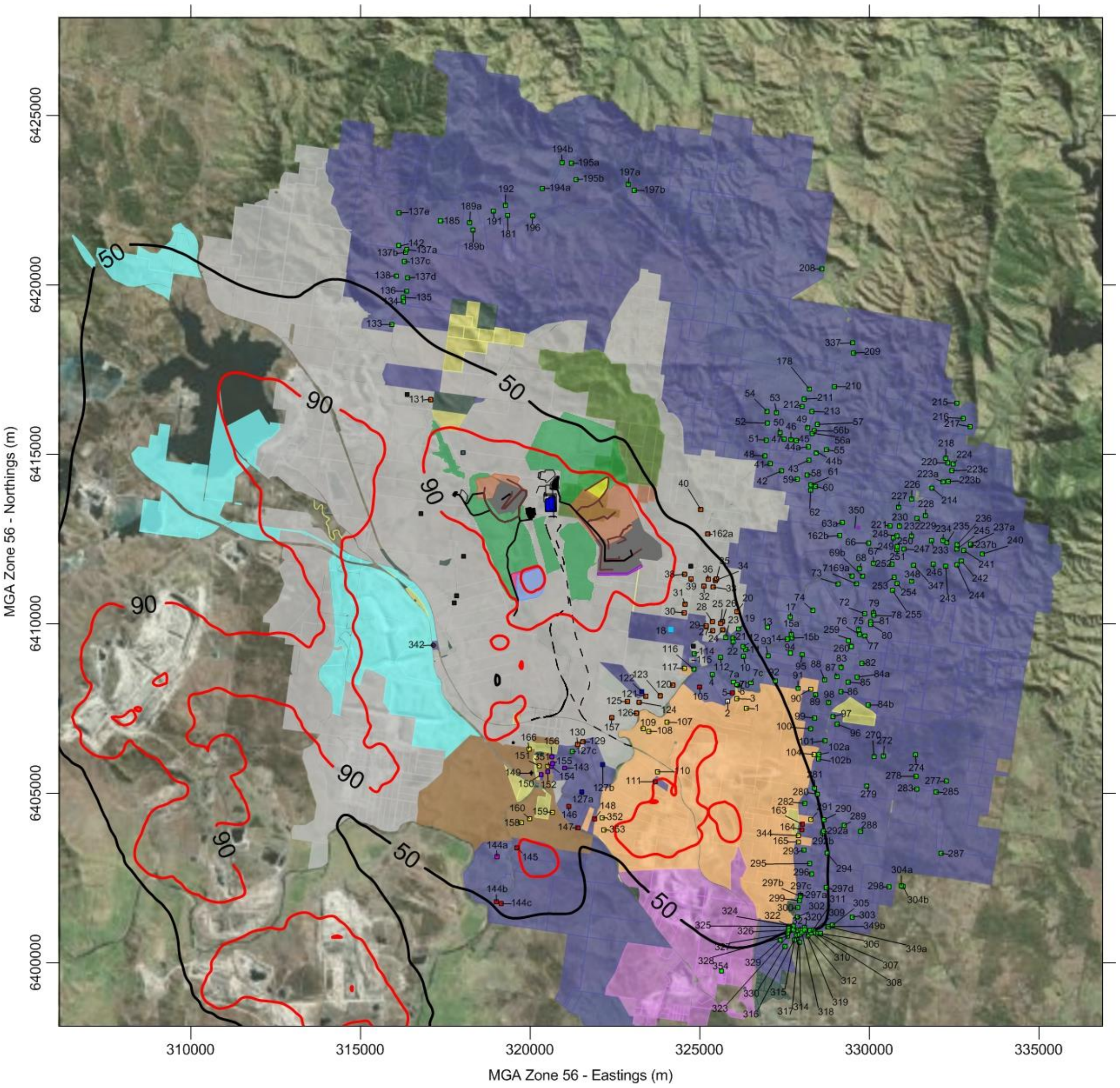
Species: PM2.5	**Location:** Mount Owen	**Scenario:** Year 5 – Cumulative	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.24: Predicted annual average $PM_{2.5}$ concentrations in Year 5 – Cumulative



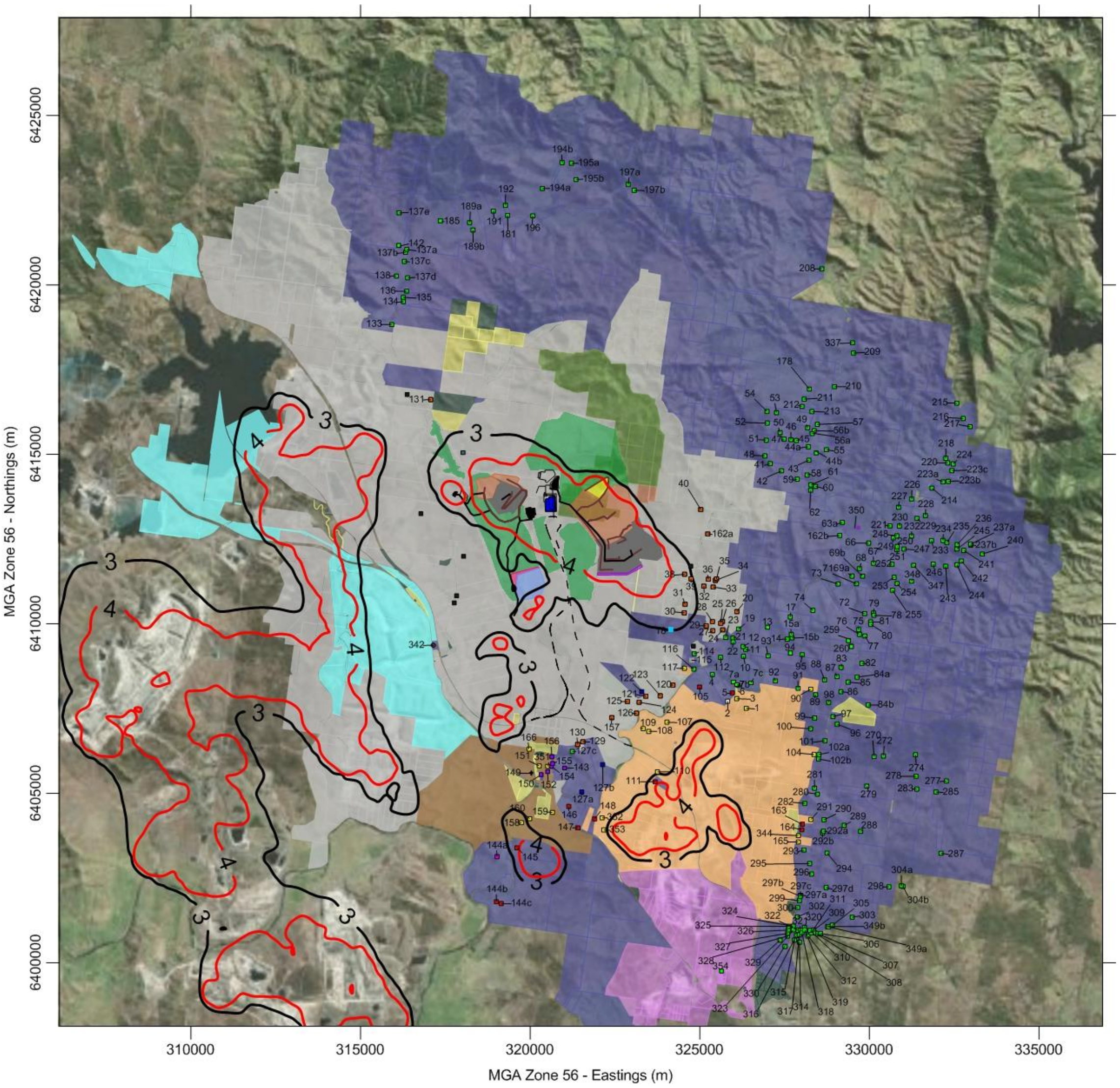
Species: PM10	Location: Mount Owen	Scenario: Year 5 – Cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 30	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.25: Predicted annual average PM_{10} concentrations in Year 5 – Cumulative



Species: TSP	**Location:** Mount Owen	**Scenario:** Year 5 – Cumulative	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 90	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.26: Predicted annual average TSP concentrations in Year 5 – Cumulative



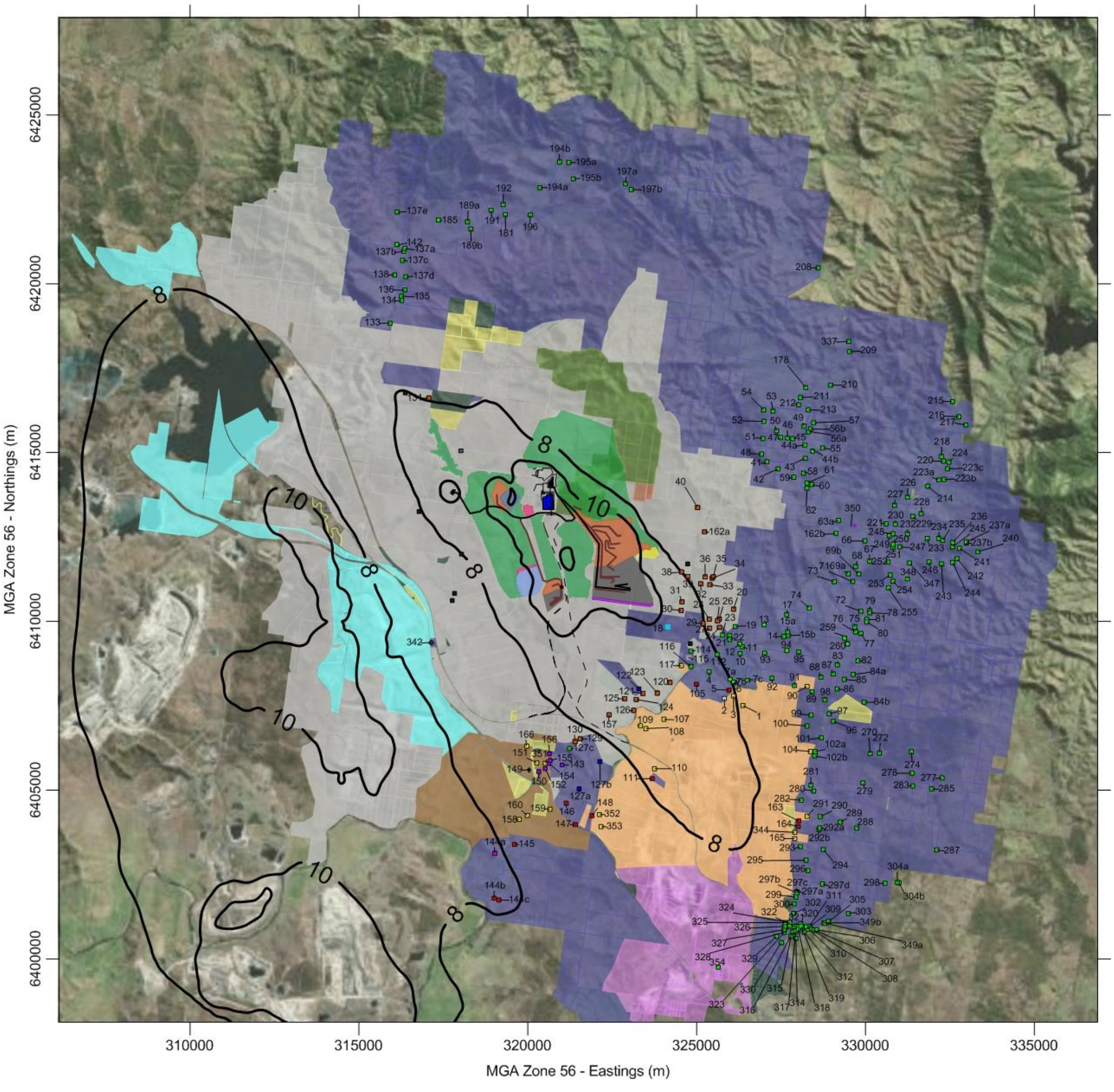
Species: Deposition	**Location:** Mount Owen	**Scenario:** Year 5 – Cumulative	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 4	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.27: Predicted annual average dust deposition in Year 5 – Cumulative

10.3.3 Year 10 (2025)

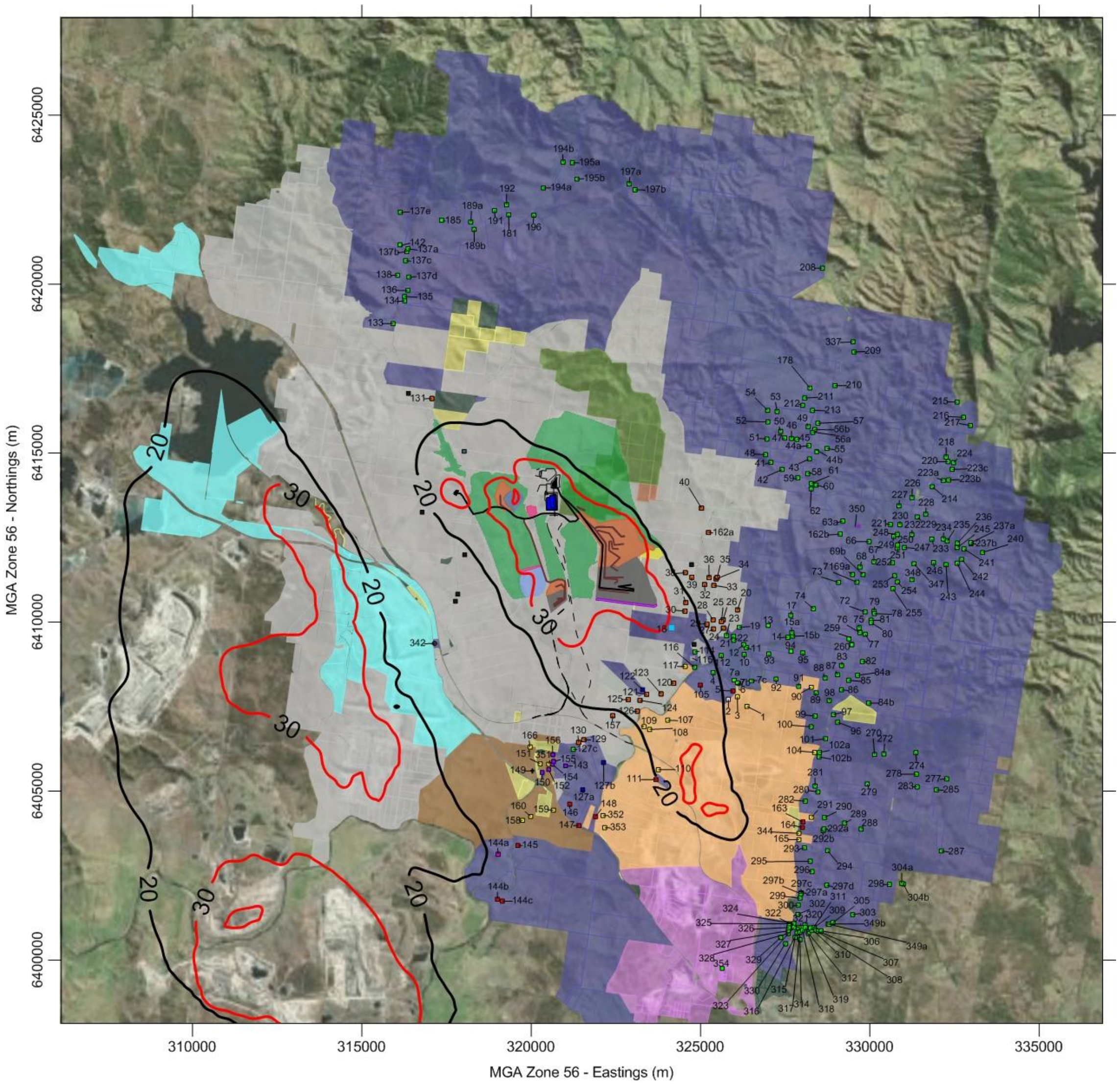
A summary of the predicted cumulative concentration and deposition levels at all sensitive receptors in Year 10 is presented in **Appendix E**. **Figure 10.28** to **Figure 10.31** show these predictions across the modelling domain for each particle size group. These plots include the emissions from the Project, background levels and neighbouring mines, calibrated according to the model evaluation process described in **Section 8.6**.

There are not predicted to be any exceedances of annual average air quality criteria at privately owned residences in Year 10 (**Figure 10.29** and **Figure 10.31**).



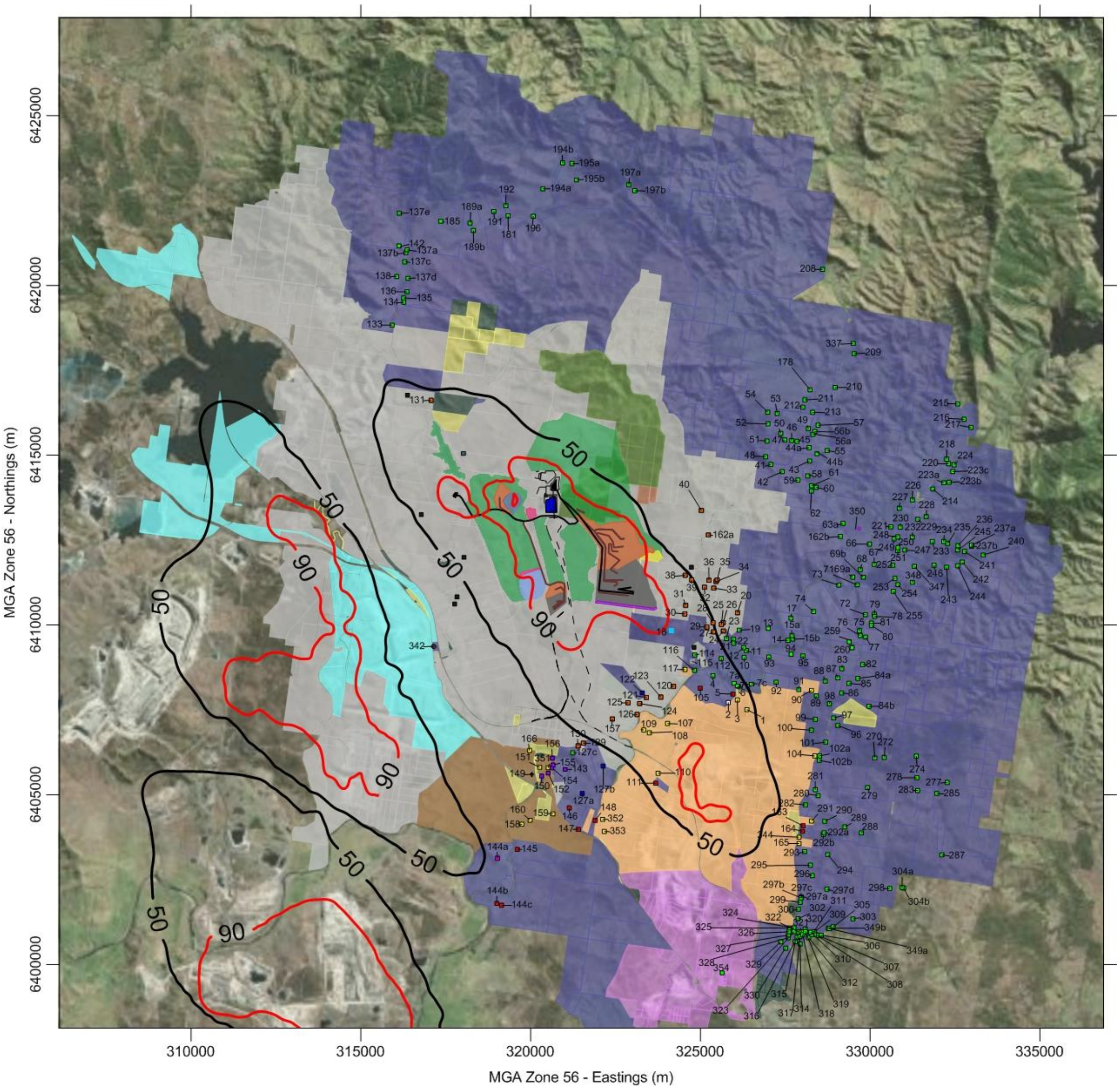
Species: PM2.5	**Location:** Mount Owen	**Scenario:** Year 10 – Cumulative	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** N/A	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.28: Predicted annual average $PM_{2.5}$ concentrations in Year 10 – Cumulative



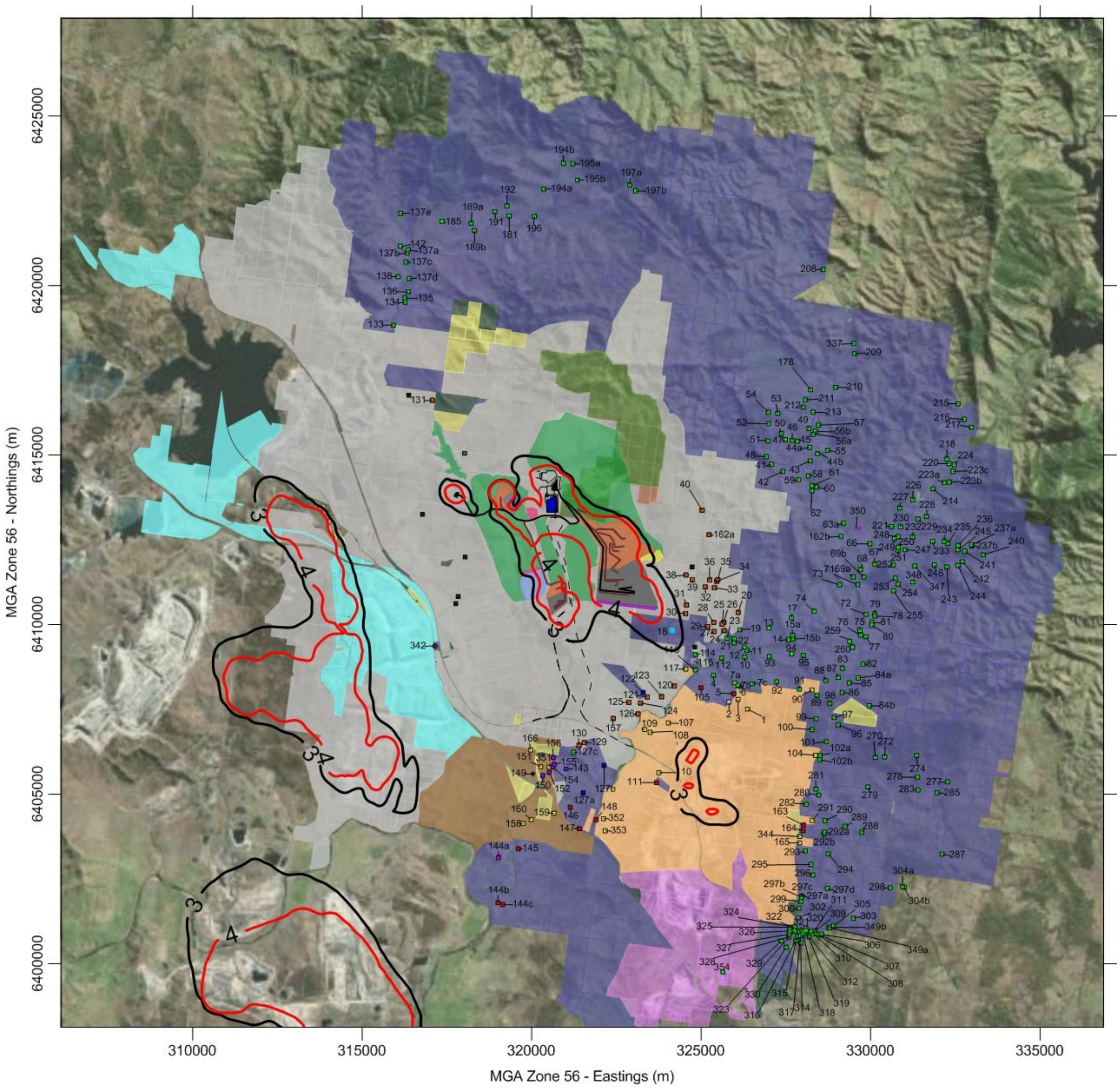
Species: PM_{10}	Location: Mount Owen	Scenario: Year 10 – Cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 30	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.29: Predicted annual average PM_{10} concentrations in Year 10 – Cumulative



Species: TSP	Location: Mount Owen	Scenario: Year 10 – Cumulative	Percentile: N/A	Averaging Time: Annual
Model Used: CALPUFF	**Units:** µg/m³	**Guideline:** 90	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.30: Predicted annual average TSP concentrations in Year 10 – Cumulative



Species: Deposition	**Location:** Mount Owen	**Scenario:** Year 10 – Cumulative	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF	**Units:** g/m²/month	**Guideline:** 4	**Met Data:** 2011/2012	**Plot:** J. Barnett

Figure 10.31: Predicted annual average dust deposition in Year 10 – Cumulative

10.4 Cumulative 24-hour Average Assessment

10.4.1 Introduction

Difficulties in predicting cumulative 24-hour impacts are compounded by the day-to-day variability in ambient dust levels and the spatial and temporal variation in any other anthropogenic activity and natural events e.g. agricultural activity, dust storms, bushfires etc., and including mining in the future. Monitoring data (presented in **Section 5.3**) show that in many cases the worst-case 24-hour average PM_{10} concentrations are strongly influenced by other sources in an area, such as bushfires and dust storms, which are essentially unpredictable. Mining operations also contribute to elevated 24-hour average PM_{10} concentrations, however, they are likely to be more localised. The variability in 24-hour average PM_{10} concentrations can be clearly seen in the data collected at the HVAS and TEOM monitors located surrounding the Project Area (see **Section 5.3.1**).

Due to the difficulties outlined above, cumulative air quality impacts have been evaluated using a statistical approach (Monte Carlo Simulation). This approach has been provided to meet the requirements of the DGRs to use an appropriate probabilistic methodology to assess 24-hour average cumulative PM_{10} and $PM_{2.5}$ and focuses on representative receptors in key areas in the vicinity of the Project Area.

As Mount Owen is an existing mine, PM_{10} concentrations measured within its monitoring network will already include contributions from the current operations. Therefore, the Project's contribution would need to be subtracted to avoid double counting the existing mine's contribution. Our assessment approach allows for this, as described below.

A number of private receptors were selected for cumulative analysis based on their proximity to operations, prevailing wind directions and the magnitude of their Project mine-only predictions (see **Section 10.2**). These include four to the northwest, sixteen in the Middle Falbrook area (three of which are currently subject to acquisition rights) and one in Camberwell Village. The locations of these receptors are shown in **Figure 10.32**.

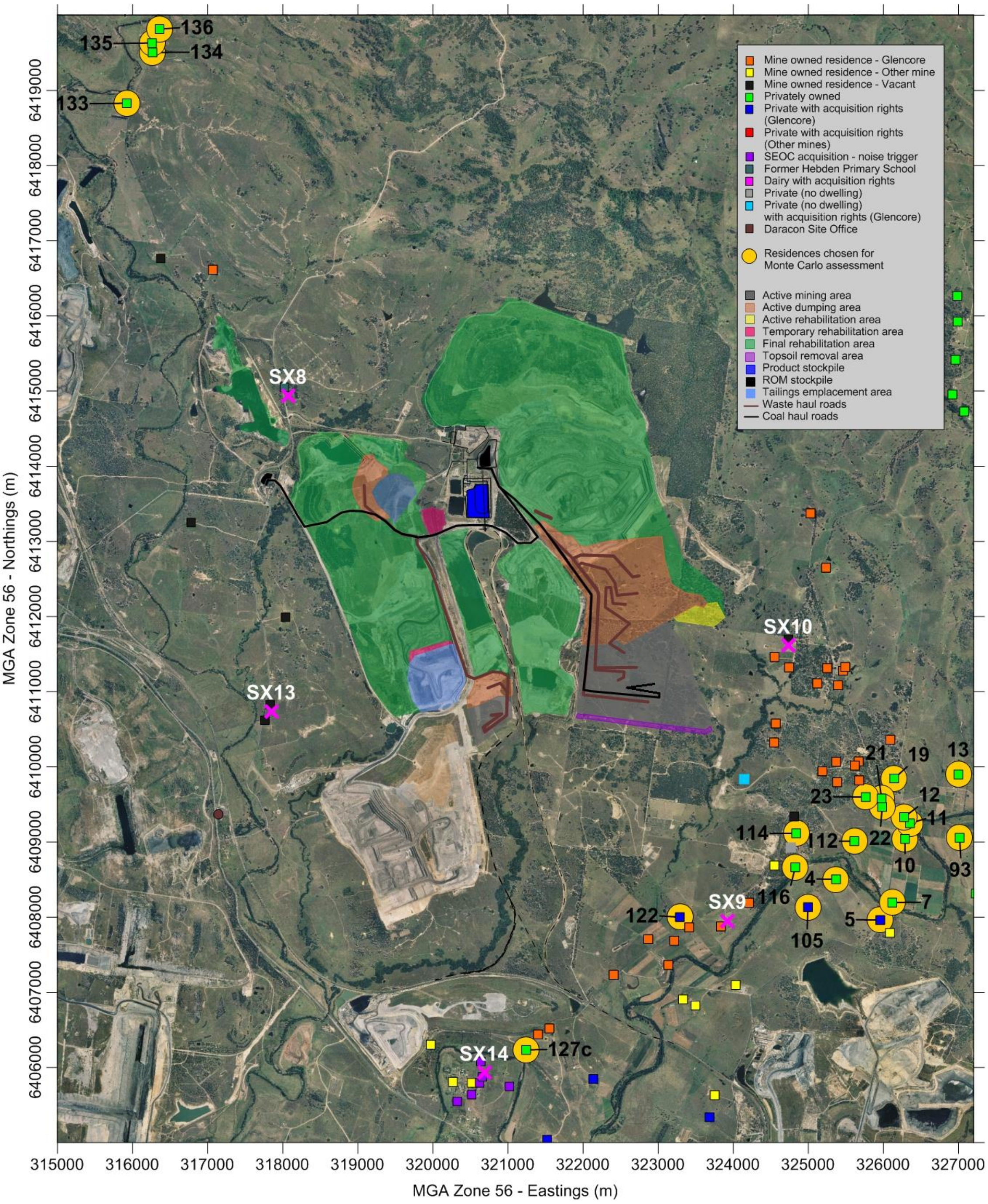


Figure 10.32: Selected Receptors for Monte Carlo Simulation

10.4.2 Monte Carlo Simulation

The Monte Carlo Simulation is a statistical approach that combines the frequency distribution of one data set (in this case, background 24-hour average PM concentrations) with the frequency distribution of another data set (modelled concentrations at a given receptor). This is achieved by randomly and repeatedly sampling and combining values within the two data sets to create a third, 'cumulative' data set and associated frequency distribution.

To generate greater confidence in the statistical robustness of the results, the Monte Carlo Simulation was repeated 250,000 times for each of the chosen receptors. In other words, the same 1-year set of predicted (modelled) 24-hour concentrations due to the Project at each receptor, were added to 250,000 variations of the randomly selected background concentrations (i.e a different random background concentration is selected each time). Under hot, dry and windy conditions, elevated monitoring levels may, in practice, have some correlation with elevated concentrations due to the Project (windblown dust in particular). It is acknowledged that this potential association is a limitation of the Monte Carlo analysis, however it is likely to be accounted for in the large number of repetitions undertaken to achieve the 'cumulative' data set. Notwithstanding this, the Monte Carlo approach has been accepted by the EPA for quantifying cumulative short-term concentrations from mining projects such as this one.

For the PM_{10} assessment, the closest TEOMs to each receptor were chosen as being the most representative for those receptor locations. TEOM SX9 was used for residences in Middle Falbrook, TEOM SX8 for residences to the northwest and TEOM SX14 for R127c. For the $PM_{2.5}$ assessment, the UHAQMN Camberwell data were used. It should also be noted that the residences to the northwest were assessed for the worst case year that relates to those locations, which is Year 1. The remaining residences were assessed for Year 10, the worst case modelling year for locations to the south and southeast.

The modelled Mount Owen 2011/2012[c] PM_{10} contributions at each of the TEOMs was subtracted from each TEOM observation on each corresponding day (i.e. modelled Mount Owen 2011/2012 contribution for 1 August 2011 was subtracted from TEOM concentration on 1 August 2011, etc.). The resultant data set is thus considered representative of 24-hour average PM_{10} concentrations associated with other sources of dust apart from Mount Owen operations, including other nearby mines.

Individual 24-hour predictions for the Project were then added to a random value from the above data set. This process is repeated thousands of times yielding the 'cumulative' data set, which is then presented as a frequency distribution.

The process assumes that a randomly selected background value would have a chance equal to that of any other background value from the data set of occurring on the given 'model day'. This is considered to be conservative as high concentrations from other mines are unlikely to occur at the same time as high concentrations at Mount Owen because of the location of the mines to the residences (e.g. at Camberwell and Middle Falbrook).

However, an analysis of the Monte Carlo method shows that over sufficient repetitions, this yields a good statistical estimate of the combined and independent effects of varying background and Project contributions to total PM_{10}.

In addition to this, contributions from operations such as Glendell and Rixs Creek will be present in the monitoring data for 2011/2012. These mines will cease operation in the later mining years of the Project and therefore their existing contribution to the monitoring data used as background is conservative.

[C] 2011/2012 refers to the meteorological data period used – August 2011 to September 2012.

The results of this PM_{10} analysis are presented graphically in **Figure 10.33** to **Figure 10.36**. The plots show the statistical probability of 24-hour average PM_{10} concentrations being above the EPA 24-hour average PM_{10} criterion of 50 µg/m³ and also compares the cumulative probability with the measured background (minus Mount Owen contribution in 2011/2012).

It is noted that the actual number of exceedances per year due to cumulative impacts cannot be predicted precisely and would depend on actual Project activities, other mining activities, weather conditions, implementation of real-time controls, and background levels in the future.

Figure 10.33 to **Figure 10.36** show that existing activities in the area already contribute to approximately 2 days per year where PM_{10} concentrations exceed 50 µg/m³ at SX8 and SX9, and 3 days per year at SX14.

Table 10.3 presents a summary of the number of days over relevant criteria for each of the selected receptors. There are no residences that are expected to exceed the DP&E acquisition criteria of 150 µg/m³. There are three privately owned residences without current acquisition rights (R4, R112 and R114), that may exceed the 24-hour average 50 µg/m³ criterion on more than 5 occasions per year.

As the cumulative results are created from random pairings of background and modelled concentrations, it is not possible to determine meteorological conditions on particular days of exceedance.

Table 10.3: Summary of days over 24-hour average PM_{10} criteria for Project only and cumulative scenarios

Receptor ID	Maximum predicted 24-hr average PM_{10} Concentration (Project only)	Predicted Days Over 50 µg/m³ (Project only)	Predicted Days Over 50 µg/m³ (Cumulative)	Predicted Days Over 150 µg/m³ (Cumulative)
Year 10 (worst case year for southeastern residences)				
R4	36	0	**8**	0
R5**	30	0	4	0
R7	34	0	5	0
R10	38	0	3	0
R11	42	0	3	0
R12	43	0	3	0
R13	26	0	2	0
R19	32	0	3	0
R21	47	0	3	0
R22	48	0	3	0
R23	51	1	3	0
R93	32	0	2	0
R105**	49	0	**10**	0
R112	31	0	**6**	0
R114	43	0	**12**	0
R116	50	0	**10**	0
R122*	29	0	**6**	0
127c	22	0	3	0
Year 5 (worst case year for northwestern residences)				
R133	38	0	4	0
R134	43	0	3	0
R135	42	0	3	0
R136	37	0	3	0

* Residences with current acquisition rights with Glencore.

** Residences with current acquisition rights with other mines.

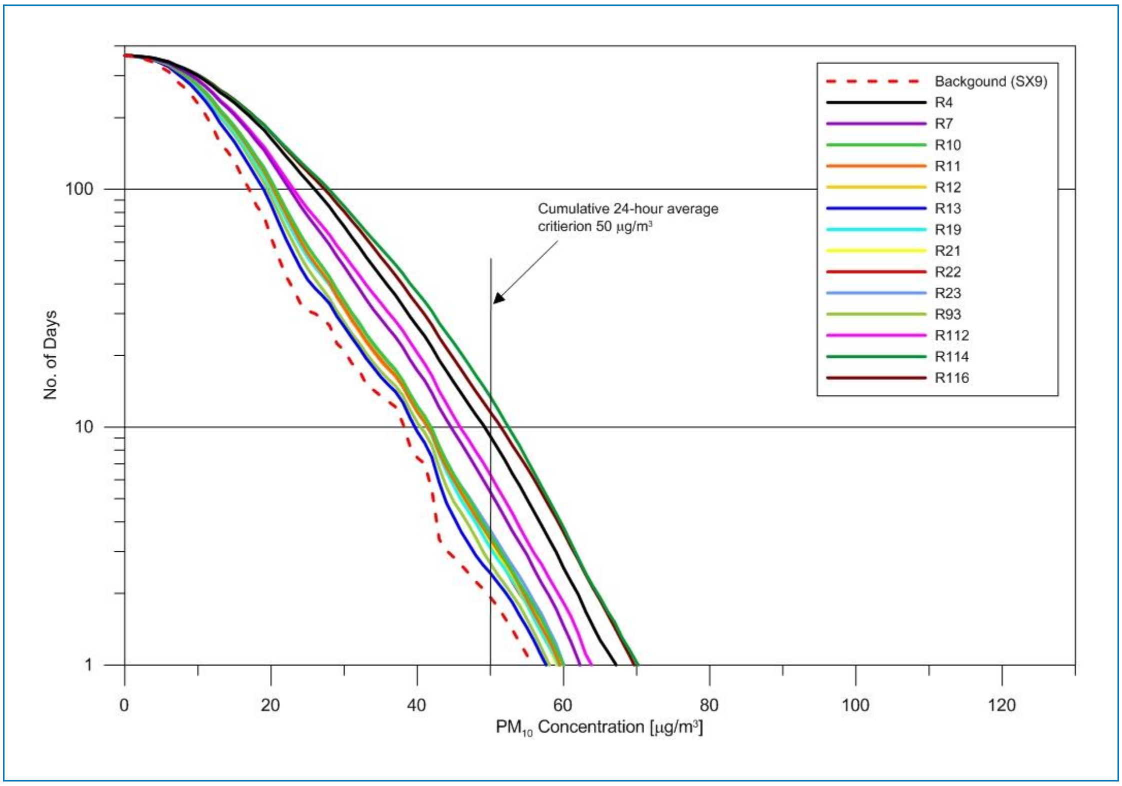


Figure 10.33: Statistical estimate of number of days exceeding 24 hour average PM_{10} average concentrations – Monte Carlo simulation for Middle Falbrook Private Residences (Year 10)

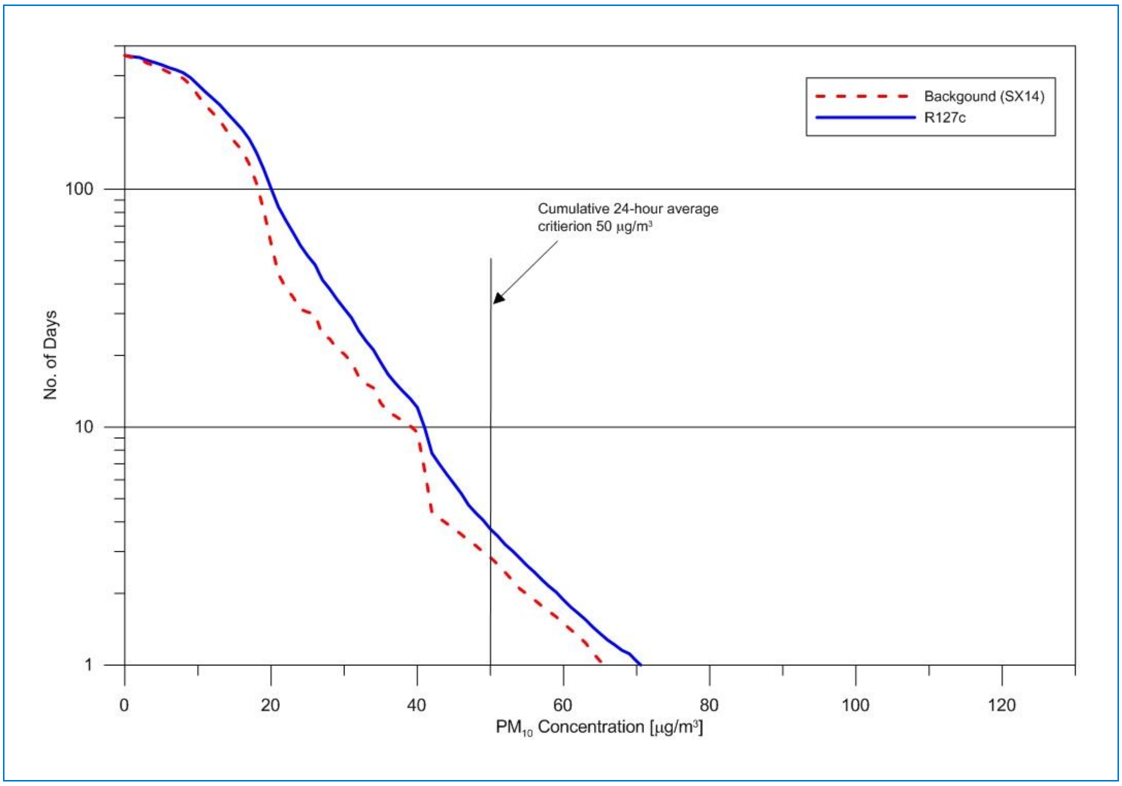


Figure 10.34: Statistical estimate of number of days exceeding 24 hour average PM_{10} average concentrations – Monte Carlo simulation for Residence 127c (Year 10)

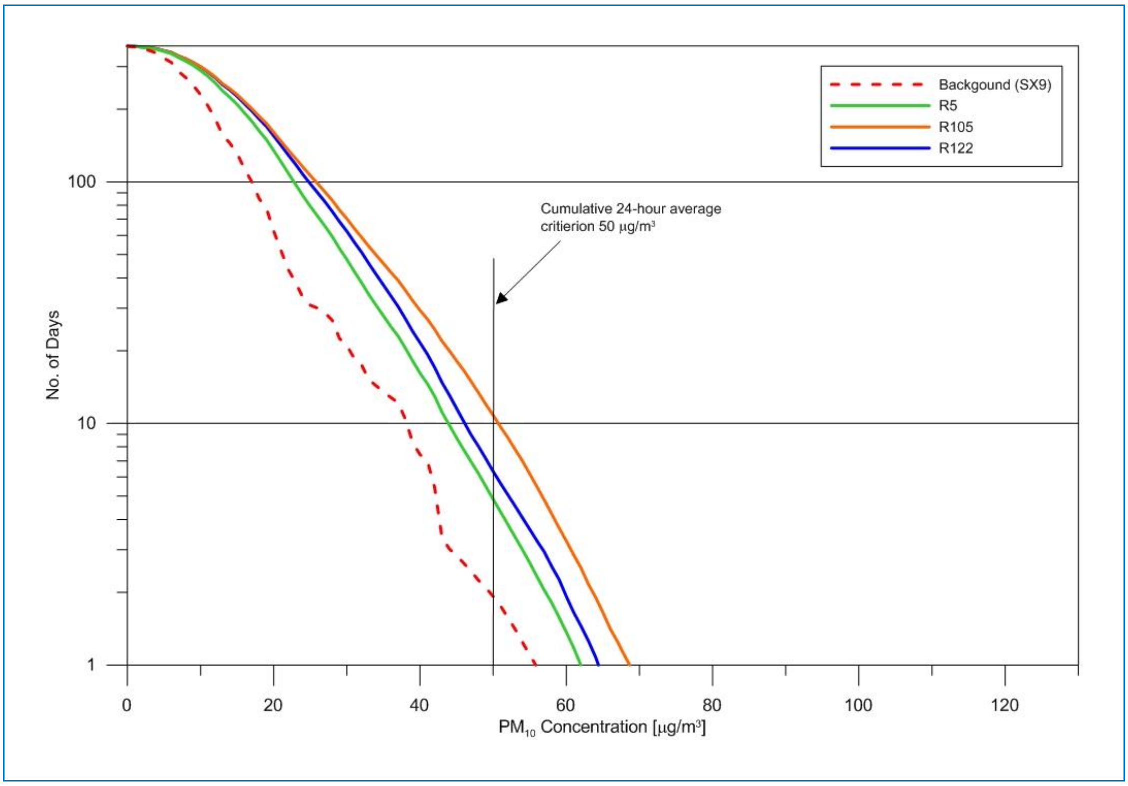


Figure 10.35: Statistical estimate of number of days exceeding 24 hour average PM_{10} average concentrations – Monte Carlo simulation for Residences Subject to Acquisition (Year 10)

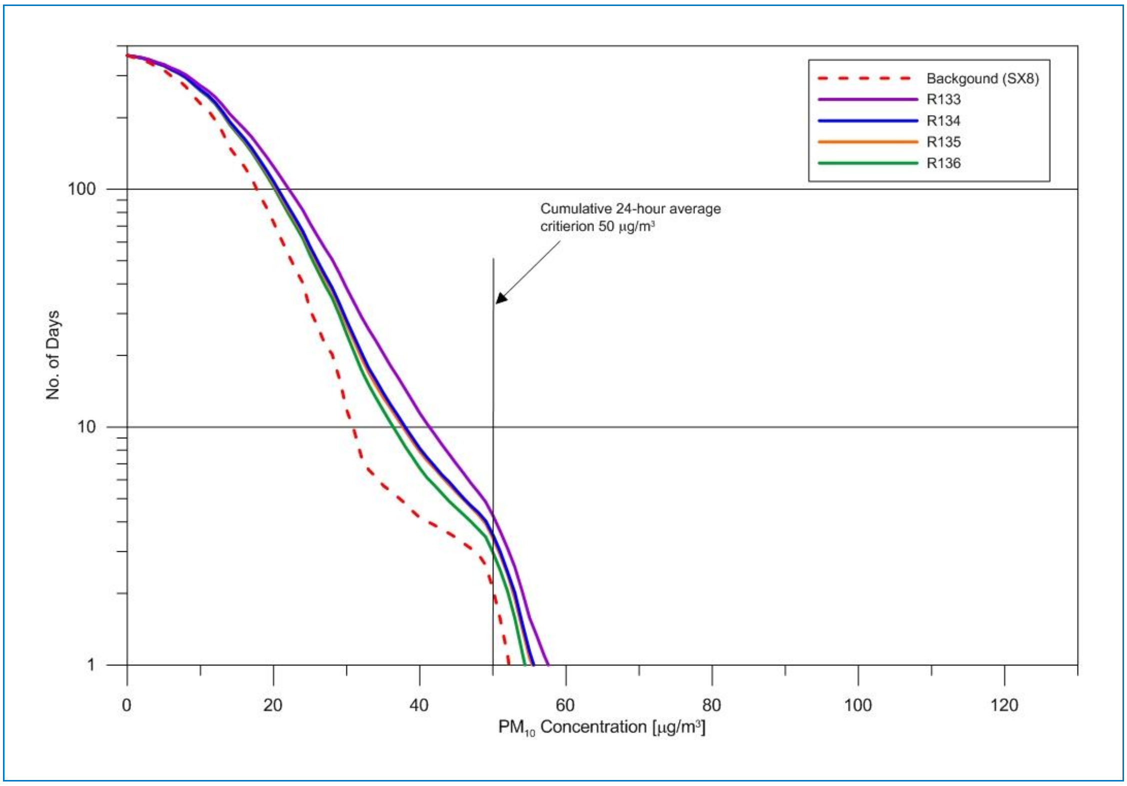


Figure 10.36: Statistical estimate of number of days exceeding 24 hour average PM_{10} average concentrations – Monte Carlo simulation for Residences to the Northwest (Year 5)

Figure 10.37 presents the results for the $PM_{2.5}$ Monte Carlo simulation for the nearest private residences in each direction. These results show that there are not predicted to be any exceedances of the 25 µg/m³ NEPM Advisory Reporting Standard for 24-hour average $PM_{2.5}$ concentrations, due to the Project.

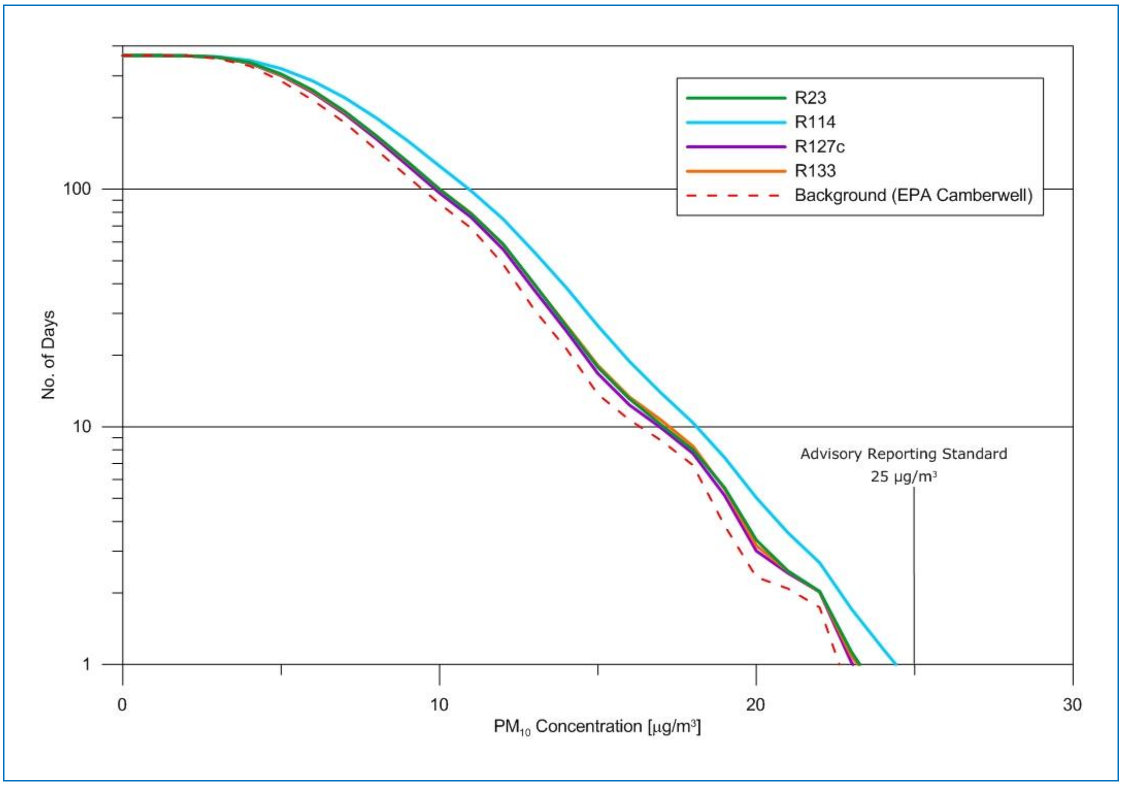


Figure 10.37: Statistical estimate of number of days exceeding 24 hour average $PM_{2.5}$ average concentrations – Monte Carlo simulation for Residences R23, R114, R127c and R133

11 NO_X ASSESSMENT

11.1 Conversion of NO_X to NO_2

To determine the NO_2 concentrations at the residences, the Approved Methods provides a number of approaches. For this assessment the Ozone Limiting Method (OLM) was used. The OLM assumes that at any given receptor location, the amount of NO that is converted to NO_2 by this reaction is proportional to the ambient O_3 concentration. If the O_3 concentration is less than the NO concentration, the amount of NO_2 formed by this reaction is limited. If the O_3 concentration is greater than or equal to the NO concentration, all the NO is assumed to be converted to NO_2. This is described by Equation 1 below.

Equation 1

$$NO_{2_{pred}} = \left[0.1 \times NO_{x_{pred}}\right] + MIN\left[\left(0.9 \times NO_{x_{pred}}\right)\ or\ \left(\left(\frac{46}{48}\right) \times O_{3_{bkgd}}\right)\right] + NO_{2_{bkgd}}$$

Where:

$[NO_2]_{pred}$ = predicted NO_2 concentration (µg/m^3)

$[NO_x]_{pred}$ = model predicted NO_x concentration (µg/m^3)

MIN = the minimum of the two quantities within the brackets

$[O_3]_{bkgd}$ = ambient O_3 concentration (µg/m^3)

(46/48) = molecular weight of NO_2 divided by the molecular weight of O_3

$[NO_2]_{bkgd}$ = background concentration of NO_2 (µg/m^3)

In the equation above, the predicted NO_x concentration is multiplied by 10 percent to account for the assumed thermal conversion of NO_x to NO_2. The remaining 90 percent of the modelled NO_x (assumed to be NO) is limited by the background O_3 concentration in determining the quantity of NO that is converted to NO_2. The background concentration of NO_2 is then added to this concentration to give the total predicted NO_2 value.

It is important to note that O_3 only forms when there are sufficient concentrations of NO and volatile organic compounds (VOCs), adequate sunlight, and high enough temperatures to allow the photochemical reactions to occur. Elevated O_3 concentrations occur when dispersion of the resulting pollution is constrained by meteorological conditions and local topography. There are no O_3 monitoring data collected near the Project area, and whilst the EPA data collected in the Sydney and Illawarra regions do sometimes exceed the relevant air quality standards, in the Lower Hunter there were only three exceedances of the 1-hour O_3 standard between 1999 – 2012 (**EPA, 2012**). These included one exceedance at each of the three monitoring sites.

NO_2 is primarily a result of fuel combustion (i.e. motor vehicles and industry). There are no NO_2 monitoring data collected near the Project Area and whilst exceedances of the 1-hour NO_2 standard were common in Sydney during the 1980's, they have not been exceeded there since 1988 and levels in the Illawarra and Lower Hunter are even lower (**EPA, 2012**). It would be expected that levels near the Project Area would be significantly below the standard.

The closest EPA monitoring station that collects NO_2 is Singleton, however, the station does not collect O_3 data, and only started operating in November 2011. As both NO_2 and O_3 data are required, hourly data from the Wallsend EPA station were used.

11.2 Blast Fume

To estimate the potential NO_2 concentration at the nearby residences due to blast fume, CALPUFF dispersion modelling was completed for where blasting may occur in Year 10. This year was selected as the mine activities are closest to residences.

Two representative private residences, R114 and R116, and two mine owned residences closest to the Project Area, R30 and R31, boundary were selected as shown in **Figure 11.1** as yellow circles.

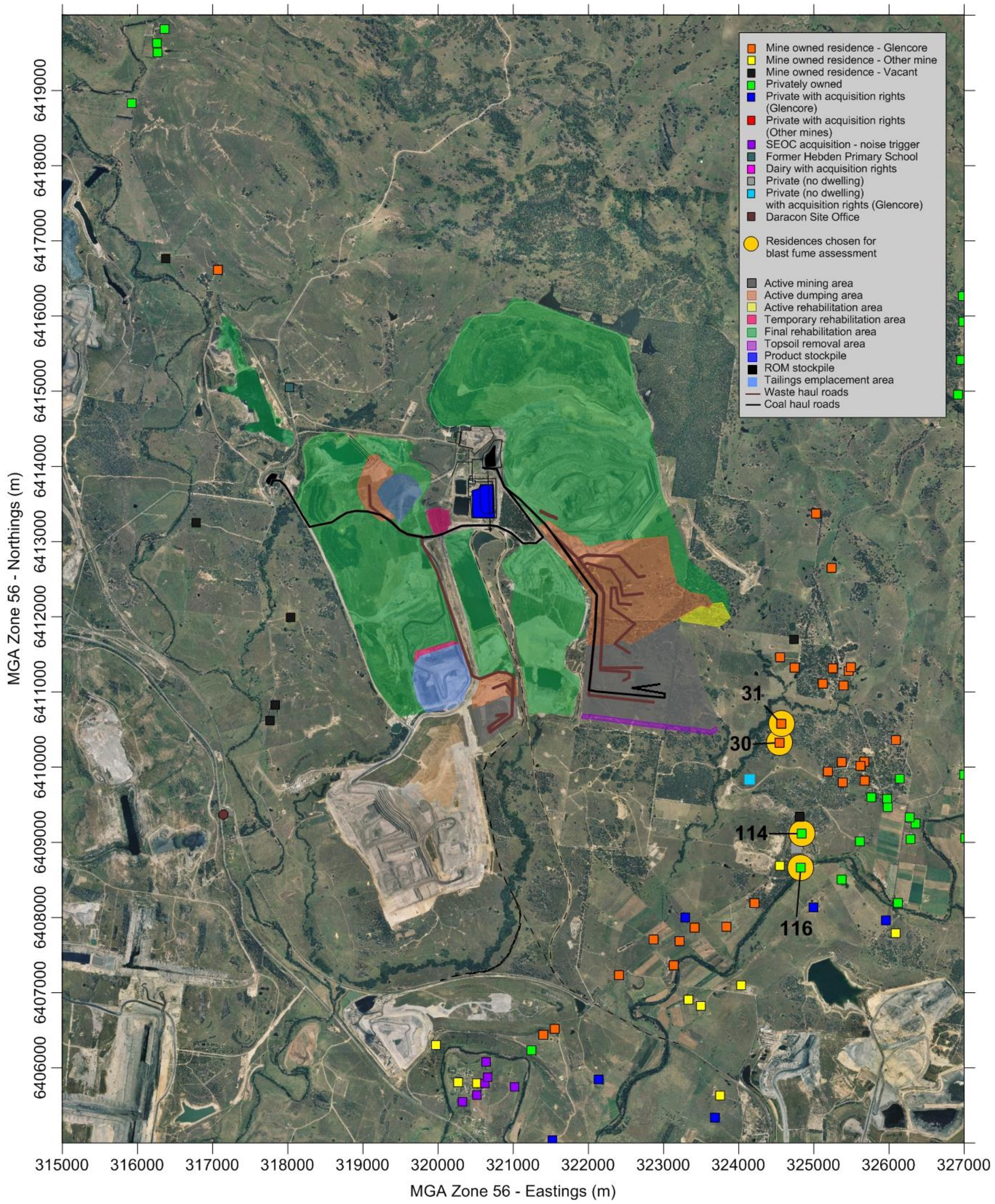


Figure 11.1: Location of residences assessed for blast fume

Table 11.1 presents the number of hours the 1-hour average NO_2 concentrations at the selected residences that are predicted to be between the listed concentration ranges during Year 10 of the Project. These are the nearest residences and concentrations would be lower at those further away.

A summary of the number of hours predicted to exceed the 1-hour average NO_2 impact assessment criteria of 246 µg/m³ due to blasting is presented in **Table 11.2.**

It is apparent from **Table 11.1** and **Table 11.2** that the vast majority of predicted concentrations are significantly below the impact assessment criteria. There are a maximum of 12 hours in a year (from a possible 2,944[d] available blasting hours) when the 1-hour average criterion is predicted to be exceeded at a privately owned residence.

As discussed in **Section 9.1**, the approach taken to assess the impacts is considered to be conservative due to a number of assumptions, including:

- that every blast has a Rating 3 Fume Category (no Rating 3 blasts have been recorded at Mount Owen since the capture of this information began in 2012), and
- that the background NO_2 and O_3 levels in the immediate vicinity of the blast are the same as Wallsend. This has a direct impact on the predicted conversion rate from NO to NO_2.

Table 11.1: Number of hours that 1-hour average NO_2 concentrations are predicted to occur due to blasting operations during Year 10

1-hour average NO_2 concentration range (µg/m³)	No. of hours 1-hour average NO_2 concentration predicted to occur			
	Mine Owned		Privately Owned	
	R30	**R31**	**R114**	**R116**
0-19	7610	7918	7817	8133
20-39	214	162	454	356
40-59	258	185	280	152
60-79	283	211	122	78
80-99	226	155	59	35
100-119	128	93	20	10
120-139	35	41	13	7
140-159	4	10	1	1
160-179	6	2	3	1
180-199	6	1	1	0
200-219	5	3	0	1
220-246	1	0	2	0
>246	**8**	**3**	**12**	**10**

Table 11.2: Summary of number of hours the 1-hour average NO_2 concentrations predicted to exceed impact assessment criteria during Year 10

Receptor ID	Number of hours predicted to exceed the 1-hour NO_2 assessment criteria of 246 µg/m³
Private residences	
R114	12
R116	10
Glencore owned residences	
R30	8
R31	3

[d] Note that even though there are only a maximum of 2,944 blasting hours, there are some values in **Table 11.1** that exceed this number of hours. This is due to the background NO_2 levels that are present in the atmosphere regardless of whether blasting occurs.

A review of the meteorological conditions when these exceedances were predicted to occur was completed. This analysis showed that all theoretical exceedances occurred when there was a rapid drop in the mixing height and the atmosphere become more stable, resulting in poor dispersion conditions. These conditions generally occur in the early morning and late afternoon, but do not occur on every day of the year.

The exceedances are predicted to occur under a specific set of meteorological conditions, that is, light winds from the northwestern quadrant and low mixing heights, combined with increasing atmospheric stability. **Table 11.3** summarises the meteorological conditions for each of these four residences under which each exceedance is predicted. It should be noted that a turbulence based scheme within CALPUFF was used in the modelling and therefore the P-G stability class frequency is shown for information only. Whilst classes A (unstable) and F (stable) are closely associated with clear skies, class D can be linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is low.

Adverse meteorological conditions for blast fume dispersion are clearly defined, occurring in the cooler months, when winds are light and from the north western quadrant in combination with a rapid drop in mixing height. The Blast Management Plan will include measures to halt blasting activity during these relatively rare occasions.

Table 11.3: Meteorological conditions under which NO_2 exceedances are predicted to occur

Wind Speed (m/s)	Wind direction	Temperature (Celcius)	Pasquill-Gifford Stability Class	Mixing Height (m)
R30				
1.4	NW	8	C	190
2.6	WNW	22	D	103
1.0	WNW	9	D	50
3.0	WNW	18	D	152
2.2	WNW	15	D	54
1.0	WNW	8	C	50
0.8	WNW	7	D	50
0.8	W	7	D	130
R31				
1.0	WNW	9	D	50
0.8	WNW	9	D	138
1.0	WNW	8	C	50
R114				
0.9	NNW	19	C	50
2.2	NW	27	D	301
1.7	NW	5	C	151
1.5	WNW	5	C	50
1.5	NW	8	C	160
0.8	WNW	10	D	50
0.6	NW	11	D	151
3.0	NW	21	D	170
2.1	NW	10	D	109
0.8	N	18	C	118
1.8	WNW	7	D	51
1.4	NW	9	D	50
R116				
2.7	NW	5	D	136
0.7	NW	22	C	50
1.0	NNE	20	F	50
1.9	NW	2	D	50
3.1	NW	4	D	166
3.2	NW	3	D	181
2.8	NW	9	D	144
2.8	NW	11	D	194
0.8	N	18	C	118
1.4	NW	9	D	50

Again, it should be noted that these are conservative estimates, with worst case blasts occurring under worst case meteorological conditions, and are very unlikely in reality as they can be easily managed.

As presented in **Section 13.3**, management measures will continue to be implemented firstly to minimise the potential for the formation of NO_x emissions, and secondly to limit blasting activity under the conditions predicted to cause exceedances of the assessment criterion.

With regard to minimising the potential for NO_x emissions, a sensitivity analysis has been carried out on the different blast category ratings experienced at the Mount Owen Mine in the last 12 months.

From 1 July 2012, the DP&E requested the commencement of the rating and reporting of post blast fume, to gain a greater understanding of the levels generated in the Hunter Valley. This requires mining operators to provide detailed information on the total number of shots and the number of shots for each category rating (0 – 5). The two years of blast rating data for the Mount Owen Mine (including North Pit and West Pit) from July 2012 to June 2014, are summarised in **Table 11.4**, and show that the vast majority of blasts at Mount Owen were categorised as Rating 0 for fume, with no blasts recorded as Rating 3 or above. The above assessment is therefore highly conservative.

Table 11.4: Number and rating of blasts at Mount Owen from July 2012 to June 2014

Rating	Number of Blasts	Percentage
0	147	77%
1	36	19%
2	9	5%
3	0	0%
4	0	0%
5	0	0%
Total Blasts	192	-

Further analysis of NO_2 emissions from blasting was done for Ratings 0, 1 and 2[e]. The results are summarised in **Table 11.5**, and show that there is theoretically potential for exceedances at private residence R114 for each blast category rating. However, as discussed previously, these are predicted to happen under specific meteorological conditions under which blasting would not occur.

Table 11.5: Summary of number of hours the 1-hour average NO_2 concentrations predicted to exceed 246 µg/m³ for different rating categories in Year 10

Receptor ID	Rating 2	Rating 1	Rating 0
Private residences			
R114	9	3	0
R116	2	0	0
Glencore owned residences			
R30	4	1	0
R31	2	2	2

These results must be considered in the context of existing and continuing blast management procedures, which dictate the meteorological conditions under which blasting may and may not occur. If these conditions were excluded from the modelling then there would be no predicted exceedances of the criterion. To manage these theoretical exceedances, as outlined in **Section 13.3**, Mount Owen will halt blasting activity during the adverse weather conditions identified here, that is, light winds from the north western quadrant and low mixing heights combined with increasing stability. Accordingly, no exceedances of the criterion are anticipated due to blasting.

[e] The NO_2 plume concentration used for the rating 3 fume category was 70 ppm, based on the Queensland Guidance Note as discussed in Section 9.1. This is reduced to 17 ppm, 7 ppm and 4 ppm for rating 2, 1 and 0 categories, respectively.

It should also be noted that a recent report published by ACARP(Australian Coal Association Research Program) measured NO_2 concentrations in the ambient air near the boundary of a large open-cut coal mine in the Hunter Valley between April 2011 and October 2012 (**Day et. al. 2013**). The report concluded that most of the NO_2 present in ambient air at the monitoring locations was likely to be derived from sources other than blasting. These sources may include vehicle operation within the mine as well as other significant sources from outside the mine such as power stations, traffic on nearby roads, and railways.

11.3 Diesel Fume

Using the emission estimates and source details outlined in **Section 9.2**, CALPUFF was used to predict the impacts of diesel emissions at selected sensitive receptors (the locations of the selected receptors are shown in **Figure 11.2**).

The predicted NO_2 concentrations were calculated from the NO_x concentrations using the OLM method described in **Section 11.1**. The same background O_3 concentrations from the EPA Wallsend site were used, but the background NO_2 concentrations were excluded to enable determination of the contribution from the diesel fumes alone.

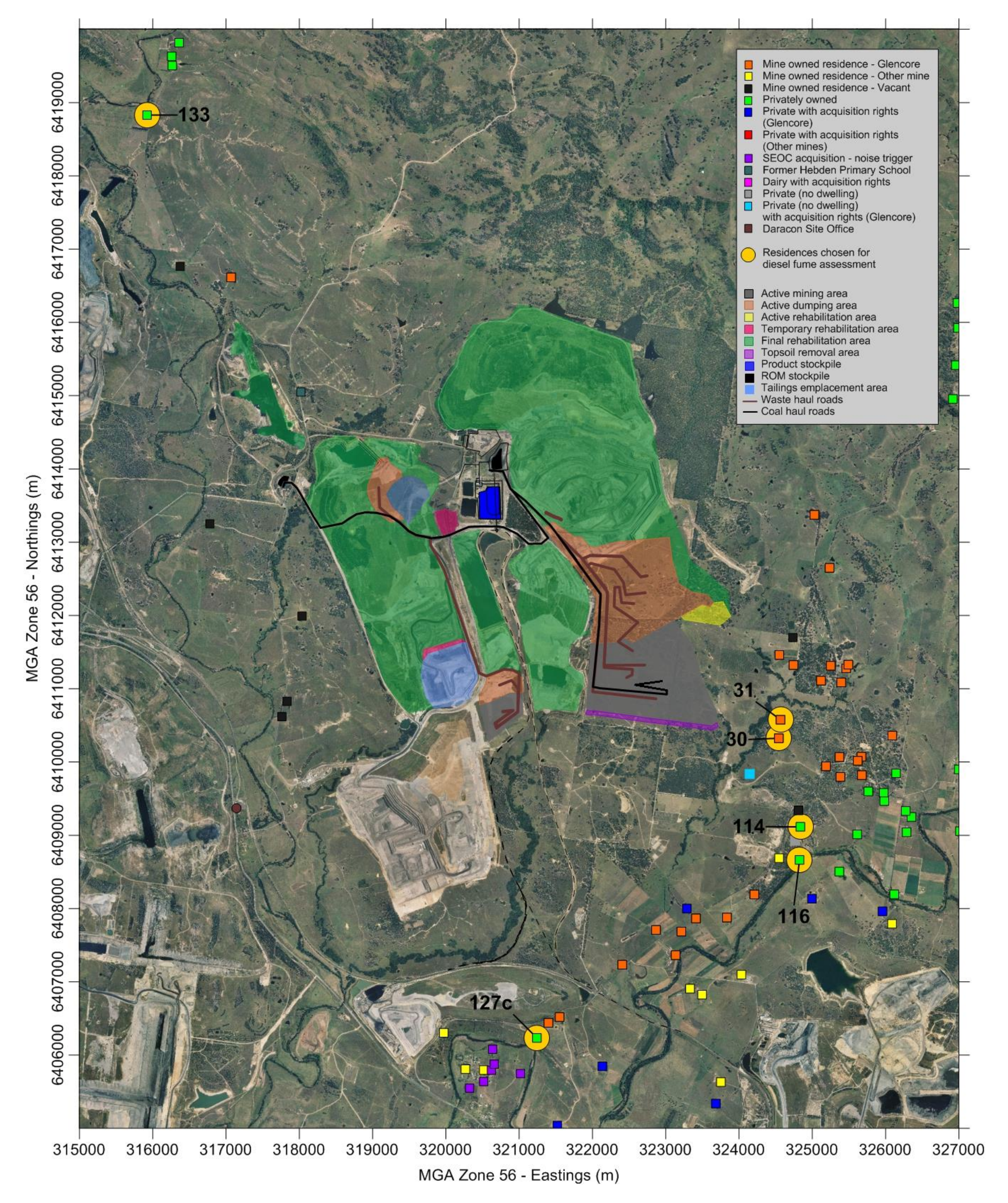


Figure 11.2: Location of residences assessed for diesel fumes

Table 11.6 presents the results of the dispersion modelling for each pollutant at the selected receptors for the Project alone. This shows that that the predicted impacts for all pollutants at all receptors are below their respective assessment criteria, with the exception of mine-owned residences R30 and R31 which may exceed the 1-hour average NO_2 criterion. **Figure 11.3** and **Figure 11.4** present the time series of these predictions at R30 and R31, respectively, and show that the criterion is exceeded once at R30 and twice at R31.

Predictions of CO and SO_2 are well below their respective criteria and are not considered further in this assessment.

Table 11.6: Predicted NO_2, SO_2 and CO concentrations due to diesel fumes on-site (Year 10)

Receptor ID	Maximum 1-hour average NO_2 (µg/m³)	Maximum 1-hour average CO (µg/m³)	Maximum 1-hour average SO_2 (µg/m³)
	Impact assessment criteria		
	246 µg/m³	*30 mg/m³*	*570 µg/m³*
Private			
114	161	0.53	0.79
116	151	0.95	1.42
127c	102	0.30	0.44
133	96	0.23	0.35
Mine Owned			
30	**252**	0.91	1.36
31	**295**	1.08	1.61

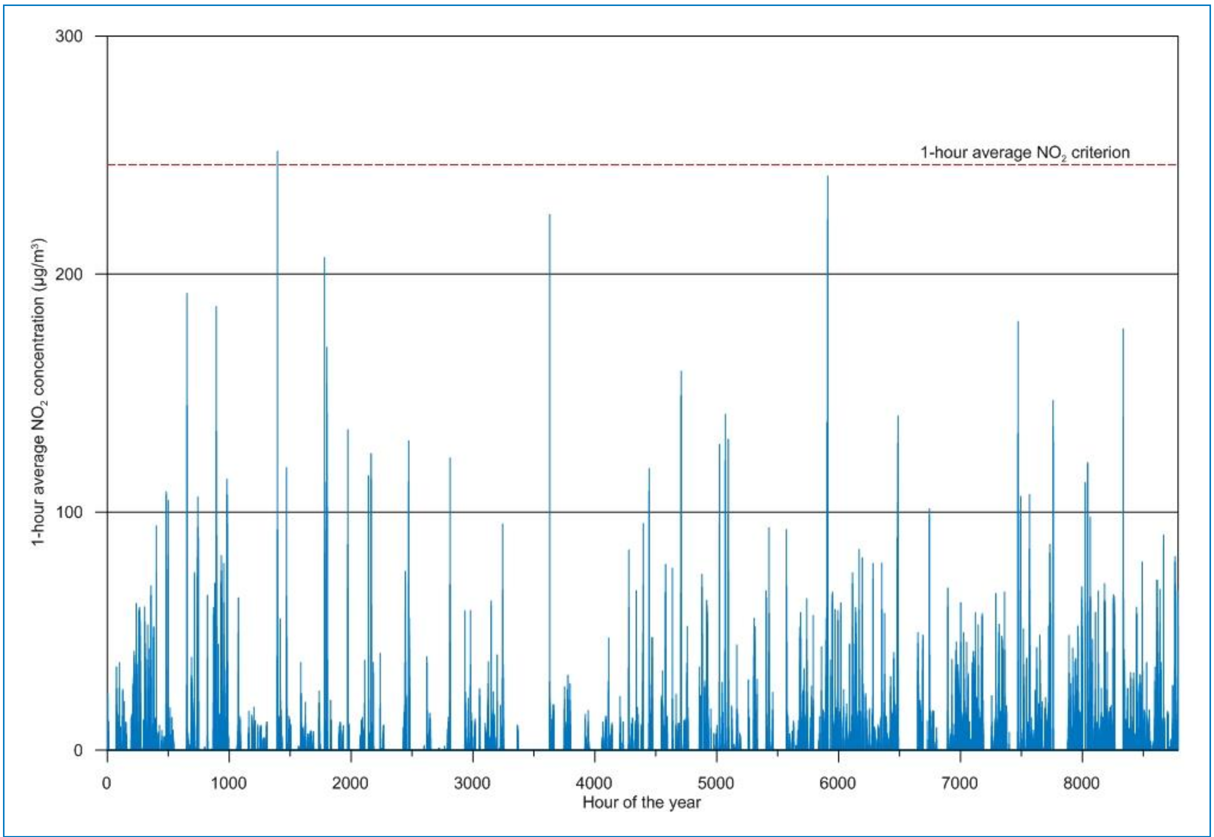


Figure 11.3: Predicted 1-hour average NO_2 concentrations due to diesel fumes – R30

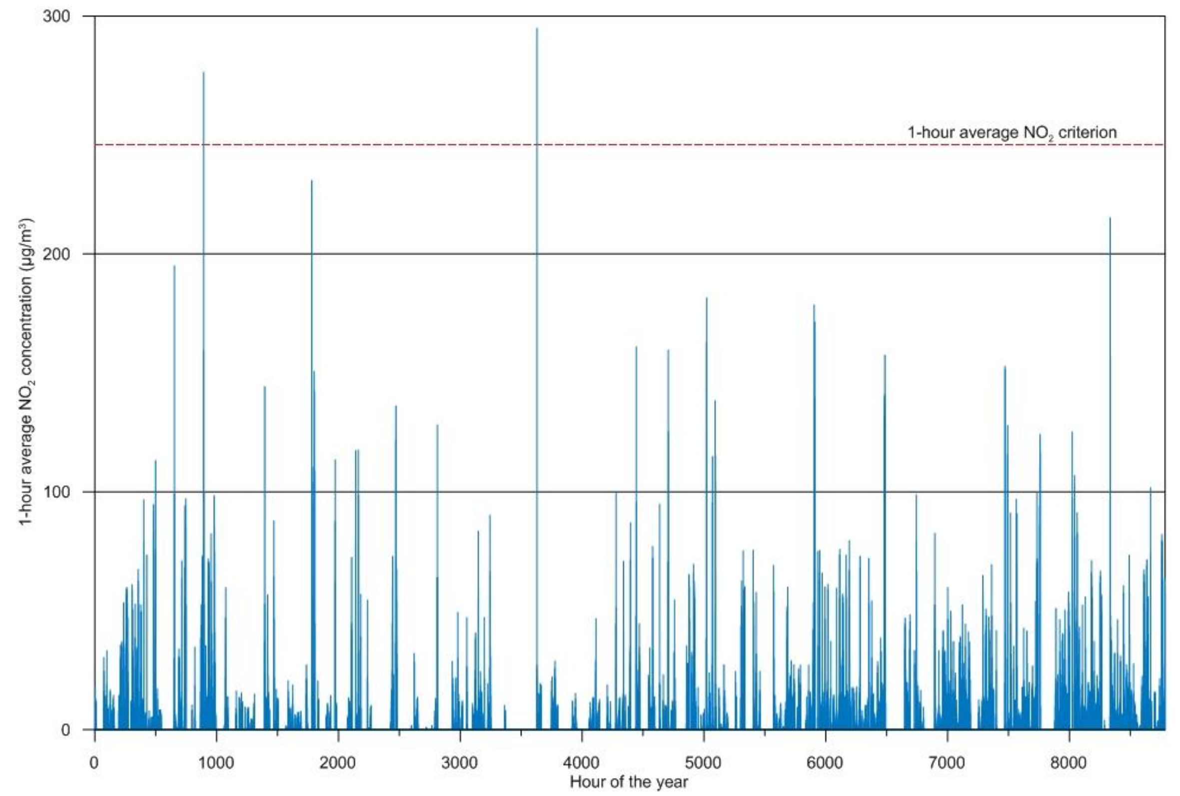


Figure 11.4: Predicted 1-hour average NO_2 concentrations due to diesel fumes – R31

11.4 Cumulative NO_2 Assessment

A cumulative assessment of NO_2 at the four nearest residences due to blast fume, diesel emissions and background concentrations was completed. The results are presented in **Table 11.7**, showing the number of hours that 1-hour average NO_2 concentrations are predicted to occur. Adding background to diesel and blasting may cause additional exceedances at the privately owned residence R114. **Figure 11.5** to **Figure 11.8** show histograms of this distribution in graphical form. It should be noted that this is highly conservative as the conservatism in both the blast and diesel assessments is compounded.

Table 11.7: Number of hours 1-hour average NO_2 concentrations predicted to occur due to blasting and diesel fumes during Year 10 (including background NO_2)

1-hour average NO_2 concentration range (µg/m³)	No. of hours 1-hour average NO_2 concentration predicted to occur			
	Mine Owned		Privately Owned	
	R30	R31	R114	R116
0-19	3962	4073	4312	4484
20-39	2506	2733	2277	2351
40-59	912	860	1138	1147
60-79	470	406	603	511
80-99	379	282	268	179
100-119	299	231	106	62
120-139	136	92	37	20
140-159	63	53	15	10
160-179	16	28	6	3
180-199	8	10	3	4
200-219	5	5	2	1
220-246	10	5	3	2
>246	**18**	**6**	**14**	**10**

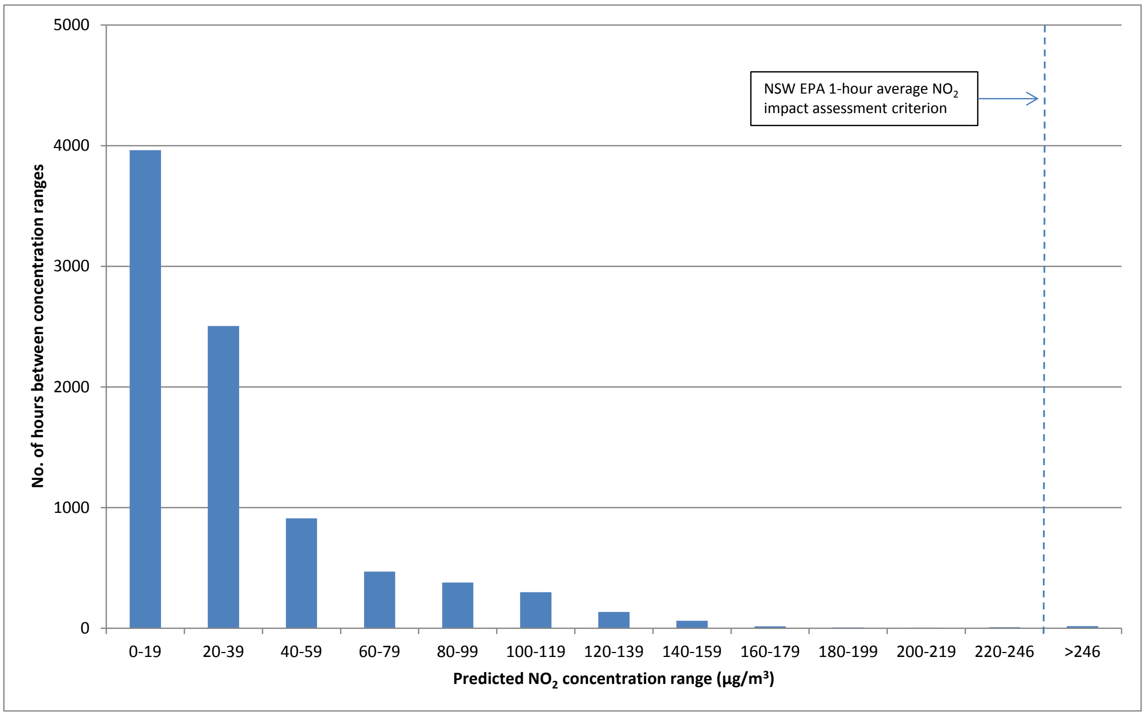


Figure 11.5: Cumulative 1-hour average NO_2 concentrations due to blasting and diesel fumes (including background) – R30

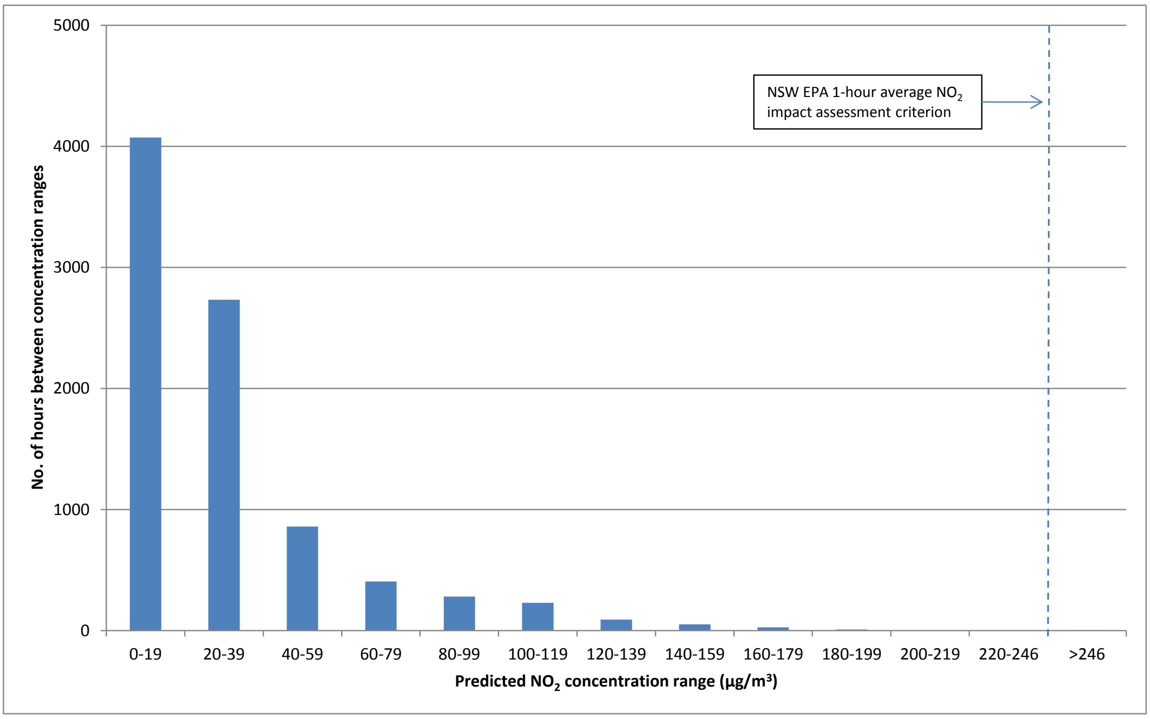


Figure 11.6: Cumulative 1-hour average NO_2 concentrations due to blasting and diesel fumes (including background) – R31

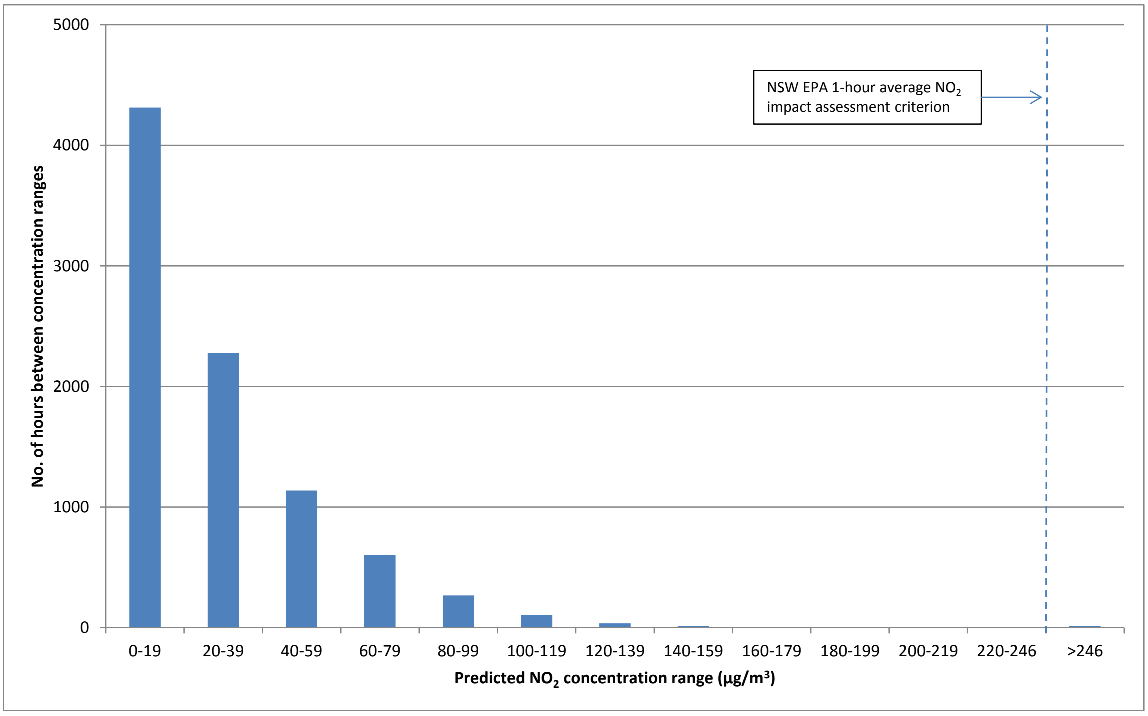


Figure 11.7: Cumulative 1-hour average NO_2 concentrations due to blasting and diesel fumes (including background) – R114

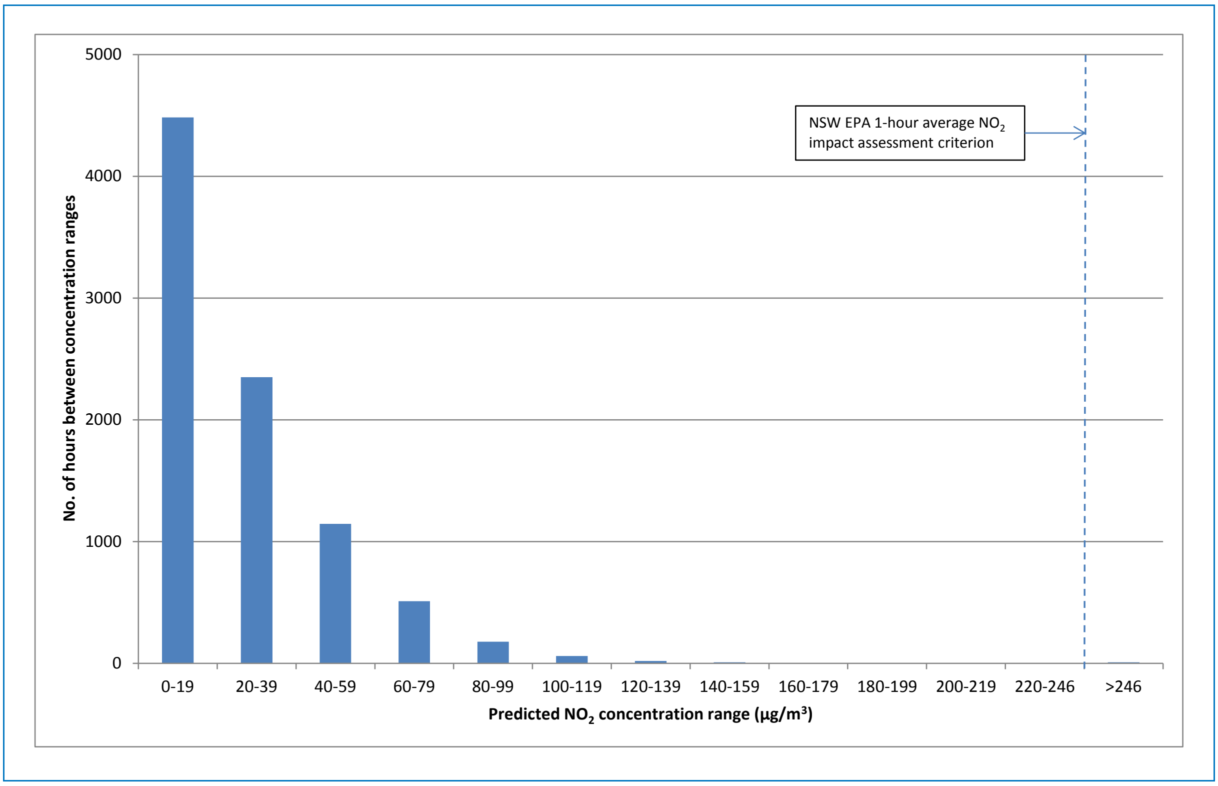


Figure 11.8: Cumulative 1-hour average NO_2 concentrations due to blasting and diesel fumes (including background) – R116

12 SPONTANEOUS COMBUSTION

Spontaneous combustion occurs when coal and other carbonaceous materials undergo natural oxidation and generate heat. Under the right conditions heat from the oxidation reaction can build-up to a point where the coal and contaminated overburden materials will ignite and burn. For self-heating to occur, the composition of the coal must be such that low temperature oxidation can occur. Further, the material must be confined in such a way that heat from the oxidation is trapped, allowing the temperature to build-up, but not so confined as to preclude the ingress of oxygen to the combustible material at a rate sufficient to promote the combustion and release of heat energy.

Once the coal reaches a high enough temperature it will liberate smoke (fine particulate matter), steam and volatile organic compounds (VOCs), some of which are odorous and some of which can be harmful in high concentrations.

The history of mining at Mount Owen Mine indicates a very low propensity for spontaneous combustion to occur within coal reject and overburden emplacement areas. However, the issue of spontaneous combustion and the potential liability for mine closure will continue to be evaluated and managed (if required) as part of the Project. This will involve the inclusion of testing for areas prone to spontaneous combustion within the routine geochemical sampling and testing program.

Material that is potentially susceptible will be placed at a suitable depth to minimise any potential interference to rehabilitation establishment as well as minimise the potential for spontaneous combustion or ignition of carbonaceous material in the event of bushfires in the revegetated areas. Measures to minimise oxygen exposure pathways to potentially susceptible material will include the following:

- Capping of tailings emplacement areas
- Co-disposal of coarse reject material with overburden and incorporated at a suitable depth into the final landform
- Selectively handling and burying at depth, overburden material that is identified as being prone to spontaneous combustion to prevent exposure of this material.

Further mitigation measures are discussed in **Section 13.5**.

13 MANAGEMENT, MITIGATION AND MONITORING

13.1 Current Arrangements for Mine-owned Properties

Existing tenants of Mount Owen-owned dwellings are alerted to mining related activities and possible impacts, including air quality, as part of the tenancy application process to help inform their decision to occupy the residence. Further, tenants are provided with a copy of the NSW Public Health Unit's 'Mine Dust and You' fact sheet prior to entering into a tenancy agreement. At any time during a tenancy, tenants can make a written request to Mount Owen if they believe that mining related impacts are unacceptable. If Mount Owen cannot resolve the issue with the tenants, they have the option of terminating their tenancy without penalty.

The modelled air quality predictions for the Project will be reviewed by Mount Owen to determine the suitability of mine-owned dwellings for habitation during certain periods of the mine life. Should the Project be approved, where mine-owned dwellings are currently tenanted and a tenant chooses to vacate the property based on the modelled air quality predictions for the Project, they will be permitted to do so without penalty. Mount Owen may also determine that certain properties are unsuitable for habitation for certain periods, which may necessitate Mount Owen to request a tenant to vacate a dwelling. This would be undertaken in accordance with the conditions of the tenancy agreement.

Existing and prospective tenants are able to access monthly environmental monitoring results, including air quality monitoring, from Mount Owen's environmental monitoring network. Results are available on Mount Owen's website, *www.mtowencomplex.com.au*.

This assessment predicts that a total of 10 currently tenanted Glencore-owned[f] dwellings will be affected by air quality levels that exceed relevant impact assessment criteria at some point during the mine life. The following sections relate to specific areas of management, mitigation and monitoring that will form part of the approved Project.

13.2 Particulate Emissions

Section 6.4 outlines the recent history behind the introduction of the Dust Stop: Pollution Reduction Program for NSW coal mines. This was one of the actions included in NSW 2021 for the Upper Hunter Region (**Section 4.7**), to "require and support NSW coal mines to reduce dust emissions." Outcomes of the Best Management Practice Review for current Mount Owen and Ravensworth East operations are discussed in **Section 7.2**, which also lists the mitigation measures identified for the proposed operations. These measures are considered the best and most practical for Mount Owen and Ravensworth East. Those identified in the BMP Review for implementation in 2012/2013 and which will be part of continued operations, are summarised in **Table 13.1**.

[f] Ten owned by Glencore and eight owned by other mines

Table 13.1: Measures currently being implemented and to be taken up for the Project

Source	Additional Measure
Wheel generated dust on unpaved haul roads	Continue to establish visual triggers and associated actions for wheel generated dust from unpaved haul roads and incorporate these within operational procedures and undertake operator training.
	Continue to establish and implement an objective measurement method to demonstrate road dust control efficiency and target an overall dust control efficiency of 85%, demonstrated through the use of objective measurement. This is over and above the target of 80% set by the EPA in their current Pollution Reduction Program attached to the Mount Owen EPL. Results from the monitoring program to date suggest that this is achievable.
	Continued implementation of PRP to monitor and manage dust generation. As noted above, results from the monitoring program indicate that current practices are achieving more than the required 80% control efficiency.
Bulldozer Operations	Continue to establish suitable visual triggers and associated actions for bulldozer operations at exposed locations and incorporate these within operational procedures and undertake operator training.
	Modify bulldozing operations at exposed locations to reduce the potential for dust impacts, in accordance with the Mount Owen Air Quality and Greenhouse Gas Management Plan (AQGHGMP).
Overburden Loading and Dumping	Continue to establish suitable visual triggers and associated actions for overburden loading and dumping operations and incorporate these within operational procedures and undertake operator training.
	Modify overburden loading and dumping operations to reduce the potential for dust impacts, in accordance with the Mount Owen AQGHGMP.
Loading Coal to Trucks	Establish suitable visual triggers and associated actions for loading coal to trucks and incorporate these within operational procedures and undertake operator training.
	Modify coal loading operations to reduce the potential for dust impacts, in accordance with the Mount Owen AQGHGMP.
Wind Erosion of Overburden Emplacement and Exposed Areas	Temporarily treat disturbed areas if prompt rehabilitation is not feasible, for example on some topsoil stockpiles.
Across varying source types including bulldozing, overburden loading and dumping, haulage on unsealed roads and loading coal to trucks.	Continue the use of the Mount Owen reactive/predictive air quality control system to inform operational dust management by undertaking the following: - Extend the real-time PM_{10} and meteorological monitoring system to integrate short-term triggers and alarms. - Develop a procedure linking triggers with associated actions. - Document within the procedure the use of dust risk forecast information for proactive dust management planning - Make provision for recording actions taken in response to alarms

As part of the ongoing management of these Best Practice measures, long-term monitoring is required to ensure that any reductions in emissions are maintained over the lifetime of the Project, and will enable Mount Owen to check that progress is being made towards environmental targets. Future monitoring is discussed in **Section 13.6**.

13.3 Blast Fume

Fumes from blasting are managed, and will continue to be managed, in accordance with Code of Good Practice: Prevention and Management of Blast Generated NO_x Gases in Surface Blasting (**Australian Explosives Industry and Safety Group Inc., 2011**). Measures that are currently implemented on-site, are detailed in the Mount Owen Blast Management Plan (**Xstrata, 2012**). In summary they include measures to:

- restrict blasting to between 9am and 5pm (EST) (9am and 6pm (EST)) Monday to Saturday and between 7am and 9am on 12 occasions per year (as per approval conditions), when winds are not blowing from the north-northwest,
- restrict blast frequency to two blasts per day,
- assess meteorological conditions such as wind speed and direction immediately prior to each blast to identify the blast exclusion arc,
- restrict blasting to suitable atmospheric and meteorological conditions,
- advise nearby private landholders of blasting times, and
- document and video record each blast to determine fume generation for a minimum of 1-minute duration while following the blast until the fume has dissipated.

Although theoretically there is potential for NO_2 from blast fumes to exceed the 1-hour average criterion under certain meteorological conditions, blasts will continue to be designed not to cause exceedances.

13.4 Diesel Fume

As described in **Section 4.9**, Mount Owen currently holds EPL 4460 issued by the EPA under the POEO Act. The *NSW POEO (Clean Air) Regulation 2010* prescribes requirements for motor vehicle emissions, which will be the main source of diesel fumes for this project. Plant equipment and motor vehicles will be maintained and operated in a proper and efficient condition.

Haul roads will also be constructed to ensure the most direct routes are taken from the pit to emplacement areas and ROM stockpiles. This will keep vehicle kilometres travelled (VKT) to a minimum and reduce diesel usage and fume. These management measures are inherent in mine planning.

13.5 Spontaneous Combustion

As mentioned in **Section 12**, history at the site indicates that the risk of spontaneous combustion occurring at Mount Owen is very low. However, if it occurs, it would continue to be managed in accordance with the Mount Owen Spontaneous Combustion Management Plan (SCMP) (**Xstrata, 2012**). Sections 5.2 and 5.3 of the SCMP, lists a number of preventative and control measures, respectively.

Preventative measures include those related to managing delays in stockpiling and reclaiming, as well as information on recognising signs of spontaneous combustion and the potential level of risk.

In the unlikely event that spontaneous combustion occurs, the control measures in the SCMP outline the various options available depending on the level of risk associated with potential hazards to personnel and equipment.

Section 5.4 of the SCMP also details a procedure for the handling of ROM hot coal, at the northern and southern stockpiles as well as at the CHPP.

13.6 Monitoring

13.6.1 Adequacy of current dust monitoring network

The current Mount Owen monitoring network described in **Section 5.3.1** is comprehensive in its measurement of dust deposition, TSP and PM_{10}. The coverage of these monitoring locations is adequate, particularly when considered in combination with the UHAQMN. In terms of dust deposition monitors, DD8 will need to be removed as the pit moves through that area. DD10 also lies within the proposed North Pit continuation footprint and will need to be removed as operations progress towards that location.

The DGRs require that this assessment consider the need for further monitoring which may be needed to manage particulate matter emissions during adverse weather conditions. Some options in this regard are discussed in the following sections.

13.6.1 Real-Time Dust Monitoring

The Mount Owen monitoring network currently includes five real-time (TEOM) dust monitors, as described in **Section 5.3.1**. Data from these sites are downloaded on a daily basis, or in response to a trigger, which notifies site personnel of any potential exceedances of 24-hour average PM_{10} criteria. This information is used to inform the *Assessment Protocol for Continuous PM_{10} Data*, as part of the existing Air Quality and Greenhouse Gas Management Plan (AQGHGMP) (**Xstrata, 2011**), and the required action can be taken. There is no need to make changes to this part of the monitoring system at this stage, although Mount Owen plan to relocate the SX14 TEOM located in Camberwell. The new location has not yet been determined, but is likely to be in a position representative of the Middle Falbrook area to the southeast of the North Pit.

13.6.2 Predictive Meteorological Forecasting System

The AQGHGMP for the Project should also include a meteorological forecasting system. This system would predict meteorological conditions for the coming day to determine, one day in advance, where the risk of dust emissions may occur (for example, based on wind speed, direction, rainfall and atmospheric stability).

The predictive meteorological forecasting system would work in conjunction with the real-time monitoring system, providing an alert for the appropriate personnel to review the real-time data and manage the intensity of activities for that day, increase controls or limit activity to various areas of the Project Area Boundary.

13.6.3 Reactive and Proactive Mitigation Measures

Real-time air quality monitoring and meteorology data would continue to be transmitted to a central data repository and used for assessing operation management practices. The analysis of short-term average concentrations would inform the Triggered Action Response Plan (TARP) and the system would send notifications to alert operations personnel when a dust risk is predicted based on pre-defined short-term reactive triggers.

The TARP would recommend dust control options for consideration by operations, depending on the data analysis and level of response that is triggered. The TARP can be updated as the system is used over time and adverse conditions for various operations and mining areas are identified.

14 CONCLUSIONS

Pacific Environment has completed an Air Quality Assessment for the Mount Owen Continued Operations Project.

Mine plans for the 'worst-case' air quality impact years (Year 1, Year 5 and Year 10) have been analysed and detailed emissions inventories have been prepared. Dispersion modelling was conducted to predict the ground level concentrations for all relevant pollutants.

Cumulative impacts were also considered, taking into account the nearby mining operations within the modelling domain, as well as other non-modelled sources. Model predictions at privately-owned residential and other mine-owned receptors were compared with applicable air quality criteria.

Dispersion modelling results indicate that PM_{10} concentrations are predicted to exceed the 24-hour average criterion of 50 µg/m^3 at private residence R23 in Year 10. This exceedance is only predicted to occur on one day throughout the year. Concentrations at a number of residences are predicted to exceed the annual average PM_{10} criterion on a cumulative basis in all years, but these residences are either already mine owned or currently subject to acquisition rights.

A Monte Carlo Simulation was completed to assess cumulative PM_{10} and $PM_{2.5}$ 24-hour impacts at the most affected receptor locations. The analysis identified four private receptors (R4, R112, R114 and R116) that may potentially exceed the 24-hour average PM_{10} cumulative criteria of 50 µg/m^3 on more than 5 occasions per year in Year 10. No exceedances of the advisory reporting standard for 24-hour $PM_{2.5}$ are predicted at those residences, and there are no predicted exceedances of the 24-hour average PM_{10} criterion of 150 µg/m^3.

A conservative quantitative assessment of diesel and blast fume was also carried out. There are predicted to be a small number of theoretical exceedances of the 1-hour average NO_2 criterion due to blasting, but these were for a specific set of meteorological conditions which are most likely to occur around sunrise and sunset in the winter months. These will be managed with predictive meteorological modelling to avoid blasting under these conditions. Two mine-owned residences are predicted to potentially exceed the 1-hour average NO_2 criterion due to diesel emissions in Year 10.

The assessment has taken a conservative approach by considering the worst case operating conditions at the Project and surrounding operations. Therefore the predicted concentrations and deposition levels due to the proposed activities are likely to be higher than measured concentrations and deposition levels. Notwithstanding, dust control would be a key part of the operation. Day-to-day dust management and best practice control measures would part of the standard operating procedures to keep both emissions and resulting ground level concentrations as low as possible.

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Appendix A Independent Peer Review

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18 September 2014 EN04520

Dear Jane

Review of Mt Owen Continued Operations air quality impact assessment report

I have completed a review of the air quality impact assessment report, prepared by Pacific Environment Limited. The document reviewed was titled:

- *"AIR QUALITY IMPACT ASSESSMENT – MOUNT OWEN CONTINUED OPERATIONS".* Mount Owen Pty Limited c/- Umwelt (Australia) Job No: 6043C, dated 16 September 2014.

This letter provides a brief overview of the Project, the review methodology and review outcome.

I am an Atmospheric Scientist with 17 years' air quality consulting experience. I have been specialising in meteorological studies, air dispersion modelling, emission estimation and air quality assessment for various industry sectors, but predominantly for coal mining in the Hunter Valley. It is in this capacity that I have undertaken the review.

1. Background

Mt Owen Pty Ltd is seeking approval for the "Mount Owen Continued Operations Project" which involves the continuation of the existing mining operations at the Mount Owen North Pit, and the Ravensworth East Mine. The Project is fully described in the Environmental Impact Statement (EIS) (Umwelt 2014). Pacific Environment Limited (PEL) has prepared the accompanying air quality impact assessment, the subject of this review.

The main objective of the air quality assessment was to address the Director-General's Requirements relating to air quality, as well as the assessment requirements of the Environment Protection Authority (EPA). The PEL assessment was based on the use of an air dispersion model to predict dust concentration and dust deposition levels in the vicinity of the project, including at the nearest sensitive receptors. Three operating years of the mine life were considered and the modelling referred to the procedures outlined by the EPA in their *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005).

In terms of potential air quality impacts, the main conclusions of the PEL assessment were as follows:

- One predicted exceedance of the 24-hour average PM_{10} acquisition criterion (Project only) at one private residence in Year 10.
- One privately owned residence (without current acquisition rights) predicted to exceed the annual average PM_{10} cumulative criterion of 30 µg/m^3 in Year 1. Predictions at this location were above the criterion without the Project contribution.
- Potential exceedances of the 1 hour average NO_2 criterion at the nearest mine-owned and private residences due to blast fume. Implementation of the Mount Owen Blast Management Plan would mitigate these impacts.
- Potential exceedances of the 1 hour average NO_2 criterion at two Glencore-owned residences, due to diesel emissions in Year 10.

2. Review Methodology

The review has considered the adequacy of the air quality assessment to address the Director General's Requirements (as relevant to the assessment of air quality), and consistency with the EPA's *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC 2005). More specifically, the review has focussed on:

- Air quality impact assessment criteria.
- Model selection and approach.
- Meteorological data and methods for inclusion.
- Background levels and approach to cumulative effects.
- Emission inventories and calculations.
- Identification of sensitive receptors.
- Accuracy/clarity of presentation and interpretation of results.
- Clarity and adequacy of impact assessment.
- Proposed mitigation and monitoring.

Review of potential health effects of airborne particulate matter was outside the scope of this review.

This review was also carried out by considering:

- Consistency with the *"Approved Methods for the Modelling and Assessment of Air Pollutants in NSW"* (DEC 2005).
- *"Preliminary Environmental Assessment - Mount Owen Continued Operations Project"* (Umwelt 2013).
- Requirements from the Department of Planning and Infrastructure *Director-General's Environmental Assessment Requirements, SSD 5850.*
- Emission factors from *"National Pollutant Inventory Emission Estimation Technique Manual for Mining, Version 3.1"* January 2012 (SEWPaC 2012).

- Emission factors from "*Compilation of Air Pollutant Emission Factors*" (US EPA 1985 and updates).
- Consistency with "*Mt Owen Complex - Coal Mine Particulate Matter Control Best Management Practice Determination*" (Xstrata Coal 2012).
- Consistency with "*NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining*" (Katestone 2011).

3. Review outcome

In my opinion, the air quality assessment (based on dispersion modelling) has been undertaken in a manner which is consistent with the requirements of the EPA (DEC 2005) for these types of projects. The methodology used in this assessment has been appropriate and applied in a conservative manner, in order to determine the potential air quality impacts. The conclusions of the assessment are supported by the model predictions.

Yours sincerely

Shane Lakmaker

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Appendix B Emission Factor Equations and Calculations

EMISSION ESTIMATION

The dust emission inventories have been prepared for each modelling year using the operational description of the proposed modification.

Estimated emissions are presented for all significant dust generating activities associated with the operations. The relevant emission factors used for the study are described below. With the exception of blasting, activities have been modelled for 24 hours per day.

Dust from wind erosion is assumed to occur over 24-hours per day, however, wind erosion is also assumed to be proportional to the third power of wind speed. This will mean that most wind erosion occurs during the day when wind speeds are highest.

Drilling overburden

Emissions from drilling for each particle size fraction were estimated using the US EPA AP42 emission factors given below.

$E_{TSP} = 0.59$ kg/blast

$E_{PM10} = 0.52 \times E_{TSP}$ kg/blast

$E_{PM2.5} = 0.03 \times E_{TSP}$ kg/blast

Blasting overburden

Emissions from blasting for each particle size fraction were estimated using the US EPA AP42 emission factors given below.

$E_{TSP} = 0.00022 \times A^{1.5}$ kg/blast

$E_{PM10} = 0.52 \times 0.00022 \times A^{1.5}$ kg/blast

$E_{PM2.5} = 0.03 \times 0.00022 \times A^{1.5}$ kg/blast

Where:
A = area to be blasted in m^2

Loading material / dumping overburden

Each tonne of material loaded will generate a quantity of dust that will depend on the wind speed and the moisture content. The equation below shows the relationship between these variables and the appropriate k-factor for each particle size fraction.

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

Where:
k = 0.74 for TSP
k = 0.35 for PM_{10}
k = 0.053 for $PM_{2.5}$
U = wind speed (m/s)
M = moisture content (%)

Hauling material / product on unsealed surfaces

The emission estimates of wheel generated dust are based the US EPA AP42 emission factor equations for unpaved surfaces at industrial sites, as shown below.

$E_{TSP} = (0.4536/1.6093) \times 4.9 \times (s/12)^{0.7} \times ((W/1.1023)/3)^{0.45}]$ kg/VKT

$E_{PM10} = (0.4536/1.6093) \times 1.5 \times (s/12)^{0.9} \times ((W/1.1023)/3)^{0.45}]$ kg/VKT

$E_{PM2.5} = (0.4536/1.6093) \times 0.15 \times (s/12)^{0.9} \times ((W/1.1023)/3)^{0.45}]$ kg/VKT

Where:
S = silt content of road surface
W = mean vehicle weight in metric tonnes

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.

A control factor of 85% has been applied for watering and the use of chemical suppressants on unpaved roads.

Dozers working on overburden

Emissions from dozers on overburden have been calculated using the US EPA AP-42 emission factor equations shown below.

$E_{TSP} = 2.6 \times (s^{1.2}/M^{1.3})$ kg/hour

$E_{PM10} = 0.3375 \times (s^{1.5}/M^{1.4})$ kg/hour

$E_{PM2.5} = 0.105 \times E_{TSP}$ kg/hour

Where:
S = silt content (%)
M = moisture (%)

Dozers working on coal

Emissions from dozers on coal have been calculated using the US EPA AP-42 emission factor equations shown below.

$E_{TSP} = 35.6 \times (s^{1.2}/M^{1.3})$ kg/hour

$E_{PM10} = 6.33 \times (s^{1.5}/M^{1.4})$ kg/hour

$E_{PM2.5} = 0.022 \times E_{TSP}$ kg/hour

Where,
S = silt content (%)
M = moisture (%)

Loading/unloading coal

The US EPA AP42 emission factor equations for each particle size fraction are shown below.

$E_{TSP} = 0.580 / M^{1.2}$ kg/t

$E_{PM10} = 0.0447 / M^{0.9}$ kg/t

$E_{PM2.5} = 0.019 \times E_{TSP}$ kg/t

Where,
M = moisture (%)

Wind erosion

The default US EPA AP42 emission factors for wind erosion on exposed surfaces are shown below for each particle size fraction

$E_{TSP} = 0.1$ kg/ha/h

$E_{PM10} = 0.5 \times E_{TSP}$ kg/ha/h

$E_{PM2.5} = 0.075 \times E_{TSP}$ kg/ha/h

Grading roads

Estimates of emissions from grading roads have been made using the US EPA AP42 emission factor equations for each particle size fraction, as shown below.

$E_{TSP} = 0.0034 \times S^{2.5}$ kg/km

$E_{PM10} = 0.00336 \times S^{2}$ kg/km

$E_{PM2.5} = 0.0001054 \times S^{2.5}$ kg/km

Where,
S = speed of the grader in km/h (taken to be 8 km/h)

The following tables provide a summary of the variables used to calculate TSP emissions for each modelling year. These variables include such things as haul road distances, silt and moisture contents vehicle payloads, vehicle weights and the volumes of material handled. Similar tables for PM_{10} and $PM_{2.5}$ can be provided if required, but will include the same variables. The differences between the particle size fractions are in the emission equations themselves which have been provided above.

Table B1: TSP emission estimates for Year 1 – North Pit

ACTIVITY	TSP emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Control measure
Mt Owen North Pit - 2016 (Year 1)																		
Topsoil - Scrapers stripping topsoil	682	47,008	t/y	0.029	kg/t											50	% control	Stripping occurs when moist
Topsoil - Scraper hauling topsoil to stockpiles	263	47,008	t/y	0.037	kg/t	26	payload (tonnes)	49	Average vehicle mass (tonnes)	3.6	km/return trip	0.27	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust suppression
Topsoil - Emplacing topsoil at stockpiles	6	47,008	t/y	0.00012	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	12	moisture content in %									
Overburden - Drilling	8,611	48,647	holes/y	0.590	kg/hole											70	% control	Water injection while drilling
Overburden - Blasting	72,818	117	blasts/y	622	kg/blast	20,003	Area of blast in square metres											
Overburden - Dozers pushing waste	88,919	21,549	h/y	4.1	kg/h	6.6	moisture content in %	11.4	silt content									
Overburden - Excavators loading haul trucks	23,701	84,033,437	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Hauling to waste dump with Cat 793	872,221	74,712,738	t/y	0.0778	kg/t	218	payload (tonnes)	275	Average vehicle mass (tonnes)	5.4	km/return trip	3.14	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Hauling to waste dump with Cat 785	148,669	9,320,699	t/y	0.1063	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	5.4	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Unloading at waste dump	23,701	84,033,437	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Dozers on waste dumps	12,351	22,717	h/y	0.54	kg/h	11.2	moisture content in %	3.7	silt content									
Rehabilitation - Dozers shaping rehab area	1,181	2,172	h/y	0.54	kg/h	11.2	moisture content in %	3.7	silt content									
Coal - Dozers pushing coal	447,705	16,855	h/y	26.6	kg/h	6.9	moisture content in %	6.4	silt content									
Coal - Excavators loading ROM to trucks	495,132	8,667,866	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Hauling MTO ROM to ROM pad with Cat 793	14,964	1,116,381	t/y	0.0894	kg/t	218	payload (tonnes)	275	Average vehicle mass (tonnes)	6.2	km/return trip	3.14	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Hauling MTO ROM to ROM pad with Cat 785	138,294	7,551,486	t/y	0.1221	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	6.2	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Hauling Glendell ROM to ROM pad with Cat 789	85,500	4,354,139	t/y	0.1309	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	8.0	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Unloading ROM at northern ROM pad	495,132	8,667,866	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Unloading Glendell ROM at southern ROM pad	248,720	4,354,139	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Primary crushing	4,464	11,022,005	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to secondary crusher	2,480	11,022,005	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Secondary crushing	4,464	11,022,005	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to tertiary crusher	2,480	11,022,005	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Tertiary crushing	4,464	11,022,005	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - FELs feeding North Pit ROM to northern ROM hopper	131,403	7,667,866	t/y	0.0571	kg/t	6.9	moisture content in %									70	% control	Water sprays at hopper
Coal - FELs feeding Glendell ROM to southern ROM hopper	57,479	3,354,139	t/y	0.0571	kg/t	6.9	moisture content in %									70	% control	Water sprays at hopper
Coal - FELs loading northern ROM to trucks for haulage to Rav East conveyer	57,123	1,000,000	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - FELs loading southern ROM to trucks for haulage to Rav East conveyer	57,123	1,000,000	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Hauling northern ROM to Rav East conveyer with Cat 785	31,310	1,000,000	t/y	0.2087	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	10.6	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Hauling southern ROM to Rav East conveyer with Cat 785	15,950	1,000,000	t/y	0.1063	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	5.4	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Unloading ROM at Rav East conveyer	114,245	2,000,000	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Material transfer of ROM to CHPP (includes Glendell ROM)	876	11,022,005	t/y	0.00027	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.9	moisture content in %							70	% control	Enclosed transfer points
Coal - Hauling coarse rejects to North Pit waste dump in Cat 789	11,915	1,618,076	t/y	0.0491	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	3.0	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Hauling coarse rejects to West Pit waste dump in Cat 789	5,106	693,461	t/y	0.0491	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	3.0	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Material transfer of product to stockpiles (includes Glendell)	377	7,301,297	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Dozers on product stockpiles	111,279	9,594	h/y	11.6	kg/h	9.4	moisture content in %	4.5	silt content									
Coal - Material transfer to train loading silo (includes Glendell)	377	7,301,297	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Material transfer to trains (included Glendell product)	377	7,301,297	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Grading roads	37,234	120,996	km	0.62	kg/km	15,124	h/y	8	speed of graders in km/h							50	% control	Keeping travel routes moist
Gravel crushing in-pit	810	2,000,000	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Wind erosion - Active waste dump area (includes WOOP area 73ha)	324,996	371	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Active exposed pit area	144,540	165	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Active rehab area	24,528	28	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Northern ROM stockpile	4,292	4.9	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Southern ROM stockpile	6,570	7.5	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Product stockpile	2,102	12	ha	0.1	kg/ha/h	8,760	h/y									80	% control	RT9 used on long-term coal stockpiles
Wind erosion - Topsoil removal area	5,344	6.1	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Topsoil stockpile/storage area	3,942	9.0	ha	0.1	kg/ha/h	8,760	h/y									50	% control	Watered and seeded
Wind erosion - Construction on Hebden Road	12,264	14.0	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Construction of Rail Loop	157,680	180.0	ha	0.1	kg/ha/h	8,760	h/y											

Table B2: TSP emission estimates for Year 1 – Bayswater North Pit

ACTIVITY	TSP emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Control measure
Bayswater North Pit - 2016 (Year 1)																		
Topsoil - Scrapers stripping topsoil	480	33,122	t/y	0.029	kg/t											50	% control	Stripping occurs when moist
Topsoil - Scraper hauling topsoil to stockpiles	51	33,122	t/y	0.010	kg/t	26	payload (tonnes)	49	Average vehicle mass (tonnes)	1.0	km/return trip	0.27	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust suppression
Topsoil - Emplacing topsoil at stockpiles	4	33,122	t/y	0.00012	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	12	moisture content in %									
Overburden - Drilling	1,293	7,303	holes/y	0.590	kg/hole											70	% control	Water injection while drilling
Overburden - Blasting	4,037	104	blasts/y	39	kg/blast	3,146	Area of blast in square metres											
Overburden - Dozers pushing waste	39,943	9,680	h/y	4.1	kg/h	6.6	moisture content in %	11.4	silt content									
Overburden - Excavators loading haul trucks	8,434	29,901,746	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Hauling to waste dump with Cat 793	244,050	18,814,357	t/y	0.0865	kg/t	218	payload (tonnes)	275	Average vehicle mass (tonnes)	6.0	km/return trip	3.14	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Hauling to waste dump with Cat 789	163,288	11,087,390	t/y	0.0982	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	6.0	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Unloading at waste dump	8,434	29,901,746	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Dozers on waste dumps	2,602	4,785	h/y	0.54	kg/h	11.2	moisture content in %	3.7	silt content									
Coal - Dozers pushing coal	31,672	1,192	h/y	26.6	kg/h	6.9	moisture content in %	6.4	silt content									
Coal - Excavators loading ROM to trucks	96,746	1,693,644	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Hauling ROM to South ROM pad with Cat 789	26,606	1,693,644	t/y	0.1047	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	6.4	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Unloading ROM at South ROM pad	96,746	1,693,644	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Primary crushing	686	1,693,644	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to secondary crusher	381	1,693,644	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Secondary crushing	686	1,693,644	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to tertiary crusher	381	1,693,644	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Tertiary crushing	686	1,693,644	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - FELs feeding ROM to ROM hopper	29,024	1,693,644	t/y	0.0571	kg/t	6.9	moisture content in %									70	% control	Water sprays at hopper
Coal - Material transfer of ROM to CHPP	135	1,693,644	t/y	0.00027	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.9	moisture content in %							70	% control	Enclosed transfer points
Coal - Hauling coarse rejects to West Pit waste dump in Cat 789	2,795	379,556	t/y	0.0491	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	3.0	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Material transfer of product to stockpiles	55	1,066,978	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Material transfer to train loading silo	55	1,066,978	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Material transfer to trains	55	1,066,978	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Grading roads	12,466	40,510	km	0.62	kg/km	5,064	h/y	8	speed of graders in km/h							50	% control	Keeping travel routes moist
Wind erosion - Active waste dump area (includes areas near West Pit)	169,418	193	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Active exposed pit area	54,224	62	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Topsoil removal area	18,396	21	ha	0.1	kg/ha/h	8,760	h/y											

Table B3: TSP emission estimates for Year 5 – North Pit

ACTIVITY	TSP emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Control measure
Mt Owen North Pit - 2020 (Year 5)																		
Topsoil - Scrapers stripping topsoil	992	68,428	t/y	0.029	kg/t											50	% control	Stripping occurs when moist
Topsoil - Scraper hauling topsoil to stockpiles	383	68,428	t/y	0.037	kg/t	26	payload (tonnes)	49	Average vehicle mass (tonnes)	3.6	km/return trip	0.27	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust suppression
Topsoil - Emplacing topsoil at stockpiles	8	68,428	t/y	0.00012	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	12	moisture content in %									
Overburden - Drilling	8,904	50,305	holes/y	0.590	kg/hole											70	% control	Water injection while drilling
Overburden - Blasting	75,308	121	blasts/y	622	kg/blast	20,003	Area of blast in square metres											
Overburden - Dozers pushing waste	99,440	24,099	h/y	4.1	kg/h	6.6	moisture content in %	11.4	silt content									
Overburden - Excavators loading haul trucks	24,509	86,900,313	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Hauling to waste dump with Cat 793	1,082,586	80,766,754	t/y	0.0894	kg/t	218	payload (tonnes)	275	Average vehicle mass (tonnes)	6.2	km/return trip	3.14	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Hauling to waste dump with Cat 785	112,327	6,133,559	t/y	0.1221	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	6.2	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Unloading at waste dump	24,509	86,900,313	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Dozers on waste dumps	12,856	23,645	h/y	0.54	kg/h	11.2	moisture content in %	3.7	silt content									
Rehabilitation - Dozers shaping rehab area	321	591	h/y	0.54	kg/h	11.2	moisture content in %	3.7	silt content									
Coal - Dozers pushing coal	494,539	18,618	h/y	26.6	kg/h	6.9	moisture content in %	6.4	silt content									
Coal - Excavators loading ROM to trucks	569,624	9,971,925	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Hauling MTO ROM to ROM pad with Cat 793	26,855	1,592,541	t/y	0.1124	kg/t	218	payload (tonnes)	275	Average vehicle mass (tonnes)	7.8	km/return trip	3.14	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Hauling MTO ROM to ROM pad with Cat 785	193,057	8,379,384	t/y	0.1536	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	7.8	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Hauling Glendell ROM to ROM pad with Cat 789	64,321	3,275,603	t/y	0.1309	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	8.0	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Unloading ROM at northern ROM pad	569,624	9,971,925	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Unloading Glendell ROM at southern ROM pad	187,111	3,275,603	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Primary crushing	4,555	11,247,528	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to secondary crusher	2,531	11,247,528	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Secondary crushing	4,555	11,247,528	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to tertiary crusher	2,531	11,247,528	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Tertiary crushing	4,555	11,247,528	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - FELs feeding North Pit ROM to northern ROM hopper	153,750	8,971,925	t/y	0.0571	kg/t	6.9	moisture content in %									70	% control	Water sprays at hopper
Coal - FELs feeding Glendell ROM to southern ROM hopper	38,997	2,275,603	t/y	0.0571	kg/t	6.9	moisture content in %									70	% control	Water sprays at hopper
Coal - FELs loading northern ROM to trucks for haulage to Rav East conveyer	57,123	1,000,000	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - FELs loading southern ROM to trucks for haulage to Rav East conveyer	57,123	1,000,000	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Hauling northern ROM to Rav East conveyer with Cat 785	31,310	1,000,000	t/y	0.2087	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	10.6	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Hauling southern ROM to Rav East conveyer with Cat 785	15,950	1,000,000	t/y	0.1063	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	5.4	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Unloading ROM at Rav East conveyer	114,245	2,000,000	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Material transfer of ROM to CHPP (includes Glendell ROM)	894	11,247,528	t/y	0.00027	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.9	moisture content in %							70	% control	Enclosed transfer points
Coal - Hauling coarse rejects to North Pit waste dump in Cat 789	23,223	3,153,679	t/y	0.0491	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	3.0	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Material transfer of product to stockpiles (includes Glendell)	357	6,916,970	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Dozers on product stockpiles	102,151	8,807	h/y	11.6	kg/h	9.4	moisture content in %	4.5	silt content									
Coal - Material transfer to train loading silo (includes Glendell)	357	6,916,970	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Material transfer to trains (included Glendell product)	357	6,916,970	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Grading roads	38,576	125,355	km	0.62	kg/km	15,669	h/y	8	speed of graders in km/h							50	% control	Keeping travel routes moist
Gravel crushing in-pit	810	2,000,000	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Wind erosion - Active waste dump area	193,596	221	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Active exposed pit area	155,928	178	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Active rehab area	14,796	16.9	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Northern ROM stockpile	4,292	4.9	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Southern ROM stockpile	6,570	7.5	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Product stockpile	2,102	12	ha	0.1	kg/ha/h	8,760	h/y									80	% control	RT9 used on long-term coal stockpiles
Wind erosion - Topsoil removal area	6,570	7.5	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Topsoil stockpile/storage area	3,942	9.0	ha	0.1	kg/ha/h	8,760	h/y									50	% control	Watered and seeded
Wind erosion - Construction on Hebden Road	0	0.0	ha	0.1	kg/ha/h	8,760	h/y											

Table B4: TSP emission estimates for Year 5 – Bayswater North Pit

ACTIVITY	TSP emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Control measure
Bayswater North Pit - 2020 (Year 5)																		
Topsoil - Scrapers stripping topsoil	352	24,282	t/y	0.029	kg/t											50	% control	Stripping occurs when moist
Topsoil - Scraper hauling topsoil to stockpiles	38	24,282	t/y	0.010	kg/t	26	payload (tonnes)	49	Average vehicle mass (tonnes)	1.0	km/return trip	0.27	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust suppression
Topsoil - Emplacing topsoil at stockpiles	3	24,282	t/y	0.00012	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	12	moisture content in %									
Overburden - Drilling	1,971	11,134	holes/y	0.590	kg/hole											70	% control	Water injection while drilling
Overburden - Blasting	7,600	104	blasts/y	73	kg/blast	4,796	Area of blast in square metres											
Overburden - Dozers pushing waste	35,271	8,548	h/y	4.1	kg/h	6.6	moisture content in %	11.4	silt content									
Overburden - Excavators loading haul trucks	7,694	27,280,080	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Hauling to waste dump with Cat 793	353,863	27,280,080	t/y	0.0865	kg/t	218	payload (tonnes)	275	Average vehicle mass (tonnes)	6.0	km/return trip	3.14	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Hauling to waste dump with Cat 789	112,519	7,640,159	t/y	0.0982	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	6.0	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Unloading at waste dump	7,694	27,280,080	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Dozers on waste dumps	2,602	4,785	h/y	0.54	kg/h	11.2	moisture content in %	3.7	silt content									
Coal - Dozers pushing coal	32,144	1,210	h/y	26.6	kg/h	6.9	moisture content in %	6.4	silt content									
Coal - Excavators loading ROM to trucks	98,187	1,718,882	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Hauling ROM to South ROM pad with Cat 789	26,158	1,718,882	t/y	0.1015	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	6.2	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Unloading ROM at South ROM pad	98,187	1,718,882	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Primary crushing	696	1,718,882	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to secondary crusher	387	1,718,882	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Secondary crushing	696	1,718,882	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to tertiary crusher	387	1,718,882	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Tertiary crushing	696	1,718,882	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - FELs feeding ROM to ROM hopper	29,456	1,718,882	t/y	0.0571	kg/t	6.9	moisture content in %									70	% control	Water sprays at hopper
Coal - Material transfer of ROM to CHPP	137	1,718,882	t/y	0.00027	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.9	moisture content in %							70	% control	Enclosed transfer points
Coal - Hauling coarse rejects to West Pit waste dump in Cat 789	2,853	387,473	t/y	0.0491	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	3.0	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Material transfer of product to stockpiles	56	1,079,145	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Material transfer to train loading silo	56	1,079,145	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Material transfer to trains	56	1,079,145	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Grading roads	10,721	34,837	km	0.62	kg/km	4,355	h/y	8	speed of graders in km/h							50	% control	Keeping travel routes moist
Wind erosion - Active waste dump area	46,078	53	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Active exposed pit area	60,794	69	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Topsoil removal area	13,212	15	ha	0.1	kg/ha/h	8,760	h/y											

Table B5: TSP emission estimates for Year 10 – North Pit

ACTIVITY	TSP emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Control measure
Mt Owen North Pit - 2025 (Year 10)																		
Topsoil - Scrapers stripping topsoil	1,135	78,261	t/y	0.029	kg/t											50	% control	Stripping occurs when moist
Topsoil - Scraper hauling topsoil to rehab area	948	78,261	t/y	0.081	kg/t	26	payload (tonnes)	49	Average vehicle mass (tonnes)	7.8	km/return trip	0.27	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust suppression
Topsoil - Emplacing topsoil at rehab area	10	78,261	t/y	0.00012	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	12	moisture content in %									
Overburden - Drilling	7,440	42,032	holes/y	0.590	kg/hole											70	% control	Water injection while drilling
Overburden - Blasting	64,727	104	blasts/y	622	kg/blast	20,003	Area of blast in square metres											
Overburden - Dozers pushing waste	94,791	22,972	h/y	4.1	kg/h	6.6	moisture content in %	11.4	silt content									
Overburden - Excavators loading haul trucks	20,973	74,361,028	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Hauling to waste dump with Cat 793	931,907	65,311,670	t/y	0.0951	kg/t	218	payload (tonnes)	275	Average vehicle mass (tonnes)	6.6	km/return trip	3.14	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Hauling to waste dump with Cat 785	176,417	9,049,358	t/y	0.1300	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	6.6	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Unloading at waste dump	20,973	74,361,028	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Dozers on waste dumps	12,320	22,660	h/y	0.54	kg/h	11.2	moisture content in %	3.7	silt content									
Rehabilitation - Dozers shaping rehab area	375	690	h/y	0.54	kg/h	11.2	moisture content in %	3.7	silt content									
Coal - Dozers pushing coal	331,965	12,497	h/y	26.6	kg/h	6.9	moisture content in %	6.4	silt content									
Coal - Excavators loading ROM to trucks	342,068	5,988,305	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Hauling MTO ROM to ROM pad with Cat 793	0	0	t/y	0.1830	kg/t	218	payload (tonnes)	275	Average vehicle mass (tonnes)	12.7	km/return trip	3.14	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Hauling MTO ROM to ROM pad with Cat 785	224,640	5,988,305	t/y	0.2501	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	12.7	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Hauling Glendell ROM to ROM pad with Cat 789	0	0	t/y	0.0000	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	0.0	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Unloading ROM at northern ROM pad	342,068	5,988,305	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Unloading Glendell ROM at southern ROM pad	0	0	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Primary crushing	1,615	3,988,305	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to secondary crusher	897	3,988,305	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Secondary crushing	1,615	3,988,305	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to tertiary crusher	897	3,988,305	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Tertiary crushing	1,615	3,988,305	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - FELs feeding North Pit ROM to northern ROM hopper	68,347	3,988,305	t/y	0.0571	kg/t	6.9	moisture content in %									70	% control	Water sprays at hopper
Coal - FELs feeding Glendell ROM to southern ROM hopper	0	0	t/y	0.0571	kg/t	6.9	moisture content in %									70	% control	Water sprays at hopper
Coal - FELs loading northern ROM to trucks for haulage to Rav East conveyer	114,245	2,000,000	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - FELs loading southern ROM to trucks for haulage to Rav East conveyer	0	0	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Hauling northern ROM to Rav East conveyer with Cat 785	62,620	2,000,000	t/y	0.2087	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	10.6	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Hauling southern ROM to Rav East conveyer with Cat 785	0	0	t/y	0.0000	kg/t	133	payload (tonnes)	184	Average vehicle mass (tonnes)	0.0	km/return trip	2.62	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Unloading ROM at Rav East conveyer	114,245	2,000,000	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Material transfer of ROM to CHPP (MTO only)	317	3,988,305	t/y	0.00027	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.9	moisture content in %							70	% control	Enclosed transfer points
Coal - Hauling coarse rejects to North Pit waste dump in Cat 789	55,850	1,791,626	t/y	0.2078	kg/t	177	payload (tonnes)	230	Average vehicle mass (tonnes)	12.7	km/return trip	2.90	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Material transfer of product to stockpiles (MTO only)	177	3,431,745	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Dozers on product stockpiles	45,374	3,912	h/y	11.6	kg/h	9.4	moisture content in %	4.5	silt content									
Coal - Material transfer to train loading silo (MTO only)	177	3,431,745	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Material transfer to trains (MTO only)	177	3,431,745	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Grading roads	39,811	129,368	km	0.62	kg/km	16,171	h/y	8	speed of graders in km/h							50	% control	Keeping travel routes moist
Gravel crushing in-pit	810	2,000,000	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Wind erosion - Active waste dump area	157,680	180	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Active exposed pit area	153,300	175	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Active rehab area	11,651	13	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Northern ROM stockpile	4,292	4.9	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Southern ROM stockpile	0	0.0	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Product stockpile	2,102	12	ha	0.1	kg/ha/h	8,760	h/y									80	% control	RT9 used on long-term coal stockpiles
Wind erosion - Topsoil removal area	8,760	10.0	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Topsoil stockpile/storage area	0	0.0	ha	0.1	kg/ha/h	8,760	h/y									50	% control	Watered and seeded
Wind erosion - Construction on Hebden Road	0	0.0	ha	0.1	kg/ha/h	8,760	h/y											

Table B6: TSP emission estimates for Year 10 – RERR Pit

ACTIVITY	TSP emission (kg/y)	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Control measure
RERR Pit - 2025 (Year 10)																		
Overburden - Drilling	2,993	16,912	holes/y	0.59	kg/hole											70	% control	Water injection and dust curtains
Overburden - Blasting	34,176	85	blasts/y	404	kg/blast	15,000	Area of blast in square metres											
Overburden - Dozers on waste (in pit)	6,668	1,616	h/y	4.1	kg/h	6.6	moisture content in %	11.4	silt content									
Overburden - Loading to haul trucks	6,390	22,656,000	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Hauling to waste dump	419,218	22,656,000	t/y	0.1234	kg/t	224	payload (tonnes)	272	Average vehicle mass (tonnes)	8.8	km/return trip	3.13	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Overburden - Unloading at waste dump	6,390	22,656,000	t/y	0.00028	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.6	moisture content in %									
Overburden - Dozers on waste dumps	7,029	12,928	h/y	0.5	kg/h	11.2	moisture content in %	3.7	silt content									
Coal - Dozers on coal (in pit)	42,926	1,616	h/y	26.6	kg/h	6.9	moisture content in %	6.4	silt content									
Coal - Loading ROM to trucks	74,260	1,300,000	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - Hauling ROM to ROM pad	25,868	1,300,000	t/y	0.1327	kg/t	165	payload (tonnes)	224	Average vehicle mass (tonnes)	7.6	km/return trip	2.86	kg/VKT	2	% silt content	85	% control	Level 2 watering and chemical dust supression
Coal - Unloading ROM at ROM pad	74,260	1,300,000	t/y	0.0571	kg/t	6.9	moisture content in %											
Coal - FELs Loading ROM to hopper	22,278	1,300,000	t/y	0.0571	kg/t	6.9	moisture content in %									70	% control	Water sprays at hopper
Coal - Material transfer of ROM to CHPP	103	1,300,000	t/y	0.00027	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	6.9	moisture content in %							70	% control	Enclosed transfer points
Coal - Primary crushing	527	1,300,000	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to secondary crusher	293	1,300,000	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Secondary crushing	527	1,300,000	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Transfer to tertiary crusher	293	1,300,000	t/y	0.0015	kg/t											85	% control	Enclosed and water sprays
Coal - Tertiary crushing	527	1,300,000	t/y	0.0027	kg/t											85	% control	Enclosed and water sprays
Coal - Material transfer of product to stockpiles	145	845,000	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %									
Coal - Material transfer to train loading silo	44	845,000	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Coal - Material transfer to trains	44	845,000	t/y	0.00017	kg/t	1.267	average of (wind speed/2.2)^1.3 in m/s	9.4	moisture content in %							70	% control	Enclosed transfer points
Grading roads	15,113	49,112	km/y	0.62	kg/km	6,139	h/y	8	speed of graders in km/h							50	% control	Keeping travel routes moist
Wind erosion - Active waste dump area	36,442	42	ha	0.1	kg/ha/h	8,760	h/y											
Wind erosion - Active exposed pit area	20,586	24	ha	0.1	kg/ha/h	8,760	h/y											

Appendix C Analysis Results for Site-Specific Parameterisation

Industrial Dust Emissions - sampling and testing US EPA methods

Client:	Pacific Environmental	**Job No:**	13-087
Address:	Suite 1, Level 1, 146 Arthur Street, Sydney 2060	**Report No:**	01-MA
Project:	Mt Owen	**Date Sampled:**	3/04/2013

Sample No	Sample Location	Moisture Content % EPA AP42 C2	Silt Content % EPA AP42 C2	Threshold friction velocity cm/s
10513	ROM Coal	7.0	6.3	100 cm/s
10514	Overburden Coal	6.6	11.5	100 cm/s
10515	Haul Road	2.7	8.5	Not Tested
10516	Overburden Inactive	11.2	3.8	>100 cm/s
10517	Reject Coal	6.6	5.5	>100 cm/s
10518	Product Coal	8.5	4.5	100 cm/s
10519	ROM Coal Duplicate	6.8	6.4	100 cm/s
10520	Overburden Coal Duplicate	6.6	11.2	100 cm/s
10521	Haul Road Duplicate	2.7	8.4	Not Tested
10522	Overburden Inactive Duplicate	11.1	3.6	>100 cm/s
10523	Reject Coal Duplicate	6.3	5.4	>100 cm/s
10524	Product Coal Duplicate	8.2	4.4	100 cm/s

Note: 10515 & 10521 Haul Road Samples not tested for TFV due to insufficient sample to perform test.

Authorised Signatory:

Jason Lewis

Date: 9/04/2013

MACQUARIE GEOTECH

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3 Blakefield Rd
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ANALYTICAL REPORT

CARBON BASED ENVIRONMENTAL
ROAD WAY DUST SAMPLES

ATT: Mr Colin Davies

MONTH: Mar-11

OUR REF: HM10161

DATE 30-Mar-11

Sample Description: **GLENDELL MEGA RAMP**
Mass Sample (a.r.): 793.1 g
Total Moisture (a.r.): 3.3 %

SIZE ANALYSIS

Aperture (mm)		Fractional		Cumulative
(-)	(+)	Mass (g)	Mass (%)	Mass (%)
	8.0	98.1	24.7	24.7
8.0	**4.0**	76.5	19.2	43.9
4.0	**1.00**	121.6	30.6	74.5
1.00	**0.600**	29.5	7.4	81.9
0.600	**0.106**	62.5	15.7	97.6
0.106	**0.075**	4.9	1.2	98.8
0.075		4.7	1.2	100.0
	Total Mass (g)	397.80		

Sample Description: **GLENDELL NORTH RAMP 1**
Mass Sample (a.r.): 2801.5 g
Total Moisture (a.r.): 1.3 %

SIZE ANALYSIS

Aperture (mm)		Fractional		Cumulative
(-)	(+)	Mass (g)	Mass (%)	Mass (%)
	8.0	127.2	32.0	32.0
8.0	4.0	48.8	12.3	44.3
4.0	1.00	74.3	18.7	63.0
1.00	0.600	24.7	6.2	69.3
0.600	0.106	100.5	25.3	94.6
0.106	0.075	11.8	3.0	97.6
0.075		9.7	2.4	100.0
	Total Mass (g)	397.00		

Sample Description: **GLENDELL NORTH RAMP 2**
Mass Sample (a.r.): 3040.9 g
Total Moisture (a.r.): 1.1 %

SIZE ANALYSIS

Aperture (mm)		Fractional		Cumulative
(-)	(+)	Mass (g)	Mass (%)	Mass (%)
	8.0	61.5	15.5	15.5
8.0	4.0	51.2	12.9	28.5
4.0	1.00	92.6	23.4	51.9
1.00	0.600	31.6	8.0	59.8
0.600	0.106	130.4	32.9	92.8
0.106	0.075	19.0	4.8	97.6
0.075		9.6	2.4	100.0
	Total Mass (g)	395.90		

Steel River Testing

5/11 McIntosh Drive, Mayfield West NSW 2304
Phone: 02 49677880

Report To: Ralph Brown
AECOM - Singleton

Report: 5970

Date: 24-Feb-14

Project: 60304393 1.1

		Uncontrolled Haul Road 7-Feb-14			Controlled Haul Road #1 7-Feb-14		
Sample Mass (g):		742.3		11:10	71.4		11:15
SIZING - AS RECEIVED SAMPLE							
Size Distribution (mm)		**Wt (g)**	**Fractional Wt %**	**Cumulative Wt %**	**Wt (g)**	**Fractional Wt %**	**Cumulative Wt %**
	+2.00	28.5	31.5	31.5	40.9	57.3	57.3
-2.00	+0.075	48.9	54.0	85.5	29.8	41.7	99.0
-0.075		13.1	14.5	100.0	0.7	1.0	100.0
	Total	90.5			71.4		
SIZING - DRIED SAMPLE							
Start Mass (g)							
Size Distribution (mm)		**Wt (g)**	**Fractional Wt %**	**Cumulative Wt %**	**Wt (g)**	**Fractional Wt %**	**Cumulative Wt %**
	+2.00	28	31.4	31.4	40	57.7	57.7
-2.00	+0.250	30.6	34.3	65.7	26.8	38.7	96.4
-0.250	+0.075	16.9	18.9	84.6	1.9	2.7	99.1
-0.075		13.7	15.4	100.0	0.6	0.9	100.0
	Total	89.2			69.3		
MOISTURE							
Moisture (ar) %		1.6			2.9		

Note:
1. All sizings performed without water washing
2. Moisture determined after drying to constant mass at 105oC
3. Sampling by client

Reported By:
Belinda Evans

Steel River Testing

5/11 McIntosh Drive, Mayfield West NSW 2304
Phone: 02 49677880

Report To: Ralph Brown
AECOM - Singleton

Report: 5970

Date: 24-Feb-14

Project: 60304393 1.1

		Controlled Haul Road #2			Controlled Haul Road #3		
		7-Feb-14			7-Feb-14		
Sample Mass (g):		126.8		11:20	497.3		11:25
SIZING - AS RECEIVED SAMPLE							
Size Distribution (mm)		**Wt (g)**	**Fractional Wt %**	**Cumulative Wt %**	**Wt (g)**	**Fractional Wt %**	**Cumulative Wt %**
	+2.00	80	63.1	63.1	63.1	56.7	56.7
-2.00	+0.075	45.6	36.0	99.1	45.9	41.3	98.0
-0.075		1.2	0.9	100.0	2.2	2.0	100.0
	Total	126.8			111.2		
SIZING - DRIED SAMPLE							
Start Mass (g)							
Size Distribution (mm)		**Wt (g)**	**Fractional Wt %**	**Cumulative Wt %**	**Wt (g)**	**Fractional Wt %**	**Cumulative Wt %**
	+2.00	78.2	62.7	62.7	62.6	56.7	56.7
-2.00	+0.250	42.9	34.4	97.1	40.8	37.0	93.7
-0.250	+0.075	2.1	1.7	98.8	4.7	4.3	97.9
-0.075		1.5	1.2	100.0	2.3	2.1	100.0
	Total	124.7			110.4		
MOISTURE							
Moisture (ar) %		1.7			1.9		

Note:
1. All sizings performed without water washing
2. Moisture determined after drying to constant mass at 105oC
3. Sampling by client

Reported By: Belinda Evans

Appendix D Predictions At All Residences – Project Only

Table D1: Predictions for Project Only – Year 1
(shading indicates an exceedance of the relevant criterion)

Receptor ID	24-hour Average $PM_{2.5}$	24-hour Average PM_{10}	Annual Average $PM_{2.5}$	Annual Average PM_{10}	Annual Average TSP	Dust Deposition
Acquisition/Assessment Criterion	-	*50 µg/m³*	-	-	-	*2 g/m²/month*
Private Receptors (including those with acquisition rights)						
2	3	24	1	4	12	0.3
4	3	26	1	4	13	0.3
5	3	20	1	4	12	0.3
6	3	22	1	4	12	0.3
7a	3	23	1	4	13	0.3
7b	3	23	1	4	12	0.3
7c	3	22	1	4	11	0.3
10	4	23	1	3	11	0.4
11	3	21	0	3	10	0.4
12	4	22	0	3	10	0.4
13	5	19	0	2	7	0.2
14	4	16	0	2	6	0.2
15b	4	18	0	2	5	0.2
15a	4	21	0	2	5	0.2
17	4	25	0	2	5	0.2
19	5	25	0	3	11	0.4
21	4	25	1	4	12	0.5
22	4	25	1	4	12	0.5
23	4	27	1	4	13	0.5
41	2	16	0	1	2	0.0
42	2	12	0	1	2	0.1
43	2	11	0	0	2	0.0
44a	2	12	0	0	1	0.0
45	2	13	0	0	1	0.0
46	2	12	0	0	1	0.0
47	2	11	0	0	1	0.0
48	2	15	0	1	2	0.0
49	2	10	0	0	1	0.0
50	1	9	0	0	1	0.0
51	2	11	0	0	1	0.0
52	1	10	0	0	1	0.0
53	1	8	0	0	1	0.0
54	1	7	0	0	1	0.0
55	1	10	0	0	1	0.0
56b	2	11	0	0	1	0.0
57	2	10	0	0	1	0.0
58	2	11	0	1	2	0.0
59	2	12	0	1	2	0.0
60	2	9	0	1	2	0.0
61	2	9	0	1	2	0.0
62	2	9	0	1	2	0.1
63a	3	9	0	1	2	0.0
162b	3	12	0	1	2	0.1
350	3	10	0	1	2	0.0
66	3	12	0	1	2	0.0
67	2	10	0	1	2	0.0
68	2	10	0	1	2	0.1
69b	2	7	0	1	2	0.1
69a	2	7	0	1	2	0.1
71	1	7	0	1	2	0.1
72	3	19	0	1	3	0.1
73	2	9	0	1	3	0.1
74	3	19	0	1	4	0.1
75	2	12	0	1	3	0.1
76	2	11	0	1	3	0.1
77	2	11	0	1	3	0.1
78	3	19	0	1	2	0.1
79	3	19	0	1	2	0.1
80	3	15	0	1	3	0.1
81	3	16	0	1	3	0.1
82	3	16	0	1	3	0.1
83	3	12	0	1	4	0.1
84a	2	10	0	1	3	0.1
85	2	10	0	1	4	0.1

Receptor ID	24-hour Average PM2.5	24-hour Average PM10	Annual Average PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
			Acquisition/Assessment Criterion			
	-	50 $\mu g/m^3$	-	-	-	2 g/m^2/month
86	2	10	0	1	4	0.2
87	2	11	0	1	4	0.1
88	3	12	0	2	5	0.2
89	2	13	0	2	5	0.2
91	2	13	0	2	6	0.2
92	3	18	0	3	8	0.3
93	3	20	0	3	8	0.3
94	3	16	0	2	6	0.2
95	4	15	0	2	5	0.2
96	2	10	0	2	5	0.2
97	2	11	0	2	5	0.2
98	2	12	0	2	5	0.2
99	3	14	0	2	6	0.2
100	3	17	0	2	7	0.2
101	3	15	0	2	6	0.2
102a	3	15	0	2	7	0.2
102b	3	15	0	2	7	0.2
105	3	19	1	4	13	0.3
111	4	24	1	3	10	0.1
112	4	28	1	4	14	0.5
114	4	31	1	5	16	0.5
116	3	23	1	4	14	0.4
122	5	30	1	6	20	0.4
127b	5	22	0	3	8	0.1
127a	4	15	0	2	5	0.1
133	10	39	1	3	10	0.2
134	9	35	0	2	7	0.1
135	8	33	0	2	7	0.1
136	7	29	0	2	6	0.1
137d	6	24	0	2	5	0.1
138	8	33	0	2	6	0.1
137c	7	27	0	2	5	0.1
137b	7	27	0	2	5	0.1
137a	7	26	0	2	5	0.1
142	8	30	0	2	5	0.1
143	4	18	0	2	5	0.1
144a	2	11	0	1	2	0.0
145	2	10	0	1	2	0.0
146	3	12	0	1	3	0.0
147	2	10	0	1	3	0.0
148	3	14	0	1	4	0.0
149	3	15	0	1	4	0.0
150	4	16	0	1	4	0.0
152	4	17	0	1	4	0.0
154	4	18	0	2	5	0.1
155	4	19	0	2	5	0.1
156	4	20	0	2	5	0.1
163	4	15	0	2	5	0.2
185	7	26	0	1	3	0.0
189a	4	16	0	1	2	0.0
189b	3	14	0	1	2	0.0
191	3	11	0	1	2	0.0
192	4	12	0	0	1	0.0
181	4	11	0	0	1	0.0
196	2	7	0	0	1	0.0
194a	2	7	0	0	1	0.0
195b	1	5	0	0	1	0.0
195a	1	6	0	0	1	0.0
194b	1	6	0	0	1	0.0
197a	1	6	0	0	1	0.0
197b	1	7	0	0	1	0.0
208	1	5	0	0	0	0.0
337	1	4	0	0	1	0.0
209	1	5	0	0	1	0.0
215	1	4	0	0	1	0.0
216	1	4	0	0	1	0.0
217	1	4	0	0	1	0.0
210	1	7	0	0	1	0.0

Receptor ID	24-hour Average PM2.5	24-hour Average PM10	Annual Average PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
Acquisition/Assessment Criterion	-	50 µg/m³	-	-	-	2 g/m²/month
211	1	9	0	0	1	0.0
178	1	7	0	0	1	0.0
212	1	9	0	0	1	0.0
213	1	7	0	0	1	0.0
56a	2	11	0	0	1	0.0
44b	2	13	0	2	5	0.2
218	1	4	0	0	1	0.0
220	1	4	0	0	1	0.0
224	1	4	0	0	1	0.0
223c	1	5	0	0	1	0.0
223a	1	5	0	0	1	0.0
223b	1	5	0	0	1	0.0
214	1	5	0	0	1	0.0
226	2	6	0	0	1	0.0
228	2	6	0	0	1	0.0
227	2	7	0	0	1	0.0
229	2	7	0	0	1	0.0
230	2	9	0	0	1	0.0
221	2	9	0	0	1	0.0
248	2	11	0	0	1	0.0
232	2	10	0	0	1	0.0
249	3	11	0	0	1	0.0
233	2	9	0	0	1	0.0
234	2	10	0	0	1	0.0
235	2	10	0	0	1	0.0
236	2	9	0	0	1	0.0
245	2	8	0	0	1	0.0
241	1	6	0	0	1	0.0
237b	1	7	0	0	1	0.0
237a	2	7	0	0	1	0.0
240	1	3	0	0	1	0.0
242	1	4	0	0	1	0.0
244	1	3	0	0	1	0.0
243	1	4	0	0	1	0.0
246	1	5	0	0	1	0.0
347	1	6	0	0	1	0.0
247	2	11	0	0	1	0.0
250	2	11	0	0	1	0.0
251	2	11	0	0	1	0.0
252	2	8	0	0	1	0.0
253	1	5	0	0	2	0.0
348	1	4	0	0	1	0.0
254	1	5	0	1	2	0.0
255	1	6	0	1	2	0.1
277	1	6	0	1	2	0.1
287	2	9	0	1	4	0.1
285	1	7	0	1	3	0.1
283	1	8	0	1	3	0.1
274	1	7	0	1	3	0.1
272	1	9	0	1	4	0.1
270	2	9	0	1	4	0.1
279	2	13	0	2	5	0.2
281	3	14	0	2	6	0.2
280	2	10	0	0	1	0.0
282	3	19	0	3	8	0.2
290	3	18	0	2	7	0.2
164	2	15	0	2	7	0.2
292a	2	17	0	2	7	0.2
292b	2	16	0	2	7	0.2
289	2	15	0	2	7	0.2
288	2	13	0	2	6	0.2
294	2	14	0	2	7	0.2
293	2	16	0	2	7	0.2
295	2	15	0	2	7	0.1
296	2	14	0	2	6	0.1
297d	2	13	0	2	6	0.1
297a	2	16	0	2	6	0.1
297b	3	16	0	2	6	0.1

Receptor ID	24-hour Average PM2.5	24-hour Average PM10	Annual Average PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
Acquisition/Assessment Criterion	-	*50 µg/m³*	-	-	-	*2 g/m²/month*
297c	2	16	0	2	6	0.1
299	3	17	0	2	6	0.1
300	3	18	0	2	6	0.1
302	3	16	0	2	5	0.1
303	2	12	0	2	5	0.1
349b	2	15	0	2	5	0.1
349a	2	15	0	2	5	0.1
305	2	15	0	2	5	0.1
298	2	14	0	2	5	0.2
304b	2	12	0	2	5	0.2
304a	2	13	0	2	5	0.2
306	3	16	0	2	5	0.1
307	3	16	0	2	5	0.1
308	3	16	0	2	5	0.1
309	3	16	0	2	5	0.1
310	3	16	0	2	5	0.1
311	2	15	0	2	5	0.1
312	2	15	0	2	5	0.1
319	3	19	0	3	8	0.2
320	3	15	0	2	5	0.1
321	3	15	0	2	5	0.1
318	3	15	0	2	5	0.1
322	3	15	0	2	5	0.1
317	2	15	0	2	4	0.1
316	2	15	0	2	4	0.1
323	2	15	0	2	5	0.1
324	3	16	0	2	5	0.1
315	2	14	0	1	4	0.1
314	2	14	0	1	4	0.1
330	2	11	0	1	4	0.1
329	1	9	0	0	1	0.0
328	2	14	0	1	4	0.1
327	2	14	0	1	4	0.1
326	2	15	0	2	4	0.1
325	3	15	0	2	5	0.1
144c	1	6	0	0	1	0.0
144b	1	7	0	0	1	0.0
278	1	7	0	1	3	0.1
84b	2	9	0	1	3	0.1
137e	5	22	0	1	3	0.1
259	3	13	0	1	3	0.1
260	3	14	0	1	3	0.1
127c	5	20	0	2	7	0.1
354	2	9	0	1	2	0.0
Mine Owned Receptors						
1	3	19	1	4	11	0.3
3	3	20	1	4	12	0.3
20	6	28	0	3	10	0.4
24	5	29	1	4	13	0.5
25	7	30	1	4	14	0.5
26	7	28	1	4	13	0.5
27	5	31	1	5	16	0.6
28	7	35	1	5	16	0.6
29	6	35	1	5	18	0.7
30	6	39	1	7	23	0.9
31	7	46	1	7	25	1.1
32	10	43	1	6	18	0.7
33	9	50	1	5	15	0.5
34	9	52	1	4	14	0.5
35	9	49	1	4	14	0.5
36	9	57	1	5	16	0.6
38	10	55	1	8	29	1.2
39	10	48	1	7	24	1.0
40	7	25	0	2	6	0.2
90	2	13	0	2	6	0.2
104	3	15	0	2	7	0.2
107	5	23	1	5	15	0.3
108	4	25	1	5	15	0.2

Receptor ID	24-hour Average		Annual Average			Dust Deposition
	PM2.5	PM10	PM2.5	PM10	TSP	
	Acquisition/Assessment Criterion					
	-	*50 µg/m³*	-	-	-	*2 g/m²/month*
109	4	25	1	5	15	0.2
110	4	24	1	4	11	0.2
117	5	25	1	5	15	0.4
120	6	28	1	5	17	0.4
121	5	31	1	6	20	0.4
123	5	26	1	6	18	0.3
124	5	25	1	6	19	0.3
125	4	24	1	5	17	0.3
126	4	25	1	5	17	0.3
129	5	25	1	3	10	0.1
130	5	26	0	3	9	0.1
131	12	72	1	7	24	0.4
151	4	18	0	1	4	0.0
351	4	18	0	2	5	0.0
157	5	24	1	4	14	0.2
158	2	11	0	1	2	0.0
159	3	11	0	1	3	0.0
160	2	11	0	1	2	0.0
162a	5	17	0	1	4	0.1
344	3	15	0	2	7	0.2
165	3	15	0	2	7	0.2
291	2	8	0	1	2	0.0
342	4	22	0	2	5	0.1
166	3	18	0	2	5	0.0
352	3	15	0	1	4	0.0
353	3	13	0	1	4	0.0

Table D2: Predictions for Project Only – Year 5 (shading indicates an exceedance of the relevant criterion)

Receptor ID	24-hour Average PM2.5	24-hour Average PM10	Annual Average PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
Acquisition/Assessment Criterion	-	*50 µg/m³*	-	-	-	*2 g/m²/month*
Private Receptors (including those with acquisition rights)						
2	4	29	1	5	16	0.3
4	5	31	1	6	18	0.5
5	4	29	1	5	15	0.4
6	4	29	1	5	15	0.4
7a	4	29	1	5	15	0.4
7b	4	28	1	5	15	0.4
7c	3	24	1	4	14	0.4
10	4	24	1	4	13	0.4
11	4	23	1	4	12	0.4
12	4	24	1	4	12	0.4
13	5	20	0	2	7	0.2
14	4	18	0	2	6	0.2
15b	4	20	0	2	6	0.2
15a	4	22	0	2	6	0.2
17	5	25	0	2	5	0.2
19	5	24	1	4	11	0.4
21	4	26	1	4	14	0.5
22	4	26	1	5	14	0.5
23	4	27	1	5	16	0.6
41	2	18	0	1	2	0.0
42	2	16	0	1	2	0.0
43	2	14	0	0	1	0.0
44a	2	13	0	0	1	0.0
45	2	13	0	0	1	0.0
46	2	12	0	0	1	0.0
47	2	10	0	0	1	0.0
48	2	13	0	1	2	0.0
49	2	11	0	0	1	0.0
50	1	9	0	0	1	0.0
51	1	10	0	0	1	0.0
52	1	7	0	0	1	0.0
53	1	6	0	0	1	0.0
54	1	6	0	0	1	0.0
55	2	13	0	0	1	0.0
56b	2	12	0	0	1	0.0
57	2	11	0	0	1	0.0
58	2	13	0	1	2	0.0
59	2	14	0	1	2	0.0
60	2	9	0	1	2	0.0
61	2	10	0	1	2	0.0
62	2	9	0	1	2	0.0
63a	3	10	0	1	2	0.0
162b	3	13	0	1	2	0.1
350	3	11	0	1	2	0.0
66	3	15	0	1	2	0.0
67	2	13	0	1	2	0.0
68	2	13	0	1	2	0.1
69b	2	10	0	1	2	0.1
69a	2	11	0	1	2	0.1
71	2	8	0	1	2	0.1
72	4	17	0	1	3	0.1
73	2	9	0	1	3	0.1
74	4	21	0	1	4	0.1
75	3	12	0	1	3	0.1
76	3	11	0	1	3	0.1
77	3	11	0	1	3	0.1
78	4	16	0	1	2	0.1
79	4	16	0	1	2	0.1
80	3	14	0	1	3	0.1
81	3	14	0	1	3	0.1
82	3	16	0	1	3	0.1
83	3	13	0	1	4	0.1
84a	2	12	0	1	3	0.1
85	2	10	0	1	4	0.1

Receptor ID	24-hour Average PM2.5	24-hour Average PM10	Annual Average PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
			Acquisition/Assessment Criterion			
	-	*50 µg/m³*	-	-	-	*2 g/m²/month*
86	2	12	0	1	4	0.1
87	2	11	0	1	4	0.1
88	2	12	0	2	5	0.2
89	2	13	0	2	6	0.2
91	3	17	0	2	7	0.2
92	3	20	0	3	10	0.3
93	3	20	0	3	9	0.3
94	3	16	0	2	6	0.2
95	3	15	0	2	5	0.2
96	2	14	0	2	6	0.2
97	2	14	0	2	6	0.2
98	2	12	0	2	6	0.2
99	2	16	0	2	7	0.2
100	3	16	0	3	8	0.2
101	2	15	0	2	7	0.2
102a	3	16	0	3	8	0.2
102b	3	17	0	3	8	0.2
105	6	41	1	6	18	0.4
111	5	26	1	3	10	0.1
112	4	31	1	6	18	0.5
114	7	48	1	8	24	0.6
116	7	50	1	7	21	0.5
122	5	29	1	6	20	0.3
127b	5	24	0	3	8	0.1
127a	4	18	0	2	5	0.1
133	10	38	1	4	12	0.2
134	11	43	0	3	8	0.1
135	11	42	0	2	7	0.1
136	10	37	0	2	7	0.1
137d	8	29	0	2	6	0.1
138	11	41	0	2	6	0.1
137c	9	32	0	2	5	0.1
137b	8	32	0	2	5	0.1
137a	8	31	0	2	5	0.1
142	10	37	0	2	5	0.1
143	4	19	0	2	6	0.1
144a	3	14	0	1	2	0.0
145	3	14	0	1	2	0.0
146	3	14	0	1	4	0.0
147	3	11	0	1	3	0.0
148	3	15	0	1	4	0.0
149	4	17	0	1	4	0.0
150	4	18	0	1	5	0.0
152	4	18	0	2	5	0.0
154	4	19	0	2	6	0.1
155	4	19	0	2	6	0.1
156	4	20	0	2	6	0.1
163	3	15	0	2	5	0.2
185	4	15	0	1	3	0.0
189a	3	12	0	1	2	0.0
189b	2	11	0	1	2	0.0
191	4	12	0	1	2	0.0
192	4	12	0	0	2	0.0
181	3	10	0	0	2	0.0
196	2	6	0	0	1	0.0
194a	1	7	0	0	1	0.0
195b	2	7	0	0	1	0.0
195a	2	8	0	0	1	0.0
194b	2	7	0	0	1	0.0
197a	1	6	0	0	1	0.0
197b	1	5	0	0	1	0.0
208	1	5	0	0	0	0.0
337	1	5	0	0	1	0.0
209	1	5	0	0	1	0.0
215	1	4	0	0	1	0.0
216	1	4	0	0	1	0.0
217	1	4	0	0	1	0.0
210	1	6	0	0	1	0.0

Receptor ID	24-hour Average		Annual Average			Dust Deposition
	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	TSP	Dust Deposition
	Acquisition/Assessment Criterion					
	-	50 µg/m³	-	-	-	2 g/m²/month
211	1	6	0	0	1	0.0
178	1	5	0	0	1	0.0
212	1	7	0	0	1	0.0
213	1	7	0	0	1	0.0
56a	2	12	0	0	1	0.0
44b	2	13	0	2	6	0.2
218	1	5	0	0	1	0.0
220	1	5	0	0	1	0.0
224	1	5	0	0	1	0.0
223c	1	5	0	0	1	0.0
223a	2	5	0	0	1	0.0
223b	2	6	0	0	1	0.0
214	2	5	0	0	1	0.0
226	2	7	0	0	1	0.0
228	2	9	0	0	1	0.0
227	2	8	0	0	1	0.0
229	3	9	0	0	1	0.0
230	3	11	0	0	1	0.0
221	3	11	0	0	1	0.0
248	3	13	0	0	1	0.0
232	3	12	0	0	1	0.0
249	3	13	0	0	1	0.0
233	3	11	0	0	1	0.0
234	3	11	0	0	1	0.0
235	2	10	0	0	1	0.0
236	2	8	0	0	1	0.0
245	2	7	0	0	1	0.0
241	1	5	0	0	1	0.0
237b	1	5	0	0	1	0.0
237a	1	5	0	0	1	0.0
240	1	3	0	0	1	0.0
242	1	4	0	0	1	0.0
244	1	4	0	0	1	0.0
243	1	5	0	0	1	0.0
246	1	7	0	0	1	0.0
347	1	8	0	0	1	0.0
247	3	13	0	0	1	0.0
250	3	14	0	0	1	0.0
251	3	13	0	0	1	0.0
252	2	11	0	0	2	0.0
253	1	7	0	1	2	0.0
348	1	6	0	0	1	0.0
254	1	6	0	1	2	0.0
255	1	7	0	1	2	0.1
277	1	8	0	1	3	0.1
287	1	9	0	1	4	0.1
285	1	8	0	1	3	0.1
283	1	10	0	1	4	0.1
274	1	9	0	1	3	0.1
272	2	11	0	1	4	0.1
270	2	12	0	2	5	0.2
279	2	12	0	2	6	0.2
281	2	16	0	2	7	0.2
280	2	11	0	0	1	0.0
282	3	23	0	3	9	0.2
290	3	21	0	3	8	0.2
164	3	25	0	3	8	0.2
292a	3	21	0	3	8	0.2
292b	3	21	0	3	8	0.2
289	2	17	0	3	8	0.2
288	2	16	0	2	7	0.2
294	3	22	0	3	8	0.2
293	3	22	0	3	8	0.2
295	3	19	0	2	7	0.1
296	2	16	0	2	7	0.1
297d	2	17	0	2	6	0.1
297a	3	18	0	2	6	0.1
297b	3	18	0	2	6	0.1

Receptor ID	24-hour Average PM2.5	24-hour Average PM10	Annual Average PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
	Acquisition/Assessment Criterion					
	-	50 µg/m³	-	-	-	2 g/m²/month
297c	3	18	0	2	6	0.1
299	3	19	0	2	6	0.1
300	3	19	0	2	6	0.1
302	3	17	0	2	6	0.1
303	2	15	0	2	6	0.1
349b	3	17	0	2	6	0.1
349a	3	17	0	2	6	0.1
305	3	17	0	2	6	0.1
298	2	16	0	2	6	0.2
304b	2	13	0	2	5	0.2
304a	2	13	0	2	5	0.2
306	3	16	0	2	5	0.1
307	3	17	0	2	5	0.1
308	3	17	0	2	5	0.1
309	3	17	0	2	5	0.1
310	3	17	0	2	5	0.1
311	2	16	0	2	5	0.1
312	2	16	0	2	5	0.1
319	3	23	0	3	9	0.2
320	3	16	0	2	5	0.1
321	2	15	0	2	5	0.1
318	2	15	0	2	5	0.1
322	2	15	0	2	5	0.1
317	2	14	0	2	5	0.1
316	2	14	0	1	5	0.1
323	2	14	0	2	5	0.1
324	2	15	0	2	5	0.1
315	2	14	0	1	4	0.1
314	2	14	0	1	4	0.1
330	2	12	0	1	4	0.1
329	1	9	0	0	1	0.0
328	2	14	0	1	4	0.1
327	2	14	0	1	4	0.1
326	2	14	0	2	5	0.1
325	2	15	0	2	5	0.1
144c	2	8	0	0	1	0.0
144b	2	9	0	0	1	0.0
278	1	9	0	1	4	0.1
84b	2	10	0	1	4	0.1
137e	8	31	0	1	4	0.1
259	3	14	0	1	3	0.1
260	3	15	0	1	3	0.1
127c	5	23	0	2	8	0.1
354	2	11	0	1	2	0
Mine Owned Receptors						
1	4	27	1	4	14	0.3
3	4	28	1	5	15	0.3
20	6	25	1	3	10	0.4
24	5	29	1	5	16	0.6
25	6	29	1	5	16	0.6
26	6	27	1	5	15	0.6
27	5	30	1	6	20	0.7
28	6	31	1	6	19	0.7
29	6	33	1	7	22	0.7
30	8	53	1	10	31	1.0
31	9	56	1	10	31	1.1
32	12	48	1	6	18	0.6
33	11	44	1	5	15	0.5
34	10	54	1	4	14	0.5
35	10	52	1	4	14	0.4
36	11	58	1	5	16	0.5
38	12	64	1	9	30	1.2
39	12	55	1	8	25	0.9
40	7	31	0	2	6	0.2
90	2	14	0	2	6	0.2
104	3	17	0	3	9	0.2
107	5	28	1	5	16	0.2
108	4	27	1	5	15	0.2

Receptor ID	24-hour Average PM2.5	24-hour Average PM10	Annual Average PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
			Acquisition/Assessment Criterion			
	-	*50 µg/m³*	-	-	-	*2 g/m²/month*
109	4	28	1	5	15	0.2
110	5	27	1	4	12	0.1
117	7	40	1	7	22	0.5
120	6	33	1	6	20	0.4
121	5	28	1	6	19	0.3
123	5	33	1	6	20	0.3
124	5	28	1	6	18	0.3
125	5	31	1	6	18	0.3
126	5	28	1	5	17	0.2
129	5	25	1	3	10	0.1
130	5	24	1	3	9	0.1
131	17	91	1	9	29	0.5
151	4	19	0	2	5	0.0
351	4	19	0	2	5	0.0
157	6	32	1	5	15	0.2
158	3	15	0	1	2	0.0
159	3	13	0	1	3	0.0
160	3	16	0	1	3	0.0
162a	6	22	0	1	4	0.1
344	3	24	0	3	8	0.2
165	3	24	0	3	8	0.2
291	2	10	0	1	2	0.0
342	4	22	0	1	5	0.0
166	4	21	0	2	6	0.1
352	4	15	0	1	5	0.0
353	3	13	0	1	4	0.0

Table D3: Predictions for Project Only – Year 10
(shading indicates an exceedance of the relevant criterion)

Receptor ID	24-hour Average		Annual Average			Dust Deposition
	$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}	TSP	
	Acquisition/Assessment Criterion					
	-	*50 µg/m³*	-	-	-	*2 g/m²/month*
Private Receptors (including those with acquisition rights)						
2	5	32	1	5	14	0.3
4	6	36	1	6	17	0.5
5	5	30	1	5	13	0.3
6	4	28	1	4	12	0.3
7a	5	34	1	4	13	0.3
7b	5	33	1	4	13	0.3
7c	5	27	0	3	10	0.3
10	5	38	0	3	8	0.2
11	6	42	0	3	7	0.2
12	6	43	0	3	7	0.2
13	4	26	0	2	4	0.1
14	4	20	0	1	4	0.1
15b	4	21	0	1	4	0.1
15a	4	23	0	1	4	0.1
17	4	19	0	1	3	0.1
19	4	32	0	2	7	0.2
21	6	47	0	3	8	0.3
22	6	48	0	3	8	0.3
23	7	51	0	3	9	0.3
41	1	10	0	0	1	0.0
42	1	8	0	0	1	0.0
43	1	7	0	0	1	0.0
44a	1	7	0	0	1	0.0
45	1	9	0	0	1	0.0
46	1	8	0	0	1	0.0
47	1	8	0	0	1	0.0
48	1	9	0	0	1	0.0
49	1	8	0	0	1	0.0
50	1	7	0	0	1	0.0
51	1	7	0	0	1	0.0
52	1	5	0	0	1	0.0
53	1	4	0	0	1	0.0
54	1	5	0	0	1	0.0
55	1	7	0	0	1	0.0
56b	1	7	0	0	1	0.0
57	1	7	0	0	1	0.0
58	1	8	0	0	1	0.0
59	1	8	0	0	1	0.0
60	1	8	0	0	1	0.0
61	1	8	0	0	1	0.0
62	1	8	0	0	1	0.0
63a	2	8	0	0	1	0.0
162b	2	8	0	0	1	0.0
350	2	8	0	0	1	0.0
66	3	9	0	0	1	0.0
67	3	13	0	0	1	0.0
68	4	15	0	0	1	0.0
69b	3	14	0	0	1	0.0
69a	4	15	0	1	1	0.0
71	3	13	0	0	1	0.0
72	1	6	0	0	1	0.0
73	4	16	0	1	1	0.0
74	2	9	0	1	2	0.1
75	2	10	0	1	2	0.0
76	3	13	0	1	2	0.0
77	3	13	0	1	2	0.0
78	1	6	0	0	1	0.0

Receptor ID	24-hour Average PM2.5	PM10	Annual Average PM2.5	PM10	TSP	Dust Deposition
	-	50 µg/m³	-	- (Acquisition/Assessment Criterion)	-	2 g/m²/month
79	1	6	0	0	1	0.0
80	1	5	0	1	1	0.0
81	1	6	0	1	1	0.0
82	2	12	0	1	2	0.1
83	2	12	0	1	2	0.1
84a	2	11	0	1	2	0.1
85	2	12	0	1	2	0.1
86	2	16	0	1	3	0.1
87	2	13	0	1	3	0.1
88	2	16	0	1	3	0.1
89	3	24	0	1	4	0.1
91	3	25	0	2	4	0.1
92	3	24	0	2	6	0.2
93	4	32	0	2	5	0.1
94	3	20	0	2	4	0.1
95	3	17	0	1	4	0.1
96	2	15	0	1	4	0.1
97	3	18	0	1	4	0.1
98	3	23	0	1	3	0.1
99	2	16	0	2	4	0.1
100	3	16	0	2	5	0.1
101	3	15	0	2	5	0.1
102a	3	19	0	2	5	0.1
102b	2	18	0	2	6	0.2
105	6	49	1	7	20	0.5
111	4	24	0	3	6	0.1
112	6	33	1	4	12	0.4
114	8	44	1	8	24	0.7
116	7	50	1	8	23	0.6
122	6	31	1	6	13	0.2
127b	4	21	0	2	4	0.0
127a	4	18	0	1	3	0.0
133	8	30	0	2	6	0.1
134	10	38	0	2	4	0.1
135	9	37	0	2	4	0.1
136	8	30	0	2	4	0.1
137d	7	26	0	1	3	0.1
138	10	39	0	2	4	0.1
137c	8	31	0	1	3	0.0
137b	8	31	0	1	3	0.0
137a	8	30	0	1	3	0.0
142	10	36	0	1	3	0.0
143	3	18	0	1	3	0.0
144a	3	15	0	0	1	0.0
145	3	14	0	1	1	0.0
146	3	13	0	1	2	0.0
147	2	10	0	1	2	0.0
148	4	16	0	1	2	0.0
149	3	16	0	1	2	0.0
150	3	16	0	1	2	0.0
152	3	17	0	1	2	0.0
154	3	17	0	1	3	0.0
155	3	17	0	1	3	0.0
156	3	18	0	2	3	0.0
163	3	17	0	1	4	0.1
185	6	23	0	1	2	0.0
189a	4	19	0	1	1	0.0
189b	4	17	0	1	1	0.0
191	3	12	0	0	1	0.0
192	2	9	0	0	1	0.0

Receptor ID	24-hour Average PM2.5	24-hour Average PM10	Annual Average PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
	-	50 µg/m³	-	-	-	2 g/m²/month
			Acquisition/Assessment Criterion			
181	2	10	0	0	1	0.0
196	1	7	0	0	1	0.0
194a	1	5	0	0	1	0.0
195b	1	5	0	0	0	0.0
195a	1	5	0	0	0	0.0
194b	1	5	0	0	0	0.0
197a	1	5	0	0	0	0.0
197b	1	6	0	0	0	0.0
208	1	3	0	0	0	0.0
337	1	5	0	0	0	0.0
209	1	4	0	0	0	0.0
215	1	4	0	0	0	0.0
216	1	3	0	0	0	0.0
217	1	3	0	0	0	0.0
210	1	5	0	0	0	0.0
211	1	4	0	0	0	0.0
178	1	4	0	0	0	0.0
212	1	5	0	0	1	0.0
213	1	6	0	0	1	0.0
56a	1	7	0	0	1	0.0
44b	3	24	0	1	4	0.1
218	1	4	0	0	0	0.0
220	1	4	0	0	0	0.0
224	1	4	0	0	0	0.0
223c	1	5	0	0	0	0.0
223a	1	5	0	0	0	0.0
223b	1	5	0	0	0	0.0
214	1	5	0	0	1	0.0
226	1	6	0	0	1	0.0
228	2	8	0	0	1	0.0
227	1	7	0	0	1	0.0
229	2	8	0	0	1	0.0
230	2	9	0	0	1	0.0
221	2	8	0	0	1	0.0
248	3	11	0	0	1	0.0
232	3	12	0	0	1	0.0
249	3	11	0	0	1	0.0
233	3	12	0	0	1	0.0
234	3	10	0	0	1	0.0
235	3	9	0	0	1	0.0
236	2	7	0	0	1	0.0
245	2	7	0	0	1	0.0
241	2	5	0	0	0	0.0
237b	1	5	0	0	0	0.0
237a	2	5	0	0	0	0.0
240	1	4	0	0	0	0.0
242	1	5	0	0	1	0.0
244	1	5	0	0	1	0.0
243	1	6	0	0	1	0.0
246	2	8	0	0	1	0.0
347	3	10	0	0	1	0.0
247	4	13	0	0	1	0.0
250	4	12	0	0	1	0.0
251	4	12	0	0	1	0.0
252	3	12	0	0	1	0.0
253	2	10	0	0	1	0.0
348	1	7	0	0	1	0.0
254	1	8	0	0	1	0.0
255	1	7	0	0	1	0.0
277	2	11	0	1	2	0.1

Receptor ID	24-hour Average PM2.5	24-hour Average PM10	Annual Average PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
	Acquisition/Assessment Criterion					
	-	50 µg/m³	-	-	-	2 g/m²/month
287	1	10	0	1	3	0.1
285	1	7	0	1	2	0.1
283	1	9	0	1	2	0.1
274	2	15	0	1	2	0.1
272	1	10	0	1	3	0.1
270	2	11	0	1	3	0.1
279	2	14	0	1	4	0.1
281	2	16	0	2	4	0.1
280	1	7	0	0	1	0.0
282	3	22	0	3	7	0.2
290	2	18	0	3	6	0.2
164	4	32	0	3	8	0.2
292a	3	21	0	3	6	0.2
292b	3	21	0	3	7	0.2
289	2	14	0	2	5	0.1
288	2	14	0	2	5	0.1
294	3	26	0	3	6	0.1
293	4	30	0	3	7	0.1
295	4	31	0	3	6	0.1
296	4	30	0	2	5	0.1
297d	4	29	0	2	5	0.1
297a	3	18	0	2	4	0.1
297b	2	17	0	2	4	0.1
297c	3	18	0	2	4	0.1
299	2	16	0	2	3	0.1
300	2	17	0	2	3	0.0
302	2	16	0	1	3	0.0
303	3	25	0	2	4	0.1
349b	2	17	0	2	3	0.1
349a	2	17	0	2	3	0.1
305	3	18	0	2	3	0.1
298	2	13	0	2	4	0.1
304b	1	10	0	2	4	0.1
304a	1	11	0	2	4	0.1
306	2	15	0	1	3	0.0
307	2	16	0	1	3	0.0
308	2	16	0	1	3	0.0
309	2	16	0	1	3	0.0
310	2	16	0	1	3	0.0
311	2	16	0	1	3	0.0
312	2	15	0	1	2	0.0
319	3	22	0	3	7	0.2
320	2	15	0	1	3	0.0
321	2	14	0	1	2	0.0
318	2	14	0	1	2	0.0
322	2	13	0	1	2	0.0
317	2	13	0	1	2	0.0
316	2	12	0	1	2	0.0
323	2	12	0	1	2	0.0
324	2	13	0	1	2	0.0
315	2	11	0	1	2	0.0
314	2	12	0	1	2	0.0
330	2	11	0	1	2	0.0
329	1	7	0	0	1	0.0
328	2	11	0	1	2	0.0
327	2	11	0	1	2	0.0
326	2	11	0	1	2	0.0
325	2	12	0	1	2	0.0
144c	1	7	0	0	1	0.0
144b	1	8	0	0	1	0.0

Receptor ID	24-hour Average PM2.5	24-hour Average PM10	Annual Average PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
			Acquisition/Assessment Criterion			
	-	50 µg/m³	-	-	-	2 g/m²/month
278	1	8	0	1	2	0.1
84b	2	14	0	1	2	0.1
137e	7	26	0	1	2	0.0
259	3	18	0	1	2	0.1
260	3	18	0	1	2	0.1
127c	4	22	0	2	4	0.0
354	2	11	0	1	2	0.0
Mine Owned Receptors						
1	4	27	1	4	11	0.3
3	5	30	1	5	13	0.3
20	6	34	0	2	6	0.2
24	7	50	0	3	9	0.3
25	6	44	0	3	9	0.3
26	5	39	0	3	9	0.3
27	8	59	1	4	11	0.4
28	7	52	1	4	11	0.3
29	8	64	1	4	12	0.4
30	14	88	1	8	23	0.7
31	16	70	1	7	20	0.6
32	12	49	1	3	9	0.3
33	11	43	0	3	7	0.2
34	11	42	0	2	7	0.2
35	11	40	0	2	6	0.2
36	11	43	0	3	8	0.2
38	9	52	1	4	12	0.4
39	11	52	1	4	11	0.4
40	3	13	0	1	2	0.1
90	3	24	0	1	4	0.1
104	3	19	0	2	6	0.2
107	5	33	1	5	11	0.2
108	4	24	1	5	9	0.1
109	4	24	1	5	9	0.1
110	4	22	1	3	6	0.1
117	8	62	1	9	26	0.6
120	6	48	1	7	18	0.3
121	5	29	1	6	13	0.2
123	5	38	1	6	14	0.2
124	5	27	1	6	11	0.2
125	5	29	1	5	10	0.1
126	5	28	1	5	9	0.1
129	4	26	0	3	5	0.1
130	5	25	0	2	4	0.0
131	9	56	1	4	11	0.2
151	3	17	0	1	2	0.0
351	3	17	0	1	3	0.0
157	5	33	1	5	8	0.1
158	3	15	0	1	1	0.0
159	2	12	0	1	2	0.0
160	3	14	0	1	1	0.0
162a	3	13	0	1	2	0.0
344	4	33	0	3	7	0.1
165	4	33	0	3	7	0.1
291	1	8	0	0	1	0.0
342	3	17	0	1	3	0.0
166	4	16	0	1	3	0.0
352	4	17	0	1	2	0.0
353	3	13	0	1	2	0.0

Appendix E Predictions At All Residences – Cumulative

Table E1: Cumulative Predictions – Year 1
(shading indicates an exceedance of the relevant criterion)

Receptor ID	PM2.5	PM10	TSP	Dust Deposition
	Annual Average			
	Assessment Criteria			
	-	30 µg/m³	90 µg/m³	4 g/m²/month
Private Receptors (including those with acquisition rights)				
2	9	22	55	2.6
4	9	22	56	2.7
5	8	21	54	2.6
6	8	21	54	2.6
7a	8	21	54	2.6
7b	8	21	54	2.6
7c	8	20	52	2.5
10	8	20	52	2.7
11	8	20	51	2.7
12	8	20	51	2.8
13	8	18	47	2.5
14	8	18	46	2.4
15b	8	17	46	2.4
15a	8	17	46	2.4
17	8	17	45	2.4
19	8	20	52	2.8
21	8	20	53	2.9
22	8	20	53	2.9
23	8	21	54	3.0
41	8	15	41	2.1
42	8	15	41	2.2
43	8	15	40	2.1
44a	7	15	40	2.1
45	7	15	40	2.1
46	7	15	40	2.1
47	7	15	40	2.1
48	8	15	41	2.1
49	7	15	40	2.1
50	7	15	40	2.1
51	8	15	40	2.1
52	7	15	40	2.1
53	7	15	40	2.1
54	7	15	40	2.1
55	7	15	40	2.1
56b	7	15	40	2.1
57	7	15	40	2.1
58	8	15	41	2.1
59	8	15	41	2.1
60	8	15	41	2.1
61	8	15	41	2.1
62	8	15	41	2.1
63a	8	15	41	2.1
162b	8	15	41	2.1
350	8	15	41	2.1
66	8	15	41	2.1
67	8	15	41	2.1
68	8	15	41	2.1
69b	8	15	41	2.1
69a	8	15	41	2.2
71	8	16	41	2.2
72	8	16	42	2.2
73	8	16	42	2.2
74	8	17	44	2.3
75	8	16	42	2.2
76	8	16	42	2.2
77	8	16	42	2.2
78	8	16	42	2.2
79	8	16	42	2.2
80	8	16	42	2.2
81	8	16	42	2.2
82	8	16	43	2.2
83	8	17	43	2.3
84a	8	16	43	2.3
85	8	17	44	2.3

Receptor ID	PM2.5	Annual Average PM10	TSP	Dust Deposition
	Assessment Criteria			
	-	30 µg/m³	90 µg/m³	4 g/m²/month
86	8	17	44	2.3
87	8	17	44	2.3
88	8	17	45	2.4
89	8	18	46	2.4
91	8	18	47	2.5
92	8	19	49	2.5
93	8	19	49	2.5
94	8	18	46	2.4
95	8	17	46	2.4
96	8	18	45	2.4
97	8	17	45	2.4
98	8	17	45	2.4
99	8	18	47	2.4
100	8	19	48	2.5
101	8	19	47	2.4
102a	8	19	48	2.4
102b	8	19	49	2.5
105	9	23	57	2.7
111	11	36	84	3.4
112	9	21	56	2.9
114	9	23	59	2.9
116	9	23	58	2.7
122	9	27	67	2.9
127b	10	28	66	2.9
127a	9	27	64	2.9
133	8	20	52	2.4
134	8	18	48	2.3
135	8	18	47	2.3
136	8	18	46	2.3
137d	8	17	45	2.3
138	8	18	46	2.3
137c	8	17	45	2.2
137b	8	17	45	2.2
137a	8	17	44	2.2
142	8	17	44	2.2
143	9	26	63	2.8
144a	9	24	58	2.6
145	11	42	120	5.0
146	9	25	61	2.7
147	9	26	60	2.7
148	10	29	68	3.0
149	9	28	69	2.9
150	9	28	68	2.9
152	9	27	68	2.9
154	9	26	65	2.8
155	9	25	63	2.7
156	9	24	62	2.7
163	8	17	46	2.4
185	8	16	42	2.1
189a	8	15	41	2.1
189b	8	15	41	2.1
191	8	15	40	2.1
192	7	15	40	2.1
181	8	15	40	2.1
196	7	15	40	2.1
194a	7	14	40	2.1
195b	7	14	39	2.1
195a	7	14	39	2.1
194b	7	14	39	2.1
197a	7	14	39	2.1
197b	7	14	39	2.1
208	7	14	39	2.1
337	7	14	39	2.1
209	7	14	39	2.1
215	7	14	39	2.1
216	7	14	39	2.1
217	7	14	39	2.1
210	7	14	39	2.1

Receptor ID	PM2.5	PM10	TSP	Dust Deposition
	Annual Average			
		Assessment Criteria		
	-	30 µg/m³	90 µg/m³	4 g/m²/month
211	7	15	39	2.1
178	7	14	39	2.1
212	7	15	39	2.1
213	7	15	39	2.1
56a	7	15	40	2.1
44b	8	18	46	2.4
218	7	14	39	2.1
220	7	14	39	2.1
224	7	14	39	2.1
223c	7	14	39	2.1
223a	7	14	39	2.1
223b	7	14	39	2.1
214	7	14	39	2.1
226	7	15	40	2.1
228	7	15	40	2.1
227	7	15	40	2.1
229	7	15	40	2.1
230	7	15	40	2.1
221	7	15	40	2.1
248	7	15	40	2.1
232	7	15	40	2.1
249	7	15	40	2.1
233	7	15	40	2.1
234	7	15	39	2.1
235	7	15	39	2.1
236	7	14	39	2.1
245	7	14	39	2.1
241	7	14	39	2.1
237b	7	14	39	2.1
237a	7	14	39	2.1
240	7	14	39	2.1
242	7	14	39	2.1
244	7	14	39	2.1
243	7	15	40	2.1
246	7	15	40	2.1
347	7	15	40	2.1
247	7	15	40	2.1
250	7	15	40	2.1
251	7	15	40	2.1
252	8	15	40	2.1
253	8	15	40	2.1
348	7	15	40	2.1
254	8	15	40	2.1
255	8	15	41	2.1
277	8	16	42	2.3
287	8	18	44	2.4
285	8	17	43	2.3
283	8	17	44	2.3
274	8	16	43	2.3
272	8	17	44	2.3
270	8	17	45	2.3
279	8	18	46	2.4
281	8	18	47	2.4
280	7	15	40	2.1
282	8	21	51	2.5
290	8	20	50	2.5
164	9	22	52	2.6
292a	8	21	50	2.5
292b	8	21	50	2.5
289	8	20	49	2.5
288	8	20	48	2.5
294	9	21	51	2.5
293	9	22	53	2.6
295	9	23	53	2.6
296	9	23	53	2.6
297d	9	22	52	2.6
297a	9	24	55	2.7
297b	9	24	55	2.7

Receptor ID	PM2.5	Annual Average PM10	Annual Average TSP	Dust Deposition
		Assessment Criteria		
	-	30 µg/m³	90 µg/m³	4 g/m²/month
297c	9	24	55	2.7
299	9	24	55	2.7
300	9	25	55	2.7
302	9	25	55	2.7
303	9	22	50	2.6
349b	9	23	53	2.7
349a	9	23	53	2.7
305	9	23	52	2.6
298	8	20	48	2.6
304b	8	19	47	2.5
304a	8	19	47	2.6
306	9	24	53	2.7
307	9	24	53	2.7
308	9	24	54	2.7
309	9	24	54	2.7
310	9	24	54	2.7
311	9	24	54	2.7
312	9	24	54	2.7
319	8	21	51	2.5
320	9	24	54	2.7
321	9	24	54	2.7
318	9	24	54	2.7
322	9	25	55	2.7
317	9	25	55	2.7
316	9	25	55	2.8
323	9	25	55	2.8
324	9	25	55	2.8
315	9	25	55	2.8
314	9	24	54	2.8
330	9	25	56	2.9
329	7	15	40	2.1
328	9	25	56	2.8
327	9	25	56	2.8
326	9	25	56	2.8
325	9	25	56	2.8
144c	8	21	49	2.3
144b	8	20	48	2.3
278	8	17	43	2.3
84b	8	17	43	2.3
137e	8	16	42	2.2
259	8	16	43	2.2
260	8	16	43	2.2
127c	10	28	66	2.9
354	11	35	83	3.8
Mine Owned Receptors				
1	8	21	53	2.6
3	8	21	54	2.6
20	8	20	51	2.8
24	8	21	55	3.0
25	8	21	55	3.0
26	8	21	55	3.0
27	9	22	58	3.1
28	9	22	57	3.2
29	9	22	59	3.2
30	9	24	65	3.6
31	9	25	66	3.9
32	9	22	59	3.3
33	9	21	56	3.1
34	8	21	55	3.0
35	8	21	54	2.9
36	9	21	57	3.1
38	9	25	70	4.2
39	9	24	65	3.8
40	8	17	45	2.5
90	8	18	46	2.4
104	8	19	49	2.5
107	9	28	68	2.9
108	10	28	68	2.9

Receptor ID	PM2.5	Annual Average PM10	TSP	Dust Deposition
		Assessment Criteria		
	-	30 µg/m³	90 µg/m³	4 g/m²/month
109	9	28	67	2.8
110	10	33	77	3.1
117	3	24	60	2.8
120	9	25	63	2.8
121	9	27	67	2.8
123	9	26	66	2.8
124	9	27	67	2.8
125	9	26	66	2.8
126	9	27	66	2.8
129	10	28	67	2.8
130	10	28	67	2.8
131	9	24	66	2.8
151	9	27	68	2.9
351	9	26	66	2.8
157	9	26	64	2.7
158	11	37	102	4.3
159	9	26	61	2.7
160	10	30	77	3.3
162a	8	17	44	2.3
344	9	22	53	2.6
165	9	22	53	2.6
291	8	15	41	2.1
342	9	21	54	2.4
166	10	30	78	3.1
352	10	31	71	3.2
353	10	32	73	3.2

Table E2: Cumulative Predictions – Year 5 (shading indicates an exceedance of the relevant criterion)

Receptor ID	PM2.5	PM10	TSP	Dust Deposition
	Annual Average			
	Assessment Criteria			
	-	30 µg/m³	90 µg/m³	4 g/m²/month
Private Receptors (including those with acquisition rights)				
2	9	22	57	2.5
4	9	22	59	2.6
5	8	21	56	2.5
6	8	21	56	2.5
7a	8	21	56	2.5
7b	8	21	56	2.5
7c	8	20	54	2.5
10	8	20	54	2.5
11	8	19	52	2.5
12	8	19	53	2.5
13	8	17	47	2.3
14	8	17	46	2.2
15b	8	17	45	2.2
15a	8	17	45	2.2
17	8	17	45	2.2
19	8	19	52	2.5
21	8	20	54	2.6
22	8	20	55	2.6
23	8	21	57	2.7
41	7	15	41	2.1
42	7	15	41	2.1
43	7	15	40	2.1
44a	7	15	40	2.1
45	7	15	40	2.1
46	7	15	40	2.1
47	7	15	40	2.1
48	7	15	40	2.1
49	7	14	40	2.1
50	7	15	40	2.1
51	7	15	40	2.1
52	7	15	40	2.1
53	7	14	40	2.1
54	7	14	40	2.1
55	7	15	40	2.1
56b	7	14	40	2.1
57	7	14	40	2.1
58	7	15	40	2.1
59	7	15	41	2.1
60	7	15	40	2.1
61	7	15	41	2.1
62	7	15	41	2.1
63a	7	15	41	2.1
162b	7	15	41	2.1
350	7	15	40	2.1
66	7	15	40	2.1
67	7	15	40	2.1
68	7	15	41	2.1
69b	7	15	41	2.1
69a	8	15	41	2.1
71	8	15	41	2.1
72	8	15	42	2.1
73	8	15	42	2.1
74	8	16	43	2.2
75	8	16	42	2.1
76	8	16	42	2.1
77	8	16	42	2.1
78	8	15	41	2.1
79	8	15	41	2.1
80	8	15	42	2.1
81	8	15	42	2.1
82	8	16	42	2.2
83	8	16	43	2.2
84a	8	16	43	2.2
85	8	16	43	2.2

Receptor ID	PM2.5	PM10	TSP	Dust Deposition
	Annual Average			
	Assessment Criteria			
	-	30 µg/m³	90 µg/m³	4 g/m²/month
86	8	16	44	2.2
87	8	16	44	2.2
88	8	17	45	2.2
89	8	17	46	2.3
91	8	18	47	2.3
92	8	19	50	2.4
93	8	18	49	2.3
94	8	17	46	2.3
95	8	17	45	2.2
96	8	17	46	2.3
97	8	17	46	2.3
98	8	17	45	2.3
99	8	18	47	2.3
100	8	18	48	2.3
101	8	18	48	2.3
102a	8	19	49	2.3
102b	8	19	49	2.3
105	9	23	60	2.6
111	11	36	89	3.6
112	9	22	59	2.7
114	9	24	65	2.8
116	9	23	63	2.7
122	9	24	64	2.6
127b	9	24	59	2.6
127a	9	23	57	2.6
133	8	20	53	2.3
134	8	18	48	2.2
135	8	18	48	2.2
136	8	17	47	2.2
137d	8	17	46	2.2
138	8	17	46	2.2
137c	8	17	45	2.2
137b	8	17	45	2.1
137a	8	17	44	2.1
142	8	17	45	2.1
143	9	22	56	2.5
144a	9	23	55	2.6
145	10	31	85	3.7
146	9	22	55	2.5
147	8	21	52	2.4
148	9	24	58	2.6
149	9	24	60	2.6
150	9	24	60	2.6
152	9	23	59	2.6
154	9	23	58	2.5
155	9	22	57	2.5
156	9	21	56	2.4
163	8	17	45	2.2
185	8	15	42	2.1
189a	8	15	41	2.1
189b	8	15	41	2.1
191	7	15	40	2.1
192	7	15	40	2.1
181	7	15	40	2.1
196	7	14	40	2.1
194a	7	14	39	2.1
195b	7	14	39	2.1
195a	7	14	39	2.1
194b	7	14	39	2.1
197a	7	14	39	2.1
197b	7	14	39	2.1
208	7	14	39	2.0
337	7	14	39	2.1
209	7	14	39	2.1
215	7	14	39	2.1
216	7	14	39	2.1
217	7	14	39	2.1
210	7	14	39	2.1

Receptor ID	PM2.5	PM10	TSP	Dust Deposition
	Annual Average			
		Assessment Criteria		
	-	30 µg/m³	90 µg/m³	4 g/m²/month
211	7	14	39	2.1
178	7	14	39	2.1
212	7	14	39	2.1
213	7	14	39	2.1
56a	7	14	40	2.1
44b	8	17	46	2.3
218	7	14	39	2.1
220	7	14	39	2.1
224	7	14	39	2.0
223c	7	14	39	2.1
223a	7	14	39	2.1
223b	7	14	39	2.1
214	7	14	39	2.1
226	7	14	39	2.1
228	7	14	40	2.1
227	7	15	40	2.1
229	7	14	40	2.1
230	7	15	40	2.1
221	7	15	40	2.1
248	7	15	40	2.1
232	7	15	40	2.1
249	7	15	40	2.1
233	7	14	40	2.1
234	7	14	39	2.1
235	7	14	39	2.1
236	7	14	39	2.1
245	7	14	39	2.1
241	7	14	39	2.1
237b	7	14	39	2.1
237a	7	14	39	2.1
240	7	14	39	2.1
242	7	14	39	2.1
244	7	14	39	2.1
243	7	14	39	2.1
246	7	14	40	2.1
347	7	15	40	2.1
247	7	15	40	2.1
250	7	15	40	2.1
251	7	15	40	2.1
252	7	15	40	2.1
253	7	15	40	2.1
348	7	15	40	2.1
254	7	15	40	2.1
255	7	15	40	2.1
277	8	16	42	2.2
287	8	17	44	2.3
285	8	16	43	2.2
283	8	17	44	2.2
274	8	16	43	2.2
272	8	17	44	2.2
270	8	17	45	2.2
279	8	18	46	2.3
281	8	18	47	2.3
280	7	14	40	2.1
282	8	20	51	2.4
290	8	19	50	2.4
164	8	20	51	2.4
292a	8	20	50	2.4
292b	8	20	50	2.4
289	8	19	49	2.4
288	8	19	48	2.4
294	8	20	50	2.4
293	8	20	51	2.5
295	8	20	51	2.5
296	8	21	51	2.5
297d	8	20	50	2.5
297a	9	21	52	2.5
297b	9	21	52	2.5

Receptor ID	PM2.5	PM10	TSP	Dust Deposition
	Annual Average			
	Assessment Criteria			
	-	30 µg/m³	90 µg/m³	4 g/m²/month
297c	9	21	52	2.5
299	9	21	52	2.5
300	9	21	51	2.5
302	8	21	51	2.5
303	8	20	49	2.4
349b	8	20	50	2.5
349a	8	20	50	2.5
305	8	20	50	2.5
298	8	19	47	2.4
304b	8	18	46	2.4
304a	8	18	47	2.4
306	8	21	50	2.5
307	8	21	50	2.5
308	8	21	50	2.5
309	8	21	50	2.5
310	8	21	50	2.5
311	8	21	50	2.5
312	8	21	50	2.5
319	8	20	51	2.4
320	8	21	50	2.5
321	8	21	50	2.5
318	8	21	50	2.5
322	8	21	50	2.5
317	8	21	50	2.5
316	8	21	50	2.5
323	8	21	50	2.5
324	8	21	50	2.5
315	8	21	50	2.5
314	8	21	49	2.5
330	8	21	49	2.5
329	7	15	40	2.1
328	8	21	50	2.5
327	8	21	50	2.5
326	8	21	50	2.5
325	8	21	50	2.5
144c	8	21	51	2.4
144b	8	21	51	2.4
278	8	16	43	2.2
84b	8	16	43	2.2
137e	8	16	43	2.1
259	8	16	42	2.2
260	8	16	42	2.2
127c	9	23	58	2.5
354	8	20	48	2.4
Mine Owned Receptors				
1	8	21	55	2.4
3	8	21	56	2.5
20	8	19	51	2.5
24	8	21	57	2.7
25	8	21	56	2.7
26	8	20	55	2.7
27	9	22	61	2.8
28	9	22	60	2.8
29	9	23	63	2.9
30	9	26	72	3.1
31	9	26	72	3.2
32	9	21	59	2.8
33	8	20	55	2.6
34	8	20	54	2.5
35	8	20	54	2.5
36	8	21	56	2.6
38	9	26	72	3.3
39	9	24	65	3.1
40	8	17	45	2.2
90	8	17	46	2.3
104	8	19	49	2.3
107	9	25	64	2.7
108	9	25	63	2.6

Receptor ID	PM2.5	PM10	TSP	Dust Deposition
		Annual Average		
		Assessment Criteria		
	-	30 µg/m³	90 µg/m³	4 g/m²/month
109	9	25	63	2.6
110	10	30	72	2.9
117	9	24	64	2.7
120	9	24	63	2.6
121	9	24	64	2.6
123	9	24	64	2.6
124	9	24	63	2.6
125	9	24	63	2.6
126	9	24	63	2.5
129	9	23	58	2.5
130	9	23	58	2.5
131	9	24	70	2.6
151	9	23	59	2.6
351	9	23	58	2.5
157	9	24	62	2.5
158	9	28	75	3.3
159	9	22	54	2.5
160	9	25	62	2.8
162a	8	16	44	2.2
344	8	20	51	2.5
165	8	20	51	2.5
291	7	15	41	2.1
342	8	20	53	2.4
166	9	25	65	2.7
352	9	25	61	2.7
353	9	25	61	2.7

Table E3: Cumulative Predictions – Year 10
(shading indicates an exceedance of the relevant criterion)

Receptor ID	$PM_{2.5}$	PM_{10}	TSP	Dust Deposition
	Annual Average			
	Assessment Criteria			
	-	30 µg/m³	90 µg/m³	4 g/m²/month
Private Receptors (including those with acquisition rights)				
2	8	20	55	2.4
4	8	21	58	2.6
5	8	19	54	2.4
6	8	19	52	2.4
7a	8	19	52	2.4
7b	8	19	52	2.4
7c	8	18	49	2.3
10	8	16	47	2.3
11	8	16	46	2.3
12	8	16	46	2.3
13	8	15	43	2.2
14	7	15	43	2.1
15b	8	17	42	2.1
15a	8	17	42	2.1
17	8	17	42	2.1
19	8	18	46	2.3
21	7	14	47	2.3
22	7	14	47	2.3
23	7	14	48	2.4
41	7	14	39	2.0
42	7	14	39	2.0
43	7	14	39	2.0
44a	7	14	39	2.0
45	7	14	39	2.0
46	7	14	39	2.0
47	7	14	39	2.0
48	7	14	39	2.0
49	7	14	39	2.0
50	7	14	39	2.0
51	7	14	39	2.0
52	7	14	39	2.0
53	7	14	39	2.0
54	7	14	39	2.0
55	7	14	39	2.0
56b	7	14	39	2.0
57	7	14	39	2.0
58	7	14	39	2.0
59	7	14	39	2.0
60	7	14	39	2.0
61	7	14	39	2.0
62	7	14	39	2.0
63a	7	14	39	2.1
162b	7	14	39	2.1
350	7	14	39	2.1
66	7	14	39	2.1
67	7	14	39	2.0
68	7	14	40	2.1
69b	7	14	40	2.1
69a	7	15	40	2.1
71	7	15	40	2.1
72	7	15	40	2.1
73	7	15	40	2.1
74	7	15	41	2.1
75	7	14	40	2.1
76	7	14	40	2.1
77	7	14	40	2.1
78	7	14	40	2.1
79	7	15	40	2.1
80	7	15	40	2.1
81	7	15	40	2.1
82	7	15	41	2.1
83	7	15	41	2.1
84a	7	15	41	2.1
85	7	15	41	2.1

Receptor ID	PM2.5	Annual Average PM10	TSP	Dust Deposition
		Assessment Criteria		
	-	30 µg/m³	90 µg/m³	4 g/m²/month
86	8	16	42	2.1
87	8	16	41	2.1
88	8	16	42	2.1
89	8	16	43	2.2
91	8	16	44	2.2
92	8	16	45	2.2
93	8	16	45	2.2
94	8	16	43	2.1
95	8	15	42	2.1
96	8	16	43	2.2
97	8	16	43	2.2
98	8	16	42	2.2
99	8	16	44	2.2
100	8	17	44	2.2
101	8	22	44	2.2
102a	8	20	45	2.2
102b	8	19	45	2.2
105	9	23	61	2.6
111	9	23	54	2.3
112	8	21	53	2.5
114	8	18	65	2.8
116	8	17	64	2.7
122	8	17	59	2.4
127b	8	16	47	2.2
127a	8	16	45	2.2
133	8	16	45	2.1
134	8	15	44	2.1
135	8	16	43	2.1
136	8	15	43	2.1
137d	8	15	42	2.1
138	8	15	43	2.1
137c	8	15	42	2.1
137b	8	17	42	2.1
137a	8	19	42	2.1
142	8	18	42	2.1
143	8	17	45	2.2
144a	8	16	48	2.4
145	8	16	46	2.3
146	8	17	44	2.2
147	8	17	43	2.2
148	8	17	44	2.2
149	8	17	44	2.2
150	8	17	45	2.2
152	8	16	45	2.2
154	8	16	45	2.1
155	7	15	44	2.1
156	7	14	45	2.1
163	7	14	42	2.1
185	7	14	40	2.1
189a	7	14	40	2.0
189b	7	14	40	2.0
191	7	14	39	2.0
192	7	14	39	2.0
181	7	14	39	2.0
196	7	14	39	2.0
194a	7	14	39	2.0
195b	7	14	38	2.0
195a	7	14	38	2.0
194b	7	14	38	2.0
197a	7	14	38	2.0
197b	7	14	38	2.0
208	7	14	38	2.0
337	7	14	38	2.0
209	7	14	38	2.0
215	7	14	38	2.0
216	7	14	38	2.0
217	7	14	38	2.0
210	7	14	38	2.0

Receptor ID	PM2.5	PM10	TSP	Dust Deposition
	Annual Average			
		Assessment Criteria		
	-	30 µg/m³	90 µg/m³	4 g/m²/month
211	7	14	39	2.0
178	7	14	38	2.0
212	8	16	39	2.0
213	7	14	39	2.0
56a	7	14	39	2.0
44b	7	14	43	2.2
218	7	14	38	2.0
220	7	14	38	2.0
224	7	14	38	2.0
223c	7	14	38	2.0
223a	7	14	38	2.0
223b	7	14	38	2.0
214	7	14	39	2.0
226	7	14	39	2.0
228	7	14	39	2.0
227	7	14	39	2.0
229	7	14	39	2.0
230	7	14	39	2.0
221	7	14	39	2.0
248	7	14	39	2.0
232	7	14	39	2.0
249	7	14	39	2.0
233	7	14	39	2.0
234	7	14	39	2.0
235	7	14	39	2.0
236	7	14	39	2.0
245	7	14	39	2.0
241	7	14	39	2.0
237b	7	14	38	2.0
237a	7	14	38	2.0
240	7	14	38	2.0
242	7	14	39	2.0
244	7	14	39	2.0
243	7	14	39	2.0
246	7	14	39	2.0
347	7	14	39	2.0
247	7	14	39	2.0
250	7	14	39	2.0
251	7	14	39	2.0
252	7	14	39	2.0
253	7	14	39	2.1
348	7	15	39	2.0
254	7	15	39	2.1
255	7	15	39	2.1
277	7	15	40	2.1
287	7	15	42	2.2
285	7	15	41	2.1
283	7	15	41	2.1
274	8	16	41	2.1
272	8	16	42	2.1
270	7	14	42	2.1
279	8	18	43	2.2
281	8	17	44	2.2
280	8	18	39	2.0
282	8	17	48	2.3
290	8	17	46	2.3
164	8	17	48	2.3
292a	8	17	47	2.3
292b	8	17	47	2.3
289	8	18	45	2.2
288	8	18	45	2.2
294	8	17	47	2.3
293	8	17	48	2.3
295	8	17	47	2.3
296	8	17	47	2.3
297d	8	17	46	2.3
297a	8	17	46	2.3
297b	8	17	46	2.3

Receptor ID	PM2.5	Annual Average PM10	TSP	Dust Deposition
		Assessment Criteria		
	-	30 µg/m³	90 µg/m³	4 g/m²/month
297c	8	17	46	2.3
299	8	17	45	2.3
300	8	17	45	2.2
302	8	17	45	2.2
303	8	17	45	2.2
349b	8	16	44	2.2
349a	8	16	44	2.2
305	8	16	44	2.2
298	8	17	44	2.3
304b	8	17	43	2.2
304a	8	17	43	2.3
306	8	17	44	2.2
307	8	17	44	2.2
308	8	17	44	2.2
309	8	17	44	2.2
310	8	18	44	2.2
311	8	17	44	2.2
312	8	17	44	2.2
319	8	17	48	2.3
320	8	17	44	2.2
321	8	17	44	2.2
318	8	17	44	2.2
322	8	17	44	2.2
317	8	17	44	2.2
316	8	16	44	2.2
323	8	16	44	2.2
324	8	16	44	2.2
315	7	14	43	2.2
314	8	16	43	2.2
330	8	16	43	2.2
329	8	17	39	2.0
328	8	17	43	2.2
327	8	19	43	2.2
326	8	19	44	2.2
325	7	15	44	2.2
144c	8	17	48	2.3
144b	8	17	48	2.3
278	8	17	41	2.1
84b	7	15	41	2.1
137e	7	15	41	2.1
259	7	15	40	2.1
260	7	15	41	2.1
127c	8	17	46	2.2
354	8	16	42	2.2
Mine Owned Receptors				
1	8	19	51	2.4
3	8	19	53	2.4
20	8	16	45	2.2
24	8	18	48	2.4
25	8	18	48	2.4
26	8	17	48	2.3
27	8	18	51	2.4
28	8	18	50	2.4
29	8	19	52	2.5
30	9	22	63	2.8
31	8	21	60	2.7
32	8	18	48	2.3
33	8	17	46	2.3
34	8	17	46	2.2
35	8	17	45	2.2
36	8	17	47	2.3
38	8	19	51	2.5
39	8	18	50	2.4
40	7	15	41	2.1
90	8	16	43	2.2
104	8	17	45	2.2
107	8	21	58	2.4
108	8	20	56	2.4

Receptor ID	PM2.5	PM10	TSP	Dust Deposition
		Annual Average		
		Assessment Criteria		
	-	30 µg/m³	90 µg/m³	4 g/m²/month
109	8	20	56	2.4
110	8	21	56	2.4
117	9	24	68	2.8
120	8	22	61	2.5
121	8	21	59	2.4
123	8	21	58	2.4
124	8	21	58	2.4
125	8	21	57	2.4
126	8	20	56	2.4
129	8	18	49	2.2
130	8	17	48	2.2
131	8	18	52	2.3
151	8	17	44	2.1
351	8	17	44	2.1
157	8	20	55	2.3
158	8	17	45	2.2
159	8	17	44	2.2
160	8	17	44	2.2
162a	7	15	41	2.1
344	8	18	49	2.3
165	8	18	49	2.3
291	7	14	39	2.0
342	8	17	45	2.2
166	8	17	45	2.1
352	8	16	44	2.2
353	8	16	43	2.2

Appendix F Predicted Exceedances

Table F1: Residences predicted to exceed PM_{10} criteria – Year 1

Exceeding Residence ID	Current Ownership Status	24-hour PM_{10} Project Specific - 50 µg/m³	Annual Average PM_{10} Total Cumulative - 30 µg/m³
34	Glencore Owned	X	
36	Glencore Owned	X	
38	Glencore Owned	X	
110	Other Mine Owned		X
111	Private - Acquisition Rights Other Mines		X
131	Glencore Owned	X	
145	Private - Acquisition Rights Other Mines		X
158	Other Mine Owned		X
352	Other Mine Owned		X
353	Other Mine Owned		X
354	Private		X

Table F2: Residences predicted to exceed PM_{10} criteria – Year 5

Exceeding Residence ID	Current Ownership Status	24-hour PM_{10} Project Specific - 50 µg/m³	Annual Average PM_{10} Total Cumulative - 30 µg/m³
30	Glencore Owned	X	
31	Glencore Owned	X	
34	Glencore Owned	X	
35	Glencore Owned	X	
36	Glencore Owned	X	
38	Glencore Owned	X	
39	Glencore Owned	X	
111	Private – Acquisition Rights Other Mines		X
131	Glencore Owned	X	
145	Private – Acquisition Rights Other Mines		X

Table F3: Residences predicted to exceed PM_{10} criteria – Year 10

Exceeding Residence ID	Current Ownership Status	24-hour PM_{10} Project Specific – 50 µg/m³	Annual Average PM_{10} Total Cumulative – 30 µg/m³
23	Private	X	
27	Glencore Owned	X	
28	Glencore Owned	X	
29	Glencore Owned	X	
30	Glencore Owned	X	
31	Glencore Owned	X	
38	Glencore Owned	X	
39	Glencore Owned	X	
117	Other Mine Owned	X	
131	Glencore Owned	X	

Table E4: Summary of all residences predicted to exceed PM_{10} criteria

Exceeding Residence ID	Current Ownership Status	24-hour PM_{10} Project Specific - 50 µg/m³			Annual Average PM_{10} Total Cumulative - 30 µg/m³		
		Year 1	Year 5	Year 10	Year 1	Year 5	Year 10
23	Private			X			
27	Glencore Owned			X			
28	Glencore Owned			X			
29	Glencore Owned			X			
30	Glencore Owned		X	X			
31	Glencore Owned		X	X			
34	Glencore Owned	X	X				
35	Glencore Owned		X				
36	Glencore Owned	X	X				
38	Glencore Owned	X	X	X			
39	Glencore Owned		X	X			
110	Other Mine Owned				X		
111	Private - Acquisition Rights Other Mines				X	X	
117	Other Mine Owned			X			
131	Glencore Owned	X	X	X			
145	Private - Acquisition Rights Other Mines				X	X	
158	Other Mine Owned				X		
352	Other Mine Owned				X		
353	Other Mine Owned				X		
354	Private				X		