AIR QUALITY ASSESSMENT

DOLWENDEE QUARRY

KMH Environmental

7 September 2015

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Prepared by

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Air Quality Impact Assessment
Dolwendee Quarry

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1 INTRODUCTION

Todoroski Air Sciences has prepared this report for KMH Environmental on behalf of Upper Hunter Holdings Pty Ltd. It presents an assessment of the potential air quality impacts associated with the proposed construction and operation of a gravel quarry located to the northwest of Denman in New South Wales (NSW) (hereafter referred to as the Project).

To assess the potential air quality impacts associated with the proposed Project, this report incorporates the following aspects:

- A background and description of the Project;
- A review of the existing meteorological and air quality environment surrounding the Project site;
- A description of the dispersion modelling approach used to assess potential air quality impacts; and
- Presentation of the predicted results and a discussion of the potential air quality impacts.

2 PROJECT SETTING AND DESCRIPTION

2.1 Project Location

The Project is located in the Upper Hunter Valley region of NSW, approximately 37 kilometres (km) southwest of Scone and 8km northwest of Denman. The immediate land use surrounding the Project is predominantly comprised of rural land used for agriculture and grazing and open cut coal mining at the Mangoola Coal mine located to the northeast.

There are several sensitive receptors in the surrounding area, with the closest residence positioned approximately 1km from the Project. **Figure 2-1** presents the location of the Project in relation to privately-owned and coal mine-owned receptors of relevance to this assessment.

The local topography in the vicinity of the Project site is illustrated in **Figure 2-2**. The Project is located on the western edge of the Hunter Valley basin in an area characterised by complex and undulating terrain to the west and south of the Project, with relatively flat open terrain to the east. The topographical features in this area would have a significant influence on the meteorological conditions and wind distribution patterns.

2.2 Project Description

The Project is proposed to operate over an approximate 26-year period with an extraction rate of 250,000 tonnes per annum (tpa) and covers a footprint of approximately 10.7 hectares (ha).

The resource would be extracted predominantly with ripping methods and blasting using plant including a combination of bulldozer, excavator, front-end-loader, articulated haul truck and road registered semi-trailers to assist with the extraction. The resource would be processed with a mobile in-pit crusher and separating equipment prior to being stockpiled for transport off-site.

An internal haul road approximately 2.5km long would connect the quarry to the Golden Highway for transport of product to customers. The quarry staging would be planned to minimise environmental impacts by limiting quarry-related disturbance to only the approved areas and minimising forward stripping of topsoil and overburden.

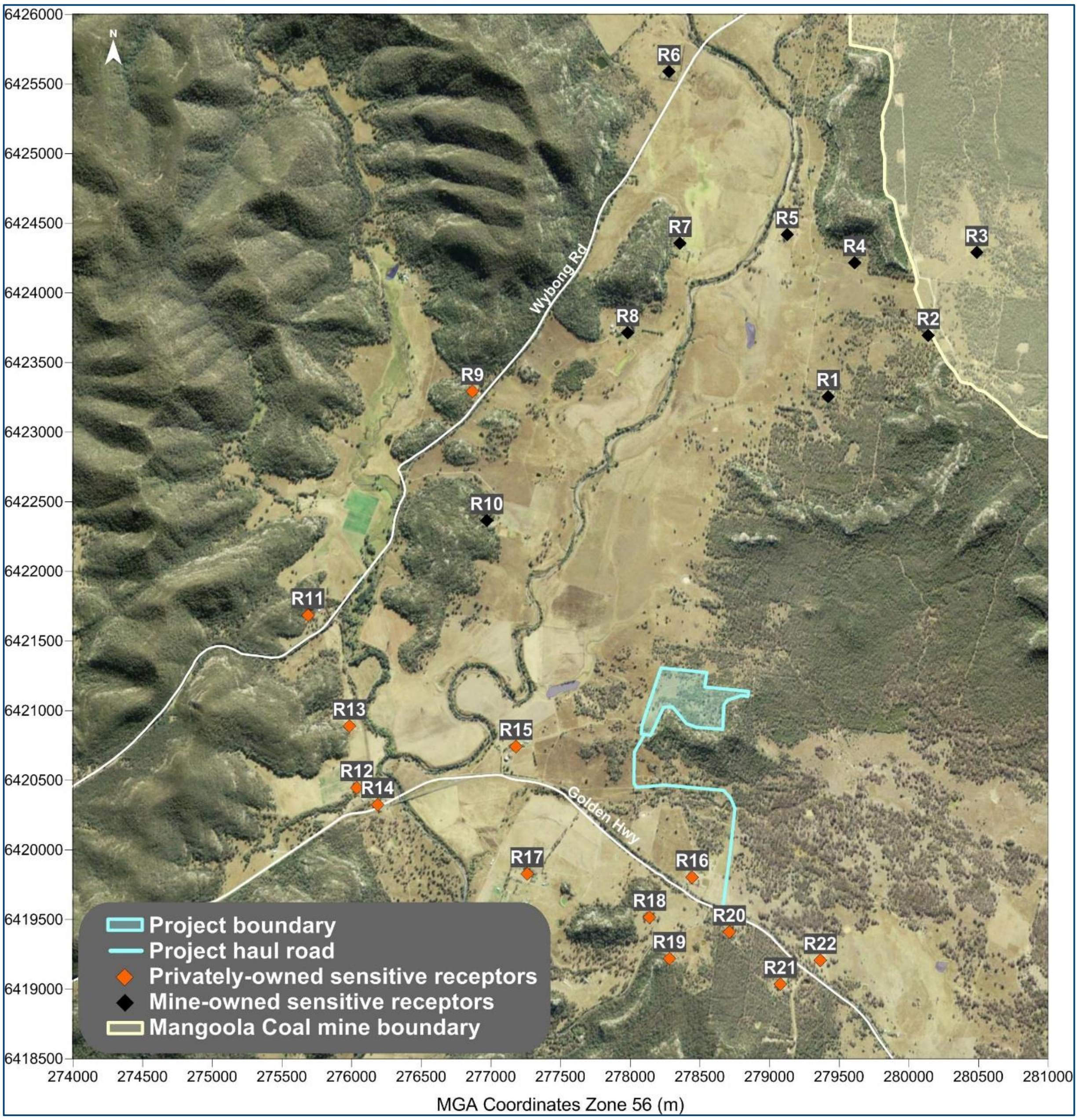


Figure 2-1: Project location

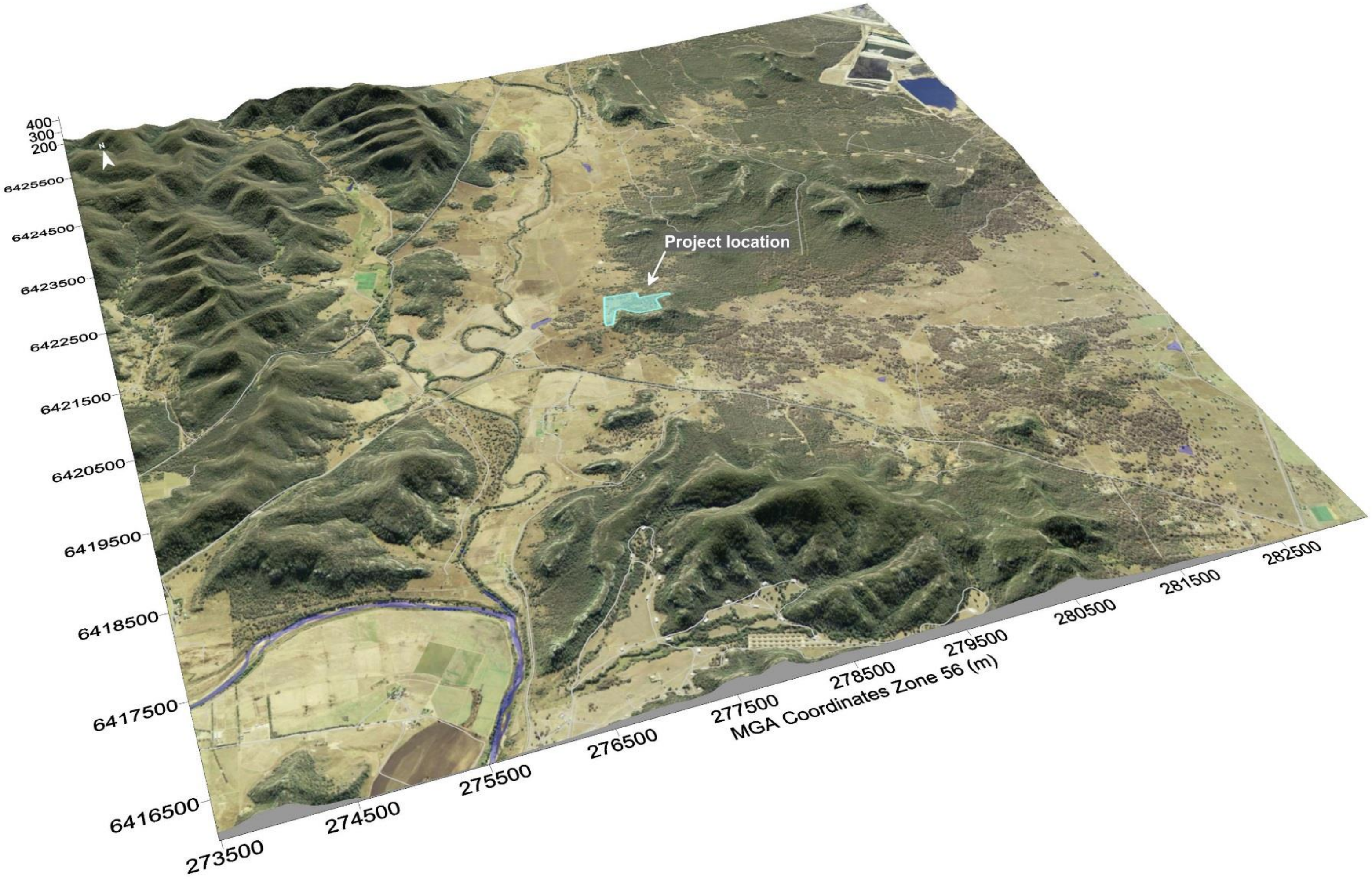


Figure 2-2: Representative view of topography surrounding the Project location

3 STUDY REQUIREMENTS

This air quality assessment has been prepared in general accordance with the Secretary's Environmental Assessment Requirements (presented in **Table 3-1**) and recommendations by the NSW Environment Protection Authority (EPA) (presented in **Table 3-2**).

Table 3-1: Secretary's Environmental Assessment Requirements

Specific matter	Requirement	Section
Air – including:	An assessment of the likely air quality impacts of the development in accordance with the Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW and the EPA's additional requirements (see Attachment 2);	This report

Table 3-2: NSW EPA Recommended Environmental Assessment Requirements

Specific matter	Requirement	Section
Air quality		
Assessment Objective	Demonstrate the proposed project will incorporate and apply best management practice emission controls; and	6.3 & Appendix A
	Demonstrate that the project will not cause violation of the project adopted air quality impact assessment criteria at any residential dwelling or other sensitive receptor.	7
Assessment Criteria	Define applicable assessment criteria for the proposed development referencing EPA (2005) - Approved Methods	4
Existing Environment	Provide a detailed description of the existing environment within the assessment domain, including: ○ Geophysical form and land-uses; ○ Location of all sensitive receptors; ○ Existing air quality; and ○ Local and regional prevailing meteorology.	2 & 5
	Justify all data used in the assessment, specifically including analysis of inter-annual trends (preferably five consecutive years of data), availability of monitoring data, and local topographical features.	5 & 6
	Meteorological modelling must be verified against monitored data. Verification should involve comparative analysis of wind speed, wind direction and temperature, at a minimum (additional guidance is included in TRC, 2011).	6
	A review of all existing, recently approved and planned developments likely to contribute to cumulative air quality impacts must be completed,	6.3
Emissions Inventory	Provide a detailed description of the project and identify key stages with regards to the potential for air emissions and impacts on the surrounding environment.	2 & 6.3
	Identify all sources of air emissions, including mechanically generated, combustion and transport related emissions likely to be associated with the proposed development.	6.3 & Appendix A
	Estimate emissions of TSP, PM_{10}, $PM_{2.5}$, NOx (tonnes per year), at a minimum, for all identified sources during each key development stage. The emissions inventory should: ○ Utilise USEPA (1995) (and updates) emissions estimation techniques, direct measurement or other method approved in writing by EPA; ○ Calculate uncontrolled emissions (with no particulate matter controls in place); and ○ Calculate controlled emissions (with proposed particulate matter controls in place).	6.3, 9 & Appendix A

Specific matter	Requirement	Section
	The emissions inventory must be explicitly coupled with the project description.	6.3
	Provide a detailed summary and justification of all parameters adopted within all emission estimation calculations, including site specific measurements, proponent recommended values or published literature.	6.3 & Appendix A
	Document, including quantification and justification, all air quality emissions control techniques/practices proposed for implementation during the project. As a minimum, consideration must be given to source control techniques, emission control through mine planning and reactive/predictive management techniques.	6.3 & Appendix A
	Blasting emission estimation should provide specific details on likely activities, including the frequency of blasts, area per blast, amount and type of explosives used and blasting hours.	9
Best Practice Determination	Based on the TSP, PM_{10}, and $PM_{2.5}$ emissions inventories calculated for the proposed development, undertake a site-specific best practice determination, in accordance with EPA (2011).	Appendix A
	Demonstrate that the proposed control techniques/practices are consistent with best management practice.	Appendix A
Dispersion Modelling and Interpretation of Results	Atmospheric dispersion modelling should be undertaken in accordance with EPA (2005).	6
	Modelling must implement fit for purpose modelling techniques that: ○ Have regard for the most up to date and scientifically accepted dispersion modelling techniques; ○ Contextualise all assumptions based on current scientific understanding and available data; and ○ Include a thorough validation of adopted methods and model performance.	6.3 & Appendix A
	Use an appropriate atmospheric dispersion model to predict, at a minimum, incremental ground level concentrations/levels to the following: ○ 24-hour and annual average PM_{10} concentrations; ○ 24-hour and annual average $PM_{2.5}$ concentrations; and ○ 1-hour and annual average NO_2 concentrations. NO_2 concentrations should be assessed using a well justified approach for the transformation of NOx to NO_2.	7
	Ground level concentrations of pollutants should be presented for surrounding privately-owned properties, mine-owned properties and other sensitive receptors (as applicable).	7
	Undertake a cumulative assessment of predicted impacts. The contribution of all identified existing and recently approved developments should be accounted for in the cumulative assessment.	7
	Cumulative 24-hour PM_{10} and $PM_{2.5}$ concentrations must be assessed in accordance with EPA (2005) and/or a suitably justified probabilistic methodology.	7
	Cumulative annual average PM_{10}, $PM_{2.5}$, and NO_2 should be assessed using a sufficiently justified background concentration(s).	7 & 9
	Results of dispersion modelling should be presented as follows: ○ Isopleth plots showing the geographic extent of maximum pollutant concentrations (incremental and cumulative); ○ Tables presenting the maximum predicted pollutant concentrations (increment and cumulative) and the frequency of any predicted exceedances at each surrounding privately-owned properties, mine-owned properties and other sensitive receptors (as applicable); and ○ Time series and frequency distribution plots of pollutant concentrations at each private receptor location at which an exceedance is predicted to occur. Where no exceedances are predicted, the analysis must be	7

Specific matter	Requirement	Section
	performed for the most impacted off site sensitive receptor.	
Air Quality Emission Control Measures	Provide a detailed discussion of all proposed air quality emissions control measures, including details of a reactive/predictive management system. The information provided must include: ○ Explicit linkage of proposed emission controls to the site specific best practice determination assessment; ○ Timeframe for implementation of all identified emission controls; ○ Key performance indicators for emission controls; ○ Monitoring methods (location, frequency, duration); ○ Response mechanisms ○ Responsibilities for demonstrating and reporting achievement of KPIs; ○ Record keeping and complaints response register; and ○ Compliance reporting.	10

4 AIR QUALITY CRITERIA

4.1 Preamble

Air quality criteria are benchmarks set to protect the general health and amenity of the community in relation to air quality. The sections below identify the potential air emissions generated by the Project and the applicable air quality criteria.

4.2 Particulate matter

Particulate matter refers to particles of varying size and composition. The air quality goals relevant to this assessment refer to three classes of particulate matter based on the sizes of the particles. The first class is referred to as Total Suspended Particulate matter (TSP) which measures the total mass of all particles suspended in air. The upper size range for TSP is nominally taken to be 30 micrometres (µm) as in practice, particles larger than 30 to 50µm settle out of the atmosphere too quickly to be regarded as air pollutants.

Two sub-classes of TSP are also included in the air quality goals, namely PM_{10}, particulate matter with aerodynamic diameters of 10µm or less, and $PM_{2.5}$, particulate matter with aerodynamic diameters of 2.5µm or less.

Particulate matter, typically in the upper size range, that settle from the atmosphere and deposit on surfaces is characterised as deposited dust. The deposition of dust on surfaces is considered a nuisance and can adversely affect the amenity of an area by soiling property in the vicinity.

4.2.1 NSW EPA impact assessment criteria

Table 4-1 summarises the air quality goals that are relevant to this study as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (**NSW DEC, 2005**).

The air quality goals for total impact relate to the total dust burden in the air and not just the dust from the proposal. Consideration of background dust levels needs to be made when using these goals to assess potential impacts.

Table 4-1: NSW EPA air quality impact assessment criteria

Pollutant	Averaging Period	Impact	Criterion
TSP	Annual	Total	90µg/m³
PM_{10}	Annual	Total	30µg/m³
	24 hour	Total	50µg/m³
Deposited dust	Annual	Incremental	2g/m²/month
		Total	4g/m²/month

Source: NSW DEC, 2005
µg/m³ = micrograms per cubic metre
g/m²/month = grams per square metre per month

4.2.2 National Environment Protection (Ambient Air Quality) Measure

The National Environment Protection Council (NEPC) Act 1994 and subsequent amendments define the National Environment Protection Measures (NEPM) as instruments for setting environmental objectives in Australia.

The Ambient Air Quality NEPM specifies national ambient air quality standards and goals for air pollutants including PM_{10} and $PM_{2.5}$. The standard for PM_{10} is outlined in **Table 4-2**. It is noted that the NEPM permits five days annually above the 24-hour average PM_{10} criterion to allow for bush fires and similar events.

Table 4-2: Standard for PM_{10} concentrations

Pollutant	Averaging Period	Maximum concentration	Maximum allowable exceedences
PM_{10}	24 hour	50µg/m³	5 days a year

Source: NEPC, 2003

The NSW EPA currently do not have impact assessment criteria for $PM_{2.5}$ concentrations. The Ambient Air Quality NEPM apply advisory reporting standards for $PM_{2.5}$ to gather sufficient data nationally to facilitate a review. The advisory reporting standards for $PM_{2.5}$ are outlined in **Table 4-3**.

As with each of the NEPM goals, these apply to the average, or general exposure of a population, rather than to "hot spot" locations.

Table 4-3: Advisory reporting standards for $PM_{2.5}$ concentrations

Pollutant	Averaging Period	Advisory Reporting Standard
$PM_{2.5}$	24 hour	25µg/m³
	Annual	8µg/m³

Source: NEPC, 2003

4.3 Other air pollutants

Emissions of other air pollutants will also potentially arise from quarrying activities, for example from diesel powered equipment. Emissions from diesel powered equipment generally include carbon monoxide (CO), nitrogen dioxide (NO_2) and other pollutants, such as sulphur dioxide (SO_2).

CO is colourless, odourless and tasteless and generated from the incomplete combustion of fuels when carbon molecules are only partially oxidised. It can reduce the capacity of blood to transport oxygen in humans resulting in symptoms of headache, nausea and fatigue.

NO_2 is reddish-brown in colour (at high concentrations) with a characteristic odour and can irritate the lungs and lower resistance to respiratory infections such as influenza. NO_2 belongs to a family of reactive gases called nitrogen oxides (NO_X). These gases form when fuel is burned at high temperatures, mainly from motor vehicles, power generators and industrial boilers (**USEPA 2011**). NO_X may also be generated by blasting activities. It is important to note that when formed, NO_2 is generally a small fraction of the total NO_X generated.

Sulphur dioxide (SO_2) is a colourless, toxic gas with a pungent and irritating smell. It commonly arises in industrial emissions due to the sulphur content of the fuel. SO_2 can have impacts upon human health and the habitability of the environment for flora and fauna. SO_2 emissions are a precursor to acid rain, which can be an issue in the northern hemisphere; however it is not known to have any widespread impact in NSW, and is generally only associated with large industrial activities. Due to its potential to impact on human health, sulphur is actively removed from fuel to prevent the release and formation of SO_2. The sulphur content of Australian diesel is controlled to a low level by national fuel standards.

Overall, the emissions of other pollutants generated from diesel powered equipment at a quarry are considered to be too low to generate any significant off-site pollutant concentrations, especially in this case where the nearest receptors are located approximately 1km away. Thus other pollutants generated from diesel combustion have not been assessed further in this study.

5 EXISTING ENVIRONMENT

This section describes the existing environment including the climate and ambient air quality in the area surrounding the Project.

5.1 Local climate

Long-term climatic data from the Bureau of Meteorology weather station at Scone SCS (Site No. 061086) were analysed to characterise the local climate in the proximity of the Project. The Scone SCS is located approximately 37km northeast of the Project.

Table 5-1 and **Figure 5-1** present a summary of data from the Scone Airport AWS collected over an approximate 17 to 65-year period for the various parameters.

The data indicate that January is the hottest month with a mean maximum temperature of 31.2°C and July as the coldest month with a mean minimum temperature of 4.7°C.

Rainfall peaks during the summer months and declines during the winter months. The data show January is the wettest month with an average rainfall of 82.6mm over 6.4 days and July is the driest month with an average rainfall of 36.5mm over 5.0 days.

Humidity levels exhibit variability over the day and seasonal fluctuations. Mean 9am humidity levels range from 59% in October to 78% in June. Mean 3pm humidity levels vary from 39% in December to 58% in June.

Wind speeds during the warmer months have a greater spread between the 9am and 3pm conditions compared to the colder months. The mean 9am wind speeds range from 6.7km/h in May to 10.0km/h in November. The mean 3pm wind speeds vary from 10.0km/h in May to 15.0km/h in November.

Table 5-1: Monthly climate statistics summary – Scone Airport AWS

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature												
Mean max. temperature (°C)	31.2	29.9	27.9	24.5	20.2	17.0	16.4	18.4	21.6	25.0	27.8	30.2
Mean min. temperature (°C)	16.9	16.9	14.6	11.3	8.0	6.0	4.7	5.5	7.9	10.8	13.3	15.7
Rainfall												
Rainfall (mm)	82.6	76.1	53.0	39.9	46.0	45.3	36.5	38.3	38.3	57.2	62.8	67.4
Mean No. of rain days (≥1mm)	6.4	5.8	5.2	4.4	5.2	6.0	5.0	5.1	5.2	6.0	6.4	6.6
9am conditions												
Mean temperature (°C)	22.9	21.9	20.2	17.6	13.3	10.4	9.5	11.5	15.2	18.7	20.3	22.5
Mean relative humidity (%)	67	73	73	71	76	78	75	67	62	59	62	61
Mean wind speed (km/h)	8.2	7.8	7.4	6.9	6.7	7.2	7.7	9.2	9.6	9.8	10.0	8.9
3pm conditions												
Mean temperature (°C)	29.3	28.5	26.4	23.0	19.0	15.6	14.9	17.1	20.1	23.3	25.8	28.5
Mean relative humidity (%)	43	47	47	47	56	58	54	46	43	42	41	39
Mean wind speed (km/h)	14.9	14.3	13.5	11.6	10.0	10.4	10.9	13.4	13.9	13.6	15.0	14.2

Source: **Bureau of Meteorology, 2015**

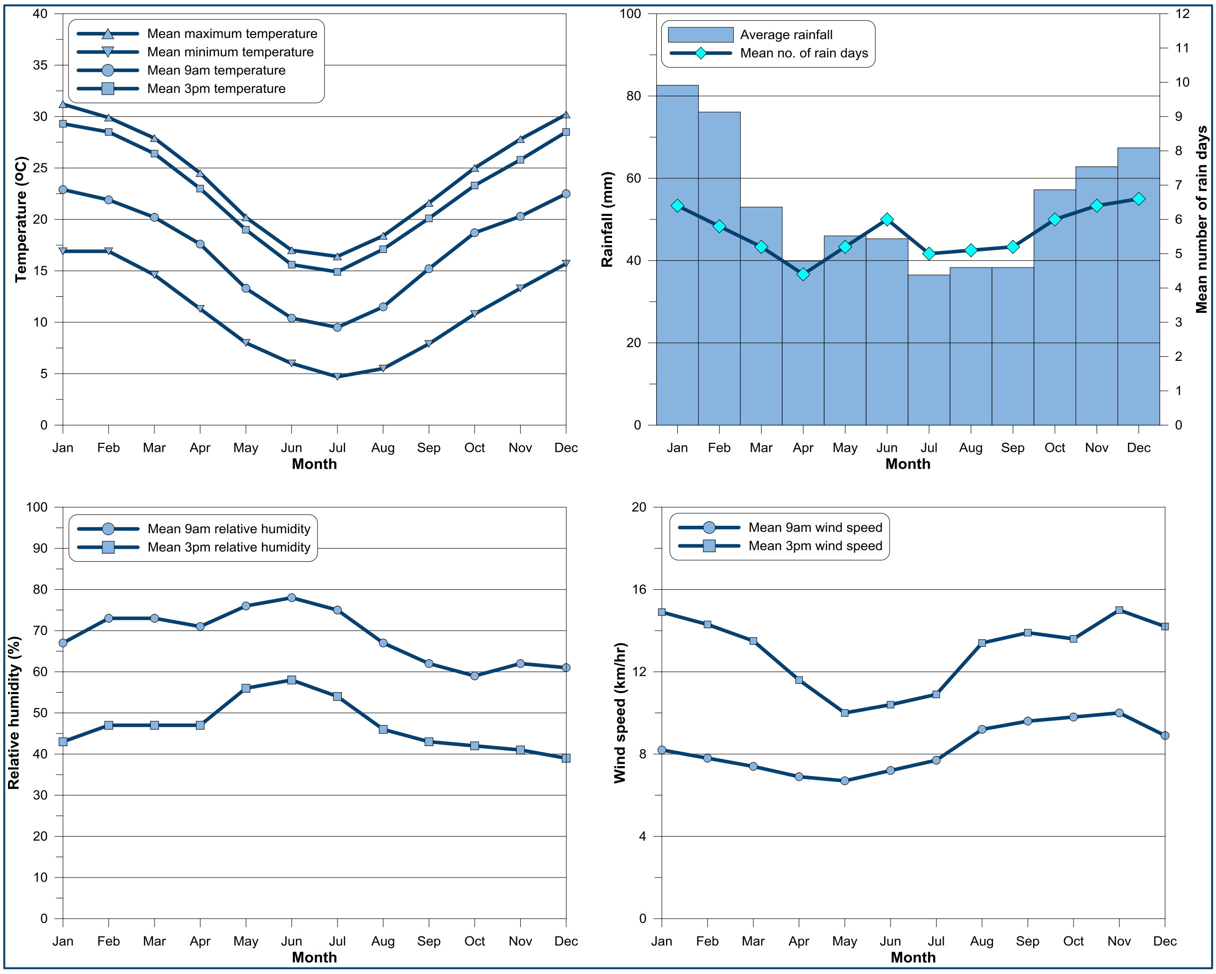
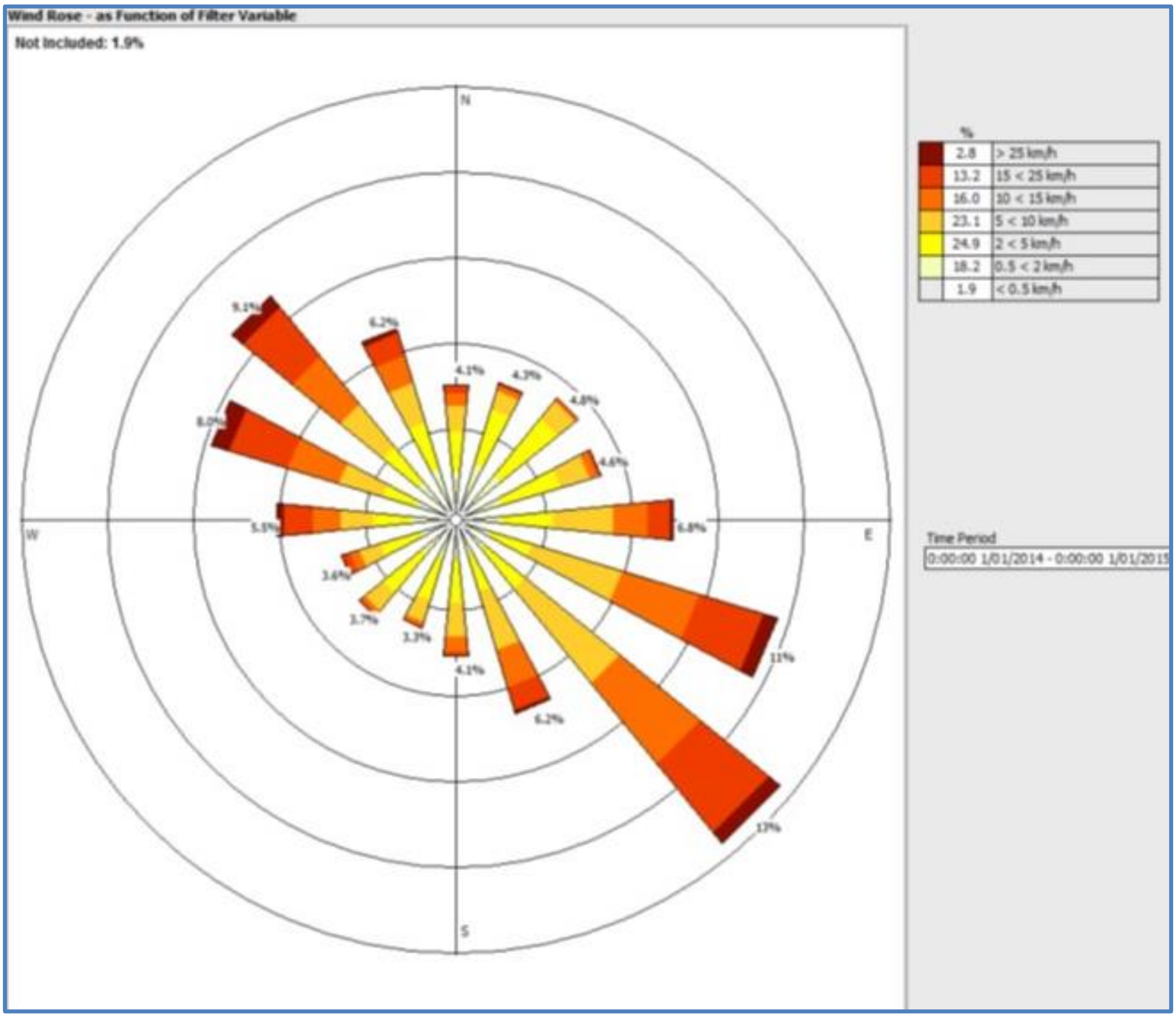


Figure 5-1: Monthly climate statistics summary – Scone SCS

5.2 Local meteorological conditions

An annual windrose for the Mangoola Coal mine operated meteorological station is presented in **Figure 5-2**. The annual windrose prepared for the 2014 calendar period has been obtained from the *Mangoola Coal 2014 Annual Review* (**SLR Consulting, 2015**). The meteorological station would be in accordance with the requirements in the *Approved Methods for Sampling of Air Pollutants in New South Wales* guidelines (**NSW DEC, 2007**).

Analysis of the windrose shows that the predominant wind flows are along a northwest to southeast axis which is typical of the Hunter Valley region of NSW. The most common winds on an annual basis are from the southeast and east-southeast, followed by the northwest and west-northwest. Few winds tend to originate from the northeast and southwest quadrants.



Source: **SLR Consulting, 2015**

Figure 5-2: Annual windrose for Wybong (Mangoola Coal) meteorological station - 2014

5.3 Ambient air quality

The main sources of particulate matter in the area surrounding the Project include active mining, agricultural activities, emissions from local anthropogenic activities (such as motor vehicle exhaust, dust from dirt roads, and domestic wood heaters) and various other commercial or industrial activities.

Ambient air quality monitoring for the Project site is not available. The publically available data from air quality monitors operated by the Mangoola Coal mine and the NSW EPA were used to quantify the existing background level for each of the assessed pollutants at the Project site.

The air quality monitors reviewed include Dust Depositional Gauges, Tapered Element Oscillating Microbalances (TEOMs) measuring PM_{10}, Beta Attenuation Monitor (BAM) measuring $PM_{2.5}$, High Volume Air Samplers (HVAS) measuring PM_{10} and TSP.

Table 5-2 lists the monitoring stations and data capture period reviewed in this section. **Figure 5-3** presents the approximate location of each of the monitoring stations relative to the Project location.

Table 5-2: Summary of ambient monitoring stations

Monitoring site ID	Type	Monitoring data review period
DG02 (Mangoola)	Dust Gauge	January 2011 - December 2014
DG03 (Mangoola)	Dust Gauge	January 2011 - December 2014
DG15 (Mangoola)	Dust Gauge	January 2011 - December 2014
DG16 (Mangoola)	Dust Gauge	January 2011 - December 2014
DG17 (Mangoola)	Dust Gauge	January 2011 - December 2014
DG21 (Mangoola)	Dust Gauge	January 2011 - December 2014
DC01 (Mangoola)	TEOM - PM_{10}	July 2011 - December 2014
DC01 (Mangoola)	TEOM - PM_{10}	July 2011 - December 2014
DC03 (Mangoola)	TEOM - PM_{10}	July 2011 - December 2014
DC04 (Mangoola)	TEOM - PM_{10}	July 2011 - December 2014
D01 (Mangoola)	HVAS - TSP	January 2011 - December 2014
D02 (Mangoola)	HVAS - TSP	January 2011 - December 2014
D03 (Mangoola)	HVAS - TSP	January 2011 - December 2014
D04 (Mangoola)	HVAS - TSP	January 2011 - December 2014
D05 (Mangoola)	HVAS - PM_{10}	July 2011 - December 2014
Muswellbrook (NSW EPA)	TEOM - PM_{10}, BAM - $PM_{2.5}$, and NO_2	January 2011 - December 2014
Muswellbrook NW (NSW EPA)	TEOM - PM_{10}	December 2011 - December 2014
Wybong (NSW EPA)	TEOM - PM_{10}	December 2011 - December 2014

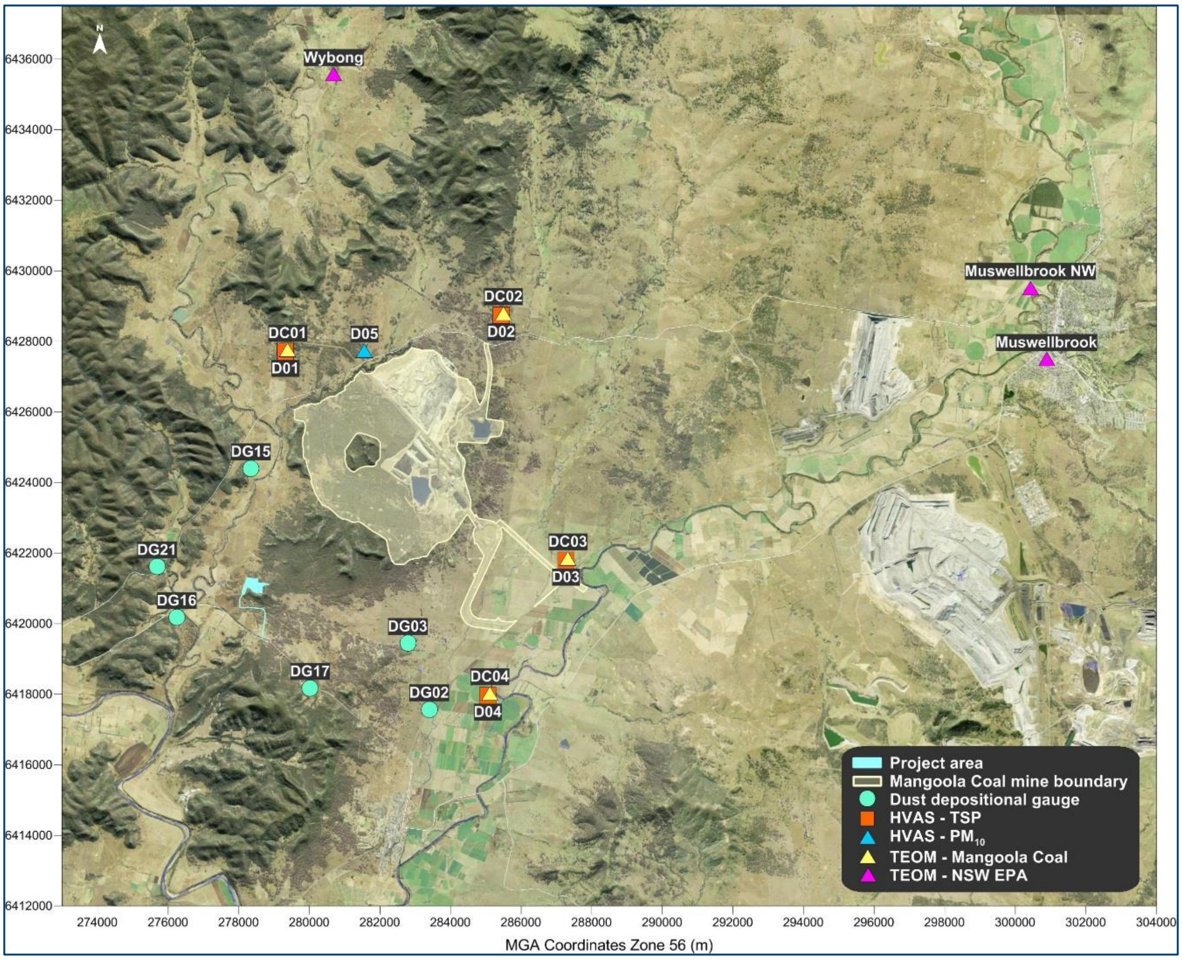


Figure 5-3: Monitoring locations

5.3.1 PM_{10} monitoring

A summary of the available data collected from the Mangoola Coal TEOM and HVAS PM_{10} monitors from January 2011 to December 2014 is presented in **Table 5-3**.

Table 5-3 indicates that the annual average PM_{10} concentrations for the monitoring stations were below the relevant criterion of 30µg/m³ during the monitoring period reviewed.

Table 5-3: Summary of PM_{10} levels from Mangoola Coal TEOM and HVAS monitoring (µg/m³)

Station ID	2011(1)	2012	2013	2014	Criterion
	Annual Average				
DC01	12.3	13.3	12.7	14.9	**30**
DC02	9.9	11.1	14.5	12.2	**30**
DC03	10.2	11.6	14.9	14.0	**30**
DC04	12.3	13.6	12.2	15.4	**30**
D05	14.4	16.8	17.3	19.3	**30**

Source: **GSS Environmental (2012 & 2013), SLR Consulting (2014 & 2015)**

(1) Reporting period from July 2011 to June 2012

A summary of the available data from nearby NSW EPA monitoring stations is presented in **Table 5-4** and the recorded 24-hour average concentrations are presented in **Figure 5-4**.

A review of **Table 5-4** indicates that the annual average PM_{10} concentrations recorded at the NSW EPA monitoring sites were below the relevant criterion of 30µg/m³. The recorded maximum 24-hour average PM_{10} concentrations were found to exceed the relevant criterion of 50µg/m³ at times during the review period.

Figure 5-4 shows seasonal variation in PM_{10} levels recorded at the NSW EPA monitors, with levels typically higher during the spring and summer months with the warmer weather raising the potential for drier ground elevating the occurrence of windblown dust, bushfires and pollen levels.

Table 5-4: Summary of PM_{10} levels from NSW EPA TEOM monitoring (µg/m³)

Station ID	2011	2012	2013	2014	Criterion
	Annual Average				
Muswellbrook	19.3	21.8	22.6	21.4	**30**
Muswellbrook NW	-	19.1	18.9	19.2	**30**
Wybong	-	15.4	15.6	17.0	**30**
	Maximum 24-hour average				
Muswellbrook	46.5	**51**	**55.6**	**53**	**50**
Muswellbrook NW	-	**55.8**	**52.4**	**50.8**	**50**
Wybong	-	**54.4**	**83**	**67.7**	**50**

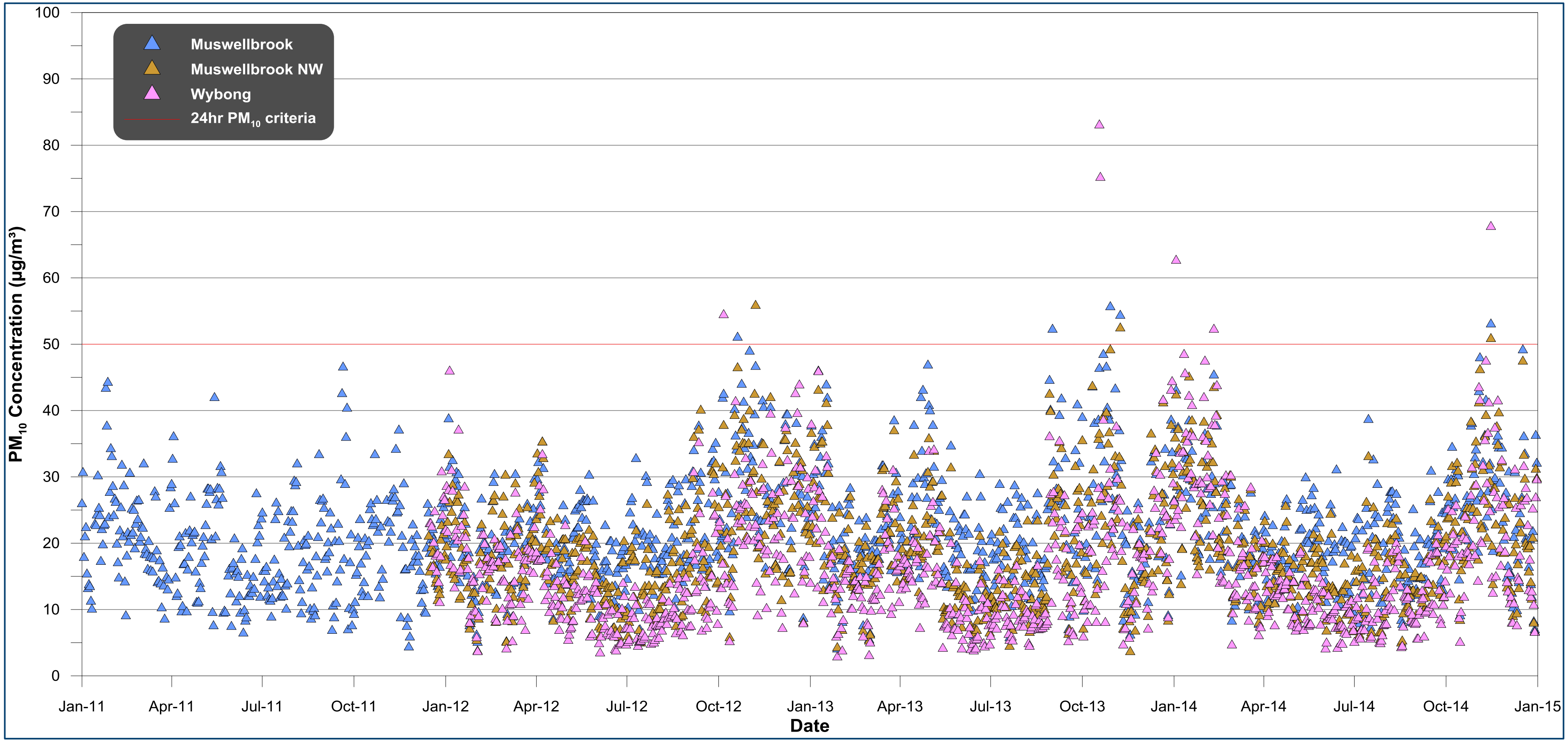


Figure 5-4: 24-hour average PM_{10} concentrations at NSW EPA monitors near to the Project site

5.3.2 $PM_{2.5}$ monitoring

Ambient $PM_{2.5}$ monitoring using a BAM is conducted by NSW EPA at Muswellbrook. A review of available $PM_{2.5}$ data in **Table 5-5** indicates that the annual average $PM_{2.5}$ concentrations recorded at Muswellbrook were consistently above the relevant criterion of 8µg/m³. The recorded maximum 24-hour average $PM_{2.5}$ concentrations were found to exceed the relevant criterion of 25µg/m³ at times during the review period.

Figure 5-5 shows a significant seasonal variation in $PM_{2.5}$ levels recorded at Muswellbrook. The elevated levels that occur during the cooler months have been identified in a CSIRO study (**CSIRO, 2013**) to be predominately associated with smoke from residential wood heaters.

This trend can also be seen in **Figure 5-6** which shows that the monitor located close to the urban area is affected by wood smoke and monitors located away from the urban areas show much lower levels during the same period.

Table 5-5: Summary of $PM_{2.5}$ levels from NSW EPA BAM monitoring (µg/m³)

Station ID	2011	2012	2013	2014	Advisory Reporting Standard
	Annual Average				
Muswellbrook	9.1	10.1	9.4	9.7	8
	Maximum 24-hour average				
Muswellbrook	28.3	26.4	36.6	27.4	25

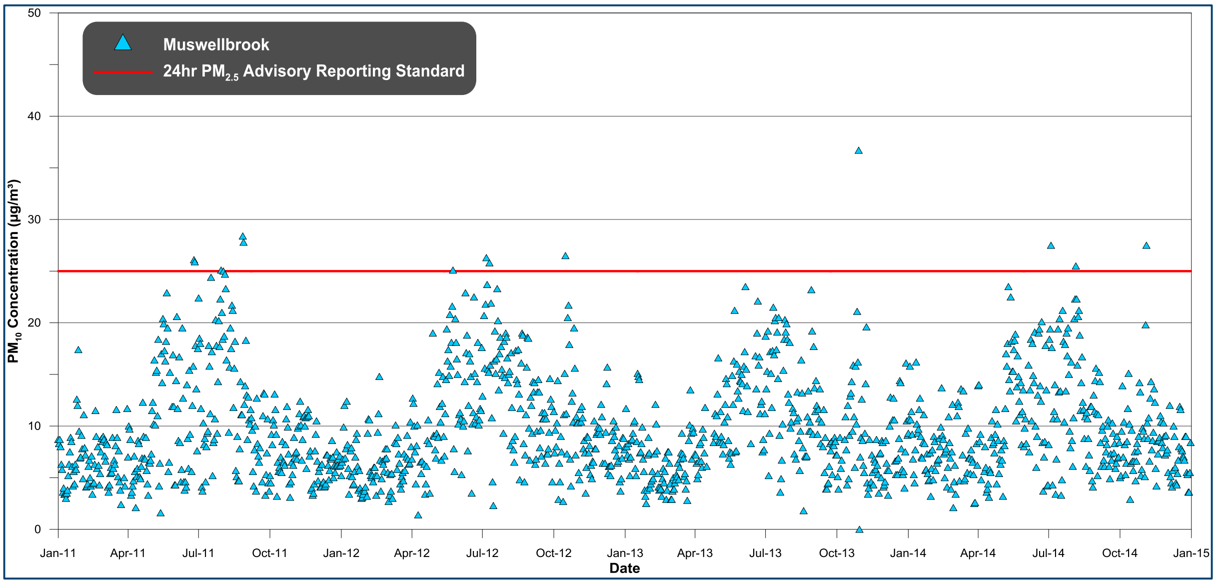
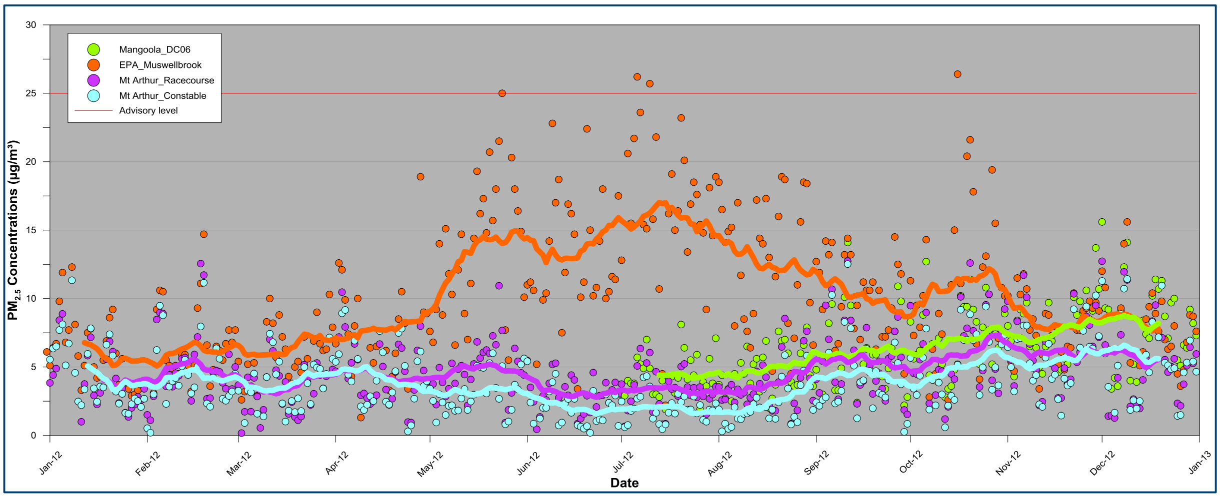


Figure 5-5: 24-hour average $PM_{2.5}$ concentrations at Muswellbrook



Source: **Todoroski Air Sciences (2014)**

Figure 5-6: Comparison of 24-hour average $PM_{2.5}$ concentrations in the Upper Hunter

5.3.3 TSP monitoring

Table 5-6 summarises the available data collected from the Mangoola Coal TSP monitors over the review period. The data indicate that all monitors recorded annual average TSP levels below the relevant criterion of 90µg/m^3.

Table 5-6: Annual average total suspended particulates (µg/m³)

Station ID	2011	2012	2013	2014	Criterion
	Annual average				
D01	35.9	37.7	32.7	43.7	**90**
D02	24.7	28.7	42.9	47.0	**90**
D03	36.4	41.4	43.5	50.0	**90**
D04	31.8	33.2	36.7	38.6	**90**

Source: **GSS Environmental (2012 & 2013), SLR Consulting (2014 & 2015)**

5.3.4 Dust Deposition monitoring

Table 5-7 summarises the annual average deposition levels from the Mangoola Coal dust gauges reviewed. All gauges recorded an annual average insoluble deposition level at or below the criterion of 4g/m^2/month for the period of review.

Table 5-7: Annual average dust deposition (g/m²/month)

Station ID	2011	2012	2013	2014	Criterion
	Annual average				
DG02	3.2	3.4	3.0	1.7	**4**
DG03	1.2	1.0	1.2	1.2	**4**
DG15	1.2	1.1	1.6	1.1	**4**
DG16	1.0	1.2	1.5	1.1	**4**
DG17	2.5	4.0	2.5	1.1	**4**
DG21	0.8	1.2	1.5	1.2	**4**

Source: **GSS Environmental (2012 & 2013), SLR Consulting (2014 & 2015)**

5.3.5 NO_2 monitoring

Figure 5-7 presents the maximum daily 1-hour average NO_2 concentrations from the Muswellbrook NSW EPA monitoring site from November 2011 to December 2014.

Ambient air quality monitoring data collected at this location would include emissions from sources such as the Liddell, Bayswater and Redbank power stations, methane gas flaring operations at mining operations as well as other various combustion sources.

The monitoring data recorded are well below the NSW EPA 1-hour average goal of 246µg/m^3 during this period at all of the monitors. The data in **Figure 5-7** indicate that levels of NO_2 are relatively low compared to the criterion level and show some marginal seasonal fluctuation.

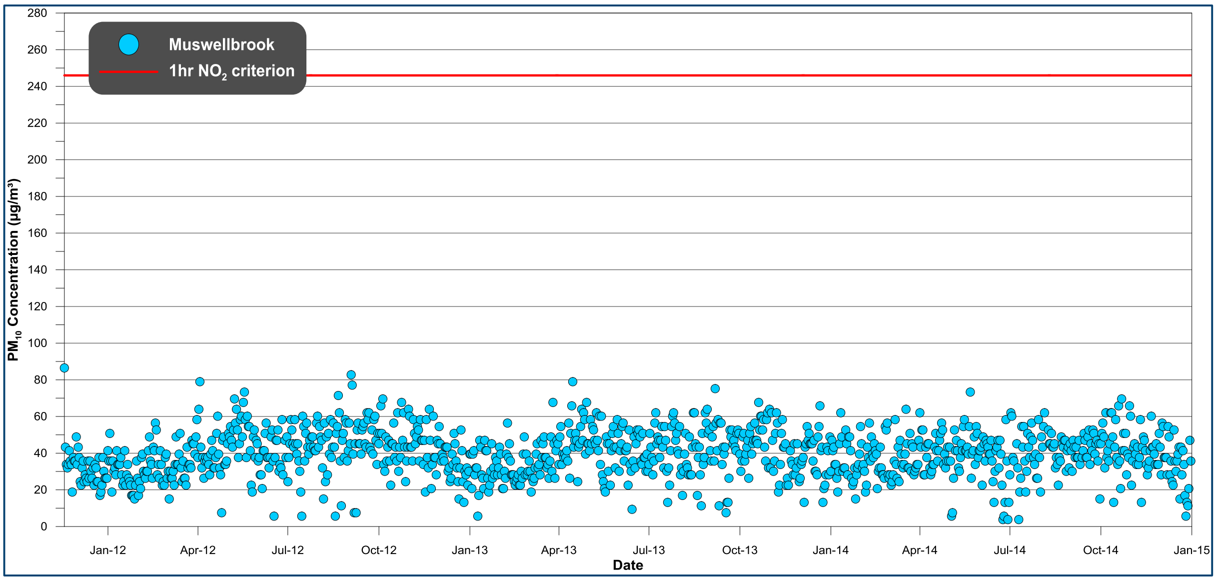


Figure 5-7: Daily 1-hour maximum NO_2 concentration at Muswellbrook

5.3.6 Carbon monoxide

The NSW EPA monitoring site at Muswellbrook and in the Hunter Valley do not record ambient concentrations of CO. Combustion activities are the cause of CO emissions and spatially there is very little such activity in the area apart from power generation, motor vehicles and wood heaters. Therefore, ambient concentrations of CO are expected to be low.

Ambient air quality goals for CO are set at higher concentration levels than NO_2 goals. Based on the NO_2 monitoring data which are low compared to the goals, and consideration of the typical mix of ambient pollutant levels, the indication is that ambient levels of CO would similarly also be well below the air quality goals.

5.3.7 Estimated background dust levels

Background dust levels at the Project site have been estimated using air quality data obtained from the Mangoola Coal air quality monitoring network and NSW EPA monitoring sites. Background PM_{10}, TSP and dust deposition levels were determined by averaging the available four years of assessed data and are presented in **Table 5-8**.

It is noted that actual background dust levels may vary in the area surrounding the Project site as a result of various factors, however for the purpose of this assessment, these estimates are considered suitable and are likely to be conservative given the monitor locations are generally closer to sources of pollution that are far away from the site.

Due to the influence of wood smoke affecting the measurements of the NSW EPA Muswellbrook monitor, these levels are not considered representative of the area surrounding the Project. The estimated background $PM_{2.5}$ level applied in a previous air quality assessment (**Todoroski Air Sciences, 2014**) for mining activities in the general area commissioned by the NSW Department of Planning & Environment has been applied and is considered representative of the actual conditions surrounding the site.

Table 5-8: Estimated background dust levels for the Project site

Pollutant type	Annual average
$PM_{2.5}$ (µg/m³)	2.9
PM_{10} (µg/m³)	15.4
TSP (µg/m³)	37.8
Deposited Dust (g/m²/month)	1.7

6 POTENTIAL CONSTRUCTION DUST EMISSIONS

The Project would require the construction of various infrastructure and associated facilities for the establishment and development of the site. The construction activity associated with the project has the potential to generate dust emissions.

Potential construction dust emissions will be primarily generated due to material handling, vehicle movements and windblown dust generated from exposed areas. Exhaust emission from the operation of construction vehicles and plant will also generate emissions.

The potential particulate impacts due to these activities is difficult to accurately quantify on any given day due to the short sporadic periods of dust generating activity that may occur over the construction time frame. The sources of dust are temporary in nature and will only occur during the construction period.

The total amount of dust generated from the construction process is unlikely to be significant given the nature of the activities. As these activities would be generally located away from the sensitive receptors, any potential dust impacts would be unlikely to be discernible beyond the existing levels of dust in the area surrounding the Project. Given that the activities would occur for a limited period, no significant or prolonged effect at any off-site receiver is predicted to arise.

To ensure dust generation during the construction activities is controlled and the potential for off-site impacts is reduced, appropriate (operational and physical) mitigation measures in **Table 6-1** will be implemented as necessary.

Table 6-1: Construction dust mitigation measures

Source	Mitigation measure
General	Activities to be assessed during adverse weather conditions and modified as required (e.g. cease activity where reasonable levels of visible dust cannot be maintained)
	Engines of on-site vehicles and plant to be switched off when not in use
	Vehicles and plant fitted with pollution reduction devices where practicable
	Maintain and service vehicles according to manufacturer's specifications
	Visual monitoring of dust generation
	Haul roads and plant to be sited away from sensitive receivers where possible
Travelling on unpaved surfaces	Watering of active haul roads
	Keep travel routes moist
	Sealed haul roads to be cleaned regularly
	Restrict vehicle traffic to designated routes
	Impose speed limits
	Covering vehicle loads when travelling off-site
	Wheel wash or grids near exit points to minimise mud/ dirt track out
Material handling	Reduce drop heights from loading and handling equipment
Exposed areas / stockpiles	Minimise area of exposed surfaces
	Water suppression on exposed areas and stockpiles
	Minimise the amount of stockpiled material
	Where possible apply barriers, covering or temporary rehabilitation
	Rehabilitate completed sections as soon as practicable
	Keep ancillary vehicles off exposed areas

7 DISPERSION MODELLING APPROACH

7.1 Introduction

The following sections are included to provide the reader with an understanding of the model and modelling approach applied for the assessment.

The CALPUFF model is an advanced "puff" model which can deal with the effects of complex local terrain on the dispersion meteorology over the entire modelling domain in a three-dimensional, hourly varying time step. CALPUFF is an air dispersion model approved by NSW EPA for use in air quality impact assessments. The model setup used is in general accordance with methods provided in the NSW EPA document *Generic Guidance and Optimum Model Setting for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia* (**TRC**, **2011**).

7.2 Modelling methodology

Modelling was undertaken using a combination of The Air Pollution Model (TAPM) and the CALPUFF Modelling System. The CALPUFF Modelling System includes three main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard, routinely available meteorological and geophysical datasets.

TAPM is a prognostic air model used to simulate the upper air data for CALMET input. The meteorological component of TAPM is an incompressible, non-hydrostatic, primitive equation model with a terrain-following vertical coordinate for three-dimensional simulations. The model predicts the flows important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analysis.

CALMET is a meteorological model that uses the geophysical information and observed/simulated surface and upper air data as inputs and develops wind and temperature fields on a three-dimensional gridded modelling domain.

CALPUFF is a transport and dispersion model that advects "puffs" of material emitted from modelled sources, simulating dispersion processes along the way. It typically uses the three dimensional meteorological field generated by CALMET.

CALPOST is a post processor used to process the output of the CALPUFF model and produce tabulations that summarise the results of the simulation.

7.2.1 Meteorological modelling

The TAPM model was applied to the available data to generate a three dimensional upper air data file for use in CALMET. The centre of analysis for the TAPM modelling used is 32deg19.5min south and 150deg39min east. The simulation involved an outer grid of 30km, with three nested grids of 10km, 3km and 1km with 35 vertical grid levels.

CALMET modelling used a nested approach where the three dimensional wind field from the coarser grid outer domain is used as the initial guess (or starting) field for the finer grid inner domain. This approach has several advantages over modelling a single domain. Observed surface wind field data from the near field as well as from far field monitoring sites can be included in the model to generate a more representative three dimensional wind field for the modelled area. Off domain terrain features for the finer grid domain can be allowed to take effect within the finer domain, as would occur in reality. Also, the coarse scale wind flow fields give a better set of starting conditions with which to operate the finer grid run.

The CALMET initial domain was run on a 100 x 100km area with a 2km grid resolution and refined for second domain on a 60 x 60km area with a 1.2km grid resolution and further refined for a final domain of 10 x 10km area with a 0.1km grid resolution.

The available meteorological data for January 2012 to December 2012 from four surrounding meteorological monitoring sites were included in this run. The 2012 calendar year was chosen based on a long-term meteorological analysis of data recorded in the wider area and has been applied in previous air quality assessments in the area (**Todoroski Air Sciences, 2014**). **Table 7-1** outlines the parameters used from each station. Three dimensional upper air data were sourced from TAPM output.

Table 7-1: Surface observation stations

Weather Stations	Parameters						
	WS	WD	CH	CC	T	RH	SLP
Scone Airport AWS (BoM) (Station No. 061363)	✓	✓			✓	✓	✓
Merriwa (Roscommon) (BoM) (Station No. 061287)	✓	✓	✓	✓	✓	✓	✓
Nullo Mountain AWS (BoM) (Station No. 062100)	✓	✓			✓	✓	
Murrurundi Gap AWS (BoM) (Station No. 061392)	✓	✓	✓	✓	✓	✓	✓
Cessnock Airport AWS (BoM) (Station No. 061260)	✓	✓			✓	✓	✓

WS = wind speed, WD= wind direction, CH = cloud height, CC = cloud cover, T = temperature, RH = relative humidity, SLP = station level pressure

Local land use and detailed topographical information was included to produce realistic fine scale flow fields (such as terrain forced flows) in surrounding areas, as shown in **Figure 7-1**.

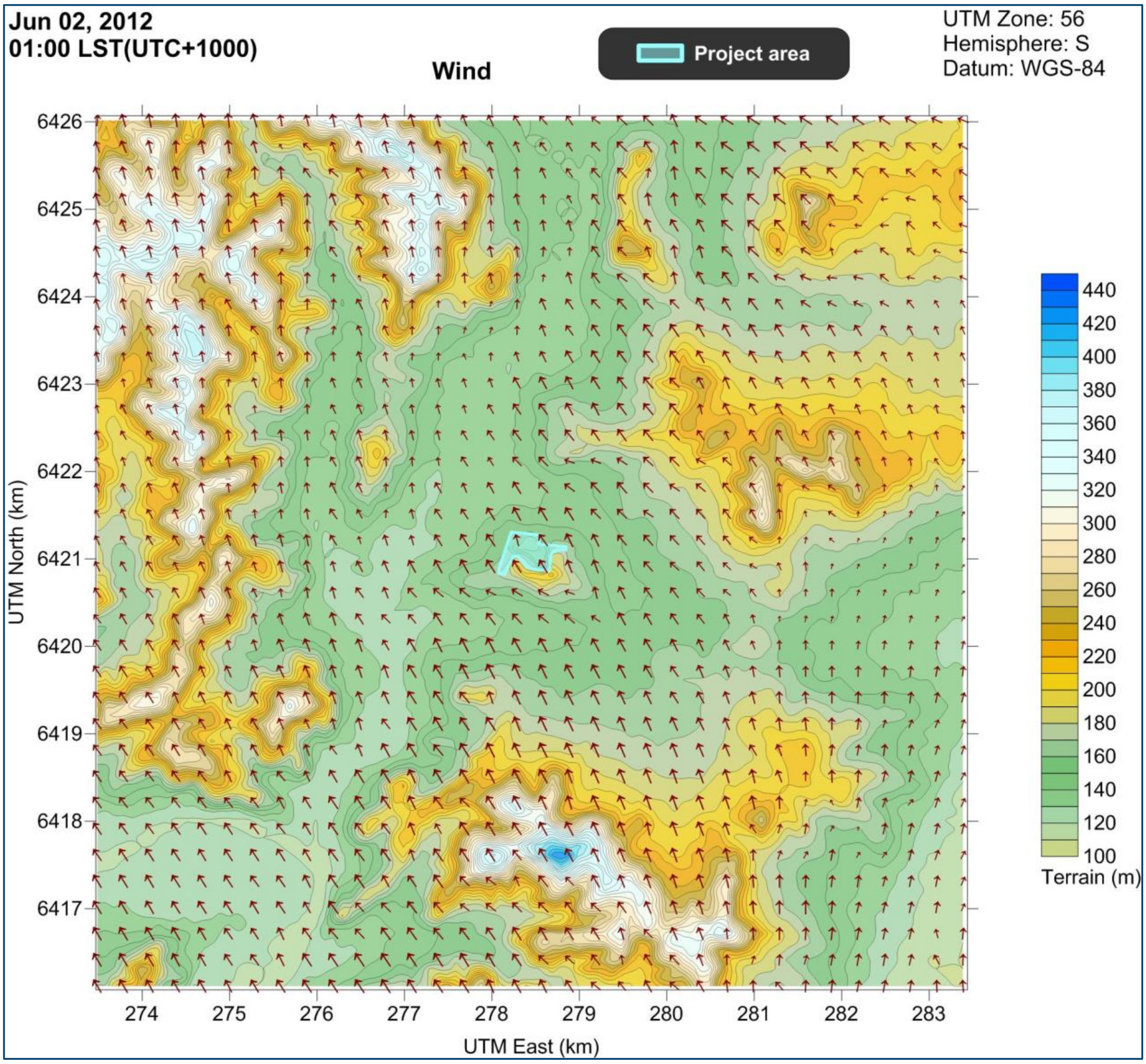


Figure 7-1: Representative snapshot of modelling wind field for Project

CALMET generated meteorological data were extracted from a point within the CALMET domain and are graphically represented in **Figure 7-2** and **Figure 7-3**.

Figure 7-2 presents annual and seasonal windroses extracted from one point in the CALMET domain. Throughout the year, winds from the west-northwest were most frequent followed by winds from the southeast with very few winds from northeast and southwest quadrants. During summer winds from the southeast are most prominent and during winter winds from the west-northwest are most prominent. During the seasons of autumn and winter, the wind distribution patterns generally reflect the annual distribution with varied winds typically from the west-northwest and the southeast.

A comparison of the windrose extracted from CALMET with the windrose from the Mangoola Coal weather station in **Figure 5-2** shows generally similar trends with winds from the southeast and northwest quadrant. The CALMET windrose is slightly skewed for winds from the northwest quadrant and may be due to the localised influences of the terrain effects.

Overall, the windroses generated in the CALMET modelling reflect the expected wind distribution patterns of the area as determined based on the available measured data and the expected terrain effects on the prevailing winds

Figure 7-3 includes graphs of the temperature, wind speed, mixing height and stability classification over the modelling period and shows sensible trends considered to be representative of the area.

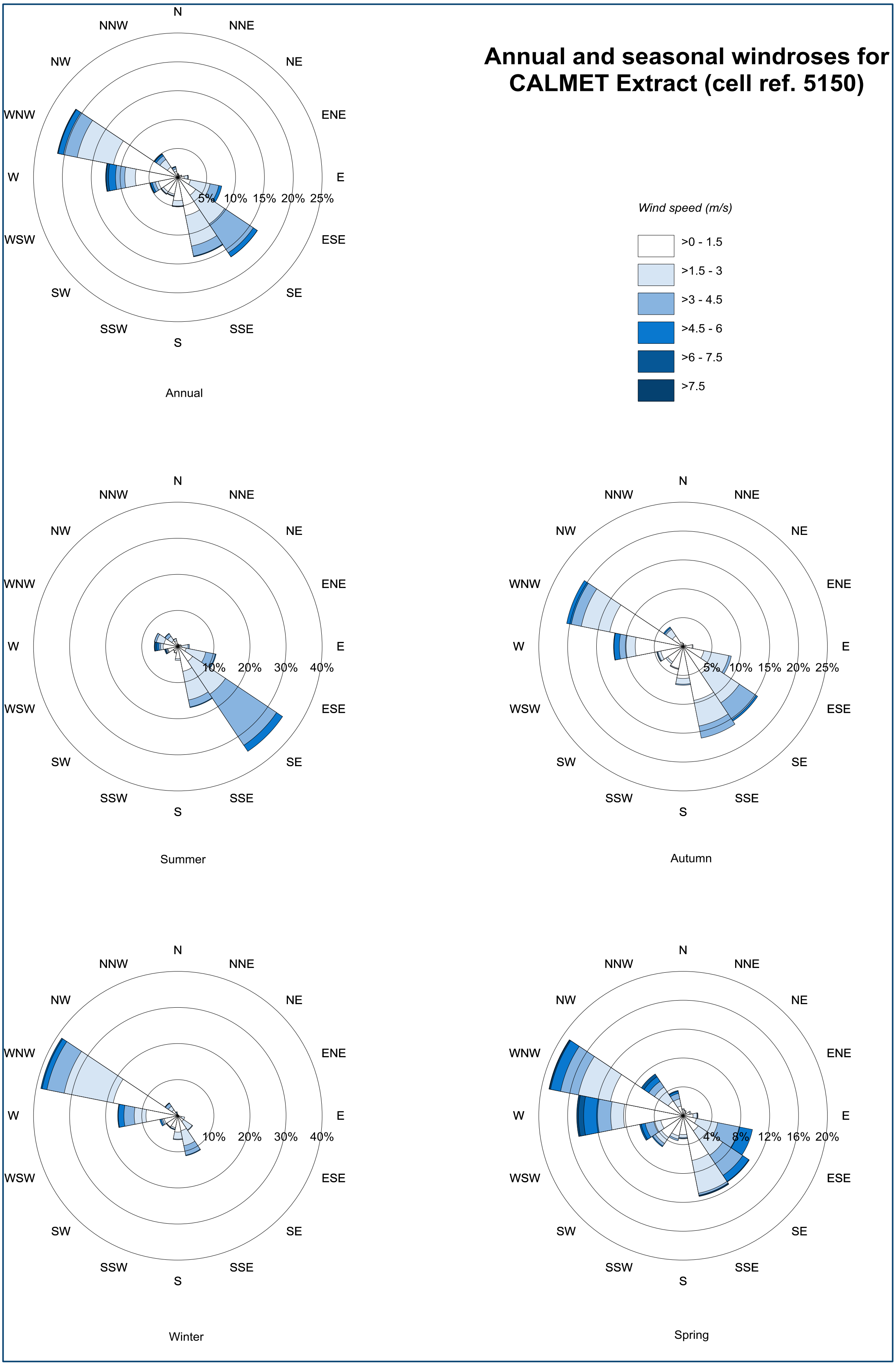


Figure 7-2: Annual and seasonal windroses from CALMET (Cell ref 5150)

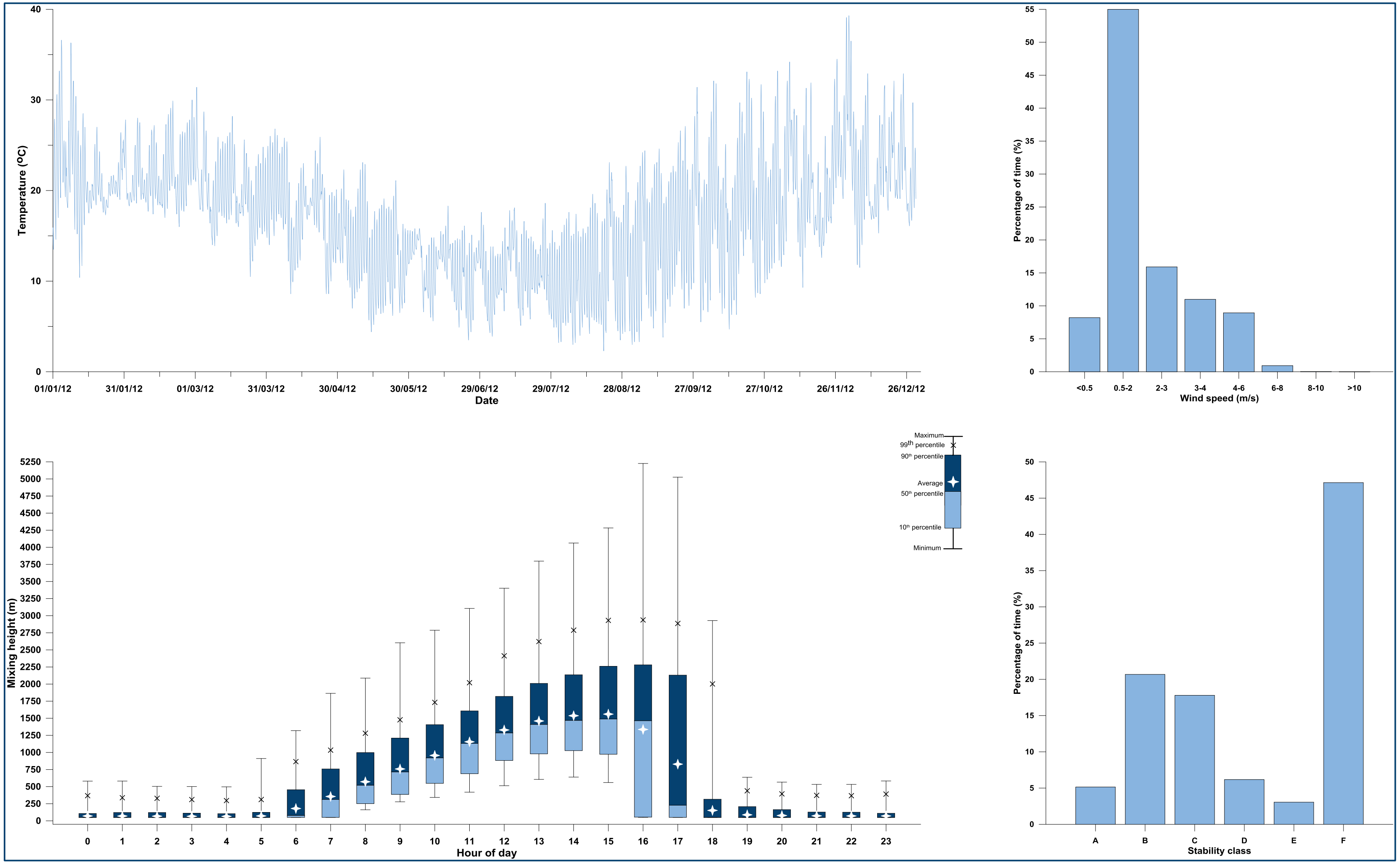


Figure 7-3: Meteorological analysis of CALMET (Cell Ref 5150)

7.2.2 Dispersion modelling

CALPUFF modelling is based on the application of three particle size categories; fine particulate, coarse matter and rest. The fraction of particles for each particle size category was derived from the measurements taken in the **SPCC (1986)** study and is presented in **Table 7-2**.

Table 7-2: Distribution of particles

Particle category	Size range	Distribution
Fine particulates	0 to 2.5µm	4.68% of TSP
Coarse matter	2.5 to 10µm	34.4% of TSP
Rest	10 to 30µm	60.92% of TSP

(1)Particle distribution sources from **SPCC (1986)**

Emissions from each activity were represented by a series of volume sources and were included in the CALPUFF model via an hourly varying emission file. Meteorological conditions associated with dust generation (such as wind speed) and levels of dust generating activity were considered in calculating the hourly varying emission rate for each source. It should be noted that as a conservative measure, the effect of the precipitation rate (rainfall) in reducing dust emissions has not been considered in this assessment.

Each particle size category is modelled separately and later combined to predict short-term and long-term average concentrations for $PM_{2.5}$, PM_{10}, and TSP. Dust deposition was predicted using the proven dry deposition algorithm within the CALPUFF model. Particle deposition is expressed in terms of atmospheric resistance through the surface layer, deposition layer resistance and gravitational settling (**Slinn and Slinn, 1980** and **Pleim *et al.*, 1984**). Gravitational settling is a function of the particle size and density, simulated for spheres by the Stokes equation (**Gregory, 1973**).

CALPUFF is capable of tracking the mass balance of particles emitted into the modelling domain. For each hour CALPUFF tracks the mass emitted, the amount deposited, the amounts remaining in the surface mixed layer or the air above the mixed layer and the amount advected out of the modelling domain. The versatility to address both dispersion and deposition algorithms in CALPUFF, combined with the 3D meteorological and land use field generally results in a more accurate model prediction compared to other Gaussian plume models (**Pfender *et al.*, 2006**).

7.3 Emission estimation

Activities associated with the proposed operations have the potential to generate dust emissions. Potential dust emissions may be generated during the extraction of material, loading/unloading of material, transport of material, drilling and blasting, crushing and screening of material, and windblown dust generated from exposed areas and stockpiles.

The estimated dust emissions for activities associated with the operation are presented in **Table 7-3**. The corresponding emission factors from the US EPA AP42 Emission Factors document (**USEPA, 1985 and updates**) and the State Pollution Control Commission document (**SPCC, 1983**) that were applied to estimate the potential dust emissions are outlined below the table. Detailed calculations of the dust emission estimates are provided in **Appendix A**.

Table 7-3: Estimated annual TSP emission rate – Operational activity

Activity	TSP emissions (kg/year)
Excavator loading Topsoil to haul truck	3
Hauling to Topsoil dump	38
Emplacing at Topsoil dump	3
Excavator loading Overburden to haul truck	53
Hauling Overburden to emplacement area	926
Emplacing at dump	53
Drilling gravel material	103
Blasting gravel material	51
Loading gravel material to crusher	263
Crushing gravel material	675
Screening gravel material	3,125
Unloading processed gravel material to stockpile	263
Rehandle processed gravel material at stockpile	263
Loading processed gravel material to haul truck	263
Hauling product gravel material offsite	37,478
Hauling product gravel material offsite - paved road	395
Wind erosion - whole site	37,493
Total	**81,446**

The calculations apply conservative variables based on the use of practical dust controls applied to the proposed activities, such as watering of haul roads.

A worst-case scenario for the Project was chosen where significant dust generating sources would be positioned to the west, located closest to the sensitive receptors within the proposed extraction boundary. The indicative quarry layout for this scenario is presented in **Figure 7-4**. Overburden and topsoil are transported via internal haul roads to the western edge of the site where the overburden emplacement area will form a visual bund. The quarry plant would be positioned behind the general progression of extraction within the pit. Product material would be transported along an unsealed internal haul road to the Golden Highway. An approximately 50m long section of this haul road adjoining the Golden Highway would be sealed.

7.4 Dust emissions from coal mining operations

In addition to the estimated dust emissions from the Project, the nearby approved open cut coal mining operations would also have some potential to contribute dust emissions in the general area surrounding the Project.

The predicted air quality impacts for Scenario 2 in the *Cumulative Impact Assessment Mt Arthur, Bengalla and Mangoola Coal Mine* (**Todoroski Air Sciences, 2014**) provide a conservative estimate of the influence of other mining activities, and includes the Mangoola Coal mine in its closest position to the Project receptors.

To assess the potential influence of these mining operations in conjunction with the Project, an assessment of the potential air quality impacts for $PM_{2.5}$ and PM_{10} is presented in **Section 8.2**.

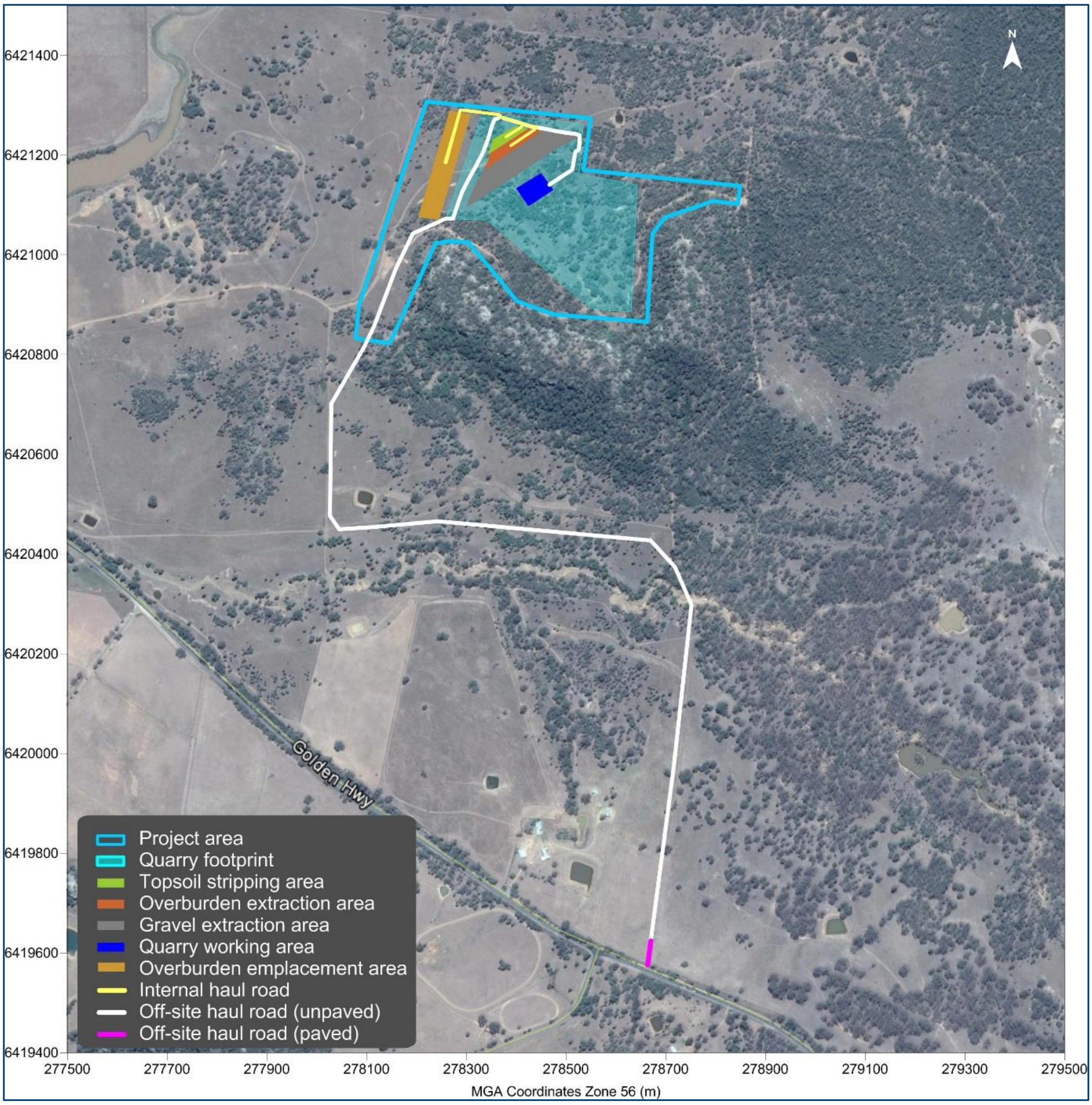


Figure 7-4: Indicative quarry layout

8 MODELLING RESULTS AND ANALYSIS

8.1 Incremental impact

Figure 8-1 to **Figure 8-6** present isopleths showing the spatial distribution of the incremental impacts predicted to arise due to the Project in isolation (incremental impact) for maximum 24-hour average $PM_{2.5}$ and PM_{10}, and annual average $PM_{2.5}$, PM_{10}, TSP and deposited dust levels, respectively.

Table 8-1 presents the predicted particulate dispersion modelling results at each of the assessed sensitive receptor locations. The results show minimal incremental effects would arise at the sensitive receptor locations due to the proposed operation.

Table 8-1: Predicted dispersion modelling results for discrete receptors – Incremental impact

Receptor ID	$PM_{2.5}$ (µg/m³)		PM_{10} (µg/m³)		TSP (µg/m³)	DD (g/m²/month)
	Incremental impact					
	24-hour average	Annual average	24-hour average	Annual average	Annual average	Annual average
	Air quality impact criteria					
	-	-	-	-	-	2
R1	0.09	0.00	0.66	0.03	0.05	0.00
R2	0.06	0.00	0.40	0.02	0.03	0.00
R3	0.03	0.00	0.27	0.01	0.02	0.00
R4	0.06	0.00	0.49	0.02	0.03	0.00
R5	0.05	0.00	0.37	0.02	0.03	0.00
R6	0.05	0.00	0.39	0.02	0.03	0.00
R7	0.09	0.01	0.76	0.04	0.07	0.00
R8	0.20	0.01	1.66	0.09	0.15	0.00
R9	0.44	0.04	3.64	0.31	0.58	0.01
R10	0.55	0.07	4.54	0.53	1.01	0.03
R11	0.14	0.02	1.12	0.16	0.28	0.01
R12	0.17	0.01	1.31	0.11	0.19	0.00
R13	0.15	0.02	1.13	0.14	0.25	0.00
R14	0.20	0.01	1.57	0.12	0.20	0.00
R15	0.47	0.06	3.63	0.49	0.91	0.02
R16	1.02	0.14	8.04	1.17	2.42	0.07
R17	0.49	0.02	3.81	0.18	0.31	0.00
R18	0.56	0.03	4.35	0.21	0.38	0.01
R19	0.41	0.02	3.16	0.12	0.21	0.00
R20	1.02	0.04	8.08	0.35	0.68	0.02
R21	0.43	0.02	3.35	0.16	0.29	0.01
R22	0.52	0.03	3.97	0.25	0.47	0.01

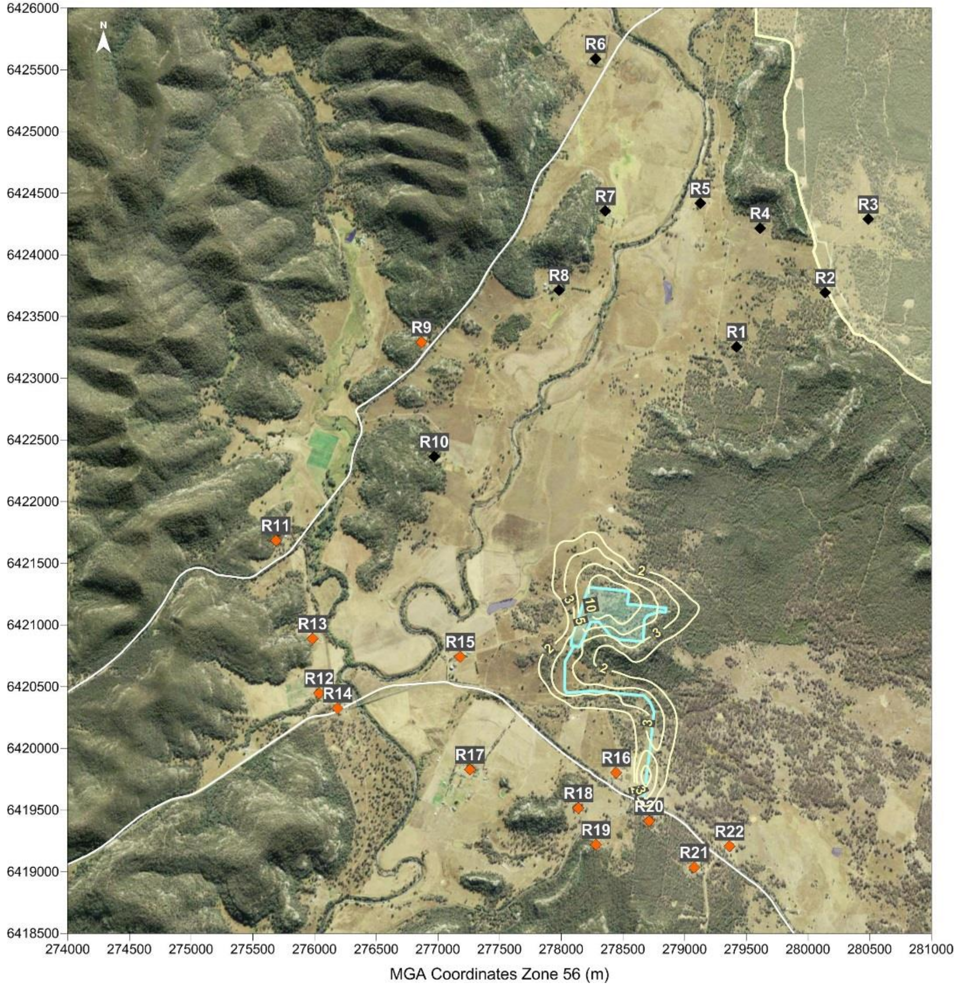


Figure 8-1: Predicted incremental maximum 24-hour average $PM_{2.5}$ concentrations (μg/m³)

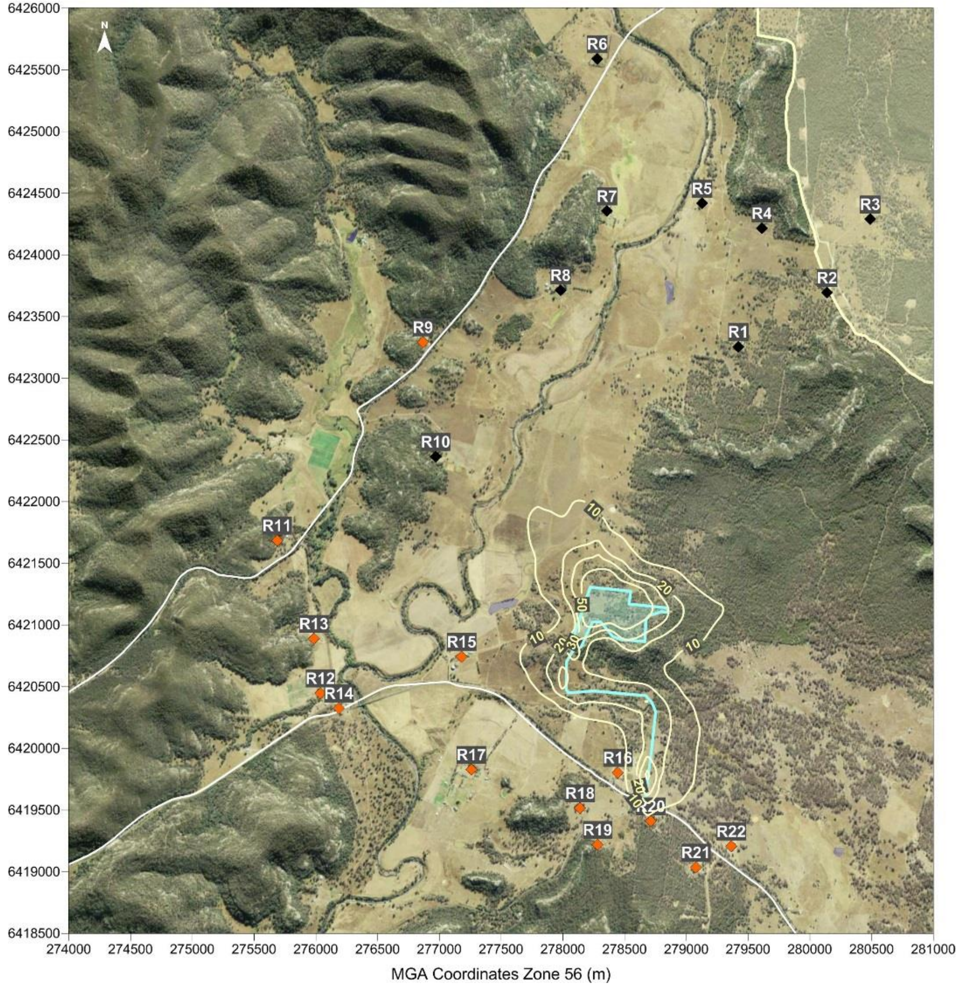


Figure 8-2: Predicted incremental maximum 24-hour average PM_{10} concentrations (μg/m³)

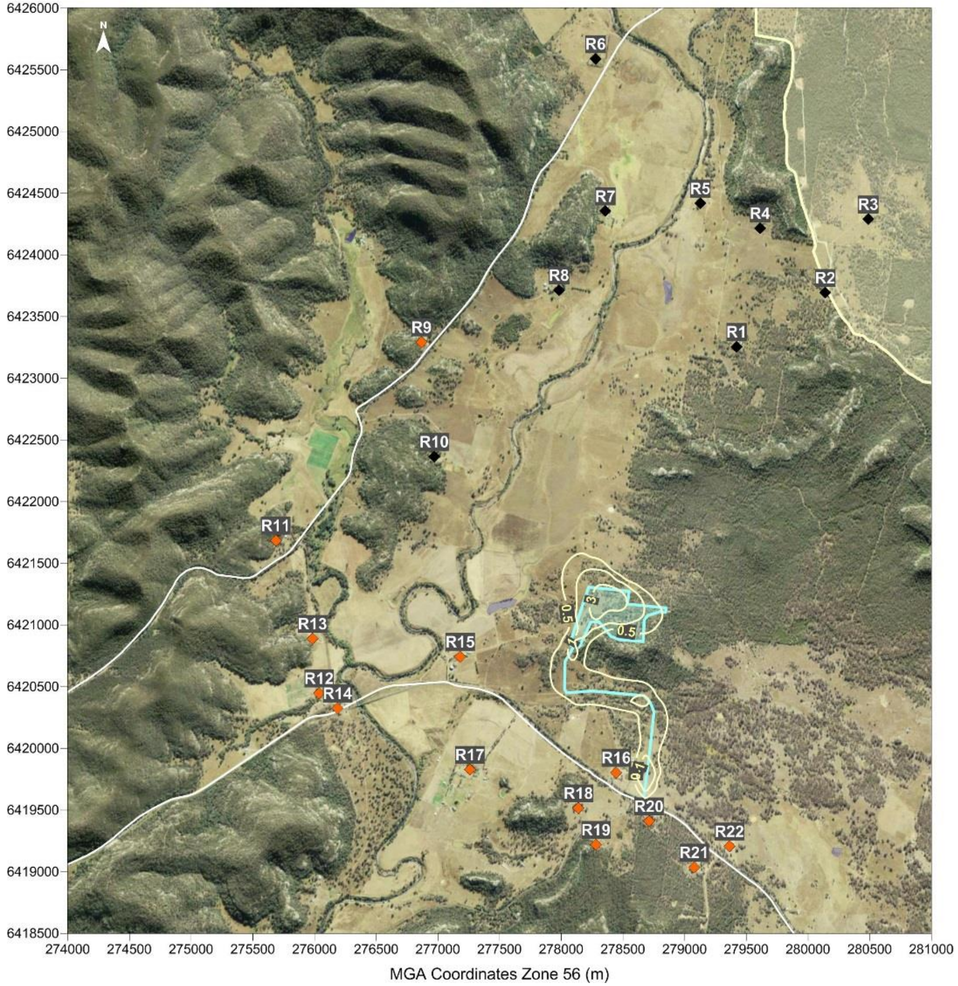


Figure 8-3: Predicted incremental annual average $PM_{2.5}$ concentrations (µg/m³)

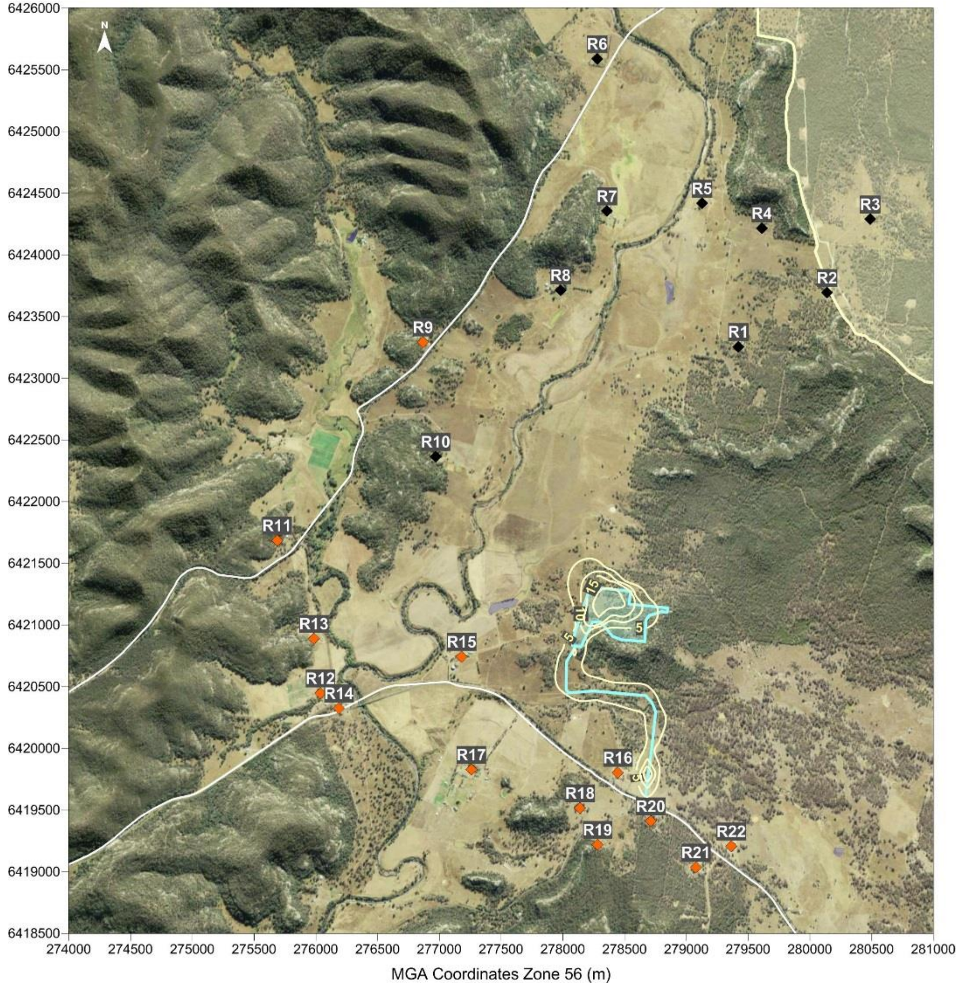


Figure 8-4: Predicted incremental annual average PM_{10} concentrations (µg/m³)

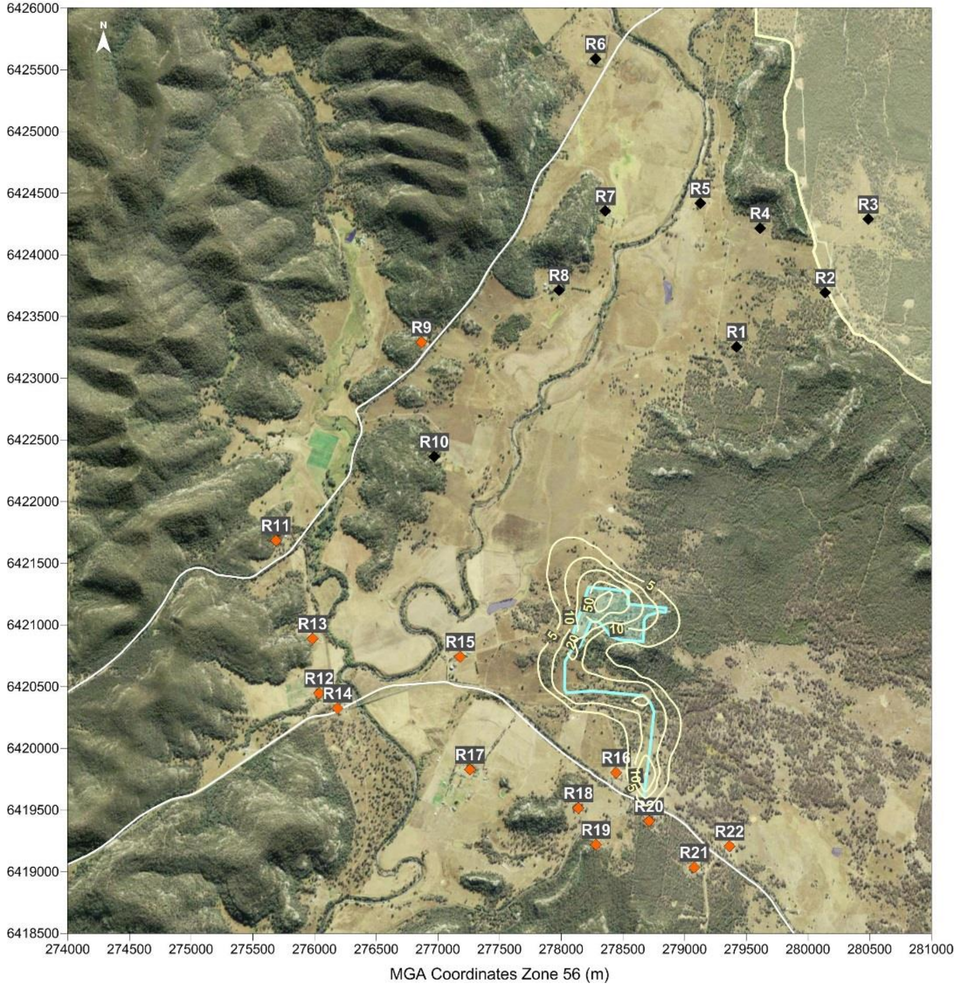


Figure 8-5: Predicted incremental annual average TSP concentrations (µg/m³)

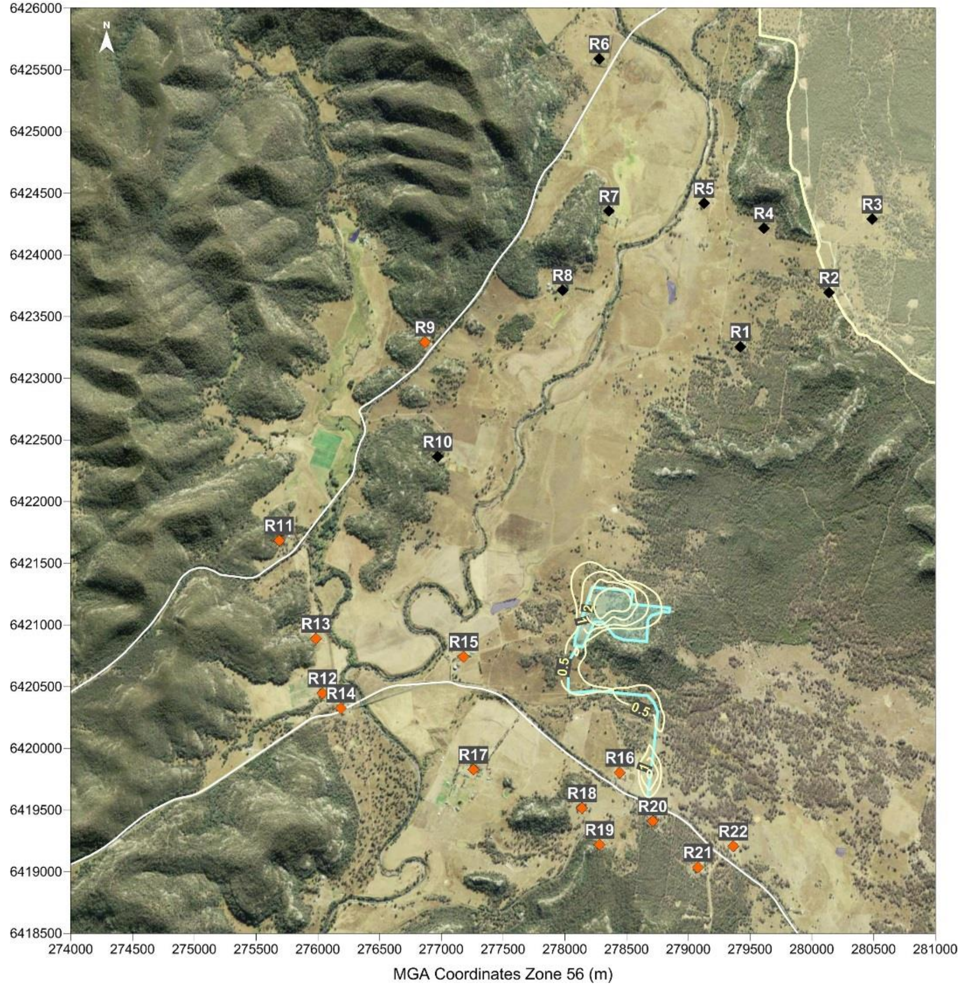


Figure 8-6: Predicted incremental annual average dust deposition levels (g/m²/month)

8.2 Cumulative impact

The predicted cumulative $PM_{2.5}$, PM_{10}, TSP and dust deposition levels due to the project with the estimated background levels in **Section 5.3.7** are presented in **Table 8-2**. The results indicate the predicted levels would be below the relevant criteria at the assessed sensitive receptor locations.

Table 8-2: Predicted dispersion modelling results for discrete receptors – Cumulative impact

Receptor ID	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Cumulative impact			
	Annual average			
	Air quality impact criteria			
	8*	30	90	4
R1	2.9	15.4	37.8	1.7
R2	2.9	15.4	37.8	1.7
R3	2.9	15.4	37.8	1.7
R4	2.9	15.4	37.8	1.7
R5	2.9	15.4	37.8	1.7
R6	2.9	15.4	37.8	1.7
R7	2.9	15.4	37.9	1.7
R8	2.9	15.5	37.9	1.7
R9	2.9	15.7	38.4	1.7
R10	3.0	15.9	38.8	1.7
R11	2.9	15.6	38.1	1.7
R12	2.9	15.5	38.0	1.7
R13	2.9	15.5	38.0	1.7
R14	2.9	15.5	38.0	1.7
R15	3.0	15.9	38.7	1.7
R16	3.0	16.6	40.2	1.8
R17	2.9	15.6	38.1	1.7
R18	2.9	15.6	38.2	1.7
R19	2.9	15.5	38.0	1.7
R20	2.9	15.7	38.5	1.7
R21	2.9	15.6	38.1	1.7
R22	2.9	15.7	38.3	1.7

*Advisory NEPM reporting standard

Figure 8-7 and **Figure 8-8** present the predicted annual average $PM_{2.5}$ and PM_{10} levels due to the Mt Arthur, Bengalla and Mangoola Coal mines for Scenario 2 of the *Cumulative Impact Assessment Mt Arthur, Bengalla and Mangoola Coal Mine* (**Todoroski Air Sciences, 2014**).

The figures indicate that the privately-owned sensitive receptors are likely to experience annual average $PM_{2.5}$ and PM_{10} levels of less than 3.5µg/m³ and 12µg/m³, respectively. When considering these levels with the predicted results in **Table 8-2**, the cumulative results for $PM_{2.5}$ and PM_{10} would remain below the relevant criteria.

It should be noted that this would be a conservative estimate that over predicts impacts as it includes some degree of double counting of the coal mining emissions.

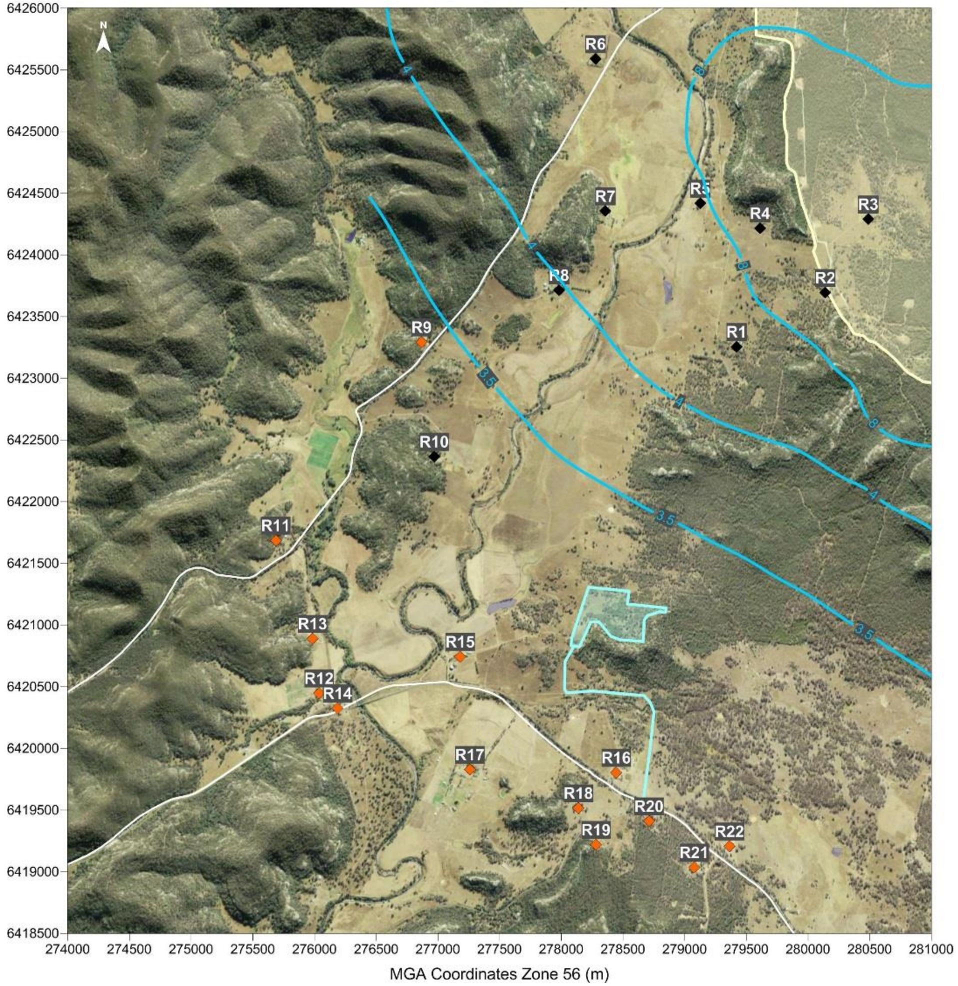


Figure 8-7: Predicted annual average $PM_{2.5}$ concentrations due to Mt Arthur, Bengalla and Mangoola Coal mines (µg/m³)

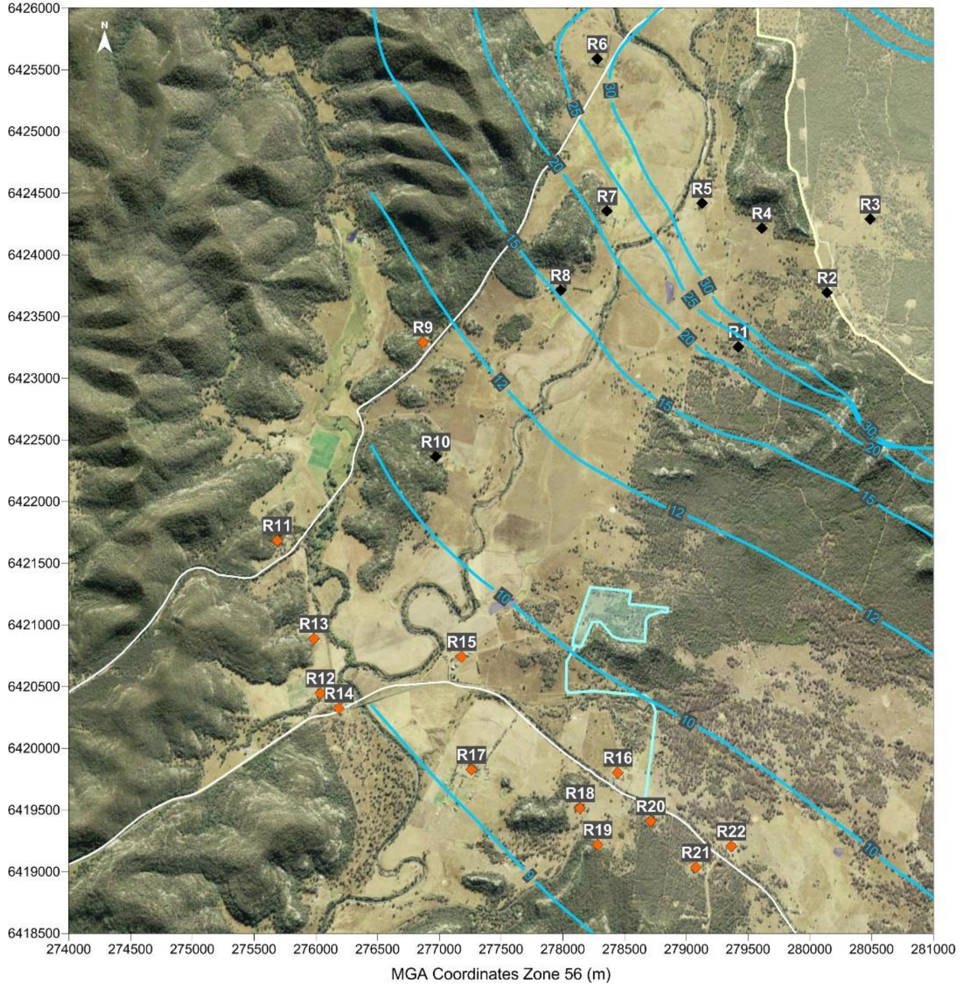


Figure 8-8: Predicted annual average PM_{10} concentrations due to Mt Arthur, Bengalla and Mangoola Coal mines (µg/m³)

8.3 Total (cumulative) 24-hour average PM_{10} concentrations

An assessment of cumulative 24-hour average PM_{10} impacts was undertaken in accordance with the methods outlined in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW DEC**, **2005**).

As shown in **Section 5.2** maximum background level data available for this assessment have in the past exceeded or come close to criterion level on some days. As a result, the Level 1 NSW EPA approach of adding maximum background levels to maximum predicted levels from the Project would show levels above the criterion whether the quarry was present or not.

In such situations, the NSW EPA applies a Level 2 contemporaneous assessment approach where the measured background levels are added to the day's corresponding predicted dust level from the Project site. Ambient (background) dust concentration data corresponding with the year of modelling (2012) from the NSW EPA monitoring site at Wybong have been applied in this case to represent the prevailing background levels in the vicinity of the Project site and surrounding sensitive receptors.

Assessment of cumulative 24-hour average PM_{10} was therefore conducted per the NSW EPA Level 2 contemporaneous assessment method as outlined in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (**NSW DEC**, **2005**) to examine the potential maximum total (cumulative) 24-hour average PM_{10} impacts for the proposed Project

The NSW EPA approach was applied at the most impacted receptor locations, Receptor R16 and Receptor R20. The background data were the measured levels at the Wybong monitoring station to which was added the predicted background dust levels due to the Project to determine the total. This was done for each day of a full year. Detailed tables of the full assessment results are provided in **Appendix B**.

Table 8-3 provides a summary of the findings from the Level 2 assessment at each assessed receptor location. The results in **Table 8-3** indicate that it is unlikely that systemic cumulative impacts would arise at the assessed receptor locations. It is therefore predicted that the maximum impact at all sensitive receptors of the Project is not likely to exceed the relevant criteria.

Table 8-3: Summary of NSW EPA contemporaneous assessment

Receptor ID	Number of additional days above 24-hour average PM_{10} criterion
R16	0
R20	0

The contemporaneous assessment indicates only low potential for any cumulative 24-hour average PM_{10} impacts to occur at the most impacted sensitive receptor locations. Given that these locations show little potential for any significant impact to occur, it can be inferred that there would also be little prospect of any significant impact to occur due to the Project at all other sensitive receptor locations.

Time series plots of the predicted cumulative 24-hour PM_{10} concentrations for R16 and R20 are presented in **Figure 8-9**. The white bars in the figure represent the measured background levels at the Wybong monitor and the orange bars represent the incremental levels due to the Project.

It is clear from the figures that the Project would have only a minor influence at these receptor locations and is unlikely to be discernible beyond the existing background level at times.

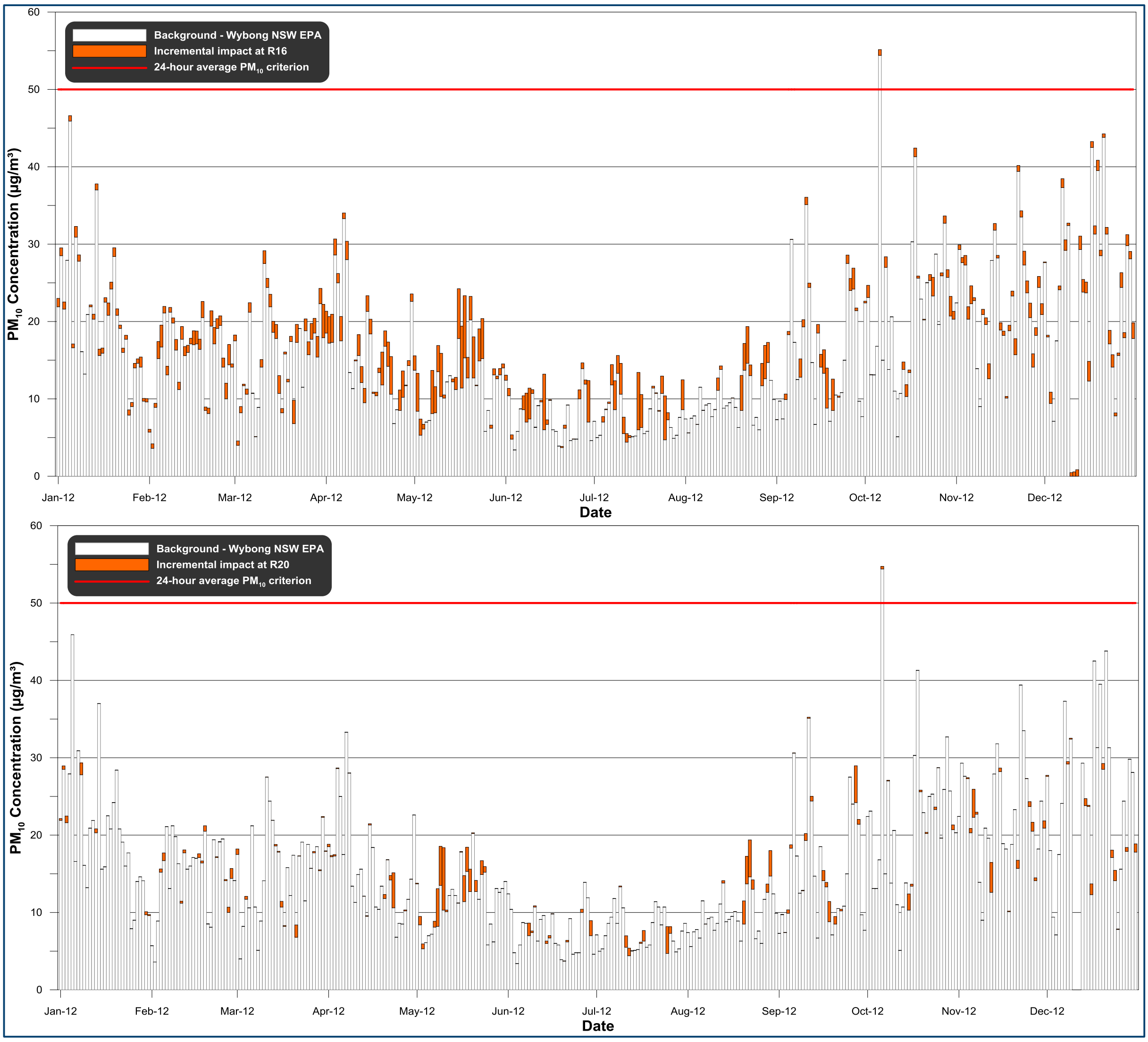


Figure 8-9: Time series plots of predicted cumulative 24-hour average PM_{10} concentrations for R16 and R20

9 ASSESSMENT OF BLAST FUME EMISSIONS

The proposed operations at the Project will also require occasional blasting to assist with the extraction of the resource. Blasting activities have the potential to generate noxious gases such as NO_2 and CO. Blast fume emissions can vary greatly depending on a number of factors but largely depend on the tendency of a particular blast (or holes within the shot) to generate significant NO_2 emissions.

The nature of the blasts at the Project will be restricted to small scale operations required to fracture hard rock material during excavation. Blasting will be undertaken between the hours of 9am to 5pm Monday to Saturday with no blasting on Sundays or public holidays. The estimated frequency of blasting at the Project will be less than or equal to 12 times per annum with the aim to undertake a maximum of eight blast per year (**Peter Bellais Consulting, 2015**). With the progression of the quarry travelling in a general westerly direction towards the nearest sensitive receptor, the active blasting face would point in an easterly direction.

Proposed blast designs in the blasting assessment for the Project (**Peter Bellais Consulting, 2015**) have been based on bench heights of 10m and 15m to accommodate the proposed operation. The estimated blast area for each of the designs is approximately 868m^2 and 579m^2 for the bench heights of 10m and 15m and utilise a combination of 44kg of ANFO with 58kg of Emulsion and 70kg of ANFO with 94kg of Emulsion, respectively.

The blasts are small, approx. size of a modest city house lot, and infrequent, less than once per month

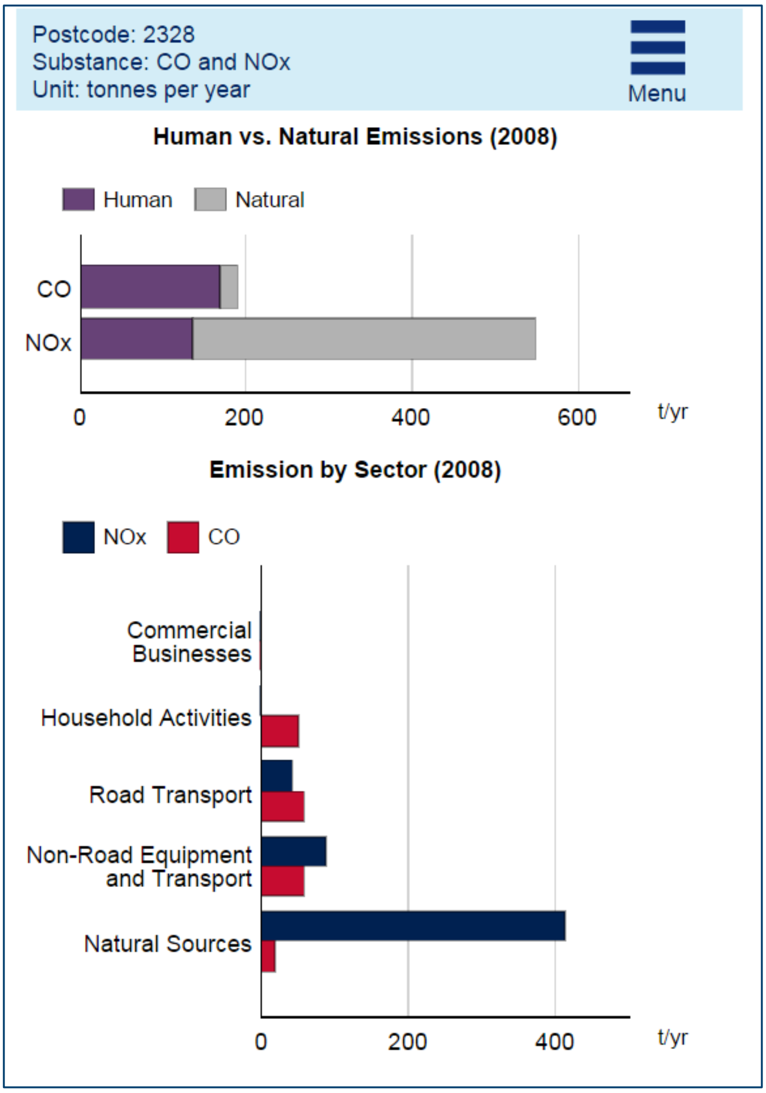
To estimate the potential NO_X and CO emissions associated with the blasting activity at the Project, emission factors of 8kg/tonne for ANFO and 0.2kg/tonne for Emulsion for NO_X and 34kg/tonne for ANFO and 2.3kg/tonne for Emulsion for CO obtained from the National Pollutant Inventory (NPI) (**NPI, 2012**) have been applied. Based on the maximum amount of explosives required for the 15m bench design, it is estimated that the Project would potentially generate approximately 6.9kg of NO_X and 31.2kg of CO per year and 0.58kg of NO_X and 2.6kg of CO per blast.

The estimated total quantity of NO_X and CO generated from the blasting activity associated with the Project each year is low.

Figure 9-1 presents the NSW EPA estimated NO_X and CO emissions for the Hollydeen area and shows that approximately 135 tonnes per year of NO_X and 169 tonnes per year of CO are estimated to be generated from human-made sources in the area. In comparison, the Project would be expected to generate approximately 0.0051% additional NO_X and 0.018% additional CO emissions associated with the blasting activity annually.

The available NO_2 monitoring data for the area (see **Figure 5-7**) is low compared to the relevant air quality goal. In consideration of this and the low emissions, it is expected that the emissions associated with the blasting would not result in any potential cumulative impacts.

As the nature of the blasting would be of a relatively small scale, the potential short term effects on air quality related to the activity can be minimised with good blast practices such as restricting the size of each blast, ensuring blasts only occur during good dispersion conditions and when winds are blowing away from the sensitive receptors.



Source: **NSW EPA (2015)**

Figure 9-1: NOX emission estimate for Postcode 2328

Good blast practices would include understanding the size of each blast, the residence time of each blast, the nature of the stemming material, the proximity to roads and nearby sensitive receptors, and weather conditions prior to blasting.

The decision to detonate a blast in each instance is based on operator judgement of the actual prevailing weather conditions, forecast weather conditions and the expected nature of potential plume travel towards the nearest assessment locations. Recommended blast management measures developed for the Project would include a review of publically available weather forecast and real-time meteorological conditions prior to each blast to estimate the potential plume travel and areas where impacts may occur.

As the blasting would be infrequent and small with low inherent scope for impact, the activity could be readily managed by selecting a suitable blast time during the day when no impacts are expected to arise.

10 DUST MITIGATION AND MANAGEMENT

The proposed operations at the Project have the potential to generate dust emissions. To ensure these activities have a minimal effect on the surrounding environment and sensitive receptor locations, it is considered that all reasonable and practicable dust mitigation measures be utilised.

Potential operational dust emissions will be primarily generated due to material handling, vehicle movements and windblown dust generated from exposed areas. Particulate emissions would also be generated from the exhaust of vehicles and plant.

To ensure dust generation is reasonably controlled and the potential for off-site impacts is minimised, appropriate operational and physical mitigation measures should be considered and implemented where feasible and reasonable as listed in **Table 10-1**.

Table 10-1: Potential dust mitigation options

Source	Mitigation Measure
General	Activities to be assessed during adverse weather conditions and modified as required (e.g. cease activity where visible dust plumes exceed several times the length of the plant)
	Engines to be switched off when not in use for any prolonged period
	Vehicles and plant fitted with pollution reduction devices where practicable
	Maintain and service vehicles according to manufacturer's specifications to ensure low emission operation
	Haul roads/ transport routes to be sited away from sensitive receivers where possible
Exposed areas and Stockpiles	Minimise area of exposed dirt surfaces
	Employ water suppression on exposed areas and stockpiles
	Minimise amount of stockpiled material
	Locate stockpiles away from sensitive receivers
	Apply barriers, covering or temporary rehabilitation
	Rehabilitation of completed sections as soon as practicable
	Keep ancillary vehicles off exposed areas
Material handling	Reduce drop heights from loading and handling equipment
	Modify activity during adverse weather conditions when visible dust plumes are generated
Hauling activities	Watering of haul roads (fixed or mobile) when required
	Keep travel routes moist
	Sealed haul roads to be cleaned regularly
	Restrict vehicle traffic to designated routes, that can be managed by regular watering
	Impose speed limits
	Cover vehicle loads when transporting material off- site
	Wheel wash or grids near exit points to minimise mud/ dirt track out

It is anticipated that the Project would develop a suitable Air Quality Management Plan (AQMP) for the site to assist with the management of air emissions. It is envisaged the AQMP would detail appropriate air emission control measures and mechanisms applied and as well as other management measures to minimise the potential for air emissions. The air emission controls applied at the site would be regularly assessed to ensure they are working effectively, any required modifications or adjustments to the air emission control measures would be revised on a regular basis and documented in the AQMP.

The key performance indicators for the applied air emission controls would be through visual means indicated by the visual dust plumes generated from each activity. The key performance indicators would be met when visual dust plumes arising from the activities are considered minimal or non-existent and that no record of complaints regarding dust plumes and impacts have been recorded.

A complaints protocol for the Project will be made available for any complaints received regarding air quality impacts. Any incident or complaint relating to air quality will be recorded and investigated to identify wherever possible the specific cause and corrective action will be implemented where necessary and feasible to do so.

Predictive and reactive measures are also expected to be implemented at the site to manage air emissions. The predictive measures would include utilising local weather forecasts to understand the potential travel of air emissions on a daily basis, if any weather fronts are predicted to occur which can cause a sudden change in wind direction or speed and if warmer weather is predicted that would increase the potential for dust emissions. The reactive measures would include ensuring adequate water is available during warm periods and if an activity is considered to be generating significant visual dust emissions to modify the activity to reduce this through application of additional control or temporarily pausing this activity until conditions improve.

As the predicted air quality impacts associated with the Project at the surrounding sensitive receptors locations are relatively low (see **Section 8**), there is no recommendation for the establishment of an ambient air quality monitoring network. It is however recommended that the Project engage with the neighbouring mining operation (Mangoola Coal) for a data sharing arrangement to utilise the ambient dust monitoring data in the local area already being measured.

11 SUMMARY AND CONCLUSIONS

This report has assessed the potential worst-case dust impacts associated with the operation of the proposed Dolwendee Quarry.

Air dispersion modelling was used to predict the potential for off-site dust impacts in the surrounding area due to the operation of the Project.

It is predicted that all the assessed air pollutants generated by the Project would comply with the applicable assessment criteria at all sensitive receptors and therefore would not lead to any unacceptable level of environmental harm or impact in the surrounding area.

Nevertheless, the site would apply appropriate dust management measures to ensure it minimises the potential occurrence of excessive dust emissions from the site.

Overall, the assessment demonstrates that even using conservative assumptions, the approved Project can operate without causing any significant air quality impact at sensitive receptors in the surrounding environment.

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Appendix A

Emission Inventory

Table A-1: Emission factor equations

Activity	Emission factor equation	Variable	Control factor
Loading / emplacing material	$EF = k \times 0.0016 \times \left(\frac{U}{2.2}^{1.3} / \frac{M}{2}^{1.4}\right) kg/tonne$	K_{tsp} = 0.74 U = wind speed (m/s) M = moisture content (%)	-
Hauling on unsealed surfaces	$EF = \left(\frac{0.4536}{1.6093}\right) \times k \times (s/12)^{0.7} \times (1.1023 \times M/3)^{0.45} kg/VKT$	k = 1.38 (kg/VKT) s = silt content (%) M = average vehicle gross mass (tonnes) a = 0.7 b = 0.45	75% - watering trafficked areas
Hauling on sealed surfaces	$EF = k \times (sL)^{0.91} \times (W)^{1.02} kg/VKT$	k = 3.23 (g/VKT) sL = road surface silt loading (g/m²) W = average weight of vehicles (tons)	-
Drilling	$EF = 0.59 \, kg/hole$	-	70% - dust suppression
Blasting	$EF = 0.00022 \times A^{1.5} kg/blast$	A = area of blast in square metres	-
Crushing	$EF = 0.0027 \, kg/tonne$	-	-
Screening	$EF = 0.0125 \, kg/tonne$	-	-
Wind erosion from exposed areas	$EF = 0.4 \, kg/ha/hour$	-	-

Table A-2: Emissions Inventory

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
Excavator loading Topsoil to haul truck	3	2,400	tonnes/year	0.00105	kg/t	0.89	average of (WS/2.2)^1.3 i	2	moisture content in %								
Hauling to Topsoil dump	38	2,400	tonnes/year	0.064	kg/t	33	tonnes/load	0.6	km/return trip	3.7	kg/VKT	10.0	% silt content	32	Ave GMV (tonnes)	75	% Control
Emplacing at Topsoil dump	3	2,400	tonnes/year	0.00105	kg/t	0.89	average of (WS/2.2)^1.3 i	2	moisture content in %								
Excavator loading Overburden to haul truck	53	50,000	tonnes/year	0.00105	kg/t	0.89	average of (WS/2.2)^1.3 i	2	moisture content in %								
Hauling Overburden to emplacement area	926	50,000	tonnes/year	0.074	kg/t	33	tonnes/load	0.7	km/return trip	3.7	kg/VKT	10.0	% silt content	32	Ave GMV (tonnes)	75	% Control
Emplacing at dump	53	50,000	tonnes/year	0.00105	kg/t	0.89	average of (WS/2.2)^1.3 i	2	moisture content in %								
Drilling gravel material	103	581.77	holes/year	0.59	kg/hole											70	% Control
Blasting gravel material	51	12	blasts/year	4	kg/blast	723	Area of blast in square metres										
Loading gravel material to crusher	263	250,000	tonnes/year	0.00105	kg/t	0.89	average of (WS/2.2)^1.3 i	2	moisture content in %								
Crushing gravel material	675	250,000	tonnes/year	0.0027	kg/t												
Screening gravel material	3,125	250,000	tonnes/year	0.0125	kg/t												
Unloading processed gravel material to stockpile	263	250,000	tonnes/year	0.00105	kg/t	0.89	average of (WS/2.2)^1.3 i	2	moisture content in %								
Rehandle processed gravel material at stockpiles	263	250,000	tonnes/year	0.00105	kg/t	0.89	average of (WS/2.2)^1.3 i	2	moisture content in %								
Loading processed gravel material to haul truck	263	250,000	tonnes/year	0.00105	kg/t	0.89	average of (WS/2.2)^1.3 i	2	moisture content in %								
Hauling product gravel material offsite	37,478	250,000	tonnes/year	0.600	kg/t	33	tonnes/load	5.4	km/return trip	3.7	kg/VKT	10.0	% silt content	32	Ave GMV (tonnes)	75	% Control
Hauling product gravel material offsite - paved road	395	250,000	tonnes/year	0.002	kg/t	33	tonnes/load	0.1	km/return trip	0.5	kg/VKT	5.0	silt loading (g/m²)	32	Ave GMV (tonnes)		
Wind erosion - whole site	37,493	10.7	ha	3,504	kg/ha/year												
Total TSP emissions (kg/yr)	**81,446**																

Appendix B

Further detail regarding 24-hour PM_{10} analysis

The analysis below provides a cumulative 24-hour PM_{10} impact assessment per the NSW EPA Approved Methods; refer to the worked example on Page 52 to 54 of the Approved Methods.

The background level is the total ambient measured level at the nearest monitoring station to the receptor assessed in each table.

The predicted increment is the level predicted to occur at the receptor due to the Project.

The total is the sum of the background level and the predicted level.

Each table assesses one receptor. The left hand half of the table examines the cumulative impact during the periods of highest background levels and the right hand side of the table examines the cumulative impact during the periods of highest contribution from the Project.

The orange shading represents days where the existing background level is already above the criteria. This can be the result of bushfire events and dust storms, and is included for completeness.

The green shading represents days ranked per the highest background level but below the criteria.

The blue shading represents days ranked per the highest predicted increment level but below the criteria.

The values in **bold red** are above the criteria.

Tables D-1 to **D-17** show the predicted maximum cumulative levels at each receptors surrounding the proposed facility. There are no days in the year assessed that have higher total levels than those shown in the tables.

The results show that:

1. No exceedance is predicted to arise due to Project;
2. The contribution to dust levels from the Project are low on the days with the highest background level.

Table B-1: Receptor R16 – PM_{10} 24-hr average concentration (µg/m³)

Ranked by Highest to Lowest Background Concentration				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment due to Project	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment due to Project	Total cumulative 24-hr average level
6/10/2012	54.4	0.8	55.2	-	-	-	-
5/01/2012	45.9	0.7	46.6	18/05/2012	15.3	8.0	23.3
18/10/2012	41.3	1.1	42.4	17/05/2012	11.4	8.0	19.4
22/11/2012	39.4	0.8	40.2	16/07/2012	6	7.4	13.4
7/12/2012	37.3	1.2	38.5	14/06/2012	6	7.2	13.2
14/01/2012	37	0.8	37.8	16/05/2012	17.8	6.4	24.2
11/09/2012	35.1	1.0	36.1	25/07/2012	4.7	5.7	10.4
23/11/2012	33.5	0.8	34.3	10/05/2012	10.3	5.6	15.9
7/04/2012	33.3	0.7	34.0	7/05/2012	8.1	5.6	13.7
28/10/2012	32.7	0.9	33.6	29/06/2012	7	5.4	12.4
9/12/2012	32.4	0.3	32.7	21/05/2012	12.7	5.3	18.0

Table B-1: Receptor R20 – PM_{10} 24-hr average concentration (µg/m³)

Ranked by Highest to Lowest Background Concentration				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment due to Project	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment due to Project	Total cumulative 24-hr average level
6/10/2012	54.4	0.3	54.7	-	-	-	-
5/01/2012	45.9	0.0	45.9	10/05/2012	10.3	8.1	18.4
18/10/2012	41.3	0.0	41.3	9/05/2012	13.5	5.1	18.6
22/11/2012	39.4	0.0	39.4	8/05/2012	8.2	4.9	13.1
7/12/2012	37.3	0.0	37.3	22/08/2012	14.6	4.8	19.4
14/01/2012	37	0.0	37.0	27/09/2012	24.2	4.8	29.0
11/09/2012	35.1	0.1	35.2	23/04/2012	10.6	4.5	15.1
23/11/2012	33.5	0.0	33.5	12/11/2012	12.6	3.9	16.5
7/04/2012	33.3	0.0	33.3	6/11/2012	22.3	3.6	25.9
28/10/2012	32.7	0.0	32.7	21/08/2012	13.7	3.6	17.3
9/12/2012	32.4	0.1	32.5	25/07/2012	4.7	3.5	8.2