APPENDIX N

Appendix N - Air Quality Impact Assessment

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Tahmoor South Project

Air Quality Impact Assessment

22 November 2018

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The business of sustainability

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22 November 2018

Tahmoor South Project

Air Quality Impact Assessment

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1. INTRODUCTION

ERM has been commissioned by Tahmoor Coal Pty Ltd (Tahmoor), a wholly owned subsidiary of SIMEC (Australia) Mining Pty Ltd, to complete an air quality assessment for the Tahmoor South Project. The purpose of this assessment is to complete the air quality component of the Environmental Impact Statement (EIS) for the Project under Part 4 the Environmental Planning and Assessment Act 1979 (EP&A Act). The maximum run-of-mine (ROM) production target from Tahmoor South is 4 million tonnes per annum (Mtpa).

1.1 Overview

Tahmoor owns and operates the Tahmoor Mine, an underground coal mine approximately 80 km south-west of Sydney, in the Southern Coalfields of NSW. Tahmoor produces up to 2 million tonnes per annum (Mtpa) of product coal from its existing operations at the Tahmoor Mine, and undertakes underground mining under existing development consents, licences and the conditions of relevant mining leases.

Tahmoor is seeking approval for the Tahmoor South Project (the Project), being the extension of underground coal mining at Tahmoor Mine, to the south of the existing Tahmoor Mine surface facilities area. The proposed development will continue to be accessed via the existing surface facilities at Tahmoor Mine, located between the towns of Tahmoor and Bargo.

The proposed development seeks to extend the life of underground mining at Tahmoor Mine until approximately 2035. The proposal will enable mining to be undertaken within the southern portion of Tahmoor’s existing lease areas and for operations and employment of the current workforce to continue for a further 13 years from the completion of Tahmoor North mining in 2022.

The proposed development will extend mining at Tahmoor Mine within the Project Area (see Figure 3.2), using longwall methods, with the continued use of ancillary infrastructure at the existing Tahmoor Mine surface facilities area. The Project Area is adjacent and to the south of the Existing Tahmoor Approved Mining Area. It also overlaps a small area of the Existing Tahmoor Approved Mining Area comprising the surface facilities area, historical workings and other existing mine infrastructure.

1.2 Proposed development

The proposed development will use longwall mining to extract coal from the Bulli seam within the bounds of CCL 716 and CCL 747. Coal extraction of up to 4 Mtpa ROM is proposed as part of the development. Once the coal has been extracted and brought to the surface, it will be processed at Tahmoor Mine’s existing Coal Handling and Preparation Plant (CHPP) and then transported via the existing rail loop, the Main Southern Railway and the Moss Vale to Unanderra Railway to Port Kembla and Newcastle (from time to time) for export to both domestic and international markets.

The components of the proposed development comprise:

- Mine development including pit bottom redevelopment, vent shaft construction, pre-gas drainage and service connection
- Longwall mining in the Central Domain
- Upgrades to the existing surface facilities area including:
    - upgrades to the CHPP
    - expansion of the existing reject emplacement area (REA)
    - additional mobile plant for coal handling
    - additions to the existing bathhouses, stores and associated access ways
    - upgrades to site onsite services and infrastructure

  - upgrades to offsite service infrastructure, including electrical supply
- Rail transport of product coal to Port Kembla and Newcastle (from time to time)
- Mine closure and rehabilitation
- Environmental management

1.3 Study requirements

The Tahmoor South Project Environmental Impact Statement has been prepared in accordance with Division 4.1, Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) which ensures that the potential environmental effects of a proposal are properly assessed and considered in the decision-making process.

In preparing this air quality assessment, the Secretary's Environmental Assessment Requirements (SEARs) issued for the Tahmoor South Project (SSD 17_8445) on 9 June 2017 have been addressed as required by Section 78A(8A) of the EP&A Act. The SEARs are outlined in Table 1.1. Agency comments have also addressed in this report including the updated NSW Environment Protection Authority (EPA) Approved Methods (EPA, 2016).

The assessment follows the procedures outlined by the NSW EPA in its document titled "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (EPA, 2016) (referred to hereafter as the Approved Methods) and contemporary standards adopted by the Department of Planning and Environment (DPE) in recent project approvals that lie outside of this document. A computer-based dispersion model is used, with local meteorological data and estimates of dust emissions, as the best available scientific tool to predict the concentration and deposition rate of particulate matter from the Project and other mines expected to be operating concurrently in the area.

Table 1.1: Secretary's Environmental Assessment Requirements

Discipline	Requirement
Air	*"- assessment of the likely air quality impacts of the development in accordance with the Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW, having a regard to EPA's requirements (see attachment 2);* *- an assessment of the likely greenhouse gas impacts of the development; and* *- an odour assessment of the ventilation shafts in accordance with the Technical Framework – Assessment and Management of Odour from Stationary Sources in NSW"*

2. PROJECT DESCRIPTION

2.1 Overview

Tahmoor is seeking approval for the continuation of mining at Tahmoor Mine, extending underground operations and associated infrastructure south, within the Bargo area. The proposed development seeks to extend the life of underground mining at Tahmoor Mine until approximately 2035, depending upon geological and mining parameters. The proposed Tahmoor South Project will commence underground mining once the existing Tahmoor North operations are completed.

The proposed development will use longwall mining methods to extract coal from the Bulli seam within CCL 716 and CCL 747. Coal extraction of up to 4 Mtpa ROM is proposed as part of the development. The ROM coal brought to the surface will be processed at Tahmoor Mine's existing CHPP, and transported via rail to Port Kembla and Newcastle (from time to time) for export to both domestic and international markets.

The proposed development will utilise the existing surface infrastructure at the Tahmoor Mine surface facilities area, with some upgrades proposed to facilitate the extension.

Additional capacity will be required for the ventilation system, both upcast and downcast shafts.

An expansion of the REA is also required for both the existing operations and to accommodate the proposed Tahmoor South Project.

The proposed also incorporates the planning for rehabilitation and mine closure.

2.2 Underground mining operations

To enable the continuation of mining to occur sequentially following completion of the current mining operations in Tahmoor North in approximately 2022, the Tahmoor South Project's development works need to commence in 2019. A number of pre-mining activities are required to be completed prior to this, to enable the commencement of coal production from the Central Domain. These pre-mining activities include:

- recovery of existing underground development panels;
- redevelopment of the underground pit bottom;
- pre-gas drainage;
- establishment of gate roads to enable longwall development and pre-gas drainage;
- installation of electrical, water and gas management network; and
- the purchase and commissioning of mining plant and equipment.

It is proposed that the Tahmoor South Project development works will occur concurrently with the ongoing mining operations at Tahmoor North. Additional site amenities, including bath houses and additional onsite car parks will be required to accommodate the increased workforce during the transition period from mining operations at Tahmoor North and the Tahmoor South Project's development works.

2.2.1 Mine ventilation

The Tahmoor South Project will utilise the existing mine's ventilation system. In addition the Project will require the construction of two new ventilation shafts to provide reliable and adequate supply of ventilation air to personnel in the mine to ensure a safe working environment is maintained.

The proposed development would make use of three vent shafts currently being used for the operations at Tahmoor North, being one upcast (T2) and two downcast shafts (T1 and T3), by drawing and returning air through the existing workings. Shaft T2 will be only used intermittently if the new upcast shaft is off-line and is not assessed as part of this assessment.

The proposed two additional vent shafts for the Tahmoor South Project are:

- TSC1: an upcast ventilation shaft that would be located south of the reject emplacement area on Tahmoor owned freehold land on Charlies Point Road,
- TSC2: an downcast ventilation shaft that would be located south of the reject emplacement area slightly east of on Crown Land adjacent to Tahmoor's Charlies Point Road property,

The locations of the proposed vent shafts are shown on Figure 3.3.

The construction of the ventilation shafts will require the disturbance of a footprint of between four to six hectares in area at each location. Access to TSC1 and TSC2 will be from the existing road network. The construction of each of the proposed ventilation shafts will involve the following:

- Establishment of the construction site to allow sufficient space for stockpiling of shaft liners, temporary spoil emplacement, water management, storage and safe movement on-site during construction activities. Establishment of the ventilation shaft site will involve:
    - Installation of environmental controls such as silt fences, fencing with lockable gates, as well as display of signage relating to restricted entry.

  - Clearing of vegetation and stripping of topsoil. Topsoil will be temporarily stockpiled for rehabilitation post construction.
  - Excavation and construction of a hardstand area for operation of drilling equipment. The hardstand footprint will be approximately four to six hectares.
- Connection of 66 kV electrical power and establishment of electrical substations at each ventilation shaft site.
- Shaft sinking using blind boring methods, and lining of the shafts using a composite concrete and steel liner.
- Installation of ventilation fans at the upcast shaft site TSC1. The upcast shaft fan will also incorporate a fan outlet flue, approximately 30 m high, to minimise the impacts of any odours discharge from the mine ventilation return air.

The shaft construction sites will incorporate water treatment sedimentation controls, with the final water treatment from the ventilation shaft being pumped via overland pipeline to a final sedimentation pond on the surface facilities area for further treatment and discharge though LDP1.

2.2.2 Gas drainage operations

Coal mines need to control underground gas concentration levels below safe limits so that miners are able to work in a safe environment and mining operations can be undertaken as efficiently as possible.

The coal seams within the Southern Coalfield are generally known to be gassy, with methane and CO_2 released from the goaf and surrounding strata during mining. Gas in the underground mine will be managed by gas drainage operations including:

- Pre-gas drainage, whereby gas will be drawn from the coal seam and surrounding strata prior to longwall mining.
- Gas extraction via the mine ventilation system, which will occur throughout mining.
- Post gas drainage, whereby gas will be drawn from the goaf.

2.2.3 Pre-gas drainage

The purpose of pre-gas drainage is to reduce gas volumes in the coal seams prior to mining, with the Bulli, Wongawilli and Balgownie seams targeted at Tahmoor Mine. Pre-gas drainage of the seams are required to facilitate the timely commencement and progression of mining as well as to reduce the demands on the mine ventilation system for the purpose of gas dilution during operations.

Pre-gas drainage activities are undertaken underground, via drilling and drainage from the roadways developed for longwall panels. Gas will be drawn from the coal seam by vacuum and piped to the on-site gas plant at the surface facilities area via the underground pipe network. Underground gas drainage of the coal seam will continue ahead of longwall development for the life of mining.

At the gas plant, the collected gas is tested to determine its composition. If the gas has sufficient methane, it will be used to generate electricity at the existing cogeneration plant. If the gas composition does not meet the specification for electricity generation, it will be sent to the onsite gas flare plant where the methane will be flared. The existing gas plant, cogeneration plant and gas flare plant will continue to be utilised and upgraded where required.

2.2.4 Post gas drainage

Post gas drainage will be required as strata relaxation caused by the retreating underground longwall face will liberate volumes of gas into the mine workings from the underlying Wongawilli seam and from overlying strata, which is released due to fracturing of the goaf. At the conclusion of mining from each panel, the panel will be sealed and gas drawn from the sealed areas as part of the post gas drainage operations. Additionally, boreholes are proposed to be drilled from the mine workings into the Wongawilli seam. These boreholes will be designed to collect the gas at its source or to intercept gas before it migrates into the mine workings.

The gas collected from the in-seam and cross-measure boreholes will be drawn by vacuum via the underground pipe network to the on-site gas plant located at the surface facilities area.

2.2.5 Gas in ventilation

The ventilation system will deliver fresh air into the mine from the existing and proposed downcast vent shafts and will extract stale air from the mine via the existing and proposed upcast vent shaft (refer to Section 2.2.1).

2.2.6 Mining method and equipment

Underground mining will be undertaken via conventional longwall development using continuous miners. Longwall development refers to the mining of a series of roadways (gate roads) and cut throughs, to form pillars of coal that will support the overlying strata during the extraction of coal. Longwalls will be up to 305 m wide, measured as the distance between gate road centrelines. Gate roads will be approximately 5.2 m wide and approximately three metres high.

Coal will be cut from the coal face by the longwall shearer and loaded onto the armoured face conveyor and transported to the surface facilities area via an underground conveyor. The longwall will retreat as coal is mined and the overlying rock strata (or goaf) will collapse into the void (or goaf) left by the coal extraction.

2.2.7 Mine access

The proposed development will use the existing infrastructure at Tahmoor Mine for employee and material access. Access to the Central Domains will be via the existing Tahmoor Mine surface facilities area.

2.2.8 Coal production limits

The proposed development is anticipated to produce a maximum of 4 Mtpa ROM coal.

The product coal generated by the proposed development will range between 70 to 80% product yield after coal preparation and processing, depending upon geological and mining conditions.

2.2.9 Coal logistics

The proposed development will transport the product coal from Tahmoor Mine to Port Kembla, via the existing mine rail load out, rail loop, the Main Southern Railway and the Moss Vale to Unanderra Railway. Some product coal will be transported by rail to Newcastle (from time to time).

Tahmoor Mine currently has four allocated train paths per day from ARTC for the rail network between the Tahmoor Mine and Port Kembla. The rail path allocation provides rail capacity of approximately 4 million tonnes of product coal per annum and is sufficient for the life of the Tahmoor South Project. As such, existing rail infrastructure and the number of allowable train movements will remain unchanged.

Tahmoor Coal has contractual arrangements in place for coal export associated with the proposed output from the Project.

2.3 Surface facilities area

The existing surface facilities and infrastructure at the Tahmoor Mine surface facilities area, operating under surface ML 1642, will be utilised for the proposed development.

Upgrades to the surface facilities area will be required within the footprint of the existing Tahmoor Mine surface lease (ML 1642) and additional surface lease area proposed for the Tahmoor South Project.

The proposed development will include upgrades to the existing surface CHPP and ancillary surface infrastructure.

The proposed upgrades are described in further detail in the following sections.

2.3.1 Coal handling and preparation plant

The existing CHPP would be utilised for the proposed development, and upgraded to operate at a consistent throughput of 650 tonnes per hour. The upgrade would involve installation of:

- a new coarse rejects screen within the existing plant building;
- installation of additional belt press filters; and
- installation of an additional thickener.

The existing ROM stockpile area will continue to be utilised by the proposed development.

Reject material from coal production would equate to approximately 20% to 30% of ROM coal, and would be transported to the expanded REA via the existing reject conveyor and bin for disposal (refer to Section 2.3.2).

2.3.2 Rejects management

The existing REA will be expanded onto adjacent areas to accommodate the reject material associated with the proposed development. The expansion area is anticipated to cover up to an additional 40 hectares, providing an additional emplacement capacity of approximately 12 Mt for the rejects generated during the operation of the proposed development.

Construction and maintenance of new internal haul roads will be required to and around the REA to cater for the REA expansion.

The stormwater management system and infrastructure at the existing REA will be augmented with the construction of additional sedimentation dams, drains and pumping station.

2.3.3 Plant and equipment

The proposed development will utilise existing plant and equipment at the surface facilities area and will also require additional mobile plant for coal material handling at the surface facilities area. The proposed additional plant will include cranes and forklifts for use around the surface facilities area to manage product and equipment stores.

2.3.4 Hours of operation

The proposed development, including construction activities, are proposed to operate 24 hours a day, seven days per week, consistent with the working hours of the current operations at the Tahmoor Mine. Construction activities will generally be undertaken during the Tahmoor Mine operating hours, that is, 24 hours a day, 7 days a week but typically during daylight hours between 6 am to 6 pm.

3. LOCAL SETTINGS AND TOPOGRAPHY

The Project operations are located just south of the Tahmoor township and approximately 80 km southwest of Sydney. The location and project area of the Tahmoor South Project is shown in Figure 3.1.

The local area is shown in Figure 3.2 and the existing Tahmoor Mine is also shown. There are a number of sensitive receptors in the vicinity of the Project, as shown in Figure 3.3. Receptors were selected based on their proximity to the air emission sources and their uses (e.g. schools). A full list of both private and mine-owned receptors assessed in this study is provided in Appendix A.

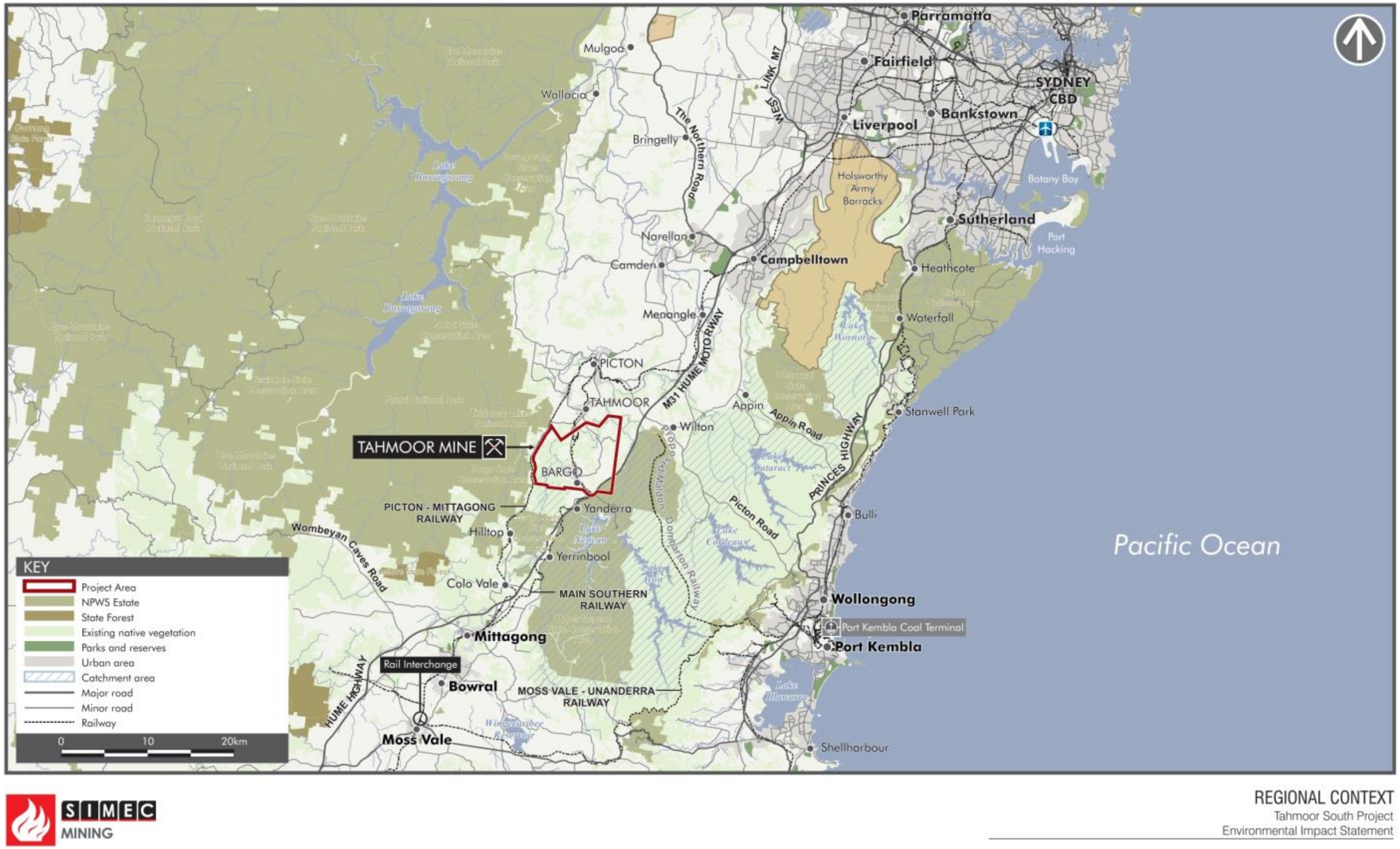
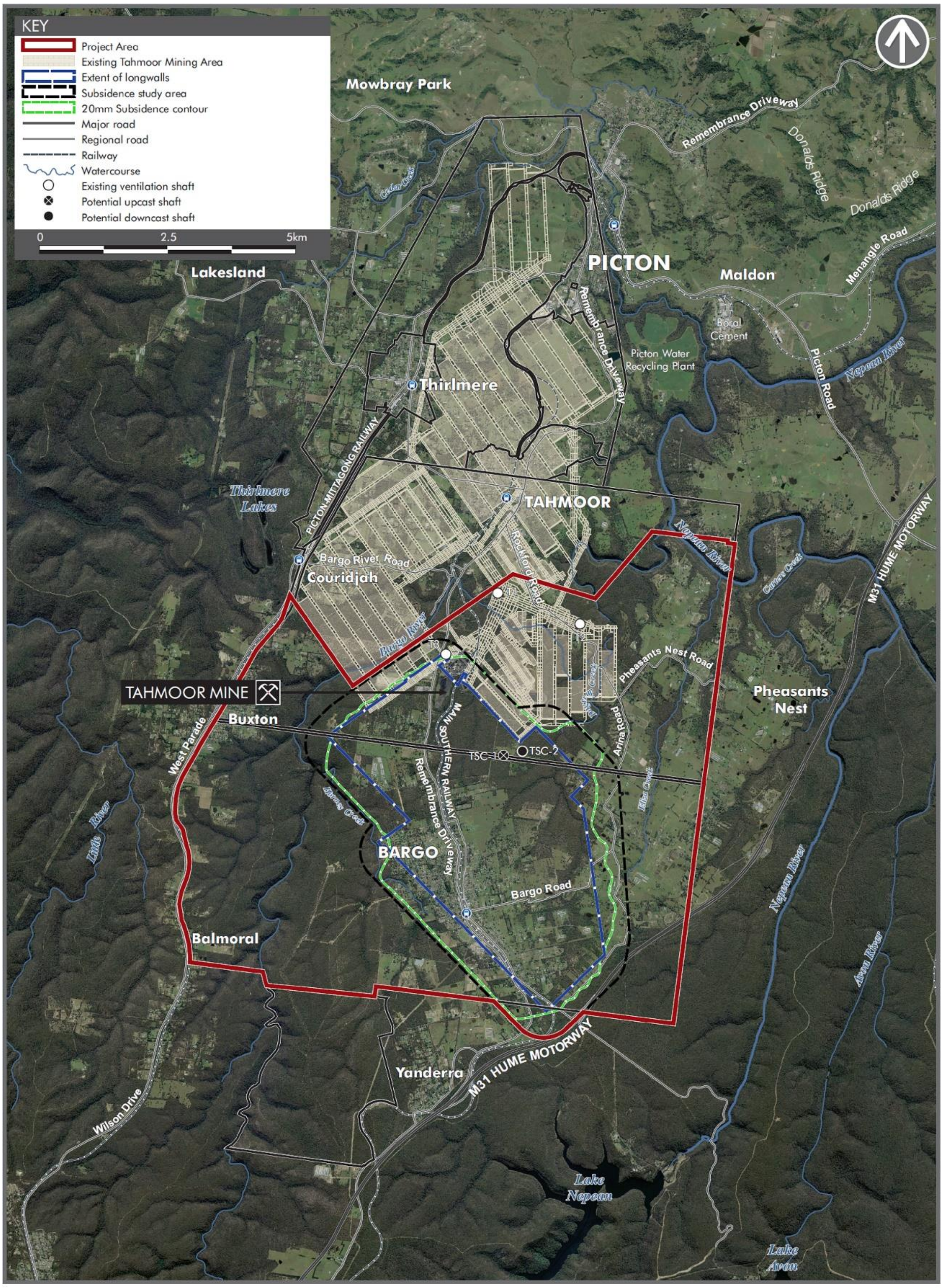


Figure 3.1: Regional setting



PROPOSED MINE PLAN AND VENTILATION SHAFTS
Tahmoor South Project
Environmental Impact Statement

Figure 3.2: Existing Tahmoor mine and mining tenements

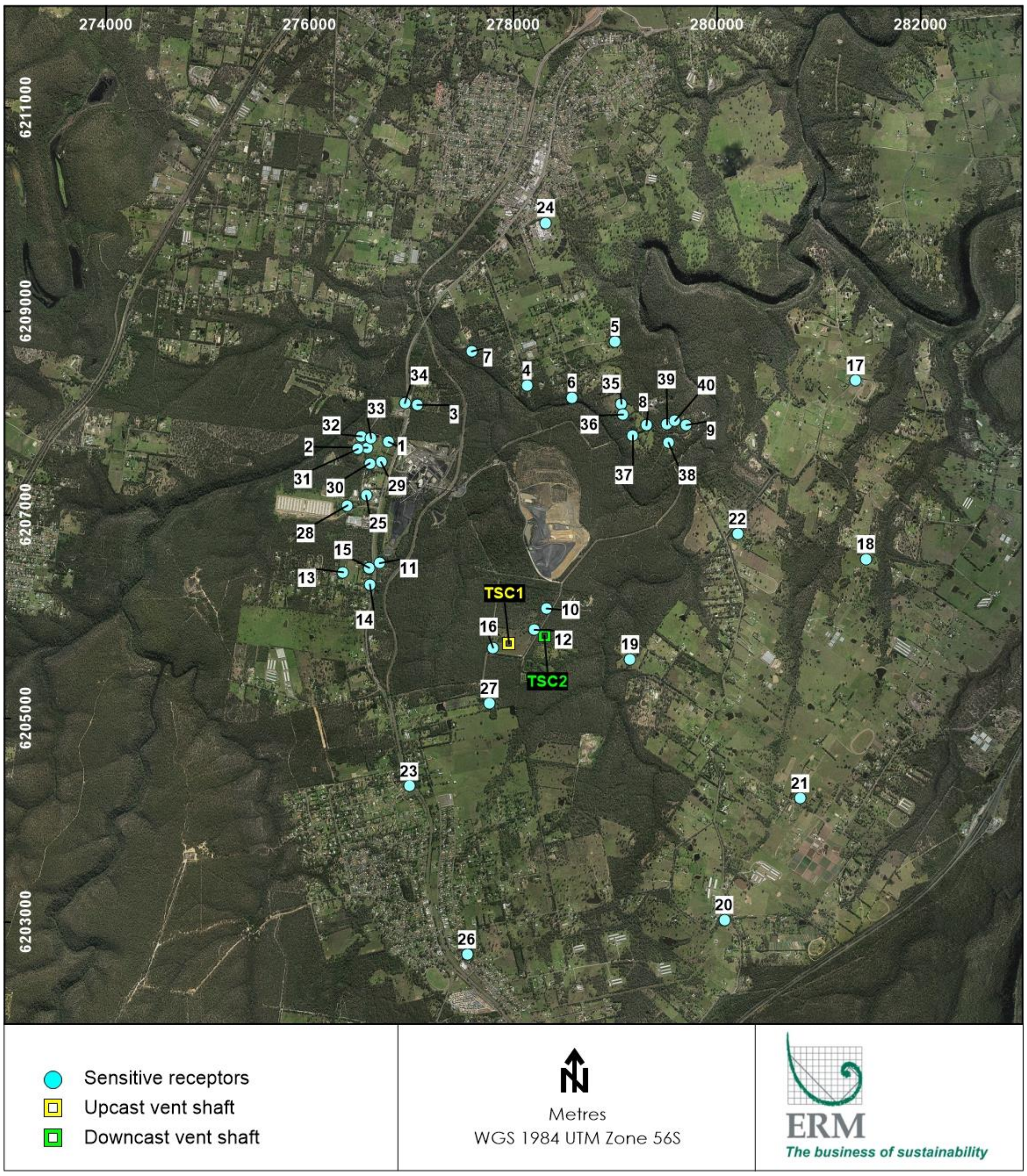


Figure 3.3: Location of private and mine receptors in the vicinity of the Project

4. AIR QUALITY ISSUES AND ASSESSMENT CRITERIA

4.1 Particulate matter

Activities associated with the extraction of coal generate fugitive dust emissions in the form of particulate matter described as total suspended particulate matter (TSP), particulate matter with equivalent aerodynamic diameters 10 µm or less (PM_{10}) and particles with equivalent aerodynamic diameters of 2.5 µm and less ($PM_{2.5}$).

In practice, emissions of carbon monoxide (CO), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) will occur from diesel-powered equipment and vehicle exhausts.

This section provides information on the air quality criteria used to assess the predicted impacts of the Project. The criteria are intended to protect the community against the adverse effects of air pollutants. These criteria generally reflect current Australian standards for the protection of health and protection against nuisance effects. To assist in interpreting the significance of predicted concentration and deposition levels, some background discussion on the potential harmful effects of dust is provided below.

4.1.1 Particulate matter and health

The key air quality issue for mining are emissions of dust and particulate matter (PM). Mining generates PM from numerous activities including vegetation stripping and topsoil removal, removal and handling of overburden removal, removal and handling of coal, hauling by heavy vehicles and wind erosion from stockpiles and exposed surfaces. PM is formed when particulate becomes entrained in the atmosphere by the turbulent action of wind, by the mechanical disturbance of materials, or through the release of particulate-rich gaseous emissions from combustion sources.

Suspended PM can be defined by its size, chemical composition and source. Particle size is an important factor influencing its dispersion and transport in the atmosphere and its potential effects on human health. Typically, the size of suspended particles ranges from approximately 0.005 to 100 micrometres (µm) and is often described by the aerodynamic diameter of the particle.

The particulate size ranges are commonly described as:

- TSP – total suspended particulate matter refers to all suspended particles in the air. In practice, the upper size range is typically 30 µm – 50 µm.
- PM_{10} – refers to all particles with equivalent aerodynamic diameters of less than 10 µm, that is, all particles that behave aerodynamically in the same way as spherical particles with a unit density.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5 µm diameter (a subset of PM_{10}). Often referred to as the fine particles.
- $PM_{2.5\text{-}10}$ – defined as the difference between PM_{10} and $PM_{2.5}$ mass concentrations. Often referred to as coarse particles.

Both natural and anthropogenic processes contribute to the atmospheric load of PM. Coarse particles ($PM_{2.5\text{-}10}$) are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal[1] materials from roads, farming, mining, dust storms, and so forth. Coarse particles also include sea salts, pollen, mould, spores, and other plant parts.

Fine particles or $PM_{2.5}$ are derived primarily from combustion processes, such as vehicle emissions, wood burning, coal burning for power generation, and natural processes, such as bush fires. Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosol from volatile organic compound emissions. Mining dust is likely to be composed of predominantly coarse particulate matter (and larger particles).

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[1] Crustal dust refers to dust generated from materials derived from the earth's crust.

There have been a number of extensive reviews of the health effects of particulates over the past several years. Particles have been associated with a range of acute and chronic adverse health effects, including increased daily hospital admissions and emergency room visits for respiratory and cardiovascular symptoms, and decreased lung function.

- The physical and chemical nature of the particles
- The physics of deposition and distribution in the respiratory tract
- The physiological events that occur in response to the presence of the particle

The size of particles determine their behaviour in the respiratory system, including how far the particles are able to penetrate, where they deposit, and how effective the body's clearance mechanisms are in removing them. Additionally, particle size is an important parameter in determining the residence time and spatial distribution of particles in ambient air, key considerations in assessing exposure. It is generally thought that the smaller PM are of greater health concern as these particles can penetrate further into the respiratory tract.

This is demonstrated in Figure 4.1 which shows the relative deposition by particle size within various regions of the respiratory tract.

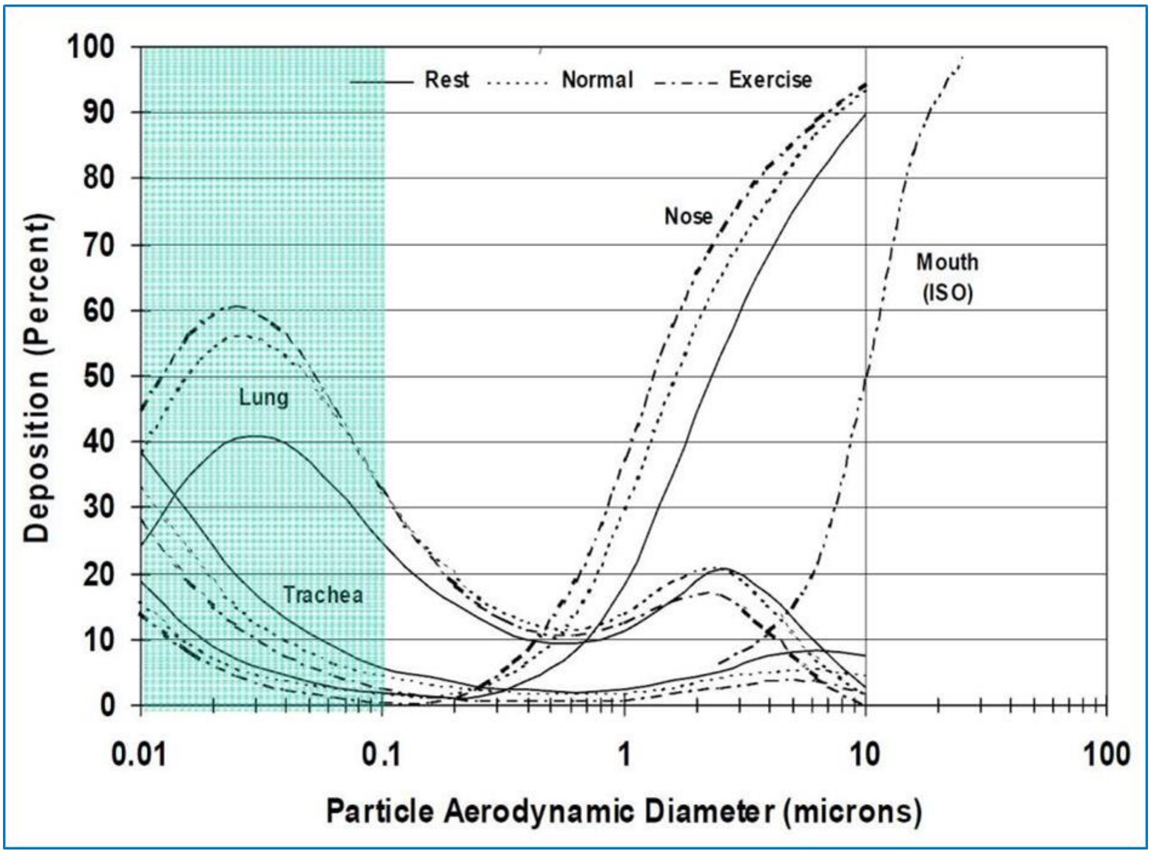

Figure 4.1: Particle deposition within the respiratory tract (Source: Phalen et al, 1991)

4.1.2 Impact assessment criteria

The Approved Methods specifies air quality assessment criteria relevant for assessing impacts from air pollution (EPA, 2016). The air quality criteria relate to the total dust burden in the air and not just the dust from the Project. In other words, consideration of background dust levels needs to be made when using these criteria to assess potential impacts.

These criteria are consistent with the National Environment Protection Measures for Ambient Air Quality (referred to as the Ambient Air-NEPM) (NEPC, 1998a). However, the EPA's criteria include averaging periods which are not included in the Ambient Air-NEPM, and also reference other measures of air quality, namely dust deposition and TSP.

Table 4.1 presents the air quality criteria for concentrations of particulate matter that are relevant to this study. For PM_{10} and $PM_{2.5}$, these are consistent with the revised National Environment Protection Measure for Ambient Air Quality (referred to as the Ambient Air-NEPM) (NEPC, 2016). However, the NSW EPA's criteria include averaging periods which are not included in the Ambient Air-NEPM, and also reference other measures of air quality, namely TSP.

Table 4.1: EPA air quality standards/criteria for particulate matter concentrations

Pollutant	**Standard**	**Averaging Period**	**Source**
TSP	90 µg/m^3	Annual	EPA (2016)
PM_{10}	50 µg/m^3 25 µg/m^3	24-Hour Annual	EPA (2016)
$PM_{2.5}$	25 µg/m^3 8 µg/m^3	24-Hour Annual	EPA (2016)

µg/m^3 = micrograms per cubic metre, µm – micrometre

In addition to health impacts, airborne dust also has the potential to cause nuisance effects by depositing on surfaces, including native vegetation and crops. Larger particles do not tend to remain suspended in the atmosphere for long periods of time and will fall out relatively close to source. Dust fallout can soil materials and generally degrade aesthetic elements of the environment, and are assessed for nuisance or amenity impacts.

Table 4.2 shows the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust fallout levels are set to protect against nuisance impacts (EPA, 2016).

Table 4.2: EPA criteria for dust (insoluble solids) fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

g/m^2/month = grams per square metre per month.

4.2 Odour

4.2.1 Measuring odour concentration

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 management by regulatory authorities.

Dynamic olfactometry is the measurement of odour by presenting a sample of odorous air diluted to the point where a trained panel of assessors cannot detect a change between the odour free air and the diluted sample. The concentration is then doubled until the difference is observed with certainty. The correlations between the 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 detectability of an odour (i.e. whether someone smells it or not) is a sensory property that refers to the theoretical minimum concentration that produces an olfactory response or sensation. The theoretical minimum concentration is referred to as the "odour threshold" and is the definition of 1 odour unit (ou). Therefore, an odour concentration of less than 1 ou would theoretically mean there is no odour.

4.2.2 Odour performance criteria

4.2.2.1 Introduction

The determination of air quality goals for odour and their use in the assessment of odour impacts is recognised as a difficult topic in air pollution science. The topic has received considerable attention in recent years and the procedures for assessing odour impacts using dispersion models have been refined considerably.

The EPA has developed odour goals and the way in which they should be applied with dispersion models to assess the likelihood of nuisance impact arising from the emission of odour.

There are two factors that need to be considered:

1. What "level of exposure" to odour is considered acceptable to meet current community standards in NSW; and
2. How can dispersion models be used to determine if a source of odour meets the goals which are based on this acceptable level of exposure.

The term "level of exposure" has been used to reflect the fact that odour impacts are determined by several factors the most important of which are (the so-called FIDOL factors):

- the Frequency of the exposure
- the Intensity of the odour
- the Duration of the odour episodes and
- the Offensiveness of the odour
- the Location of the source

In summary, whether or not an individual considers an odour to be a nuisance will depend on the FIDOL factors outlined above and although it is possible to derive formulae for assessing odour annoyance in a community, the response of any individual to an odour is still unpredictable. Odour goals need to take account of these factors.

4.2.2.2 Complex mixtures of odorous air pollutants

The Approved Methods (NSW EPA, 2016) include ground-level concentration (glc) criteria for complex mixtures of odorous air pollutants. They have been refined by the EPA to take account of population density in a given area. Table 4.3 lists the odour glc criteria to be exceeded not more than 1% of the time, for different population densities.

The difference between odour criteria is based on considerations of risk of odour impact rather than differences in odour acceptability between urban and rural areas. For a given odour level there will be a wide range of responses in the population exposed to the odour. In a densely populated area there will therefore be a greater risk that some individuals within the community will find the odour unacceptable than in a sparsely populated area. Given the proximity of the new upcast shaft to the nearest sensitive receptors, an impact assessment glc criterion of 7 ou is appropriate for this area.

Table 4.3: Odour performance criteria for the assessment of odour

Population of affected community	Criterion for complex mixtures of odorous air pollutants 99th percentile (ou)
≤ ~2	7
~10	6
~30	5
~125	4
~500	3
Urban (2000) and/or schools and hospitals	2

4.2.2.3 Peak-to-mean ratios

It is a common practice to use dispersion models to determine compliance with odour goals. This introduces a complication because conventional Gaussian dispersion models are typically only able to directly predict concentrations over a one hour averaging period or greater. The human nose, however, responds to odours over periods of the order of a second or so. During a one hour period, odour levels can fluctuate significantly above and below the mean depending on the nature of the source.

To determine more rigorously the ratio between the one-second peak concentrations and longer period average concentrations (referred to as peak-to-mean, or P/M ratio) that might be predicted by a Gaussian dispersion model, EPA commissioned a study by Katestone Scientific Pty Ltd (1995, 1998). This study recommended peak-to-mean ratio for a range of circumstances. The ratio is also dependent on atmospheric stability and the distance from the source. Table 4.4 summarises the current P/M ratios used in NSW.

Near-field can be defined as the zone where the stack structure itself directly affects the dispersion and structure of the plume. This is typically 10 times the largest source dimension, in this case the 30 m height of the tallest stack. This leads to a near-field in the order of up to 300 m.

The term ‘tall’ point source usually refers to sources that protrude out of the surface boundary layer (e.g. over 30 to 50 m tall). A wake-affected point source is where nearby buildings interfere with the trajectory and growth of the plume, the source is called a wake-affected point source. A point source is wake-affected if stack height is less than or equal to 2.5 times the height of buildings located within a distance of 5L (where L is the lesser of the height or width of the building) from each release point.

The Approved Methods take account of these P/M ratios and the goals shown in Table 4.3 are based on nose-response time, which is effectively assumed to be 1 second (i.e. appropriate P/M ratios have been applied to all predictions).

Table 4.4: Factors for estimating peak concentration on flat terrain

Source type	Pasquil-Gifford stability class	Near field P/M60 [1]	Far field P/M60
Area	A, B, C, D	2.5	2.3
	E, F	2.3	1.9
Line	A – F	6	6
Surface point	A, B, C	12	4
	D, E, F	25	7
Tall wake-free point	A, B, C	17	3
	D, E, F	35	6
Wake-affected point	A – F	2.3	2.3
Volume	A – F	2.3	2.3

Notes: 1. Ratio of peak 1-second average concentrations to mean 1-hour average concentrations

4.3 Oxides of nitrogen

The key pollutant released from flaring of coal seam methane will be oxides of nitrogen NOx. NOx is comprised of nitric oxide (NO) and nitrogen dioxide (NO_2), however NO is not considered harmful to human health and is generally not considered an air pollutant at the concentrations that are typically found in ambient environments.

Concern with nitric oxide is related to its transformation to nitrogen dioxide and its role in the formation of photochemical smog. Nitrogen dioxide has been reported to have an effect on respiratory function, although the evidence concerning effects has been mixed and conflicting. NSW EPA prescribes ambient impact assessment criteria for NO_2, as outlined in Table 4.5.

4.4 Carbon monoxide

Emissions of Carbon Monoxide (CO) can be expected from the flaring of coal seam methane. Carbon monoxide is a colourless, odourless gas, formed from the incomplete or inefficient combustion of fuels containing carbon and may be emitted from the flaring of goaf gas.

Carbon monoxide can be harmful to humans because its affinity for haemoglobin is more than 200 times greater than that of oxygen. When it is inhaled it is taken up by the blood and therefore reduces the capacity of the blood to transport oxygen. This process is reversible and reducing the exposure will lead to the establishment of a new equilibrium. A period of three hours is the approximate time required to reach fifty percent of the equilibrium value.

Symptoms of carbon monoxide intoxication are lassitude and headaches, however these are generally not reported until the concentrations of carboxyhaemoglobin in the blood are in excess of ten percent of saturation. This is approximately the equilibrium value achieved with an ambient atmospheric concentration of 70 mg/m^3 for a person engaged in light activity. However, there is evidence that there is a risk for individuals with cardiovascular disease when the carboxyhaemoglobin concentration reaches four percent, and the WHO recommends that ambient concentrations be kept to values which would protect individuals from exceeding the four percent level.

The NSW EPA prescribes ambient impact assessment criteria for CO, as outlined in Table 4.5.

Table 4.5: Ambient air quality goals for NO_2 and CO

Pollutant	Averaging period	Goal	
Nitrogen dioxide	1-Hour	0.12 ppm	246 µg/m^3
	Annual	0.03 ppm	62 µg/m^3
Carbon monoxide	8-Hour	9 ppm	10 mg/m^3
	1-Hour	25 ppm	30 mg/m^3
	15-Minute	87 ppm	100 mg/m^3

4.5 Volatile organic compounds

Flaring of coal seam methane may also result in emissions of volatile organic compounds (VOCs). Organic hydrocarbons are comprised of a collection of various VOCs, and several of these compounds may be toxic, including benzene, ethylbenzene, 1,3-butadiene, toluene and xylenes. Methane itself is a common VOC but is often distinguished from other VOCs using the term non-methane VOCs or NMVOCs.

Air toxics are present in the air in low concentrations, however characteristics such as toxicity or persistence means they can be hazardous to human, plant or animal life. There is evidence that cancer, birth defects, genetic damage, immuno-deficiency, respiratory and nervous system disorders can be linked to exposure to occupational levels of air toxics. Organic hydrocarbons also include reactive organic compounds, which play a role in the formation of photochemical smog. There are no impact assessment criteria specified for total VOCs, however modelling predictions can be compared to the impact assessment criteria for individual organic pollutants that may be present in the extracted gas.

4.6 Action for air

In 1998, the NSW Government implemented a 25 year air quality management plan, Action for Air, for Sydney, Wollongong and the Lower Hunter (DECCW, 2009). Action for Air seeks to provide long-term ongoing emission reductions. It does not target acute and extreme exceedances from events such as bushfires. The aim of Action for Air includes:

- Meeting the national air quality standards for six pollutants as identified in the Ambient Air NEPM.
- Reducing the population’s exposure to air pollution, and the associated health costs.

The six pollutants in the Ambient Air NEPM include CO, NO_2, SO_2, lead, ozone and PM_{10}. The main pollutant from the Project that is relevant to the Action for Air is PM_{10}. Action for Air aims to reduce air emissions to enable compliance with the Ambient Air NEPM targets to achieve the aims described above, with a focus on motor vehicle emissions.

The Tahmoor South Project is located within the area relevant to the Action for Air plan (i.e. the Illawarra) and the Project generally addresses the aims of the Action for Air Plan in the following ways:

- Tahmoor Coal and ERM have reviewed potential mitigation measures and a range of measures have been adopted for the Project (Section 8).
- Air quality emissions potentially associated with the Project have been quantified (Section 9).

- Dispersion modelling has been conducted by ERM to predict the impact of these emissions on nearby receptors and assess these emissions against the Ambient Air NEPM goals (Section 10).

4.7 Protection of the Environment Operations Act, 1997

Tahmoor Coal currently holds Environment Protection Licence (EPL) No. 1389 issued by the EPA under the NSW Protection of the Environment Operations Act, 1997 (PoEO Act). Relevant to air quality, the EPL includes a requirement to minimise dust emissions and specifies dust deposition and PM_{10} sampling requirements.

It is understood that a variation of EPL 1389 would be sought to incorporate the Project as may be required.

5. EXISTING ENVIRONMENT

5.1 Introduction

A monitoring network was established for the Tahmoor South project, which consists of the following elements:

- One high volume air sampler (HVAS), measuring TSP concentrations for 24-hours periods on a one day in six run cycle
- One Tapered Element Oscillating Microbalances (TEOMs) continuously measuring PM_{10} at 5-minute intervals
- Five dust depositional gauges (DDGs)
- One meteorological station

In addition, Tahmoor Mine has a monitoring network consisting of six DDGs and one meteorological station. All air quality monitoring stations relevant to the Project are shown below in Figure 5.1.

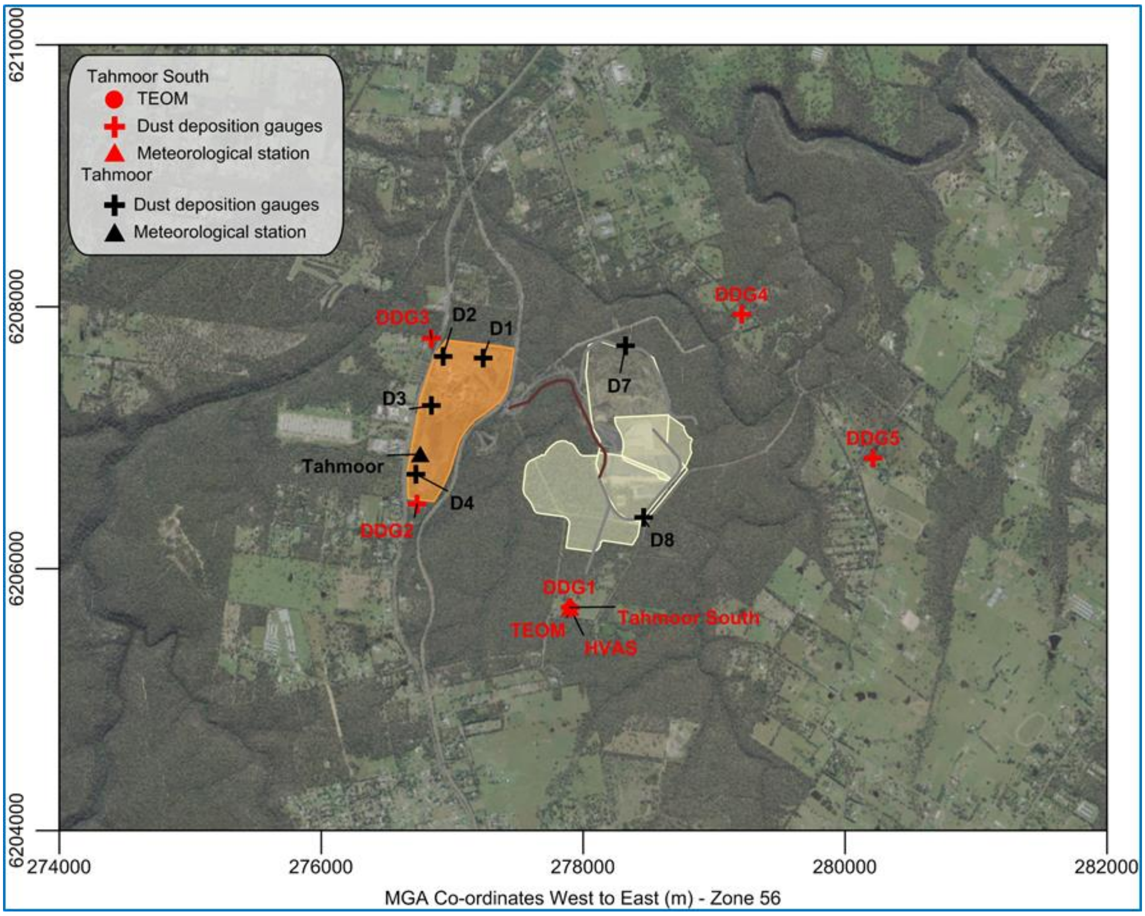

Figure 5.1: Location of air quality monitoring sites

5.2 Meteorology

Local meteorological data has been collected at the Tahmoor South meteorological station since July 2012, as shown in Figure 5.2. Annual and seasonal wind roses from March 2012 to February 2013 are presented in Figure 3.3. On an annual basis, the most common winds are from the southwest and south-southwest. This pattern is reflected in most seasons except during summer when the predominant winds are from the north-eastern quadrant. The average wind speed recorded at Tahmoor South is 1.6 m/s and calm conditions (<= 0.5 m/s) are frequent at approximately 24% of the time.

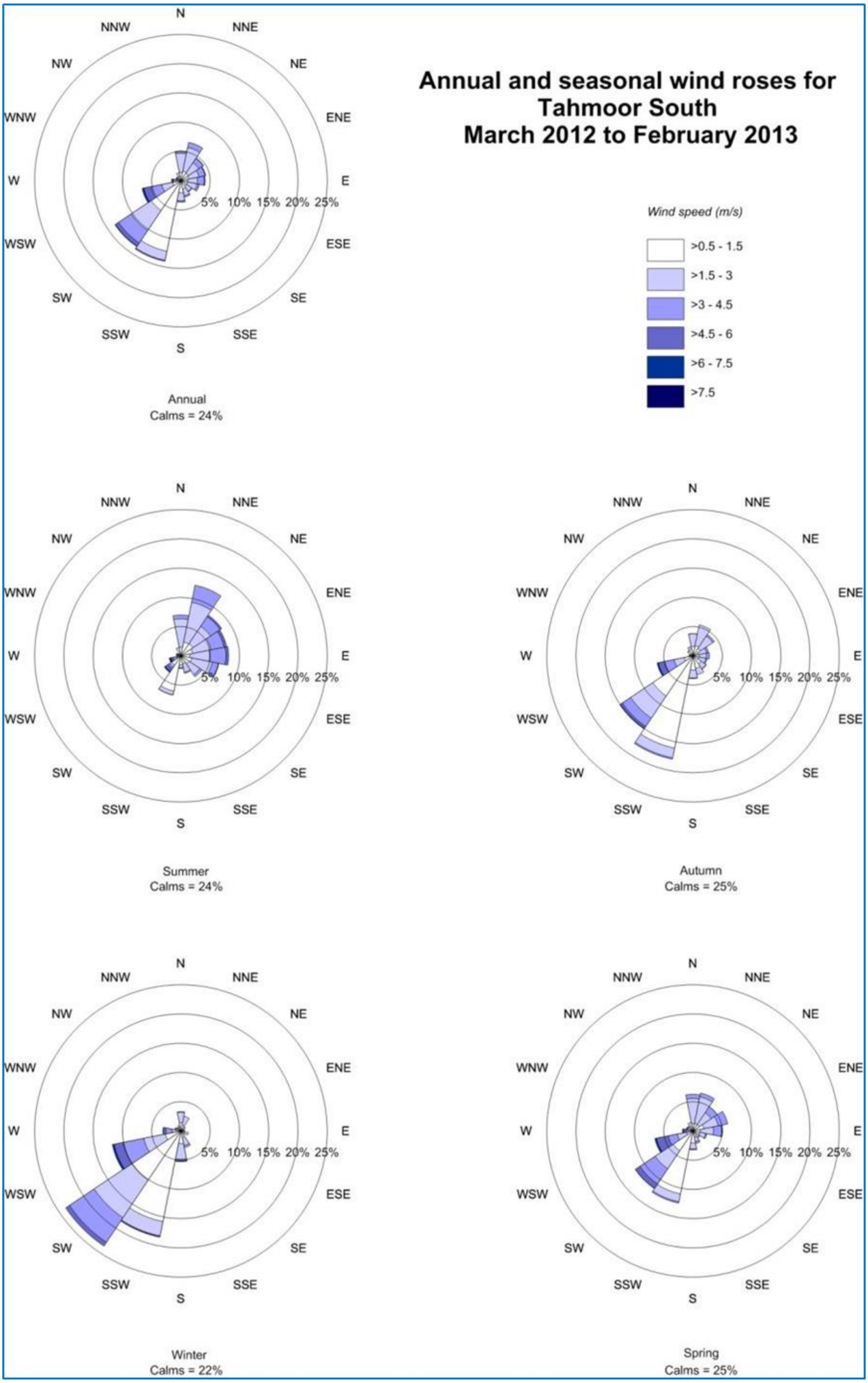

Figure 5.2: Wind roses for Tahmoor – 2012/2013

5.3 Local climatic conditions

The BoM collects climatic information in the vicinity of the study area. A range of climatic information collected from Picton Council Depot Automatic Weather Station (AWS) (located approximately 6 km from the Project) are presented in Table 5.1 (BoM, 2013). Temperature data consist of monthly averages of 9 am and 3 pm readings. Also presented are monthly averages of maximum and minimum temperatures. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures experienced at Picton are 23.4°C and 8.8°C respectively. On average January is the hottest month, with an average maximum temperature of 29.3°C. July is the coldest month, with average minimum temperature of 1.7°C.

Rainfall data collected at Picton shows that February is the wettest month, with an average rainfall of 91.2 mm over 9.5 rain days. The average annual rainfall is 804.8 mm with an average of 97.1 rain days.

Table 5.1: Climate information for Picton Council Depot AWS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean Maximum Temperature (ºC) 1													
Mean	29.3	28.6	27.0	23.7	20.2	17.3	16.8	18.2	21.4	24.0	26.3	28.5	23.4
Mean Minimum Temperature (°C) 1													
Mean	15.2	15.4	13.1	9.2	5.7	3.2	1.7	2.9	5.2	8.8	11.5	14.0	8.8
Rainfall (mm) 2													
Mean	87.3	91.2	88.2	69.7	57.1	65.1	50.6	44.1	44.5	64.7	72.2	69.8	804.8
Raindays (Number)													
Mean	9.4	9.5	9.6	7.8	7.0	7.4	6.6	6.8	7.2	8.5	8.7	8.6	97.1
Mean 9 am Temperatures (ºC) 1													
Dry-bulb	21.8	21.5	19.9	16.8	12.2	9.4	7.7	10.4	14.0	17.3	19.0	21.0	15.9
Mean 3 pm Temperatures (ºC) 1													
Dry-bulb	26.4	25.4	24.5	22.5	18.3	15.7	15.6	16.2	19.0	21.3	23.1	25.6	21.1

Source: BOM (2013)

1 ºC = degrees Celsius
2 mm = millimetres
Climate averages for Station: 061260; Commenced: 1968, Last record: 2012; Latitude: 32.79 °S; Longitude: 151.34 °E.

6. EXISTING AIR QUALITY

Air quality standards and goals are used to assess the total pollutant level in the environment, including the contribution from specific projects and existing sources. To fully assess impacts against all the relevant air quality standards and goals it is necessary to have information on the background concentrations to which the project is likely to contribute.

Data from EPA monitoring stations (outlined in Section 6.2) and from dust monitors operated by Tahmoor have been included below.

6.1 Tahmoor South dust monitoring

6.1.1 HVAS

Tahmoor has also installed a HVAS measuring TSP concentrations located south of the REA (refer to Figure 5.1). Data from the HVAS was available from 9 March 2012 to 26 July 2013 and 6 December 2014 to 29 July 2017. The annual average for each annual period ranged between 16.6 µg/m^3 (2016) and 20.4 µg/m^3 (2012), well below the EPA annual average criterion of 90 µg/m^3. The average across the entire monitoring period is 18.3 µg/m^3. The maximum rolling annual average over the entire monitoring period (i.e. 4 years of data) is 20.7 µg/m^3. The maximum measured TSP concentration at the monitor was 67.8 µg/m^3 on 12 December 2012. The TSP concentrations recorded by the HVAS are shown in Figure 6.1.

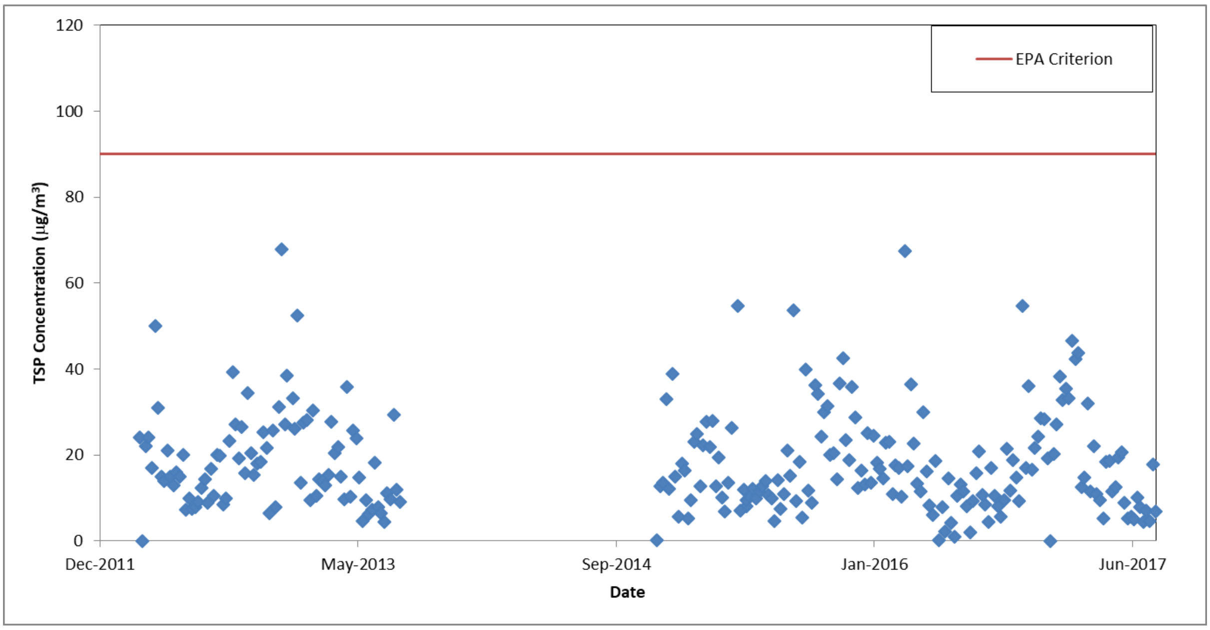

Figure 6.1: HVAS TSP concentrations (µg/m^3)

6.1.2 TEOM

PM_{10} concentrations are monitored by TEOM at 5-minute intervals at the location shown on Figure 5.1. Data is available from January 2012 to July 2013, and from January 2015 to August 2017. A summary of the data collected is shown in Table 6.1. The average PM_{10} across all years of data is 12.6 µg/m^3.

The day to day variability in ambient levels of 24-hour average PM_{10} concentrations for the available data period is shown in Figure 6.2. Exceedances of the EPA assessment criterion of 50 µg/m^3 are seen in 2012 on 31 October and 1 November, in 2015 on 6 May, and in 2016 on 25 March, 7 May and 22 May. The BoM monthly review (BoM, 2012b) indicated that the October-November 2012 period was very dry across the state. There were also a number of bushfires across the state in the latter periods of 2012. There were hazard reduction burns in May 2016 with elevated levels across a number of EPA stations in the same period.

Table 6.1: TEOM PM_{10} monitoring results

Year	Annual Average PM_{10} (µg/m^3)	24-hour Maximum PM_{10} (µg/m^3)
2012	13.3	74.1
2013 [1]	13.0	31.4
2014	-	-
2015	12.6	59.8
2016	12.3	65.3
2017	11.9	49.0
Average	**12.6**	**n/a**
Maximum 24-hour Average [3]	**n/a**	**74.1**

Notes: 1 Data provided to 13 July 2013
2 Event occurred 31 October 2012

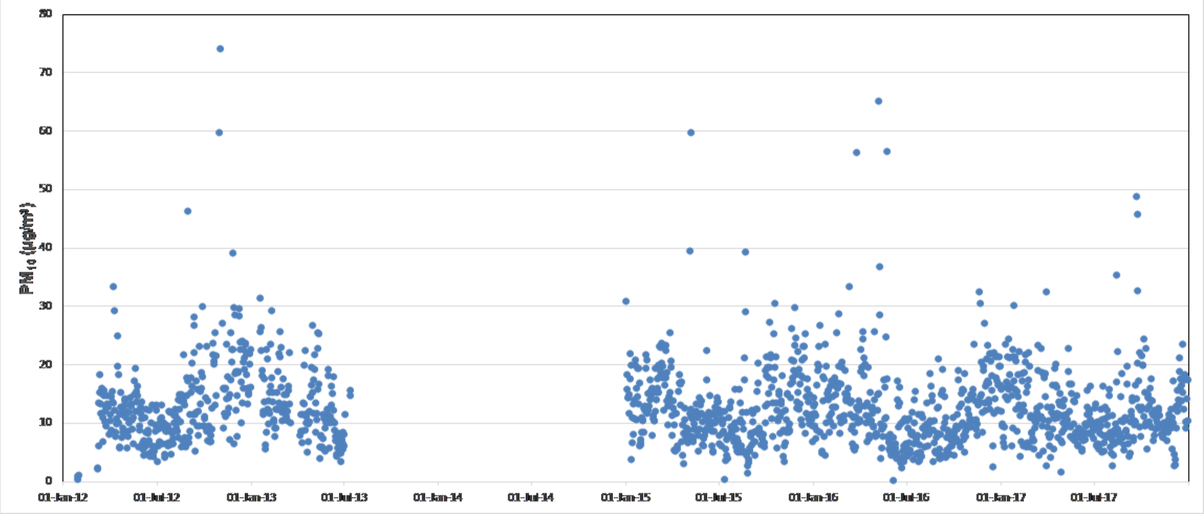

Figure 6.2: TEOM 24-hour PM_{10} concentrations (µg/m^3)

6.1.3 *Dust deposition*

There are five dust deposition gauges located off-site for Tahmoor. Table 6.2 provides a summary of the annual average dust deposition data collected from April 2012 to May 2013 and December 2015 to June 2017.

Review of the monitoring data on a month by month basis shows occasions where elevated dust deposition levels at detected in certain months at DDG3 and DDG4. However, the annual average dust deposition levels at all monitors are below the EPA criterion of 4 g/m^2/month, as shown in Table 6.2. The average across all off-site gauges is 1.4 g/m^2/month which is also below the EPA assessment criterion of 4 g/m^2/month.

Table 6.2: Tahmoor South monthly average dust deposition concentrations

Month	DDG1	DDG2	DDG3	DDG4	DDG5
EPA annual average dust deposition criterion = 4 g/m^2/month					
2012	0.3	1.1	0.8	3.7	0.6
2013	0.3	0.9	1.7	3.1	0.8
2015	0.6	2.4	1.2	1.4	0.7
2016	0.5	1.0	1.1	2.3	0.6
2017	0.5	0.9	0.5	6.0	7.6
Average	**0.4**	**1.4**	**1.1**	**2.9**	**1.2**
Average across all sites					**1.4**

6.2 Tahmoor dust monitoring

In addition to the Tahmoor South dust monitoring network, the existing Tahmoor Mine also operates six dust deposition gauges.

6.2.1 *Dust deposition*

There are six dust deposition gauges located off-site for the existing Tahmoor Mine. Table 6.3 provides a summary of the monthly average dust deposition data collected from 2008 to August 2017.

The annual average dust deposition levels at all monitors are below the EPA criterion of 4 g/m^2/month. The average across all off-site gauges is 1.2 g/m^2/month which is also below the EPA assessment criterion of 4 g/m^2/month.

Table 6.3: Tahmoor Mine annual average dust deposition concentrations

Year	D1	D2	D3	D4	D7	D8
EPA annual average dust deposition criterion = 4 g/m^2/month						
2008	0.8	1.0	1.2	1.0	0.7	3.1
2009	1.0	1.4	2.5	1.8	1.4	2.3
2010	1.1	1.0	2.4	1.2	1.1	1.8
2011	0.9	0.8	1.1	0.7	0.4	1.4
2012	1.0	0.7	0.9	1.9	0.7	1.8
2013	0.6	0.5	1.7	0.8	0.7	1.2
2014	1.0	0.8	2.1	1.0	0.9	0.9
2015	0.8	0.5	1.5	0.8	0.8	0.9
2016	0.7	0.8	2.4	1.0	0.5	1.0
2017	0.6	0.6	3.2	0.6	0.5	0.7
Average	**0.8**	**0.8**	**1.9**	**1.1**	**0.8**	**1.5**
Average across all sites						**1.2**

6.3 EPA dust monitoring

In addition to the monitoring data collected on-site at Tahmoor, data from a number of NSW EPA monitoring stations has been analysed. There are five monitoring stations in South West Sydney, as follows:

- Bargo (Silica Road) located approximately 6 km south of the Project
- Oakdale (Ridge Road) located approximately 23 km northwest of the Project
- Macarthur (UWS Campbelltown Campus) located approximately 27 km northeast of the Project
- Campbelltown West (Campbelltown TAFE) located approximately 28 km northeast of the Project
- Camden (aerodrome) located approximately 24 km north of the Project

Data from these monitoring sites between 2007 and 2017 have been used to provide an indication of existing ambient air quality in the area. The on-site mine data will be more representative of the nearest receptors (such as the school) but these data from further afield are useful to demonstrate the levels in the wider area.

6.3.1 PM_{10}

A summary of the annual average PM_{10} concentration collected at the EPA monitoring stations is provided in Table 6.4. The annual average 14.6 µg/m^3. There have been no exceedances of the annual average EPA criterion of 25 µg/m^3 at any of the monitors between 2007 and 2017.

Figure 6.5 presents the 24-hour average PM_{10} concentration data collected at the EPA monitoring stations listed above. There have been exceedances of the 24-hour average EPA impact assessment criterion of 50 µg/m^3 at all sites.

On several occasions, the monitors recorded 24-hour PM_{10} concentrations greater than 300 µg/m^3 due to dust storm events. These data have been removed from the figure to provide a clearer representation of the data.

Regional dust events have been reported by BoM (BoM, 2012b) and coincided with monitored exceedances at Macarthur and Oakdale. 2009 was a very dry year with extreme weather conditions and a record number of dust events occurred in that year. This is reflected in the monitoring where there were a number of exceedances recorded, the majority of which occurred in September and November. Exceedances of the EPA criterion can be observed at the same time at the Macarthur and Oakdale stations indicating it is most likely due to a localised event.

Exceedances of greater than 10% of the 24-hour average criterion of 50 µg/m^3 were recorded at Bargo on 5 occasions (17 September 2011, 5 and 17 October 2013, and 7 and 22 May 2016). The reason for these exceedances are not clear, however as this is an isolated event at both sites it may be due to localised activity in the area.

Table 6.4: EPA annual average PM$_{10}$ concentrations

Year	Bargo	Macarthur	Oakdale	Campbellto	Camden
EPA annual average PM$_{10}$ criterion = 25 µg/m^3					
2007	-	16	13	-	-
2008	-	15	12	-	-
2009	18	21	20	-	-
2010	13	14	11	-	-
2011	13	13	11	-	-
2012 $^{1, 2, 3}$	14	13	12	19	20
2013	15	-	14	16	15
2014	14	-	13	17	16
2015	13	-	11	16	14
2016	14	-	12	16	14
2017	13	-	11	15	14
Average	**14**	**15**	**13**	**16**	**15**
Average across all sites					**15**

Notes: 1 Macarthur station was decommissioned in July 2012.
2 Campbelltown West was commissioned in August 2012.
3 Camden was commissioned in October 2012.

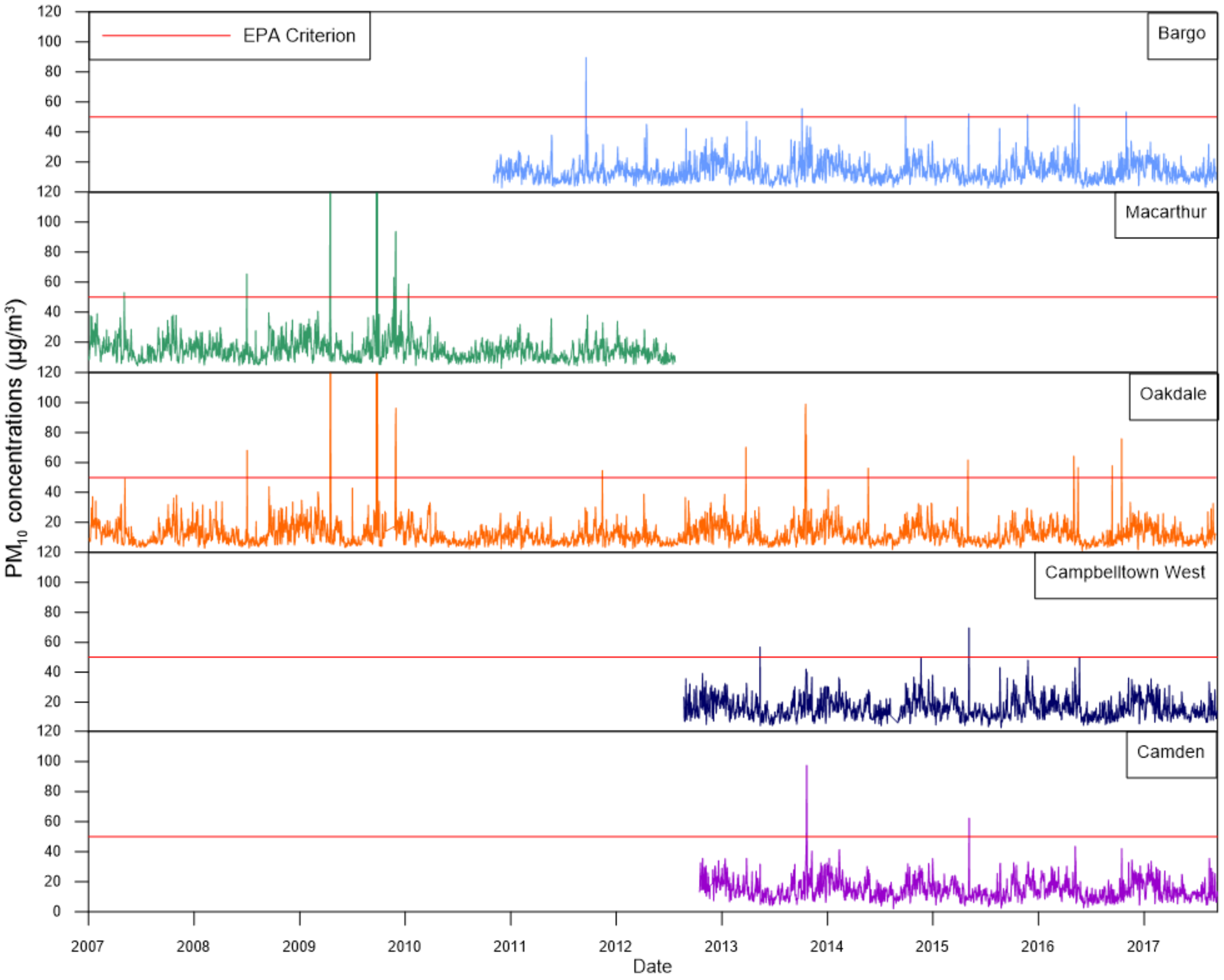

Figure 6.3: EPA PM$_{10}$ monitoring

6.3.2 $PM_{2.5}$

EPA operates a Beta Attenuation Mass (BAM) monitoring $PM_{2.5}$ instrument at Camden, commissioned in December 2012. The average for the available monitoring data is 6 µg/m^3. The ratio of $PM_{2.5}/PM_{10}$ over the monitoring period is 0.4.

The 24-hour average $PM_{2.5}$ concentrations at the Camden monitoring site are shown in Figure 6.4.

There have been three periods of exceedance in the 24-hour average $PM_{2.5}$ criterion of 25 µg/m^3 since the activation of the Camden monitoring site.

On the dates of 20th, 21st and 22nd October 2013, an exceedance of the criterion for $PM_{2.5}$ occurred. These dates were compared with PM_{10} data from other EPA sites nearby (Camden, Campbelltown West, Bargo & Oakdale) which showed similar elevated results. This is likely to be a regional event associated with wood smoke from fire activity.

On the dates of 7th, 8th and 9th May 2016, an exceedance of the criterion for $PM_{2.5}$ also occurred. These dates were compared with PM_{10} data from other EPA sites nearby which showed similar elevated results. This is likely to be a regional event associated with wood smoke from fire activity.

On the dates of 14th and 15th August 2017, an exceedance of the criterion for $PM_{2.5}$ also occurred. These dates were compared with PM_{10} data from other EPA sites nearby (Camden, Campbelltown West, Bargo & Oakdale) which showed similar elevated results. This is likely to be a regional event associated with wood smoke from fire activity.

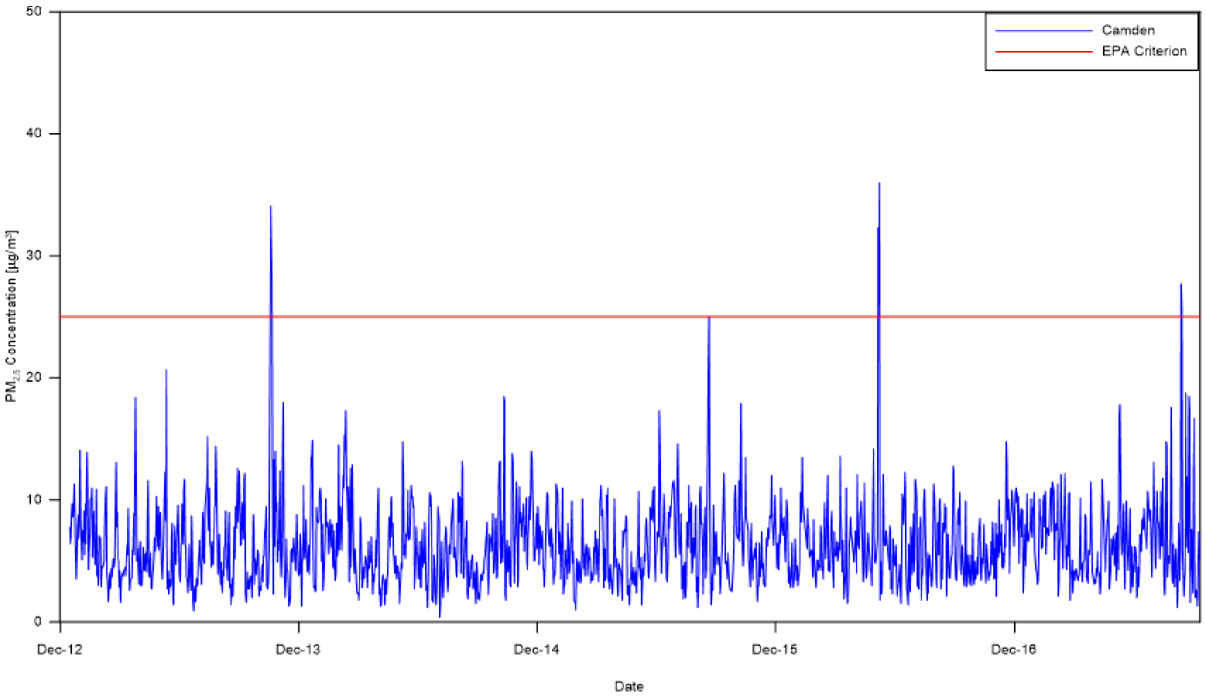

Figure 6.4: EPA Camden 24-hour $PM_{2.5}$ concentrations (µg/m^3)

6.4 Other pollutants

The NSW EPA collects concentration data for other pollutants of relevance to this study at several monitoring sites around the Project area. The closest monitoring sites to the Project are Bargo, Camden, Macarthur and Campbelltown West. NO_2 and CO data have been collated from the EPA website to determine current ambient concentrations of these pollutants.

6.4.1 *NO_2 concentrations*

Figure 6.5 presents the maximum hourly NO_2 concentration data collected at the EPA monitoring stations listed above. All four monitoring stations are well below the EPA impact assessment criterion of 246 µg/m^3. The maximum hourly concentration recorded at the Macarthur site is 166 µg/m^3. It is noted that the Macarthur site is located within a high population density area. The maximum value of 166 µg/m^3 recorded at the Macarthur site over a period of nearly eight years represents approximately 68% of the assessment criterion.

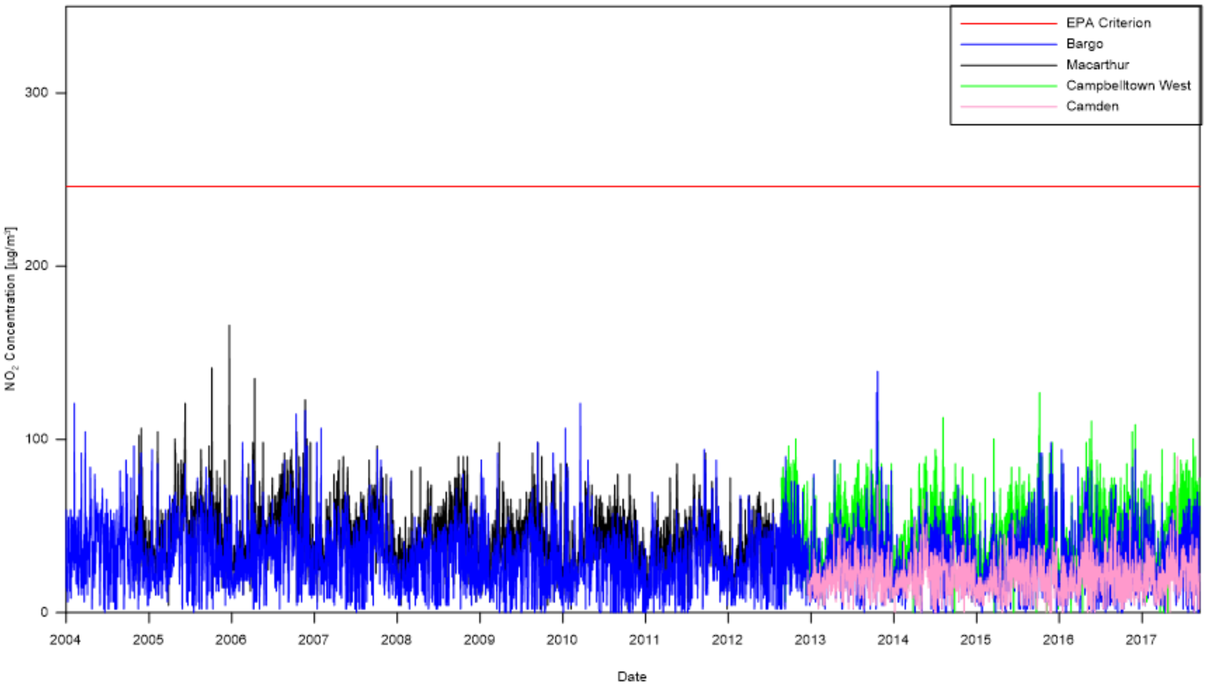

Figure 6.5: 1-hour average NO_2 concentrations measured at EPA Bargo monitoring station (2004 to 2017)

6.4.2 CO concentrations

Figure 6.6 presents the maximum 8-hour rolling CO concentration data collected at the EPA Macarthur, Campbelltown West and Camden sites. It shows that CO concentrations measured at the three sites are well below the impact assessment criterion of 10 mg/m^3. The maximum value recorded was 2.3 mg/m^3 which occurred in July 2006 and September 2007.

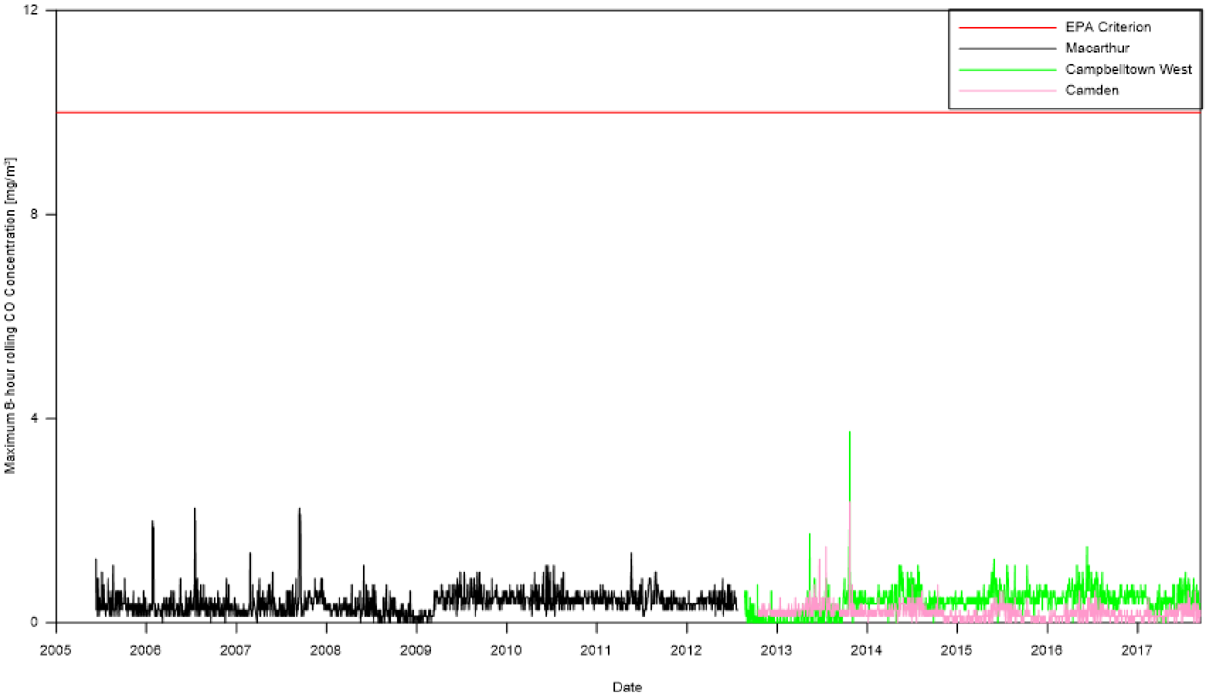

Figure 6.6: 8-hour average CO concentrations measured at EPA Macarthur, Camden & Campbelltown West stations (2005 to 2017)

7. MODELLING APPROACH

The assessment follows a conventional approach commonly used for air quality assessment in Australia and outlined in the Approved Methods (NSW EPA, 2016).

7.1 Modelling system

The CALMET/CALPUFF modelling system was chosen for this study. The local meteorology has been modelled using TAPM and CALMET models. Output from TAPM, plus data from the Tahmoor South weather station were entered into CALMET. CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional meteorological fields that are utilised in the CALPUFF dispersion model. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region.

CALPUFF is a multi-layer, multi-species non-steady state puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal (Scire et al., 2000). The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer-range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across the puff and takes into account the complex arrangement of emissions from point, area, volume, and line sources.

In March 2011 the NSW EPA published generic guidance and optional settings for the CALPUFF modelling system for inclusion in the Approved Methods (TRC, 2011). The model set up for this study has been completed in consideration of these guidelines.

7.2 TAPM

The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. Detailed description of the TAPM model and its performance is provided in (Hurley 2008 and Hurley, Edwards et al 2008).

TAPM solves the fundamental fluid dynamics and scalar transport equations to predict meteorology and pollutant concentrations. It consists of coupled prognostic meteorological and air pollution concentration components. The model predicts airflow important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology provided by synoptic analyses.

For this project, TAPM was set up with 4 domains, composed of 30 grids along both the x and the y axes, centred on -34˚17’ Latitude and 150˚36’ Longitude. Each nested domain had a grid resolution of 30 km, 10 km and 3 km and 1km respectively.

7.3 CALMET

CALMET was initially run for a grid domain of 20 km x 20 km with a 200 m resolution. Terrain for this area was derived from 90 m DEM data sourced from GeoScience Australia. Land use for the domain was determined by aerial photography from Google Earth.

Observed hourly surface data were incorporated into the modelling from the Tahmoor South meteorological station. Meteorological parameters such as wind speed, wind direction, temperature and relative humidity were sourced from the Tahmoor South meteorological station. As the Tahmoor South station does not measure sea level pressure, this was sourced from the nearest BoM station at

Camden (station number 068192). Cloud data was obtained from prognostic 3-dimensional data (3D.dat) from TAPM.

Table 7.1summarises the inputs used for both the TAPM and CALMET models.

Table 7.1: Meteorological parameters used for TAPM and CALMET

TAPM (v 4.0.4)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grid points	30 x 30 x 30
Year of analysis	March 2012 to February 2013*
Centre of analysis (local co-ordinates)	279100, 6203700
CALMET (v. 6.327)	
Meteorological grid domain	20 km x 20 km
Meteorological grid resolution	0.2 km
Vertical levels	0m, 20m, 80m, 120m, 280m, 720m, 1280, 2720, 3280m
Surface meteorological stations	Tahmoor South Meteorological Station - Wind speed - Wind direction - Temperature - Relative humidity - Sea level pressure (from BoM Camden)
Upper air	Prognostic 3D.dat extracted from TAPM at 1 km grid

** Representative and most complete year for analysis at the time of modelling*

7.4 Wind speed and direction

The CALMET generated winds are compared with measured data from the Tahmoor South site (refer to Figure 5.2) and the CALMET wind rose displays very similar characteristics to the measured data with dominant winds from the south-western and north-eastern quadrants. Figure 7.1 shows the annual and seasonal wind roses extracted (from the CALMET generated data).

As discussed in Section 5.2, the average wind speed at the Tahmoor South station was measured to be 1.6 m/s in 2012/2013, with calm conditions (wind speeds less than 0.5 m/s) occurring 24% of the time. The CALMET generated data showed similar average wind speed of 1.6 m/s and percentage of calm conditions occurring 20.9% of the time.

The similarities in both wind speed and directions indicate that the CALMET model is representative of measured conditions at the Project Area.

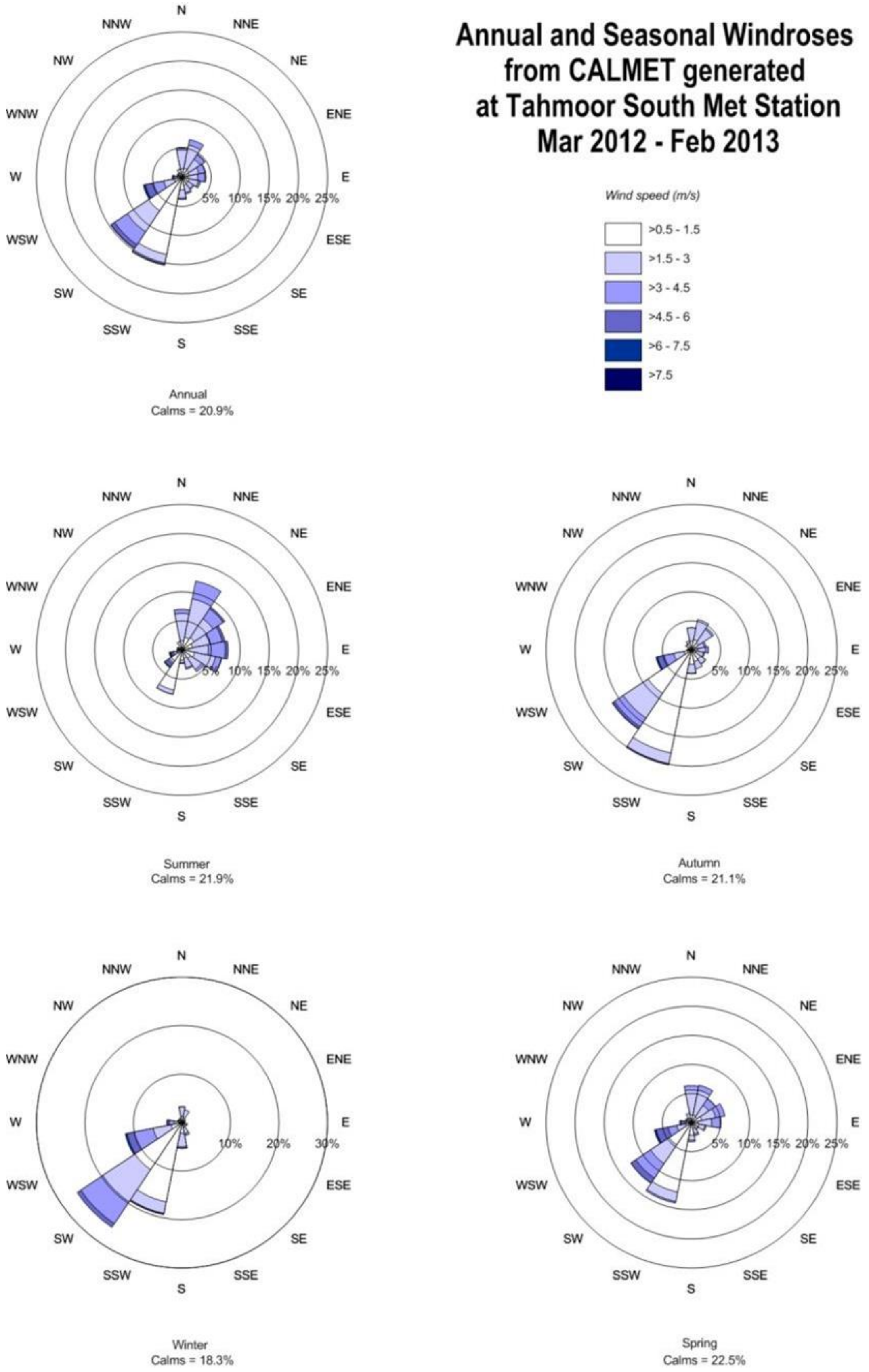

Figure 7.1: Wind roses for CALMET extracted at Project Area

7.5 Atmospheric stability

An important aspect of pollutant dispersion is the level of turbulence in the atmosphere near the ground. Turbulence acts to dilute or diffuse a plume by increasing the cross-sectional area of the plume due to random motion. As turbulence increases, the rate of plume dilution or diffusion increases. Weak turbulence limits diffusion and is a critical factor in causing high plume concentrations downwind of a source. Turbulence is related to the vertical temperature gradient, the condition of which determines what is known as stability, or thermal stability. For traditional dispersion modelling using Gaussian plume models, categories of atmospheric stability are used in conjunction with other meteorological data to describe the dispersion conditions in the atmosphere.

The best known stability classification is the Pasquill-Gifford scheme, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, such as those that commonly occur under clear skies at night and in the early morning. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are closely associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small.

The CALMET-generated meteorological data can be used to estimate stability class for the site and the frequency distribution of estimated stability classes is presented in Figure 7.2. The data show a high proportion of neutral and stable conditions (class D and class F).

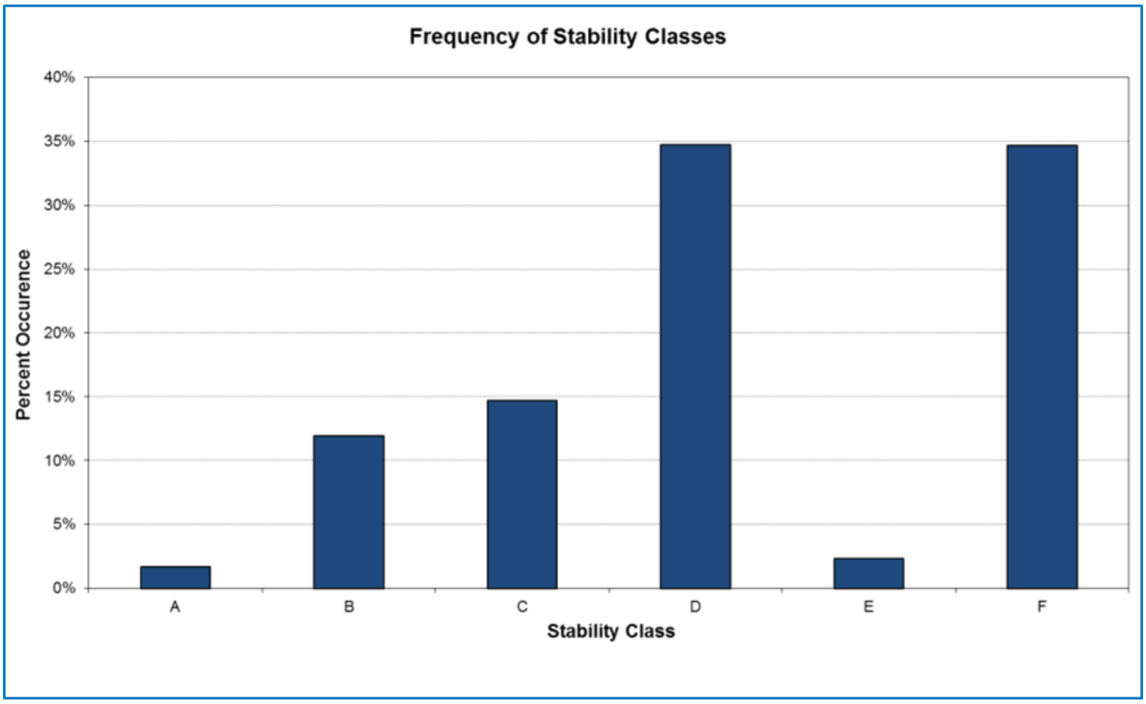

Figure 7.2: Stability Class Frequency (2012/2013)

7.6 Mixing height

Mixing height is defined as the height above ground of a temperature inversion or statically stable layer of air capping the atmospheric boundary layer. It is often associated with, or measured by, a sharp increase of temperature with height, a sharp decrease of water-vapour, a sharp decrease in turbulence intensity and a sharp decrease in pollutant concentration. Mixing height is variable in space and time, and typically increases during fair-weather daytime over land from tens to hundreds of metres around sunrise up to 1–3 km in the mid-afternoon, depending on the location, season and day-to-day weather conditions.

Mixing heights show diurnal variation and can change rapidly after sunrise and at sunset. Diurnal variations in the minimum, maximum and average mixing depths, based on the CALMET-generated meteorological data for the site, are shown in Figure 7.3. As expected, mixing heights begin to grow following sunrise with the onset of vertical convective mixing with maximum heights reached in mid to late afternoon.

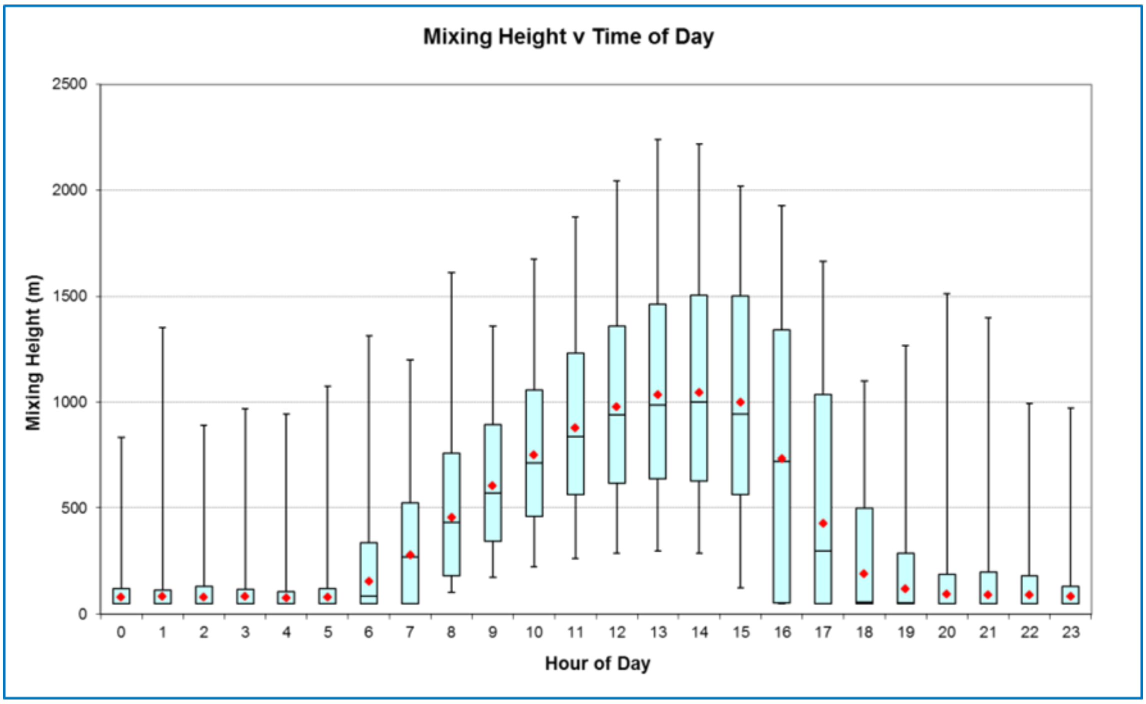

Figure 7.3: Average daily diurnal variation in mixing layer depth

8. MANAGEMENT AND MITIGATION

Current air quality management measures current employed at the existing Tahmoor Mine are described in the Tahmoor Air Quality & Greenhouse Gas Management Plan (AQ & GHGMP) (Tahmoor Underground, 2017). This management plan takes into account the recommendations in the “Particulate Matter Control Best Practise Determination for Tahmoor Colliery” (Tahmoor, 2012) which was required under Licence Condition PRP 24. A surface characterisation study, along with an audit and risk assessment using the Air Quality Minimum Requirements conducted at Tahmoor Mine was conducted in August 2011. Each work area at the site has been categorised and rated for its dust generation risk level without dust controls. The existing controls in each of these work areas include:

- Unsealed roads
  - Watering with a water truck on daily circuit and increased frequency based on weather conditions. If dusty conditions are detected which require watering, personnel to contact CHPP Control Room to notify water truck
  - Chemical dust suppressant applied once a month (more if required)
  - Obsolete roads are ripped and re-vegetated
  - Operators cover loads if the material being hauled is dry (<10% moisture content)
  - Operators avoid overloading and minimise spillage
  - Spillages are regularly cleared off roads
  - Supervisors conduct regular visual inspection at the start of each shift to identify the requirement for modifying operations or calling for additional dust controls
  - Haulage distances are minimised to the extent possible
  - Operators reduce speed to suit road conditions
- Sealed roads
  - Watering with a water truck on daily circuit and increased frequency based on weather conditions. If dusty conditions are detected which require watering, personnel to contact CHPP Control Room to notify water truck
  - Operators cover loads if the material being hauled is dry (<10% moisture content)
  - Operators avoid overloading and minimise spillage
  - Spillages are regularly cleared off roads
  - Supervisors conduct regular visual inspection at the start of each shift to identify the requirement for modifying operations or calling for additional dust controls
  - Haulage distances are minimised to the extent possible
  - Road sweeper utilised if required
- Exposed areas
  - Watering with a water truck on daily circuit and increased frequency based on weather conditions. If dusty conditions are detected which require watering, personnel to contact CHPP Control Room to notify water truck
  - Chemical dust suppressant applied once a month (more if required)
  - Areas not needed are sealed and/or re-vegetated
  - Supervisors conduct regular visual inspection at the start of each shift to identify the requirement for modifying operations or calling for additional dust controls

- Stockpiles (ROM, product and topsoil)

  - Automatic water sprays are triggered by wind speed monitoring at the on-site Weather Station, linked back to CHPP Control. If wind is in excess of 5m/s they are automatically triggered. The CHPP Control Room also has the ability to manually override them so that they may be switch on at any time as required by conditions

  - Watering with a water truck on daily circuit and increased frequency based on weather conditions. If dusty conditions are detected which require watering, personnel to contact CHPP Control Room to notify water truck.

  - Supervisors conduct regular visual inspection at the start of each shift to identify the requirement for modifying operations or calling for additional dust controls.

  - Revegetation of topsoil stockpiles based on a risk based approach.

  - Reduce vehicle traffic and speed around stockpiles until dust controls are implemented.

Following completion of a Particulate Matter Pollution Reduction Program (PRP) (XCN, 2012), where current controls were compared to recommendations of the NSW Coal Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining [Katestone Report] (Donnelly et al, 2011), the top dust generating activities at the existing Tahmoor Mine are:

- Wheel generated dust from paved roads
- Ventilation shaft emissions
- Bulldozing coal
- Bulldozing rejects
- Wind erosion of exposed areas
- Loading coal fines to trucks

Potential additional mitigation measures were also identified in the PRP and were evaluated based on the implementation costs, regulatory requirements, safety implications and compatibility with existing and future developments (e.g. this Project). The additional best practice dust management measures identified are considered to be the most reasonable and feasible for the existing and proposed future operations at Tahmoor (including the proposed Project).

The current Air Quality and GHG Management Plan outlines all the dust management practices on site.

9. EMISSIONS TO AIR

The operation of the Project has been analysed and estimates of dust emissions for the key dust generating activities have been made. Emission factors developed both locally, and by the US EPA, have been applied to estimate the amount of dust produced by each activity. The emission factors applied are considered to be the most reliable, contemporary methods for determining dust generation rates. The mitigation measures identified in Section 8 have been incorporated into the various control factors used for each emission activity.

There are no changes to the existing gas plant and cogeneration plant and it was not considered further in this air quality assessment. Worst case emissions from the flares are detailed in Section 9.5.

9.1 Selection of modelling scenario

The modelling scenario was selected based on the maximum ROM production being sought for approval and the proposed mine production schedule. As Tahmoor is seeking approval for a maximum 4 Mtpa of ROM, it is appropriate that this level be modelled to assess the impacts if this were to occur.

The average yield for product coal over the course of the Project is approximately 73%. Applying this to the maximum ROM extraction of 4 Mtpa results in a product of 2.92 Mtpa. The average yield for rejects over the course of the Project is approximately 30%, resulting in 1.21 Mtpa of rejects. It is noted that the sum of these product and reject rates result in a total of slightly more than 4 Mtpa. However, they do represent values higher than those likely to happen in reality and therefore represent a worst case dust scenario modelled for this assessment. That is, 4 Mtpa ROM, 2.92 Mtpa product and 1.21 Mtpa rejects.

Dispersion modelling results are considered to represent the worst case for the Project at any particular residential receptor for air impacts. Emissions vent shafts and flares are also included in this assessment.

Detailed calculations are provided in Appendix B which provides information on the equations used, the basic assumptions about material properties (e.g. moisture content, silt content etc.), information on the way in which equipment would be used to undertake different mining operations and the quantities of materials that would be handled in each operation.

9.2 Particle size categories

Emission rates of TSP, PM_{10} and $PM_{2.5}$ have been calculated using emission factors developed both within NSW and by the US EPA. Modelling of PM_{10} and $PM_{2.5}$ was undertaken using the particle size specific inventories and was assumed to emit and deposit from the plume in accordance with the deposition rate appropriate for particles with an aerodynamic diameter equal to the geometric mass of the particle size range.

TSP and dust deposition modelling was undertaken by splitting the TSP inventory into three particle size categories. The distribution of particles in each particle size range for TSP and dust deposition modelling is as follows (SPCC, 1986):

- $PM_{2.5}$ (FP) is 0.0468 of the TSP.
- $PM_{2.5-10}$ (CM) is 0.3440 of TSP.
- PM_{10-30} (Rest) is 0.6090 of TSP.

The resultant predicted concentrations are then summed to determine the concentrations of TSP and dust deposition.

9.3 Emission estimates

Estimates of emissions for each source were developed on an hourly time step, taking into account the representative activities that would take place at that location. Thus, for each source, for each hour, an emission rate was determined which depended upon the level of activity and the wind speed. For the current study, the operations were represented by a series of volume sources, with the exception of the upcast ventilation shafts and flares, which were represented as point sources. Sources were positioned according to the location of activities for the modelled (see Figure 9.1). All activities have been modelled for 24 hours per day. The sources allocations as represented in Figure 9.1 are provided in Appendix B.

The information used for developing the inventory has been based on the operational descriptions and mine plan drawings and used to determine haul road distances and routes and stockpile areas, activity operating hours, truck sizes and other details that are necessary to estimate dust emissions.

Table 9.1, Table 9.2 and Table 9.3 summarise the quantities of TSP, PM_{10} and $PM_{2.5}$, respectively, estimated to be released by each activity of the Project for the modelled scenario

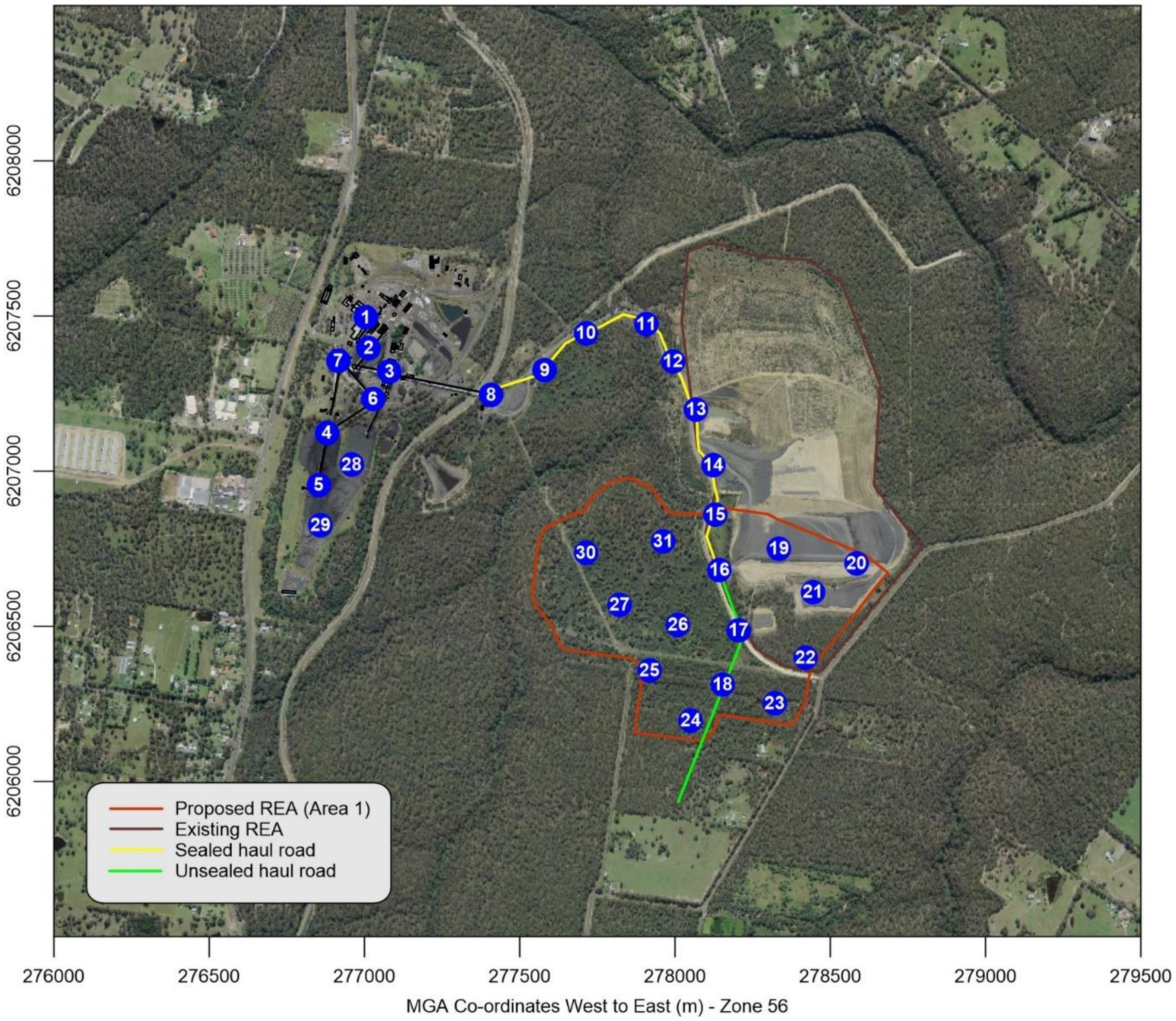

Figure 9.1: Location of sources

Table 9.1: Estimated TSP emissions for the Project

Activity	kg/y
Loading ROM to stockpile (via conveyer)	78
Loading ROM to raw coal bins	313
Wind erosion on ROM Stockpiles	131
Dozers on ROM stockpile	43,007
Unloading conveyer from ROM	286
FEL loading ROM to washery	286
Screening ROM coal	7,500
Crushing ROM coal	1,620
Conveying product coal	108
Unloading conveyer to product coal stockpile	180
Dozers on product coal stockpiles	26,947
Wind erosion on product coal stockpiles	2,453
Conveying rejects for hauling	54
Unloading conveyer for reject hauling	90
Hauling rejects to emplacement areas (sealed road)	15,425
Hauling rejects to emplacement areas (unsealed road)	21,442
Dozers on reject emplacement area (REA)	91,223
Trucks dumping to REA	289
Wind erosion on REA	26,017
Loading product coal to product bin (via conveyor)	108
Unloading coal to product bin	108
Loading coal to trains	108
TOTAL	**237,773**

Table 9.2: Estimated PM_{10} emissions for the Project

Activity	kg/y
Loading ROM to stockpile (via conveyer)	37
Loading ROM to raw coal bins	148
Wind erosion on ROM Stockpiles	66
Dozers on ROM stockpile	10,530
Unloading conveyer from ROM	135
FEL loading ROM to washery	135
Screening ROM coal	2,580
Crushing ROM coal	720
Conveying product coal	51
Unloading conveyer to product coal stockpile	85
Dozers on product coal stockpiles	6,307
Wind erosion on product coal stockpiles	1,226
Conveying rejects for hauling	26
Unloading conveyer for reject hauling	43
Hauling rejects to emplacement areas (sealed road)	2,961
Hauling rejects to emplacement areas (unsealed road)	6,197
Dozers on reject emplacement area (REA)	38,370
Trucks dumping to REA	136
Wind erosion on REA	13,009
Loading product coal to product bin (via conveyor)	51
Unloading coal to product bin	51
Loading coal to trains	51
TOTAL	**82,916**

Table 9.3: Estimated $PM_{2.5}$ emissions for the Project

Activity	kg/y
Loading ROM to stockpile (via conveyer)	6
Loading ROM to raw coal bins	22
Wind erosion on ROM Stockpiles	10
Dozers on ROM stockpile	946
Unloading conveyer from ROM	20
FEL loading ROM to washery	20
Screening ROM coal	1,125
Crushing ROM coal	243
Conveying product coal	8
Unloading conveyer to product coal stockpile	13
Dozers on product coal stockpiles	593
Wind erosion on product coal stockpiles	184
Conveying rejects for hauling	4
Unloading conveyer for reject hauling	6
Hauling rejects to emplacement areas (sealed road)	716
Hauling rejects to emplacement areas (unsealed road)	620
Dozers on reject emplacement area (REA)	2,007
Trucks dumping to REA	21
Wind erosion on REA	1,951
Loading product coal to product bin (via conveyor)	8
Unloading coal to product bin	8
Loading coal to trains	8
TOTAL	**8,539**

9.4 Upcast ventilation shafts

As discussed in Section 2.2.1, the Tahmoor South Project will utilise some of the existing mine's ventilation system. In addition the Project will require the construction of a new upcast ventilation shaft.

9.4.1 *Odour emission testing*

The predictions were based on using the only in-stack odour measurements available, those measured by AECOM and summarised in its July 2010 report (AECOM, 2010). These measurements were conducted in May 2010 during shale oil[2] operations. A number of samples were taken, with the maximum concentration being approximately 609 odour units (OU).

9.4.2 *Particulate matter testing*

Particulate matter concentrations were measured in the existing Vent Shaft No 2 (T2) on 22 December 2008. The measured TSP and PM_{10} concentration at the fan duct was 8.9 mg/m^3 and 0.61 mg/m^3 at standard temperature pressure (i.e. 0°C and 1 atmosphere), respectively.

In the Tahmoor PRP, $PM_{2.5}$ concentration was assumed to be 1.7% of TSP concentration within the vent shaft. This results in a $PM_{2.5}$ concentration of 0.15 mg/m^3.

9.4.3 *Parameters for the vent shafts*

The parameters used for the air dispersion modelling are listed in Table 9.4. The parameters provided are the proposed design for the ventilation stack based on results from previous odour assessments of the existing T2 shaft. The predicted ground level concentrations of particulates from the proposed new vent shaft was combined with other surface mining operations described in Section 9.3 to represent impacts from the Project.

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[2] 'Shale oil operations' refers to occasions when extremely odorous shale oil is exposed in the longwall causing elevated odour emissions through the ventilation shaft.

Table 9.4: Stack design and exit conditions

Parameter	Value
Stack locations (MGA co-ordinates)	277956, 6205738 277980, 6205732
Stack height	30 m
Stack tip diameter (equivalent)	3.9 m
Volumetric flow rate	300 m^3/s
Exit velocity	25 m/s
Exit temperature	22°C
In-stack concentration	609 OU
Peak to mean ratio (for odour only)	2.3
Odour emission rate	420,210 $OU.m^3/s$
Particulates emission rate	
- TSP	2.5 g/s
- PM_{10}	0.17 g/s
- $PM_{2.5}$	0.04 g/s

9.5 Emissions from flaring

The flaring of coal seam methane is a high-temperature oxidation process used to burn gases containing methane. Emissions from flaring include unburned hydrocarbons, CO and NOx. In combustion, gaseous hydrocarbons react with atmospheric oxygen to form carbon dioxide (CO^2) and water. The quantities of hydrocarbon emissions generated relate to the degree of combustion. Properly operated flares achieve at least 98% combustion efficiency in the flare plume, meaning that hydrocarbon and CO emissions amount to less than 2% of hydrocarbons in the gas stream (US EPA, 1995). Similarly, if operated efficiently, the creation of smoke or particles from the flare should be minor. The expected VOC combustion efficiency of the Tahmoor flares is 99% as provided by the supplier.

Modelling flare emissions differs from conventional plumes in that the buoyancy flux is affected due to radiative heat lose during plume rise. Flare emissions can be modelled by replacing Briggs plume rise with numerical plume rise to better account for radiative heat loss, vertical wind shear and ambient temperature stratification, with the “no stack tip downwash” option chosen (Robe, 2009).

The emission parameters adopted for the assessment are given in Table 9.5. Emission estimates have been derived from emission factors presented in the US EPA AP42 for Industrial Flares. Emissions rate calculations have assumed a total potential maximum gas flow of 1,600 L/s per flare. There is estimated to be two flares operational at any time with the third flare used as a backup flare.

The effective stack height and effective stack diameter have been taken as the actual stack height and diameter. This is due to the fact that the proposed flare is enclosed within a flare stack, and the assumption is made that the flare stack dimensions will reflect, on a reasonable basis, the effective release height and plume diameter. The effective exit velocity is set to 10 m/s and the effective exit temperature is set to 1273 K in accordance with typical approaches for modelling flare emissions.

Table 9.5: Emissions and stack parameters – flares

Parameter	Value
Stack locations (MGA co-ordinates)	277175, 6207532 277181, 6207525
Gas flow to flare	1,600 L/s per flare
Stack Height	9 m
Stack Diameter	4.66 m
Exit Velocity	10 m/s
Temperature	1000°C
Mass Emission Rates	
NOx	1.7 g/s
CO	9.5 g/s
VOC	3.6 g/s

9.6 Rail transportation

To ensure fugitive dust emissions from coal transportation are kept to a minimum, Tahmoor is committed to water spraying of the coal surface during train loading, as well as best practice load profiling. A recent study of dust emissions from rail transport at Duralie Coal mine found that the water spray system in place at the train loading facility was very effective in controlling dust emissions from rail transport, achieving 99% control of emissions (Katestone, 2012).

Two recent studies have also been completed for the Australian Rail Track Corporation (ARTC), assessing particulate emissions from coal trains (Environ, 2012 and Katestone, 2013). Both studies investigated particulate matter (PM) emissions from coal trains (loaded and unloaded) compared with emissions from passenger and freight trains. The Environ study found that at one site there was no statistical difference in concentrations across all particulate size fractions for all train types. At the other site, it was concluded that concentrations coinciding with loaded and unloaded coal train passes are statistically higher for PM_{10}, but not other size fractions, compared with concentrations recorded during passenger train passes. There was no statistical difference between loaded coal train and unloaded coal trains.

The Katestone study concluded that loaded coal trains were not associated with a statistically significant difference in PM_{10} and $PM_{2.5}$ compared with concentrations when no train passed. Unloaded coal trains were associated with a statistically significant difference in PM_{10} and $PM_{2.5}$ compared with concentrations when no train passed.

It is noted that for both studies, PM concentrations were recorded at short distances from the track and for short averaging periods to coincide train passes, therefore no quantification of impact at residential areas can be inferred from the studies.

Glencore Coal has also conducted a series of wind tunnel tests on various coal types across its mines in NSW, to determine the potential for coal dust being emitted from loaded coal wagons. The testing simulated travel times, travel speeds and conditions experienced during rail transport from different mines to ports. The research indicated that the moisture content of the coal types tested makes dust emissions from the surface of loaded coal wagons unlikely during transport from the mine to the port.

The research indicates that the emission of coal dust from the surface of loaded coal wagons is unlikely to be a significant source of dust along the rail corridor. Notwithstanding this, Tahmoor is committed to making sure exposed coal in loaded wagons is moistened when loaded to minimise the potential for wind erosion.

To put the potential fugitive emissions from loaded coal trains into context, an estimate has been made as to the levels of PM that may occur. Assuming a loaded train contains a maximum of 45 wagons, each 16.1 m in length and 2 m in width, the total surface area of exposed coal would be just under 1,500 m2 (0.15 ha). Katestone (2012) suggests that if the product is watered as it is loaded to trains, then emissions can be controlled by up to 99%. Assuming a conservative control factor of 50% (allowing time for the coal to dry somewhat en route to Port Kembla), and an emission factor of 0.1 kg/ha/y (USEPA, 1985), then the total windblown dust emissions from loaded coal trains may be of the order of 66 kg/y. Even if no control factor was taken into account this would be approximately 131 kg/y, which constitutes less than 0.1 % of the total annual emissions calculated in Section 9.3 and would be spread across a large area between Tahmoor and Port Kembla. Any resulting ground level concentrations due to this source would therefore be extremely low. Emissions from loaded coal trains are not considered further in this assessment.

9.7 Rainwater tanks

Studies in coal mining areas in Queensland and NSW have investigated the health risks of coal dust deposited on rooftops entering rainwater systems used for potable water supply. The results of the studies have shown that health risks of coal dust entering rainwater systems are low.

Results from leaching tests on numerous coal types in Queensland showed 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) (Lucas et. al, 2009). The ADWG provide the threshold levels considered safe for human consumption.

Additionally, studies in NSW near Stratford and villages remote from mining areas failed to indicate any significant difference in laboratory tested results between the two. Majority of the results were within ADWG with isolated results that exceed aesthetic values for zinc, aluminium and iron. Two results exceeded ADWG for lead but these were believed to be due to poor conditions at the dwelling and tanks (Parkinson and Stimson, 2010).

It is noted, however that all rainwater tanks should be maintained in accordance with the advice outlined in NSW Health's Rainwater Tanks brochure to ensure water is safe for drinking (NSW Health, 2007). Regardless of the above, it is good practice for any rain water system in any location to install a simple first flush system to prevent particulate matter (or any other undesirable materials) that have collected on the roof being washed into the rain water tank.

9.8 $PM_{2.5}$ emissions from neighbouring sources

There are limited $PM_{2.5}$ concentration data available in the vicinity of the Project. Co-located monitors for PM_{10} and $PM_{2.5}$ have been operated by the EPA at a number of locations. The closest EPA monitor to the Project, Camden, has been in operation since December 2012 (refer to Section 6.3.2). The average ratio of $PM_{2.5}/PM_{10}$ across all EPA monitoring sites is 0.4 (EPA, 2012), the same average as at EPA Camden station.

As discussed in Section 6.1.2, the annual average PM_{10} concentration measured at the site is 12.6 µg/m^3. Using a $PM_{2.5}/PM_{10}$ ratio of 0.4 and applying it to the annual average PM_{10} concentration measured at the Tahmoor TEOM of 12.6 µg/m^3, the annual average $PM_{2.5}$ background concentration would be approximately 5 µg/m^3. This is a conservative estimate of background $PM_{2.5}$ concentration and accounts for over 60% of the annual $PM_{2.5}$ advisory reporting standard.

9.9 Background air quality for assessment purposes

To assess impacts against the relevant air quality standards and goals it is necessary to consider the existing dust concentration and deposition levels for the area in which the Project would contribute. The existing background levels account for other sources that are not modelled in the assessment. In this case, background levels are conservative as there will be a contribution from existing operations accounted for in the on-site dust monitoring.

Based on the review of air quality data available (Section 6), the background air quality is taken from either the on-site monitoring station or the closest station to the site with long-term data (i.e. over one year of data available), whichever is relevant for each pollutant. The following background levels are adopted for this assessment:

- Annual Average PM_{10} – 12.6 µg/m^3 (refer to Section 6.3.1)
- 24-hour PM_{10} – varies daily (refer to Section 10.4)
- Annual Average TSP – 18.3 µg/m^3 (refer to Section 6.1.1)
- Annual Average $PM_{2.5}$ – 5 µg/m^3 (refer to Section 6.3.2)
- Dust deposition – 1.4 g/m^2/month (refer to Section 6.1.3)

10. MODELLING RESULTS

Dust concentrations and deposition levels for the selected scenario of assessment are presented as contour plots in this section showing the following:

- Predicted annual average PM_{10} concentration
- Predicted annual average $PM_{2.5}$ concentration
- Predicted annual average TSP concentration
- Predicted annual average dust deposition
- Predicted maximum 24-hour average PM_{10} concentration
- Predicted maximum 24-hour average $PM_{2.5}$ concentration

Dispersion model predictions have been made for the operational mining scenario. Contour plots of particulate concentrations and deposition levels show the areas that are predicted to be affected by dust at different levels. It is important to note that the isopleth figures are presented to provide a visual representation of the predicted impacts. To produce the isopleths it is necessary to make interpolations, and as a result the isopleths will not always match exactly with predicted impacts at any specific location.

The actual predicted particulate concentrations/levels at nearby receptors are presented in tabular form, with private receptors that are predicted to experience levels above the EPA's impact assessment criteria highlighted in bold.

The following sections examine predicted 24-hour PM_{10}, annual average PM_{10}, TSP and dust deposition impacts. A separate cumulative assessment of 24-hour average PM_{10} is provided in Section 10.2.

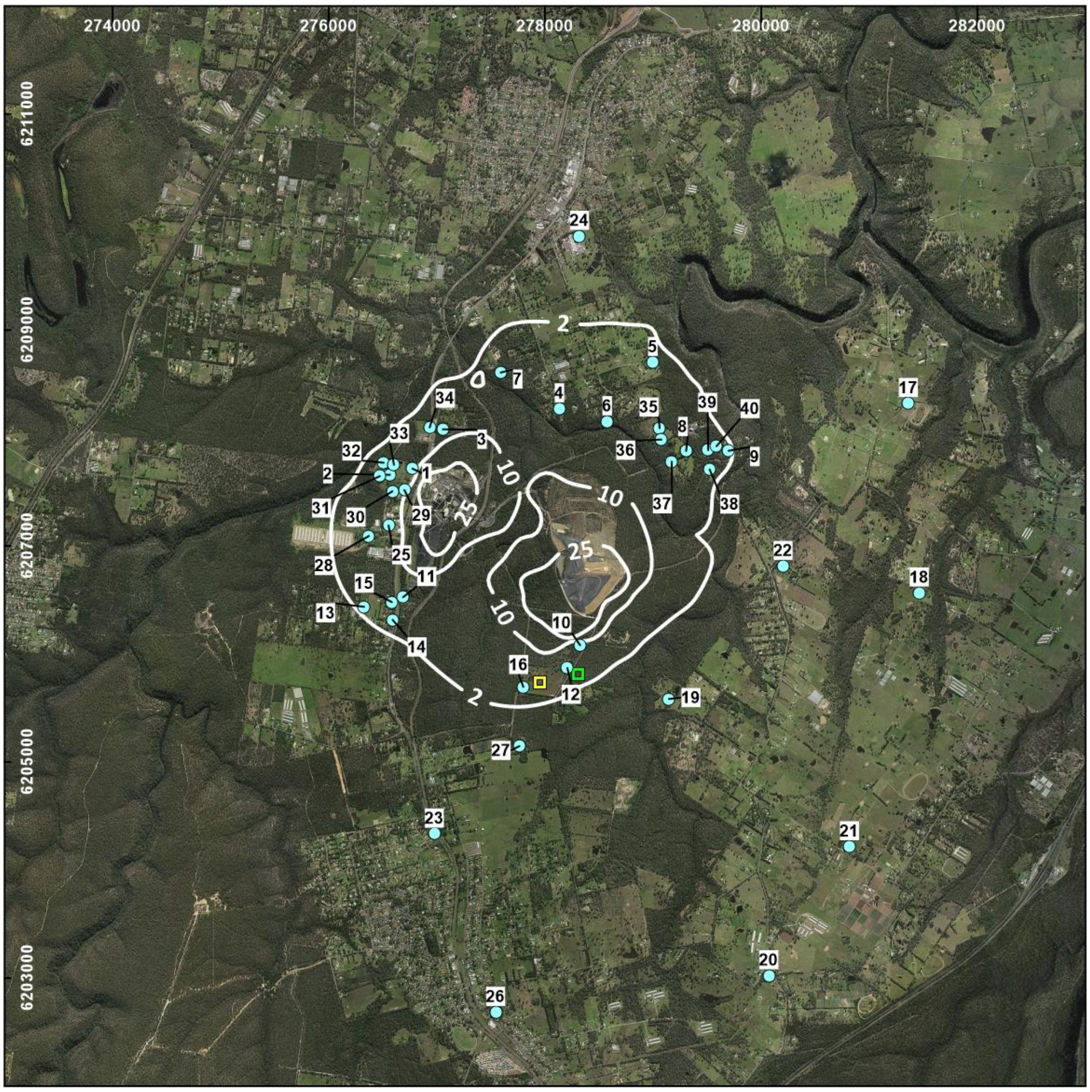
10.1 Annual average particulate predictions

10.1.1 Annual average PM_{10}

A summary of the predicted annual average PM_{10} concentrations at each of the individual receptors is provided in Table 10.1. Figure 10.1 shows the predicted annual average PM_{10} concentrations due to the operations of the Project alone.

It is noted that the background annual average PM_{10} concentration included for the assessment was 12.6 µg/m^3 (discussed in Section 9.9). This is considered to be conservative, accounting for 50% of the annual average PM_{10} criterion of 25 µg/m^3.

No sensitive receptors are predicted to exceed the annual average PM_{10} criterion of 25 µg/m^3. The highest prediction is at R29 with an annual average (mine only) PM_{10} concentration of 9.1 µg/m^3.



Species: PM_{10}	Averaging Time: Annual	Percentile: Maximum	Scenario: Worst case	Location: Tahmoor Mine
Model Used: CALPUFF v6.42	Units: µg/m^3	Assessment criterion: N/A	Met Data: Mar 2012 – Feb 2013 (CALMET)	Plot: J Barnett

Figure 10.1: Predicted annual average PM_{10} concentrations due to emissions due to the Project alone

Table 10.1: Annual average PM_{10} concentrations (μg/m^3)

Receptor ID	Project Only	Cumulative
R1	7.7	20.3
R2	4.7	17.3
R3	6.5	19.1
R4	5.2	17.8
R5	2.7	15.3
R6	4.1	16.7
R7	3.3	15.9
R8	3.6	16.2
R9	2.1	14.7
R10	7.3	19.9
R11	3.8	16.4
R12	3.9	16.5
R13	2.2	14.8
R14	2.4	15.0
R15	3.2	15.8
R16	2.9	15.5
R17	0.3	12.9
R18	0.1	12.7
R19	0.5	13.1
R20	0.1	12.7
R21	0.1	12.7
R22	0.7	13.3
R23	0.4	13.0
R24	0.9	13.5
R25	6.3	18.9
R26	0.1	12.7
R27	1.1	13.7
R28	3.9	16.5
R29	9.1	21.7
R30	6.1	18.7
R31	3.7	16.3
R32	3.2	15.8
R33	4.3	16.9
R34	4.7	17.3
R35	4.0	16.6
R36	4.1	16.7
R37	4.2	16.8
R38	2.9	15.5
R39	2.8	15.4
R40	2.5	15.1

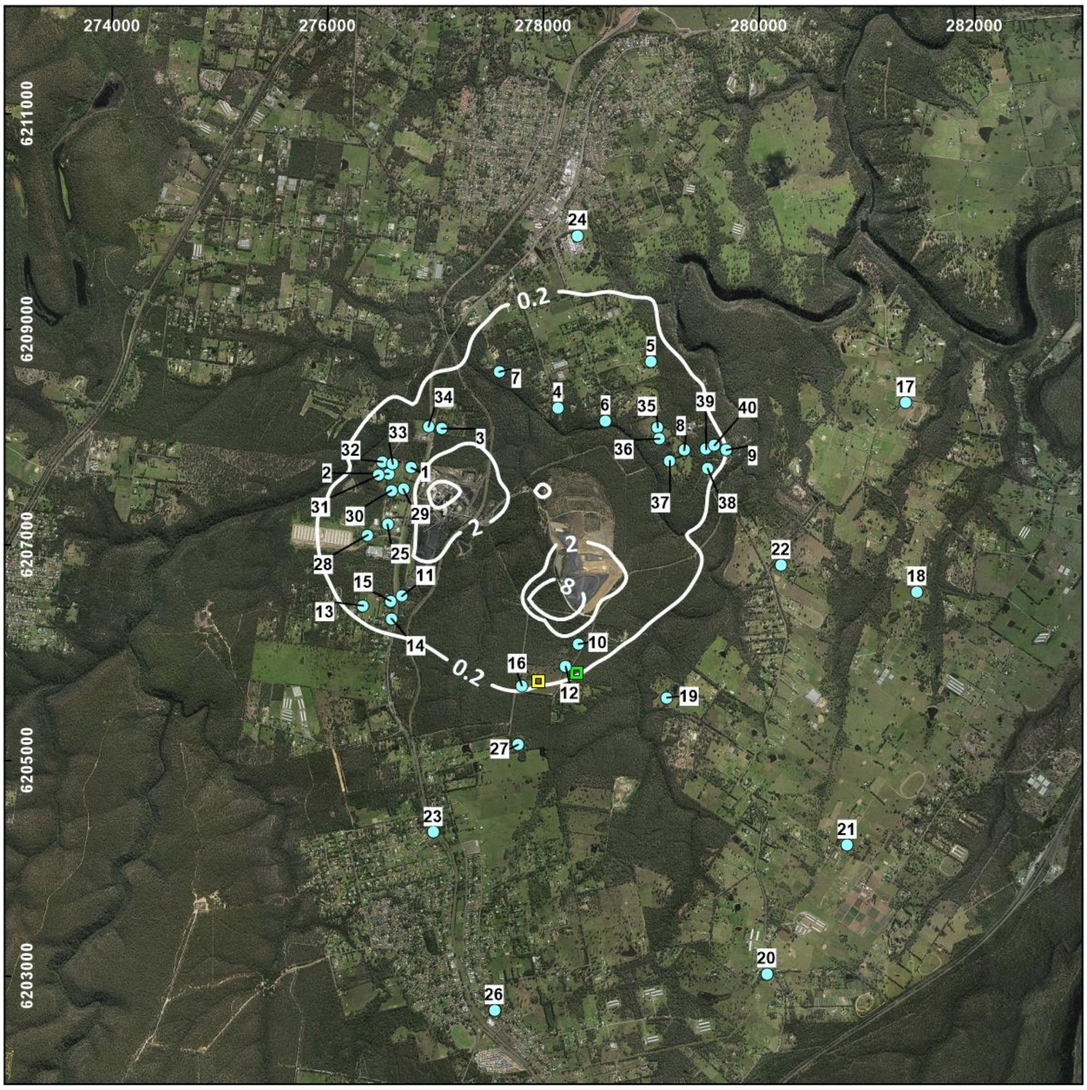
Notes: 16 & 37 Owned by Tahmoor Coal. 25 & 26 are schools

10.1.2 Annual average $PM_{2.5}$

A summary of the predicted $PM_{2.5}$ project only and cumulative annual average concentrations at each of the individual receptors is provided in Table 10.2.

There are no privately owned receptors that are predicted to experience annual average $PM_{2.5}$ concentrations above the criterion, due to emissions from the Project-only and the Project and other sources.

Figure 10.2 shows the predicted annual average $PM_{2.5}$ concentrations due to the operations of the Project alone.



Species: $PM_{2.5}$	Averaging Time: Annual	Percentile: Maximum	Scenario: Worst case	Location: Tahmoor Mine
Model Used: CALPUFF v6.42	Units: µg/m^3	Assessment criterion: N/A	Met Data: Mar 2012 – Feb 2013 (CALMET)	Plot: R Kan

Figure 10.2: Predicted annual average $PM_{2.5}$ concentrations due to emissions due to the Project alone

Table 10.2: Annual average $PM_{2.5}$ concentrations ($\mu g/m^3$)

Receptor ID	Project Only	Cumulative
R1	1.0	6.0
R2	0.6	5.6
R3	0.9	5.9
R4	0.8	5.8
R5	0.3	5.3
R6	0.6	5.6
R7	0.5	5.5
R8	0.3	5.3
R9	0.2	5.2
R10	0.5	5.5
R11	0.4	5.4
R12	0.3	5.3
R13	0.2	5.2
R14	0.2	5.2
R15	0.3	5.3
R16 [1]	0.2	5.2
R17	0.0	5.0
R18	0.0	5.0
R19	0.0	5.0
R20	0.0	5.0
R21	0.0	5.0
R22	0.1	5.1
R23	0.0	5.0
R24	0.1	5.1
R25	0.8	5.8
R26	0.0	5.0
R27	0.1	5.1
R28	0.5	5.5
R29	1.2	6.2
R30	0.8	5.8
R31	0.5	5.5
R32	0.4	5.4
R33	0.6	5.6
R34	0.6	5.6
R35	0.4	5.4
R36	0.4	5.4
R37	0.4	5.4
R38	0.3	5.3
R39	0.3	5.3
R40	0.2	5.2

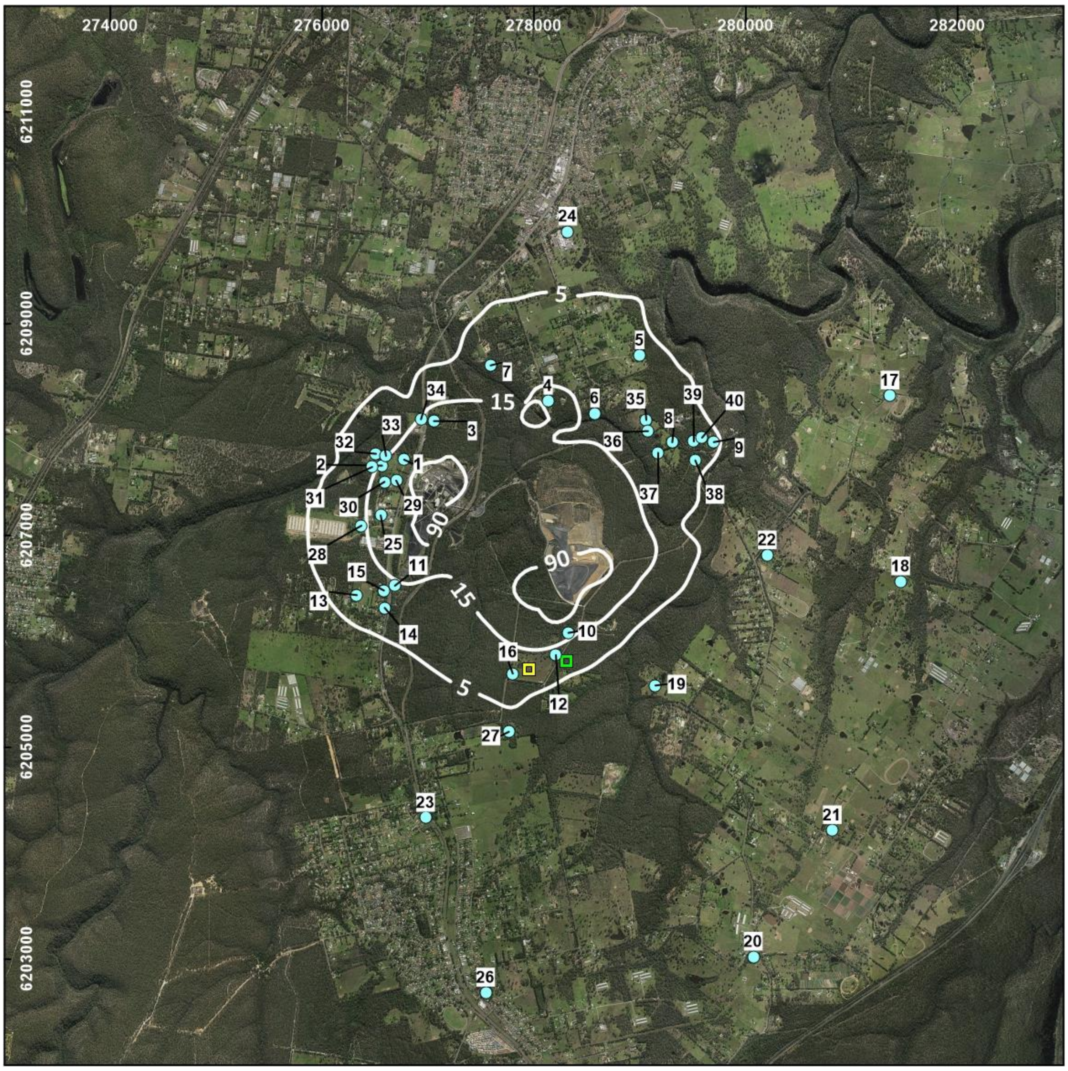
Notes: 16 & 37 Owned by Tahmoor Coal. 25 & 26 are schools

10.1.3 Annual average TSP

A summary of the predicted annual average TSP concentrations at each of the individual receptors is provided in Table 10.3.

There are no privately owned receptors that are predicted to experience annual average TSP concentrations above the impact assessment criterion of 90 µg/m³, due to emissions from the Project-only or Project and other sources.

Figure 10.3 shows the predicted annual average TSP concentrations due to the operations of the Project alone.



Species: TSP	Averaging Time: Annual	Percentile: Maximum	Scenario: Worst case	Location: Tahmoor Mine
Model Used: CALPUFF v6.42	Units: µg/m³	Assessment criterion: N/A	Met Data: Mar 2012 – Feb 2013 (CALMET)	Plot: R Kan

Figure 10.3: Predicted annual average TSP concentrations due to emissions due to the Project alone

Table 10.3: Annual average TSP concentrations (µg/m^3)

Receptor ID	Project Only	Cumulative
R1	26.2	44.5
R2	15.8	34.1
R3	21.2	39.5
R4	16.5	34.8
R5	8.1	26.4
R6	12.8	31.1
R7	10.5	28.8
R8	9.5	27.8
R9	5.4	23.7
R10	18.2	36.5
R11	12.2	30.5
R12	10.3	28.6
R13	7.1	25.4
R14	7.5	25.8
R15	10.2	28.5
R16	7.4	25.7
R17	0.9	19.2
R18	0.5	18.8
R19	1.7	20.0
R20	0.2	18.5
R21	0.3	18.6
R22	2.0	20.3
R23	1.5	19.8
R24	2.8	21.1
R25	21.2	39.5
R26	0.5	18.8
R27	3.7	22.0
R28	13.1	31.4
R29	31.4	49.7
R30	20.6	38.9
R31	12.2	30.5
R32	10.5	28.8
R33	14.5	32.8
R34	15.4	33.7
R35	11.1	29.4
R36	11.2	29.5
R37	11.1	29.4
R38	7.3	25.6
R39	7.4	25.7
R40	6.5	24.8

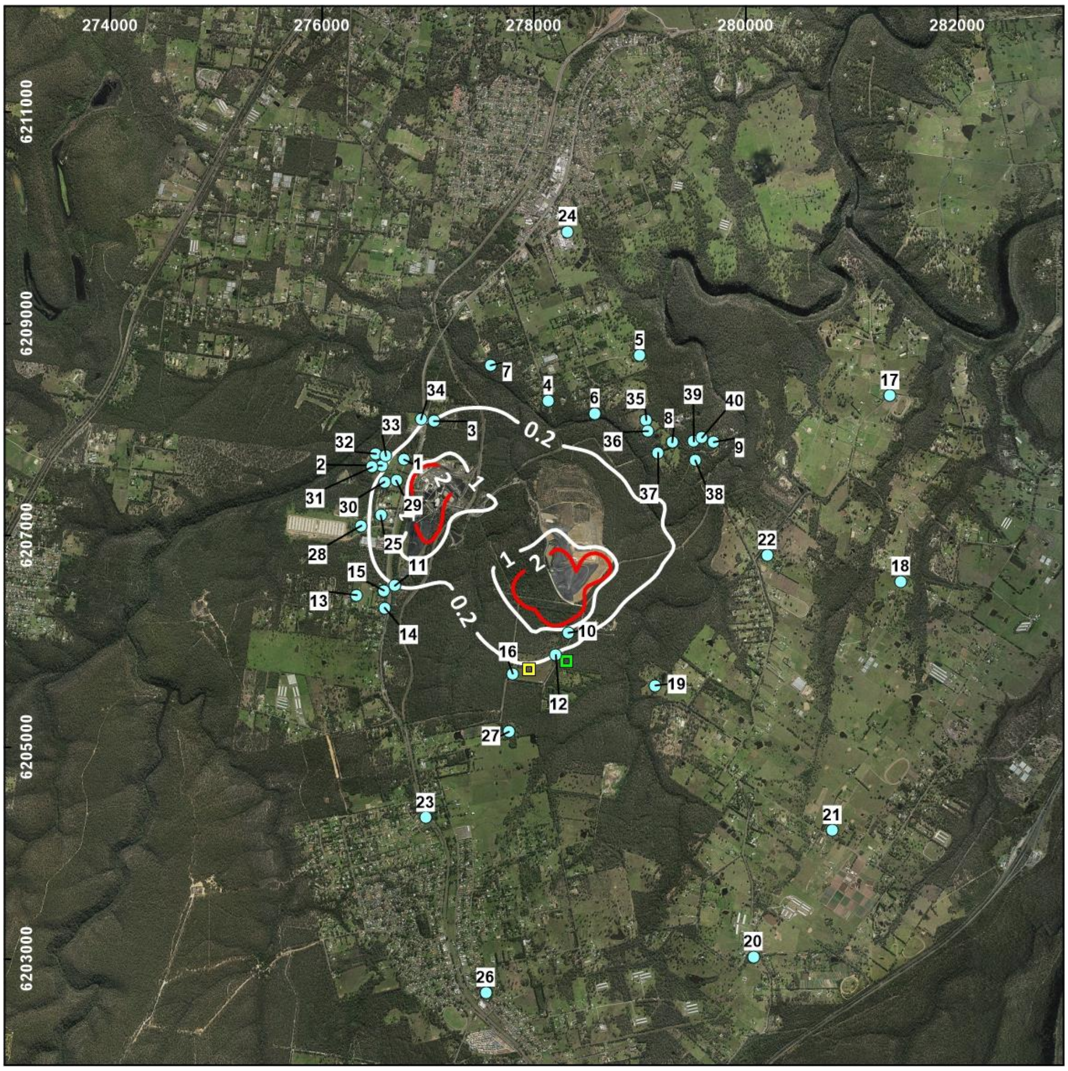
Notes: 16 & 37 Owned by Tahmoor Coal. 25 & 26 are schools

10.1.4 *Annual average dust deposition*

A summary of the predicted particulate concentrations at each of the individual receptors is provided in Figure 10.4.

There are no privately owned receptors that are predicted to experience annual average dust deposition levels above the impact assessment criterion, due to emissions from the Project-only or Project and other sources.

Figure 10.4 shows the predicted annual average dust deposition levels due to the operations of the Project alone.



Species: Dust Deposition	**Averaging Time:** Annual	**Percentile:** Maximum	**Scenario:** Worst case	**Location:** Tahmoor Mine
Model Used: CALPUFF v6.42	**Units:** g/m^2/month	**Assessment criterion:** N/A	**Met Data:** Mar 2012 – Feb 2013 (CALMET)	**Plot:** R Kan

Figure 10.4: Predicted annual average dust deposition levels due to emissions due to the Project alone

Table 10.4: Annual average dust deposition levels (g/m^2/month)

Receptor ID	Project Only	Cumulative
R1	0.3	1.7
R2	0.2	1.6
R3	0.2	1.6
R4	0.2	1.6
R5	0.1	1.5
R6	0.1	1.5
R7	0.1	1.5
R8	0.1	1.5
R9	0.1	1.5
R10	0.4	1.8
R11	0.2	1.6
R12	0.2	1.6
R13	0.1	1.5
R14	0.1	1.5
R15	0.1	1.5
R16	0.1	1.5
R17	0.0	1.4
R18	0.0	1.4
R19	0.0	1.4
R20	0.0	1.4
R21	0.0	1.4
R22	0.0	1.4
R23	0.0	1.4
R24	0.0	1.4
R25	0.3	1.7
R26	0.0	1.4
R27	0.0	1.4
R28	0.2	1.6
R29	0.4	1.8
R30	0.2	1.6
R31	0.1	1.5
R32	0.1	1.5
R33	0.2	1.6
R34	0.2	1.6
R35	0.1	1.5
R36	0.1	1.5
R37	0.1	1.5
R38	0.1	1.5
R39	0.1	1.5
R40	0.1	1.5

Notes: 16 & 37 Owned by Tahmoor Coal. 25 & 26 are schools

10.2 24-hour average PM_{10}

A summary of the predicted particulate concentrations at each of the individual receptors is provided in Table 10.5. Predicted exceedances of the 24-hour average EPA criterion of 50 µg/m^3 are shown in bold.

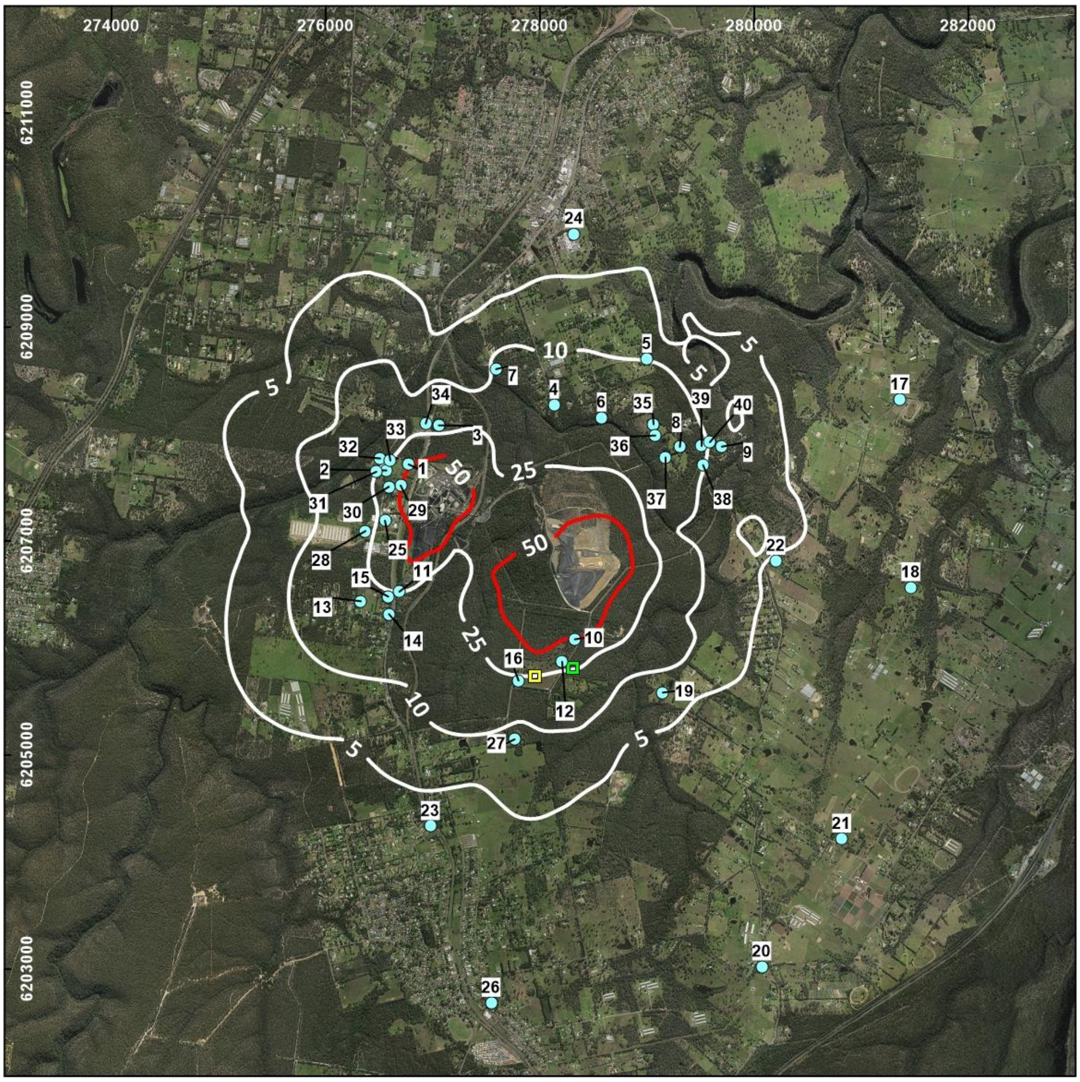
Model predictions show that Receptor 10 is predicted to experience 24 hour average PM_{10} concentrations at the criterion of 50 µg/m^3. This receptor is located in close proximity to the REA area. On investigation, R10 predicted to reach the 24-hour average impact assessment criterion of 50 µg/m^3 on one day of the year, due to the Project operations alone.

Figure 10.5 presents contour plots for the predicted maximum 24-hour average PM_{10} concentrations for the Project-only. The 24-hour average PM_{10} contours presented in Figure 10.5 do not represent a single worst case day, but rather represent the potential worst case 24-hour average PM_{10} concentration that could be reached at any particular location across the entire modelling year.

Table 10.5: 24-hour average PM_{10} concentrations due to the Project alone ($\mu g/m^3$)

Receptor ID	Predicted Concentration
R1	46
R2	28
R3	21
R4	15
R5	10
R6	13
R7	11
R8	15
R9	7
R10	50
R11	23
R12	29
R13	19
R14	18
R15	22
R16	22
R17	2
R18	2
R19	7
R20	1
R21	1
R22	5
R23	3
R24	4
R25	29
R26	1
R27	8
R28	21
R29	48
R30	35
R31	25
R32	19
R33	27
R34	19
R35	16
R36	17
R37	17
R38	10
R39	11
R40	9

Notes: 16 & 37 Owned by Tahmoor Coal. 25 & 26 are schools



Species: PM_{10}	**Averaging Time:** 24-hour	**Percentile:** Maximum	**Scenario:** Worst case	**Location:** Tahmoor Mine
Model Used: CALPUFF v6.42	**Units:** µg/m^3	**Assessment criterion:** 50	**Met Data:** Mar 2012 – Feb 2013 (CALMET)	**Plot:** R Kan

Figure 10.5: Predicted 24-hour average PM_{10} concentrations due to emissions due to the Project alone

10.3 24-hour average $PM_{2.5}$

A summary of the predicted particulate concentrations at each of the individual receptors is provided in Table 10.6.

There are no privately owned receptors that are predicted to experience 24-hour average $PM_{2.5}$ concentrations above the 24-hour advisory reporting standard, due to emissions from the Project-only.

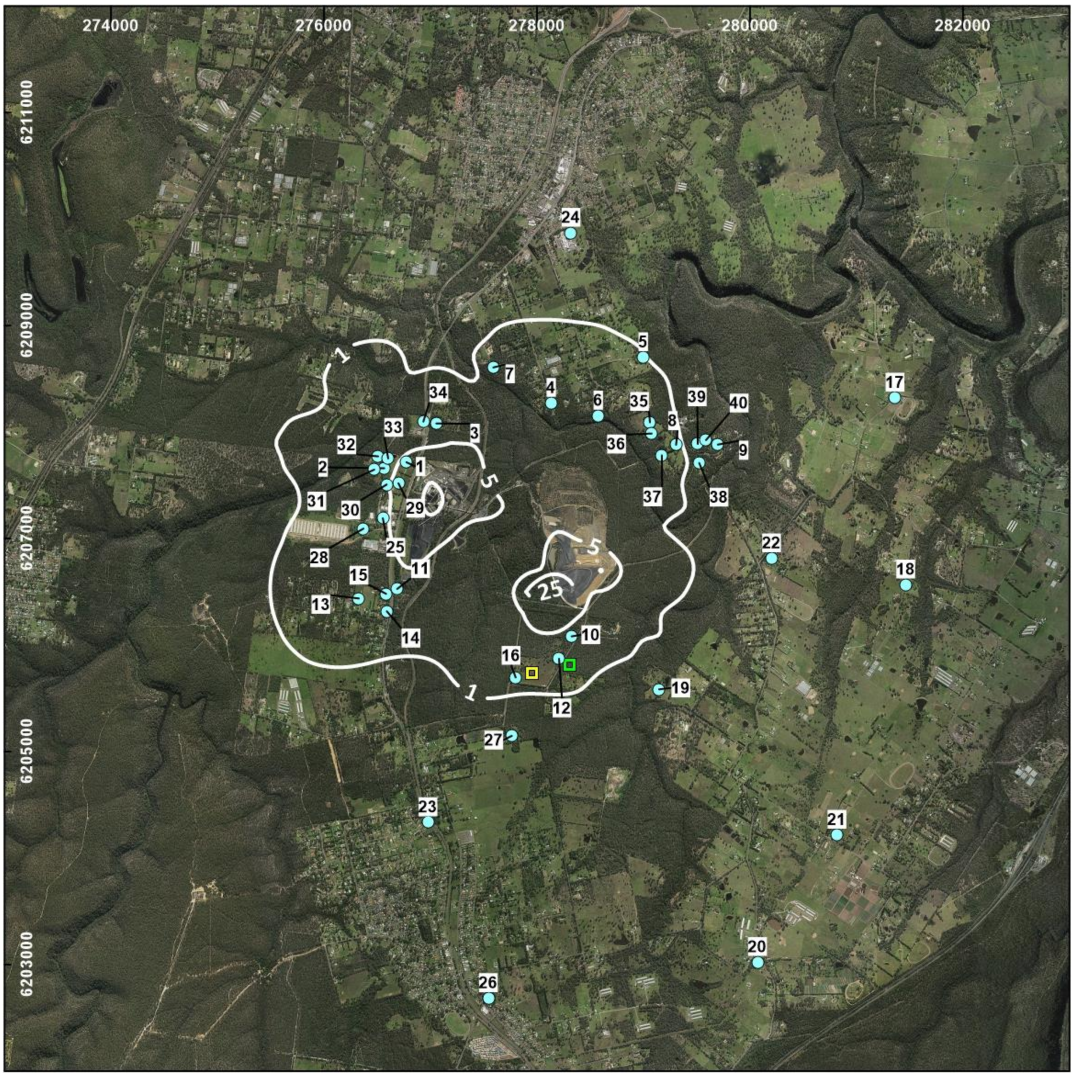
Figure 10.6 presents the contour plot for the predicted maximum 24-hour average $PM_{2.5}$ concentrations for the Project-only.

The 24-hour $PM_{2.5}$ contours do not represent a single worst case day, but rather represent the potential worst case 24-hour average $PM_{2.5}$ concentration that could be reached at any particular location across the entire modelling year. There are no predicted exceedances of the 24-hour average $PM_{2.5}$ concentration at the private receptors due to the Project alone.

Table 10.6: 24-hour Average $PM_{2.5}$ concentrations due to the Project alone ($\mu g/m^3$)

Receptor ID	Predicted Concentration
R1	6
R2	4
R3	3
R4	2
R5	1
R6	1
R7	1
R8	1
R9	1
R10	3
R11	2
R12	2
R13	2
R14	2
R15	2
R16	1
R17	0
R18	0
R19	0
R20	0
R21	0
R22	0
R23	0
R24	0
R25	4
R26	0
R27	1
R28	3
R29	7
R30	5
R31	4
R32	3
R33	3
R34	3
R35	1
R36	1
R37	1
R38	1
R39	1
R40	1

Notes: 16 & 37 Owned by Tahmoor Coal. 25 & 26 are schools



Species: $PM_{2.5}$	Averaging Time: 24-hour	Percentile: Maximum	Scenario: Worst case	Location: Tahmoor Mine
Model Used: CALPUFF v6.42	Units: µg/m^3	Assessment criterion: N/A	Met Data: Mar 2012 – Feb 2013 (CALMET)	Plot: R Kan

Figure 10.6: Predicted 24-hour average $PM_{2.5}$ concentrations due to emissions due to the Project alone

10.4 Cumulative 24-hour average PM_{10} concentrations

10.4.1 Introduction

It is difficult to accurately predict cumulative 24-hour PM_{10} concentration using dispersion modelling due to the difficulties in resolving (on a day-to-day basis) the varying intensity, duration and precise locations of activities at mine sites, weather conditions at the time of the activity, or a combination of activities.

Difficulties in predicting cumulative 24-hour impacts are compounded by the day-to-day variability in ambient dust levels and the spatial and temporal variation in any other anthropogenic activity and natural events e.g. agricultural activity, dust storms, bushfires etc., and including mining in the future. Experience shows that in many cases the worst-case 24-hour average PM_{10} concentrations are strongly influenced by other sources in an area, such as bushfires and dust storms, which are essentially unpredictable. Mining operations also have the potential to contribute to elevated 24-hour average PM_{10} concentrations, however, they are likely to be more localised. The variability in 24-hour average PM_{10} concentrations can be clearly seen in the data collected at the HVAS and TEOM monitors located surrounding the mine (see Section 6).

Due to the difficulties outlined above, cumulative air quality impacts have been evaluated using a statistical approach (Monte Carlo Simulation). This approach has been provided to achieve the objectives of a Level 2 Assessment (i.e. refined dispersion modelling technique using site-specific input data) (see Section 11.2 of (EPA, 2016). The cumulative assessment focuses on representative receptors in key areas in the vicinity of the mine. ERM has received feedback from EPA that if used appropriately, a Monte Carlo approach is an appropriate way to characterise cumulative 24-hr average concentrations from coal mines.

Private receptors were selected for cumulative analysis based on their proximity to the surface operations, and the magnitude of their Project-only predictions (see Section 10.2). Receptors with 24-hour average PM_{10} concentrations above 35 $\mu g/m^3$ as a result of the Project-only were selected for the cumulative analysis. Additional receptors downwind of the predominant wind direction and receptors away from operations were also selected to provide an overview of the potential cumulative 24-hour average PM_{10} impacts.

With regard to 24-hour $PM_{2.5}$, there are no nearby monitoring data to use for a similar analysis. The discussion in Section 6.3.2 notes that all the measured exceedances at the Camden site are related to regional events such as bushfires or hazard reduction burns. It is therefore unlikely that there will be any exceedances of this criterion as a result of the Project.

10.4.2 Cumulative 24-hour PM_{10} model predictions and analysis

The Monte Carlo Simulation is a statistical approach that combines the frequency distribution of one data set (in this case background 24-hour average PM_{10} concentrations) with the frequency distribution of another data set (modelled concentrations at a given receptor). This is achieved by repeatedly randomly sampling and combining values within the two data sets to create a third, ‘cumulative’ data set and associated frequency distribution.

To generate greater confidence in the statistical robustness of the results, the Monte Carlo Simulation was repeated 250,000 times for each of the receptors. In other words, the same 1-year set of predicted (modelled) 24-hour PM_{10} concentrations due to the Project were added to 250,000 variations of the randomly selected background concentrations at each receptor (i.e. a different random background concentration is selected each time).

The on-site TEOM to the operations at Tahmoor South operations was the most representative of the potential impacts. Data from this site (Section 6.1.2) from the period of January 2012 to July 2013 was used for the analysis.

Individual 24-hour predictions for the Project were then added to a random value from the data set. This process is repeated thousands of times yielding the ‘cumulative’ data set, which is then presented as a frequency distribution for the year modelled.

The process assumes that a randomly selected background value would have a chance equal to that of any other background value from the data set of occurring on the given ‘model day’. This is considered to be conservative as high PM_{10} concentrations from other sources are unlikely to occur at the same time as high PM_{10} concentrations at the Project.

However, an analysis of the Monte Carlo method shows that over sufficient repetitions, this yields a good statistical estimate of the combined and independent effects of varying background and Project contributions to total PM_{10}.

The results of this analysis are presented graphically in Figure 10.7. The plots show the statistical probability of 24-hour average PM_{10} concentrations being above the EPA 24-hour average PM_{10} criterion of 50 µg/m^3 and also compare the cumulative probability with the measured background.

Table 10.7 presents a summary of the number of days over for each of the selected receptors and for mine-only and cumulative scenarios. The maximum predicted 24-hour average PM_{10} concentration for the Project alone is shown in Section 10.2.

It is noted that the actual number of exceedances per year due to cumulative impacts cannot be predicted precisely and would depend on actual Project activities, other nearby dust generating activities, weather conditions, implementation of real-time controls and predictive meteorological forecasting, and background levels in the future.

Whilst the actual number of exceedances per year cannot be predicted with certainty, the analysis shows that when cumulative impacts are considered, the probability of exceedance at the selected receptors is between one day to 9 days. The highest predictions occur at Receptor 10 where over nine days of exceedances were predicted. Receptor 10 is in close proximity to the reject emplacement area and additional management may be required to reduce potential dust impacts.

The plot also shows that due to background alone, the 24 hour average PM_{10} criterion would be exceeded on approximately 1 day in the year.

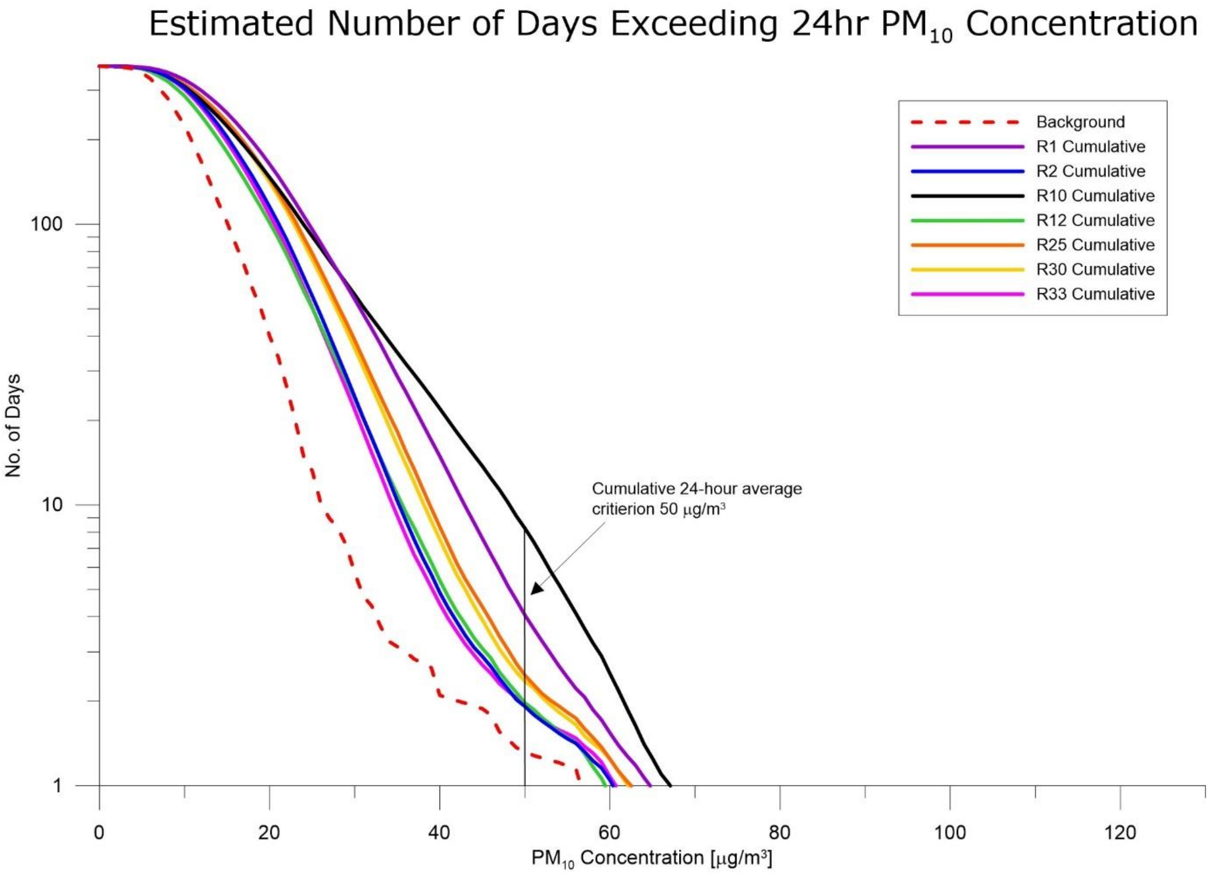


Figure 10.7: Frequency Distribution of 24-hr PM10 concentration (µg/m^3) following Monte Carlo Simulation

Table 10.7: Summary of days over 50 µg/m^3 for mine alone and cumulative scenarios

Receptor ID	Maximum predicted 24-hr PM$_{10}$ Concentration (mine alone)	Predicted Days Over 50 µg/m^3 (mine alone)	Predicted Days Over 50 µg/m^3 (background)	Predicted Days Over 50 µg/m3 (cumulative)
R1	47	0	1	5
R2	29	0	1	2
R10	51	1	1	9
R12	30	0	1	2
R25	30	0	1	3
R30	36	0	1	3
R33	28	0	1	2

10.5 Odour impacts

Contour plots of the 99th percentile odour concentrations are presented in Figure 10.8. The predicted maximum and 99th percentile glc odour concentrations at the residences are summarised in Table 10.8. The results indicate that the 99th percentile odour concentrations are predicted to remain below 7 ou at nearby residences. However, there may be instances during the year when some of the residences in close proximity to the vent shafts experience odour concentrations well above 7 ou from time to time. This can be seen by the maximum value in Table 10.8 which show the peak predictions, but the 99th percentile results are those which need to be compared to the criterion.

Significant odour modelling work was undertaken in 2012 for the existing T2 shaft, due to a history of odour complaints from local residents in Hodgson Grove and Rockford Road. Much of this was done in order to understand the conditions that cause these spikes in odour levels from time to time.

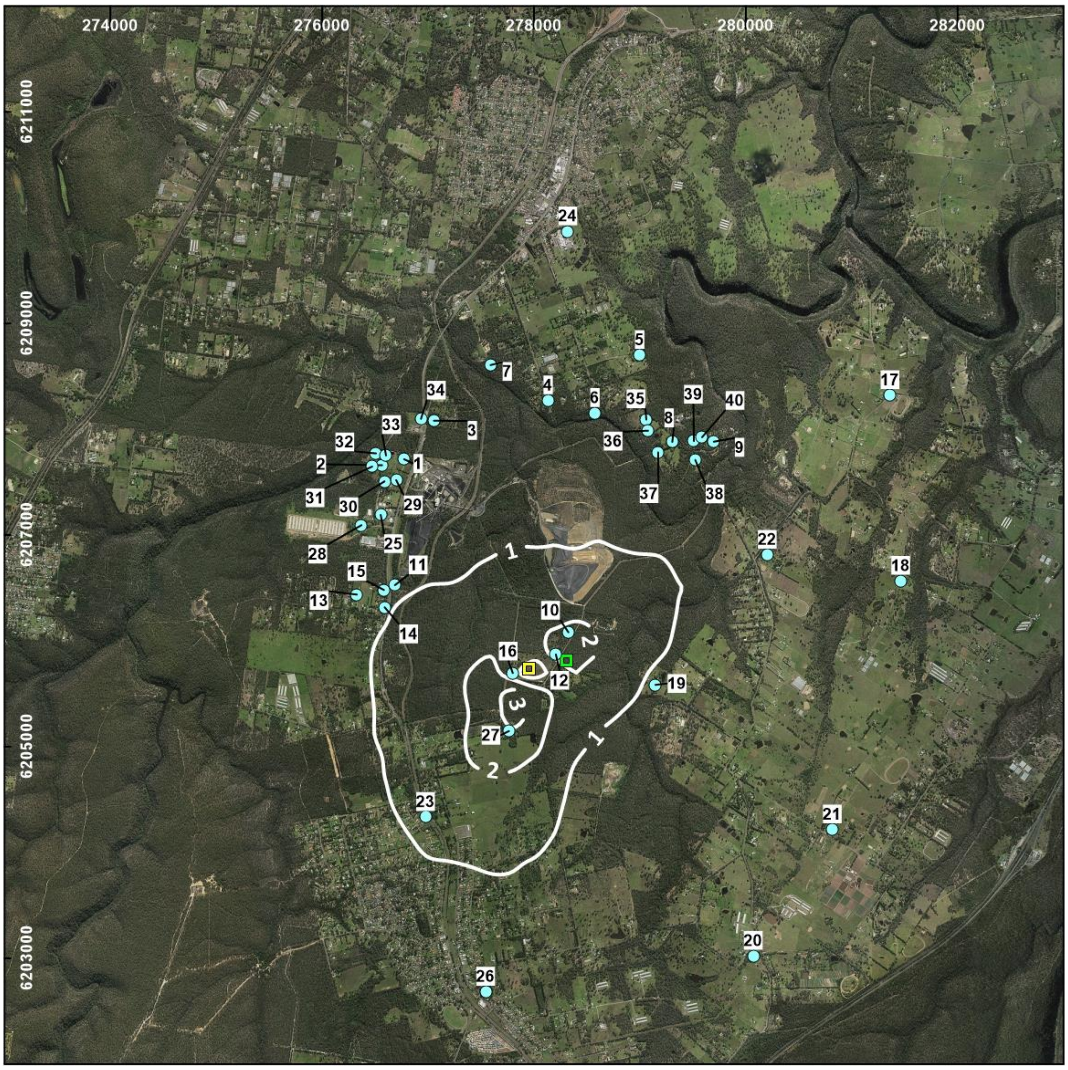
To that end, both dispersion modelling and computational fluid dynamics (CFD) modelling was carried out to test a variety of dispersion conditions and emission parameters. Dispersion modelling was also carried out for specific odour events which occurred in 2012 where odour complaints were received from local residents, when the underground operations came into contact with shale oil which is the source of the offensive odour.

Modelling determined that ground level odour concentrations could be reduced by increasing the height of the vent shaft, as well as significantly increasing the velocity at which the ventilation air is emitted. It was not determined that odour would never be experienced at these nearby residences, but that reductions in the magnitude and frequency could be achieved. Vent shaft T2 does not form part of this assessment as it will only be operated as a backup during times when TSC1 is not available, such as during maintenance periods.

Table 10.8: Odour dispersion modelling results

Receptor ID	Odour level (ou) Assessment 99th criteria = 7 ou (2 ou at R25)	
	Maximum	99th percentile
R1	2	0
R2	1	0
R3	2	0
R4	4	0
R5	2	0
R6	3	0
R7	3	0
R8	2	0
R9	2	1
R10	18	2
R11	3	1
R12	23	2
R13	3	1
R14	3	1
R15	3	1
R16	22	1
R17	2	0
R18	2	0
R19	8	1
R20	1	0
R21	2	0
R22	4	1
R23	8	1
R24	2	0
R25	2	1
R26	2	1
R27	6	3
R28	2	1
R29	3	0
R30	2	0
R31	1	0
R32	1	0
R33	1	0
R34	1	0
R35	2	0
R36	2	0
R37	2	1
R38	2	1
R39	2	0
R40	2	0

Notes: 16 & 37 Owned by Tahmoor Coal. 25 & 26 are schools



Species: Odour	Averaging Time: Nose-response	Percentile: 99th percentile	Scenario: Tahmoor South	Location: Tahmoor Mine
Model Used: CALPUFF v6.42	Units: ou	Assessment criterion: 7	Met Data: Mar 2012 – Feb 2013 (CALMET)	Plot: R Kan

Figure 10.8: Predicted 99th percentile nose-response average ground level odour concentrations

10.6 Other pollutant impacts

As discussed in Section 5, monitoring in the area has shown that CO and NO_2 concentrations have been consistently well below the EPA criteria. CALPUFF was used to predict the impacts of emissions from flaring at the site using emissions discussed in Section 9.5.

Table 10.9 presents a summary of the predicted impacts at the private receptors. The predicted 1-hour and 8-hour average for CO is well below their respective EPA criterion of 10 mg/m^3 and 30 mg/m^3.

The predicted NOx concentrations were assumed to be 100% NO_2, which is very conservative. The results indicate that even if all NOx emissions from the flares converted to NO_2, the predicted concentrations are still well below the 1-hour average and annual average criteria of 246 µg/m^3 and 62 µg/m^3, respectively.

The US EPA provides speciation of emissions from flaring of natural gas and the emissions consist of 30% ethane, 20% formaldehyde, 20% methane and 30% propane (US EPA, 2013). The highest predicted hydrocarbon concentration is at receptor 35 of 52 µg/m^3. Assuming that 20% is formaldehyde, the predicted concentration of 10.4 µg/m^3 is well below the EPA 1-hour average formaldehyde criterion of 20 µg/m^3.

Table 10.9: NO_2, CO and HC predicted impacts due to flares

Receptor	Carbon Monoxide (mg/m^3)		Nitrogen Dioxide (µg/m^3)		Hydrocarbon (µg/m^3)
	1-hour	8-hour	1-hour	Annual	1-hour
Criteria	10	30	246	62	-
R1	0.04	0.021	7	0.08	16
R2	0.07	0.016	12	0.07	25
R3	0.09	0.015	15	0.05	32
R4	0.06	0.011	11	0.07	24
R5	0.05	0.009	10	0.07	20
R6	0.08	0.011	14	0.08	29
R7	0.07	0.011	12	0.03	26
R8	0.03	0.006	5	0.04	11
R9	0.03	0.005	5	0.04	11
R10	0.03	0.004	6	0.02	12
R11	0.02	0.007	4	0.07	8
R12	0.03	0.004	6	0.02	12
R13	0.02	0.006	4	0.05	9
R14	0.02	0.007	4	0.06	9
R15	0.02	0.007	4	0.06	8
R16	0.03	0.008	5	0.03	11
R17	0.02	0.004	4	0.03	9
R18	0.02	0.003	3	0.02	7
R19	0.01	0.004	2	0.02	5
R20	0.01	0.003	2	0.02	4
R21	0.01	0.003	2	0.01	5
R22	0.04	0.006	8	0.02	16
R23	0.01	0.005	3	0.04	6
R24	0.05	0.006	8	0.02	17
R25	0.05	0.014	8	0.07	17
R26	0.01	0.003	2	0.03	5
R27	0.007	0.0002	4	0.03	9
R28	0.05	0.009	10	0.05	21
R29	0.06	0.026	10	0.12	21
R30	0.07	0.018	12	0.09	25
R31	0.07	0.014	12	0.06	25
R32	0.05	0.013	10	0.05	21
R33	0.05	0.015	9	0.06	20
R34	0.07	0.013	13	0.04	27
R35	0.14	0.018	25	0.06	52
R36	0.09	0.013	16	0.06	35
R37	0.04	0.007	6	0.04	13
R38	0.03	0.006	6	0.04	13
R39	0.03	0.005	6	0.04	12
R40	0.03	0.005	6	0.04	13

Notes: 16 & 37 Owned by Tahmoor Coal. 25 & 26 are schools

11. MONITORING AND MANAGEMENT

The Monte Carlo simulation as described in Section 10.4.2 found that there is a possibility of increase in PM_{10} concentrations and number of days over the 24-hour criterion when impacts are considered cumulatively.

Existing and proposed mitigation measures are discussed in detail in Section 8. One of the largest sources of emissions is dozers on stockpiles at the pit top area and no control measures were applied in the emissions inventory to dozer sources. The use of water sprays on the stockpiles will assist in reducing dust impacts when dozers are working in the stockpile area.

Tahmoor Coal has established a reactive and predictive Air Quality Control System to manage dust impacts at Tahmoor. The reactive and predictive system includes daily alerts for site personnel of meteorological conditions and predicted daily dust risk over the site and at nominated receptors around the site.

Tahmoor Coal also sets meteorological triggers and associated contingency actions, documented within a trigger action response plan (TARP). Visual triggers are already applied at Tahmoor Mine for wheel generated dust on unsealed roads and for truck dumping.

The site has developed a TARP to integrate visual triggers for truck activity on unsealed roads. Additional measures involve the extension of the TARP to cover other mining activities including dozer and loader operations, in addition to wind-blown dust from exposed areas.

The implementation of the TARP and other measures, especially at the pit top, will result in reduced emissions in practice and therefore likely lower concentrations than those predicted at the closest receptors, such as R1 and R25 across Remembrance Driveway opposite the surface facilities.

12. CONSTRUCTION AND OTHER IMPACTS

The main air pollution (and amenity) issues at construction sites are dust deposition (soiling), visible dust plumes, elevated PM_{10} concentrations due to dust-generating activities, and emissions from diesel-powered construction equipment. Sensitive receptors (e.g. residential dwellings) close to the site will be most sensitive to construction dust, but these are likely to be short-term.

Emissions can occur during the preparation of the land (e.g. demolition, land clearing, and earth moving) and during construction itself, and can vary substantially from day to day depending on the level of activity, the specific operations being undertaken, and the weather conditions. A significant portion of the emissions results from site plant and road vehicles moving over temporary roads and open ground. If mud is tracked onto local public roads, dust emissions can occur at some distance from the construction site. However, the evidence on the distance over which impacts may occur is limited (IAQM, 2012).

12.1 Construction of mine ventilation shaft

Two new ventilation shafts will be constructed as part of the Project. The construction of the ventilation shafts will require the disturbance of a footprint of between four to six hectares in area at each location.

The construction of each of the proposed ventilation shafts will involve the following:

- Construction of access roads to each vent shaft site off the existing road network.
- Establishment of the construction site to allow sufficient space for stockpiling of shaft liners for TSC1 and TSC2, temporary spoil emplacement, water management, storage and safe movement on-site during construction activities.
- Establishment of the ventilation shaft site will involve:
    - Installation of environmental controls such as silt fences, fencing with lockable gates, as well as display of signage relating to restricted entry.
    - Clearing of vegetation and stripping of topsoil. Topsoil will be temporarily stockpiled for rehabilitation post construction.
    - Excavation and construction of a hardstand area for operation of drilling equipment. The hardstand footprint will be approximately four to six hectares.
    - Connection of 66 kV electrical power and establishment of electrical substations at each ventilation shaft site.
    - Shaft sinking using blind boring methods, and lining of the shafts using a composite concrete and steel liner.
    - Installation of ventilation fans at upcast shaft site TSC2. The upcast shaft site fans will also incorporate a fan outlet flue, approximately 30 metres high, to minimise any odours discharge from the mine ventilation return air.

The shaft construction sites will incorporate water treatment sedimentation controls, with the final water treatment from the ventilation shaft being pumped via overland pipeline to a final sedimentation pond on the surface facilities area for further treatment and discharge though LDP1.

12.2 Construction of additional reject emplacement area

The existing REA will be expanded onto adjacent areas to accommodate the reject material associated with the proposed development (Figure 3.2). The expansion area is anticipated to cover up to an additional 40 hectares, providing an additional emplacement capacity of approximately 12 million tonnes for the rejects generated during the operation of the proposed development.

Construction and maintenance of new internal haul roads will be required to and around the REA to cater for the REA expansion.

The stormwater management system and infrastructure at the existing REA will be augmented with the construction of additional sedimentation dams, drains and pumping station.

12.3 Estimation of construction emissions

It is noted that the key construction activities may not occur simultaneously, for example construction of the reject emplacement area will be progressive throughout the life of the Project and upgrade of surface infrastructure will occur in the early preparation stages of the Project. The activities are also located well apart in separate areas.

An emissions inventory for construction activities has been generated and estimated PM_{10} emissions are compared with emissions during mining (Table 12.1). Table 12.1 shows that estimated PM_{10} emissions for each construction activity are less than the three mining scenarios as assessed in the report.

Should all construction activities occur simultaneously with mining operations this would increase the estimated emissions for the modelled of the Project by approximately 10-12%. This increase in emissions would not significantly change the model predictions presented in Section 10. Additionally, the construction activities are unlikely to all happen at the same time.

Table 12.1: Estimated PM_{10} emissions for construction activities

Construction Activity	Estimated PM_{10} Emissions (kg/y)
Construction of ventilation shaft (per ventilation shaft)	3,980
Construction of a reject emplacement area	2,105
Upgrade of surface facilities	5,386

13. CONCLUSIONS

Mine plans for the predicted 'worst-case' air quality impact scenario of the proposed Project have been analysed and detailed emissions inventories have been prepared. Dispersion modelling was conducted to predict the ground level concentrations (glcs) for all relevant pollutants.

Cumulative impacts were also considered, taking into account other dust generating sources in the area from ambient dust monitoring. Model predictions at privately owned residential receptors were compared with applicable air quality criteria.

Dispersion modelling results indicate that one private receptor (R10), in close proximity to the REA, is predicted to experience maximum 24-hour average PM_{10} concentrations above 50 $\mu g/m^3$, due to the Project's operations alone. Importantly, this receptor is predicted to exceed the 24-hour average impact assessment criterion on only one day of the year as a result of emissions from the Project.

A Monte Carlo Simulation was completed to assess cumulative PM_{10} 24-hour impacts at the most affected receptor locations. The analysis concluded that there was a probability that the selected receptors may exceed the EPA criterion of 50 $\mu g/m^3$ when impacts are considered cumulatively. The receptor with the highest estimated number of days exceeding the 24-hour average PM_{10} criterion was at R10. However, with the incorporation of the TARP and other dust management practices, these exceedances would be well managed.

There are unlikely to be any additional exceedances of the cumulative 24-hour $PM_{2.5}$ criterion due to the Project. Measured exceedances are the result of regional events such as bushfires and hazard reduction burns and the contribution from the Project is low.

There are no sensitive receptors that are predicted to experience annual average $PM_{2.5}$, PM_{10}, TSP concentration or dust deposition levels above the EPA assessment criteria, either from the Project alone or cumulatively.

Potential impacts from construction were assessed and are considered to be low. Emissions from flaring and the ventilation vents were also assessed. The potential NO_2, CO and HC impacts from flaring were all well below their respective EPA criterion. Odorous emissions from the ventilation vents were considered and the results indicate that the 99th percentile odour concentration limit of 7 ou will not be exceeded at the nearby residences. However, there may be peak periods where higher concentrations of odour may be detected at the closest receptors from time to time.

Generally, the predictions presented in this report incorporate a level of conservatism due to worst case assumptions and the inherent conservative nature of dispersion modelling. As a result, it is expected that actual ground level concentrations would be lower during the normal operation of the Project. Notwithstanding, it is proposed that the emissions would be managed day-to-day using Tahmoor Coal's reactive and predictive management system.

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APPENDIX A RECEPTOR DETAIL

Assessment ID	Address	Lot Number and DP	X (MGA)	Y (MGA)
R1	2 Olive Lane	Lot 1 DP877585	276807	6207692
R2	4 Olive Lane	Lot 7 DP1029837	276565	6207661
R3	2897 Remembrance Driveway	Lot 201 DP733965	277055	6208049
R4	130 Stratford Road	Lot 8 DP3306	278133	6208273
R5	7 Hodgson Grove	Lot 134 DP879762	278979	6208660
R6	20 Dietrich Road - PO Box 119 Tahmoor	Lot 5 DP3306	278575	6208154
R7	84 Stratford Road	Lot 14 DP3306	277589	6208607
R8	250 Rockford Road	Lot 45 DP751270	279305	6207881
R9	11 Kammer Place	Lot 22 DP777104	279697	6207883
R10	215 Charlies Point Road	Lot 2231 DP787222	278324	6206082
R11	3085 Remembrance Driveway	Lot 34 DP654711	276686	6206527
R12	185 Charlies Point Road	Lot 216 DP751250	278206	6205872
R13	30 Caloola Road	Lot 10 DP25735	276327	6206438
R14	3092 Remembrance Driveway	Lot 14 DP656820	276589	6206318
R15	3076 Remembrance Driveway	Lot 18 DP656823	276611	6206479
R16	115 Charlies Point Road	Lot 217 DP751250	277799	6205697
R17	60 Lyrebird Road, Pheasants Nest 2574	Lot 3 DP791071	281361	6208323
R18	45 Knox Road, Pheasants Nest 2573	Lot 3 DP264153	281462	6206568
R19	70 Warrobyn Road, Bargo	Lot 10 DP605241	279146	6205585
R20	70 Hinkler Ave Bargo 2574	Lot 1 DP202891	280070	6203024
R21	105 Dwyers Road, Pheasants Nest	Lot 9 DP 616757	280816	6204218
R22	10 Pheasants Nest Rd, Pheasants Nest	Lot 7 DP243112	280202	6206815
R23	Edge of Bargo township closest to site	-	276976	6204336
R24	Edge of Tahmoor township closest to site	-	278319	6209871
R25 (Anglical College)	Remembrance Driveway	Lot 12 DP1122904	276552	6207191

R26 (Bargo Public School)	Great Southern Road	Lot 1 DP782052	277543	6202685
R27	80 Charlies Point Road	Lot 228 DP751250	277763	6205148
R28	3030 Remembrance Driveway	Lot 2 DP213596	276370	6207094
R29	1 Olive Lane	Lot 2 DP877585	276698	6207520
R30	5 Olive Lane	Lot 4 DP1010127	276588	6207508
R31	7 Olive Lane	Lot 5 DP1010127	276471	6207648
R32	6 Olive Lane	Lot 6 DP1029837	276508	6207772
R33	4 Olive Lane	Lot 7 DP1029837	276602	6207753
R34	2900 Remembrance Driveway	Lot 2063 DP1014538	276932	6208099
R35	230 Rockford Road	Lot 454 DP751270	279060	6208092
R36	230 Rockford Road	Lot 454 DP751270	279076	6207987
R37	260 Rockford Road	Lot2 DP1037712	279172	6207783
R38	280 Rockford Road	Lot10 DP775465	279522	6207710
R39	285 Rockford Road	Lot1 DP725580	279509	6207889
R40	5 Kammer Place	Lot21 DP777104	279586	6207925

APPENDIX B ESTIMATION OF EMISSIONS

B1 ESTIMATION OF EMISSIONS

The dust emission inventories have been prepared using the operational description of the proposed mining activities provided by the proponent.

Estimated emissions are presented for all significant dust generating activities associated with the operations. The relevant emission factors used for the study are described below. Activities have been modelled for 24 hours per day.

Dust from wind erosion is assumed to occur over 24-hours per day, however, wind erosion is also assumed to be proportional to the third power of wind speed. This will mean that most wind erosion occurs during the day when wind speeds are highest.

B1.1 Hauling material/product on unsealed surfaces

The emission estimate of wheel generated dust presented in the EA is based the US EPA AP42 emission factor for unpaved surfaces at industrial sites shown below:

$$E = 0.2189 \times \left[\left(\frac{s}{12}\right)^{a} \times \left(\frac{W \times 1.1023}{3}\right)^{b}\right] (kg|VKT)$$

Where:

$k = 4.9$ for TSP, 1.5 for PM_{10} and 0.15 for $PM_{2.5}$

$a = 0.7$ for TSP and 0.9 for PM_{10} and $PM_{2.5}$

$b = 0.45$ for TSP, PM_{10} and $PM_{2.5}$

s = silt content of road surface (%)

W = mean vehicle weight (t)

The adopted silt content (s) for the Project was 9%. This silt content is the silt content provided in the Tahmoor Air Quality Management Plan.

The mean vehicle weight used in the emissions estimates is an average of the loaded and unloaded gross vehicle mass, to account for one empty trip and one loaded trip. The trucks used in the assessment are equivalent of a CAT 775G with a capacity of 64 tonnes. The full (GVM) is 112 tonnes and was assumed to be 48 tonnes when empty. Therefore, a mean vehicle weight of 80 tonnes was assumed in the assessment.

A control factor of 80% has been applied as the haul roads will be watered with watering carts.

B1.2 Dozers working on coal

The US EPA (1985 and updates) emission factor equation has been used. It is given below in Equation 1.

Equation 1

$$E = k \times \frac{s^a}{M^b} \left({}^{kg}/_{hr} \right)$$

Where,

k = 35.6 for TSP, 6.33 for PM_{10} and 0.7832 for $PM_{2.5}$

a = 1.2 for TSP and $PM_{2.5}$ and 1.5 for PM_{10}

b = 1.3 for TSP and $PM_{2.5}$ and 1.4 for PM_{10}

s = silt content

M = moisture content.

The silt content for the different materials were given by the client and are as shown below.

Material type	Moisture (%)	Silt (%)
ROM Coal	5	5
Product Coal	8	5
Rejects at REA	10	38

B1.3 Loading/unloading coal by trucks

The US EPA (1985 and updates) emission factor equation has been used. It is given below in Equation 2.

Equation 2

$$E = \frac{k}{M^{a}}(kg|t)$$

Where,

k = 0.58 for TSP, 0.0447 for PM_{10} and 0.01102 for $PM_{2.5}$

a = 1.2 for TSP and $PM_{2.5}$ and 0.9 for PM_{10}

M = moisture content (%)

The moisture content of the coal was assumed to be as per table below.

Material type	Moisture (%)
ROM Coal	5
Product Coal	8
Rejects transported via conveyor	7
Rejects transported by trucks	5

B1.4 Transfer/unloading of coal via conveyor

Each tonne of material transferred via conveyors will generate a quantity of dust that will depend on the wind speed and the moisture content. Equation 3 shows the relationship between these variables.

Equation 3

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

Where,

k = 0.74 for TSP, 0.35 for PM_{10} and 0.053 for $PM_{2.5}$

U – wind speed (m/s)

M – moisture content (%)

The moisture content has been taken to be the same as for Equation 2. A control factor of 70 % has been applied as the conveyors will be enclosed.

B1.5 Crushing coal

The emission factor used for crushing has been taken to be 0.0027 kg/t (US EPA, 1985 and updates). A control factor of 85% has been applied which includes water sprays on the crusher and located within a building.

B1.6 Screening coal

The emission factor used for crushing has been taken to be 0.0125 kg/t (US EPA, 1985 and updates). This factor has been applied for controlled screening which includes water sprays and located within a building.

B1.7 Wind erosion

The latest wind erosion equation made available from the US EPA (1985 and updates) requires information on the threshold frictional velocity for the surface of the exposed area.

As this information is not available the default emission factor of 0.1 kg/ha/h (SPCC, 1983) has been used to estimate TSP emissions for wind erosion. For PM_{10} this is multiplied by a factor of 0.5 and for 0.075 for $PM_{2.5}$.

A control of 50% has been applied to the stockpiles and the REA for the use of water sprays.

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