Appendix 6

Air Quality Impact Assessment

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Northparkes Step Change Project

AIR QUALITY IMPACT ASSESSMENT

- Final
- 28 June 2013

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Executive Summary

The purpose of the report is to provide a quantitative assessment of potential air quality impacts due to proposed mining activities at the existing copper and gold mine near Parkes in central west NSW; a project referred to as the Step Change Project (the 'Project').

The assessment follows the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*, published by the Environment Protection Authority (DEC, 2005). Computer-based dispersion modelling has been used to predict ground-level dust concentrations and deposition levels due to the proposed mining activities and the model predictions have been compared with relevant air quality criteria to assess the effect that the Project may have on the existing air quality environment.

A review of the existing environment showed that local air quality has improved in recent years (2010, 2011 and 2012), and compliance with annual average air quality criteria has been achieved for the key dust classifications; PM_{10}, TSP and dust deposition. However, there have been between two and five days each year when PM_{10} concentrations exceeded the EPA criteria of 50 µg/m^3. The exact causes of the exceedances could not be fully established from the monitoring data although the measured wind patterns suggested the mining activities may have contributed on some occasions, but to an unknown extent. In many cases it appeared as though non-mining sources of dust were the main factor.

An assessment of air dispersion model predictions led to the following conclusions:

- Annual average PM_{10}, TSP and dust deposition levels will be in compliance with air quality criteria at sensitive receptors during Project operation.
- Proposed mining activities, on their own, will comply with the PM_{10} criterion (50 µg/m^3). However, there is a potential risk that existing and proposed activities will contribute to exceedances of the 24-hour average PM_{10} criterion (50 µg/m^3), especially if background levels are higher than average.
- The maximum 24-hour average PM_{10} concentrations due to proposed mining activities will be at levels that are unlikely to cause exceedances of the DP&I acquisition criterion (150 µg/m^3), taking account of background levels.

A monitoring program has been recommended to help identify adverse meteorological conditions (in terms of elevated dust concentrations) and for developing targeted dust mitigation measures that will avoid exceedances of the short-term PM_{10} criterion as far as practicable.

1. Introduction

Northparkes Mines (NPM) is seeking approval for additional mining activities at the existing copper and gold mine near Parkes in central west NSW; a project referred to as the Step Change Project (the 'Project').

The Project requires the preparation of an Environmental Assessment (EA). This report has been prepared by Sinclair Knight Merz (SKM) for Umwelt Australia Pty Limited (Umwelt), who is in turn acting on behalf of NPM. The purpose of this report is to quantitatively assess the potential air quality impacts of the Project, and to accompany the EA.

1.1. Director General's Requirements

This report addresses the Director General's Requirements (DGRs) for the Project (11_0060), which require the preparation of a quantitative air quality impact assessment. **Table 1** lists the DGRs that are relevant to air quality and the sections of the report where they are addressed.

Table 1 Director General Requirements for air quality assessment

Requirement	Section of this report
Air Quality *including a quantitative assessment of potential:*	
▪ *construction and operational impacts, with a particular focus on extraction, processing and transport dust emissions, as well as diesel and blast fume emissions;*	Section 7
▪ *reasonable and feasible mitigation measures to minimise processing, dust, diesel and blast fume emissions, including evidence that there are no such measures available other than those proposed; and*	Section 8
▪ *monitoring and management measures, in particular real-time air quality monitoring.*	Section 8

1.2. Project Scope

The assessment follows the procedures outlined in the *Approved Methods for the Modelling and Assessment of Pollutants in NSW* (DEC 2005), and is based on the use of an air dispersion model to predict ground-level dust concentrations and deposition levels due to existing (approved) and proposed mining activities. Model predictions have been compared with air quality criteria specified by the Environment Protection Authority (EPA) to assess the effect that the Project would have on the existing air quality environment in the surrounding area.

In summary, the report provides information on the following:

- Existing (approved) and proposed operations (**Section 2**);
- Assessment criteria, as relevant to air quality (**Section 3**);
- Existing meteorological, climatic and air quality conditions (**Section 4**);
- Emissions to air from existing and proposed operations (**Section 5**);

- Methods used to predict air quality impacts (**Section 6**);
- Expected air quality impacts, as determined by comparison of model results with air quality assessment criteria (**Section 7**); and
- Suitable mitigation, monitoring and management measures to be implemented such that potential impacts are avoided as far as practicable (**Section 8**).

2. Project Description

Northparkes is a copper and gold mine that is located approximately 27 kilometres (km) north-northwest of Parkes, in central west NSW. The mine is operated by NPM and consists of underground mining of copper sulphide porphyry orebodies.

NPM is seeking approval, in accordance with Part 3A of the NSW *Environmental Planning and Assessment (EP&A) Act 1979*, for the Project which encompasses the continuation of underground block cave mining in two existing ore bodies, the development of underground block cave mining in the E22 resource, additional campaign open cut mining located in existing mining leases and an extended mine life of 7 years until 2032.

The Project area is shown in **Figure 1** and consists of existing and proposed mining operations and associated infrastructure. The major components of the Project which include:

- Continuation of approved underground block cave mining in the E48 and E26 ore bodies, and associated underground infrastructure;
- Development of underground block caving in the E22 resource beneath the E22 open cut void;
- Campaign open cut mining through development of five open cut resources including;
  - Development of four small open cut pits E31, E31N, E28, E28N; and
  - Proposed E26 open cut which is located in an area of previous underground block cave subsidence (existing vertical extent of subsidence void is approximately 200 metres);
- Amendments to the configuration of tailings storage facilities (TSFs) including;
  - continuation of tailings disposal to the existing and approved TSFs (TSF 1 and 2, infill between TSF 1 and 2, and Estcourt) to an approved height of 28 metres;
  - provision for additional raises on Estcourt TSF to provide for an increased height from the approved 25 metres to up to approximately 28 metres above ground surface; and
  - development of a new TSF 3, which will extend to the south and from the southern embankment of TSF 2 to a height of approximately 28 metres above ground surface, which incorporates the approved Rosedale TSF;
- Development of new waste dumps for the management of E28/E28N and E26 open cut waste rock. Waste rock from open cut mining areas will be utilised in the development of TSF 3.
- Continuation of approved ore processing infrastructure up to 8.5 Mtpa capacity, and road haulage of copper concentrate to the existing Goonumbla rail siding;
- Continued use of existing site infrastructure including administration buildings, workshop, internal access roads and service infrastructure;
- Continued use of surface mining infrastructure including ventilation shafts, hoisting shaft and ore conveyors;
- Continuation of existing approved water supply and management processes;
- Development of an amended access road to service all mine related traffic entering the site;

- Establishment of new visitor car parking facilities and access control to support the amended mine site access;
- Continuation of approved mining operations for an extended life of an additional 7 years until end of 2032; and
- Rehabilitation and closure of the mine site will be carried out after the end of the operational life of the Project in accordance with relevant approvals.

One of the objectives of this assessment was to determine how air quality may change as a result of the Project. This was done by quantifying the potential impacts of both existing (approved) and proposed activities.

- **Figure 1 Location of Northparkes mine**

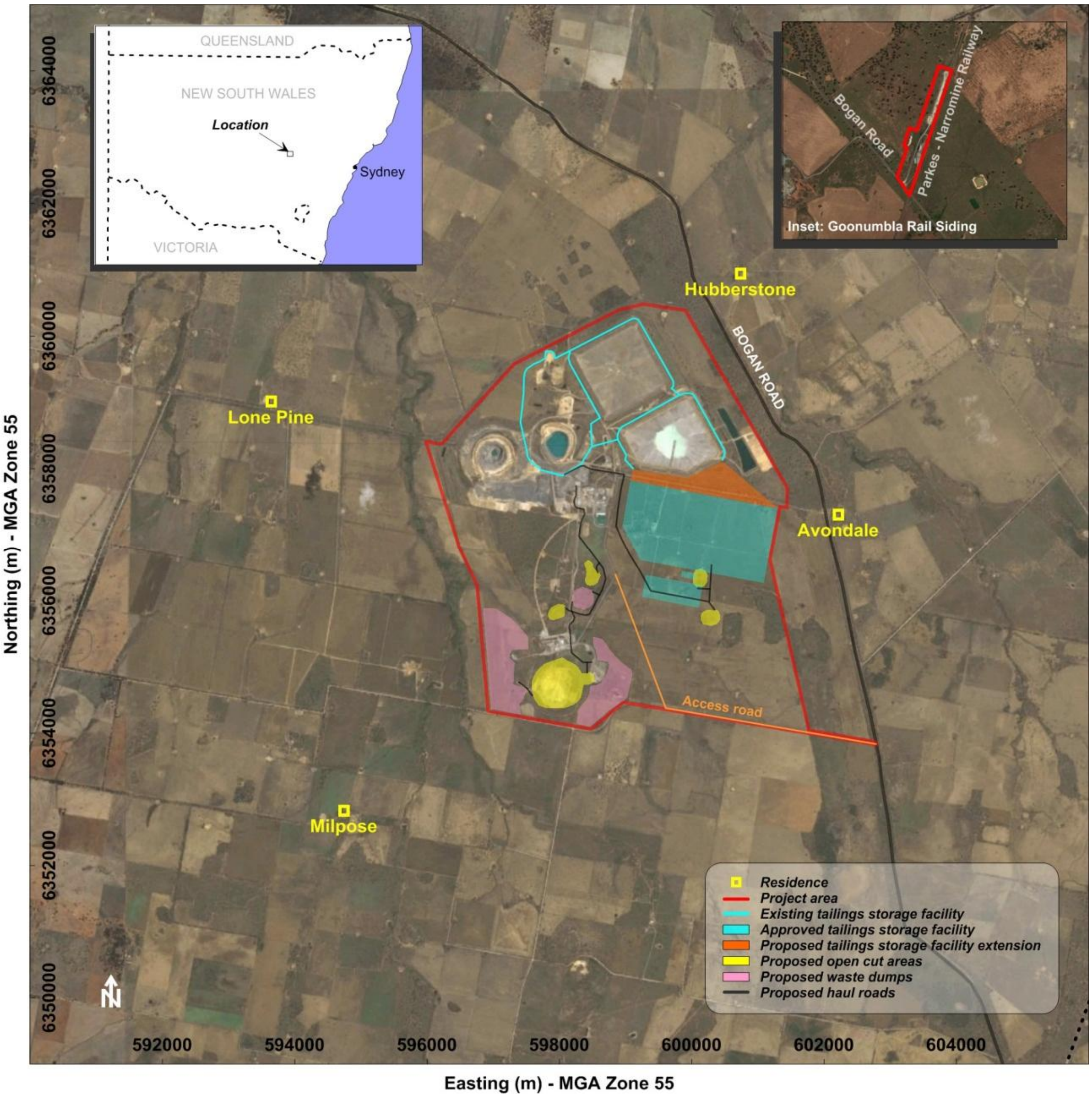

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Figure 1 also shows four of the nearest private residences. These four residences were selected to examine potential changes to air quality in various directions as a result of the Project.

Table 2 outlines the key components of the existing (approved) and proposed operations.

Table 2 Comparison of existing (approved) and proposed operations

Major Project Components / Aspects	Existing and Approved Operations	Proposed Operations
Mining Areas	• Underground block cave mining of E26 and E48 ore bodies; and • Open cut mining of E22 (ceased in 2010).	• Continued block caving of the E26 and E48 ore bodies (as per current approval); • Development of block cave mining in the E22 resource (previously subject to open cut mining); and • Development of open cut mining area in existing mine subsidence zone for E26 • Development of four small open cuts to extract ore from E28, E28N, E31 and E31N. • All proposed open cut mining areas are located within the existing PA 06_0026 Project Area and existing Mining leases.
Ore Processing	• Up to 8.5Mtpa of ore, sourced from underground and open cut mining areas	• Continuation of processing up to 8.5Mtpa of ore through the existing processing plant sourced from underground and open cut mining areas
Mine Life	• Until 2025	• Extension of mining by 7 years until end of 2032.
Operating Hours	• 24 hours a day, 7 days per week	• No Change.
Number of Employees	• Approximately 700 full time equivalents	• No Change.
Mining Methods	• Multiple Underground Block Cave; and • Campaign open cut mining yielding up to 2Mtpa for stockpiling and processing as required	• Multiple Underground Block Cave; and • Campaign Open cut mining of up to 6Mtpa for stockpiling and processing as required .
Infrastructure	**Operation of:** • tailings storage facilities (TSF 1-4); • ore processing plant including surface crusher, crushed ore stockpiles, active grinding mills, froth flotation area and concentrate storage; • site offices, training rooms and workshop facilities; • road haulage of concentrate to the Goonumbla rail siding for transport to Port Kembla; • an overland conveyor to transport ore from the hoisting shaft to the ore processing plant stockpiles; and • operation of four wastewater treatment plants.	**Construction and operation of:** • tailings storage facilities to be augmented to connect existing and approved tailings facilities, through the development of TSF 3 southward from the existing southern embankment of TSF 2. The proposed TSF 3 will substantially include the approved TSF 3 (known as Rosedale); • establishment of new waste stockpiles to store waste material generated during open cut mining campaigns including a vehicle washdown area; • continued operation of existing processing plant, site offices, underground access, water supply infrastructure and logistics connections; • continued road haulage of concentrate to Goonumbla rail siding for transport to Port Kembla; • closure of the existing site access road

Major Project Components / Aspects	Existing and Approved Operations	Proposed Operations
		through the development of TSF3; • provision of an upgraded site access road along a new alignment from McClintocks Lane; • development of a access control and visitors car parking at the intersection of the proposed site access and McClintocks Lane; • Upgrade/ sealing of McClintocks Lane between the NPM access road and Bogan Road; and • Upgrades as required to the intersection of McClintocks Lane and Bogan Road.
Block Cave Knowledge Centre	• Onsite Rio Tinto Block Cave Knowledge Centre operates for the domestic and international training of underground block cave mining methodology	• Continued operation of the Rio Tinto Block Cave Knowledge Centre.

Further details on the Project can be found in the main body of the EA.

3. Assessment Criteria

Airborne particulate matter is generally the primary pollutant of interest for mining activities. Emissions of particulate matter are generated from land clearing, excavation, ore extraction and processing activities, as well as from wind erosion of exposed areas of land.

There are various classifications of particulate matter. The classifications included in the EPA assessment process are:

- Particulate matter less than 10 microns in equivalent aerodynamic diameter, identified as PM_{10};
- Total suspended particulate (TSP) matter, generally regarded as airborne particulate matter of equivalent aerodynamic diameters less than about 30 microns; and
- Deposited dust.

Impact assessment criteria for PM_{10} are usually set for the protection of human health, since these smaller particles can be inhaled deep into the lungs. Criteria for TSP and deposited dust are usually set to protect against impacts on amenity. State regulatory authorities are responsible for setting assessment criteria which allow for determination of whether emissions, and resulting concentrations and deposition levels, will give rise to adverse air quality impacts.

3.1. EPA assessment criteria

The EPA has set criteria to assess the air quality impacts of existing or proposed facilities. These criteria are outlined in the EPA's *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005) and the relevant particulate matter criteria are shown below in **Table 3**.

An objective of this air quality assessment was to compare dispersion modelling results, predicted at nearest sensitive receptors, with these criteria. Adverse dust impacts are generally expected if model results exceed the air quality criteria.

Table 3 EPA assessment criteria for particulate matter

Pollutant	Averaging time	Criterion
TSP	Annual average	90 µg/m^3
PM_{10}	Annual average	30 µg/m^3
	Maximum 24-hour average	50 µg/m^3
Deposited dust	Annual average (maximum increase)	2 g/m^2/month
	Annual average (maximum total)	4 g/m^2/month

The criteria from **Table 3** relate to the total burden of dust in the air (that is "cumulative") and not just the dust from project-specific sources. Therefore, some consideration of background levels needs to be made when using these criteria to assess impacts. Background levels in the study area are discussed further in **Section 4.3**.

For maximum 24-hour average PM_{10} concentrations, contemporary EPA practice has been to assess the "Project only" contribution against the 50 µg/m^3 assessment criterion, assuming the mine will operate with best-practice dust control measures. This approach is consistent with recent approval conditions for mining projects in the Hunter Valley (see **Section 3.2** below) whereby the Department of Planning and Infrastructure (DP&I) often, but not always, invoke requirements for acquisition and negotiated agreements if the 50 µg/m^3 assessment criterion is exceeded due to the Project on more than five days each year.

3.2. Department of Planning and Infrastructure project approvals

In addition to the EPA assessment criteria outlined above, it is useful to understand how these criteria are typically adopted as conditions in project approvals. **Table 4** shows an example of acquisition criteria as specified by the DP&I in the recent project approval for Tarrawonga Coal Mine Pty Ltd (Department of Planning, 2012).

It can be seen from **Table 4** that the criteria are essentially the same as the EPA assessment criteria. The only difference is the addition of a "cumulative" criterion (150 µg/m^3) for maximum 24-hour average PM_{10} concentrations, which is numerically identical to a former US EPA standard for PM_{10}. Typically, the DP&I approval conditions for air quality mean that a landowner can request acquisition of their property if any of the criteria listed in **Table 4** are exceeded due to emissions from the Project.

- **Table 4 Example of DP&I acquisition criteria for particulate matter**

Pollutant	Averaging time	Criterion	Comment
TSP	Annual average	90 µg/m^3	Total impact
PM_{10}	Annual average	30 µg/m^3	Total impact
	Maximum 24-hour average	150 µg/m^3	Total impact
	Maximum 24-hour average	50 µg/m^3	Incremental impact
Deposited dust	Annual average (maximum increase)	2 g/m^2/month	Incremental impact
	Annual average (maximum total)	4 g/m^2/month	Total impact

Source: Department of Planning, 2012

From **Table 4**, "Total impact" refers to the incremental increase due to the project plus background due to all other sources. "Incremental impact" refers to the incremental increase due to the project alone.

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3.3. Particulate matter (as $PM_{2.5}$)

There is an increasing body of evidence to suggest that criteria for finer particulate matter (that is, $PM_{2.5}$) may be more important for protecting against adverse health impacts however the EPA has not set criteria for $PM_{2.5}$ that are applied on a project-specific basis.

In 2003, the National Environmental Protection Council (NEPC) developed "Advisory Reporting Standards" as a National Environmental Protection Measure (NEPM) for $PM_{2.5}$. These standards have numerical values as follows:

- A maximum 24-hour average $PM_{2.5}$ concentration of 25 µg/m^3, and
- An annual average $PM_{2.5}$ concentration of 8 µg/m^3.

The goal for the NEPM is to gather sufficient data nationally to facilitate a review of the Advisory Reporting Standards, so that air quality goals can be developed and adopted by state regulatory authorities. As noted above, the EPA has yet to develop an assessment criteria for $PM_{2.5}$ that can be applied on a project specific basis and at present there is no timeline for states to show compliance with any goals. The NEPM standards do not provide any particular health guideline value although they are a reference for State Government to report to the NEPC.

It is useful to note that the EPA health based assessment criteria, such as those for PM_{10}, have generally been developed from epidemiological studies undertaken in urban areas where the main air pollutants are due to emissions from combustion sources, such as motor vehicles. In these urban areas, the airborne particulate matter contains a higher fraction of smaller particles (for example $PM_{2.5}$ and PM_1) than that found in rural areas where emissions are from a crustal origin. Particles generated through mining are predominantly due to the crushing or abrasion of rock, and in the case of mining, most of the emissions will be larger than $PM_{2.5}$. The difference in $PM_{2.5}$ fractions in urban and rural areas is supported by the State Pollution Control Commission (SPCC) study (SPCC, 1986) which provided data on the distribution of particle sizes near mining dust sources. Data from this study showed that $PM_{2.5}$ was less than 5% of total dust (TSP) emissions.

While no $PM_{2.5}$ predictions have been made specifically for this assessment, other air quality assessments[1] have shown that the impact zone of $PM_{2.5}$, defined by comparing annual $PM_{2.5}$ predictions with the NEPM standard, were very similar to the impact zone of PM_{10}. The inference is that predicted compliance with the PM_{10} criteria would also result in predicted compliance with the NEPM advisory standards for $PM_{2.5}$.

3.4. Project assessment criteria

This assessment has adopted the EPA criteria outlined in **Table 3**, with reference made to the acquisition guidance provided through recent DP&I mining approvals (**Table 4**).

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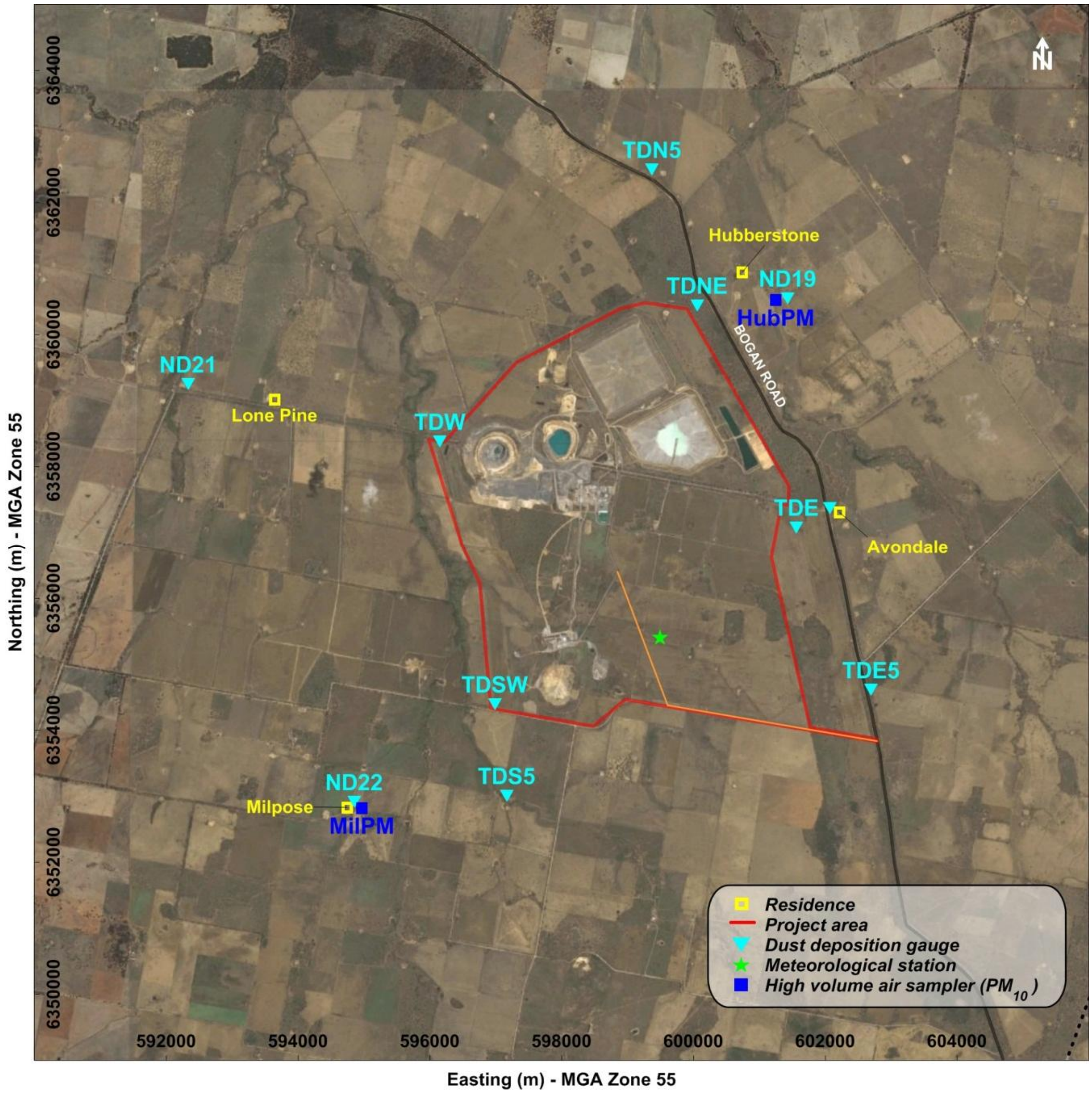
[1] For example, the air quality assessment for Mangoola Mine (formerly Anvil Hill); Holmes Air Sciences, 2006.

4. Existing Environment

For air quality assessments, the existing environment can be characterised by the local meteorology, climatic conditions, and the existing air quality. Local meteorological conditions have been identified from an analysis of data collected at the NPM site meteorological station while the climate of the area has been determined from a review of long term records collected by the Bureau of Meteorology. The existing air quality has been characterised from data collected by NPM at monitoring sites. **Figure 2** shows the location of meteorological and air quality monitoring sites; the data from which are discussed in this section.

Figure 2 Location of meteorological and air quality monitoring sites



4.1. Dispersion Meteorology

Meteorological conditions are important for determining the direction and rate at which pollutant emissions will disperse. The key meteorological requirements of air dispersion models are, typically, hourly records of wind speed, wind direction, temperature, atmospheric stability class and mixing height. For air quality assessments, a minimum one year of hourly data is usually required which ensures that almost all possible meteorological conditions, including seasonal variations, are considered in the simulations.

The EPA's *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005) lists the requirements for meteorological data that are used in air quality assessments. Specifically, the EPA requirements for meteorological data are as follows:

- Data must span at least one year;
- Data must be at least 90% complete; and
- Data must be representative of the area in which emissions are modelled.

The data used for this assessment were collected on site by the NPM meteorological station (refer to **Figure 2** for location). This meteorological station collects 15-minute records of temperature, wind speed, wind direction, rainfall, and solar radiation, among other parameters, and data for 2008 to 2012 were obtained. Data recovery for the years 2008, 2009 and 2010 was 90% or more, which satisfies the EPA's minimum requirements. Data from 2011 and 2012 did not satisfy the 90% complete criterion and were therefore not considered for the modelling.

Given the proximity of the meteorological station to NPM operations, data from this site should be relevant to the Project location and the nearest sensitive receptors. The potential spatial variability in meteorology across the study area has been addressed by the use of a three dimensional dispersion model, however very little variability would be expected given that the area is flat and relatively homogeneous landuse.

To summarise the dispersion meteorology near the Project site, wind-roses have been prepared from hourly records of wind speed and wind direction data collected by the site meteorological station. Annual and seasonal wind-roses for 2008, 2009 and 2010 are provided in **Figure 3**, **Figure 4** and **Figure 5** respectively to show the observed frequency and speed of winds from each direction. The wind-roses for these three years have been presented to examine any variability in meteorology from year to year, and to inform the decision on a representative meteorological dataset for use in the air dispersion modelling.

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- **Figure 3 Annual and seasonal wind roses for Northparkes mine (2008)**

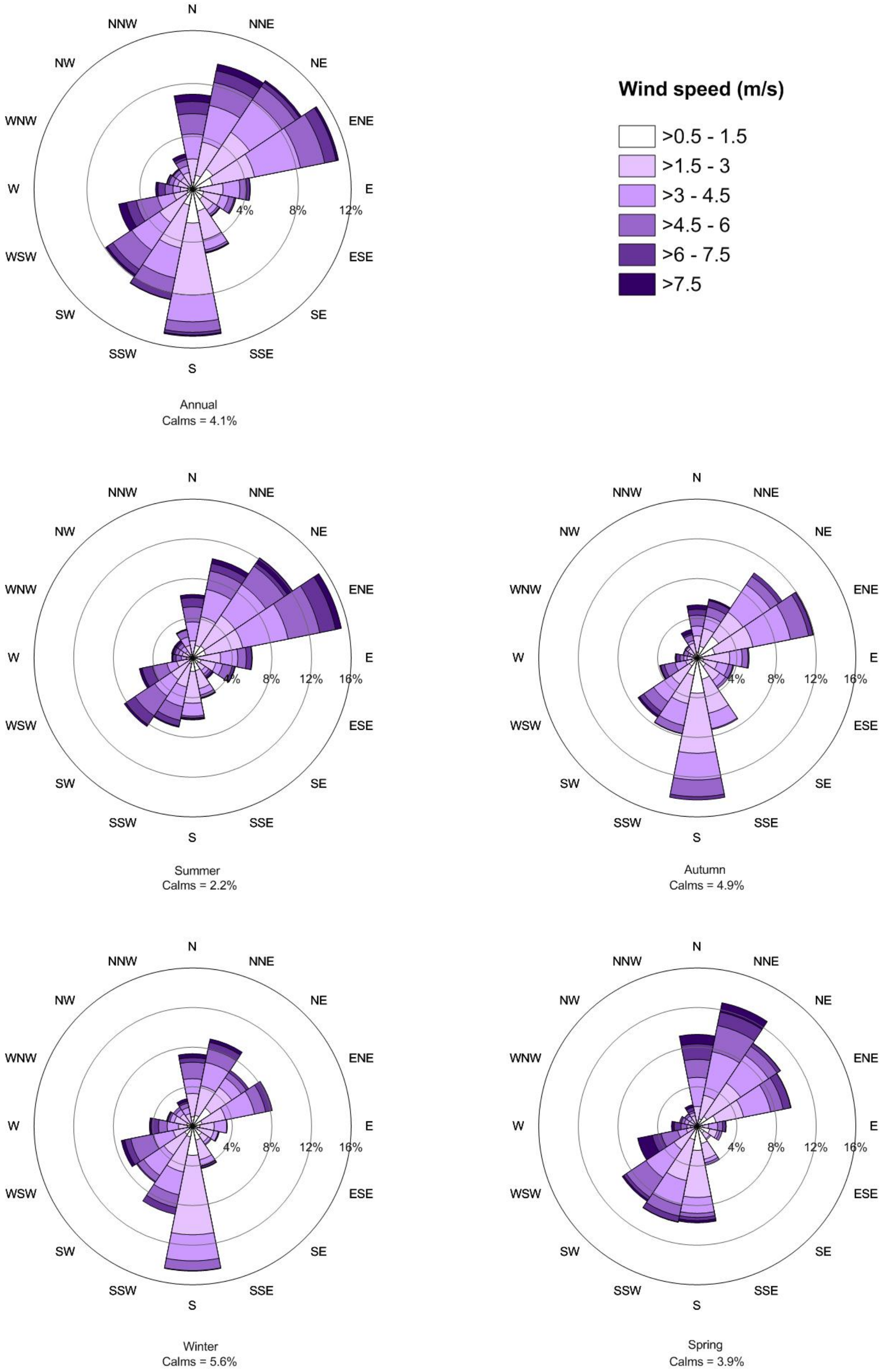

Figure 4 Annual and seasonal wind roses for Northparkes mine (2009)

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Figure 5 Annual and seasonal wind roses for Northparkes mine (2010)

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The wind-roses (**Figure 3** to **Figure 5**) show that, in all years, the prevailing winds are from the north east (typically summer and autumn) or south (winter and spring). This pattern of winds suggests that dust emissions from the site will be transported to the southwest in summer and autumn and to the north in winter and spring. It can be seen from the wind-roses that wind patterns are generally similar from year to year, although 2009 appears to be less representative, with less southerly winds than recorded in 2008 and 2010. The frequency of calm conditions (that is, winds less than or equal to 0.5 metres per second) are also similar at around 4% each year.

Atmospheric stability class has been determined for each hour in the 2008 to 2010 datasets using sigma-theta and the method recommended by the US EPA (US EPA, 2000). Sigma-theta is a measure of the horizontal variability of wind direction while stability class is a measure of the turbulence of the atmosphere. In the Pasquill-Gifford stability class assignment scheme, stability ranges from Class A to Class F. Class A is associated with highly unstable or turbulent conditions, while class F relates to night-time stable conditions.

Table 5 shows the annual distribution of stability classes, estimated from the NPM data. The high frequency of D class conditions (approximately 40%) suggest that dust emissions will disperse rapidly for a large proportion of the time, although it is also under these conditions that dust emissions from wind sensitive activities will be higher.

- **Table 5 Frequency of occurrence of atmospheric stability classes**

Stability class	Frequency of occurrence (%)		
	2008 data	**2009 data**	**2010 data**
A	7.5	5.4	4.7
B	4.5	4.1	4.1
C	7.6	9.5	8.8
D	39.9	42.9	44.4
E	25.8	28.6	29.2
F	14.7	9.4	8.8
Total	**100%**	**100%**	**100%**

All meteorological datasets show consistency from year to year, in terms of stability distributions. The 2008 data have been selected for use in the air dispersion modelling, since the wind patterns appear to be representative of other years, and because as the frequency of occurrence of F class conditions (stable with poor dispersion) was calculated to be slightly higher than the other two years. From an impact assessment perspective, the higher proportion of F class conditions would provide for more conservative results.

Statistics on the frequency of wind speed, wind direction, stability class and mixing height for the 2008 meteorological data are provided in **Appendix A**.

4.2. Climatic conditions

Long-term climatic data have been reviewed to provide a more complete picture of the local environment. The Bureau of Meteorology (BoM) collects climatic information at Parkes Airport, approximately 30 km southeast of Northparkes mines, and a range of climatic data collected from this station is presented in **Table 6** (BoM, 2013). Temperature and humidity data consist of monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

- **Table 6 Climatic information for Parkes Airport AWS**

Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean max. temperature (C)	34	32	28	24	19	15	14	16	20	24	28	31	24
Mean min. temperature (C)	18	17	14	9	5	4	2	3	5	8	12	14	9
Mean rainfall (mm)	62	66	50	32	49	48	48	47	44	54	59	53	612
Mean number of days of rain	6	7	5	5	8	12	13	11	8	8	7	6	97

Monthly climate statistics for Parkes Airport AWS, station number 065068. *Commenced: 1941; Last record: 2013; Latitude (deg S): -33.13; Longitude (deg E): 148.24; Elevation: 323 m; State: NSW. Source: Bureau of Meteorology, 2013. The shaded cells are values referred to in the text.*

The data from **Table 6** show that the area is characterised by warm to hot summers and cool to cold winters. January is typically the warmest month with a mean daily maximum temperature of 34°C. July is the coolest month with a mean daily minimum temperature of 2°C.

Rainfall data collected at Parkes show that February is usually the wettest month with mean rainfall of 66 mm, falling over an average of 7 days in the month. The mean annual rainfall is 612 mm with an average of 97 rain days each year.

4.3. Existing Air Quality (Background Levels)

The EPA air quality assessment criteria (see **Table 3**) refer to pollutant levels which are either project-specific or include the contribution from existing pollutant sources (that is, cumulative). To assess impacts for criteria which include the contribution from existing pollutant sources, it is therefore necessary to have information on existing dust concentrations and deposition levels in the area in which the Project is likely to contribute to these levels.

Dust concentrations and deposition levels have been measured by a network of high volume air samplers and dust deposition gauges as shown in **Figure 2**. The monitoring data will include contributions from all sources of particulate matter relevant to the monitoring locations, such as mining activities, traffic on unsealed roads, rural land uses including farming and animal grazing activities, and to a lesser extent traffic from the other local roads.

There are eleven (11) dust deposition gauges around the site which are analysed for insoluble solids and ash residue once per month. PM_{10} concentrations are sourced from high volume air samplers located at the "Hubberstone" and "Milpose" properties (refer to **Figure 2**). The high volume air samplers are operated by NPM and collect a sample every six days, in accordance with EPA procedures (**DEC, 2007**).

Measured 24-hour average PM_{10} concentrations from 2009 to 2012 for Hubberstone and Milpose are shown in **Figure 6** and **Figure 7** respectively. These results show that PM_{10} concentrations are generally below the EPA criterion (50 µg/m^3), although some exceedances have been measured in each year of available data. The results also suggest that concentrations tend to be higher in the warmer months and lower in the cooler months.

- **Figure 6 Measured 24-hour average PM_{10} concentrations at Hubberstone**

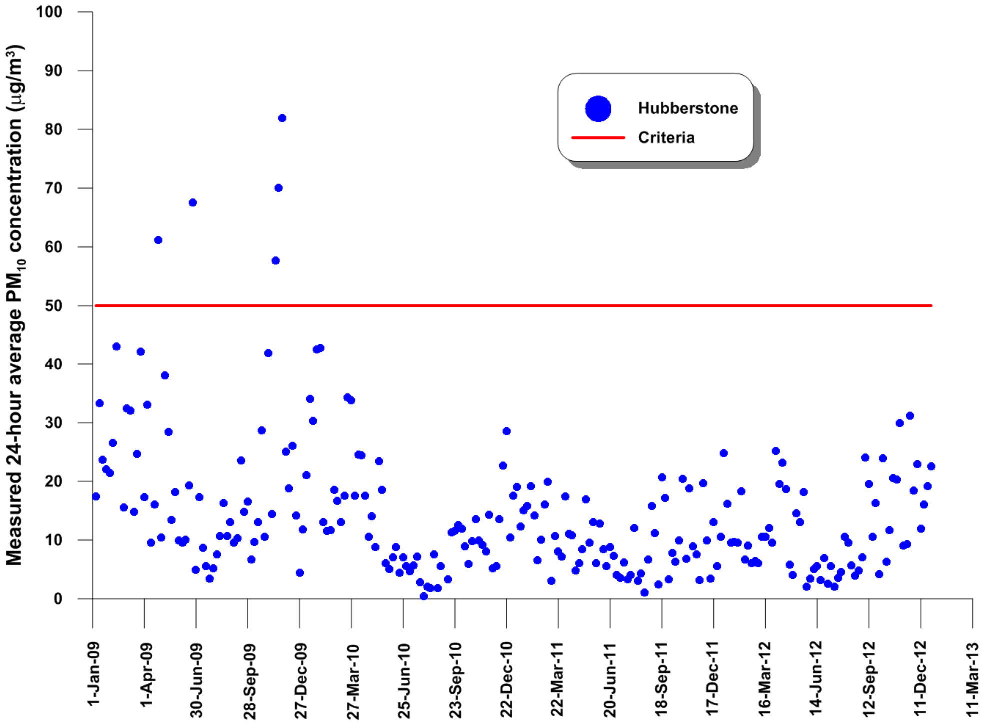
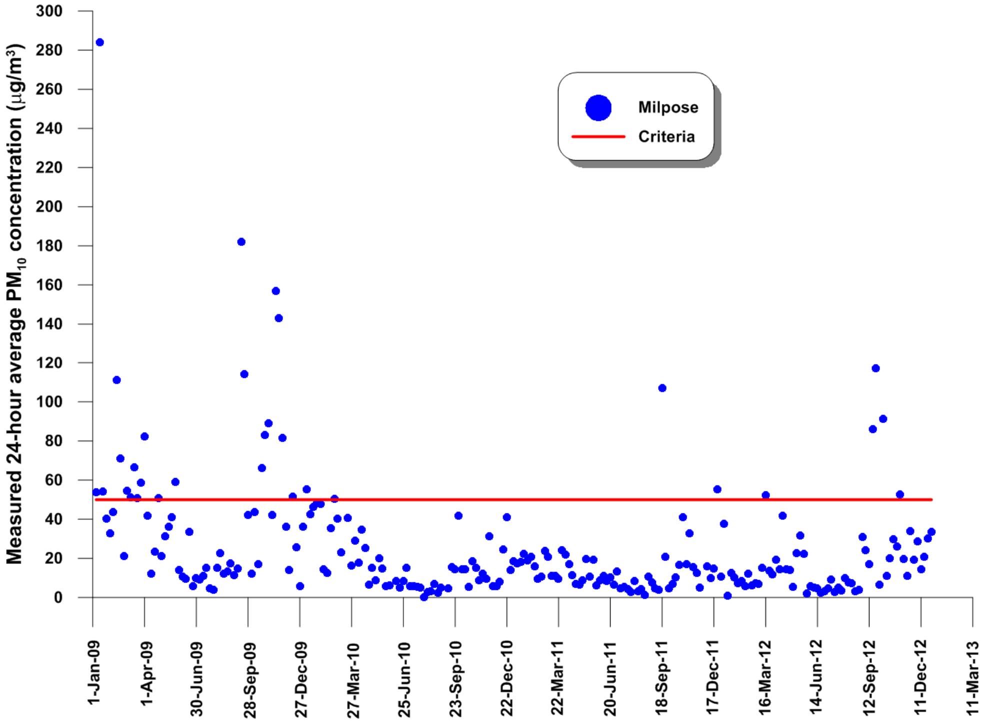
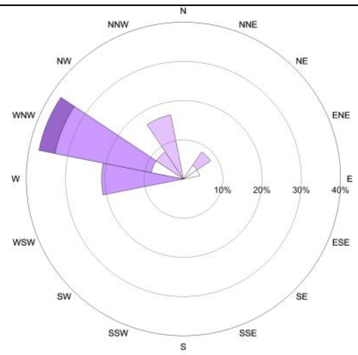


Figure 7 Measured 24-hour average PM_{10} concentrations at Milpose



The highest PM_{10} concentrations from each monitoring location have been further investigated by examining the wind conditions on the day. **Table 7** shows the analysis, which aims to identify whether there are any trends to elevated concentrations. Based on this analysis, no consistent pattern of winds was identified for elevated concentrations. At times when activities at Northparkes mines may have been contributing to the measured results, the winds were moderate (less than 5 m/s).

Table 7 Wind conditions on days of highest measured PM_{10} concentrations

Date	24-hour average PM_{10} concentration ($\mu g/m^3$)	Wind patterns	Comments
Hubberstone			
27-Nov-09	82		Moderate winds. Activities at Northparkes mines may have contributed partly towards the monitored result.

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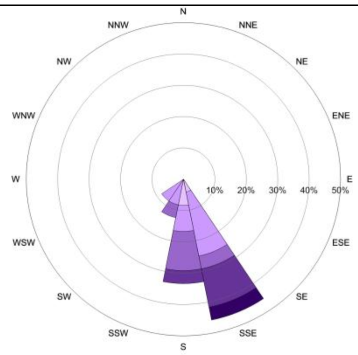
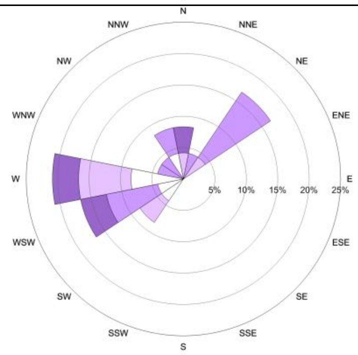
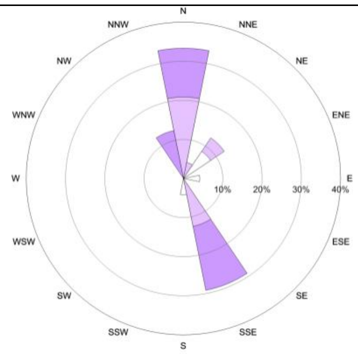
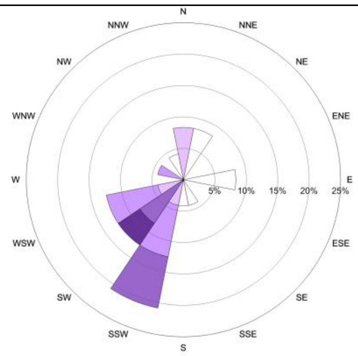
Date	24-hour average PM_{10} concentration ($\mu g/m^3$)	Wind patterns	Comments
21-Nov-09	70		Strong winds but not blowing from Northparkes mines towards the monitor. Elevated result likely due to non-mining sources.
24-Jun-09	68		Moderate winds. Activities at Northparkes mines may have contributed partly towards the monitored result.
Milpose			
7-Jan-09	284	Not available	-
16-Sep-09	182		Light to moderate winds, few from mine towards monitor.
15-Nov-09	157		Elevated result likely due to non-mining sources, since winds were predominantly from the south-southwest and not blowing from mine towards monitor.

Statistics on the measured PM_{10} concentrations are provided in **Table 8** and include minimum 24-hour average, maximum 24-hour average and annual average PM_{10} concentrations, based on 24-hour average samples collected every six days.

Annual average PM_{10} concentrations have been, and are currently, below the 30 µg/m^3 criterion at the Hubberstone site. At the Milpose site, annual average PM_{10} concentrations were above the 30 µg/m^3 in 2009, but have consistently been below 30 µg/m^3 from 2010 onwards.

The PM_{10} concentrations were unusually high in 2009, compared to other years. These levels are likely to have been influenced by the State-wide dust storms in September 2009, drought conditions (450 mm of rainfall in 2009 compared to the long term average of 650 mm), or a combination of these factors. Another trend in the data is that concentrations at Milpose (southwest of NPM) have consistently been higher than at Hubberstone (north-northeast of NPM). The monitoring records suggest that farming activities near Milpose often contribute to the measured levels.

Finally, **Table 8** shows that air quality has improved in recent years, in terms of average levels.

- **Table 8 Measured PM_{10} concentrations**

Year	Measured PM_{10} concentrations (µg/m^3)							
	Hubberstone				Milpose			
	Minimum 24-hour average	Maximum 24-hour average	No. days above 50 µg/m^3	Annual average	Minimum 24-hour average	Maximum 24-hour average	No. days above 50 µg/m^3	Annual average
2009	3	82	5	22	4	284	22	47
2010	0	43	0	14	0	55	2	19
2011	1	21	0	10	1	107	2	15
2012	2	31	0	12	1	117	5	20
All data	0	**82**	**-**	14	0	284	-	25
Criteria	-	50	5 (NEPM)	30	-	50	5 (NEPM)	30

Existing 24-hour hour average PM_{10} concentrations will vary from day to day. The PM_{10} monitoring data described above showed that, on most days in the year, 24-hour average concentrations are below the 50 µg/m^3 criterion but exceedances have been measured on a number of occasions each year (refer **Table 8**). Many parts of NSW experience a few exceedances each year. Mining does contribute in some locations but often natural events such as bushfires and dust storms are the main factors. As noted above, the highest 24-hour average PM_{10} concentrations have exceeded the 50 µg/m^3 criterion in all years on two or more occasions. This complicates the assessment process as projects with quite small PM_{10} contributions may still show exceedances when the background levels are high or when maximum background levels are added to predicted project levels.

For this study, 24-hour average PM_{10} concentrations have been assessed by examining model predictions at the nearest sensitive receptors and determining the probability of the project causing exceedences of 50 $\mu g/m^3$ at these locations. This approach is discussed further in **Section 7**.

No monitoring of TSP concentrations occurs in the area around Northparkes mine. Annual average TSP concentrations have been estimated from measured PM_{10} concentrations by assuming that 40% of the TSP was PM_{10}. This relationship was obtained from data collected by co-located TSP and PM_{10} monitors operated for reasonably long periods of time in the Hunter Valley (NSW Minerals Council, 2000). Application of this relationship to the existing PM_{10} data (20 $\mu g/m^3$ for annual average PM_{10} from all available data) indicates that annual average TSP concentrations in the area are of the order of 50 $\mu g/m^3$, which is less than the EPA assessment criterion of 90 $\mu g/m^3$.

Monthly dust deposition records are shown in **Table 9**. The data show that most of the results (28 out of 33 months) have complied with the 4 g/m^2/month criterion. There have been five instances where annual average dust deposition levels exceeded the 4 g/m^2/month criterion, namely, at ND22 (2009), TDE (2009 and 2010), TDS5 (2008) and TDSW (2009). These four sites are generally to the south of the current mining operations. The average for the three years of available data across all sites was 2.8 g/m^2/month.

- **Table 9 Dust deposition data**

Site	Annual average - Insoluble solids (g/m^2/month)			
	2008	2009	2010	Average
ND19	2.0	2.3	2.3	2.2
ND20	1.9	2.1	0.9	1.6
ND21	2.0	2.4	1.3	1.9
ND22	2.3	**4.4**	3.4	3.4
TDE	2.1	**5.8**	**4.2**	4.0
TDE5	1.7	2.2	1.6	1.8
TDN5	3.6	3.4	3.2	3.4
TDNE	3.0	3.1	1.6	2.6
TDS5	**4.1**	3.6	2.9	3.5
TDSW	3.6	**4.5**	2.8	3.6
TDW	3.5	3.6	1.2	2.8
Average	2.7	3.4	2.3	2.8

From the monitoring data discussed above, it has been assumed that the following background levels apply at the nearest sensitive receptors:

- Daily varying 24-hour average PM_{10} concentrations, ranging from near zero up to 284 $\mu g/m^3$ on one occasion (worst-case);
- Annual average PM_{10} concentrations of 20 $\mu g/m^3$;
- Annual average TSP concentrations of 50 $\mu g/m^3$; and
- Annual average dust deposition levels of 2.8 g/m^2/month.

5. Air Emissions

The most significant emissions to air from the Project will be due to the material handling (ore processing), exposed areas, including waste and ore stockpiles, tailings facilities and open cut/subsidence voids and vehicle activity. Estimates of these emissions are required by the dispersion model. Total dust emissions due to the Project have been estimated by analysing the material handling schedule, equipment listing and mine plan for maximum production, for existing (approved and proposed activities, and identifying the location and intensity of dust generating activities. Operations have been combined with emissions factors developed both locally and by the US EPA. The emission factors used for this assessment have been drawn largely from the following sources:

- *Emission Estimation Technique Manual for Mining* (NPI, 2012); and
- AP 42 (US EPA, 1985 and updates).

The emission factors applied are considered to be the most up to date methods for determining dust generation rates from mining activities.

The mine plans have been used to determine haul road distances and routes, stockpile areas and locations, activity operating hours, truck sizes and other details necessary to estimate dust emissions for the assessment scenario.

The details of the Project, needed to quantify emissions, have been provided by NPM. The key assumptions for the modelling were based around emission estimation and included:

- Maximum of 8.5 Mtpa ore handling, processing and stockpiling;
- Operating hours for 24 hours per day, 7 days per week;
- One (1) blast per day;
- Concurrent construction of tailings dams;
- Concurrent mining of E26 and E31 open pits (worst case);
- Two per cent (2%) moisture content of ore and overburden (but more realistically, 3%);
- Handling (loading, transporting, dumping and shaping) of 1,000 m^3 of material per day for tailings dam construction;
- Tailings construction by dozers, scrapers and haul trucks;
- Transporting concentrate via existing means (concentrate trucks); and
- 75% control of dust from unsealed haul roads (including haulage of material around tailings dams).

Table 10 shows the annual dust emission estimates, as TSP, the existing (approved) and proposed scenarios. Road transport to Goonumbla and loading the sealed containers to trains are also associated with the Project, but not included an in **Table 10** as these activities would have negligible dust emissions. Details of the dust emission calculations are provided in **Appendix B**.

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▪ Table 10 Dust emission estimates

ACTIVITY	Annual TSP emissions (kg/y)	
	Existing / Approved	**Proposed**
E28 - Stripping topsoil	-	-
E26 - Stripping topsoil	-	5,110
E31 - Stripping topsoil	-	5,110
E28 - Drilling	-	-
E26 - Drilling	-	1,077
E31 - Drilling	-	1,077
E28 - Blasting	-	-
E26 - Blasting	-	5,019
E31 - Blasting	-	5,019
E28 - Sh/Ex/FELs loading overburden	-	-
E26 - Sh/Ex/FELs loading overburden	-	16,477
E31 - Sh/Ex/FELs loading overburden	-	4,033
E28 - Hauling to emplacement areas	-	-
E26 - Hauling to emplacement areas	-	70,066
E31 - Hauling to emplacement areas	-	14,290
E28 - Emplacing at dumps	-	-
E26 - Emplacing at dumps	-	16,477
E31 - Emplacing at dumps	-	4,033
E28 - Dozers working in pit	-	-
E26 - Dozers working in pit	-	268,769
E31 - Dozers working in pit	-	134,385
E28 - Loading ROM ore to trucks	-	-
E26 - Loading ROM ore to trucks	-	35,540
E31 - Loading ROM ore to trucks	-	72,352
E28 - Hauling ROM ore to surface crusher from pit	-	-
E26 - Hauling ROM ore to surface crusher from pit	-	8,256
E31 - Hauling ROM ore to surface crusher from pit	-	16,807
Unloading ore from UG/OC to surface crusher	18,035	18,035
Primary ore crushing	85,000	85,000
Transfer by conveyor to mill	18,035	18,035
Unloading ore to stockpile	34,000	34,000
Ore processing in mill (enclosed / wet)	-	-
Wind erosion - plant stockpiles and exposed areas	202,421	545,738
Wind erosion - tailings storage dams	668,130	745,834
Ventilation shaft emissions	97,762	97,762
Tailings construction - dozers working on tailings lifts	43,193	43,193
Tailings construction - loading trucks	675	675
Tailings construction - trucks hauling	33,580	33,580
Tailings construction - trucks dumping	675	675
Grading roads	36,928	36,928
Total dust (kg)	**1,238,432**	**2,343,348**

6. Assessment Methodology

This assessment has followed the EPA's *Approved Methods of the Modelling and Assessment of Air Pollutants in New South Wales* (DEC, 2005), which specifies how assessments based on the use of air dispersion models should be undertaken. The "Approved Methods" include guidelines for the preparation of meteorological data, reporting requirements and air quality assessment criteria to assess the significance of dispersion model predictions.

6.1. Model selection

Historically, most assessments of dust emissions from mining operations in NSW have been based on simulations using the AUSPLUME or ISCST3 air dispersion models. A modified version of this model, referred to as ISCMOD, has also been used with an objective of improving the performance of predicting short-term (that is, 24-hour average) PM_{10} concentrations. While ISCMOD has often shown reasonably good performance for predicting dust concentrations and depositions levels, and has been accepted for use in NSW by the EPA for a number of recently completed mining and quarry assessments, there are some limitations of this model that should be identified in the model selection process for the current Project.

Some of the key limitations of AUSPLUME, ISCST3, and ISCMOD are identified below.

- Meteorological conditions are assumed to be the same, spatially, over the entire modelling domain for any given hour. This may be adequate for emission sources in relatively uncomplicated terrain, although when the terrain or land use is more complex, the assumption of spatially uniform meteorology may not be appropriate.
- The inability to handle calm winds; that is, winds below 0.5 m/s. Calms are generally either removed or increased to the minimum wind speed of 0.5 m/s.
- As a straight-line, steady-state[2] model, dust plumes are assumed to be transported to an infinite distance downwind of the source.

In summary, model selection should consider the expected transport distances for the emissions, as well as the potential for temporally and/or spatially varying flow fields due to influences of complex terrain, non-uniform land use, coastal effects, and stagnation conditions characterised by calm or very low wind speeds with variable wind directions. If any of these complexities are relevant to the area of interest then the traditional straight-line, steady-state assumption in AUSPLUME, ISCST3 and ISCMOD may not be valid, even beyond a few kilometres from the emission sources.

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[2] Air dispersion models can generally be classed as being one of two types; steady-state or non steady-state. Steady-state models essentially create a plume which extends to infinity downwind for a given hour of meteorology. Once the next hour of meteorological data is read a new plume is created and memory of the plume in the previous hour is lost. Non steady-state models allow the plume to grow and bend with differences in meteorology over the modelling area. Unlike steady-state models these types of models have a 'memory' of the plume for the previous hours. The concept of non steady-state is a more realistic simulation of plume behaviour than that provided by steady-state models.

Given that some of the nearby sensitive receptors are more than about three or four kilometres from the mine, the non-steady-state “puff” model known as CALPUFF has been used. CALPUFF is an EPA approved model for these types of assessments.

The CALPUFF model, through the CALMET meteorological processor, simulates complex meteorological patterns that exist in a particular region. The effects of local topography and changes in land surface characteristics are accounted for by this model. The CALPUFF model comprises meteorological modelling as well as dispersion modelling, both of which are described below.

6.2. Meteorological modelling

The meteorology has been incorporated into the CALPUFF model by considering data from the on-site meteorological station and synoptic analyses, and extrapolating these data to other areas using a wind-field model. The result is a three-dimensional, time-varying wind-field.

Surface meteorological data from the on-site meteorological station for 2008 have been used for development of the meteorological wind field. Upper-air temperature, wind speed, wind direction, pressure and height data are also required by the CALMET model. Unfortunately no upper-air observations are acquired close to the area of interest. In the absence of suitable upper air data sources, these data were generated by the CSIRO’s prognostic model known as TAPM (The Air Pollution Model). TAPM is a prognostic model which has the ability to generate meteorological data for any location in Australia based on synoptic model outputs produced by the Bureau of Meteorology and other sources. TAPM is further discussed in the model’s user manual (Hurley, 2008) and various model verification studies (see for example Hurley *et al*, 2009).

While there is some influence of real observations to TAPM inputs (that is, via synoptic scale model simulations), it is recognised that this approach is a simulation of actual conditions. In recognition of using a prognostic model to generate upper air data, the three-dimensional meteorological data from TAPM were used as CALMET’s initial guess wind-field. This approach places less emphasis on the prognostic data for the development of the final wind field as the prognostic data are not treated as observations. A summary of the data and parameters used as part of the meteorological component of this study is shown below in **Table 11**.

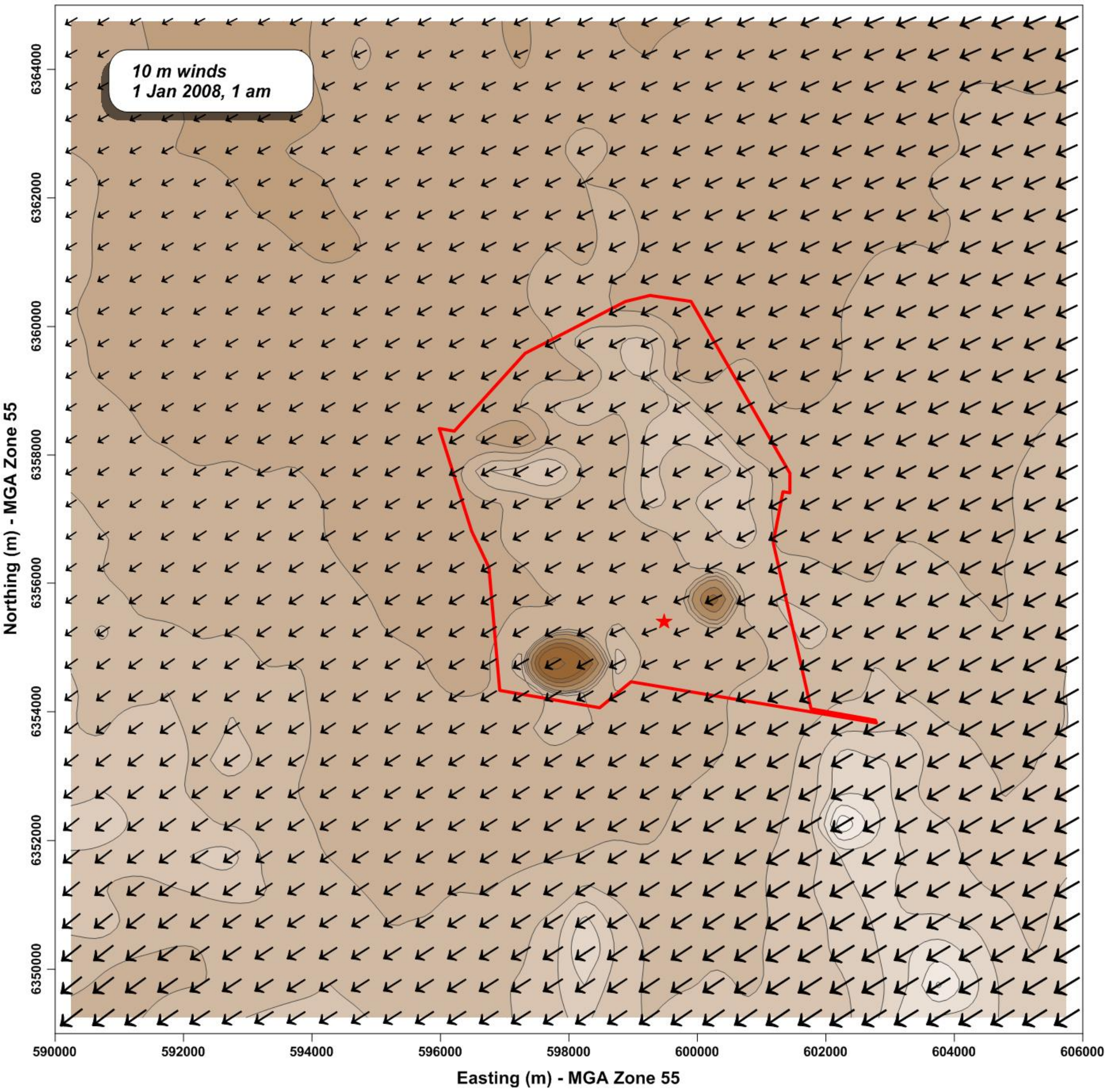
Table 11 Summary of parameters used for CALMET meteorological modelling

Meteorological modelling with TAPM (v 4.0.5)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grids point	35 x 35 x 25
Year of analysis	Jan 2008 to Dec 2008, with one "spin-up" day
Centre of analysis	Northparkes Mines (32°54' S, 148°4' E)
Meteorological data assimilation	None
Meteorological modelling with CALMET (v 6.326)	
Meteorological grid domain	16 km x 16 km (32 x 32 x 10 grid dimensions)
Meteorological grid resolution	0.5 km
Surface meteorological stations	One surface station site: - Wind speed, wind direction and temperature from NPM meteorological station. - Relative humidity, barometric pressure, cloud cover and ceiling height data generated for the NPM site by TAPM simulation.
Upper air meteorological station	No upper air meteorological stations. The 3-dimensional meteorological output from TAPM was used as the initial guess wind-field for CALMET.
Simulation length	8784 hours (Jan 2008 to Dec 2008)

Terrain information was extracted from both the NASA Shuttle Research Topography Mission database (which has global coverage at approximately 90 metre resolution) and the DTM information provided by NPM. Land use data were extracted from aerial imagery.

Figure 8 shows a snapshot of winds as simulated by the CALMET model for stable night-time conditions. The plot shows that winds (for this particular hour) are relatively uniform, which is a reflection of the flat topography.

▪ **Figure 8 Example of ground-level wind field as simulated by CALMET**



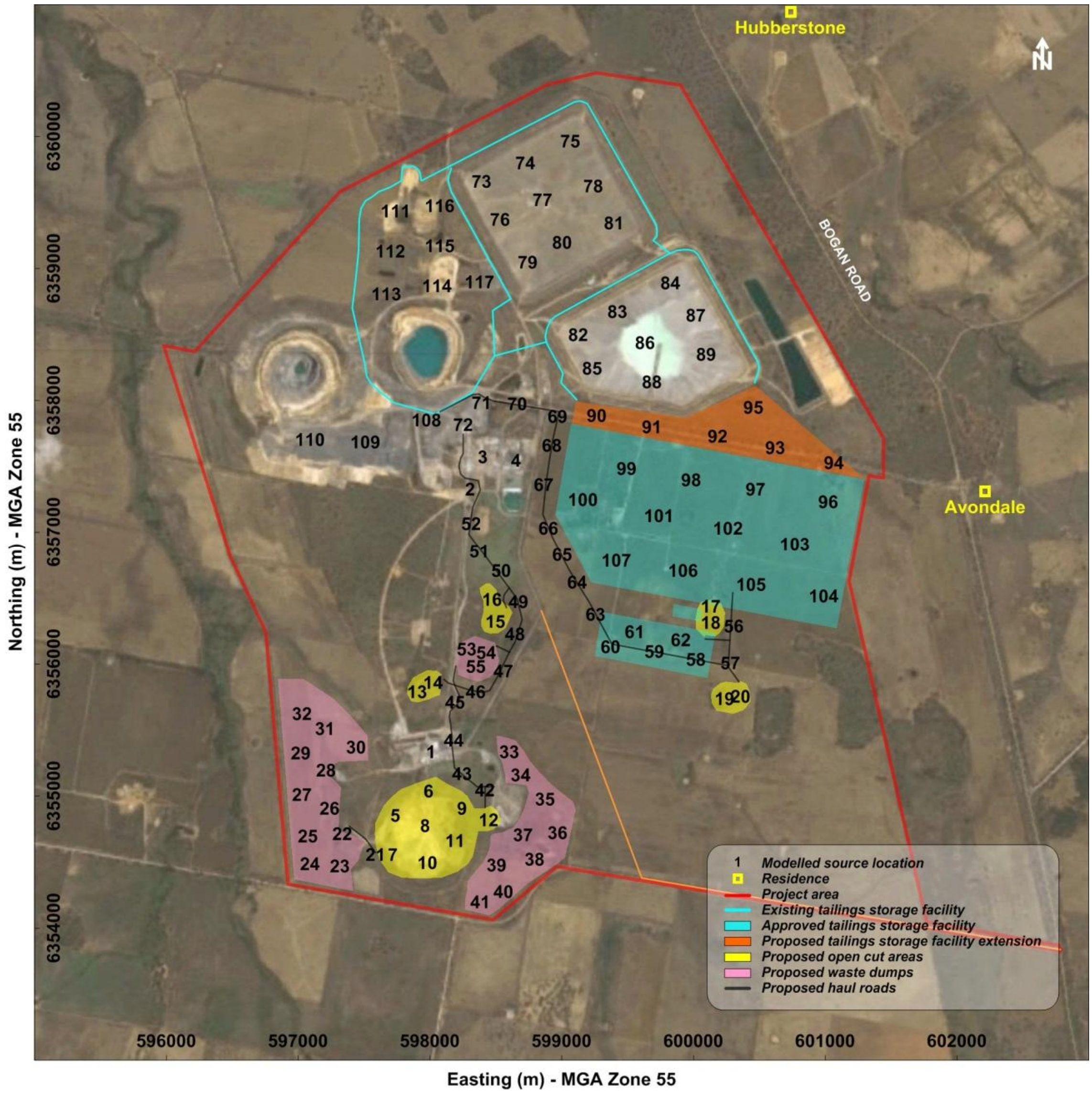
6.3. Dispersion modelling

Ground-level pollutant concentrations and deposition levels have been predicted using the air dispersion model known as CALPUFF (Version 6.263). CALPUFF is a Lagrangian dispersion model that simulates the dispersion of pollutants within a turbulent atmosphere by representing emissions as a series of puffs emitted sequentially. Provided the rate at which the puffs are emitted is sufficiently rapid, the puffs overlap and the serial release is representative of a continuous release.

The modelling has been performed using the emission estimates from **Section 5** and using the meteorological information provided by the CALMET model, described in **Section 6.2**. Dust concentration and deposition levels were predicted at 362 discrete receptors in the region of 16 km by 16 km whereby receptors were finely spaced close to the emission sources and coarsely spaced at locations further from the sources. Dispersion coefficients have used turbulence computed from micrometeorology and partial plume path was used for terrain adjustment.

Mining operations were represented by a series of volume sources located according to the location of activities for each modelled scenario. **Figure 9** shows the location of the modelled Project sources, where the emissions from the dust generating activities listed in **Table 10** were assigned to one or more of these source locations (refer **Appendix B**).

- **Figure 9 Location of modelled sources**



Dust emissions for all modelled Project related sources have been considered to fit in one of three categories, as follows:

1) Wind insensitive sources, where emissions do not vary with wind speed (for example, trucks transporting overburden over unsealed roads);
2) Wind sensitive sources, where emissions vary with the hourly wind speed, raised to the power of 1.3 (for example, conveyor deposition of ore to stockpile or the loading and unloading of ore/waste from trucks); and
3) Wind erosion sources, where emissions vary with the wind speed, raised to the power of 3 (for example, wind erosion from stockpiles, overburden dumps or active pits).

Emissions from each volume source were developed on an hourly time step, taking into account the level of activity at that location and, in some cases, the hourly wind speed. This approach ensured that light winds corresponded with lower dust generation and higher winds, with higher dust generation.

Project emissions associated with blasting activities were assumed to take place only during daylight hours (9 am to 5 pm for the purposes of the modelling) while all other activities have been modelled for 24 hours per day.

All volume sources were given TSP emission rates and duplicated into three source groups, representing three particle size categories; namely:

- $PM_{2.5}$ (particles in size range 0 to 2.5 μm)
- $PM_{2.5-10}$ (particles in size range 2.5 to 10 μm); and
- PM_{10-30} (particles in size range 10 to 30 μm).

Each source group was assumed to have an aerodynamic particle diameter equal to the geometric mean of the limits of the particle size range, except for the $PM_{2.5}$ group, which was assumed to have a particle size of 1 μm.

Once the models had completed each simulation, the three output files from each source group were combined according to the distribution of particles in each particle size range. The distribution of particles in each size range has been derived from measurements published by the State Pollution Control Commission (SPCC, 1986) and is as follows:

- $PM_{2.5}$ is 4.7% of TSP;
- $PM_{2.5-10}$ is 34.4% of TSP; and
- PM_{10-30} is 60.9% of TSP.

Model predictions were then compared with the current EPA air quality assessment criteria, including background levels where relevant to the criteria. Contour plots have also been created to show the spatial distribution of model predictions.

To understand the contribution that the Project may have on existing air quality, two scenarios were developed, as follows:

- "Existing" sources, representing the predicted impact of the existing / approved operations; and
- "Proposed" sources, representing the predicted impact of the proposed operations.

7. Assessment of Impacts

The main objectives of this study were to predict the extent of air quality (that is, dust) impacts due to the Project, and to identify potential changes in air quality over existing levels. The extent of impacts has been determined by comparison of the air dispersion model predictions with relevant air quality assessment criteria. Contour plots have been prepared to show the areas in which adverse dust impacts are predicted.

Results from the dispersion modelling have been presented as contour plots of dust concentration and deposition levels, shown in **Figure 10** and **Figure 11**. All figures represent the contribution of the Project only (that is, without background levels) and include predictions of:

- Maximum 24-hour average PM_{10} concentrations;
- Annual average PM_{10} concentrations;
- Annual average TSP concentrations; and
- Annual average dust deposition levels.

The 24-hour average PM_{10} plots do not show the dispersion pattern for any particular day, rather they show the highest 24-hour average PM_{10} concentration that was predicted at each location in the model domain over the entire simulation year. The highest levels are predicted to be near the mining areas, stockpiles, processing plant and tailings dams.

The air quality criteria used for deciding which areas are likely to experience air quality impacts are specified by the EPA and are listed in **Table 3**.

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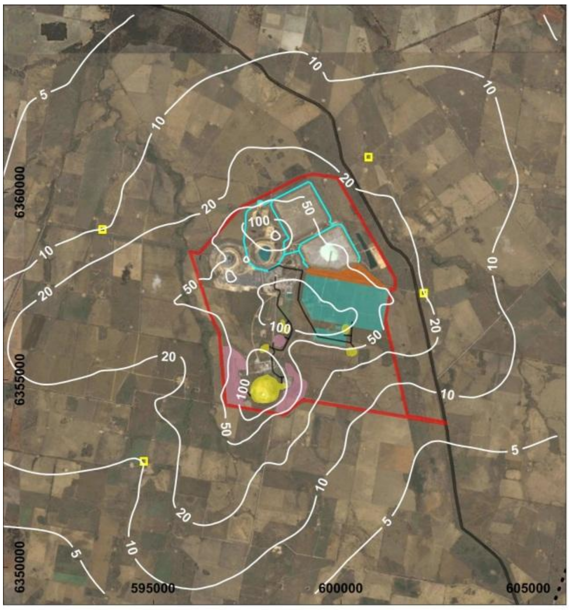
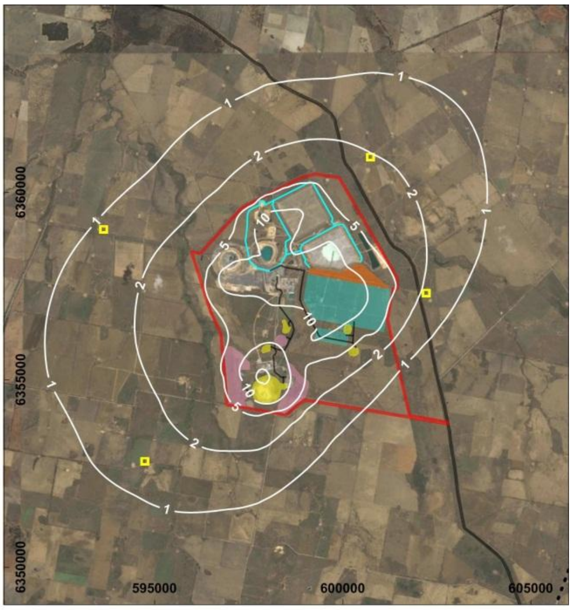
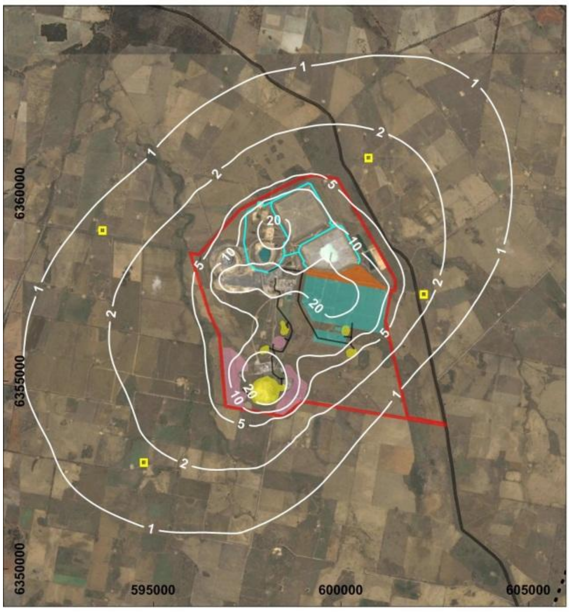
▪ Figure 10 Predicted dust concentrations and deposition levels (existing)



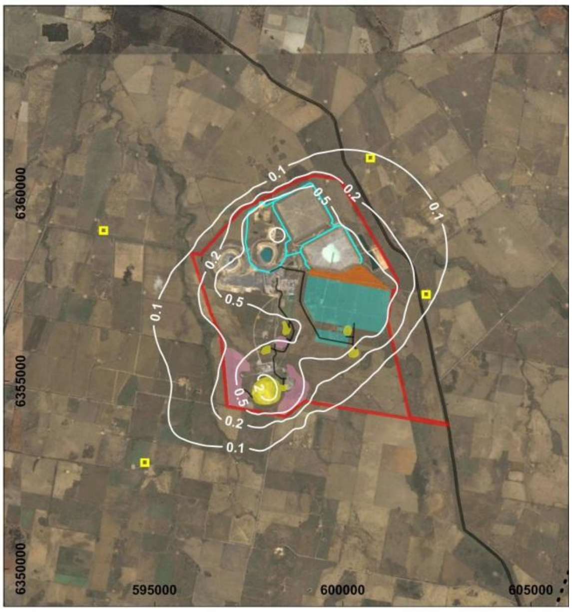
Maximum 24-hour average PM_{10} ($\mu g/m^3$)



Annual average PM_{10} ($\mu g/m^3$)



Annual average TSP ($\mu g/m^3$)



Annual average dust deposition (g/m^2/month)

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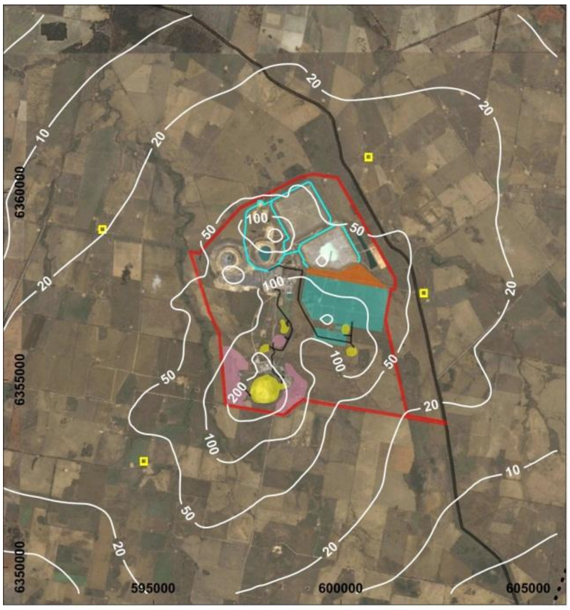
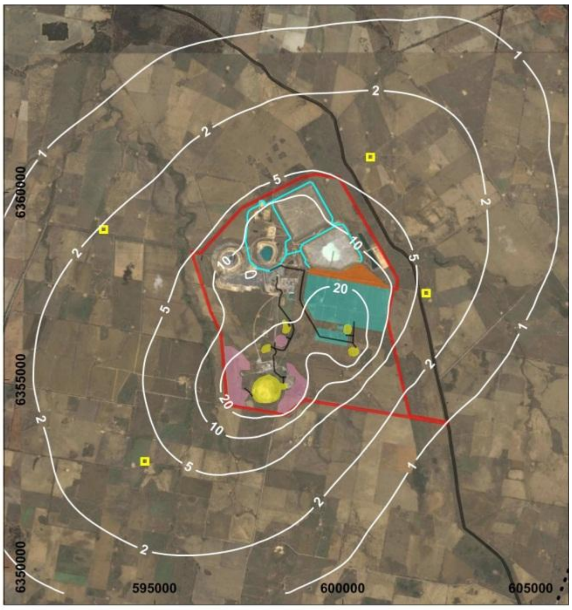
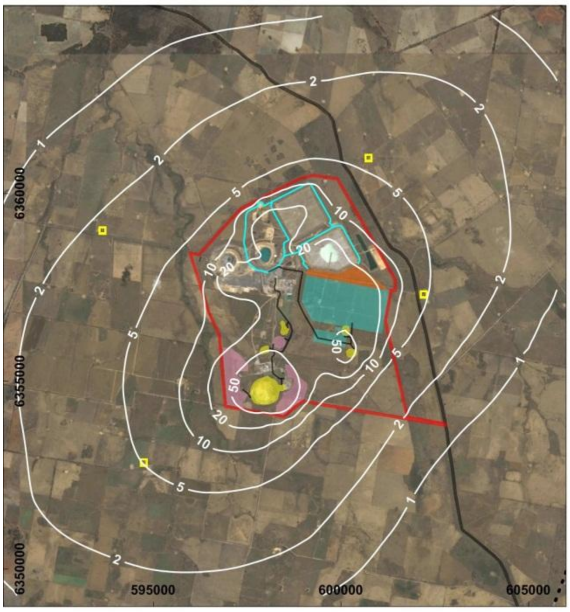
- **Figure 11 Predicted dust concentrations and deposition levels (proposed)**



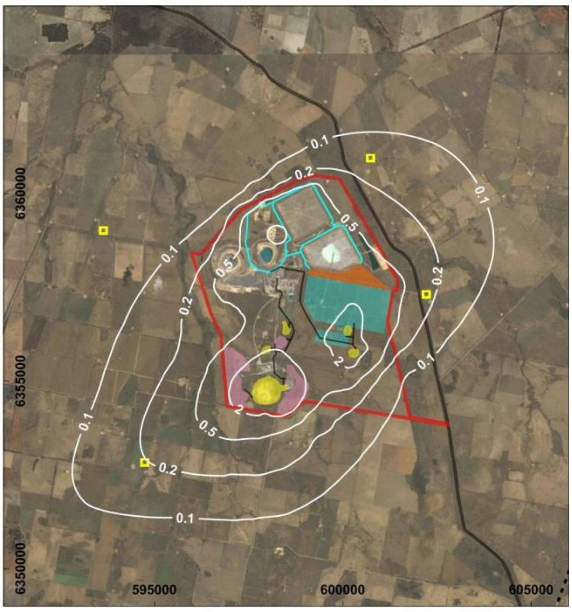
Maximum 24-hour average PM_{10} (µg/m^3)



Annual average PM_{10} (µg/m^3)



Annual average TSP (µg/m^3)



Annual average dust deposition (g/m^2/month)

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Model predictions for four (4) selected locations in the study region are shown below in **Table 12**. These locations represent the four closest residences. One of the objectives of this study was to quantify the potential change in air quality. This has been done by adding the predicted change in impacts (proposed minus existing) to the existing background levels, as determined by the review of air quality monitoring data in **Section 4.3**.

It can be seen from **Table 12** that annual average PM_{10}, TSP and dust deposition levels are predicted to comply with the EPA criteria under the proposed scenario (which represents the worst-case in terms of material handling and exposed areas).

Table 12 Dispersion model predictions at selected locations

Residence	Predicted mine contribution		Predicted air quality		Criteria
	Existing	Proposed	Existing (Background levels from Section 4.3)	Proposed (Background levels plus predicted change)	
Predicted maximum 24-hour average PM_{10} concentrations ($\mu g/m^3$)					
Hubberstone	16	28	Variable (0 to 284)	Variable (0 to 295)	50
Avondale	20	43	Variable (0 to 284)	Variable (0 to 295)	50
Milpose	10	35	Variable (0 to 284)	Variable (0 to 295)	50
Lone Pine	10	19	Variable (0 to 284)	Variable (0 to 295)	50
Predicted annual average PM_{10} concentrations ($\mu g/m^3$)					
Hubberstone	2	3	20	21	30
Avondale	2	4	20	22	30
Milpose	1	4	20	23	30
Lone Pine	1	2	20	21	30
Predicted annual average TSP concentrations ($\mu g/m^3$)					
Hubberstone	3	4	50	52	90
Avondale	2	5	50	53	90
Milpose	2	5	50	53	90
Lone Pine	1	2	50	51	90
Predicted annual average dust deposition (g/m^2/month)					
Hubberstone	0.11	0.14	2.8	2.8	4
Avondale	0.13	0.24	2.8	2.9	4
Milpose	0.07	0.20	2.8	2.9	4
Lone Pine	0.02	0.03	2.8	2.8	4

The results from **Table 12** also suggest that the mine contribution in both existing and proposed scenarios in less than 50 $\mu g/m^3$ at all sensitive receptor locations. This means that the existing and proposed activities would not be the sole contributor to an exceedance of the 24-hour average PM_{10} criterion. In terms of potential cumulative impacts, the approach of adding maximum measured to maximum predicted 24-hour average PM_{10} concentrations will rarely show compliance with the 50 $\mu g/m^3$ criterion. This is because the maximum measured value of 284 $\mu g/m^3$ (which was recorded on one day in the past four years as noted in **Section 4.3**) does not permit any project contribution before 50 $\mu g/m^3$ is exceeded.

The potential 24-hour average PM_{10} impacts have been investigated further by examining the predicted frequency of PM_{10} concentrations occurring at the four nearby receptors. **Figure 12** and **Figure 13** show histograms of model predictions at the nearest receptors for the existing and proposed scenarios respectively. These results indicate that 24-hour average PM_{10} concentrations due to the mining activities will be less 10 $\mu g/m^3$ for the majority of the time (more specifically, less than 10 $\mu g/m^3$ for a minimum of 83% of the time under the proposed scenario).

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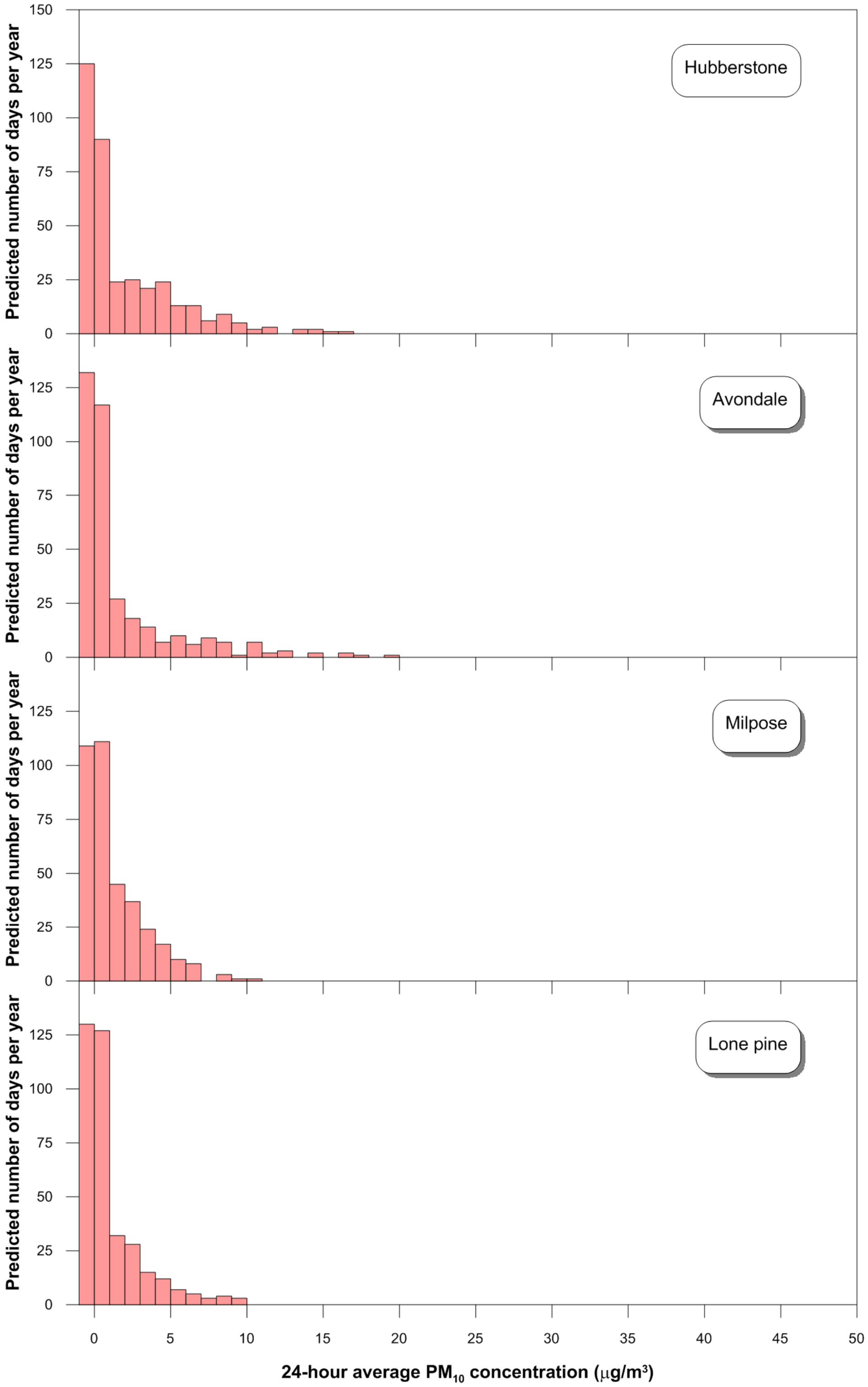
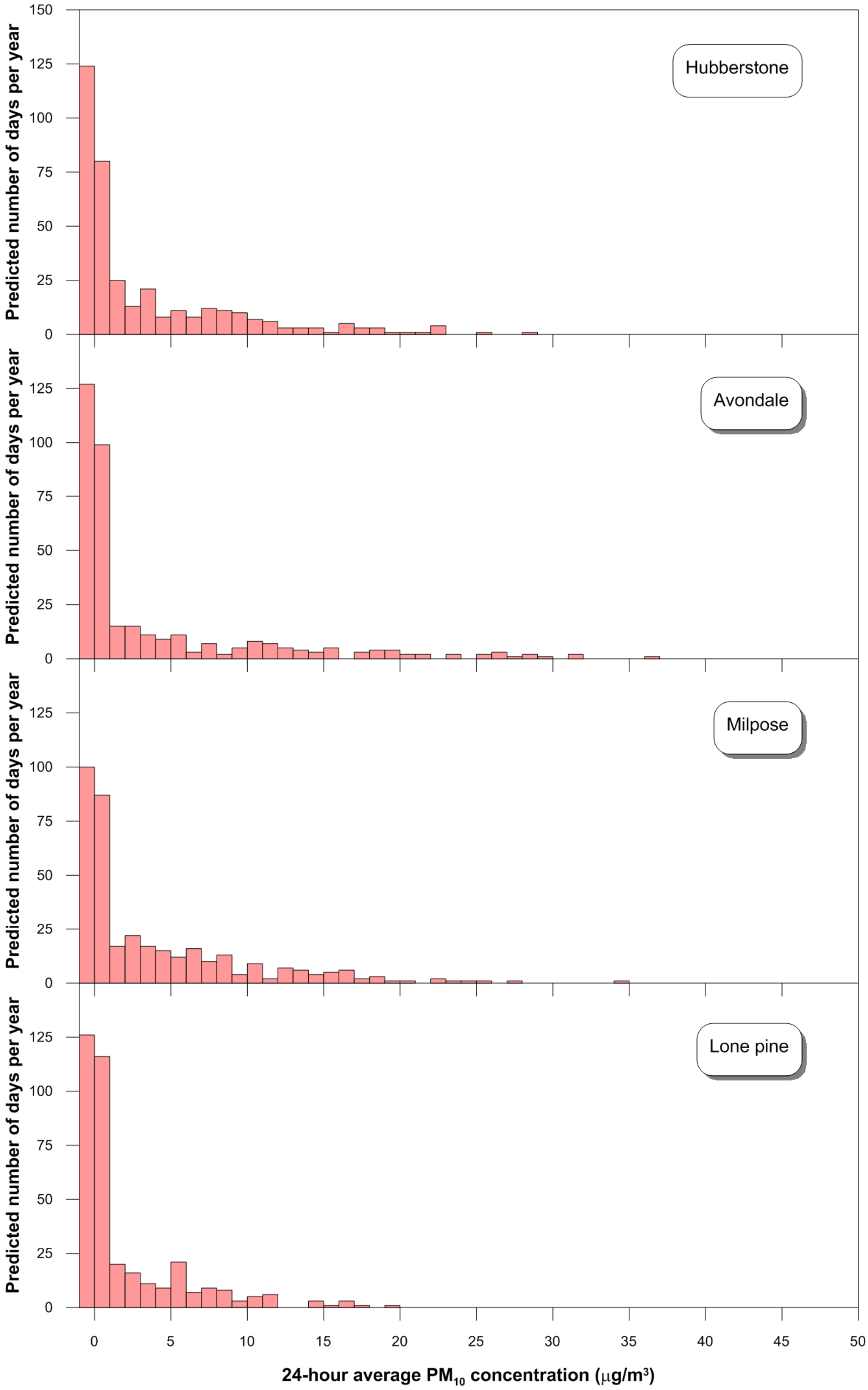
Figure 12 Predicted distribution of 24-hour average PM_{10} concentrations (existing)



▪ **Figure 13 Predicted distribution of 24-hour average PM_{10} concentrations (proposed)**



SKM

If it were assumed that the existing annual average PM_{10} concentration (say, 20 $\mu g/m^3$) occurred every day of the year then the assessment would be very much simplified as a maximum project contribution of around 30 $\mu g/m^3$ or more would be the point at which air quality impacts would be observed - assuming 50 $\mu g/m^3$ is the level at which impacts occur. However, existing PM_{10} concentrations will vary from day to day so **Table 13** has been constructed to show the approximate number of days when the cumulative PM_{10} concentration will exceed 50 $\mu g/m^3$ (due to the Project increment) for various background levels.

- **Table 13 Predicted number of days when PM_{10} concentration exceeds 50 $\mu g/m^3$**

Assumed background PM_{10} level ($\mu g/m^3$)	Permitted contribution from project before exceedance is predicted ($\mu g/m^3$)	Approximate number of exceedances of 50 $\mu g/m^3$ per year due to Project increment (proposed minus existing)			
		Hubberstone	Avondale	Milpose	Lone pine
10 or less (occurs 63% of the time)	40	0	0	0	0
20 (occurs 22% of the time)	30	0	0	0	0
30 (occurs 15% of the time)	20	0	6	2	0

From the information in **Table 13** it can be seen that, as the existing background levels increase, the potential for cumulative impacts (above 50 $\mu g/m^3$) also increases. When the background concentration is above average levels (say, 30 $\mu g/m^3$ or more), which according to the monitoring data in 2012 occurs about 15% of the time, there is potential that the mining activities will cause two or more exceedance days each year at some locations. The actual probability of an exceedance will be the probability of a high mine contribution coinciding with a high background level, which cannot be accurately quantified with the existing monitoring data and model results.

In summary, the model results have suggested that:

- Annual average PM_{10}, TSP and dust deposition levels will be in compliance with air quality criteria at sensitive receptors during Project operation.
- Proposed mining activities, on their own, will comply with the PM_{10} criterion (50 $\mu g/m^3$). However, there is a potential risk that existing and proposed activities will contribute to exceedances of the 24-hour average PM_{10} criterion (50 $\mu g/m^3$), especially if background levels are higher than average. Mining activities will need to be suitably managed to minimise or avoid these events (refer **Section 8**).
- The maximum 24-hour average PM_{10} concentrations due to proposed mining activities will be at levels that are unlikely to cause exceedances of the DP&I acquisition criterion (150 $\mu g/m^3$), taking account of background levels.

8. Mitigation, Monitoring and Management

The foregoing assessment has indicated that annual average PM_{10}, TSP and dust deposition levels will be in compliance with air quality criteria at sensitive receptors during Project operation. There is however a potential risk that existing and proposed activities will contribute to exceedances of the 24-hour average PM_{10} criterion (50 $\mu g/m^3$). The dispersion model used for this assessment is only indicative of the potential future impacts, so it will be important to manage site activities to avoid these exceedances as far as practicable. This section outlines suitable mitigation, monitoring and management measures for minimising daily impacts.

As noted in **Section 4**, the current monitoring program consists of two high volume air samplers, eleven dust deposition gauges, and a meteorological station. One of the difficulties in the evaluation of the high volume air sampler data has been understanding the meteorological conditions which led to the highest daily PM_{10} concentrations. As high volume air samplers produce one PM_{10} concentration record every six days, only general trends in associated meteorological conditions can be established. The understanding of "adverse" meteorological conditions for mining could be improved with the installation of one or more real-time PM_{10} monitors. The real-time monitor(s) would allow NPM to analyse hourly (or finer resolution) variations in PM_{10} levels, which would assist with operations management.

A monitoring program to identify "adverse" meteorological conditions, from the Project construction phase onwards, would therefore include the existing air quality and meteorological monitoring sites plus:

- One real-time PM_{10} monitor (such as a BAM or TEOM) to the southwest of NPM; and
- One real-time PM_{10} monitor (such as a BAM or TEOM) to the northeast of NPM.

NPM has an Environmental Dust Management Plan (DMP) which provides a framework to assess, monitor and manage potential dust impacts as a result of its activities. Specific measures in the DMP to manage air quality impacts are outlined below:

- *Environmental training and awareness to employees and contractors;*
- *Sealing high traffic roads, where possible;*
- *Copper concentrate product transported in sealed containers;*
- *Road sweeper used on sealed trafficable areas;*
- *Use of water carts on unsealed roads;*
- *Minimising clearing activities and undertaking progressive rehabilitation;*
- *Use of conveyor systems as opposed to haul trucks in the material handling system wherever possible;*
- *Control mechanisms on crushing and conveying infrastructure and transfer points, including complete or partial enclosure, dust extraction filters and mist sprays;*

- *Operation of the tailings storage facilities to minimise dust;*
- *Application of polymer coverage on TSF1 to minimise airborne dust generation;*
- *Daily proactive dust mitigation based on assess risk level;*
- *Dust controls on surface reverse circulation drill rigs; and*
- *Monthly air quality monitoring, including directional dust monitoring to obtain additional air quality information*

In addition to the current dust management measures listed above, it is anticipated that NPM will also adopt, where practicable, some general principles of dust management such as those listed below:

- Water sprays at material handling transfer points;
- Defining all roads and limiting access to minor and non designated access alignments roads;
- Imposition of speed limits on all internal roads;
- Disturbance of the minimum area practicable;
- Reshaping and rehabilitating stockpile and dump areas as soon as practicable;
- Dust suppressants fitted to drills;
- Design blasts to minimise dust; and
- Consideration of current and forecast weather conditions prior to blasting and other dust intensive activities.

9. Conclusions

This report has provided a quantitative assessment of the potential air quality impacts associated with the Northparkes Mines Step Change Project. Dispersion modelling has been used to predict off-site dust concentration and dust deposition levels due to identified dust generating activities, taking account of local meteorological conditions. The CALPUFF model was used for this assessment.

The main conclusions of this assessment were as follows:

- Annual average PM_{10}, TSP and dust deposition levels will be in compliance with air quality criteria at sensitive receptors during Project operation.
- Proposed mining activities, on their own, will comply with the PM_{10} criterion (50 $\mu g/m^3$). However, there is a potential risk that existing and proposed activities will contribute to exceedances of the 24-hour average PM_{10} criterion (50 $\mu g/m^3$), especially if background levels are higher than average.
- The maximum 24-hour average PM_{10} concentrations due to proposed mining activities will be at levels that are unlikely to cause exceedances of the DP&I acquisition criterion (150 $\mu g/m^3$), taking account of background levels.

A monitoring program has been recommended to help identify adverse meteorological conditions (in terms of elevated dust concentrations) and for developing targeted dust mitigation measures that will avoid exceedances of the PM_{10} criterion as far as practicable.

10. References

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Appendix A Meteorological data statistics

PASQUILL STABILITY CLASS 'A'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.001710	0.004077	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005786
NE	0.001184	0.004208	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005392
ENE	0.001578	0.004340	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005918
E	0.000132	0.004340	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004471
ESE	0.000789	0.002367	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003156
SE	0.000526	0.001973	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002499
SSE	0.002236	0.002104	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004340
S	0.001578	0.003419	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004997
SSW	0.001315	0.004340	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.005655
SW	0.001184	0.002367	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003551
WSW	0.000789	0.002367	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003156
W	0.000658	0.002104	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002762
WNW	0.000658	0.002104	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002762
NW	0.000789	0.002499	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003288
NNW	0.000395	0.003288	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003682
N	0.001841	0.004340	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006181
CALM									0.006970
TOTAL	0.017359	0.050237	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.074566

MEAN WIND SPEED (m/s) = 1.80
NUMBER OF OBSERVATIONS = 567

PASQUILL STABILITY CLASS 'B'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000789	0.001710	0.003551	0.000000	0.000000	0.000000	0.000000	0.000000	0.006049
NE	0.000526	0.000921	0.002499	0.000000	0.000000	0.000000	0.000000	0.000000	0.003945
ENE	0.000789	0.001184	0.002893	0.000000	0.000000	0.000000	0.000000	0.000000	0.004866
E	0.000000	0.000526	0.000789	0.000000	0.000000	0.000000	0.000000	0.000000	0.001315
ESE	0.000263	0.000132	0.000132	0.000000	0.000000	0.000000	0.000000	0.000000	0.000526
SE	0.000395	0.000263	0.000395	0.000000	0.000000	0.000000	0.000000	0.000000	0.001052
SSE	0.000526	0.000395	0.000921	0.000000	0.000000	0.000000	0.000000	0.000000	0.001841
S	0.001184	0.001315	0.001578	0.000000	0.000000	0.000000	0.000000	0.000000	0.004077
SSW	0.000263	0.001447	0.002630	0.000000	0.000000	0.000000	0.000000	0.000000	0.004340
SW	0.000263	0.001052	0.002630	0.000000	0.000000	0.000000	0.000000	0.000000	0.003945
WSW	0.000000	0.000921	0.001184	0.000000	0.000000	0.000000	0.000000	0.000000	0.002104
W	0.000000	0.000263	0.000789	0.000000	0.000000	0.000000	0.000000	0.000000	0.001052
WNW	0.000395	0.000263	0.000789	0.000000	0.000000	0.000000	0.000000	0.000000	0.001447
NW	0.000132	0.000395	0.001184	0.000000	0.000000	0.000000	0.000000	0.000000	0.001710
NNW	0.000000	0.000658	0.000921	0.000000	0.000000	0.000000	0.000000	0.000000	0.001578
N	0.000263	0.001184	0.003288	0.000000	0.000000	0.000000	0.000000	0.000000	0.004734
CALM									0.000132
TOTAL	0.005786	0.012625	0.026170	0.000000	0.000000	0.000000	0.000000	0.000000	0.044713

MEAN WIND SPEED (m/s) = 2.92
NUMBER OF OBSERVATIONS = 340

PASQUILL STABILITY CLASS 'C'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.000395	0.001578	0.001841	0.002762	0.000000	0.000000	0.000000	0.000000	0.006575
NE	0.000263	0.000789	0.001841	0.001052	0.000000	0.000000	0.000000	0.000000	0.003945
ENE	0.000132	0.001184	0.002893	0.001578	0.000000	0.000000	0.000000	0.000000	0.005786
E	0.000000	0.000395	0.001973	0.000658	0.000000	0.000000	0.000000	0.000000	0.003025
ESE	0.000263	0.000526	0.001052	0.000526	0.000000	0.000000	0.000000	0.000000	0.002367
SE	0.000132	0.000395	0.000263	0.000395	0.000000	0.000000	0.000000	0.000000	0.001184
SSE	0.001052	0.000921	0.000789	0.000789	0.000000	0.000000	0.000000	0.000000	0.003551
S	0.000921	0.002104	0.002367	0.001184	0.000000	0.000000	0.000000	0.000000	0.006575
SSW	0.000132	0.000789	0.004077	0.001973	0.000000	0.000000	0.000000	0.000000	0.006970
SW	0.000000	0.000526	0.004997	0.004077	0.000000	0.000000	0.000000	0.000000	0.009600
WSW	0.000132	0.000526	0.002236	0.003025	0.000000	0.000000	0.000000	0.000000	0.005918
W	0.000132	0.000395	0.000395	0.001710	0.000000	0.000000	0.000000	0.000000	0.002630
WNW	0.000132	0.000395	0.000789	0.001315	0.000000	0.000000	0.000000	0.000000	0.002630
NW	0.000000	0.000789	0.000789	0.001052	0.000000	0.000000	0.000000	0.000000	0.002630
NNW	0.000132	0.000789	0.001841	0.001315	0.000000	0.000000	0.000000	0.000000	0.004077
N	0.000132	0.001578	0.004997	0.002236	0.000000	0.000000	0.000000	0.000000	0.008943
CALM									0.000000
TOTAL	0.003945	0.013677	0.033140	0.025644	0.000000	0.000000	0.000000	0.000000	0.076407

MEAN WIND SPEED (m/s) = 3.93
NUMBER OF OBSERVATIONS = 581

PASQUILL STABILITY CLASS 'D'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.002367	0.008417	0.013940	0.012230	0.008943	0.004603	0.000526	0.000000	0.051026
NE	0.003814	0.008285	0.006444	0.009337	0.003682	0.000921	0.000789	0.000000	0.033272
ENE	0.002104	0.007628	0.009337	0.014203	0.008811	0.001578	0.000263	0.000000	0.043924
E	0.001052	0.004340	0.004866	0.003551	0.002499	0.000263	0.000000	0.000000	0.016570
ESE	0.000526	0.003419	0.001973	0.003288	0.001052	0.000132	0.000000	0.000000	0.010389
SE	0.001973	0.003025	0.001315	0.000921	0.000395	0.000263	0.000132	0.000000	0.008022
SSE	0.003419	0.007233	0.003814	0.000526	0.000526	0.000395	0.000000	0.000000	0.015913
S	0.004997	0.016833	0.006575	0.006049	0.002104	0.000658	0.000132	0.000132	0.037480
SSW	0.003945	0.007891	0.008680	0.008811	0.004866	0.000395	0.000000	0.000000	0.034587
SW	0.000921	0.005392	0.007496	0.011310	0.004866	0.001710	0.000000	0.000000	0.031694
WSW	0.000526	0.002104	0.003945	0.011178	0.007628	0.004208	0.001710	0.000132	0.031431
W	0.000658	0.001052	0.003025	0.003945	0.005392	0.001578	0.000000	0.000132	0.015781
WNW	0.000132	0.001578	0.001184	0.001710	0.001315	0.000526	0.000000	0.000000	0.006444
NW	0.000263	0.002104	0.001841	0.001447	0.000526	0.000395	0.000132	0.000132	0.006839
NNW	0.000263	0.002236	0.001973	0.003288	0.001973	0.001710	0.000526	0.000263	0.012230
N	0.000658	0.005523	0.009074	0.012888	0.009206	0.004471	0.001052	0.000000	0.042872
CALM									0.000789
TOTAL	0.027617	0.087059	0.085481	0.104682	0.063782	0.023803	0.005260	0.000789	0.399264

MEAN WIND SPEED (m/s) = 4.49
NUMBER OF OBSERVATIONS = 3036

PASQUILL STABILITY CLASS 'E'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.002104	0.006575	0.008943	0.002762	0.000000	0.000000	0.000000	0.000000	0.020384
NE	0.004997	0.013019	0.018674	0.001841	0.000000	0.000000	0.000000	0.000000	0.038532
ENE	0.003025	0.010521	0.020384	0.002893	0.000000	0.000000	0.000000	0.000000	0.036823
E	0.001184	0.006312	0.005129	0.000921	0.000000	0.000000	0.000000	0.000000	0.013546
ESE	0.001973	0.003551	0.003025	0.000526	0.000000	0.000000	0.000000	0.000000	0.009074
SE	0.002236	0.003419	0.001841	0.000263	0.000000	0.000000	0.000000	0.000000	0.007759
SSE	0.003419	0.007628	0.002367	0.000395	0.000000	0.000000	0.000000	0.000000	0.013809
S	0.007628	0.019463	0.009732	0.000658	0.000000	0.000000	0.000000	0.000000	0.037480
SSW	0.003156	0.013677	0.007628	0.000789	0.000000	0.000000	0.000000	0.000000	0.025250
SW	0.000921	0.010258	0.010258	0.001841	0.000000	0.000000	0.000000	0.000000	0.023277
WSW	0.000658	0.004077	0.004997	0.002104	0.000000	0.000000	0.000000	0.000000	0.011836
W	0.000263	0.001578	0.001447	0.000263	0.000000	0.000000	0.000000	0.000000	0.003551
WNW	0.000658	0.002762	0.000789	0.000263	0.000000	0.000000	0.000000	0.000000	0.004471
NW	0.000132	0.001184	0.000395	0.000000	0.000000	0.000000	0.000000	0.000000	0.001710
NNW	0.000526	0.002236	0.000395	0.000132	0.000000	0.000000	0.000000	0.000000	0.003288
N	0.000921	0.003551	0.001447	0.000263	0.000000	0.000000	0.000000	0.000000	0.006181
CALM									0.000658
TOTAL	0.033798	0.109811	0.097449	0.015913	0.000000	0.000000	0.000000	0.000000	0.257628

MEAN WIND SPEED (m/s) = 2.84
NUMBER OF OBSERVATIONS = 1959

PASQUILL STABILITY CLASS 'F'

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.003551	0.003156	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.006707
NE	0.007628	0.006312	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.013940
ENE	0.007759	0.007496	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.015255
E	0.003419	0.001315	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004734
ESE	0.004734	0.003156	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007891
SE	0.003814	0.000789	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.004603
SSE	0.006181	0.003814	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.009995
S	0.009206	0.011310	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.020516
SSW	0.003419	0.004997	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.008417
SW	0.003156	0.004077	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.007233
WSW	0.002104	0.000526	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002630
W	0.001710	0.000526	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002236
WNW	0.001841	0.000658	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002499
NW	0.001052	0.001578	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002630
NNW	0.001973	0.000526	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.002499
N	0.001710	0.001315	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.003025
CALM									0.032614
TOTAL	0.063256	0.051552	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.147422

MEAN WIND SPEED (m/s) = 1.28
NUMBER OF OBSERVATIONS = 1121

ALL PASQUILL STABILITY CLASSES

Wind Speed Class (m/s)

WIND SECTOR	0.50 TO 1.50	1.50 TO 3.00	3.00 TO 4.50	4.50 TO 6.00	6.00 TO 7.50	7.50 TO 9.00	9.00 TO 10.50	GREATER THAN 10.50	TOTAL
NNE	0.010915	0.025513	0.028275	0.017754	0.008943	0.004603	0.000526	0.000000	0.096528
NE	0.018411	0.033535	0.029458	0.012230	0.003682	0.000921	0.000789	0.000000	0.099027
ENE	0.015387	0.032351	0.035508	0.018674	0.008811	0.001578	0.000263	0.000000	0.112572
E	0.005786	0.017228	0.012756	0.005129	0.002499	0.000263	0.000000	0.000000	0.043661
ESE	0.008548	0.013151	0.006181	0.004340	0.001052	0.000132	0.000000	0.000000	0.033403
SE	0.009074	0.009863	0.003814	0.001578	0.000395	0.000263	0.000132	0.000000	0.025118
SSE	0.016833	0.022094	0.007891	0.001710	0.000526	0.000395	0.000000	0.000000	0.049448
S	0.025513	0.054445	0.020252	0.007891	0.002104	0.000658	0.000132	0.000132	0.111126
SSW	0.012230	0.033140	0.023014	0.011573	0.004866	0.000395	0.000000	0.000000	0.085218
SW	0.006444	0.023672	0.025381	0.017228	0.004866	0.001710	0.000000	0.000000	0.079300
WSW	0.004208	0.010521	0.012362	0.016307	0.007628	0.004208	0.001710	0.000132	0.057075
W	0.003419	0.005918	0.005655	0.005918	0.005392	0.001578	0.000000	0.000132	0.028012
WNW	0.003814	0.007759	0.003551	0.003288	0.001315	0.000526	0.000000	0.000000	0.020252
NW	0.002367	0.008548	0.004208	0.002499	0.000526	0.000395	0.000132	0.000132	0.018806
NNW	0.003288	0.009732	0.005129	0.004734	0.001973	0.001710	0.000526	0.000263	0.027354
N	0.005523	0.017491	0.018806	0.015387	0.009206	0.004471	0.001052	0.000000	0.071936
CALM									0.041163
TOTAL	0.151762	0.324961	0.242241	0.146239	0.063782	0.023803	0.005260	0.000789	1.000000

MEAN WIND SPEED (m/s) = 3.28
NUMBER OF OBSERVATIONS = 7604

STABILITY CLASS BY HOUR OF DAY

Hour	A	B	C	D	E	F
01	0000	0000	0000	0073	0149	0096
02	0000	0000	0000	0079	0134	0105
03	0000	0000	0000	0085	0140	0093
04	0000	0000	0000	0077	0145	0096
05	0000	0000	0000	0088	0143	0087
06	0003	0002	0002	0077	0143	0091
07	0028	0008	0015	0133	0077	0057
08	0038	0013	0012	0197	0032	0026
09	0041	0011	0034	0232	0000	0000
10	0043	0010	0039	0224	0000	0000
11	0041	0018	0067	0189	0000	0000
12	0050	0034	0081	0150	0000	0000
13	0061	0055	0065	0134	0000	0000
14	0071	0051	0073	0120	0000	0000
15	0071	0046	0070	0129	0000	0000
16	0069	0045	0064	0138	0000	0000
17	0042	0031	0044	0165	0014	0020
18	0009	0016	0015	0188	0056	0033
19	0000	0000	0000	0169	0107	0041
20	0000	0000	0000	0105	0172	0040
21	0000	0000	0000	0058	0186	0073
22	0000	0000	0000	0066	0168	0083
23	0000	0000	0000	0070	0156	0091
24	0000	0000	0000	0090	0137	0089

```
-------------------------------------------
FREQUENCY OF OCCURENCE OF STABILITY CLASSES
-------------------------------------------
  A : 7.5%
  B : 4.5%
  C : 7.6%
  D : 39.9%
  E : 25.8%
  F : 14.7%

--------------------------------
STABILITY CLASS BY MIXING HEIGHT
--------------------------------
Mixing height    A    B    C    D    E    F
    <=500 m    0103 0020 0047 0555 1922 1076
   <=1000 m    0134 0065 0178 1201 0008 0008
   <=1500 m    0330 0255 0356 0884 0029 0037
   <=2000 m    0000 0000 0000 0227 0000 0000
   <=3000 m    0000 0000 0000 0164 0000 0000
    >3000 m    0000 0000 0000 0005 0000 0000

----------------------------
MIXING HEIGHT BY HOUR OF DAY
----------------------------
       0000  0100  0200  0400  0800  1600  Greater
        to    to    to    to    to    to   than
Hour   0100  0200  0400  0800  1600  3200  3200
  01   0079  0088  0087  0016  0021  0027  0000
  02   0092  0071  0082  0027  0021  0025  0000
  03   0074  0095  0073  0026  0028  0022  0000
  04   0080  0089  0080  0021  0023  0025  0000
  05   0085  0084  0082  0026  0020  0021  0000
  06   0098  0133  0062  0011  0004  0010  0000
  07   0061  0085  0126  0037  0005  0004  0000
  08   0000  0081  0098  0139  0000  0000  0000
  09   0000  0000  0087  0192  0039  0000  0000
  10   0000  0000  0000  0199  0117  0000  0000
  11   0000  0000  0000  0125  0190  0000  0000
  12   0000  0000  0000  0072  0243  0000  0000
  13   0000  0000  0000  0052  0263  0000  0000
  14   0000  0000  0000  0000  0315  0000  0000
  15   0000  0000  0000  0000  0316  0000  0000
  16   0000  0000  0000  0000  0316  0000  0000
  17   0000  0000  0000  0000  0316  0000  0000
  18   0007  0019  0029  0005  0224  0032  0001
  19   0020  0046  0069  0014  0122  0046  0000
  20   0021  0088  0105  0018  0043  0042  0000
  21   0040  0104  0119  0016  0013  0025  0000
  22   0055  0102  0095  0017  0017  0030  0001
  23   0070  0087  0095  0021  0017  0027  0000
  24   0068  0084  0086  0025  0024  0029  0000
```

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Appendix B Emission calculations

The dust emission inventories have been formulated from the operational description of the proposed mining activities provided by NPM (via Umwelt). Estimated emissions are presented for all significant dust generating activities associated with the operations. The relevant emission factors used for the study are described below.

Dozers stripping topsoil

An emission rate of 14 kg/h has been used for dozers stripping topsoil and shaping overburden dumps (SPCC, 1983).

Drilling overburden

The emission factor used for drilling has been taken to be 0.59 kg/hole (US EPA, 1985 and updates).

Blasting overburden

TSP emissions from blasting were estimated using the US EPA (1985 and updates) emission factor equation given in Equation 1.

Equation 1

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

where,
A = area to be blasted in m^2

Loading / unloading ore and overburden

Each tonne of material loaded will generate a quantity of TSP that will depend on the wind speed and the moisture content. Equation 2 shows the relationship between these variables.

Equation 2

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

where,
E_{TSP} = *TSP emissions*
$k = 0.74$
U = *wind speed (m/s)*
M = *moisture content (%)*
[where $0.25 \le M \le 4.8$*]*

Hauling over on unsealed surfaces

After the application of water and/or chemical dust suppressant the emission factor used for trucks hauling overburden or ROM ore on unsealed surfaces was 1 kg per vehicle kilometre travelled (kg/VKT). This represents 75% control efficiency.

Dozers on overburden and in pit

Emissions from dozers on overburden have been calculated using the US EPA emission factor equation (US EPA, 1985 and updates). The equation is as follows:

Equation 3

$$E_{TSP} = 2.6 \times \frac{s^{1.2}}{M^{1.3}} \qquad \text{kg/hour}$$

where,
E_{TSP} = *TSP emissions*
s = silt content (%), and
M = moisture (%)

Wind erosion

The emission factor for wind erosion is given in Equation 4 below.

Equation 4

$$E_{TSP} = 1.9 \times \left(\frac{s}{1.5}\right) \times \left(\frac{365 - p}{235}\right) \times \left(\frac{f}{15}\right) \qquad \text{kg/ha/day}$$

where,
s = silt content (%)
p = number of raindays per year, and
f = percentage of the time that wind speed is above 5.4 m/s

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Grading roads

Estimated of TSP emissions from grading roads have been made using the US EPA (1985 and updates) emission factor equation (Equation 5).

Equation 5

$$E_{TSP} = 0.0034 \times S^{2.5} \qquad \text{kg/VKT}$$

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

Existing (approved):

ACTIVITY	TSP emission/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units
E31 - Drilling	-	-	holes/y	0.59	kg/hole						
E28 - Blasting	-	-	blasts/y	28	kg/blast	2500	Area of blast in square metres				
E26 - Blasting	-	-	blasts/y	28	kg/blast	2500	Area of blast in square metres				
E31 - Blasting	-	-	blasts/y	28	kg/blast	2500	Area of blast in square metres				
E28 - Sh/Ex/FELs loading overburden	-	-	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E26 - Sh/Ex/FELs loading overburden	-	-	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E31 - Sh/Ex/FELs loading overburden	-	-	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E28 - Hauling to emplacement areas	-	-	t/y	0.00752	kg/t	133	t/truck load	1	km/return trip	1.0	kg/VKT
E26 - Hauling to emplacement areas	-	-	t/y	0.00902	kg/t	133	t/truck load	1.2	km/return trip	1.0	kg/VKT
E31 - Hauling to emplacement areas	-	-	t/y	0.00752	kg/t	133	t/truck load	1	km/return trip	1.0	kg/VKT
E28 - Emplacing at dumps	-	-	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E26 - Emplacing at dumps	-	-	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E31 - Emplacing at dumps	-	-	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E28 - Dozers working in pit	-	-	h/y	16.7	kg/h	10	silt content (%)	2	moisture content (%)		
E26 - Dozers working in pit	-	-	h/y	16.7	kg/h	10	silt content (%)	2	moisture content (%)		
E31 - Dozers working in pit	-	-	h/y	16.7	kg/h	10	silt content (%)	2	moisture content (%)		
E28 - Loading ROM ore to trucks	-	-	t/y	0.25246	kg/t	2	moisture content (%)				
E26 - Loading ROM ore to trucks	-	-	t/y	0.25246	kg/t	2	moisture content (%)				
E31 - Loading ROM ore to trucks	-	-	t/y	0.25246	kg/t	2	moisture content (%)				
E28 - Hauling ROM ore to surface crusher from pit	-	-	t/y	0.03910	kg/t	133	t/load	5.2	km/return trip	1.0	kg/VKT
E26 - Hauling ROM ore to surface crusher from pit	-	-	t/y	0.05865	kg/t	133	t/load	7.8	km/return trip	1.0	kg/VKT
E31 - Hauling ROM ore to surface crusher from pit	-	-	t/y	0.05865	kg/t	133	t/load	7.8	km/return trip	1.0	kg/VKT
Unloading ore from UG/OC to surface crusher	18,035	8,500,000	t/y	0.00212	kg/t	1.792	average (ws/2.2)^1.3	2	moisture content (%)		
Primary ore crushing	85,000	8,500,000	t/y	0.01000	kg/t						
Transfer by conveyor to mill	18,035	8,500,000	t/y	0.00212	kg/t	1.792	av of (ws/2.2)^1.3 in m/	2	moisture content (%)		
Unloading ore to stockpile	34,000	8,500,000	t/y	0.00400	kg/t						
Ore processing in mill	-	8,500,000	t/y	0.00000	kg/t						
Transporting concentrate off site (pipeline)	-	8,500,000	t/y	0.00000	kg/t						
Wind erosion - plant stockpiles and exposed areas	202,421	77.3	ha	2620.3	kg/ha/y	86	Av no. of raindays	5	silt content (%)	14.3214	% of winds above 5.4 m/s
Wind erosion - tailings storage dams	608,729	232.3	ha	2620.3	kg/ha/y	86	Av no. of raindays	5	silt content (%)	14.3214	% of winds above 5.4 m/s
Ventilation shaft emissions	97,762	8,760	h/y	11.16	kg/h	1116000	m3/h	10.00	mg/m3		
Tailings construction - dozers working on tailings lifts	43,193	14,600	h/y	3.0	kg/h	5	silt content (%)	4	moisture content (%)		
Tailings construction - loading trucks	675	839,500	t/y	0.00080	kg/t	1.792	average (ws/2.2)^1.3	4	moisture content (%)		
Tailings construction - trucks hauling	33,580	839,500	t/y	0.04000	kg/t	50	t/load	2	km/return trip	1.0	kg/VKT
Tailings construction - trucks dumping	675	839,500	t/y	0.00080	kg/t	1.792	average (ws/2.2)^1.3	4	moisture content (%)		
Grading roads	36,928	60,000	km	0.61547	kg/VKT	8	speed of graders in km/h				

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Proposed:

ACTIVITY	TSP emission/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units
E28 - Stripping topsoil	-	-	h/y	14.0	kg/h						
E26 - Stripping topsoil	5,110	365	h/y	14.0	kg/h						
E31 - Stripping topsoil	5,110	365	h/y	14.0	kg/h						
E28 - Drilling	-	-	holes/y	0.59	kg/hole						
E26 - Drilling	1,077	1,825	holes/y	0.59	kg/hole						
E31 - Drilling	1,077	1,825	holes/y	0.59	kg/hole						
E28 - Blasting	-	-	blasts/y	28	kg/blast	2500	Area of blast in square metres				
E26 - Blasting	5,019	183	blasts/y	28	kg/blast	2500	Area of blast in square metres				
E31 - Blasting	5,019	183	blasts/y	28	kg/blast	2500	Area of blast in square metres				
E28 - Sh/Ex/FELs loading overburden	-	-	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E26 - Sh/Ex/FELs loading overburden	16,477	7,765,626	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E31 - Sh/Ex/FELs loading overburden	4,033	1,900,613	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E28 - Hauling to emplacement areas	-	-	t/y	0.00752	kg/t	133	t/truck load	1	km/return trip	1.0	kg/VKT
E26 - Hauling to emplacement areas	70,066	7,765,626	t/y	0.00902	kg/t	133	t/truck load	1.2	km/return trip	1.0	kg/VKT
E31 - Hauling to emplacement areas	14,290	1,900,613	t/y	0.00752	kg/t	133	t/truck load	1	km/return trip	1.0	kg/VKT
E28 - Emplacing at dumps	-	-	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E26 - Emplacing at dumps	16,477	7,765,626	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E31 - Emplacing at dumps	4,033	1,900,613	t/y	0.00212	kg/t	1.792	average of (wind speed	2	moisture content (%)		
E28 - Dozers working in pit	-	-	h/y	16.7	kg/h	10	silt content (%)	2	moisture content (%)		
E26 - Dozers working in pit	268,769	16,060	h/y	16.7	kg/h	10	silt content (%)	2	moisture content (%)		
E31 - Dozers working in pit	134,385	8,030	h/y	16.7	kg/h	10	silt content (%)	2	moisture content (%)		
E28 - Loading ROM ore to trucks	-	-	t/y	0.25246	kg/t	2	moisture content (%)				
E26 - Loading ROM ore to trucks	35,540	140,774	t/y	0.25246	kg/t	2	moisture content (%)				
E31 - Loading ROM ore to trucks	72,352	286,587	t/y	0.25246	kg/t	2	moisture content (%)				
E28 - Hauling ROM ore to surface crusher from pit	-	-	t/y	0.03910	kg/t	133	t/load	5.2	km/return trip	1.0	kg/VKT
E26 - Hauling ROM ore to surface crusher from pit	8,256	140,774	t/y	0.05865	kg/t	133	t/load	7.8	km/return trip	1.0	kg/VKT
E31 - Hauling ROM ore to surface crusher from pit	16,807	286,587	t/y	0.05865	kg/t	133	t/load	7.8	km/return trip	1.0	kg/VKT
Unloading ore from UG/OC to surface crusher	18,035	8,500,000	t/y	0.00212	kg/t	1.792	average (ws/2.2)^1.3	2	moisture content (%)		
Primary ore crushing	85,000	8,500,000	t/y	0.01000	kg/t						
Transfer by conveyor to mill	18,035	8,500,000	t/y	0.00212	kg/t	1.792	av of (ws/2.2)^1.3 in m/	2	moisture content (%)		
Unloading ore to stockpile	34,000	8,500,000	t/y	0.00400	kg/t						
Ore processing in mill	-	8,500,000	t/y	0.00000	kg/t						
Transporting concentrate off site (pipeline)	-	8,500,000	t/y	0.00000	kg/t						
Wind erosion - plant stockpiles and exposed areas	545,738	208.3	ha	2620.3	kg/ha/y	86	Av no. of raindays	5	silt content (%)	14.3214	% of winds above 5.4 m/s
Wind erosion - tailings storage dams	686,433	262.0	ha	2620.3	kg/ha/y	86	Av no. of raindays	5	silt content (%)	14.3214	% of winds above 5.4 m/s
Ventilation shaft emissions	97,762	8,760	h/y	11.16	kg/h	1116000	m3/h	10.00	mg/m3		
Tailings construction - dozers working on tailings lifts	43,193	14,600	h/y	3.0	kg/h	5	silt content (%)	4	moisture content (%)		
Tailings construction - loading trucks	675	839,500	t/y	0.00080	kg/t	1.792	average (ws/2.2)^1.3	4	moisture content (%)		
Tailings construction - trucks hauling	33,580	839,500	t/y	0.04000	kg/t	50	t/load	2	km/return trip	1.0	kg/VKT
Tailings construction - trucks dumping	675	839,500	t/y	0.00080	kg/t	1.792	average (ws/2.2)^1.3	4	moisture content (%)		
Grading roads	36,928	60,000	km	0.61547	kg/VKT	8	speed of graders in km/h				

An example (proposed) of the dust emission estimates for each activity, activity type, location of emission sources and activity hours is provided below. The location of the sources can be obtained from **Figure 9**. The CALPUFF input files can be provided on request.

```
-------------------------------      03-Apr-2013 16:35
  DUST EMISSION CALCULATIONS V3
 -------------------------------

 Output emissions file  : C:\Users\SLakmaker\Projects\EN03022_Northparkes\calpuff\2016\emiss.vol
 Meteorological file    : C:\Users\SLakmaker\Projects\EN03022_Northparkes\calmet\met.aus
 Number of dust sources : 110
 Number of activities   : 41
 Pollutant mode         : FP, CM, RE
 No-blast conditions    : None
 Wind sensitive factor  : 1.785 (1.821 adjusted for activity hours)
 Wind erosion factor    : 77.065

  -----ACTIVITY SUMMARY-----
 ACTIVITY NAME : E28 - Stripping topsoil
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 4
13 14 15 16
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E26 - Stripping topsoil
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 5110 kg/y
 FROM SOURCES  : 8
5 6 7 8 9 10 11 12
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

```
 ACTIVITY NAME : E31 - Stripping topsoil
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 5110 kg/y
 FROM SOURCES  : 4
17 18 19 20
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E28 - Drilling
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 4
13 14 15 16
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E26 - Drilling
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 1077 kg/y
 FROM SOURCES  : 8
5 6 7 8 9 10 11 12
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E31 - Drilling
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 1077 kg/y
 FROM SOURCES  : 4
17 18 19 20
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E28 - Blasting
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 4
13 14 15 16
 HOURS OF DAY  :
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0

 ACTIVITY NAME : E26 - Blasting
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 5019 kg/y
 FROM SOURCES  : 8
5 6 7 8 9 10 11 12
 HOURS OF DAY  :
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0

 ACTIVITY NAME : E31 - Blasting
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 5019 kg/y
 FROM SOURCES  : 4
17 18 19 20
 HOURS OF DAY  :
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0

 ACTIVITY NAME : E28 - Sh/Ex/FELs loading overburden
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 4
13 14 15 16
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E26 - Sh/Ex/FELs loading overburden
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 16477 kg/y
 FROM SOURCES  : 8
5 6 7 8 9 10 11 12
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

```
 ACTIVITY NAME : E31 - Sh/Ex/FELs loading overburden
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 4033 kg/y
 FROM SOURCES  : 4
17 18 19 20
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E28 - Hauling to emplacement areas
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 12
13 14 15 16 45 46 47 48 49 53 54 55
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E26 - Hauling to emplacement areas
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 70066 kg/y
 FROM SOURCES  : 25
5 6 7 8 9 10 11 12 21 22 23 24 25 26 27 28 33 34 35 36 37 38 39 40 41
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E31 - Hauling to emplacement areas
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 14290 kg/y
 FROM SOURCES  : 7
17 18 19 20 56 57 58
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E28 - Emplacing at dumps
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 3
53 54 55
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E26 - Emplacing at dumps
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 16477 kg/y
 FROM SOURCES  : 20
22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E31 - Emplacing at dumps
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 4033 kg/y
 FROM SOURCES  : 3
56 57 58
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E28 - Dozers working in pit
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 4
13 14 15 16
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E26 - Dozers working in pit
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 268769 kg/y
 FROM SOURCES  : 8
5 6 7 8 9 10 11 12
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

```
 ACTIVITY NAME : E31 - Dozers working in pit
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 134385 kg/y
 FROM SOURCES  : 4
17 18 19 20
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E28 - Loading ROM ore to trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 4
13 14 15 16
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E26 - Loading ROM ore to trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 35540 kg/y
 FROM SOURCES  : 8
5 6 7 8 9 10 11 12
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E31 - Loading ROM ore to trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 72352 kg/y
 FROM SOURCES  : 4
17 18 19 20
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E28 - Hauling ROM ore to surface crusher from pit
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 11
1 13 14 15 16 44 45 46 47 48 49
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E26 - Hauling ROM ore to surface crusher from pit
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 8256 kg/y
 FROM SOURCES  : 12
1 5 6 7 8 9 10 11 12 42 43 44
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : E31 - Hauling ROM ore to surface crusher from pit
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 16807 kg/y
 FROM SOURCES  : 20
1 17 18 19 20 56 57 58 59 60 63 64 65 66 67 68 69 70 71 72
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Unloading ore from UG/OC to surface crusher
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 18035 kg/y
 FROM SOURCES  : 3
1 3 4
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Primary ore crushing
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 85000 kg/y
 FROM SOURCES  : 1
1
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
```

```
 ACTIVITY NAME : Transfer by conveyor to mill
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 18035 kg/y
 FROM SOURCES  : 3
2 3 4
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Unloading ore to stockpile
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 34000 kg/y
 FROM SOURCES  : 2
3 4
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Ore processing in mill
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 2
3 4
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Transporting concentrate off site (pipeline)
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 0 kg/y
 FROM SOURCES  : 2
3 4
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Wind erosion - plant stockpiles and exposed areas
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 545738 kg/y
 FROM SOURCES  : 46
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 53 54 55
108 109 110
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Wind erosion - tailings storage dams
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 686433 kg/y
 FROM SOURCES  : 40
58 59 60 61 62 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105
106 107
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Ventilation shaft emissions
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 97762 kg/y
 FROM SOURCES  : 4
1 108 109 110
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Tailings construction - dozers working on tailings lifts
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 43193 kg/y
 FROM SOURCES  : 23
58 59 60 61 62 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107
 HOURS OF DAY  :
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0

 ACTIVITY NAME : Tailings construction - loading trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 675 kg/y
 FROM SOURCES  : 23
58 59 60 61 62 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107
```

```
 HOURS OF DAY  :
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0

 ACTIVITY NAME : Tailings construction - trucks hauling
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 33580 kg/y
 FROM SOURCES  : 23
58 59 60 61 62 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107
 HOURS OF DAY  :
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0

 ACTIVITY NAME : Tailings construction - trucks dumping
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 675 kg/y
 FROM SOURCES  : 23
58 59 60 61 62 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107
 HOURS OF DAY  :
0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0

 ACTIVITY NAME : Grading roads
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 36928 kg/y
 FROM SOURCES  : 110
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44
45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85
86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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Source locations:

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x,y,z,id
598009,6355332,283,1
598306,6357324,286,2
598402,6357569,286,3
598655,6357542,287,4
597738,6354851,280,5
597991,6355035,284,6
597720,6354554,284,7
597965,6354773,284,8
598245,6354904,289,9
597982,6354493,288,10
598192,6354659,289,11
598446,6354816,289,12
597904,6355786,281,13
598026,6355856,282,14
598498,6356319,289,15
598472,6356485,288,16
600132,6356433,291,17
600132,6356310,292,18
600237,6355734,291,19
600359,6355751,292,20
597589,6354554,284,21
597336,6354711,281,22
597318,6354467,284,23
597091,6354484,283,24
597074,6354694,281,25
597240,6354904,281,26
597030,6355008,280,27
597213,6355192,280,28
597021,6355323,280,29
597441,6355367,281,30
597205,6355507,279,31
597030,6355620,279,32
598603,6355332,282,33
598690,6355157,283,34
598874,6354974,285,35
598970,6354720,287,36
598708,6354703,289,37
598795,6354519,289,38
598507,6354475,290,39
598559,6354274,289,40
598384,6354196,290,41
598419,6355043,287,42
598245,6355166,286,43
598183,6355419,284,44
598192,6355707,282,45
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598349,6355786,282,46
598559,6355943,285,47
598647,6356223,289,48
598673,6356468,289,49
598542,6356704,287,50
598376,6356852,287,51
598314,6357062,286,52
598280,6356109,287,53
598428,6356083,287,54
598349,6355978,285,55
600307,6356284,293,56
600281,6356005,293,57
600019,6356031,290,58
599704,6356092,287,59
599372,6356127,285,60
599555,6356241,287,61
599905,6356179,290,62
599258,6356372,284,63
599118,6356616,286,64
599005,6356826,287,65
598900,6357027,288,66
598865,6357359,288,67
598926,6357656,287,68
598970,6357875,286,69
598664,6357971,285,70
598393,6357979,286,71
598253,6357813,286,72
598393,6359657,286,73
598725,6359797,286,74
599066,6359963,284,75
598533,6359369,284,76
598856,6359517,286,77
599241,6359622,288,78
598743,6359045,285,79
599005,6359194,286,80
599398,6359342,285,81
599127,6358495,286,82
599424,6358670,288,83
599826,6358888,289,84
599232,6358241,285,85
599634,6358434,284,86
600019,6358643,287,87
599686,6358137,281,88
600097,6358346,282,89
599267,6357883,286,90
599686,6357796,288,91
600185,6357726,288,92
600622,6357639,285,93
601067,6357525,285,94
600456,6357944,285,95
601024,6357228,285,96
600473,6357324,285,97
599984,6357394,287,98
599494,6357481,288,99
599162,6357245,289,100
599739,6357123,287,101
600263,6357027,286,102
600770,6356905,286,103
600989,6356511,290,104
600438,6356599,289,105
599922,6356704,289,106
599416,6356782,287,107
597974,6357848,285,108
597511,6357682,287,109
597091,6357700,286,110
597741,6359432,281,111
597700,6359128,282,112
597670,6358804,284,113
598054,6358865,287,114
598075,6359169,283,115
598075,6359472,283,116
598378,6358895,287,117
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