Tarrawonga Coal Project

Environmental Assessment

APPENDIX D

AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

Resource Strategies

Tarrawonga Coal Pty Ltd

REPORT

TARRAWONGA COAL PROJECT – AIR QUALITY AND GREENHOUSE GAS ASSESSMENT

Tarrawonga Coal Pty Ltd

Job No: 5622

9 January 2012

A PEL Company

9 January 2012

Mr Danny Young
Group Environmental Manager
Whitehaven Coal Limited
PO Box 600
GUNNEDAH NSW 2380

Dear Danny

Re: Tarrawonga Coal Project – Air Quality and Greenhouse Gas Assessment

During the adequacy test phase for the Tarrawonga Coal Project Environmental Assessment, the New South Wales Environment Protection Authority (EPA) identified an error in the estimation of emissions associated with scraper operations in the Tarrawonga Coal Project Air Quality and Greenhouse Gas Assessment (prepared by PAEHolmes).

Annual total suspended particulate (TSP) emissions associated with scrapers are reported in the Tarrawonga Coal Project Air Quality and Greenhouse Gas Assessment as 43,200 kilograms (kg). The correct estimate of annual TSP emissions from scrapers is 70,848 kg (i.e. 43,200 kilometres [km] travelled by scrapers per year multiplied by an emission rate of 1.64 kg TSP per km). The error was a result of an incorrect cell reference in the emissions inventory spreadsheet.

Annual TSP emissions for years 2, 4, 6 and 16 from all sources are predicted to be approximately 2,776,396 kg, 2,855,504 kg, 2,861,085 kg and 2,719,719 kg, respectively. As such, the error associated with scraper emissions results in a potential underestimation of total annual TSP emissions of approximately 1%. As noted by the EPA in their letter dated 5 December 2011, "this is a very minor error in the emission estimates". It should also noted that an increase in emissions is not necessarily directly proportional to changes in modelled ground level concentrations, and any predicted impact as a result of this error is likely to be less than 1%.

Therefore, this error would not materially change the air quality results and conclusions presented in the Tarrawonga Coal Project Air Quality and Greenhouse Gas Assessment, and remodelling of air quality impacts is not considered to be required.

Please do not hesitate to contact the undersigned should you have any queries.

Regards

R. Kellaghan

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ES1 EXECUTIVE SUMMARY

Overview

The Tarrawonga Coal Mine is owned and operated by Tarrawonga Coal Pty Ltd (TCPL), which is a joint venture between Whitehaven Coal Mining Pty Ltd (70% interest) and Boggabri Coal Pty Limited (a wholly owned subsidiary of Idemitsu Australia Resources Pty Ltd) (30% interest). TCPL is seeking approval for the proposed extension of the Tarrawonga Coal Mine (hereafter referred to as the Tarrawonga Coal Project [the Project]).

The Project is proposed to continue for 17 years, commencing in 2013 and would involve conventional open cut mining methods to extract coal at a rate of up to 3 million tonnes per annum.

Existing Environment

The Tarrawonga Coal Mine is an open cut mining operation located approximately 15 kilometres (km) north-east of Boggabri and 42 km north-northwest of Gunnedah in New South Wales (NSW). Land use in the local area is dominated by agricultural operations and open cut mining, with rural residential receivers mainly located to the south and west of the Project. The Tarrawonga Coal Mine Automatic Weather Station records 15-minute averages of wind speed, wind direction, temperature, solar radiation and rainfall. During 2010, the prevailing wind directions were from the north. The Tarrawonga Coal Mine air quality monitoring network currently consists of 13 dust deposition gauges and a High Volume Air Sampler and data from this network are used to describe and characterise existing ambient air quality.

Office of Environment and Heritage (OEH) Criteria

OEH assessment criteria are generally based on thresholds relating to human health effects. These criteria have been developed to a large extent in urban areas, where the primary pollutants are the products of combustion, which are more harmful to human health than particulates of crustal origin, such as dust from mining operations.

Emissions, Dispersion Modelling and Assessment Approach

The CALMET/CALPUFF modelling system was chosen for this study. Mining plans for the Project have been analysed and detailed emissions inventories have been prepared for four key operating scenarios, being Project Years 2, 4, 6 and 16. These modelled scenarios are considered to be representative of worst-case operations; for example where coal and waste material amounts are highest, where extraction or wind erosion areas are largest or where operations are located closest to receivers.

The Project includes the haulage of ROM coal to the Boggabri Coal Mine for handling, processing and transportation. This assessment has conservatively accounted for these potential emissions.

TCPL has committed to additional haul road watering and/or the use of surfactants for the Project. This commitment has been included in the emissions estimates and dispersion modelling.

Impact Assessment

Dispersion model predictions have been made for Project Years 2, 4, 6 and 16 of mining operations. There are no privately owned receivers predicted to experience 24-hour particulate matter less than 10 microns in size (PM_{10}) concentrations, annual average PM_{10} concentrations, annual average total suspended particulate matter concentrations or annual average dust deposition levels above the relevant OEH impact assessment criteria.

One privately-owned vacant property is predicted to exceed the 24-hour PM_{10} criterion for over 25% of its area.

The assessment of potential cumulative impacts has identified potential for 24-hour PM_{10} exceedances of criteria at one receiver and annual average PM_{10} exceedance of criteria at one receiver due to emissions from the Project, Boggabri Coal Mine and the Maules Creek Coal Project. These potential impacts would be managed through the implementation of real-time controls.

Greenhouse Gas Emissions

The potential greenhouse gas emissions that are likely to occur as a result of the operation of the Project have been estimated. On average, scope 1 emissions from the Project would contribute 0.03% of Australia's Kyoto commitment.

Some 66% of direct (scope 1) emissions from the Project are from fugitive emissions of methane. These emissions have been estimated using the standard National Greenhouse Accounts factor which is some 45 times greater than the factor measured for the same coal seams for a nearby mining project. It is therefore expected that this is a significant overestimate of scope 1 emissions.

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1 INTRODUCTION

The Tarrawonga Coal Mine is owned and operated by Tarrawonga Coal Pty Ltd (TCPL), which is a joint venture between Whitehaven Coal Mining Pty Ltd (Whitehaven) (70% interest) and Boggabri Coal Pty Limited (BCPL) (a wholly owned subsidiary of Idemitsu Australia Resources Pty Ltd) (30% interest). TCPL is seeking approval for the proposed extension of the Tarrawonga Coal Mine (hereafter referred to as the Tarrawonga Coal Project [the Project]).

PAEHolmes has been commissioned by TCPL to undertake an Air Quality and Greenhouse Gas Assessment for the proposed extension.

1.1 Background

The Tarrawonga Coal Mine commenced operations in 2006 and currently produces approximately 2 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal. The original approval for the Tarrawonga Coal Mine was granted by the New South Wales (NSW) Minister for Planning in November 2005 under Part 4 of the *Environmental Planning and Assessment Act, 1979* (EP&A Act) (i.e. Development Consent DA-88-4-2005).

In 2010 TCPL sought approval under Section 75W of the EP&A Act for a modification to Development Consent DA-88-4-2005, to increase the extent of open cut operations. Approval for the 2010 Modification was granted by the NSW Minister for Planning in October 2010 (i.e. Development Consent DA-88-4-2005 MOD 1).

1.2 Study Requirements

The Air Quality and Greenhouse Gas Assessment is guided by the Director-General's Environmental Assessment Requirements (EARs), outlined in **Table 1.1**. Detailed agency comments have also been outlined by the NSW Office of Environment and Heritage (OEH) (Letter from Lindsay Fulloon of OEH to Howard Reed of the NSW Department of Planning and Infrastructure [DP&I] dated 31 March 2011) and are provided in **Table 1.2**.

The Air Quality and Greenhouse Gas Assessment has been prepared in accordance with the EARs, NSW OEH *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (Approved Methods)* (**NSW Department of Environment and Conservation [DEC], 2005**) and in consideration of the OEH's agency comments in regards to the Project.

Table 1.1: Director-General's environmental assessment requirements

Discipline	Requirement
Air	*"a quantitative assessment of the potential air quality impacts of the project"*
Greenhouse Gases	*"a quantitative assessment of the potential scope 1, 2 and 3 greenhouse gas emissions from the project"*
	"a qualitative assessment of the potential impacts of these emissions on the environment"
	"an assessment of the reasonable and feasible measures that could be implemented on site to minimise the greenhouse gas emissions of the project"

Table 1.2: OEH specific agency comments

Air Quality	
Assess the risk associated with potential discharges of fugitive and point source emissions for all stages of the proposal. Assessment of risk relates to environmental harm, risk to human health and amenity *Justify the level of assessment undertaken on the basis of risk factors, including but not limited to:* *a. proposal location,* *b. characteristics of the receiving environment,* *c. type and quantity of pollutants emitted.*	Section 6.1.3 (Note: Dust effects on fauna and flora are addressed in Appendices E and F of the Environmental Assessment [EA], respectively)
Describe the receiving environment in detail. The proposal must be contextualised within the receiving environment (local, regional and inter-regional as appropriate). The description must include but need not be limited to: *a. Meteorology and climate,* *b. Topography,* *c. Surrounding land use, receptors and* *d. Ambient air quality.*	Section 3 Section 5
Include a description of the proposal. All processes that could results in air emissions must be identified and described. Sufficient detail to accurately communicate the characteristics and quantify of all emissions must be provided.	Section 2 Section 8.2
Include a consideration of 'worse case' emission scenarios and impacts at proposed emission limits.	Section 9
Account for cumulative impacts associated with existing emission sources as well as any currently approved developments linked to the receiving environment.	Section 8.4
Include air dispersion modelling where there is a risk of adverse air quality impacts or where there is sufficient uncertainty to warrant a rigorous numerical impact assessment. Air dispersion modelling must be conducted in accordance with the Approved Methods of the Modelling and Assessment of Air Pollutants in NSW (2005). *http://www.environment.nsw.gov.au/resources/air/ammodelling05361.pdf.*	Sections 8 and 9
Demonstrate the proposals ability to comply with the relevant regulatory framework specifically the Protection of the Environment Operations (POEO) Act (1997) and the POEO (Clean Air) Regulation (2002). [now *POEO (Clean Air) Regulation (2010)*]	Section 4.2.1
Provide an assessment of the project in terms of the priorities and targets adopted under the NSW State plan 2010 and its implementation plan Action for Air.	Section 4.2.2
Detail emission control techniques / practices that will be employed by the proposal.	Section 7
Greenhouse Gas	
The EA should include a comprehensive assessment of, and report on, the project's predicted greenhouse gas emissions (tCO2e). Emissions should be reported broken down by: • *direct emissions (scope 1 as defined by the Greenhouse Gas Protocol),* • *indirect emissions from electricity (scope 2), and* • *upstream and downstream emissions (scope 3).*	Section 12
before and after implementation of the project, including annual emissions for each year of the project (construction, operation and decommissioning).	
The EA should include an estimate of the greenhouse emissions intensity (per unit of production). Emissions intensity should be compared with best practice if possible.	
The emissions should be estimated using an appropriate methodology, in accordance with NSW, Australian and international guidelines.	
The proponent should also evaluate and report on the feasibility of measures to reduce greenhouse gas emissions associated with the project. This could include a consideration of energy efficiency opportunities or undertaking an energy use audit for the site	

2 PROJECT DESCRIPTION

2.1 Overview

The general arrangement of the Project utilises the existing infrastructure and service facilities at the Tarrawonga Coal Mine and integrates with the neighbouring Boggabri Coal Mine.

The main activities associated with the development of the Project would include:

- continued development of mining operations in the Maules Creek Formation to facilitate a Project ROM coal production rate of up to 3 Mtpa, including open cut extensions:
  - to the east within Mining Lease (ML) 1579 and Mining Lease Application (MLA) 2; and
  - to the north within Coal Lease (CL) 368 (MLA 3) which adjoins ML 1579;
- ongoing exploration activities;
- construction and use of a services corridor (including haul road link) directly from the Project open cut mining operation to the upgraded Boggabri Coal Mine Infrastructure Facilities (subject to approvals and upgrades being in place for the transfer of Project ROM coal to the Boggabri Coal Mine Infrastructure Facilities);
- use of upgraded Boggabri Coal Mine Infrastructure Facilities for the handling and processing of Project coal and the loading of Project product coal to trains for transport on the Boggabri Coal Mine private rail spur to the Werris Creek Mungindi Railway (subject to approvals and upgrades being in place for the transfer of Project ROM coal to the Boggabri Coal Mine Infrastructure Facilities);
- construction and use of a new mine facilities area including relocation of existing mine facilities infrastructure and service facilities;
- use of an existing on-site mobile crusher for coal crushing and screening of up to 150,000 tonnes (t) of domestic specification coal per annum for direct collection by customers at the mine site;
- use an existing on-site mobile crusher to produce up to approximately 90,000 cubic metres (m^3) of gravel materials per annum for direct collection by customers at the mine site;
- progressive backfilling of the mine void behind the advancing open cut mining operation with waste rock and minor quantities of coarse reject material;
- continued and expanded placement of waste rock in the Northern Emplacement (including integration with the Boggabri Coal Mine emplacement) and Southern Emplacement, as mining develops;
- progressive development of new haul roads and internal roads, as mining develops;
- realignment of sections of Goonbri Road and construction of new intersections;
- construction of an engineered low permeability barrier to the east and south-east of the open cut to reduce the potential for local drainage of alluvial groundwater into the open cut;
- removal of a section of Goonbri Creek within the Project open cut and the establishment of a permanent Goonbri Creek alignment and associated flood bund to the east and south-east of the open cut;
- progressive development of sediment basins and storage dams, pumps, pipelines and other water management equipment and structures;

- continued development of soil stockpiles, laydown areas and gravel/borrow areas;
- ongoing monitoring and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

The proposed life of the Project is 17 years, commencing 1 January 2013.

In Project Year 1 only, or until approvals and upgrades are in place for the transfer of Project ROM coal to the Boggabri Coal Mine Infrastructure Facilities, the Project would make continued use of the existing on-site ROM coal handling areas, coal crushing, screening and loadout facilities. Road transport of sized ROM coal to the Whitehaven Coal Handling and Preparation Plant (CHPP) would also continue in this initial period (with no increase in the currently approved maximum off-site coal trucking rate).

Further details regarding the Project are provided in the sections below, with a focus on those aspects of the Project with the potential to be material from an air quality perspective.

A description of the Project is also provided in Section 2 of the Main Report of the EA.

2.2 Project Construction/Development Activities

The Project would continue to utilise the existing infrastructure and services at the Tarrawonga Coal Mine, where possible. Additional infrastructure and the relocation of existing infrastructure would be required to support the Project, including:

- relocation of the mine facilities area;
- construction of a services corridor to the upgraded Boggabri Coal Mine Infrastructure Facilities;
- realignment of sections of Goonbri Road and construction of new intersections; and
- permanent Goonbri Creek alignment and associated flood bund and low permeability barrier.

2.3 Mining Operations

Project mining operations would be conducted 24 hours per day, seven days per week.

The Project includes extension of the existing approved open cut in coal seams to the east in ML 1579 and MLA 2 and to the north in MLA 3. The Southern Emplacement and new mine facilities area would also extend into MLA 1.

Progressive vegetation clearing and soil stripping would be undertaken ahead of the advancing open cut mining operation, and would typically be conducted using a fleet of dozers, scrapers and a water cart/truck.

Drill and blast techniques are used for the removal of competent overburden (and interburden) material at the Tarrawonga Coal Mine and would continue for the Project. A mixture of ammonium nitrate and fuel oil (ANFO) (dry holes) and emulsion blend (wet holes) explosives would continue to be used.

Following blasting, overburden and interburden would continue to be removed by excavator and dump truck, with supporting dozers. The overburden/interburden would be placed in out-of-pit mine waste rock emplacements, or as infill in the mine void, behind the advancing open cut mining operations.

The waste rock emplacements would be progressively shaped by dozers for rehabilitation activities (i.e. final re-contouring, topsoiling and revegetation).

Coal mining would continue to involve excavators loading ROM coal into haul trucks for haulage to either the Project or the Boggabri Coal Mine ROM coal handling areas.

During Project Year 1, or until approvals and upgrades are in place for the transfer of Project ROM coal to the Boggabri Coal Mine Infrastructure Facilities, ROM coal would continue to be hauled to the existing ROM pad via internal haul roads, with no increase in the existing approved rate of 2 Mtpa ROM coal. Processing and transport of this ROM coal would be as per the existing operations, and would continue to be loaded into haulage contractor trucks and transported via the approved transport route to the Whitehaven CHPP.

At the Whitehaven CHPP, the sized ROM coal would continue to be either directly loaded onto trains (i.e. bypass) or crushed, screened and washed before being loaded onto trains for rail transport to the Port of Newcastle and export markets. No change to existing Whitehaven CHPP rail movements would be required for the Project.

Once approvals and upgrades are in place for the transfer of Project ROM coal to the Boggabri Coal Mine Infrastructure Facilities, ROM coal would be transported via the services corridor haul road directly from the Project open cut.

The Continuation of Boggabri Coal Mine (Boggabri Coal Continuation Project) includes upgrades to the existing ROM pad, construction of a CHPP, upgrades to product handling and a 17 kilometres (km) private rail spur, rail loop and rail loadout facility.

Once approvals and upgrades are in place for the transfer of Project ROM coal to the Boggabri Coal Mine Infrastructure Facilities, subsequent handling (on a campaign basis), processing and train loading of up to approximately 2.8 Mtpa of Project product coal would be undertaken at Boggabri.

With a typical coal train capacity of 5,400 t to 6,000 t, up to ten Project coal trains would be dispatched per week on the Boggabri Coal Mine private rail spur and Werris Creek Mungindi Railway to the Port of Newcastle.

A summary of the projected ROM coal extracted and overburden removed over the life of the Project is shown in **Table 2.1** with the years chosen for quantitative air quality modelling highlighted in bold. The general arrangements for these years are shown on **Figures 2.1, 2.2, 2.3** and **2.4**.

Up to 150,000 t ROM coal per annum would be selectively hauled to the on-site mobile crusher for crushing and screening to produce domestic specification (15 to 35 millimetres [mm]) coal. In addition, up to 90,000 m^3 per annum of gravel material would be produced by crushing and screening of select overburden material (excavated from within the open cut extent) in the on-site mobile crusher.

The mobile crusher would be operated during daytime hours only (i.e. 7.00 am to 6.00 pm).

Table 2.1: ROM coal extracted and overburden removed over the life of the Project

Project Year*	ROM extraction (Mtpa)	Overburden removed (Mbcm)
Year 1	2.5	25.0
Year 2	**3.0**	**29.5**
Year 3	3.0	27.5
Year 4	**3.0**	**28.0**
Year 5	3.0	29.0
Year 6	**3.0**	**33.0**
Year 7	3.0	32.0
Year 8	3.0	32.0
Year 9	3.0	27.0
Year 10	3.0	29.0
Year 11	3.0	30.0
Year 12	3.0	28.0
Year 13	3.0	31.0
Year 14	3.0	31.0
Year 15	3.0	31.0
Year 16	**3.0**	**31.0**
Year 17	3.0	23.0

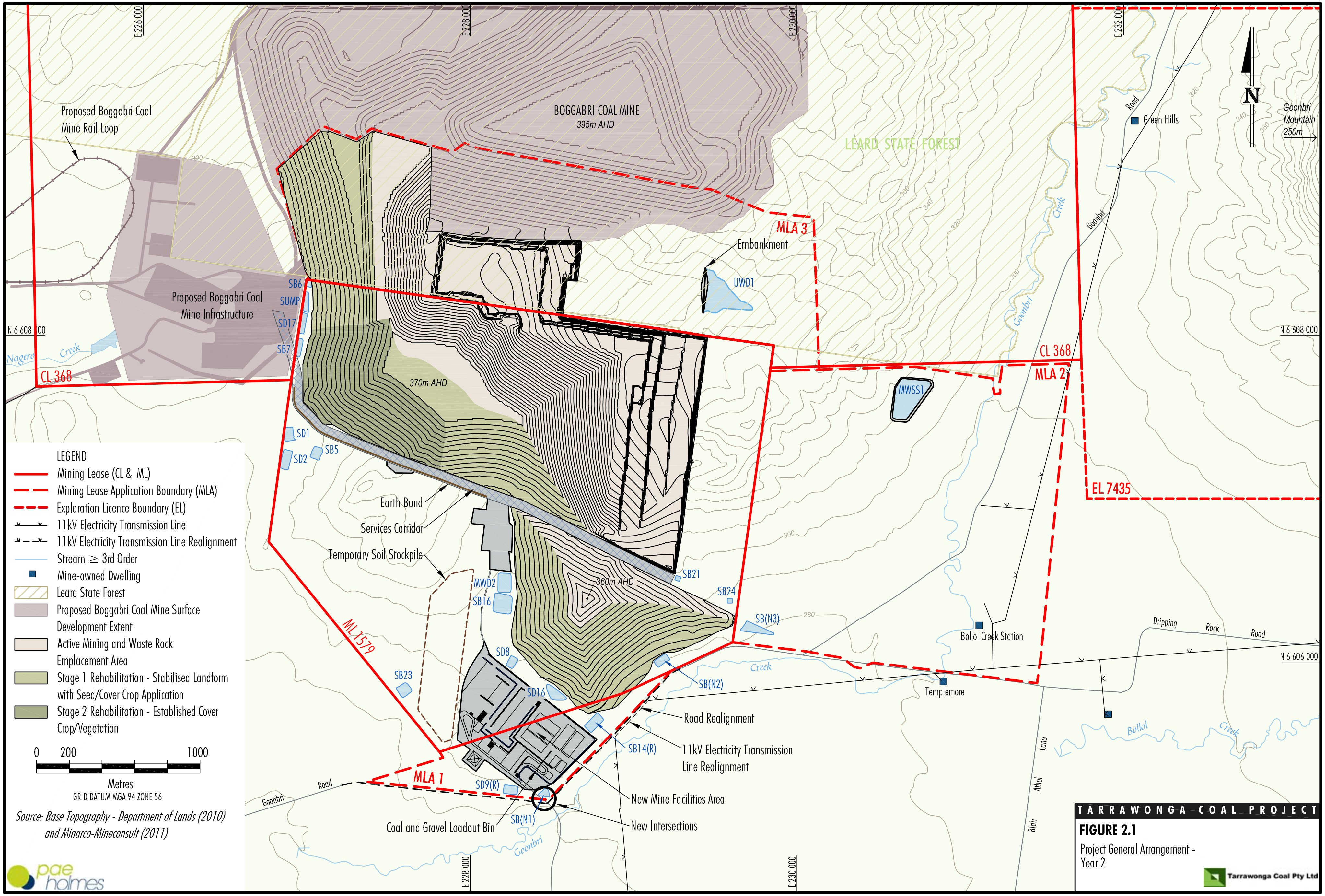
Source: After Section 2.7.2 of the EA.

* Assumed Project commencement date is 1 January 2013.

Notes: Mbcm - million bank cubic metres.

Up to 90,000 m^3 per annum of gravel material would be produced by crushing and screening of select overburden material (excavated from within the open cut extent) in the on-site mobile crusher.

On-site gravel crushing and screening operations would be conducted during daytime hours only (i.e. 7.00 am to 6.00 pm).



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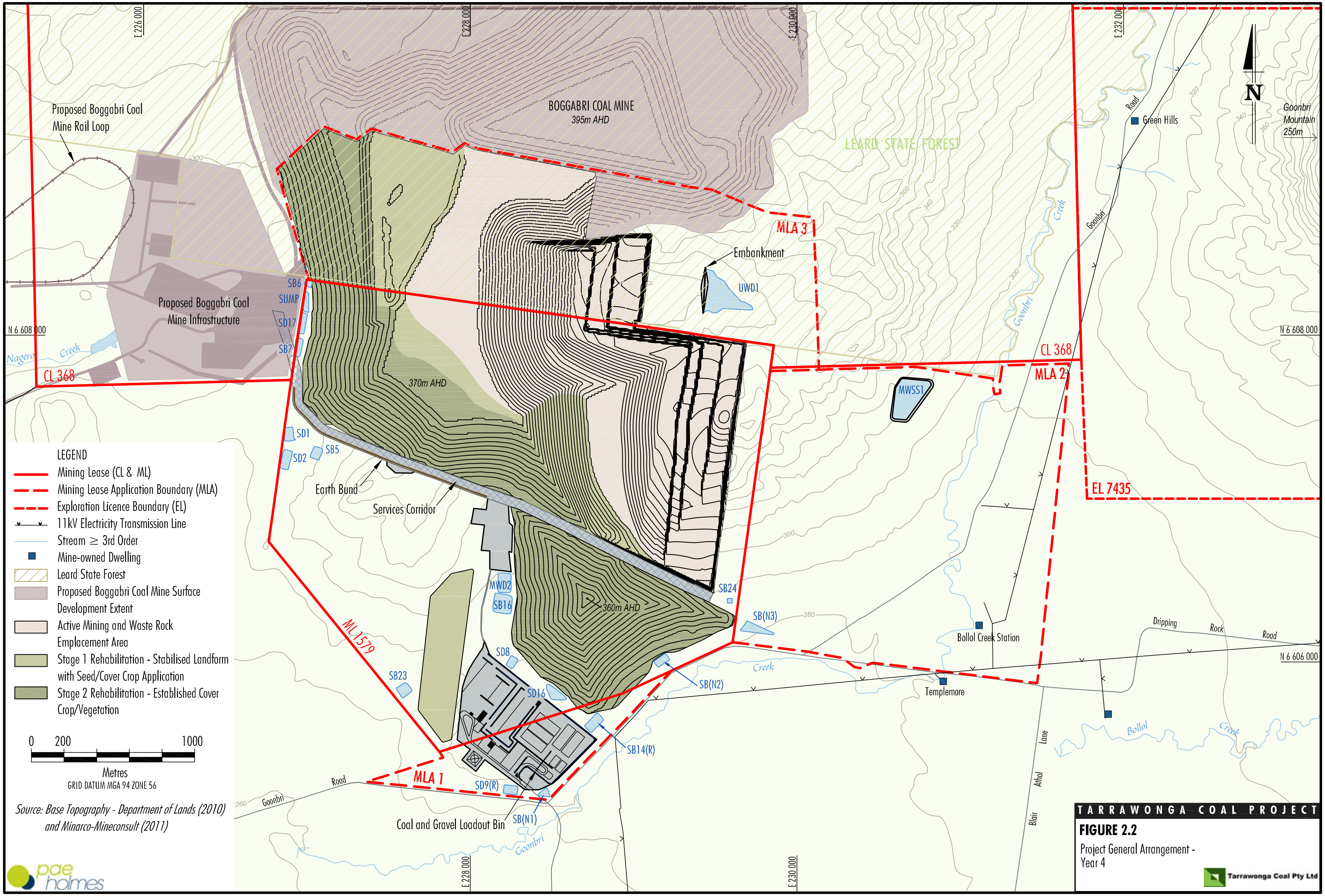

TARRAWONGA COAL PROJECT

FIGURE 2.2

Project General Arrangement - Year 4

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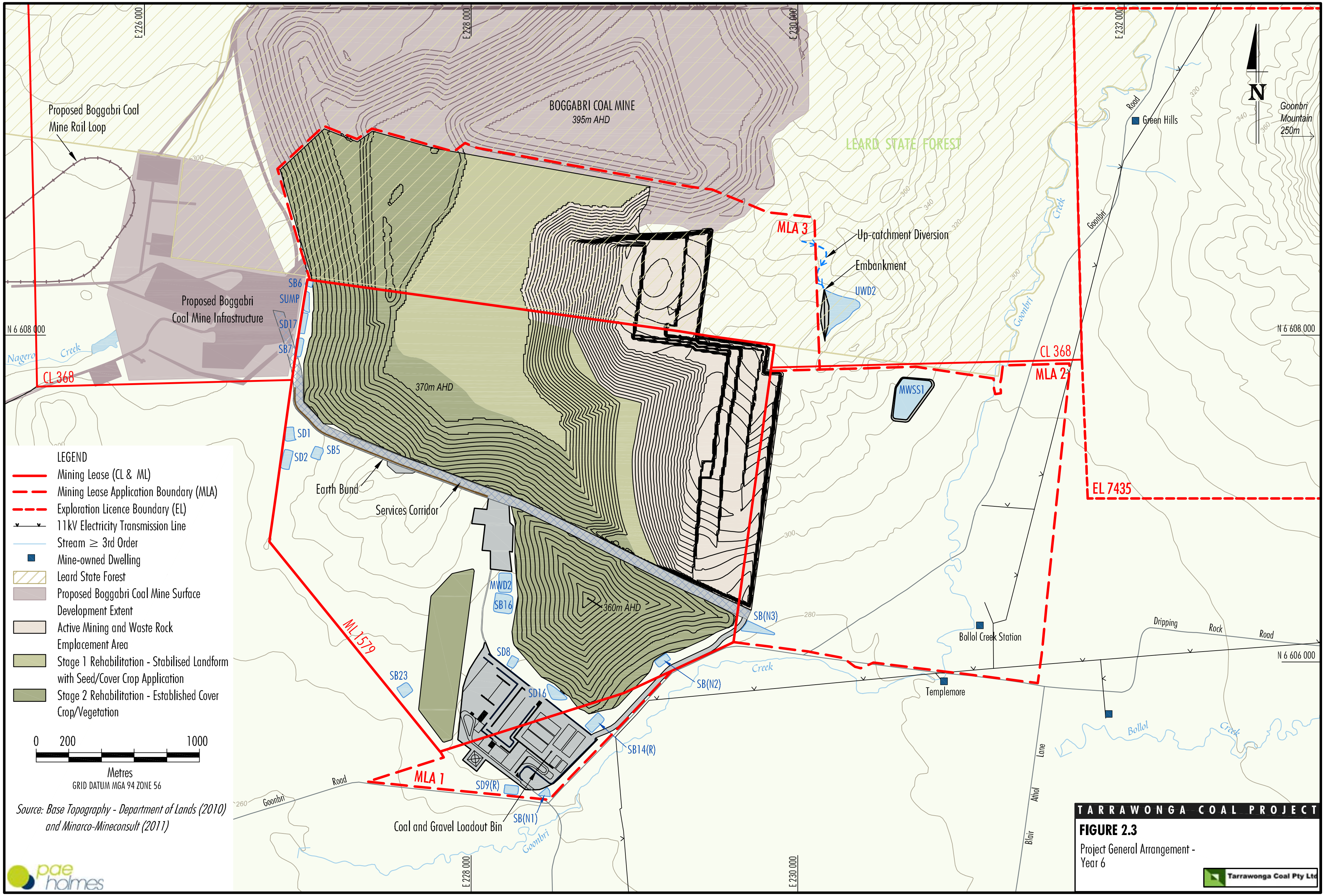

TARRAWONGA COAL PROJECT

FIGURE 2.3

Project General Arrangement - Year 6

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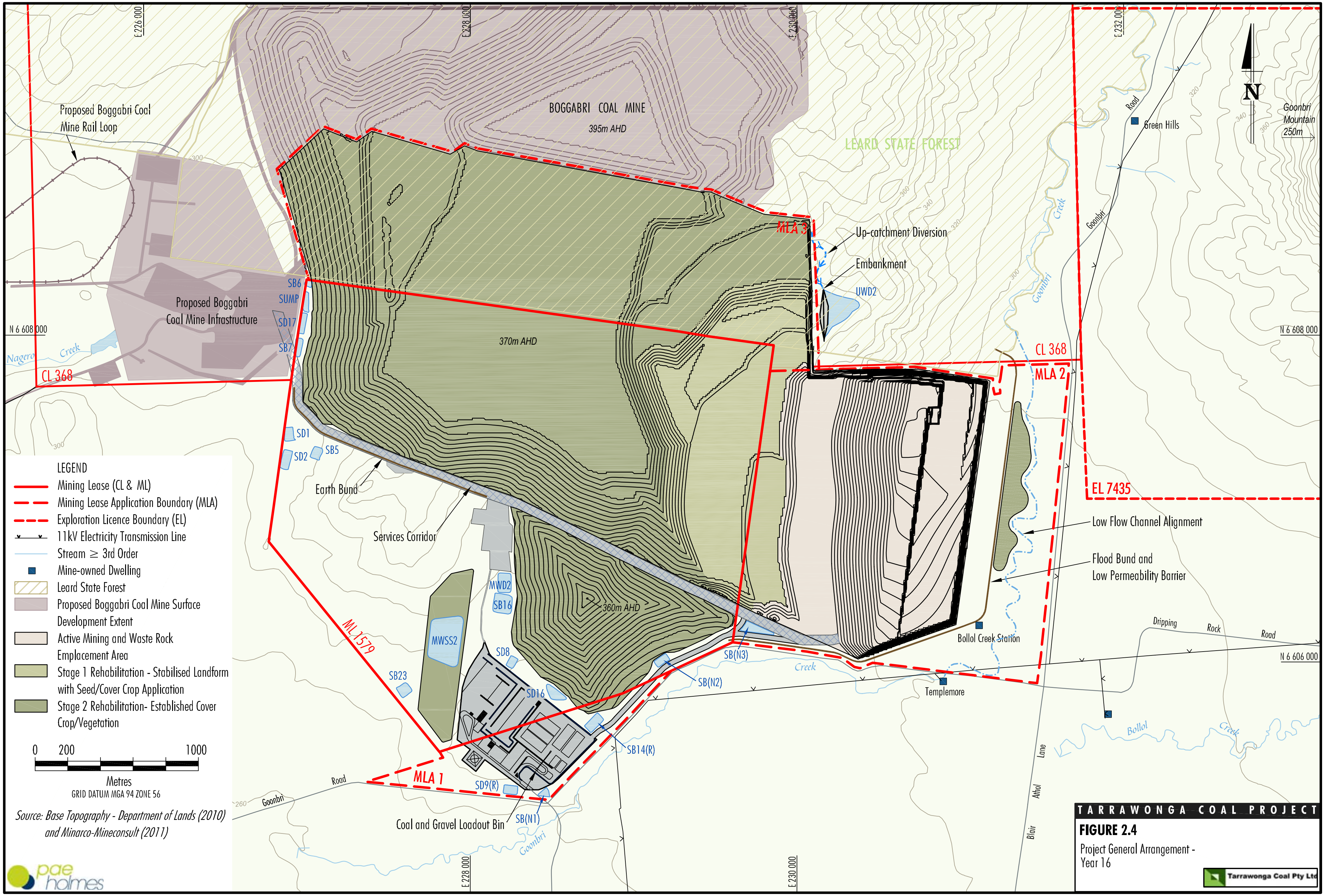

FIGURE 2.4

Project General Arrangement - Year 16

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3 LOCAL SETTING

The Tarrawonga Coal Mine is an open cut mining operation located approximately 15 km north-east of Boggabri and 42 km north-northwest of Gunnedah in NSW (**Figure 3.1**).

Land use in the local area is dominated by agricultural operations and open cut coal mining, with privately-owned rural residential receivers located predominantly to the south and west of the Project. Agricultural production is dominated by grazing (primarily cattle) and cereal/fodder cropping in the flatter and more fertile areas to the south, east and west. State-owned forestry (Leard State Forest) and another coal mining operation (Boggabri Coal Mine) occur to the north of the Tarrawonga Coal Mine.

The Tarrawonga Coal Mine is situated in the foothills of the Willowtree Range some 12 km east of the Namoi River (**Figure 3.1**). The main local drainages are Nagero Creek and Goonbri Creek which drain west to the Namoi River. Areas of higher elevation in the region include peaks on the Willow Tree Range approximately 7 km to the north (465 metres [m] Australian Height Datum [AHD]), and Goonbri Mountain approximately 4 km to the north-east (540 m AHD) (**Figure 3.1**).

The regional setting of the Project is shown in **Figure 3.1**. Significant geographic features in the wider area include the Mount Kaputar National Park to the north and the Namoi River to the southwest of the Project.

Locally, the Tarrawonga Coal Mine is bounded by the undulating landforms of Leard State Forest to the north and is surrounded by low lying flood plains of Goonbri Creek (a tributary of the Namoi River) to the south (**Figure 3.1**). Nagero Creek drains the southern slopes of the Willowtree Range including the north-western portions of ML 1579. In their lower floodplain areas Goonbri and Nagero Creeks comprise poorly defined channels and a series of depressions. These areas become wide, shallow, slow moving waterways during and following significant rainfall runoff events.

The existing mine landforms of the Tarrawonga Coal Mine have modified the topography within ML 1579. The Northern Emplacement has an approved approximate height of 370 m AHD in the north-western corner of ML 1579, while the base of the open cut is currently at approximately 200 m AHD. The Southern Emplacement near the centre of ML 1579 rises to an approved elevation of approximately 340 m AHD.

There are a number of rural receivers in the vicinity of the Project, as shown in **Figure 3.2.**

Figure 3.3 shows a pseudo 3-dimensional representation of the terrain in the area of the Project and surrounds.

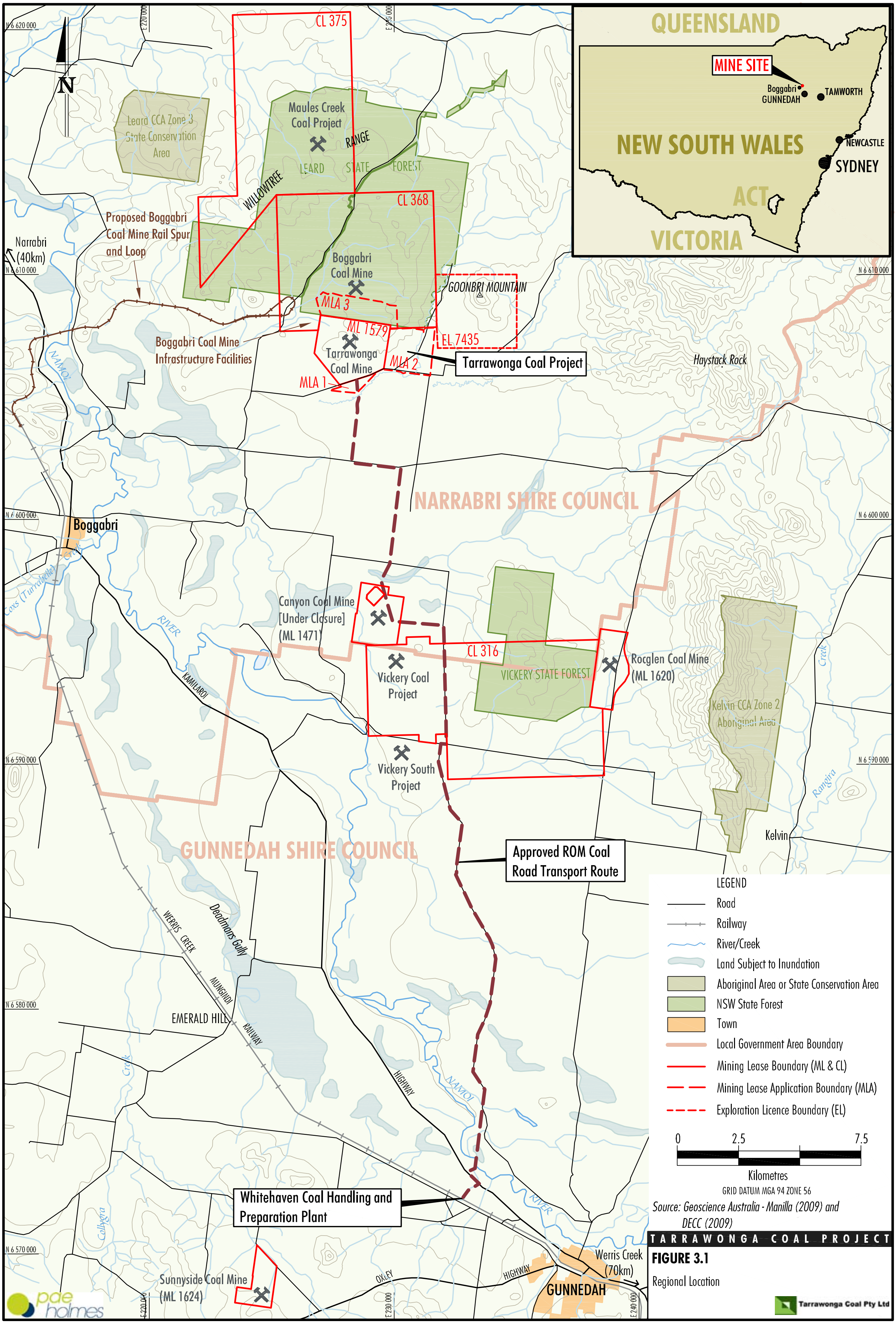
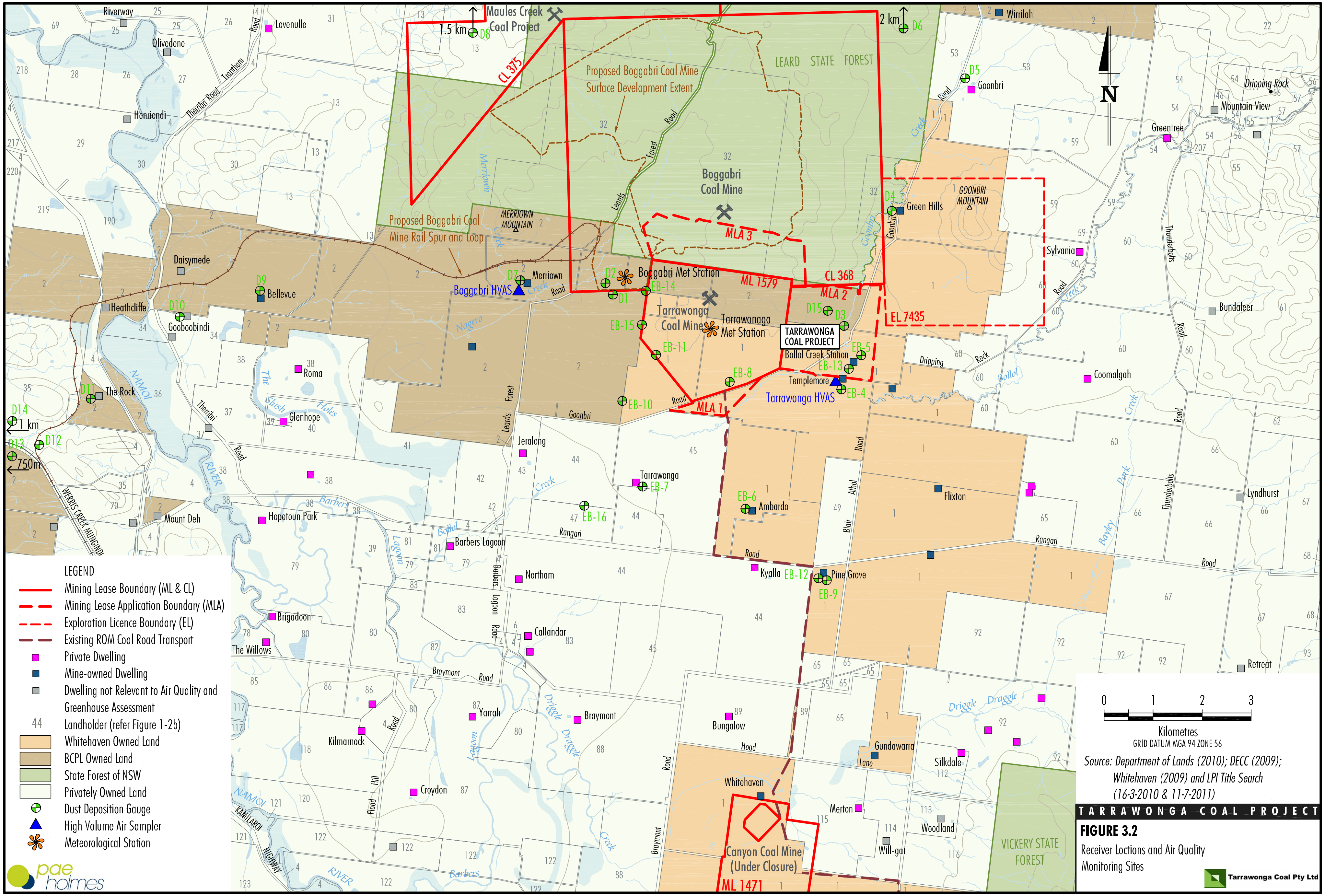


FIGURE 3.1
Regional Location



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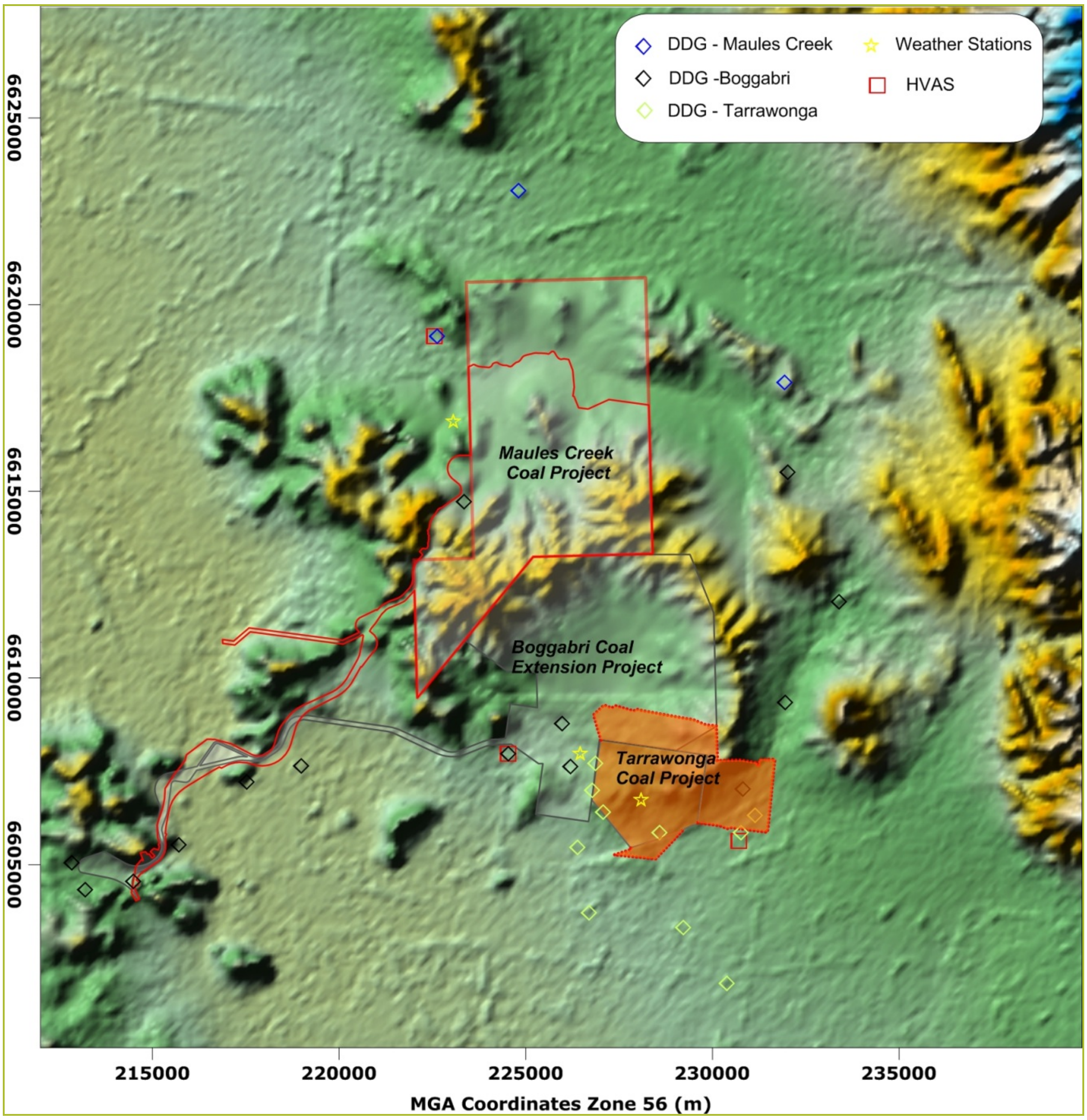


Figure 3.3: Pseudo 3-dimensional plot of the surrounding terrain

4 AIR QUALITY CRITERIA AND LEGISLATIVE CONSIDERATIONS

4.1 Criteria

4.1.1 Introduction

Project mining activities described in **Section 2** have the potential to generate fugitive dust emissions in the form of particulate matter described as total suspended particulate matter (TSP), particulate matter with an equivalent aerodynamic diameter of 10 micrometres (µm) or less (PM_{10}) and deposited dust emissions. In addition, combustion engines of generators and vehicles release emissions through engine exhausts including carbon monoxide (CO), minor quantities of sulphur dioxide (SO_2) and nitrogen dioxide (NO_2).

The low sulphur content of Australian diesel, in combination with the fact that mining equipment (including generators) is widely dispersed over mine sites, is such that the SO_2 goals would not be exceeded, even in mining operations that use large quantities of diesel. For this reason, no detailed study is required to demonstrate that emissions of SO_2 from the Project would not significantly affect ambient SO_2 concentrations. Similarly, NO_2 and CO emissions from the mining activities are limited and too widely dispersed to require a detailed modelling assessment. For this reason these emissions are not considered further in this report.

Other emissions to air from the Project include greenhouse gases (GHG) such as fugitive methane from exposed coal, carbon dioxide from the combustion of fuel in combustion engines, blasting and indirect GHG emissions from the combustion of coal produced on-site. GHG emissions are assessed in **Section 12**.

The following sections provide information on the air quality criteria used to assess the impact of dust and particulate emissions. To assist in interpreting the significance of predicted concentration and deposition levels some background discussion is also provided.

4.1.2 Particulate Matter and its Health Significance

Particulate matter has the capacity to affect health and to cause nuisance effects and is categorised by size and/or by chemical composition. The potential for harmful effects depends on both.

Existing evidence suggests that health effects from exposure to airborne particulate matter are predominantly related to the respiratory and cardiovascular systems. The human respiratory system has in-built defensive systems that prevent larger particles from reaching the more sensitive parts of the respiratory system. Particles larger than 10 µm, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. For this reason air quality goals make reference to measures of the total mass of all particles suspended in the air, this is referred to as TSP. In practice particles larger than 30 to 50 µm settle out of the atmosphere too quickly to be regarded as air pollutants. The upper size range for TSP is usually taken to be 30 µm. TSP includes PM_{10}.

Just as PM_{10} particles are a sub-component of TSP, $PM_{2.5}$ particles are also a sub-component of PM_{10} and therefore a sub-component of TSP. $PM_{2.5}$ are fine particles with aerodynamic diameters of 2.5 µm or less which may penetrate beyond the larynx and into the thoracic respiratory tract. There is evidence that particles in this size range are more harmful than the coarser component of PM_{10}, namely the 2.5 to 10 µm fraction. The health effects of particulate matter are further compounded by the chemical nature of the particles and by the possibility of adverse synergistic effects with other air pollutants.

The health-based assessment criteria used by OEH have, to a large extent, been developed by reference to epidemiological studies undertaken in urban areas with large populations where the primary pollutants are the products of combustion (**NSW Environment Protection Authority [EPA]**, **1998**; **National Environment Protection Council** [**NEPC**], **1998a**; **NEPC**, **1998b**). This means that, in contrast to dust of crustal origin, the particulate matter from urban areas would be composed of smaller particles and would generally contain acidic and carcinogenic substances that are associated with combustion. The indication therefore is that particulate matter of crustal origin, such as dust from mining, may be less harmful to health as it contains a smaller fraction of fine particulate matter, (e.g. $PM_{2.5}$ and PM_1) and also relatively less matter containing acidic and carcinogenic substances.

Both long term and short term exposure to particulate matter are important and, as such, short-term (24-hour) and long term (annual mean) guidelines are needed to protect health.

Mining emissions will also include particles from diesel exhausts in activities where diesel powered equipment is used. Thus mining generates particles in all the above size categories, namely $PM_{2.5}$, PM_{10} and TSP. However, the great majority of the particles from mining operations are due to the abrasion, crushing of rock and coal and general disturbance of dusty material. As such most of the emissions will be larger than 2.5 µm. This is in contrast to particles found in bushfire smoke, or in the atmosphere in urban areas, where many of the particles are the result of combustion processes. A study of the distribution of particle sizes near (10 to 200 m) mining dust sources was undertaken on behalf of the State Pollution Control Commission (SPCC) (now OEH) in 1986. The average of approximately 120 samples showed that $PM_{2.5}$ comprised 4.7% of the TSP, and PM_{10} comprised 39.1% of the TSP in the samples (**SPCC, 1986**). Thus, although emissions of $PM_{2.5}$ do occur from mining, the percentages of the emissions in this size range are small and in practice the concentrations of $PM_{2.5}$ in the vicinity of mining dust sources are likely to be low compared with internationally recognised goals.

The United States (US) EPA also suggests ratios of $PM_{2.5}$ to PM_{10} from various emissions sources for use in emissions estimation. The ratios for various activities that may take place at a mine (unpaved roads, aggregate handling and wind erosion) are in the range of 0.1 to 0.15 (i.e. 10% to 15% of PM_{10} is $PM_{2.5}$). While mining does generate fine particulate, it appears that the bulk of fine particles in the atmosphere are typically derived from other sources, such as combustion sources.

4.1.3 OEH Criteria

In the *Approved Methods*, the OEH specifies air quality assessment criteria relevant for assessing impacts from air pollution (**DEC, 2005**). **Table 4.1** summarises the air quality goals for concentrations of particulate matter that are relevant to this study. The air quality goals for annual average TSP and PM_{10} 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 goals to assess potential impacts. These criteria are health-based (i.e. they are set at levels to reduce the risk of adverse health effects).

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 OEH's criteria include averaging periods, which are not included in the Ambient Air-NEPM, and also references other measures of air quality, namely dust deposition and TSP.

Table 4.1: OEH air quality standards/goals for particulate matter concentrations

Pollutant	Averaging period	Standard/Goal	Agency
Total suspended particulate matter (TSP)	Annual mean	90 $\mu g/m^3$	National Health and Medical Research Council (NHMRC)
Particulate matter with an equivalent aerodynamic diameter less than 10 µm (PM_{10})	24-hour maximum	50 $\mu g/m^3$	OEH impact assessment criteria; NEPM reporting goal, allows five exceedances per year for bushfires and dust storms;[1]
	Annual mean	30 $\mu g/m^3$	OEH impact assessment criteria;

Notes: $\mu g/m^3$ – micrograms per cubic metre, µm – micrometre;

[1] The 50 $\mu g/m^3$ 24-hour maximum PM_{10} criteria are cumulative (i.e. include background concentrations but exclude regional dust event such as bushfires) in the existing Tarrawonga Coal Mine Development Consent (DA 88-4-2005 MOD 1), however property acquisition criteria are specifically Project-only.

In addition to potential health effects, airborne dust also has the potential to cause nuisance effects by depositing on surfaces. **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 (**DEC, 2005**).

Table 4.2: OEH 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

Notes: g/m^2/month – grams per square metre per month.

In May 2003, NEPC released a variation to the Ambient Air-NEPM (**NEPC, 2003**) to include advisory reporting standards for particulate matter with an equivalent aerodynamic diameter of 2.5 µm or less ($PM_{2.5}$). The purpose of the variation was to gather sufficient data nationally to facilitate the review of the Ambient Air-NEPM which is currently underway. The variation includes a protocol setting out monitoring and reporting requirements for $PM_{2.5}$ particles. The NEPM $PM_{2.5}$ advisory reporting standards are not impact assessment criteria. As there are no such criteria in NSW (i.e. $PM_{2.5}$ is not included in the *Approved Methods* [**DEC, 2005**]) and $PM_{2.5}$ assessment is not mentioned as a requirement in the EARs and OEH agency comments (**Section 1.2**), no assessment of $PM_{2.5}$ is required.

4.2 Legislative Considerations

4.2.1 Protection of the Environment Operations Act, 1997

TCPL currently holds Environment Protection Licence (EPL) 12365 issued under Chapter 3 of the NSW *Protection of the Environment Operations Act, 1997* (PoEO Act) by the Environment Protection Authority in January 2006 (as modified by subsequent licence variations).

Relevant to air quality, the EPL includes a requirement to minimise dust emissions, cover coal trucks leaving the site and also specifies dust deposition and PM_{10} sampling particulars.

It is understood that a variation of EPL 12365 would be sought to incorporate the Project as may be required.

In addition, the *POEO (Clean Air) Regulation, 2010* prescribes requirements for domestic solid fuel heaters, control of burning, motor vehicle emissions and industrial emissions (such as Volatile Organic Carbons). Motor vehicle emissions would be addressed by regular maintenance of all vehicles associated with the Project.

In addition, any burning on-site would be conducted to minimise potential for smoke impacts on neighbouring receivers (e.g. by avoiding burning activities during winds prevailing towards receivers).

4.2.2 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 (**Department of Environment, Climate Change and Water [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; and
- 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.

Whilst the Tarrawonga Coal Mine is not located within the areas relevant to the Action for Air plan (i.e. Sydney, Wollongong and the Lower Hunter), the Project generally addresses the aims of the Action for Air Plan in the following ways:

- TCPL and PAEHolmes have reviewed potential mitigation measures and a range of measures have been adopted for the Project (**Section 7**);
- air quality emissions potentially associated with the Project have been quantified (**Section 8.2**);

- dispersion modelling has been conducted by PAEHolmes to predict the impact of these emissions on nearby receivers and assess these emissions against the Ambient Air-NEPM goals (**Section 9**); and
- TCPL has committed to a real-time air quality monitoring system to facilitate real-time management of elevated dust levels due to Project activities (**Section 7.3**).

5 EXISTING ENVIRONMENT

5.1 Prevailing Winds

The OEH *Approved Methods* outline requirements for meteorological data that are used for air dispersion modelling. The requirements are as follows:

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

An automatic weather station (AWS) was installed in the vicinity of the Project boundary in August 2006. The location of the Tarrawonga Coal Mine AWS is shown in **Figure 3.2**.

The Tarrawonga Coal Mine AWS records 15-minute averages of wind speed, wind direction, temperature, solar radiation and rainfall. For the duration of the collection period the prevailing wind directions are from the north. Although the Tarrawonga Coal Mine AWS has recorded a full year of meteorological data, the data are discontinuous with information on wind speed and wind direction missing for intermittent periods throughout the dataset. A windrose for the available measured data during 2010 is presented in **Figure 5.1**.

There are two other AWSs located to the west and north-west of the Project and these are owned and operated by Boggabri Coal Mine and Maules Creek Coal Project, respectively (**Figure 3.3**). These data are incorporated into the modelling assessment as surface station inputs in the generation of the final wind field in CALMET (refer to **Section 6.1.2**).

The closest Bureau of Meteorology (BoM) stations are located at Narrabri Airport (Station Number 054038), approximately 46 km to the north-west of the Project and Gunnedah Airport (Station Number 055202), approximately 35 km south-east of the Project. These data have similarly been incorporated into the modelling assessment as surface station inputs in the generation of the final wind field in CALMET to simulate regional conditions.

5.2 Existing Air Quality

Air quality standards and goals refer to pollutant levels that include 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 data on existing dust concentration and deposition levels in the area in which the Project is likely to contribute to these levels. It is important to note that the existing air quality conditions (that is, background conditions) will be influenced to some degree by existing mining operations in the area (i.e. the Boggabri Coal Mine and the Tarrawonga Coal Mine).

The Tarrawonga Coal Mine air quality monitoring network currently consists of 13 dust deposition gauges and a High Volume Air Sampler (HVAS). Data collected at the Boggabri Coal Mine and the proposed Maules Creek Coal Project have also been made available for this Air Quality and Greenhouse Gas Assessment. The location of the air quality monitoring network for the Project, along with the neighbouring Boggabri Coal Mine is shown in **Figure 3.2** and the monitoring results are discussed below. The Maules Creek Coal Project monitoring network is shown on **Figure 3.3**.

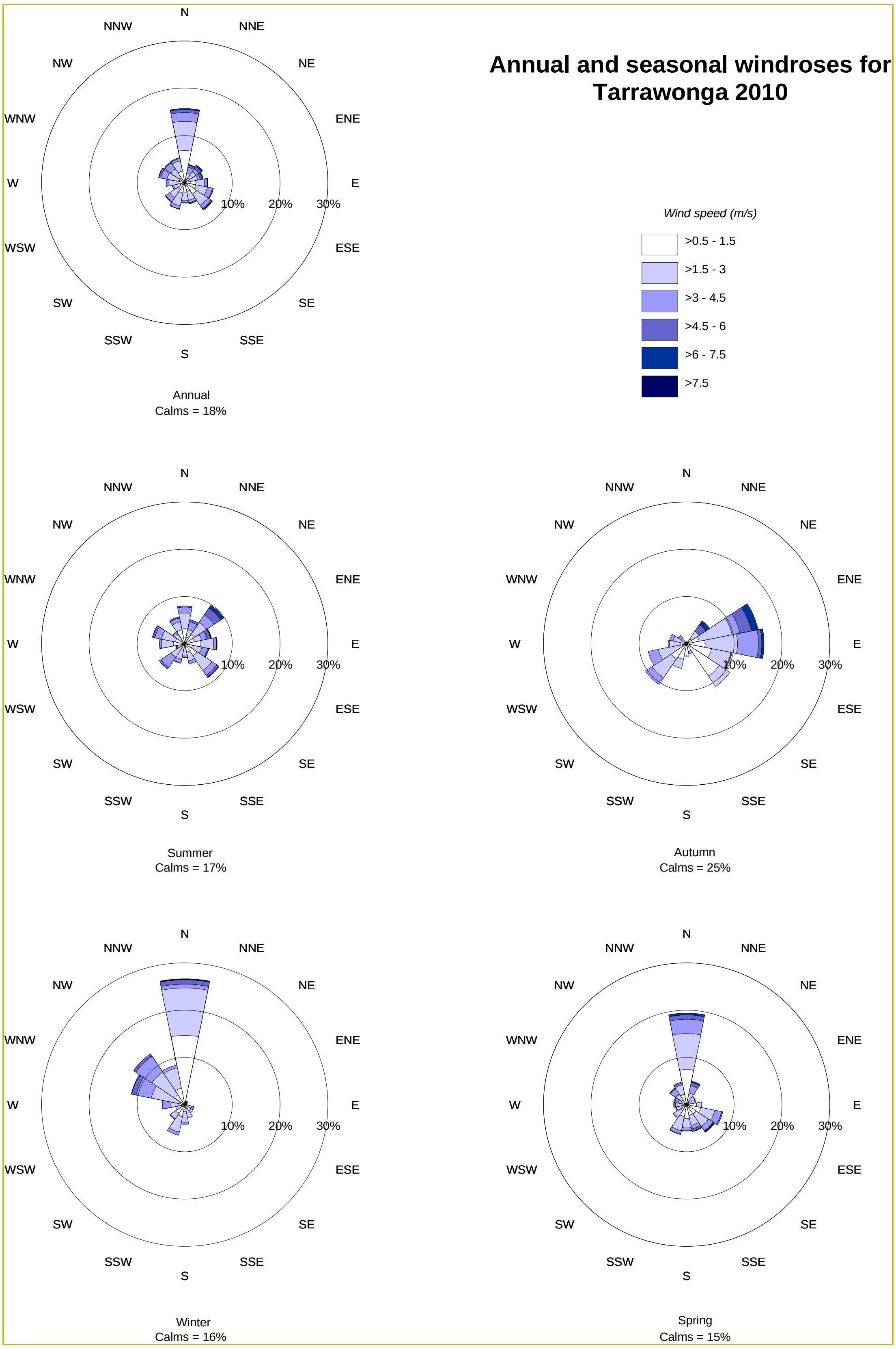


Figure 5.1: Annual and seasonal windrose for Tarrawonga Coal Mine AWS

5.2.1 PM_{10}

The determination of the 24-hour average PM_{10} concentration is conducted using a HVAS run on a one day in six cycle. Long term PM_{10} monitoring data have been collected by the Boggabri Coal Mine (from November 2005) and the Tarrawonga Coal Mine (from June 2006) at two locations, which includes emission sources from the current mining operations in the area along with other localised activities.

The monitoring data collected to date are presented in **Figure 5.2**, displaying 24-hour average and rolling annual average PM_{10} concentrations.

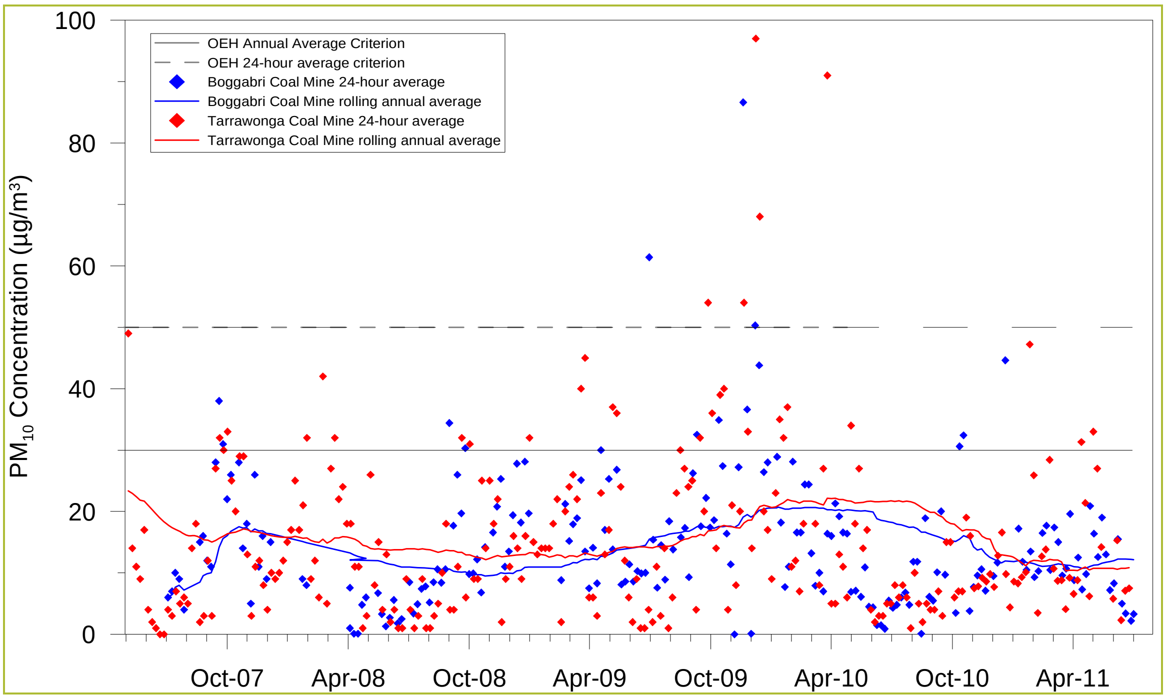


Figure 5.2: 24-hour average PM_{10} concentrations – µg/m^3

The monitoring data collected at the Tarrawonga Coal Mine HVAS indicates that there have been five elevated recordings above the OEH 24-hour average criterion during the monitoring period, with four occurring between September and December 2009, a period in which a number of dust storms and strong winds were experienced across NSW (http://www.bom.gov.au/climate/mwr/). The maximum 24-hour average PM_{10} concentration recorded was 97 µg/m^3 on 8 December 2009. This event coincided with a regional bushfire in the Kelvin Range to the east of the Project (**TCPL, 2010**).

The elevated levels recorded at the Boggabri Coal Mine HVAS coincide reasonably well (i.e. with some limited exceptions) with those periods where elevated levels were also recorded at the Tarrawonga Coal Mine HVAS and are thus likely indicative of regional scale events rather than a direct contribution from either mine's operations.

Also shown in **Figure 5.2** is the rolling annual average for the Boggabri Coal Mine and Tarrawonga Coal Mine HVAS monitors. In spring 2008 the rolling annual average PM_{10} concentrations at the Tarrawonga Coal Mine HVAS were as low as 12 µg/m^3. Rolling annual average PM_{10} steadily increased towards the end of 2009, before decreasing back to 2008 levels in 2010. A similar trend was observed at the Boggabri Coal Mine HVAS where the rolling annual average PM_{10} concentration was 10 µg/m^3 in spring 2008, increased to 20 µg/m^3 towards the end of 2009 and decreased in 2010.

The increasing trend in rolling annual average PM_{10} concentration in 2009 is considered likely to be a result of the generally drier conditions experienced across NSW during 2009 and are not necessarily as a result of intensification in mining activity. 2009 was the warmest year on record for the state of NSW and annual average rainfall for the state was low at 484 mm. This is lower than that recorded in 2008 (519 mm), 2007 (543 mm), although higher than in 2006 (349 mm) and on a par with 2005 (494 mm). 2010 had the highest rainfall recorded in the state for 50 years at 803 mm (http://www.bom.gov.au/climate/current/index.shtml).

The similar pattern seen at both sites suggests an influence external to mining activities given that the Tarrawonga Coal Mine HVAS is located in a prevailing downwind direction from both mining operations whereas the Boggabri Coal Mine HVAS is not in a prevailing downwind direction from either operation.

A summary of the annual average PM_{10} concentrations are shown in **Table 5.1**. Annual average PM_{10} concentrations are generally higher at the Tarrawonga Coal Mine HVAS, as expected, although all measurements were below the OEH's annual average criterion of 30 µg/m^3.

Table 5.1: Annual average PM_{10} concentrations - µg/m^3

HVAS	2007	2008	2009	2010	2011
Boggabri Coal Mine	14[a]	11	20	12	13.5[b]
Tarrawonga Coal Mine	16	13	21	13	14[c]

[a] Data available from July 2007.
[b] Data available until July 2011.
[c] Data available until June 2011.

HVAS monitoring data are also available for the Maules Creek Coal Project, located approximately 5 km north of Tarrawonga Coal Mine, and are shown in **Table 5-2**. Based on the available data collected to date, average PM_{10} concentrations at Maules Creek (11 µg/m^3) are marginally lower than those recorded at Boggabri and Tarrawonga.

A plot of the available contemporaneous 24-hour PM_{10} concentrations from the Maules Creek Coal Project HVAS and the Tarrawonga Coal Mine HVAS are presented in **Figure 5.3**. There were no contemporaneous measurements from the Boggabri Coal Mine HVAS as the HVAS run cycle does not match.

The plot indicates that at lower concentrations there is a correlation in the two datasets, however the higher concentrations recorded at the Tarrawonga Coal Mine HVAS appear to be influenced by local mining activity, with lower corresponding concentrations recorded at the Maules Creek Coal Project HVAS on these days.

Table 5.2: Maules Creek Coal Project HVAS PM_{10} monitoring to date

HVAS Run Date	PM_{10} Concentration (µg/m³)	HVAS Run Date	PM_{10} Concentration (µg/m³)	PM_{10} Concentration (µg/m³)	HVAS Run Date
4/10/2010	7	26/01/2011	8	26/05/2011	2
10/10/2010	8	1/02/2011	16	1/06/2011	7
16/10/2010	4	7/02/2011	18	7/06/2011	10
22/10/2010	10	13/02/2011	18	13/06/2011	5
28/10/2010	27	19/02/2011	8	19/06/2011	6
4/11/2010	11	25/02/2011	33	25/06/2011	10
10/11/2010	9	3/03/2011	18	1/07/2011	9
16/11/2010	3	21/03/2011	<0.1	7/07/2011	4
22/11/2010	22	27/03/2011	7	13/07/2011	11
4/12/2010	7	2/04/2011	15	19/07/2011	3
10/12/2010	8	8/04/2011	19	25/07/2011	6
16/12/2010	11	14/04/2011	15	31/07/2011	6
21/12/2010	8	20/04/2011	12	6/08/2011	8
27/12/2010	4	26/04/2011	7	12/08/2011	3
2/01/2011	14	2/05/2011	16	18/08/2011	2
8/01/2011	8	8/05/2011	14	24/08/2011	8
14/01/2011	21	14/05/2011	5	30/08/2011	9
20/01/2011	12	20/05/2011	35		
Average (µg/m³)	**11**				

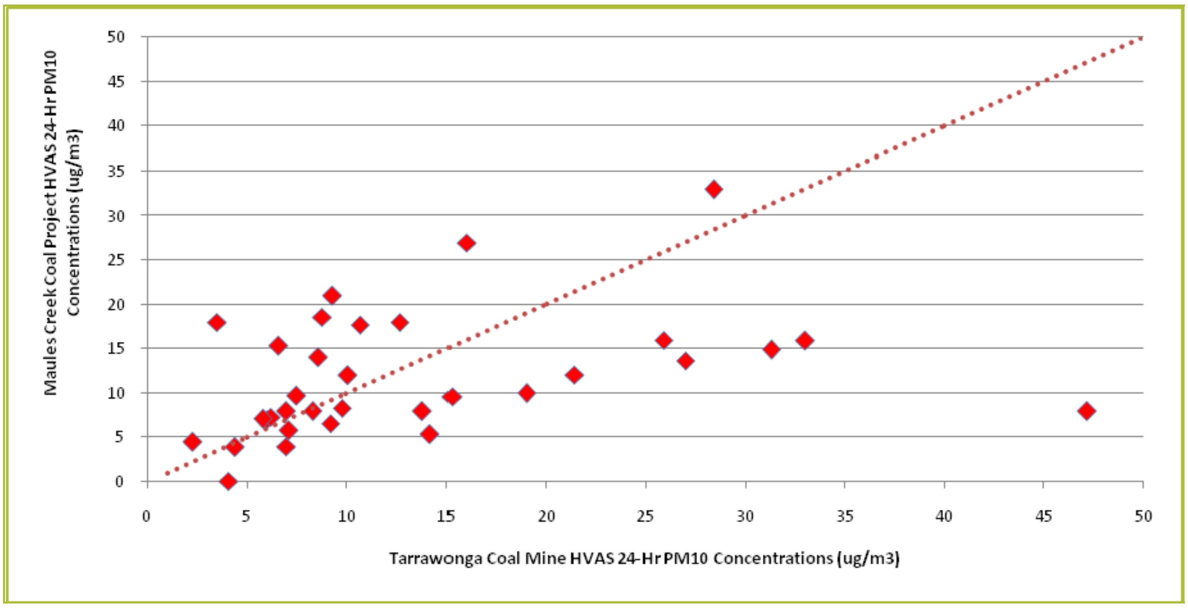


Figure 5.3: Contemporaneous 24-hour average PM_{10} concentrations – µg/m³

5.2.2 Total Suspended Particulate Matter (TSP)

There are no TSP data collected in the vicinity of the Project, however, experience with monitoring in other mining areas in the state indicates that where mining activities are a significant source of the particulate matter, then on an annual basis, approximately 39% of the TSP will be in the form PM_{10} **(SPCC, 1986)**. This is generally consistent with the study undertaken by **NSW Minerals Council (2000)**, which determined a relationship of 40% where TSP and PM_{10} monitors were collocated in the Hunter Valley. Assuming an annual average PM_{10} concentration of 12 µg/m^3 (refer to discussion in **Section 5.2.4**), this would suggest that the annual average TSP concentrations are approximately 30 µg/m^3, which is well below the relevant OEH criterion of 90 µg/m^3.

5.2.3 Dust Deposition

Tarrawonga Coal Mine and Boggabri Coal Mine have collected dust deposition for a number of years. The locations of the Tarrawonga Coal Mine and Boggabri Coal Mine dust gauges are also shown in **Figure 3.2**.

A summary of the Tarrawonga Coal Mine dust deposition data collected from the gauges between 2005 and 2011 are summarised in **Table 5.3**. Measured levels above the 4 g/m^2/month criteria (**Section 4.1**) are shown in bold.

A number of Tarrawonga Coal Mine dust gauges including EB-8, EB-11, EB-14 and EB-15 are located within the existing ML. These gauges are often in close proximity to active mining operations, therefore these data provide diagnostic data only.

Site EB-13 exhibits consistently higher dust deposition levels relative to the adjacent sites EB-4 and EB-5. This is likely to be due to a localised dust source on the Bollol Creek Station property, rather than a larger scale effect.

Table 5.3: Tarrawonga Coal Mine dust deposition data (insoluble solids)– g/m^2/month[a]

Dust Gauge	2005	2006	2007	2008	2009	2010	2011[b]
EB-3[c]	-	1.6	2.6	**4.2**	-	-	-
EB-4	1.4	1.4	1.4	2.0	3.2	2.6	**5.7**
EB-5	**5.8**	1.6	2.2	2.3	**4.4**	2.9	3.4
EB-6	1.3	1.1	1.0	1.3	2.1	1.0	0.7
EB-7	0.8	1.1	1.1	1.2	2.3	1.0	0.7
EB-8	1.3	1.0	1.1	2.5	**4.7**	2.1	**4.1**
EB-9	1.2	0.9	1.2	1.0	2.3	0.8	0.6
EB-10	-	-	1.0	2.9	3.1	**4.5**	1.8
EB-11	-	-	1.4	1.4	3.2	2.0	1.8
EB-12	-	-	1.0	1.7	3.1	2.1	1.3
EB-13	-	-	-	**12.9**	**7.3**	**4.7**	2.3
EB-14	-	-	-	2.7	**4.8**	3.3	1.6
EB-15	-	-	-	2.7	**6.5**	**4.3**	**4.7**
EB-16	-	-	-	-	-	1.6	1.6

[a] *All contaminated results have been removed from the annual averages.*

[b] *Data available until June/July 2011.*

[c] *EB-3 discontinued, and as such, has not been shown on Figure 3.2.*

Dust deposition is also monitored in the vicinity of Boggabri Coal Mine at 15 locations. Data collected from the gauges between 2005 and 2011 are summarised in **Table 5.4**. Measured levels above the 4 g/m^2/month criteria (**Section 4.1**) are shown in bold.

Table 5.4: Boggabri Coal Mine dust deposition data (insoluble solids) - *g*/m^2/month[a]

Dust gauge	2005 average	2006 average	2007 average	2008 average	2009 average	2010 average	2011[b] average
D1	0.7	0.9	1.8	2.6	2.6	4.3	1.4
D2	0.7	1.5	2.0	2.4	2.1	2.7	1.4
D3	2.1	1.6	2.9	**5.6**	**4.1**	**9.1**	**5.5**
D4	2.2	1.5	2.3	3.9	2.2	2.9	**4.2**
D5	1.4	1.3	1.7	1.4	2.2	0.8	0.9
D6	1.5	1.0	1.7	1.9	2.6	0.9	1.1
D7	0.8	1.2	1.5	1.6	2.4	0.8	1.0
D8	1.1	1.1	1.3	1.2	2.0	0.9	1.1
D9	1.1	1.3	1.0	2.3	2.3	1.5	**4.4**
D10	1.1	0.8	1.1	1.1	2.0	0.4	0.5
D11	1.5	1.2	1.0	1.4	2.6	0.7	0.4
D12	1.1	1.6	1.9	2.9	**4.8**	**5.0**	1.6
D13	1.5	1.8	2.2	2.4	2.9	1.6	0.4
D14	0.9	0.9	1.6	**7.4**	**4.7**	**5.7**	1.0
D15	-	-	-	1.1	**22.4**	1.1	1.8

[a] *All contaminated results have been removed from the annual averages.*
[b] *Data available until June/July 2011.*

Dust deposition levels are also monitored at three sites in the vicinity of the proposed Maules Creek Coal Project. The annual average dust deposition monitoring data for the period November 2010 to September 2011 are presented in **Table 5.5**.

Table 5.5: Maules Creek Coal Project dust deposition (insoluble solids) results – g/m^2/month

MC01	MC02	MC03	MC04
1.0	1.3	2.2	1.3

Note: Based on data from November 2010 to September 2011.

The average dust deposition recorded at the Boggabri Coal Mine and Tarrawonga Coal Mine, across all sites for the same period as the Maules Creek Coal Project data are shown **Table 5.6**.

Table 5.6: Comparison of dust deposition (insoluble solids) results – g/m^2/month

Location	g/m^2/month
Maules Creek Coal Project (All sites)	1.6
Boggabri Coal Mine (All sites)	1.8
Tarrawonga Coal Mine (All sites)	2.7

5.2.4 Existing Air Quality for Assessment Purposes

The assessment of Project and cumulative air quality impacts requires background particulate matter concentrations and dust deposition levels to be defined.

For Project impacts, this includes contributions from local sources such as dust from vehicles using unsealed roads, stock movements, cropping and exposed ground, as well as more regional air quality sources such as bushfires and dust storms.

The assessment of cumulative air quality impacts of the Project requires background particulate concentrations and levels to be defined, inclusive of contributions from other mining operations. The proximity of dust gauges and HVASs to existing mining operations means that air quality data includes contributions from the existing Tarrawonga and Boggabri Coal Mines.

For this assessment, impacts for cumulative assessment relating to the Boggabri Coal Continuation Project and the Maules Creek Coal Project have been quantified by dispersion modelling conducted for those projects as part of their respective EAs. Therefore, background levels for assessment have been estimated from available data to minimise double-counting whilst still providing conservative background levels.

The total PM_{10} average for the Tarrawonga and Boggabri Coal Mines HVASs (all years) is approximately 14.8 $\mu g/m^3$. For PM_{10}, a background concentration of 12 $\mu g/m^3$ has been selected to represent local and regional dust sources as it is representative of concentrations measured for Tarrawonga Coal Mine and Boggabri Coal Mine and is higher than levels recorded at Maules Creek Coal Project (which does not have nearby mining operations) to date. TSP concentrations have been calculated from this level and a TSP of 30 $\mu g/m^3$ has been adopted.

The total dust deposition average for the Tarrawonga Coal Mine and Boggabri Coal Mine sites (all years) is approximately 2.6 g/m^2/month. This level reduces to 2.1 g/m^2/month when sites EB-15 (which is located on the Mining Lease in close proximity to the waste emplacement) and EB-13 (which exhibits dust levels consistently higher than the adjacent EB-5 and EB-4) are excluded. A dust deposition level of 2 g/m^2/month has been adopted for assessment. This level is close to the average of Tarrawonga Coal Mine and Boggabri Coal Mine sites when excluding the two sites with anomalously high levels and is higher than the majority of records at the Maules Creek Coal Project to date.

In summary, for the purposes of assessing potential impacts, the following existing air quality levels are assumed for sources other than local mining activity.

- annual average PM_{10} concentration of 12 $\mu g/m^3$;
- 24-hour PM_{10} concentrations – daily varying;
- annual average TSP concentration of 30 $\mu g/m^3$; and
- annual average dust deposition of 2 g/m^2/month.

5.3 Existing Air Quality Mitigation and Management Measures

Air quality management at the Tarrawonga Coal Mine is described in the Air Quality and Greenhouse Gas Management Plan (AQGHGMP) (**TCPL, 2011a**). Current air quality mitigation and management measures employed at the Tarrawonga Coal Mine are provided below (**TCPL, 2011a**):

Vegetation Clearing and Soil Stripping

- *Cleared trees and branches are retained for the use in stabilising slopes identified for rehabilitation with native woodland communities.*
- *Where practicable, soil stripping is undertaken at a time when there is sufficient soil moisture to prevent significant dust lift-off.*
- *Stripping soil is avoided in periods of high winds.*
- *Dust suppression by water application is used to increase soil moisture if stripping occurs during periods of high wind or low soil moisture.*

Drilling and Blasting Activities

- *The drill rig utilises water injection or alternatively, is fitted with dust collectors.*
- *Blast hole stemming is used to prevent venting of explosion gases.*
- *Blasting is conducted both before the establishment, and after the break-up of low-level atmospheric temperature inversions.*
- *The following factors contributing to non-ideal detonation behaviour and higher emission (principally NO_2) concentrations are avoided whenever possible.*
  - *weak overburden which reduces the necessary explosive confinement is ripped in preference to blasting.*
  - *water infiltration.*
  - *long explosive columns.*
  - *explosive pre-compression, caused by hole-to-hole shock propagation due to wet overburden and clay veins.*

Overburden Ripping and Coal Mining

- *Ripping of softer overburden material is avoided during periods of high wind.*
- *Low moisture coal is sprayed with water prior to excavation to raise moisture content to > 5.5%.*

Internal Road and Hardstand Area Construction

- *Clearing ahead of construction activities is minimised.*
- *Cleared areas are watered regularly during any construction activities, where appropriate.*

Coal Processing Area

- *Water is applied to the coal at the feed hopper, crusher and at all conveyor transfer and discharge points.*
- *All conveyors are fitted with appropriate cleaning and collection devices to minimise the amount of material falling from the return of conveyor belts.*
- *Some flexibility exists to temporarily cease operation in the event of protracted dry periods, high winds, or significant dust generation and dispersal towards the surrounding residences.*
- *Trucks transporting coal offsite from the Coal Processing Area must be covered immediately after loading to prevent windblown emissions and spillage. The covering must be maintained until immediately before unloading the trucks (as per Condition O3.2 of EPL 12365).*

Wind Erosion Management

- *The extent of clearing/site preparation in advance of mining is minimised.*
- *Progressive rehabilitation of areas of disturbance, including topsoil and subsoil stockpiles is undertaken.*
- *Bund walls and windbreaks are constructed as required.*

Internal Transport

- *The road for the transportation of coal product between the mine facilities area and mine entrance is sealed.*
- *Internal roads are regularly watered.*
- *Earthmoving equipment and on-site vehicles:*
  - *are fitted with exhaust controls which satisfy NSW DECCW emission requirements;*
  - *are properly maintained and any mobile equipment which does not comply with NSW DECCW guidelines is removed; and*
  - *have the exhausts directed upwards or to the side (where applicable) so as not to cause dust lift-off.*

5.4 Air Quality Complaints Overview

Examination of the Annual Environmental Management Reports (AEMRs) for the period from 2006/2007 to 2009/2010 (**TCPL, 2007; 2008; 2009; 2010**) indicates that six complaints pertaining to air quality issues have been received and were recorded in the complaints register between May 2006 and April 2009. It is noted that of these six complaints, five were received from the occupant of a single residence, which has subsequently become a mine-owned residence.

No complaints regarding air quality were received by TCPL during the 2008/2009 or 2009/2010 AEMR reporting periods (**TCPL, 2009; 2010**).

During the 2010/2011 AEMR reporting period (up to April), one complaint was received. Between April and August 2011, a further four complaints were received from nearby residences relating to air quality. Three were received from a single receiver to the east of the Project, and one was a single complaint that was received via the OEH. **Table 5.7** provides a summary of air quality complaints received since April 2010, including a summary of how these complaints were resolved.

Table 5.7: Tarrawonga Coal Mine complaints summary April 2010 – August 2011

Date Received	Issue	Results of TCPL Investigation	TCPL Response
28/02/2011	Excessive dust from both Boggabri and Tarrawonga Coal Mines on Friday 25 February and Monday 28 February.	Matter was investigated with site personnel and Boggabri Coal Mine Environmental Coordinator. Review of meteorological data undertaken. On Friday 25 February, site personnel were not aware of any significant additional dust issues from site. Usual operations were occurring, with three water carts/trucks in operation. Scrapers were relocating a soil stockpile from the north-west corner of the lease. Wind conditions were light and predominantly from the north, east and south, and not from the west as would be expected if significant impacts were prevalent at the complainant's property. A temperature inversion was present throughout the night and up to around 9am on the Friday morning. This may have restricted capacity for dust to disperse and may have made dust more visible at the complainant's property. On Monday 28 February, conditions were poor with wind gusts up to 15 metres per second (m/s) and average wind speeds of around 5m/s. Dust lift off was prevalent from all sources on Monday, not just production areas of the mine. There was no capacity to control dust lift off with the conditions at the time which were hot, dry and very windy. Scraper operations were suspended at Tarrawonga Coal Mine at approximately 10am on the Monday morning due to the poor conditions. There was little more that could be done in relation to dust lift on Monday as a consequence of the poor conditions throughout the day.	Advice was issued to DECCW confirming the outcomes of the investigation. The advice was a combined response from Tarrawonga and Boggabri Coal Mines.
13/05/2011	Complaint relating to dust on Monday morning and afternoon 9 May.	A review of the weather conditions determined incidence of inversion that may have caused dust to become trapped beneath the inversion layer, causing it to become concentrated and visible.	Follow-up occurred in conjunction with installation of a real-time noise monitoring instrument at the complainant's property.
16/05/2011	Complaint relating to dust on Monday morning 16 May. Dust plume from Tarrawonga site floating out towards their property.	The complainant was advised that an Environmental Officer would investigate the dust generation from site to ensure dust lift off was minimised. Dust was evident across the valley and some localised dust generation was identified at Tarrawonga Coal Mine. Site personnel advised that water carts/trucks commenced watering roads before mining commenced and that the water trucks had been operational throughout the morning. Dust generation was also noted on adjacent unsealed public roads and from Boggabri Coal Mine.	Advice was issued to OEH confirming the outcomes of the investigation. The advice was a combined response from Tarrawonga and Boggabri Coal Mines.

Table 5.6: Tarrawonga Coal Mine complains summary April 2010 – August 2011 (Continued)

Date Received	Issue	Results of TCPL Investigation	TCPL Response
21/06/2011	Complaint on behalf of anonymous complainant in relation to dust generation off the Tarrawonga Coal Mine.	An Environmental Officer travelled to site to review conditions. Dust was observed leaving site due to strong north-westerly winds. Whilst some dust was evident from overburden dumping, the majority of dust was associated with soil relocation from stockpiles at the southern end of site to the new stockpiling location west of the haul road. The issue was raised with the Project Manager and it was determined that shortening the haul length for topsoil relocation, and additional runs by the water carts/trucks would reduce dust lift off. This practice was implemented and observed to effectively reduce dust impact.	No further action required.
2/08/2011	Complaint in relation to extent of dust in the area during the morning, which seemed to be travelling east from the direction of the mines. It was acknowledged that conditions were very dry and prevailing winds determined how dust dispersed however it was requested that more be done to control dust from off the mine sites.	The extent of dust during the morning was acknowledged with Boggabri Coal Mine and review of photographs taken by the Boggabri Coal Mine Environmental Coordinator. Both Boggabri and Tarrawonga Coal Mines acknowledge dust generation from their operations, however, a significant proportion of dust is also generated from traffic on the nearby unsealed roads including Manilla Road, Wean Road, Goonbri Road, Dripping Rock Road and Leard Forest Road.	Actions currently under investigation to reduce dust impact include consideration to ongoing gravel collection by Narrabri Shire Council requiring Council to water the affected roads to reduce dust impact; review of water cart/truck operations on both day and night shift to confirm adequate dust suppression is being implemented; and consideration to the use of a surfactant to further reduce dust lift off from haul roads on the mine site.

Source: TCPL (2011b).

6 DISPERSION METEOROLOGY

6.1 Modelling Approach

6.1.1 Introduction

The CALMET/CALPUFF modelling system was chosen for this study. 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. CALPUFF is endorsed by the US EPA and is an approved air quality modelling system in accordance with the Approved Methods (**DEC, 2005**).

6.1.2 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 (i.e. the CALPUFF dispersion model requires meteorological data in three dimensions). 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.

CALMET was initially run for a coarse outer grid domain of 90 km x 90 km, centred near the Project site, with a 2 km grid resolution. This coarse outer grid was used as input to the initial guess field for a finer resolution inner grid domain of 20 km x 20 km with a 0.25 km grid resolution, also centred over the Project site. The rationale for modelling an outer meteorological domain was to capture significant regional features, for example Mount Kaputar, and to allow cloud data from BoM monitoring sites to be incorporated. The inner grid modelling was used to create a fine resolution three-dimensional meteorological field for the area around the Project site. Observed hourly data from the Tarrawonga Coal Mine AWS, Boggabri Coal Mine AWS, Maules Creek Coal Project AWS, and the BoM site located at Narrabri Airport AWS were used as input for CALMET. Cloud cover and cloud heights were sourced from observations at Tamworth Airport AWS. Upper air data were also extracted from The Air Pollution Model (TAPM).

6.1.3 Justification of Approach

As described in **Section 2.3**, four years have been chosen for quantitative dispersion modelling. These years along with their rationale for selection are provided below:

- Year 2 – first year of the Project at 3 Mtpa ROM coal production, representative of western-most operations during the Project and placement of waste rock in the southern emplacement.

- Year 4 – coincides with Boggabri Coal Continuation Project assessment year to assist with cumulative impact assessment.
- Year 6 - year of maximum materials (i.e. ROM coal and waste rock) movements.
- Year 16 – representative of eastern-most operations during the Project.

Dispersion modelling results for the above years are considered to represent the worst case for the Project at any particular residential receiver.

Air quality impacts are estimated in this study via use of dispersion modelling (i.e. CALPUFF). This is considered to be appropriate to quantify potential impacts on privately-owned receivers which are located in the vicinity of the Project. The results of dispersion modelling are compared with the relevant OEH air quality criteria, which are generally health-based (with the exception of dust deposition, which is an amenity-based criterion) (**Section 4.1**).

The CALPUFF dispersion model has been selected for this Air Quality and Greenhouse Gas Assessment as it is considered by the OEH to be appropriate for locations of complex terrain. The local area is undulating to the north of the Project, which is the direction where the prevailing winds come from, therefore the use of CALPUFF is considered to be appropriate.

Blasting (fume and dust emissions) and dust emission effects on surrounding receivers were identified in the Project Environmental Risk Assessment (Appendix O of the EA) as key potential environmental impacts. In accordance with the outcomes of the Environmental Risk Assessment, this Air Quality and Greenhouse Gas assessment includes dust emissions from blasting activities (**Section 8.2**) and assesses potential air quality emissions in the context of health-based air quality criteria (**Section 9**).

Fumes from blasting emissions were also raised as an issue in the Environmental Risk Assessment. However, it is expected that with the implementation of appropriate blast design and management, and in consideration of the distance from open cut areas to receivers (approximately 3 km), the potential for blasting fumes being an issue at privately-owned receivers is considered to be low. This is further evidenced by the complaints review (**Section 5.4**), which found that no complaints relating to blasting fumes were received.

Fumes from blasting would be managed in accordance with *Code of Good Practice: Prevention and Management of Blast Generated* NO_x *Gases in Surface Blasting* (Australian Explosives Industry and Safety Group Inc., 2011).

6.2 CALMET Generated Wind Data

The performance of the CALMET model is compared with observations made at the Tarrawonga Coal Mine AWS based on the annual and seasonal windroses extracted for a point at the approximate location of the weather station. This is shown in **Figure 6.1**.

The CALMET annual wind rose displays similar characteristics to the measured wind speeds at the Tarrawonga Coal Mine with moderate to strong wind speeds dominating from the north. There is also a dominant north-east component in the CALMET data, particularly during autumn and winter, which is not present in the measured Tarrawonga Coal Mine data, however is apparent in the available data measured at the Boggabri Coal Mine AWS.

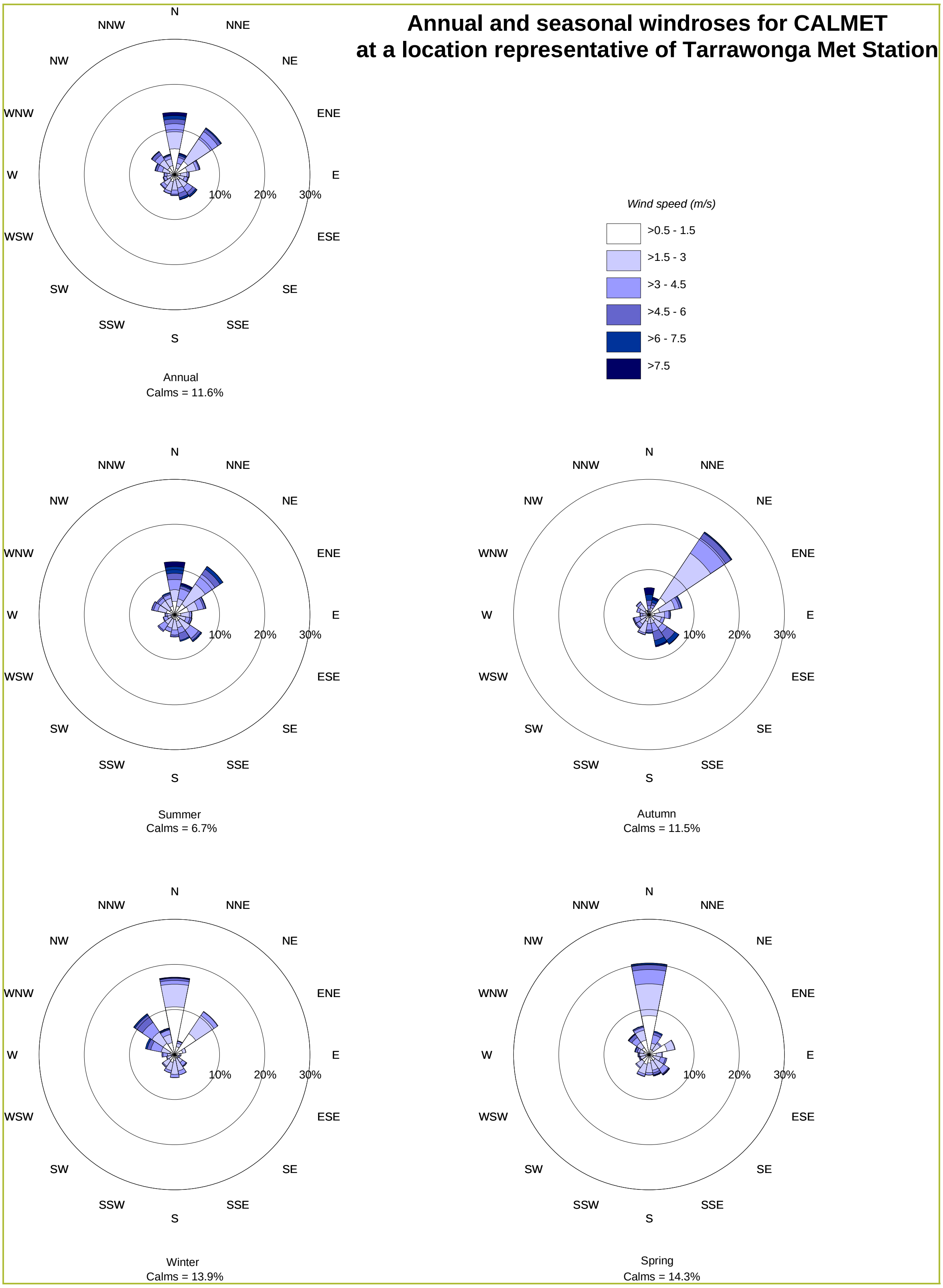


Figure 6.1: CALMET Generated Wind Rose for the site

The estimated mean wind speed at the site is 3.0 m/s with an estimated percentage of calm conditions (< 0.5m/s) of 12% of the time. This is less than the measured 18% calms at the Tarrawonga Coal Mine AWS during 2010, however there is a significant number of wind speeds recorded at zero in the Tarrawonga Coal Mine AWS 2010 dataset and it is not clear if these data are calms or are a result of the instrument stalling.

6.3 Atmospheric Stability

An important aspect of emissions 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 (P-G) 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 class), through neutral (D class) to slightly stable (E class). 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 6.2**. The data show a high proportion of stable conditions (class F).

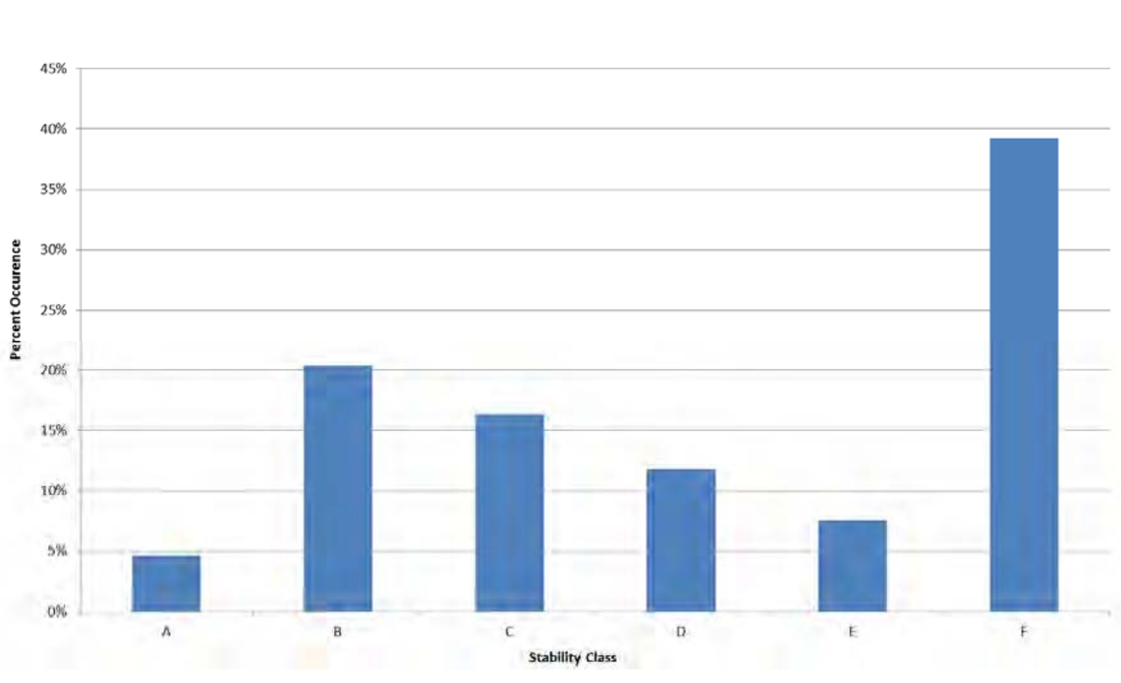


Figure 6.2: Stability Class Frequency (2010)

It is noted that a turbulence based scheme within CALPUFF was used in the modelling and the P-G stability class frequency is shown for information only. The use of turbulence based dispersion coefficients is recommended (**TRC, 2010**) for the same reasons that the US EPA has replaced P-G-based dispersion with a turbulence-based approach in their regulatory model (AERMOD) and is in accordance with best science practice and model evaluation studies.

6.4 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 an important parameter within air pollution meteorology as vertical diffusion or mixing of a plume is generally considered to be limited by the mixing height, as the air above this layer tends to be stable, with restricted vertical motion.

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 6.3**. 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. The median, highest and lowest mixing heights for each hour are represented by the horizontal lines. The vertical bars represent the lower quartile and upper quartile of mixing heights.

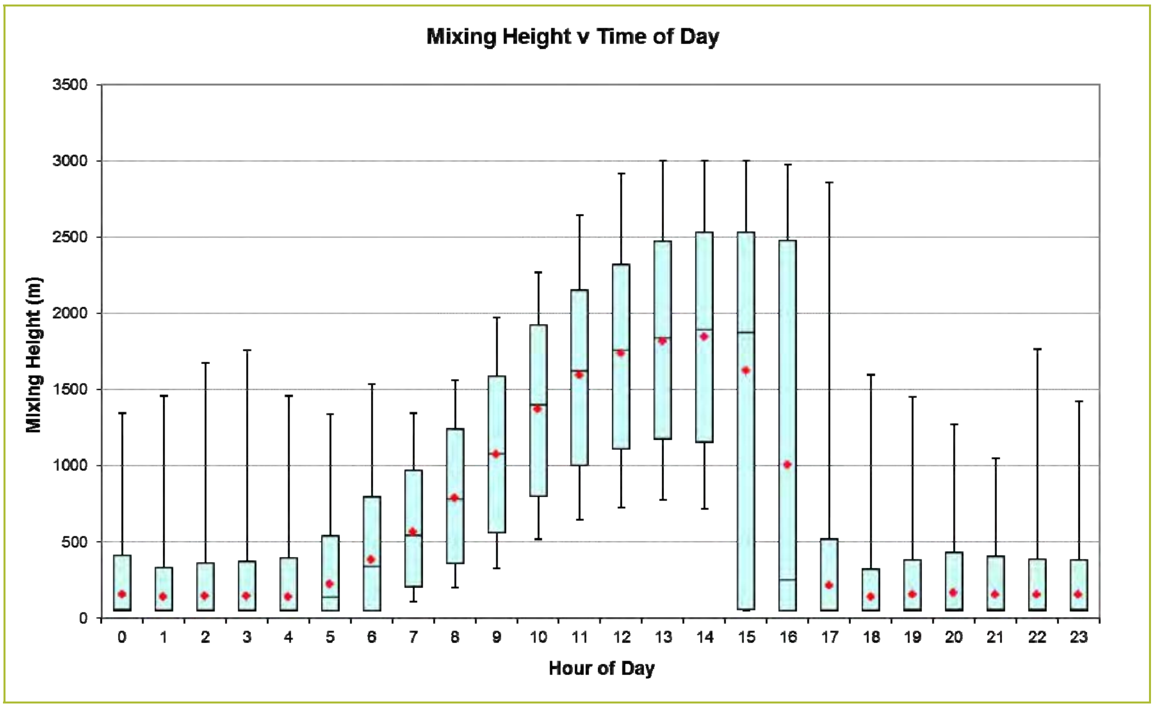


Figure 6.3: Average Daily Diurnal Variation in Mixing Layer Depth

7 OVERVIEW OF BEST PRACTICE DUST CONTROL

This section describes the best practice air quality mitigation measures to be implemented for the Project with reference to the recommendations of the *NSW Coal Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (**Katestone Environmental Pty Ltd [Katestone], 2011**), a study that was commissioned by the DECCW.

7.1 Overview of Measures to be Implemented

Katestone (2011) identifies that the top three dust producing activities at NSW coal mines; namely haul trucks travelling on unpaved roads, wind erosion of overburden and use of bulldozers account for approximately 75% of air quality emissions in the NSW coal mining industry. **Katestone (2011)** also identifies a range of measures that are considered to be best practice with respect to the management of air quality emissions at NSW coal mines.

Table 7.1 provides an overview of the best practice air quality mitigation measures to be implemented for the Project. These are targeted at the main sources of air quality emissions identified in **Katestone (2011)**.

7.2 Discussion

Table 7.1 demonstrates that the majority of the best practice management measures described in the recommendations of **Katestone (2011)** are implemented at the existing Tarrawonga Coal Mine. Measures to be employed for the Project include:

- Use of water carts/trucks to control emissions from haul roads.
- Use of additional water application and/or surfactants on haul roads.
- Control of the speed of trucks.
- Progressive rehabilitation.
- Application of water at the feed hopper, on conveyor transfer points and at coal discharge points.
- Watering of trafficked areas for bulldozing.
- Minimisation of travel speed and distance travelled for bulldozing.
- Delay of blasts if unfavourable weather prevails.
- Minimisation of blast area.
- Use of water sprays or curtains for drilling operations.
- Minimisation of drop heights for dumping of overburden.

TCPL would undertake additional haul road watering and/or use surfactants to further reduce air quality emissions from haul roads (**Section 8.3**). From review of the air quality emissions inventory, these measures are estimated contribute to an overall annual reduction in air quality emissions of approximately 30% (i.e. compared with a scenario where additional watering and/or use surfactants are not used).

Table 7.1: Overview of best practice emission reduction measures described in Katestone (2011)

Air Quality Emission Source	Emission Reduction Measure	Used for the Existing Tarrawonga Coal Mine[1]	Used for the Project?	Comments	Effectiveness of reduction in Emissions Inventory
Haul Trucks travelling on Unpaved Roads	Use of water carts/trucks to control emissions	Yes	Yes	Up to four water carts used plus a water truck.	75% haul road control of emissions
	Additional water application and/or use of surfactants	No	Yes	Additional/extended water truck shifts to be undertaken and surfactants to be used (**Section 8.3**). TCPL would also undertake an education campaign with water cart/truck drivers to facilitate targeted application of additional watering.	15% (taking total haul road control of emissions to 90%)
	Use of conveyor for coal transportation instead of haulage on unpaved roads	No	No	Use of a conveyor to the Boggabri Coal Mine has been investigated by TCPL, however is considered to be not feasible at this stage.	N/A
	Control of the speed of trucks	Yes	Yes	Speed of haul trucks controlled to approximately 40 kilometres per hour (km/hr).	The emission factor is based on the amount of material moved, so no reduction to the emissions inventory is necessary, however there would be a marginal reduction in practice.
Wind Erosion of Overburden	Progressive Rehabilitation	Yes	Yes	Rehabilitation to occur as described in Section 5 of the main text of the EA.	Partially rehabilitated areas are assumed to be 99% effective in terms of dust control as they are not trafficked and will therefore be subject to surface 'crusting' and progressive establishment of groundcover/grasses. Rehabilitated areas are 100% effective in terms of dust control.
ROM Coal Handling	Water application	Yes	Yes	Water is applied to the coal at the feed hopper, crusher and at all conveyor transfer and discharge points.	50% control of emissions
	Use of surfactants	No	No	Not considered to be necessary by TCPL based on operational experience with the effectiveness of the existing sprays. TCPL would review the feasibility over the life of the Project.	N/A

Air Quality Emission Source	Emission Reduction Measure	Used for the Existing Tarrawonga Coal Mine[1]	Used for the Project?	Comments	Effectiveness of reduction in Emissions Inventory
ROM Coal Handling (Cont.)	Minimisation of drop heights	Yes	Yes	TCPL would undertake an education campaign with truck drivers to minimise drop heights where possible.	Emission factor does not consider drop height, so no reduction to the emissions inventory is necessary, however there would be a material reduction in practice.
	Enclosure of ROM coal stockpile	No	No	This is not considered to be warranted by TCPL due to the effectiveness of the existing control measures, as evidenced by operational experience and compliance with air quality criteria. Operational concerns regarding restriction of stockpile access have also been considered.	N/A
Bulldozing	Watering of trafficked areas	Yes	Yes	Application rates would be as per unpaved roads.	Emission factor based on hours used, so no reduction to the emissions inventory is necessary, however there would be a marginal reduction in practice.
	Minimisation of travel speed and distance travelled	Yes	Yes	TCPL would undertake an education campaign with dozer drivers to encourage appropriate speeds and routes are used.	
Blasting	Delay of blasts if unfavourable weather prevails	Yes	Yes	TCPL routinely delays blasting during unfavourable conditions, including strong winds and temperature inversions.	Emission factor does not consider weather conditions, so no reduction to the emissions inventory is necessary, however there would be a material reduction in short-term emissions in practice.
	Minimisation of blast area	Yes	Yes	Appropriate blast design, including minimisation of blasting area is an objective of blasting operations.	Blasting area assumed to be 6,000 square metres (m^2).
Drilling	Water Sprays or curtains	Yes	Yes	Drilling typically uses water injection.	Emission factor does not consider moisture content, so no reduction to the emissions inventory is necessary, however there would be a marginal reduction in practice.
	Air Extraction to a Bag Filter	No	No	This is not considered to be warranted by TCPL due to the effectiveness of the existing control measures as evidenced by operational experience and compliance with air quality criteria.	N/A

Air Quality Emission Source	Emission Reduction Measure	Used for the Existing Tarrawonga Coal Mine[1]	Used for the Project?	Comments	Effectiveness of reduction in Emissions Inventory
Loading and dumping of Overburden	Minimisation of drop heights	Yes	Yes	TCPL would undertake an education campaign with truck drivers to minimise drop heights where possible.	Emission factor does not consider drop height, so no reduction to the emissions inventory is necessary, however there would be a material reduction in practice.
	Use of water sprays	No	No	Direct water spraying of overburden loading and dumping is not considered to be operationally feasible by TCPL due to the dispersed nature of potential overburden loading/unloading locations (i.e. multiple loading and unloading locations are typically used). Water carts/trucks are used on active haul roads as described above.	N/A

1 Generally in accordance with the Air Quality Monitoring Program (TCPL, 2011a).

TCPL has investigated the possible use of a conveyor to transport ROM coal to the Boggabri Coal Mine Infrastructure Facilities, rather than the use of haul trucks on unpaved roads. This was identified as an effective method to control of emissions in **Katestone (2010)**. PAEHolmes estimates that the use of a conveyor would reduce total emissions by approximately 2% (based on estimates for Year 16 emissions). TCPL has estimated the cost of installing this conveyor at approximately $10 million. As described in **Table 7.1**, TCPL considers that the capital cost is prohibitive and is not feasible from an economic perspective and the modest (2%) reduction of emissions in total means that the conveyor is not reasonable from an emissions reduction perspective. Therefore, the conveyor is not proposed for the Project.

7.3 Description of Real Time Air Quality Monitoring and Controls

TCPL is committed to leading practice dust management at the site through the use of a real-time and proactive dust management system. This is described in the existing AQGHGMP (**TCPL, 2011a**) would enable TCPL to pro-actively manage the short-term impacts of the Project and prevent or minimise dust impacts at privately-owned receivers to the greatest practical extent.

TCPL has been in discussions with the proponents of nearby mining projects (i.e. Boggabri Coal Mine and Maules Creek Coal Project) with the objective of integrating the monitoring network as far as practicable.

TCPL proposes to contribute to a network of real-time dust monitors in the vicinity of the Project. The real-time monitoring network would continuously log short-term particulate concentrations (15 minute, 30 minute and 1 hour averages) and report the data via GPS/GRSM modem to a web based recording system.

When certain short-term trigger levels are reached or exceeded, a message would be delivered to a TCPL representative, alerting them to the elevated short-term dust levels. The on-site weather station would report wind conditions at the time, allowing appropriate personnel to determine the potential origin of the elevated dust levels.

The short-term trigger levels (e.g. 1-hour average) would be derived based on a statistical analysis of appropriate peak to mean ratios and set at a level where a few consecutive readings at these high levels risks a breach of the 24-hour PM_{10} impact assessment criteria. During the life of the Project, should more suitable technology become available, this system may be modified and enhanced.

An additional potential component of the dust management procedures currently being investigated by TCPL would be to develop a meteorological and air quality forecasting system to predict, one day in advance, what the meteorological conditions and air quality impact would be. This would allow the appropriate personnel to manage the intensity of activities for that day, increase controls or limit activity to various areas of the Project.

It is anticipated that real-time air quality monitoring and controls would be particularly effective in relation to the measurement of cumulative short-term emissions which are predicted in **Section 9.2**.

The above measures would be incorporated into the revised AQGHGMP for the Project.

8 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 mining plans for the Project have been analysed and detailed emissions inventories have been prepared for four key operating scenarios, being Project Years 2, 4, 6 and 16. As discussed in **Section 6.1.3**, these modelled scenarios are considered to be representative of worst-case operations; for example where coal and waste production are highest, where extraction or wind erosion areas are largest or where operations are located closest to receivers.

Detailed calculations are provided in **Appendix A** 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.

8.1 Particle Size Categories

Emission estimates have been based on the use of three particle-size categories (0 to 2.5 µm - referred to as fine particulate [FP], 2.5 to 10 µm - referred to as coarse matter [CM] and 10 to 30 µm - referred to as Rest). Emission rates of TSP have been calculated using emission factors developed both within NSW and by the US EPA (**Appendix A**).

The distribution of particle sizes has been derived from measurements published by the **SPCC (1986)**. The distribution of particles in each particle size range is as follows:

- $PM_{2.5}$ (FP) is 4.7% of the TSP;
- $PM_{2.5-10}$ (CM) is 34.4% of TSP; and
- PM_{10-30} (Rest) is 60.9% of TSP.

Modelling was performed using CALPUFF for each size fraction according to a particle size category. Each dust source was assumed to emit at the full TSP emission rate and to deposit from the plume in accordance with the deposition rate appropriate for particles with an aerodynamic diameter equal to the geometric mean of the limits of the particle size range, except for the $PM_{2.5}$ group, which was assumed to have a particle size of 1 µm.

8.2 Emission Estimates

Estimates of emissions for each source were developed on an hourly time step taking into account the 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. Dust generating activities were represented by a series of volume sources situated according to the location of activities for the modelled scenarios (**Figures 2.1** to **2.4).**

To model the effect of pit retention for emissions within the open cut, detailed mine terrain has been incorporated into the modelling. All activities have been modelled for 24 hours per day, with the exception of blasting which is limited in the modelling between the hours of 7.00 am and 6.00 pm, which is conservative given that the actual hours are 9.00 am and 5.00 pm Monday to Saturday (excluding public holidays).

For each stage of the mine shown in **Figures 2.1** to **2.4**, a corresponding emissions inventory has been developed. The information used for developing the inventories has been based on the operational descriptions and mine plan drawings and used to determine haul road distances and routes, stockpile and pit areas, activity operating hours, truck sizes and other details that are necessary to estimate dust emissions.

Table 8.1 summarises the quantities of TSP estimated to be released by each activity of the Project.

As described in **Section 2.3**, the Project would include the transportation of Tarrawonga Coal Mine ROM coal to the Boggabri Coal Mine for handling, processing and transportation via trains. The potential air quality emissions associated with the interactions between the Project and the Boggabri Coal Mine are included in **Table 8.1** (i.e. where the description of the activity includes the word 'Boggabri'). These emissions are herein conservatively reported as part of the Project emissions.

It should be noted that the emissions inventory summarised in **Table 8.1** includes consideration of screening and crushing of domestic coal at a maximum rate of up to 450,000 t and also consideration of export of coal (through the Boggabri Coal Mine Infrastructure Facilities at up to 3 Mtpa). In practice, the actual proposed domestic coal production rate for the Project is 150,000 tonnes per annum (tpa) and overall coal handling would be limited to 3 Mtpa, therefore the assessment provided is conservative.

8.3 Additional Haul Road Controls

Preliminary modelling indicated that of the potential dust sources on-site, emissions from the hauling of overburden and ROM coal contributes more than any other source group to short-term PM_{10} impacts at the closest residential receivers. Typically, modelling assessments for mine sites apply a haul road control level of 75% (representing control via > Level 2 watering).

For the modelling scenarios presented in this report, an additional level of control on hauling (90% control) has been applied to the emission estimates, following a commitment made by TCPL to control off-site impacts to the maximum extent achievable.

The 90% control is expected to be achieved by increasing the application rate of water and/or through the use of chemical dust suppressants. As shown in **Figure 8.1**, 90% control can be achieved through the application of water, provided the moisture content of the surface material is approximately 8%. Alternatively, chemical dust suppressants would be used as described below.

Table 8.1: Estimated TSP emissions each stage of the Project (kg TSP/year)

Activity	Year 2	Year 4	Year 6	Year 16
Topsoil Removal- Scraper clearing and stripping	43,200	43,200	43,200	43,200
OB – Drilling	4,194	4,194	4,194	4,194
OB – Blasting	11,043	11,043	11,043	11,043
OB - Excavator loading OB to haul truck	62,277	59,110	69,665	65,443
OB - Hauling to Waste Emplacement(s)	567,816	605,978	715,361	615,640
OB - Hauling to Mobile Crusher	8,751	9,232	8,751	8,751
OB - Emplacing at Waste Emplacement(s)	61,643	58,477	69,032	64,810
OB - Dozers on OB in Pit	112,512	112,512	112,512	112,512
OB - Dozers on OB working on Waste Emplacement(s) and rehabilitation	197,978	197,978	197,978	197,978
OB - unloading waste rock at mobile plant	633	633	633	633
OB – Loading gravel stockpile	633	633	633	633
CL - Dozers ripping/pushing/clean-up	242,694	242,694	242,694	242,694
CL - Loading ROM coal to trucks with excavator	143,496	143,496	143,496	143,496
CL - Hauling open pit coal to mobile plant	6,658	6,658	6,658	6,658
CL - Hauling open pit coal to Boggabri ROM Pad / hopper	55,484	57,259	61,032	66,581
CL – unloading ROM coal at mobile plant	21,524	21,524	21,524	21,524
CL – Screening domestic coal[1]	5,625	5,625	5,625	5,625
CL – Crushing domestic coal	4,500	4,500	4,500	4,500
CL – Screening gravel[2]	5,244	5,244	5,244	5,244
CL – Crushing gravel	828	828	828	828
CL - Loading domestic coal stockpile	21,524	21,524	21,524	21,524
CL – unloading ROM coal at Boggabri ROM pad	143,496	143,496	143,496	143,496
CL - Loading coal to hopper with FEL at Boggabri	143,496	143,496	143,496	143,496
CL – Screening at Boggabri	37,500	37,500	37,500	37,500
CL – Crushing at Boggabri	30,000	30,000	30,000	30,000
CL - Loading Product coal stockpile	143,496	143,496	143,496	143,496
CL - Dozers on product stockpiles	242,694	242,694	242,694	242,694
CL - Rail Load Out at Boggabri	540	540	540	540
WE - Overburden emplacement areas	216,512	294,520	149,648	175,120
WE - Open pit	175,120	143,280	159,200	95,520
WE – Partially rehabilitated northern area	1,703	1,512	2,261	1,719
WE – Partially rehabilitated southern area	955	-	-	-
WE - Coal and gravel stockpiles mobile plant	398	398	398	398
WE - Coal stockpiles Boggabri ROM Pad	143	143	143	143
WE – Product Coal stockpiles Boggabri	143	143	143	143
Grading roads	61,940	61,940	61,940	61,940
Total	**2,776,396**	**2,855,504**	**2,861,085**	**2,719,719**

Notes: OB – overburden; CL – coal; WE – wind erosion.

kg TSP/year - kilograms of TSP per year.

Totals may differ to the sum of the columns due to rounding and significant figures.

1 Emissions from domestic coal were calculated based on the currently approved 450,0000 tpa rate rather than the proposed 150,000 tpa rate for the Project. This leads to a conservative assessment of the associated potential impacts.

2 Emissions from gravel were calculated based on 300,000 cubic metres per annum (m^3/annum) rather than the proposed 90,000 m^3/annum for the Project. This leads to a conservative assessment of the associated potential impacts.

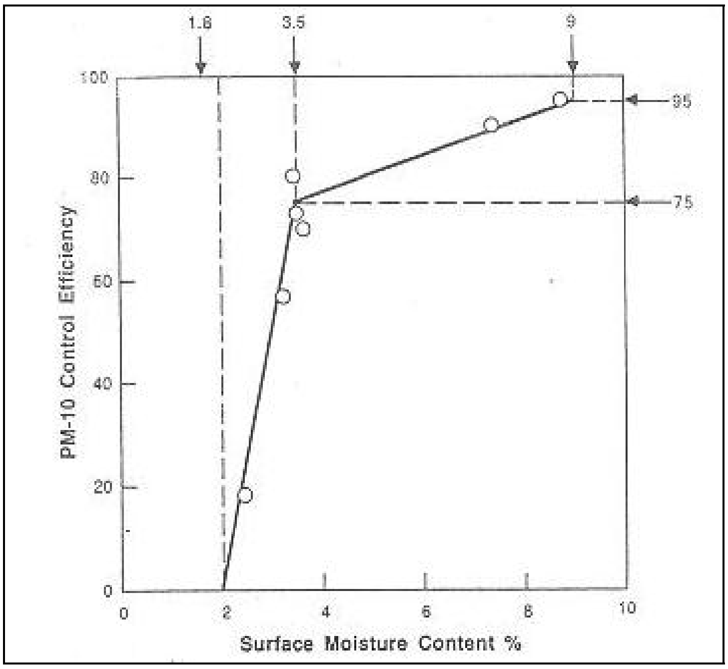


Figure 8.1: Watering control effectiveness for unpaved roads (Buonicore and Davis, 1992)

There are no known validation studies of the use of chemical suppressants completed in Australia, other than a study completed in 1984 by the NSW Coal Association, Pacific Chemical Industries (suppliers of the chemical suppressant "Pacwet") and the SPCC which investigated the efficiency of chemical treatment in reducing dust emissions from unsealed roads at a mine site in the Hunter Valley (**Ferrari and Pender, c.1986**).

The study measured dust levels at distances of 15 m, 25 m and 50 m from a haul road that were untreated, watered and treated with "Pacwet" under temperature ranges of 4^{o}C to 21^{o}C, relative humidity of between 29% and 98% and wind speeds between calm and 11 m/s. The study concluded that regardless of the control applied, dust levels originating from the road decrease rapidly with distance and that it was clear that both water and "Pacwet" were very effective in controlling dust.

The US EPA Air Pollution Control Technology Centre independently verifies commercial-ready technologies and has verified the performance of five products for the control of dust from unpaved roads.

As shown in **Table 8.2**, the majority of the verified products showed control efficiencies for PM_{10} of 90% assumed in the dispersion modelling completed for the proposed operations.

Table 8.2: Average PM_{10} control efficiencies of dust suppressants as verified by US EPA

Product	Average PM_{10} control efficiency (%)	Source
EK35	84-90	EPA/600/R-05/128, 2006
EnviroKleen	87-98	EPA/600/R-05/134, 2006
DustGard	88-90	EPA/600/R-05/127, 2006
PetroTac	73-98	EPA/600/R-05/135, 2006
TechSuppress	46-76	EPA/600/R-05/129, 2006

TCPL has previously trialled the PetroTac product at the Tarrawonga Coal Mine and anecdotal evidence from this trial suggested that the product was effective in terms of dust suppression.

8.4 Estimated Emissions from Neighbouring Mines

The OEH's agency comments include a requirement to assess cumulative emissions in the context of all existing and approved projects (**Table 1.2**). This Air Quality and Greenhouse Gas Assessment has conservatively considered the emissions associated with the Boggabri Coal Continuation Project and the Maules Creek Coal Project, although these Projects have not yet been approved by the State or Commonwealth governments. It is noted that the Maules Creek Coal Project has an existing Development Consent (DA 85/1819), however, the project's proponents are pursuing a new approval prior to commencing the Maules Creek Coal Project.

Similarly, the Boggabri Coal Mine currently operates under an existing approval (DA 36-1988), however the proponents are also pursuing a new approval (the Boggabri Coal Continuation Project).

Potential mining operations at the Goonbri Exploration Lease were not considered in this Air Quality and Greenhouse Gas Assessment, as no environmental impact assessment has been submitted, therefore, no details in relation to the possible mining operations are available. Exploration activities within the Goonbri lease would not be anticipated to involve significant air quality emissions, therefore, exploration activities are not considered further in this report.

8.4.1 Boggabri Coal Continuation Project

Boggabri Coal Mine has submitted an EA dated December 2010 to the NSW Department of Planning (DoP) (now the DP&I) for the continuation and expansion of the current mining operations for a further 21 years (Boggabri Coal Continuation Project) (**Hanson Bailey, 2010**). The continuation of mining would extract up to 7 Mtpa of ROM coal which would progress the operations to the north-west of the current operations, towards the Maules Creek Coal Project CL 368 boundary (**Figure 3.1**). The proponents of the Boggabri Coal Mine (and the Boggabri Coal Continuation Project) are Idemitsu Australia Resources Pty Ltd.

Boggabri Coal Mine is also seeking approval for modifications to the existing site infrastructure including construction of a CHPP and a 17 km rail spur which would connect to the Werris Creek Mungindi Railway and enable the transport of product coal directly from the mine, rather than using the existing haul road to the existing rail loop on the Werris Creek Mungindi Railway.

An air quality impact assessment was undertaken for the Boggabri Coal Continuation Project by **PAEHolmes** (**2010**). This assessment concluded that the 24 hour PM_{10} criterion is likely to be exceeded at receiver 45 and that the annual average PM_{10} criterion is likely to be exceeded at receiver 45 and also at mine-owned receiver 1g.

Year 1 of the Project is scheduled to commence in 2013 and therefore concurrent emissions from the Boggabri Coal Continuation Project would arise from Year 1 to Year 17 of the Project. Accordingly, the potential maximum air quality impacts from Years 1, 5 and 10 of the Boggabri Coal Continuation Project have been included in the cumulative assessment for annual average potential impacts from the Project (**Section 9**). For comparison with the Project (**Table 8.1**), the estimated emissions from the Boggabri Coal Continuation Project for Year 10 is 7,512,262 kilograms (kg) TSP (**PAEHolmes, 2010**).

As described in **Section 8.2**, Project emission estimates also conservatively includes consideration of coal handling, processing and transportation of Tarrawonga Coal Mine coal at the proposed Boggabri Coal Mine Infrastructure Facilities.

8.4.2 Maules Creek Coal Project

The Maules Creek Coal Project proponent (Aston Coal 2 Pty Ltd) have submitted an EA dated July 2011 to the NSW DP&I (**Hanson Bailey, 2011**). The Maules Creek Coal Project is located to the north of the Project (**Figure 3.1).** Aston Coal 2 Pty Ltd is seeking approval for a 21 year Project commencing in 2012, including extraction of ROM coal up to 13 Mtpa.

The Maules Creek Coal Project also involves the construction of a CHPP and a rail spur connecting to the Werris Creek Mungindi Railway.

An air quality impact assessment was undertaken for the Maules Creek Coal Project by **PAEHolmes** (**2011**). This assessment concluded that the 24 hour PM_{10} criterion is likely to be exceeded at a number of privately-owned receivers. All of these receivers are located to the north of the Project, and these receivers are too remote to be relevant to the Project assessment. Based on **PAEHolmes** (**2011**), particulate concentrations arising from the Maules Creek Coal Project at receivers in the vicinity of the Project are anticipated to be limited.

Similar to the Boggabri Coal Continuation Project, cumulative emissions would potentially arise from Year 1 to Year 17 of the Project. Accordingly, the potential air quality impacts from Years 5, 10 and 15 of the Maules Creek Coal Project have been included in the cumulative assessment for annual average impacts from the Project (**Section 9**). For comparison with the Project (**Table 8.1**), the estimated emissions from the Maules Creek Coal Project for Year 10 is 7,862,321 kg TSP (**PAEHolmes, 2011**).

8.5 Estimated Emissions from Other Sources

In addition to those mining-related sources identified in **Section 8.4**, contributions from other local sources such as dust from vehicles using unsealed roads, stock movements, cropping and exposed ground will contribute to PM_{10} and TSP concentrations and dust deposition.

Existing air quality levels assumed for this assessment are described in **Section 5.2.4**, with PM_{10} TSP, and dust deposition conservatively assumed to be 12 µg/m^3, 30 µg/m^3 and 2 g/m^2/month respectively. These levels include allowance for the above non-mining sources for cumulative assessment.

9 EMISSIONS ASSESSMENT

Dispersion model predictions have been made for Years 2, 4, 6 and 16 of Project mining operations. This section provides an interpretation of the predicted particulate concentrations (PM_{10} and TSP) and dust deposition produced by these simulations.

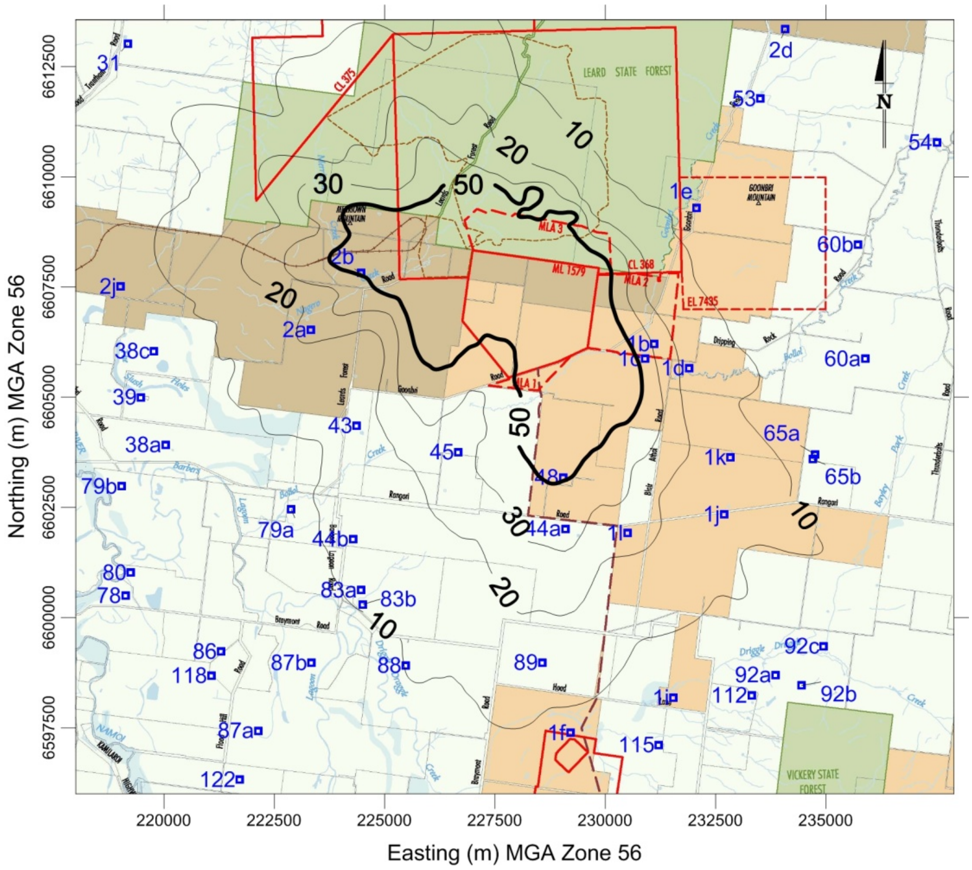
Contour plots of particulate concentrations and deposition levels show the areas that are predicted to be affected by dust at different levels. It is important to note that the isopleth figures are presented to provide a visual representation of the predicted impacts. To produce the isopleths it is necessary 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 receivers are presented in tabular form, with those that are predicted to experience levels above the OEH's impact assessment criteria highlighted in bold.

9.1 Project-only 24-hour Average PM_{10}

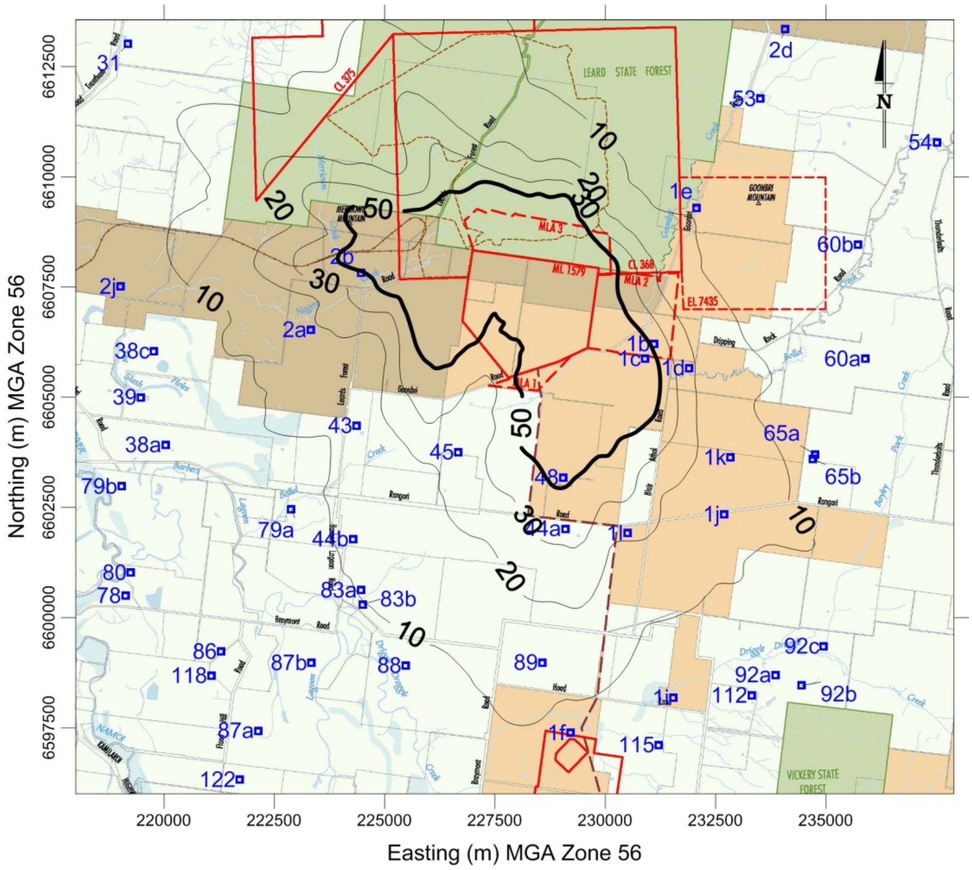
Figure 9.1 to **Figure 9.4** present contour plots for the predicted maximum 24-hour PM_{10} concentrations for the Project-only for each modelled scenario. The isopleth representative of the OEH 24-hour average criterion of 50 µg/m^3 is highlighted in bold.

The 24-hour PM_{10} contours presented in **Figure 9.1** through **Figure 9.4** do not represent a single worst case day, but rather represent the potential worst case 24-hour PM_{10} concentration that can potentially be reached based on the conditions modelled across the entire modelling year.



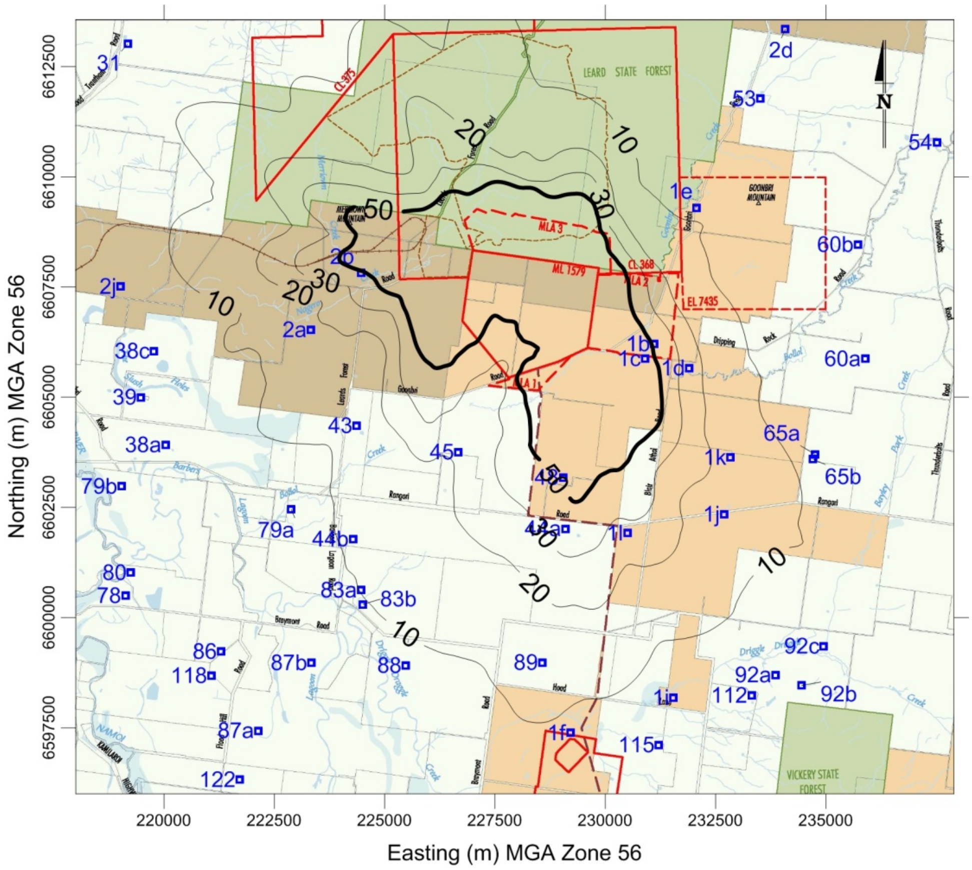
Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
PM_{10}	Tarrawonga	Year 2	Maximum	24-Hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m³	50 µg/m³	CALMET 2010	R Kan

Figure 9.1: Predicted Maximum 24-hour PM_{10} Concentration Project-Only –Year 2



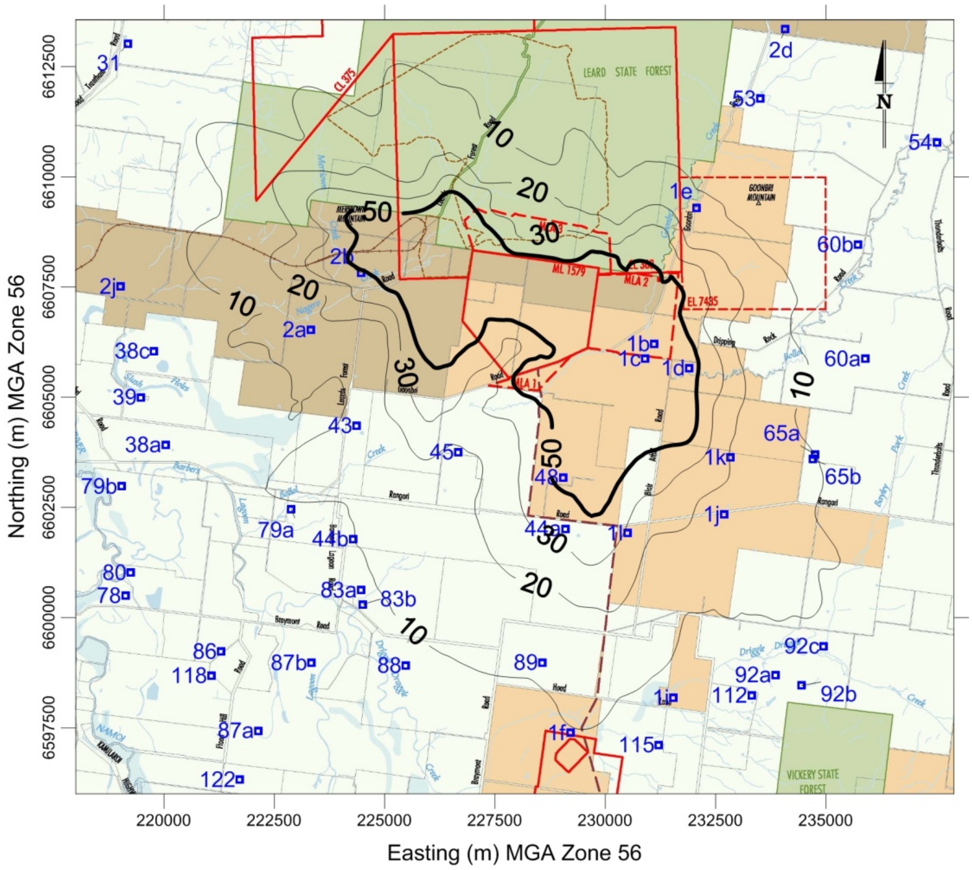
Species: PM10	Location: Tarrawonga	Scenario: Year 4	Percentile: Maximum	Averaging Time: 24-Hour
Model Used: CALPUFF v6.42	**Units:** µg/m^3	**Guideline:** 50 µg/m^3	**Met Data:** CALMET 2010	**Plot:** R Kan

Figure 9.2: Predicted Maximum 24-hour PM_{10} Concentration Project-Only –Year 4



Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Tarrawonga	Year 6	Maximum	24-Hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m³	50 µg/m³	CALMET 2010	R Kan

Figure 9.3: Predicted Maximum 24-hour PM_{10} Concentration Project-Only –Year 6



Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
PM_{10}	Tarrawonga	Year 16	Maximum	24-Hour
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m^3	50 µg/m^3	CALMET 2010	R Kan

Figure 9.4: Predicted Maximum 24-hour PM_{10} Concentration Project-Only –Year 16

A summary of the predicted particulate concentrations at each of the individual receivers is provided in **Table 9.1**. Those receivers that are predicted to experience maximum 24-hour average PM_{10} concentrations above the OEH annual average criterion of 50 µg/m^3 have been highlighted in bold.

Table 9.1: Maximum predicted Project-only 24-hour average PM_{10} concentrations (µg/m^3)

Receiver ID	Property Owner	Year 2	Year 4	Year 6	Year 16
31	Estate: Perpetual Lease M.J. and M.L. Nott	4	4	5	3
38a	R.J. Heiler	7	7	7	4
38c	R.J. Heiler	7	7	6	5
39	D.V. Gillham	6	6	6	4
43	G., L.S. and J.A. Suey	15	14	14	13
44a	R.R. and P.L. Crosby	36	34	39	35
44b	R.R. and P.L. Crosby	12	11	11	10
45	R.P. and R.D. McGregor	26	23	21	19
53	V.P. and S.M. Mcauliffe	3	3	3	4
54	P.A. Devine	2	2	2	2
60a	R.R. and P.L. Crosby	4	4	4	6
60b	R.R. and P.L. Crosby	3	3	3	4
65a	T.R. Hall and A.I. Myers Johnson	7	8	8	10
65b	T.R. Hall and A.I. Myers Johnson	8	8	8	10
78	J.M. and N.M. McKechnie	5	4	4	3
79a	K.D. Gillham	8	8	7	9
79b	K.D. Gillham	5	5	5	4
80	A.D. Watson Holdings Pty Ltd	5	4	4	4
83a	R.P. McGregor	11	10	10	9
83b	R.P. McGregor	10	10	10	9
86	Peter J Watson Holdings Pty Ltd	6	6	5	5
87a	D.S. Riley	4	4	4	4
87b	D.S. Riley	7	7	6	6
88	M.J. and J.H. Maunder	10	9	9	8
89	K.A. and C. Blanch	15	14	15	12
92a	I. Macleod Hall	7	6	8	7
92b	I. Macleod Hall	7	6	6	6
92c	I. Macleod Hall	7	7	7	8
112	N.P. and S.A. Jackson	6	5	6	6
115	R.D. Mitchell and C.T. Palmer	4	4	5	5
118	A.D. Watson	6	6	5	4
1b	Whitehaven Coal Mining Pty Limited	29	43	47	*
1c	Whitehaven Coal Mining Pty Limited	40	**77**	**76**	*
1d	Whitehaven Coal Mining Pty Limited	18	22	25	**64**
1e	Whitehaven Coal Mining Pty Limited	8	9	8	12
1f	Whitehaven Coal Mining Pty Limited	8	7	8	9
1h	Whitehaven Coal Mining Pty Limited	**51**	**56**	**56**	**59**
1i	Whitehaven Coal Mining Pty Limited	6	6	7	8
1j	Whitehaven Coal Mining Pty Limited	13	14	15	16
1k	Whitehaven Coal Mining Pty Limited	14	15	16	20
1l	Whitehaven Coal Mining Pty Limited	24	22	27	28
2a	Boggabri Coal Pty Limited	24	19	18	17
2b	Boggabri Coal Pty Limited	**54**	46	45	45
2d	Boggabri Coal Pty Limited	2	3	3	2
2j	Boggabri Coal Pty Limited	6	5	5	5

Note: Receivers with prefix 1 and 2 (eg. 1a and 2a) are mine-owned.

* Receivers 1b and 1c would not be occupied in Year 16.

There are no privately owned receivers that are predicted to experience 24-hour average PM_{10} concentrations above the assessment criteria, due to emissions from the Project-only.

9.2 Cumulative 24-hour Average PM_{10}

It is difficult to predict with any accuracy the cumulative 24-hour PM_{10} concentrations 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 neighbouring mine sites. More accurate operational assumptions can be made on an annual average basis.

The difficulties in predicting 24-hour impacts are compounded by the day to day variability in ambient levels and the spatial and temporal variation in any other anthropogenic activity, including mining in the future. Experience shows that the worst-case 24-hour PM_{10} concentrations are strongly influenced by other sources in the area, such as bushfires and dust storms, which are essentially unpredictable from a long-term modelling perspective. The variability in 24-hour average PM_{10} concentrations can be clearly seen in the data collected at the two HVAS monitors located in the vicinity of Tarrawonga Coal Mine and Boggabri Coal Mine (**Figure 5.2**).

This assessment provides a discussion of the likelihood of 24-hour PM_{10} cumulative exceedances if air quality criteria at receivers near to the Project.

Cumulative 24-hour PM_{10} impacts are expected to be most significant from the concurrent operations of the Tarrawonga Coal Mine and Boggabri Coal Mine, particularly for those receivers to the south where impacts are predicted to the greatest. This is most obviously due to the locations of these two mines, but also due to the prevailing winds under which impacts would be the most pronounced.

The wind conditions under which 24-hour impacts from the Tarrawonga Coal Mine would be highest (e.g. northerly flows creating highest concentrations at receiver 44a) would not correspond to days when highest impacts also occur from the Maules Creek Coal Project. This is a feature of both the physical location of mining activity and also the variation in meteorological conditions at the two sites and has been confirmed by indicative modelling results and analysis of meteorological data. Based on an analysis of wind data, the prevailing winds measured at the Maules Creek Coal Project differ somewhat from those measured at the Tarrawonga Coal Mine and Boggabri Coal Mine, due to the influence of channelling and terrain induced flows. Conversely, northerly flows producing elevated concentrations at receivers to the south of the Tarrawonga Coal Mine would be expected to also produce cumulative impacts from operations at the Boggabri Coal Mine.

This was confirmed by indicative modelling predictions (i.e. using the emissions inventory reported in **PAEHolmes** [**2011**]) for the Maules Creek Coal Project, which indicated that during northerly winds, maximum 24-hour concentrations at the closest privately-owned residence to the south of the Project (44a) were predicted to be 3 - 5 $\mu g/m^3$. This indicates that the Maules Creek Coal Project would not be a significant contributor to cumulative impacts in the vicinity of the Project.

It is assumed in the analysis below that the maximum predictions for the Boggabri Coal Mine would occur on the same day as the maximum predictions for the Tarrawonga Coal Mine (based on the adjacent locations of mining and prevailing winds).

The maximum predicted 24-hour PM_{10} concentrations from Years 1, 5 and 10 of the Boggabri Coal Continuation Project presented in the EA (**Hanson Bailey, 2010**) indicates the following:

- Closest receivers to the south of the Project:
  - Receiver 45 (Boggabri ID 54) exceeds the 50 µg/m^3 criterion as a result of the Boggabri Coal Continuation Project alone.
  - Receiver 44a (Boggabri ID 86) would experience a maximum 24-hour concentration of approximately 40 µg/m^3 as a result of the Boggabri Coal Continuation Project.
- Closest receivers to the south-east of the Project:
  - Receivers 1k, 1j and 65 (Boggabri ID 98b, 98a and 100) would experience a maximum 24-hour concentration of between 15 and 23 µg/m3 as a result of the Boggabri Coal Mine.
- Closest receivers to the south-west of the Project:
  - Receivers 43, 44b, 79 and 83 (Boggabri ID 51, 79, 90 and 94) would experience a maximum 24-hour concentration of between 14 and 22 µg/m3 as a result of the Boggabri Coal Mine.

As a conservative worst case scenario, the Boggabri Coal Mine predictions are added to the Tarrawonga Coal Mine predictions presented in **Table 9.1** and the following is noted:

- Cumulative exceedances may occur at receiver 44a to the south.
- Additional cumulative exceedances from the operations of the Boggabri Coal Mine and the Tarrawonga Coal Mine would not be expected at the closest receivers located to the south-east and south-west.

It is also expected that there would be a contribution from all other sources of dust (i.e. background excluding mining). Predicting this contribution is difficult because, although PM_{10} data are recorded on a six day cycle (i.e. using HVASs), no continuous monitoring data are available.

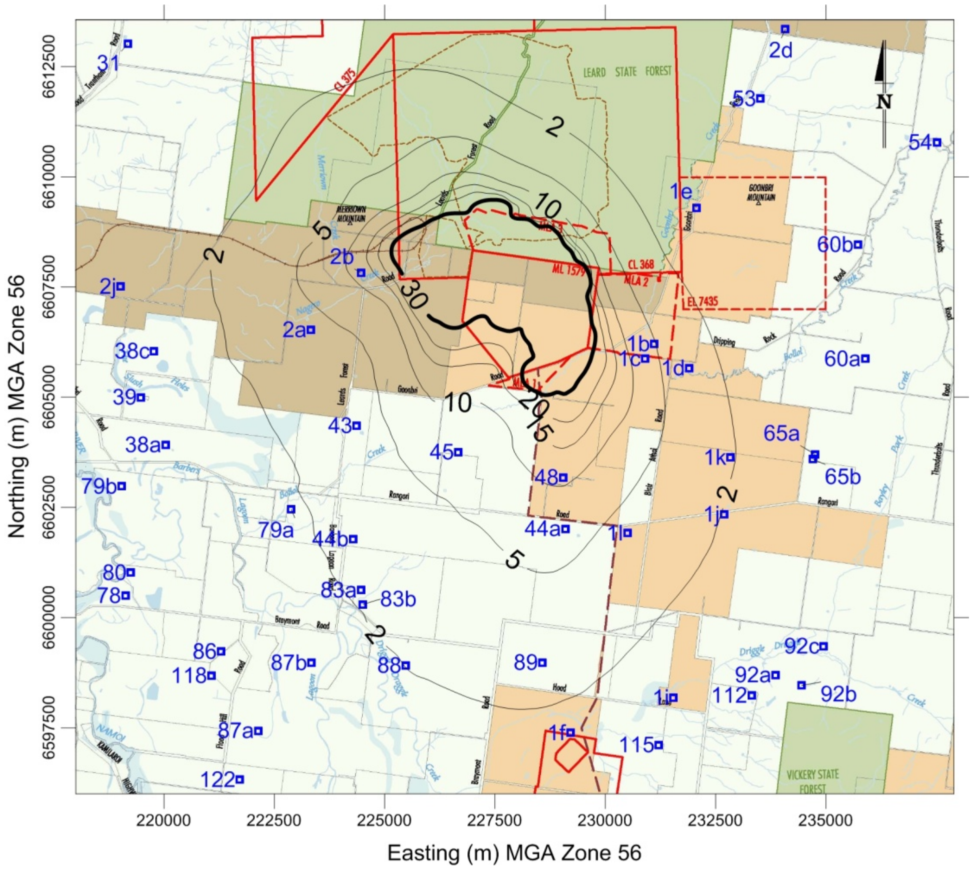
The potential for cumulative exceedances would be greatly increased during periods of elevated background levels. **PAEHolmes (2011)** provides a statistical analysis of available Tarrawonga Coal Mine HVAS data, which indicates that the probability of the HVAS recording greater than 40 µg/m^3 is approximately 4.4%.

Potential cumulative exceedances from mining operations would be effectively managed by TCPL's commitment to real-time monitoring and measurement of air quality emissions (**Section 7.3**). It is understood that Idemitsu Resources Australia Pty Ltd and Aston Coal 2 Pty Ltd are also proposing a similar system for the Boggabri Coal Mine and Maules Creek Coal Project, respectively. The commitment to real-time measurements, controls and management would reduce the occurrence of cumulative potential 24-hour PM_{10} exceedances of criteria to the minimum practicable.

9.3 Project-Only Annual Average PM_{10}

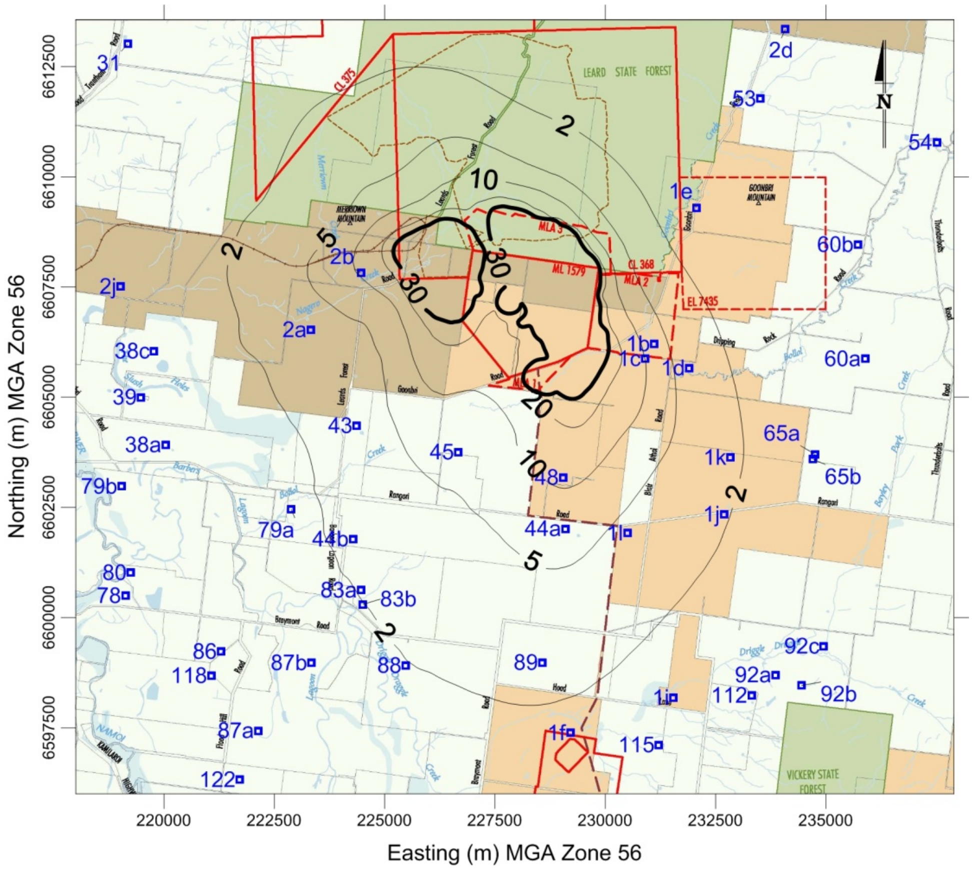
The Project-only contributions to annual average PM_{10} concentrations are presented in **Figure 9.5** through **Figure 9.8** for each modelled year. The model predictions for annual average PM_{10} concentrations at each receiver are presented in **Table 9.2.**

When including the background of 12 µg/m³ (**Section 5.2.4**), there are no privately-owned receivers predicted to experience annual average PM_{10} concentrations above the OEH annual average criterion of 30 µg/m³ for the operation of the Project-only.



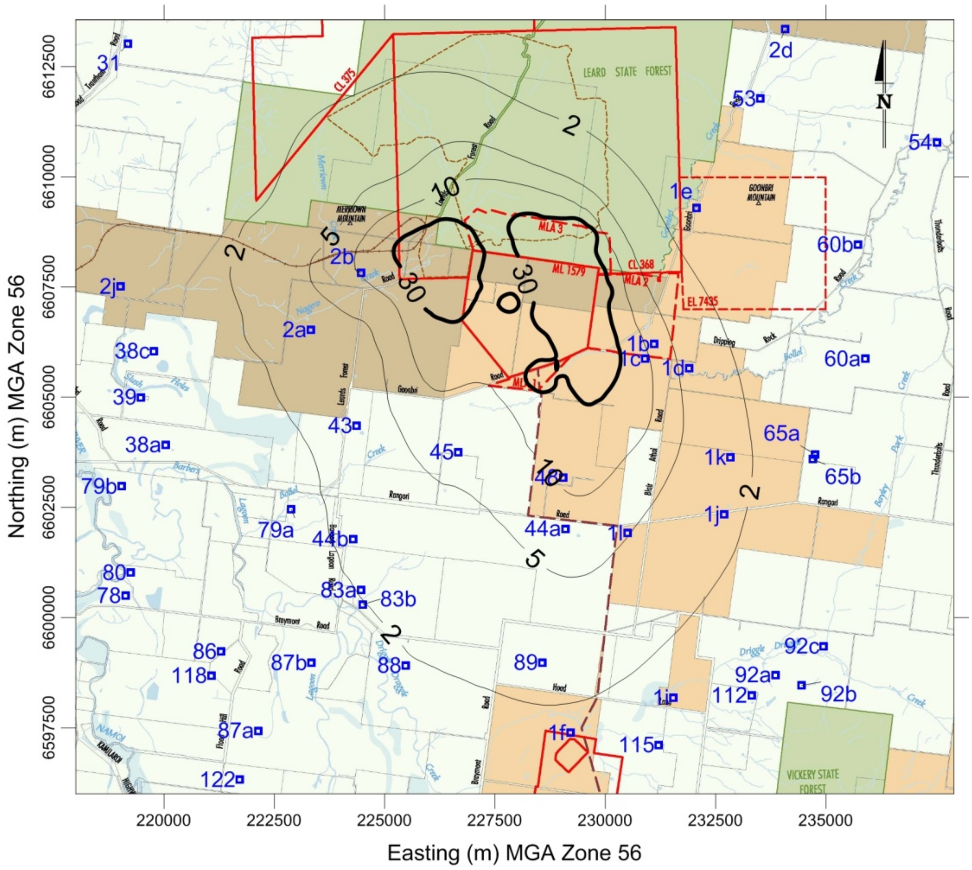
Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
PM_{10}	Tarrawonga	Year 2	Maximum	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m³	30 µg/m³	CALMET 2010	R Kan

Figure 9.5: Predicted Maximum Annual PM_{10} Concentration Project-Only –Year 2



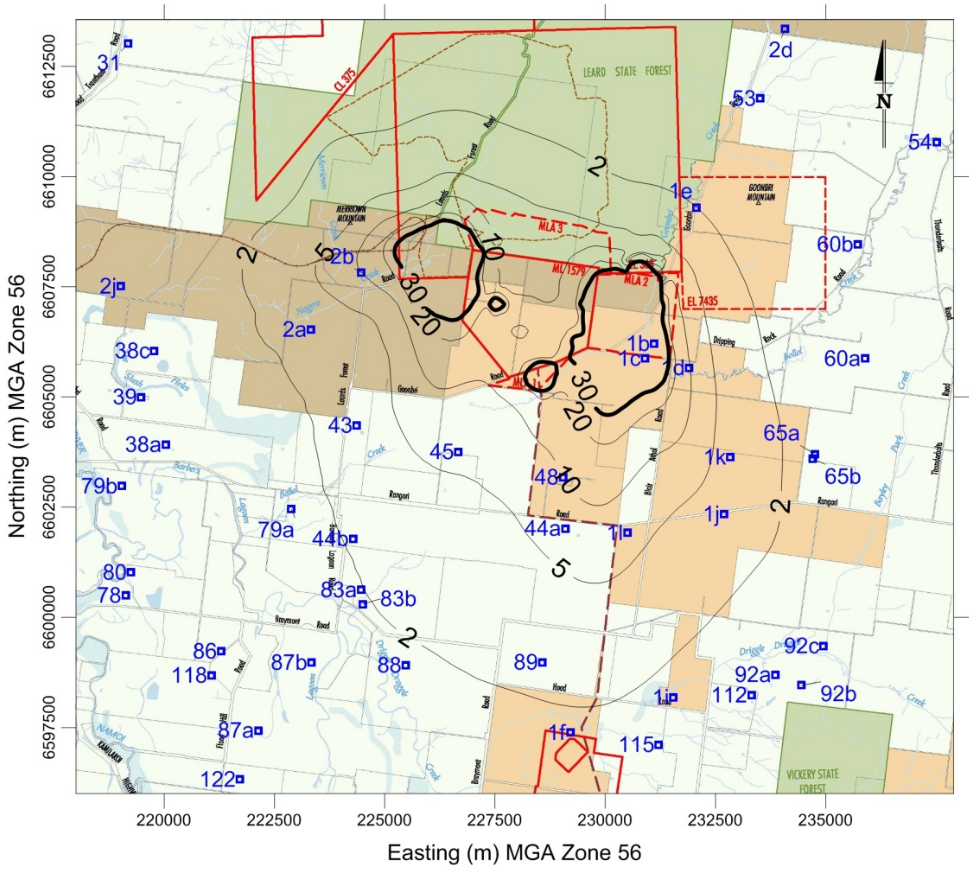
Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
PM_{10}	Tarrawonga	Year 4	Maximum	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m³	30 µg/m³	CALMET 2010	R Kan

Figure 9.6: Predicted Maximum Annual PM_{10} Concentration Project-Only –Year 4



Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Tarrawonga	Year 6	Maximum	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	$\mu g/m^3$	30 $\mu g/m^3$	CALMET 2010	R Kan

Figure 9.7: Predicted Maximum Annual PM_{10} Concentration Project-Only –Year 6



Species:	Location:	Scenario:	Percentile:	Averaging Time:
PM_{10}	Tarrawonga	Year 16	Maximum	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	$\mu g/m^3$	30 $\mu g/m^3$	CALMET 2010	R Kan

Figure 9.8: Predicted Maximum Annual PM_{10} Concentration Project-Only –Year 16

Table 9.2: Maximum predicted annual average PM_{10} concentrations (μg/m^3)

Receiver ID	Property Owner	Year 2	Year 4	Year 6	Year 16
31	Estate: Perpetual Lease M.J. and M.L. Nott	1	1	1	0
38a	R.J. Heiler	1	1	1	1
38c	R.J. Heiler	1	1	1	1
39	D.V. Gillham	1	1	1	1
43	G., L.S. and J.A. Suey	4	3	3	3
44a	R.R. and P.L. Crosby	7	7	7	7
44b	R.R. and P.L. Crosby	3	2	2	2
45	R.P. and R.D. McGregor	7	6	6	6
53	V.P. and S.M. Mcauliffe	0	0	0	1
54	P.A. Devine	0	0	0	0
60a	R.R. and P.L. Crosby	1	1	1	1
60b	R.R. and P.L. Crosby	0	0	0	0
65a	T.R. Hall and A.I. Myers Johnson	1	1	1	1
65b	T.R. Hall and A.I. Myers Johnson	1	1	1	2
78	J.M. and N.M. McKechnie	1	1	1	1
79a	K.D. Gillham	2	2	2	2
79b	K.D. Gillham	1	1	1	1
80	A.D. Watson Holdings Pty Ltd	1	1	1	1
83a	R.P. McGregor	2	2	2	2
83b	R.P. McGregor	2	2	2	2
86	Peter J Watson Holdings Pty Ltd	1	1	1	1
87a	D.S. Riley	1	1	1	1
87b	D.S. Riley	1	1	1	1
88	M.J. and J.H. Maunder	2	2	2	2
89	K.A. and C. Blanch	3	3	3	3
92a	I. Macleod Hall	1	1	1	1
92b	I. Macleod Hall	1	1	1	1
92c	I. Macleod Hall	1	1	1	1
112	N.P. and S.A. Jackson	1	1	1	1
115	R.D. Mitchell and C.T. Palmer	1	1	1	1
118	A.D. Watson	1	1	1	1
1b	Whitehaven Coal Mining Pty Limited	5	7	8	*
1c	Whitehaven Coal Mining Pty Limited	7	10	12	*
1d	Whitehaven Coal Mining Pty Limited	3	4	4	10
1e	Whitehaven Coal Mining Pty Limited	1	1	1	2
1f	Whitehaven Coal Mining Pty Limited	2	2	2	2
1h	Whitehaven Coal Mining Pty Limited	11	11	11	10
1i	Whitehaven Coal Mining Pty Limited	1	1	1	2
1j	Whitehaven Coal Mining Pty Limited	2	2	2	3
1k	Whitehaven Coal Mining Pty Limited	2	2	3	4
1l	Whitehaven Coal Mining Pty Limited	4	4	5	7
2a	Boggabri Coal Pty Limited	4	3	3	3
2b	Boggabri Coal Pty Limited	12	11	10	10
2d	Boggabri Coal Pty Limited	0	0	0	0
2j	Boggabri Coal Pty Limited	1	1	1	1

Note: Receivers with prefix 1 and 2 (eg. 1a and 2a) are mine-owned.

* Receivers 1b and 1c would not be occupied in Year 16.

9.4 Cumulative Annual Average PM_{10}

A summary of the cumulative assessment of annual average PM_{10} concentrations is presented in **Table 9.3**.

The contribution of other dust sources to cumulative impacts is included as follows:

- Project – modelled predictions for worst case year at each receiver;
- Boggabri Coal Continuation Project - modelled predictions for worst case year (from Years 1, 5 and 10 modelling results presented in **PAEHolmes [2010]**) at each receiver;
- Maules Creek Coal Project – modelling predictions for worst case year (from Years 5, 10 and 15 modelling results presented in **PAEHolmes [2011]**) at each receiver; and
- all other sources – measured background PM_{10} from monitoring data.

When the contribution of other mining activities (including the Boggabri Coal Continuation Project and Maules Creek Coal Project) are added along with a background for all other sources, one privately owned receiver (45) is predicted to exceed the OEH annual average criterion of 30 µg/m^3. It is noted that the Project contribution at this receiver is less than half of the predicted Boggabri Coal Continuation Project concentration at this receiver.

Table 9.3: Predicted cumulative annual average PM_{10} concentrations (µg/m^3)

Receiver ID	Project	Boggabri Coal Continuation Project[a]	Maules Creek Coal Project[b]	Non-Mining Sources	Cumulative PM_{10} Concentration
31	1	N/A	N/A	12	13
38a	1	1	3	12	17
38c	1	2	3	12	18
39	1	2	N/A	12	15
43	4	4	1	12	21
44a	7	10	N/A	12	29
44b	3	4	N/A	12	19
45	7	15	N/A	12	**34**
53	1	3	2	12	18
54	0	2	N/A	12	14
60a	1	2	1	12	16
60b	0	3	1	12	16
65a	1	3	N/A	12	16
65b	2	3	N/A	12	17
78	1	N/A	N/A	12	13
79a	2	2	N/A	12	16
79b	1	N/A	N/A	12	13
80	1	N/A	N/A	12	13
83a	2	4	N/A	12	18
83b	2	4	N/A	12	18
86	1	N/A	N/A	12	13
87a	1	N/A	N/A	12	13
87b	1	N/A	N/A	12	13
88	2	N/A	N/A	12	14
89	3	N/A	N/A	12	15
92a	1	N/A	N/A	12	13
92b	1	N/A	N/A	12	13
92c	1	N/A	N/A	12	13
112	1	N/A	N/A	12	13
115	1	N/A	N/A	12	13
118	1	N/A	N/A	12	13
1b	8	N/A	N/A	12	20
1c	12	N/A	N/A	12	24
1d	10	N/A	N/A	12	22
1e	2	N/A	N/A	12	14
1f	2	N/A	N/A	12	14
1h	11	13	N/A	12	**36**
1i	2	N/A	N/A	12	14
1j	3	4	N/A	12	19
1k	4	4	N/A	12	20
1l	7	7	N/A	12	26
2a	4	N/A	N/A	12	16
2b	12	N/A	N/A	12	24
2d	0	3	3	12	18
2j	1	3	2	12	18

[a] PM_{10} concentrations from Boggabri Coal Continuation Project EA (**PAE Holmes, 2010**).

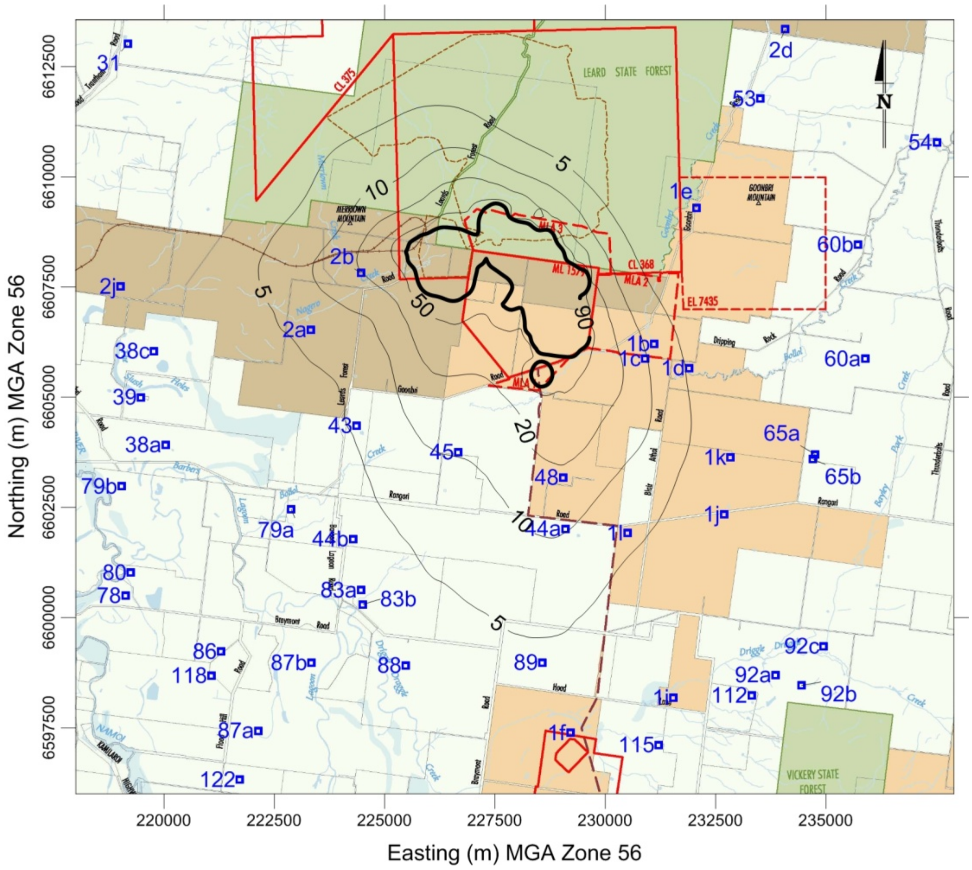
[b] PM_{10} concentrations from Maules Creek Coal Project EA (**PAE Holmes, 2011**).

N/A – No predictions provided in relevant EA or contribution is zero.

Note: Receivers with prefix 1 and 2 (eg. 1a and 2a) are mine-owned.

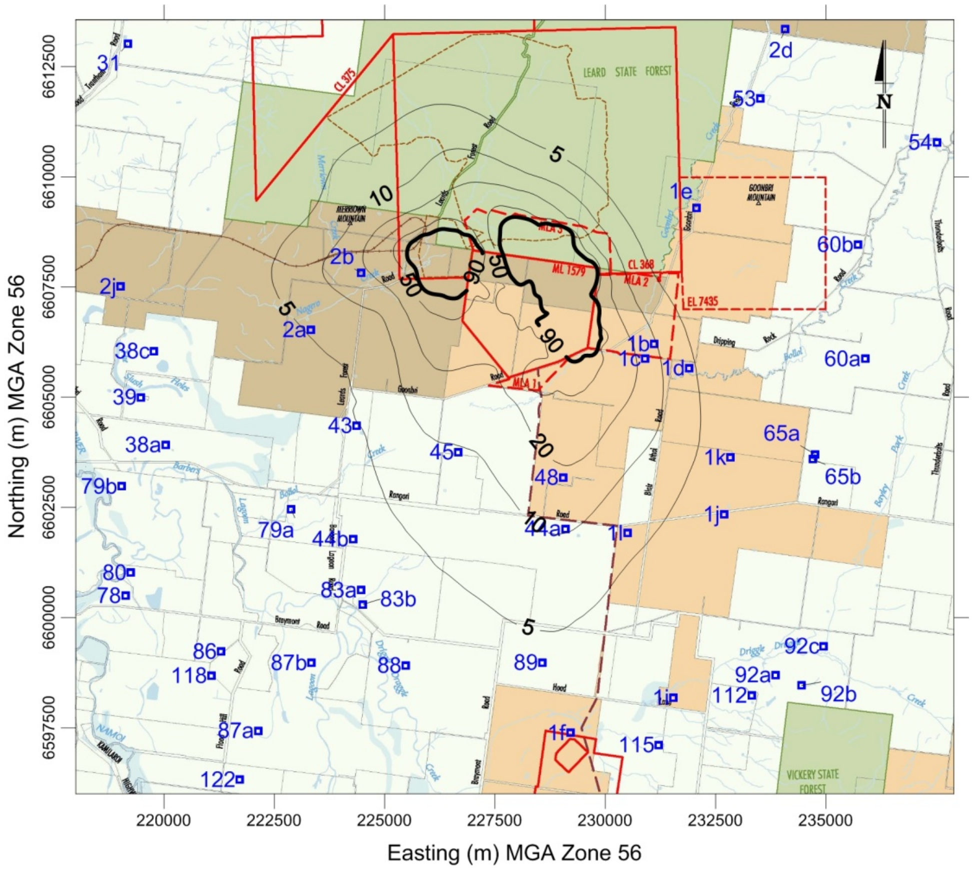
9.5 Project-Only Annual Average TSP

The predicted TSP concentrations for the contribution of the Project-only for annual average TSP concentrations are presented in **Figure 9.9** through **Figure 9.12** for each modelled year.



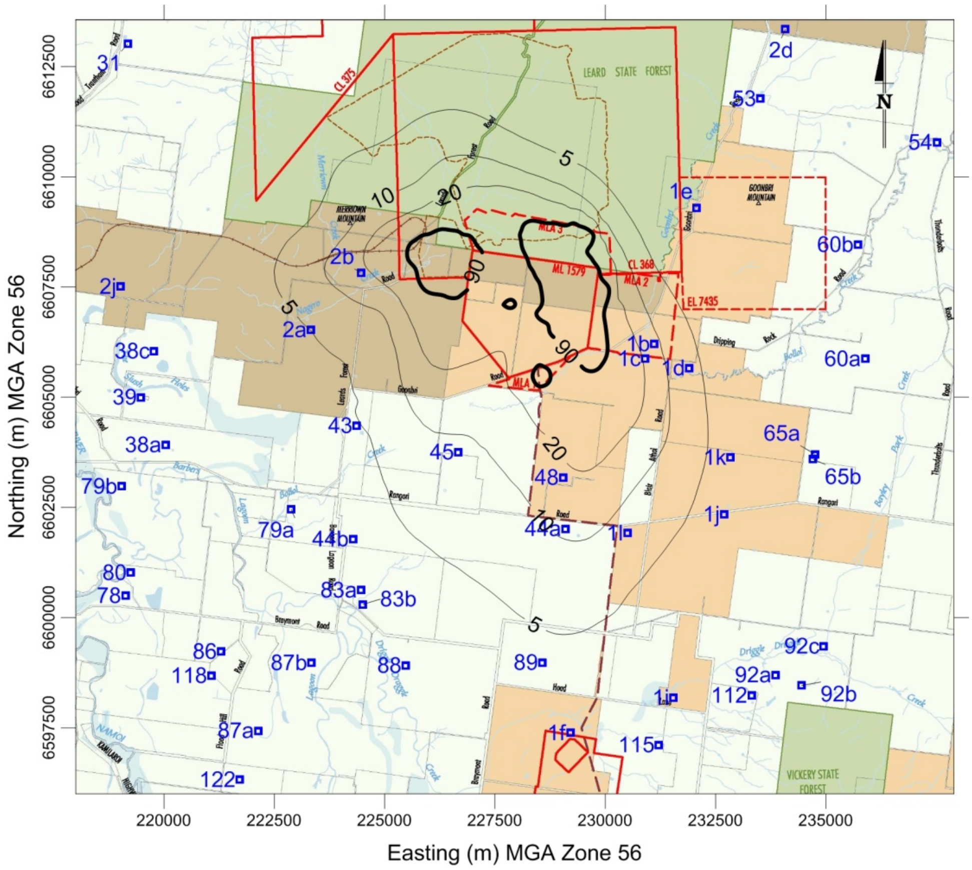
Species:	Location:	Scenario:	Percentile:	Averaging Time:
TSP	Tarrawonga	Year 2	Maximum	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m³	90 µg/m³	CALMET 2010	R Kan

Figure 9.9: Predicted Maximum Annual TSP Concentration Project-Only –Year 2



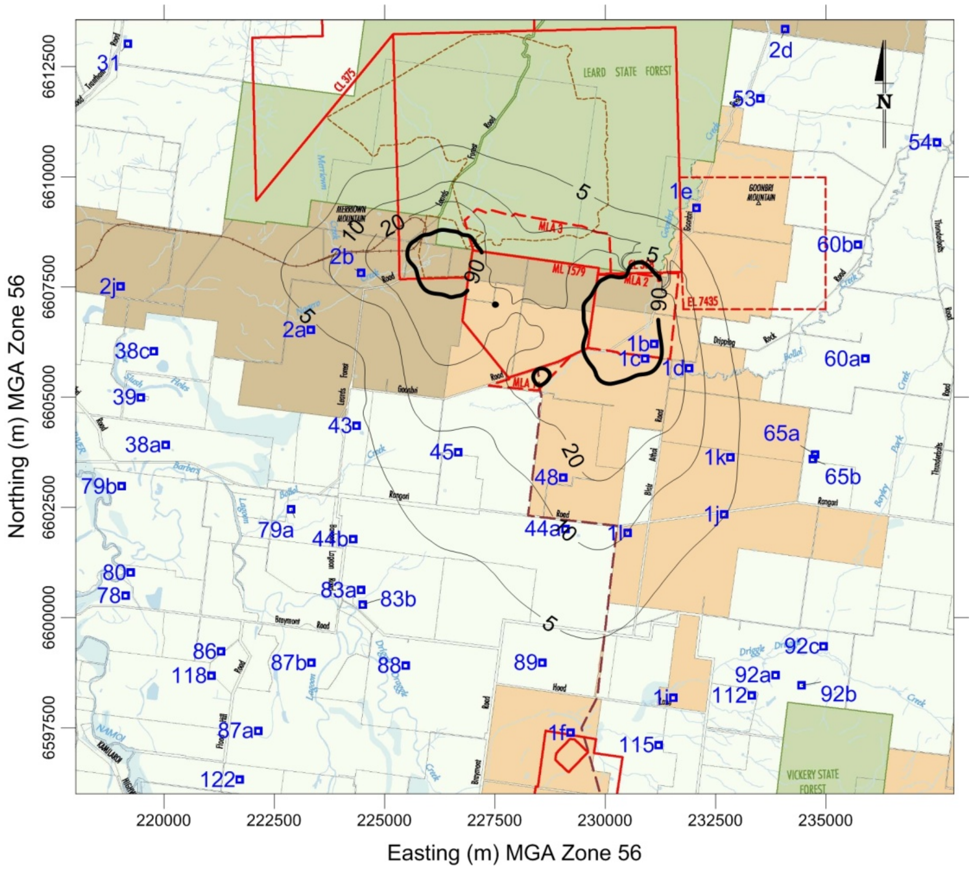
Species: TSP	Location: Tarrawonga	Scenario: Year 4	Percentile: Maximum	Averaging Time: Annual
Model Used: CALPUFF v6.42	**Units:** µg/m³	**Guideline:** 90 µg/m³	**Met Data:** CALMET 2010	**Plot:** R Kan

Figure 9.10: Predicted Maximum Annual TSP Concentration Project-Only –Year 4



Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
TSP	Tarrawonga	Year 6	Maximum	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	µg/m^3	90 µg/m^3	CALMET 2010	R Kan

Figure 9.11: Predicted Maximum Annual TSP Concentration Project-Only –Year 6



Species: TSP	**Location:** Tarrawonga	**Scenario:** Year 16	**Percentile:** Maximum	**Averaging Time:** Annual
Model Used: CALPUFF v6.42	**Units:** µg/m^3	**Guideline:** 90 µg/m^3	**Met Data:** CALMET 2010	**Plot:** R Kan

Figure 9.12: Predicted Maximum Annual TSP Concentration Project-Only –Year 16

The model predictions for annual average TSP concentrations at each receiver are presented in **Table 9.4**. Exceedances of the OEH TSP criterion are highlighted in bold.

Table 9.4: Maximum predicted annual average TSP concentrations (µg/m³)

Receiver ID	Property Owner	Year 2	Year 4	Year 6	Year 16
31	Estate: Perpetual Lease M.J. and M.L. Nott	1	1	1	1
38a	R.J. Heiler	2	1	1	1
38c	R.J. Heiler	2	1	1	1
39	D.V. Gillham	1	1	1	1
43	G., L.S. and J.A. Suey	6	5	5	4
44a	R.R. and P.L. Crosby	10	10	11	10
44b	R.R. and P.L. Crosby	4	3	3	3
45	R.P. and R.D. McGregor	10	10	9	9
53	V.P. and S.M. Mcauliffe	1	1	1	1
54	P.A. Devine	0	0	0	0
60a	R.R. and P.L. Crosby	1	1	1	1
60b	R.R. and P.L. Crosby	1	1	1	1
65a	T.R. Hall and A.I. Myers Johnson	2	2	2	2
65b	T.R. Hall and A.I. Myers Johnson	2	2	2	2
78	J.M. and N.M. McKechnie	1	1	1	1
79a	K.D. Gillham	3	2	2	2
79b	K.D. Gillham	1	1	1	1
80	A.D. Watson Holdings Pty Ltd	1	1	1	1
83a	R.P. McGregor	3	3	3	3
83b	R.P. McGregor	3	3	3	3
86	Peter J Watson Holdings Pty Ltd	1	1	1	1
87a	D.S. Riley	1	1	1	1
87b	D.S. Riley	2	2	2	2
88	M.J. and J.H. Maunder	3	3	3	3
89	K.A. and C. Blanch	4	4	4	4
92a	I. Macleod Hall	1	1	1	2
92b	I. Macleod Hall	1	1	1	1
92c	I. Macleod Hall	1	1	1	1
112	N.P. and S.A. Jackson	1	1	1	2
115	R.D. Mitchell and C.T. Palmer	1	1	1	2
118	A.D. Watson	1	1	1	1
1b	Whitehaven Coal Mining Pty Limited	8	11	12	*
1c	Whitehaven Coal Mining Pty Limited	11	15	18	*
1d	Whitehaven Coal Mining Pty Limited	5	6	6	16
1e	Whitehaven Coal Mining Pty Limited	2	2	2	3
1f	Whitehaven Coal Mining Pty Limited	2	2	2	2
1h	Whitehaven Coal Mining Pty Limited	18	18	17	15
1i	Whitehaven Coal Mining Pty Limited	2	2	2	2
1j	Whitehaven Coal Mining Pty Limited	3	3	4	5
1k	Whitehaven Coal Mining Pty Limited	3	3	4	6
1l	Whitehaven Coal Mining Pty Limited	6	6	8	10
2a	Boggabri Coal Pty Limited	6	5	5	5
2b	Boggabri Coal Pty Limited	20	17	17	16
2d	Boggabri Coal Pty Limited	0	0	0	0
2j	Boggabri Coal Pty Limited	1	1	1	1

Note: Receivers with prefix 1 and 2 (eg. 1a and 2a) are mine-owned.

* Receivers 1b and 1c would not be occupied in Year 16.

When including the background of 30 µg/m³ (**Section 5.2.4**), no privately-owned receivers are predicted to exceed the OEH assessment criterion of 90 µg/m³ for the Project-only.

9.6 Cumulative Annual Average TSP

A summary of the cumulative assessment of annual average TSP concentrations is presented in **Table 9.5**. The approach to cumulative assessment is similar as that for annual average PM_{10}. When the contribution of other mining activity (including the Boggabri Coal Continuation Project and Maules Creek Coal Project) are added along with a background for all other sources, no privately owned receivers are predicted to exceed the OEH assessment criterion of 90 µg/m^3.

It is also relevant to note that the Project emissions alone, plus non-mining sources, would similarly not result in any predicted exceedances of the OEH assessment criterion.

Table 9.5: Cumulative annual average TSP concentrations (µg/m^3)

Receiver ID	Project	Boggabri Coal Continuation Project[a]	Maules Creek Coal Project[b]	Non-Mining Sources	Cumulative TSP Concentration
31	1	N/A	N/A	30	31
38a	2	1	3	30	36
38c	2	2	3	30	37
39	1	2	N/A	30	33
43	6	4	1	30	41
44a	11	10	N/A	30	51
44b	4	4	N/A	30	38
45	10	15	N/A	30	55
53	1	4	3	30	38
54	0	2	N/A	30	32
60a	1	3	1	30	35
60b	1	3	1	30	35
65a	2	3	N/A	30	35
65b	2	3	N/A	30	35
78	1	N/A	N/A	30	31
79a	3	2	N/A	30	35
79b	1	N/A	N/A	30	31
80	1	N/A	N/A	30	31
83a	3	4	N/A	30	37
83b	3	4	N/A	30	37
86	1	N/A	N/A	30	31
87a	1	N/A	N/A	30	31
87b	2	N/A	N/A	30	32
88	3	N/A	N/A	30	33
89	4	N/A	N/A	30	34
92a	2	N/A	N/A	30	32
92b	1	N/A	N/A	30	31
92c	1	N/A	N/A	30	31
112	2	N/A	N/A	30	32
115	2	N/A	N/A	30	32
118	1	N/A	N/A	30	31
1b	12	N/A	N/A	30	42
1c	18	N/A	N/A	30	48
1d	16	N/A	N/A	30	46
1e	3	N/A	N/A	30	33
1f	2	N/A	N/A	30	32
1h	18	14	N/A	30	62
1i	2	N/A	N/A	30	32
1j	5	4	N/A	30	39
1k	6	4	N/A	30	40
1l	10	7	N/A	30	47
2a	6	N/A	N/A	30	36
2b	20	N/A	N/A	30	50
2d	0	3	3	30	36
2j	1	3	3	30	37

[a] TSP concentrations from Boggabri Coal Continuation Project EA (**PAE Holmes, 2010**).

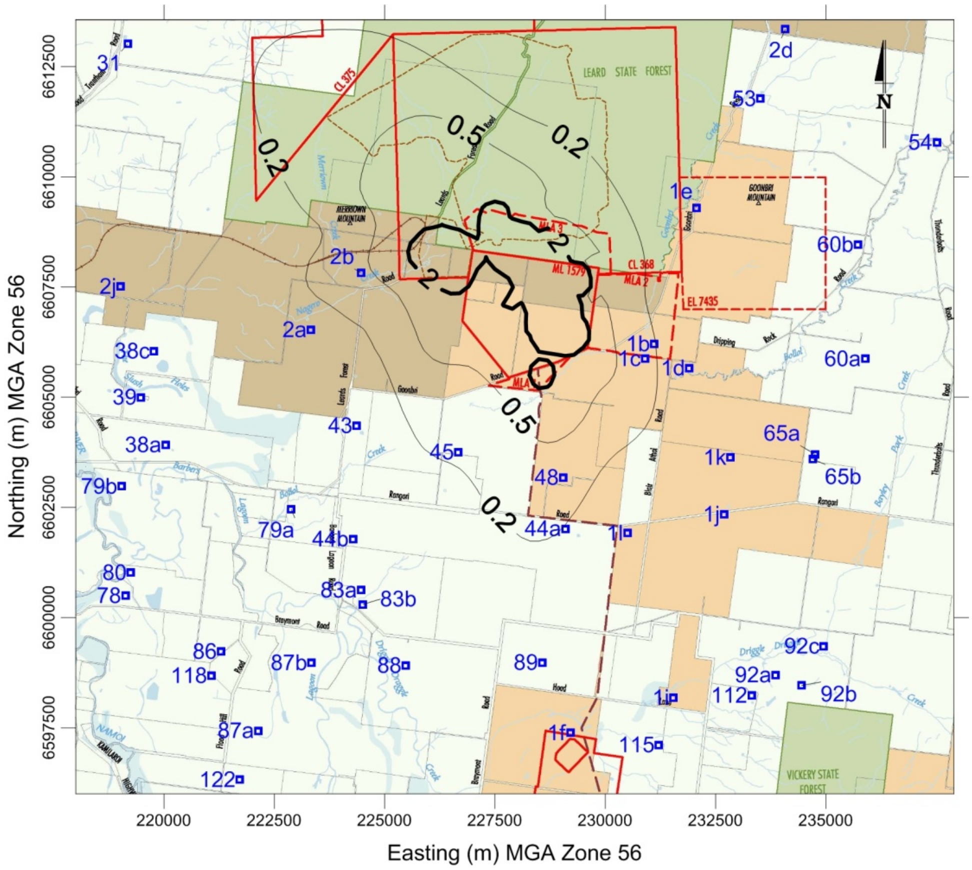
[b] TSP concentrations from Maules Creek Coal Project EA (**PAE Holmes, 2011**).

N/A – No predictions provided in relevant EA or contribution is zero.

Note: Receivers with prefix 1 and 2 (eg. 1a and 2a) are mine-owned.

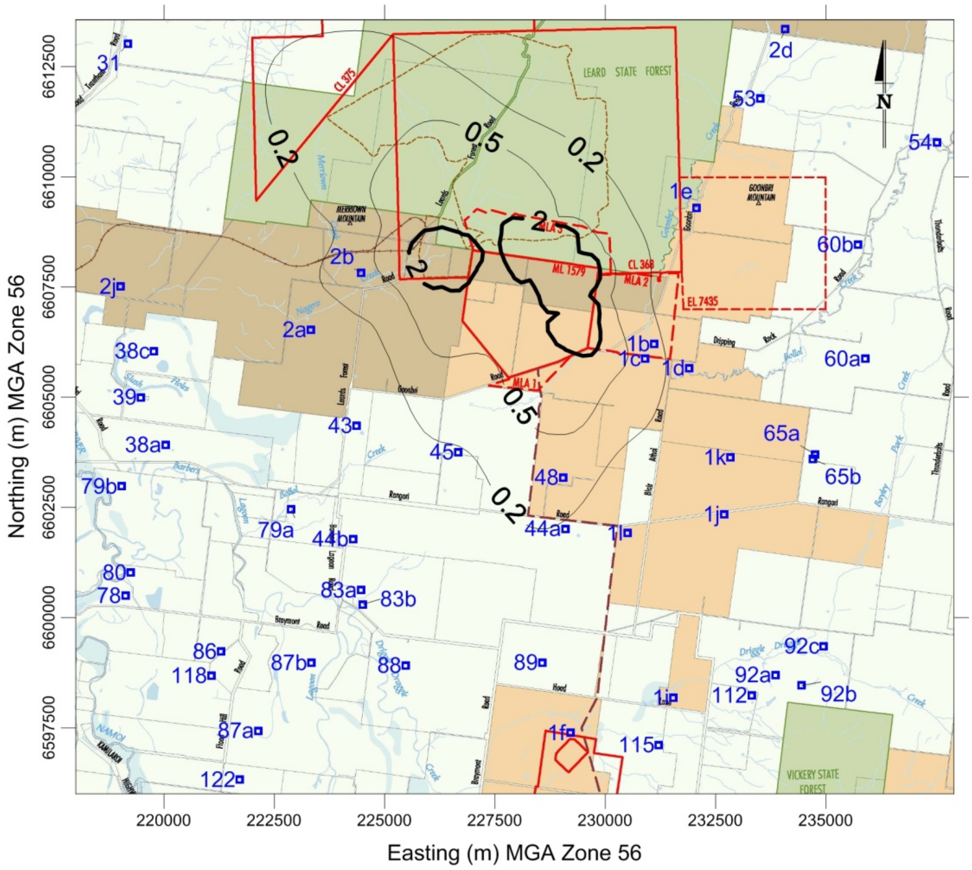
9.7 Project-Only Annual Average Dust deposition

The predicted contribution of the Project-only to annual average dust deposition levels are presented in **Figure 9.13** through **Figure 9.16** for each modelled year. The Project-only OEH assessment criterion for dust deposition is 2 g/m^2/month.



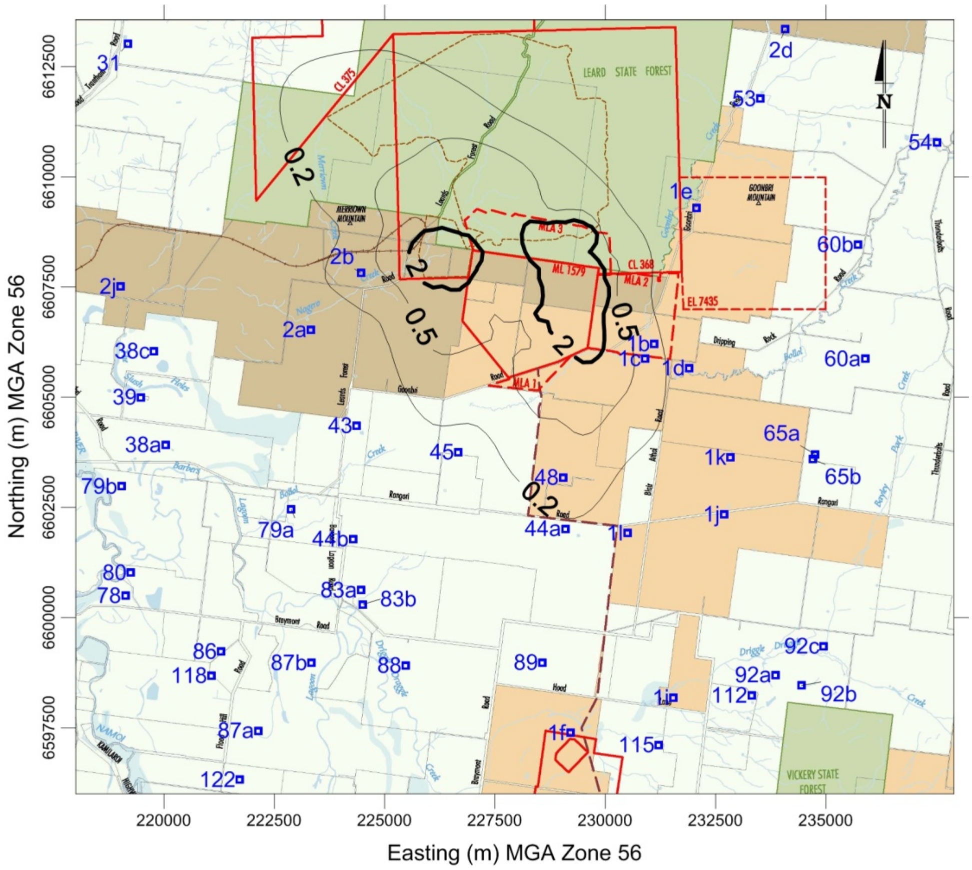
Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
Dust Deposition	Tarrawonga	Year 2	Maximum	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	g/m^2/month	2 g/m^2/month	CALMET 2010	R Kan

Figure 9.13: Predicted Maximum Annual Dust Deposition Concentration Project-Only –Year 2



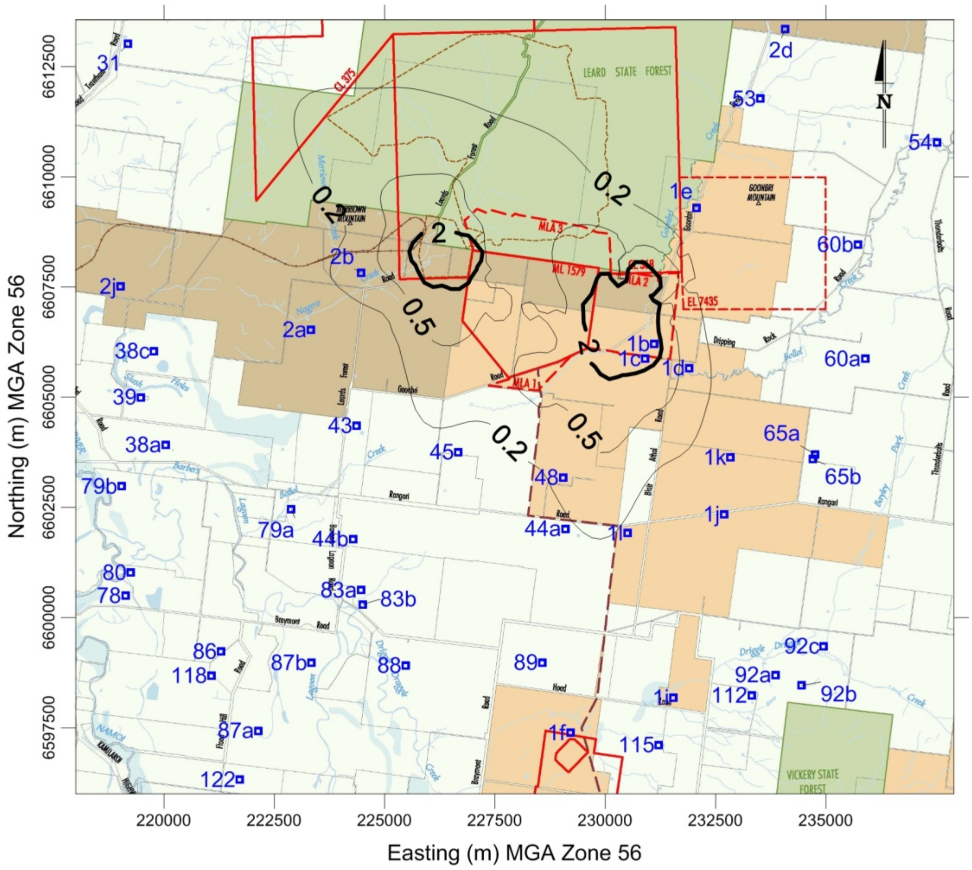
Species:	Location:	Scenario:	Percentile:	Averaging Time:
Dust Deposition	Tarrawonga	Year 4	Maximum	Annual
Model Used:	**Units:**	**Guideline:**	**Met Data:**	**Plot:**
CALPUFF v6.42	g/m^2/month	2 g/m^2/month	CALMET 2010	R Kan

Figure 9.14: Predicted Maximum Annual Dust Deposition Concentration Project-Only –Year 4



Species: Dust Deposition	Location: Tarrawonga	Scenario: Year 6	Percentile: Maximum	Averaging Time: Annual
Model Used: CALPUFF v6.42	**Units:** g/m²/month	**Guideline:** 2 g/m²/month	**Met Data:** CALMET 2010	**Plot:** R Kan

Figure 9.15: Predicted Maximum Annual Dust Deposition Concentration Project-Only –Year 6



Species: Dust Deposition	**Location:** Tarrawonga	**Scenario:** Year 16	**Percentile:** Maximum	**Averaging Time:** Annual
Model Used: CALPUFF v6.42	**Units:** g/m^2/month	**Guideline:** 2 g/m^2/month	**Met Data:** CALMET 2010	**Plot:** R Kan

Figure 9.16: Predicted Maximum Annual Dust Deposition Concentration Project-Only –Year 16

The model predictions for annual average dust deposition at each receiver are presented in **Table 9.6**.

Table 9.6: Maximum predicted annual average dust deposition concentrations (g/m^2/month)

Receiver ID	Property Owner	Year 2	Year 4	Year 6	Year 16
31	Estate: Perpetual Lease M.J. and M.L. Nott	0	0	0	0
38a	R.J. Heiler	0	0	0	0
38c	R.J. Heiler	0	0	0	0
39	D.V. Gillham	0	0	0	0
43	G., L.S. and J.A. Suey	0.1	0.1	0.1	0.1
44a	R.R. and P.L. Crosby	0.2	0.2	0.2	0.2
44b	R.R. and P.L. Crosby	0.1	0.1	0.1	0.1
45	R.P. and R.D. McGregor	0.2	0.2	0.2	0.2
53	V.P. and S.M. Mcauliffe	0	0	0	0
54	P.A. Devine	0	0	0	0
60a	R.R. and P.L. Crosby	0	0	0	0
60b	R.R. and P.L. Crosby	0	0	0	0
65a	T.R. Hall and A.I. Myers Johnson	0	0	0	0.1
65b	T.R. Hall and A.I. Myers Johnson	0	0	0	0.1
78	J.M. and N.M. McKechnie	0	0	0	0.0
79a	K.D. Gillham	0	0	0	0
79b	K.D. Gillham	0	0	0	0
80	A.D. Watson Holdings Pty Ltd	0	0	0	0
83a	R.P. McGregor	0.1	0.1	0.1	0.1
83b	R.P. McGregor	0.1	0.1	0.1	0.1
86	Peter J Watson Holdings Pty Ltd	0	0	0	0
87a	D.S. Riley	0	0	0	0
87b	D.S. Riley	0	0	0	0
88	M.J. and J.H. Maunder	0.1	0.1	0.1	0.0
89	K.A. and C. Blanch	0.1	0.1	0.1	0.1
92a	I. Macleod Hall	0	0	0	0
92b	I. Macleod Hall	0	0	0	0
92c	I. Macleod Hall	0	0	0	0
112	N.P. and S.A. Jackson	0	0	0	0
115	R.D. Mitchell and C.T. Palmer	0	0	0	0
118	A.D. Watson	0	0	0	0
1b	Whitehaven Coal Mining Pty Limited	0.2	0.2	0.2	*
1c	Whitehaven Coal Mining Pty Limited	0.3	0.3	0.3	*
1d	Whitehaven Coal Mining Pty Limited	0.1	0.1	0.1	0.3
1e	Whitehaven Coal Mining Pty Limited	0.1	0.1	0.1	0.1
1f	Whitehaven Coal Mining Pty Limited	0	0	0	0
1h	Whitehaven Coal Mining Pty Limited	0.3	0.3	0.3	0.3
1i	Whitehaven Coal Mining Pty Limited	0	0	0	0
1j	Whitehaven Coal Mining Pty Limited	0.1	0.1	0.1	0.1
1k	Whitehaven Coal Mining Pty Limited	0.4	0.4	0.3	0.3
1l	Whitehaven Coal Mining Pty Limited	0.1	0.1	0.1	0.2
2a	Boggabri Coal Pty Limited	0	0	0	0
2b	Boggabri Coal Pty Limited	0.1	0.1	0.1	0.1
2d	Boggabri Coal Pty Limited	0.1	0.1	0.1	0.1
2j	Boggabri Coal Pty Limited	0	0	0	0

Note: Receivers with prefix 1 and 2 (eg. 1a and 2a) are mine-owned.

* Receivers 1b and 1c would not be occupied in Year 16.

No privately-owned receivers are predicted to exceed the OEH assessment criterion of 2 g/m^2/month for the Project-only. Similarly, when including the background of 2 g/m^2/month (**Section 5.2.4**), no privately-owned receivers are predicted to exceed the cumulative OEH criterion of 4 g/m^2/month.

9.8 Cumulative Annual Average Dust Deposition

A summary of the cumulative assessment of annual average dust deposition is presented in **Table 9.7.** When the contribution of other mining activity (including the Boggabri Coal Continuation Project and Maules Creek Coal Project) are added along with a background for all other sources, no privately-owned receivers are predicted to exceed the OEH assessment criterion 4 g/m^2/month.

Table 9.7: Cumulative annual average dust deposition concentrations (g/m^2/month)

Receiver ID	Project	Boggabri Coal Continuation Project[a]	Maules Creek Coal Project[b]	Non-Mining Sources	Cumulative Dust Deposition Rate
31	0	N/A	N/A	2	2.0
38a	0	N/A	N/A	2	2.0
38c	0	N/A	N/A	2	2.0
39	0	N/A	N/A	2	2.0
43	0.1	N/A	0.1	2	2.2
44a	0.2	0.1	N/A	2	2.3
44b	0.1	N/A	N/A	2	2.1
45	0.2	0.1	N/A	2	2.3
53	0	0.1	0.1	2	2.2
54	0	0.1	N/A	2	2.1
60a	0	0.1	N/A	2	2.1
60b	0	0.1	N/A	2	2.1
65a	0.1	0.1	N/A	2	2.2
65b	0.1	0.1	N/A	2	2.2
78	0.0	N/A	N/A	2	2.0
79a	0	N/A	N/A	2	2.1
79b	0	N/A	N/A	2	2.0
80	0	N/A	N/A	2	2.0
83a	0.1	N/A	N/A	2	2.1
83b	0.1	N/A	N/A	2	2.1
86	0	N/A	N/A	2	2.0
87a	0	N/A	N/A	2	2.0
87b	0	N/A	N/A	2	2.0
88	0.1	N/A	N/A	2	2.1
89	0.1	N/A	N/A	2	2.1
92a	0	N/A	N/A	2	2.0
92b	0	N/A	N/A	2	2.0
92c	0	N/A	N/A	2	2.0
112	0	N/A	N/A	2	2.0
115	0	N/A	N/A	2	2.0
118	0	N/A	N/A	2	2.0
1b	4.1	N/A	N/A	2	6.1
1c	4.7	N/A	N/A	2	6.7
1d	0.3	N/A	N/A	2	2.3
1e	0.1	N/A	N/A	2	2.1
1f	0	N/A	N/A	2	2.0
1h	0.3	0.1	N/A	2	2.4
1i	0	N/A	N/A	2	2.0
1j	0.1	0.1	N/A	2	2.2
1k	0.4	0.1	N/A	2	2.5
1l	0.2	0.1	N/A	2	2.3
2a	0	N/A	N/A	2	2.0
2b	0.1	N/A	N/A	2	2.1
2d	0.1	0.1	0.1	2	2.3
2j	0	0.1	0.1	2	2.2

[a] Dust deposition rates from Boggabri Coal Continuation Project EA (**PAE Holmes, 2010**).

[b] Dust deposition rates from Maules Creek Coal Project EA (**PAE Holmes, 2011**).

N/A – No predictions provided in relevant EA or contribution is zero.

Note: Receivers with prefix 1 and 2 (eg. 1a and 2a) are mine-owned.

9.9 Consideration of Vacant Land

Recent conditions of consent in relation to air quality has included reference to vacant land in air quality criteria. Specifically, vacant land is considered to be affected if greater than 25% of a property is predicted to exceed the impact assessment criteria.

PAEHolmes has reviewed the relevant air quality contours and land tenure information for the Project. From this review, it is concluded that property 49 (**Figure 3.2**) is likely to be affected by Project-only 24-hour PM_{10} emissions (i.e. potentially exceeds 50 $\mu g/m^3$ for greater than 25% of the property). No other potential vacant land impacts have been identified for the Project.

10 CONSTRUCTION IMPACTS

Construction/development activities which would potentially contribute to dust and particulate matter emissions include:

- relocation of the mine facilities area;
- construction of a services corridor to the upgraded Boggabri Coal Mine Infrastructure Facilities;
- realignment of sections of Goonbri Road and construction of new intersections; and
- permanent Goonbri Creek alignment and associated flood bund and low permeability barrier.

From an air quality perspective it is important to consider the potential emissions that would occur during construction. While dust emissions from construction activities can have impacts on local air quality, impacts are typically of a short duration (especially when compared to the life of mining operations) and relatively easy to manage through commonly applied dust control measures. Dust emissions from construction sites vary substantially from day-to-day, depending on the intensity and location of particular activities and it is very difficult to confidently estimate emissions on a day-to-day basis.

Procedures for controlling dust impacts during construction would include, but not necessarily be limited to the following:

Clearing/Excavation

Emissions from vegetation stripping, topsoil clearing and excavation may occur, particularly during dry and windy conditions. Emissions would be effectively controlled by increasing the moisture content of the soil/surface (i.e. through the use of water carts/trucks). Other controls that would be undertaken include:

- modifying working practices by limiting excavation during periods of high winds; and
- limiting the extent of clearing of vegetation and topsoil to the designated footprint required for construction and appropriate staging of any clearing.

Access Road/Service Corridor

The use of earth moving equipment can be a significant source of dust, and emissions would be controlled through the use of water sprays. Where conditions are excessively dusty and windy, work practices would be modified by limiting scraper/grader activity.

Haulage, Heavy Plant and Equipment

Vehicles travelling over paved or unpaved surfaces tend to produce wheel generated dust. The following measures would be implemented during construction to minimise dust emissions from these activities:

- all vehicles on-site would be confined to designated routes with speed limits enforced;
- trips and trip distances would be controlled and reduced where possible, for example by coordinating delivery and removal of materials to avoid unnecessary trips; and

- when conditions are excessively dusty and windy, a water cart/truck (for water spraying of travel routes) would be used.

Wind Erosion

Wind erosion from exposed surfaces during construction would be controlled as part of the best practice environmental management of the site. Wind erosion from exposed ground would be limited by avoiding unnecessary vegetation clearing and by progressively rehabilitating exposed areas as quickly as possible (e.g. through the use of a cover crop). Wind erosion from temporary stockpiles would be limited by minimising the number of stockpiles on-site and minimising the number of work faces on stockpiles.

11 COAL TRANSPORTATION

During Year 1 of the Project, coal would continue to be transported to the Whitehaven CHPP as per the current practice. Air quality impacts associated with coal transportation via the haulage route are assessed in **Richard Heggie Associates** (**2005**). As no change to the approved coal transportation regime is proposed during Year 1, this assessment is considered to continue to apply. This assessment concluded (**Richard Heggie Associates, 2005**):

> *An estimated maximum 99,600 truck movements to and from the Project Site would be required per year to despatch the coal mine products during peak production. This equates to maximum of 332 movements per day, Monday to Saturday.*
>
> *The low background concentrations of relevant pollutants, including NO_2, SO_2 and particulate matter (refer Section 2), are indicative of the local airshed's high capacity to assimilate these pollutants. In view of the expected magnitude of vehicle traffic, it is expected that the local airshed will have the capacity to assimilate emissions from this source and easily meet the relevant air quality goals. It is not anticipated that particulate emissions from vehicle exhausts would significantly contribute to dust deposition rates in the area immediately adjacent to the Project Site. In addition to the comparatively low magnitude of heavy vehicle traffic required for product transportation, all roads from the Project Site boundary to the Whitehaven CHPP and rail loading facility would be sealed, therefore wheel-generated dust emissions would be minimal. As such, vehicles travelling from the Project Site are not anticipated to adversely impact upon nearby residences from an air quality perspective.*

From Year 2, it is proposed to use Boggabri Coal Mine Infrastructure Facilities for processing, loading and off-site transport of Tarrawonga Coal Mine product coal by train. Potential dust generating activities associated with transportation of ROM coal to the Boggabri Coal Mine, coal handling and train loading at Boggabri Coal Mine have been included in the Project modelling. Issues associated with fugitive dust emissions from coal wagons during rail transportation are discussed below.

Fugitive dust from coal train wagons, has recently been studied extensively in Queensland. Queensland Rail (QR) commissioned an environmental evaluation of coal dust emissions from rolling stock in the Central Queensland Coal Industry (**Connell Hatch, 2008**). The purpose of this study was to determine the extent of the issue and identify any potential environmental harm caused by fugitive dust from coal wagons, in the context of nuisance and health impacts and to identify the potential reasonable and feasible measures that could reduce any environmental harm.

In terms of impacts on human health, the QR study concluded that there appears to be minimal risk of adverse impacts due to fugitive coal emissions from trains throughout the network, based on results of monitoring and modelling predictions (**Connell Hatch, 2008**). In terms of impacts on amenity, the results of monitoring and modelling indicate that fugitive coal dust at the edge of the rail corridor are below levels that are known to cause adverse impacts on amenity (**Connell Hatch, 2008**).

PAEHolmes has reviewed the QR study to determine if the conclusions presented are applicable to NSW based on, for example, differences in coal volumes, loading practices, train speeds, wagon shapes and coal properties. It was concluded that many of the observations from the QR study can be applied to the NSW network.

On this basis, consistent with **Connell Hatch (2008)**, the potential for exceedances of OEH air quality criteria caused by the increased coal train movements from the Project is likely to be low, in terms of health and amenity impacts, beyond distances of approximately 15 m from the rail lines.

The Australian Rail Track Corporation Limited (ARTC) is the relevant entity responsible for off-site rail emissions. The ARTC's Environment Protection License (3142) contains a Pollution Reduction Program (PRP) entitled "PRP 4 Particulate Emissions from Coal Trains". This PRP include a requirement for a pilot monitoring program to determine PM_{10} and $PM_{2.5}$ concentrations in the vicinity of the Main Northern Railway (in the lower Hunter Valley). The objective of the PRP is to determine whether loaded coal trains are a source of Particulate Matter emissions in close proximity to the rail line.

It is anticipated that this PRP would become the relevant avenue to address emissions from rail operations, including Project-related rail operations.

12 GREENHOUSE GAS ASSESSMENT

The Director-General's EARs identified GHG as an issue requiring assessment. The EARs for GHG assessment require:

- quantitative assessment of the potential scope 1, 2 and 3 GHG emissions of the Project;
- qualitative assessment of the potential impacts of these emissions on the environment; and
- an assessment of the reasonable and feasible measures that could be implemented on site to minimise the GHG emissions of the Project and ensure it is energy efficient.

This GHG assessment has been prepared in accordance with these requirements.

12.1 Introduction

Greenhouse gas emissions have been estimated based upon the methods outlined in the following documents:

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) Greenhouse Gas Protocol *The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition* **(WRI/WBCSD, 2004**);
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008*; and
- The Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) *National Greenhouse Accounts* (NGA) *Factors 2011* (**DCCEE, 2011)**.

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Standard Organisation, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes.

Three 'scopes' of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes, as described below. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment.

The 'scope' of an emission is relative to the reporting entity. Indirect scope 2 and scope 3 emissions will be reportable as direct scope 1 emissions from another facility.

1) Scope 1: Direct Greenhouse Gas Emissions

Direct GHG emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct greenhouse gas emissions are those emissions that are principally the result of the following types of activities undertaken by an entity:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources, the principal source of GHG emissions associated with the operation of the Project.
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials, e.g., the manufacture of cement, aluminium, etc.

- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources (e.g. trucks, trains, ships, aeroplanes, buses and cars).
- Fugitive emissions. These emissions result from intentional or unintentional releases (e.g. equipment leaks from joints, seals, packing, and gaskets; methane emissions from coal mines and venting); hydroflurocarbon (HFC) emissions during the use of refrigeration and air conditioning equipment; and methane leakages from gas transport.

2) Scope 2: Energy Product Use Indirect Greenhouse Gas Emissions

Scope 2 emissions are a category of indirect emissions that account for GHG emissions from the generation of purchased energy products (principally, electricity, steam/heat and reduction materials used for smelting) by the entity.

Scope 2 in relation to coal mines typically covers purchased electricity, defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity. However, at the Tarrawonga Coal Mine, all energy consumed is produced by diesel generators (which are assessed via scope 1). This would continue for the Project. Scope 2 is therefore not discussed further in this GHG assessment.

3) Scope 3: Other Indirect Greenhouse Gas Emissions

Scope 3 emissions are defined as those emissions that are a consequence of the activities of an entity, but which arise from sources not owned or controlled by that entity. Some examples of scope 3 activities provided in the GHG Protocol are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

In the case of the Project, scope 3 emissions will include emissions associated with the extraction, processing and transport of diesel, and the transportation and combustion of product coal. The GHG Protocol provides that reporting scope 3 emissions is optional. If an organisation believes that scope 3 emissions are a significant component of the total emissions inventory, these can be reported along with scope 1 and scope 2. However, the GHG Protocol notes that reporting scope 3 emissions can result in double counting of emissions and can also make comparisons between organisations and/or products difficult because reporting is voluntary.

Double counting needs to be avoided when compiling national (country) inventories under the Kyoto Protocol. The GHG Protocol also recognises that compliance regimes are more likely to focus on the "point of release" of emissions (i.e. direct emissions) and/or indirect emissions from the purchase of electricity.

12.2 Greenhouse Gas Emission Estimates

Emissions of carbon dioxide (CO_2) and methane (CH_4) would be the most significant GHGs for the Project. These gases are formed and released during the combustion of fuels used on site and from fugitive emissions occurring during the mining process, due to the liberation of methane from coal seams.

Inventories of GHG emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as global warming potentials) and emission factors take into account the global warming potentials of the gases created during combustion. The estimated emissions are referred to in terms of carbon dioxide equivalent or CO_2-equivalent (CO_2-e) emissions by applying the relevant global warming potential. The greenhouse gas assessment has been conducted using the NGA Factors, published by the **DCCEE (2011)**. Project-related GHG sources included in the assessment are as follows:

- fuel consumption (diesel) during on-site electricity generation and mining operations – scope 1;
- release of fugitive CH_4 during mining – scope 1;
- emissions associated with use of explosives in blasting – scope 1;
- emissions associated with vegetation clearing – scope 1;
- indirect emissions associated with the production and transport of fuels – scope 3;
- emissions from the processing of ROM coal – scope 3;
- emissions from coal transportation – scope 3; and
- emissions from the use of the product coal – scope 3.

Emissions from the shipping of product coal are not included in this assessment due to the uncertainties in emission estimates, including uncertainty in future export destinations and limited data on emission factors and/or fuel consumption for ocean going vessels.

12.2.1 Fuel Consumption

Greenhouse gas emissions from diesel consumption were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

where:

E_{CO2-e}	=	Emissions of GHG from diesel combustion	(t CO_2-e)[1]
Q	=	Estimated combustion of diesel	(GJ)[2]
EF	=	Emission factor (scope 1 or scope 3) for diesel combustion	(kg CO_2-e/GJ)[3]

1 tCO_2-e = tonnes of carbon dioxide equivalent.
2 GJ = gigajoules.
3 kg CO_2-e/GJ = kilograms of carbon dioxide equivalents per gigajoule.

The quantity of diesel consumed (kilolitres per annum [kL/annum]) in the on-site generators, mine vehicles and transportation, for each mine year, has been provided by TCPL. Diesel consumption was pro-rated from existing diesel use data for operational activities (i.e. pre-stripping, coal mining, waste rock movements, diesel generators and other civil works on-site). The quantity of diesel consumed in gigajoules (GJ) (Q) is then calculated using an energy content factor for diesel of 38.6 gigajoules per kilolitre (GJ/kL).

Greenhouse gas emission factors and energy content for diesel were sourced from the NGA Factors (**DCCEE, 2011**). The estimated annual and Project total GHG emissions from diesel usage are presented in **Table 12.1**.

It is also noted that diesel would be consumed post-mining during rehabilitation and decommissioning of the Project. However, TCPL estimates that this would involve less diesel consumption due to the reduced demand for diesel-generated power and reduced quantities of material movements relative to the operational phase. These emissions have therefore not been specifically quantified.

Table 12.1: Estimated CO_2-e (tonnes) for diesel consumption

Year	Diesel Consumption (kL/annum)	Emission Factor (kg CO_2-e/GJ)		Energy Content (GJ/kL)	Emissions (t CO_2-e)		Total
		Scope 1	Scope 3		Scope 1	Scope 3	
Year 1	18,815	69.9	5.3	38.6	50,766	3,849	54,615
Year 2	22,235	69.9	5.3	38.6	59,993	4,549	64,542
Year 3	20,867	69.9	5.3	38.6	56,302	4,269	60,571
Year 4	21,208	69.9	5.3	38.6	57,222	4,339	61,561
Year 5	21,892	69.9	5.3	38.6	59,068	4,479	63,546
Year 6	24,629	69.9	5.3	38.6	66,452	5,039	71,491
Year 7	23,945	69.9	5.3	38.6	64,607	4,899	69,506
Year 8	23,945	69.9	5.3	38.6	64,607	4,899	69,506
Year 9	20,525	69.9	5.3	38.6	55,379	4,199	59,578
Year 10	21,892	69.9	5.3	38.6	59,068	4,479	63,546
Year 11	22,577	69.9	5.3	38.6	60,916	4,619	65,535
Year 12	21,208	69.9	5.3	38.6	57,222	4,339	61,561
Year 13	23,261	69.9	5.3	38.6	62,761	4,759	67,520
Year 14	23,261	69.9	5.3	38.6	62,761	4,759	67,520
Year 15	23,261	69.9	5.3	38.6	62,761	4,759	67,520
Year 16	23,261	69.9	5.3	38.6	62,761	4,759	67,520
Year 17	17,788	69.9	5.3	38.6	47,995	3,639	51,634
Total	**374,570.0**	-	-	-	**1,010,642**	**76,630**	**1,087,272**

Note: Totals may differ to the sum of the columns due to rounding to significant figures.

12.2.2 Fugitive Methane

Emissions from fugitive CH_4 were estimated using the following equation:

$$E_{CO_2-e} = Q \times EF$$

where:

$E_{CO2\text{-}e}$	=	Emissions of greenhouse gases from fugitive CH_4	(t CO_2-e/annum)
Q	=	ROM coal extracted during the year	(t)
EF	=	Scope 1 emission factor	(t CO_2-e/tonne)

The default emission factor for fugitive emissions from open cut mines was sourced from the NGA Factors (**DCCEE, 2011**). The estimated annual and Project total GHG emissions from fugitive methane are presented in **Table 12.2**.

Table 12.2: Estimated CO_2-e (tonnes) for fugitive methane

Year	ROM (Mtpa)	Emission Factor (t CO_2-e/tonne ROM)	Scope 1 Emissions (t CO_2-e)
Year 1	2.5	0.045	112,500
Year 2	3.0	0.045	135,000
Year 3	3.0	0.045	135,000
Year 4	3.0	0.045	135,000
Year 5	3.0	0.045	135,000
Year 6	3.0	0.045	135,000
Year 7	3.0	0.045	135,000
Year 8	3.0	0.045	135,000
Year 9	3.0	0.045	135,000
Year 10	3.0	0.045	135,000
Year 11	3.0	0.045	135,000
Year 12	3.0	0.045	135,000
Year 13	3.0	0.045	135,000
Year 14	3.0	0.045	135,000
Year 15	3.0	0.045	135,000
Year 16	3.0	0.045	135,000
Year 17	3.0	0.045	135,000
Total	-	-	**2,272,500**

Note: tCO_2-e/tonne – tonne of carbon dioxide equivalent per tonne

It is noted that a site specific emission factor for fugitive methane for the Maules Creek Coal Project was derived based on measurements of gas content for borehole samples in the same coal seams as those proposed to be mined for the Project (**PAEHolmes, 2011**). The derived site specific emission factor of 0.001 t CO_2-e/t ROM is 45 times lower than the NGA Factors default. Therefore, as an indication of the sensitivity of fugitive emissions to this factor, maximum annual emissions would reduce from 135,000 tonnes of carbon dioxide equivalent per annum (t CO_2-e/annum) to approximately 3,000 t CO_2-e/annum if this factor was adopted. Therefore the total emissions presented in **Table 12.2** are likely to be a significant overestimate of fugitive methane emissions.

12.2.3 Explosives

Emissions from explosive usage were estimated based on the using the following equation:

$$E_{CO_2-e} = Q \times EF$$

where:

E_{CO2-e}	=	Emissions of greenhouse gases from explosives	(t CO_2-e/annum)
Q	=	Quantity of explosive used (assumed ANFO)	(t)
EF	=	Scope 1 emission factor	(t CO_2-e/tonne explosive)

Greenhouse gas emission factors were sourced from the Australian Greenhouse Office (AGO) Factors and Methods Workbook – December 2006. It is noted that the AGO Factors and Methods were replaced by the NGA Factors (**DCCEE, 2011**), however the emission factor for explosives was omitted from the latest version.

The estimated annual and Project total GHG emissions from explosive usage are presented in **Table 12.3.**

Table 12.3: Estimated CO_2-e (tonnes) for explosive use

Year	Explosive Usage (tpa)	Emission Factors ($t\ CO_2$-e/t product)	Scope 1 Emissions ($t\ CO_2$-e)
		ANFO	
Year 1	10,160	0.167	1,697
Year 2	12,008	0.167	2,005
Year 3	11,269	0.167	1,882
Year 4	11,453	0.167	1,913
Year 5	11,823	0.167	1,974
Year 6	13,301	0.167	2,221
Year 7	12,931	0.167	2,159
Year 8	12,931	0.167	2,159
Year 9	11,084	0.167	1,851
Year 10	11,823	0.167	1,974
Year 11	12,192	0.167	2,036
Year 12	11,453	0.167	1,913
Year 13	12,562	0.167	2,098
Year 14	12,562	0.167	2,098
Year 15	12,562	0.167	2,098
Year 16	12,562	0.167	2,098
Year 17	9,606	0.167	1,604
Total	**-**	**-**	**33,780**

12.2.4 Vegetation Clearance

GHG emissions due to vegetation clearance have been calculated based on estimated areas of vegetation communities to be cleared and are presented in **Table 12.4**. Assumptions have been made as to the biomass density for each vegetation community based on information presented in the AGO Technical Report No.17 (**AGO, 2000**). It is assumed that 50% of the biomass in the vegetation cleared is carbon.

Table 12.4: Estimated greenhouse gas emissions from vegetation clearance

Community	Area (ha)	Biomass Density (t/ha)	Carbon (t/ha)	Total Carbon (t)	Emission Factor (t CO_2-e /t carbon)	Total Emission (t CO_2-e)
White Cypress Pine - Narrow-leaved Ironbark shrubby open forest	189	272	136	25,704	3.67	94,334
White Cypress Pine - Narrow-leaved Ironbark shrubby open forest (White Cypress Pine Regeneration)	55	200	100	5,500	3.67	20,185
White Cypress Pine - Narrow-leaved Ironbark shrubby open forest (Narrow-leaved Ironbark and White Cypress Pine Regeneration)	9	200	100	900	3.67	3,303
White Cypress Pine - Narrow-leaved Ironbark shrubby open forest (derived Native Grasslands)	25	200	100	2,500	3.67	9,175
White Box - White Cypress Pine shrubby woodland	41	100	50	2,050	3.67	7,524
White Box - White Cypress Pine shrubby woodland (Narrow-leaved Ironbark and White Cypress Regeneration)	5	100	50	250	3.67	918
White Box - White Cypress Pine grassy woodland	5	100	50	250	3.67	918
White Box - White Cypress Pine grassy woodland (White Cypress Pine Regeneration)	3	100	50	150	3.67	551
White Box - White Cypress Pine grassy woodland (Narrow-leaved Ironbark and White Cypress Pine Regeneration)	2	100	50	100	3.67	367
White Box - White Cypress Pine grassy woodland (Derived Native Grasslands)	3	100	50	150	3.67	551
Pilliga Box - Poplar Box - White cypress Pine grassy open woodland	12	100	50	600	3.67	2,202
Pilliga Box - Poplar Box - White cypress Pine grassy open woodland (derived Native grasslands)	33	100	50	1,650	3.67	6,056
Bracteate Honeymyrtle low riparian forest	15	272	136	2,040	3.67	7,487
Cleared farmland	160	2	1	160	3.67	587
Total						**154,158**

Note: ha – hectare.

12.2.5 ROM Coal Processing

During Year 1, or prior to approvals and upgrades being in place for the transfer of Project ROM coal to the Boggabri Coal Mine Infrastructure Facilities, ROM coal would continue to be transported by private haulage contractors to the Whitehaven CHPP using on-road haulage trucks, as per the existing Tarrawonga Coal Mine. At the Whitehaven CHPP the ROM coal would be either directly loaded onto trains (i.e. bypass the CHPP) or crushed, screened and washed before being loaded onto trains for dispatch.

Following the approvals and upgrades being in place for the transfer of Project ROM coal to the Boggabri Coal Mine Infrastructure Facilities, ROM coal would be processed in either the Boggabri Coal Mine coal preparation plant (CPP) or by-pass crusher before being loaded onto trains for dispatch.

The scope 3 emissions associated with the electricity consumption for the processing of Project coal were estimated using the following equation:

$$E_{CO_2-e} = Q \times EF$$

Where:

E_{CO2-e}	=	Emissions of GHG from electricity consumption	(t CO_2-e)
Q	=	Quantity of electricity	(MWh)[1]
EF	=	Emission factor for electricity consumption	(kg CO_2-e/kWh)[2]

1 MWh = megawatt hours.

2 kg CO_2-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour.

It has been assumed that 1.7 kWh electricity is required to process 1 tonne of ROM coal, based on historical electricity consumption and ROM coal processing rates at the Whitehaven CHPP, as provided by TCPL. The scope 2 and 3 emissions factors for electricity consumption in NSW were sourced from the NGA Factors (**DCCEE, 2011**). It should be noted that while the scope 2 emissions factor has been used, all emissions associated with the processing of ROM coal would be scope 3 emissions for the Project.

The total estimated GHG emissions from ROM coal processing are provided in **Table 12.5**.

Table 12.5: Estimated CO_2-e (tonnes) for ROM coal processing

Year	ROM (Mtpa)	Electricity Consumption (kWh/t ROM)	Electricity Consumption (MWh)	Emission Factor (kg CO_2-e / kWh)		Emissions (t CO_2-e)
				Scope 2	Scope 3	
Year 1	2.5	1.7	4,250	0.89	0.17	4,505
Year 2	3.0	1.7	5,100	0.89	0.17	5,406
Year 3	3.0	1.7	5,100	0.89	0.17	5,406
Year 4	3.0	1.7	5,100	0.89	0.17	5,406
Year 5	3.0	1.7	5,100	0.89	0.17	5,406
Year 6	3.0	1.7	5,100	0.89	0.17	5,406
Year 7	3.0	1.7	5,100	0.89	0.17	5,406
Year 8	3.0	1.7	5,100	0.89	0.17	5,406
Year 9	3.0	1.7	5,100	0.89	0.17	5,406
Year 10	3.0	1.7	5,100	0.89	0.17	5,406
Year 11	3.0	1.7	5,100	0.89	0.17	5,406
Year 12	3.0	1.7	5,100	0.89	0.17	5,406
Year 13	3.0	1.7	5,100	0.89	0.17	5,406
Year 14	3.0	1.7	5,100	0.89	0.17	5,406
Year 15	3.0	1.7	5,100	0.89	0.17	5,406
Year 16	3.0	1.7	5,100	0.89	0.17	5,406
Year 17	3.0	1.7	5,100	0.89	0.17	5,406

Note: kWh/t ROM = kilowatt hours per tonne of run-of-mine coal.

12.2.6 ROM Coal and Product Coal Transportation

12.2.6.1 Transportation by Road and Rail

The annual diesel consumption for the transportation of ROM coal to the Whitehaven CHPP (Year 1 only) is estimated by TCPL to be 3,065 kilolitres (kL). These scope 3 emissions have been estimated using the same method described in **Section 12.2.1,** and are provided in **Table 12.6**.

The scope 3 emissions associated with product coal transportation have been estimated based on all product coal being transported to Newcastle for export by rail. Emissions associated with product coal transportation have been estimated based on an emission factor for loaded trains of 12.3 grams per net tonne per kilometre (**QR Network Access, 2002**). In reality, some coal would be sold at the mine gate for domestic use. However, this coal is sold in multiple small quantities, therefore, its related transportation emissions are difficult to estimate.

Emission factors were not available for unloaded trains so the factor for loaded trains is conservatively applied for the return trip. The return rail trip to the port of Newcastle is estimated to be 720 km.

The total estimated GHG emissions from rail transport of product coal are provided in **Table 12.6**.

Table 12.6: Estimated CO_2-e (tonnes) for ROM coal and product coal transportation

Year	Product Coal Mtpa	t CO_2-e from rail transport	t CO_2-e from road transport	Total t CO_2-e from transport
		Scope 3	Scope 3	
Year 1	2.3	17,902	8,897	26,799
Year 2	2.8	24,947	0	24,947
Year 3	2.8	24,938	0	24,938
Year 4	2.8	24,930	0	24,930
Year 5	2.8	24,947	0	24,947
Year 6	2.8	24,930	0	24,930
Year 7	2.8	24,930	0	24,930
Year 8	2.8	24,947	0	24,947
Year 9	2.8	24,930	0	24,930
Year 10	2.8	24,938	0	24,938
Year 11	2.8	24,938	0	24,938
Year 12	2.8	25,009	0	25,009
Year 13	2.8	24,956	0	24,956
Year 14	2.8	24,965	0	24,965
Year 15	2.8	24,965	0	24,965
Year 16	2.8	24,965	0	24,965
Year 17	2.8	24,947	0	24,947
Total	**47.4**	**417,086**	**8,897**	**425,983**

Note: Totals may differ to the sum of the columns due to rounding to significant figures.

12.2.6.2 Transportation by Ship

Emissions from the shipping of product coal are not included in this assessment due to the difficulties in emission estimates, including uncertainty in export markets and limited data on emission factors and/or fuel consumption for ocean going vessels.

12.2.7 Use of Product Coal

Approximately 18% of product coal would be sold as thermal coal, with the remaining 82% sold as coking coal.

The scope 3 emissions associated with the combustion of product coal were estimated using the following equation:

$$E_{CO_2-e} = \frac{Q \times EC \times EF}{1000}$$

Where:

E_{CO2-e}	=	Emissions of GHG from coal combustion	(t CO_2-e)
Q	=	Quantity of product coal burnt	(GJ)
EC	=	Energy Content Factor for black / coking coal	(GJ/t)[1]
EF	=	Emission factor for black / coking coal combustion	(kg CO_2-e/GJ)

[1] GJ/t = gigajoules per tonne

The quantity of thermal coal burnt in Mtpa is converted to GJ using an energy content factor for black coal of 27 GJ/t. The quantity of coking coal burnt in Mtpa is converted to GJ using an energy content factor for coking coal of 30 GJ/t.

The greenhouse gas emission factor and energy content for coal were sourced from the NGA Factors (**DCCEE, 2011**). The emissions associated with the use of the product coal are presented in **Table 12.7**.

Table 12.7: Scope 3 emissions for product coal

Year	Product Coal Mtpa		Energy Content GJ/t		Emission Factor kg CO_2 e/GJ		Scope 3 Emissions (t CO_2-e)		
	Thermal	Coking	Black	Coking	Black	Coking	Black	Coking	Total
Year 1	0.42	1.93	27	30	88.43	90.22	1,008,765	5,210,205	6,218,970
Year 2	0.51	2.31	27	30	88.43	90.22	1,210,518	6,252,246	7,462,764
Year 3	0.51	2.31	27	30	88.43	90.22	1,210,518	6,249,539	7,460,058
Year 4	0.51	2.31	27	30	88.43	90.22	1,210,518	6,246,833	7,457,351
Year 5	0.51	2.31	27	30	88.43	90.22	1,210,518	6,252,246	7,462,764
Year 6	0.51	2.31	27	30	88.43	90.22	1,210,518	6,246,833	7,457,351
Year 7	0.51	2.31	27	30	88.43	90.22	1,210,518	6,246,833	7,457,351
Year 8	0.51	2.31	27	30	88.43	90.22	1,210,518	6,252,246	7,462,764
Year 9	0.51	2.31	27	30	88.43	90.22	1,210,518	6,246,833	7,457,351
Year 10	0.51	2.31	27	30	88.43	90.22	1,210,518	6,249,539	7,460,058
Year 11	0.51	2.31	27	30	88.43	90.22	1,210,518	6,249,539	7,460,058
Year 12	0.51	2.32	27	30	88.43	90.22	1,210,518	6,271,192	7,481,710
Year 13	0.51	2.31	27	30	88.43	90.22	1,210,518	6,254,953	7,465,471
Year 14	0.51	2.31	27	30	88.43	90.22	1,210,518	6,257,659	7,468,177
Year 15	0.51	2.31	27	30	88.43	90.22	1,210,518	6,257,659	7,468,177
Year 16	0.51	2.31	27	30	88.43	90.22	1,210,518	6,257,659	7,468,177
Year 17	0.51	2.31	27	30	88.43	90.22	1,210,518	6,252,246	7,462,764
Total	-	-	-	-	-	-	**20,377,058**	**105,254,261**	**125,631,318**

12.3 Summary of Emissions

A summary of the average annual GHG emissions is provided in **Table 12.8**.

Average annual scope 1 emissions from the Project (0.2 million tonnes of carbon dioxide equivalent [Mt CO_2-e]) would represent 0.03% of Australia's Kyoto commitment (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions.

Some 66% of direct (scope 1) emissions from the Project are from fugitive emissions of methane. These emissions have been estimated using the standard NGA factor which is some 45 times greater than the factor measured for the Maules Creek Coal Project (**Section 12.2.2**). It is therefore expected that this is a significant overestimate of scope 1 emissions. **Section 12.6** outlines proposed Project GHG mitigation measures, including gas content testwork to confirm scope 1 emission quantities.

12.4 Greenhouse Gas Emissions Intensity

The estimated greenhouse gas emissions intensity of the Project is approximately 0.08 t CO_2-e/t saleable coal (this includes all scope 1 emissions and the scope 3 emissions associated with ROM coal processing). The estimated emissions intensity of the Project is comparable with the average emissions intensity of existing open cut coal mines in Australia (0.05 t CO_2-e/t saleable coal) (**Deslandes, 1999**) and the estimated emissions intensity of the Boggabri Coal Continuation Project (0.07 t CO_2-e/t saleable coal) (**PAEHolmes, 2010)**. For comparison, the estimated emissions intensity of the Maules Creek Coal Project is 0.02 t CO_2-e/t saleable coal, which is due to the site specific fugitive methane emission factor used (see discussion below).

Figure 12.1 (derived from **Deslandes, 1999**) shows the GHG intensity of the Project compared to other Australian coal mines. The emissions intensity is comparable to other open cut coal mines and significantly less than gassy underground mines.

Table 12.8: Summary of estimated annual GHG emissions from Tarrawonga Coal Project

Year	Scope 1 Emissions (t CO_2-e)					Scope 3 Emissions (t CO_2-e)				
	On-site Diesel	Fugitive Methane	Blasting	Vegetation Clearing[1]	Total	ROM Coal Processing	On-site Diesel	Coal Burning	Transport	Total
Year 1	50,766	112,500	1,697	9,068	174,030	4,505	3,849	6,218,970	26,799	6,250,072
Year 2	59,993	135,000	2,005	9,068	206,066	5,406	4,549	7,462,764	24,947	7,492,154
Year 3	56,302	135,000	1,882	9,068	202,252	5,406	4,269	7,460,058	24,938	7,489,168
Year 4	57,222	135,000	1,913	9,068	203,203	5,406	4,339	7,457,351	24,930	7,486,531
Year 5	59,068	135,000	1,974	9,068	205,110	5,406	4,479	7,462,764	24,947	7,492,084
Year 6	66,452	135,000	2,221	9,068	212,742	5,406	5,039	7,457,351	24,930	7,487,231
Year 7	64,607	135,000	2,159	9,068	210,834	5,406	4,899	7,457,351	24,930	7,487,091
Year 8	64,607	135,000	2,159	9,068	210,834	5,406	4,899	7,462,764	24,947	7,492,504
Year 9	55,379	135,000	1,851	9,068	201,298	5,406	4,199	7,457,351	24,930	7,486,391
Year 10	59,068	135,000	1,974	9,068	205,110	5,406	4,479	7,460,058	24,938	7,489,377
Year 11	60,916	135,000	2,036	9,068	207,020	5,406	4,619	7,460,058	24,938	7,489,518
Year 12	57,222	135,000	1,913	9,068	203,203	5,406	4,339	7,481,710	25,009	7,510,890
Year 13	62,761	135,000	2,098	9,068	208,927	5,406	4,759	7,465,471	24,956	7,495,071
Year 14	62,761	135,000	2,098	9,068	208,927	5,406	4,759	7,468,177	24,965	7,497,777
Year 15	62,761	135,000	2,098	9,068	208,927	5,406	4,759	7,468,177	24,965	7,497,777
Year 16	62,761	135,000	2,098	9,068	208,927	5,406	4,759	7,468,177	24,965	7,497,777
Year 17	47,995	135,000	1,604	9,068	193,667	5,406	3,639	7,462,764	24,947	7,491,244
Total	**1,010,642**	**2,272,500**	**33,781**	**154,155**	**3,471,078**	**91,001**	**76,630**	**125,631,318**	**425,983**	**126,132,658**

[1] Annual average vegetation clearance taken as total emissions divided by 17 years.

Note: Totals may differ to the sum of the columns due to rounding and significant figures.

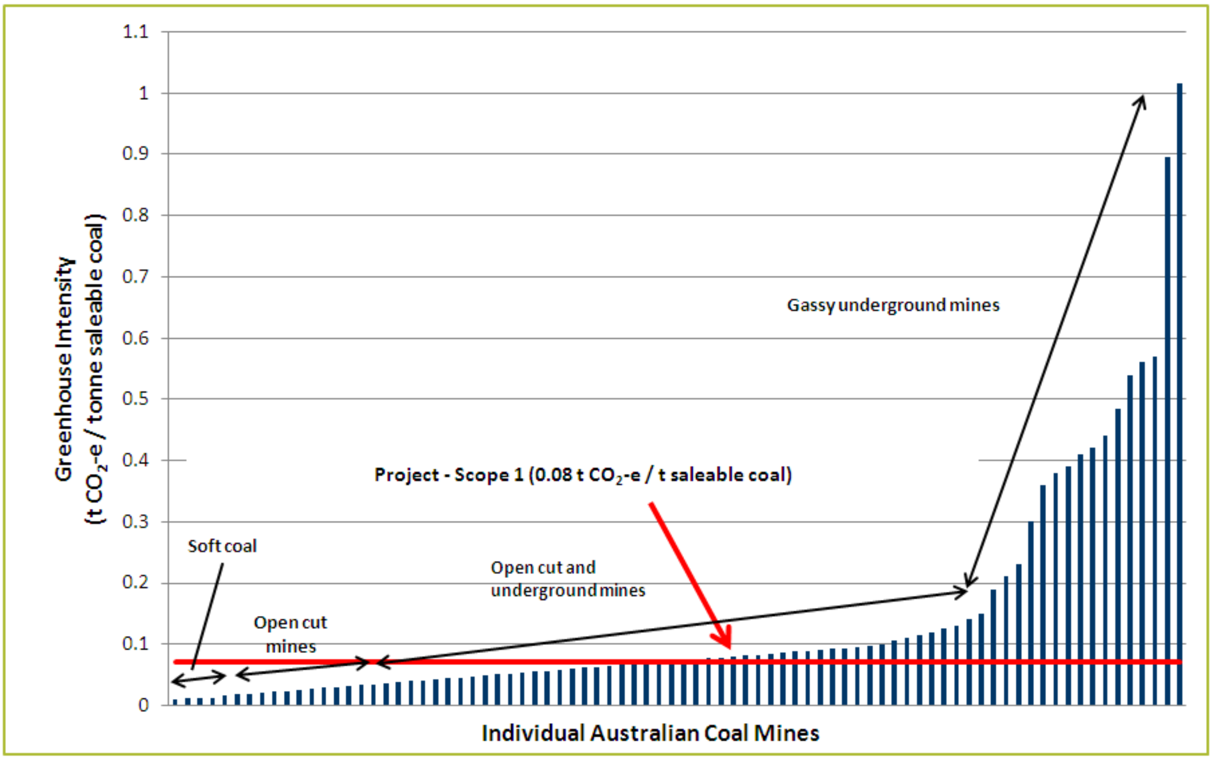


Figure 12.1: Greenhouse Gas Intensity Comparison

The largest source of scope 1 GHG emissions is fugitive methane emissions (approximately 65%) (**Table 12.8**). As noted in **Section 12.2.2**, these emissions have likely been significantly over-estimated. Using the site specific fugitive methane emission factor derived for the Maules Creek Coal Project (0.001 t CO_2-e/t), as opposed to the NGA Factors default (0.045 t CO_2-e/t), the emissions intensity of the Project would be approximately 0.03 t CO_2-e/t saleable coal (i.e. comparable with the emissions intensity of the Maules Creek Coal Project).

12.5 Qualitative Assessment of Impact

According to the Intergovernmental Panel of Climate Change's (IPCC) Fourth Assessment Report, global surface temperature has increased 0.74 ± 0.18°C during the 100 years ending 2005 (**IPCC, 2007a**). The IPCC has determined *"most of the observed increase in globally averaged temperatures since the mid-twentieth century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations".* "Very likely" is defined by the IPCC as greater than 90% probability of occurrence (**IPCC, 2007b**).

Climate change projections specific to Australia have been determined by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), based on the following global emissions scenarios predicted by the IPCC (**CSIRO, 2007**):

- A1F1 (high emissions scenario) – assumes very rapid economic growth, a global population that peaks in mid-century and technological change that is fossil fuel intensive.
- A1B (mid emissions scenario) – assumes the same economic and population growth as A1F1, with a balance between fossil and non-fossil fuel intensive technological changes.
- B1 (low emissions scenario) – assumes the same economic and population growth as A1F1, with a rapid change towards clean and resource efficient technologies.

For the global emissions scenarios described above, the projected changes in annual temperature relative to 1990 levels for Australian cities for 2030 and 2070 are presented in **Table 12.9,** as determined by the **CSIRO (2007)**. The towns/cities presented in **Table 12.9** are those closest to the Tarrawonga Coal Mine for which results are available.

Table 12.9: Projected changes in annual temperature (relative to 1990)

Location	2030 - A1B (mid-range emissions scenario)	2070 - B1 (low emissions scenario)	2070 - A1F1 (high emissions scenario)
Temperature (°C)			
Brisbane	0.7 - 1.4	1.1 - 2.3	2.1 - 4.4
Dubbo	0.7 - 1.5	1.2 - 2.5	2.2 - 4.8
St George (Queensland)	0.7 - 1.6	1.2 - 2.7	2.4 - 5.2
Sydney	0.6 - 1.3	1.1 - 2.2	2.1 - 4.3

Notes: Range of values represents the 10^{th} and 90^{th} percentile results.
For 2030, only A1B results are shown as there is little variation in projected results for the global emission scenarios A1B, B1 and A1F1 (**CSIRO, 2007**).

Source: **CSIRO (2007)** *Climate Change in Australia – Technical Report 2007*, Commonwealth Scientific and Industrial Research Organisation.

The CSIRO also details projected changes to other meteorological parameters (for example rainfall, potential evaporation, wind speed, relative humidity and solar radiation) and the predicted changes to the prevalence of extreme weather events (for example droughts, bush fires and cyclones).

The potential social and economic impacts of climate change to Australia are detailed in the Garnaut Climate Change Review (**Garnaut, 2008**), which draws on IPCC assessment work and the CSIRO climate projections. The Garnaut review details the negative and positive impacts associated with predicted climate change with respect to:

- agricultural productivity;
- water supply infrastructure;
- urban water supplies;
- buildings in coastal settlements;
- temperature related deaths;
- ecosystems and biodiversity; and
- geopolitical stability and the Asia-Pacific region.

The Project's contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global greenhouse gas emissions. Average annual scope 1 emissions from the Project (0.2 Mt CO_2-e) would represent approximately 0.03% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions, given that Australia contributed approximately 1.5% of global greenhouse gas emissions in 2005 **(Commonwealth of Australia, 2011)**.

A comparison of predicted annual greenhouse gas emissions from the Project with global, Australian and NSW emissions inventories are presented in **Table 12.10**.

Table 12.10: Comparison of greenhouse gas emissions

Geographic coverage	Source coverage	Timescale	Emission Mt CO_2-e	Reference
Project	Scope 1 only	Average annual	0.2	This report.
Global	Consumption of fossil fuels	Total since industrialisation 1750 - 1994	865,000	IPCC (2007a) Figure 7.3 converted from Carbon unit basis to CO_2 basis. Error is stated greater than ±20%.
Global	CO_2-e emissions	2005	35,000	Based on Australia representing 1.5% of global emissions (Commonwealth of Australia, 2011). Australian National Greenhouse Gas Inventory (2005) taken from http://www.ageis.greenhouse.gov.au/
Global	CO_2-e emission increase 2004 to 2005	2005	733	IPCC (2007a) From tabulated data presented in Table 7.1 on the basis of an additional 733 Mt/a. Data converted from Carbon unit basis to CO_2 basis.
Australia	1990 Base	1990	547.7	Taken from the National Greenhouse Gas Inventory (2009) http://www.ageis.greenhouse.gov.au/
Australia	Kyoto target	Average annual 2008 - 2012	591.5	Based on 1990 net emissions multiplied by 108% Australia's Kyoto emissions target.
Australia	Total (inclusive of existing Tarrawonga Coal Mine)	2009	564.5	Taken from the National Greenhouse Gas Inventory (2009) http://www.ageis.greenhouse.gov.au/
NSW	Total	2009	160.5	Taken from the National Greenhouse Gas Inventory (2009) http://www.ageis.greenhouse.gov.au/

Greenhouse gas emissions from Australian sources will be collectively managed at a national level, through initiatives implemented by the Australian Government. The Australian Government has committed to reduce greenhouse gas emissions by between 5-25% below 2000 levels by 2020, with the level of reduction dependent on the extent of reduction actions undertaken internationally **(Commonwealth of Australia, 2011)**. Similarly, the Federal Opposition has committed to a 5% reduction below 1990 levels by 2020 in its Direct Action Plan **(Liberal Party of Australia, 2010)**.

The commitment from the Australian Government to reduce greenhouse gas emissions is proposed to be achieved through the introduction of the Australian Government's proposed carbon pricing mechanisms. From 1 July 2012, this will involve a fixed price on greenhouse gas emissions, with no cap on Australia's greenhouse gas emissions, or emissions from individual facilities **(Commonwealth of Australia, 2011)**.

From 1 July 2015 (i.e. during Project Year 3) an emissions trading scheme is proposed to be implemented. As such, Australia's greenhouse gas emissions, inclusive of emissions associated with the Project, would be capped at a level specified by the Australian Government. Under the emissions trading scheme, there will specifically be no limit on the level of greenhouse gas emissions from individual facilities, with the incentive for facilities to reduce their greenhouse gas emissions driven by the carbon pricing mechanism **(Commonwealth of Australia, 2011)**.

It is expected that the Project would exceed the facility threshold of 25,000 t CO_2-e per annum for participation in the carbon pricing mechanisms, and as such scope 1 greenhouse gas emissions from the Project would be subject to the carbon pricing mechanism. As such, Whitehaven would directly contribute to the revenue generated by the carbon pricing mechanism, which is to be used to fund the following initiatives designed to reduce Australia's greenhouse gas emissions **(Commonwealth of Australia, 2011)**:

- $1.2 billion Clean Technology Program to improve energy efficiency in manufacturing industries and support research and development in low-pollution technologies.
- $10 billion Clean Energy Finance Corporation to invest in renewable energy, low-pollution and energy efficiency technologies.
- $946 million Biodiversity Fund (over the first six years) to protect biodiverse carbon stores and secure environmental outcomes from carbon farming.

In addition to contributing to these initiatives, TCPL would implement Project-specific greenhouse gas mitigation measures, as described in **Section 12.6**, below.

12.6 Greenhouse Gas Reduction Measures

TCPL is committed to implementing reasonable and feasible greenhouse gas mitigation measures.

The potential for reducing greenhouse gas emissions at the Tarrawonga Coal Mine is related predominantly to consumption of diesel use by plant and equipment. Methods are in place at site to maximise efficiency from the mining fleet through regular maintenance scheduling and, where possible, minimising the gradient and length of loaded haul runs for the operating dump trucks. This is achieved by appropriate mine scheduling and planning.

TCPL remains committed to a reduction in emission levels as a result of operations at the mine site. As part of this process, TCPL continues to run a fleet of Terex dump trucks (electric drive) which have proven to burn less diesel fuel as compared to the standard mechanical drive fleet at other Whitehaven operations (**TCPL, 2009**).

The ROM coal haulage contractor, Toll Resources continues to utilise a fleet of purpose built B-Doubles with the Prime Mover's specifically engineered to comply with emission and noise criteria. This includes being speed limited to 93 km/hr which has been determined as the optimum operating speed in terms of operational and fuel efficiency. This measure is relevant to Year 1 of the Project only.

In addition to the above, the proposed Project biodiversity offset at the Willeroi property would also assist with reducing the Project's overall carbon footprint, in particular the regeneration of areas previously cleared for agricultural purposes and the conservation commitment for the offset in perpetuity. This is in addition to the on-site rehabilitation of areas cleared during the development of the Project.

Ongoing monitoring and management of greenhouse gas emissions and energy consumption at the Tarrawonga Coal Mine would be achieved through Whitehaven's participation in the Commonwealth Government's National Greenhouse and Energy Report System (NGERS). Under NGERS requirements, relevant sources of greenhouse gas emissions and energy consumption must be measured and reported on an annual basis, allowing major sources and trends in emissions/energy consumption to be identified.

Whitehaven is also a participant in the Commonwealth Government's Energy Efficiency Opportunities (EEO) Program. As such, Whitehaven will assess energy usage from all aspects of its operations, including the Tarrawonga Coal Mine, and publicly report the results of energy efficiency assessments, and the opportunities that exist for energy efficiency projects with a financial payback of up to four years.

As part of its obligations under the EEO Program, Whitehaven has set up an internal steering committee with the objective of identifying and implementing GHG mitigation initiatives. The initial EEO Program report will be provided to the Commonwealth Department of Resources, Energy and Tourism by the end of December 2011.

For the Project, TCPL would also directly measure the gas content of the coal seams being mined in order to provide a site-specific emissions factor of these scope 1 emissions.

13 CONCLUSIONS

Dispersion modelling has been used to predict off-site dust concentration and deposition levels due to the activities that would occur as a result the Project. Emissions inventories were developed for Years 2, 4, 6 and 16 of the Project. The dispersion conditions in the vicinity of the Project were characterised based on regional and local meteorological data, generated using a diagnostic meteorological modelling system known as CALMET. The annual winds predicted by CALMET correlate with the windroses presented for onsite data. CALPUFF was used to predict the maximum 24-hour average PM_{10}, annual average PM_{10}, annual average TSP and annual average dust deposition. Preliminary modelling identified that wheel generated dust emissions contributed the most to air quality impacts from the Project and additional levels of haul road dust control were incorporated into the model.

The Project includes the haulage of ROM coal to the Boggabri Coal Mine Infrastructure Facilities for handling, processing and transportation. This assessment has conservatively accounted for these potential emissions associated with these activities (e.g. coal stockpile sources).

OEH assessment criteria are generally based on thresholds relating to human health effects. These criteria have been developed to a large extent in urban areas, where the primary pollutants are the products of combustion, which are more harmful to human health than particulates of crustal origin, such as dust from mining operations.

Detailed modelling was conducted to assess whether the proposed mining operations of the Project would adversely impact any privately owned or mine-owned receivers located in the vicinity of the Project. The assessment included predictions of air quality impacts from the Project in isolation as well as the potential cumulative impacts of other neighbouring mines and other cumulative sources.

There are no privately-owned receivers predicted to experience 24-hour PM_{10}, annual average PM_{10} concentrations, TSP concentrations or dust deposition levels above the OEH assessment criteria due to the Project-only. The assessment identified the potential for cumulative 24-hour PM_{10} exceedances at one privately-owned receiver (44a) and cumulative annual average PM_{10} exceedances at one privately-owned receiver (45). The cumulative assessment considered emissions from the Project, the Boggabri Coal Continuation Project and the Maules Creek Coal Project.

In addition, one privately-owned vacant property (receiver 49) is predicted to exceed the 24-hour PM_{10} criterion over greater than 25% of its area.

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 a best practice real-time dust management system.

The potential greenhouse gas emissions that are likely to occur as a result of the operation of the Project have been estimated based on an inventory for each year of the Project's life. On average, Scope 1 emissions from the Project represent 0.03% of Australia's Kyoto commitment.

Some 66% of direct (scope 1) emissions from the Project are from fugitive emissions of methane. These emissions have been estimated using the standard NGA factor which is some 45 times greater than the factor measured for the same coal seams for a nearby mining project. It is therefore expected that this is a significant overestimate of scope 1 emissions.

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APPENDIX A – Emissions Inventory

Tarrawonga Coal Project

The dust emission inventories have been prepared using the operational description of the proposed mining activities provided by Tarrawonga Coal Pty Limited (TCPL).

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. All activities have been modelled for 24-hours per day (except for blasting activities).

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.

Removal of topsoil

For a scraper clearing and stripping topsoil a total suspended particulate matter (TSP) emission rate of 1.64 kilogram per vehicle kilometre travelled (kg/VKT) has been used (**NPI EET for Mining v2.3**).

Drilling overburden and coal

The emission factor used for drilling has been taken to be 0.59 kg/hole (United States Environmental Protection Agency [**US EPA], 1985 and updates**).

The number of holes per year were calculated based on information provided by TCPL. The number of holes has been calculated to be 66 holes/blast with a hole spacing of 7.5 metre (m).

Blasting overburden and coal

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

Equation 1

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

where,
A = area to be blasted in square metres (m^2)

The area to be blasted per blast and number of blasts per year were calculated based on information provided by TCPL. The maximum number of blasts per year was determined to be 108. The area to be blasted is 6,000 m^2.

Loading material/stockpiling topsoil and overburden using shovels/excavators/front end loaders (FELs)

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

Equation 2

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

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

The wind speed value was taken from the CALMET generated 2010 meteorological dataset for the Tarrawonga Coal Mine. The moisture content for overburden and topsoil was assumed to be 2.5%. A density of 2.3 tonnes per bank cubic metre was assumed.

Hauling material/product on unsealed surfaces

In accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Department of Environment and Conservation, 2005), the Emission Factor for wheel generated dust from unpaved roads was used from the US EPA AP42 emission factor for unpaved surfaces at industrial sites shown in **Equation 3** below:

Equation 3

$$EF_{TSP} = 0.2819 \times \left(4.9 \times \left(\frac{s}{12} \right)^{0.7} \times \left(\frac{(W \times 1.1023)}{3} \right)^{0.45} \right)$$

Where:
EF_{TSP} = *TSP emission factor from wheel generated dust*
s = silt content of road surface
W = mean vehicles weight

The variables are silt content (S) and vehicle mass (W). The silt content used was 2% and the total 'W' weight used was 140 t. Using those parameters and the 90% control level results in the adopted emissions factor of 0.2 kg TSP/Vehicle Kilometre Travelled (VKT).

Regarding the silt content applied, it is considered that 2% is within the range typically applied for coal mines (e.g. Heggies used 1.8% in the *East Boggabri Joint Venture Environmental Impact Statement* and the subsequent *Tarrawonga Coal Mine Modification Environmental Assessment*). Measured average haul road silt contents of 2 to 3% have been recorded at multiple mine sites in the Hunter Valley. This testing was completed for a current ACARP project (in prep).

The vehicle mass used was 140 t. This is considered to be appropriate given the fact that a variety of trucks are used throughout an operational year, trucks are operated both empty and whilst transporting various amounts of material and that the weight/density of the material itself is variable.

Dozers on overburden

Emissions from dozers on overburden have been calculated using the US EPA emission factor equation (**US EPA, 1985 and updates**), per **Equation 4**.

Equation 4

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

where,

$\mathrm{E_{TSP}} = TSP\ \ emissions$

$\mathrm{s = silt\ content\ (\%), and}$

$\mathrm{M = moisture\ (\%)}$

The silt content in the overburden was assumed to be 10%, and the moisture content 2.5%. This results in an emission factor of 12.5 kg/hour.

Dozers ripping coal

The **US EPA (1985 and updates)** emission factor equation has been used. It is given below in **Equation 5**.

Equation 5

$$E_{TSP} = 35.6 \times \frac{s^{1.2}}{m^{1.4}} \qquad kg/hour$$¶

Where,
s = silt content (%), and
M = moisture (%)

The silt content in the coal whilst ripping was assumed to be 10%, and the moisture content 8%, resulting in an emission factor of 30.7 kg/hour.

Loading/unloading coal

The **US EPA (1985 and updates)** emission factor equation has been used. It is given below in **Equation 6**.

Equation 6

$$\mathrm{E_{TSP}} = \frac{0.580}{M^{1.2}} \qquad \text{kg/t}$$

where,

$\mathrm{E_{TSP}} = TSP\ \ emissions$

$\mathrm{M = moisture\ (\%)}$

The moisture content was assumed to be 8%.

Wind erosion

The **US EPA (1985 and updates)** emission factor equation has been used for wind erosion. It is given below in **Equation 7**.

Equation 7

$$E = 1.9\left(\frac{s}{1.5}\right)365\left(\frac{365-p}{235}\right)\left(\frac{f}{15}\right) \text{kg/ha/year}$$

s = silt content (%)

p = number of days when rainfall is greater than (0.25 mm)

f = percentage of time that wind speed is greater than 5.4 m/s at the mean height of the stockpile.

The silt content in the stockpiles was assumed to be 10% for the stockpiles. The number of days when rainfall is greater than 0.25 millimetres was estimated to be 76 and the percentage of time that wind speed is greater than 5.4 metres per second was 4.2%.

Theoretically, the inclusion of the variable for the average number of rain days in a year may lead to an underestimation of the hourly emissions, and as such, potentially under-estimate the worst-case 24-hour impacts on days when there is no rain. However, this is considered to be offset by the fact that the modelled wind erosion area was based on annual mine plans. The implications of this are that for any hour of the year, modelling assumes that wind erosion is generated across these entire areas, whereas, in reality, wind erosion may only occur across the exposed areas that are actively disturbed on those days.

50% control was assumed for the stockpiles at the Tarrawonga Coal Mine and the stockpiles at the Boggabri Coal Mine. For partially rehabilitated areas, 99% control was applied.

Grading roads

Estimations of TSP emissions from grading roads have been made using the **US EPA (1985 and updates)** emission factor equation (**Equation 8**).

Equation 8

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

where,

S = speed of the grader in km/hour (taken to be 7.5 km/hour).

The following tables present the calculated emissions for each year of operations modelled and the allocation of the sources as represented in **Figure 6.1** to **Figure 6.5**.

The abbreviations used in the tables are as follows:

- O/B - overburden
- CL - coal
- Sh/Ex/FELs - shovels/excavators/front-end-loaders
- WE - wind erosion emissions
- WI - wind insensitive emissions
- WS - wind sensitive emissions

Estimated emissions of TSP for the Project – Year 2

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units
Scrapers - 4 scrapers removing vegetation	43,200	43,200	VKT	1.6	kg/vkt								
OB - Drilling	4,194	7,108	holes/y	0.59	kg/hole	66	holes/blast	7.5	hole spacing (m)				
OB - Blasting	11,043	108	blasts / year	102	kg/blast	6,000	Area of blast in square metres						
OB - Excavator loading OB to haul truck	62,277	67,850,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Hauling to North Dump	212,931	22,386,667	t/y	0.0095	kg/t	140	t/truck load	6.0	km/return trip	0.2	kg/VKT	90	% Control
OB - Hauling to South Dump	354,885	44,773,333	t/y	0.0079	kg/t	140	t/truck load	5.0	km/return trip	0.2	kg/VKT	90	% Control
OB - Hauling to Mobile Crusher	8,751	690,000	t/y	0.0127	kg/t	140	t/truck load	8.0	km/return trip	0.2	kg/VKT	90	% Control
OB - Emplacing at Northern Dump	20,548	22,386,667	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Emplacing at Southern Dump	41,095	44,773,333	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Dozers on OB in Pit	112,512	8,986	h/y	12.5	kg/h	10	silt content in %	2.5	moisture content in %				
OB - Dozers on OB working on northern dump and rehabilitation	98,989	7,906	h/y	12.5	kg/h	10	silt content in %	2.5	moisture content in %				
OB - Dozers on OB working on southern dump and rehabilitation	98,989	7,906	h/y	12.5	kg/h	10	silt content in %	2.5	moisture content in %				
OB - unloading waste rock at mobile plant	633	690,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Loading gravel stockpile	633	690,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
CL - Dozers ripping/pushing/clean-up	242,694	7,906	h/y	30.699	kg/h	10	silt content in %	8	moisture content in %				
CL - Loading ROM coal to trucks with excavator	143,496	3,000,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Hauling open pit coal to mobile plant	6,658	450,000	t/y	0.015	kg/t	120	t/truck load	8	km/return trip	0.2	kg/VKT	90	% Control
CL - Hauling from Southern end of open pit coal to Boggabri ROM Pad / hopper	29,591	2,000,000	t/y	0.015	kg/t	120	t/truck load	8	km/return trip	0.2	kg/VKT	90	% Control
CL - Hauling from Northern end of open pit coal to Boggabri ROM Pad / hopper	25,892	1,000,000	t/y	0.026	kg/t	120	t/truck load	14	km/return trip	0.2	kg/VKT	90	% Control
CL - unloading ROM coal at mobile plant	21,524	450,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Screening domestic coal	5,625	450,000	t/y	0.0125	kg/t								
CL - Crushing domestic coal	4,500	450,000	t/y	0.010	kg/t								
CL - Screening gravel	5,244	690,000	t/y	0.0076	kg/t								
CL - Crushing gravel	828	690,000	t/y	0.0012	kg/t								
CL - Loading domestic coal stockpile	21,524	450,000	t/y	0.048	kg/t	8	moisture content in %						
CL - unloading ROM coal at Boggabri ROM pad	143,496	3,000,000	t/y	0.0478	kg/t	8	moisture content in %						
CL - Loading coal to hopper with FEL at Boggabri	143,496	3,000,000	t/y	0.0478	kg/t	8	moisture content in %						
CL - Screening at Boggabri	37,500	3,000,000	t/y	0.0125	kg/t								
CL - Crushing at Boggabri	30,000	3,000,000	t/y	0.010	kg/t								
CL - Loading Product coal stockpile	143,496	3,000,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Dozers on product stockpiles	242,694	7,906	h/y	30.699	kg/h	10	silt content in %	8.0	moisture content in %				
CL - Rail Load Out at Boggabri	540	3,000,000	t/y	0.0002	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	8.0	moisture content in %				
WE - Overburden northern emplacement areas	181,488	114	ha	1,592	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)		
WE - Overburden southernemplacement areas	35,024	22	ha	1,592	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)		
WE - Open pit	175,120	110	ha	1,592	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)		
WE - Partially rehabilitated northern area	1,703	107	ha	16	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	99	% control
WE - Partially rehabilitated southern area	955	60	ha	16	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	99	% control
WE - Coal and gravel stockpiles mobile plant	398	0.5	ha	796	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
WE - Coal stockpiles Boggabri ROM Pad	143	1	ha	143.28	kg/ha/year	1.8	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
WE - Product Coal stockpiles Boggabri	143	1	ha	143.28	kg/ha/year	1.8	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
Grading roads	61,940	118,260	km	0.52	kg/km	7.5	speed of graders in km/h	15768	grader hours				

Table A.1: Year 2 – source allocation

Activity	Source ID		
Scrapers - 4 scrapers removing vegetation	20-22		
OB - Drilling	23-26		
OB - Blasting	23-27		
OB - Excavator loading OB to haul truck	23-28		
OB - Hauling to North Dump	1-5		
OB - Hauling to South Dump	9-11		
OB - Hauling to Mobile Crusher	9-10	12-15	
OB - Emplacing at Northern Dump	27-29		
OB - Emplacing at Southern Dump	11	30	
OB - Dozers on OB in Pit	23-26		
OB - Dozers on OB working on northern dump and rehabilitation	27-29		
OB - Dozers on OB working on southern dump and rehabilitation	11	30	
OB - unloading waste rock at mobile plant	19		
OB - Loading gravel stockpile	19		
CL - Dozers ripping/pushing/clean-up	23-26		
CL - Loading ROM coal to trucks with excavator	23-27		
CL - Hauling open pit coal to mobile plant	9-10	12-15	
CL - Hauling from Southern end of open pit coal to Boggabri ROM Pad / hopper	9-10	12	16-18
CL - Hauling from Northern end of open pit coal to Boggabri ROM Pad / hopper	4-9	12	16-18
CL - unloading ROM coal at mobile plant	19		
CL - Screening domestic coal	19		
CL - Crushing domestic coal	19		
CL - Screening gravel	19		
CL - Crushing gravel	19		
CL - Loading domestic coal stockpile	19		
CL - unloading ROM coal at Boggabri ROM pad	39		
CL - Loading coal to hopper with FEL at Boggabri	39		
CL - Screening at Boggabri	40-41		
CL - Crushing at Boggabri	40-41		
CL - Loading Product coal stockpile	42		
CL - Dozers on product stockpiles	42		
CL - Rail Load Out at Boggabri	43		
WE - Overburden northern emplacement areas	1-2	27-29	
WE - Overburden southernemplacement areas	11	30	
WE - Open pit	23-26		
WE - Partially rehabilitated northern area	31-35		
WE - Partially rehabilitated southern area	36-38	43	
WE - Coal and gravel stockpiles mobile plant	19		
WE - Coal stockpiles Boggabri ROM Pad	39		
WE - Product Coal stockpiles Boggabri	42		
Grading roads	1-18	20-38	

Estimated emissions of TSP for the Project – Year 4

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units
Scrapers - 4 scrapers removing vegetation	43,200	43,200	VKT	1.6	kg/vkt								
OB - Drilling	4,194	7,108	holes/y	0.59	kg/hole	66	holes/blast	7.5	hole spacing (m)				
OB - Blasting	11,043	108	blasts / year	102	kg/blast	6,000	Area of blast in square metres						
OB - Excavator loading OB to haul truck	59,110	64,400,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Hauling to North Dump	605,978	63,710,000	t/y	0.0095	kg/t	140	t/truck load	6.0	km/return trip	0.2	kg/VKT	90	% Control
OB - Hauling to Mobile Crusher	9,232	690,000	t/y	0.0134	kg/t	140	t/truck load	8.4	km/return trip	0.2	kg/VKT	90	% Control
OB - Emplacing at Northern Dump	58,477	63,710,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Dozers on OB in Pit	112,512	8,986	h/y	12.5	kg/h	10	silt content in %	2.5	moisture content in %				
OB - Dozers on OB working on northern dump and rehabilitation	197,978	15,811	h/y	12.5	kg/h	10	silt content in %	2.5	moisture content in %				
OB - unloading waste rock at mobile plant	633	690,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Loading gravel stockpile	633	690,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
CL - Dozers ripping/pushing/clean-up	242,694	7,906	h/y	30.699	kg/h	10	silt content in %	8	moisture content in %				
CL - Loading ROM coal to trucks with excavator	143,496	3,000,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Hauling open pit coal to mobile plant	6,658	450,000	t/y	0.015	kg/t	120	t/truck load	8	km/return trip	0.2	kg/VKT	90	% Control
CL - Hauling from Southern end of open pit coal to Boggabri ROM Pad / hopper	29,591	2,000,000	t/y	0.015	kg/t	120	t/truck load	8	km/return trip	0.2	kg/VKT	90	% Control
CL - Hauling from Northern end of open pit coal to Boggabri ROM Pad / hopper	27,668	1,000,000	t/y	0.028	kg/t	120	t/truck load	14.96	km/return trip	0.2	kg/VKT	90	% Control
CL - unloading ROM coal at mobile plant	21,524	450,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Screening domestic coal	5,625	450,000	t/y	0.0125	kg/t								
CL - Crushing domestic coal	4,500	450,000	t/y	0.010	kg/t								
CL - Screening gravel	5,244	690,000	t/y	0.0076	kg/t								
CL - Crushing gravel	828	690,000	t/y	0.0012	kg/t								
CL - Loading domestic coal stockpile	21,524	450,000	t/y	0.048	kg/t	8	moisture content in %						
CL - unloading ROM coal at Boggabri ROM pad	143,496	3,000,000	t/y	0.0478	kg/t	8	moisture content in %						
CL - Loading coal to hopper with FEL at Boggabri	143,496	3,000,000	t/y	0.0478	kg/t	8	moisture content in %						
CL - Screening at Boggabri	37,500	3,000,000	t/y	0.0125	kg/t								
CL - Crushing at Boggabri	30,000	3,000,000	t/y	0.010	kg/t								
CL - Loading Product coal stockpile	143,496	3,000,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Dozers on product stockpiles	242,694	7,906	h/y	30.699	kg/h	10	silt content in %	8.0	moisture content in %				
CL - Rail Load Out at Boggabri	540	3,000,000	t/y	0.0002	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	8.0	moisture content in %				
WE - Overburden emplacement areas	294,520	185	ha	1,592	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)		
WE - Open pit	143,280	90	ha	1,592	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)		
WE - Partially rehabilitated northern area	1,512	95	ha	16	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	99	% control
WE - Coal and gravel stockpiles mobile plant	398	0.5	ha	796	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
WE - Coal stockpiles Boggabri ROM Pad	143	1.0	ha	143.28	kg/ha/year	1.8	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
WE - Product Coal stockpiles Boggabri	143	1.0	ha	143.28	kg/ha/year	1.8	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
Grading roads	61,940	118,260	km	0.52	kg/km	7.5	speed of graders in km/h	15768	grader hours				

Table A.2: Year 4 – source allocation

Activity	Source ID			
Scrapers - 4 scrapers removing vegetation	20-21			
OB - Drilling	22-26			
OB - Blasting	22-27			
OB - Excavator loading OB to haul truck	22-28			
OB - Hauling to North Dump	1-4	8-12		
OB - Hauling to Mobile Crusher	8-11	13-15	19	
OB - Emplacing at Northern Dump	1	12	27-32	
OB - Dozers on OB in Pit	22-26			
OB - Dozers on OB working on northern dump and rehabilitation	1	12	27-32	
OB - unloading waste rock at mobile plant	19			
OB - Loading gravel stockpile	19			
CL - Dozers ripping/pushing/clean-up	22-26			
CL - Loading ROM coal to trucks with excavator	22-26			
CL - Hauling open pit coal to mobile plant	8-11	13-15	19	
CL - Hauling from Southern end of open pit coal to Boggabri ROM Pad / hopper	8-11	13	16-18	
CL - Hauling from Northern end of open pit coal to Boggabri ROM Pad / hopper	3-8	10-11	13	16-18
CL - unloading ROM coal at mobile plant	19			
CL - Screening domestic coal	19			
CL - Crushing domestic coal	19			
CL - Screening gravel	19			
CL - Crushing gravel	19			
CL - Loading domestic coal stockpile	19			
CL - unloading ROM coal at Boggabri ROM pad	37			
CL - Loading coal to hopper with FEL at Boggabri	37			
CL - Screening at Boggabri	38-39			
CL - Crushing at Boggabri	38-39			
CL - Loading Product coal stockpile	40			
CL - Dozers on product stockpiles	40			
CL - Rail Load Out at Boggabri	41			
WE - Overburden emplacement areas	1	12	27-32	
WE - Open pit	22-26			
WE - Partially rehabilitated northern area	33-36			
WE - Coal and gravel stockpiles mobile plant	19			
WE - Coal stockpiles Boggabri ROM Pad	37			
WE - Product Coal stockpiles Boggabri	40			
Grading roads	1-18	20-36		

Estimated emissions of TSP for the Project – Year 6

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units
Scrapers - 4 scrapers removing vegetation	43,200	43,200	VKT	1.6	kg/vkt								
OB - Drilling	4,194	7,108	holes/y	0.59	kg/hole	66	holes/blast	7.5	hole spacing (m)				
OB - Blasting	11,043	108	blasts / year	102	kg/blast	6,000	Area of blast in square metres						
OB - Excavator loading OB to haul truck	69,665	75,900,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Hauling to North Dump	715,361	75,210,000	t/y	0.0095	kg/t	140	t/truck load	6.0	km/return trip	0.2	kg/VKT	90	% Control
OB - Hauling to Mobile Crusher	8,751	690,000	t/y	0.0127	kg/t	140	t/truck load	8.0	km/return trip	0.2	kg/VKT	90	% Control
OB - Emplacing at Northern Dump	69,032	75,210,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Dozers on OB in Pit	112,512	8,986	h/y	12.5	kg/h	10	silt content in %	2.5	moisture content in %				
OB - Dozers on OB working on northern dump and rehabilitation	197,978	15,811	h/y	12.5	kg/h	10	silt content in %	2.5	moisture content in %				
OB - unloading waste rock at mobile plant	633	690,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Loading gravel stockpile	633	690,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
CL - Dozers ripping/pushing/clean-up	242,694	7,906	h/y	30.699	kg/h	10	silt content in %	8	moisture content in %				
CL - Loading ROM coal to trucks with excavator	143,496	3,000,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Hauling open pit coal to mobile plant	6,658	450,000	t/y	0.015	kg/t	120	t/truck load	8	km/return trip	0.2	kg/VKT	90	% Control
CL - Hauling from Southern end of open pit coal to Boggabri ROM Pad / hopper	33,290	2,000,000	t/y	0.017	kg/t	120	t/truck load	9	km/return trip	0.2	kg/VKT	90	% Control
CL - Hauling from Northern end of open pit coal to Boggabri ROM Pad / hopper	27,742	1,000,000	t/y	0.028	kg/t	120	t/truck load	15	km/return trip	0.2	kg/VKT	90	% Control
CL - unloading ROM coal at mobile plant	21,524	450,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Screening domestic coal	5,625	450,000	t/y	0.0125	kg/t								
CL - Crushing domestic coal	4,500	450,000	t/y	0.010	kg/t								
CL - Screening gravel	5,244	690,000	t/y	0.0076	kg/t								
CL - Crushing gravel	828	690,000	t/y	0.0012	kg/t								
CL - Loading domestic coal stockpile	21,524	450,000	t/y	0.048	kg/t	8	moisture content in %						
CL - unloading ROM coal at Boggabri ROM pad	143,496	3,000,000	t/y	0.0478	kg/t	8	moisture content in %						
CL - Loading coal to hopper with FEL at Boggabri	143,496	3,000,000	t/y	0.0478	kg/t	8	moisture content in %						
CL - Screening at Boggabri	37,500	3,000,000	t/y	0.0125	kg/t								
CL - Crushing at Boggabri	30,000	3,000,000	t/y	0.010	kg/t								
CL - Loading Product coal stockpile	143,496	3,000,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Dozers on product stockpiles	242,694	7,906	h/y	30.699	kg/h	10	silt content in %	8.0	moisture content in %				
CL - Rail Load Out at Boggabri	540	3,000,000	t/y	0.0002	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	8.0	moisture content in %				
WE - Overburden emplacement areas	149,648	94	ha	1,592	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)		
WE - Open pit	159,200	100	ha	1,592	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)		
WE - Partially rehabilitated northern area	2,261	142	ha	16	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	99	% control
WE - Coal and gravel stockpiles mobile plant	398	0.5	ha	796	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
WE - Coal stockpiles Boggabri ROM Pad	143	1.0	ha	143.28	kg/ha/year	1.8	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
WE - Product Coal stockpiles Boggabri	143	1.0	ha	143.28	kg/ha/year	1.8	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
Grading roads	61,940	118,260	km	0.52	kg/km	7.5	speed of graders in km/h	15768	grader hours				

Table A.3: Year 6 – source allocation

Activity	Source ID			
Scrapers - 4 scrapers removing vegetation	20-21			
OB - Drilling	22-25			
OB - Blasting	22-25			
OB - Excavator loading OB to haul truck	22-25			
OB - Hauling to North Dump	1-4	9-12		
OB - Hauling to Mobile Crusher	9-11	13-15	19	
OB - Emplacing at Northern Dump	1	12	26-30	
OB - Dozers on OB in Pit	22-25			
OB - Dozers on OB working on northern dump and rehabilitation	1	12	26-30	
OB - unloading waste rock at mobile plant	19			
OB - Loading gravel stockpile	19			
CL - Dozers ripping/pushing/clean-up	22-25			
CL - Loading ROM coal to trucks with excavator	22-25			
CL - Hauling open pit coal to mobile plant	9-11	13-15	19	
CL - Hauling from Southern end of open pit coal to Boggabri ROM Pad / hopper	9-11	13	16-18	
CL - Hauling from Northern end of open pit coal to Boggabri ROM Pad / hopper	3-9	11	13	16-18
CL - unloading ROM coal at mobile plant	19			
CL - Screening domestic coal	19			
CL - Crushing domestic coal	19			
CL - Screening gravel	19			
CL - Crushing gravel	19			
CL - Loading domestic coal stockpile	19			
CL - unloading ROM coal at Boggabri ROM pad	35			
CL - Loading coal to hopper with FEL at Boggabri	35			
CL - Screening at Boggabri	36-37			
CL - Crushing at Boggabri	36-37			
CL - Loading Product coal stockpile	38			
CL - Dozers on product stockpiles	38			
CL - Rail Load Out at Boggabri	39			
WE - Overburden emplacement areas	1	12	26-30	
WE - Open pit	22-25			
WE - Partially rehabilitated northern area	31-34			
WE - Coal and gravel stockpiles mobile plant	19			
WE - Coal stockpiles Boggabri ROM Pad	35			
WE - Product Coal stockpiles Boggabri	38			
Grading roads	1-18	20-34		

Estimated emissions of TSP for the Project – Year 16

ACTIVITY	TSP emission (kg/y)	Intensity	Units	Emission Factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Varia ble 4	Units
Scrapers - 4 scrapers removing vegetation	43,200	43,200	VKT	1.6	kg/vkt								
OB - Drilling	4,194	7,108	holes/y	0.59	kg/hole	66	holes/blast	7.5	hole spacing (m)				
OB - Blasting	11,043	108	blasts / year	102	kg/blast	6,000	Area of blast in square metres						
OB - Excavator loading OB to haul truck	65,443	71,300,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Hauling to North Dump	615,640	70,610,000	t/y	0.0087	kg/t	140	t/truck load	5.5	km/return trip	0.2	kg/VKT	90	% Control
OB - Hauling to Mobile Crusher	8,751	690,000	t/y	0.0127	kg/t	140	t/truck load	8.0	km/return trip	0.2	kg/VKT	90	% Control
OB - Emplacing at Northern Dump	64,810	70,610,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Dozers on OB in Pit	112,512	8,986	h/y	12.5	kg/h	10	silt content in %	2.5	moisture content in %				
OB - Dozers on OB working on northern dump and rehabilitation	197,978	15,811	h/y	12.5	kg/h	10	silt content in %	2.5	moisture content in %				
OB - unloading waste rock at mobile plant	633	690,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
OB - Loading gravel stockpile	633	690,000	t/y	0.001	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	2.5	moisture content in %				
CL - Dozers ripping/pushing/clean-up	242,694	7,906	h/y	30.699	kg/h	10	silt content in %	8	moisture content in %				
CL - Loading ROM coal to trucks with excavator	143,496	3,000,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Hauling open pit coal to mobile plant	6,658	450,000	t/y	0.015	kg/t	120	t/truck load	8	km/return trip	0.2	kg/VKT	90	% Control
CL - Hauling from open pit coal to Boggabri ROM Pad / hopper	66,581	3,000,000	t/y	0.022	kg/t	120	t/truck load	12	km/return trip	0.2	kg/VKT	90	% Control
CL - unloading ROM coal at mobile plant	21,524	450,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Screening domestic coal	5,625	450,000	t/y	0.0125	kg/t								
CL - Crushing domestic coal	4,500	450,000	t/y	0.010	kg/t								
CL - Screening gravel	5,244	690,000	t/y	0.0076	kg/t								
CL - Crushing gravel	828	690,000	t/y	0.0012	kg/t								
CL - Loading domestic coal stockpile	21,524	450,000	t/y	0.048	kg/t	8	moisture content in %						
CL - unloading ROM coal at Boggabri ROM pad	143,496	3,000,000	t/y	0.0478	kg/t	8	moisture content in %						
CL - Loading coal to hopper with FEL at Boggabri	143,496	3,000,000	t/y	0.0478	kg/t	8	moisture content in %						
CL - Screening at Boggabri	37,500	3,000,000	t/y	0.0125	kg/t								
CL - Crushing at Boggabri	30,000	3,000,000	t/y	0.010	kg/t								
CL - Loading Product coal stockpile	143,496	3,000,000	t/y	0.048	kg/t	8	moisture content in %						
CL - Dozers on product stockpiles	242,694	7,906	h/y	30.699	kg/h	10	silt content in %	8.0	moisture content in %				
CL - Rail Load Out at Boggabri	540	3,000,000	t/y	0.0002	kg/t	1.06	average of (wind speed/2.2)^1.3 in m/s	8.0	moisture content in %				
WE - Overburden emplacement areas	175,120	110	ha	1,592	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)		
WE - Open pit	95,520	60	ha	1,592	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)		
WE - Partially rehabilitated northern area	1,719	108	ha	16	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	99	% control
WE - Coal and gravel stockpiles mobile plant	398	0.5	ha	796	kg/ha/year	10.0	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
WE - Coal stockpiles Boggabri ROM Pad	143	1.0	ha	143.28	kg/ha/year	1.8	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
WE - Product Coal stockpiles Boggabri	143	1.0	ha	143.28	kg/ha/year	1.8	silt content in %	76	days >0.25mm rainfall (p)	4.2	% time ws>5.4 m/s (f)	50	% control
Grading roads	61,940	118,260	km	0.52	kg/km	7.5	speed of graders in km/h	15768	grader hours				

Table A.4: Year 16 – source allocation

Activity	Source ID			
Scrapers - 4 scrapers removing vegetation	18-20			
OB - Drilling	21-23			
OB - Blasting	21-23			
OB - Excavator loading OB to haul truck	21-23			
OB - Hauling to North Dump	1-8			
OB - Hauling to Mobile Crusher	1-4	8-10		
OB - Emplacing at Northern Dump	5-7	24-27		
OB - Dozers on OB in Pit	21-23			
OB - Dozers on OB working on northern dump and rehabilitation	5-7	24-27		
OB - unloading waste rock at mobile plant	17			
OB - Loading gravel stockpile	17			
CL - Dozers ripping/pushing/clean-up	21-23			
CL - Loading ROM coal to trucks with excavator	21-23			
CL - Hauling open pit coal to mobile plant	1-4	8-10		
CL - Hauling from open pit coal to Boggabri ROM Pad / hopper	1-4	8	11-16	
CL - unloading ROM coal at mobile plant	17			
CL - Screening domestic coal	17			
CL - Crushing domestic coal	17			
CL - Screening gravel	17			
CL - Crushing gravel	17			
CL - Loading domestic coal stockpile	17			
CL - unloading ROM coal at Boggabri ROM pad	31			
CL - Loading coal to hopper with FEL at Boggabri	31			
CL - Screening at Boggabri	32-33			
CL - Crushing at Boggabri	32-33			
CL - Loading Product coal stockpile	34			
CL - Dozers on product stockpiles	34			
CL - Rail Load Out at Boggabri	35			
WE - Overburden emplacement areas	5-7	24-27		
WE - Open pit	21-23			
WE - Partially rehabilitated northern area	28-30			
WE - Coal and gravel stockpiles mobile plant	17			
WE - Coal stockpiles Boggabri ROM Pad	31			
WE - Product Coal stockpiles Boggabri	34			
Grading roads	1-16	18-30		