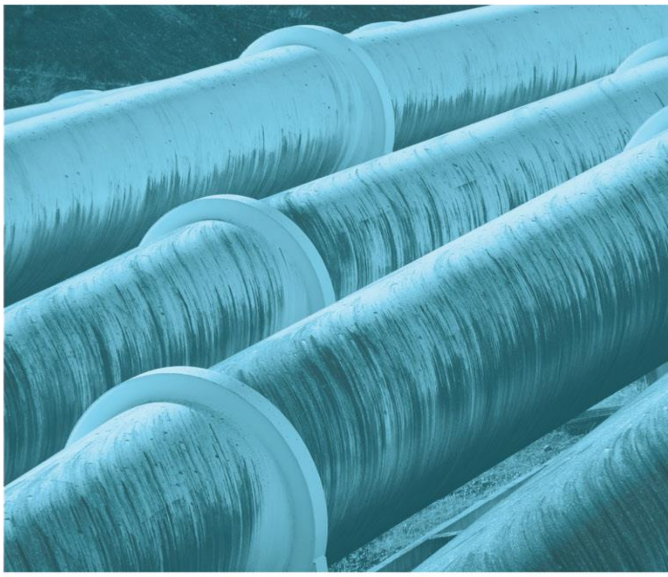
APPENDIX C

Air Quality and Greenhouse Gas Assessment

Appin Mine Ventilation and Access Project

Air Quality and Greenhouse Gas Assessment

Prepared for Illawarra Metallurgical Coal
June 2021



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Appin Mine Ventilation and Access Project

Air Quality and Greenhouse Gas Assessment

Report Number

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Illawarra Metallurgical Coal

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Executive Summary

ES1 Introduction

EMM Consulting Pty Ltd (EMM) has been commissioned to prepare an air quality and greenhouse gas assessment for the construction and operation of infrastructure critical to the ongoing viability of the Appin Mine. Referred to as the Appin Mine Ventilation and Access Project, the Project includes the development of mine access facilities, a downcast ventilation shaft (Ventilation Shaft 7), an upcast ventilation shaft (Ventilation Shaft 8), three extraction fans, ducting and evases and associated ancillary infrastructure.

ES2 Local setting and existing environment

The Project is located approximately 35 km northwest of Wollongong and 8 km northwest of Appin. The township of Menangle is located approximately 1.3 km to the northeast of the Site. To assess potential air quality impacts across the surrounding area, residences within approximately 1.5 km of the Site have been selected as discrete assessment locations.

Analysis of meteorology for the region is presented based on the regional automatic weather stations located at Camden, Campbelltown West, Douglas Park and Appin. Analysis of background air quality is based on air quality monitoring stations at Camden and Campbelltown West.

ES3 Emission sources

This report presents a quantitative modelling assessment of potential air quality impacts for both the construction and operation phases of the Project, prepared in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales.

The construction phase assessment focuses on fugitive dust from site preparation, earthworks, shaft spoil handling. An emissions inventory has been developed for a nominal year of the construction period, selected to assess the worst-case air quality impacts when material handling/movement is at a maximum. The primary dust generating activity occurs during site preparation/bulk earthworks and shaft sinking.

During operations, the key emissions source is the ventilation fan evases for Ventilation Shaft 8 and the modelling assessment focuses on the key emission sources of particulate matter (TSP, PM_{10}, $PM_{2.5}$), oxides of nitrogen (NO_x) and odour.

ES4 Modelling results

The highest predicted dust concentrations during construction occur at the closest assessment location to the north of the Project. Modelling predictions indicate that there would be no additional days over the 24-hour average impact assessment criterion for PM_{10} and $PM_{2.5}$ and no exceedances of the annual average impact assessment criterion at any assessment location for PM_{10}, $PM_{2.5}$, TSP and dust deposition.

For operations, two flow scenarios are assessed based on ventilation requirement milestones for 2025 and 2033. The highest predicted impacts for PM_{10} and $PM_{2.5}$ during operations occur at assessment locations to the southwest of the Project. When background concentrations are added to the Project increment, there are no additional days over the 24-hour average impact assessment criterion for PM_{10} and $PM_{2.5}$, for both flow scenarios. For annual average PM_{10} and $PM_{2.5}$ concentrations, there are no exceedances of the annual average impact assessment criterion at any assessment location for both flow scenarios. Similarly, for annual average TSP concentrations and dust deposition there are no exceedances of the annual average impact assessment criterion at any assessment location for both flow scenarios. For the assessment of NO_2, the atmospheric conversion of NO_x to NO_2 is accounted for using the ozone limiting method. When background concentrations are added to the Project increment, the highest cumulative 1-hour average NO_2 concentration (95.8 $\mu g/m^3$) is approximately 39% of the impact assessment criterion. For annual average NO_2 concentrations, the Project increments are small (less than 1 $\mu g/m^3$ or 1% of the impact assessment criterion). When background concentrations are added to the Project increment, there are no exceedances of the annual average impact assessment criterion at any assessment location.

Potential odour impacts are evaluated by modelling emission of odour and hydrogen sulphide (H_2S). There are no exceedances of the most stringent odour and H_2S impact assessment criteria at all assessment locations and for both flow scenarios.

ES5 Greenhouse gas

Annual average GHG emissions (Scope 2) for the operation of the Project represent approximately 0.03% of total GHG emissions for NSW and 0.008% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2018. However, it is noted that the proposed surface fans at Ventilation Shaft 8 will reduce the need for underground booster fans and therefore reduce the overall electricity consumption for the Appin Mine (compared to what would otherwise be required under a business-as-usual scenario without the Project).

Measures to minimise the release of GHG and to support the South32 Climate Change Strategy at the Appin Mine continue to be implemented and reported in the Annual Review.

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1 Introduction

The Appin Mine (the Mine) is an existing underground coal mine situated in the Southern Coalfield of New South Wales (NSW) approximately 25 kilometres north-west of Wollongong. The Mine is owned and operated by Endeavour Coal Pty Ltd, a subsidiary of Illawarra Coal Holdings Pty Ltd, which is a wholly owned subsidiary of South32 Limited. Appin Mine, Cordeaux Colliery and Dendrobium Mine (and associated facilities) collectively operate as South32 Illawarra Metallurgical Coal (IMC).

IMC received Project Approval 08_0150 (the Appin Mine approval) from the Planning Assessment Commission of NSW under delegation of the Minister for Planning and Infrastructure on 22 December 2011 for current and proposed mining of the Bulli Seam Operations (BSO). The Appin Mine approval was gazetted as a State Significant Development for the purposes of future modifications on 23 November 2018.

IMC is seeking to modify the existing Appin Mine approval, pursuant to Section 4.55(2) of the NSW *Environment Planning and Assessment Act 1979* (EP&A Act), to incorporate the construction and operation of infrastructure critical to the ongoing viability of the Mine referred to as the Appin Mine Ventilation and Access Project (hereafter referred to as the Project).

1.1 Purpose of this report

EMM Consulting Pty Ltd (EMM) has been commissioned to prepare an air quality and greenhouse gas assessment for the Project. The assessment presents a quantitative assessment of potential air quality impacts for both the construction and operation phases of the Project, prepared in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW Environment Protection Authority (EPA) 2017).

The assessment follows a Level 2 assessment approach, including the following tasks:

- emissions are estimated for all activities using best practice emission estimation techniques;
- dispersion modelling, using a regulatory dispersion model, is used to predict ground level concentrations for key pollutants at assessment locations;
- cumulative impacts are considered by taking into account the combined effect of existing baseline air quality, other local sources of emissions, reasonably foreseeable future emissions and any indirect or induced effects;
- air quality impacts are evaluated by comparing against impact assessment criteria presented in the Appin Mine Approval and NSW EPA 2017; and
- estimates of the greenhouse gas (GHG) emissions are presented and benchmarked against GHG accounts for NSW and Australia.

2 Project overview

2.1 Existing operations

The Appin Mine approval incorporates the underground longwall mining operations, which extract coal from the Bulli Seam, and the associated surface activities. The Mine primarily produces hard coking (metallurgical) coal and has an approved operational capacity of up to 10.5 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal until 2041.

Longwall mining is currently being undertaken in the approved mining areas, Area 9 and Area 7, following completion of longwall mining activities at West Cliff Colliery in early 2016. Key surface facilities at the Mine include the:

- Appin East Colliery (Appin East);
- Appin West Colliery (Appin West);
- Appin North Colliery (Appin North);
- West Cliff Coal Preparation Plant (WCCPP);
- West Cliff Emplacement Area (WCEA);
- Appin East No.1 and No. 2 ventilation shaft site;
- Appin East No. 3 ventilation shaft site;
- Appin West No. 6 ventilation shaft site; and
- Douglas Park substation site.

ROM coal is extracted from the Appin underground mining operations and delivered directly to the WCCPP by winder and conveyor or is transported from Appin East via truck along Appin and Wedderburn Roads to the WCCPP. Processed coal (clean coal product) from the WCCPP is transported by road to the Port Kembla Coal Terminal (PKCT) for shipping to domestic and international customers, or to BlueScope Steel or other local customers.

The Mine is accessed via the shaft at Appin West and drifts at Appin North and Appin East. The Mine is ventilated by two distinct ventilation districts; Appin Mine and Appin North. The Appin Mine district is ventilated by two upcast shafts (No. 2 and No. 6), four downcast shafts (No. 1, No. 3, No. 4, and No. 5) and two intake drifts at Appin East. The Appin North district is ventilated by one upcast shaft (No. 1), one downcast shaft (No. 2) and one intake drift at Appin North.

2.2 Proposed Modification

An integral requirement of underground mining is adequate ventilation infrastructure and mine access facilities to ensure a safe and efficient underground working environment. Appin Mine operations are progressing further away from the existing surface infrastructure located in the Appin and Douglas Park areas, and additional infrastructure is required to support the ongoing operations.

The Project involves the construction and operation of a downcast ventilation shaft (Ventilation Shaft 7), an upcast ventilation shaft (Ventilation Shaft 8), three (3) extraction fans, ducting and evases and associated ancillary infrastructure. Based on the current mining schedule, the additional ventilation shafts are required to be operational prior to 2025.

The Project also involves the development of mine access facilities including headframe and personnel and materials winder (within Ventilation Shaft 7), and surface facilities consisting of offices, stores, bathhouse facilities and car parking areas. The establishment of these facilities would provide access for personnel and consumable materials to the Mine and will increase the safety and efficiency of transporting personnel and consumable materials underground.

To support the key infrastructure noted above, the Project will also include the following activities:

- installation of temporary and permanent site access arrangements, including upgrade or improvement to the Site/Menangle Road intersection, internal roadways, associated hardstand and car parking areas;
- site preparation, including clearing of vegetation, demolition of existing structures and earthworks;
- installation of appropriate security (e.g. fencing) to prevent unauthorised access to the site;
- installation of a water supply, power supply and transmission and associated electrical switch rooms, transformers and ancillary infrastructure;
- shaft material/spoil handling and emplacement activities and associated revegetation and landscaping activities to minimise visual impact of the site;
- installation of personnel amenities such as bathhouses (e.g. changerooms), administration facilities and mines rescue facilities;
- installation of diesel storage tanks and associated pipelines;
- progressive development of sumps, pumps, pipelines, water storages and other water management infrastructure including fire protection and sewerage treatment facilities;
- installation of covered storage areas;
- installation of communications equipment including fibre optic cable and wireless infrastructure;
- installation of service boreholes to provide underground services;
- controlled release of excess water and/or re-use of water where practicable;
- progressive rehabilitation of disturbed areas post construction;
- installation of erosion and sediment control infrastructure, where required; and
- other associated minor infrastructure, plant, equipment and activities.

The Project would be similar to previously approved ventilation and mine access infrastructure for the Appin Mine and will not increase the volume of coal produced. Coal handling infrastructure is not proposed as part of the Project.

The shafts would be constructed from the surface down to the underground workings using conventional shaft sinking methods (mechanical excavation, drilling and controlled blasting) with material from the excavation being removed from the top of the shaft. The excavated material resulting from the construction of the shafts would be used as engineered fill and for construction of earth screening bunds and sediment dams. Where practicable, excess material would be stockpiled on-site, revegetated and used for future rehabilitation of the shaft site upon decommissioning. The two shafts would be lined progressively during excavation.

The Project will comprise multiple phases of construction and operation.

Construction of the ventilation shafts is critical to the ongoing safe and efficient operation of the Appin Mine, and as such, will take priority for the construction phase. Construction of the downcast shaft will commence first. Once the shaft sinking is complete and the ventilation infrastructure is installed, each shaft will commence commissioning and operation immediately.

The construction phase (12-18 months) for establishing mine access infrastructure would occur subsequent to the ventilation infrastructure. Construction of mine access infrastructure will be influenced by scheduling and timing of longwall operations over the life of the BSO Project and will be developed in parallel with the requirements of the ongoing mining operations.

Activities associated with sinking the shafts would occur 24 hours per day, seven days per week. The remainder of construction activities associated with the facility (e.g. installation of surface infrastructure) would generally be limited to daytime construction hours[1]. Once operational, the site would be required to operate 24 hours per day, seven days per week, consistent with other similar facilities of the Mine.

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[1] Daytime construction hours are defined as Monday to Saturday, 7.00am to 6.00pm.

3 Local setting and assessment locations

3.1 Project Area (the Site)

The Project Area (hereafter referred to as the Site) is approximately 35 km northwest of Wollongong and 8 km northwest of Appin (Figure 1). The township of Menangle is located approximately 1.3 km to the northeast of the Site. The Site is located on land owned by IMC, within the Bulli Seam Operations Project Longwall Mining Area and within the South Campbelltown Mine Subsidence District in the Southern Coalfield of NSW.

The Site will incorporate Ventilation Shaft 7, Ventilation Shaft 8, mine access facilities and additional areas for associated works and infrastructure, such as the construction of site access and the provision of services to the Site. The boundary of the Site and the extent of the assessment area are shown in Figure 3.2.

Infrastructure that will be developed on the Site will be positioned to align with the approved layout of the underground workings for Appin Area 7 (Figure 3.3), to be proximal to required services and to minimise the potential impacts on the environment and communities of Menangle and Douglas Park.

3.2 Assessment locations

To assess potential air quality impacts across the surrounding area, residences within approximately 1.5 km of the Site have been selected as discrete assessment locations. The assessment locations are shown in Figure 3.4 and Table A.1 (Appendix A). It is noted the assessment location R1 is within the construction boundary, is currently unoccupied and will be demolished as part of the preparatory works or utilised by the Project for the duration of the Project construction and operation phase. R1 is therefore not considered as an occupied assessment location for air quality assessment.

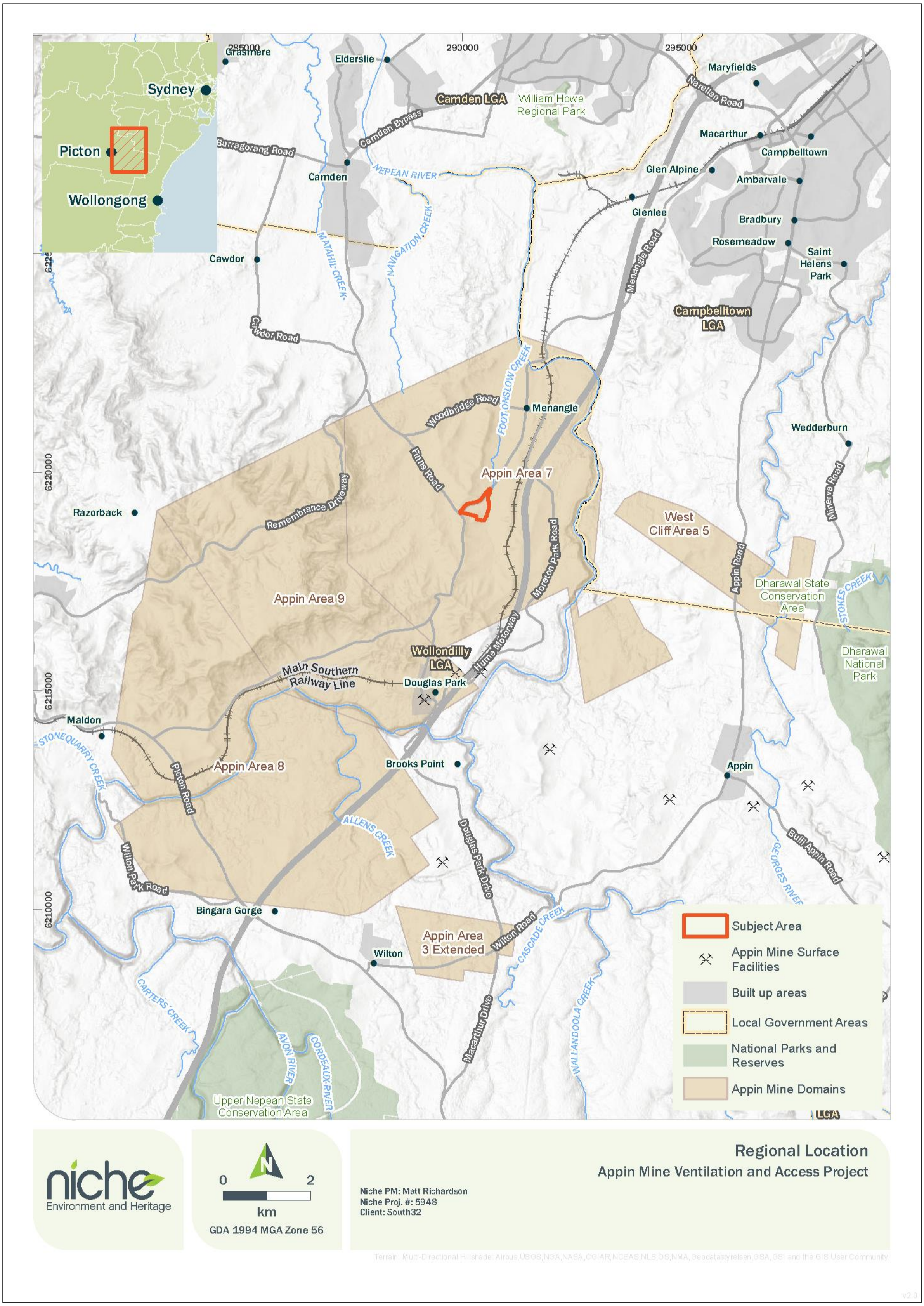

Figure 3.1 Regional Location

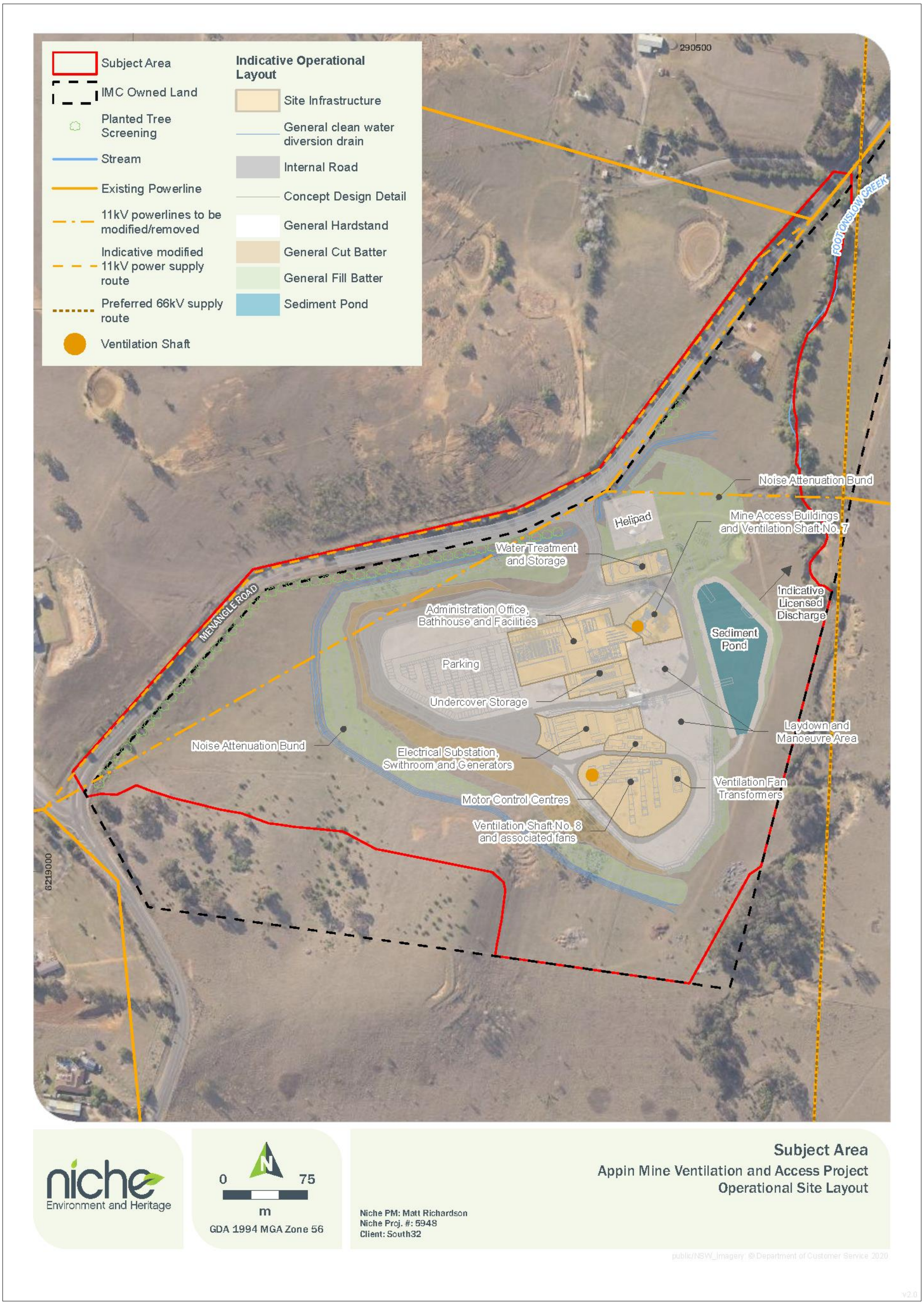

Figure 3.2 Operational Site Layout

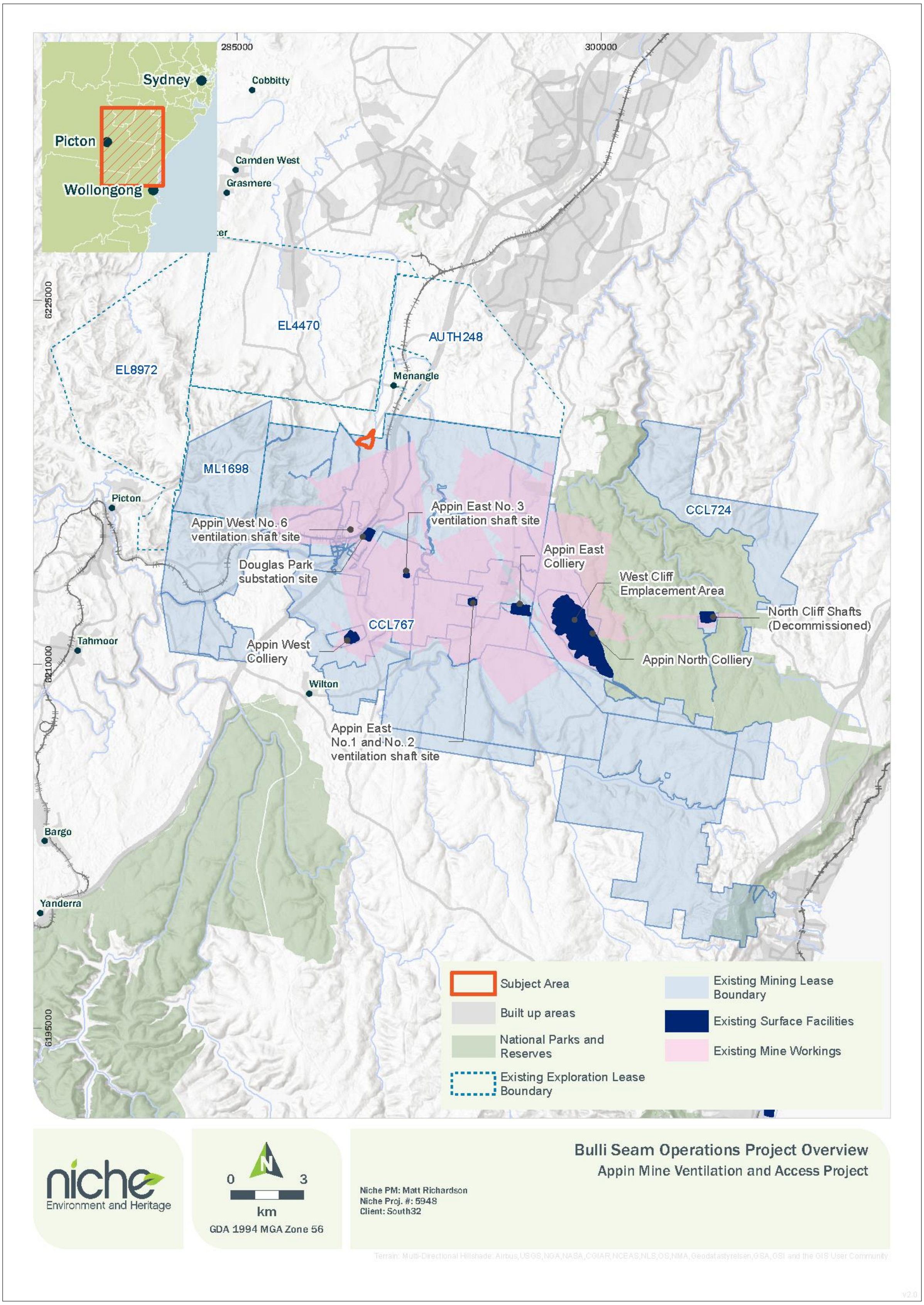

Figure 3.3 Bulli Seam Operations Project Overview

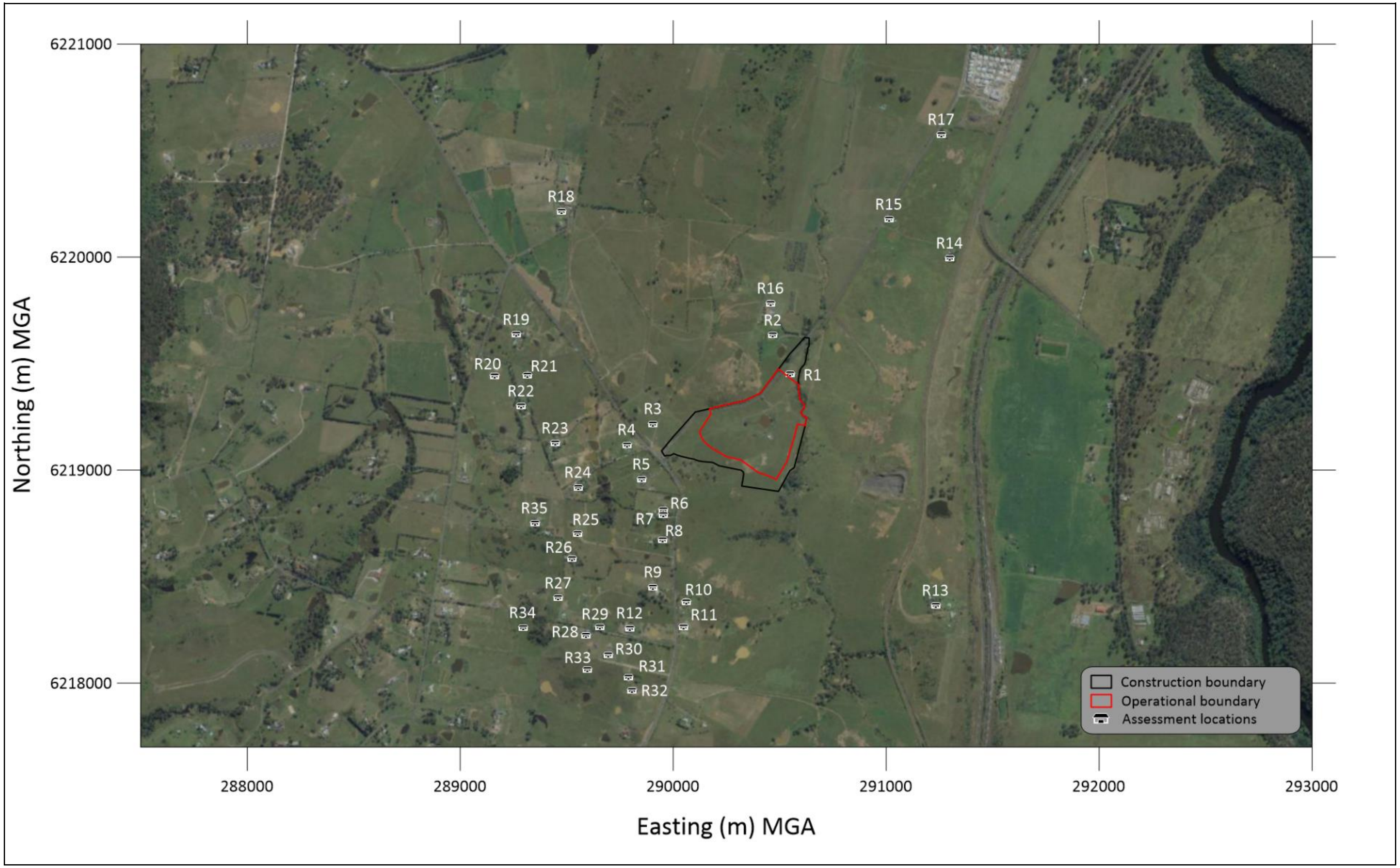

Figure 3.4 Assessment locations for air quality modelling

4 Pollutants and assessment criteria

The primary purpose of mine ventilation is to provide a safe working environment for mine employees underground. Mine ventilation air (MVA) will typically contain pollutants which can be broadly classified as:

- dust/particulate matter; and
- gaseous pollutants.

Dust, or particulate matter (PM[2]) in MVA will comprise of mechanically generated material from the mining process (ie coal dust, stone dust) and from the combustion of diesel in underground mining equipment. PM may also comprise of other trace elements, for example metals. The combustion of diesel in mining equipment results in the emission of PM mostly in the $PM_{2.5}$ fraction, as well as gases including oxides of nitrogen (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2) and volatile organic compounds (VOCs).

Due to the requirement to protect mine employees working underground, pollution controls are required for all underground diesel equipment which significantly reduces emissions. Pollutant concentrations in MVA are managed to be below levels that would normally be associated with adverse health effects for employees (ie below time-weighted average workplace exposure standards). Notwithstanding, ambient air quality standards are typically more stringent than workplace exposure standards, as the ambient air quality goals are set to protect the most sensitive individuals in the community, such as children, the elderly and those with respiratory or cardiovascular illness.

MVA will also include gases released from the disturbance of the coal seam. The gases released in the highest concentrations are carbon dioxide (CO_2) and methane (CH_4). These gases are not considered pollutants from an ambient air quality and health perspective, but are assessed as greenhouse gases. Other gases, including VOCs and sulphur compounds, may be odorous. A summary of all the potential emission sources and pollutants relevant to the Project is presented in Table 4.1.

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[2] Dust, or particulate matter (PM) is classified according to particle size. The size metrics in most common use are TSP, PM_{10} and $PM_{2.5}$. TSP, which refers to airborne particles less than around 30-50 µm in diameter, is used as a metric for assessing amenity impacts (reduction in visibility, dust deposition and soiling of buildings and surfaces) rather than health impacts (NSW EPA 2013). Particles less than 10 µm and 2.5 µm in diameter, classified as PM_{10} and $PM_{2.5}$ respectively, are subsets of TSP. Particles in these size ranges are fine enough to enter the human respiratory system and can therefore lead to adverse human health impacts.

Table 4.1 Emission sources and pollutants relevant to the Project

Project component	Category	Emission source / activity	Key pollutants	Relevant section in this report
Construction	Air quality	Fugitive dust from site preparation, earthworks, shaft spoil handling	TSP, PM_{10}, $PM_{2.5}$ and dust deposition	Emissions quantified and assessed – refer Section 7.1 and 8.2
		Onsite fuel combustion	PM_{10} and $PM_{2.5}$	
			NO_x, SO_2, CO, VOCs	Gaseous emissions from diesel combustion have not been modelled. Based on the relatively minor quantities of diesel consumed, there would be no impact on local air quality – refer Section 4.3
		Explosive use	Blast fume (NOx and odour)	Emissions from blasting are not quantitatively assessed – refer Section 4.4. Management measures are outlined in Section 9.1.1
	Greenhouse gas	Onsite fuel combustion	CO_2, N_2O and CH_4	Emissions quantified and assessed (Section 10)
		Explosive use	CO_2, N_2O and CH_4	
		Electricity consumption	CO_2, N_2O and CH_4	
Operation	Air quality	Mine ventilation air	TSP, PM_{10}, $PM_{2.5}$	Emissions quantified and assessed where relevant – refer Section 7.2 and 8.3
			Odour	
			NO_x, SO_2, CO, VOCs	
			Metals	
	Greenhouse gas	Mine ventilation air	CO_2 and CH_4	Emissions quantified and assessed (Section 10)
		Onsite fuel consumption	CO_2, N_2O and CH_4	
		Electricity consumption	CO_2, N_2O and CH_4	

4.1 Assessment criteria

The NSW EPA's impact assessment criteria, as documented in Section 7 of the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW EPA 2017), are presented in Table 4.2 (common or 'criteria' air pollutants) and Table 4.3 (principal and individual toxic air pollutants).

For the pollutants listed in Table 4.2, the assessment criteria are applied at the nearest existing or likely future sensitive receptor[3] and the following must be reported:

- the incremental impact (ie the predicted impact due to the project alone); and
- the total impact (ie the incremental impact plus the existing background concentration). Guidance on the selection of background concentrations is provided in the Approved Methods for Modelling.

The NSW EPA's impact assessment criteria for particulate matter are generally consistent with the Air Quality Criteria outlined in the Appin Mine Approval. The only exception is the numerical limit for annual average PM_{10}, which is set at 30 µg/m^3 in the Appin Mine Approval. The Appin Mine Approval was granted in 2008 and, at the time, the NSW EPA's impact assessment criterion for annual average PM_{10} was 30 µg/m^3. In 2017, the NSW EPA's annual average criterion for PM_{10} was revised from 30 µg/m^3 to 25 µg/m^3, consistent with the revised national standards in the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) (Department of Environment (DoE) 2016). It is also noted that the 2017 update to the Approved Methods added impact assessment criteria for $PM_{2.5}$, which were not included as compliance criteria in the Appin Mine Approval.

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[3] NSW EPA (2016) defines a sensitive receptor as a location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area.

Table 4.2 Impact assessment criteria – 'criteria' pollutants

Pollutant	Averaging period	Impact assessment criteria
TSP	Annual	90 µg/m^3
PM$_{10}$	24-hour	50 µg/m^3
	Annual	25 µg/m^3
PM$_{2.5}$	24-hour	25 µg/m^3
	Annual	8 µg/m^3
Dust deposition	Annual	2 g/m^2/month (project increment only)
		4 g/m^2/month (cumulative)
NO$_2$	1-hour	246 µg/m^3
	Annual	62 µg/m^3
SO$_2$	10-minute	712 µg/m^3
	1-hour	570 µg/m^3
	24-hour	228 µg/m^3
	Annual	60 µg/m^3
CO	15-minute	100 mg/m^3
	1-hour	30 mg/m^3
	8-hour	10 mg/m^3
Lead	Annual	0.5 µg/m^3

Notes: µg/m^3: micrograms per cubic meter

In the case of the short-term criteria (ie 1-hour NO$_2$, 24-hour PM$_{10}$ and 24-hour PM$_{2.5}$), the total prediction must be reported as the 100th percentile (ie the highest) value. At some locations, the background concentrations can exceed the impact assessment criteria. This is most commonly the case for PM$_{10}$ and PM$_{2.5}$, which are affected by events such as bushfires and dust storms. In such circumstances, there is a requirement to demonstrate that no additional exceedances of the impact assessment criteria will occur as a result of the proposed activity and that best management practices will be implemented to minimise emissions of air pollutants as far as is practical.

Impact assessment criteria for principal and individual toxic air pollutants are listed in Table 4.3[4]. The criteria are applied at and beyond the boundary of the emitting source, with the incremental impact reported as the 99.9th percentile concentration for an averaging period of 1 hour.

There are no impact assessment criteria for total VOCs, however impact assessment criteria are prescribed for various individual toxic and odorous VOCs, and a few of the more commonly assessed substances are presented in Table 4.3.

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[4] Impact assessment criteria are presented for certain trace elements and VOCs that may be present in MVA or have been tested as part of the monitoring program at ventilation shaft 6 (refer Section 7.2).

Table 4.3 Impact assessment criteria – principal and individual toxic air pollutants

Pollutant	Averaging period	Impact assessment criteria
Trace elements		
Antinomy	1-hour (99.9th percentile)	9 µg/m^3
Arsenic	1-hour (99.9th percentile)	0.09 µg/m^3
Beryllium	1-hour (99.9th percentile)	0.004 µg/m^3
Cadmium	1-hour (99.9th percentile)	0.018 µg/m^3
Chromium III	1-hour (99.9th percentile)	9.0 µg/m^3
Chromium VI	1-hour (99.9th percentile)	0.09 µg/m^3
Manganese	1-hour (99.9th percentile)	18 µg/m^3
Mercury inorganic	1-hour (99.9th percentile)	1.8 µg/m^3
Nickel	1-hour (99.9th percentile)	0.18 µg/m^3
Individual VOCs		
Benzene	1-hour (99.9th percentile)	29 µg/m^3
Formaldehyde	1-hour (99.9th percentile)	20 µg/m^3
Toluene	1-hour (99.9th percentile)	360 µg/m^3
Xylene	1-hour (99.9th percentile)	190 µg/m^3

4.2 Odour impact assessment criteria

There are no instrument-based methods that can measure an odour response in the same way as the human nose. Therefore "dynamic olfactometry" is typically used as the basis of odour quantification by regulatory authorities. Dynamic olfactometry is the measurement of odour by presenting a sample of odorous air to a panel of people with decreasing quantities of clean odour-free air. The panellists then note when the smell becomes detectable. The correlations between the known dilution ratios and the panellists' responses are then used to calculate the number of dilutions of the original sample required to achieve the odour detection threshold. The units for odour measurement using dynamic olfactometry are "odour units" (ou) which are dimensionless and are effectively "dilutions to threshold".

The odour nuisance level can be as low as 2 ou and as high as 10 ou (for less offensive odours), whereas an odour assessment criterion of 7 ou is likely to represent the level below which 'offensive' odours should not occur. The Technical Framework for Assessment and Management of Odour from Stationary Sources in NSW (NSW DECC 2006) recommends that, as a design criterion, no individual should be exposed to ambient odour levels of greater than 7 ou.

NSW EPA (2017) prescribes odour goals which take into account the population density for a particular area. The most stringent odour goal of 2 ou is acceptable for the whole population and therefore appropriate for built-up areas. Odour goals are only applied for odour impact assessment (ie compared against the 99th percentile of the dispersion modelling predictions) and are not used, for example, to determine compliance for an existing facility.

A summary of the NSW EPA's population-based odour assessment criteria is presented in Table 4.4. For individual rural residences an odour goal of 6 to 7 ou is appropriate. The population of the community in the vicinity of the Project that could potentially be affected by odour is estimated to be in the region of 125, therefore an odour goal of 4 ou is applied for this assessment.

Table 4.4 Impact assessment criteria for complex mixtures of odorous air pollutants

Population of affected community	Odour units (ou), nose response time average^, 99th percentile
2	7
10	6
30	5
125	4
500	3
Urban (2000) and / or schools and hospitals	2

Note:^ a nose response average refers to the instantaneous perception of odours by the human nose and is derived using peak-to-mean ratios, described in Section 8.3.4i

Air samples collected underground at Appin detected certain sulphur compounds in the return air, therefore odour impacts are also evaluated for hydrogen sulphide (H_2S). The impact assessment criteria for hydrogen sulphide are presented in Table 4.5. Consistent with the odour criterion, a goal of 2.76 µg/m^3 is adopted based on a population of potentially affected community in the region of 125.

Table 4.5 Impact assessment criteria for hydrogen sulphide

Population of affected community	µg/m^3, nose response time average^, 99th percentile
2	4.83
10	4.14
30	3.45
125	2.76
500	2.07
Urban (2000) and / or schools and hospitals	1.38

Note:^ a nose response average refers to the instantaneous perception of odours by the human nose and is derived using peak-to-mean ratios, described in Section 8.3.4i

4.3 Emissions from the combustion of diesel fuel during construction

Gaseous air emissions generated by diesel combustion in construction projects do not generally result in significant off-site concentrations and would not compromise ambient air quality goals at the closest assessment locations. Accordingly, with the exception of PM, diesel combustion emissions have not been quantitatively assessed.

The emission factors developed for fugitive dust emission inventories do not separate PM emissions from mechanical processes (ie handling material) and diesel exhaust (combustion). However, to be conservative, the contribution from diesel combustion has been inventoried separately and assessed.

Greenhouse gas emissions from diesel combustion are considered in Section 10.

4.4 Blast fume

Blast fume is the result of a less than optimal chemical reaction of ammonium nitrate explosives during the blasting process, resulting in the release of nitric oxide and NO_2. Fume generation can be the result of water and explosives mixing in the hole (geological and/or meteorological influences), the quality of explosive product supplied, and contamination of the explosive product. Potential adverse impacts from blast fume can be effectively managed through good practice blast management.

A Blast Management Plan would be developed for the Project, which would include blast fume prevention measures, developed in accordance with the Code of Good Practice: Prevention and Management of Blast Generated NOx Gases in Surface Blasting (AEISG 2011).

Given that it has been demonstrated within the industry that adoption of measures outlined in the Code of Practice effectively controls blast fume, no further assessment of blast fume is presented in this report.

The blast management practices and blast fume prevention measures that would be implemented for the Project are outlined in Section 9.1.1.

5 Meteorology and climate

5.1 Introduction

Meteorological mechanisms govern the generation, dispersion, transformation and eventual removal of pollutants from the atmosphere. To adequately characterise the dispersion meteorology of a region, information is needed on the prevailing wind regime, ambient temperature, rainfall, relative humidity, mixing depth and atmospheric stability.

Analysis of meteorology for the region is presented based on the closest automatic weather station (AWS) to the Site, as follows:

- Ventilation Shaft 6 AWS, located approximately 3.5 km south, at Douglas Park;
- Appin Power Station AWS, located approximately 8 km south-east of the site;
- Camden Airport AWS (Bureau of Meteorology (BoM))[5], located approximately 13 km north-west of the site; and
- Campbelltown West air quality monitoring station (AQMS) (Department of Planning Industry and Environment (DPIE)), located approximately 11 km north-east of the site.

The location of these surface observation sites in relation to the Site is shown in Figure 5.1.

5.2 Selection of a representative dataset for modelling

In selecting a representative year for modelling, it is important to select a year that is representative of longer-term conditions for the area. Five years of data were reviewed for the period 2015 to 2019 and the calendar year 2018 was selected for modelling as representative of longer-term averages. For example, the period 2016 to 2019[6] at Ventilation Shaft 6 (Figure C.1) and Campbelltown West (Figure C.2) displays consistency in wind direction, average wind speed and percentage occurrence of calm winds (<= 0.5 m/s). Similarly, the inter-annual variation in temperature (Figure C.3 and Figure C.4) displays consistency across each year for a recent period of measurements.

It is noted that the ambient background is also relevant for the selection of a representative year (the meteorological modelling period should avoid years with significantly lower or higher ambient background concentrations if these years are not representative of longer-term averages). The calendar year 2019 was specifically excluded because extensive bushfire events in November and December resulted in elevated levels of PM_{10} and $PM_{2.5}$ which are not representative of a typical year. In 2019, exceptional events led to poor air quality on 127 days, compared with 50 days in 2018 and 18 days in 2017[7]. Background PM_{10} and $PM_{2.5}$ concentrations for the calendar year 2018 were also higher than previous years and therefore provide a more conservative (higher) existing background than 2016 or 2017 (refer Section 6).

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[5] Camden Airport AWS is operated by the BoM. The DPIE operated AQMS at Camden records very similar winds to the BoM station. The BoM Camden Airport station is used for modelling instead of the DPIE AQMS as more parameters are measured by BoM, including cloud cover.

[6] There was not a complete year available for 2015.

[7] https://www.environment.nsw.gov.au/topics/air/nsw-air-quality-statements/annual-air-quality-statement-2019

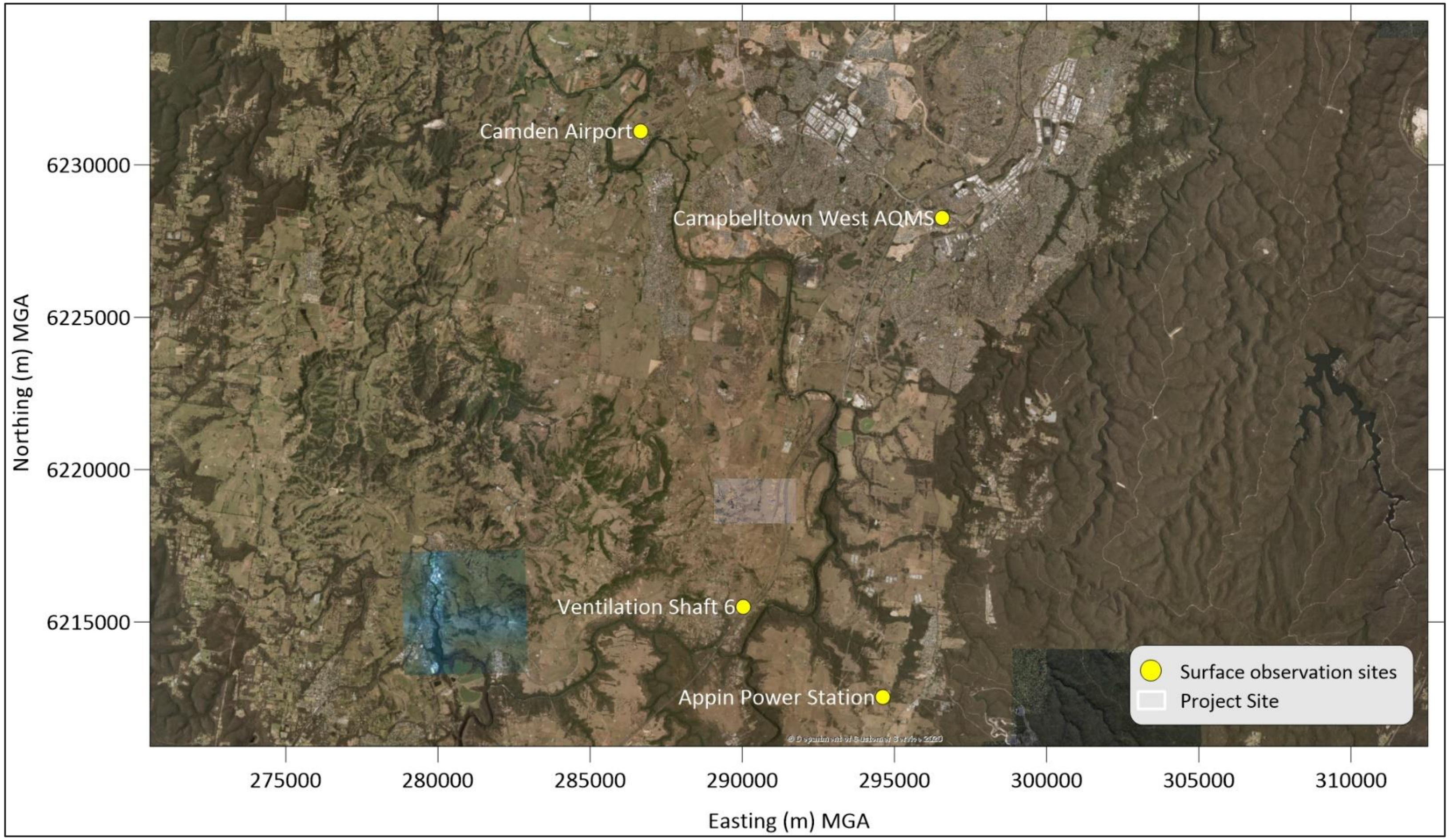


Figure 5.1 Meteorological observation sites for the region

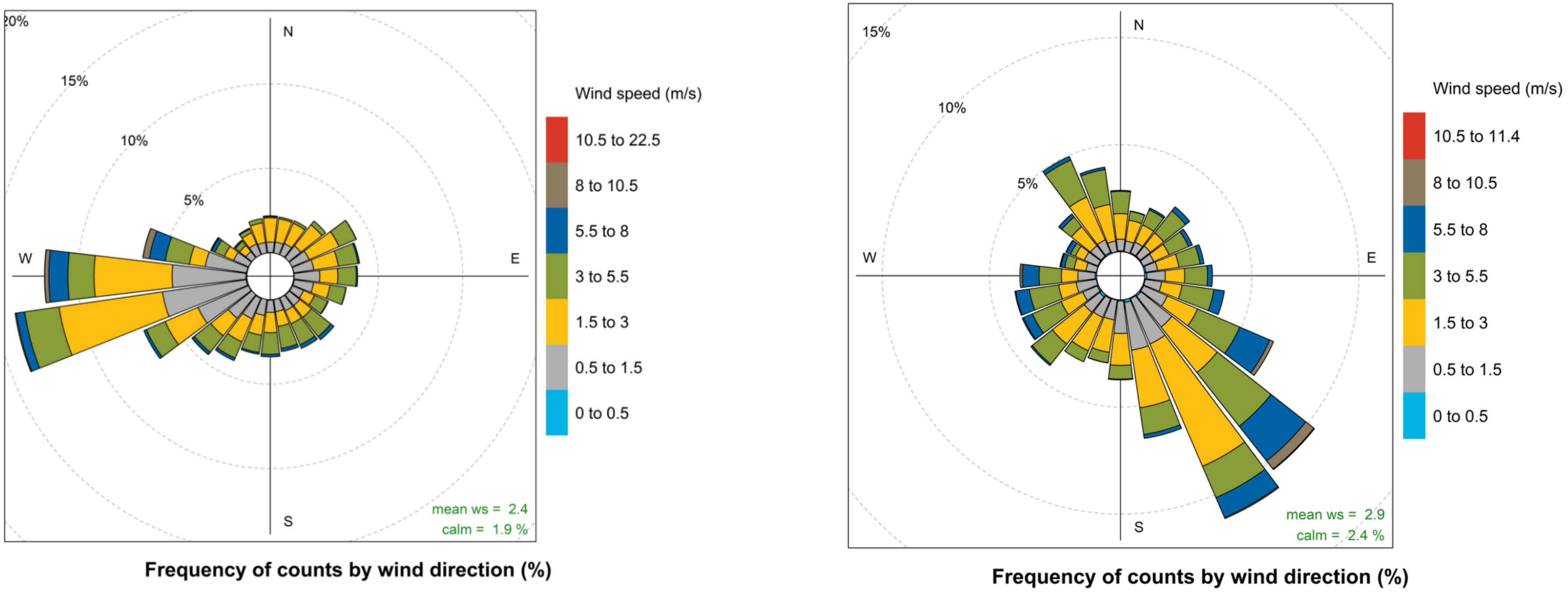
5.3 Overview of meteorological modelling

The atmospheric dispersion modelling for this assessment uses the CALMET/CALPUFF model suite. Surface observations are included in the modelling (referred to as data assimilation) to provide real-world observations and improve the accuracy of the wind field. Surface observations from the four sites listed in Section 5.1 are incorporated into the CALMET modelling.

In the absence of upper air measurements, CALMET has been run using prognostic upper air data (as a three-dimensional '3D.dat' file), which is used to derive an initial wind field (known as the Step 1 wind field in the CALMET model). The model then incorporates mesoscale and local scale effects, including surface observations, to adjust the wind field. This modelling approach is known as the 'hybrid" approach (TRC 2011) and is adopted for this assessment. The Air Pollution Model (TAPM) was used to generate the upper air data ('3D.dat') for each hour of the model run period for input into CALMET. TAPM and CALMET model settings are described in Appendix B, selected in accordance with recommendations in the Approved Methods for Modelling and in TRC (2011).

5.4 Prevailing winds

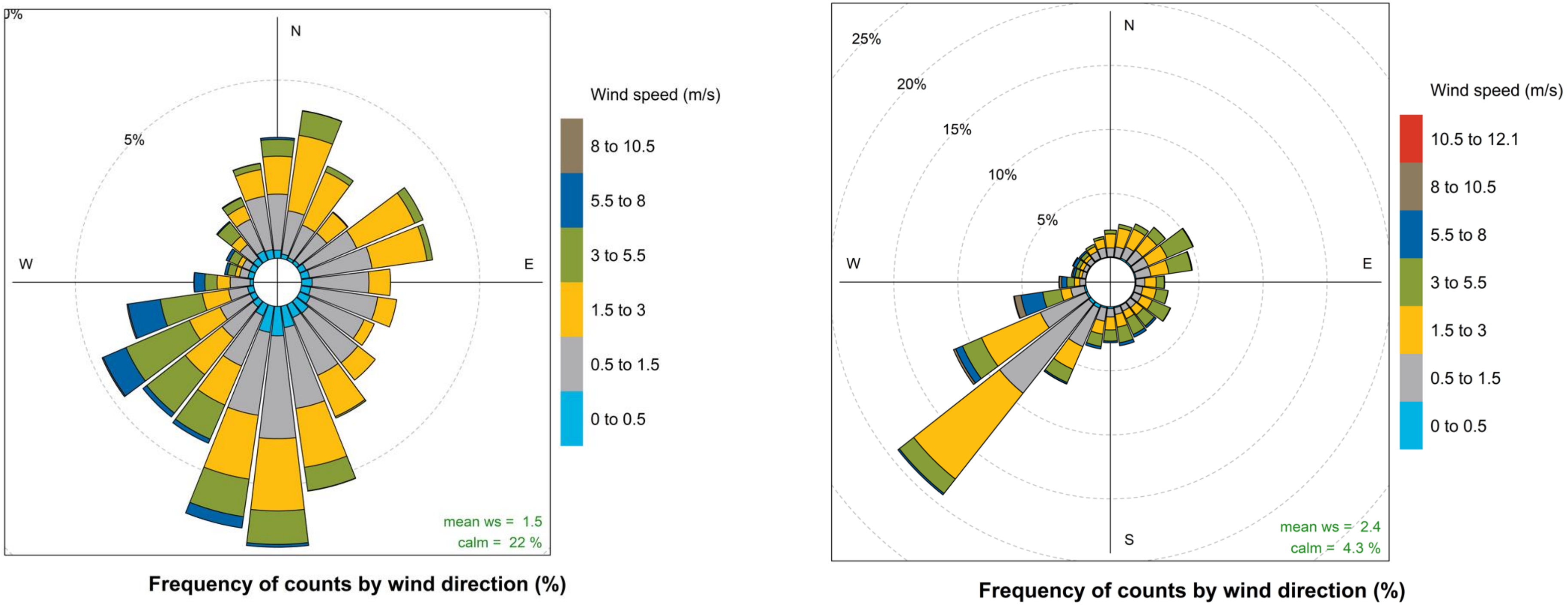
Annual wind roses for 2018 for Ventilation Shaft 6, the Appin Power Station, Camden Airport and Campbelltown West AQMS are presented in Figure 5.2 and Figure 5.3. The wind roses show regional variation in wind direction, with a prevailing west to west-southwest flow at Ventilation Shaft 6, a south-east flow at Appin Power Station, a dominant south-west flow at Campbelltown West AQMS and a more even spread of winds across the south-west and south-east quadrants at Camden Airport. The mean wind speeds at all sites are comparable, with slightly lower wind speeds and more frequent calm wind conditions measured at Camden Airport.



Ventilation Shaft 6

Appin Power Station

Figure 5.2 Annual wind roses for Ventilation Shaft 6 and Appin Power Station



Camden Airport

Campbelltown West AQMS

Figure 5.3 Annual wind roses for Camden Airport and Campbelltown West AQMS

The CALMET predicted winds for the Site are presented as a wind rose in Figure 5.4. The CALMET winds for the Site are most like the observations at the Campbelltown West AQMS. The distance at which the observation influences the model (radius of influence (ROI)) is determined by the CALMET setting 'RMAX'. The relative importance of the observation in the model (relative weighting of the Step 1 wind field and the observation) is determined by the CALMET setting 'R1'. An RMAX of 5 km and R1 of 2 km is assigned in the model, therefore the predicted wind field at the Site is not biased to any of the observation sites and the resultant wind pattern is more likely influenced by local terrain (slope flows, terrain blocking etc).

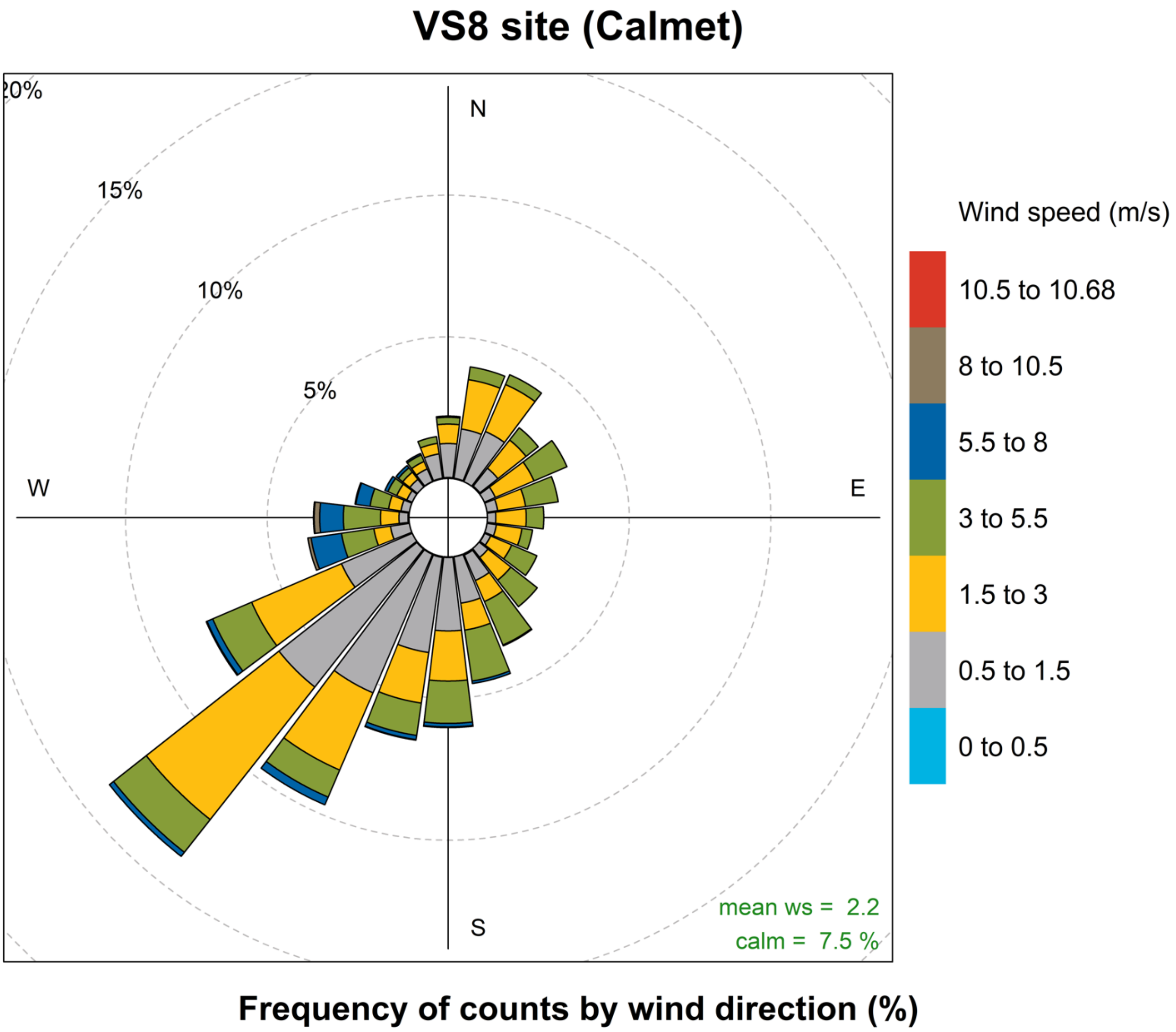


Figure 5.4 CALMET predicted winds at the Site

5.5 Rainfall

Precipitation is important to air pollution, as it impacts on dust generation potential and represents a removal mechanism for atmospheric pollutants. Fugitive dust emissions during construction may be harder to control during low rainfall years while drier periods may also result in more frequent dust storms and bushfire activity, resulting in higher regional background dust levels. Rainfall also acts as a removal mechanism for dust, lowering pollutant concentrations by removing them more efficiently than during dry periods.

Long-term average monthly rainfall data were obtained from the BoM rainfall station at Menangle Bridge, located approximately 3 km north-northeast of the Site. The local area is characterised by moderate rainfall with a mean annual rainfall in the order of 984 mm. Monthly variation in rainfall is illustrated in Figure 5.5. Rainfall is typically highest in February, March and June.

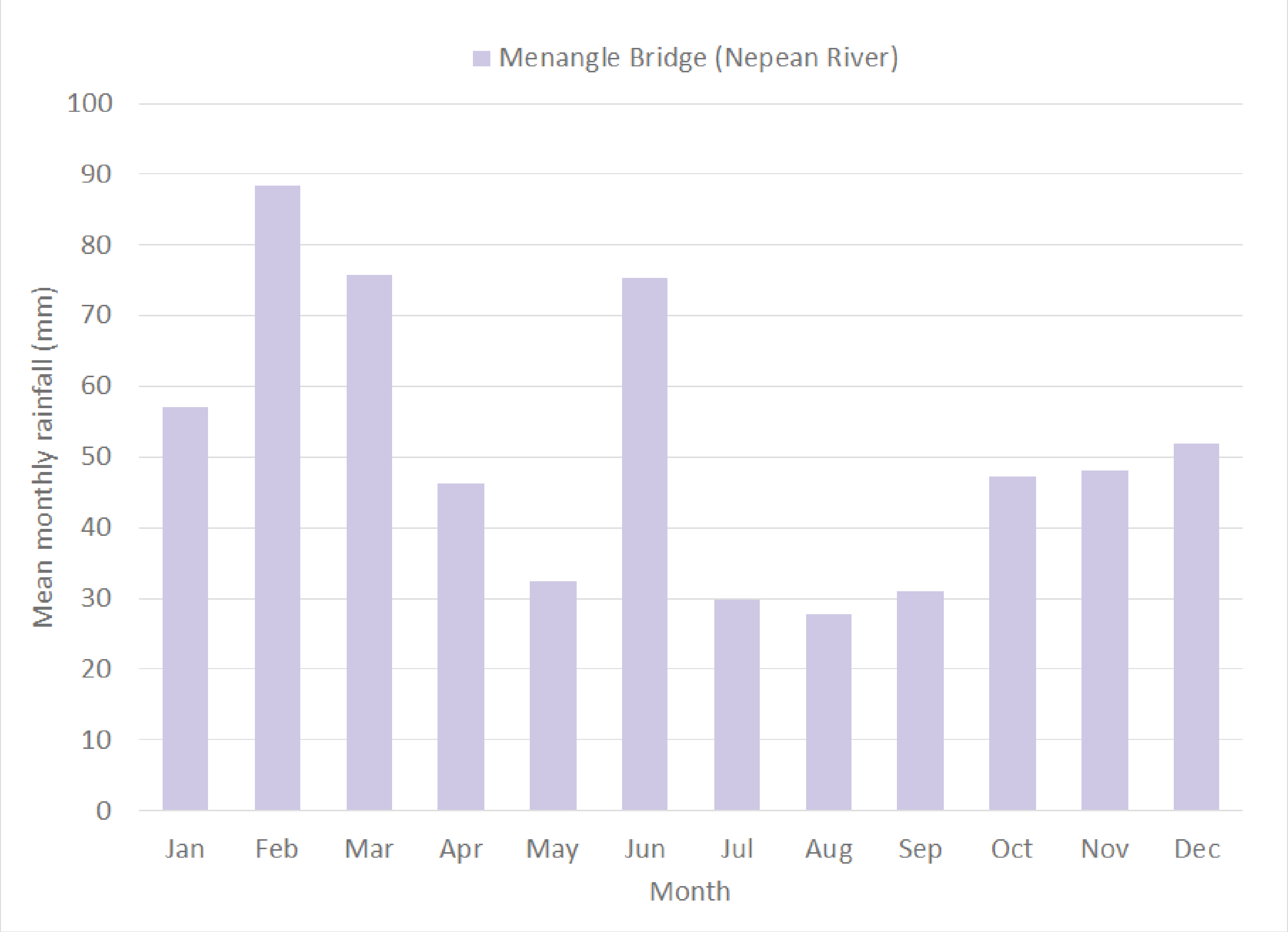


Figure 5.5 Monthly mean rainfall from the BoM Menangle Bridge (Nepean River) rainfall station

5.6 Atmospheric stability and boundary layer heights

Atmospheric stability refers to the degree of turbulence or mixing that occurs within the atmosphere and is a controlling factor in the rate of atmospheric dispersion of pollutants. The Monin-Obukhov length (L) provides a measure of the stability of the surface layer (ie the layer above the ground in which vertical variation of heat and momentum flux is negligible; typically, about 10% of the mixing height). Negative L values correspond to unstable atmospheric conditions, while positive L values correspond to stable atmospheric conditions. Very large positive or negative L values correspond to neutral atmospheric conditions. Figure 5.6 illustrates the diurnal variation of atmospheric stability, derived from the Monin-Obukhov length calculated by CALMET. The diurnal profile shows that atmospheric instability increases during the daylight hours as the sun generated convective energy increases, whereas stable atmospheric conditions prevail during the night-time.

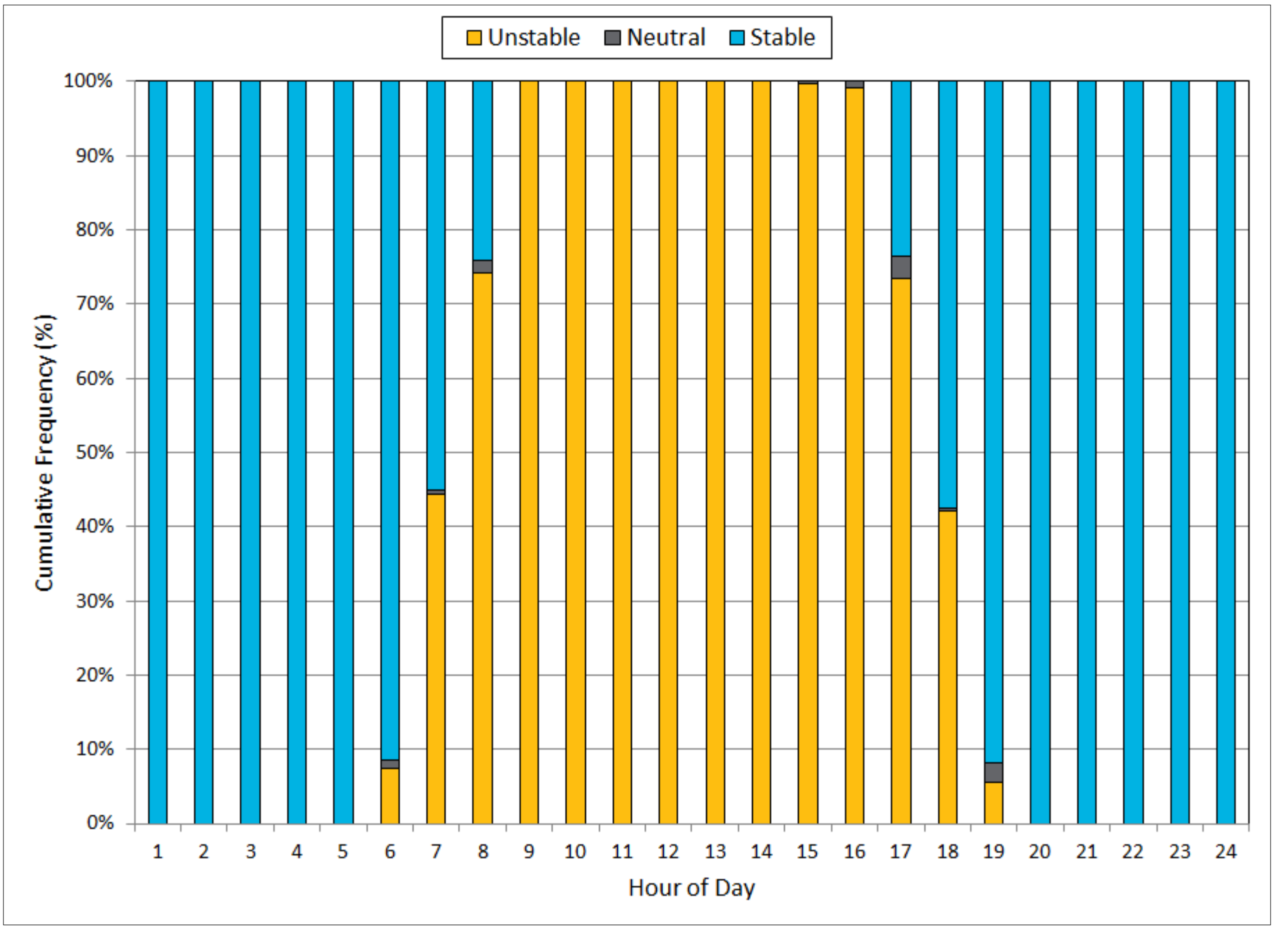


Figure 5.6 Diurnal variations in CALMET-generated atmospheric stability

The seasonal variation in atmospheric stability is presented in Table 5.1, showing the highest percentage occurrence of stable conditions (poor dispersion) during the winter months.

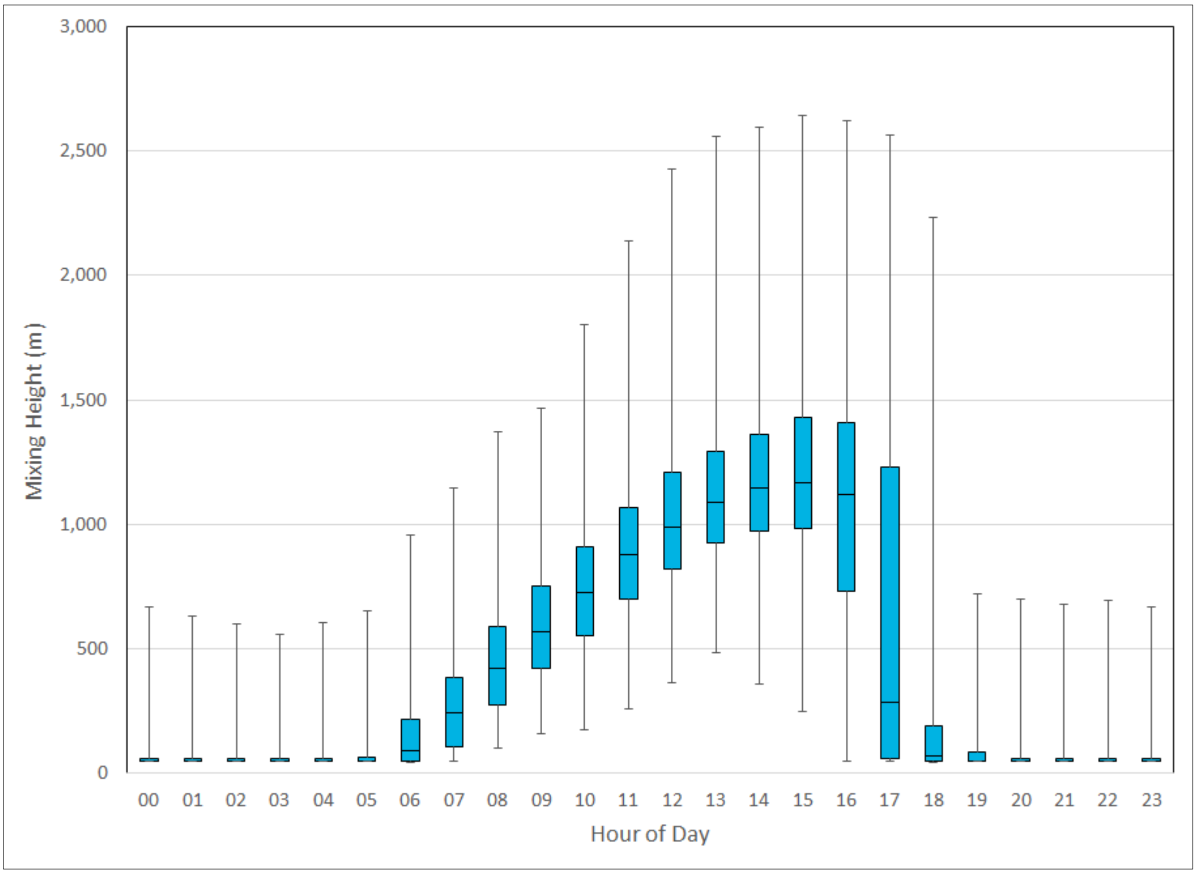
Table 5.1 Frequency of occurrence of atmospheric stability by season

Season	Unstable	Neutral	Stable
Summer	52%	0.5%	48%

Table 5.1 Frequency of occurrence of atmospheric stability by season

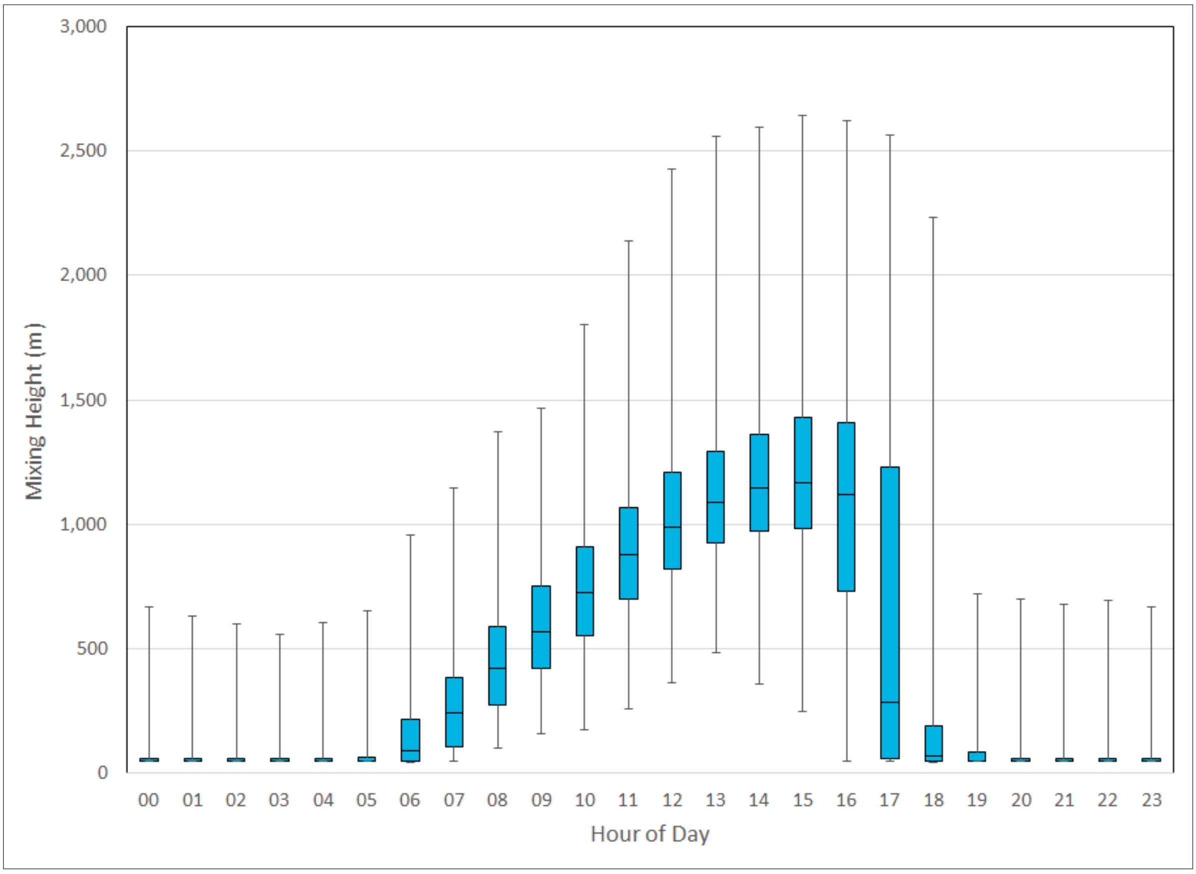
Season	Unstable	Neutral	Stable
Autumn	41%	0.4%	59%
Winter	35%	0.5%	64%
Spring	47%	0.3%	53%

Mixing height refers to the height of the atmosphere above ground level within which the dispersion of air pollution occurs. The mixing height of the atmosphere is influenced by mechanical (associated with wind speed) and thermal (associated with solar radiation) turbulence. Similar to the Monin-Obukhov length analysis above, higher daytime wind speeds and the onset of incoming solar radiation increases the amount of mechanical and convective turbulence in the atmosphere. As turbulence increases, so too does the depth of the boundary layer, generally contributing to higher mixing heights and greater potential for the atmospheric dispersion of pollutants.



Box and whisker plot showing upper and lower quartile range (boxes) and minimum and maximum (whiskers). The mean is shown by the line in the centre of the box.

Figure 5.7 presents the hourly-varying atmospheric boundary layer depths generated by CALMET. This diurnal profile for stability and mixing height indicates that the dispersion of emissions would be greatest during daytime hours.



Box and whisker plot showing upper and lower quartile range (boxes) and minimum and maximum (whiskers). The mean is shown by the line in the centre of the box.

Figure 5.7 Diurnal variation in CALMET-generated mixing heights

6 Existing ambient air quality

To demonstrate compliance with impact assessment criteria, consideration of cumulative impact is required to assess how the Project will interact with existing and future sources of emissions. The closest background air quality monitoring sites are operated by DPIE, including Camden AQMS and Campbelltown West AQMS, located approximately 13 km and 11 km north-east of the site, respectively.

The AQMS at Camden and Campbelltown West are representative of the local air quality environment at the Site, which is expected to be primarily influenced by:

- local traffic travelling along sealed and unsealed roads;
- regional traffic movements along the Hume Motorway and freight rail movements along the rail line;
- fugitive dust during dry conditions, from agricultural activity and wind erosion from exposed ground;
- other Appin Mine operations, including Ventilation Shaft 6;
- Appin Power Station;
- seasonal emissions from household wood heaters;
- episodic emissions from bushfires; and
- long-range transport of fine particles into the region.

There are no known proposed major projects in the vicinity of the Site that would result in cumulative impacts during the construction or operation of the Project. Cumulative impacts are therefore assessed by taking into account the existing baseline or background air quality for the area.

6.1 PM_{10} and $PM_{2.5}$ concentrations

Summary statistics for PM_{10} and $PM_{2.5}$ for the period 2015 to 2020 are presented in Table 6.1. In 2019, a significantly higher number of exceedances occurred because of the extensive bushfires that occurred in November and December. Exceptional events led to poor air quality on 127 days across NSW, compared with 50 days in 2018 and 18 days in 2017[8]. Therefore, 2019 is not considered a representative year for a discussion on existing air quality.

Excluding 2019, annual mean PM_{10} concentrations range from 13.8 µg/m³ in 2015 to 17.9 µg/m³ in 2018 and on average across the region is 16.0 µg/m³, or 64% of the NSW EPA annual average criterion of 25 µg/m³.

Excluding 2019, annual mean $PM_{2.5}$ concentrations range from 6.2 µg/m³ in 2015 to 8.4 µg/m³ in 2018 and on average across the region, background concentrations are 7.1 µg/m³ or 88% of the NSW EPA annual average criterion. Exceedances of the 24-hour average reporting standards for PM_{10} and $PM_{2.5}$ occurred in most years.

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[8] https://www.environment.nsw.gov.au/topics/air/nsw-air-quality-statements/annual-air-quality-statement-2019

Table 6.1 Summary statistics for background particulate matter

Year	Campbelltown West AQMS		Camden AQMS	
	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
Annual mean concentration				
2015	15.6	7.9	13.8	6.2
2016	16.1	7.9	14.4	6.4
2017	15.7	7.4	14.7	6.7
2018	17.9	8.4	17.5	7.2
2019	22.3	11.8	22.5	11.8
2020	17.0	7.5	16.6	7.7
Maximum 24-hour average concentration				
2015	69.7	15.7	62.4	25.0
2016	50.1	35.8	43.6	36.0
2017	53.1	25.0	48.4	27.7
2018	72.3	45.4	68.1	37.0
2019	132.0	106.0	139.2	155.3
2020	249.7	69.0	268.6	149.3
Number of days that the 24-hour average concentration is above the impact assessment criteria				
2015	1	0	1	0
2016	1	3	0	3
2017	1	0	0	2
2018	3	2	6	2
2019	24	27	27	28
2020	10	12	9	11

6.1.1 Background dataset for modelling

As described previously, the calendar year 2018 is selected for modelling. To provide a representative dataset for cumulative modelling, a regional average is derived based on the average of concurrent daily concentrations recorded at the Camden AQMS and Campbelltown West AQMS. Timeseries plots of the daily 24-hour PM_{10} and $PM_{2.5}$ concentrations for 2018 are presented in Figure 6.1 and Figure 6.2, showing daily average concentrations for the Camden AQMS, Campbelltown West AQMS and the combined regional average dataset used for background. Figure 6.1 shows that there were three existing exceedances of the daily PM_{10} criterion at Campbelltown West and six existing exceedances of the daily PM_{10} criterion at Camden Airport. When combined into a regional average, there are four existing exceedances of the daily PM_{10} criterion in the background dataset. Figure 6.2 shows that there were two existing exceedances of the daily $PM_{2.5}$ criterion at Campbelltown West and Camden, although the PM_{10} and $PM_{2.5}$ exceedances occur on different days. When combined into a regional average, there are three existing exceedances of the daily $PM_{2.5}$ criterion in the background dataset. For annual average background of PM_{10} and $PM_{2.5}$, the 2018 regional average is 17.7 µg/m³ for PM_{10} and 7.7 µg/m³ for $PM_{2.5}$.

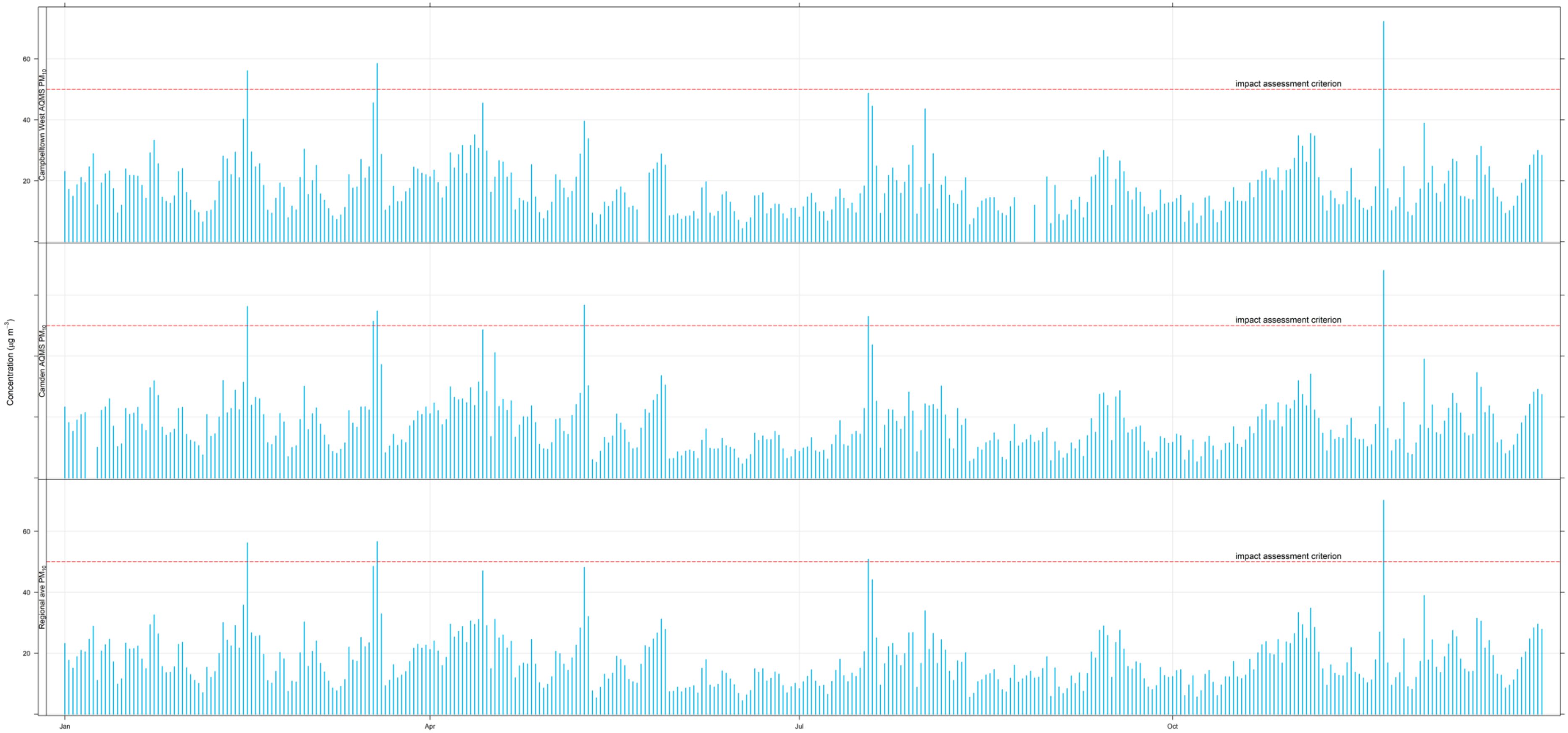

Figure 6.1 Timeseries plot for 24-hour PM_{10} – Campbelltown West AQMS, Camden AQMS and regional average

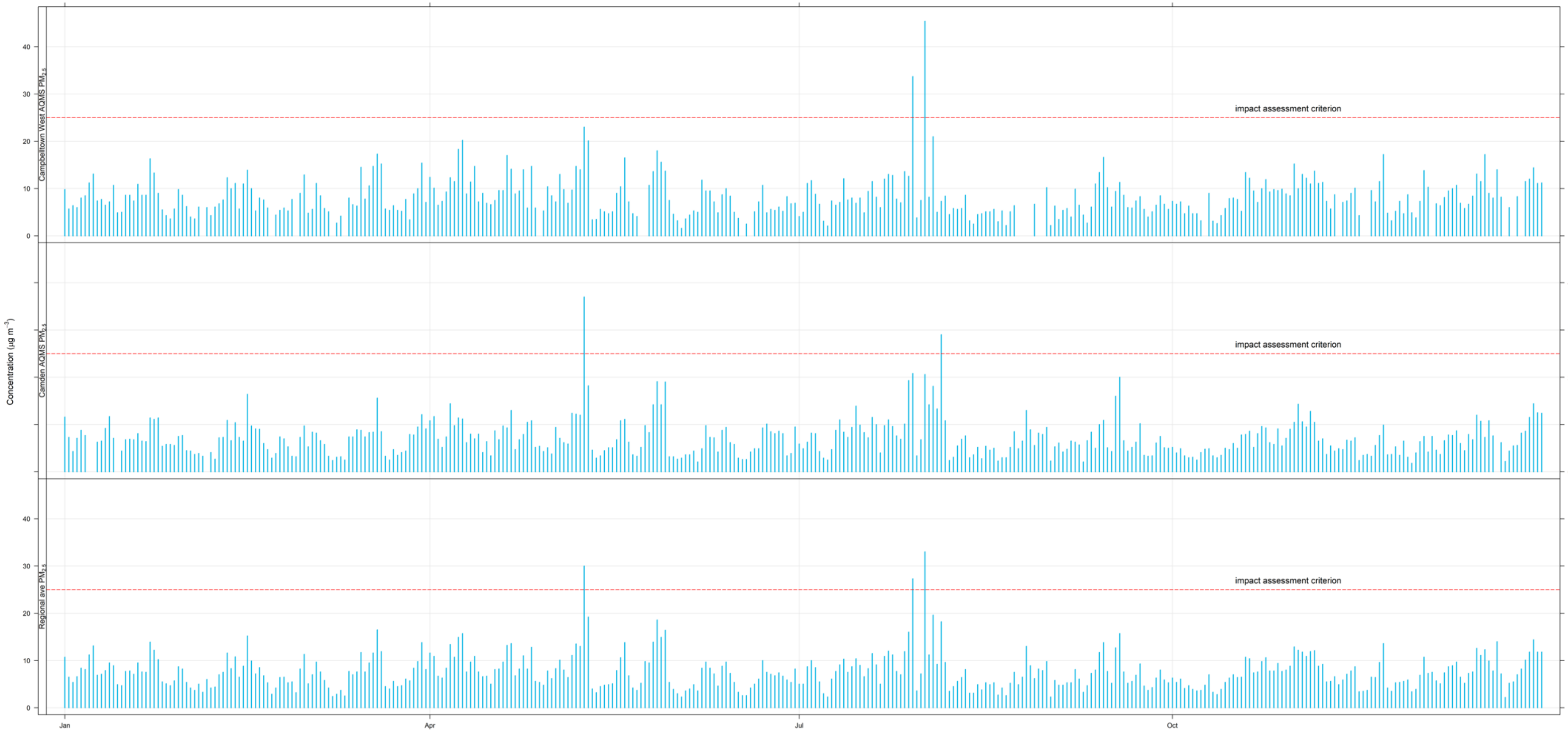

Figure 6.2 Timeseries plot for 24-hour $PM_{2.5}$ – Campbelltown West, Camden and regional average

6.2 Background TSP concentrations

TSP concentrations are not measured at the Campbelltown West AQMS. In the absence of local measurements, annual average TSP concentrations can be derived from the PM_{10} data, based on ratios of PM_{10}/TSP which typically ranges from 0.4 to 0.5 in rural areas (ie PM_{10} is typically 40% to 50% of TSP).

To derive an annual average TSP concentration consistent with the 2018 background period, the ratio of 0.4 has been applied to the annual average PM_{10} concentration for 2018, returning a TSP background concentration of 44.2 µg/m³.

6.3 Background dust deposition

There is no monitoring data available for dust deposition near the project, therefore modelling results are primarily assessed against the incremental impact assessment criterion only. Background dust deposition levels in rural areas where there are no significant local dust sources would typically be in the range of 1-2 g/m^2/month. Therefore, compliance with the cumulative impact assessment criterion of 4 g/m^2/month can be inferred for these areas if the project contribution is well below the incremental impact assessment criterion of 2 g/m^2/month.

6.4 Background NO_2 concentrations

Summary statistics for NO_2 at the Camden AQMS and Campbelltown West AQMS are presented in Table 6.2. A regional average is derived based on the average of the hourly-varying NO_2 concentrations recorded at the Camden AQMS and Campbelltown West AQMS during 2018. The maximum 1-hour average for the derived regional background is approximately 30% of impact assessment criterion while the annual average for the derived regional background is approximately 20% of impact assessment criterion.

Table 6.2 2018 summary statistics for background NO_2 (µg/m³)

Statistic	Campbelltown West AQMS	Camden AQMS	Regional average
1-hour maximum	101.5	54.4	68.6
Annual average	20.1	9.8	15.0

Timeseries plots of the 1-hour average NO_2 concentrations for 2018 is presented in Figure 6.3, showing daily average concentrations for Camden, Campbelltown West and the combined regional average dataset used for background.

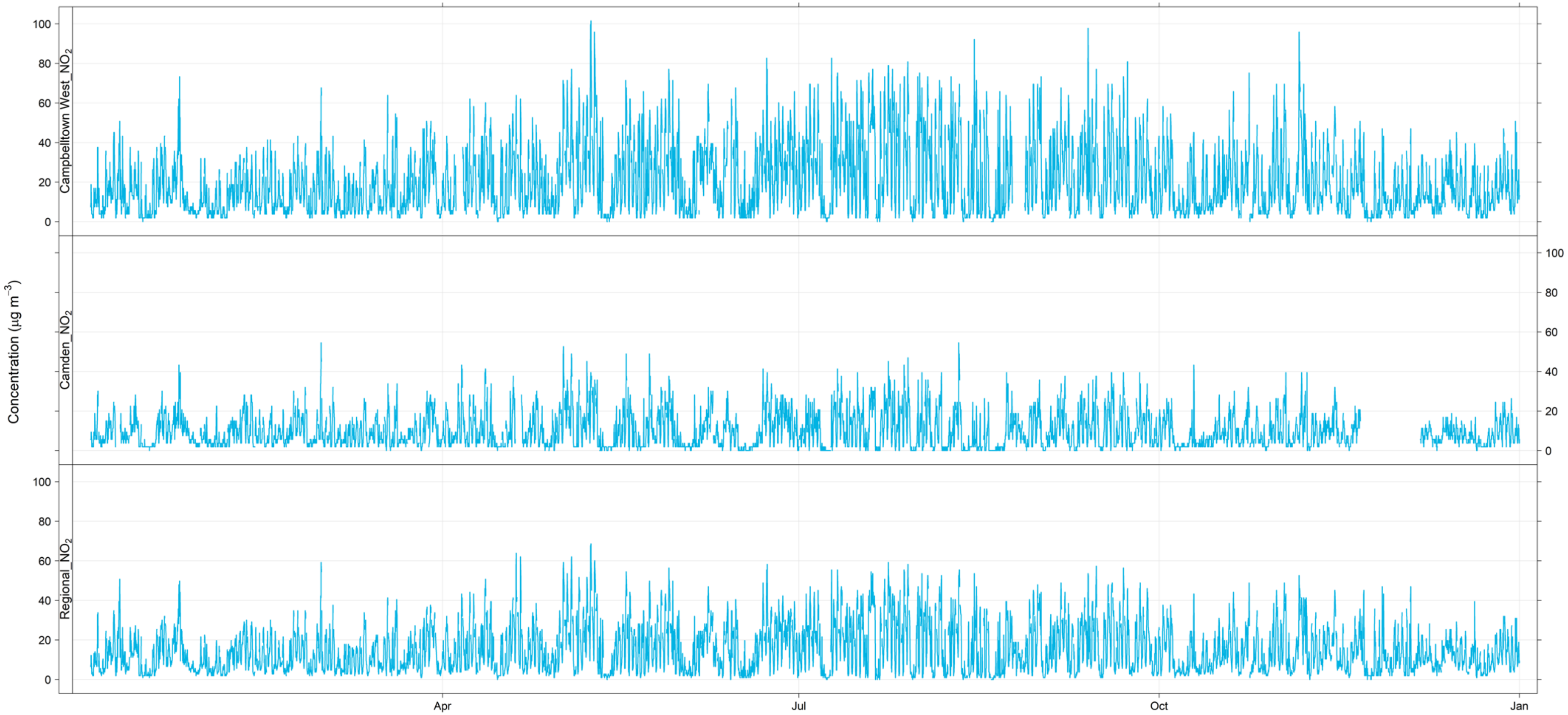

Figure 6.3 Timeseries plot for 1-hour NO_2 – Campbelltown West, Camden and regional average

6.5 Summary of adopted background for cumulative assessment

For cumulative 24-hour PM_{10} concentrations, the daily varying regional background dataset for 2018 is added to the project increment for each day of the year. The highest concentration that is not already above the impact assessment criteria is 48.5 µg/m³. For cumulative 24-hour $PM_{2.5}$ concentrations, the daily varying regional background dataset for 2018 is added to the project increment for each day of the year. The highest concentration that is not already above the impact assessment criteria is 19.6 µg/m³.

For cumulative annual average PM_{10} and $PM_{2.5}$ concentrations, the regional background concentrations of 17.7 µg/m³ and 7.7 µg/m³ are added to the project increment. Annual average background TSP concentrations is 43.5 µg/m³ derived based on the assumption that PM_{10} is 40% of TSP. Annual average background dust deposition is assumed to be 1 to 2 g/m^2/month.

For cumulative 1-hour NO_2 concentrations, the hourly varying regional background dataset for 2018 is added to the project increment for each hour of the year. For cumulative annual average NO_2 concentration, the regional background concentrations of 15.0 µg/m³ is added to the project increment.

7 Emissions inventory

7.1 Construction phase emissions

An emissions inventory has been developed for a nominal year of the construction period, selected to assess the worst-case air quality impacts when material handling/movement is at a maximum. The primary dust generating activity occurs during site preparation/bulk earthworks and shaft sinking.

Based on the existing indicative construction schedule, there is little overlap between the site preparation/bulk earthworks phase and the shaft sinking phase. It is noted that shaft pre-sink will occur as part of site establishment phase but will mostly occur once bulk earthworks has finished.

The indicative scheduling is as follows:

- Site establishment, bulk earthworks, shaft pre-sink – July 2022 to March 2023;
- VS7 sinking and lining – August 2023 to December 2024;
- VS8 sinking and lining – June 2023 to October 2024.

Emissions are estimated for each of these stages, for activities including:

- stripping of vegetation and topsoil and stockpiling, excavation and handling of bulk material; and
- drilling, blasting, excavation, and handling of spoil material from ventilation shafts 7 and 8.

Other construction activities, such as construction of buildings and infrastructure are either not considered significant dust emission sources or are not considered as concurrent emissions sources for the emissions scenario. Notwithstanding, dust management and monitoring for the entire construction period is outlined in Section 9.1. A detailed description of the assumptions adopted in the development of the emissions inventory are provided in Appendix D.

7.1.1 Emission reduction factors

The following dust mitigation measures have been incorporated into the emission inventory based on emission reduction factors reported by the National Pollution Inventory (NPI) (NPI 2011) and Katestone (2011):

- emissions from hauling are controlled by 75%, based on level 2 watering (application rate >2 litres per m^2 per hour);
- emissions from drilling are controlled by 70% based on the water injection; and
- emissions from unloading trucks are controlled by 30%, based on keeping drop heights to a minimum.

It is noted that the Project team are investigating additional control measures, including using water blankets for blasting and construction of an acoustic shed over each shaft for shaft sinking. However, as these controls have not yet been confirmed, they are not included in the emission inventory.

7.1.2 Emission estimates

Fugitive dust emissions during construction were quantified using United States Environmental Protection Agency (US EPA) AP-42 emission factor equations (US EPA 1995). A description of the AP-42 emission factor equations, assumptions and inputs used for the development of the emissions inventory are provided in Appendix D.

It is noted that fugitive dust emission factors are also provided in the NPI emission estimation technique manuals published by the Australian Government (e.g. NPI 2011); however, the NPI emission factors are largely based on the AP-42 documentation and the use of the AP-42 emission factors for fugitive dust emission inventories is therefore accepted by the NSW EPA for use in NSW.

Particulate matter emissions were quantified for the three size fractions identified in Section 4, with the TSP fraction also used to model dust deposition. Emission rates for coarse particles (PM_{10}) and fine particles ($PM_{2.5}$) were estimated using ratios for the different particle size fractions available in the literature (principally the US EPA AP-42).

7.1.3 Summary of emissions

The estimated annual emissions by project component and source are presented in Table 7.1. The particulate matter control measures documented in Section 7.1.1 are accounted for in these emission totals.

As shown in Table 7.1, estimated emissions for TSP and PM_{10} during bulk earthworks are slightly higher than the estimated emissions during shaft sinking (assuming both shafts are constructed concurrently). As described previously, these construction stages do not overlap, therefore our modelling assessment focuses on bulk earthworks only.

It is noted that the emission estimates for the shaft sinking phase in Table 7.1 are likely to be overestimated, as not all potential controls have been applied (ie the acoustic shed and potential water blankets for drilling). It is also noted that dust emissions from shaft pre-sink are included within the shaft sinking phase, as emissions are estimated based on the total amount of excavated material, which is not disaggregated for pre-sink. Although shaft pre-sink will commence as soon as bulk earthworks has finished (ie included in site preparation scheduling), the most intensive period for material handling and associated dust emission remains the bulk earthworks. Therefore, as the stage with the highest potential emissions for the key pollutant of concern (PM_{10}), if compliance can be demonstrated for bulk earthworks, compliance can be assumed for all other stages of construction.

Table 7.1 Calculated annual TSP, PM_{10} and $PM_{2.5}$ emissions

Emission source	Calculated annual emissions (kg/annum) by source		
	TSP	PM_{10}	$PM_{2.5}$
Bulk Earthworks			
Vegetation and topsoil stripping	2,729.7	953.7	84.6
Loading trucks with soil	10.6	5.0	0.8
Hauling soil across site	329.6	84.7	8.5
Emplacement of soil to stockpile	7.4	3.5	0.5
Excavation of bulk material	63.0	29.8	4.5
Loading bulk material to trucks	63.0	29.8	4.5
Hauling soil across site	1,954.8	502.3	50.2
Emplacement of soil to stockpile	66.0	31.2	4.7
Dozer spreading/shaping	5,384.9	986.2	565.4
Exposed ground wind erosion	5,712.3	2,856.1	428.4
Onsite diesel consumption	238	238	231
Total – Bulk Earthworks	**16,559.5**	**5,720.6**	**1,383.2**
VS7 - main shaft sink			
Drilling	619.5	322.1	18.6
Blasting	27.4	14.3	0.8
Material handling - spoil to surface	86.5	40.9	6.2
Loading trucks with spoil	86.5	40.9	6.2
Hauling spoil across site	919.8	236.4	23.6
Emplacement of spoil	60.6	28.7	4.3
Dozer spreading/shaping	5,903.0	1,158.7	619.8
Exposed ground wind erosion	2,543.1	1,271.6	190.7
Onsite diesel consumption	175	175	170
VS8 - main shaft sink			
Drilling	619.5	322.1	18.6
Blasting	11.6	6.0	0.3
Material handling - spoil to surface	46.5	22.0	3.3
Loading trucks with spoil	46.5	22.0	3.3
Hauling spoil across site	494.3	127.0	12.7
Emplacement of spoil	32.6	15.4	2.3
Dozer spreading/shaping	3,172.1	622.6	333.1
Exposed ground wind erosion	1,366.6	683.3	102.5
Onsite diesel consumption	175	175	170
Total -VS7 + VS8 shaft sink	**16,385.9**	**5,283.7**	**1,685.7**

A summary of the contribution to annual dust emissions by source type is provided in Figure 7.1. The most significant source of emissions is handling of material and wind erosion. The significance of diesel combustion emissions increases with decreasing particle size.

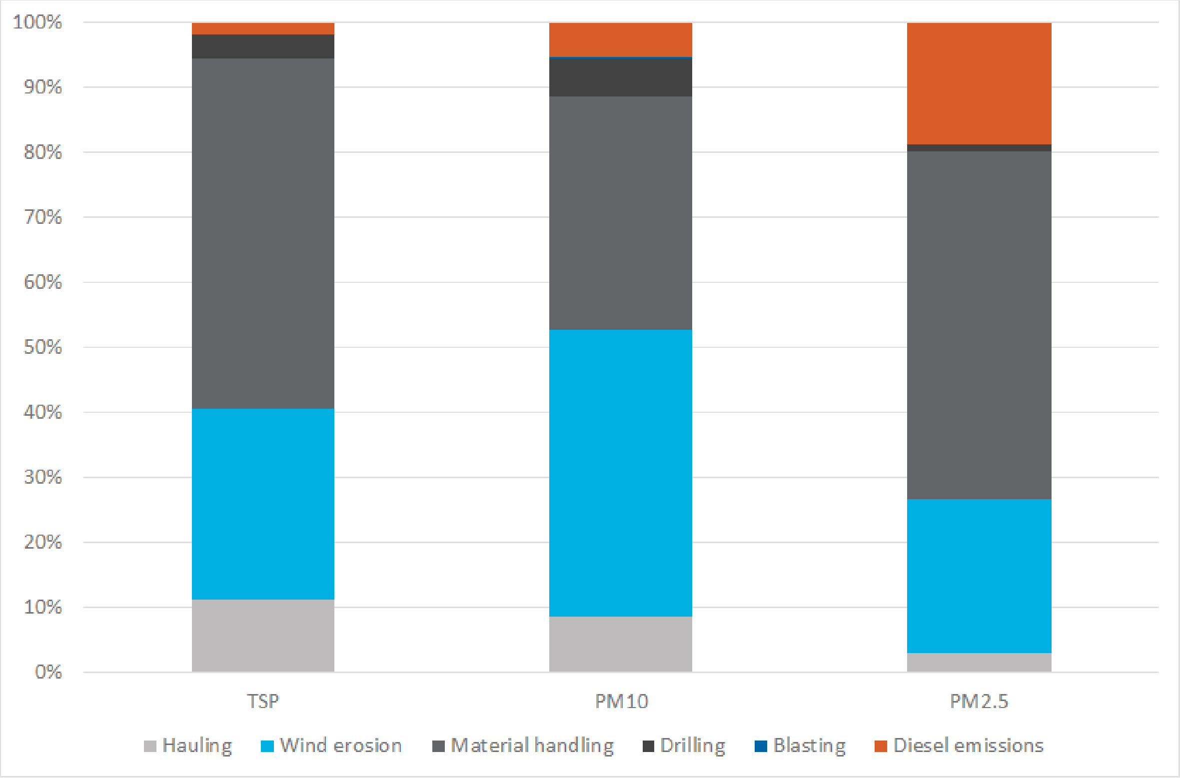

Figure 7.1 Contribution to annual emissions by emissions source type and particle size

7.2 Operational phase emissions

7.2.1 Characterisation of emissions

During operations, the key emissions source is the ventilation fan evases for Ventilation Shaft 8. Emission rates for modelling are derived from emission testing at Ventilation Shaft 6, which included testing for particles, NO_x, odour, metals and VOCs (Ektimo 2019). Testing for TSP and odour has been performed at other ventilation shafts in the region, including Dendrobium (2005), Metropolitan (2008), West Cliff (2009) and Appin Ventilation Shaft 3 (2010). The average of all historical measurements, including the 2019 testing at Ventilation Shaft 6, is lower than the average for the 2019 testing at Ventilation Shaft 6, therefore it is more conservative to use the testing data for Ventilation Shaft 6.

In addition to samples collected at Ventilation Shaft 6, bag samples of return air were also collected from underground at the Appin West Colliery. Analysis for hydrocarbons and sulphur gases was performed for the underground return air.

The majority of VOC compounds tested at Ventilation Shaft 6 were below the laboratory limit of detection. For the individual VOCs that were not below the laboratory limit of detection, the measured concentration at the ventilation shaft outlet was less than the ambient impact assessment criteria specified by the NSW EPA (where one exists for that compound). Similarly, all trace elements tested were below the laboratory limit of detection, except for lead. The measured lead concentration was less than the ambient impact assessment criterion for lead (noting that the criterion is expressed as an annual average and therefore not directly applicable to an instantaneous grab sample).

If, at the point of release, the ventilation shaft emissions comply with the impact assessment criteria, there is no need to model these pollutants for their impacts on the local area. Therefore, the modelling assessment focuses on emissions of TSP, PM_{10}, $PM_{2.5}$, NO_x and odour. The emission testing results for Ventilation Shaft 6 are summarised in Table 7.2.

For the bag samples collected underground, most VOCs were detected above the laboratory limit of detection, however all were less than the ambient impact assessment criteria specified by the NSW EPA (where one exists for that compound). Most of the sulphur compounds were detected above the laboratory limit of detection with methyl mercaptan and hydrogen sulphide also detected above the ambient impact assessment criteria. These compounds are assessed for odour impacts (refer Section 4.2).

Table 7.2 Summary of emission testing for Appin mine ventilation air

Test location	TSP (mg/m³)	PM_{10} (mg/m³)	$PM_{2.5}$ (mg/m³)	NO_x (mg/m³)	Odour (OU)	H_2S
Appin Vent Shaft No 6 - Test 1	1.1	0.54	0.13	2.68	91	-
Appin Vent Shaft No 6 - Test 2	1.7	0.83	0.20	-	83	-
Appin Vent Shaft No 6 - Test 3	3.1	1.52	0.37	-	-	-
Appin underground sample 1	-	-	-	-	91	0.0028
Appin underground sample 2	-	-	-	-	120	0.012
Appin underground sample 3	-	-	-	-	-	0.0021
Average	**2.0**	**1.0**	**0.2**	**2.7**	**96**	**0.0056**

Note: Dash (-) indicates not measured

7.2.2 Air flow scenarios for Ventilation Shaft 8

Two fans are assumed to be operating at any one time, with the third fan designed to provide redundancy. Two flow scenarios are presented based on ventilation requirement milestones as follows:

- November 2025 - volumetric airflow requirement of 315 m^3/s split across two fans; and
- August 2033 - volumetric airflow requirement of 440 m^3/s, split across two fans.

Mass emission rates (g/s) are derived by multiplying the measured concentrations (mg/m^3) by the volumetric air flow (m^3/s) and are summarised in Table 7.3. Mass emission rates are lower for the lower flow rate, however this lower emission rate is offset somewhat by the corresponding reduction in exit velocity, which results in a reduction in the initial plume dispersion. In other words, a lower emission rate does not necessarily result in lower ground level concentrations. The stack parameters assumed for modelling are also presented in Table 7.3.

Table 7.3 Derived emission rates and stack parameters for modelling

Scenario	Total flow rate (m^3/s)	Flow rate per fan (m^3/s)	Exit velocity (m/s)	Height (m)	Exit temp (K)	Diameter (m)	Emission rates				
							NO_x (g/s)	PM_{10} (g/s)	$PM_{2.5}$ (g/s)	Odour ($OU.m^3/s$)	H_2S (g/s)
2025	315	158	5.6	8	290-273[1]	6.0	0.31	0.15	0.04	18,900	2.64
2033	440	220	7.7	8	290-273[1]	6.0	0.43	0.21	0.05	26,400	3.68

Note: [1] A monthly varying temperature profile is used for modelling with temperatures varying within this range.

The ventilation fan evases are rectangular, however they are required to be configured as conventional circular stack sources in the model. An equivalent circular diameter of 6 m is calculated based on the measured area for the rectangular evasee. The influence of the ventilation structures is accounted for in the dispersion modelling through the ISC[9] building downwash module.

To account for variation in temperature of the MVA, a temperature profile has been derived based on two years of 5-minute average temperature measurements from the existing Ventilation Shaft 6. A monthly average temperature profile was derived from the 5-minute data and used to generate an hourly varying emission file for modelling (ie constant temperature applied for each hour of the month). It is noted that all other parameters in the emissions file (exit velocity and emission rates) remain constant for each hour of the year. The derived monthly temperature profile is presented in Figure 7.2, showing a peak temperature of 20.5 degrees Celsius in February and a low of 17.1 degrees Celsius in August.

It is noted that a monthly average profile was used in lieu of an hourly varying temperature profile as the time-period for the temperature measurements do not match the hourly ambient temperature data in the model. A monthly profile therefore avoids any disparity between the release and local ambient temperature. Also, the temperature measurements display a pronounced monthly profile but very little hourly variation in temperature data on a daily basis.

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[9] Recommended in TRC (2011) for structures where the length to width ratio is greater than 5-10. As the vent structures are long narrow 'buildings' this method is selected.

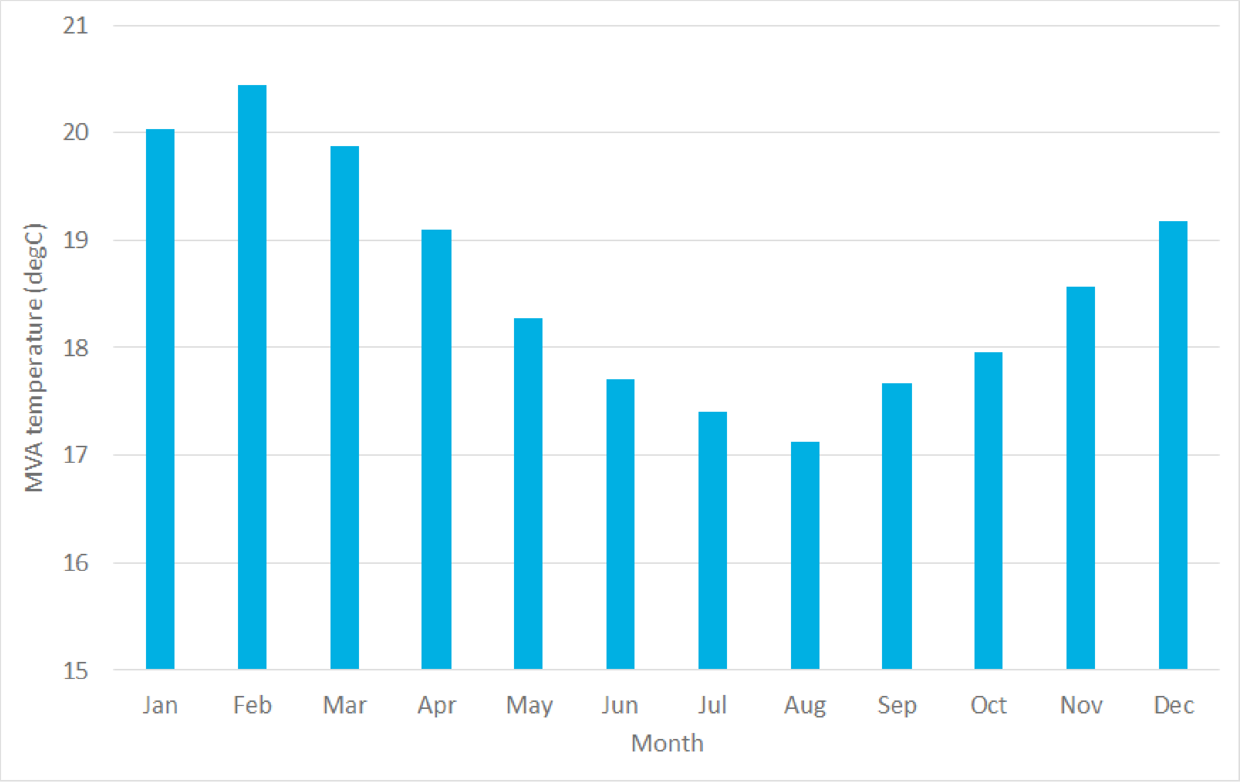

Figure 7.2 Monthly average temperature profile for MVA

8 Dispersion modelling

8.1 Dispersion model selection and configuration

Dispersion modelling for this assessment uses the CALPUFF modelling system, which is commonly used in NSW for applications where non-steady state conditions may occur (ie complex terrain or coastal locations). CALPUFF is selected for this assessment due to the lack of local or site-specific meteorological inputs to drive the model.

Instead, regional observations are input into the CALMET model and the derived meteorological field for the site takes into account the local terrain slope flows and blocking effects expected in the local area.

For the construction phase, the activities and emission sources listed in Table 7.1 are represented by volume and area sources, as follows:

- all material excavation, handling and haulage is modelled as a series of volume sources, positioned across the main area for bulk earthworks; and

- wind erosion is modelled as an area source, covering the main area for bulk earthworks.

For the operational phase, the ventilation fan evases are modelled as conventional circular stack sources and as a vertical release.

The predicted project increment and cumulative ground level concentrations (GLCs) are tabulated for each assessment location. Gridded GLCs were also predicted over a 10 km by 10 km domain with a 250 m spacing and used to generate contour plots, showing the extent of predicted ground level concentrations across the local area (Appendix E).

8.2 Construction phase impacts

8.2.1 PM_{10} and $PM_{2.5}$

The Project increment ground level PM_{10} and $PM_{2.5}$ concentrations from construction are presented in Table 8.1. Cumulative results are presented by adding the modelled increment to the adopted background concentrations described in Section 6.

The highest Project increment 24-hour average PM_{10} concentration occurs at assessment location R2 (6.1 µg/m^3). When background concentrations are added to the Project increment, there are no additional days over the 24-hour average impact assessment criterion for PM_{10}. For annual average PM_{10} concentrations, the Project increments are all less than 1 µg/m^3. When background concentrations are added to the Project increment, there are no exceedances of the annual average impact assessment criterion at any assessment location.

The highest Project increment 24-hour average $PM_{2.5}$ concentration occurs at assessment location R2 (2.1 µg/m^3). When background concentrations are added to the Project increment, there are no additional days over the 24-hour average impact assessment criterion for $PM_{2.5}$. For annual average $PM_{2.5}$ concentrations, the Project increments are small (<0.2 µg/m^3). When background concentrations are added to the Project increment, there are no exceedances of the annual average impact assessment criterion at any assessment location.

Table 8.1 Predicted ground level concentrations for PM_{10} and $PM_{2.5}$ ($\mu g/m^3$) during construction

Receptor ID	PM_{10}				$PM_{2.5}$			
	24-hour average		Annual average		24-hour average		Annual average	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
	IAC = 50 µg/m³		IAC = 25 µg/m³		IAC = 25 µg/m³		IAC = 8 µg/m³	
R2	6.1	48.6	0.7	18.3	2.1	19.8	0.2	8.0
R3	2.7	48.6	0.3	17.9	1.1	19.6	0.1	7.8
R4	2.7	48.5	0.2	17.8	1.1	19.6	0.1	7.8
R5	2.6	48.5	0.3	17.9	1.1	19.6	0.1	7.8
R6	3.1	48.6	0.3	18.0	1.2	19.7	0.1	7.8
R7	3.0	48.6	0.3	18.0	1.2	19.7	0.1	7.8
R8	2.4	48.6	0.2	17.9	0.9	19.7	0.1	7.8
R9	1.6	48.6	0.1	17.8	0.6	19.7	0.1	7.8
R10	1.9	48.6	0.1	17.8	0.8	19.7	0.1	7.8
R11	1.8	48.6	0.1	17.8	0.8	19.7	<0.1	7.8
R12	1.3	48.5	0.1	17.8	0.5	19.7	<0.1	7.8
R13	1.0	48.6	<0.1	17.7	0.4	19.6	<0.1	7.7
R14	4.4	48.9	0.3	18.0	1.0	19.7	0.1	7.8
R15	2.6	49.1	0.4	18.0	1.0	20.4	0.1	7.9
R16	3.8	48.5	0.3	18.0	1.5	19.6	0.1	7.9
R17	1.4	48.8	0.2	17.9	0.6	19.8	0.1	7.8
R18	0.9	48.5	<0.1	17.7	0.4	19.6	<0.1	7.7
R19	1.1	48.5	<0.1	17.7	0.5	19.6	<0.1	7.7
R20	0.4	48.5	<0.1	17.7	0.2	19.6	<0.1	7.7
R21	0.7	48.5	<0.1	17.7	0.3	19.6	<0.1	7.7
R22	0.8	48.5	<0.1	17.7	0.3	19.6	<0.1	7.7
R23	1.7	48.5	0.1	17.7	0.7	19.6	<0.1	7.8
R24	1.1	48.5	0.1	17.8	0.5	19.6	<0.1	7.8
R25	1.7	48.5	0.1	17.8	0.7	19.6	<0.1	7.8
R26	1.5	48.5	0.1	17.8	0.6	19.6	<0.1	7.8
R27	1.4	48.5	0.1	17.7	0.6	19.6	<0.1	7.8
R28	0.9	48.5	0.1	17.7	0.4	19.6	<0.1	7.8
R29	1.0	48.5	0.1	17.7	0.5	19.6	<0.1	7.8
R30	1.1	48.5	0.1	17.7	0.4	19.6	<0.1	7.8
R31	1.1	48.5	0.1	17.7	0.5	19.6	<0.1	7.8
R32	1.2	48.5	0.1	17.7	0.5	19.6	<0.1	7.8
R33	0.9	48.5	0.1	17.7	0.4	19.6	<0.1	7.7

Table 8.1 Predicted ground level concentrations for PM_{10} and $PM_{2.5}$ (µg/m^3) during construction

Receptor ID	PM_{10}				$PM_{2.5}$			
	24-hour average		Annual average		24-hour average		Annual average	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
	IAC = 50 µg/m^3		IAC = 25 µg/m^3		IAC = 25 µg/m^3		IAC = 8 µg/m^3	
R34	1.2	48.5	<0.1	17.7	0.5	19.6	<0.1	7.7
R35	1.2	48.5	0.1	17.7	0.5	19.6	<0.1	7.8

Note: IAC = impact assessment criterion

8.2.2 TSP and dust deposition

The Project increment ground level TSP concentrations and dust deposition from construction are presented in Table 8.2. Cumulative results are presented by adding the modelled increment to the adopted background concentrations described in Section 6.

For annual average TSP concentrations, the Project increments are all less than 2 µg/m^3. When background concentrations are added to the Project increment, there are no exceedances of the annual average impact assessment criterion at any assessment location.

For annual average dust deposition, the Project increments are minor (<=0.1 g/m^2/month). As described in Section 6.3, there is no local monitoring data available for dust deposition, therefore modelling results are assessed against the incremental impact assessment criterion only. However, given the minor incremental increase from the Project, no exceedances of the cumulative impact assessment criterion would be expected.

Table 8.2 Predicted ground level TSP concentration (µg/m³) and dust deposition (g/m²/month) during construction

Receptor ID	TSP (Annual average)		Dust Deposition (Annual average)
	Increment	Cumulative	Increment
	IAC = 90 µg/m³		IAC = 2 g/m²/month
R2	1.4	45.6	0.1
R3	0.7	44.9	<0.1
R4	0.4	44.6	<0.1
R5	0.6	44.8	<0.1
R6	0.7	44.9	<0.1
R7	0.6	44.8	<0.1
R8	0.5	44.7	<0.1
R9	0.3	44.5	<0.1
R10	0.3	44.5	<0.1
R11	0.2	44.4	<0.1
R12	0.2	44.4	<0.1
R13	0.1	44.3	<0.1
R14	0.6	44.8	<0.1
R15	0.7	44.9	<0.1
R16	0.7	44.9	<0.1
R17	0.3	44.5	<0.1
R18	0.1	44.3	<0.1
R19	0.1	44.3	<0.1
R20	0.1	44.3	<0.1
R21	0.1	44.3	<0.1
R22	0.1	44.3	<0.1
R23	0.2	44.4	<0.1
R24	0.2	44.4	<0.1
R25	0.2	44.4	<0.1
R26	0.2	44.4	<0.1
R27	0.1	44.3	<0.1
R28	0.1	44.3	<0.1
R29	0.2	44.4	<0.1
R30	0.1	44.3	<0.1
R31	0.1	44.3	<0.1
R32	0.1	44.3	<0.1
R33	0.1	44.3	<0.1
R34	0.1	44.3	<0.1

Table 8.2 Predicted ground level TSP concentration (µg/m^3) and dust deposition (g/m^2/month) during construction

Receptor ID	TSP (Annual average)		Dust Deposition (Annual average)
	Increment	Cumulative	Increment
	IAC = 90 µg/m^3		IAC = 2 g/m^2/month
R35	0.1	44.3	<0.1

Note: IAC = impact assessment criterion

8.3 Operation phase impacts

8.3.1 PM_{10}

The Project increment ground level PM_{10} concentrations from the operation of the ventilation shaft are presented in Table 8.3. Cumulative results are presented by adding the modelled increment to the adopted background concentrations described in Section 6.

The highest Project increment 24-hour average PM_{10} concentration occurs at assessment location R7 for both flow scenarios (5.4 µg/m^3 for 2025-(315m^3/s) and 6.7 µg/m^3 for 2033-(440m^3/s)). When background concentrations are added to the Project increment, there are no additional days over the 24-hour average impact assessment criterion for PM_{10} for either flow scenario.

For annual average PM_{10} concentrations, the Project increments are all less than 0.5 µg/m^3. When background concentrations are added to the Project increment, there are no exceedances of the annual average impact assessment criterion at any assessment location.

Table 8.3 Predicted ground level PM_{10} concentrations (µg/m^3) during operations

Receptor ID	2025 – 315 m^3/s				2033 – 440 m^3/s			
	24-hour average		Annual average		24-hour average		Annual average	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
	IAC = 50 µg/m^3		IAC = 25 µg/m^3		IAC = 50 µg/m^3		IAC = 25 µg/m^3	
R2	2.4	48.7	0.1	17.8	2.3	48.5	0.1	17.8
R3	1.7	48.5	0.1	17.8	1.7	48.5	0.2	17.8
R4	1.5	48.5	0.1	17.8	1.3	48.5	0.1	17.8
R5	1.9	48.5	0.2	17.8	1.6	48.5	0.2	17.8
R6	4.6	48.6	0.2	17.9	4.6	48.5	0.3	18.0
R7	5.4	48.6	0.2	17.9	6.7	48.5	0.3	18.0
R8	1.8	48.6	0.2	17.9	2.8	48.6	0.3	17.9
R9	1.7	48.6	0.1	17.8	2.0	48.6	0.2	17.8
R10	1.4	48.7	0.1	17.8	2.0	48.8	0.2	17.8
R11	1.4	48.8	0.1	17.8	3.5	49.0	0.2	17.9
R12	1.6	48.6	0.1	17.8	2.1	48.6	0.1	17.8
R13	3.3	49.2	<0.1	17.7	0.8	49.3	<0.1	17.7

Table 8.3 Predicted ground level PM_{10} concentrations (µg/m^3) during operations

Receptor ID	2025 – 315 m^3/s				2033 – 440 m^3/s			
	24-hour average		Annual average		24-hour average		Annual average	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
	IAC = 50 µg/m^3		IAC = 25 µg/m^3		IAC = 50 µg/m^3		IAC = 25 µg/m^3	
R14	1.0	48.5	0.1	17.7	1.0	48.5	0.1	17.7
R15	0.6	48.5	0.1	17.7	0.6	48.5	0.1	17.7
R16	1.9	48.7	0.1	17.8	1.8	48.5	0.1	17.8
R17	0.4	48.5	<0.1	17.7	0.6	48.5	<0.1	17.7
R18	0.4	48.5	<0.1	17.7	0.6	48.5	<0.1	17.7
R19	0.4	48.5	<0.1	17.7	0.5	48.5	<0.1	17.7
R20	0.4	48.5	<0.1	17.7	0.5	48.5	<0.1	17.7
R21	0.4	48.5	<0.1	17.7	0.6	48.5	<0.1	17.7
R22	0.5	48.5	<0.1	17.7	0.7	48.5	0.1	17.7
R23	0.8	48.5	0.1	17.7	0.8	48.5	0.1	17.7
R24	1.4	48.5	0.1	17.8	0.9	48.5	0.1	17.8
R25	2.1	48.5	0.1	17.8	1.9	48.5	0.1	17.8
R26	3.9	48.5	0.1	17.8	3.6	48.5	0.2	17.8
R27	2.7	48.5	0.1	17.8	3.0	48.5	0.1	17.8
R28	2.6	48.5	0.1	17.8	3.7	48.6	0.1	17.8
R29	2.7	48.5	0.1	17.8	3.7	48.6	0.1	17.8
R30	1.6	48.6	0.1	17.8	2.9	48.6	0.1	17.8
R31	2.2	48.7	0.1	17.8	3.8	48.8	0.1	17.8
R32	2.4	48.7	0.1	17.8	4.0	48.8	0.1	17.8
R33	1.6	48.5	0.1	17.8	2.2	48.6	0.1	17.8
R34	1.5	48.5	0.1	17.7	1.2	48.5	0.1	17.7
R35	1.0	48.5	0.1	17.7	1.6	48.5	0.1	17.7

Note: IAC = impact assessment criterion

8.3.2 $PM_{2.5}$

The Project increment ground level $PM_{2.5}$ concentrations from the operation of the ventilation shaft are presented in Table 8.4. Cumulative results are presented by adding the modelled increment to the adopted background concentrations described in Section 6.

The highest Project increment 24-hour average $PM_{2.5}$ concentration occurs at assessment location R7 for both flow scenarios (1.5 µg/m^3 for 2025-(315m^3/s) and 1.6 µg/m^3 for 2033-(440m^3/s)). When background concentrations are added to the Project increment, there are no additional days over the 24-hour average impact assessment criterion for $PM_{2.5}$ for either flow scenario.

For annual average $PM_{2.5}$ concentrations, the Project increments are small (0.1 µg/m³ or below). When background concentrations are added to the Project increment, there are no exceedances of the annual average impact assessment criterion at any assessment location.

Table 8.4 Predicted ground level $PM_{2.5}$ concentrations (µg/m³) during operations

Receptor ID	2025 – 315 m³/s				2033 – 440 m³/s			
	24-hour average		Annual average		24-hour average		Annual average	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
	IAC = 25 µg/m³		IAC = 8 µg/m³		IAC = 25 µg/m³		IAC = 8 µg/m³	
R2	0.6	19.6	<0.1	7.8	0.5	19.6	<0.1	7.8
R3	0.6	19.6	<0.1	7.8	0.5	19.6	<0.1	7.8
R4	0.5	19.6	<0.1	7.8	0.4	19.6	<0.1	7.8
R5	0.6	19.6	<0.1	7.8	0.4	19.6	<0.1	7.8
R6	1.2	19.6	0.1	7.8	1.1	19.6	0.1	7.8
R7	1.5	19.6	0.1	7.8	1.6	19.6	0.1	7.8
R8	0.5	19.6	0.1	7.8	0.7	19.6	0.1	7.8
R9	0.5	19.6	<0.1	7.8	0.5	19.6	<0.1	7.8
R10	0.4	19.7	<0.1	7.8	0.5	19.7	<0.1	7.8
R11	0.4	19.7	<0.1	7.8	0.9	19.7	<0.1	7.8
R12	0.5	19.6	<0.1	7.8	0.5	19.6	<0.1	7.8
R13	1.0	19.6	<0.1	7.7	0.2	19.6	<0.1	7.7
R14	0.3	19.6	<0.1	7.7	0.3	19.6	<0.1	7.7
R15	0.2	19.6	<0.1	7.7	0.1	19.6	<0.1	7.7
R16	0.5	19.6	<0.1	7.8	0.4	19.6	<0.1	7.8
R17	0.1	19.6	<0.1	7.7	0.1	19.6	<0.1	7.7
R18	0.2	19.6	<0.1	7.7	0.2	19.6	<0.1	7.7
R19	0.2	19.6	<0.1	7.7	0.1	19.6	<0.1	7.7
R20	0.2	19.6	<0.1	7.7	0.2	19.6	<0.1	7.7
R21	0.2	19.6	<0.1	7.7	0.2	19.6	<0.1	7.7
R22	0.2	19.6	<0.1	7.7	0.2	19.6	<0.1	7.7
R23	0.3	19.6	<0.1	7.7	0.3	19.6	<0.1	7.7
R24	0.4	19.6	<0.1	7.8	0.3	19.6	<0.1	7.7
R25	0.6	19.6	<0.1	7.8	0.5	19.6	<0.1	7.8
R26	1.1	19.6	<0.1	7.8	0.9	19.6	<0.1	7.8
R27	0.7	19.6	<0.1	7.8	0.7	19.6	<0.1	7.8
R28	0.7	19.6	<0.1	7.8	0.9	19.6	<0.1	7.8
R29	0.7	19.6	<0.1	7.8	0.9	19.6	<0.1	7.8
R30	0.4	19.6	<0.1	7.8	0.7	19.6	<0.1	7.8
R31	0.7	19.6	<0.1	7.8	1.0	19.6	<0.1	7.8

Table 8.4 Predicted ground level $PM_{2.5}$ concentrations (µg/m^3) during operations

Receptor ID	2025 – 315 m^3/s				2033 – 440 m^3/s			
	24-hour average		Annual average		24-hour average		Annual average	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
	IAC = 25 µg/m^3		IAC = 8 µg/m^3		IAC = 25 µg/m^3		IAC = 8 µg/m^3	
R32	0.8	19.6	<0.1	7.8	1.1	19.6	<0.1	7.8
R33	0.4	19.6	<0.1	7.8	0.5	19.6	<0.1	7.8
R34	0.4	19.6	<0.1	7.7	0.3	19.6	<0.1	7.7
R35	0.3	19.6	<0.1	7.7	0.4	19.6	<0.1	7.7

Note: IAC = impact assessment criterion

8.3.3 NO$_2$

Emissions from the ventilation shafts are modelled as NO$_x$ while the impact assessment criteria are applied to NO$_2$. It is necessary therefore to account for the atmospheric conversion of NO$_x$ to NO$_2$. For this assessment, the ozone limiting method (OLM) is applied (as described in the NSW EPA's Approved Methods for Modelling). This method assumes that all the available ozone (O$_3$) in the atmosphere will react with NO in the plume until either all the O$_3$ or all the NO is used up. Cumulative results are presented by adding the modelled increment NO$_2$ to the adopted background concentrations described in Section 6.

The highest Project increment 1-hour average NO$_2$ concentration (65.0µg/m^3) is approximately 26% of the impact assessment criterion. When background concentrations are added to the Project increment, the highest cumulative 1-hour average NO$_2$ concentration (95.8 µg/m^3) is approximately 39% of the impact assessment criterion.

For annual average NO$_2$ concentrations, the Project increments are small (less than 1 µg/m^3 or 1% of the impact assessment criterion). When background concentrations are added to the Project increment, there are no exceedances of the annual average impact assessment criterion at any assessment location.

Table 8.5 Predicted ground level NO$_2$ concentrations (µg/m^3) during operations

Receptor ID	2025 – 315 m^3/s				2033 – 440 m^3/s			
	1-hour average		Annual average		1-hour average		Annual average	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
	IAC = 246 µg/m^3		IAC = 62 µg/m^3		IAC = 246 µg/m^3		IAC = 62 µg/m^3	
R2	21.2	68.6	0.4	15.3	21.4	68.6	0.4	15.3
R3	38.3	68.6	0.4	15.3	30.2	68.6	0.4	15.4
R4	39.7	68.6	0.3	15.3	19.3	68.6	0.3	15.3
R5	42.1	68.6	0.4	15.4	28.7	68.6	0.5	15.4
R6	51.2	70.0	0.6	15.6	55.5	74.3	0.8	15.8
R7	55.0	73.8	0.6	15.6	58.8	76.7	0.8	15.8
R8	43.7	68.6	0.5	15.4	65.0	79.1	0.7	15.6
R9	41.1	90.9	0.3	15.3	39.6	89.4	0.4	15.4
R10	31.3	69.8	0.4	15.3	30.8	68.6	0.4	15.4
R11	28.3	70.9	0.3	15.3	44.5	69.9	0.4	15.4
R12	44.1	69.1	0.3	15.2	46.5	68.6	0.3	15.3
R13	40.6	71.0	0.1	15.0	21.4	68.6	0.1	15.0
R14	13.3	68.6	0.2	15.1	17.1	68.6	0.2	15.1
R15	10.5	68.6	0.1	15.1	17.7	68.6	0.1	15.1
R16	21.3	68.6	0.3	15.2	20.3	68.6	0.3	15.2
R17	8.4	68.6	0.1	15.0	12.3	68.6	0.1	15.1
R18	14.8	68.6	0.1	15.0	17.2	68.6	0.1	15.1
R19	12.1	68.6	0.1	15.0	13.6	68.6	0.1	15.1
R20	17.8	68.6	0.1	15.0	10.7	68.6	0.1	15.0
R21	12.6	68.6	0.1	15.1	11.3	68.6	0.1	15.1

Table 8.5 Predicted ground level NO_2 concentrations (µg/m^3) during operations

Receptor ID	2025 – 315 m^3/s				2033 – 440 m^3/s			
	1-hour average		Annual average		1-hour average		Annual average	
	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative	Increment	Cumulative
	IAC = 246 µg/m^3		IAC = 62 µg/m^3		IAC = 246 µg/m^3		IAC = 62 µg/m^3	
R22	19.1	68.6	0.1	15.1	16.4	68.6	0.1	15.1
R23	24.1	68.6	0.2	15.1	12.1	68.6	0.2	15.1
R24	36.1	68.6	0.2	15.2	22.9	68.6	0.2	15.2
R25	31.4	68.6	0.3	15.2	52.0	68.6	0.3	15.3
R26	38.8	71.2	0.3	15.3	53.0	68.8	0.4	15.3
R27	52.3	72.4	0.3	15.2	51.4	74.1	0.3	15.3
R28	46.2	91.5	0.2	15.2	48.7	93.8	0.3	15.3
R29	45.6	93.6	0.3	15.2	47.7	95.8	0.3	15.3
R30	40.9	71.4	0.2	15.2	46.0	68.6	0.3	15.2
R31	59.0	73.7	0.2	15.2	46.4	77.2	0.3	15.3
R32	62.6	75.8	0.2	15.2	45.9	69.2	0.3	15.3
R33	50.8	83.4	0.2	15.2	39.0	72.4	0.2	15.2
R34	41.7	68.6	0.2	15.1	29.7	68.6	0.2	15.1
R35	25.3	68.6	0.2	15.1	49.1	68.6	0.2	15.2

Note: IAC = impact assessment criterion

8.3.4 Odour

Potential odour impacts are evaluated in two ways, as a complex mixture of odour, using emission rates derived from the measured odour concentration and as hydrogen sulphide (H_2S), using emission rates derived from the measured sulphur compounds in the underground return air.

i Peak-to-mean ratios

The instantaneous perception of odours by the human nose occurs over very short timescales (~ 1 second), but dispersion model predictions are typically made for a one hour averaging period. To estimate the effects of plume meandering and concentration fluctuations perceived by the human nose, it is possible to multiply dispersion model predictions by a correction factor called a “peak-to-mean ratio”. The peak-to-mean ratio (P/M60) is defined as the ratio of peak 1-second concentrations to mean 1-hour average concentrations.

CALPUFF has been modelled at hourly time-steps. To estimate peak 1-second concentrations from hourly averaged odour concentrations, a peak-to-mean ratio (P/M60) of 2.3 has been applied in accordance with Table 6.1 of the Approved Methods for Modelling.

ii Modelling results

The Project increment ground level odour and H_2S concentrations from the ventilation shaft are presented in Table 8.6. Results are presented as the 99th percentile, 1-second average. All assessment locations are below the most stringent odour and H_2S impact assessment criteria for both flow scenarios.

Table 8.6 Predicted ground level concentrations of odour and H_2S during operations

Receptor ID	Odour (ou)		H_2S (µg/m^3)	
	2025 – 315 m^3/s	2033 – 440 m^3/s	2025 – 315 m^3/s	2033 – 440 m^3/s
	IAC = 4 ou		IAC = 2.76 µg/m^3	
R2	1	1	0.16	0.18
R3	<1	<1	0.16	0.14
R4	<1	1	0.13	0.17
R5	<1	2	0.15	0.25
R6	1	2	0.21	0.26
R7	1	1	0.20	0.22
R8	<1	<1	0.15	0.14
R9	<1	<1	0.11	0.14
R10	<1	<1	0.11	0.14
R11	<1	<1	0.10	0.10
R12	<1	<1	0.09	0.05
R13	<1	<1	0.04	0.09
R14	<1	<1	0.09	0.06
R15	<1	<1	0.06	0.13
R16	<1	<1	0.12	0.06
R17	<1	<1	0.05	0.04
R18	<1	<1	0.03	0.05
R19	<1	<1	0.04	0.04
R20	<1	<1	0.04	0.05
R21	<1	<1	0.04	0.06
R22	<1	<1	0.05	0.08
R23	<1	<1	0.07	0.09
R24	<1	<1	0.08	0.10
R25	<1	<1	0.09	0.14
R26	<1	<1	0.11	0.12
R27	<1	<1	0.10	0.10
R28	<1	<1	0.08	0.10
R29	<1	<1	0.09	0.09
R30	<1	<1	0.08	0.11
R31	<1	<1	0.09	0.11
R32	<1	<1	0.09	0.07
R33	<1	<1	0.07	0.06
R34	<1	<1	0.06	0.07

Table 8.6 Predicted ground level concentrations of odour and H_2S during operations

Receptor ID	Odour (ou)		H_2S (µg/m³)	
	2025 – 315 m³/s	2033 – 440 m³/s	2025 – 315 m³/s	2033 – 440 m³/s
	IAC = 4 ou		IAC = 2.76 µg/m³	
R35	<1	1	0.06	0.17

Note: IAC = impact assessment criterion

It is noted that, in accordance with the NSW EPA's Approved Methods, the 99th percentile of the dispersion model predictions are used to compare against the impact assessment criteria for odour. The 99th percentile corresponds to the 88 highest modelling prediction for a full year of hourly predictions. In other words, there will be 88 hours in the modelled year where the odour will be higher than what is presented in Table 8.6. Furthermore, the modelling is based on emission rates derived from odour measurements taken from ventilation shafts during typical mining operations. There may be occasions when odour emissions are higher than what was modelled. However, this uncertainly is accounted for by the margin of safety in the modelling results, with the highest modelling prediction being 50% of the adopted impact assessment criterion for odour. In other words, odour emissions from the ventilation shaft could double and would still comply with the impact assessment criterion.

8.3.5 TSP and dust deposition

The Project increment ground level TSP concentrations and dust deposition are presented in Table 8.7. Cumulative results are presented by adding the modelled increment to the adopted background concentrations described in Section 6.

For annual average TSP concentrations, the Project increments are all less than 1 µg/m³. When background concentrations are added to the Project increment, there are no exceedances of the annual average impact assessment criterion at any assessment location.

For annual average dust deposition, the Project increments are minor (less than 0.1 g/m²/month). As described in Section 6.3, there is no local monitoring data available for dust deposition, therefore modelling results are assessed against the incremental impact assessment criterion only. However, given the minor incremental increase from the Project, no exceedances of the cumulative impact assessment criterion would be expected.

Table 8.7 Predicted ground level TSP concentration (µg/m³) and dust deposition (g/m²/month) during operations

Receptor ID	2025 – 315 m³/s			2033 – 440 m³/s		
	Annual average TSP		Annual average Dust Dep	Annual average TSP		Annual average Dust Dep
	Increment	Cumulative	Increment	Increment	Cumulative	Increment
	IAC = 90 µg/m³		IAC = 2 g/m²/month	IAC = 90 µg/m³		IAC = 2 g/m²/month
R2	0.5	44.7	<0.1	0.3	44.5	<0.1
R3	0.5	44.7	<0.1	0.2	44.5	<0.1
R4	0.4	44.6	<0.1	0.3	44.4	<0.1
R5	0.6	44.8	<0.1	0.6	44.5	<0.1
R6	0.9	45.1	0.1	0.6	44.8	<0.1

Table 8.7 Predicted ground level TSP concentration (µg/m^3) and dust deposition (g/m^2/month) during operations

Receptor ID	2025 – 315 m^3/s			2033 – 440 m^3/s		
	Annual average TSP		Annual average Dust Dep	Annual average TSP		Annual average Dust Dep
	Increment	Cumulative	Increment	Increment	Cumulative	Increment
	IAC = 90 µg/m^3		IAC = 2 g/m^2/month	IAC = 90 µg/m^3		IAC = 2 g/m^2/month
R7	0.9	45.1	0.1	0.5	44.8	<0.1
R8	0.7	44.9	<0.1	0.3	44.7	<0.1
R9	0.5	44.7	<0.1	0.3	44.5	<0.1
R10	0.5	44.7	<0.1	0.3	44.5	<0.1
R11	0.4	44.6	<0.1	0.2	44.5	<0.1
R12	0.4	44.6	<0.1	0.1	44.4	<0.1
R13	0.2	44.4	<0.1	0.2	44.3	<0.1
R14	0.3	44.5	<0.1	0.1	44.4	<0.1
R15	0.2	44.4	<0.1	0.2	44.3	<0.1
R16	0.4	44.6	<0.1	0.1	44.4	<0.1
R17	0.1	44.3	<0.1	0.1	44.3	<0.1
R18	0.1	44.3	<0.1	0.1	44.3	<0.1
R19	0.1	44.3	<0.1	0.1	44.3	<0.1
R20	0.1	44.3	<0.1	0.1	44.3	<0.1
R21	0.1	44.3	<0.1	0.1	44.3	<0.1
R22	0.2	44.4	<0.1	0.1	44.3	<0.1
R23	0.2	44.4	<0.1	0.2	44.3	<0.1
R24	0.3	44.5	<0.1	0.2	44.4	<0.1
R25	0.4	44.6	<0.1	0.3	44.4	<0.1
R26	0.4	44.6	<0.1	0.2	44.5	<0.1
R27	0.4	44.6	<0.1	0.2	44.4	<0.1
R28	0.3	44.5	<0.1	0.2	44.4	<0.1
R29	0.4	44.6	<0.1	0.2	44.4	<0.1
R30	0.3	44.5	<0.1	0.3	44.4	<0.1
R31	0.4	44.6	<0.1	0.3	44.5	<0.1
R32	0.4	44.6	<0.1	0.2	44.5	<0.1
R33	0.3	44.5	<0.1	0.1	44.4	<0.1
R34	0.2	44.4	<0.1	0.2	44.3	<0.1
R35	0.2	44.4	<0.1	0.3	44.4	<0.1

8.4 Potential dust impacts on rainwater tanks

The predicted deposited dust levels for the Project are less than 5% of the relevant criterion for nuisance dust at all assessment locations. Previous studies, as noted below, have shown that dust fallout at levels higher than this do not constitute a risk to locally collected drinking water.

A study conducted by Gloucester Shire Council (Parkinson and Stimson 2010) included laboratory testing of rainwater tanks in Stratford village (close to the Stratford open cut coal mine) as well as from tanks in other villages remote from coal mining areas. The study found no statistical difference in values between Stratford and the other villages tested.

Research conducted in Queensland in close proximity to the Dalrymple Bay Coal Terminal investigated the potential health risks as a result of elements contained in coal dust deposited on rooftops entering rainwater tank systems used for potable supply (Lucas et al 2009). Leaching tests were conducted on numerous coal types to identify the potential for trace element release into rainwater in the tank. In addition, rainwater samples were collected from both the rainwater tanks and taps of three homes within the dust deposition zone of the Dalrymple Bay Terminal. The leaching tests indicated that negligible amounts of trace elements in coal dust were released in the rainwater, and all trace elements were below the Australian Drinking Water Guidelines (ADWG). The analysis of the rainwater from homes also showed that no trace element exceeded the ADWG.

Research conducted by the University of Queensland examined the relationship between mining and levels of lead in the air and in rainwater tanks (Noller 2009). The village of Camberwell and an outlying rural area of Muswellbrook were chosen for the study because of their close proximity to open cut coal mining operations. The research involved an extensive sampling program covering local rainwater tanks, soils, airborne particles and house dust. The study found that no tank water exceeded Australian Drinking Water Guidelines for lead and there was no significant difference in drinking water lead levels between houses close to coal mining operations and those obtained from background sites including Newcastle town water.

The predicted deposited dust levels for the Project are significantly lower than levels that would be observed close to open cut mining operations, such as the areas included in these studies. Based on this, no adverse impact on water collected within rainwater tanks is expected from the Project. However, all rainwater tanks, regardless of location, should be maintained in accordance with the advice outlined in NSW Health's Rainwater Tanks brochure[10] to ensure water is safe for drinking.

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[10] https://www.health.nsw.gov.au/environment/water/Documents/rainwater_tanks.pdf

9 Mitigation and monitoring

9.1 Construction phase

A Construction Environmental Management Plan (CEMP) will be prepared for the Project which will outline measures to manage dust. Dust mitigation measures may include but not be limited to those listed in Table 9.1.

Table 9.1 Mitigation measures – construction dust

Impact	Mitigation measure	Responsibility	Timing
Reporting and record keeping	• Implement Stakeholder Engagement Management Plan (SEMP) to notify the potentially impacted residences of the Project (duration, types of works, etc), relevant contact details for environmental complaints reporting. • Implement IMC procedure Handling Community Complaints Enquiries and Disputes (ICHP0112) during construction for any complaints related to dust. Where a dust complaint is received, the details of the response actions to the complaint should be recorded. • Record any exceptional incidents that cause dust and/or air emissions, either on or off site, and the action taken to resolve the situation. • Carry out regular site inspections, record inspection results, and make the records available for review as requested.	Contractor	Update SEMP prior to the commencement of construction. Ongoing reporting and record keeping throughout the duration of construction activities.
Dust generation - general	• Erect screens or barriers to site fences around potentially dusty activities and material stockpiles where practicable. • Provide an adequate water supply on the construction site for effective dust/particulate matter suppression/mitigation. • Avoid site runoff of dirty water or mud. • Temporary cessation of non-essential dust generating activities during high winds. • Schedule activities to avoid adverse weather conditions by reviewing weather forecasts	Contractor	Throughout the duration of construction activities.
Materials handling	• Prevention of truck overloading to reduce spillage during loading/unloading and hauling. • Minimise drop heights from loading, unloading or handling equipment.	Contractor	Throughout the duration of construction activities.
Soil stripping	• Soil stripping will be limited to areas required for construction.	Contractor	Throughout the duration of construction activities.
Exposed areas	• Minimum the disturbance area. • Exposed areas will be stabilised as soon as practicable. • Long-term soil stockpiles will be revegetated.	Contractor	Throughout the duration of construction activities.
Dust generation from vehicles moving on paved and unpaved roads	• Watering of main haulage routes or applying dust suppressants, as required. • Routes to be clearly marked and speed limits enforced. • Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	Contractor	Throughout the duration of construction activities.

Table 9.1 Mitigation measures – construction dust

Impact	Mitigation measure	Responsibility	Timing
	• Installation of a wheel wash or shaker grid or hose down area to prevent dirt track out		
Vehicle fuel combustion emissions	• Undertake maintenance of equipment. • Switch off vehicles when stationary.	Contractor	Throughout the duration of construction activities.

Due to the low risk of air quality impacts during construction, no air quality monitoring is recommended. Regular visual inspections of activities would be undertaken and recorded to monitor the effectiveness of dust controls and allow for reactive and corrective measures to be implemented. The inspections will focus on the following key issues:

- inspect and report on excessive dust being generated at source (wheel generated dust, excavators, wind erosion);
- inspect and report on water cart activity and effectiveness; and
- inspect and report on any dust leaving the site and moving towards sensitive receptors.

9.1.1 Blast fume

The blast management practices and blast fume prevention measures for the Project would be documented in the Projects Blast Management Strategy, and may include but not be limited to:

- best practice blast design and drill and blast practice in accordance with Australian Standard AS 2187.2 2006 'Storage and Use of Explosives;
- training of all drill and blast crew;
- require the manufacturer and supplier of explosives to have appropriate quality control systems to ensure formulation specifications are met, in particular, explosive type and optimum fuel content for any damp/wet holes;
- review geological conditions in the formulation of blast design;
- review ground conditions (e.g. presence of clay or loose/broken ground);
- minimise the time between drilling and loading, and loading and firing the shot (ie ignition of the blast);
- ensuring shot sleep times (ie duration explosives remain within the holes prior to blasting) are within the technical guidelines of the bulk explosive; and
- prior to each blast, a pre-blast assessment would be undertaken to ensure meteorological conditions are suitable and to determine/review the blast exclusion zone and fume management zone.

9.2 Operational phase

There is no mitigation proposed for the operation of the fan evases due to predicted low risk of air quality impacts. It is noted that air quality controls are already employed underground, with pollution controls required for all underground diesel equipment. Other practices, such as wet stone dusting can also be used to minimise the generation of emissions underground. No onsite or community-based air quality monitoring is recommended for ongoing operations.

10 Greenhouse gas assessment

10.1 Introduction

For accounting and reporting purposes, GHG emissions are defined as 'direct' and 'indirect' emissions. Direct emissions (also referred to as Scope 1 emissions) occur within the boundary of an organisation and are as a result of that organisation's activities. Indirect emissions are generated as a consequence of an organisation's activities but are physically produced by the activities of another organisation (DoEE 2020).

Indirect emissions are further defined as Scope 2 and Scope 3 emissions. Scope 2 emissions occur from the generation of the electricity purchased and consumed by an organisation. Scope 3 emissions occur from all other upstream and downstream activities, for example the downstream extraction and production of raw materials or the upstream use of products and services.

Scope 3 is an optional reporting category (Bhatia et al 2010) and should not be used to make comparisons between organisations, for example in benchmarking GHG intensity of products or services. Typically, only major sources of Scope 3 emissions are accounted and reported by organisations.

GHG emissions are presented as carbon dioxide equivalents (CO_2-e) and include emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) calculated based on the Global Warming Potentials (GWPs) adopted by the Parties to the United Nations (UN) Framework Convention on Climate Change and its Kyoto Protocol.

10.2 Emissions sources and scope of the assessment

Scope 1 GHG emissions sources for construction include the combustion of fuel (diesel) by onsite plant and equipment and emissions released from explosive use for shaft sinking. Although not a direct source of GHG emissions, vegetation stripping during construction would result in the loss of a carbon sink and is categorised as a Scope 1 emission source for the construction phase.

Emissions associated with mine ventilation air (Scope 1) are associated with continuing underground mining activities assessed as part of the Appin Mine Approval. As such, they are not within the scope of the assessment for the Project. Similarly, there would be no change to the overall operational fuel consumption for the mine, as the Project will not alter the underground operations.

Scope 2 GHG emission sources during construction and operations include the consumption of purchased electricity.

Scope 3 emission sources for construction include the upstream production and transport of construction materials, employee travel and the decomposition of waste in landfill. Scope 3 emission sources during operations include employee travel and the decomposition of waste in landfill. Scope 3 is an optional reporting category and the sources described above are relatively minor or already assessed and reported under the existing Appin Mine Approval. Therefore Scope 3 emissions are not considered in this report.

The GHG emissions sources considered in this assessment is summarised in Table 10.1.

Table 10.1 Summary of GHG emission sources included in assessment

Phase	Source	Type
Construction	Onsite fuel combustion	Scope 1
	Direct emissions from explosive use	Scope 1
	Electricity consumption during construction	Scope 2
	Loss of carbon sink from vegetation stripping within construction footprint	Scope 1
Operation	Electricity consumption for operation of the fans and facilities	Scope 2

10.3 Scope 1 GHG emissions during construction and operations

10.3.1 Fuel and explosive use during construction

Scope 1 GHG emissions are estimated using the methodologies outlined in the NGAF workbook (DoEE 2020) and using fuel energy contents and emission factors for diesel and explosives, as follows:

- diesel consumption on-site (Scope 1) – diesel oil factors from Table 3 of the NGAF workbook (2020); and
- explosives use (Scope 1) - emission factor for ammonium nitrate/fuel oil (ANFO) from the NGAF workbook (2008).

The annual diesel consumption for the construction period is estimated based on an assumed construction fleet and estimated average fuel consumption (L/hr) taken from the Caterpillar Performance Handbook. Fuel consumption during bulk earthworks is estimated based on an 11-hour day (at 70% utilisation) and during shaft sinking based on a 24 hour day (at 70% utilisation). The maximum annual fuel consumption is estimated at approximately 530 kilolitres (kL), which results in annual (worst case) emissions of 1,436 t CO_2-e.

Explosive use is estimated based on 300 kg of explosives per blast and an assumed 350 blasts occurring in a year per shaft, resulting in a total of 210 tonnes of explosive per year. The resultant annual emission estimate from blasting is 35.7 t CO_2-e.

10.3.2 Vegetation stripping

Vegetation clearing is not technically a GHG emission source, although the net impact of vegetation clearing is less CO_2 being removed from the atmosphere (through loss of a carbon sink) and therefore an equivalent amount of CO_2 would remain.

Emissions from vegetation clearing are estimated based on a methodology developed by Australian state road authorities and NZ Transport Agency, under the banner of the Transport Authorities Greenhouse Group (TAGG 2013). The TAGG (2013) workbook methodology for vegetation clearing results in a conservatively high estimate in that it assumes that all carbon pools are removed, all carbon removed is converted to CO_2 and released, and sequestration from revegetation is not included.

Emission factors are provided for defined vegetation classes (A to I) corresponding to potential maximum biomass classes (expressed as tonnes dry matter per hectare). As the Site is predominantly grassland, the maximum biomass class is redundant, as the emissions factor for grassland (110 t CO_2-e/ha) is the same for each vegetation class.

Applying this emission factor to a maximum potential clearing and grubbing area of 21.44 hectares results in a conservatively high estimate of 2,358 t CO_2-e.

It is noted that the emission estimates are not expressed on a per annum basis. Instead, they represent the total emissions that would have otherwise been sequestered for the period that the vegetation would have remained under a 'business as usual' scenario.

The disposal of cleared vegetation also results in GHG emissions, the significance of which is dependent on the disposal method. If left to decompose naturally, the rate at which GHGs are emitted is very slow and considered negligible; however, if disposed of the material is to landfill or burned, the rate is much higher. For this assessment, we have assumed that removed vegetation will remain onsite and re-used (ie as mulch) and therefore GHG emissions are negligible.

It is noted that the visual and acoustic bunds will be revegetated once constructed, thereby offsetting some of the vegetation removed during construction.

10.3.3 Mine ventilation air

As described in Section 2, the Project will not increase the volume of coal produced, therefore there is no substantial increase in fugitive emissions generated by the Mine; rather the Project will alter how the Mine is ventilated by redistributing the various components of mine ventilation air (MVA). Therefore, GHG emissions from MVA are not considered for the Project.

10.3.4 Fuel use during operations

As described in Section 2, there would be no change to the overall fuel consumptions for the mine, as the Project will not alter the underground operations. Therefore, GHG emissions from fuel consumption are not considered for the Project.

10.4 Scope 2 emissions during construction and operations

10.4.1 Construction

The estimated electricity consumption during construction (mainly during shaft sinking) is 15,321,600 kWh over a period of approximately 84 weeks. This equates to approximately 9,484,800 kWh on an annual basis.

The NGAF workbook emission factor for purchased electricity in NSW is applied to estimate annual emissions of 7,683 t CO_2-e.

10.4.2 Operation

The estimated electricity consumption for the fans and pit top infrastructure is 56,219,570 kWh per annum, which results in annual emissions of 45,538 t CO_2-e.

It is noted that the operation of the proposed surface fans at Ventilation Shaft 8 will remove the dependency on two existing underground booster fans. Furthermore, without the operation of Ventilation Shaft 7 and 8, additional underground booster fans are likely to be required to maintain a business-as-usual scenario. Due to lower frictional resistance, the proposed surface fans at Ventilation Shaft 8, would therefore result in an overall reduction in electricity consumption for the Appin Mine.

10.5 Significance of emissions

A summary of the GHG emissions for construction and operations are presented in Table 10.2. The significance of emissions during construction and operations is compared to annual average GHG emissions for the most recent available GHG accounts for NSW (131,685 kt CO_2-e) and Australia (537,446 kt CO_2-e) (AGEIS 2021).

Annual average GHG emissions (Scope 1 and Scope 2) generated during construction represent approximately 0.007% of total GHG emissions for NSW and 0.002% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2018. The comparison does not include vegetation removal, which represents loss of a carbon sink and is not expressed on a per annum basis.

Annual average GHG emissions (Scope 2) generated during operations represent approximately 0.03% of total GHG emissions for NSW and 0.008% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2018 (AGEIS 2021). It is noted that the most significant source of GHG emissions for the Project is associated with electricity consumption during operations; however as described above, the proposed surface fans at Ventilation Shaft 8 will reduce the need for underground booster fans and therefore reduce the overall electricity consumption for the Appin Mine (compared to what would otherwise be required to maintain a business-as-usual scenario without the Project).

Table 10.2 Summary of Scope 1 and 2 emissions for construction and operation (t CO_2-e/annum)

Phase	Activity/source	Scope 1	Scope 2
Construction	Onsite fuel consumption	1,436	
	Explosives	35.7	
	Vegetation stripping	2,358	
	Electricity use		7,683
Operations	Electricity use		45,538

The calculated annual Scope 1 and 2 emissions from the Project are greater than the NGER Scheme facility reporting threshold of 25,000 tpa CO_2-e. IMC currently calculate and report Scope 1 and 2 GHG emissions annually in accordance with the requirements of the NGER Act and will continue to do so as long as Scope 1 and 2 GHG emissions are above the reporting threshold.

10.6 GHG emission management

10.6.1 Operations

The Appin Mine continues to identify and implement measures to minimise the release of GHG and to support the South32 Climate Change Strategy, directed towards reducing methane emissions which make up the majority of GHG emissions from the Appin Mine. IMC has set relatively aggressive greenhouse gas emission targets, including to progressively reduce emissions, such that the business is carbon neutral by 2050. The goal of carbon neutrality by 2050 aligns South32 with the Paris Agreement, as well as the NSW aspirational target for 2050.

The Appin Mine gas drainage system improvement efficiency project achieved post drainage capture efficiency of 56.5% in the financial year 2020. The captured methane is either flared or directed to a third party to generate power. Both activities significantly reduce the amount of carbon dioxide equivalent (CO2-e) released into the atmosphere by converting methane to CO_2, providing abatement of approximately 88,700 tonnes of CO2-e in the financial year 2020 (South32 2020). As described above, the Project will not increase the volume of coal produced, therefore there is no substantial increase in fugitive emissions generated by the Mine as a result of the Project.

Further measures implemented to minimise the release of GHG emissions associated with Appin Mine are detailed in the Appin Mine Air Quality and Greenhouse Gas Management Plan (South32 / Illawarra Metallurgical Coal 2020a), the Appin Mine Annual Review (South32 / Illawarra Metallurgical Coal 2020b) and South32 Sustainable Development Report (South32 2020).

It is noted that the most significant source of GHG emissions for the Project is associated with electricity consumption during operations; however as described above, the proposed surface fans at Ventilation Shaft 8 will reduce the need for underground booster fans and therefore reduce the overall electricity consumption for the Appin Mine (compared to what would otherwise be required to maintain a business-as-usual scenario without the Project).

Furthermore, the Appin Mine gas drainage and capture network enables the reuse of waste coal mine gas to generate power. The methane gas extracted from the coal seam by the underground gas extraction network is directed to the surface, via the gas drainage plants, and used to generate electricity at the power generation plants. The gas captured from the Appin Mine is used to generate equivalent electricity for approximately 52,000 homes annually, or roughly 45 per cent of all homes in Wollongong. This electricity has a lower carbon intensity than the NSW grid average.

10.6.2 Construction

A summary of potential measures that could be implemented to reduce Project GHG emissions during construction include:

- efficient scheduling and planning (eg minimising rehandling and haulage of materials) to minimise fuel consumption;
- reduce idling and turn off equipment when not in use
- use of 10% blended ethanol for select petrol-powered light vehicles, where practicable
- maintenance of plant and equipment to optimise fuel consumption;
- sourcing materials (aggregates etc) from local sources where possible; and
- reuse of the removed vegetation through mulching or composting and avoiding disposal to landfill or burning.

11 Conclusion

The report provides a quantitative assessment of potential air quality impacts for both the construction and operation phases of the Project.

An emissions inventory was developed for a single construction year, selected to assess the worst-case air quality impacts when material handling/movement is at a maximum. The highest predicted dust concentrations during construction occur at the closest assessment location (R2). Modelling predictions indicate that there would be no additional days over the 24-hour average impact assessment criterion for PM_{10} and $PM_{2.5}$ and no exceedances of the annual average impact assessment criterion at any assessment location for PM_{10}, $PM_{2.5}$, TSP and dust deposition.

During operations, the key emissions source is the ventilation fan evases for Ventilation Shaft 8. Two flow scenarios are assessed based on ventilation requirement milestones for 2025 and 2033. The highest predicted impacts for PM_{10} and $PM_{2.5}$ during operations occur at assessment location R7. When background concentrations are added to the Project increment, there are no additional days over the 24-hour average impact assessment criterion for PM_{10} and $PM_{2.5}$, for both flow scenarios. For annual average PM_{10} and $PM_{2.5}$ concentrations, there are no exceedances of the annual average impact assessment criterion at any assessment location for both flow scenarios.

For annual average TSP concentrations and dust deposition there are no exceedances of the annual average impact assessment criterion at any assessment location for both flow scenarios.

For the assessment of NO_2, the atmospheric conversion of NO_x to NO_2 is accounted for using the ozone limiting method. When background concentrations are added to the Project increment, the highest cumulative 1-hour average NO_2 concentration (95.8 $\mu g/m^3$) is approximately 39% of the impact assessment criterion. For annual average NO_2 concentrations, the Project increments are small (less than 1 $\mu g/m^3$ and 1% of the impact assessment criterion). When background concentrations are added to the Project increment, there are no exceedances of the annual average impact assessment criterion at any assessment location.

Potential odour impacts are evaluated in two ways. There are no exceedances of the most stringent odour and H_2S impact assessment criteria at all assessment locations and for both flow scenarios.

Annual average GHG emissions (Scope 2) for operations represent approximately 0.03% of total GHG emissions for NSW and 0.008% of total GHG emissions for Australia, based on the National Greenhouse Gas Inventory for 2018. However, it is noted that the proposed surface fans at Ventilation Shaft 8 will reduce the need for underground booster fans and therefore reduce the overall electricity consumption for the Appin Mine (compared to what would otherwise be required to maintain a business-as-usual scenario without the Project). Measures to minimise the release of GHG and to support the South32 Climate Change Strategy at the Appin Mine continue to be implemented and reported in the Annual Review.

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Abbreviations

AAQ NEPM	Ambient Air Quality National Environment Protection Measure
AEISG	Australian Explosives Industry and Safety Group
ANFO	Ammonium nitrate/fuel oil
AQMS	Air Quality Monitoring Station
AQIA	Air quality impact assessment
AWS	Automatic weather station
BoM	Bureau of Meteorology
BSO	Bulli Seam Operations
C&D	Construction and demolition
CEMP	Construction environmental management plan
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
CO	Carbon monoxide
CH_4	Methane
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DoEE	Department of the Environment and Energy
DPIE	Department of Planning, Industry and Environment
EP&A Act	NSW Environment Planning and Assessment Act 1979
EPA	Environment Protection Authority
GHG	Greenhouse gas
GWP	Global Warming Potential
GLC	ground level concentration
H_2S	Hydrogen sulphide
IMC	Illawarra Metallurgical Coal
kL	Kilolitres
kW	Kilowatt
kWhr	Kilowatt hour
MVA	Mine ventilation air
Mtpa	Million tonnes per annum

NGAF	National Greenhouse Accounts Factors
N_2O	Nitrous oxide
NO_x	Oxides of nitrogen
NO_2	Nitrogen Dioxide
NPI	National Pollution Inventory
NSW	New South Wales
O_3	Ozone
PM	Particulate matter
PM_{10}	Particulate matter less than 10 microns in aerodynamic diameter
$PM_{2.5}$	Particulate matter less than 2.5 microns in aerodynamic diameter
ROI	Radius of influence
ROM	Run-of-mine
SO_2	Sulphur dioxide
TAGG	Transport Authorities Greenhouse Group
TAPM	The Air Pollution Model
TSP	Total suspended particulate matter
US-EPA	United States Environmental Protection Agency
VOC	Volatile organic compounds
VS7	Ventilation Shaft 7
VS8	Ventilation Shaft 8
WCCPP	West Cliff Coal Preparation Plant
WCEA	West Cliff Emplacement Area

Appendix A

Tabulated assessment locations

A.1 Assessment locations for air quality modelling

Table A.1 Assessment locations

Figure ID	Address	Easting	Northing
R1	345 MENANGLE ROAD MENANGLE	290549	6219450
R2	310 MENANGLE ROAD MENANGLE	290469	6219633
R3	30 FINNS ROAD MENANGLE	289906	6219217
R4	15 FINNS ROAD MENANGLE	289783	6219119
R5	3 FINNS ROAD MENANGLE	289852	6218957
R6	430 MENANGLE ROAD MENANGLE	289955	6218814
R7	436 MENANGLE ROAD MENANGLE	289952	6218789
R8	450 MENANGLE ROAD MENANGLE	289950	6218672
R9	470 MENANGLE ROAD MENANGLE	289906	6218450
R10	475 MENANGLE ROAD MENANGLE	290060	6218382
R11	485 MENANGLE ROAD MENANGLE	290049	6218264
R12	486 MENANGLE ROAD MENANGLE	289797	6218258
R13	775 MORETON PARK ROAD MENANGLE	291233	6218364
R14	251 MENANGLE ROAD MENANGLE	291299	6219994
R15	235 MENANGLE ROAD MENANGLE	291014	6220177
R16	310 MENANGLE ROAD MENANGLE	290458	6219782
R17	195 MENANGLE ROAD MENANGLE	291259.7	6220575
R18	110 FINNS ROAD MENANGLE	289475.4	6220214
R19	25 CARROLLS ROAD MENANGLE	289263.9	6219636
R20	47 CARROLLS ROAD MENANGLE	289163	6219441
R21	45 FINNS ROAD MENANGLE	289316.7	6219445
R22	45 CARROLLS ROAD MENANGLE	289287.1	6219301
R23	35 FINNS ROAD MENANGLE	289447	6219126
R24	5 FINNS ROAD MENANGLE	289554	6218918
R25	454 MENANGLE ROAD MENANGLE	289549.8	6218701
R26	460 MENANGLE ROAD MENANGLE	289526.5	6218583
R27	474 MENANGLE ROAD MENANGLE	289461.1	6218399
R28	514 MENANGLE ROAD MENANGLE	289589.4	6218223
R29	490 MENANGLE ROAD MENANGLE	289655.6	6218262
R30	510 MENANGLE ROAD MENANGLE	289695.3	6218131
R31	520 MENANGLE ROAD MENANGLE	289791.6	6218027

Table A.1 Assessment locations

Figure ID	Address	Easting	Northing
R32	530 MENANGLE ROAD DOUGLAS PARK	289807.7	6217966
R33	516 MENANGLE ROAD MENANGLE	289595.6	6218062
R34	165 CARROLLS ROAD MENANGLE	289294.7	6218260
R35	115 CARROLLS ROAD MENANGLE	289350.4	6218751

Appendix B

Modelling configuration

B.1 Overview of modelling

CALMET was used to produce 3-dimensional meteorological fields for use in the CALPUFF model. In the absence of upper air measurements, CALMET was run using prognostic upper air data (as a three-dimensional '3D.dat' file), which is used to derive an initial wind field (known as the Step 1 wind field in the CALMET model). The model then incorporates mesoscale and local scale effects, including surface observations, to adjust the wind field. This modelling approach is known as the 'hybrid' approach (TRC 2011) and is adopted for this assessment.

The Commonwealth Scientific and Industry Research Organisation (CSIRO) prognostic meteorological model TAPM was used to generate gridded upper air data for each hour of the model run period, for input into CALMET. TAPM configuration and settings is presented in Table B.1.

Table B.1 TAPM settings

Parameter	**Setting**
Model Version	TAPM v.4.0.5
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grid points	25 x 25
Vertical grids / vertical extent	30 / 8000m (~400mb)
Centre of analysis	Lat -34.14167, long 150.725 Easting 290374, Northing 6219129
Year of analysis	2018
Terrain and landuse	Default TAPM values based on land-use and soils data sets from Geoscience Australia and the US Geological Survey, Earth Resources Observation Systems (EROS) Data Center Distributed Active Archive Center (EDC DAAC)
Assimilation sites	Ventilation Shaft 6, the Appin Power Station, BoM Camden Airport and DPIE Campbelltown West

CALMET model settings are presented in Table B.2. CALMET and CALPUFF model options are presented in Table B.3 and Table B.4, selected in accordance with recommendations in the Approved Methods for Modelling and in TRC (2011).

Table B.2 CALMET settings

Parameter	**Setting**
Grid domain	40 km x 40 km
Grid resolution	0.25 km
Number of grid points	160 x 160
Reference grid coordinate	267.3900, 6199.1290
Vertical grids / vertical extent	10 cell heights / 4,000m
Upper air meteorology	Prognostic 3D.dat extracted from TAPM at 3 km grid

Table B.2 CALMET settings

Parameter	Setting
Surface observations	Ventilation Shaft 6, the Appin Power Station, BoM Camden Airport and DPIE Campbelltown West

Table B.3 CALMET model options

Flag	Description	Recommended setting	Value used
NOOBS	Meteorological data options	0,1,2	1 - combination of surface and prognostic data
ICLOUD	Cloud Data Options – Gridded Cloud Fields	4	4 -Gridded cloud cover from Prognostic relative humidity at all levels (MM5toGrads algorithm)
IEXTRP	Extrapolate surface wind observations to upper layers	-4	-4 - similarity theory used
IFRADJ	Compute Froude number adjustment effects	1	1 - applied
IKINE	Compute kinematic effects	0	0 - not computed
BIAS (NZ)	Relative weight given to vertically extrapolated surface observations vs. upper air data	NZ * 0	NZ * 0 - layers in lower levels of model will have stronger weighting towards surface, higher levels will be have stronger weighting to upper air data
TERRAD	Radius of influence of terrain	No default (typically 5-15km)	5 km
RMAX1 and RMAX2	Maximum radius of influence over land for observations in layer 1 and aloft	No Default	5 km, 5 km
R1 and R2	Distance from observations in layer 1 and aloft at which observations and Step 1 wind fields are weighted equally	No Default	R1 - 2 km, R2 – 2 km

Table B.4 CALPUFF model options

Flag	Description	Value used	Description
MCHEM	Chemical Transformation	0	Not modelled
MDRY	Dry Deposition	1	Yes

Table B.4 CALPUFF model options

Flag	Description	Value used	Description
MWET	Wet Deposition	0	Not modelled
MTRANS	Transitional plume rise allowed?	1	Yes
MTIP	Stack tip downwash?	1	Yes
MRISE	Method to compute plume rise	1	Briggs plume rise
MSHEAR	Vertical wind Shear	0	Vertical wind shear not modelled
MPARTL	Partial plume penetration of elevated inversion?	1	Yes
MSPLIT	Puff Splitting	0	No puff splitting
MSLUG	Near field modelled as slugs	0	Not used
MDISP	Dispersion Coefficients	2	Based on micrometeorology
MPDF	Probability density function used for dispersion under convective conditions	1	Yes
MROUGH	PG sigma y,z adjusted for z	0	No
MCTADJ	Terrain adjustment method	3	Partial Plume Adjustment
MBDW	Method for building downwash	1	ISC Method

Appendix C

Multi-year analysis of wind and temperature

C.1 Wind roses

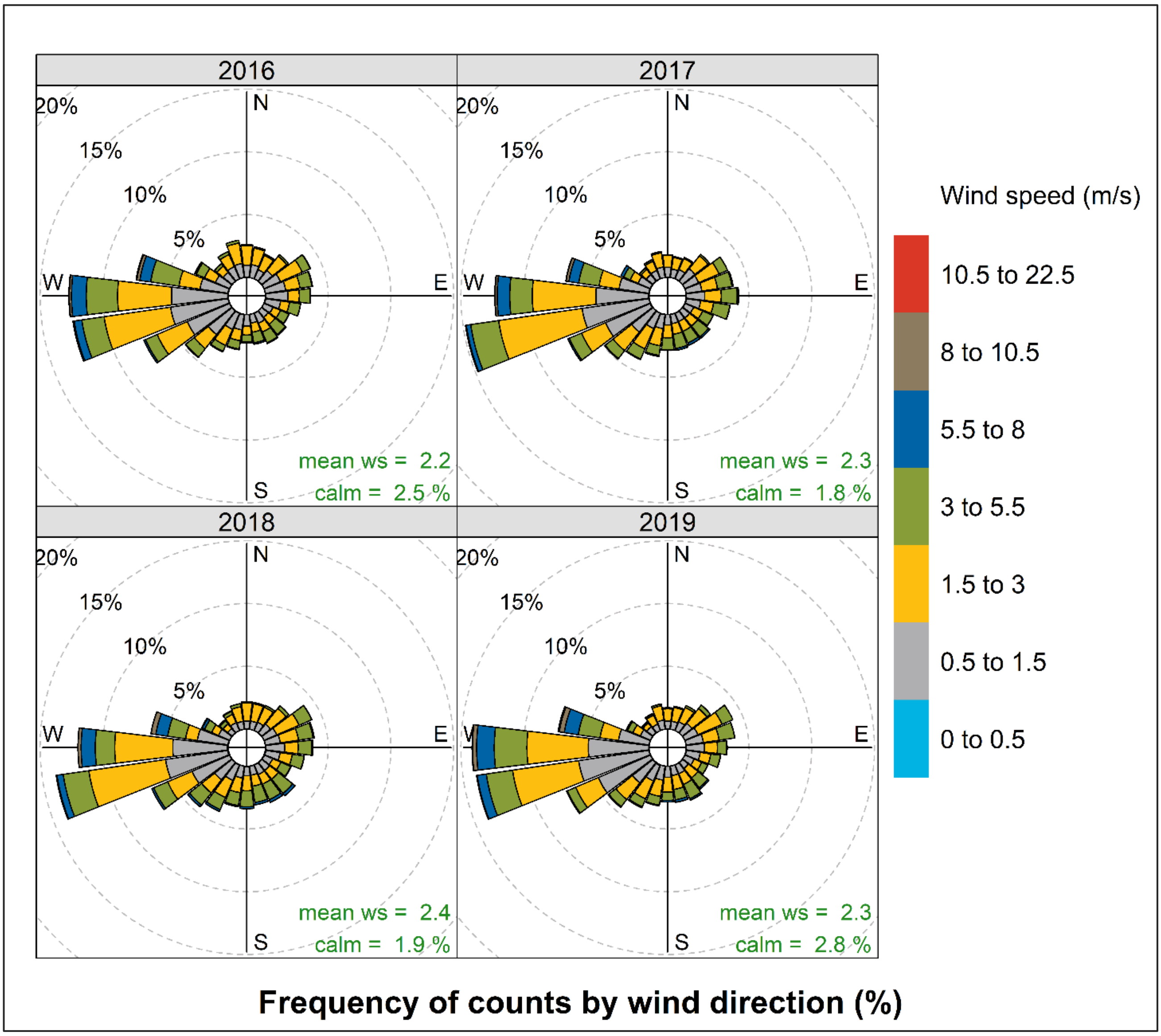


Figure C.1 Annual wind roses for Ventilation Shaft 6

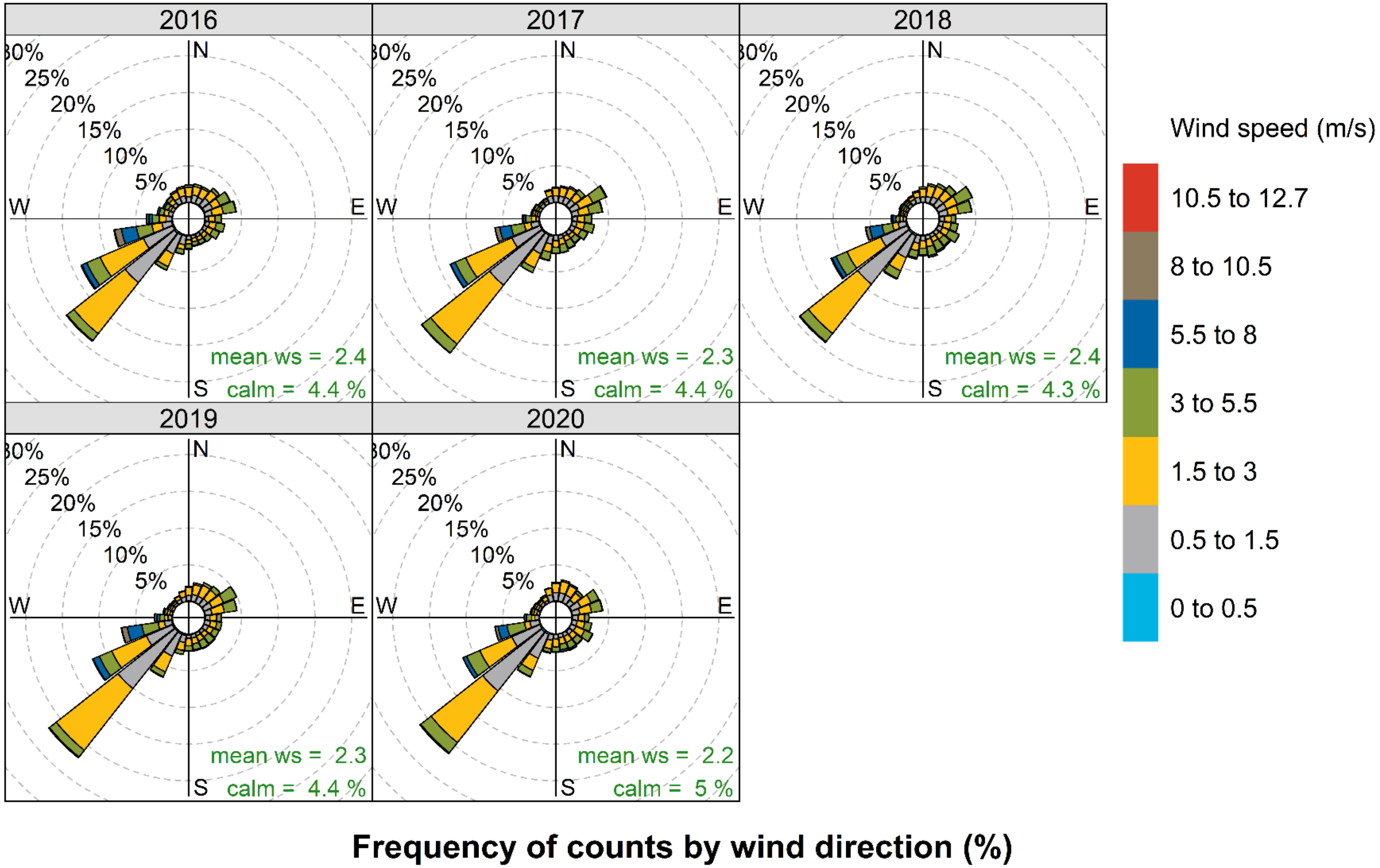


Figure C.2 Annual wind roses for Campbelltown West

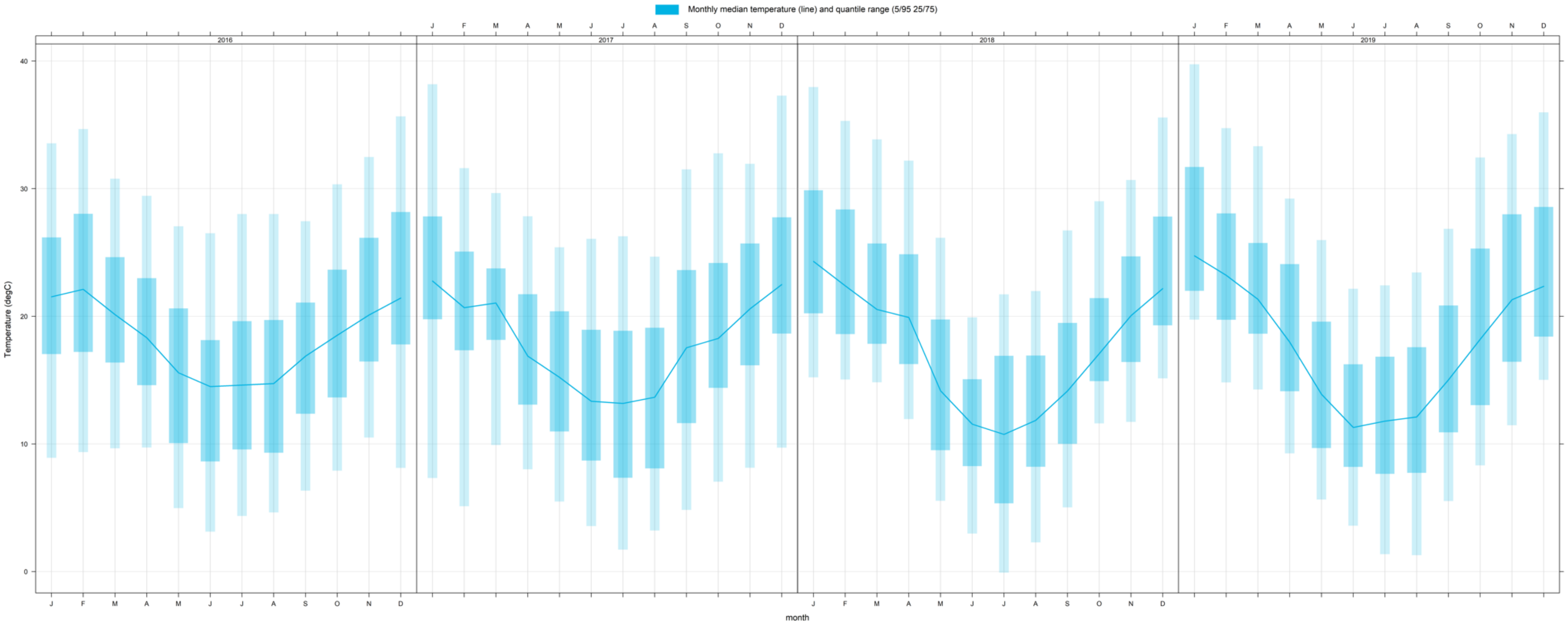


Figure C.3 Interannual variation in temperature for Ventilation Shaft 6

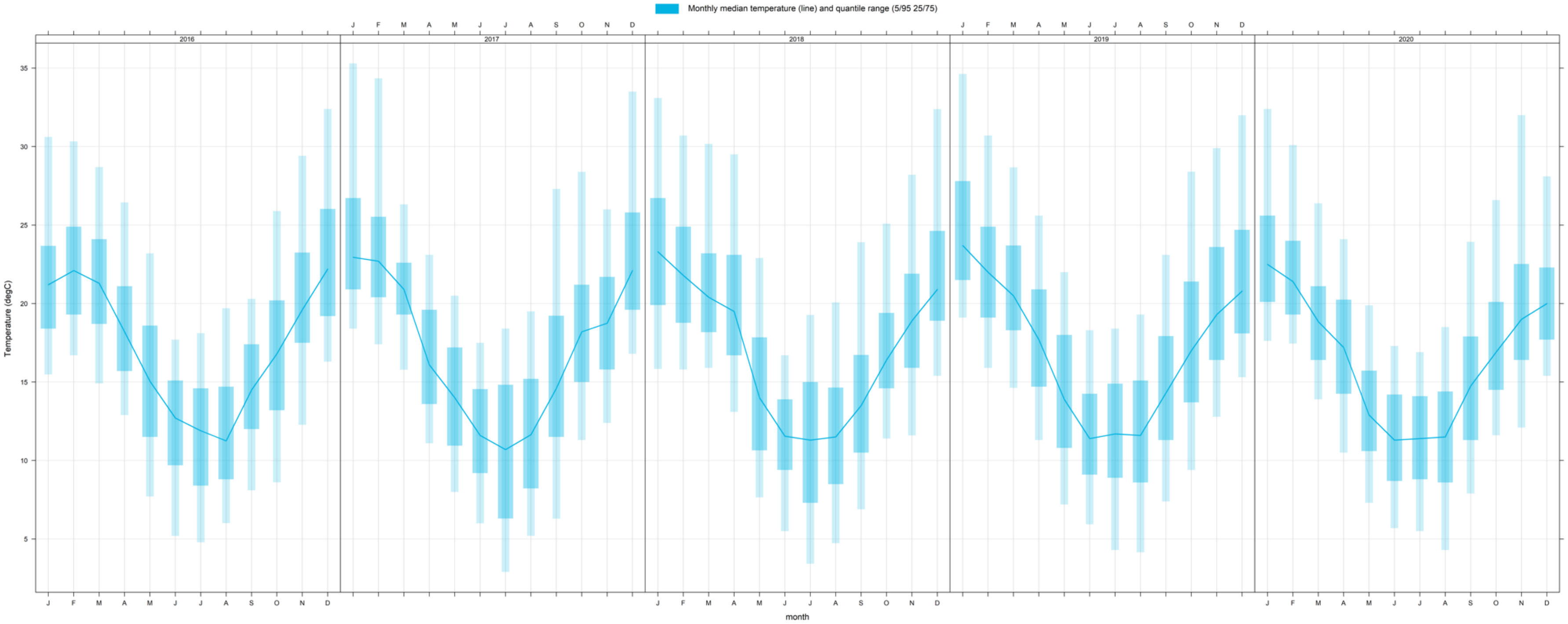


Figure C.4 Interannual variation in temperature for Campbelltown West

Appendix D

Emission inventory

D.1 Construction phase emission estimates

Particulate matter emissions were quantified through the application of accepted published emission estimation factors, collated from United States Environmental Protection Agency (US EPA) AP-42 Air Pollutant Emission Factors (US EPA 1995) as follows:

- AP-42 Chapter 13.2.2 Unpaved roads (November 2006) – emission factor equation for wheel generated dust;
- AP-42 Chapter 13.2.4 Aggregate handling and storage piles (November 2006) – emission factor equation for material handling; and
- AP-42 Chapter 11.9 Western Surface Coal Mines (October 1998) – emission factor equation for drilling and blasting and wind erosion from exposed areas.

Assumptions used to estimate emissions from diesel consumption are:

- the fleet comprised primarily of equipment with an engine power of 75-130 kW;
- a corresponding US EPA Tier 2 emission standards for PM of 0.2 g/kWh (US EPA 2016); and
- the PM emission standard is assumed to correspond to TSP and PM_{10}. $PM_{2.5}$ emissions are assumed to comprise 97% of PM_{10} emissions.

D.1.1 Project-related input data used for particulate matter emission estimates

The main inputs used in the emission estimates are summarised in Table D.1.

Table D.1 Inputs for emission estimation

Material properties	Value	Source of information
Unpaved road silt content (%)	5.0	Assumed, based on similar projects
Soil moisture (%)	4.0	Assumed, based on similar projects
Bulk material moisture (%)	2.0	Assumed, based on similar projects
Diesel consumption	Bulk earthworks = 361 kL/yr Shaft Sinking = 530 kL/yr	Diesel use estimated based on indicative fleet and fuel consumption from Caterpillar Handbook
Average wind speed (m/s)	2.2	Calculated from CALMET at project site.
Average truck load (t)	40 t	Assumed, based on similar projects
Average truck gross mass (t)	50 t	Average of full and empty loads based on 40 t payload.

D.2 Particulate matter emissions inventory

The emissions inventory developed for the construction scenario is presented in Table D.2, Table D.3 and Table D.4

Table D.2 Construction emission inventory inputs – Bulk earthworks

			Emission Factors				**Variables**										**Control**	**Control type**
Activities	**Activity rate**	**Units**	**TSP**	**PM10**	**PM2.5**	**Units**												
Bulk Earthworks																		
Vegetation and topsoil stripping	4,435	km/y	0.62	0.22	0.02	kg/km	8	speed of scraper in km/h	554	scraper hours								
Loading trucks with soil	23,686	t/y	0.0004	0.0002	0.00003	kg/t	2.2	Average wind speed (m/s)	4.0	Moisture content (%)								
Hauling soil across site	592	VKT/year	2.23	0.57	0.06	kg/VKT	5.0	% silt content	1.0	km/return trip	592	Loads/year	50	Average weight (t)	40	Truck capacity (t)	0.75	Water sprays
Emplacement of soil to stockpile	23,686	t/y	0.0004	0.0002	0.00003	kg/t	2.2	Average wind speed (m/s)	4.0	Moisture content (%)							0.3	minimise drop heights
Excavation of bulk material	140,484	t/y	0.0004	0.0002	0.00003	kg/t	2.2	Average wind speed (m/s)	4.0	Moisture content (%)								
Loading bulk material to trucks	140,484	t/y	0.0004	0.0002	0.00003	kg/t	2.2	Average wind speed (m/s)	4.0	Moisture content (%)								
Hauling soil across site	3,512	VKT/year	2.23	0.57	0.06	kg/VKT	5.0	% silt content	1.0	km/return trip	3,512	Loads/year	50	Average weight (t)	40	Truck capacity (t)	0.75	Water sprays
Emplacement of soil to stockpile	140,484	t/y	0.0007	0.0003	0.00005	kg/t	3.0	Average wind speed (m/s)	4.0	Moisture content (%)							0.3	minimise drop heights
Dozer spreading/shaping	3,640	h/y	3.0	0.5	0.3	kg/h	4.0	moisture content in %	5.0	silt content in %							0.5	keep material moist
Exposed ground wind erosion	6.7	Area (ha)	850	425	64	kg/ha/year												
Onsite diesel consumption	361	kl/annum	0.66	0.66	0.64	kg/kL												

Table D.3 Construction emission inventory inputs – VS7 main shaft sink

			Emission Factors				**Variables**										**Control**	**Control type**
Activities	**Activity rate**	**Units**	**TSP**	**PM10**	**PM2.5**	**Units**												
VS7 - main shaft sink																		
Drilling	3,500	holes/y	0.59	0.3068	0.01770	kg/hole											0.7	Enclosure
Blasting	350	blasts/y	0.08	0.0408	0.00235	kg/blast	50	Area of blast in m2									0.7	Enclosure
Material handling - spoil to surface	73,090	t/y	0.0012	0.0006	0.00008	kg/t	2.2	Average wind speed (m/s)	2.0	Moisture content (%)							0.7	Enclosure
Loading trucks with spoil	73,090	t/y	0.0012	0.0006	0.00008	kg/t	2.2	Average wind speed (m/s)	2.0	Moisture content (%)							0.7	Enclosure
Hauling spoil across site	1,827	VKT/year	2.01	0.52	0.05	kg/VKT	5.0	% silt content	1.0	km/return trip	1,827	Loads/year	40	Average weight (t)	40	Truck capacity (t)	0.75	Water sprays
Emplacement of spoil	73,090	t/y	0.0012	0.0006	0.00008	kg/t	2.2	Average wind speed (m/s)	2.0	Moisture content (%)							0.3	minimise drop heights
Dozer spreading/shaping	1,621	h/y	7.3	1.4	0.8	kg/h	2.0	moisture content in %	5.0	silt content in %							0.5	keep material moist
Exposed ground wind erosion	3.0	Area (ha)	850	425	64	kg/ha/year												
Onsite diesel consumption	265	kl/annum	0.66	0.66	0.64	kg/kL												

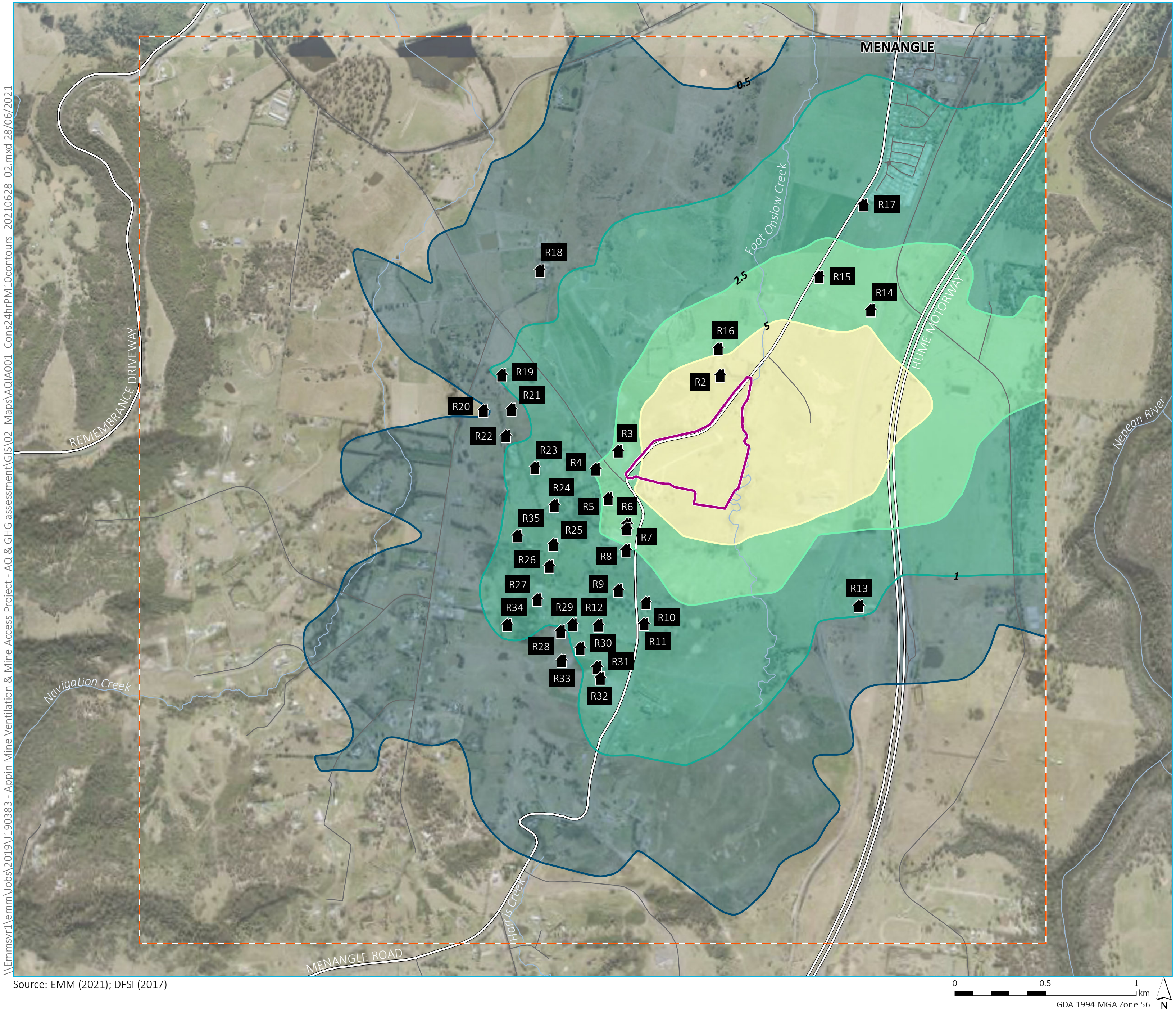
Table D.4 Construction emission inventory inputs – VS8 main shaft sink

			Emission Factors				Variables										Control	Control type
Activities	**Activity rate**	**Units**	**TSP**	**PM10**	**PM2.5**	**Units**												
VS7 - main shaft sink																		
Drilling	3,500	holes/y	0.59	0.3068	0.01770	kg/hole											0.7	Enclosure
Blasting	350	blasts/y	0.03	0.0172	0.00099	kg/blast	28	Area of blast in m^2									0.7	Enclosure
Material handling - spoil to surface	39,276	t/y	0.0012	0.0006	0.00008	kg/t	2.2	Average wind speed (m/s)	2.0	Moisture content (%)							0.7	Enclosure
Loading trucks with spoil	39,276	t/y	0.0012	0.0006	0.00008	kg/t	2.2	Average wind speed (m/s)	2.0	Moisture content (%)							0.7	Enclosure
Hauling spoil across site	982	VKT/year	2.01	0.52	0.05	kg/VKT	5.0	% silt content	1.0	km/return trip	982	Loads/year	40	Average weight (t)	40	Truck capacity (t)	0.75	Water sprays
Emplacement of spoil	39,276	t/y	0.0012	0.0006	0.00008	kg/t	2.2	Average wind speed (m/s)	2.0	Moisture content (%)							0.3	minimise drop heights
Dozer spreading/shaping	871	h/y	7.3	1.4	0.8	kg/h	2.0	moisture content in %	5.0	silt content in %							0.5	keep material moist
Exposed ground wind erosion	1.6	Area (ha)	850	425	64	kg/ha/year												
Onsite diesel consumption	265	kl/annum	0.66	0.66	0.64	kg/kL												

Appendix E

Contour plots

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02 Maps\AQIA001 Cons24hrPM10contours 20210628 02.mxd 28/06/2021



Source: EMM (2021); DFSI (2017)

KEY

- ☗ Assessment location
- ▭ Construction boundary
- ⬚ Model extent
- ═ Major road
- — Minor road
- — Named watercourse

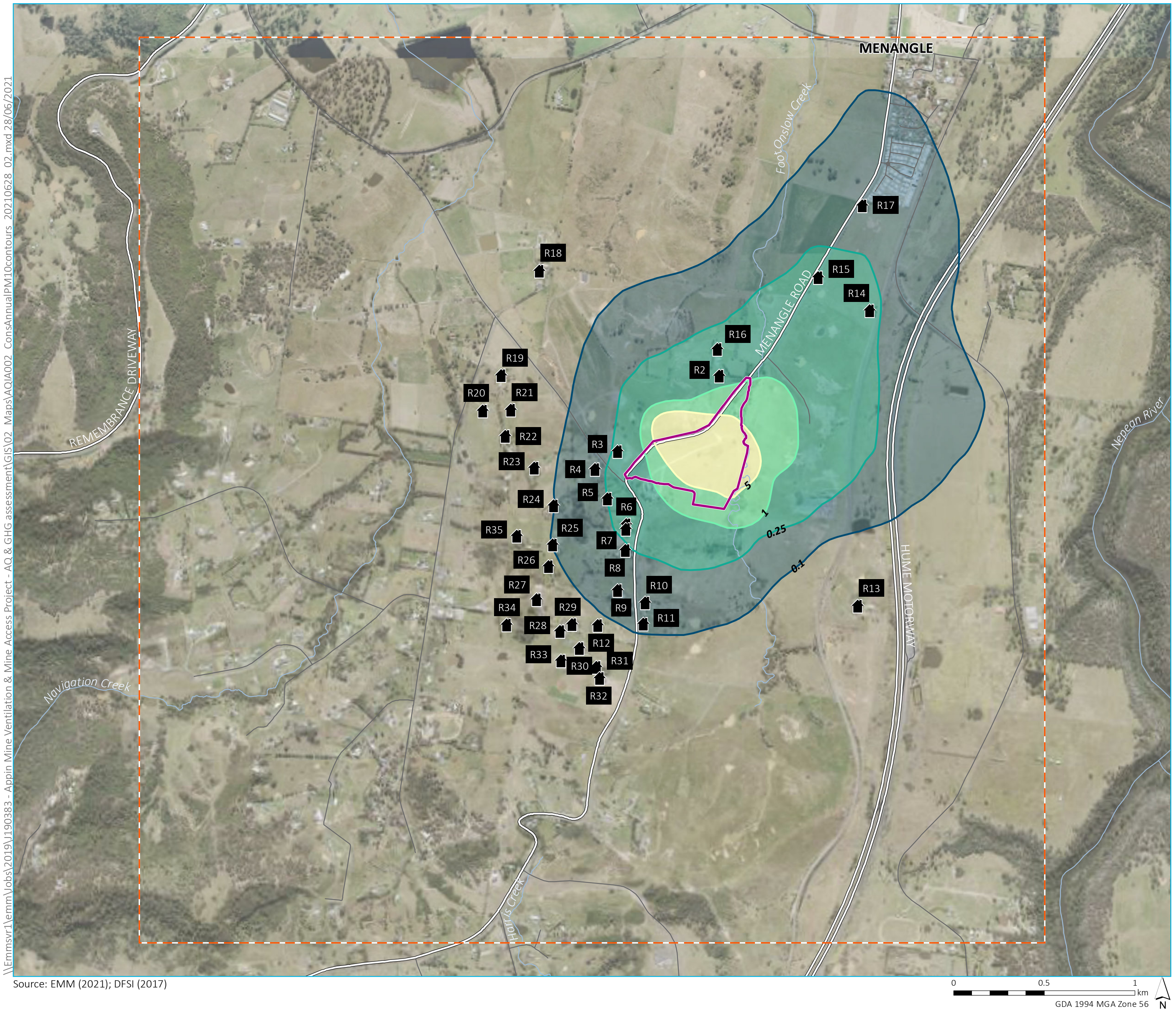
24-hour average PM₁₀ concentration

- ■ 0.5 - 1 µg/m³
- ■ 1 - 2.5 µg/m³
- ■ 2.5 - 5 µg/m³
- ■ > 5 µg/m³

Maximum 24-hour average PM$_{10}$ concentrations (µg/m^3) - construction phase

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.1

creating opportunities



Source: EMM (2021); DFSI (2017)

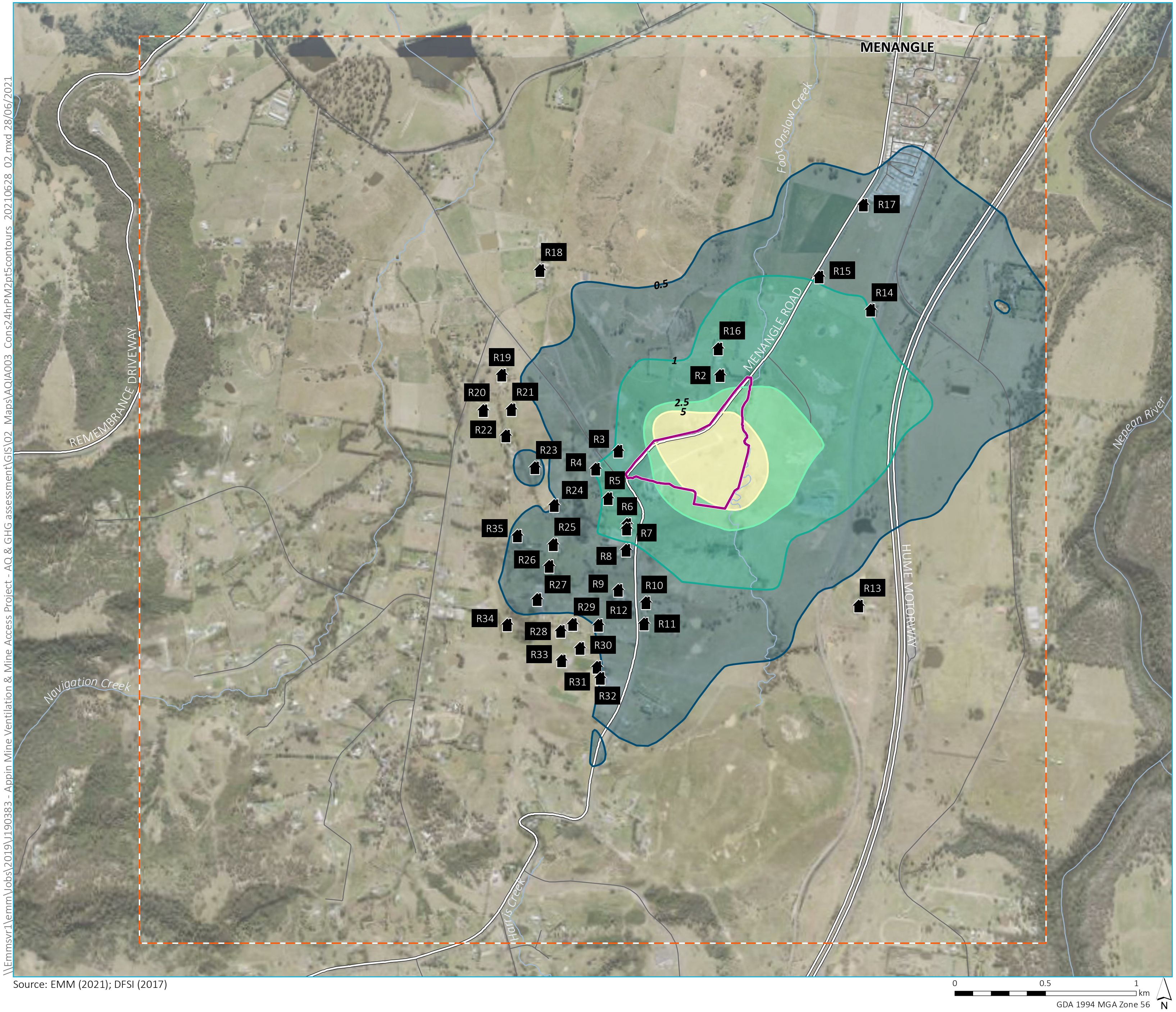
KEY
- Assessment location
- Construction boundary
- Model extent
- Major road
- Minor road
- Named watercourse

Annual average PM_{10} concentration
- 0.1 - 0.25 µg/m³
- 0.25 - 1 µg/m³
- 1 - 5 µg/m³
- > 5 µg/m³

Annual average
PM_{10} concentrations (µg/m³) -
construction phase

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.2

EMM
creating opportunities



Source: EMM (2021); DFSI (2017)

KEY

☗	Assessment location
▭	Construction boundary
⌜⌟	Model extent
═	Major road
─	Minor road
─	Named watercourse

24-hour average $PM_{2.5}$ concentration

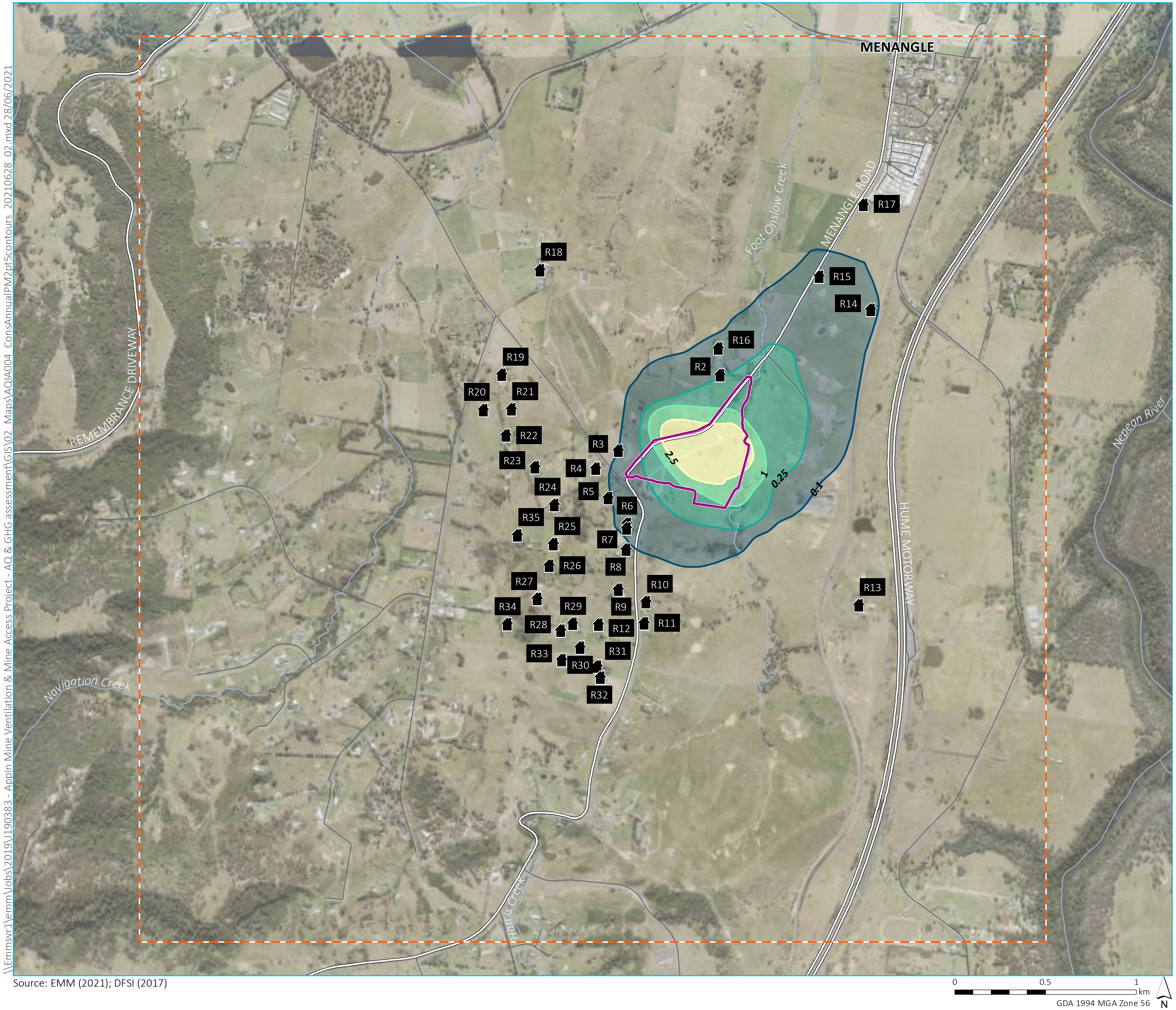
🟦	0.5 - 1 µg/m³
🟩	1 - 2.5 µg/m³
🟩	2.5 - 5 µg/m³
🟨	> 5 µg/m³

Maximum 24-hour average $PM_{2.5}$ concentrations (µg/m³) - construction phase

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.3

EMM
creating opportunities

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02_Maps\AQIA003_Cons24hrPM2pt5contours_20210628_02.mxd 28/06/2021



KEY
- ☗ Assessment location
- ▭ Construction boundary
- ⬚ Model extent
- ═ Major road
- — Minor road
- — Named watercourse

Annual average $PM_{2.5}$ concentration
- 🟦 0.1 - 0.25 µg/m³
- 🟩 0.25 - 1 µg/m³
- 🟩 1 - 2.5 µg/m³
- 🟨 > 2.5 µg/m³

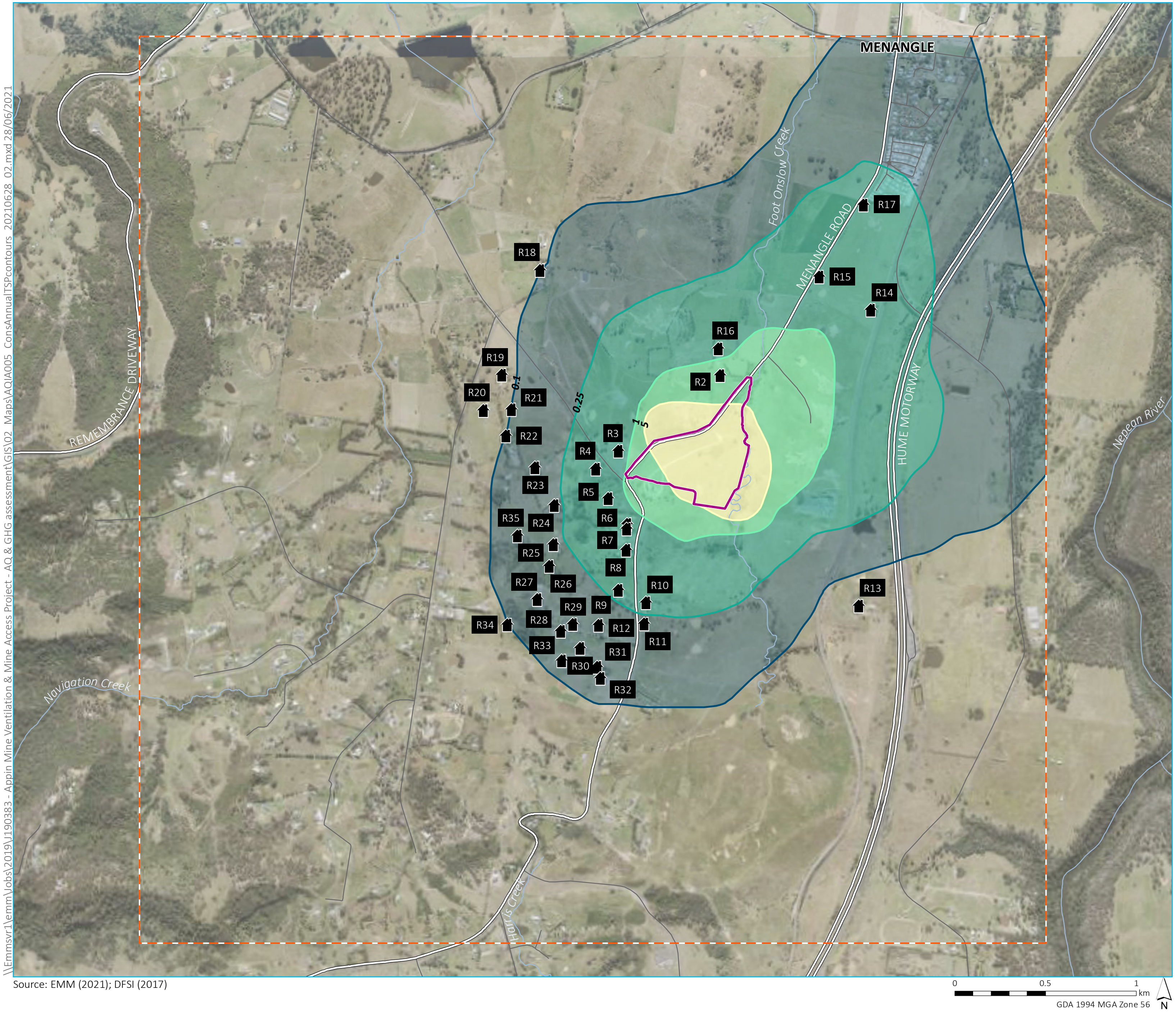
Source: EMM (2021); DFSI (2017)

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02_Maps\AQIA004_ConsAnnualPM2pt5contours_20210628_02.mxd 28/06/2021

Annual average $PM_{2.5}$ concentrations (µg/m³) - construction phase

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.4

EMM
creating opportunities



Source: EMM (2021); DFSI (2017)

KEY
- ⌂ Assessment location
- ▭ Construction boundary
- ⌜⌟ Model extent
- ═ Major road
- — Minor road
- — Named watercourse

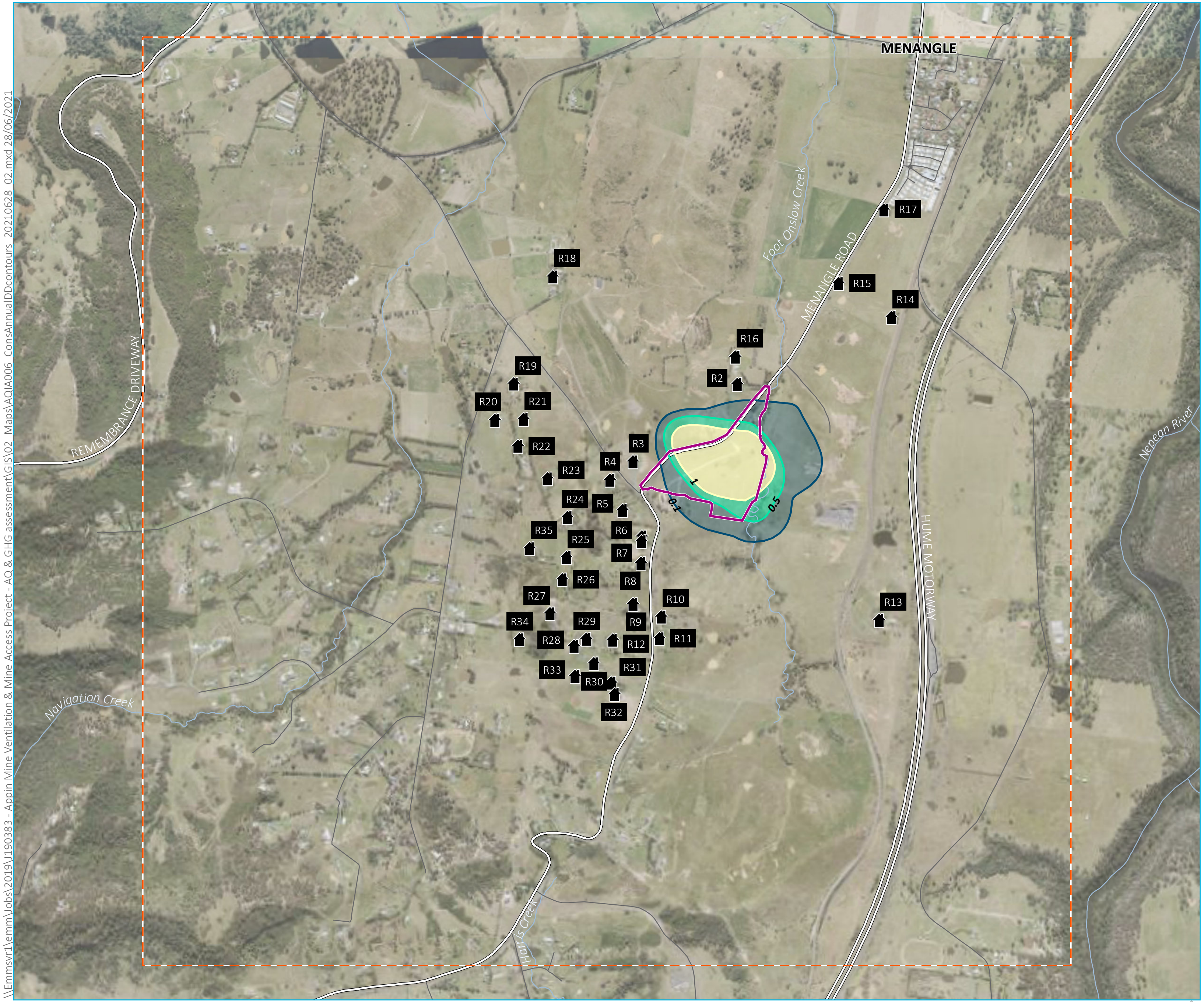
Annual average TSP concentration
- ■ 0.1 - 0.25 µg/m³
- ■ 0.25 - 1 µg/m³
- ■ 1 - 5 µg/m³
- ■ > 5 µg/m³

Annual average TSP concentrations (µg/m³) - construction phase

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.5

EMM
creating opportunities

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02_Maps\AQIA005_ConsAnnualTSPcontours_20210628_02.mxd 28/06/2021



Source: EMM (2021); DFSI (2017)

KEY

- ☗ Assessment location
- ▭ Construction boundary
- ⌐ ¬ Model extent
- ═ Major road
- — Minor road
- — Named watercourse

Annual average dust deposition

- ■ 0.1 - 0.5 (g/m²/month)
- ■ 0.5 - 1 (g/m²/month)
- ■ >1 (g/m²/month)

Annual average dust deposition (g/m²/month) - construction phase

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.6

EMM
creating opportunities

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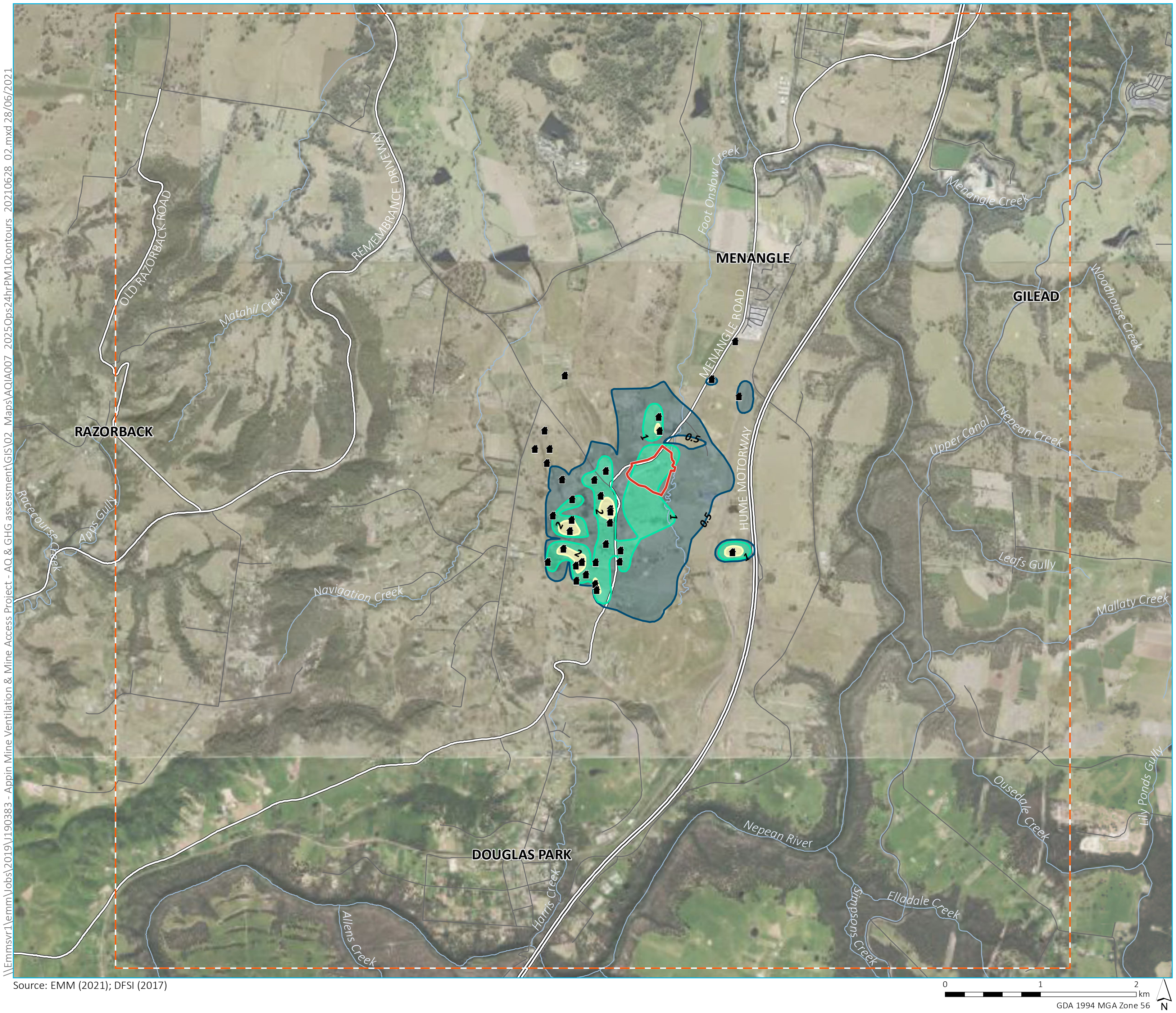
KEY

- ☗ Assessment location
- ▭ Operational boundary
- ⬚ Model extent
- ═ Major road
- — Minor road
- — Named watercourse

24-hour average PM_{10} concentration

- ■ 0.5 - 1 µg/m³
- 🟩 1 - 2 µg/m³
- ■ > 2 µg/m³



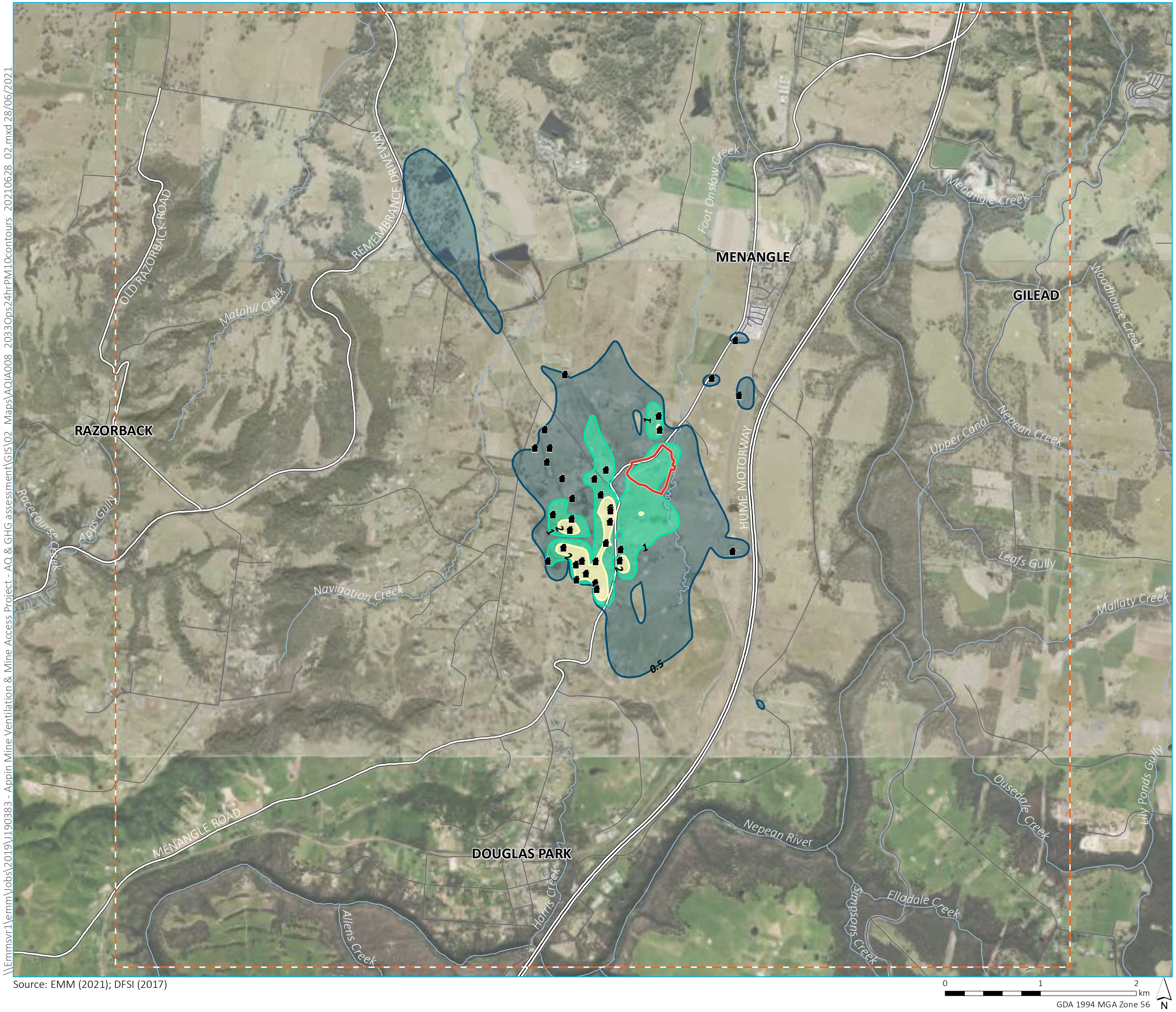
Source: EMM (2021); DFSI (2017)

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02_Maps\AQIA007_2025Ops24hrPM10contours_20210628_02.mxd 28/06/2021

Maximum 24-hour average PM_{10} concentrations (µg/m³) - 2025 operations (315 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.7

EMM
creating opportunities



\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02_Maps\AQIA008_2033Ops24hrPM10contours_20210628_02.mxd 28/06/2021

Source: EMM (2021); DFSI (2017)

KEY

- ▲ Assessment location
- ▭ Operational boundary
- ⬚ Model extent
- ═ Major road
- — Minor road
- — Named watercourse

24-hour average PM_{10} concentration

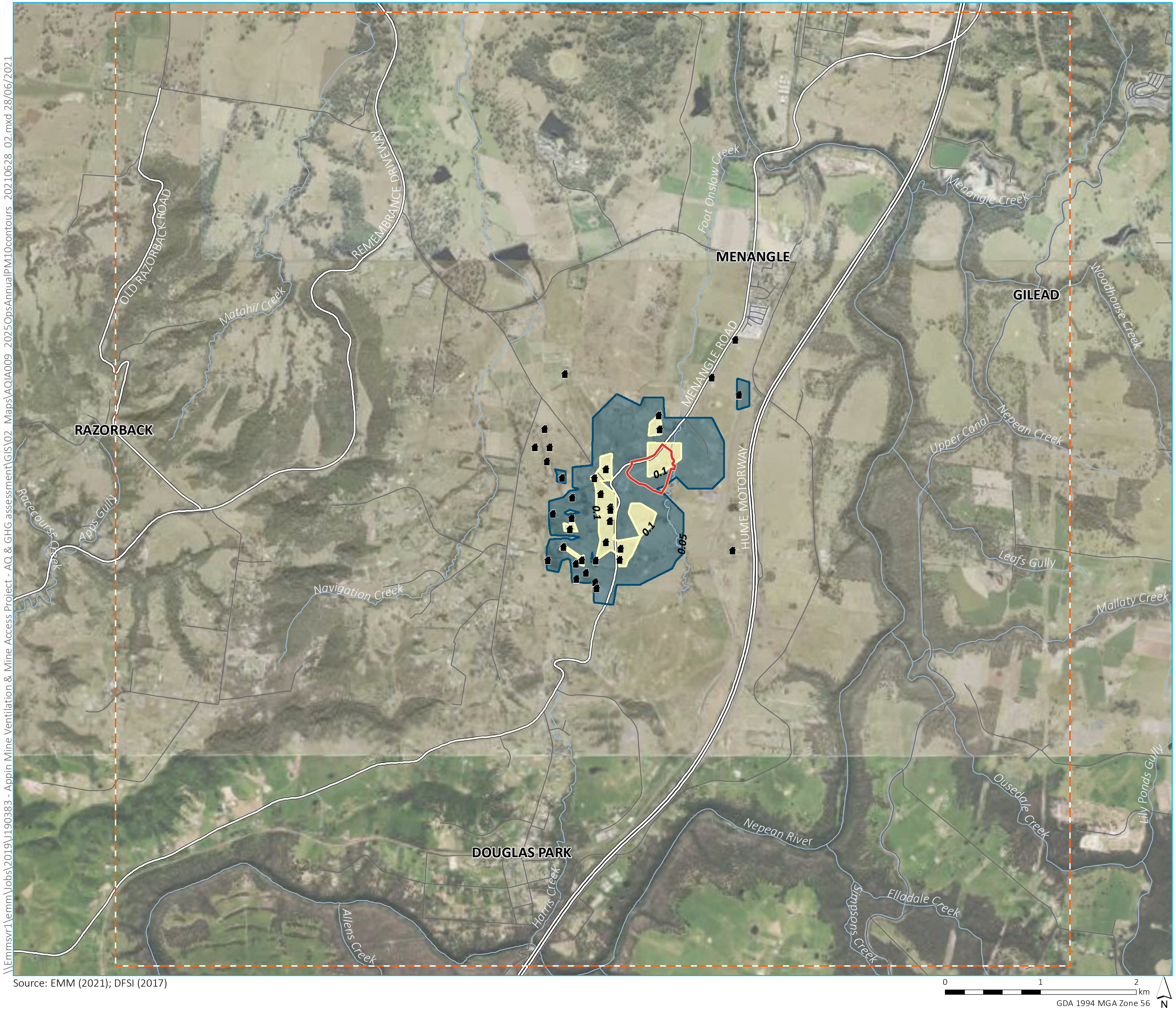
- ■ 0.5 - 1 µg/m³
- 🟩 1 - 2 µg/m³
- ■ > 2 µg/m³

Maximum 24-hour average PM_{10} concentrations (µg/m³) - 2033 operations (440 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.8

EMM
creating opportunities

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02 Maps\AQIA009 2025OpsAnnualPM10contours 20210628 02.mxd 28/06/2021



Source: EMM (2021); DFSI (2017)

KEY

- Assessment location
- Operational boundary
- Model extent
- Major road
- Minor road
- Named watercourse

Annual average PM_{10} concentration

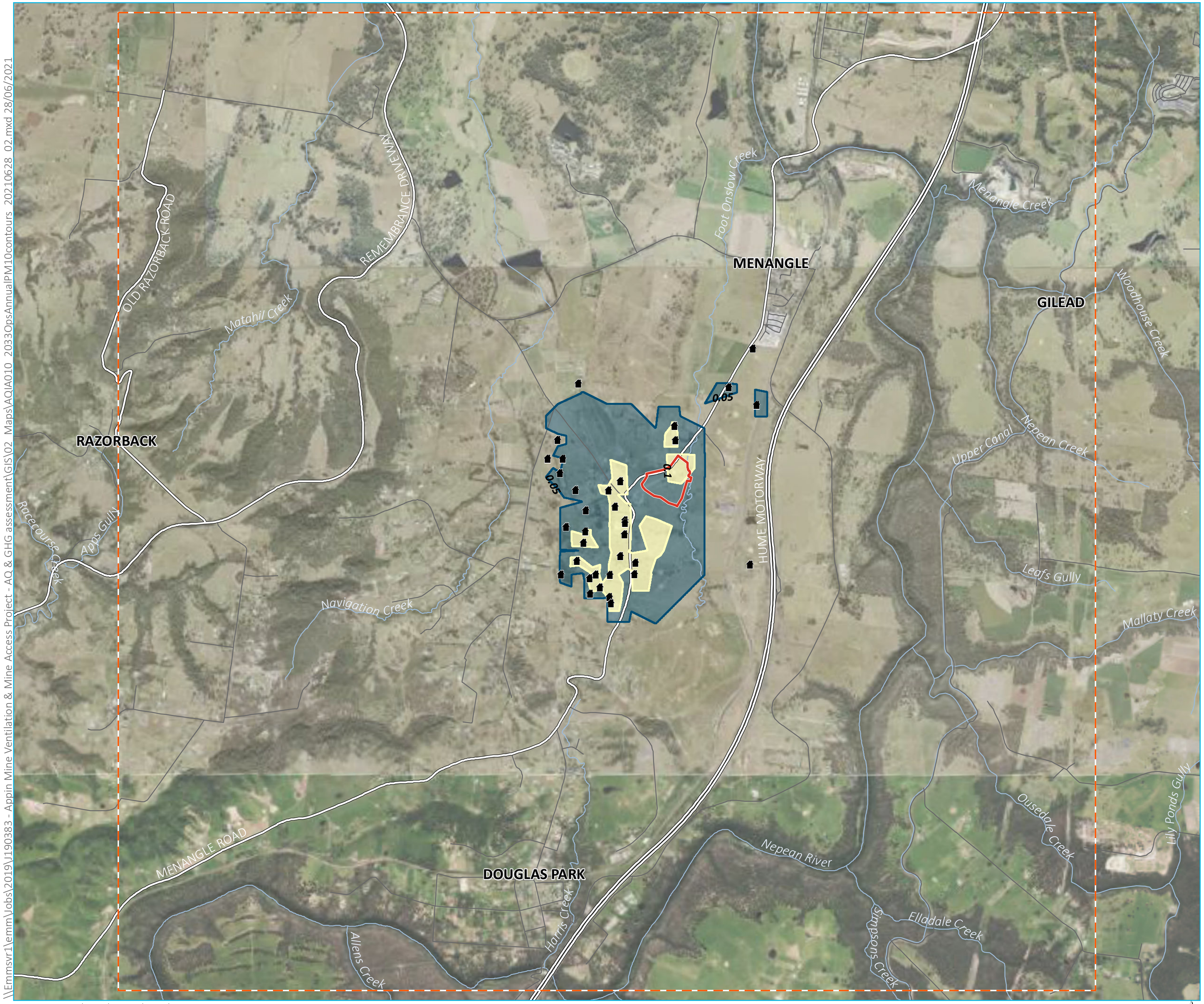
- 0.05 - 1 µg/m³
- > 0.1 µg/m³

Annual average PM_{10} concentrations (µg/m³) - 2025 operations (315 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.9

EMM
creating opportunities

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02_Maps\AQIA010_2033OpsAnnualPM10contours_20210628_02.mxd 28/06/2021



Source: EMM (2021); DFSI (2017)

KEY

- ⌂ Assessment location
- ▭ Operational boundary
- ┌┐ Model extent
- ═ Major road
- ─ Minor road
- ─ Named watercourse

Annual average PM_{10} concentration

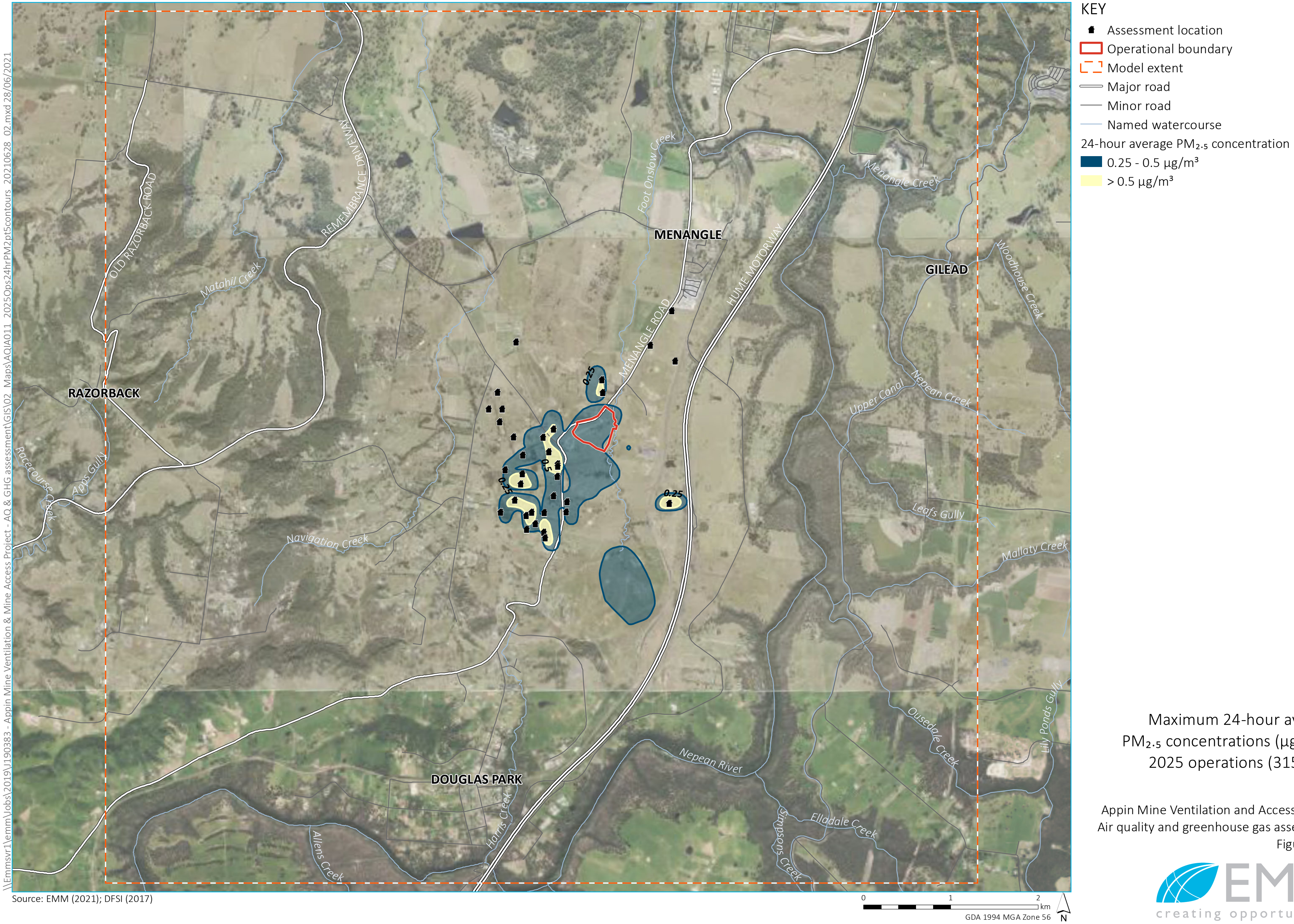
- ■ 0.05 - 1 µg/m³
- ▨ > 0.1 µg/m³

Annual average PM_{10} concentrations (µg/m³) - 2033 operations (440 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.10

EMM
creating opportunities

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02 Maps\AQIA011 2025Ops24hrPM2pt5contours 20210628 02.mxd 28/06/2021

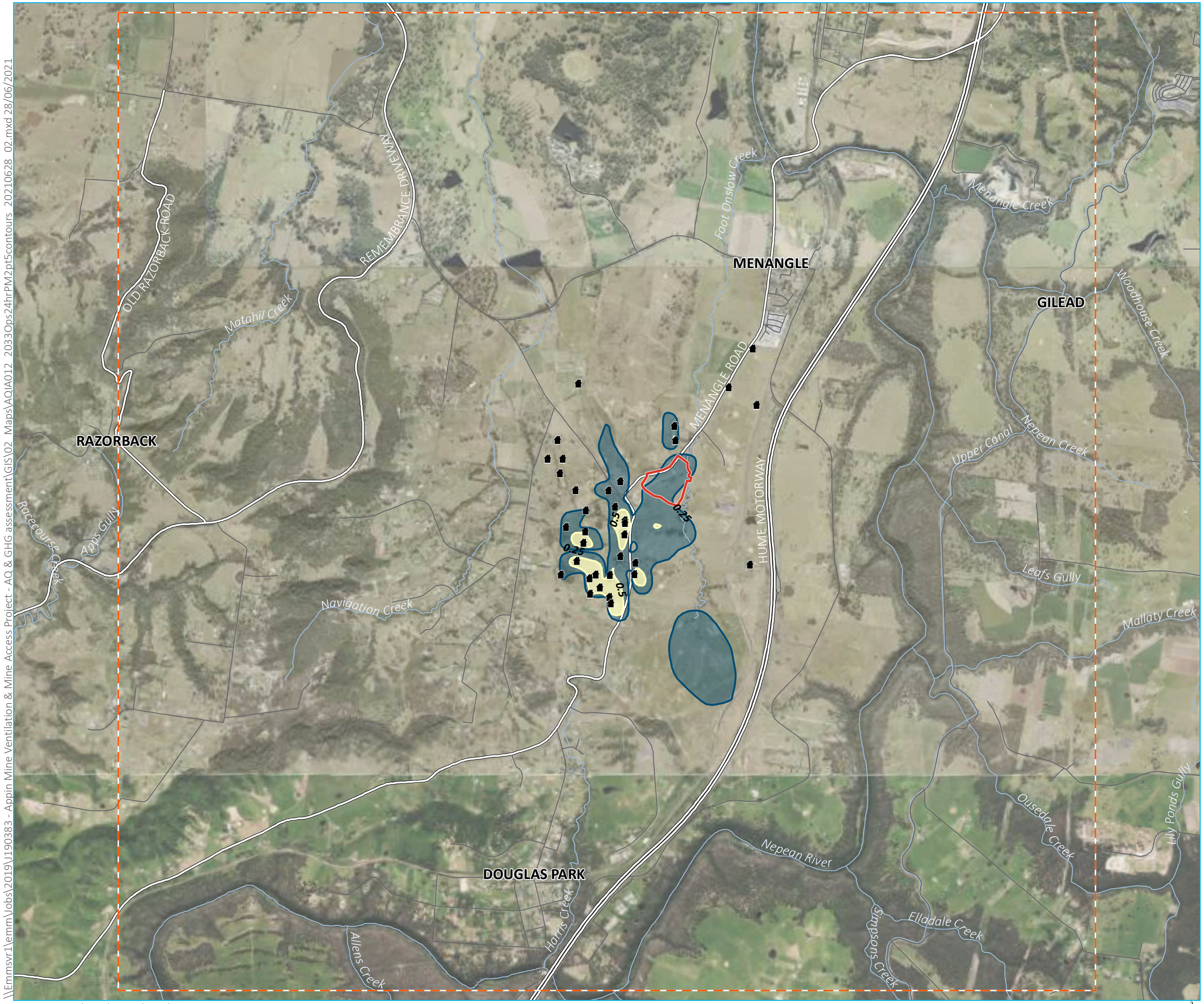


Source: EMM (2021); DFSI (2017)

Maximum 24-hour average PM$_{2.5}$ concentrations (µg/m^3) - 2025 operations (315 m^3/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.11

EMM
creating opportunities



KEY

■ Assessment location

▭ Operational boundary

▭ Model extent

═ Major road

— Minor road

— Named watercourse

24-hour average PM$_{2.5}$ concentration

🟦 0.25 - 0.5 µg/m^3

🟨 > 0.5 µg/m^3

Source: EMM (2021); DFSI (2017)

0 1 2 km

GDA 1994 MGA Zone 56

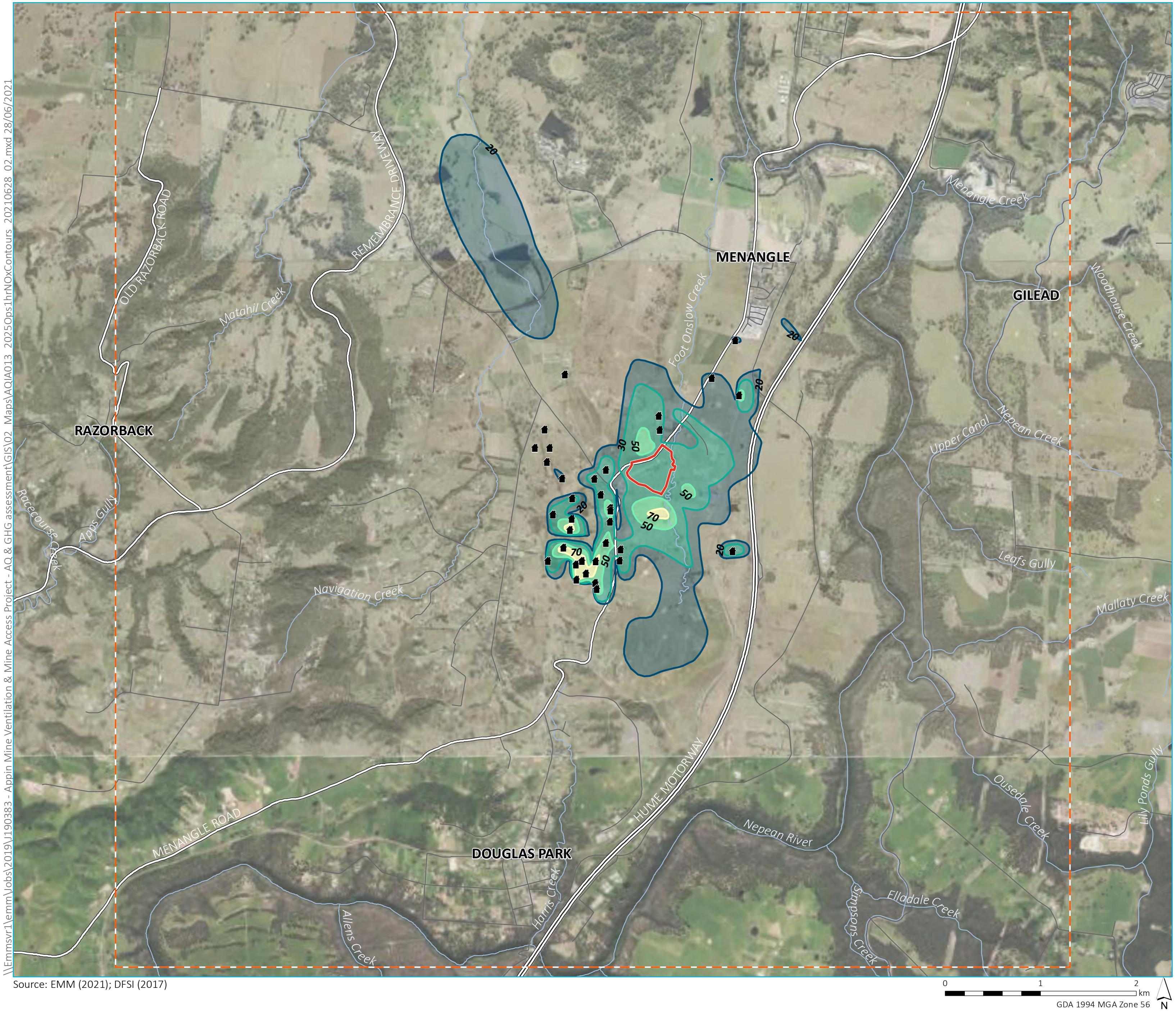
N

Maximum 24-hour average PM$_{2.5}$ concentrations (µg/m^3) - 2033 operations (440 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.12

EMM
creating opportunities

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02_Maps\AQIA012_2033Ops24hrPM2pt5contours_20210628_02.mxd 28/06/2021

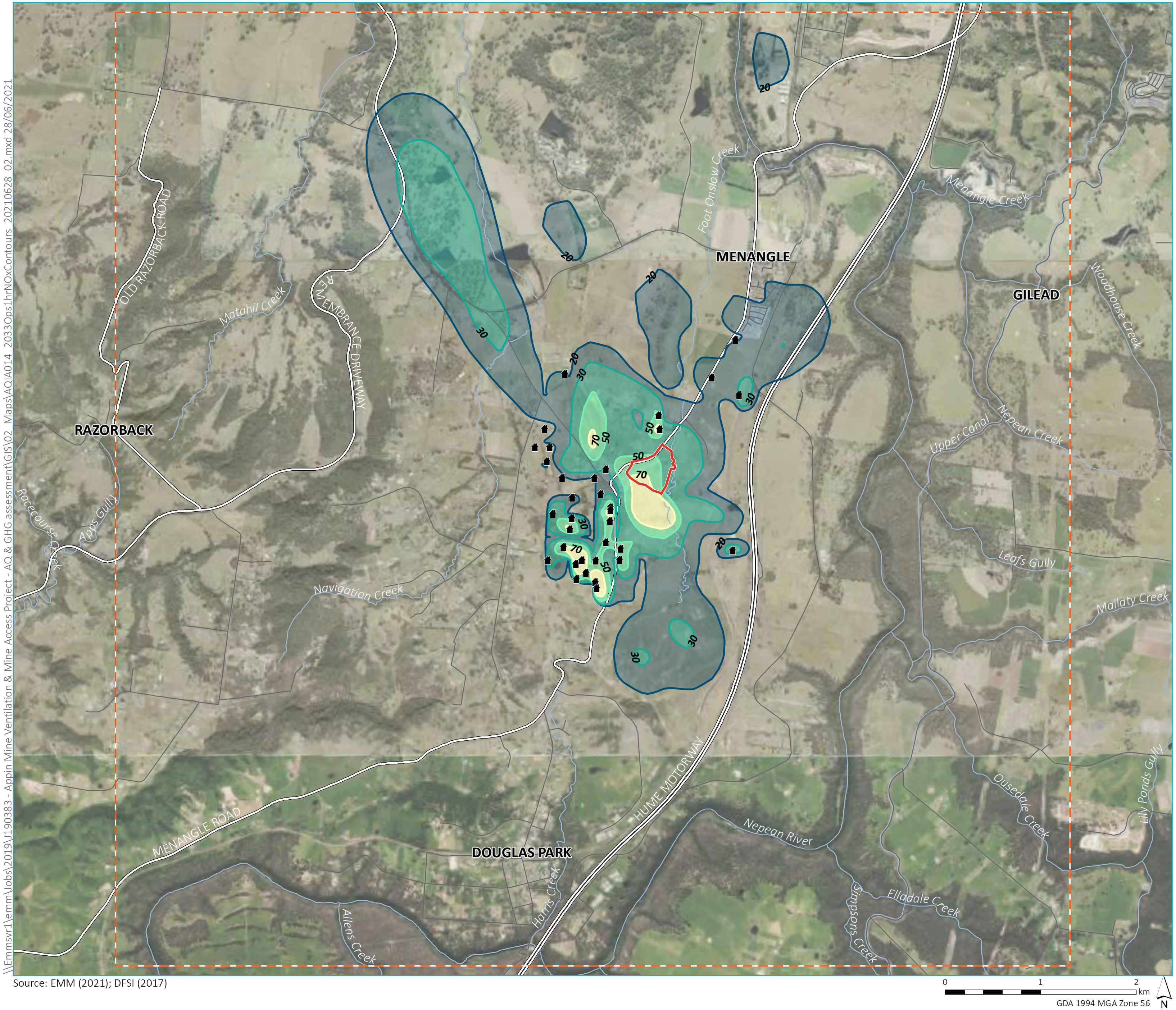


Source: EMM (2021); DFSI (2017)

Maximum 1-hour average NOx concentrations (µg/m³) - 2025 operations (315 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.13

EMM
creating opportunities



Source: EMM (2021); DFSI (2017)

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02_Maps\AQIA014_2033Ops1hrNOxContours_20210628_02.mxd 28/06/2021

KEY

- ☗ Assessment location
- ☐ Operational boundary
- ⬚ Model extent
- ═ Major road
- ─ Minor road
- ─ Named watercourse

1-hour average NOx concentration

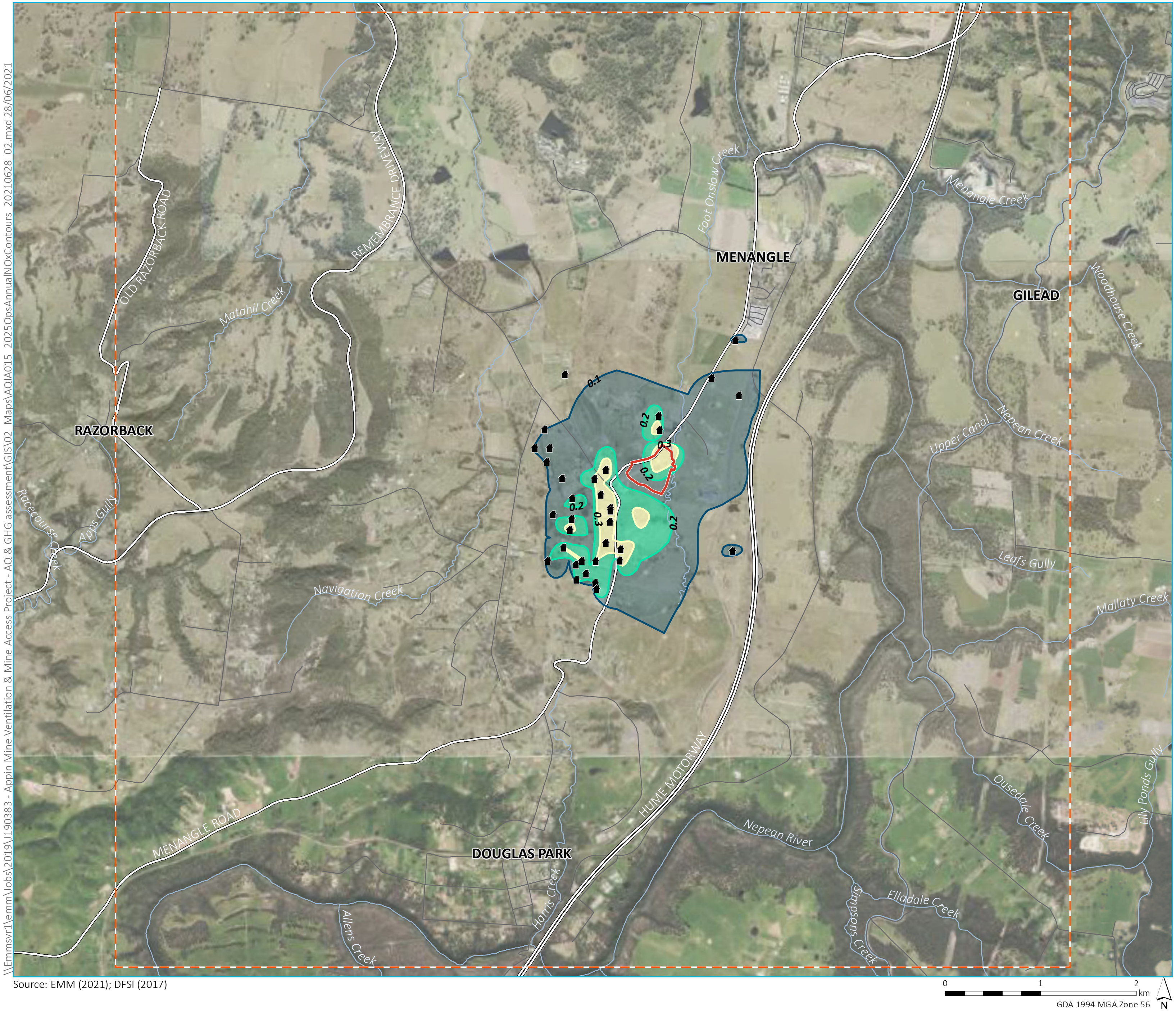
- 🟦 20 - 30 µg/m³
- 🟦 30 - 50 µg/m³
- 🟩 50 - 70 µg/m³
- 🟨 > 70 µg/m³

Maximum 1-hour average
NOx concentrations (µg/m³) -
2033 operations (440 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.14

EMM
creating opportunities

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02 Maps\AQIA015 2025OpsAnnualNOxContours 20210628 02.mxd 28/06/2021



Source: EMM (2021); DFSI (2017)

KEY

- ☗ Assessment location
- ▭ Operational boundary
- ⬚ Model extent
- ═ Major road
- — Minor road
- — Named watercourse

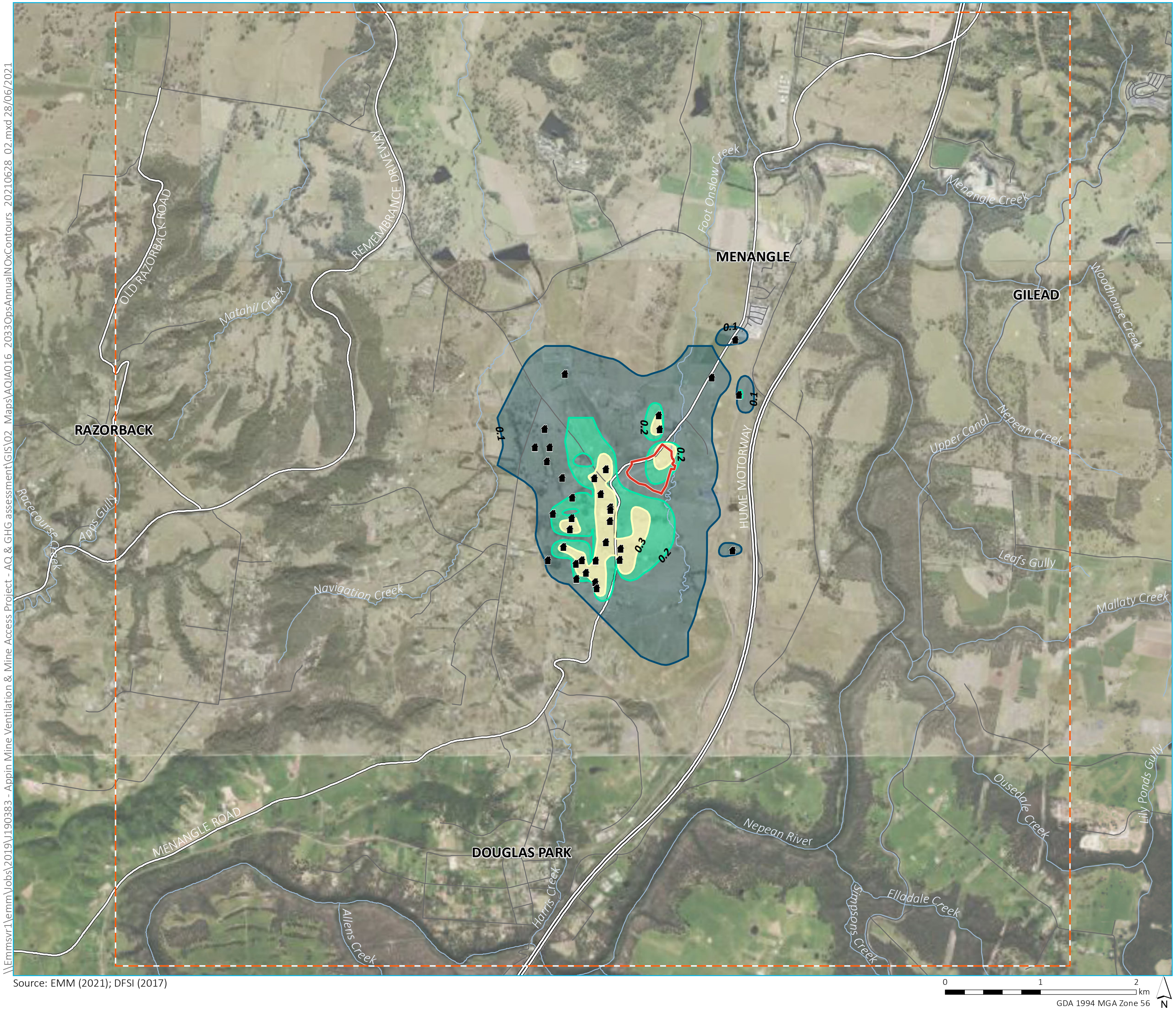
Annual average NOx concentration

- ■ 0.1 - 0.2 µg/m³
- ■ 0.2 - 0.3 µg/m³
- ■ > 0.3 µg/m³

Annual average NOx concentrations (µg/m³) - 2025 operations (315 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.15

EMM
creating opportunities



Source: EMM (2021); DFSI (2017)

KEY

- ▲ Assessment location
- ☐ Operational boundary
- ⌜⌟ Model extent
- ═ Major road
- — Minor road
- — Named watercourse

Annual average NOx concentration

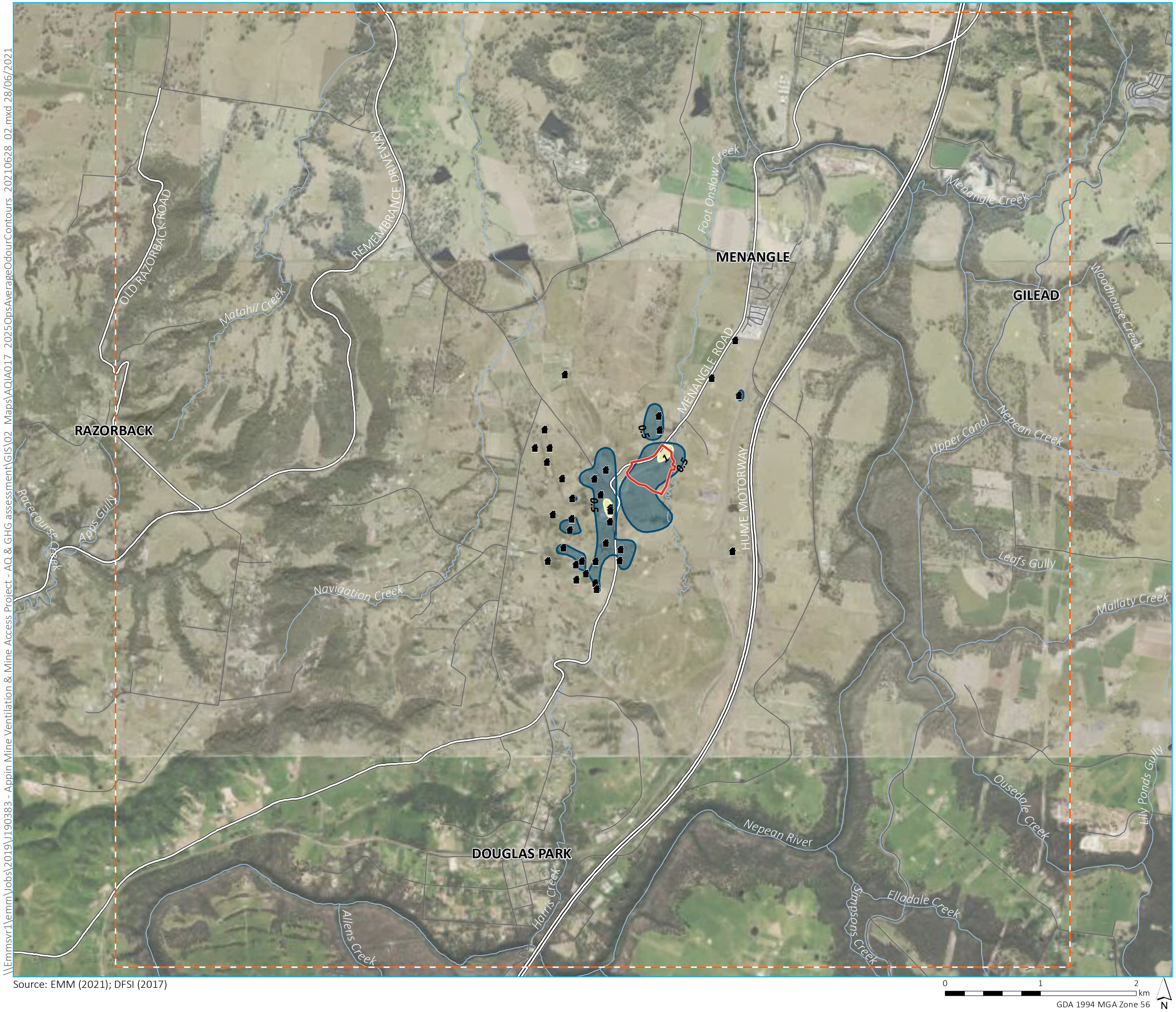
- ■ 0.1 - 0.2 µg/m³
- 🟩 0.2 - 0.3 µg/m³
- ▢ > 0.3 µg/m³

Annual average
NOx concentrations (µg/m³) -
2033 operations (440 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.16

EMM
creating opportunities

\\Emmsvr1\emm\Jobs\2019\J190383 - Appin Mine Ventilation & Mine Access Project - AQ & GHG assessment\GIS\02 Maps\AQIA016 2033OpsAnnualNOxContours 20210628 02.mxd 28/06/2021



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Source: EMM (2021); DFSI (2017)

KEY

- ☗ Assessment location
- ▭ Operational boundary
- ⬚ Model extent
- ═ Major road
- — Minor road
- — Named watercourse

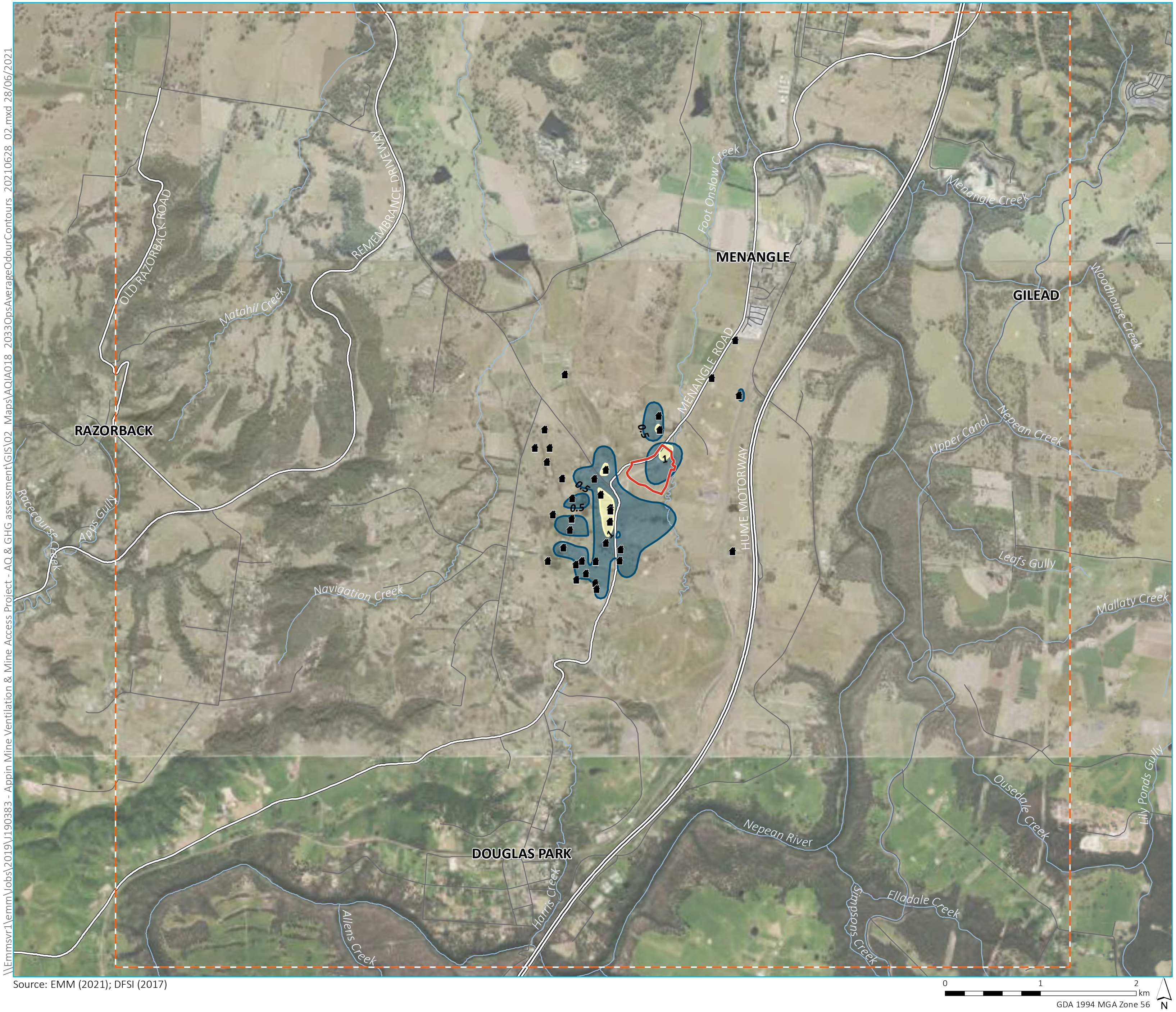
Average odour concentration

- ■ 0.5 - 1 ou
- ■ > 1 ou

99th percentile nose-response
average odour concentration (ou) -
2025 operations (315 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.17

EMM
creating opportunities



Source: EMM (2021); DFSI (2017)

KEY
- ▲ Assessment location
- ▭ Operational boundary
- ⬚ Model extent
- ═ Major road
- — Minor road
- — Named watercourse

Average odour concentration
- ■ 0.5 - 1 ou
- □ > 1 ou

99th percentile nose-response
average odour concentration (ou) -
2033 operations (440 m³/s)

Appin Mine Ventilation and Access Project
Air quality and greenhouse gas assessment
Figure E.18

EMM
creating opportunities