YTC
RESOURCES LIMITED

Hera Project, via Nymagee

Air Quality and Greenhouse Gas Assessment

Prepared by

ENVIRON Australia Pty Ltd

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Hera Project, via Nymagee

Air Quality and Greenhouse Gas Assessment

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EXECUTIVE SUMMARY

YTC Resources Limited is proposing to construct and operate the Hera Project (the Project), an underground gold and base metals operation at a location 4 km south of Nymagee in central NSW (the Project Site).

The potential air quality impacts associated with the Project have been assessed within this report. Dispersion modelling has been conducted utilising the USEPA regulatory model AERMOD for emissions of TSP, PM_{10}, metals and diesel-combustion related pollutants.

Particulate matter and diesel combustion related emissions from the Project were estimated utilising published emission literature from the National Pollution Inventory and US-EPA AP-42. A single modelling scenario configured to reflect a worst-case operational 24-hour period continuously throughout a calendar year was established.

The results from the dispersion modelling conducted indicate that for emissions of TSP, PM_{10}, dust deposition, and assorted metals and combustion-related pollutants, there is unlikely to be an adverse cumulative impact upon the surrounding environment associated with the proposed Project. A summary of the maximum predicted incremental and cumulative impacts for TSP, PM_{10} and Dust Deposition across the selected off-site sensitive receptor locations is presented in the following table.

Air Pollutant	Averaging Period	Maximum Predicted Project Only Increment	Maximum Predicted Cumulative Impact	NSW OEH Cumulative Criterion
PM_{10}	24-hour	10.6 µg/m³	48.9 µg/m³	50 µg/m³
	Annual	0.8 µg/m³	19.2 µg/m³	30 µg/m³
TSP	Annual	1.3 µg/m³	47.3 µg/m³	90 µg/m³
Dust Deposition	Annual	0.3 g/m^2/month	2.5 g/m^2/month	4 g/m^2/month

Note: Daily Varying Background dataset used for assessing cumulative 24-hour PM_{10} impacts from Project

Pollutant concentrations were also predicted for the on-site mine accommodation camp. Exceedance of the cumulative 24-hour average PM_{10} criterion and the 1-hour average cadmium (scaled based on PM_{10} predictions) were predicted at the accommodation camp location. It is noted that the exceedances were directly attributable to the emissions from the underground mine Ventilation Rise. Emissions from this source were estimated in a highly conservative manner in the absence of site-specific monitoring data. It is considered that the model predictions of emissions from the Ventilation Shaft represent an upper bound estimation of concentrations likely to be experienced from this source, with a low probability of occurrence.

The assessment also considers emissions of greenhouse gas (GHG) from the Project and includes estimates of both direct and indirect GHG emissions. Direct (Scope 1) emissions from the Project, associated with diesel combustion for power generation and by mining equipment and blasting in underground operations, were calculated to generate approximately 19,158 t CO_2-e/annum.

Indirect (Scope 2 and 3) emissions, primarily associated with the third-party transportation of product from the Project Site and dominated by international shipping, were calculated to generate approximately 29,394 t CO_2-e/annum. When the annual GHG emissions calculated for the Project (excluding Scope 3 shipping emissions) are compared with the NSW and Australian totals for 2008, the Project represents an increase of approximately 0.0125% and 0.0036% on state and national level GHG emissions. When the annual GHG emissions calculated for the Project (including Scope 3 shipping emissions) are compared with the NSW and Australian totals for 2008 and global total for 2004, the Project represents an increase of approximately 0.0295%, 0.0084% and 0.000099% on state, national and global level GHG emissions, respectively.

1. INTRODUCTION

YTC Resources Limited (the Proponent) is proposing to construct and operate the Hera Project (the Project), an underground gold and base metals operation at a location 4km south of Nymagee in central NSW (the Project Site).

ENVIRON Australia Pty Ltd (ENVIRON) has been commissioned by R.W. Corkery & Co. Pty. Limited (RWC) on behalf of the Proponent to conduct an air quality and greenhouse gas assessment to identify potential impacts of the Project and to recommend any potential emission mitigation measures.

1.1 RESPONSE TO DIRECTOR GENERAL REQUIREMENTS

Table 1 provides a reference list for the sections within this report which address the relevant Director General Requirements for the Project. The Department of Environment, Climate Change and Water (DECCW) referenced in the table is the current Office of Environment and Heritage (OEH).

2. PROJECT OVERVIEW

2.1 PROPOSED MINING OPERATIONS

As identified in Section 1.7 of the *Environmental Assessment*, a number of components of the Hera Project have been previously approved. These include the following (**Figure 1**).

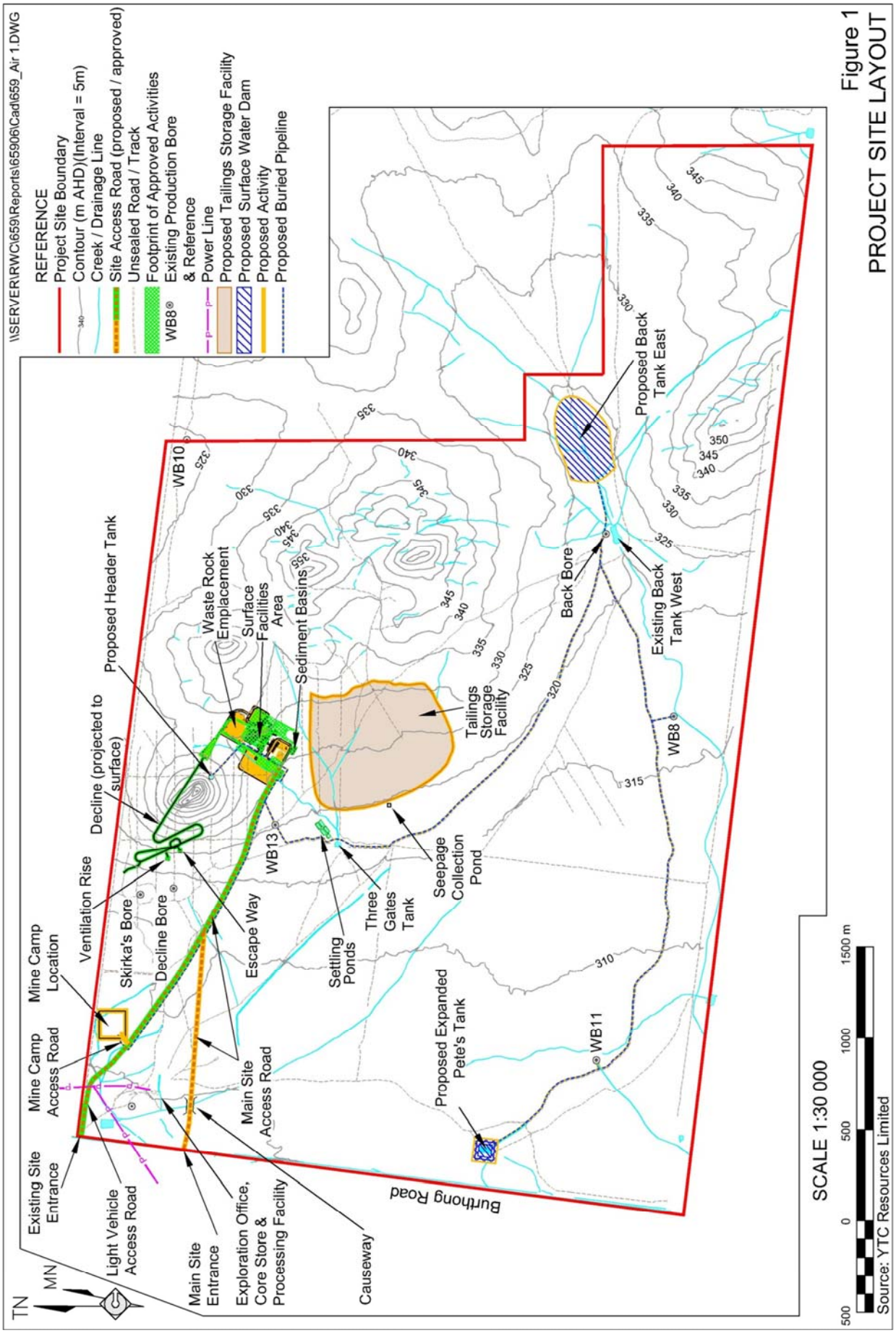
- Construction and use of infrastructure required for an underground mine including a box cut, portal and decline, magazine and ventilation rises.
- Construction and use an integrated ore stockpile area and temporary Waste Rock Emplacement.
- Installation and use of one or more diesel generators within the power station and the associated Fuel Storage and Recycling Area.
- Construction and use of site offices, ablutions facilities, vehicle parking, workshop, laydown area and associated infrastructure.
- Establishment of on-site communications facilities.
- Construction and use of water management structures.
- Construction and use of an access road (referred to in this document as the Light Vehicle Access Road). For the purposes of this application, the Light Vehicle Access Road would be used by light vehicles only.

The Project would include the following activities which would require approval (**Figure 1**).

- Road and the associated intersection to allow site access from Burthong Road Extraction of waste rock and ore material, using underground sublevel open-stope mining methods at the maximum rate of material would be approximately 350 000t per year for approximately 5.5 years.

Table 1
Air Quality Summary of Director-General's Requirements and other Government Departments in the Environmental Assessment

Government Agency	Paraphrased Requirement	Relevant Section(s)
AIR QUALITY		
DECCW 3/11/10	The goal should be to maintain existing rural air quality and protect sensitive receptors, both on and off site, from adverse impacts of dust and odour in particular and other relevant air pollutants. Background ambient air levels should be identified to inform the assessment.	4,8
	Dust is of primary concern with potential emissions from roads, conveyors, transfer points, loading facilities and from stockpiles.	6,7,8
	Analysis of local meteorologic and terrain data is necessary to undertake an appropriate assessment of impact and to inform decisions about design and management options.	2,5
	The proponent should assess air impacts in accordance with the DECCW document *"Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in New South Wales 2005"*. Appropriate dust and odour mitigation measures must be outlined in the EA.	3,5,7
GREENHOUSE GAS EMISSIONS		
DECCW 3/11/10	The EA should also include a comprehensive assessment of the projects predicted greenhouse gas emissions (tCo2e) and associated impact. Emissions should be reported down to include: a) Direct emissions (scope 1 as defined by the Greenhouse Gas Protocol – refer reference in Attachment B); b) Scope 2 and 3 indirect emissions (all other emissions that are a consequence of the mine's activities, including annual emissions for each year of the project (construction, operation and decommissioning).	10
	If relevant, greenhouse emissions intensity (per unit of production) should be compared before and after the project. Emissions intensity should be compared with best practice if possible.	
	Greenhouse emissions should be estimated using an appropriate methodology, in accordance with NSW, Australian and International Guidelines (refer guidelines mentioned in Attachment B).	
	The EA should identify which emissions would be covered by the Federal Government's proposed Carbon Pollution Reduction Scheme (CPRS) once commenced.	
	The EA should also evaluate and report on the feasibility of measures to reduce greenhouse gas emissions associated with the project, concentrating on emissions not covered by the CPRS.	
	For emissions covered by the CPRS, any evaluation should include a consideration of expected price increases due to the CPRS. This could include a consideration of energy efficiency opportunities or undertaking an energy use audit for the site. The proponent should also identify if there are any cost-effective opportunities to reduce scope 3 emissions (e.g. by using different methods of supply distribution).	


\\SERVER\RWC\659\Reports\65906\Cad\659_Air 1.DWG
REFERENCE
Project Site Boundary
Contour (m AHD)(Interval = 5m)
Creek / Drainage Line
Site Access Road (proposed / approved)
Unsealed Road / Track
Footprint of Approved Activities
Existing Production Bore & Reference
Power Line
Proposed Tailings Storage Facility
Proposed Surface Water Dam
Proposed Activity
Proposed Buried Pipeline
Figure 1
PROJECT SITE LAYOUT
Proposed Back Tank East
Back Bore
Existing Back Tank West
WB10
WB8
WB11
WB13
Proposed Header Tank
Waste Rock Emplacement
Surface Facilities Area
Sediment Basins
Tailings Storage Facility
Decline (projected to surface)
Ventilation Rise
Mine Camp Location
Skirka's Bore
Decline Bore
Escape Way
Settling Ponds
Three Gates Tank
Seepage Collection Pond
Mine Camp Access Road
Main Site Access Road
Proposed Expanded Pete's Tank
Existing Site Entrance
Light Vehicle Access Road
Main Site Entrance
Exploration Office, Core Store & Processing Facility
Causeway
Burthong Road
TN
MN
SCALE 1:30 000
500 0 500 1000 1500 m
Source: YTC Resources Limited

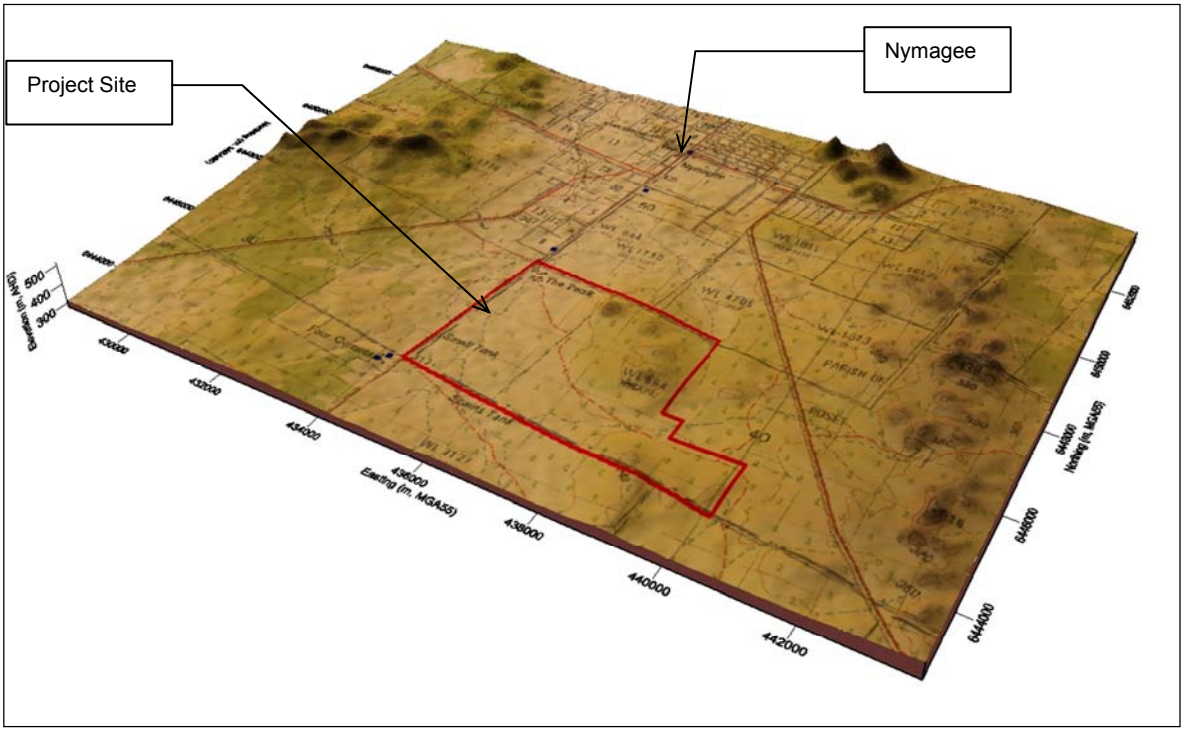
- Construction and use of a Surface Facilities Area that would incorporate a range of approved infrastructure, including expanded site offices for the Proponent and Contractors, ablutions facilities, vehicle parking, power station, fuel storage, refuelling area, workshop and laydown areas.
- Construction and use of a Processing Plant within the Surface Facilities Area comprising crushing and grinding, gravity separation, flotation, leach and gold recovery circuits and ancillary infrastructure to produce approximately 33 000oz of gold, 74 000oz of silver, 10 000t of lead and 10 000t of zinc per year.
- Construction and use of a temporary Waste Rock Emplacement, incorporating an acid rock drainage encapsulation area and an associated Leachate Management Pond.
- Construction and use of a Tailings Storage Facility with the associated Seepage Collection Pond.
- Construction of a Mine Camp and Mine Camp Access Road for mine personnel.
- Construction and use of a surface water harvesting system, including expansion of Pete's Tank and construction of Back Tank East and associated water reticulation system.
- Construction and use of the Main Site Access by light and heavy vehicles.
- Transportation of concentrate from the Project Site to the Proponent's customers via public roads surrounding the Project Site.
- Construction and use of ancillary infrastructure, including soil stockpiles, core storage yards, internal roads and tracks, and sediment and erosion management structures not already approved.
- Construction and rehabilitation of a final landform that would be geotechnically stable and suitable for an end land use of agriculture or nature conservation.

2.2 PROJECT AREA LAND USE AND TOPOGRAPHY

The Project Site is situated within the boundary of "The Peak" property, located approximately 4 km south of the township of Nymagee. The property covers an area of approximately 2,128 ha and the lease on the property (Western Lands Lease) is currently held by the Proponent. Historically, the property has been used primarily for grazing purposes. Existing land cover at the site is a mixture of cleared and forested areas.

The Project surface workings are located to the central north of the Project Site at an altitude of approximately 335 m AHD. The Project Site is marked by reasonable flat terrain, increasing in elevation from approximately 305 m AHD along the western boundary to 345 m at the southeastern corner. A series of hills, with elevations up to approximately 470 m AHD occur towards the northeast corner of the Project Site.

A three-dimensional representation of the topography of the region surrounding the Project Site extending north to Nymagee is presented in **Figure 2**.



Note: Vertical Exaggeration of 4 applied to image

Figure 2 3-Dimensional Topography Surrounding the Project Site

2.3 SENSITIVE RECEPTOR LOCATIONS

Following an inspection of the area surrounding the Project Site, it is clear that the region is sparsely populated. The four closest non-Project related sensitive receptors situated along Burthong Road have been selected as sensitive receptor locations for the assessment of air quality emissions from the Project. An additional receptor location, R5, has been selected as a general location within the township of Nymagee.

Finally, in addition to the five selected off-site receptor locations, a receptor point representative of the proposed on-site mining camp has been included as receptor R6. The details of each of the selected assessment locations are presented in **Table 2**, while the spatial distribution of the receptors is illustrated in **Figure 3**.

Table 2
Selected Non-Project Related Sensitive Receptors

Receptor ID	Location (m, MGA55)		Distance (km) / Direction from Processing Plant	Elevation (m AHD)
	Easting	Northing		
R1	434054	6444176	4.0 / SW	320
R2	434182	6444316	3.8 / SW	320
R3	434871	6448174	2.5 / WNW	310
R4	435387	6450587	4.1 / NNW	310
R5	435471	6452217	5.6 / NNW	310
R6	435570	6447380	1.5 / WNW	310

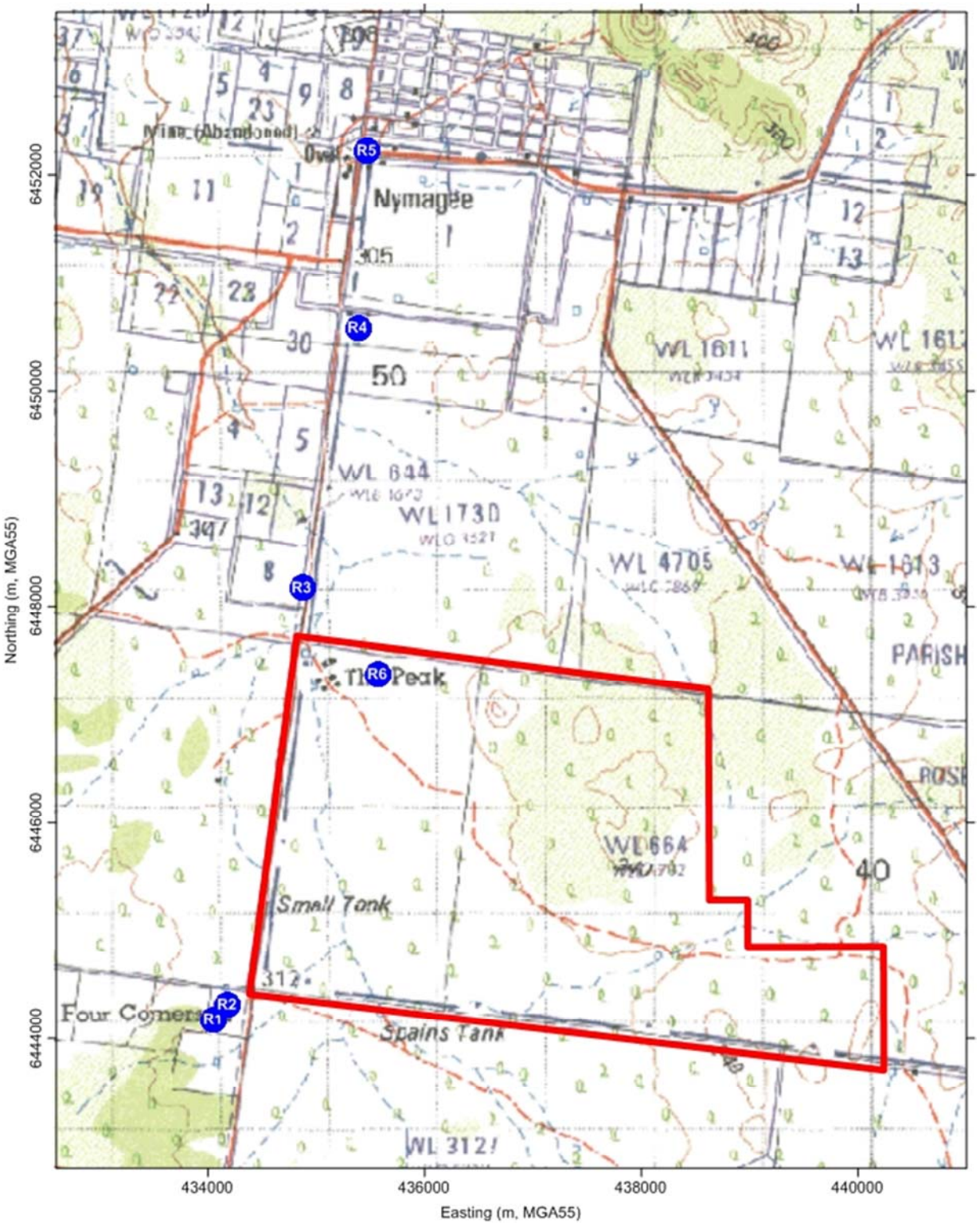


Figure 3 Location of Selected Non-Project Related Sensitive Receptors

3. AIR QUALITY ASSESSMENT CRITERIA

To satisfy the requirements of the NSW Office of Environment and Heritage (OEH), proposed operations must demonstrate that cumulative air pollutant concentrations, taking into account incremental concentrations due to the operation's emissions and existing background concentrations, are within ambient air quality limits.

For proposed developments within NSW, ground level assessment criteria specified by the NSW OEH within the 2005 document *The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* ("the Approved Methods", DEC 2005) are applicable. These assessment criteria are designed to maintain an ambient air quality that allows for the adequate protection of human health and well-being.

Relevant ambient air quality criteria applicable to the proposed development are presented in this section.

3.1 CRITERIA APPLICABLE TO AIRBORNE PARTICULATE MATTER AND LEAD

Air quality limits for particulates are typically given for various particle size fractions, including total suspended particulates (TSP) and inhalable particulates or PM_{10} (i.e. particulates with an aerodynamic diameter of less than 10 µm). Although TSP is defined as all particulate with an aerodynamic diameter of less than 100 µm, an effective upper limit of 30 µm aerodynamic diameter is frequently assigned. PM_{10} is of concern due to its health impact potential. Such fine particles are able to be deposited in, and cause damage to, the lower airways and gas-exchanging portions of the lung. Potential adverse health impacts associated with exposure to PM_{10} include increased mortality from respiratory and cardiovascular diseases, chronic obstructive pulmonary disease, and heart disease and reduced lung capacity in asthmatic children (Pope and Dockery, 2006; WHO, 2007).

Despite the international medical community not having been able to establish a threshold value for particulate matter below which there are no adverse health impacts, air quality criteria are routinely issued for this pollutant, including by federal and state governments in Australia. Air quality criteria issued by federal and NSW government for particulates and lead are given in **Table 3**.

Table 3
Impact Assessment Criteria for Airborne Particulates and Lead

Pollutant	Averaging Period	Concentration (µg/m³)	Reference
TSP	Annual	90	NSW OEH[(a)(b)]
PM_{10}	24-hour	50	NSW OEH[(a)]
	24-hour	50[(d)]	NEPM[(c)]
	Annual	30	NSW OEH[(a)]
Lead	Annual	0.5	NSW OEH[(a)]

(a) NSW DEC, 2005 Approved Methods.
(b) NSW DEC impact assessment criterion based on the subsequently rescinded National Health and Medical Research Council (NHMRC) recommended goal.
(c) NEPC, 2003, National Environment Protection (Ambient Air Quality) Measure, as amended.
(d) Provision made for up to five exceedances of the limit per year.

The NSW 24-hour PM_{10} assessment goal of 50 µg/m^3 is numerically identical to the equivalent National Environment Protection Measure (or NEPM) reporting standard except that the NEPM reporting standard allows for five exceedances per year. The NEPM goals were developed by the National Environmental Protection Council (NEPC) in 1998 to be achieved within 10 years of commencement.

Air quality goals for TSP were typically set prior to the development of an improved understanding of the relationship between health impacts and exposure to fine particulate concentrations, and have subsequently either been discarded or given reduced importance by countries internationally. The NSW OEH TSP impact assessment criterion is based on the goal recommended by the National Health and Medical Research Council (NHMRC) (DEC, 2005; NHMRC, 1996), although the NHMRC goals have subsequently been rescinded.

In rurally-located mining areas, the PM_{10} particle size fraction is typically of the order of 40% of the TSP mass (SPPC, 1986). In semi-urban and urban areas impacted by motor vehicles, this percentage may be expected to be even higher. Based on this PM_{10} to TSP ratio, the impact assessment goal for TSP would be equivalent to an annual PM_{10} goal of at least 36 µg/m^3. Thus, the historical NHMRC goal may be regarded as less stringent than the OEH PM_{10} goal of 30 µg/m^3 expressed as an annual average.

While it is anticipated therefore that the annual TSP criterion will be seen to be achieved if the annual PM_{10} goal is satisfied, predictions of annual average TSP concentrations are provided within this report for completeness.

3.2 DUST DEPOSITION CRITERIA

Nuisance dust deposition is regulated through the stipulation of maximum permissible dust deposition rates. The NSW OEH impact assessment goals for dust deposition are given in **Table 4** illustrating the allowable increment in dust deposition rates above ambient (background) dust deposition rates which would be acceptable so that dust nuisance could be avoided.

Table 4
OEH Goals for Allowable Dust Deposition

Averaging Period	Maximum Increase in Deposited Dust Level	Maximum Total Deposited Dust Level
Annual	2 g/m^2/month	4 g/m^2/month
Source: Approved Methods DEC, 2005		

3.3 IMPACT ASSESSMENT CRITERIA FOR TOXIC AIR POLLUTANTS

The OEH specifies impact assessment criteria for a range of principal and individual toxic air pollutants within the Approved Methods. A synopsis of the criteria relevant to metals of interest in the current study is given in **Table 5**.

Additionally, it has been identified by the Proponent that trace emissions of carbon disulfide (CS_2), hydrogen cyanide (HCN) and hydrogen sulfide (H_2S) could result from the ROM ore and gold processing circuit.

The impact assessment criteria specified by the OEH for toxic air pollutants must be applied at and beyond the boundary of the facility, with the incremental impact (predicted impacts due to the pollutant source alone) for each pollutant reported as the 99.9th percentile concentration for an averaging period of 1 hour. The exception to this is H_2S which is reported as the 99th percentile 1 second peak average concentration, derived through the application of NSW OEH prescribed peak-to-mean factors (further discussion in **Section 8.6**).

Table 5
Impact Assessment Criteria for Toxic Air Pollutants

Toxic Air Pollutant	99.9th Percentile 1-hour Average Assessment Criteria (µg/m^3)
Antimony and compounds	9.0
Arsenic and compounds	0.09
Barium (soluble compound)	9.0
Cadmium and compounds	0.018
Carbon disulfide	70
Chromium III and compounds	9.0
Chromium VI and compounds	0.09
Copper dusts and mists	18
Hydrogen cyanide	200
Hydrogen sulfide	1.38[1]
Manganese and compounds	18
Mercury organic	0.18
Mercury inorganic	1.8
Nickel and compounds	0.18
Silver	0.18

Source: Approved Methods DEC, 2005
Note 1: Hydrogen Sulphide criterion relevant to 99th percentile 1-second peak model prediction. Criterion applicable to exposure population of more than 2000 people.

3.4 AIR QUALITY CRITERIA FOR DIESEL COMBUSTION EMISSIONS

Emissions may occur as a result of diesel combustion by the surface based diesel generator, mobile mining and vehicle equipment and underground operations exhausted via the surface ventilation fan. Key combustion and blasting-related pollutants of interest include nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) and Volatile Organic Compounds (VOCs). While numerous VOC species are emitted during the combustion of diesel fuel, the pollutant benzene has been selected as a representative indicator of the potential for risk.

Air quality criteria issued by federal and NSW government applicable to these potential gaseous emissions are given in **Table 6**. Air quality criteria are not specified for total VOCs.

Table 6
Air Quality Criteria for Combustion Emissions

Pollutant	Averaging Period	Concentration		Reference
		µg/m³	ppm	
NO_2	1-hour	246	0.12	NSW OEH[1]
		-	0.12	NEPM[2]
	Annual	62	0.03	NSW OEH[1]
		-	0.03	NEPM
SO_2	10-minute	712	0.25	NSW OEH[1]
	1-hour	570	0.20	NSW OEH[1]
		-	0.20	NEPM[2]
	24-hour	228	0.08	NSW OEH[1]
		-	0.08	NEPM[2]
	Annual	60	0.02	NSW OEH[1]
		-	0.02	NEPM
CO	15-minute	100,000	87	NSW OEH[1]
	1-hour	30,000	25	NSW OEH[1]
	8-hour	10,000	9	NSW OEH[1]
Benzene	1-hour (99.9th percentile)	29	0.009	NSW OEH[1]

Note 1: Approved Methods DEC, 2005
Note 2: Provision made for one exceedance of the limit per year.

3.5 PROJECT AIR QUALITY ASSESSMENT CRITERIA

To summarise the previous sections, the air quality impact assessment criteria to be used in this study are presented within **Table 7**.

4. EXISTING AIR QUALITY ENVIRONMENT

The quantification of cumulative air pollution concentrations and the assessment of compliance with ambient air quality limits necessitate the characterisation of baseline air quality. Given that particulate matter and several heavy metals represent the primary emissions from the Project, it is pertinent that existing sources and ambient air pollutant concentrations of these pollutants be considered.

4.1 EXISTING LOCAL SOURCES OF ATMOSPHERIC EMISSIONS

The National Pollutant Inventory (NPI) and NSW OEH environment protection licence databases has been reviewed for significant existing sources of air pollutants in the Nymagee region. This review determined that there are no notable industrial or extractive operations in the region surrounding the Project Site. The closest operations with the potential to generate air pollutant emissions are situated near Cobar, approximately 70 km north-northwest of the Project Site. It is unlikely that significant cumulative impact from these operations would occur for emissions from the Project Site.

Table 7
NSW OEH Ambient Air Quality Criteria Applied in the Study for Impact Assessment Purposes

Pollutant	Averaging Period	Criterion (µg/m^3)
Antimony and compounds	1-hour (99.9th Percentile)	0.09
Arsenic and compounds	1-hour (99.9th Percentile)	9.0
Barium (soluble compound)	1-hour (99.9th Percentile)	0.004
Benzene	1-hour (99.9th percentile)	29
Cadmium and compounds	1-hour (99.9th Percentile)	0.09
Carbon disulfide	1-hour (99.9th Percentile)	70
CO (carbon monoxide)	1-hour 8-hour	30,000 11,000
Chromium (III) compounds	1-hour (99.9th Percentile)	9.0
Chromium (VI) compounds	1-hour (99.9th Percentile)	0.09
Copper dust	1-hour (99.9th Percentile)	18
Dust Deposition	Annual (increment)	2 g/m^2/month
Hydrogen cyanide	1-hour (99.9th Percentile)	200
Hydrogen sulfide	Peak 1-second (99th Percentile)	1.38
Lead	Annual	0.5
Manganese and compounds	1-hour (99.9th Percentile)	18
Mercury organic	1-hour (99.9th Percentile)	0.18
Mercury inorganic	1-hour (99.9th Percentile)	1.8
Nickel and compounds	1-hour (99.9th Percentile)	0.18
NO_2 (nitrogen dioxide)	1-hour Annual	246 62
PM_{10}	24-hour Annual	50 30
Silver	1-hour (99.9th Percentile)	0.18
SO_2 (sulfur dioxide)	1-hour 24-hour Annual	570 228 60
Total Suspended Particles	Annual	90

Given the lack of industrial and extractive operations in the Nymagee region, the dominant sources of particulate matter emissions in the vicinity of the Project are expected to include:

- Wind generated dust from exposed and dry areas within the semi-arid region of Nymagee;
- Dust entrainment due to vehicle movements along unsealed and sealed town and rural roads with high silt loading levels; and
- Episodic emissions from vegetation fires.

Long-range transport of fine particles from more remote sources is also expected to contribute to background suspended fine particulate concentrations in the region.

With the exception of periodic motor vehicle movements, it is considered that existing concentrations of fuel-combustion related pollutants will be negligible given the general absence of such sources currently in the Nymagee region.

4.2 MONITORING DATA AVAILABLE FOR BASELINE AIR QUALITY CHARACTERISATION

4.2.1 Dust Deposition Monitoring Data

No dust deposition monitoring is currently undertaken in the vicinity of the Nymagee area.

To provide an indication of dust deposition levels that could occur at the Project Site, monitoring data was sourced from CBH Resources at their Endeavor Mine, located approximately 125 km to the north-northwest. Data from five locations was provided by CBH Resources for the period July 2009 to July 2010. Four of these locations flank the mining operations and are used for the purpose of regulatory reporting. The fifth location is situated approximately 13 km southwest of the mine and used to monitor background dust deposition levels.

It is considered that monitoring data from this fifth location will provide a reasonable estimate of likely existing dust deposition levels at the Project Site. The average monthly dust deposition level recorded by CBH Resources at the background monitoring site for the Endeavor Mine between July 2009 and July 2010 was 2.2 g/m^2/month. This level will be adopted for the purpose of assessing cumulative dust deposition levels associated with the operation of the Project.

4.2.2 PM_{10} Monitoring Data

No monitoring of ambient PM_{10} concentrations is conducted in the vicinity of the Project Site.

To demonstrate fluctuations in PM_{10} concentrations within rural areas of NSW, reference is made to continuous PM_{10} data recorded at the NSW OEH monitoring stations situated at Tamworth and Bathurst. It is noted that these stations are geographically removed from the Nymagee region (approximately 450 km east-northeast and 335 km east-southeast of the Project Site for Tamworth and Bathurst, respectively).

Furthermore, it is acknowledged that these stations are situated in less arid areas than the Project Site. Given however, that these are the only continuous 24-hour varying PM_{10} monitoring datasets available from the OEH for the area of NSW west of the Great Dividing Range, these datasets are referenced to provide an indication of PM_{10} concentration ranges. Although not ideal, the referencing of data from these stations provide a means of deriving cumulative PM_{10} concentrations for assessment purposes in the absence of site specific monitoring data.

Section 5.1.1 of the Approved Methods for Modelling states that for Level 2 air quality assessments, ambient monitoring data for at least one year of continuous measurements should be used in the air dispersion modelling process.

The daily-varying (24-hour average) PM_{10} concentrations recorded at the Tamworth and Bathurst stations between 2007 and 2011 were analysed. A frequency histogram of recorded 24-hour average PM_{10} concentrations at the OEH Tamworth and Bathurst stations between 2007 and 2011 is presented in **Figure 4**.

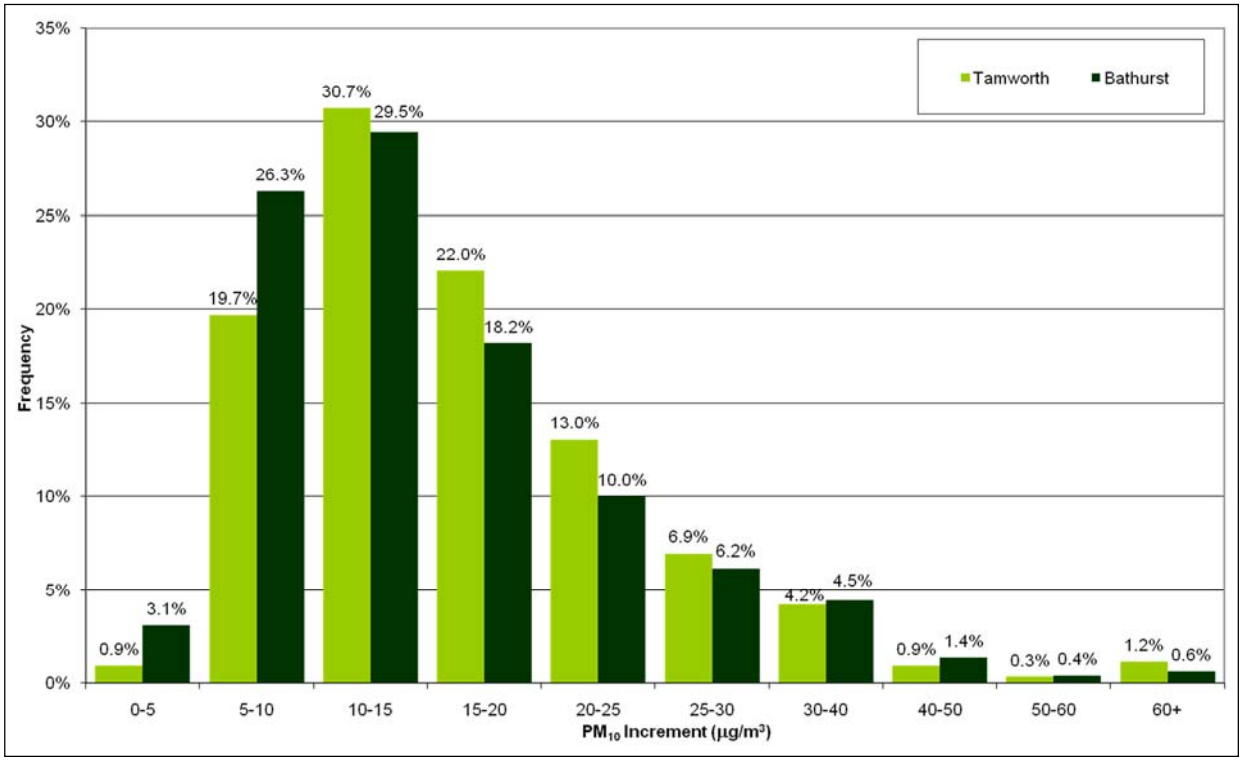


Figure 4 Recorded 24-hour Average PM_{10} Concentration Distribution – NSW OEH Tamworth and Bathurst – 2005 to 2009

Figure 4 shows similar distribution profiles of measured 24-hour average PM_{10} concentrations at the Tamworth and Bathurst monitoring stations between 2005 and 2009. Measured PM_{10} concentrations were less than 25 µg/m^3 approximately 87% of the time between 2005 and 2009 at both stations. Elevated concentrations greater than 40 µg/m^3 are experienced on approximately 1.5% and 1.0% of days at the Tamworth and Bathurst stations respectively, and are likely to be associated with anomalous regional-scale events such as bushfires and dust storms. Given the more arid environment at Nymagee, it is feasible that naturally generated peak particulate matter events, such as dust storms, could be more frequent. The average PM_{10} concentration recorded between 2005 and 2009 was 18.4 µg/m^3 and 17.0 µg/m^3 for Tamworth and Bathurst, respectively.

To assist with the assessment of cumulative impacts associated with Project, the daily-varying 2009 PM_{10} dataset for Bathurst, excluding exceedances of OEH criterion of 50 µg/m^3, was adopted. The Bathurst dataset was selected based on the highest 24-hour PM_{10} concentration not in exceedance of the OEH criterion, 48.4 µg/m^3. The highest non-exceedance concentration in the corresponding Tamworth dataset was 47.0 µg/m^3. An annual average PM_{10} background of 18.4 µg/m^3 was also adopted. Further discussion regarding the assessment of cumulative impacts is provided within **Section 7.3.2**.

4.2.3 Total Suspended Particulate Monitoring Data

No monitoring of ambient Total Suspended Particulate (TSP) concentrations is conducted in the vicinity of the Project Site.

As stated in **Section 3.1**, the PM_{10} particle size fraction is typically of the order of 40% of the TSP mass rurally-located mining areas. On this basis, and in the absence of site-specific TSP monitoring data, an annual average TSP concentration of 46.0 µg/m^3 was derived from the annual average PM_{10} concentration of 18.4 µg/m^3 recorded by the OEH at Tamworth. This concentration was adopted as the existing annual average TSP concentrations at the Project Site for assessment purposes.

4.2.4 Other Pollutants

Other than particulate matter, Project-related emissions of products of fuel combustion and metals/metalloids, as listed within **Section 3** are also of interest within this assessment.

No measurements of such air quality indicators are available for the Nymagee area. For the purpose of this assessment, given the general absence of associated sources of these indicators in the Nymagee area, it is considered that existing ambient concentrations in the local air shed will be minimal. The modelling assessment therefore focused on the incremental impact of these indicators from the Project.

5. CLIMATE AND DISPERSION METEOROLOGY

Meteorological mechanisms govern the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction, and the variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading. Pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, concurrent variations in the mixing depth, and shifts in the wind field (Oke, 2003; Sturman and Tapper, 2006).

Meteorological observations and long-term climatic records for the Nymagee region are very limited, with the nearest and most comprehensive data source located at the Bureau of Meteorology (BoM) Cobar Meteorological Office (Cobar MO, Station number 048027), approximately 85 km north-northwest of the Project Site. This station was established in 1962 and provides a comprehensive record of a wide range of meteorological parameters. In the absence of meteorological data closer to the Project Site, the data from Cobar MO was drawn upon as a measure of regional trends. Additionally, the BoM have maintained an Automatic Weather Station (AWS) at Cobar Airport (Station number 048237), approximately 6.8 km south-southwest of the Cobar MO AWS, since 1993.

OEH specifies in Section 4.1 of the Approved Methods that meteorological data representative of a site should be used in the absence of actual onsite observations. Data should cover a period of at least one year with a percentage completeness of at least 90%. Site representative data can be obtained from either a nearby meteorological monitoring station or synthetically generated using the CSIRO prognostic meteorological model The Air Pollution Model (TAPM).

Given the distance between the Project Site and the Cobar MO AWS location, it is not considered appropriate to simply adopt the hourly observations recorded at Cobar for application at the Project Site. Rather, a meteorological dataset for the Project Site was generated using the CSIRO's model TAPM. TAPM was used to predict hourly meteorological parameters including wind speed and direction, temperature, pressure, water vapour, cloud, rain water and turbulence by referencing various databases including terrain, vegetation and soil type, sea surface temperature and synoptic scale meteorological analyses. TAPM modelling was conducted for the 2009 calendar year, in accordance with the model set-up specifications listed in Section 4.5 of the Approved Methods.

Historical climate data recorded at the Cobar MO was taken to be representative of regional meteorological conditions and was used within this assessment to illustrate the suitability of the TAPM predictions.

5.1 CLIMATE STATISTICS

Climate statistics from the BoM Cobar MO AWS (Station number 048027) are presented in **Appendix 1**.

5.2 PREVAILING WIND REGIME

As discussed, due to the absence of on-site measurements of wind speed and direction, the meteorological model component of TAPM was used to generate an hourly varying meteorological dataset for the Project Site.

As a first step in the analysis of the prevailing wind regime of the Project Site, the annual wind roses recorded at Cobar MO AWS between 2005 and 2009 were reviewed. Analysis of these wind roses indicates that light to moderate winds (0.5 m/s to 8 m/s) from the south to southwest and north to east prevail at Cobar. Based on the wind roses for the previous four years, airflow patterns for 2009 were concluded to be representative of typical conditions experienced at Cobar with regards to wind speed and direction patterns. **Appendix 2** presents the annual wind roses for Cobar MO AWS recorded between 2005 and 2009.

The 2009 TAPM-generated meteorological dataset for the Project Site was compared with the 2009 annual wind rose recorded at Cobar MO AWS to determine whether TAPM predictions reflected regional conditions. Annual average wind roses for 2009 from the TAPM Project Site and Cobar MO AWS are compared in **Figure 5**. The airflow patterns are noted to compare fairly well, with notable south to southwest and north to east components prevailing at both sites. The southerly and easterly flow components are noted not to be as prominent in the TAPM-generated dataset.

Wind speeds recorded at the Cobar MO AWS between 2005 and 2009 were also compared with the TAPM predicted meteorology for the Project Site. **Figure 6** presents a frequency distribution histogram illustrating this comparison. In comparison with the data recorded by the Cobar MO AWS during 2009, TAPM accurately predicts the frequency of very calm conditions (<0.5 m/s), despite marginally under predicting wind speeds in the range of 0.5 to 1.5 m/s and over predicting moderate wind speeds. Inter-annual variations are evident in the frequency distribution histogram with some years being characterised by marginally higher periods of calm or elevated wind speed conditions.

Seasonal and diurnal wind roses generated based on the TAPM Project Site meteorological dataset are presented in **Appendix 2**.

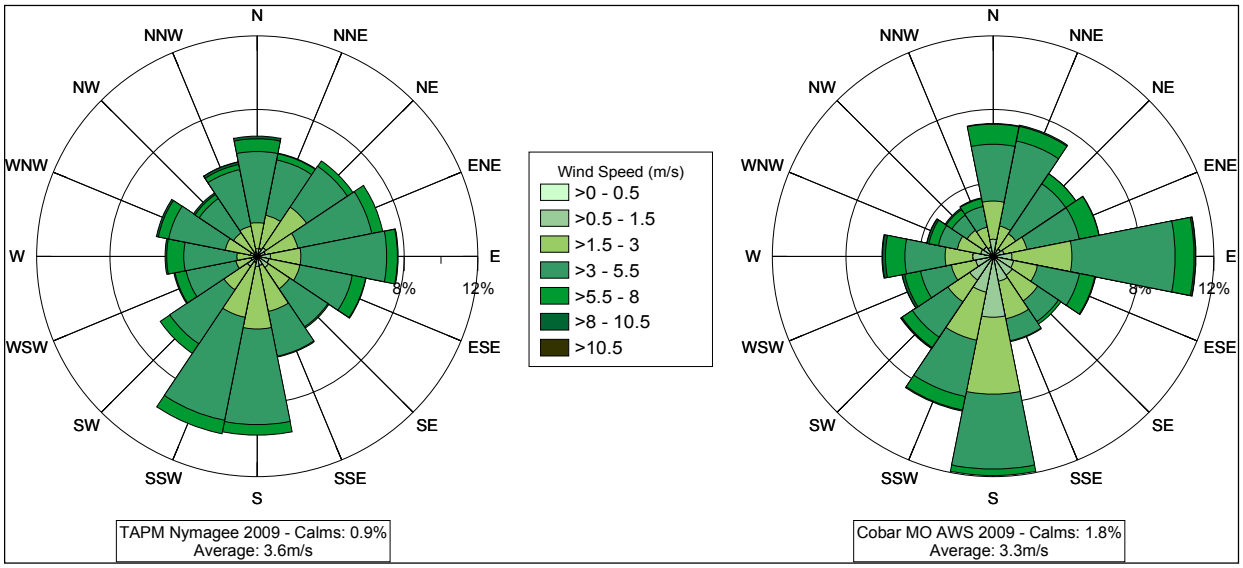


Figure 5 2009 Annual Average Wind Roses – TAPM Project Site and Cobar MO AWS

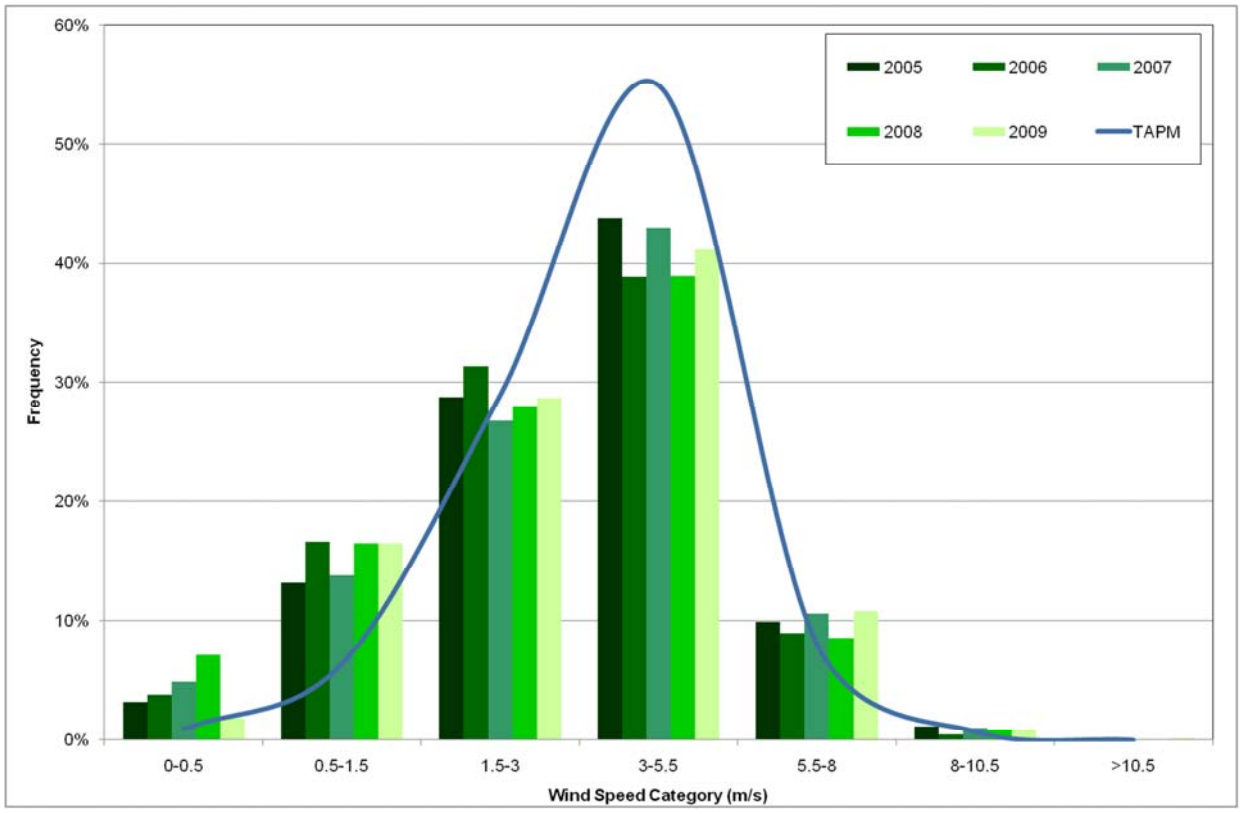


Figure 6 Wind Speed Distribution Comparison – TAPM Project Site 2009 and Cobar MO AWS 2005 to 2009

Distinct seasonal shifts in the wind field are evident. During summer and autumn, east to south-southwest airflow prevails, with a significantly lower incidence of westerly winds, particularly in summer. With the onset of winter, southwest to northeast winds become increasingly prevalent. Spring shows an increase in southerly and easterly airflow is dominated by westerly and west-northwesterly wind. The strongest winds typically occur from the northerly quadrant.

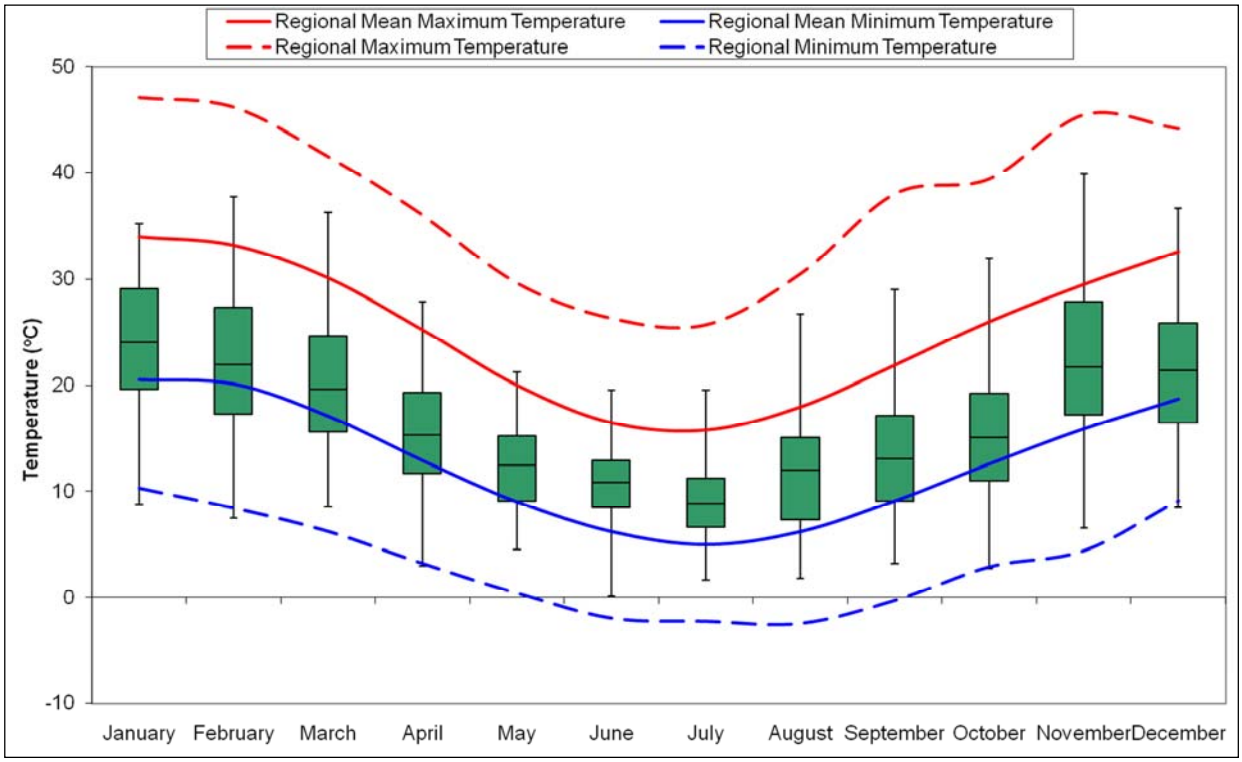
Comparison of day-time and night-time wind roses from the 2009 TAPM Project Site dataset shows no significant diurnal shift in airflow, with day-time and night-time airflow patterns being relatively similar (**Appendix 2**). This indicates that thermo-topographic flows are not prevalent at the site. Daytime wind speeds were on average higher (3.9 m/s) than nocturnal wind speeds (3.2 m/s), with a similar incidence of calm periods throughout the two periods (1.0% day versus 0.9% night).

5.3 AMBIENT TEMPERATURE

Air temperature is important, both for determining the effect of plume buoyancy and determining the development of the mixing and inversion layers. The Cobar region is characterised by a mild to hot climate, with mean day-time temperatures in the range of 16°C to 34°C and mean night-time temperatures in the range of 5°C to 21°C based on the long-term records. Peaks occur during summer months with the highest temperatures typically being recorded in January to February. The lowest temperatures are usually experienced during July and August.

The TAPM-predicted temperature throughout 2009 for the Project Site has been compared with long-term trends recorded at the BoM Cobar MO AWS to determine the representativeness of the dataset.

Figure 7 presents the monthly variation in recorded temperature during 2009 compared with the regional mean, minimum and maximum temperatures recorded at the BoM Cobar MO AWS. There is good agreement between the TAPM-generated temperature for 2009 and recorded historical trends measured at Cobar MO AWS.



Note: Boxes indicate 25th, Median and 75th percentile of TAPM-predicted temperature data while upper and lower whiskers indicate maximum and minimum values. Measured maximum and minimum temperatures are depicted as line graphs.

Figure 7 Temperature Comparison – TAPM Predicted Recorded Monthly Variation (2009) vs Historic Mean and Maximum Trends at Cobar MO AWS

5.4 RAINFALL

Precipitation is important to air pollution studies since it represents an effective removal mechanism of atmospheric pollutants. Rainfall for the greater Cobar region is low. Annual rainfall measured at Cobar MO between 1962 and 2010 ranges from approximately 102 mm to 685 mm, and is on average about 399 mm. Rainfall is distributed fairly evenly throughout all months of the year, with a slightly higher monthly average rainfall occurring in January and February than the remaining months of the year. On average 69 rain days occur per year, with 4 to 7 rain days experienced each month on average.

The influence of rainfall on pollution removal from the atmosphere has not been accounted for within this assessment so as to provide an upper bound estimate of airborne concentrations.

5.5 ATMOSPHERIC STABILITY AND BOUNDARY LAYER DEPTH

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of flow due to the frictional drag of the earth's surface (mechanical mechanisms), or as result of the heat and moisture exchanges that take place at the surface (convective mixing) (Stull, 1997; Oke, 2003).

During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated subsidence inversion. Elevated inversions may occur for a variety of reasons including anti-cyclonic subsidence and the passage of frontal systems. Due to radiative flux divergence, night-times are typically characterised by weak vertical mixing and the predominance of stable conditions. These conditions are normally associated with low wind speeds, and hence lower dilution potentials.

For low level, wind independent, continuous sources, the highest ground level concentrations tend to occur during stable night-time conditions with pollutants accumulating close to the source. Sources characteristic of the proposed Project are mostly low level and wind dependent, with some of the dust generating activities restricted to day-time hours. Atmospheric conditions conducive to peak ground level concentrations from such sources are more complicated and best characterised through the application of dispersion modelling in which temporal variations in atmospheric conditions and source profiles are adequately represented.

Diurnal variations in average boundary layer depth generated by AERMET, the meteorological processor for the AERMOD dispersion model (see **Appendix 3** for detailed discussion), for the Project based on TAPM-predicted meteorology are illustrated in **Figure 8**. Average convectively-generated and mechanically-generated boundary layer depths are also indicated in the figure. Higher day-time wind velocities and the onset of insolation, resulting in increased mechanical and convective mixing respectively, contribute to greater mixing depths during the day-time.

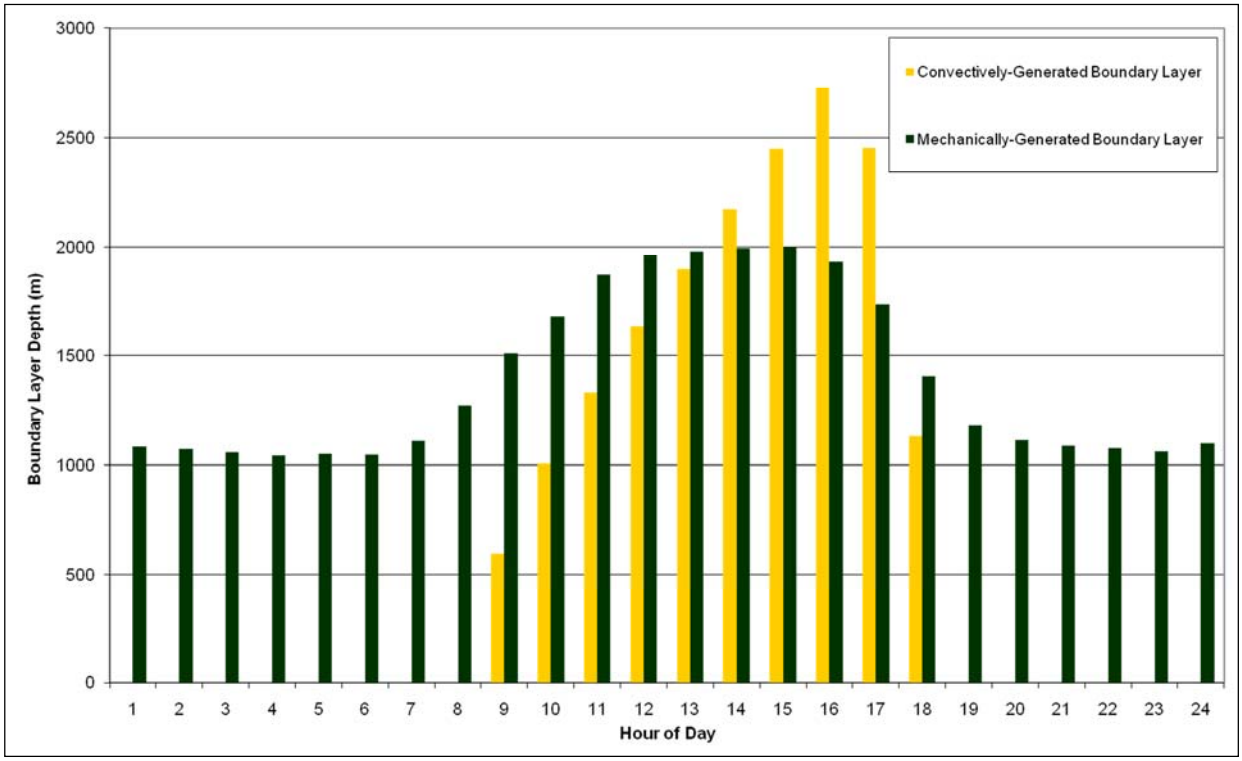


Figure 8 AERMET-Generated Diurnal Variations in Average Boundary Layer Depth – Project Site 2009

The Monin-Obukhov length (L) provides a measure of the stability of the surface layer (i.e. the layer above the ground in which vertical variation of heat and momentum flux is negligible; typically about 10% of the mixing height). Seinfield and Pandis (2006) provide typical values ranges for atmospheric stability as listed with **Table 8**.

Table 8
Monin-Obukhov Length with Respect to Atmospheric Stability

L	Range	Stability Class
Very Large Negative	$L < -10^5$ m	Neutral
Large Negative	-10^5 m $\leq L \leq -100$ m	Unstable
Small Negative	-100 m $< L < 0$	Very Unstable
Small Positive	$0 < L < 100$ m	Very Stable
Large Positive	100 m $\leq L \leq 10^5$ m	Stable
Very Large Positive	$L > 10^5$ m	Neutral

Source: Table 16.2, Seinfield and Pandis (2006)

Figure 9 illustrates the diurnal profile variation of atmospheric stability derived from the Monin-Obukhov length calculated by AERMET for the Project Site. The profile illustrates that atmospheric instability increases during daylight hours as convective energy increases, while stable atmospheric conditions prevail during night periods.

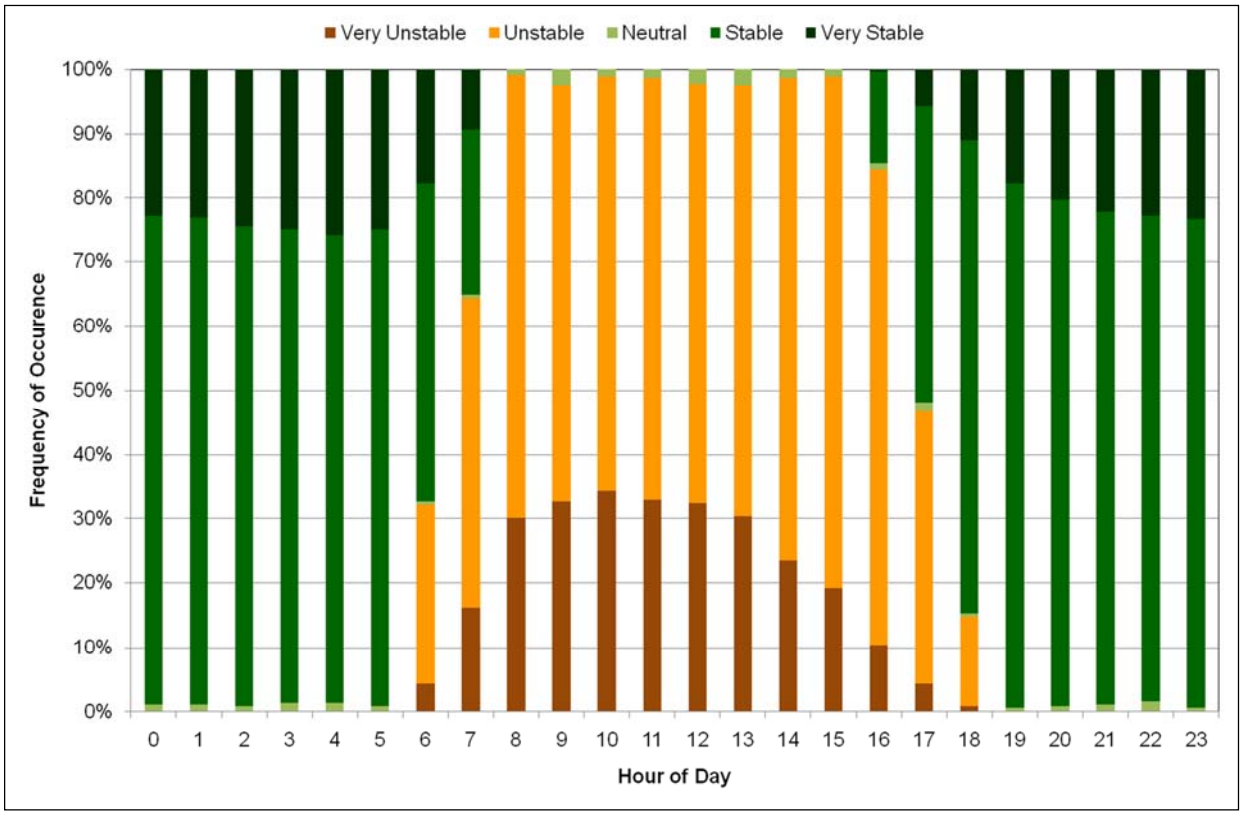


Figure 9 AERMET-Generated Diurnal Variations in Atmospheric Stability – Project Site 2009

6. EMISSION ESTIMATION

Fugitive dust sources associated with the operation the Project were principally quantified through the application of Australian National Pollutant Inventory (NPI) emission estimation techniques (in particular the NPI Emission Estimation Technique Manual for Mining (NPI EETMM, 2001) and Gold Ore Processing (NPI EETMGOP, 2006)) and United States Environmental Protection Agency (US EPA) AP-42 predictive emission factor equations. Particulate releases were quantified for various particle size fractions, with the TSP fraction being estimated and simulated to provide an indication of nuisance dust deposition rates. Fine particulates (PM_{10}) were estimated using ratios for the smaller particle size fractions available within the literature. Additionally, gaseous emissions from the combustion of diesel fuel across the Project were assessed.

6.1 SOURCES OF OPERATIONAL EMISSIONS

Sources of atmospheric emissions associated with the Project include:

- Surface-based materials handling activities across the Project Site by Front End Loader (FEL) about the Processing Plant and associated stockpiles;
- Vehicle entrainment of particulate matter due to the haulage of ROM ore along the unsealed haul road between underground box cut and the ROM pad and the movements along the unsealed site access road by product transportation road trains and miscellaneous vehicles;

- Trucks dumping of ROM ore to the ROM Pad;
- Wind erosion associated with exposed surfaces of the pit-top operations, ROM and surge ore stockpiles;
- Wind erosion associated with operation of the Tailings Storage Facility (Tailings Storage Facility);
- Maintenance of unsealed roads by grader;
- Handling of ore by the Processing Plant, including primary and secondary crushing points, screening, conveyor transfer points and wind erosion from open conveyor belts;
- Emissions from the Ventilation Rise associated with underground operations; and
- Diesel combustion emissions from on-site electricity generation and mobile plant.

It is noted that the site establishment phase of the Project, including the stripping and stockpiling of topsoil, excavation of box cut and establishment of Ventilation Rises will have the potential to generate emissions, primarily particulate matter, to the atmosphere. Given that these operations are lower in intensity than emissions from the overall operational phase of the Project, emissions associated with the establishment of the Project have not been addressed within this assessment. Any stockpiles associated with the stripping of topsoil would be stabilised through vegetation by the commencement of the operational phase and would therefore not be a significant contributing source to site emissions.

6.2 PARTICULATE MATTER EMISSIONS

Annual particulate matter emission estimates for the Project from fugitive and combustion emission sources are presented within **Table 9**. Information on the emission factors applied in the quantification of sources is also provided, with the inputs used in the predictive emission factor equations documented in that table.

6.2.1 Annual Particulate Matter Emissions Summary

Emission estimates presented in **Table 9** are graphically presented in **Figure 10** to illustrate source contributions to total annual emissions. Wind erosion from the Tailings Storage Facility, activities associated with the Processing Plant (principally crushing and screening activities), the movement of vehicles along unsealed roads and underground Ventilation Rise emissions are the four most significant contributing sources to annual particulate matter emissions based on the calculations within **Table 9**. It is noted that the calculated Ventilation Rise emissions are based on a highly conservative set of assumptions (see **Section 6.2.4** for further details).

Table 9
Estimated Annual Particulate Matter Emissions for Proposed Project Operations

Source	TSP	PM_{10}	Emission and Control Factor Applied	Calculation Inputs
	tonnes/ annum	tonnes/ annum		
Ore dumping at ROM Pad Stockpile	21.00	10.50	Default Emission Factor for Low Moisture Content Ore - Handling (Table 2, NPI EETMM) 0% control efficiency applied.	Throughput based on annual mining production
FEL at ROM Stockpile/Crusher	21.00	10.50	Default Emission Factor for Low Moisture Content Ore - Handling (Table 2, NPI EETMM) 0% control efficiency applied.	Throughput based on annual mining production
Waste rock dumping at Waste Rock Emplacement	4.91	2.45	Default Emission Factor for Low Moisture Content Ore - Handling (Table 2, NPI EETMM) 0% control efficiency applied.	Throughput based on annual waste rock (81.75 ktpa) at maximum mining production rate
FEL at Waste Rock Emplacement	4.91	2.45	Default Emission Factor for Low Moisture Content Ore - Handling (Table 2, NPI EETMM) 0% control efficiency applied.	Throughput based on annual waste rock (81.75 ktpa) at maximum mining production rate
Crushing - Primary	29.05	2.91	Default Emission Factors for Low Moisture Content Ore - Crushing (Table 2, NPI EETMM) 50% control efficiency for water application 83% control efficiency for hooding with fabric filters	Throughput based on annual mining production
Crushing - Secondary	87.15	8.72	Default Emission Factors for Low Moisture Content Ore - Crushing (Table 2, NPI EETMM) 50% control efficiency for water application 83% control efficiency for hooding with fabric filters	Throughput based on annual mining production
Screening	11.62	8.72	Default Emission Factor for Low Moisture Content Ore - Handling (Table 2, NPI EETMM) 50% control efficiency for water application 83% control efficiency for hooding with fabric filters	Throughput based on annual mining production

Table 9 (cont'd)
Estimated Annual Particulate Matter Emissions for Proposed Project Operations

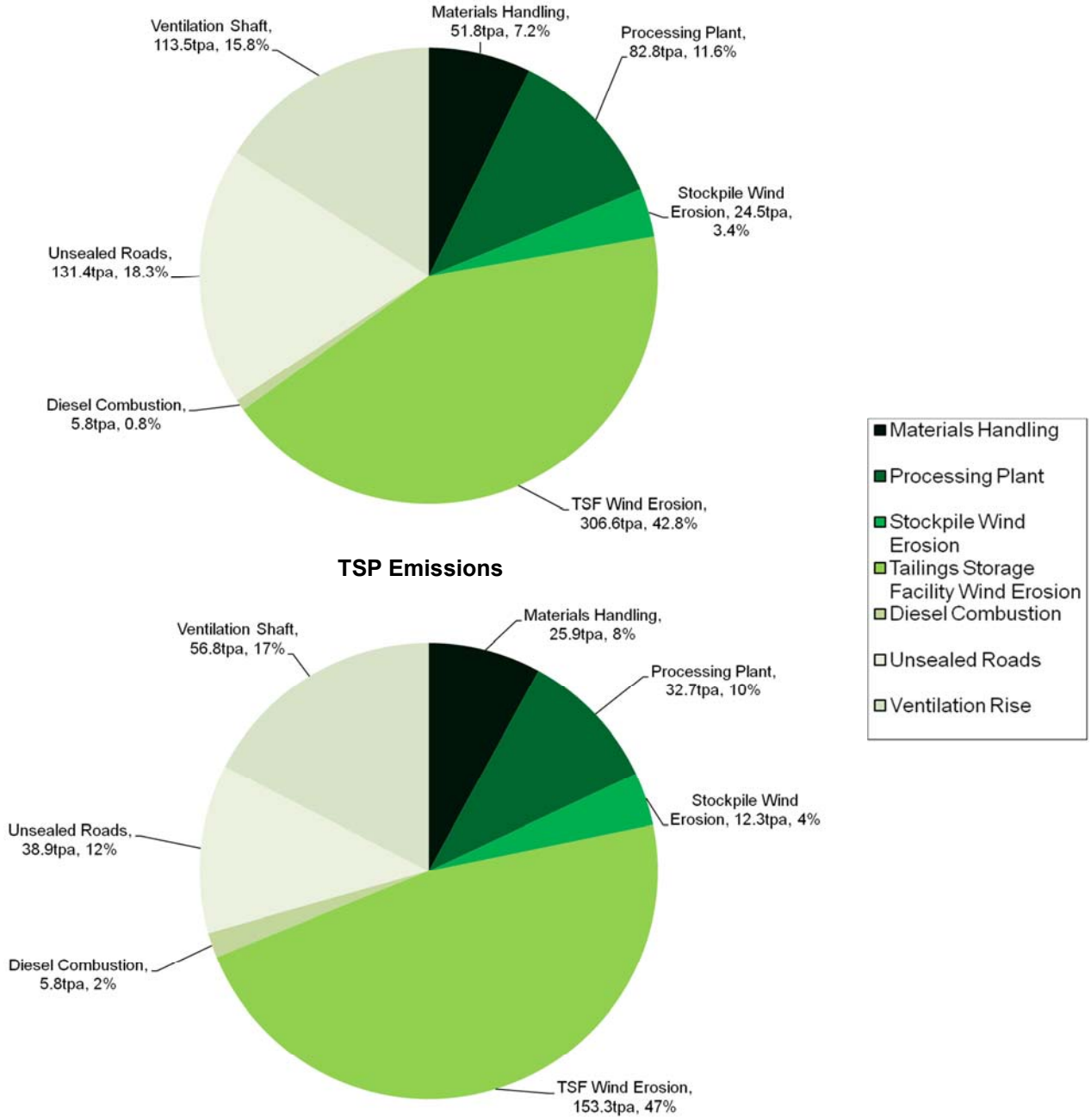
Source	TSP	PM_{10}	Emission and Control Factor Applied	Calculation Inputs
	tonnes/ annum	tonnes/ annum		
Surge Bin Transfer Point	21.00	10.50	Default Emission Factor for High Moisture Content Ore - Handling (Table 2, NPI EETMM) 0% control efficiency applied.	Throughput based on annual mining production
Surge Stockpile Loading	21.00	10.50	Default Emission Factor for High Moisture Content Ore - Handling (Table 2, NPI EETMM) 0% control efficiency applied.	Throughput based on annual mining production
ROM Pad Area Wind Erosion	22.63	11.31	Annual emissions calculated by Equation A1.1.15 (NPI EETMM) 0% control efficiency applied.	Total area of ROM Pad Area taken to be 5.3 ha. Emission Factor parameters used: - Silt Content – 10% - Percentage Time wind speed > 5.4m/s – 10.3% - Number of days with rain > 0.25 mm - 45.6
ROM Stockpile Wind Erosion	0.75	0.38	Annual emissions calculated by Equation A1.1.15 (NPI EETMM) 0% control efficiency applied.	Total area of ROM Stockpile taken to be 0.2 ha. Emission Factor parameters used: - Silt Content – 10% - Percentage Time wind speed > 5.4 m/s – 10.3% - Number of days with rain > 0.25 mm - 45.6
Surge Stockpile Wind Erosion	0.21	0.10	Annual emissions calculated by Equation A1.1.15 (NPI EETMM) 0% control efficiency applied.	Total area of Surge Stockpile taken to be 0.05 ha. Emission Factor parameters used: - Silt Content – 10% - Percentage Time wind speed > 5.4 m/s – 10.3% - Number of days with rain > 0.25 mm - 45.6

Table 9 (cont'd)
Estimated Annual Particulate Matter Emissions for Proposed Project Operations

Source	TSP	PM_{10}	Emission and Control Factor Applied	Calculation Inputs
	tonnes/ annum	tonnes/ annum		
Tailings Storage Facility Wind Erosion	306.59	153.29	Annual emissions calculated by Equation A1.1.15 (NPI EETMM) 0% control efficiency applied to the 25% of the Tailings Storage Facility which is assumed to dry. The greater portion of the Tailings Storage Facility (assumed 75%) is given as being kept wet and therefore not a source of emissions.	Total Emitting area of Tailings Storage Facility taken to be 25% of total Tailings Storage Facility area – 10.2 ha. Emission Factor parameters used: - Silt Content – 70% - Percentage Time wind speed > 5.4 m/s – 10.3% - Number of days with rain >0.25 mm - 45.6
Waste Rock Emplacement Stockpile Wind Erosion	0.91	0.46	Annual emissions calculated by Equation A1.1.15 (NPI EETMM) 0% control efficiency applied.	Total area of Waste Rock Emplacement Stockpile taken to be 0.2 ha. Emission Factor parameters used: - Silt Content – 10% - Percentage Time wind speed > 5.4 m/s – 10.3% - Number of days with rain >0.25 mm - 45.6
Conveyor Belt Wind Erosion	0.09	0.04	Annual emissions calculated by Equation A1.1.15 (NPI EETMM) 0% control efficiency applied.	Total area of individual conveyor belts calculated assuming general width of 2 m. Emission Factor parameters used: - Silt Content – 10% - Percentage Time wind speed > 5.4 m/s – 10.3% - Number of days with rain >0.25 mm - 45.6
Unpaved roads - Box Cut to ROM Pad and Waste Rock Emplacement	23.08	6.81	US-EPA AP-42 Unpaved Roads (Section 13.2.2) (November 2006) 50% control factor applied associated with application of water	Road silt content assumed to be 10%, moisture content 2% Total annual haul truck related VKT estimated based on load in truck of 30 t. The mean vehicle weight was taken to be 40 t (accounting for full (60 t) and empty (30 t) trips).

Table 9 (cont'd)
Estimated Annual Particulate Matter Emissions for Proposed Project Operations

Source	TSP	PM_{10}	Emission and Control Factor Applied	Calculation Inputs
	tonnes/ annum	tonnes/ annum		
Unpaved roads – Main Site Access Road for Concentrate Transportation	17.26	5.09	US-EPA AP-42 Unpaved Roads (Section 13.2.2) (November 2006) 50% control factor applied associated with application of water	Road silt content assumed to be 10%, moisture content 2% Total annual haul truck related VKT estimated based on 6 truck loads with 30 t load leaving site per day. The mean vehicle weight was taken to be 30 t (accounting for full (45 t) and empty (15 t) trips).
Unpaved roads – Light vehicle Site Access Road for Light Vehicles	87.13	25.72	US-EPA AP-42 Unpaved Roads (Section 13.2.2) (November 2006) 50% control factor applied associated with application of water	Road silt content assumed to be 10%, moisture content 2% Total annual small vehicle emissions related VKT estimated based 75 movements per day The mean vehicle weight was taken to be 4 t.
Grader – Road Maintenance	3.92	1.24	Annual emissions calculated by Equation A1.1.12 (NPI EETMM) 50% control efficiency applied.	Assumed to operate for 2 hours each day. Mean grader speed 10 km/hour.
Ventilation Rise	113.53	56.76	Emissions for Ventilation Rise estimated from OHS criteria for dust 0% control efficiency applied.	Further discussion regarding Ventilation Rise Emissions provided in **Section 6.2.4**.
Gold Room Furnace Stack	0.01	0.01	Particulate emissions from Gold Room furnace stack calculated from NPI Boiler Emission factors for LPG combustion (industrial Propane) TSP emissions assumed to be 100% PM_{10} fraction	Further discussion regarding Gold Room Emissions provided in **Section 6.2.4**.
Diesel Combustion – Electricity Generation	5.78	5.78	Diesel Combustion particulate emissions calculated from NPI Boiler Emission factors TSP emissions assumed to be 100% PM_{10} fraction	Further discussion regarding Power Generation Emissions provided in **Section 6.2.3**.
TOTAL	**803.53**	**334.24**		



TSP Emissions

PM_{10} Emissions

Figure 10 Summary of Particulate Matter Emissions by Source Type

6.2.2 Heavy Metal Emissions

A range of metals are likely to be present in the particulates released. To provide an estimate of metal emissions, reference has been made to metals analysis for a number of material types.

Firstly, the likely individual metals content of tailings produced by the Processing Plant has been adopted from a Tailings Geochemistry study conducted by Coffey Mining (2010) for the Project.

In the absence of site specific material, reference has been made to a study conducted by the Cooperative Research Centre for Landscape Environments and Mineral Exploration in 2005 of a copper/lead/zinc deposit located approximately 90 km north-northwest of the Project Site. This study (Munro, McQueen and Stockton, 2005) provided maximum anomaly concentrations of individual metals within the primary mineralization, saprolite, soil and gap material.

The maximum metals concentrations reported for the primary mineralization and saprolite samples were taken for ROM Ore related processes (including dumping of underground material, Processing Plant operations, etc). As some waste rock material from the site may be used for the construction of the unsealed haul roads, the maximum metals concentrations reported for the soil and gap samples noted above were taken for unsealed haul roads emission sources.

While the metals profile of individual deposits would likely vary, it is considered that in the absence of metals analysis for the Project Site deposit, this study provides a representative metals profile for the Cobar region for use in this assessment.

A summary of the metal analysis of the various materials of interest in the current study is given in **Table 10** for ROM Ore, Tailings and Unpaved Road. It is recognised that the metal content is likely to vary with particle size class. Insufficient information was however available to characterise specifically the metal content of the PM_{10} fraction. The metal content was therefore assumed representative across particle size fractions.

The following assumptions are made based on the data presented in **Table 10**.

- The metals profile for ROM Ore was used to estimate metal emissions associated with ore handling, Processing Plant operations (crushing, screening, etc) and wind erosion of exposed areas and stockpiles.
- The Tailings profile was used to estimate metals emissions from the Tailings Storage Facility.
- The Unpaved Road profile was used to estimate metal emissions from vehicle entrainment from unpaved roads.

It is noted that of the metals listed within **Table 10**, only antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel and silver have NSW OEH assessment criterion. Therefore, not all metals listed in **Table 10** will be assessed within the dispersion modelling conducted for the Project.

Table 10
Composite Metal/Metalloid/Non-metal Content of Materials

Page 1 of 2

Metal / Metalloid	ROM Ore	Tailings	Unpaved Road	Unit
Aluminium	-	42,000		ppm
Antimony	99	3.2	250	ppm
Arsenic	100	20	509	ppm
Barium	1,840	290	833	ppm
Bismuth	154	<10	77	ppm
Boron	-	44		ppm
Beryllium	-			ppm
Cadmium	52.2	<5	61.2	ppm
Calcium	-	2,500		ppm

Table 10 (Cont'd)
Composite Metal/Metalloid/Non-metal Content of Materials

Metal / Metalloid	ROM Ore	Tailings	Unpaved Road	Unit
Chromium	-	210		ppm
Cobalt	-	5		ppm
Copper	2,000	38	690	ppm
Flourine	-	670		ppm
Iron		22,700	120,000	ppm
Lead	2,960	235	3,960	ppm
Magnesium		10,300		ppm
Manganese		1000		ppm
Mercury	0.5	0.2		ppm
Molybdenum		10		ppm
Nickel		65		ppm
Phosphorus		400		ppm
Potassium	2,700	18,300		ppm
Radium		0		ppm
Selenium		3.2		ppm
Silver	3	6	3.1	ppm
Sodium	60	100		ppm
Strontium	105	100		ppm
Thorium		20		ppm
Tin		100		ppm
Titanium		6.9		ppm
Uranium		0		ppm
Vanadium		2		ppm

Estimated annual metal emission estimates for proposed operations at the Project Site are summarised in **Table 11**.

Table 11
Estimated Metal/Metalloid Emissions for Project

Metal / Metalloid	TSP Fraction (tonnes/annum)	PM_{10} Fraction (tonnes/annum)
Antimony	0.07	0.02
Arsenic	0.11	0.04
Barium	0.86	0.33
Cadmium	0.03	0.01
Chromium	0.06	0.03
Copper	0.82	0.31
Lead	1.66	0.59
Manganese	0.31	0.15
Mercury	<0.01	<0.01
Nickel	0.02	0.01
Silver	<0.01	<0.01

6.2.3 Wind Erosion Emissions

Wind entrained emissions from stockpiles, Tailings Storage Facility and other `exposed surfaces were varied on an hourly basis by wind speed. The calculated annual wind erosion for each source listed within **Table 9** were distributed proportionally across the hours throughout the modelling period that experienced wind speeds greater than 5.4 m/s.

Emissions were varied by wind speed band (0-5 m/s, 5-6 m/s, 6-7 m/s, 7-8 m/s, 8-9 m/s, >9 m/s) to reflect the increase in wind erosion potential with increasing wind speed. Proportion of annual emissions by wind speed was determined by applying the USEPA's erosion potential equation (AP-42, Chapter 13.2.5). A friction threshold velocity value of 5.4 m/s was adopted, based on the wind speed referenced within Equation A1.1.15 of the NPI EETMM.

To account for the surface drying that can occur at an operational Tailings Storage Facility, it has been assumed that, at any given time, 25% of the total area of the Tailings Storage Facility is crusted and therefore has the potential to generate emissions. It is understood that the majority of the surface (>75%) of the Tailings Storage Facility would be wet during the operational stage.

6.2.4 Ventilation Rise Emissions

To provide fresh air to the underground mining areas at the Project Site, a ventilation system will be installed by the Proponent. It is understood that the system will comprise two Ventilation Rises. One Ventilation Rise would act as the exhaust for the underground mine air and would be fitted with a fan located on the surface, and the second one would be for fresh air intake (in addition to the decline) and for emergency egress (labelled as Escape way in **Figure 1**). . Only the Ventilation Rise acting as the exhaust shaft will be considered as an emissions source within this assessment.

To estimate emissions from an underground mining operation released into the atmosphere via a ventilation rise the NPI EETMM identifies that the average concentration of the pollutant in the vented air and the volume of air to be vented should be drawn upon.

Underground mining operations at the Project Site will primarily involve drill and blast activities, loading of material to underground haul trucks, movement of mined material to the surface by haul truck and backfilling operations. Such operations could generate emissions of particulate matter and combustion emissions from both diesel use and intermittent explosives detonation.

The relationship between emissions generated underground and the in-stack concentration at the surface release point of a ventilation rise is not clear, given a number of confounding factors including fallout over the vertical distance of the ventilation rise and the dilution effect of added fresh air. In the absence of actual ventilation rise monitoring data, the concentration of particulate matter within the exhaust stream will be estimated based on the potential concentration in the underground areas.

Safe Work Australia (formerly the National Occupational Health and Safety Commission) prescribe a range of exposure standards for atmospheric containments that should be met in working environments. As the Ventilation Rise would be designed to maintain a safe working environment for the underground operations with regards to air quality, it is assumed that the air quality of the underground mining areas will satisfy all applicable exposure standards. The Safe Work Australia time weighted (8-hour) average exposure standard for inspirable dust (equating roughly to PM_{10}) is 10 mg/m^3 (NOHSC, 1995). Assuming that underground air quality levels would be suitably maintained by operational controls and the performance of the ventilation system, this exposure standard was taken as a conservative upper bound estimate of the average ventilation PM_{10} concentration in the exhaust air stream.

For comparative purposes, reference and use of the ventilation rise monitoring data from an underground coal mine in NSW (EML, 2005) is made in this assessment. The justification for using the measured data from that coal mine for the assessment of the Project's emissions is as follows. The coal mining comprises similar underground TSP and PM_{10} source types such as drilling, blasting, diesel-powered equipment exhaust and continuous mining. The coal mine comprises significantly larger scale operations than the Project (approximately 5.2 Mtpa compared with the proposed 350 ktpa for the Project). The measured ventilation rise (in-stack) concentrations of TSP and PM_{10} from the coal mine ventilation rise in operational mode was 1.6 mg/m^3 and 1.1 mg/m^3, respectively, at the point of release to atmosphere. From this comparison it is considered that the particulate matter concentration adopted within this assessment (10 mg/m^3) as discussed above, and therefore the resultant modelling of emissions, is a conservatively high upper bound representation of likely operating conditions.

The surface Ventilation Rise release point for the Project was configured as a point source with 4 m diameter and a flow rate of 180 m^3/s. It is noted that combustion related emissions from underground operations, occurring as a result of diesel-fuel combustion will be represented by surface based sources. This represents a further conservative (upper bound) estimate, necessitated by the absence of information regarding the split of diesel consumption underground and at surface.

6.2.5 Particulate Matter Emission Controls

Based on details provided by the Proponent, control of the generation of particulate matter emissions from the Project Site will be undertaken through water spraying of unsealed roadways and the implementation vacuum hooding with filter bags and water suppressants at key crushing and transfer points. Given these proposed mitigation controls, default emission reduction factors of 50% for water spraying and 83% for hooding with fabric filters, as per **Table 3** of the NPI EETMM, have been applied to the emission calculations for the relevant sources within **Table 9**.

6.3 PROCESSING PLANT EMISSIONS (NON-PARTICULATE)

In addition to particulate matter emissions generated by the crushing, screening and handling of ROM Ore, a number of other components of the Processing Plant have the potential to generate emissions to the atmosphere, and are discussed below. **Figure 11** provides a basic illustration of the proposed Processing Plant operations at the Project Site.

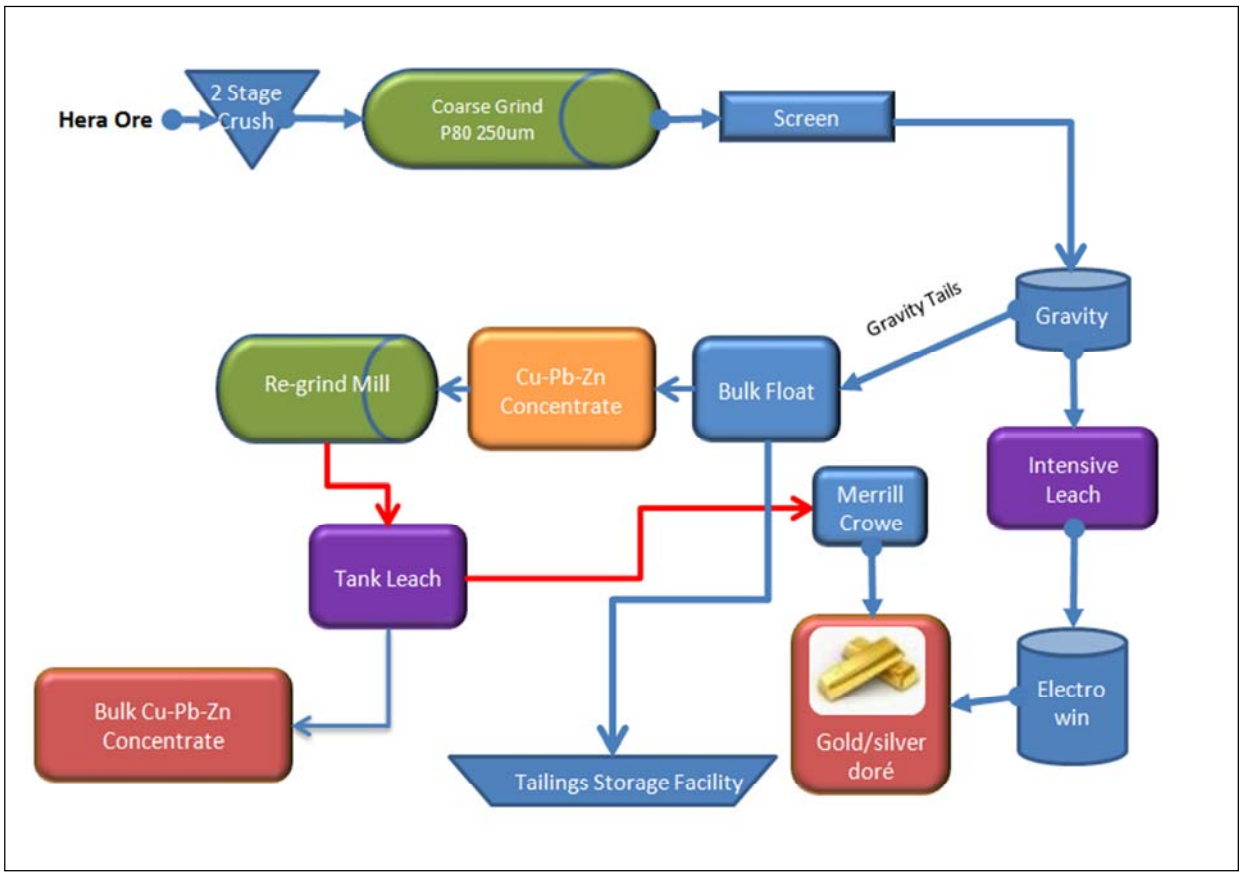


Figure 11 Flow Chart of the Proposed Processing Plant (Source: Proponent 2011)

The milling process is a wet operation and is assumed to have no particulate emissions to the atmosphere.

The Proponent has identified that fugitive emissions of H_2S and CS_2 would be generated by the flotation tanks (Bulk and Cleaner) and HCN could be generated by the Merrill Crowe de-aeration column. Concentrations of each of these substances are expected to be below the applicable occupational exposure standards. The Proponent has provided air exchange flow rates for these processes (24 m^3/min, 8 m^3/min and 0.3 m^3/min, respectively, for Bulk Flotation, Cleaner Flotation Tank and Merrill-Crowe processes) which have been used in combination with the applicable Safe Work Australia exposure standards (14 mg/m^3, 31 mg/m^3 and 11 mg/m^3 respectively as per NOSHC 1995) to estimate maximum fugitive emissions to atmosphere.

The Proponent has identified that very minor concentrations of HCN would be present at the surface of the tank leach process. However, as the air exchange associated with this component is very low, emissions from this stage of the process have been excluded from the assessment.

Finally, emissions for a range of pollutants, including ammonia, SO_2 and particulate matter, could be generated within the Gold Room area by the calcining oven, electrowinning cell and smelting furnace. The Proponent advises that all emissions from these processes will pass through a scrubber system to remove generated pollutants before being released to atmosphere via an exhaust stack. Emissions from the Gold Room are only expected to relate to the combustion of LPG, limited in this assessment to NO_X, SO_2, CO and benzene emissions for consistency with the diesel combustion emission estimation. The estimation of emissions from this exhaust stack are based on the expected LPG consumption rate (50 L/day), hours of operation per day (maximum 4 hours) and emission estimation factors from Table 25 of the NPI Emission Estimation Technique Manual for Boilers (NPI, 2011).

According to the Proponent, the exhaust stack for the Gold Room stack would be 10 m high, 0.4 m in diameter, have an exit temperature of 80°C and exit velocity of 0.04 m/s.

Table 12 presents the annual emissions calculated for the proposed Processing Plant at the Project Site. It is noted however that in the dispersion modelling process, peak emissions rates were modelled for the entire year to assess the maximum potential concentrations associated with these emission sources under all meteorological conditions.

Table 12
Annual Emissions – Processing Plant (non-Particulate)

Pollutant	Annual Emissions (t) by Process			
	Bulk Flotation Tanks	**Cleaner Flotation Tanks**	**Merrill Crowe De-aeration Column**	**Gold Room Stack**
H_2S	0.18	0.06	-	-
CS_2	0.39	0.13	-	-
HCN	-	-	0.002	-
SO_2	-	-	-	0.03
NO_X	-	-	-	0.17
CO	-	-	-	0.02
Benzene (C_6H_6)	-	-	-	0.002

6.4 TAILING STORAGE FACILITY CYANIDE EMISSIONS

In addition to particulate matter emissions already accounted for in Section 6.2, the Tailings Storage Facility could have the potential to generate fugitive emissions of cyanide to the atmosphere. However, it is understood that the Proponent would ensure the Weak Acid Dissociable (WAD) cyanide concentration in the tailings would be reduced to <10 mg/L within the cyanide destruction tank prior to discharge to the Tailings Storage Facility. As such the tailings material would contain WAD cyanide concentration <10 ppm. The Project Site would be managed in accordance with NICNAS Category 1 (NICNAS, 2010) where Category 1 (<10 ppm of WAD cyanide) represents the category with the lowest risk to the wildlife because stronger WAD cyanide concentration controls are in place. Cyanide emissions from the Tailings Storage Facility are likely to be significantly lower than 10 mg/L given that photolysis under sunlight continually destroys cyanide containing species in the tailings materials. For this reason cyanide emissions from the Tailings Storage Facility was not included in the emissions inventory and the dispersion modelling.

6.5 DIESEL COMBUSTION EMISSIONS

In addition to particulate matter emissions already accounted for in **Section 6.2** (it is noted that particulate matter emissions factors for mining processes account for diesel exhaust emissions), diesel combustion related pollutants that could be generated by the operation of the Project include NO_2, SO_2, CO and the individual VOC species. While numerous VOC species are emitted during the combustion of diesel fuel, the pollutant benzene has been selected as a representative indicator of risk.

Project sources of diesel combustion emissions include the following:

- Diesel-fired generators at the Processing Plant and Mine Camp;
- Mobile mining equipment; and
- Haul trucks.

6.5.1 Diesel Generator Emissions

Emissions from the combustion of diesel by diesel-fuelled generators located at the Processing Plant and Mine Camp were estimated based on emission factors from Table 28 (Emission Factors for diesel oil (≤30 MW)) of the NPI Emission Estimation Technique Manual for Boilers (NPI, 2008). The Processing Plant location will comprise of four 640 kW generator sets and has a projected annual diesel consumption rate of 2,190 kL/annum. The Mine Camp location will consist of two 275 kW generator sets and has a projected annual diesel consumption rate of 447.2 kL/annum.

The estimated annual emissions from diesel-fired generators at the Project Site derived from adopted NPI emission factors are listed within **Table 13**.

Table 13
Annual Emissions – Diesel Generator Emissions

Pollutant	Annual Emissions (t)
SO_2	0.2
NO_X	148.3
CO	37.8
Benzene (C_6H_6)	0.04

6.5.2 Mobile Mining Equipment and Haul Truck Emissions

In addition to diesel associated with the generation of electricity for the Mine Camp, projected annual diesel consumption for the mining and processing operations of the Project was provided by the Proponent. Emissions from the combustion of diesel by surface operations and haul truck movements across the Project Site were estimated using the emissions factors within Table 35 of the NPI Emission Estimation Manual for Combustion Engines (NPI, 2008) – Miscellaneous Diesel Industrial Vehicles. Benzene was derived from total VOC emissions based on a VOC speciation profile for diesel engines (6% of TVOC) as per the findings of Liu *et al.* (2008).

The Proponent estimates annual diesel consumption associated with mining and processing operations to be of the order of 4,473 kL/annum. While the projected annual diesel consumption accounts for consumption by both underground and surface operations, all estimated diesel consumption will be applied to surface based sources within the dispersion modelling process.

The estimated annual emissions from surface-based and underground equipment at the Project Site based NPI emission factors are listed within **Table 14**.

Table 14
Annual Emissions – Surface Equipment and Underground Operations

Pollutant	Annual Emission (t)
SO_2	0.1
NO_x	201.3
CO	83.2
Benzene(C_6H_6)	1.1

7. DISPERSION MODELLING METHODOLOGY

7.1 DISPERSION MODEL SELECTION AND APPLICATION

The atmospheric dispersion modelling carried out within this assessment utilises the US-EPA regulatory AERMOD model (US-EPA, 2004).

AERMOD is designed to handle a variety of pollutant source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain.

AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006 as it provides more realistic results with concentrations that are generally lower and more representative of actual concentrations compared to the conservative ISC model. Ausplume, a steady state Gaussian plume dispersion model developed by the Victorian EPA and frequently used in Australia for simple near-field applications, is largely based on the ISC model.

Compared to ISC and Ausplume, AERMOD represents an advanced new-generation model which requires additional meteorological and land-use inputs to provide more refined predictions.

Air pollutant concentrations of particulate matter and diesel combustion-related pollutants were simulated for a regular Cartesian receptor grid covering a 14 km by 14 km computational domain centred over the Processing Plant, with a grid resolution of 1 km. Additionally, a 6 km by 6 km nested grid with a resolution of 500 m, also centred over the Processing Plant, was configured to provide greater resolution of model predictions in the vicinity of the Project Site. Finally, concentrations were also predicted at the various discrete receptor points as listed within **Table 2**.

A detailed account of the model selection and modelling methodology is presented in **Appendix 3**.

7.2 SOURCE AND EMISSIONS DATA

The methodology and results of the emissions inventory developed for this study are presented in **Section 6**. Process and material specific particle size distribution data for an extractive operation of similar nature to the Project was adopted within this assessment to assist with dispersion calculations of particulate matter emissions.

Figure 12 illustrates the location about the Project Site of the assorted operational emissions sources, listed within **Table 9**, as input into the dispersion modelling process.

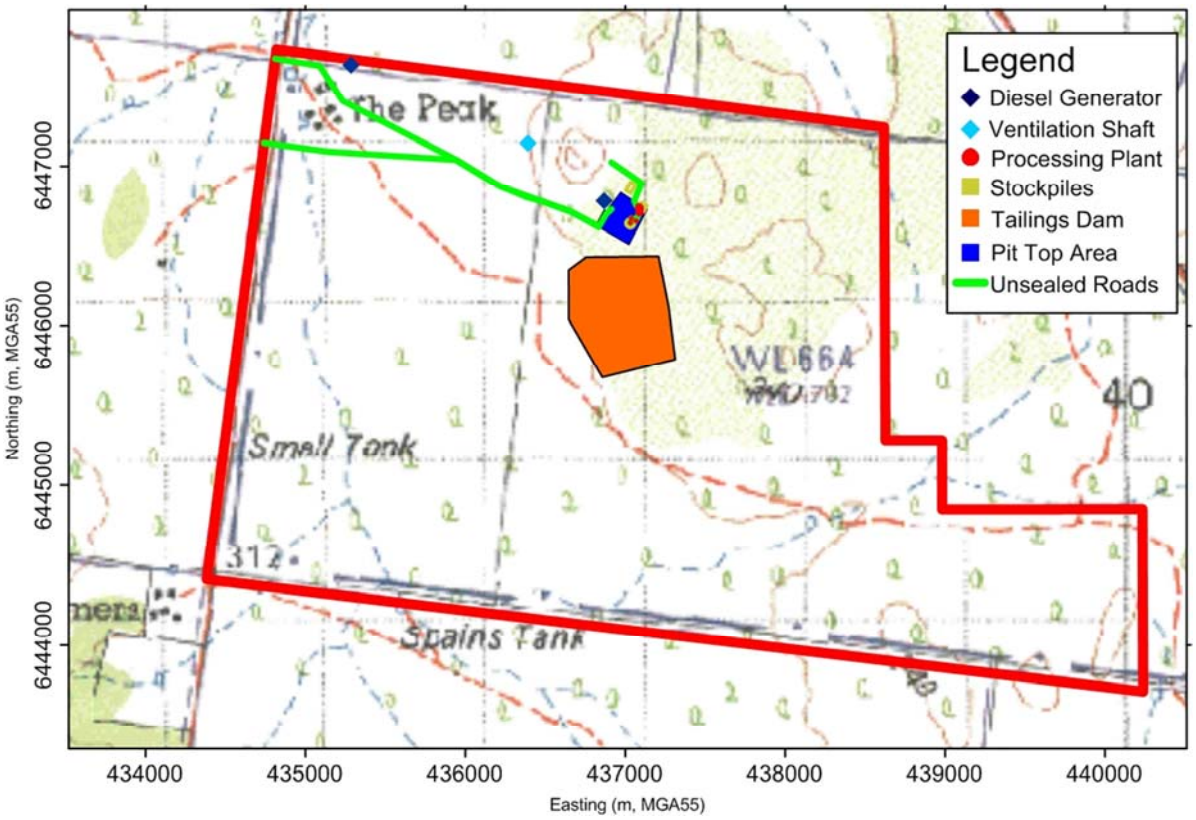


Figure 12 Location of Emission Sources within AERMOD Modelling

7.3 MODELLING METHODOLOGY

7.3.1 Analysis of Dispersion Modelling Results

A single modelling scenario configured to reflect a worst-case operational 24-hour period continuously throughout a calendar year was established.

Dispersion simulations were undertaken and results analysed for TSP, PM_{10}, dust deposition, SO_2, NO_2, CO and benzene. Heavy metal concentrations were derived based on modelled TSP and PM_{10} concentrations and measured metals analysis from site-representative material as documented in **Section 6.2.2**.

Incremental Project-related concentrations and deposition rates occurring due to the Project were modelled based on one year of site-representative meteorological data (2009 calendar year).

Model results are expressed as the maximum predicted concentration for each averaging period at the selected assessment locations over the 2009 calendar year, with the exception of benzene and assorted metals which, consistent with OEH Approved Methods, are reported as the 9th highest (99.9th percentile) 1-hour average concentrations.

Results are presented in the following formats:

- Tabulated results of particulate concentrations, gaseous pollutant concentrations and dust deposition rates at the selected assessment locations are presented and discussed in **Section 8**.
- Isopleth plots, illustrating spatial variations in Project-related incremental TSP, PM_{10}, dust deposition and NO_2 are provided in **Appendix 4**.

Isopleth plots of the maximum 1-hour and 24-hour average concentrations presented in **Appendix 4** do not represent the dispersion pattern on any individual hour or day, but rather illustrate the maximum hourly or daily concentration simulated at each model calculation point given the range of meteorological conditions occurring over the 2009 modelling period.

7.3.2 Assessing Cumulative Impacts

To assess likely background concentrations and potential cumulative impacts from the Project, the following steps will be undertaken:

- Each individual 24-hour average predicted PM_{10} concentration was paired in time with the corresponding 24-hour concentration within the adopted 2009 PM_{10} monitoring dataset from Bathurst to obtain daily-varying cumulative impact at each receptor. This is in accordance with Section 5.1.1 of the Approved Methods.
- The frequency distribution of predicted 24-hour average concentrations of PM_{10} was compared with the corresponding frequency distribution of the Bathurst and Tamworth monitoring datasets to provide an indication of the likelihood of elevated cumulative impacts occurring.
- Cumulative annual average PM_{10}, TSP and monthly dust deposition was assessed through the addition of the dataset average concentrations, as identified in the preceding sections (18.4 µg/m^3, 46.0 µg/m^3 and 2.2 g/m^2/month, respectively).

The existing ambient air quality levels adopted for this assessment are summarised in **Table 15**.

Table 15
Background Air Quality for the Assessment of Cumulative Emissions from the Project

Air Pollutant	Averaging Period	Assumed Ambient Background Level	Source of Monitoring Data
Dust Deposition	Annual	2.2 g/m^2/month	CBH Endeavor
PM_{10}	24-hour	Daily Varying	OEH
	Annual	18.4 µg/m^3	
TSP	Annual	46.0 µg/m^3	Derived from OEH annual PM_{10} background

7.3.3 Modelling of NO_X Emissions

NO_x emissions associated with fuel combustion are primarily emitted as NO. The transformation in the atmosphere of NO to NO_2 was accounted for using the USEPA's Ozone Limiting Method (OLM) which requires ambient ozone data. No site specific ozone (O_3) concentrations are available for the Nymagee area.

Reference was therefore made to the NSW OEH O_3 monitoring station at Beresfield, approximately 500 km east-southeast of the Project Site. The Beresfield station is located in a significantly different setting to that of the Project Site, with close proximity to significant vehicle emissions, industrial and residential development and the coastline. While it is not considered that the O_3 concentrations recorded at Beresfield are representative of concentrations at the Project Site, it is considered that the Beresfield data provides a conservatively high estimate of ambient O_3 concentrations in the absence of site specific or representative data.

Daily maximum 1-hour average O_3 data recorded at Beresfield between January 2007 and December 2009 was sourced from the NSW OEH and analysed. The 75th percentile concentration, equating to a concentration of 66.6 µg/m^3, was taken to be a reasonable estimate of potential upper bound O_3 concentrations for the Nymagee area. This concentration was adopted as the continuous 1-hour average ambient O_3 background concentration within the OLM calculations of NO_2 from predicted NO_x concentrations.

The equation used to calculate incremental NO_2 concentrations from predicted NO_x concentrations is as follows:

$$NO_2 = \{0.1 \times [NO_x]PRED\} + MIN\{(0.9) \times [NO_x]PRED \text{ or } (46/48) \times [O_3]BKGD\}$$

where:

NO_2 = The predicted incremental concentration of NO_2

$[NO_x]PRED$ = The AERMOD prediction of ground level NO_x concentrations

MIN = The minimum of the two quantities within the braces

$[O_3]BKGD$ = The assumed background ambient O_3 concentration – 66.6 µg/m³

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

The USEPA's OLM assumes that all of the available O_3 in the atmosphere will react with NO until either all of the O_3, or all of the NO species has reacted. A major assumption of this method is that the reaction is instant. In reality, this reaction takes place over a number of hours and over a large distance. Further to this, the method assumes that the complete mixing of the plume NO and ambient ozone, down to the level of molecular contact will have occurred by the time the plume reaches the ground level receptor of maximum ground level NO_x concentration.

Consequently, concentrations of the NO_2 reported within this study should be viewed as an upper bound estimate.

8. DISPERSION MODELLING RESULTS

8.1 TSP CONCENTRATIONS

Table 16 presents the predicted incremental and cumulative annual average ground level concentrations of TSP at the selected receptor locations as a result of operations at the Project Site.

Table 16
Predicted Incremental and Cumulative Annual Average TSP Concentrations at Selected Receptors

Receptor ID	Predicted Annual Average TSP Concentrations (µg/m^3)	
	Incremental (Project Only)	Cumulative (Project + Background)
R1	0.5	46.5
R2	0.6	46.6
R3	1.3	47.3
R4	0.4	46.4
R5	0.2	46.2
R6	5.8	51.8
Note: Annual Average TSP Background – 46 µg/m³ as per **Section 4.2.3** Note: Assessment Criteria: Annual – 90 µg/m³		

It can be seen from the results presented within **Table 16** that the predicted TSP concentrations satisfy the applicable NSW OEH criterion at all selected receptor locations. Incremental Annual Average TSP concentration isopleth plots are presented in **Appendix 4**, as **Figure A4-1**.

8.2 PM_{10} (24-HOUR AND ANNUAL AVERAGE) CONCENTRATIONS

8.2.1 24-hour Average PM_{10}

Table 17 presents the predicted incremental 24-hour average ground level concentrations of PM_{10} at the selected receptor locations as a result of operations at the Project Site. Additionally, **Table 17** presents the model predictions at all receptors for maximum incremental 24-hour average PM_{10} with an in-stack concentration in the Ventilation Rise exhaust of 1.6 mg/m^3 (corresponding to the PM_{10} concentration measured at the 5.2 Mtpa coal mine discussed in **Section 6.2.4**), and with no emissions being generated by the Ventilation Rise. These additional model predictions have been included in response to the highly conservative assumptions adopted in estimating particulate emissions from this source and to illustrate the variability in resultant model predictions relating to these assumptions.

Table 17
Maximum Predicted Incremental 24-hour Average PM_{10} Concentrations at Receptor Locations

	Maximum Predicted Incremental (Project Only) 24-hour Average PM_{10} Concentrations (µg/m^3)		
Receptor ID	Project Operations – as per **Table 9**	Project Operations with Vent Rise Concentration 1.6 mg/m^3	Project Operations with No Vent Rise Emissions
R1	5.6	5.6	5.6
R2	6.3	6.3	6.3
R3	10.6	7.0	6.8
R4	4.2	3.3	3.1
R5	2.5	1.7	1.5
R6	34.1	20.7	19.3

It can be seen from **Table 17** that the maximum predicted 24-hour PM_{10} concentration at the surrounding non-project related receptors (R1 – R5) is predicted to be less than 10.6 µg/m^3 for an adopted Ventilation Rise emissions rate of 10 mg/m^3 (see Section 6.2.4) while the predicted 24-hour average PM_{10} concentration at 34.1 µg/m^3 at R6 (Mine Camp) is higher than those predicted for the non-project related receptors.

The results in **Table 17** clearly show that the maximum predicted 24-hour PM_{10} concentration at R3, R4, R5 and, in particular, R6 decrease when the measured in-stack concentration from the operational coal mine (significantly larger in operational intensity than the proposed Project) is applied. Specifically, it is identified that the predicted maximum 24-hour average PM_{10} concentration at R6 reduces, from 34.1 µg/m³ to 20.7 µg/m³, when the Ventilation Rise emission rate is based on an in-stack concentration of 1.6 mg/m^3. In using 10 mg/m^3 as the in-stack particulate matter concentration for this Project, it is considered that model predictions in the surrounding environment influenced by the Ventilation Rise, such as at R6, should be viewed as a upper bound estimate of concentrations that could likely be experienced.

To assess cumulative impacts from the Project at the surrounding receptors in accordance with the OEH Approved Methods, the daily varying model predictions were paired in time with the daily varying Bathurst PM_{10} dataset, as discussed in **Section 7.3.2**. The maximum cumulative 24-hour average PM_{10} concentrations, consisting of the predicted incremental (Project Only) concentration and the corresponding background concentration from Bathurst for that 24-hour period, are presented within **Table 18**. Similar to **Table 17, Table 18** also presents the model predictions at Receptor R6 (Mine Camp) for maximum cumulative 24-hour average PM_{10} with an in-stack concentration in the Ventilation Rise exhaust of 1.6 mg/m^3 (equivalent to the concentration measured at the 5.2 Mtpa coal mine discussed in **Section 6.2.4**), and with no emissions being generated by the Ventilation Rise.

The results within **Table 18** illustrate that the maximum cumulative 24-hour PM_{10} concentrations associated with the Project, derived from this cumulative assessment approach, would be lower than the OEH assessment criterion of 50 µg/m^3 at the surrounding non-project related receptor locations (R1 to R5).

The maximum cumulative 24-hour PM_{10} concentrations associated with the Project at receptor R6 is in exceedance of the OEH assessment criterion. The principal contributing emissions source causing the exceedance is the Ventilation Rise. **Table 18** also shows that the maximum cumulative 24-hour PM_{10} concentrations associated with the Project at R6, when the Ventilation Rise emissions were based on an in-stack concentration of 1.6 mg/m^3, is not in exceedance of the OEH criterion. The results of the modelling at the closest receptors, R6 in particular, are therefore highly dependent on the calculated emissions from the Ventilation Rise. As stated in **Section 6.2.4**, the emission estimation for this source was based on a set of highly conservative assumptions and as a result, the predicted results should be viewed as an upper bound estimation of possible concentrations that could be experienced.

Table 18
Maximum Predicted Cumulative (Project Increment plus Corresponding Background) 24-hour Average PM_{10} Concentrations at Selected Receptors

Receptor ID	Predicted 24-hour Average PM_{10} Concentrations ($\mu g/m^3$)		
	Cumulative (Project + Background)	Incremental Component (Project Only)	Background Component
R1	48.4	<0.1	48.4
R2	48.4	<0.1	48.4
R3	48.9	0.5	48.4
R4	48.7	0.3	48.4
R5	48.6	0.2	48.4
R6 – Vent Rise Concentration of 10 mg/m^3	52.9	20.9	32.0
R6 – Vent Rise Concentration of 1.6 mg/m^3	49.5	1.1	48.4
R6 – No Vent Rise Emissions	49.5	1.1	48.4
Note: 24-hour PM_{10} background data varies on a daily basis – thus variable background component at R6 Note: Assessment Criteria: 24-hour – 50 $\mu g/m^3$ (OEH)			

To illustrate the likelihood of PM_{10} emissions from the Project causing an exceedance of the cumulative 24-hour average assessment criterion of 50 $\mu g/m^3$, the frequency distributions of predicted 24-hour average PM_{10} increments at each of the selected receptor locations has been analysed and illustrated within **Figure 13**.

The data in **Figure 13** highlights that the 24-hour average incremental increase in PM_{10} from the Project is predicted to be less than 5 $\mu g/m^3$ approximately 98% of the time and less than 10 $\mu g/m^3$ approximately 100% of the time across all selected non-project related receptors. When the frequency distribution of the OEH Bathurst and Tamworth datasets illustrated within **Figure 4** are taken into consideration, particularly the frequency of concentrations greater than 30 $\mu g/m^3$ (approximately 8% and 4% of the Tamworth and Bathurst respectively), it is considered that the potential for the proposed operations at the Project Site to cause a cumulative exceedance of the OEH 24-hour average PM_{10} criterion is extremely low.

As stated previously, the predicted 24-hour average PM_{10} concentrations at the Mine Camp (R6) are higher than those predicted for the non-project related receptors. The 24-hour average PM_{10} concentrations attributable to the Project are predicted to be less than 20 $\mu g/m^3$ approximately 98% of the time at R6. It is noted, however, that the most significant contributing source to predicted concentrations at R6 is the Ventilation Rise. Given the illustrated influence of the Ventilation Rise emissions on predicted concentrations at R6 and the discussed high level of conservatism incorporated into the emissions estimation from this source, it is considered that the predicted concentrations at this location should be viewed as an upper bound estimation of possible concentrations that could be experienced.

An incremental 24-hour average PM_{10} concentration isopleth plot for the Project is presented in **Appendix 4** as **Figure A4-2**

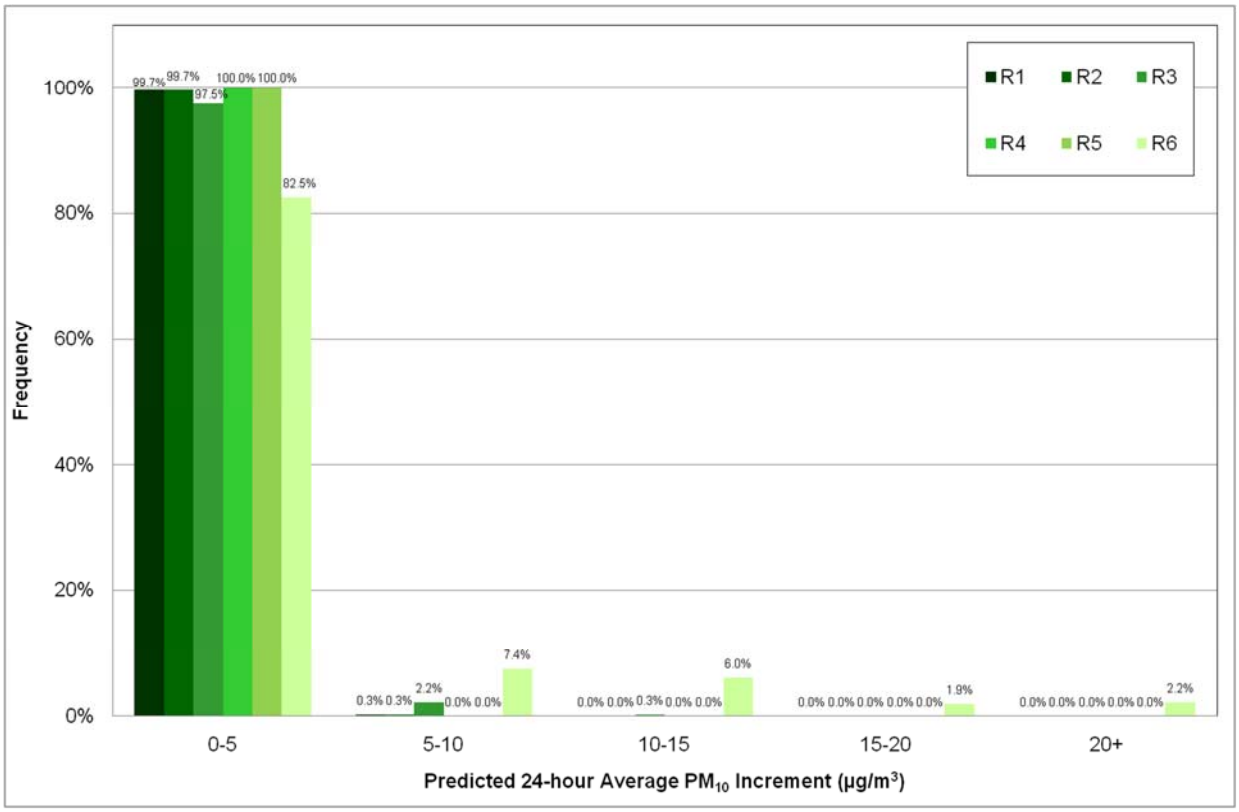


Figure 13 Frequency Distribution of Predicted 24-hour Average Incremental PM_{10} Concentrations by Receptor

8.2.2 Annual Average PM_{10}

Table 19 presents the predicted incremental and cumulative annual average ground level concentrations of PM_{10} at the selected receptor locations as a result of operations at the Project Site.

Table 19
Predicted Incremental and Cumulative Annual Average PM_{10} Concentrations at Selected Receptors

Receptor ID	Predicted Annual Average PM_{10} Concentrations (µg/m^3)	
	Incremental (Project Only)	Cumulative (Project + Background)
R1	0.3	18.7
R2	0.4	18.8
R3	0.8	19.2
R4	0.2	18.6
R5	0.1	18.5
R6	3.4	21.8
Note: Annual Average PM_{10} Background – 18.4 µg/m³ as per **Section 4.2.2** Note: Assessment Criteria: Annual – 30 µg/m³		

It can be seen from the results presented within **Table 19** that the predicted PM_{10} concentrations satisfy the applicable NSW OEH criterion at all selected receptor locations.

An incremental annual average PM_{10} concentration isopleth plot for the Project is presented in **Appendix 4** as **Figure A4-3**.

8.3 DUST DEPOSITION

Table 20 presents the predicted incremental and cumulative annual average ground level concentrations of PM_{10} at the selected receptor locations as a result of operations at the Project Site.

Table 20
Predicted Incremental and Cumulative Annual Average Monthly Dust Deposition Levels at Selected Receptors

Receptor ID	Predicted Annual Average Dust Deposition Levels (g/m^2/month)	
	Incremental (Project Only)	Cumulative (Project + Background)
R1	0.2	2.4
R2	0.2	2.4
R3	0.3	2.5
R4	0.1	2.3
R5	<0.1	2.2
R6	1.5	3.7
Note: Dust Deposition Background – 2.2 g/m^2/month as per **Section 4.2.1** Note: Assessment Criteria: Incremental – 2 g/m^2/month; Cumulative – 4 g/m^2/month (OEH)		

It can be seen from the results presented within **Table 20** that the predicted incremental and cumulative dust deposition levels satisfy the applicable NSW OEH criterion at all selected receptor locations. An incremental annual average dust deposition level isopleth plot for the Project is presented in **Appendix 4**, as **Figure A4-4**.

8.4 HEAVY METAL CONCENTRATIONS

Table 21 presents the predicted incremental ground level concentrations of metallic species relevant to the Project predicted for the selected receptor locations as a result of operations at the Project Site.

It can be seen from the results presented within **Table 21** that the predicted incremental concentrations for metallic species of interest emitted by the Project satisfy the applicable NSW OEH criteria at all selected receptor locations.

8.5 COMBUSTION EMISSION CONCENTRATIONS

Table 22 presents the predicted incremental ground level concentrations of various diesel-combustion related emissions at the selected receptor locations as a result of operations at the Project Site.

Table 21
Predicted Incremental Metallic Species Concentrations at Selected Receptors

Pollutant	99.9th Percentile Predicted 1-hour Average Metal Species Concentrations (µg/m³) by Receptor Location						Assessment Criterion (µg/m³)
	R1	R2	R3	R4	R5	R6	
Antimony	0.022	0.002	0.007	0.002	0.001	0.022	9
Arsenic	0.003	0.003	0.013	0.003	0.002	0.042	0.09
Barium	0.029	0.032	0.102	0.034	0.021	0.242	9
Cadmium	0.001	0.001	0.003	0.001	0.001	0.008	0.018
Chromium	0.002	0.003	0.003	0.001	0.001	0.006	0.09
Copper	0.031	0.035	0.11	0.037	0.022	0.262	18
Lead[1]	0.001	0.001	0.002	0.001	<0.001	0.01	0.5
Manganese	0.011	0.012	0.012	0.004	0.003	0.029	18
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.18
Nickel	0.001	0.001	0.001	<0.001	<0.001	0.002	0.18
Silver	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.18
Note 1: Averaging Period for Lead is Annual							

Table 22
Predicted Incremental Concentrations of Diesel Combustion Pollutants at Selected Receptors

Pollutant	Averaging Period	Predicted Concentrations (µg/m³) by Receptor Location						Assessment Criterion (µg/m³)
		R1	R2	R3	R4	R5	R6	
CO	1-hour	90.3	104.7	266.3	145.9	75.0	147.1	30,000
	8-hour	19.4	22.0	67.9	18.4	10.8	64.7	10,000
NO_2	1-hour	85.7	89.2	128.8	99.2	82.0	99.5	246
	Annual	0.7	0.7	2.8	0.7	0.4	9.8	62
SO_2	1-hour	0.1	0.1	0.4	0.2	0.1	0.3	570
	24-hour	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	228
	Annual	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	60
Benzene	1-hour (99.9th Percentile)	0.2	0.2	0.5	0.2	<0.1	1.8	29

It can be seen from the results presented within **Table 22** that the predicted incremental concentrations for various diesel-combustion related pollutants emitted by the Project satisfy the applicable NSW OEH criteria at all selected receptor locations. It is reiterated that the NO2 concentrations were obtained through the use of the OLM approach and provide an upper bound estimate, as discussed in Section 7.3.3. Furthermore, all Project-related diesel combustion was assumed to occur at the surface. The majority of diesel combustion would however occur below ground, with a greater potential for removal of combustion products from the air prior to release within the ventilated airstream. The predictions thus provide an upper bound estimate of ground level concentrations associated with Project-related activities.

An incremental 1-hour average NO_2 concentration isopleth plot for the Project is presented in **Appendix 4**, as **Figure A4-5**.

8.6 FUGITIVE ORE PROCESSING EMISSION CONCENTRATIONS

Table 23 presents the predicted incremental ground level concentrations of fugitive trace emissions of H_2S, CS_2 and HCN from the gravity processing/flotation/concentrate leaching (due to use of potassium amyl xanthate, copper sulfate and sodium cyanide chemicals) at the Processing Plant. Such concentrations are presented for each of the selected receptor locations. To derive peak 1-second average concentrations of H_2S from the modelled 1-hour average concentrations, a peak-to-mean ratio of 2.3 (for volume sources as per Table 6.1 of the Approved Methods) was applied to model predictions.

Table 23
Predicted Incremental Concentrations of Fugitive Emissions from Ore Processing at Selected Receptors

Pollutant	Averaging Period	Predicted Concentrations (µg/m^3) by Receptor Location						Assessment Criterion (µg/m^3)
		R1	R2	R3	R4	R5	R6	
H_2S	1-Second (99th Percentile)	0.02	0.03	0.04	0.02	0.01	0.09	1.38
CS_2	1-hour (99.9th Percentile)	0.12	0.13	0.21	0.11	0.06	0.42	70
HCN	1-hour (99.9th Percentile)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	200

It can be seen from the results presented within **Table 23** that the predicted incremental concentrations for H_2S, CS_2 and HCN emissions from the gold processing circuit at the Project satisfy the applicable NSW OEH criteria at all selected receptor locations.

9. SOURCE SIGNIFICANCE

To gain a better understanding of the key sources of particulate matter emissions from the Project Site, further analysis into the modelling results for TSP and PM_{10} was undertaken. By understanding the significance of each source type contributing to likely ground level concentrations can assist greatly with the future management of air quality emissions.

Table 24 and **Table 25** present the contribution of each primary source category to predicted annual average TSP and PM_{10} concentrations at the six receptor locations. For illustrative purposes, the source contribution to the predicted annual average TSP and PM_{10} concentrations at R3 and R6 is presented in **Figure 14** and **Figure 15,** respectively.

It can be seen from the results presented within **Table 24** and **Table 25** that the key contributing sources to annual ground level concentrations at the surrounding receptors are the Ventilation Rise, Processing Plant operations (dominated by the crushing and screening circuit) and the movement of trucks along unsealed roads (primarily associated with light vehicle movements between the Mine Camp and the Processing Plant). The contribution of diesel combustion to the predicted ground level concentrations at each receptor varies, being dependent on the proximity of receptors to the onsite diesel-fired generators.

Table 24
Contribution of Individual Source Categories to Predicted Annual Average TSP Concentrations

Source Category	Percentage Contribution to Predicted Annual Average TSP Concentrations by Receptor Location					
	R1	R2	R3	R4	R5	R6
Materials Handling[1]	7.2%	7.1%	5.4%	9.2%	8.9%	3.1%
Processing Plant[2]	27.6%	27.3%	20.1%	33.9%	32.8%	11.4%
Stockpile Wind Erosion[3]	0.2%	0.3%	0.2%	0.1%	0.2%	0.2%
Tailings Storage Facility Wind Erosion	29.1%	29.9%	5.7%	6.8%	9.9%	4.1%
Diesel Combustion	1.0%	1.0%	4.2%	2.2%	2.1%	1.5%
Unsealed Roads	11.1%	11.0%	35.9%	16.8%	15.9%	50.5%
Ventilation Rise	23.7%	23.4%	28.4%	30.9%	30.1%	29.2%

- Note 1: Materials handling comprises sources: ROM ore and Waste Rock dumping and FEL handling.

Note 2: Processing Plant sources include: Crushing, Screening, Transfer Points, Gold Room Furnace and Conveyor Belts
Note 3: Stockpile Wind Erosion comprises sources - Waste Rock, ROM and Surge Stockpiles, and ROM Pad

Table 25
Contribution of Individual Source Categories to Predicted Annual Average PM_{10} Concentrations

Source Category	Percentage Contribution to Predicted Annual Average PM_{10} Concentrations by Receptor Location					
	R1	R2	R3	R4	R5	R6
Materials Handling[1]	9.7%	9.6%	7.5%	12.4%	11.9%	4.7%
Processing Plant[2]	26.3%	26.0%	19.6%	31.6%	30.6%	11.9%
Stockpile Wind Erosion[3]	0.2%	0.2%	0.2%	0.1%	0.1%	0.2%
Tailings Storage Facility Wind Erosion	27.1%	27.9%	5.4%	6.3%	9.0%	4.2%
Diesel Combustion	1.6%	1.5%	6.6%	3.3%	3.1%	2.5%
Unsealed Roads	9.2%	9.1%	29.1%	13.2%	12.8%	41.7%
Ventilation Rise	25.9%	25.7%	31.6%	33.0%	32.3%	34.7%

- Note 1: Materials handling comprises sources ROM ore and Waste Rock dumping and FEL handling.

Note 2: Processing Plant sources includes Crushing, Screening, Transfer Points, Gold Room Furnace and Conveyor Belts
Note 3: Stockpile Wind Erosion comprises sources - Waste Rock, ROM and Surge Stockpile and ROM Pad

The significance of wind erosion sources to annual TSP and PM_{10} ground level concentrations is generally lower than the contribution to annual emissions to the local air shed, as discussed within **Section 6.2**. It is considered that such sources would have a more significant contribution to short term ground level concentrations (i.e. during periods of high winds) rather than long term concentrations. The significance of the Tailings Storage Facility contribution to predicted TSP and PM_{10} concentrations varies spatially around the Project Site.

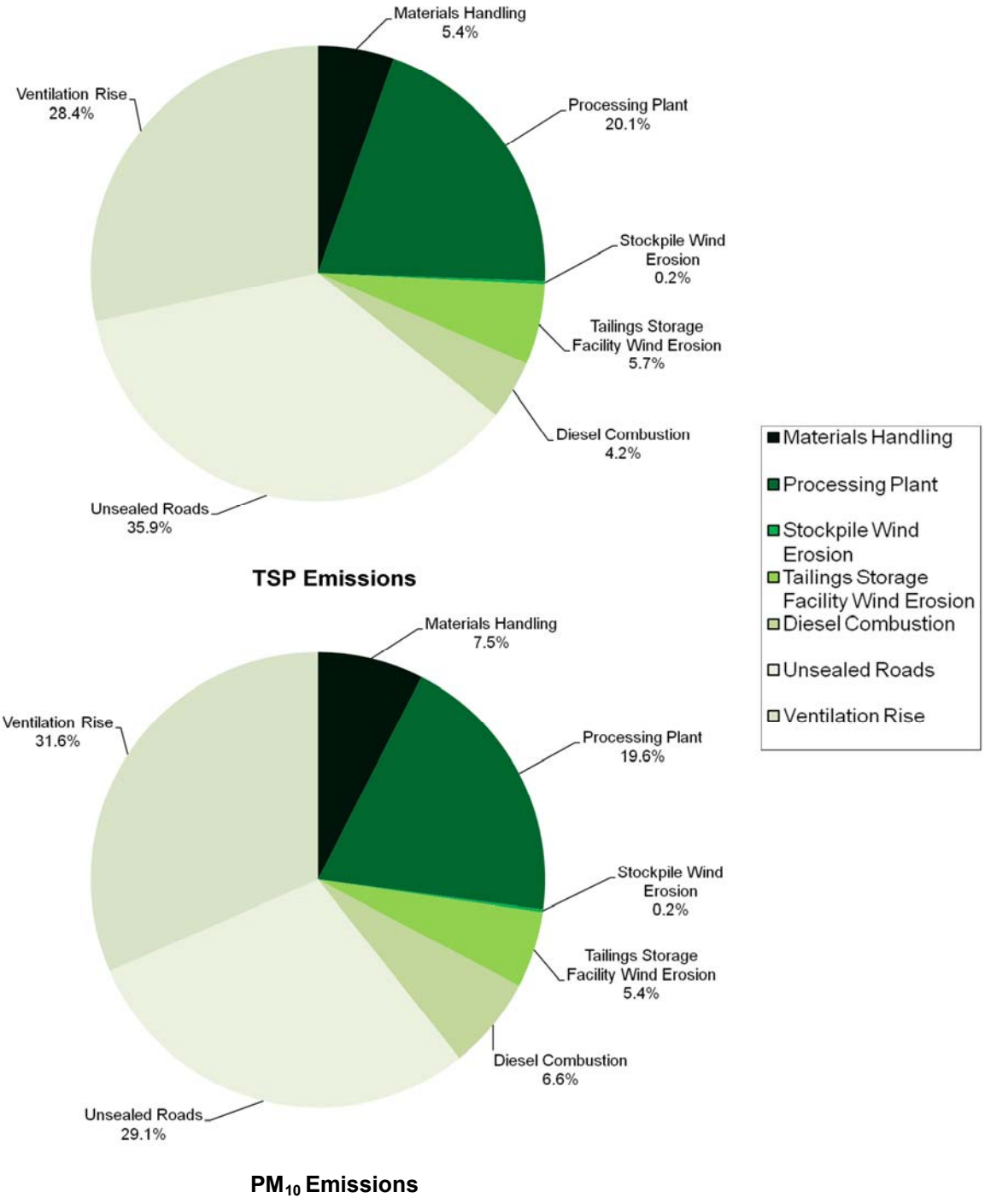


Figure 14 Contribution to Predicted Annual Average TSP and PM10 Concentrations at Receptor R3

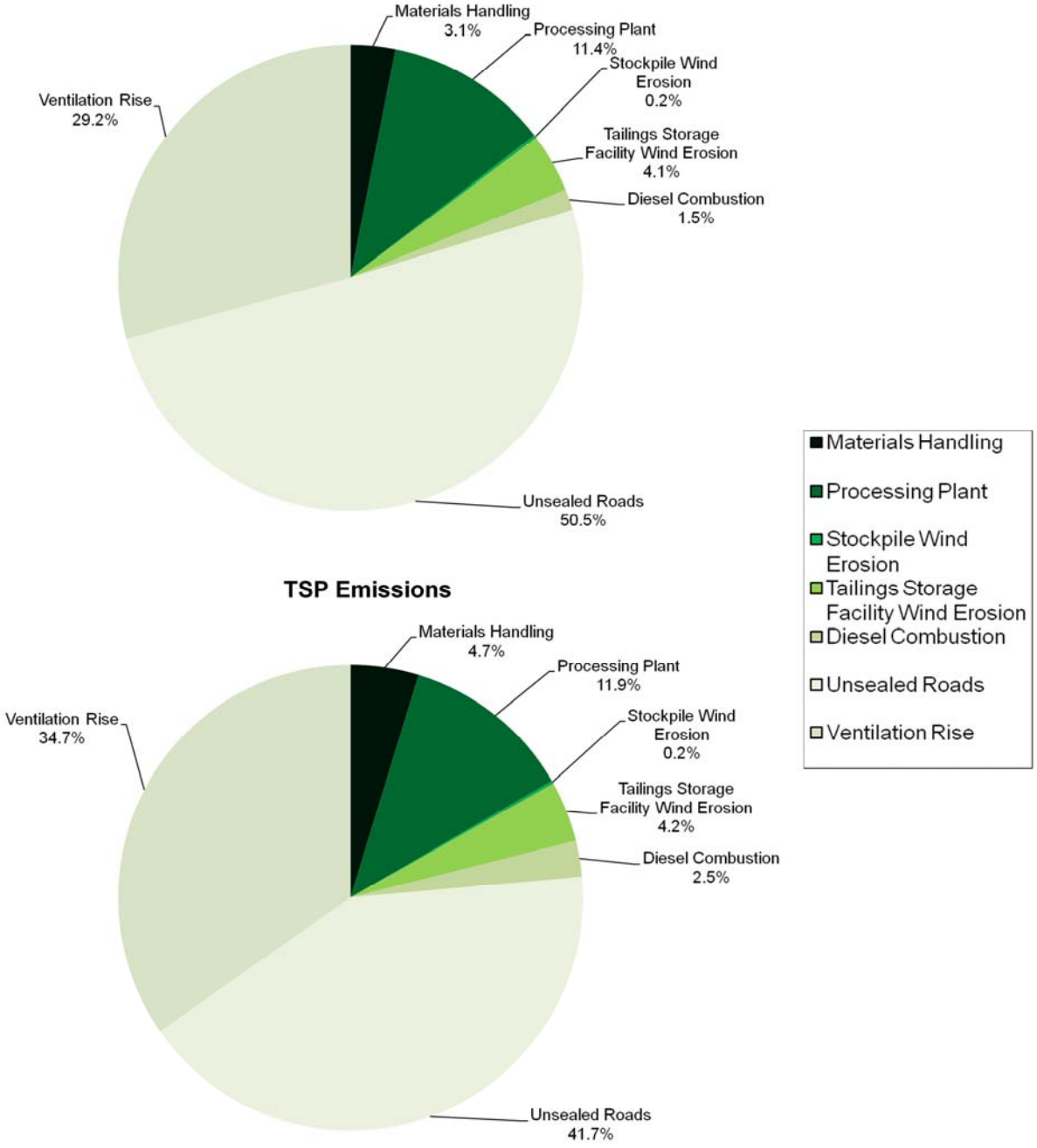


Figure 15 Contribution to Predicted Annual Average TSP and PM_{10} Concentrations at Receptor R6

10. MITIGATION AND MONITORING RECOMMENDATIONS

10.1 AIR QUALITY MITIGATION TECHNIQUES

Section 6.2.5 identifies the emission control techniques proposed for implementation at the Project Site. These include:

- Spraying of unsealed roads with water carts at a rate of 2 L/m^2/hour, as required, when visible dust is generated;
- Incorporation of water spray facilities to all transfer points in the crushing and screening circuit;
- Enclosure of the crushing and dry screening plant components of processing plant, with venting to a fabric filter or equivalent device for removal of particulate matter from the airstream prior to release; and
- Maintaining a substantial portion of the Tailings Storage Facility as wet (assumed to be 75% for the purpose of the assessment), with emissions restricted to 25% of the surface area of the Tailings Storage Facility. Furthermore, capping or otherwise treating or rehabilitating the Tailings Storage Facility following completion of operations.

These emission control techniques have been incorporated into the dispersion modelling process and should be implemented in order to achieve the predicted concentrations.

While not incorporated in the dispersion modelling process, emissions from the Tailings Storage Facility throughout the life of the Project could be further mitigated through implementation of additional controls such as the installation of temporary wind breaks and the application of chemical dust suppressant technologies.

10.2 AIR QUALITY MANAGEMENT PLAN

A comprehensive Air Quality Management Plan should be established for the Project. This plan should detail all air pollution mitigation measures to be implemented and include provision for source measurements and an Air Quality Monitoring Program, listing monitoring techniques and procedures.

The Air Quality Monitoring Program should be developed to confirm on an on-going basis, the consistent and effective implementation of dust management measures at the Project and to demonstrate compliance with air quality criteria.

Recommendations in respect of the Air Quality Monitoring Program and source measurements are discussed below.

10.2.1 Source-Based Measurements

Provision should be made for the following source-based measurements within the Air Quality Management Plan for the Project:

- The in-stack particulate concentration in the Ventilation Rise exhaust stream should be monitored and logged to assess the performance of the system and clarify the uncertainty in the emission estimation process.

- Periodic maintenance and inspection of the crusher and screen circuit hood and filter systems and all other dust control technologies, as per supplier recommendations.
- Staff awareness training on air emissions, and the timely reporting of any visible air emissions by site personnel followed by prompt action represents a routine but effective management measure for extractive operations.

10.2.2 Ambient Particulate Monitoring

Monitoring of emissions at the Project should involve the routine sampling of PM_{10} and dust deposition to assess the ongoing compliance of the Project with NSW OEH air quality criteria.

Monitoring of ambient PM_{10} concentrations should be conducted in accordance with a method that complies with published Australian Standards and with the recommendations of the NSW OEH *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* (DEC, 2007). A filter-based method should be deployed for the analyses of trace metals of interest. PM_{10} monitoring should be conducted at a minimum one (1) location in the vicinity of the northwest corner of the Project Site (receptor R3 or the Mine Camp R6 could provide suitable locations). An additional location, either to the east of the Project Site or near the residences at the southwest corner of the Project Site (adjacent to R1 and R2) could provide a useful indication of background concentrations for comparison against the monitoring conducted at the northwest corner location. The selection of monitoring methods and locations should be conducted in consultation with the NSW OEH. The ongoing requirement for the program reviewed after a period of 12 months, in consultation with NSW OEH.

Dust deposition monitoring should be conducted on a monthly basis at a minimum of two (2) locations about the Project Site, with the two identified locations for PM_{10} monitoring representing recommended locations. All monitoring of dust deposition should be conducted in accordance with AS 3580.10.1-2003 *Methods for Sampling and Analysis of Ambient Air - Determination of Particulates - Deposited Matter - Gravimetric Method.*

In addition to air quality monitoring, it is recommended real-time meteorological monitoring is conducted at the Project Site. Meteorological monitoring should be conducted in accordance with the recommendations of the NSW OEH *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* (DEC, 2007). Real-time meteorological data, specifically wind measurements, can be used to inform dust management planning and impact potential minimisation at the Project Site.

11. GREENHOUSE GAS ASSESSMENT

The proposed operations at the Project Site have the potential to generate greenhouse gas emissions. This section of the report will detail the quantification of greenhouse gas (GHG) emissions from a range of sources associated with the typical operation of the Project. Emissions will be calculated largely using the methods prescribed by the Australian Government Department of Climate Change and Energy Efficiency (DCCEE) within the National Greenhouse Accounts Factors (NGA Factors) 2010 (DCCEE, 2010a).

11.1 GREENHOUSE GAS EMISSION FACTORS

11.1.1 NGA Factors Emission Definitions

Direct and indirect GHG emissions are defined by the DCCEE within the NGA Factors, as the following:

Direct emissions are produced from sources within the boundary of an organisation and as a result of that organisation's activities. These emissions mainly arise from the following activities:

- generation of energy, heat, steam and electricity, including carbon dioxide and products of incomplete combustion (methane and nitrous oxide);
- manufacturing processes which produce emissions (for example, cement, aluminium and ammonia production);
- transportation of materials, products, waste and people; for example, use of vehicles owned and operated by the reporting organisation;
- fugitive emissions: intentional or unintentional GHG releases (such as methane emissions from coal mines, natural gas leaks from joints and seals); and
- on-site waste management, such as emissions from landfill sites.

Indirect emissions are emissions generated in the wider economy as a consequence of an organisation's activities (particularly from its demand for goods and services), but which are physically produced by the activities of another organisation. Examples of indirect emission sources include:

- consumption of purchased electricity;
- upstream emissions generated in the extraction and production of fossil fuels;
- downstream emissions from transport of an organisation's product to customers; and
- emissions from contracted/outsourced activities.

Emission factors for calculating direct emissions are expressed within the NGA Factors in the form of a quantity of a given GHG emitted per unit of energy, fuel or a similar measure. Within the NGA Factors, emission factors are provided for each of the following greenhouse gases:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- synthetic gases
  - HFCs, SF_6, CF_4, C_2F_6

All emission factors are standardised by being expressed as a CO_2 equivalent (CO_2-e). This is achieved by multiplying the individual gas emission factor by the respective gas global warming potential (GWP). The GWPs of relevance to this assessment are:

- **Methane (CH_4)**: GWP of 21 (21 times more effective as a greenhouse gas than CO_2); and
- **Nitrous Oxide (N_2O)**: GWP of 310 (310 times more effective as a greenhouse gas than CO_2).

11.1.2 Types of Greenhouse Gas Emission Factors

On the basis of the above definitions, the NGA Factors prescribe a range of emission factors to estimate associated GHG emissions. These emissions factors are activity-specific, with the scope of the activity determining the emission factor used. Specifically, the scope that emissions are reported under is determined by whether the activity is within the organisation's boundary (direct—scope 1) or outside it (indirect—scope 2 and scope 3). The NGA Factors define the scope of emissions through the following:

- **Direct (or point-source) emission factors** give the kilograms of carbon dioxide equivalent (CO_2-e) emitted per unit of activity at the point of emission release (i.e. fuel use, energy use, manufacturing process activity, mining activity, on-site waste disposal, etc.). These factors are used to calculate **Scope 1 emissions**.
- **Indirect emission factors** are used to calculate **Scope 2 emissions** from the generation of the electricity purchased and consumed by an organisation as kilograms of CO_2-e per unit of electricity consumed. Scope 2 emissions are physically produced by the burning of fuels (coal, natural gas, etc.) at the power station.
- Various emission factors can be used to calculate **Scope 3 emissions**. For ease of use, this workbook reports specific 'scope 3' emission factors for organisations that:
  (a) burn fossil fuels: to estimate their indirect emissions attributable to the extraction, production and transport of those fuels; or
  (b) consume purchased electricity: to estimate their indirect emissions from the extraction, production and transport of fuel burned at generation and the indirect emissions attributable to the electricity lost in delivery in the transmission and distribution network.

11.2 PROJECT RELATED GREENHOUSE GAS EMISSIONS

The primary sources and relevant scope of GHG emissions associated with the operation of the Project greenhouse gas sources include the following:

- Combustion of diesel for electricity generation during the operation of the Project (Scope 1 and Scope 3);
- Combustion of diesel by mobile equipment during the operation of the Project (Scope 1 and Scope 3);
- Emissions associated with explosive use (Scope 1); and
- Transportation of product offsite, regionally, nationally and internationally (Scope 3).

11.3 SCOPE 1: DIRECT EMISSIONS

11.3.1 Diesel Combustion – Electricity Generation and Mining Equipment

Electricity for the Project (mining operations and accommodation camp) is principally provided through the use of on-site diesel generators. Annual diesel consumption associated with the generation of electricity is estimated by the Proponent to be 2,637.2 kL/annum.

In addition to the combustion of diesel for electricity generation purposes, the mobile equipment associated with the mining and processing and transportation will involve the use of diesel oil. Annual diesel consumption associated with mobile equipment (including mine personnel transportation) is estimated by the Proponent to be 4,473.1 kL/annum. Total annual diesel consumption associated with the Project is therefore estimated to be 7,110.3 kL/annum.

The annual emissions of CO_2-e from this source have been estimated using the factors for Diesel Oil listed within Table 3 of the NGA Factors.

11.3.2 LPG Combustion – Gold Room Furnace

Based on details provided by the Proponent, the Gold Room Smelter Furnace will consume LPG at a rate of 50 L/day. Assuming an operation each day of the year, this equates to an LPG consumption rate of 18,250 L/annum.

The annual emissions of CO_2-e from this source have been estimated using the factors for Liquefied Petroleum Gas listed within Table 3 of the NGA Factors.

11.3.3 Explosives

The underground mining operations will involve the use of explosives during development and extractive phases. The use of explosives in mining leads to the release of greenhouse gases. The activity level is the mass of explosive used (in tonnes). The Proponent provided projections of the monthly-variance in explosives use throughout the life of the Project. In order to conservatively calculate annual GHG emissions from the Project, the maximum 12 month total of explosives to be used as listed within these projections was adopted. This equates to approximately 326 t per annum. Explosives type to be used at the Project is Ammonium Nitrate with Fuel Oil (ANFO).

The NGA Factors 2010 does not include GHG emission estimation factors for the use of explosives, however a historical version of this document, published in January 2008, provides emission factors for the use of ANFO, Heavy ANFO and Emulsion explosives types. Therefore, an estimate of the CO_2-e emissions resulting from blasting activities at the Project has been derived using the factor for ANFO listed in Table 4 of the NGA Factors 2008.

11.4 SCOPE 2: ELECTRICITY-RELATED INDIRECT EMISSIONS

As the majority of electricity consumed by the Project will be sourced from on-site diesel generators, there are not anticipated to be significant Scope 2 GHG emissions generated by the operation of the Project.

11.5 SCOPE 3: OTHER INDIRECT EMISSIONS

Scope 3 emissions generated by the Project are expected to be associated with the extraction, production and transportation of the purchased fuels consumed during the operation of the Project, and emissions associated with the transportation of the Product concentrate from the Project Site to end users.

The concentrate produced by the Project will be transported from the Project Site to assorted customers regionally, nationally and internationally. Advice provided by the Proponent details planned proposed transportation routes as the following:

- Haulage by diesel road trucks to the rail siding at Endeavor Mine or Hermidale Siding;
- Rail transportation to the Port of Newcastle; and
- Bulk Carrier shipping to Japan and/or India.

While the exact details of the transport route and final destination of the Product are likely to be variable through the life of the Project, the following fixed transport path has been adopted for the calculation of GHG emissions from the Project:

- Haulage by diesel road trucks to the rail siding at Endeavor Mine;
- Rail transportation to the Port of Newcastle; and
- Bulk Carrier shipping to Bombay, India.

It is noted that the path is likely to be the furthest distance travelled in the distribution of the Product and should be viewed as a conservative upper estimate of Scope 3 emissions from this process. It is assumed that all Product concentrate distributed from the Project Site, 40,000 tpa, will be transported by this path.

11.5.1 Extraction, Production and Transport of Purchased Fuels Consumed

In order to account for the indirect GHG emissions associated with the extraction, production and delivery of the diesel oil and LPG consumed by the Project (as per **Sections 11.3.1** and **11.3.2**), the NGA Factors provide a Scope 3 emission factor for diesel oil and LPG within Table 39. These factors have been adopted to derive the relevant Scope 3 GHG emissions for the Project.

11.5.2 Distribution of Product from the Project Site – Regional Road Haulage

As stated previously, it is assumed that all Product concentration will be transported by road to the rail siding at the CBH Endeavor Mine, which is approximately a 300 km round trip from the Project Site. While no diesel consumption data is available at the time of reporting, using the above details and an assumed truck diesel economy rate of 2 km/L, the annual diesel consumption likely to be associated with the transportation of produced concentrate from the Project Site is approximately 328.5 kL/annum.

In order to account for the indirect GHG emissions associated with the road transportation of product from the Project Site, the NGA Factors Scope 3 emission factor for diesel oil listed within Table 39 (DCCEE, 2010a) has been adopted.

11.5.3 Distribution of Product from the Project Site – Rail Transportation

From the rail siding at Endeavor Mine, the concentrate produced by the Project will be transported by rail to Port of Newcastle. Based on NSW rail network maps, this route is estimated to be 850 km. Based the amount of concentrate to be transported (40,000tpa) and a round trip distance of (1,700 km), a total annual tonne-kilometres (t-km) value of 68,000,000 t-km is derived. The total annual tonne-kilometres was then multiplied by the GHG indicator for freight rail activity of 20 g CO_2 per tonne-km (g CO/t-km) (AGO, 2007) to obtain an estimate of total Scope 3 emissions from rail transport from Endeavor Mine to the Port of Newcastle.

11.5.4 Distribution of Product from the Project Site – International Shipping

Product concentrate is to be delivered to international customers by bulk carrier departing the Port of Newcastle. Details on the exact specifications of the bulk carrier fleet to be utilised in the shipping of concentrate are unknown at the time of reporting. Additionally, the final destination of the concentrate will be variable based on demand. However, in order to calculate Scope 3 emissions from this process, some general assumptions were made.

Firstly, GHG efficiency values in g CO_2/t-km for different bulk carrier classes were sourced from Table 9.1 of the Second International Maritime Organisation GHG Study (IMO, 2009) (total efficiencies used). The bulk carrier class with lowest Deadweight Tonnage (DWT) 0 – 99,000 DWT and highest GHG efficiency rate (29.2 g CO_2/t-km) was adopted for a conservative estimate of emissions.

Secondly, a final destination of the Port of Bombay in India, representing the likely furthest destination from the Port of Newcastle was assumed for all concentrate distributed from the Project. Based on typical shipping lanes, this equates to a distance of approximately 12,000 km and, based on a round trip distance of 24,000 km, a total annual t-km value of 960,000,000 t-km.

11.6 PREDICTED GREENHOUSE GAS EMISSIONS

Table 26 presents the relevant emissions factors from the NGA Factors for the Scope 1 to 3 emissions sources discussed in the previous sections. **Table 27** then provides the calculated annual greenhouse gas emissions (as CO_2-e) for each source and for the total Project.

Table 26
Relevant Greenhouse Gas Emission Factors

Emission Source	Emission Factor			Units
	Scope 1	Scope 2	Scope 3	
Diesel	2,682.7[1]	-	204.6[1]	kg CO_2-e/kL fuel
LPG	1539.4[2]		128.5[2]	kg CO_2-e/kL fuel
Explosives	170	-	-	kg CO_2-e /t explosives
Rail Emissions			20.0	g CO_2/t-km
Shipping Emissions			29.2	g CO_2/t-km

Note 1: Emission Factor accounts for energy content of diesel oil of 38.6 GJ/kL as per Table 3 of NGA Factors 2010
Note 2: Emission Factor accounts for energy content of LPG of 25.7 GJ/kL as per Table 3 of NGA Factors 2010

Table 27
Predicted Annual Greenhouse Gas Emissions for the Project

Emission Source	Emissions (t CO_2-e)			Total (t CO_2-e)
	Scope 1	Scope 2	Scope 3	
Diesel	19,074.7		1.5	19,076.2
LPG	28.1		0.002	28.1
Explosives	55.4			55.4
Rail Emissions			1,360	1,360
Shipping Emissions			28,032	28,032
TOTAL	**19,158.2**		**29,394**	**48,558**

As can be seen from the above tables, the operation of the Project is expected to generate approximately 48,558 t CO_2-e annually. By means of providing context, the most recently published annual GHG emissions for NSW and Australia have been resourced from the Australia National Greenhouse Accounts – State and Territory Greenhouse Gas Inventories 2008 (DCCEE, 2010b). According to this Inventory, annual GHG emissions for NSW and Australia in 2008 totalled 164.7 Mt and 575.8 Mt CO_2-e, respectively. Additionally, as the final destination of the product may be an international customer, annual global emissions are also considered. The Intergovernmental Panel on Climate Change (IPCC) reports that global GHG emissions for 2004 (most recently published year) were approximately 49 Gt CO_2-e.

In comparing Project-related GHG emissions with NSW and Australian emissions, calculated Scope 3 emissions associated with international shipping will be excluded as the majority of these emissions would occur offshore. In comparing Project-related GHG emissions with Global emissions, all calculated emissions (Scope 1, 2 and 3) will be included.

When the annual GHG emissions calculated for the Project (excluding Scope 3 shipping emissions) are compared with the NSW and Australian totals for 2008, the Project represents an increase of approximately 0.0125% and 0.0036% on state and national level GHG emissions. When the annual GHG emissions calculated for the Project (including Scope 3 shipping emissions) are compared with the NSW and Australian totals for 2008 and global total for 2004, the Project represents an increase of approximately 0.0295%, 0.0084% and 0.000099% on state, national and global level GHG emissions respectively.

11.7 ENERGY MANAGEMENT & GREENHOUSE GAS EMISSION MITIGATION

A number of design, control and operational management measures proposed to be implemented by the Proponent to minimise energy usage and GHG emissions from the Project are listed in the following:

- Progressively optimise the underground mine design to minimise travel distances for mining equipment and re-handling of waste and ore material.
- Use mining equipment which is regularly maintained and serviced to maximise efficiency.
- Optimise the design of the Processing Plant to:
  - minimise the amount of conveyor operating hours with zero load;

  - maximise the use of gravity to move material through the Processing Plant reducing the need for pumping; and
  - maximise the use of energy efficient motors in major pieces of the Processing Plant.
- Adopt the use of energy efficient lighting technologies and hot water and air conditioning systems wherever practical.
- Maximise the recovery of recyclable materials where practicable, including:
  - waste hydrocarbons;
  - polyethylene; and
  - scrap metals.
- Minimise waste sent to landfill through the development of appropriate purchasing and waste management plans.
- Progressively review and implement energy efficiency measures throughout the life of the Project.

12. CONCLUSIONS

The potential air quality impacts associated with the proposed Hera Project (the Project), an underground gold and base metals operation at a location 4 km south of Nymagee in Western NSW (the Project Site) have been assessed within this report.

Particulate matter and diesel combustion related emissions from the Project were estimated utilising published emission literature from the National Pollution Inventory and USEPA AP-42. A single modelling scenario configured to reflect a worst-case operational 24-hour period continuously throughout a calendar year was established. Dispersion modelling has been conducted utilising the USEPA regulatory model AERMOD for emissions of TSP, PM_{10}, metals and diesel-combustion related pollutants.

The results from the dispersion modelling conducted indicate that for emissions of TSP, PM_{10}, dust deposition, and various trace metals and combustion-related pollutants, there is unlikely to be an adverse cumulative impact upon the surrounding off-site receptors associated with the proposed Project.

Pollutant concentrations were also predicted for the on-site Mine Camp. Exceedance of the cumulative 24-hour average PM_{10} criterion was predicted at the Mine Camp location. The exceedances were directly attributable to the emissions from the underground mine via the Ventilation Rise. Emissions from this source were estimated in a highly conservative (upper bound) manner due to the absence of site-specific monitoring data. Ventilation rise measurement data from a larger scale coal mining operation indicates that the upper bound estimates may overestimate Ventilation Rise emissions by up to a factor of 10. Analysis of the model predictions at R6 identified that the Ventilation Shaft emissions as modelled would contribute approximately 43% and 35% to peak 24-hour and annual average PM_{10} concentrations at R6. In the event that a the Ventilation Rise emissions are reduced in line with such measurements, no exceedance of the NSW OEH 24-hour average PM_{10} assessment criterion is predicted at R6.

The assessment also considers emissions of greenhouse gas emissions from the Project and includes estimates of direct and indirect GHG emissions. Calculated direct (Scope 1) emissions from the Project were associated with diesel combustion for power generation and by mining equipment and blasting in underground operations, and were calculated to generate approximately 48,558 t CO_2-e/annum. Indirect (Scope 3) emissions, primarily associated with the third-party transportation of product from the Project Site and dominated by international shipping, were calculated to generate approximately 29,394 t CO_2-e/annum. When the annual GHG emissions calculated for the Project (excluding Scope 3 shipping emissions) are compared with the NSW and Australian totals for 2008, the Project represents an increase of approximately 0.0125% and 0.0036% on state and national level GHG emissions. When the annual GHG emissions calculated for the Project (including Scope 3 shipping emissions) are compared with the NSW and Australian totals for 2008 and global total for 2004, the Project represents an increase of approximately 0.0295%, 0.0084% and 0.000099% on state, national and global level GHG emissions respectively.

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GLOSSARY OF ACRONYMS AND SYMBOLS

AHD	Australian Height Datum
ANFO	Ammonium nitrate with Fuel Oil
Approved Methods	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW
AWS	Automatic Weather Station
BoM	Australian Bureau of Meteorology
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-e	CO_2 equivalent
CS_2	Carbon disulfide
Cobar MO	Cobar Meteorological Office
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCCEE	Department of Climate Change and Energy Efficiency
DEC	NSW Department of the Environment and Conservation
DWT	Dead Weight Tonnage
ENVIRON	ENVIRON Australia Pty Ltd
GHG	Greenhouse Gas
HCN	Hydrogen cyanide
H_2S	Hydrogen sulfide
IPCC	Intergovernmental Panel on Climate Change
IMO	International Maritime Organisation
ISC	Industrial Source Complex model
ktpa	kilotonnes per annum
mg	Milligram ($g \times 10^{-3}$)
µg	Microgram ($g \times 10^{-6}$)
µm	Micrometre or micron ($metre \times 10^{-6}$)
m^3	Cubic metre
Mtpa	Megatonnes per annum
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NGA Factors	National Greenhouse Accounts Factors
NPI	National Pollutant Inventory
NO_2	Nitrogen dioxide
N_2O	Nitrous oxide
PM_{10}	Particulate matter less than 10microns in aerodynamic diameter
O_3	Ozone
OEH	Office of Environment and Heritage
ROM	Run of Mine
RWC	R.W. Corkery & Co Pty Limited
SO_2	Sulfur dioxide
TAPM	"The Air Pollution Model"
TEOM	Tapered Element Oscillating Microbalance
The Project	The Hera Project
The Proponent	YTC Resources Pty Limited
TSP	Total Suspended Particulate
USEPA	United States Environmental Protection Agency

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APPENDICES

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Appendix 1
Historic Climate Averages – Cobar MO

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Climate Statistics for the Bureau of Meteorology Cobar MO Station, Station Number 048027, 31.48°S, 145.83°E, 260 m elevation													
Statistic Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (Degrees C) for years 1962 to 2010	34	33.2	30.1	25.2	20	16.5	15.8	18	21.9	26	29.5	32.6	25.2
Highest temperature (Degrees C) for years 1962 to 2010	47	46.1	41.5	36	29.6	26.3	25.7	30.5	38	39.4	45.4	44.1	47
Lowest maximum temperature (Degrees C) for years 1962 to 2010	15.9	16.8	16.6	13.4	10.1	6.6	6.2	8.6	9.8	12.9	13.8	18.4	6.2
Decile 1 maximum temperature (Degrees C) for years 1962 to 2010	27.6	27.2	24.2	19.8	15.4	12.6	12.2	13.6	16.3	19.6	23	26.1	
Decile 9 maximum temperature (Degrees C) for years 1962 to 2010	39.9	38.7	35.5	30.3	24.8	20.3	19.6	23	28.6	32.8	36.4	38.6	
Mean number of days >= 30 Degrees C for years 1962 to 2010	25.1	22.2	16.9	3.8	0	0	0	0.1	1.6	7	13.9	22.2	112.8
Mean number of days >= 35 Degrees C for years 1962 to 2010	14.2	10.3	3.9	0.1	0	0	0	0	0.1	1.2	4.6	10.3	44.7
Mean number of days >= 40 Degrees C for years 1962 to 2010	3	1.6	0.2	0	0	0	0	0	0	0	0.5	1.4	6.7
Mean minimum temperature (Degrees C) for years 1962 to 2010	20.5	20.1	17.1	12.9	9	6.2	5	6.2	9.1	12.6	15.9	18.7	12.8
Lowest temperature (Degrees C) for years 1962 to 2010	10.3	8.4	6.2	3.2	0.4	-2	-2.3	-2.5	-0.3	2.9	4.4	9.1	-2.5
Highest minimum temperature (Degrees C) for years 1962 to 2010	32.1	31.9	28.9	22.6	18.9	16.4	14.7	17.9	21.2	26.1	28.8	29.7	32.1
Decile 1 minimum temperature (Degrees C) for years 1962 to 2010	15.5	15.6	12.1	7.9	4.4	2.2	1.2	2.2	4.5	7.7	10.6	13.6	
Decile 9 minimum temperature (Degrees C) for years 1962 to 2010	25.2	24.6	21.7	17.4	13.7	10.5	9.2	10.5	14.2	18.1	21.3	24	
Mean number of days <= 2 Degrees C for years 1962 to 2010	0	0	0	0	0.5	2.9	5.1	2.7	0.4	0	0	0	11.6
Mean number of days <= 0 Degrees C for years 1962 to 2010	0	0	0	0	0	0.4	0.9	0.4	0	0	0	0	1.7
Mean daily ground minimum temperature Degrees C for years 1962 to 2010	18.7	18.6	15.3	10.8	7	4.1	2.7	3.7	6.4	10.2	13.7	16.5	10.6
Lowest ground temperature Degrees C for years 1962 to 2010	5.4	6.8	0.6	-1.6	-4.6	-5.8	-6	-5.2	-4.9	-2.9	0.9	5.4	-6
Mean number of days ground min. temp. <= -1 Degrees C for years 1962 to 2010	0	0	0	0	0.6	2.1	5.2	3.4	0.9	0	0	0	12.2
Mean rainfall (mm) for years 1962 to 2010	46.8	44.5	34.3	26.9	32.9	27.4	29.2	27.4	24.5	35.2	34.3	36.1	399.3
Highest rainfall (mm) for years 1962 to 2010	233.8	188.9	217.6	201.4	144	88.8	102.4	76.3	104.6	104.6	157.1	151.6	684.8
Date of Highest rainfall for years 1962 to 2010	1984	1971	1969	1990	1977	2005	1998	1971	1998	1973	2000	1992	1973
Lowest rainfall (mm) for years 1962 to 2010	1.4	0	0	0	0	0.3	0.2	0	0	0	0.4	1.4	101.6
Date of Lowest rainfall for years 1962 to 2010	2002	2006	1992	1977	1975	1962	2002	1995	2007	2002	1982	1984	1982
Decile 1 monthly rainfall (mm) for years 1962 to 2010	3.3	1.4	0.6	0.5	1.8	4	1.9	3.7	3.1	7.1	4.4	4.5	209.5
Decile 5 (median) monthly rainfall (mm) for years 1962 to 2010	20.2	24.9	28.2	10	26.4	24.6	20.8	18.6	17.8	32.2	21.5	17.9	390
Decile 9 monthly rainfall (mm) for years 1962 to 2010	142.3	126.9	67.4	77.1	77.6	54.7	70.3	62.9	64	69.6	81.8	100.1	626.3
Highest daily rainfall (mm) for years 1962 to 2010	102.2	89.7	108.8	71.4	59.4	38.8	44.6	56.9	44.4	44.6	56.6	74.8	108.8
Mean number of days of rain for years 1800 to 3000	5.8	4.6	4.8	4.4	6.1	6.7	6.6	6.2	5.8	6.7	5.9	5.1	68.7
Mean number of days of rain >= 1 mm for years 1962 to 2010	4.3	3.4	3.4	2.9	3.7	4.3	4	4	3.7	4.2	4.1	3.6	45.6
Mean number of days of rain >= 10 mm for years 1962 to 2010	1.3	1.2	1	0.9	1.2	0.8	0.8	0.8	0.8	1.1	1.1	1	12
Mean number of days of rain >= 25 mm for years 1962 to 2010	0.5	0.5	0.3	0.2	0.2	0.1	0.3	0.2	0.2	0.3	0.3	0.3	3.4
Mean daily wind run (km) for years 2000 to 2010	310	289	277	245	220	235	232	261	287	299	291	304	271
Maximum wind gust speed (km/h) for years 1962 to 2010	106	97	91	89	72	84	84	109	97	95	98	111	111
Mean daily sunshine (hours) for years 1978 to 2010	10.8	10.3	9.6	8.9	7.4	6.4	7	8.4	9.1	9.8	10.1	10.6	9
Mean daily solar exposure (MJ/(m*m)) for years 1990 to 2010	28.1	24.7	22.4	17	12.8	10.5	11.5	14.8	19.2	23.4	26.1	28.2	19.9
Mean number of clear days for years 1962 to 2010	14.5	11.8	15.4	14	11.6	10.5	11.7	13.2	14.9	12.7	12.2	13.8	156.3
Mean number of cloudy days for years 1962 to 2010	6.3	5.7	5.5	6.5	9	9.6	8.9	7.3	6	8	7.7	6.9	87.4
Mean daily evaporation (mm) for years 1971 to 2010	11.5	10	8.2	5.3	3.1	2.1	2.3	3.4	5.4	7.4	9.5	11.2	6.6
Mean 9am temperature (Degrees C) for years 1962 to 2010	25.2	24.1	21.7	18	13.2	9.5	8.6	11	15	19.1	21.5	24.1	17.6
Mean 9am wet bulb temperature (Degrees C) for years 1962 to 2010	17.3	17.4	15.6	13.1	10.3	7.8	6.7	7.9	10.2	12.6	14.3	15.8	12.4
Mean 9am dew point temperature (Degrees C) for years 1962 to 2010	10.8	12	10.3	8.3	7.3	5.7	4.2	4.1	4.7	5.8	7.2	8.3	7.4
Mean 9am relative humidity (%) for years 1962 to 2010	44	50	51	56	69	79	75	65	54	46	44	40	56
Mean 9am cloud cover (okas) for years 1962 to 2010	2.6	2.6	2.4	2.7	3.4	3.8	3.4	3	2.6	3	3	2.7	2.9
Mean 9am wind speed (km/h) for years 1962 to 2010	14.1	13.5	12.6	11.1	8.7	8.3	8.4	10.4	12.4	13.8	14	13.9	11.8
Mean 3pm temperature (Degrees C) for years 1962 to 2010	32.3	31.6	28.7	24.3	19.3	15.8	15	17.1	20.9	24.6	27.8	30.8	24
Mean 3pm wet bulb temperature (Degrees C) for years 1962 to 2010	19.1	19.4	17.6	15.1	12.8	10.6	9.7	10.4	12.2	14.3	16.1	17.5	14.6
Mean 3pm dew point temperature (Degrees C) for years 1962 to 2010	8.1	9.8	8.1	6.3	6	4.9	3.2	2.1	2.1	3	4.5	5.1	5.3
Mean 3pm relative humidity (%) for years 1962 to 2010	27	30	31	35	45	51	48	40	33	29	27	23	35
Mean 3pm cloud cover (oktas) for years 1962 to 2010	3.6	3.8	3.2	3.5	3.9	4.1	3.8	3.5	3.3	3.8	3.9	3.6	3.7
Mean 3pm wind speed (km/h) for years 1962 to 2010	13.5	12.3	11.8	10.9	10.3	11	12	13.5	14.5	14.7	14.4	14.5	12.8

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Appendix 2
Annual, Seasonal and Diurnal Wind Roses – Cobar MO AWS and Project Site

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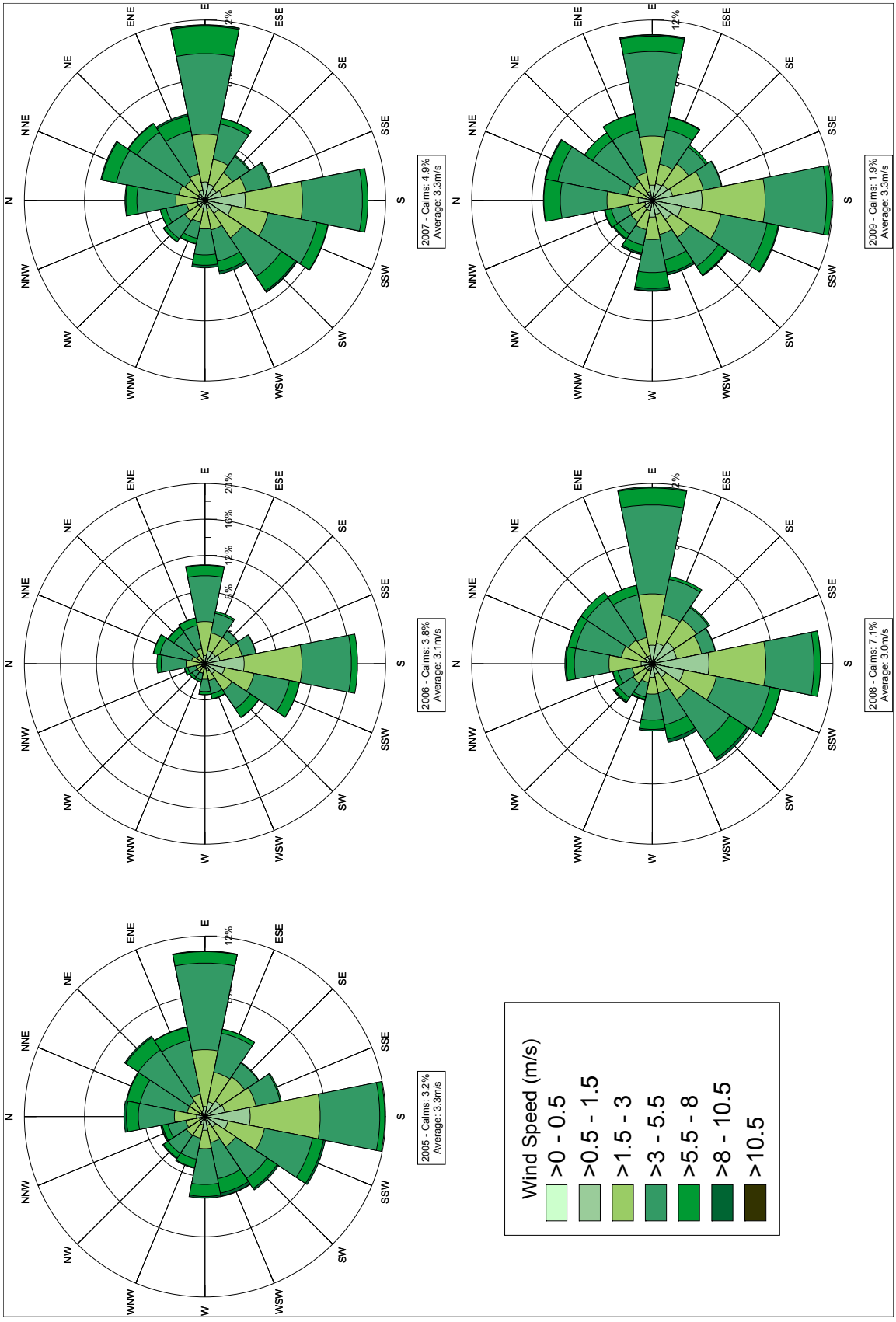

Figure A2-1 – Annual Wind Roses – Cobar MO AWS – 2005 to 2009

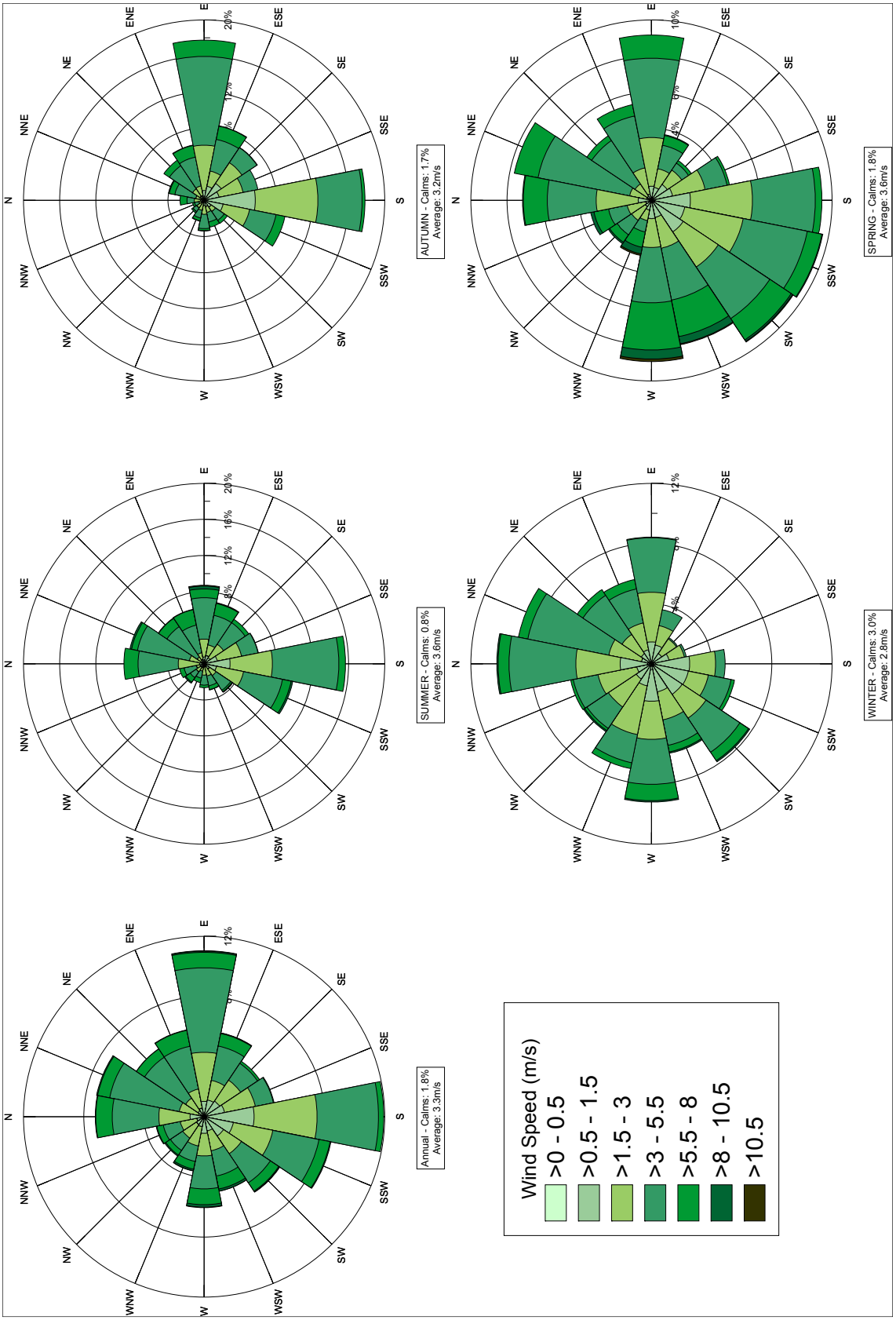

Figure A2-2 – Seasonal Wind Roses – Cobar MO AWS – 2009

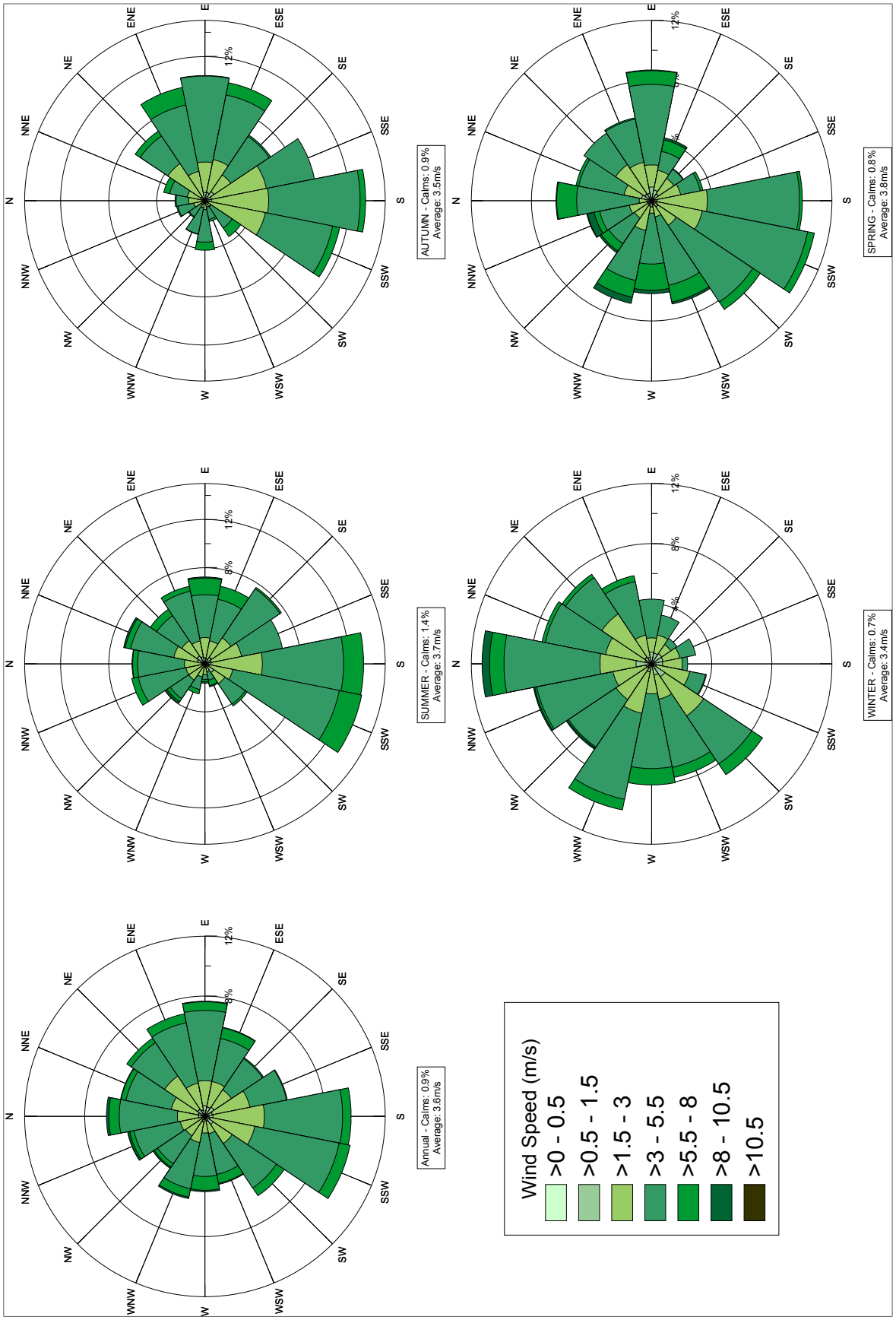

Figure A2-3 – Seasonal Wind Roses – TAPM Project Site – 2009

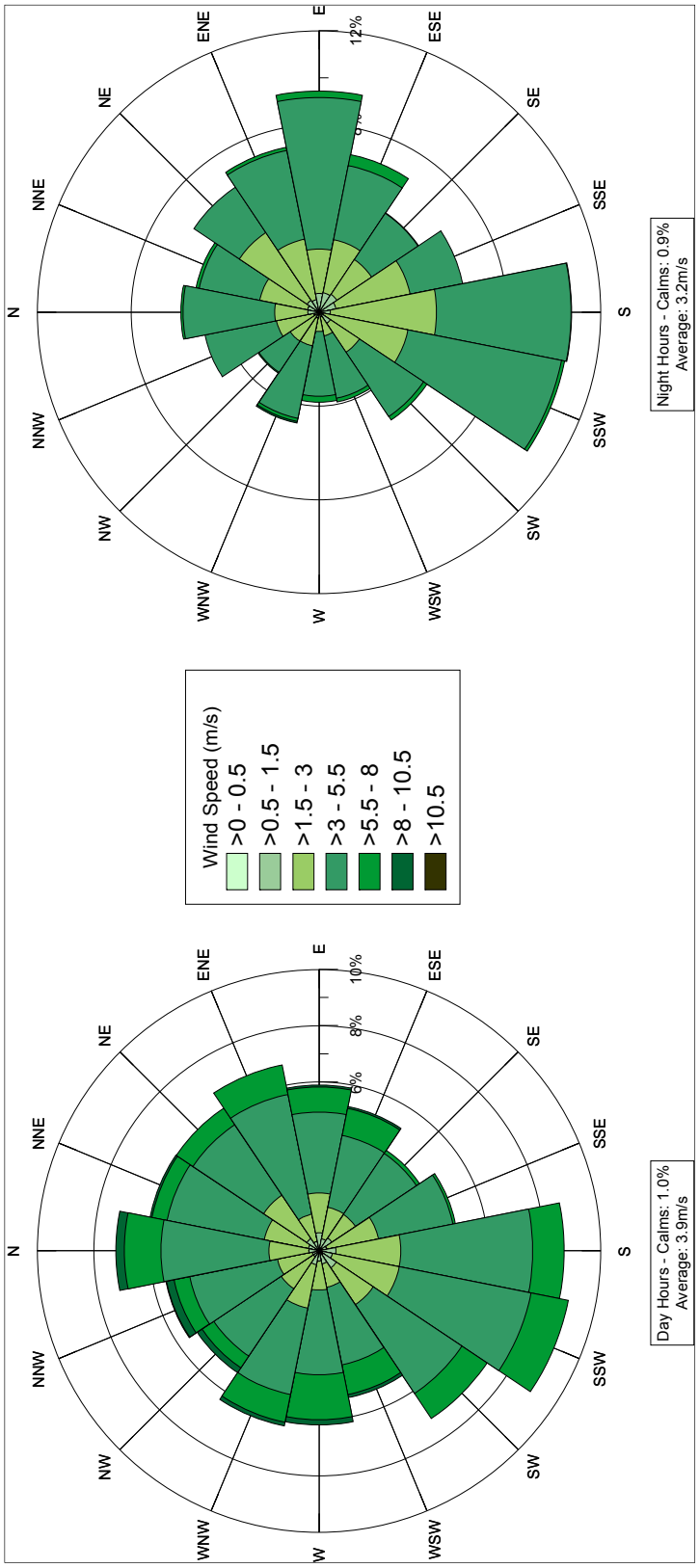

Figure A2-4 – Diurnal Wind Roses – TAPM Project Site –2009

Appendix 3
Dispersion Modelling Methodology and Data Inputs

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Dispersion Model Selection and Application

Dispersion models compute ambient concentrations and deposition rates as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations. Knowledge of spatial and temporal variations in pollutant concentrations is essential for the assessment of the potential which exists for non-compliance with ambient air quality limits and for impact on human health and the biophysical environment.

Given the nature of the source and the local environment, AERMOD was selected for application in the prediction of ambient particulate matter and diesel combustion pollutant concentrations and dust deposition rates occurring due to the operational emissions from the Project. AERMOD is the US-EPA's recommended steady-state plume dispersion model for US regulatory purposes. AERMOD is designed to handle a variety of pollutant source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain[(1)]. Source types for which AERMOD is able to predict pollutant concentrations include point, area and volume sources in addition to 'open pit' sources.

AERMOD replaced the Industrial Source Complex (ISC) model for regulatory purposes in the US in December 2006 as it provides more realistic results with concentrations that are generally lower and more representatives of actual concentrations compared to the conservative ISC model. Ausplume, a steady state Gaussian plume dispersion model developed by the Victorian EPA and frequently used in Australia for simple near-field applications.

Compared to ISC and Ausplume, AERMOD represents an advanced new-generation model which requires additional meteorological and land use inputs to provide more refined predictions. The most important feature of AERMOD, compared to ISC and Ausplume, is its modification of the basic dispersion model to account more effectively for a variety of meteorological factors and surface characteristics. In particular it uses the Monin-Obukhov length scale rather than Pasquill-Gifford stability categories to account for the effects of atmospheric stratification. Whereas Ausplume and ISC parameterise dispersion based on semi-empirical fits to field observations and meteorological extrapolations, AERMOD uses surface-layer and boundary-layer theory for improved characterisation of the planetary boundary layer turbulence structure.

Verification studies have been undertaken for AERMOD both locally and abroad (Hanna *et al.,* 2001*;* Perry *et al*., 2005; Hurley 2006). Hanna *et al.* (2001) concluded that AERMOD performed better than ISC with predictions generally within a factor of two of actual values. It was noted that AERMOD did tend to under-predict actual concentrations by 20% to 40%, with predictions more accurate for short-term averaging periods. Perry *et al.* (2005) summarises the performance of AERMOD across 17 field study databases placing emphasis on statistics that demonstrate the model's abilities to reproduce the upper end of the concentration distribution which are of importance in terms of regulatory modelling. The field studies include flat and complex terrain cases, urban and rural conditions and elevated and surface releases with and without building wake effects. Perry et al. (2005) concludes that, with few exceptions AERMOD's performance was superior to that of the other applied models tested.

[1] Under complex wind conditions and for regional applications, CALPUFF is the US-EPA's recommended model for regulatory purposes.

Hurley (2006) compared the performance of Ausplume, AERMOD and TAPM across several case studies including flat terrain, flat terrain with building downwash, in complex terrain and coastal terrain. AERMOD was determined to perform acceptably for all of the datasets but was found unable to simulate shoreline fumigation in the case of the Kwinana case study. This potential limitation of AERMOD is not relevant to this Project due to inland nature of the location.

AERMET Meteorological Modelling

The AERMOD system is composed of two pre-processors that generate the input files required by the AERMOD dispersion model: AERMET (for the preparation of meteorological data) and AERMAP (for the preparation of terrain data. Terrain data for the modelling domain was sourced from NASA's Shuttle Radar Topography Mission (SRTM) Data. This data set provides high-resolution topography at 3 arc-second (~90 m) grid spacings.

AERMET produces data characterising the planet boundary layer (PBL) such as friction velocity, mixing height. Inputs in the AERMET modelling are described below.

Surface Characteristics

In applying the AERMET meteorological processor to prepare the meteorological data for the AERMOD model appropriate values for three surface characteristics need to be determine, viz.: surface roughness length, albedo, and Bowen ratio. The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

Aerial photographs were used to define the land use and associated effective surface roughness on a sector-by-sector basis within a 1km radius around the Project Site. Values of Bowen ratio and albedo were determined over a greater domain centered on the Project Site. Semi-arid scattered forest prevailed within proximity to the Station. Reference was made to the AERMET user's guide (USEPA, 2004) and to Sturman and Tapper (2006) in assigning surface roughness, Bowen ratio and albedo values to designated land cover categories.

The land use values of surface roughness, Albedo and Bowen rations are tabulated below. The Bowen ratio was calculated assuming dry conditions. Surface roughness has been allocated consistent with a semi-arid forested setting.

Month	Surface Roughness	Albedo	Bowen
Jan	1.3	0.12	6.0
Feb	1.3	0.12	6.0
Mar	1.3	0.12	6.0
Apr	1.3	0.12	2.0
May	1.3	0.12	5.0
Jun	1.3	0.12	2.0
Jul	1.3	0.12	2.0
Aug	1.3	0.12	6.0
Sep	1.3	0.12	6.0
Oct	1.3	0.12	6.0
Nov	1.3	0.12	6.0
Dec	1.3	0.12	6.0

Meteorological Inputs

AERMET typically requires surface and upper air meteorological data as input. In the absence of local meteorological data, the CSIRO's TAPM meteorological processor was utilised to generate hourly varying meteorological conditions for the Project Site. The TAPM dataset was then formatted for use as input into the AERMET processor.

AERMET Outputs

AERMET calculates planetary boundary layer parameters, including: friction velocity, Monin-Obukhov length, convective velocity scale, temperature scale, mixing height and surface heat flux based on the input meteorological data. These parameters are used, in conjunction with measurements, to calculate vertical profiles of wind speed, lateral and vertical turbulent fluctuations, potential temperature gradient and potential temperature based on similarity theory.

AERMET outputs two files: a surface data file and a profile data file for input to AERMOD (US-EPA, 2004).

AERMOD Dispersion Modelling

Input data types required for the AERMOD model include: meteorological data (from AERMET), source data (from the emissions inventory compiled), and information on the nature of the receptor grid.

Meteorological Inputs

The AERMET generated meteorological files were used as input in the dispersion simulations.

Source and Emissions

Emissions estimated for the Project, as documented in **Section 6**, were simulated using a mixture of point, volume and area sources.

Receptor Grid and Discrete Receptors

Air pollutant concentrations of particulate matter and diesel combustion-related pollutants were simulated for a regular Cartesian receptor grid covering a 14 km by 14 km computational domain centred over the Processing Plant, with a grid resolution of 1 km. Additionally, a 6 km by 6 km nested grid with a resolution of 500 m, also centered over the Processing Plant, was configured to provide greater resolution of model predictions in the vicinity of the Project Site. Finally, concentrations were also predicted at the various discrete receptor points in **Section 2.3**.

Ground-level concentrations and deposition rates were simulated for the gridded receptors for use in the generation of isopleth plots to demonstrate spatial variations in pollutant concentrations/deposition rates. Model outputs for discrete receptor points were used in the compliance assessment of cumulative levels.

Model Results

Dispersion simulations were undertaken and results analysed for annual average Total Suspended Particulate (TSP) and dust deposition, highest 24-hour and annual average PM_{10} concentrations along with concentrations of metals and diesel combustion related pollutants. Results were presented as contour plots (Ref **Appendix 4**), illustrating spatial variations in particulate concentrations and dust deposition, and tabulated results for discrete receptor points.

Appendix 4
Dispersion Modelling Isopleth Plots

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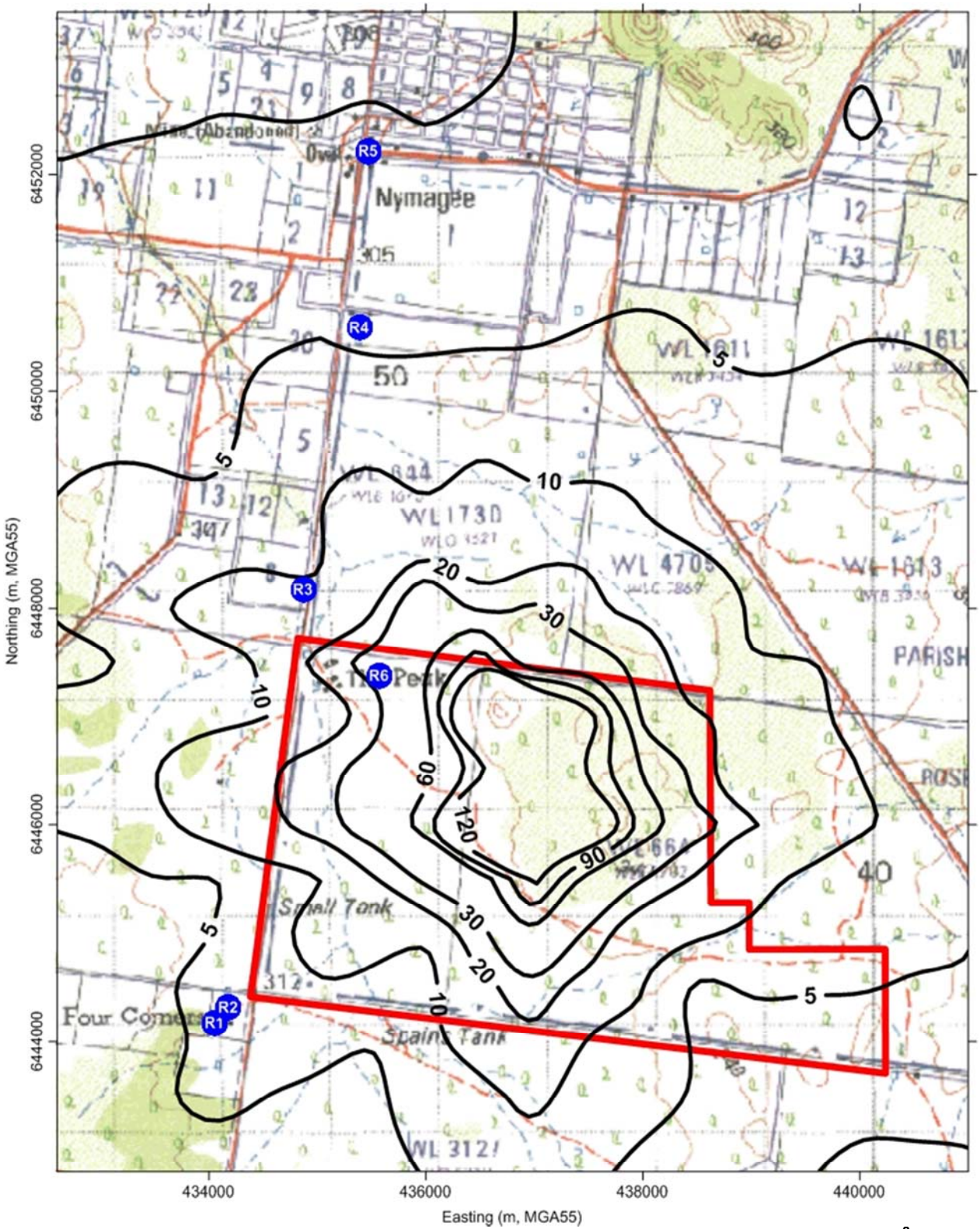

Figure A4-1 Predicted Incremental Annual Average TSP Concentrations (µg/m^3)

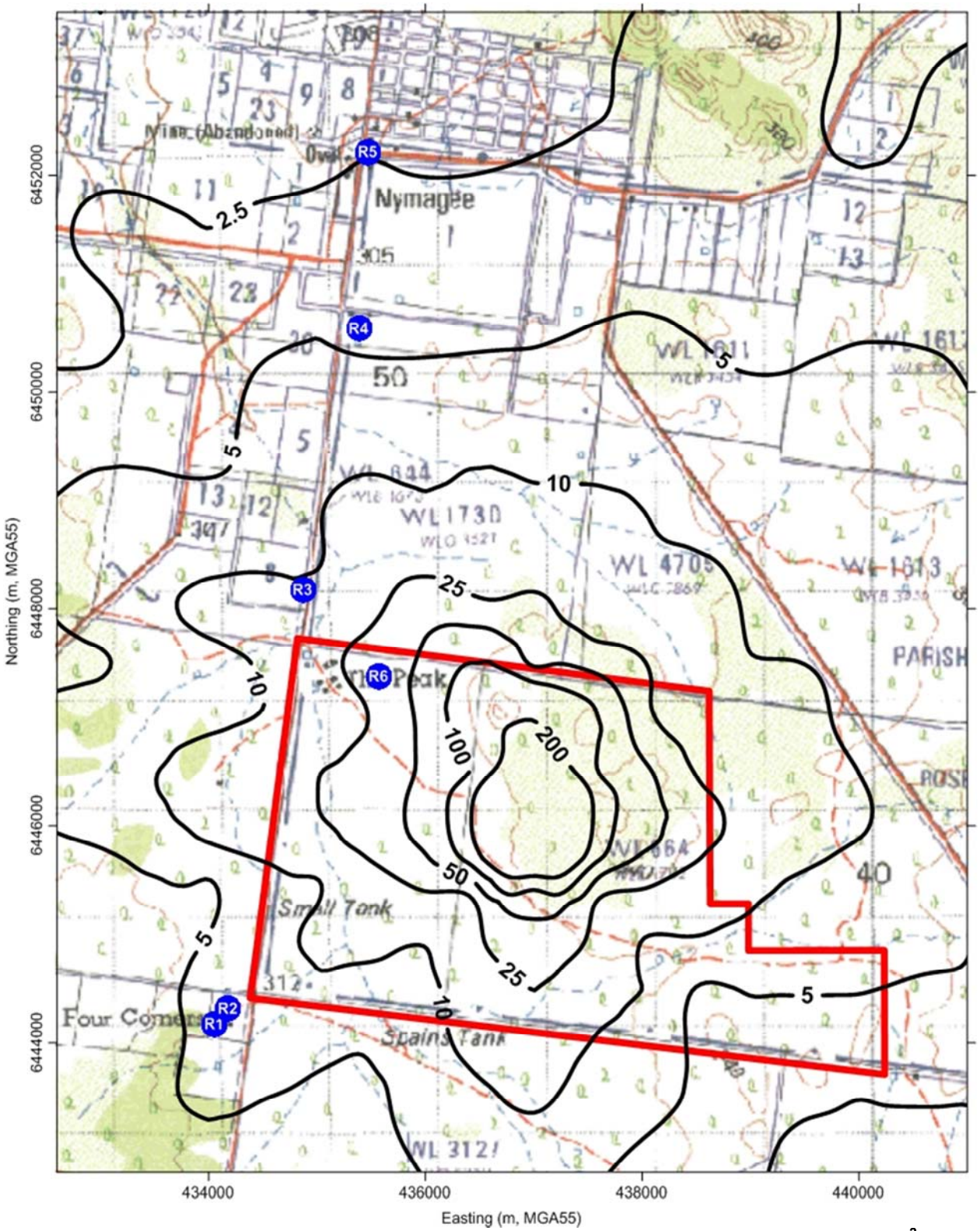

Figure A4-2 Predicted Incremental 24-hour Average PM_{10} Concentrations ($\mu g/m^3$)

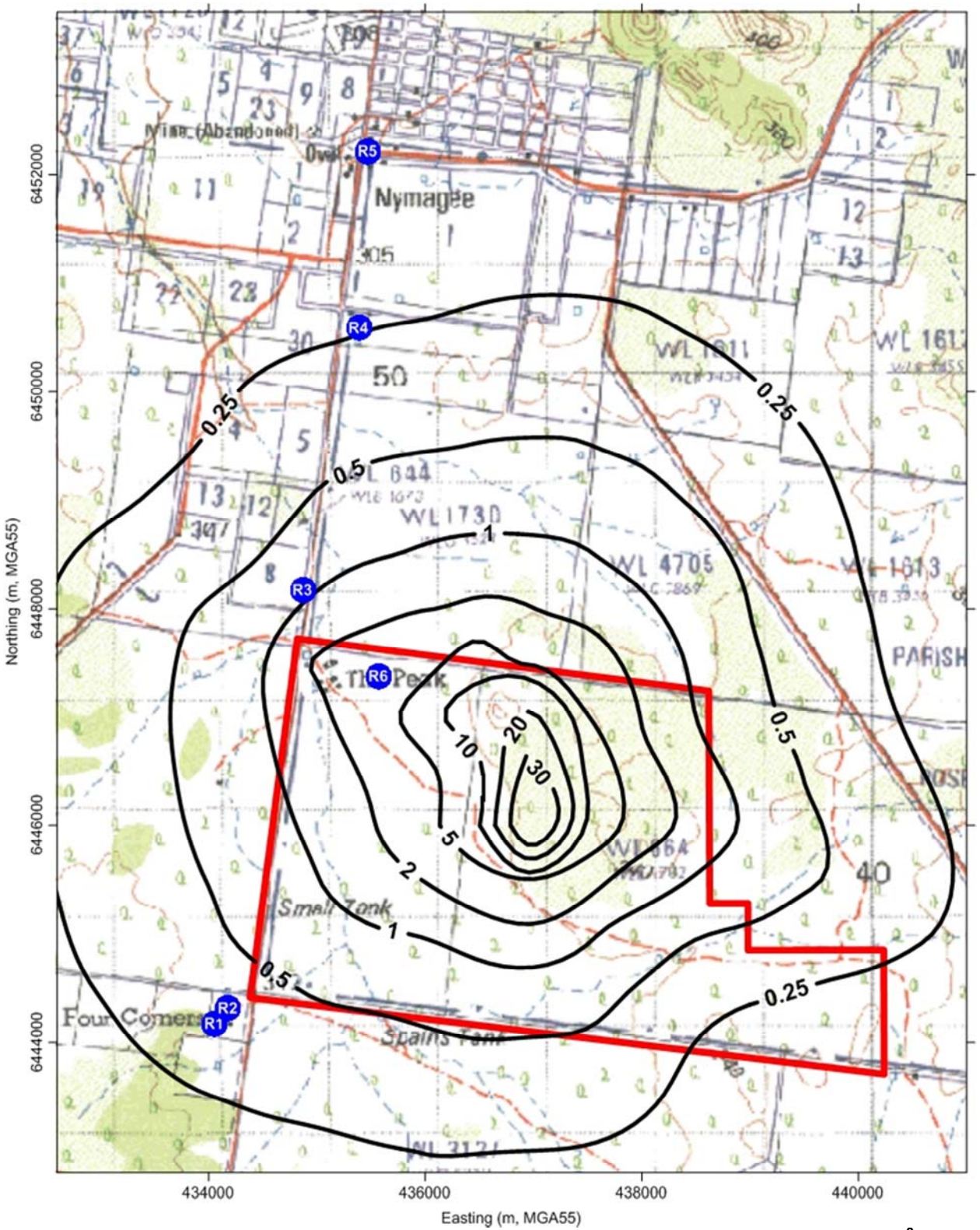

Figure A4-3 Predicted Incremental Annual Average PM_{10} Concentrations (µg/m^3)

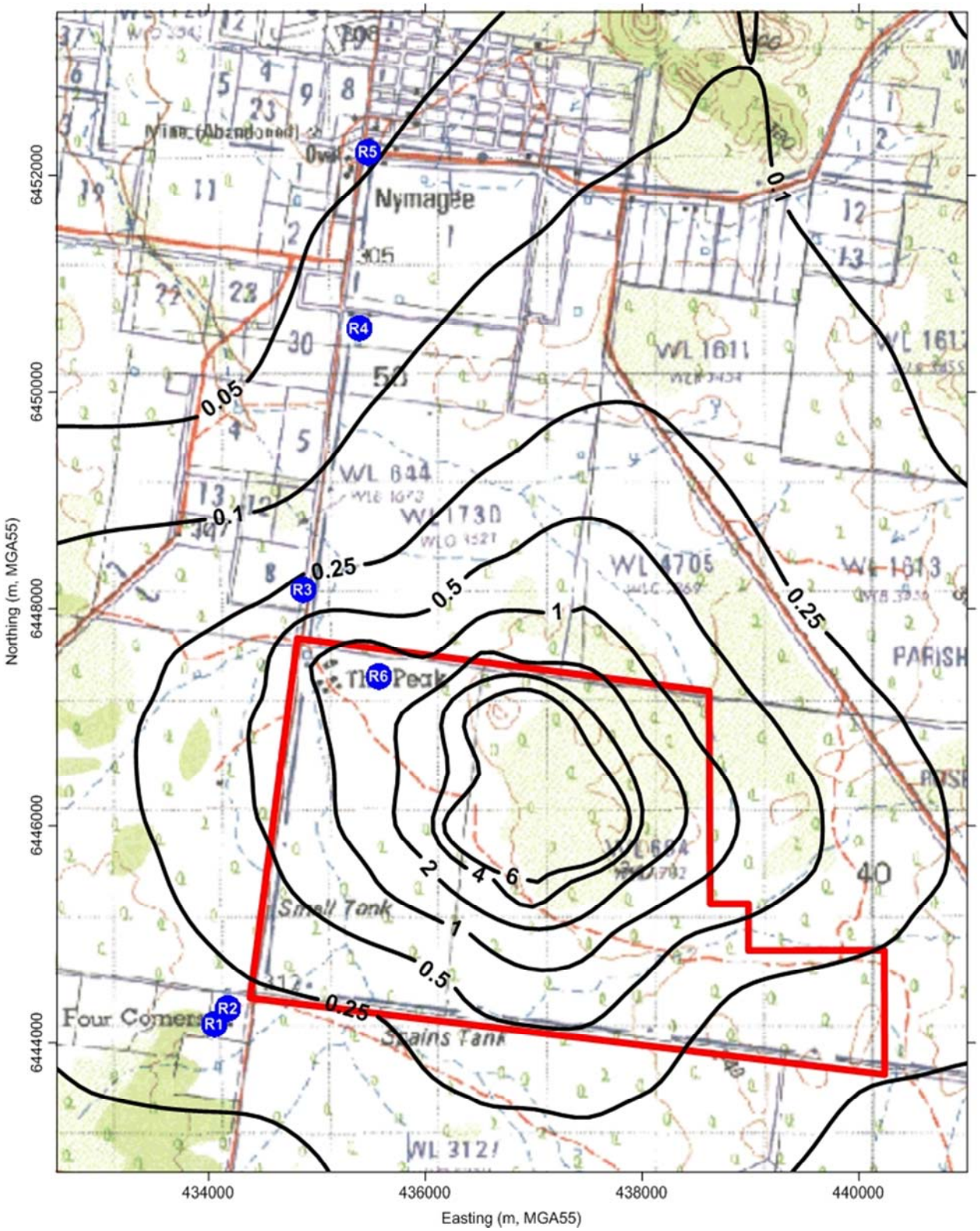

Figure A4-4 Predicted Incremental Annual Average Dust Deposition Levels (g/m^2/month)

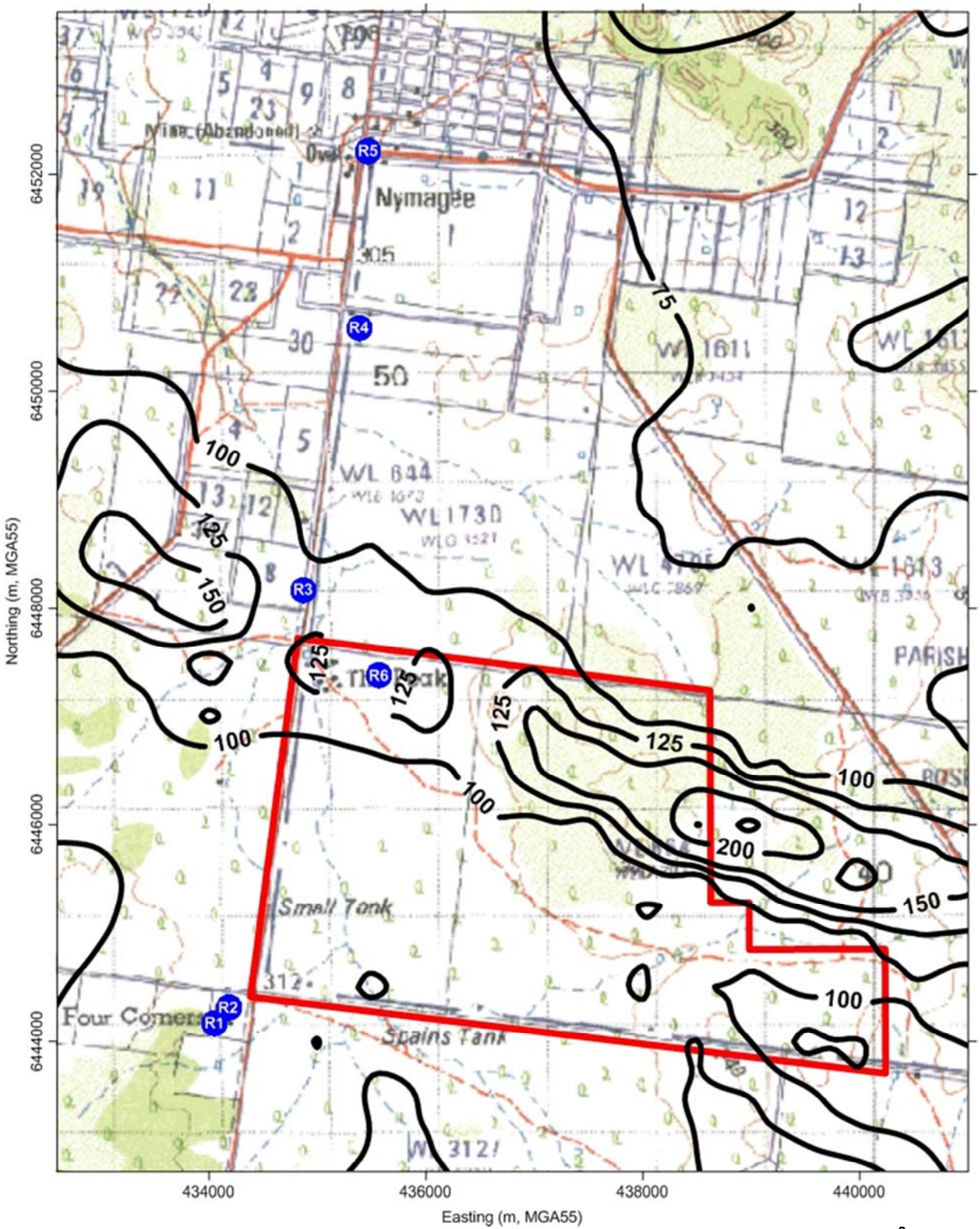

Figure A4-5 Predicted Incremental 1-hour Average NO_2 Concentrations (µg/m^3)

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