

APPENDIX 6: AIR QUALITY IMPACT ASSESSMENT



AIR QUALITY IMPACT ASSESSMENT CABBAGE TREE ROAD QUARRY EXTENSION

Wedgetail Project Consulting

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Air Quality Impact Assessment

Cabbage Tree Road Quarry Extension

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1 INTRODUCTION

Todoroski Air Sciences has prepared this report for Wedgetail Project Consulting. The report presents an assessment of the potential air quality impacts associated with the proposed modification to the Cabbage Tree Road Quarry located at 282 Cabbage Tree Road, Williamstown, New South Wales (NSW) (hereafter referred to as the Modification).

The site is currently approved for the quarrying of materials at a maximum annual production rate of 530,000 tonnes per annum (tpa). The Modification is seeking to expand the quarry operations, primarily to allow extraction in a new area immediately to the west of the site. There are no proposed changes to the existing approved maximum annual production rate, the onsite processing of material at the site or hours of operation.

The report presents an assessment of potential air quality impacts associated with the Modification. This air quality impact assessment has been prepared in general accordance with the NSW Environment Protection Authority (EPA) document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2022).

To assess the potential air quality impacts associated with the Modification, this report comprises:

- ✦ A background to the Modification and description of the proposed site and operations;
- ✦ A review of the existing meteorological and air quality environment surrounding the site;
- ✦ A description of the dispersion modelling approach and emission estimation used to assess potential air quality impacts; and,
- ✦ Presentation of the predicted results and discussion of the potential air quality impacts and associated mitigation and management measures.

1.1 Overview of existing operations

The Cabbage Tree Road Quarry (the site) is an existing sand quarry located in Williamstown in the Port Stephens local government area (LGA). Development Consent SSD_6125 was approved on 9 May 2018 with construction at the site commencing in August 2019 and the quarry commencing operations in May 2020.

SSD_6125 allows for the extraction and processing of up to 530,000 tpa of sand product. Approved operating hours for the site are outlined in **Table 1-1**.

Table 1-1: Operating hours

Activity	Permissible hours
Quarrying operations	7am to 5pm Monday to Friday 7am to 4pm Saturday At no time on Sundays or public holidays
Loading and dispatch of laden trucks	6am to 6pm Monday to Friday 7am to 4pm Saturday At no time on Sundays or public holidays
Maintenance	May be conducted at any time, provided that these activities are not audible at any privately-owned residence



SSD_6125 has been modified on two occasions to date to allow for a trial to supply up to 5,000 tonnes of specific sand for glass manufacturing and to permit the inclusion of a sand washing plant onsite.

1.2 Modification description

This Modification seeks to expand the quarry operations to allow extraction in a new area immediately to the west of the site (Western Extension) and a minor expansion of some areas and relinquishment of other areas. Existing quarrying methods would continue to be employed with production levels remaining at the currently approved 530,000tpa.

2 LOCAL SETTING

The Cabbage Tree Road Quarry is located approximately 14 kilometres (km) northeast of Newcastle and approximately 13km east of Beresfield. The area surrounding the site is predominantly comprised of rural residences and bushland, with the coastline approximately 7km southeast.

Table 2-1 identifies the receptor locations considered in this assessment. **Figure 2-1** presents the location of the site and the proposed extensions with reference to the nearby receptors. The nearest residential receptor to the proposed Western Extension (R14) is located approximately 35 metres (m) west.

Table 2-1: Assessed receptor locations

Receptor ID	Easting (m)	Northing (m)	Address	Approximate distance from Modification (m)
R14	387178	6369033	14 Barrie Close	35
R16	386777	6368663	19 Barrie Close	105
R24	387182	6368812	464 Cabbage Tree Road	160
R25	387243	6368797	458 Cabbage Tree Road	140
R26	387298	6368797	452 Cabbage Tree Road	125
R27	387390	6368791	444 Cabbage Tree Road	115
R35	387450	6368645	435 Cabbage Tree Road	120
R36	387514	6368640	431 Cabbage Tree Road	110
R37	387584	6368632	425 Cabbage Tree Road	115
R38	387654	6368636	415 Cabbage Tree Road	95
R39	387716	6368639	409 Cabbage Tree Road	95
R40	387753	6368641	407 Cabbage Tree Road	100
R41	387826	6368639	397 Cabbage Tree Road	80

Figure 2-2 presents a pseudo three-dimensional visualisation of the topography in the general vicinity of the site. The local topography surrounding the site is relatively flat, with a body of water to the south.

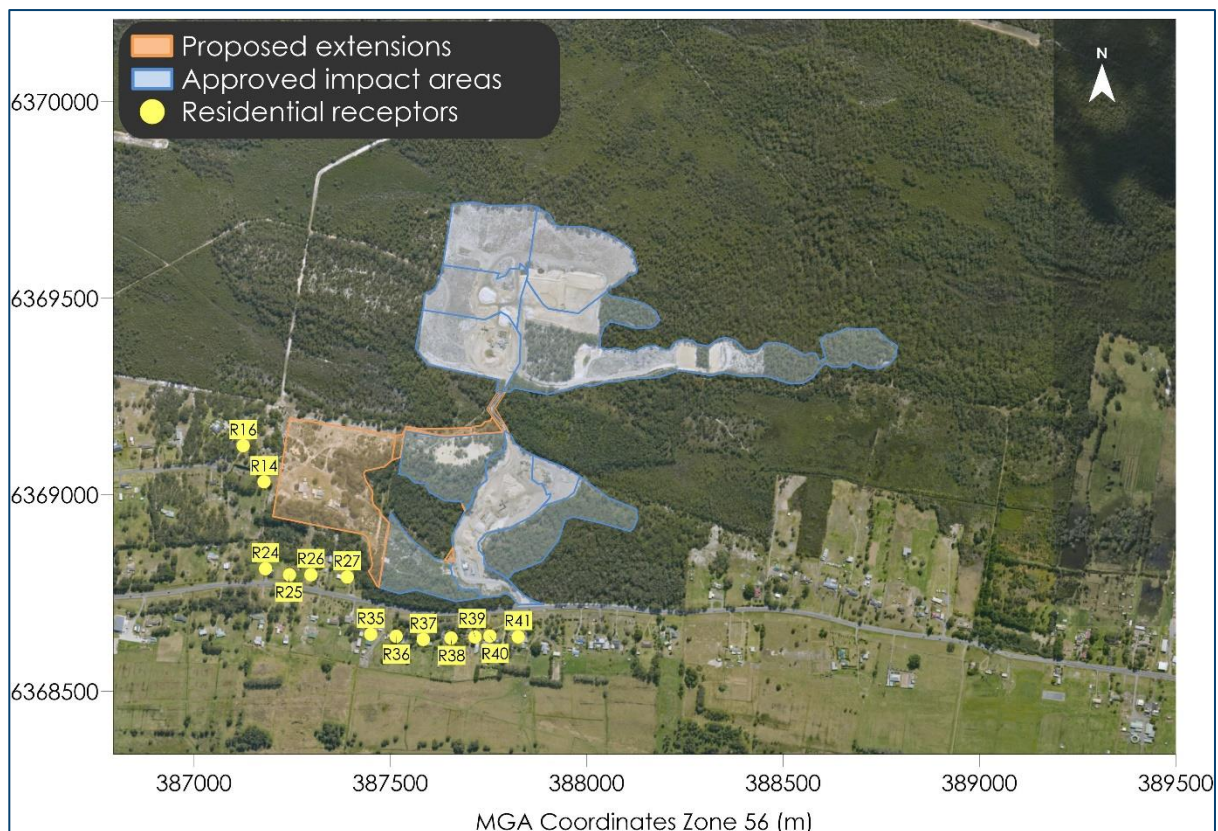


Figure 2-1: Local setting

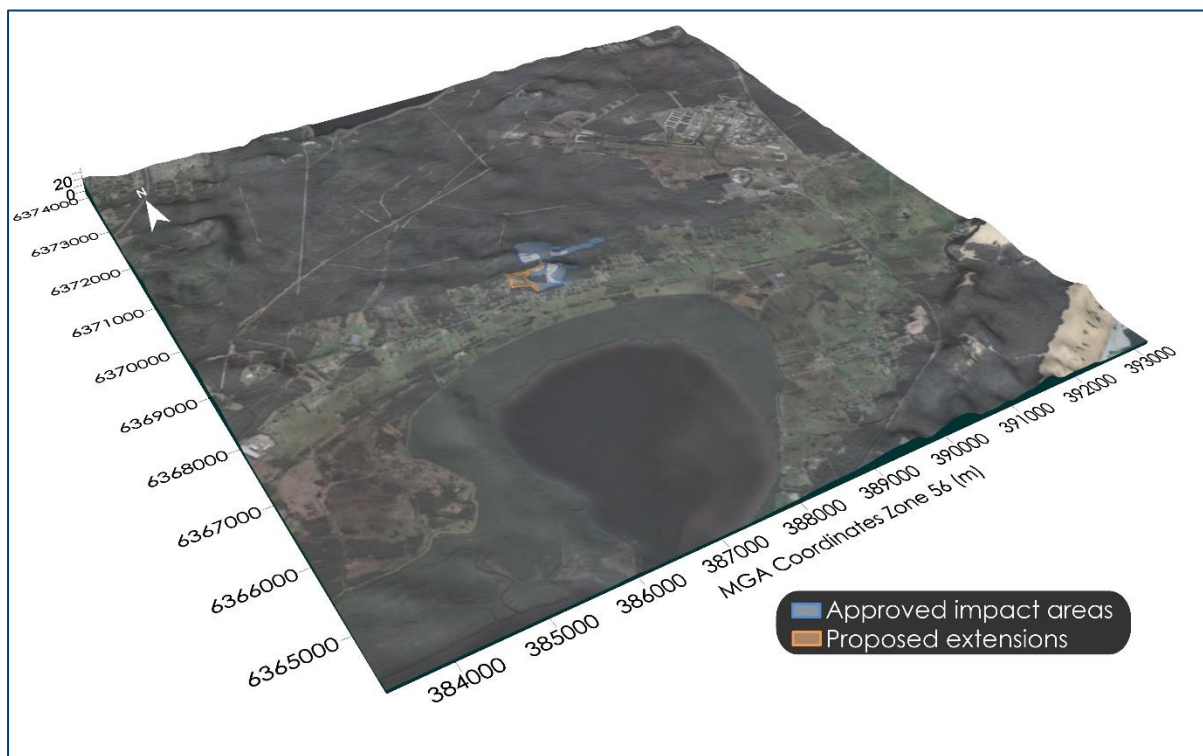


Figure 2-2: Representative visualisation of topography in the area surrounding the site

3 AIR QUALITY CRITERIA

Air quality goals are set to protect the general health and amenity of the community. The sections below identify the potential air emissions generated by the Modification and the applicable air quality goal.

3.1 Particulate matter

Particulate matter consists of dust particles of varying size and composition. Air quality goals refer to measures of the total mass of all particles suspended in air defined as the Total Suspended Particulate matter (TSP). The upper size range for TSP is nominally taken to be 30 micrometres (μm) as in practice particles larger than 30 to 50 μm will settle out of the atmosphere too quickly to be regarded as air pollutants. Two sub-classes of TSP are also included in the air quality goals, namely PM_{10} , particulate matter with equivalent aerodynamic diameters of 10 μm or less, and $\text{PM}_{2.5}$, particulate matter with equivalent aerodynamic diameters of 2.5 μm or less.

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

3.2 Project approved limits

A summary of the applicable air quality criteria for the Cabbage Tree Road Quarry as outlined in SSD-6125 is presented in **Table 3-1**.

The Cabbage Tree Road Quarry must ensure that all reasonable and feasible avoidance and mitigation measures are employed so that particulate matter emissions generated by the development do not cause exceedances of the criteria in **Table 3-1** at any residence on privately-owned land.

Table 3-1: Summary of applicable air quality criteria (SSD-6125)

Pollutant	Averaging period	Criterion
Total suspended particulates (TSP)	Annual	^{a,c} 90 $\mu\text{g}/\text{m}^3$
Particulate matter $\leq 10\mu\text{m}$ (PM_{10})	Annual	^{a,c} 25 $\mu\text{g}/\text{m}^3$
	24-hour	^b 50 $\mu\text{g}/\text{m}^3$

$\mu\text{g}/\text{m}^3$ = micrograms per cubic metre and μm = micrometres

Notes:

- Cumulative impact (i.e. increase in concentrations due to the development plus background concentrations due to all other sources);
- Incremental impact (i.e. increase in concentrations due to the development alone, with zero allowable exceedances of the criteria over the life of the development);
- Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents or any other activity agreed by the Secretary
- "Reasonable and feasible avoidance measures" includes, but is not limited to, the operational requirements in conditions 8 and 9 to develop and implement an air quality management system that ensures operational responses to the risks of exceedances of the criteria.

3.3 NSW EPA impact assessment criteria

Table 3-2 summarises the air quality goals that are relevant to this assessment as outlined in the NSW EPA document *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2022).

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

Table 3-2: NSW EPA air quality impact assessment criteria

Pollutant	Averaging Period	Impact	Criterion
TSP	Annual	Total	90µg/m ³
PM ₁₀	Annual	Total	25µg/m ³
	24 hour	Total	50µg/m ³
PM _{2.5}	Annual	Total	8µg/m ³
	24 hour	Total	25µg/m ³
Deposited dust	Annual	Incremental	2 g/m ² /month
		Total	4 g/m ² /month

Source: **NSW EPA, 2022**

µg/m³ = micrograms per cubic metre

g/m²/month = grams per square metre per month

3.4 Respirable crystalline silica

Silica occurs in nature in a crystalline or amorphous form and may be synthetically produced in amorphous forms. Silica is naturally occurring and commonly found in soil and rocks, the most common form is quartz, followed by cristobalite and tridymite. The crystalline form of silica has potential to cause adverse health effects in humans. Occupational exposure to respirable crystalline silica has potential to result in silicosis (**NIOSH, 1974**).

Various jurisdictions have developed criteria for acceptable levels of exposure to crystalline silica. It is understood that the NSW EPA have advised that the interim impact assessment criteria for respirable crystalline silica (RCS) as outlined in **Table 3-3** are to be applied to the Modification.

Table 3-3: Interim NSW Impact assessment criterion for RCS

Pollutant	Averaging period	Criterion
RCS (PM _{2.5} dust fraction)	24-hour	24 µg/m ³
	Annual	3 µg/m ³

3.5 NSW Voluntary Land Acquisition and Mitigation Policy

Part of the NSW *Voluntary Land Acquisition and Mitigation Policy for State Significant Mining, Petroleum and Extractive Industry Developments* (VLAMP) (**NSW Government, 2018**) describes the NSW Government's policy for voluntary mitigation and land acquisition to address particulate matter (dust) impacts from state significant mining, petroleum and extractive industry developments.

From the VLAMP, voluntary mitigation rights (such as air conditioning [including heating]) may apply where, even with best practice management, the development contributes to exceedances of the criteria in **Table 3-4** at any residence on privately owned land or workplace on privately owned land.¹

¹ Where the consequences of those exceedances in the opinion of the consent authority are unreasonably deleterious to worker health or the carrying out of business at that workplace, including consideration of the relevant factors identified on this subject in the VLAMP.

Table 3-4: VLAMP Particulate matter mitigation criteria

Pollutant	Averaging period	Mitigation criterion		Impact type
PM _{2.5}	Annual	8 µg/m ³ *		Human health
PM _{2.5}	24 hour	25 µg/m ³ **		Human health
PM ₁₀	Annual	25 µg/m ³ *		Human health
PM ₁₀	24 hour	50 µg/m ³ **		Human health
TSP	Annual	90 µg/m ³ *		Amenity
Deposited dust	Annual	2 g/m ² /month**	4 g/m ² /month*	Amenity

Source: **NSW Government (2018)**

*Cumulative impact (i.e. increase in concentration due to the development plus background concentrations due to all other sources).

**Incremental impact (i.e. increase in concentrations due to the development alone), with zero allowable exceedances of the criteria over the life of the development.

Voluntary acquisition rights may apply as per the VLAMP where, even with best practice management, the development contributes to exceedances of the criteria in **Table 3-5** at any residence on privately owned land, workplace on privately-owned land where the consequences of those exceedances in the opinion of the consent authority are unreasonably deleterious to worker health or the carrying out of business at that workplace (including consideration of the relevant factors identified on this subject in the VLAMP), or on more than 25% of any privately-owned land where there is an existing dwelling or where a dwelling could be built under existing planning controls (vacant land).

Table 3-5: VLAMP Particulate matter acquisition criteria

Pollutant	Averaging period	Acquisition criterion		Impact type
PM _{2.5}	Annual	8 µg/m ³ *		Human health
PM _{2.5}	24 hour	25 µg/m ³ **		Human health
PM ₁₀	Annual	25 µg/m ³ *		Human health
PM ₁₀	24 hour	50 µg/m ³ **		Human health
TSP	Annual	90 µg/m ³ *		Amenity
Deposited dust	Annual	2 g/m ² /month**	4 g/m ² /month*	Amenity

Source: **NSW Government (2018)**

*Cumulative impact (i.e. increase in concentration due to the development plus background concentrations due to all other sources).

**Incremental impact (i.e. increase in concentrations due to the development alone), with up to five allowable exceedances of the criteria over the life of the development.

The particulate matter levels for comparison with the criteria in **Table 3-4** and **Table 3-5** must be calculated in accordance with the Approved Methods.

4 EXISTING ENVIRONMENT

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

4.1 Local climatic conditions

Long-term climatic data from the closest Bureau of Meteorology (BoM) weather station at Williamstown RAAF (Site No. 061078) were analysed to characterise the local climate in the proximity of the site. Williamstown RAAF is located approximately 3.5km northwest of the site.

Table 4-1 and **Figure 4-1** present a summary of data from the Williamstown RAAF collected over a 68 to 82 year period for the various meteorological parameters.

The data indicate that January is the hottest month with a mean maximum temperature of 28.3 degrees Celsius (°C) and July is the coldest month with a mean minimum temperature of 6.5°C.

Rainfall decreases during the second half of the year, with an annual average rainfall of 1128.2 millimetres (mm) over 86.4 days. The data indicate that March is the wettest month with an average rainfall of 126.9mm over 8.5 days and September is the driest month with an average rainfall of 60.1mm over 5.7 days.

Relative humidity levels exhibit variability over the day and seasonal fluctuations. Mean 9am relative humidity ranges from 64% in October to 80% in June. Mean 3pm relative humidity levels range from 50% in August and September to 62% in February.

Wind speeds exhibit seasonal variations with lower wind speed records for 9am and higher observations for 3pm conditions. Mean 9am wind speeds range from 10.2 kilometres per hour (km/h) in March to 16.8km/h in August. Mean 3pm wind speeds range from 15.8km/h in May to 23.5km/h in November and December.

Table 4-1: Monthly climate statistics summary – Williamstown RAAF

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann.
Temperature													
Mean max. temp. (°C)	28.3	27.7	26.4	23.7	20.4	17.7	17.2	18.8	21.5	23.8	25.6	27.4	23.2
Mean min. temp. (°C)	18.2	18.2	16.5	13.2	10.1	8.0	6.5	6.9	9.2	12.0	14.5	16.6	12.5
Rainfall													
Rainfall (mm)	98.4	118.7	126.9	109.6	108.2	121.5	75.2	71.7	60.1	75.9	82.7	76.8	1128.2
No. of rain days (≥1mm)	7.2	7.5	8.5	7.6	7.6	8.3	6.5	6.0	5.7	7.3	7.2	7.0	86.4
9am conditions													
Mean temp. (°C)	23.0	22.5	21.2	18.2	14.3	11.6	10.5	12.2	15.7	18.8	20.5	22.2	17.6
Mean R.H. (%)	72.0	76.0	77.0	76.0	79.0	80.0	77.0	71.0	66.0	64.0	66.0	68.0	73.0
Mean W.S. (km/h)	11.9	10.6	10.2	11.4	13.7	15.9	16.4	16.8	15.3	14.4	14.4	12.9	13.7
3pm conditions													
Mean temp. (°C)	26.5	26.1	24.9	22.5	19.3	16.8	16.2	17.6	20.0	21.9	23.8	25.6	21.8
Mean R.H. (%)	59.0	62.0	61.0	59.0	60.0	60.0	55.0	50.0	50.0	54.0	55.0	56.0	57.0
Mean W.S. (km/h)	21.9	20.6	18.9	17.2	15.8	17.5	18.7	20.9	22.0	22.5	23.5	23.5	20.2

Source: **Bureau of Meteorology, 2024**

R.H. – Relative Humidity, W.S. – wind speed

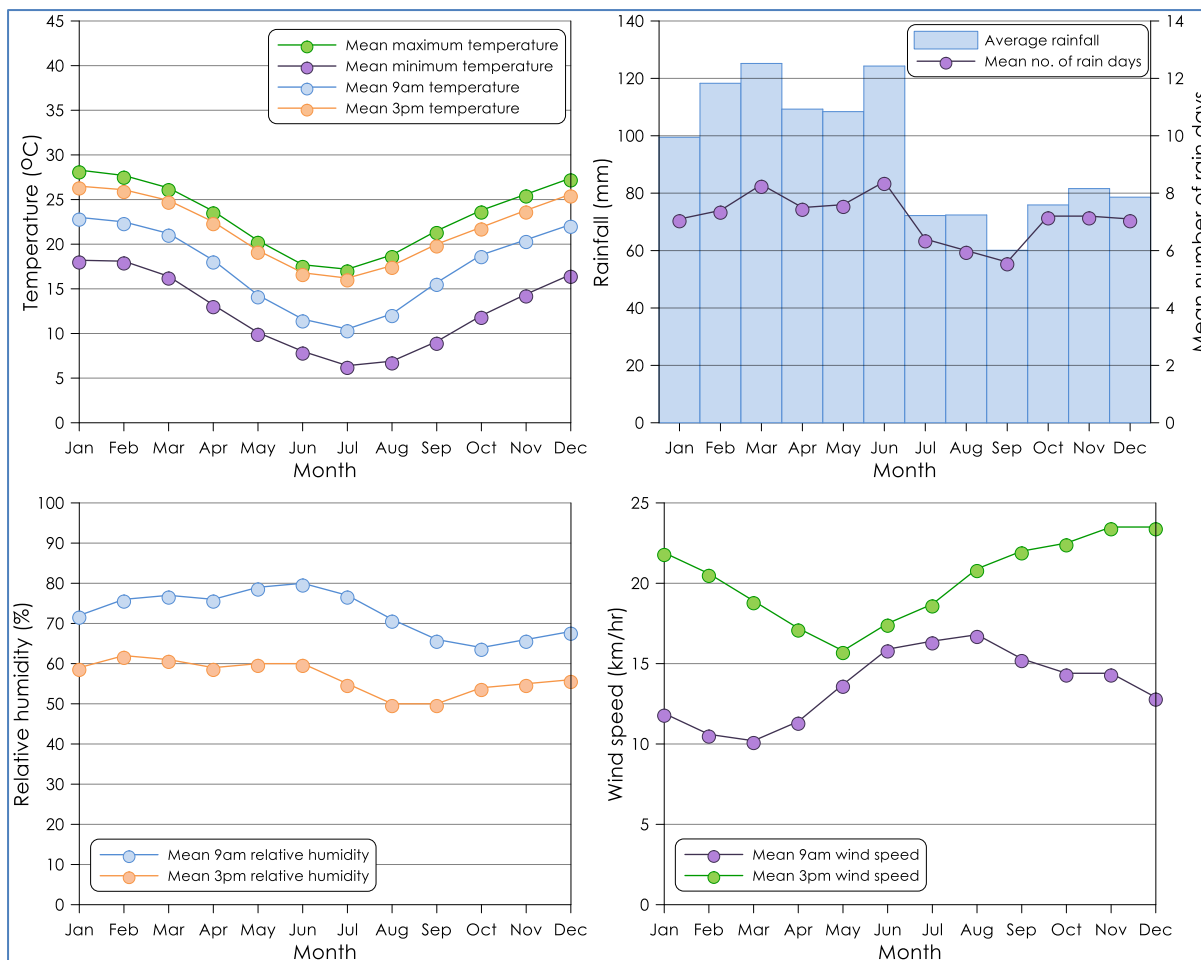


Figure 4-1: Monthly climate statistics summary – Williamtown RAAF

4.2 Local meteorological conditions

Annual and seasonal windroses for the Williamtown RAAF during the 2021 calendar period are presented in **Figure 4-2**.

The 2021 calendar year was selected as the meteorological year for the dispersion modelling based on an analysis of data trends in meteorological data recorded and appropriate monitoring data for the area as outlined in **Appendix A**.

On an annual basis, winds are predominately from the west-northwest and northwest with varied winds from other directions. In summer, winds from the northeast to the south are most frequent. The autumn windrose shows a similar distribution pattern as the annual windrose with the greatest winds from the west-northwest and northwest with varied winds from other directions. During winter, winds from the west-northwest and northwest are most frequent. In spring, wind directions predominately range from the north-northeast to east-northeast and west-northwest to northwest with varied winds from other directions.

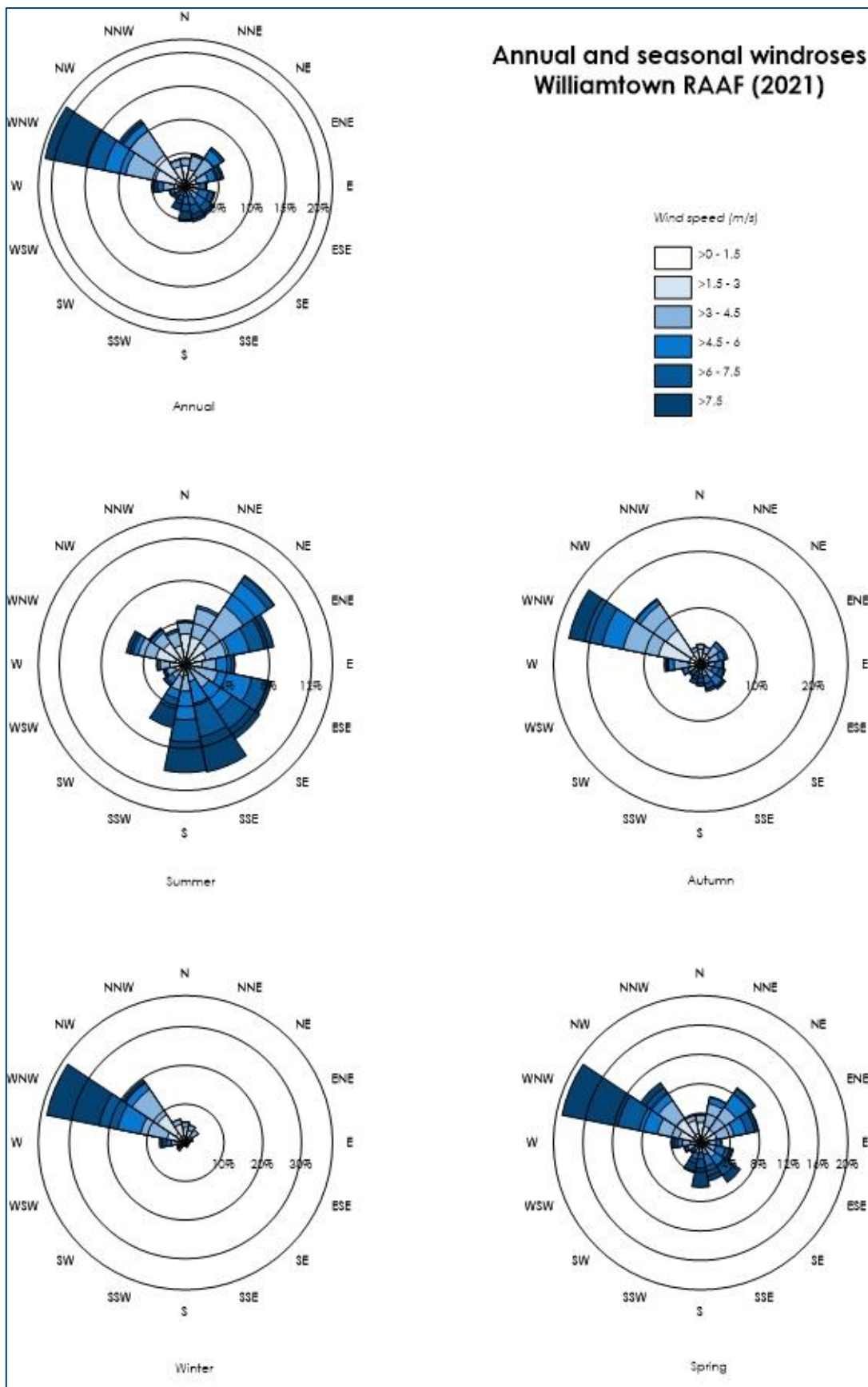


Figure 4-2 : Annual and seasonal windroses – Williamtown (2021)

4.3 Local air quality monitoring

The main sources of air pollutants in the area surrounding the site includes emissions from active sand quarrying, agricultural activities, anthropogenic activities such as various industrial and commercial activities and motor vehicle exhaust, and also natural sources such as the local sand dunes, sea salt, windblown dust, and bushfire smoke. Additionally, activities associated with the Newcastle airport, Williamstown RAAF base and the mines situated in the Hunter Valley, have the potential to influence the air quality monitoring systems in the surrounding area and potentially influence the recorded levels.

This section reviews the ambient monitoring data collected from a number of ambient monitoring locations in the vicinity of the Cabbage Tree Road Quarry. The monitoring data reviewed in this assessment include data collected at High Volume Air Samplers (HVAS) measuring TSP and PM₁₀, Environmental Beta Attenuation Mass Monitors (E-BAM) measuring PM₁₀, as well as a Tapered Element Oscillating Microbalance (TEOM) measuring PM₁₀ and a Beta Attenuation Mass (BAM) monitor at Wallsend measuring PM_{2.5} operated by the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW).

Figure 4-3 shows the approximate location of the Cabbage Tree Road Quarry monitoring stations reviewed in this assessment. The NSW DCCEEW monitor at Wallsend is not shown in the figure.

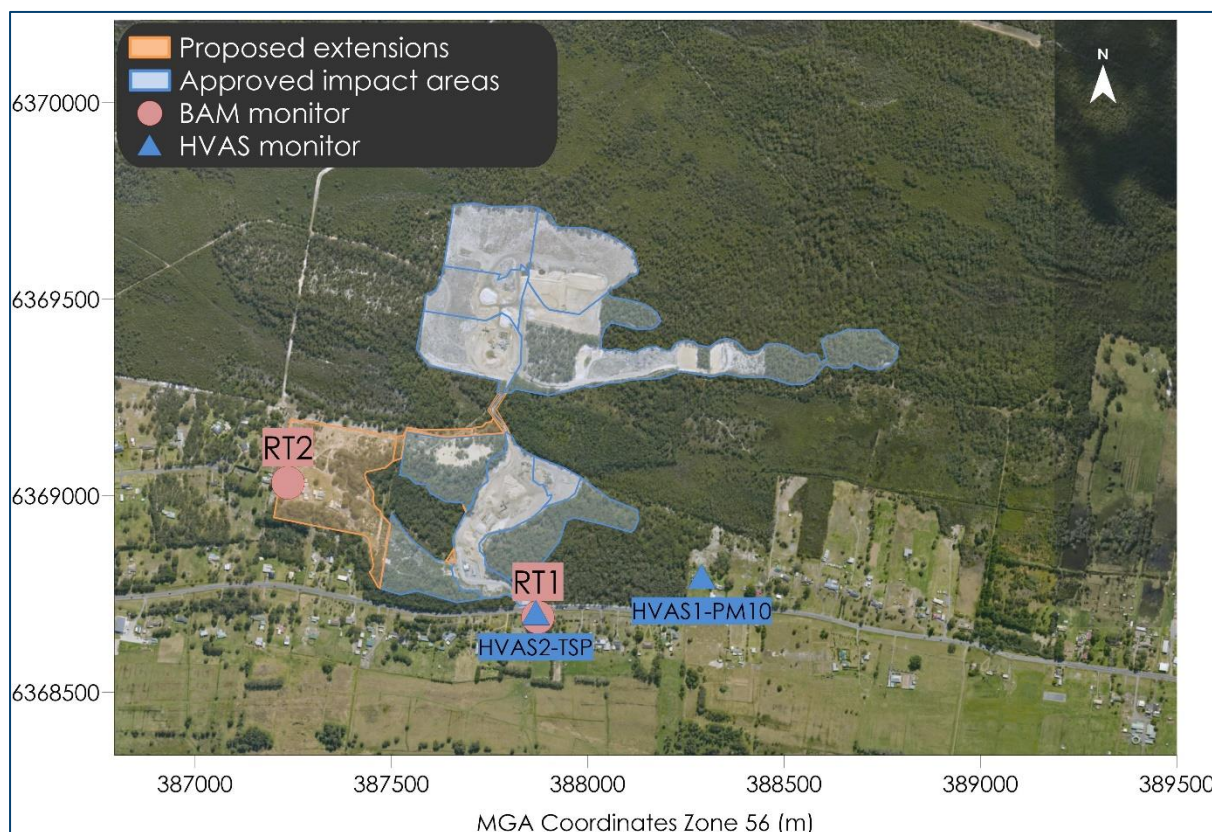


Figure 4-3: Air quality monitoring locations

4.3.1 PM₁₀ monitoring

A summary of the available PM₁₀ monitoring data from 2020 to 2022 is presented in **Table 4-2**. Recorded 24-hour average PM₁₀ concentrations are presented in **Figure 4-4**.

A review of **Table 4-2** indicates that the annual average PM₁₀ concentrations for all stations were below the relevant criterion of 25µg/m³ for all years. The maximum 24-hour average PM₁₀ concentrations were found to exceed the relevant criterion of 50µg/m³ in 2020 at all monitors. The high PM₁₀ concentrations recorded in January 2020 are attributed to wildfires and the drought period (**NSW DPIE 2020**).

Table 4-2: Summary of PM₁₀ levels from monitoring stations (µg/m³)

Year	Annual average				Criterion
	Wallsend	RT1	RT2	HVAS-1	
2020	17.7	16.3	16.3	16.2	25
2021	14.7	12.6	7.4	12.0	25
2022	12.7	10.2	6.1	10.0	25
Year	Maximum 24-hour average				Criterion
2020	77.9	80.0	75.1	51.6	50
2021	33.0	33.2	26.3	32.0	50
2022	27.0	28.7	21.9	34.2	50

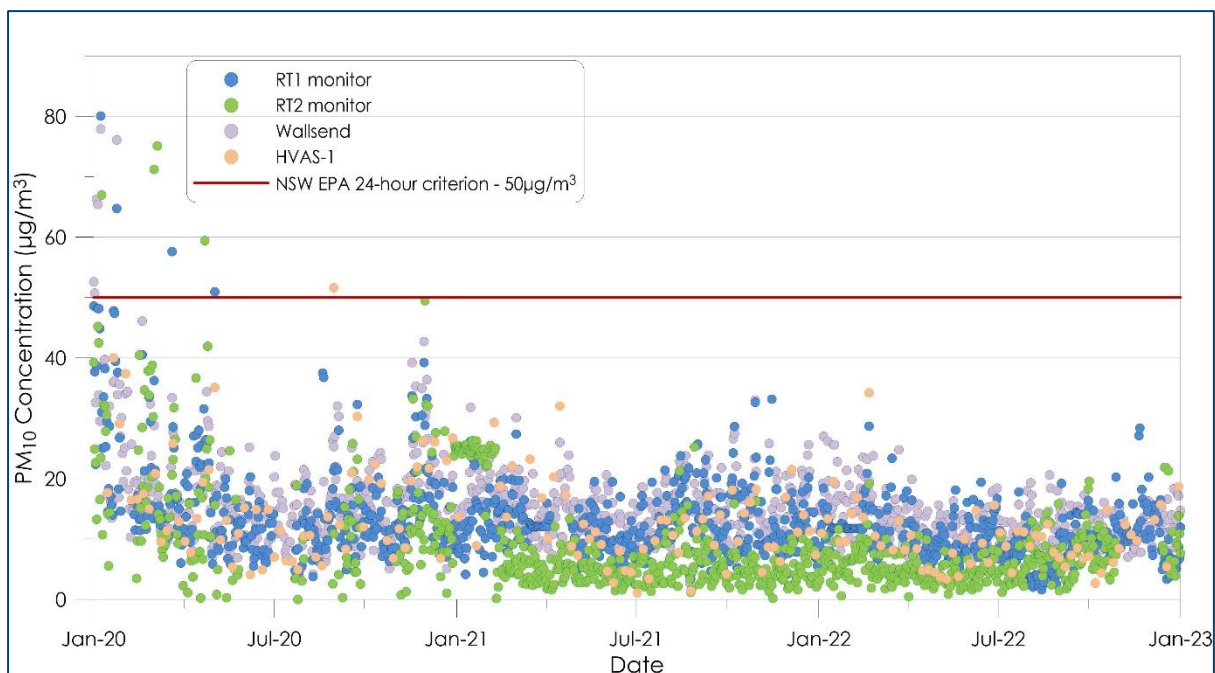


Figure 4-4: 24-hour average PM₁₀ concentrations

4.3.2 PM_{2.5} monitoring

A summary of the PM_{2.5} monitoring data from 2020-2022 at the Wallsend monitoring station is presented in **Table 4-3**. Recorded 24-hour average PM_{2.5} concentrations are presented in **Figure 4-5**.

Table 4-3 indicates that the annual average PM_{2.5} concentrations for the monitoring station was below the annual average criterion of 8µg/m³ for all years. The maximum 24-hour PM_{2.5} concentrations for the monitoring station was above the relevant criterion of 25µg/m³ in 2020. Similar

to the PM₁₀ monitoring data, the mass bushfires affecting NSW in 2020 can be seen in the PM_{2.5} monitoring data.

Table 4-3: Summary of PM_{2.5} levels from monitoring station (µg/m³)

Year	Annual average	Criterion
	Wallsend	
2020	7.3	8
2021	6.1	8
2022	5.1	8
Year	Maximum 24-hour average	Criterion
2020	56.8	25
2021	21.4	25
2022	18.7	25

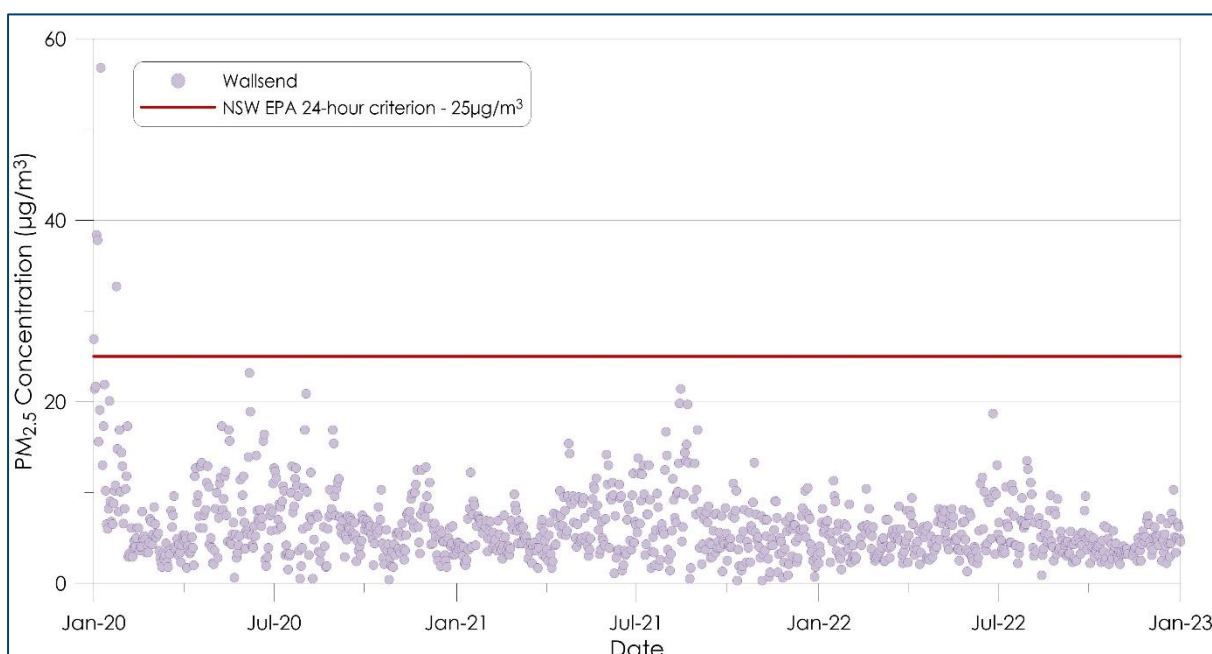


Figure 4-5: 24-hour average PM_{2.5} concentrations

4.3.3 TSP monitoring

A summary of the available TSP monitoring data from 2020-2022 is presented in **Table 4-4**. Recorded 24-hour average TSP concentrations are presented in **Figure 4-6**.

The annual average TSP concentrations in **Table 4-4** are below the relevant criterion of 90µg/m³ for all years.

Table 4-4: Summary of TSP levels from monitoring stations (µg/m³)

Year	Annual average	Criterion
	HVAS-2	
2020	41.9	90
2021	28.6	90
2022	22.6	90

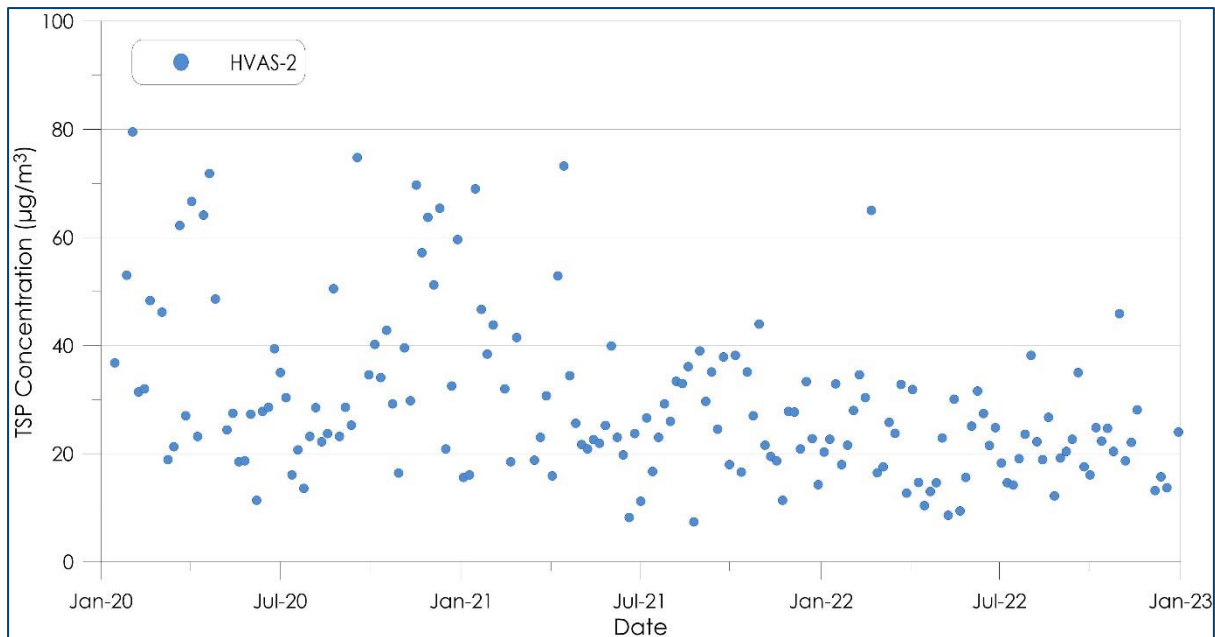


Figure 4-6: 24-hour average TSP concentrations

4.3.4 Estimated background levels

The ambient air quality data for the monitors onsite were used to characterise the background levels for the site.

As discussed, the 2021 calendar period corresponds to the period of meteorological modelling based on an analysis of data trends in meteorological data and appropriate monitoring data recorded for the area as outlined in **Appendix A**. As such background levels are based on data from the 2021 calendar year.

Measured ambient PM_{10} levels from the RT1 onsite monitor were used to represent the background levels for the Modification. The selection of the RT1 monitor over the RT2 monitor was based on its closer alignment with both the HVAS monitor located on site and the Wallsend monitor. Where data was not available, data from the NSW DECCW at Wallsend was used. We note that there are additional NSW DECCW monitors within the surrounding area which are subject to local industrial, urban, and sea sources that may not accurately reflect the conditions at the site. The Wallsend monitor is situated in areas more akin to the site, and is therefore considered to be a more reliable indicator of the background levels at the site.

The annual average TSP level of $28.6\mu\text{g}/\text{m}^3$ at the HVAS-2 monitor was selected as the estimated background level for the site.

In the absence of available onsite data, the $PM_{2.5}$ background level was estimated by applying the ratio of $PM_{2.5}/PM_{10}$ measured at Wallsend to the background PM_{10} levels. This results in an estimated $PM_{2.5}$ annual average level of $5.3\mu\text{g}/\text{m}^3$.

Deposited dust levels were determined from a relationship between PM_{10} and deposited dust concentrations. This relationship assumes that an annual average PM_{10} concentration of $25\mu\text{g}/\text{m}^3$ corresponds to a dust deposition value of $4\text{g}/\text{m}^2/\text{month}$. This assumption is based on the NSW EPA air quality impact criteria. Applying this relationship with the background annual average PM_{10}

concentration of $12.8\mu\text{g}/\text{m}^3$ indicates an approximate annual average deposition value of $2.1\text{g}/\text{m}^2/\text{month}$, respectively.

The background air quality levels applied in this assessment are summarised in **Table 4-5**.

Table 4-5: Summary of background levels

Pollutant	Background level	Units
Annual average TSP	28.6	$\mu\text{g}/\text{m}^3$
24-hour average PM_{10}	Daily varying	$\mu\text{g}/\text{m}^3$
Annual average PM_{10}	12.8	$\mu\text{g}/\text{m}^3$
24-hour average $\text{PM}_{2.5}$	Daily varying	$\mu\text{g}/\text{m}^3$
Annual average $\text{PM}_{2.5}$	5.3	$\mu\text{g}/\text{m}^3$
Annual average deposited dust	2.1	$\text{g}/\text{m}^2/\text{month}$

5 DISPERSION MODELLING APPROACH

5.1 Introduction

The following sections are included to provide the reader with an understanding of the model and modelling approach applied for the assessment. The CALPUFF is an advanced air dispersion model which can deal with the effects of complex local terrain on the dispersion meteorology over the modelling domain in a three-dimensional, hourly varying time step.

The model was set up in general accordance with the NSW EPA's *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia'* (TRC, 2011).

5.2 Modelling methodology

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

5.2.1 Meteorological modelling

The meteorological modelling methodology applied a 'hybrid' approach which includes a combination of prognostic model data from TAPM with surface observations.

The TAPM model was applied to the available data to generate a three-dimensional upper air data file for use in CALMET. The centre of analysis for the TAPM modelling used is 32deg 49min south and 151deg 48min east. The simulation involved an outer grid of 30km, with three nested grids of 10km, 3km and 1km with 35 vertical grid levels.

The CALMET domain was run on a domain of 10 x 10km with a 0.1km grid resolution. The available meteorological data for January 2021 to December 2021 from Williamtown RAAF (BoM) (Station No. 067105) was included in the simulation.

Local land use and detailed topographical information was included to produce realistic fine scale flow fields (such as terrain forced flows) in surrounding areas, as shown in **Figure 5-1**.

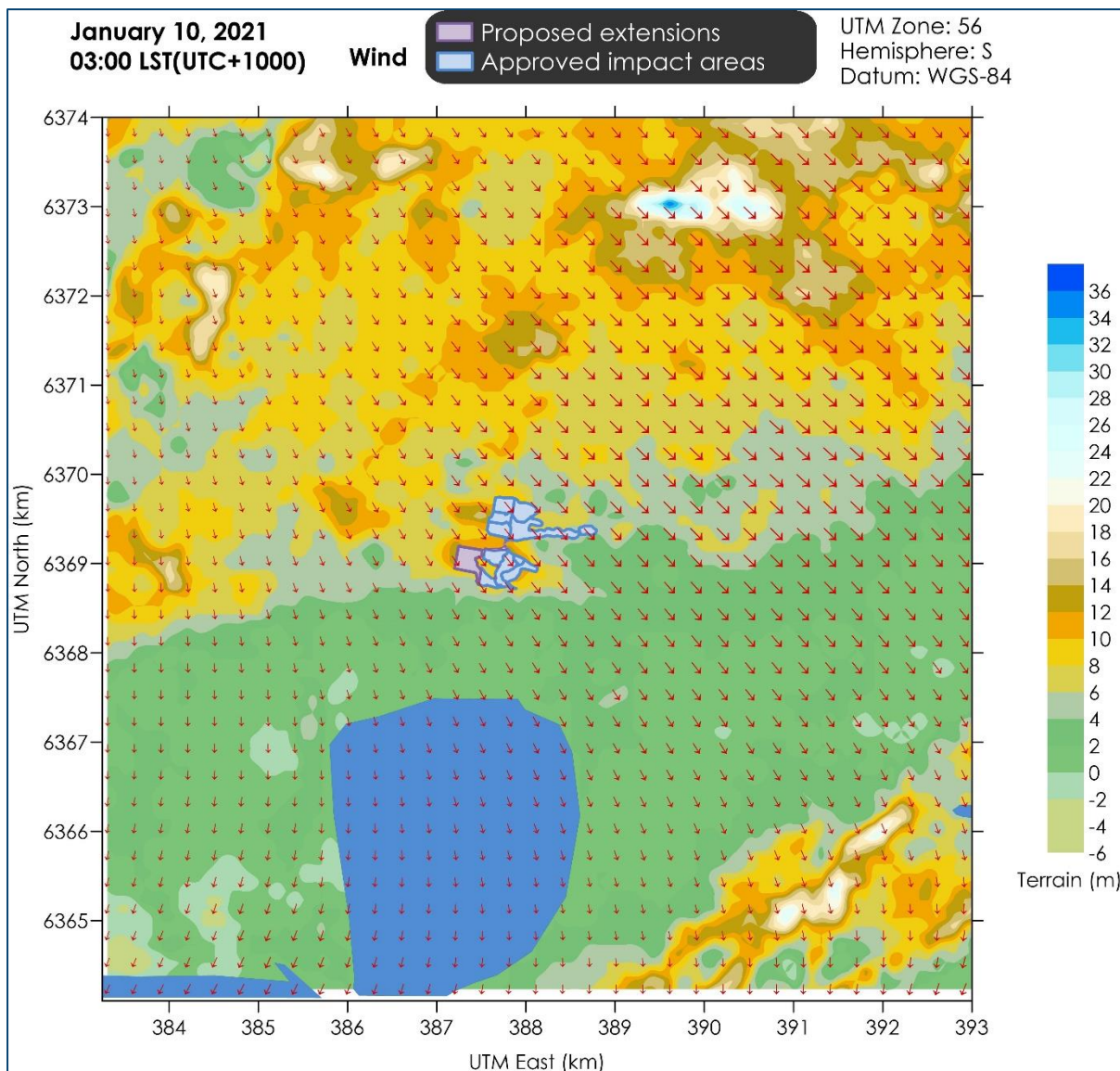


Figure 5-1: Representative 1-hour average snapshot of wind field for the Modification

CALMET generated meteorological data were extracted from a point within the CALMET domain and are graphically represented in **Figure 5-2** and **Figure 5-3**.

Figure 5-2 presents the annual and seasonal windroses from the CALMET data. Overall, the windroses generated in the CALMET modelling reflect the expected wind distribution patterns of the area as determined based on the available measured data and the expected terrain effects on the prevailing winds. **Figure 5-3** includes graphs of the temperature, wind speed, mixing height and stability classification over the modelling period and shows sensible trends considered to be representative of the area.

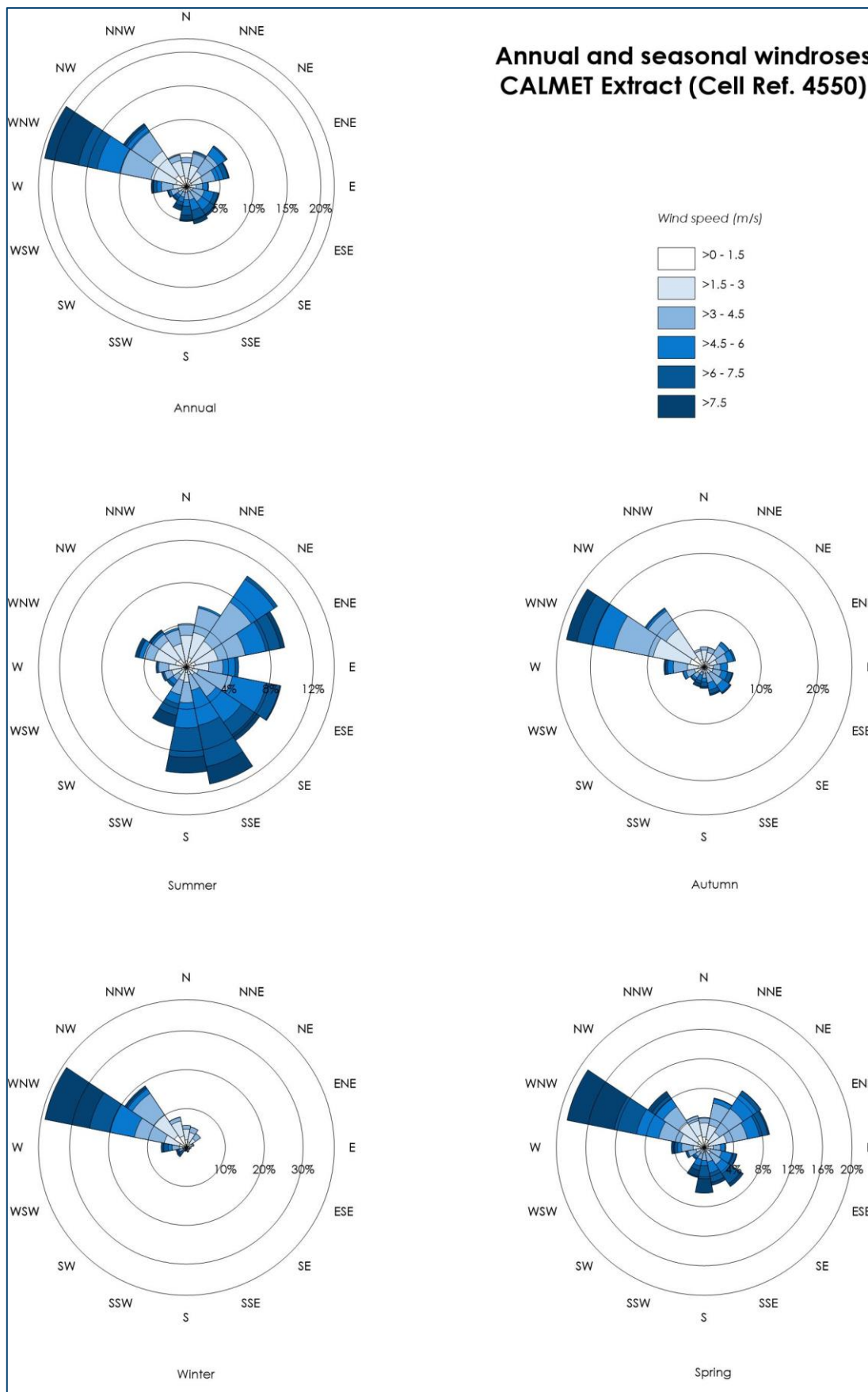


Figure 5-2: Annual and seasonal windroses from CALMET (Cell Ref 4550)

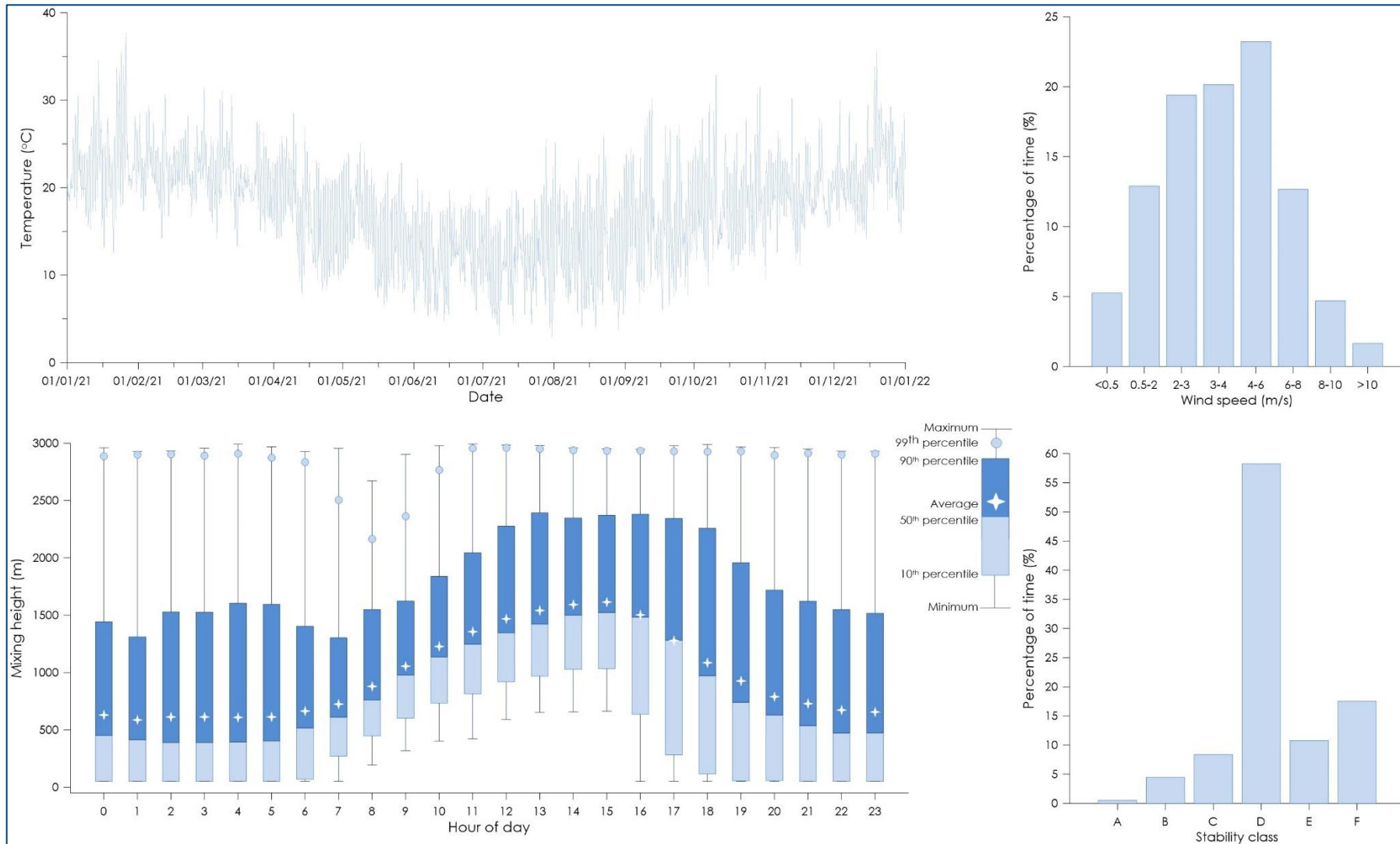


Figure 5-3: Meteorological analysis of CALMET (Cell Ref 4550)

5.3 Dispersion modelling

Dust emissions from each operational activity of the Modification were represented by a series of volume sources and were included in the CALPUFF model via an hourly varying emission file. Meteorological conditions associated with dust generation (such as wind speed) and levels of dust generating activity were considered in calculating the hourly varying emission rate for each source.

It should be noted that as a conservative measure, the effect of the precipitation rate (rainfall) in reducing dust emissions has not been considered in this assessment.

5.4 Modelling scenario

The assessment considers an annual average scenario, and a peak daily emissions scenario to represent the Modification. The modelled activities were chosen to represent potential worst-case dust impacts (i.e. highest dust generating activities and locations) in regard to the quantity of material extracted and handled in each period, the location of the activity and the potential to generate dust at the receptor locations.

The significant dust generating activities associated with operation of the Modification are identified as the loading/unloading of material, vehicles travelling on-site and off-site, screening process, drilling, blasting and windblown dust from exposed areas and stockpiles. The vehicle and plant equipment also have the potential to generate particulate emissions from the diesel exhaust.

The annual average scenario selected for assessment represents an expected operation scenario with quarrying mainly occurring in the proposed Western Extension (up to 80% of total production) and other quarrying occurring in Sector 7 (20% of total production). For the peak daily emissions scenario, it was assumed that all the quarrying activity was occurring in the Western Extension.

Indicative locations for the Modification activities are presented in **Figure 5-4**.

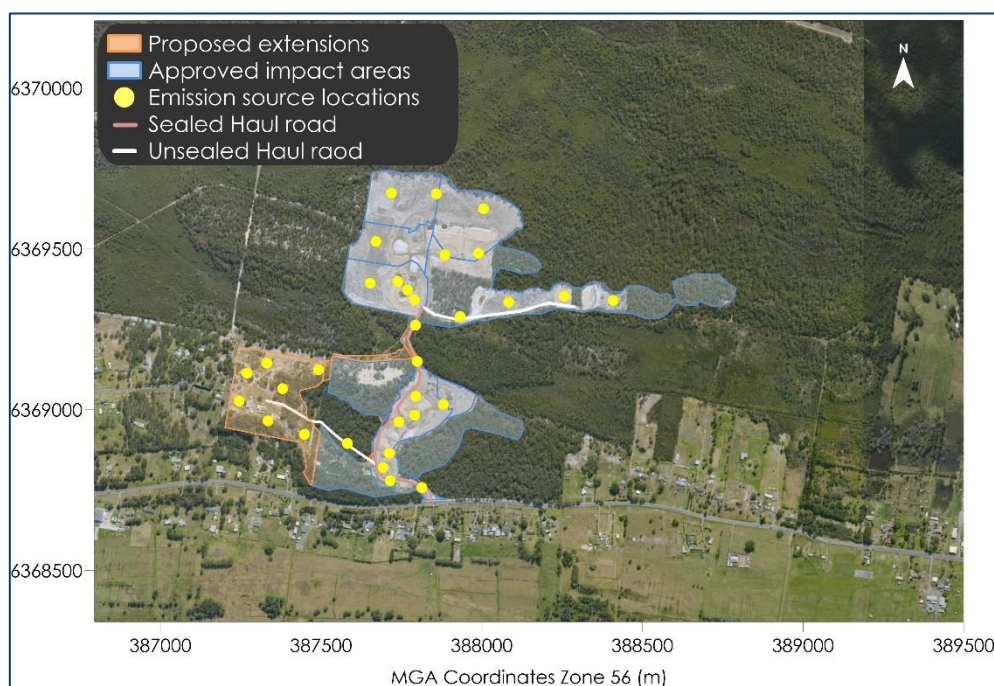


Figure 5-4: Indicative source locations for the modelling scenario

5.5 Emission estimation

Dust emission estimates for the operation of the Modification have been calculated by analysing the various types of dust generating activities taking place and utilising suitable emissions sourced from both locally developed and United States Environmental Protection Agency (US EPA) developed documentation. Detailed calculations of the dust emission estimates are provided in **Appendix B**.

An average and a peak scenario have been assessed for the operation of the Modification.

The annual average scenario is based on the approved annual tonnage of 530,000tpa of material produced at the site and used to assess annual average dust impacts.

The peak daily scenario is based on a maximum daily production rate assumed to apply every day of the modelling period (i.e. 365 days). This results in an estimated maximum annual tonnage processed of 1,095,500tpa (3,000tpd x 365 days), a maximum annual tonnage of material transported internally of 1,460,000tpa (4,000tpd x 365 days) and a maximum annual tonnage of material hauled off-site of 1,277,500tpa (3,500tpd x 365 days). The peak daily scenario is used to assess 24-hour average dust impacts.

A summary of the estimated dust emissions for the average and peak scenarios is presented in **Table 5-1**.

Table 5-1: Summary of estimated dust emissions for the Modification (kg/year)

Scenario	TSP emissions	PM ₁₀ emissions	PM _{2.5} emissions
Average (annual)	39,224	15,546	2,418
Peak (24 hour)	70,672	25,629	3,561



6 DISPERSION MODELLING RESULTS

The dispersion model predictions presented in this section include those for the operation of the Modification in isolation (incremental impact) and the operation of the Modification with consideration of other sources (total impact). The results show the predicted:

- ✦ Maximum 24-hour average PM_{2.5} and PM₁₀ concentrations;
- ✦ Annual average PM_{2.5}, PM₁₀ and TSP concentrations; and
- ✦ Annual average dust (insoluble solids) deposition rates.

It is important to note that when assessing impacts per the maximum 24-hour average levels, these predictions are based on the highest predicted 24-hour average concentrations which were modelled at each point within the modelling domain for the worst day (i.e. a 24-hour period) during the one year long modelling period.

6.1 Assessment of dust impacts

Table 6-1 presents the predicted incremental and cumulative particulate dispersion modelling results at the assessed residential receptor locations for the assessed scenario. **Appendix C** shows the isopleths of all the different dust impacts. The cumulative (total) impact is defined as the modelling impact associated with the operation of the Modification combined with the estimated ambient background levels in **Section 4.3.4**.

The predicted incremental results presented show that no incremental impacts would arise at the receptor locations due to the Modification. The predicted cumulative results indicate that the assessed receptors are predicted to experience levels below the relevant criteria for each of the assessed dust metrics.

Table 6-1: Dust dispersion modelling results for most impacted receptor locations

Assessment ID	PM _{2.5} (µg/m ³)		PM ₁₀ (µg/m ³)		TSP (µg/m ³)	DD (g/m ² /mth)	PM _{2.5} (µg/m ³)	PM ₁₀ (µg/m ³)	TSP (µg/m ³)	DD* (g/m ² /mth)
	Incremental						Cumulative			
	24-hr ave.	Ann. ave.	24-hr ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.	Ann. ave.
	Air quality impact criteria									
-	-	-	-	-	-	2	8	25	90	4
14	3.8	0.8	18.0	2.8	6.8	1.7	6.1	15.7	35.4	3.8
16	1.7	0.1	8.0	0.5	1.0	0.2	5.5	13.3	29.6	2.2
24	2.1	0.1	13.8	0.4	1.0	0.1	5.4	13.3	29.6	2.1
25	2.8	0.1	18.0	0.6	1.3	0.1	5.5	13.4	29.9	2.1
26	3.5	0.2	23.7	0.8	1.9	0.1	5.5	13.6	30.5	2.2
27	4.3	0.2	30.1	1.2	3.0	0.4	5.6	14.0	31.6	2.4
35	2.0	0.1	13.8	0.5	1.0	0.1	5.4	13.3	29.6	2.1
36	1.8	0.1	12.2	0.5	1.0	0.1	5.4	13.3	29.6	2.1
37	1.7	0.1	11.3	0.5	1.1	0.1	5.4	13.4	29.7	2.1
38	1.6	0.1	10.2	0.5	1.1	0.1	5.4	13.4	29.8	2.1
39	1.5	0.1	9.6	0.5	1.2	0.1	5.4	13.4	29.8	2.2
40	1.3	0.1	8.3	0.5	1.1	0.1	5.4	13.4	29.7	2.2
41	1.0	0.1	6.7	0.4	0.8	0.1	5.4	13.2	29.4	2.1

*Deposited dust

6.2 Assessment of cumulative 24-hour average PM_{2.5} and PM₁₀ concentrations

The results for incremental 24-hour average PM_{2.5} and PM₁₀ concentrations indicate there are no predicted exceedances of the relevant criteria at the assessment locations for the assessed scenario.

When assessing the total (cumulative) 24-hour average impacts based on model predictions, an assessment of cumulative 24-hour average PM_{2.5} and PM₁₀ impacts was undertaken in accordance with Section 11.2 of the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW EPA, 2022).

The “Level 2 assessment – Contemporaneous impact and background approach” was applied to assess potential impacts for PM_{2.5} and PM₁₀. In simple terms, the Level 2 assessment involves matching one year of ambient air quality monitoring data with meteorological data representing the same period.

Table 6-2 provides a summary of the findings from the Level 2 assessment for selected receptor locations. The assessment found that no receptors exceeded the 24-hour average criterion.

Detailed tables of the contemporaneous assessment results are provided in **Appendix D**.

Table 6-2: NSW EPA contemporaneous assessment - number days above 24-hour average criterion

Receptor ID	PM _{2.5}	PM ₁₀
R14	0	0
R25	0	0
R26	0	0
R27	0	0

Time series plots of the predicted cumulative 24-hour average PM_{2.5} and PM₁₀ concentrations at Receptor R14 are presented in **Figure 6-1**. The orange bars in the figure represent the contribution from the Modification and the blue bars represent the background levels. It is clear from the figures that the Modification has a relatively small influence at the assessed receptor location.

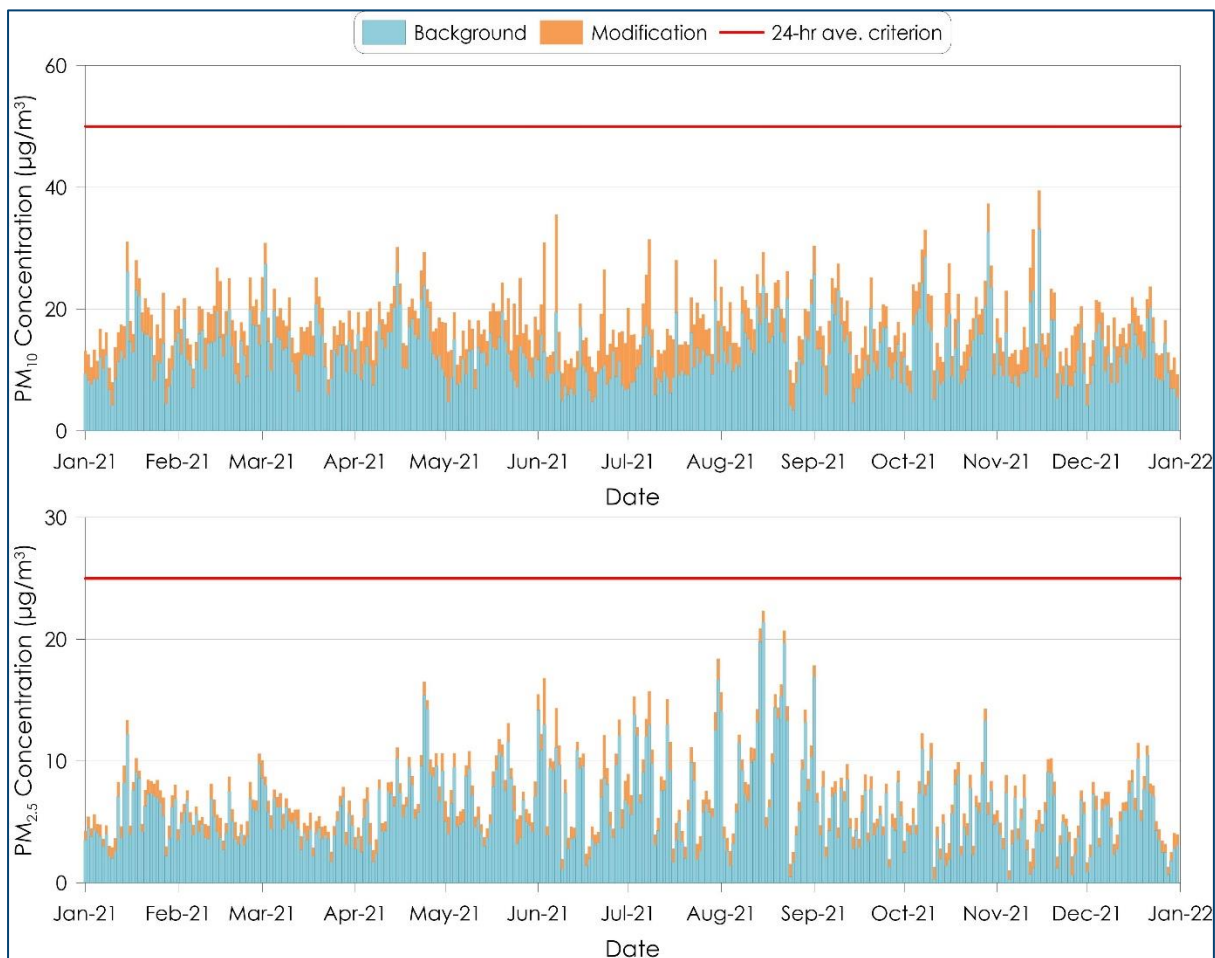


Figure 6-1: Time series plots of predicted cumulative 24-hour average $PM_{2.5}$ and PM_{10} concentrations for R14

6.3 Assessment of impacts per VLAMP criteria

6.3.1 Summary of modelling predictions

The results in **Table 6-1** indicate the highest maximum predicted level at the assessed privately-owned receptors would be below the applicable VLAMP mitigation and acquisition criteria outlined in **Table 3-4** and **Table 3-5** respectively.

6.3.2 Dust impacts on privately-owned land

As required by the VLAMP, the potential impacts due to the Modification, extending over more than 25% of any privately-owned land, have been evaluated using the predicted pollutant dispersion contours.

The cumulative annual average deposited dust levels ($4g/m^2/month$) were found to have the greatest extent of any of the other dust metrics relevant to the application of acquisition upon request rights on vacant land in accordance with the VLAMP. **Figure 6-2** presents the extent of the cumulative annual average dust deposition levels.

The isopleth in **Figure 6-2**, indicates that the predicted cumulative annual average dust deposition levels would not extend over more than 25% of any privately-owned land parcels as a result of the Modification, and as such the Modification would not exceed this criterion.

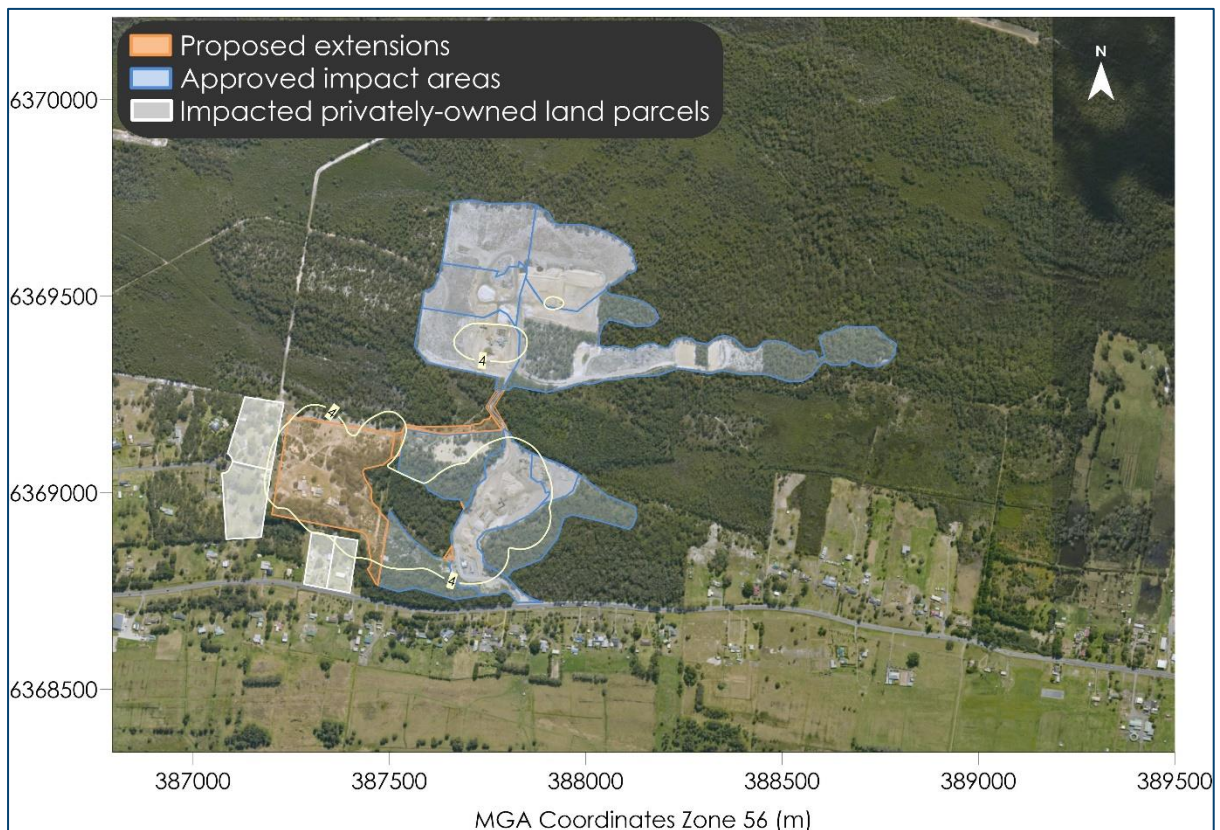


Figure 6-2: Predicted cumulative annual average dust deposition levels (g/m²/month)

6.4 Respirable crystalline silica

The assessment results in **Table 6-1** show that the most affected receptor (Receptor 14) has a total maximum predicted incremental 24-hour and annual average PM_{2.5} concentration level of 3.8µg/m³ and 0.8µg/m³, respectively. This level is due to the total dust from the site, and only a small portion of this dust would contain silica.

Even if the entire PM_{2.5} fraction of dust associated with the Modification is comprised of RSC, the levels at this receptor would be well below the interim criterion of 24µg/m³ for 24-hour average and 3µg/m³ for annual average, and thus there would be no potential for impacts from RSC.

7 MITIGATION AND MANAGEMENT

The Modification has the potential to generate dust emissions. To ensure that activities associated with the Modification have a minimal effect on the surrounding environment and at residential receptor locations, it is recommended that all reasonable and practicable dust mitigation measures be utilised.

The site currently employs a number of air quality control measures such as regularly watering the spine road through the Northern Resource Area with road side static sprays or water carts to minimise dust generation. These are included within the site's *Air Quality Management Plan (Wedgetail Project Consulting, 2022)*. It is recommended that existing air quality control measures continue to be applied as they appear to be effective based on the available air quality monitoring data reviewed (see **Section 4.3**).

8 SUMMARY AND CONCLUSIONS

This report has assessed the potential air quality impacts associated with the Modification.

Air dispersion modelling was used to predict the potential for off-site dust impacts in the surrounding area due to the operation of the Modification. The estimated emissions of dust applied in the modelling are likely to be conservative and would overestimate the actual impacts.

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

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

Overall, the assessment demonstrates that even using conservative assumptions, the Modification can operate without causing any significant air quality impact at residential receptors or within the surrounding environment.

9 REFERENCES

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<http://www.bom.gov.au/climate/averages>

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"Compilation of Air Pollutant Emission Factors", AP-42, Fourth Edition United States Environmental Protection Agency, Office of Air and Radiation Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711.

Wedgetail Project Consulting (2022)

"Air Quality Management Plan – Williamtown Sand Cabbage Tree Road, Williamtown", Prepared for Williamtown Sand Syndicate Pty Ltd by Wedgetail Project Consulting, February 2022



Appendix A

Selection of Meteorological Year



Selection of meteorological year

A statistical analysis of the latest six contiguous years of meteorological data from the nearest BoM weather station with suitable available data, Williamtown RAAF weather station, is presented in **Table A-1**.

The standard deviation of the latest six years of meteorological data spanning 2018 to 2023 was analysed against the available measured wind speed, temperature and relative humidity. The analysis indicates that 2021 is closest to the mean for wind speed, 2020 is the closest for relative humidity and 2022 is the closest for temperature. Based on a score weighting analysis, the 2021 period is the most representative of the long-term average and was selected for modelling.

Table A-1: Statistical analysis results for Williamtown RAAF

Year	Wind speed	Temperature	Relative humidity	Weighted Score
2018	0.61	0.8	5.1	7.1
2019	0.59	1.1	5.1	7.4
2020	0.55	0.6	2.6	4.3
2021	0.55	0.5	2.6	4.2
2022	0.59	0.4	5.4	6.9
2023	0.58	0.9	3.5	5.6

Figure A-1 shows the frequency distributions for wind speed, wind direction, temperature and relative humidity for the 2021 year compared with the mean of the 2018 to 2023 data set. The 2021 year data appear to be well aligned with the mean data.

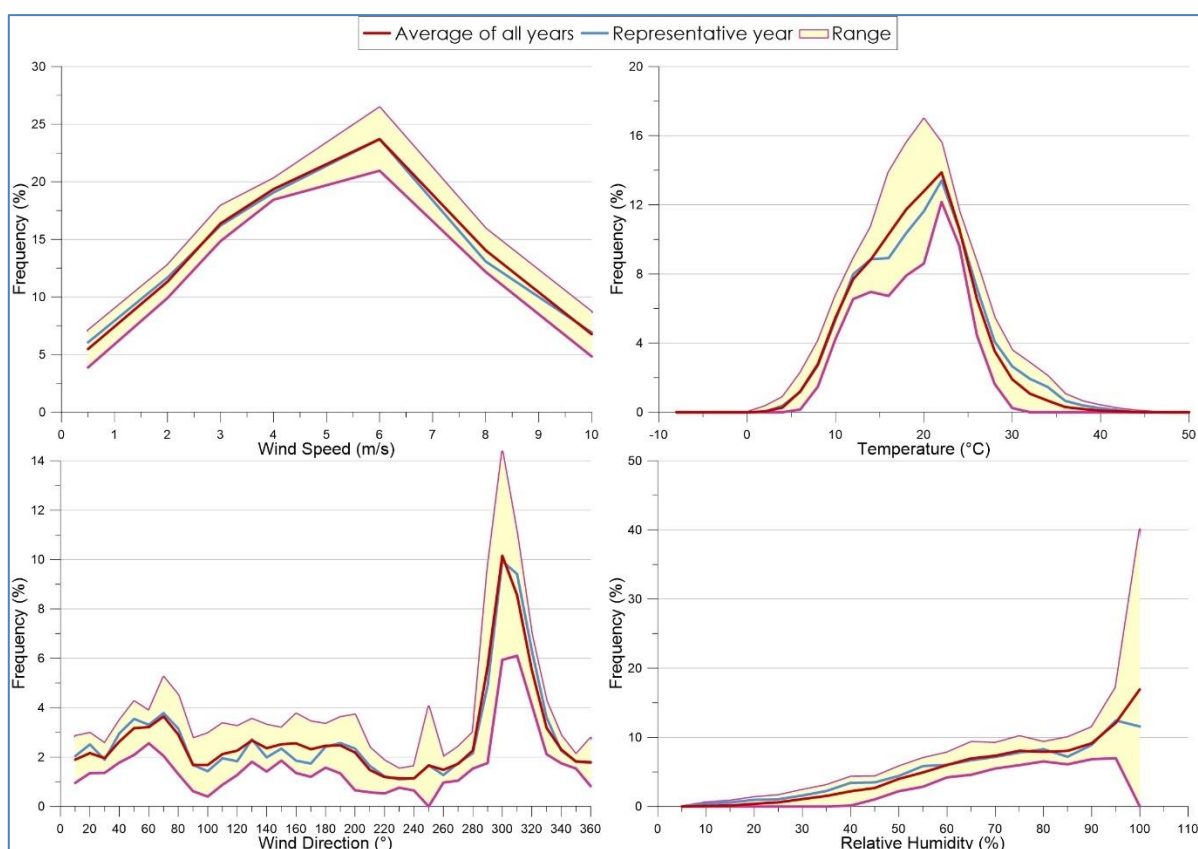


Figure A-1: Frequency distributions for wind speed, wind direction, temperature and relative humidity

Appendix B
Emission Calculation

Emission Calculation

The dust emissions from the Modification have been estimated from the operational description of the proposed activities provided by the Proponent and have been combined with emissions factor equations and utilising suitable emission and load factors that relate to the quantity of dust emitted from particular activities based on intensity, the prevailing meteorological conditions and composition of the material being handled.

Emission factors and associated controls have been sourced from:

- ✦ United States (US) EPA AP42 Emission Factors (**US EPA, 1985 and Updates**);
- ✦ Office of Environment and Heritage document, "NSW Coal Mining Benchmarking Study: Best Practise Measures for Reducing Non-Road Diesel Exhaust Emissions, Final Report" (**NSW EPA, 2015**).

The emission factor equations used for each dust generating activity are outlined in **Table B-1** below. A detailed dust emission inventory for the different scenarios is presented in **Table B-2** and **Table B-3**.

Control factors applied in the emissions inventory include the following:

- ✦ Loading / emplacing material in enclosed areas - 70% control for being in an enclosed environment.
- ✦ Wind erosion from rehab areas – 70% control for application of mulch or similar.
- ✦ Hauling on unsealed surfaces - 75% control for watering.



Table B-1: Emission factor equations

Activity	Emission factor equation		
	TSP	PM ₁₀	PM _{2.5}
Loading / emplacing material	$EF = 0.74 \times 0.0016 \times \left(\frac{U^{1.3}}{2.2} / \frac{M^{1.4}}{2} \right) kg / tonne$	$EF = 0.35 \times 0.0016 \times \left(\frac{U^{1.3}}{2.2} / \frac{M^{1.4}}{2} \right) kg/tonne$	$EF = 0.053 \times 0.0016 \times \left(\frac{U^{1.3}}{2.2} / \frac{M^{1.4}}{2} \right) kg/tonne$
Hauling on unsealed surfaces	$EF = \left(\frac{0.4536}{1.6093} \right) \times 4.9 \times (s/12)^{0.7} \times (1.1023 \times M/3)^{0.45} kg /VKT$	$EF = \left(\frac{0.4536}{1.6093} \right) \times 1.5 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45} kg /VKT$	$EF = \left(\frac{0.4536}{1.6093} \right) \times 0.15 \times (s/12)^{0.9} \times (1.1023 \times M/3)^{0.45} kg/VKT$
Hauling on sealed surfaces	$EF = \frac{3.23}{1000} \times s.L.^{0.91} \times (1.1023 \times W)^{1.02} kg /VKT$	$EF = \frac{0.62}{1000} \times s.L.^{0.91} \times (1.1023 \times W)^{1.02} kg /VKT$	$EF = \frac{0.15}{1000} \times s.L.^{0.91} \times (1.1023 \times W)^{1.02} kg /VKT$
Dozer	$(2.6 \times (s^{1.2}))/M^{1.3}$	$0.45 \times (s^{1.5})/M^{1.4} \times 0.75$	$(2.6 \times (s^{1.2}))/M^{1.3} \times 0.105$
Screening (uncontrolled)	$EF = 0.0125 kg/t$	$EF = 0.0043 kg/t$	$EF = 0.00032 kg/t$
Wind erosion on exposed areas, stockpiles	$EF = 850 kg/ha /year$	$EF = 0.5 \times TSP$	$EF = 0.075 \times TSP$

EF = emission factor, U = wind speed (m/s), M = moisture content (%), s = silt content (%), s.L. = silt loading (g/m²), W = average weight of vehicle (tonne), VKT = vehicle kilometres travelled (km),



Table B-2: Dust Emissions Inventory – Mod 4 extension annual average emissions

Stage 1	TSP emission (kg/y)	PM10 emission (kg/y)	PM25 emission (kg/y)	Intensity	Units	EF - TSP	EF - PM10	EF - PM25	Units	Var 1	Units	Var 2	Units	Var 3 - TSP	Var 3 - PM10	Var 3 - PM25	Units	Var 4	Units	Var 5	Units	Var 6	Units	Dust Controls
Dozer stripping & spreading topsoil	1,624.68	345.89	170.59	504	hr/yr	3.2236	0.6863	0.3385	kg/h	10	S.C. %	7.1	M.C. %											
Excavator sand removal (all sectors)	552.15	261.15	39.55	530,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
Excavator unloading to moxy truck	552.15	261.15	39.55	530,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
Moxy truck hauling sand to conveyor loader (unsealed) - sector 7	1,740.36	443.55	44.36	106,000	t/yr	0.066	0.017	0.002	kg/t	37.0	t/load	0.96	km/return	2.5	0.6	0.06	kg/VKT	4.8	S.C. %	43.5	ave weight (t)	75	C %	Watering lvl 2
Moxy truck hauling sand to conveyor loader (sealed) - sector 7	158.27	30.38	7.35	106,000	t/yr	0.0015	0.0003	0.0001	kg/t	37.0	t/load	0.76	km/return	0.073	0.014	0.003	kg/VKT	0.4	sl (g/m^2)	43.5	ave weight (t)	75	C %	Watering lvl 2
Moxy truck hauling sand to conveyor loader (unsealed) - mod4 collection area	1,450.30	369.63	36.96	424,000	t/yr	0.014	0.003	0.000	kg/t	37.0	t/load	0.20	km/return	2.5	0.6	0.06	kg/VKT	4.8	S.C. %	43.5	ave weight (t)	75	C %	Watering lvl 2
Moxy truck hauling sand to conveyor loader (unsealed) - mod4	5,830.22	1,485.91	148.59	424,000	t/yr	0.055	0.014	0.001	kg/t	37.0	t/load	0.80	km/return	2.5	0.6	0.06	kg/VKT	4.8	S.C. %	43.5	ave weight (t)	75	C %	Watering lvl 2
Moxy truck hauling sand to conveyor loader (sealed) - mod4	326.54	62.68	15.16	424,000	t/yr	0.0008	0.0001	0.0000	kg/t	37.0	t/load	0.39	km/return	0.073	0.014	0.003	kg/VKT	0.4	sl (g/m^2)	43.5	ave weight (t)			
Moxy truck unloading sand to processing stockpile	524.55	248.10	37.57	503,500	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
FEL truck loading from stockpile for transfer to conveyor loader	524.55	248.10	37.57	503,500	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
conveyor loading to transfer to conveyor loader	157.36	74.43	11.27	503,500	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
conveyor material to screen	524.55	248.10	37.57	503,500	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
transfer from conveyor to screen	157.36	74.43	11.27	503,500	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
Dry screening sand (uncontrolled)	6,293.75	2,165.05	162.38	503,500	t/yr	0.0125	0.0043	0.00032	kg/t															
dry screened material unloaded to conveyors	524.55	248.10	37.57	503,500	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
convey to screened sand stockpile	524.55	248.10	37.57	503,500	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
transfer from conveyor to screened sand stockpile	157.36	74.43	11.27	503,500	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
transfer from dry screening directly to wash plant	149.08	70.51	10.68	477,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
transfer from wash plant to conveyor	149.08	70.51	10.68	477,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
transfer from conveyor to washed sand stockpile	496.94	235.04	35.59	477,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
transfer from all stockpiles to trucks	552.15	261.15	39.55	530,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3>	5	M.C. %											
Hauling to site boundary (sealed road)	793.68	152.35	36.86	530,000	t/yr	0.0015	0.0003	0.0001	kg/t	32.0	t/load	0.84	km/return	0.057	0.011	0.003	kg/VKT	0.4	sl (g/m^2)	34.1	ave weight (t)			
Wind erosion - exposed areas and stockpiles	12,155.00	6,077.50	911.63	14.3	ha	850	425	64	kg/ha/year															
<2 year old rehab (mulch or similar, 70% control)	3,187.50	1,593.75	239.06	12.5	ha	850	425	64	kg/ha/year															
Diesel usage/Exhaust emissions	266.13	266.13	258.15	250	kl/y			0.66000																
Total TSP emissions (kg/yr.)	39,223.74	15,545.60	2,417.65																					

Table B-3: Dust Emissions Inventory – Mod 4 extension peak daily emissions

Stage 1	TSP emission (kg/y)	PM10 emission (kg/y)	PM25 emission (kg/y)	Intensity	Units	EF - TSP	EF - PM10	EF - PM25	Units	Var 1	Units	Var 2	Units	Var 3 - TSP	Var 3 - PM10	Var 3 - PM25	Units	Var 4	Units	Var 5	Units	Var 6	Units	Dust Controls
Dozer stripping & spreading topsoil	1,624.68	345.89	170.59	504	hr/yr	3.2236	0.6863	0.3385	kg/h	10	S.C. %	7.1	M.C. %											
Excavator sand removal (all sectors)	1,140.77	539.55	81.70	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
Excavator unloading to moxy truck	1,140.77	539.55	81.70	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
Moxy truck hauling sand to conveyor loader (unpaved) - 7	-	-	-	-	t/yr	0.066	0.017	0.002	kg/t	37.0	t/load	0.96	km/return	2.5	0.6	0.06	kg/VKT	4.8	S.C. %	43.5	ave weight (t), inc return	75	C %	Watering lvl 2
Moxy truck hauling sand to conveyor loader (paved) - sector 7	-	-	-	-	t/yr	0.0015	0.0003	0.0001	kg/t	37.0	t/load	0.76	km/return	0.073	0.014	0.003	kg/VKT	0.4	sl (g/m^2)	43.5	ave weight (t), inc return	75	C %	Watering lvl 2
Moxy truck hauling sand to conveyor loader (unsealed) - mod4 collection area	4,993.97	1,272.78	127.28	1,460,000	t/yr	0.014	0.003	0.000	kg/t	37.0	t/load	0.20	km/return	2.5	0.6	0.06	kg/VKT	4.8	S.C. %	43.5	ave weight (t)	75	C %	Watering lvl 2
Moxy truck hauling sand to conveyor loader (unsealed) - mod4	20,075.75	5,116.57	511.66	1,460,000	t/yr	0.055	0.014	0.001	kg/t	37.0	t/load	0.80	km/return	2.5	0.6	0.06	kg/VKT	4.8	S.C. %	43.5	ave weight (t), inc return	75	C %	Watering lvl 2
Moxy truck hauling sand to conveyor loader (paved) - mod4	562.20	107.91	26.11	1,460,000	t/yr	0.0004	0.0001	0.0000	kg/t	37.0	t/load	0.20	km/return	0.073	0.014	0.003	kg/VKT	0.4	sl (g/m^2)	43.5	ave weight (t), inc return			
Moxy truck unloading sand to processing stockpile	1,521.03	719.41	108.94	1,460,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
FEL truck loading from stockpile for transfer to conveyor loader	1,140.77	539.55	81.70	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
conveyor loading to transfer to conveyor	342.23	161.87	24.51	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
conveyor material to screen	1,140.77	539.55	81.70	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
transfer from conveyor to screen	342.23	161.87	24.51	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
Dry screening sand (uncontrolled)	13,687.50	4,708.50	353.14	1,095,000	t/yr	0.0125	0.0043	0.00032	kg/t															
dry screened material unloaded to conveyors	1,140.77	539.55	81.70	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
convey to screened sand stockpile	1,140.77	539.55	81.70	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
transfer from conveyor to screened sand stockpile	342.23	161.87	24.51	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
transfer from dry screening directly to wash plant	342.23	161.87	24.51	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
transfer from wash plant to conveyor	342.23	161.87	24.51	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
transfer from conveyor to washed sand stockpile	1,140.77	539.55	81.70	1,095,000	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
transfer from all stockpiles to trucks	1,330.90	629.48	95.32	1,277,500	t/yr	0.00104	0.00049	0.00007	kg/t	3.2	<(ws/2.2)^1.3> (U is hourly)	5	M.C. %											
Hauling to site boundary (sealed road)	1,913.07	367.21	88.84	1,277,500	t/yr	0.0015	0.0003	0.0001	kg/t	32.0	t/load	0.84	km/return	0.057	0.011	0.003	kg/VKT	0.4	sl (g/m^2)	34.1	ave weight (t), inc return			
Wind erosion - exposed areas and stockpiles	12,155.00	6,077.50	911.63	14.3	ha	850	425	64	kg/ha/year															
<2 year old rehab (mulch or similar, 70% control)	3,187.50	1,593.75	239.06	12.5	ha	850	425	64	kg/ha/year															
Diesel usage/Exhaust emissions	266.13	266.13	258.15	250	kl/y			0.66000																
Total TSP emissions (kg/yr.)	70,672.06	2																						

Appendix C

Isopleth Diagrams

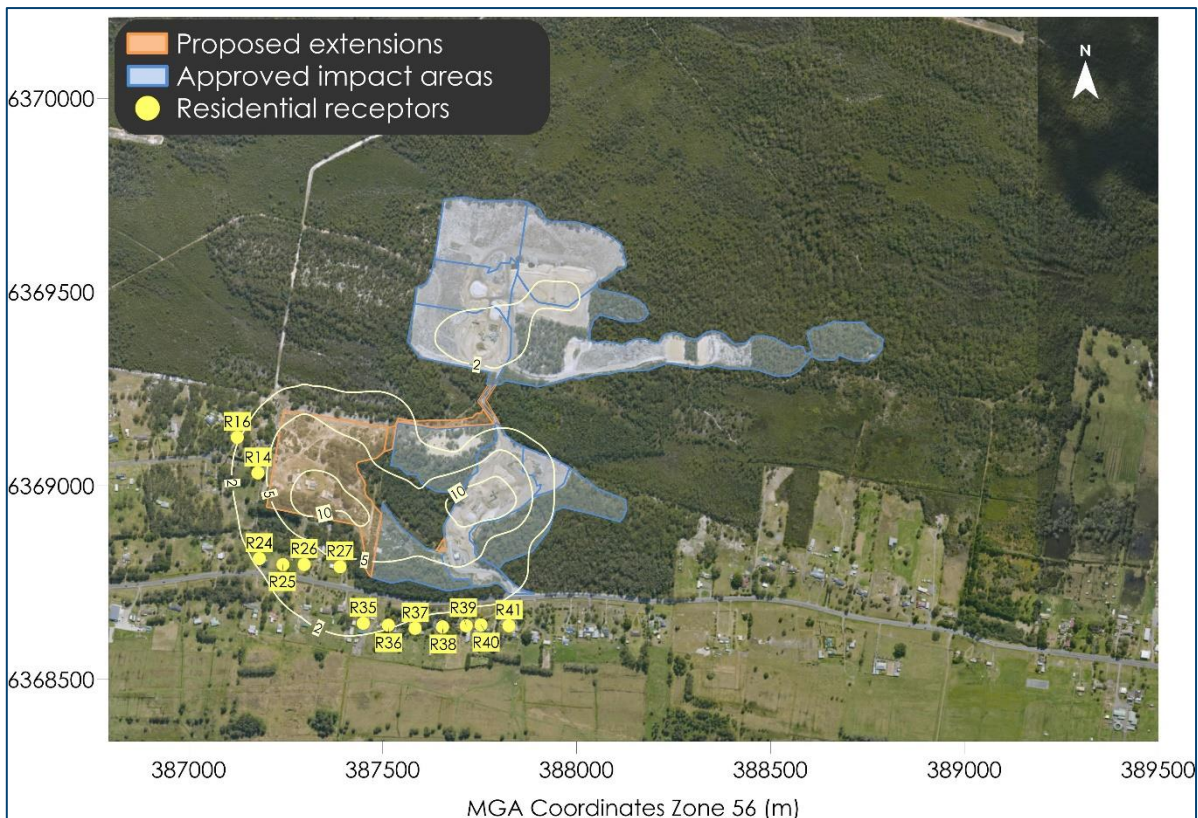


Figure C-1: Predicted incremental maximum 24-hour average PM_{2.5} concentrations (µg/m³)

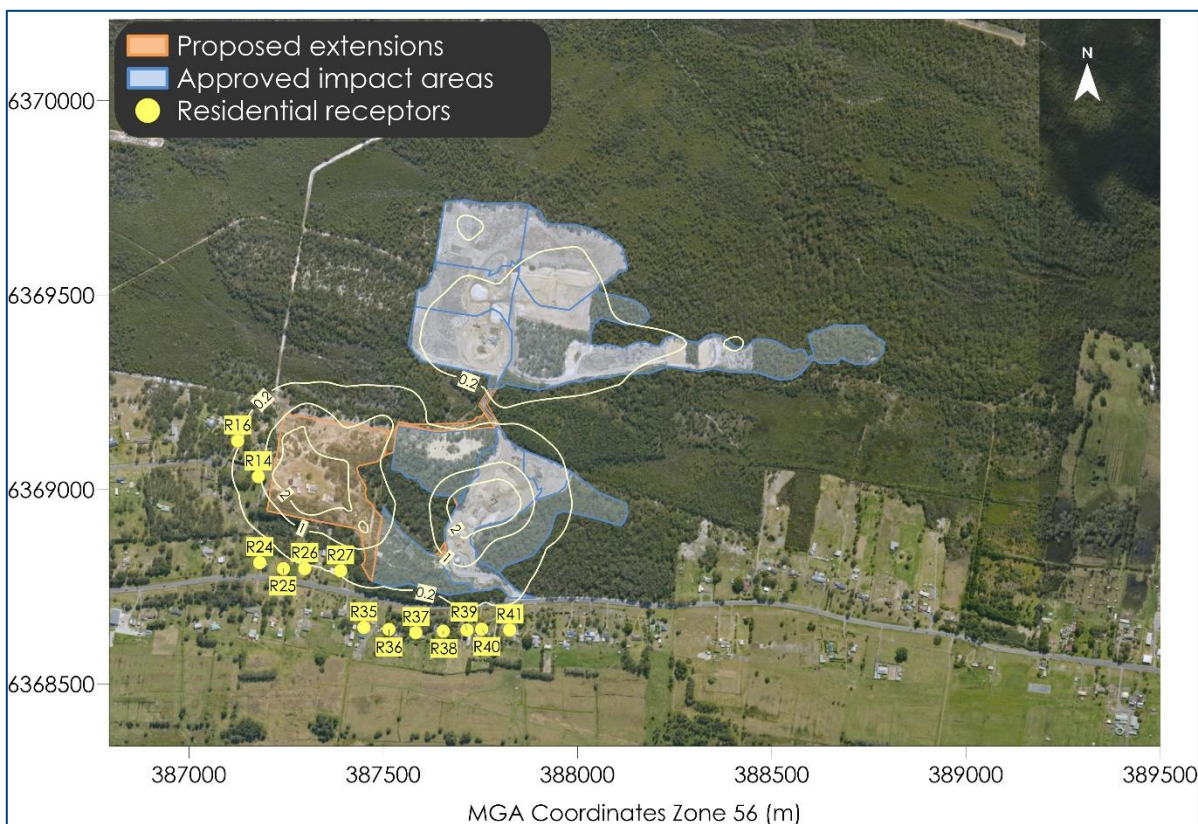


Figure C-2: Predicted incremental annual average PM_{2.5} concentrations (µg/m³)

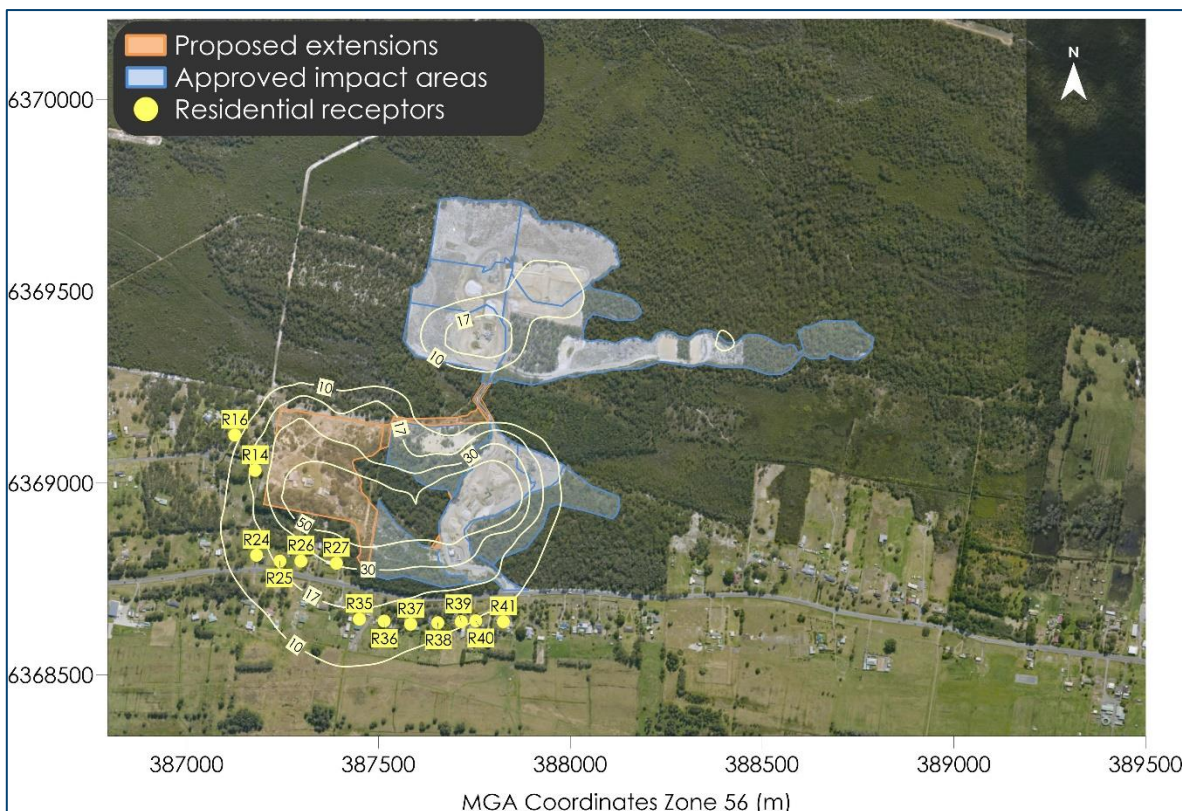


Figure C-3: Predicted incremental maximum 24-hour average PM₁₀ concentrations (µg/m³)

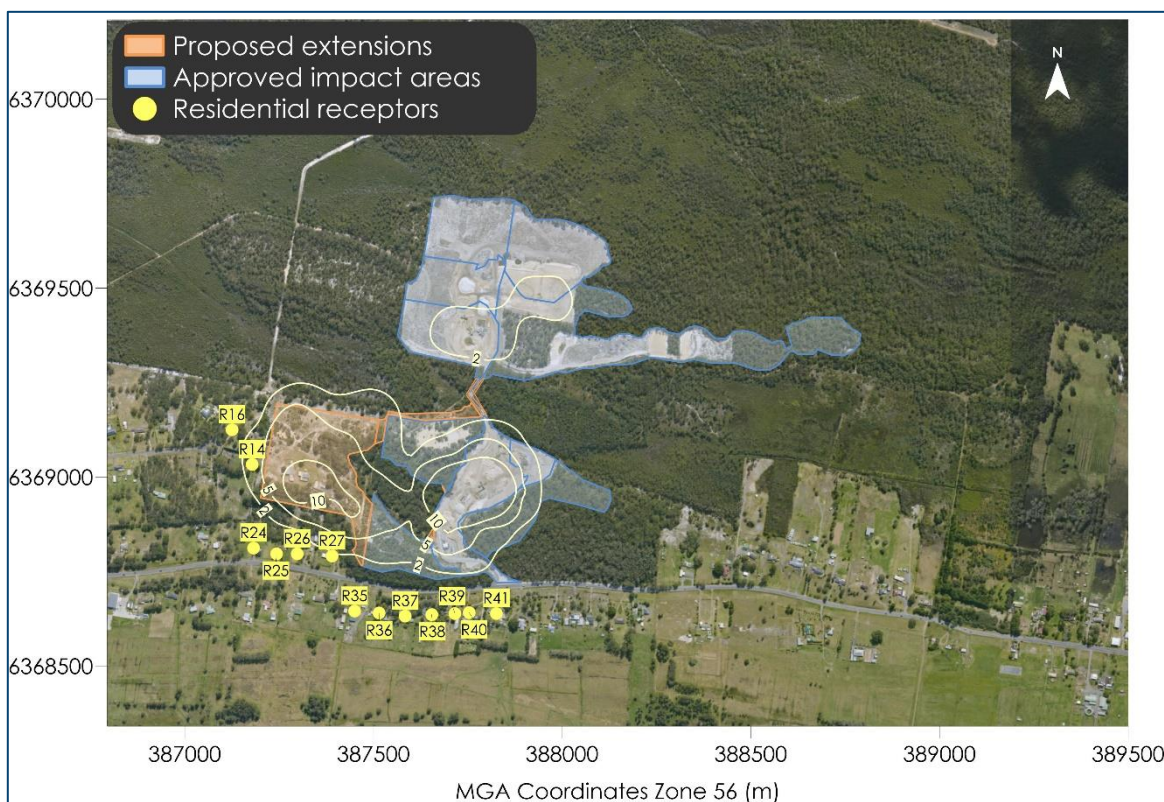


Figure C-4: Predicted incremental annual average PM₁₀ concentrations (µg/m³)

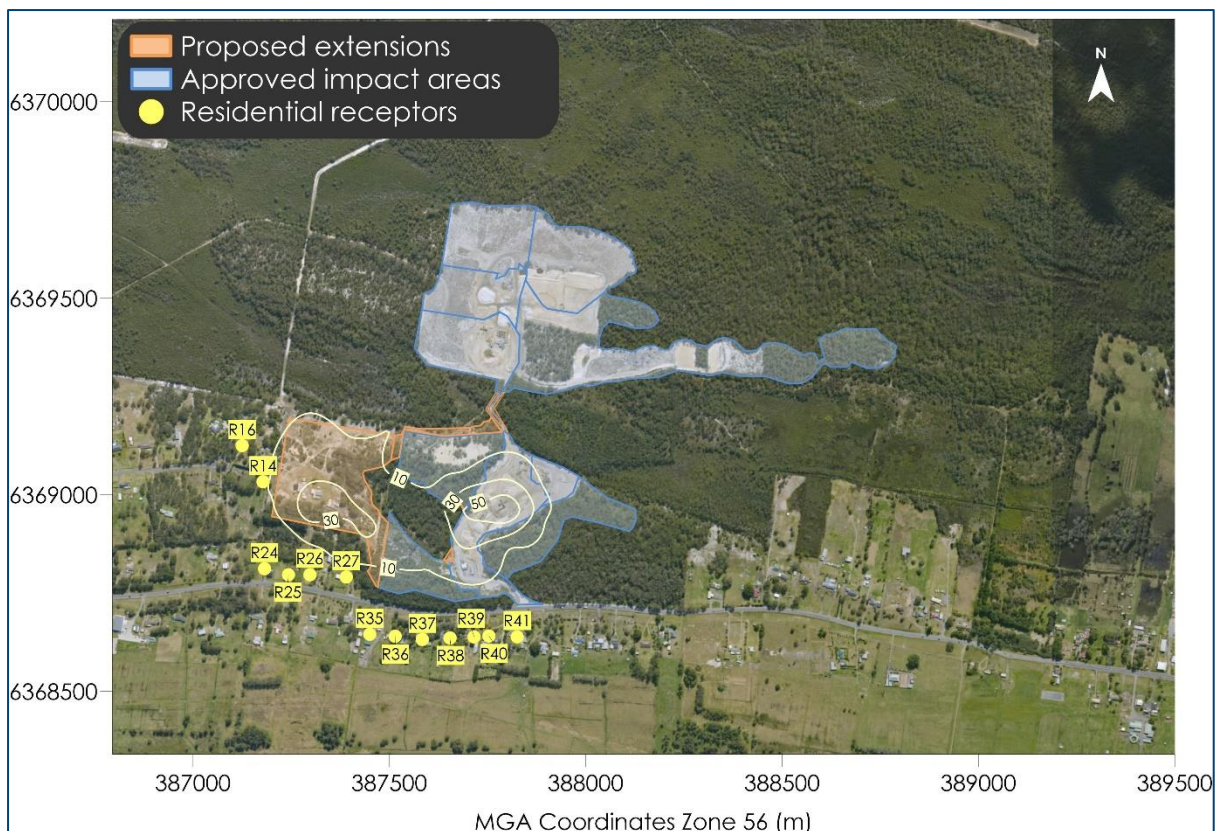


Figure C-5: Predicted incremental annual average TSP concentrations ($\mu\text{g}/\text{m}^3$)

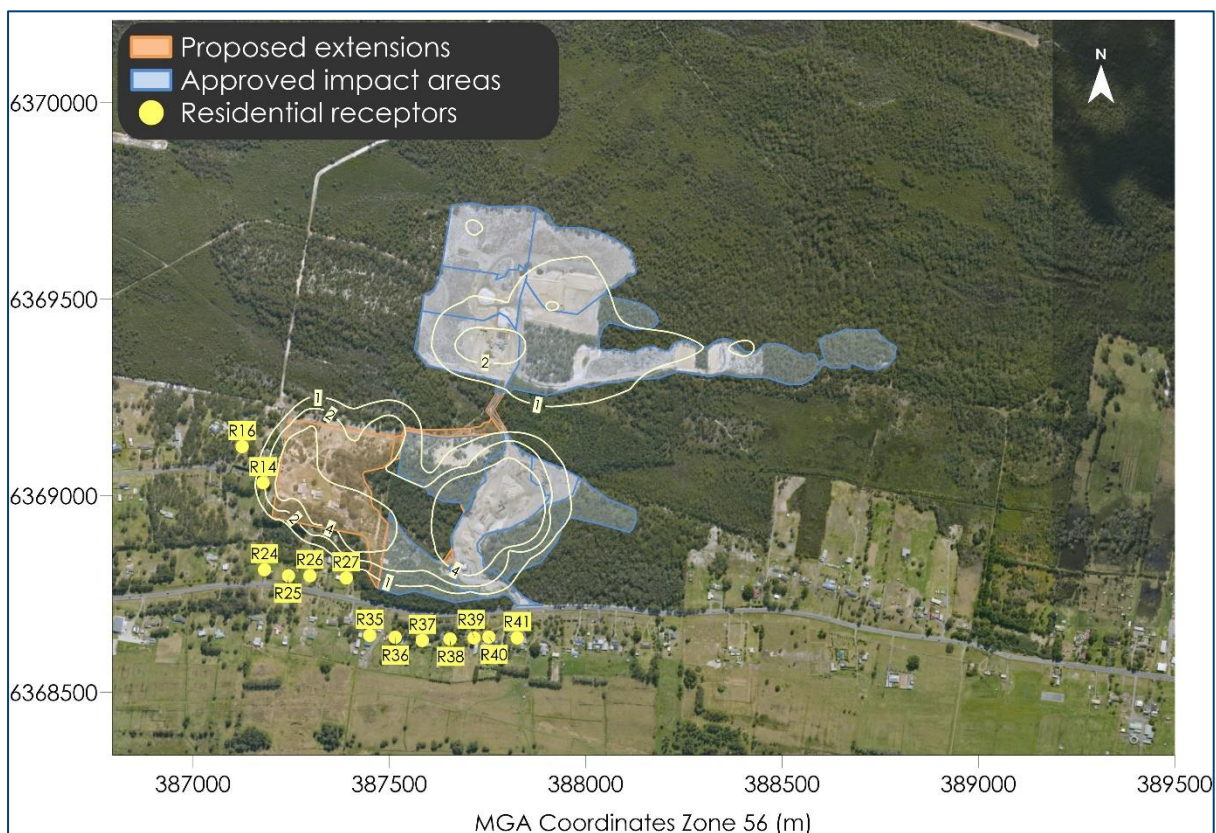


Figure C-6: Predicted incremental annual average dust deposition levels ($\text{g}/\text{m}^2/\text{month}$)

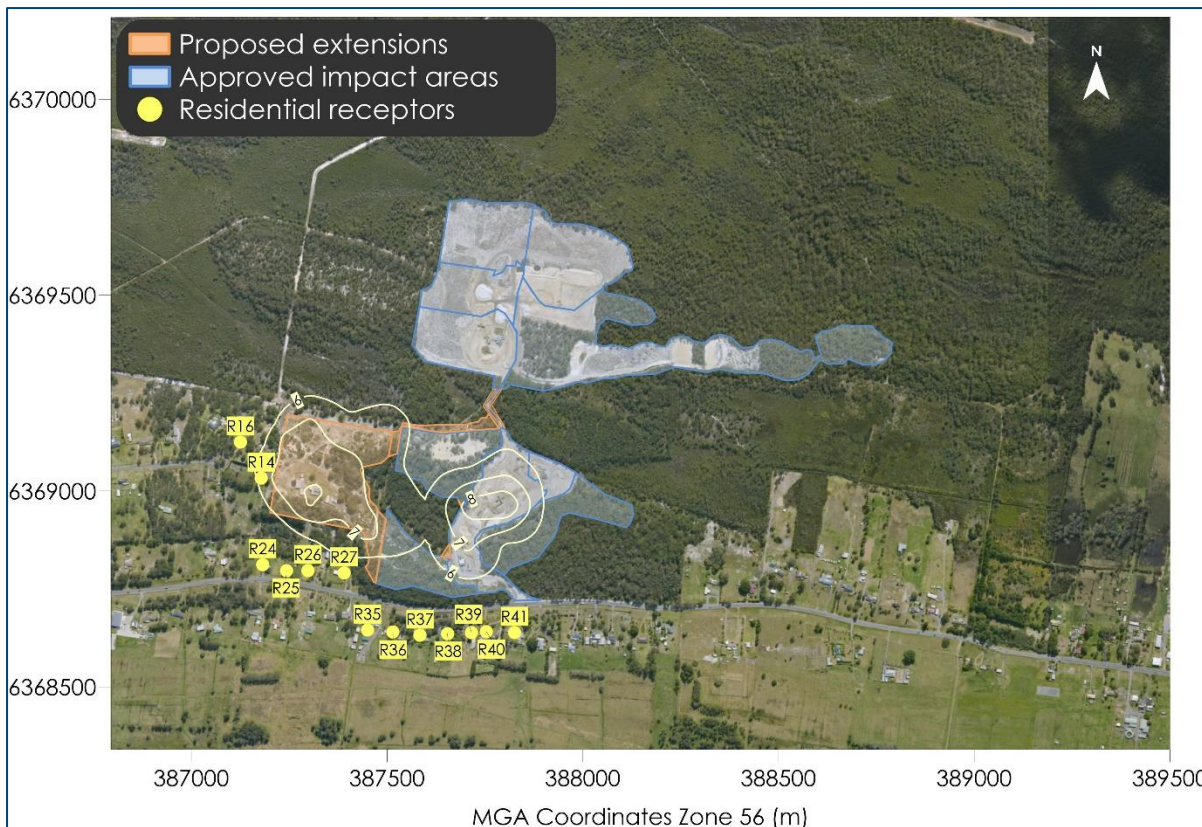


Figure C-7: Predicted cumulative annual average PM_{2.5} concentrations (µg/m³)



Figure C-8: Predicted cumulative annual average PM₁₀ concentrations (µg/m³)

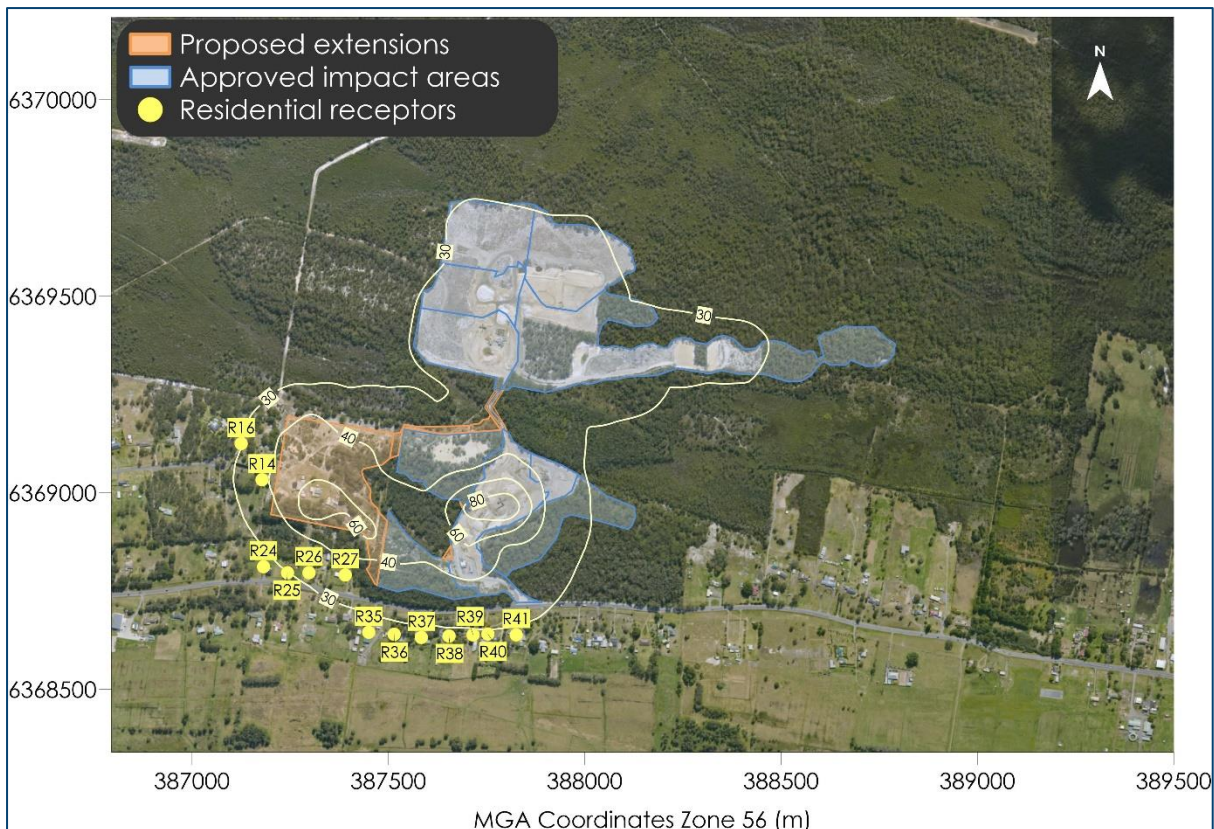


Figure C-9: Predicted cumulative annual average TSP concentrations ($\mu\text{g}/\text{m}^3$)

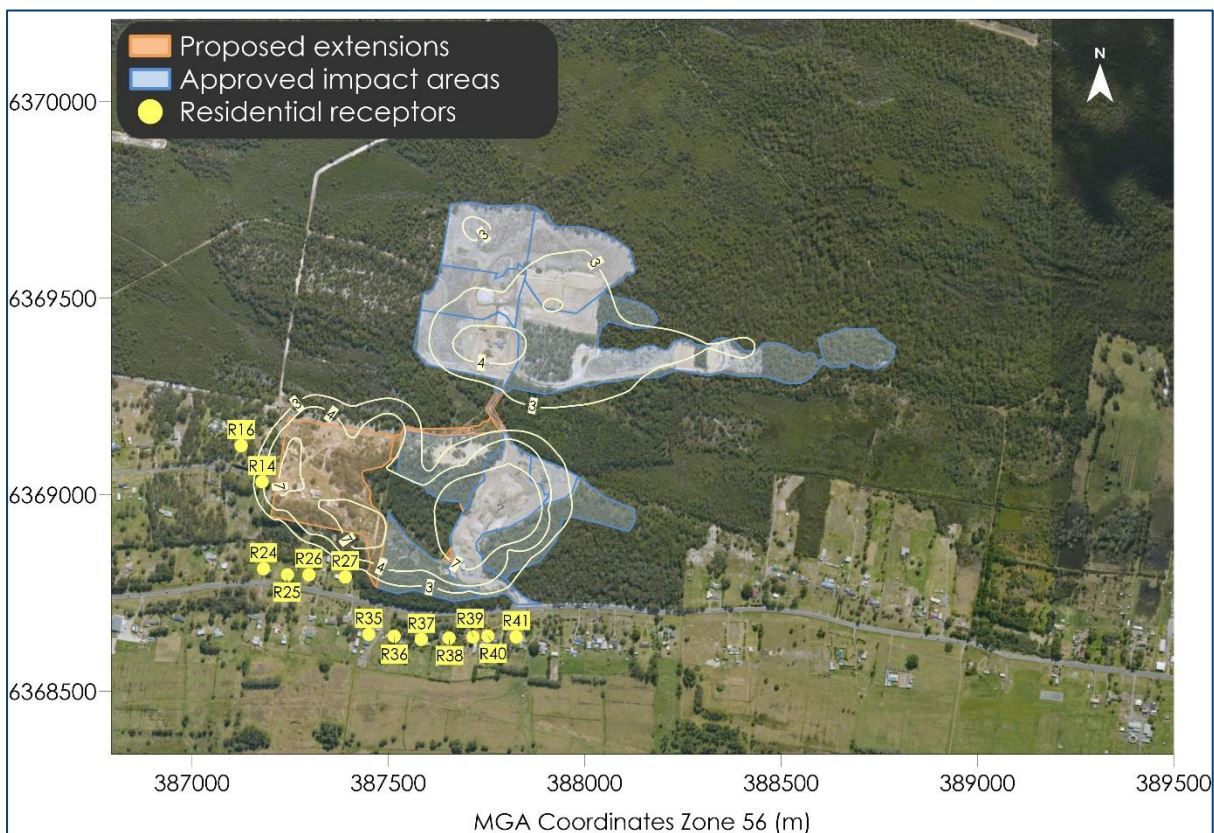


Figure C-10: Predicted cumulative annual average dust deposition levels ($\text{g}/\text{m}^2/\text{month}$)

Appendix D

Further detail regarding 24-hour $PM_{2.5}$ and PM_{10} analysis



Further detail regarding 24-hour average PM_{2.5} and PM₁₀ analysis

The analysis below provides a cumulative 24-hour PM_{2.5} and PM₁₀ impact assessment in accordance with the NSW EPA Approved Methods; refer to the worked example on Page 46 to 47 of the Approved Methods.

The background level for PM₁₀ is the ambient level at the onsite RT1 (BAM) monitor.

The background level for PM_{2.5} is the ambient level at the Wallsend monitoring station for PM_{2.5}.

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

The total is the sum of the background level and the predicted level. The totals may have minor discrepancies due to rounding.

Table D-1 to **Table D-8** assesses selected receptors 14, 25, 26 and 27 and shows the predicted maximum cumulative levels at the selected receptors. The left half of the table examines the cumulative impact during the periods of highest background levels and the right half of the table examines the cumulative impact during the periods of highest contribution from the project.

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

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

The **orange** shading represents days where the measured background level is already over the criteria.

Any value above the PM_{2.5} criterion of 25µg/m³ or above the PM₁₀ criterion of 50µg/m³ is in **bold red**.



Table D-1: Cumulative 24-hour average PM₁₀ concentration (µg/m³) – Receptor 14

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
15/11/2021	33.2	6.3	39.5	3/06/2021	13.0	18.0	30.9
29/10/2021	32.7	4.7	37.3	7/06/2021	19.5	16.1	35.6
8/10/2021	28.6	4.4	33.0	23/06/2021	10.7	15.8	26.5
2/03/2021	27.4	3.5	30.9	8/07/2021	15.7	15.7	31.5
15/01/2021	26.2	4.9	31.0	1/07/2021	6.9	13.3	20.2
15/04/2021	26.0	4.2	30.2	24/05/2021	8.3	12.6	20.9
1/09/2021	25.7	4.7	30.4	26/05/2021	13.9	11.2	25.1
7/10/2021	24.2	5.5	29.8	13/11/2021	23.1	10.0	33.1
24/04/2021	23.9	5.4	29.3	15/07/2021	6.2	9.4	15.7
15/08/2021	23.8	5.6	29.4	6/04/2021	10.7	9.4	20.1

Table D-2: Cumulative 24-hour average PM_{2.5} concentration (µg/m³) – Receptor 14

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
15/08/2021	21.4	1.0	22.4	3/06/2021	13.0	3.8	16.8
14/08/2021	19.8	1.1	20.9	23/06/2021	8.6	3.5	12.1
22/08/2021	19.7	1.0	20.7	7/06/2021	11.1	3.2	14.3
1/09/2021	16.9	1.0	17.9	8/07/2021	13.0	2.7	15.7
31/07/2021	16.7	1.7	18.4	1/07/2021	6.4	2.5	8.9
24/04/2021	15.4	1.1	16.5	15/07/2021	9.2	2.4	11.6
21/08/2021	15.3	1.0	16.3	24/05/2021	5.9	2.1	8.0
19/08/2021	14.4	1.1	15.5	14/07/2021	13.0	2.1	15.1
25/04/2021	14.3	0.7	15.0	25/05/2021	3.2	2.0	5.2
1/06/2021	14.2	1.3	15.5	10/11/2021	7.0	1.9	8.9



Table D-3: Cumulative 24-hour average PM₁₀ concentration (µg/m³) – Receptor 25

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
15/11/2021	33.2	<0.1	33.2	23/06/2021	10.7	18.0	28.8
29/10/2021	32.7	0.3	33.0	7/06/2021	19.5	16.9	36.4
8/10/2021	28.6	2.0	30.6	3/06/2021	13.0	15.0	28.0
2/03/2021	27.4	<0.1	27.4	15/07/2021	6.2	10.5	16.7
15/01/2021	26.2	0.8	26.9	14/07/2021	8.8	10.0	18.8
15/04/2021	26.0	1.5	27.5	2/05/2021	4.7	9.9	14.7
1/09/2021	25.7	0.7	26.4	1/07/2021	6.9	9.3	16.2
7/10/2021	24.2	1.0	25.2	23/07/2021	10.4	8.8	19.3
24/04/2021	23.9	2.4	26.3	25/05/2021	7.2	8.7	15.9
15/08/2021	23.8	0.3	24.1	8/07/2021	15.7	8.6	24.4

Table D-4: Cumulative 24-hour average PM_{2.5} concentration (µg/m³) – Receptor 25

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
15/08/2021	21.4	<0.1	21.4	23/06/2021	8.6	2.8	11.4
14/08/2021	19.8	0.2	20.0	7/06/2021	11.1	2.5	13.6
22/08/2021	19.7	0.5	20.2	3/06/2021	13.0	2.4	15.4
1/09/2021	16.9	0.1	17.0	15/07/2021	9.2	1.7	10.9
31/07/2021	16.7	1.1	17.8	14/07/2021	13.0	1.5	14.5
24/04/2021	15.4	0.3	15.7	2/05/2021	4.0	1.3	5.3
21/08/2021	15.3	0.3	15.6	1/07/2021	6.4	1.3	7.7
19/08/2021	14.4	0.4	14.8	8/06/2021	9.7	1.2	10.9
25/04/2021	14.3	<0.1	14.3	25/05/2021	3.2	1.2	4.4
1/06/2021	14.2	0.9	15.1	23/07/2021	8.4	1.1	9.5



Table D-5: Cumulative 24-hour average PM₁₀ concentration (µg/m³) – Receptor 26

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
15/11/2021	33.2	0.2	33.4	23/06/2021	10.7	23.7	34.4
29/10/2021	32.7	0.8	33.5	7/06/2021	19.5	20.4	39.9
8/10/2021	28.6	2.1	30.7	3/06/2021	13.0	19.2	32.2
2/03/2021	27.4	<0.1	27.4	15/07/2021	6.2	15.0	21.2
15/01/2021	26.2	0.9	27.0	14/07/2021	8.8	13.8	22.7
15/04/2021	26.0	1.7	27.7	1/07/2021	6.9	13.0	19.9
1/09/2021	25.7	1.1	26.8	8/06/2021	9.7	12.1	21.8
7/10/2021	24.2	1.9	26.1	23/07/2021	10.4	11.9	22.3
24/04/2021	23.9	2.7	26.6	25/05/2021	7.2	11.8	19.0
15/08/2021	23.8	0.5	24.3	8/07/2021	15.7	11.5	27.2

Table D-6: Cumulative 24-hour average PM_{2.5} concentration (µg/m³) – Receptor 26

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
15/08/2021	21.4	0.1	21.5	23/06/2021	8.6	3.5	12.1
14/08/2021	19.8	0.2	20.0	3/06/2021	13.0	2.9	15.9
22/08/2021	19.7	0.6	20.3	7/06/2021	11.1	2.9	14.0
1/09/2021	16.9	0.2	17.1	15/07/2021	9.2	2.3	11.5
31/07/2021	16.7	1.5	18.2	14/07/2021	13.0	1.9	14.9
24/04/2021	15.4	0.3	15.7	1/07/2021	6.4	1.8	8.2
21/08/2021	15.3	0.5	15.8	8/06/2021	9.7	1.7	11.4
19/08/2021	14.4	0.6	15.0	25/05/2021	3.2	1.6	4.8
25/04/2021	14.3	<0.1	14.3	23/07/2021	8.4	1.5	9.9
1/06/2021	14.2	1.3	15.5	2/05/2021	4.0	1.5	5.5

Table D-7: Cumulative 24-hour average PM₁₀ concentration (µg/m³) – Receptor 27

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
15/11/2021	33.2	1.3	25.4	23/06/2021	10.7	30.1	40.8
29/10/2021	32.7	2.1	25.4	3/06/2021	13.0	24.9	37.8
8/10/2021	28.6	2.3	25.4	7/06/2021	19.5	23.4	42.9
2/03/2021	27.4	0.3	25.4	15/07/2021	6.2	20.1	26.4
15/01/2021	26.2	1.2	25.4	1/07/2021	6.9	19.8	26.6
15/04/2021	26.0	2.3	25.4	14/07/2021	8.8	17.5	26.4
1/09/2021	25.7	2.1	25.4	8/06/2021	9.7	16.5	26.2
7/10/2021	24.2	3.8	25.4	8/07/2021	15.7	16.3	32.0
24/04/2021	23.9	3.3	25.4	2/07/2021	7.8	15.3	23.1
15/08/2021	23.8	1.6	25.4	23/07/2021	10.4	15.1	25.5

Table D-8: Cumulative 24-hour average PM_{2.5} concentration (µg/m³) – Receptor 27

Ranked by Highest to Lowest Background Concentrations				Ranked by Highest to Lowest Predicted Incremental Concentration			
Date	Measured background level	Predicted increment	Total cumulative 24-hr average level	Date	Measured background level	Predicted increment	Total cumulative 24-hr average level
15/08/2021	21.4	0.2	21.6	23/06/2021	8.6	4.3	12.9
14/08/2021	19.8	0.4	20.2	3/06/2021	13.0	3.5	16.5
22/08/2021	19.7	0.8	20.5	7/06/2021	11.1	3.3	14.4
1/09/2021	16.9	0.3	17.2	15/07/2021	9.2	2.9	12.1
31/07/2021	16.7	2.1	18.8	1/07/2021	6.4	2.7	9.1
24/04/2021	15.4	0.4	15.8	14/07/2021	13.0	2.3	15.3
21/08/2021	15.3	0.7	16.0	8/06/2021	9.7	2.1	11.8
19/08/2021	14.4	1.0	15.4	31/07/2021	16.7	2.1	18.8
25/04/2021	14.3	0.1	14.4	8/07/2021	13.0	2.0	15.0
1/06/2021	14.2	1.7	15.9	23/07/2021	8.4	1.9	10.3

