APPENDIX D

Air Quality and Greenhouse Gas Assessment – Addendum

Pacific Environment Limited

Consulting • Technologies • Monitoring • Toxicology

Report

Wallarah 2 Coal Project Air Quality and Greenhouse Gas Assessment - Addendum

Wyong Areas Coal Joint Venture

Job ID. 20803

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EXECUTIVE SUMMARY

OVERVIEW

The Wyong Areas Coal Joint Venture (WACJV) is seeking development consent under Division 4.1 of Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act), for the Wallarah 2 Coal Project (the Project). The Project has been subject to the assessment process under Division 4.1 of Part 4 of the EP&A Act, including a review by the Planning Assessment Commission (PAC). In June 2014, the PAC concluded that 'if the recommendations concerning improved strategies to avoid, mitigate or manage the predicted impacts of the project are adopted, then there is merit in allowing the project to proceed'.

Following the review by the PAC, the Tooheys Road Site was re-designed to avoid land use conflicts with third parties. The changes to the design of the Tooheys Road Site (the Amendment) include:

- Removal of the previously proposed rail loop;
- Re-location of the rail spur and train load out facility to the eastern side of the Main Northern Rail Line; and
- A conveyor system to deliver product coal from the stockpile to the new train load out facility.

Whilst all other aspects of the Project are unchanged from the original proposal, this updated assessment assesses emissions from all proposed operations (see **Section 6.2**).

To give effect to the proposed changes to the Project, WACJV is seeking an amendment to the Development Application (DA) under clause 55 of the Environmental Planning and Assessment Regulation 2000. This report forms part of the Amendment Document being prepared by Hansen Bailey to support the application to amend the DA.

This report assesses the air quality and greenhouse gas emissions due to the all operations that form part of the Project, and where necessary, recommends additional management and mitigation measures to ameliorate these impacts.

MODIFIED EMISSIONS AND MODELLING

Fugitive dust emissions are expected during construction, and from coal handling and stockpiling at the Tooheys Road site during operations. This air quality and greenhouse gas assessment (AQGHGA) presents an update of the previous AQGHGA (**PAEHolmes, 2012**) Consistent with the previous AQGHGA, emissions at the Buttonderry Site will occur from the ventilation shaft, and will include particulate matter and potentially odour. The key pollutant assessed from the flaring of methane in the previous assessment is oxides of nitrogen (NO_x). As there has been no change to the ventilation shaft, proposed flaring or use of on-site power generators, odour and NO_x have not been reassessed.

Discrete receptor locations have been modelled using the same locations as the previous assessment, with the addition of 10 further receptors in the proximity of the re-located rail spur. Meteorological data used in the modelling has also been kept consistent with the previous assessment.

An Environmental Monitoring Program for the Project commenced in 1996 providing monthly averages of dust fallout and 24-hour average TSP and PM_{10} concentrations. The monitoring data have been updated and consistent with the previous assessment, the monitoring data collected for the Project has been used as background concentrations for TSP, PM_{10} and dust deposition in the region in order to perform a cumulative assessment. Annual average concentrations of dust deposition, TSP and PM_{10} - remain generally below the relevant air quality goals.

Dispersion modelling has been used to predict ground level concentrations (glcs) of key pollutants associated with the Project. Revised dust emissions during operations have been estimated by analysing the activities taking place for the Project, including those associated with the proposed new coal transport and load-out activities. Maximum annual predicted TSP, PM_{10}, $PM_{2.5}$ and dust deposition concentrations are presented for a maximum production scenario of 5 Mtpa product coal, consistent with the previous assessment.

The previous assessment determined the maximum 24-hour concentrations based on the modelling of a maximum daily production scenario. For the purposes of this assessment, the maximum 24-hour average concentrations have been estimated by calculating the ratio of the maximum 24-hour average concentrations from the modelling of the maximum annual production scenario and the maximum daily production scenarios and applying this to the results from this assessment from the maximum annual production scenario. These ratios have been applied at all receptor sites for PM_{10} and $PM_{2.5}$ under the current assessment.

The results of the dispersion modelling indicate that the predicted incremental glcs for PM_{10}, $PM_{2.5}$, TSP and dust deposition at the closest residential receptors are all below the impact assessment criteria. The highest predicted glcs occur at the closest residence to the north of the site (assessment location P11).

The estimated emissions for construction are 84%, 48% and 22% of the emissions estimated to occur during operation of the Project for TSP, PM_{10} and $PM_{2.5}$ respectively. Therefore compliance with air quality goals during the operation of the mine would represent compliance during construction.

A cumulative assessment, incorporating existing background levels, indicates that the Project is unlikely to result in any additional exceedances of relevant impact assessment criteria at the neighbouring receivers.

NO_x emissions associated with the flaring of methane and use in power generation were calculated during the previous air quality impact and greenhouse gas assessment (**PAEHolmes, 2012**). NO_x emissions from these sources will not change as a result of the Amendment and have therefore not been reassessed.

GREENHOUSE GAS ASSESSMENT

A re-assessment of the GHG emissions associated with the revised Project indicates that average annual scope 1 emissions would represent approximately 0.04% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions.

The capture and flaring of methane (pre and post mining) will have significant benefits in terms of GHG emission reductions, resulting in savings of approximately 8 Mt CO_2-e or 54% of Scope 1 emissions, over the Project duration.

AIR QUALITY & GREENHOUSE GAS MANAGEMENT AND MONITORING

The proposed dust management measures for the Project are based on recommendations outlined in the EPA's Best Practice Report.

The Project will develop an Energy and Greenhouse Strategy to address interim and long term energy and greenhouse management plans and initiatives, including monitoring, reporting and continuous improvement.

The existing monitoring network will be reviewed and augmented for the operation of the Project and would be outlined in an Air Quality & Greenhouse Gas Management Plan for the Project. It is recommended that post commissioning verification of the ventilation shaft emissions is conducted once operational, to validate the assumptions presented in this report.

CONTENTS

List of Figures

1 INTRODUCTION

The Wyong Areas Coal Joint Venture (WACJV) is seeking development consent under Division 4.1 of Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) for the Wallarah 2 Coal Project (the Project). The key features of the Project include:

- A deep underground longwall mine extracting up to 5 million tonnes per annum (Mtpa) of export quality thermal coal;
- The Tooheys Road Site between the M1 Motorway and the Motorway Link Road, which includes a portal, coal handling facilities and stockpiles, water and gas management facilities, small office buildings, workshop, rail spur, train load out bin and connections to the municipal water and sewerage systems;
- The Buttonderry Site near the intersection of Hue Hue Road and Sparks Road, which includes administration offices, bathhouse, personnel access to the mine, ventilation shafts and water management structures;
- The Western Shaft Site in the Wyong State Forest, which includes a downcast ventilation shaft and water management structures;
- An inclined tunnel (or "drift") from the surface at the Tooheys Road Site to the coal seam beneath the Buttonderry Site;
- Transportation of product coal to the Port of Newcastle by rail; and
- An operational workforce of approximately 300 full time employees.

The Project has been subject to the assessment process under Division 4.1 of Part 4 of the EP&A Act, including a review by the Planning Assessment Commission (PAC). In June 2014, the PAC concluded that 'if the recommendations concerning improved strategies to avoid, mitigate or manage the predicted impacts of the project are adopted, then there is merit in allowing the project to proceed'.

Following the review by the PAC, the Tooheys Road Site was re-designed to avoid land use conflicts with third parties. The changes to the Project include:

- Removal of the previously proposed rail loop;
- Re-location of the previously proposed rail spur to the eastern side of the Main Northern Rail Line;
- Re-location of the train load out facility to the eastern side of the Main Northern Rail Line;
- A conveyor system to deliver product coal from the stockpile to the new train load out facility; and
- Realignment of the sewer connection

These proposed changes are referred to as the 'Amendment'. All other aspects of the Project remain identical to the original proposal.

To give effect to the proposed changes to the Project, WACJV is seeking an amendment to the Development Application (DA) under clause 55 of the *Environmental Planning and Assessment Regulation 2000*. This report forms part of the "*Amendment to Development Application SSD-4974*" (Amendment Document) being prepared by Hansen Bailey to support the application to amend the DA.

This report assesses the air quality impacts of the Amendment and all other activities of the Project as defined above. Where necessary, it recommends additional management and mitigation measures to ameliorate these impacts.

1.1 Revised Layout

The revised proposed layout of the Tooheys Road Site is shown in **Figure 1.1**.

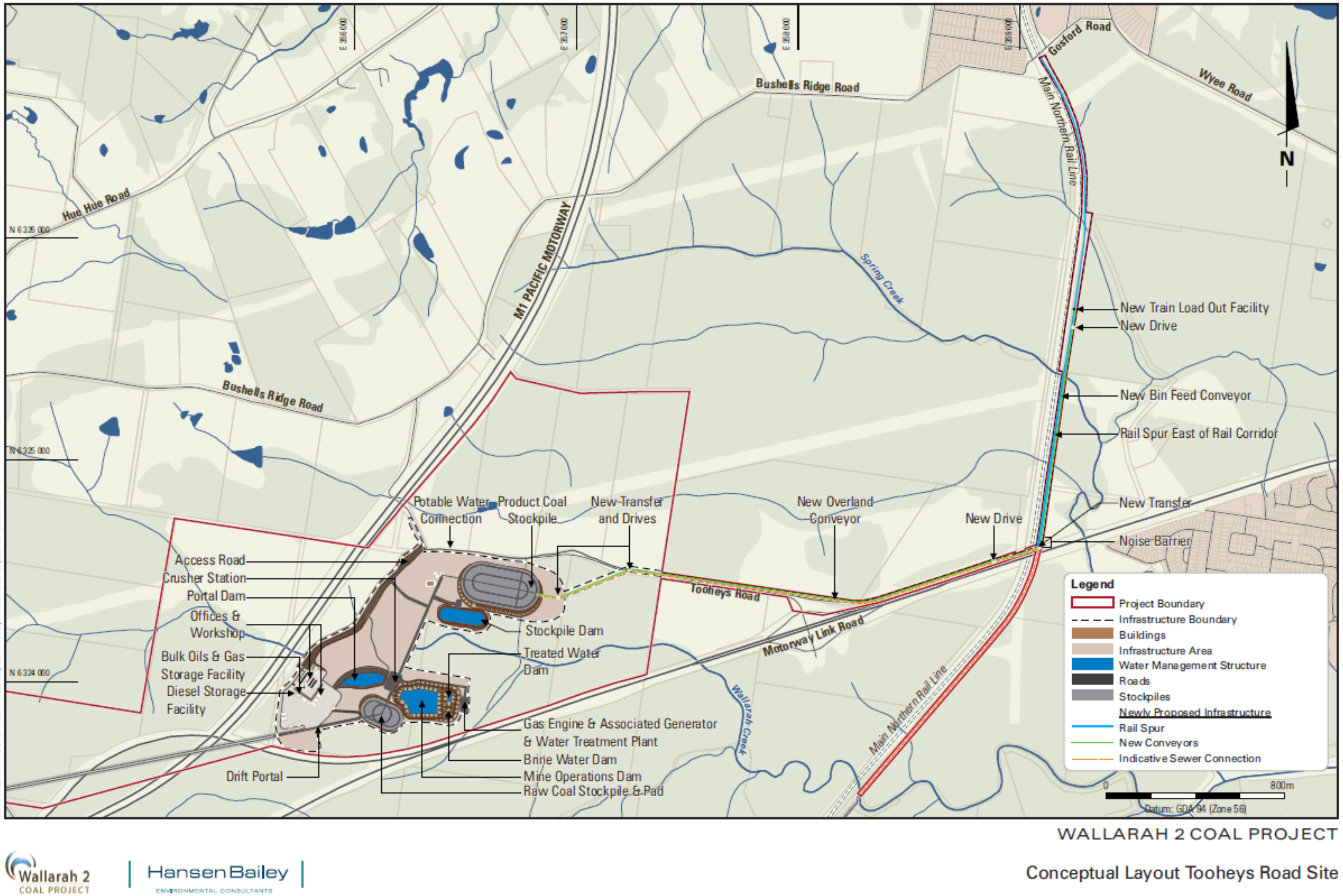


Figure 1.1: Revised Project Layout – Tooheys Road Site

2 LOCAL SETTING

The closest township to the Project is Blue Haven which is located approximately 0.35 km to the east of the closest Project Boundary (see **Figure 2.1**). The F3 Freeway and Main Northern Railway Line run north – south, adjacent to the Project Boundary and forms part of the major road and rail network within the region.

The largest proportion of the Project Boundary is the underground coal extraction area which is mostly located beneath the Wyong State Forest and adjacent forested hills, including beneath part of the Jilliby SCA which was created in 2003. In the east of the Project Area is Jilliby Creek which joins Wyong River further to the south-east. Wyong River which borders the southern part of the underground coal extraction area enters Tuggerah Lake, a large coastal saltwater lagoon on the Central Coast of NSW to the southeast of the Project.

The Project's three surface facilities are the Tooheys Road site, Buttonderry Site, and the Western Ventilation Shaft site. The Tooheys Road site is located on the eastern side of the F3 Freeway and in the vicinity of Wyong's industrial estate. The new train load-out facility is located approximately 1.1 km north of where the Motorway Link Road overpass crosses the Main Northern Rail Line.

The Buttonderry Site is located on the western side of the F3 Freeway and within a rural (non-urban constrained land zone) residential area. The Wyong Waste Management Facility is located to the immediate northeast of the Buttonderry Site.

For the purposes of assessing impacts from the Project, discrete assessment locations are selected and presented in **Table 2.1** and **Figure 2.1**. These are based on the receptors previously assessed, with the addition of a further 10 receptors (P33 to P43). These receptors represent assessment locations in close proximity to the surface facilities for the Project. A list of the assessment locations are presented in **Appendix A**.

Table 2.1: Relevant Receptor Locations

Receptor ID	Easting (m)	Northing (m)	Elevation (m)
P1	357855	6322289	25
P2	357021	6322338	42
P3	356284	6322807	25
P4	354803	6322823	48
P5	353943	6323781	49
P6	355040	6325280	65
P7	355524	6325206	55
P8	355898	6325231	50
P9	356509	6325499	52
P10	357203	6326257	42
P11	356222	6325149	50
P12 (Blue Haven)	359426	6324622	7
P13	351245	6322968	19
P14	351364	6322948	16
P15	351632	6322985	19
P16	351783	6322837	30
P17	351940	6322848	45
P18	351815	6323743	28
P19	351054	6323433	34
P20	351205	6323857	28
P21	351920	6323989	34
P22	351795	6322769	31
P23	351869	6322717	39
P24	352046	6322637	57
P25	352248	6322672	57
P26	352359	6322615	47
P27	352154	6322523	51
P28	352245	6322549	49
P29	352319	6322512	43
P30	352693	6322395	29
P31	352562	6322475	31
P32	352562	6322404	32
P33	352462	6322452	35
P34*	361381	6323610	10
P35*	361587	6323932	21
P36*	359671	6324160	7
P37*	359364	6323755	6
P38*	358556	6328262	24
P39*	358831	6328322	21
P40*	358813	6327963	23
P41*	358926	6326668	41
P42*	359543	6326914	40
P43*	359243	6327014	41

*Receptors not previously assessed

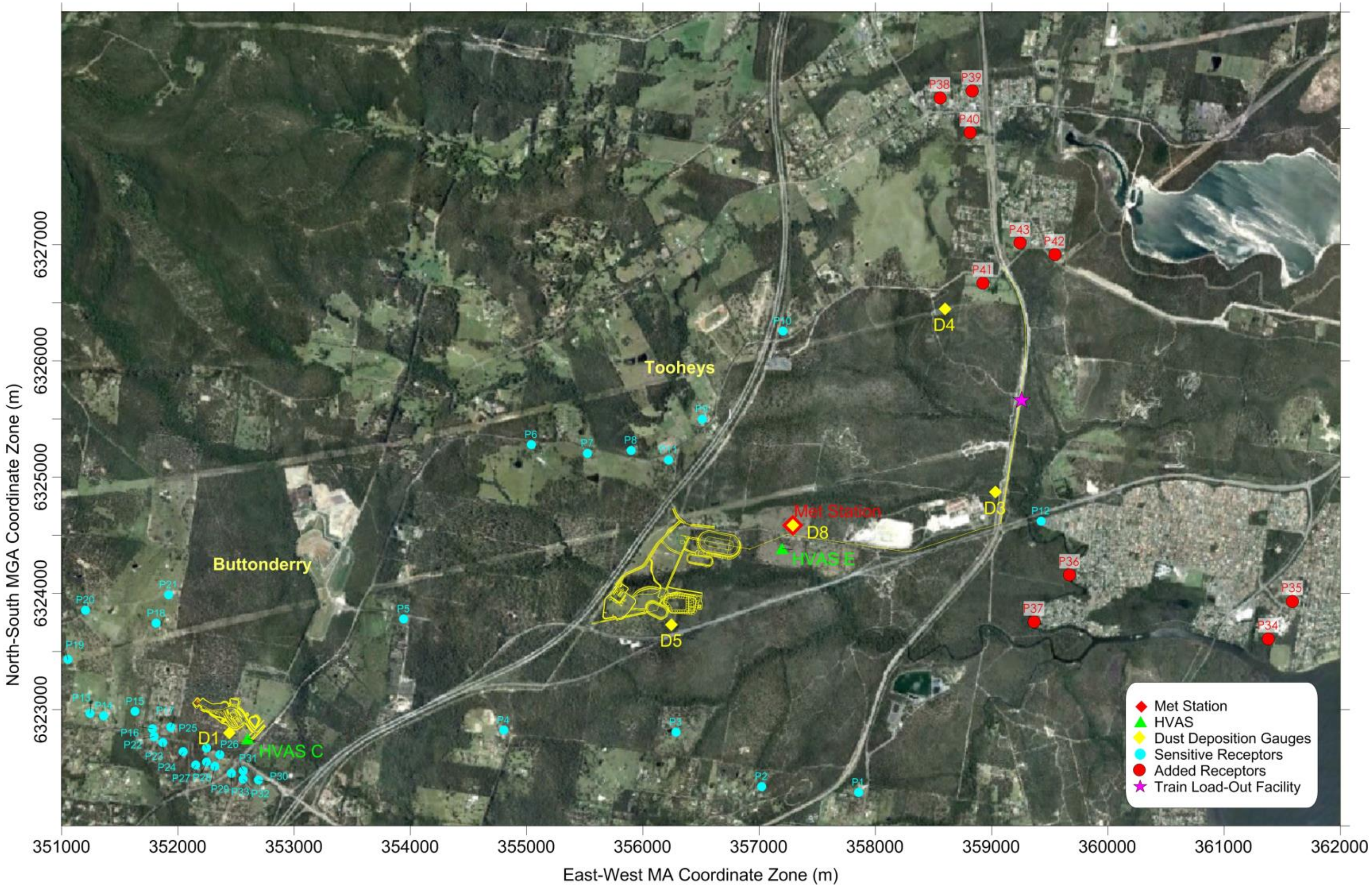


Figure 2.1: Local Setting, Relevant Receptor Locations and Monitoring Sites

Figure 2.2 shows a pseudo three-dimensional (3D) representation of the local topography in the vicinity of the Project. Vertical exaggeration is applied to emphasise terrain features.

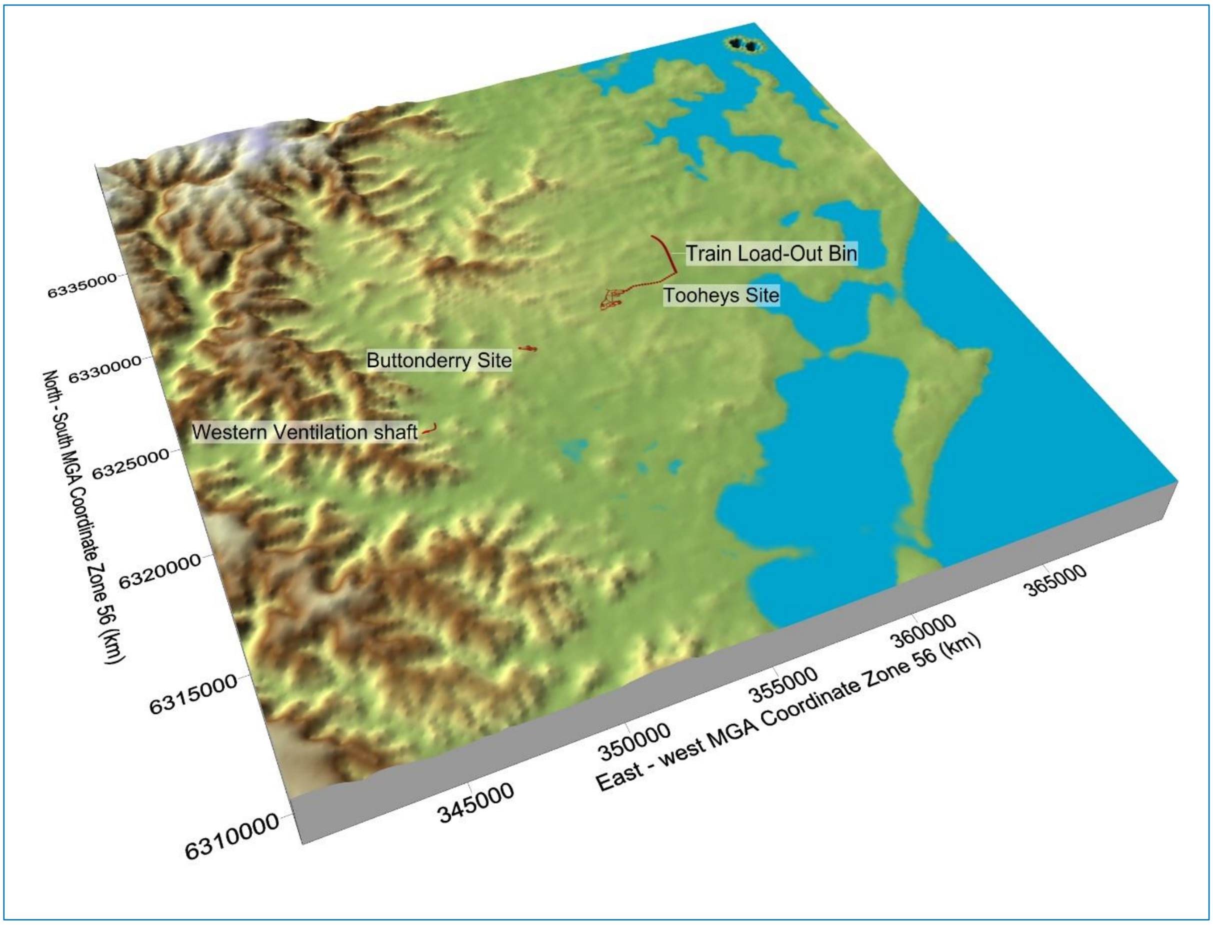


Figure 2.2: Pseudo 3-D representation of regional topography within modelling domain

3 AIR QUALITY CRITERIA

3.1 Emissions to Air

The potential emissions to air from the Project which require reassessment due to the Amendment are summarised as follows:

- Project activities described in **Section 6** have the potential to generate fugitive dust emissions, particularly from conveying and stockpiling at the Tooheys Road Site. Fugitive dust emissions can also be expected as a result of bulk earthworks and material handling during construction of the Tooheys Road, Buttonderry and Western Ventilation Shaft sites.

- Greenhouse gases (GHG) such as fugitive methane (CH_4) and carbon dioxide (CO_2) from the combustion of fuel in combustion engines and indirect emissions from the combustion of coal have been re-assessed in **Section 9**.

Changes to emissions from the Amended Project have been reassessed. These changes include:

- Removal of the previously proposed rail loop;

- Re-location of the rail spur and train load out facility to the eastern side of the Main Northern Rail Line; and

- A conveyor system to deliver product coal from the stockpile to the new train load out facility.

The following activities have not changed and have therefore not been reassessed:

- Emissions from the ventilation shaft at the Buttonderry Site (mine ventilation air (MVA) will be comprised of particulate matter, dilute methane, combustion emissions (from underground mining equipment) and potentially other hydrocarbons, which may be odorous. The ventilation shaft emissions are not expected to change as a result of the Amendment.

- Combustion of diesel in mining equipment will result in emission of coarse and fine fractions of particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2) and organic compounds. The mining fleet associated with an underground mine is relatively small and emissions from diesel-powered equipment during both construction and operation would not result in significant off-site concentrations. It is noted that, as with the previous assessment, emissions of particulate matter from diesel consumption in mining equipment is accounted for in the estimates of fugitive emissions for relevant sources (i.e. dozers).

- The flaring of coal seam methane is a high-temperature oxidation process used to burn waste gases containing methane. Emissions from flaring include unburned hydrocarbons, carbon monoxide (CO) and oxides of nitrogen (NO_x). In combustion, gaseous hydrocarbons react with atmospheric oxygen to form carbon dioxide (CO_2) and water. The quantities of hydrocarbon emissions generated relate to the degree of combustion. Properly operated flares achieve at least 98% combustion efficiency in the flare plume, meaning that hydrocarbon and CO emissions amount to less than 2% of hydrocarbons in the gas stream (**US EPA, 1995**). Similarly, if operated efficiently, the creation of smoke or particles from the flare should be minor. Therefore, the key pollutant from flaring is oxides of nitrogen (NO_x). NO_x emissions from flaring have been modelled in the previous assessment. As there is no change to the flaring of the coal seam gas, NO_x emissions from this source have not been reassessed.

- Options are being considered for the potential beneficial re-use of methane in on-site power generation. Emissions from the gas engines used in on-site power generation would include particulate matter, NO_x, CO and SO_2. The emission rates for CO and SO_2 are are lower than emissions for NO_x, however, the impact assessment criteria for CO and SO_2 are higher than NO_x (NO_2). Therefore, compliance with the NO_2 criteria, demonstrates compliance with these other criteria. NO_x emissions from on-site power generation have been modelled in the previous assessment. As there is no change to the number of gas engines to be used, NOx emissions from this source have not been reassessed.

The following sections provide information on the air quality criteria used to re-assess the impact of dust emitted from the Project site.

3.2 Particulate Matter and Health Effects

A discussion of Particulate Matter health effects has been provided in **Section 4.2** of the previous AQGHGA (**PAEHolmes, 2012**).

3.3 Oxides of Nitrogen

NO_x emissions have been discussed and assessed in the previous AQGHGA (**PAEHolmes, 2012**). There will be no change to the sources of NO_x at the Project associated with the Amendment. Therefore NO_x has not been reassessed.

3.4 NSW EPA Impact Assessment Criteria/NEPM Standards

The air quality assessment criteria relevant for assessing impacts from air pollution have been discussed in Section 4.4 of the previous AQGHGA (**PAEHolmes, 2012**). These criteria are health-based (i.e. they are set at levels to protect against health effects) and for PM_{10} are consistent with the now superseded National Environment Protection Measure for Ambient Air Quality (referred to as the Ambient Air-NEPM) (**NEPC, 1998a**). However, the Approved Methods include other measures of air quality, namely dust deposition and TSP which are not stated in the Ambient Air-NEPM.

In January 2016, the NEPC released an amended Ambient Air-NEPM (**NEPC, 2016**) to take into account the latest scientific evidence about the health impacts of particles. The amendment changed the 'advisory reporting standards' status for annual average and 24-hour average $PM_{2.5}$ (particulate matter with an equivalent aerodynamic diameter of 2.5 µm or less) to 'standards', but in absence of any other relevant standard/goal, the 2016 NEPM for $PM_{2.5}$ standards have been used in this report for comparison against dispersion modelling results.

Table 3.1 presents the air quality goals for pollutants that are relevant to this study. It is important to note that the criteria are applied to the cumulative impacts due to the Project and other sources.

Table 3.1: NSW EPA Air Quality Standards/Goals for Particulate Matter Concentrations

Pollutant	Standard	Averaging Period	Source
TSP	90 µg/m³	Annual	NSW DEC (2005) (assessment criteria)
PM_{10}	50 µg/m³	24-Hour	NSW DEC (2005) (assessment criteria)
	30 µg/m³	Annual	NSW DEC (2005) (assessment criteria)
$PM_{2.5}$	25 µg/m³	24-Hour	NEPC (2016)
	8 µg/m³	Annual	NEPC (2016)
Nitrogen Dioxide	246 µg/m³	1-Hour	NSW DEC (2005) (assessment criteria)
	62 µg/m³	Annual	NSW DEC (2005) (assessment criteria)

Notes: µg/m³ – micrograms per cubic metre.

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

Table 3.2 shows the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust deposition levels are set to protect against nuisance impacts (**NSW DEC, 2005**).

Table 3.2: EPA Criteria for Dust (Insoluble Solids) Fallout

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

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

3.5 NSW Department of Planning and Environment Voluntary Land Acquisition and Mitigation Policy

In December 2014, the NSW Department of Planning and Environment (DP&E) released a policy relating to voluntary mitigation and land acquisition criteria for air quality and noise (**DP&E, 2014**).

The policy sets out voluntary mitigation and land acquisition rights where it is not possible to comply with the EPA impact assessment criteria even with the implementation of all reasonable and feasible avoidance and/or mitigation measures.

The voluntary mitigation and acquisition criteria are summarised in **Table 3.3** and **Table 3.4**, respectively. The Project has been assessed against these criteria, in addition to the EPA impact assessment criteria discussed in **Section 6**.

Table 3.3: DP&E particulate matter mitigation criteria

Pollutant	Criterion	Averaging Period	Application
TSP	90 $\mu g/m^3$	Annual mean	Cumulative impact
PM_{10}	50 $\mu g/m^3$	24-hour average	Incremental impact[(a)]
	30 $\mu g/m^3$	Annual mean	Cumulative impact
Deposited dust	2 g/m^2/month	Annual mean	Incremental impact[(a)]
	4 g/m^2/month	Annual mean	Cumulative impact

Note:
(a) Zero allowable exceedances of the criterion over the life of the development.

Table 3.4: DP&E particulate matter acquisition criteria

Pollutant	Criterion	Averaging Period	Application[(a)]
TSP	90 $\mu g/m^3$	Annual mean	Cumulative impact
PM_{10}	50 $\mu g/m^3$	24-hour average	Incremental impact[(b)]
	30 $\mu g/m^3$	Annual mean	Cumulative impact
Deposited dust	2 g/m^2/month	Annual mean	Incremental impact[(b)]
	4 g/m^2/month	Annual mean	Cumulative impact

Notes:
(a) Voluntary acquisition rights apply where the Project contributes to exceedances of the acquisition criteria at any residence or workplace on privately-owned land, or, on more than 25% of any privately-owned land, and a dwelling could be built on that land under exiting planning controls.
(b) Up to five allowable exceedances of the criterion over the life of the development.

Cumulative impact includes the impact of the Project and all other sources, whilst incremental impact refers to the impact of the Project considered in isolation.

3.6 Other Legislative Requirements

3.6.1 NSW Action for Air

The NSW State Plan identifies cleaner air and progress on GHG reductions as priorities. In 1998, the NSW Government implemented a 25 year air quality management plan, Action for Air, for Sydney, Wollongong and the Lower Hunter (**DECCW, 2009**). Action for Air is a key strategy for implementing the NSW State Plan's cleaner air goals. 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 aims of Action for Air include:

- 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 pollutants from the Project that are relevant to the Action for Air include PM_{10} and NO_2. 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 Project 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:

- Potential mitigation measures have been reviewed, and a range of measures have been adopted for the Project (see **Section 10**);

- Air quality emissions potentially associated with the Project have been quantified (see **Section 6**); and

- Dispersion modelling has been conducted to predict the impact of these emissions on nearby receivers, and assess the effect of the emissions on ambient concentrations which can then be compared with the Ambient Air-NEPM goals (see **Section 7**).

3.6.2 Protection of the Environment Operations (POEO) Act 1997

Detail on the applicable emission to air concentration limits from scheduled activities under the *Protection of the Environment Operations (Clean Air) Regulations 2010* (POEO (Clean Air) Regulation) (**POEO, 2010**) is provided in Section 4.6.2 of the previous AQGHGA (**PAEHolmes, 2012**).

3.6.3 The Best Practice Report

The NSW EPA commissioned *the NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining* (**Donnelly et al., 2011**) (hereafter referred to as the Best Practice Report).

The Best Practice report provides guidance on controls for reducing emissions and is benchmarked on the international best practice for the following activities:

- Haul roads.
- Wind erosion of exposed materials and stockpiles.
- Bulldozing.
- Blasting.
- Drilling.
- Draglines.
- Loading and dumping overburden.
- Loading and dumping ROM coal.
- Monitoring, proactive and reactive management.

The full set of potential best practice control measures to be adopted by the Project, have been summarised in **Section 6.3**.

4 EXISTING ENVIRONMENT

4.1 Meteorology

4.1.1 Local Climatic Conditions

The Bureau of Meteorology (BoM) collects climatic information in the vicinity of the Project. A range of climatic information collected from the Norah Head Automated Weather Station (Norah Head AWS) which is located approximately 10 km southeast of the Project is presented in **Table 4.1**. Temperature and humidity data consist of monthly averages of 9 am and 3 pm readings. Monthly daily averages of maximum and minimum temperatures are also provided. Rainfall data consist of mean monthly rainfall and the average number of rain days per month.

The annual average maximum and minimum temperatures recorded at the Norah Head AWS are 22.1°C and 15.1°C respectively. On average, January and February are the hottest months, with average maximum temperatures of 25.9°C. July is the coldest month, with average minimum temperature of 9.7°C.

The annual average relative humidity reading collected at 9.00 am from the Norah Head station is 71% and at 3.00 pm the annual average is 65%. The month with the highest relative humidity on average is February with 9.00 am and 3.00 pm averages of 78% and 72% respectively. The month with the lowest relative humidity is August with 9.00 am and 3.00 pm averages of 63% and 56% respectively.

Rainfall data collected at the Norah Head AWS shows that May is the wettest month, with an average rainfall of 148 mm over 13.9 rain days. The average annual rainfall is 1,164.6 mm with an average of 144.6 rain days.

Table 4.1: Climate Averages for the Norah Head AWS for 1964-2016

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
9am Mean Dry-bulb and Wet-bulb Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	22.3	22.4	21.1	19.3	16.2	13.7	12.8	14.5	17.2	19.3	20.0	21.6	18.4
Humidity	76.0	78.0	76.0	71.0	72.0	72.0	69.0	63.0	64.0	65.0	72.0	72.0	71.0
3pm Mean Dry-bulb and Wet-bulb Temperatures (°C) and Relative Humidity (%)													
Dry-bulb	24.0	24.2	23.3	21.2	18.9	16.7	16.1	17.4	19.0	20.3	21.5	23.1	20.5
Humidity	70.0	72.0	69.0	65.0	64.0	63.0	59.0	56.0	60.0	64.0	68.0	68.0	65.0
Daily Maximum Temperature (°C)													
Mean	25.9	25.9	24.9	22.8	20.1	18.0	17.2	18.8	21.0	22.7	23.6	24.8	22.1
Daily Minimum Temperature (° C)													
Mean	19.6	19.9	18.7	15.8	13.1	11.0	9.7	10.5	12.8	14.9	16.8	18.4	15.1
Rainfall (mm)													
Mean	86.8	109.9	106.7	136.7	148.0	143.6	88.5	71.6	64.0	54.7	97.4	68.0	1164.6
Rain days (Number)													
Mean	12.3	12.0	12.9	13.6	13.9	13.7	11.3	9.0	11.4	10.4	12.9	11.2	144.6

Source: BOM (2016) Climate averages for Station: 061366; Commenced: 1989; Latitude: 33.28 °S; Longitude: 151.58 °E

4.1.2 Local Wind Data

Local meteorological data have been collected at the Tooheys Road Site since 2007. The meteorological station was replaced during 2009 and site specific data were not available for 2009. There were also periods from January to March of 2010 and 2013 where the weather station failed and/or data was not available. The weather station has been operational since March 2013 with no further outages.

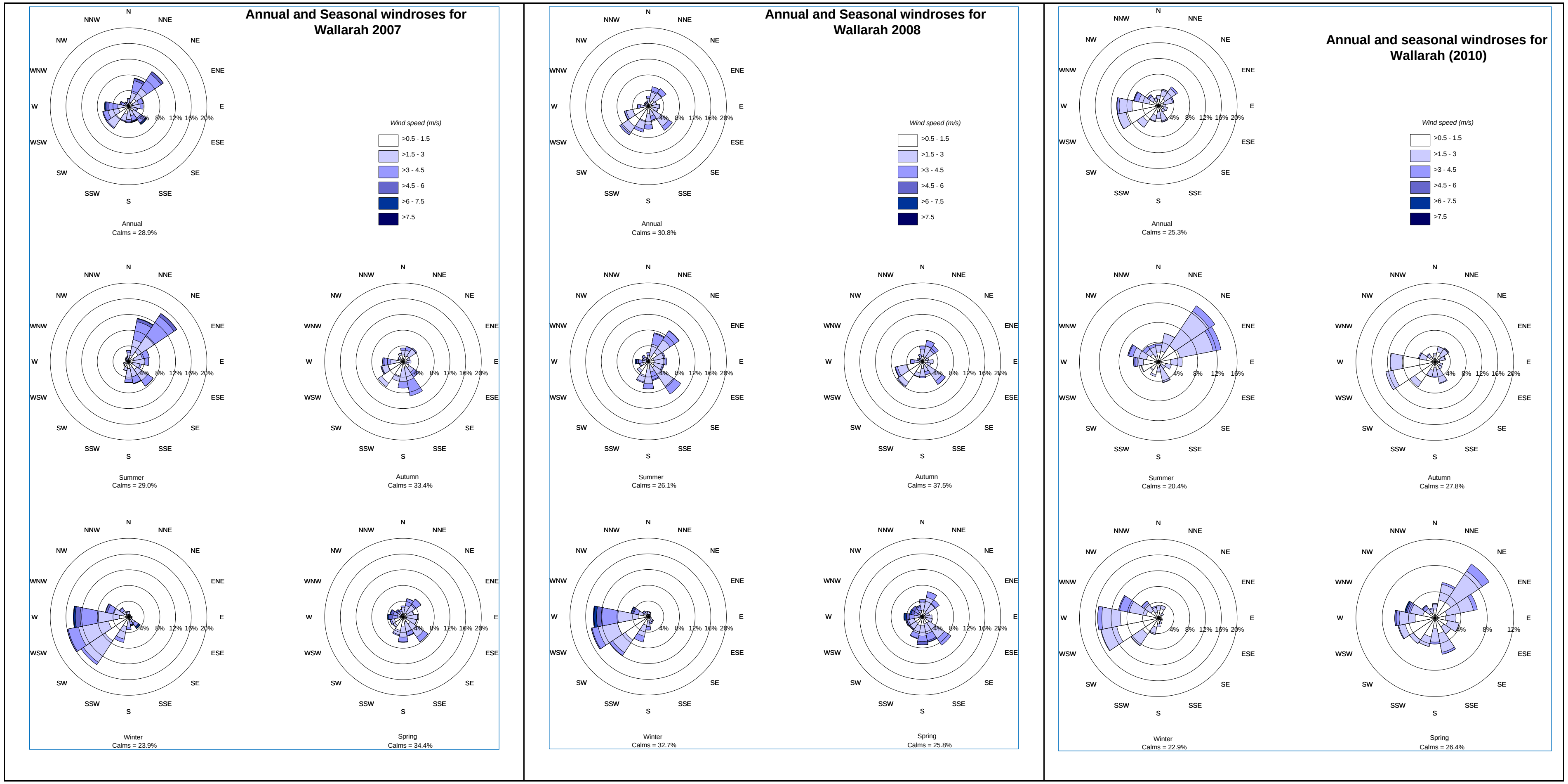
Comparative statistics are shown in **Table 4.2** and wind roses for each available year are presented in **Figure 4.1**. Based on an analysis of data availability during the original assessment (**PAEHolmes, 2012**), a period from July 2010 to June 2011 was chosen for modelling. To remain consistent with the previous assessment, this period has been used for modelling under the current assessment

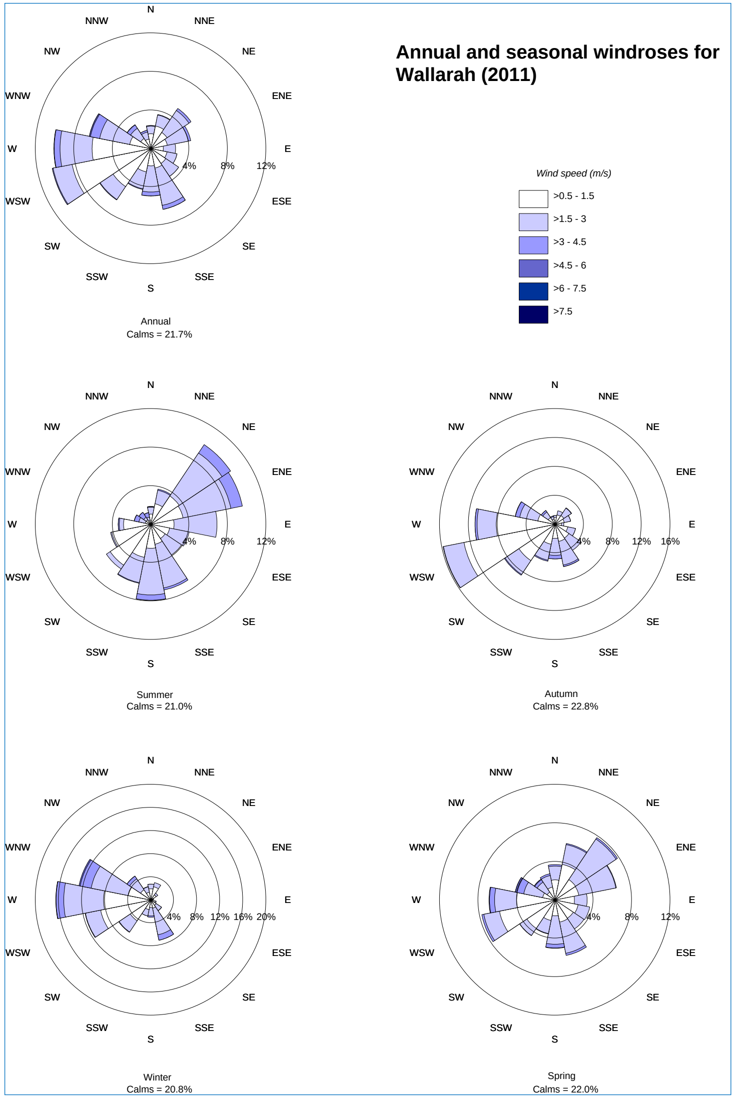
On an annual basis, **Figure 4.1** shows winds to be mainly from the west, west-southwest and west-northwest. The average annual percentage of calms across all years presented is high (winds less than 0.5 m/s) at 20% with a decrease from 2013 to 2015. This decrease can be attributed to a change in wind speed and wind direction sensor after the upgrade of the entire meteorological station at the Tooheys Road Site in 2013. The annual average wind speed is 1.6 m/s.

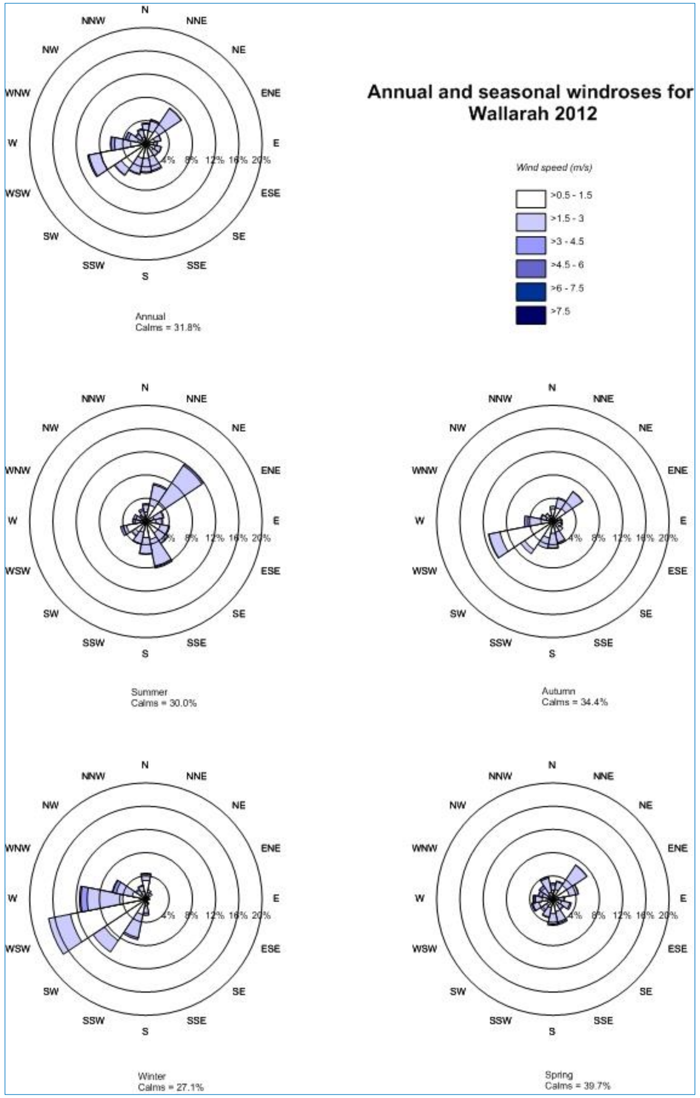
Table 4.2: Comparative Statistics for Meteorological Data

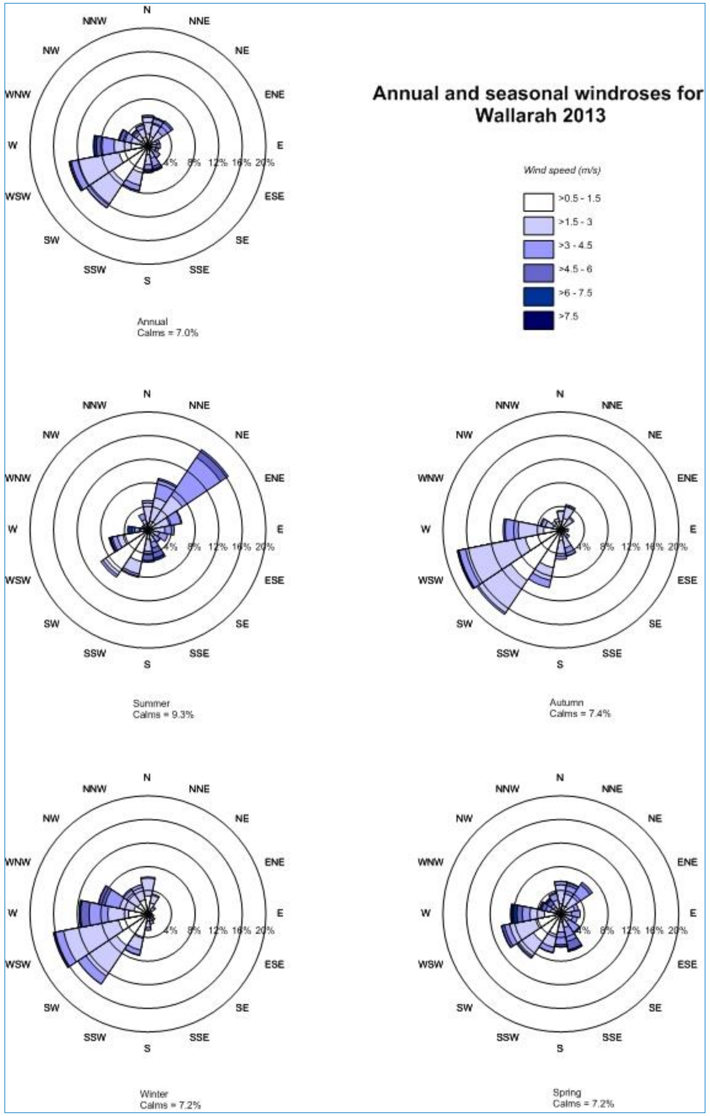
Period	% Calms	Average Wind Speed (m/s)	% Data Recovery [a]
2007	29	1.7	60% – 70%
2008	31	1.6	62%
2009	-	-	0%
2010	25	1.2	80%
2011	22	1.3	86%
2012	32	1.2	89%
2013	7	2.0	71%
2014	7	2.0	96%
2015	7	1.9	98%
July 2010 – June 2011	22	1.3	95%

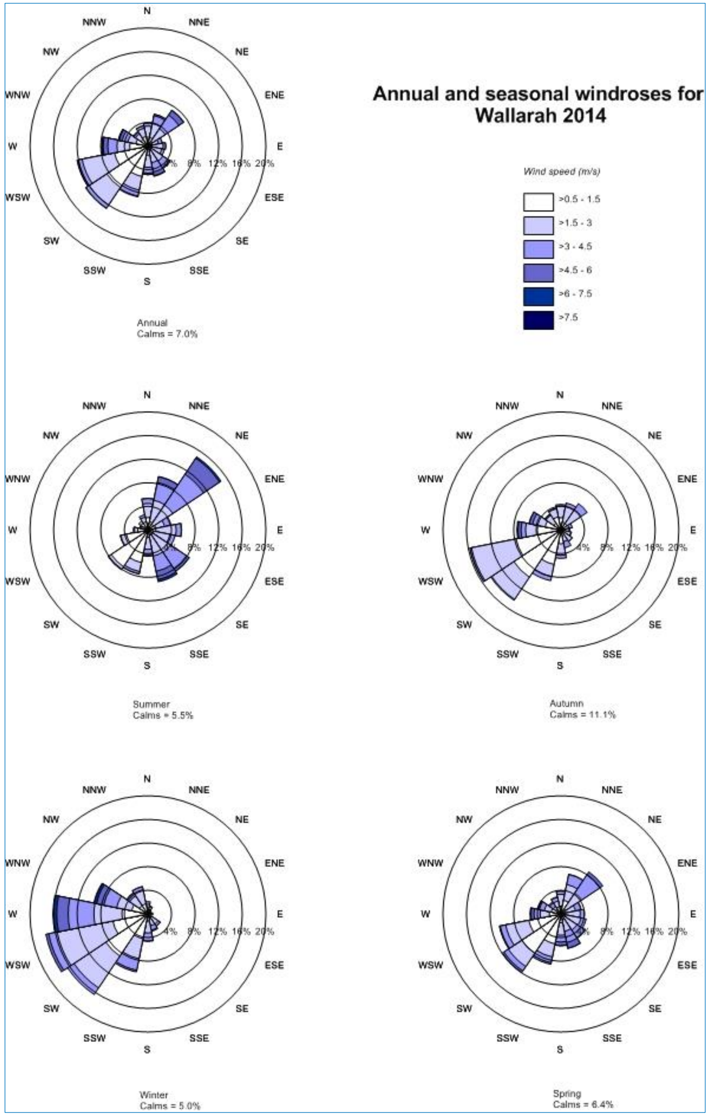
Note: [a] based on wind speed/direction


Annual and Seasonal windroses for Wallarah 2007
Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
Annual
Calms = 28.9%
Summer
Calms = 29.0%
Autumn
Calms = 33.4%
Winter
Calms = 23.9%
Spring
Calms = 34.4%
Annual and Seasonal windroses for Wallarah 2008
Annual
Calms = 30.8%
Summer
Calms = 26.1%
Autumn
Calms = 37.5%
Winter
Calms = 32.7%
Spring
Calms = 25.8%
Annual and seasonal windroses for Wallarah (2010)
Annual
Calms = 25.3%
Summer
Calms = 20.4%
Autumn
Calms = 27.8%
Winter
Calms = 22.9%
Spring
Calms = 26.4%


Annual and seasonal windroses for Wallarah (2011)
Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
4%
8%
12%
16%
20%
Annual
Calms = 21.7%
Summer
Calms = 21.0%
Autumn
Calms = 22.8%
Winter
Calms = 20.8%
Spring
Calms = 22.0%


Annual and seasonal windroses for Wallarah 2012
Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW
4%
8%
12%
16%
20%
Annual
Calms = 31.8%
Summer
Calms = 30.0%
Autumn
Calms = 34.4%
Winter
Calms = 27.1%
Spring
Calms = 39.7%


Annual and seasonal windroses for Wallarah 2013
Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
Annual
Calms = 7.0%
Summer
Calms = 9.3%
Autumn
Calms = 7.4%
Winter
Calms = 7.2%
Spring
Calms = 7.2%


Annual and seasonal windroses for Wallarah 2014
Wind speed (m/s)
>0.5 - 1.5
>1.5 - 3
>3 - 4.5
>4.5 - 6
>6 - 7.5
>7.5
Annual
Calms = 7.0%
Summer
Calms = 5.5%
Autumn
Calms = 11.1%
Winter
Calms = 5.0%
Spring
Calms = 6.4%

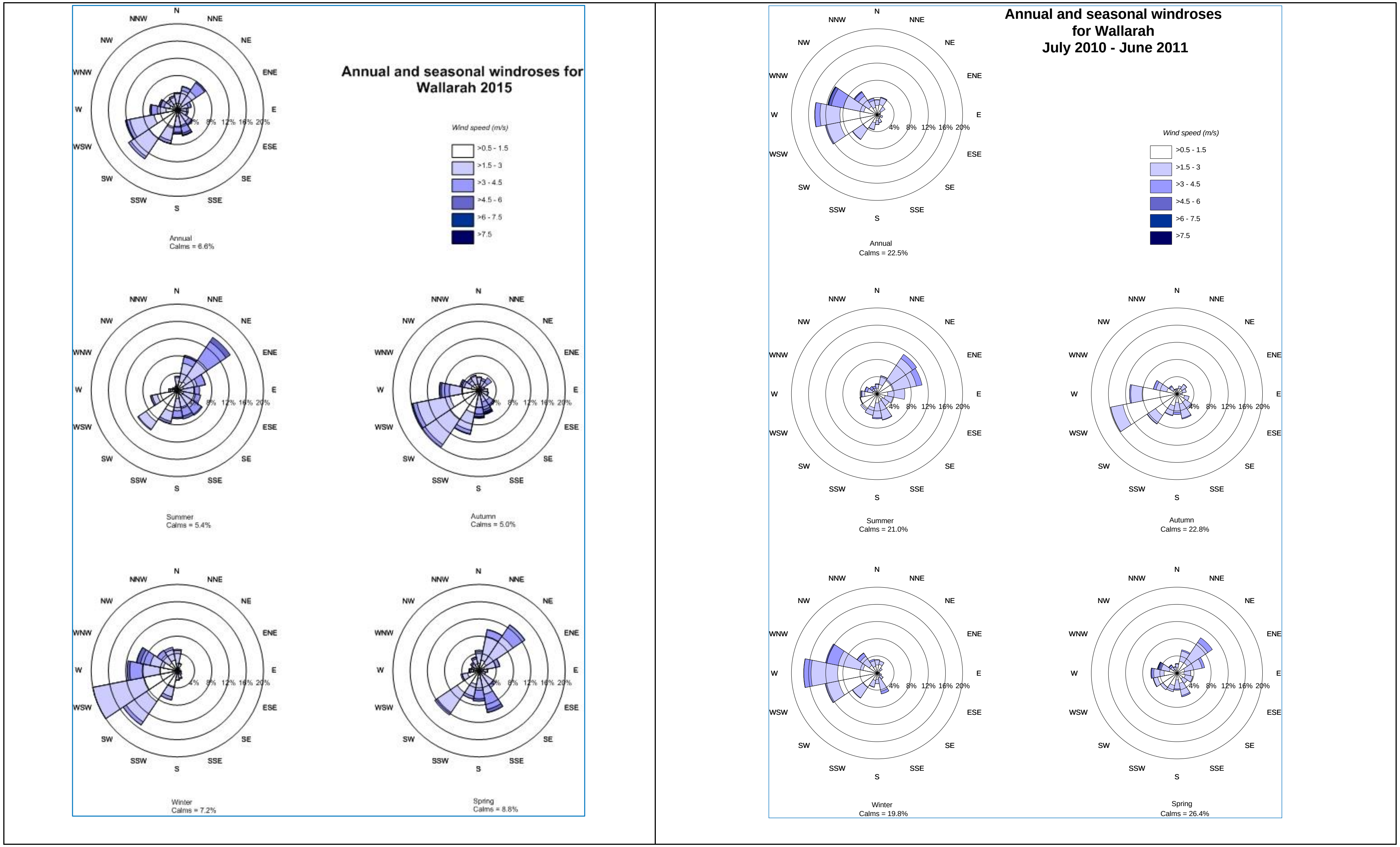


Figure 4.1: Annual and seasonal windroses for Tooheys Road weather station

4.2 Existing Ambient Air Quality

Air quality standards and goals refer to pollutant levels which include the contribution from proposed projects as well as other sources. To fully assess impacts against all the relevant air quality standards and goals it is necessary to have information or estimates on existing dust concentration and deposition levels in the area in which the Project is likely to contribute to dust levels.

An Environmental Monitoring Program for the Project commenced in 1996 providing monthly averages of dust deposition levels. Dust concentrations were also measured by high volume air samplers (HVAS). Air monitoring was discontinued in early 2004 and recommenced in late 2006. All data presented are based on data files provided by Wyong Areas Coal Joint Venture, however most data are also largely summarised in reports by ERM (**ERM, 2008, 2009, 2010, 2011, 2012 and 2013**). Available data commencing in 1999 from the two relevant HVAS and eight (later six) dust deposition gauges are provided below.

The locations of the current monitoring sites in place for the mine operations are shown on **Figure 2.1** and include:

- Two HVASs measuring PM_{10} on a one day in six cycle;
- Two HVASs measuring total suspended particles (TSP) on a one day in six cycle; and
- Six dust deposition gauges.

The HVASs are located near each of the Tooheys Road and Buttonderry sites. Dust deposition gauges are located near the Tooheys Road and Buttonderry sites and also representative of nearby residential areas.

4.2.1 PM_{10} and TSP Concentrations

HVAS C is located at the Buttonderry Site and HVAS E at the Tooheys Road Site. The HVAS monitoring results will include all background sources relevant to that location, including any contribution which may occur from local activities. Concentrations of 24-hour PM_{10} above the goal of 50 µg/m^3 are measured on occasion, often associated with bushfires, dust storms or dry, hot conditions.

A summary of the monitoring data is presented in **Table 4.3**. There was a gap of monitoring data collection between 2003 to 2006. HVAS C was damaged by lightning which caused data loss between April 2015 to October 2015. Since the recommencement of monitoring in September 2006 to date (December 2015) these data are 68% complete (HVAS C) and 77% - 79% complete (HVAS E). TSP data are unavailable at HVAS C from April 2012 when the filter was swapped to HVAS C PM_{10}.

Annual average concentrations of PM_{10} are generally below the relevant air quality goals for the monitoring period. Exceedances of the annual average PM_{10} goal of 30 µg/m^3 were recorded in 2002 and 2006. In 2002, the annual average PM_{10} concentration was based on data collected over November and December only, a period impacted by bushfires. During 2006 a large number of nearby regions all experienced an increased number of 24-hour PM_{10} exceedances which may be attributed to bushfires towards the end of the year (**DECC, 2007**). The average annual PM_{10} over both monitoring sites for the monitoring period is 17 µg/m^3.

Table 4.3 also provides a summary of the annual average TSP concentration data collected at these sites. Monitoring results show that from 1999 to 2015 there have been no recorded exceedances of the EPA impact average assessment criterion for TSP of 90 µg/m^3. The highest annual average TSP was 64 µg/m^3 measured in 2002 by HVAS C and 61 µg/m^3 also measured in 2002 by HVAS E. The average annual TSP concentrations across both HVAS monitors over all monitoring data available is 33 µg/m^3.

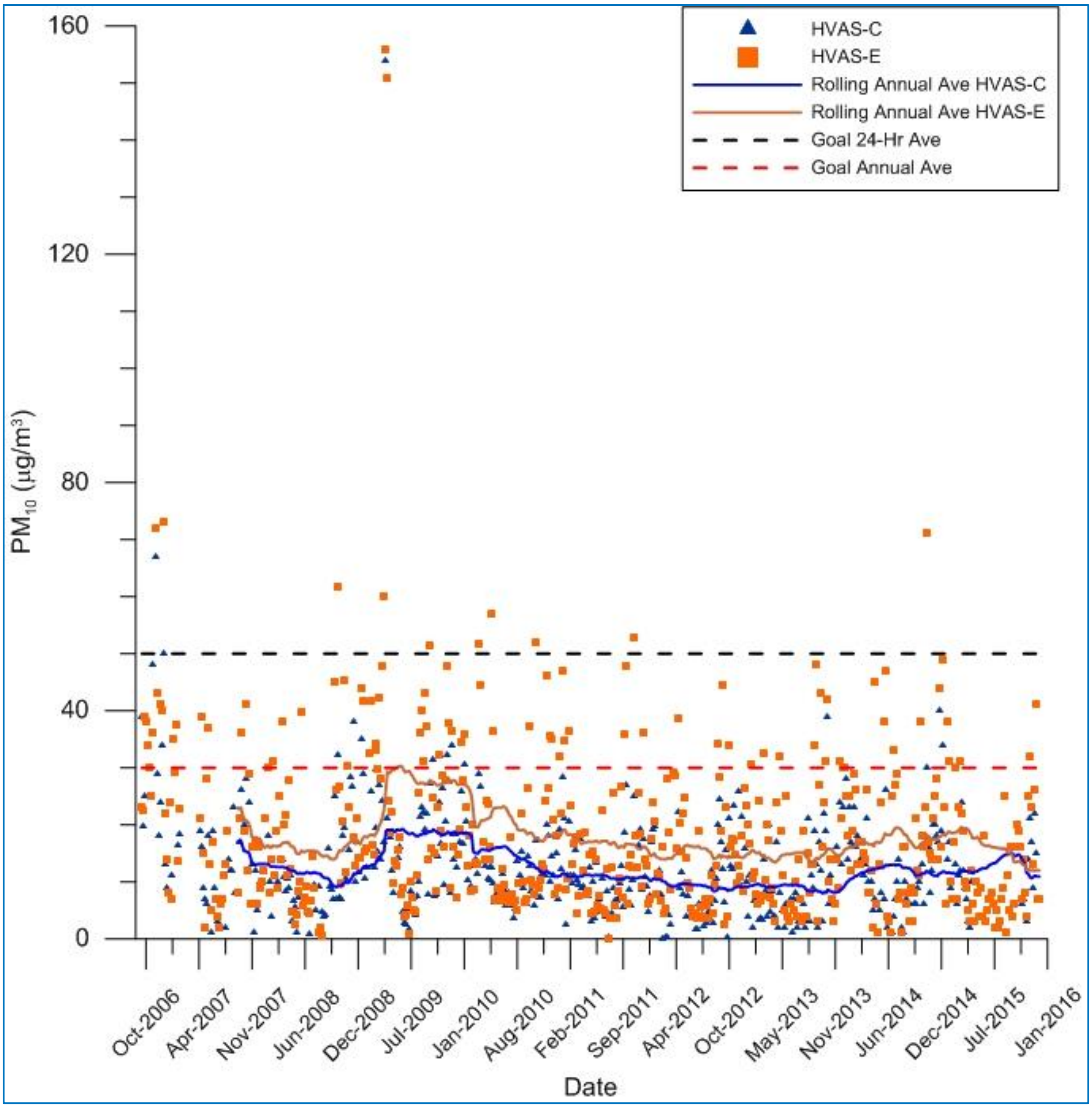


Figure 4.2: 24-hour average and rolling annual 24-hour average PM_{10} concentrations for November 2006 to December 2015

Table 4.3: Summary of PM_{10} and TSP concentrations (µg/m³)

Year	HVAS C				HVAS E			
	PM_{10} Annual Ave	PM_{10} Maximum 24-hour average	Days above criteria [(a)]	TSP Annual Ave	PM_{10} Annual Ave	PM_{10} Maximum 24-hour average	Days above criteria [(a)]	TSP Annual Ave
Goal	*30 (µg/m³)*	*50 (µg/m³)*	-	*90 (µg/m³)*	*30 (µg/m³)*	*50 (µg/m³)*	-	*90 (µg/m³)*
1999	10	14	0	24	9	14	0	21
2000	11	30	0	20	12	66	1	26
2001	12	33	0	27	13	32	0	30
2002[(b)]	38	116	2	64	24	85	6	61
2003[(b)]	12	44	0	29	21	49	0	42
2006[(b)]	31	67	1	51	37	73	2	57
2007	13	29	0	19	17	41	0	33
2008	12	38	0	18	17	62	1	33
2009	19	154	1	30	28	156	4	50
2010	12	31	0	19	19	57	3	32
2011	11	28	0	18	16	53	2	29
2012	10	26	0	20[(c)]	15	45	0	30
2013	9	39	0	-	16	48	0	30
2014	13	40	0	-	19	71	1	36
2015	11	24	0	-	13	41	0	25
Average	**15**	**-**	**-**	**29**	**18**	**-**	**-**	**36**

Note: [(a)] HVAS monitors only recorded dust levels one day in six, so this does not represent all days above criteria.

[(b)] 2002 data are for November and December only. Gap in monitoring from 2003 to 2006, recommenced September 2006.

[(c)] Data for TSP available until 02/04/2012 when the filter was swapped from HVAS C TSP to HVAS C PM_{10}.

4.2.2 Dust Deposition

Dust deposition data have been collected in the area surrounding the Project since September 1996. The locations of the relevant dust deposition gauges are shown in **Figure 2.1**. Gauges D6, D10 and D20 are no longer in use. The data, from 1997, expressed as insoluble solids, are presented in **Table 4.4**. Monitoring ceased in 2004 and recommenced in September 2006. For most years, less than a full year of data was available, due to contamination of samples or monitoring for only parts of the year.

Annual average dust deposition levels recorded since September 2006 are shown in **Figure 4.3**. In recent years there have been no exceedances of the EPA criterion of 4 g/m²/month. The average dust deposition rate across all sites for the entire monitoring period is 1.6 g/m²/month.

Table 4.4: Dust Deposition Yearly Average (g/m²/month of insoluble solids)

Year	D1	D3	D4	D5	D6	D8	D10	D11	D20
1997	-	1.2	0.8	1.1	1.5	-	-	-	2.6
1998	-	0.8	0.6	0.5	2.9	-	-	-	0.9
1999	1.6	0.8	0.8	0.6	2.7	0.2	-	-	0.9
2000	1.3	0.9	0.7	0.7	1.9	4.8	1.0	1.4	1.0
2001	1.1	0.8	0.4	0.9	3.0	3.2	2.3	2.3	0.9
2002	2.2	1.6	-	0.8	2.3	1.2	1.9	2.9	5.2
2003	2.4	1.5	-	1.6	1.9	1.8	0.9	-	1.1
2004	3.5	1.6	-	1.5	1.9	2.3	1.7	-	1.1
2006 (from Sept)	2.0	1.5	1.1	1.1	-	1.6	-	1.9	-
2007	3.9	2.6	1.3	1.1	-	3.4	-	3.1	-
2008	1.4	1.0	0.7	0.8	-	3.9	-	2.2	-
2009	1.8	1.7	1.1	1.0	-	1.4	-	2.2	-
2010	2.2	0.7	0.8	0.5	-	0.8	-	2.5	-
2011	2.1	0.6	0.5	0.4	-	0.6	-	3.5	-
2012	2.4	0.7	0.9	0.6	-	1.7	-	2.6	-
2013	0.7	0.8	0.5	0.7	-	0.7	-	1.1	-
2014	1.1	0.7	0.6	0.8	-	0.7	-	1.1	-
2015	0.8	1.3	0.5	0.6	-	1.9	-	1.6	-
Average	***1.9***	***1.2***	***0.8***	***0.9***	***2.3***	***1.9***	***1.6***	***2.2***	***1.7***
Average over all sites =1.6									

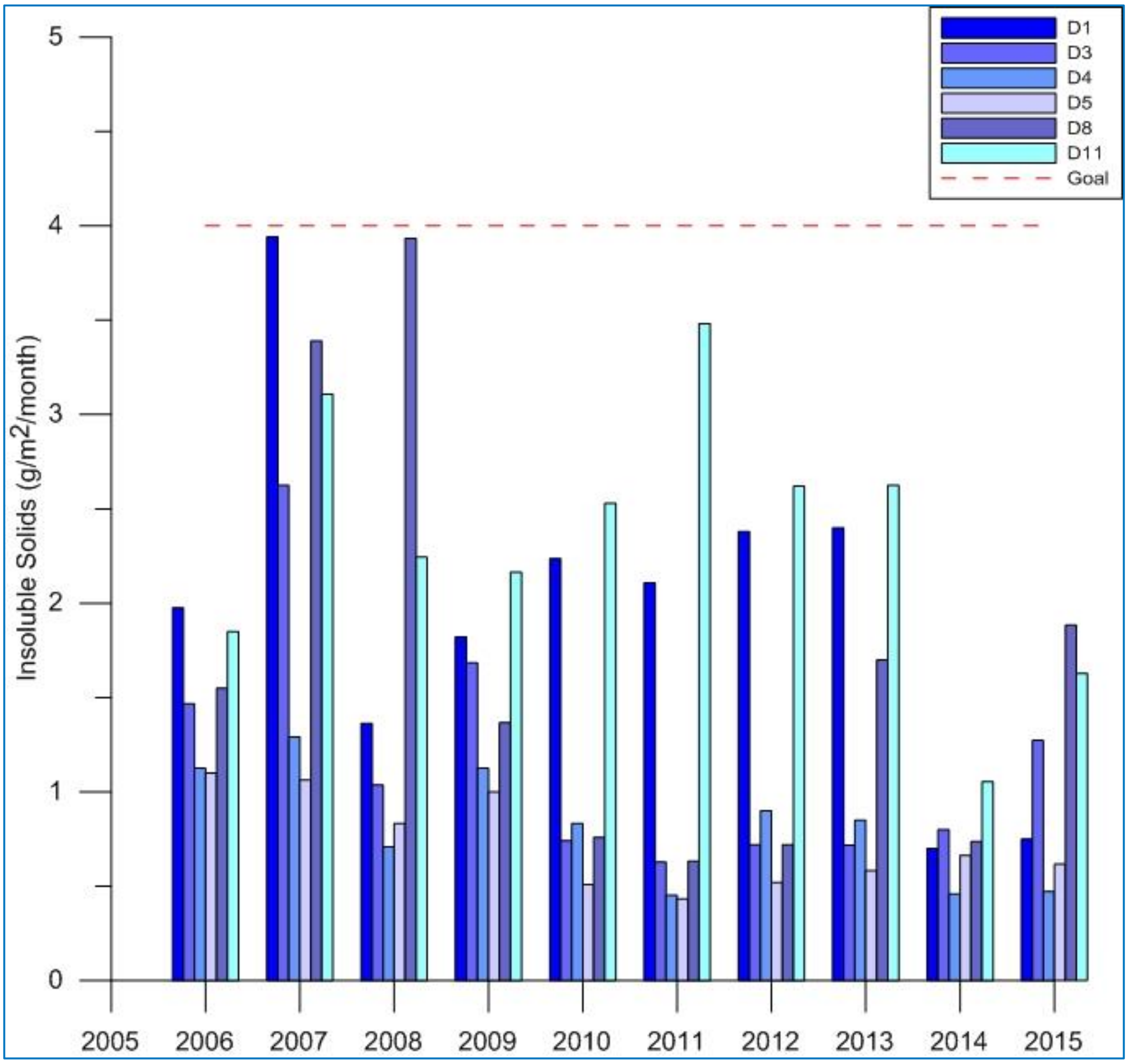


Figure 4.3: Annual Average Dust Deposition (g/m^2/month)

4.2.3 $PM_{2.5}$ Concentrations

The closest available $PM_{2.5}$ monitoring locations are operated by the EPA at Beresfield and Wallsend, located approximately 40 km – 50 km north of the site. Co-located monitors for PM_{10} and $PM_{2.5}$ are operated at these sites and the average recorded ratio of $PM_{2.5}/PM_{10}$ for both of these sites during 2014 was 0.4.

Applying this ratio to the average of the annual average PM_{10} concentration (16.5 µg/m^3) recorded at HVAS C and HVAS E (**Table 4.3**), the annual average $PM_{2.5}$ concentration is estimated to be approximately 7 µg/m^3.

It is noted that the ratios of $PM_{2.5}/PM_{10}$ vary across different areas, usually a function of local industrial activity, vehicle traffic, residential density and domestic wood burning. However, in the absence of available recent local data, these ratios are adopted for use in this assessment.

4.3 Existing Air Quality for Assessment Purposes

The assessment of air quality impacts for the Project requires consideration of the contributions from other local sources, including traffic along major transport routes, local power stations, domestic wood fires, local unsealed roads and exposed areas.

The raw monitoring data collected for the Project provides an indication of background concentrations for TSP, PM_{10} and dust deposition in the region. In the absence of monitoring data for $PM_{2.5}$ an estimate has been made based on ratios of $PM_{2.5}/PM_{10}$ measured at the closest available EPA monitoring sites.

In summary, for the purposes of assessing potential air quality impacts, the following existing air quality levels are assumed.

- annual average PM_{10} concentration of 17 µg/m^3 (previously 18 µg/m^3);
- annual average $PM_{2.5}$ concentration of 7 µg/m^3 (previously 5 µg/m^3);
- annual average TSP concentration of 33 µg/m^3 (previously 31 µg/m^3);
- annual average dust deposition of 1.6 g/m^2/month (consistent with previous assessment);
- 24-hour PM_{10} concentrations – daily varying (consistent with previous assessment).

5 MODELLING APPROACH

This Air Quality Assessment has been conducted generally in accordance with the Approved Methods (**NSW DEC, 2005**) and the approach is described in the following sections. Other than updating the emission sources and the additional of some receptors to reflect the Amendment, no changes were made to the approach compared with the previous AQGHGA (**PAEHolmes, 2012**).

5.1 Modelling System

The CALMET/CALPUFF modelling system was chosen for this study. 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 3-D meteorological fields that are utilised in the CALPUFF dispersion model. CALMET uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict gridded meteorological fields for the region. CALPUFF is a multi-layer, multi-species non-steady state puff dispersion model that can simulate the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal (**Scire *et al.*, 2000**). The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer-range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across the puff and takes into account the complex arrangement of emissions from point, area, volume, and line sources. In March 2011 the NSW EPA published generic guidance and optional settings for the CALPUFF modelling system for inclusion in the Approved Methods (**TRC, 2011**). The model set up for this study has been conducted in consideration of these guidelines.

5.2 Model Set Up

CALMET was run for a domain of 30 km x 30 km with a 250 m resolution, centred on the proposed Tooheys Road Site. Observed hourly surface data were incorporated into the domain modelling, including the Wallarah site data plus the BoM data from Cooranbong (located 15 km north) and Norah Head (located 14 km southeast). Cloud amount and cloud heights were sourced from observations at Williamtown RAAF base (located 60 km northeast) and included at the Cooranbong site. Any gaps in the data were supplemented with data extracted from TAPM[1]. Further details on model set up are provided in **Appendix B**.

5.3 Dispersion Meteorology

To compare winds predicted by the model with the measured data from the Wallarah AWS (**Figure 4.1**), a CALMET windrose is presented in **Figure 5.1**. The CALMET windrose is extracted for a single point at the approximate location of the Wallarah AWS. The CALMET wind rose displays similar characteristics to the measured data at Wallarah AWS with dominant winds annually from west, west-southwest. The percentage occurrence of calm conditions (defined as wind speeds less than 0.5m/s) are also a similar magnitude between those recorded at Wallarah AWS and those predicted by CALMET for the same time period.

[1] The Air Pollution Model, or TAPM, is a three dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. Detailed description of the TAPM model and its performance is provided in **(Hurley 2008; Hurley, Edwards et al. 2009**).

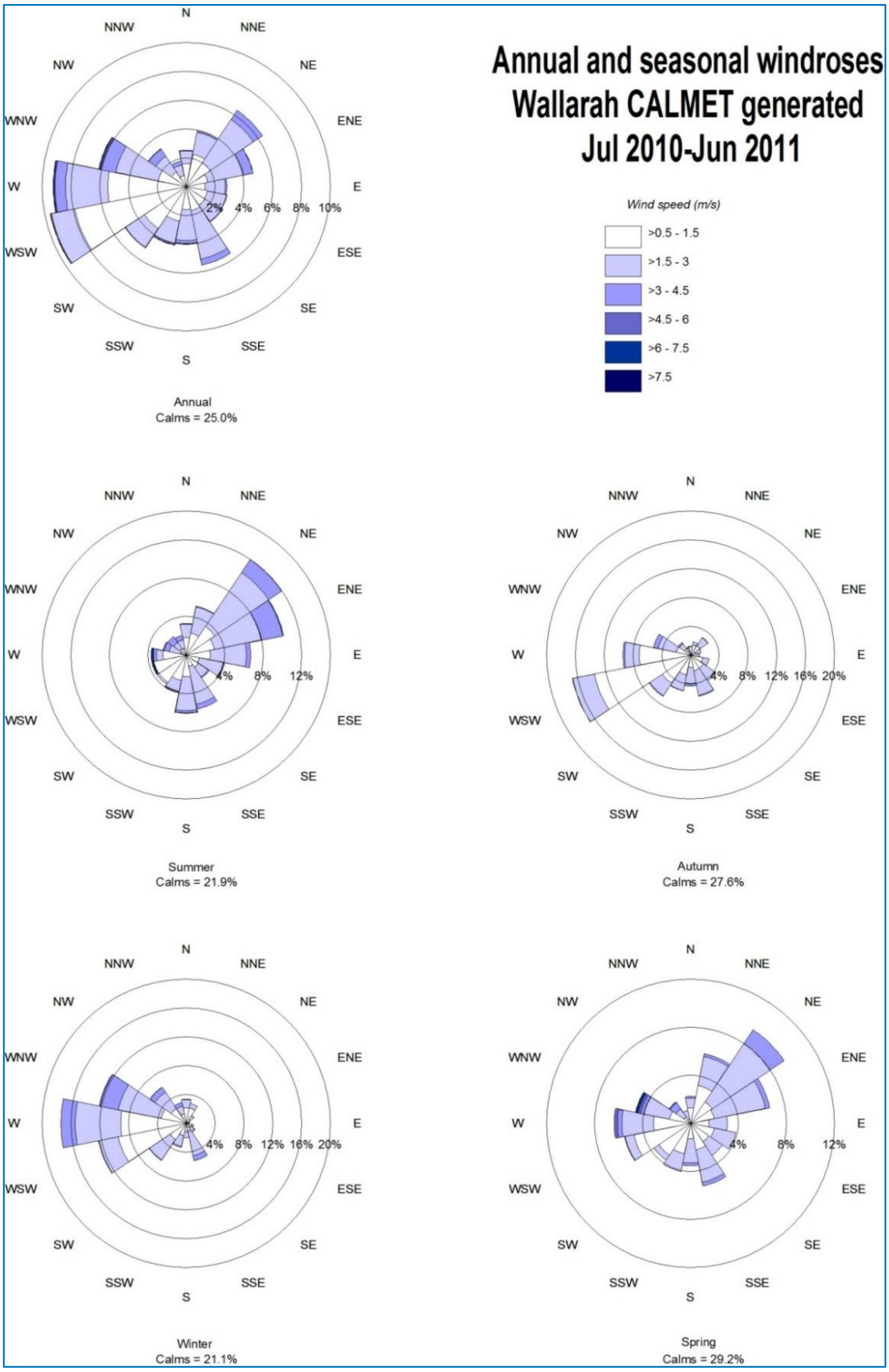


Figure 5.1: Annual and seasonal CALMET generated windroses for Wallarah (July 2010 to June 2011)

6 EMISSIONS TO AIR

6.1 Construction Phase

During construction of the surface infrastructure, fugitive dust emissions can be expected from the activities including:

- Vegetation clearing/stripping;
- Bulk earthworks and material handling;
- Hauling along unsealed surfaces;
- Crushing of drift material
- Transfer of crushed material along conveyor
- Wind erosion on exposed areas

An estimate of the amount of dust produced during the construction phase is presented in **Table 6.1** and compared with the previous AQGHGA

The revised total estimated annual emissions during construction are less than 85% of the emissions estimated to occur during operation of the Project (see **Section 6.2**) and therefore further assessment for construction is not considered necessary. Compliance with air quality goals during the operation of the mine is assumed to represent compliance during mine construction.

Notwithstanding the above, suitable dust mitigation measures would be implemented during the construction phase to ensure that dust emissions are kept to a minimum, especially during adverse meteorological conditions. These mitigation measures are discussed in **Section 10**.

Table 6.1: Estimated Dust Emissions– Construction

ACTIVITY	TSP		PM_{10}		$PM_{2.5}$	
	Previous Assessment	Current Assessment	Previous Assessment	Current Assessment	Previous Assessment	Current Assessment
	kg/y					
Tooheys Road Site						
Dozer clearing vegetation	16,066	11,583	3,882	2,799	1,687	1,216
Loading of excavated material to trucks	331	69	156	33	24	5
Hauling of excavated material by trucks	5,441	2,729	932	468	134	67
Hauling of drift material from drift to crusher by truck	-	3,431	-	588	-	84
CL - Processing - Crushing Station	-	69	-	31	-	6
CL - Conveyor transfer of drift material from crusher to rail spur	-	87	-	41	-	5
Dumping of excavated material	331	156	156	74	24	11
FEL / Dozer Shaping	6,525	6,525	1,471	1,471	685	685
Wind erosion - exposed areas	24,528	24,528	12,264	12,264	1,840	1,840
Buttonderry Site						
Dozer clearing vegetation	4,820	4,820	1,165	1,165	506	506
Loading of excavated material to trucks	33	33	16	16	2	2
Hauling of excavated material by trucks	547	1,316	94	225	13	32
Dumping of excavated material	33	33	16	16	2	2
FEL / Dozer Shaping	6,525	6,525	1,471	1,471	685	685
Wind erosion	14,016	14,016	7,008	7,008	1,051	1,051
Total Annual	**79,195**	**75,919**	**28,632**	**27,669**	**6,653**	**6,198**

6.2 Operation Phase

During operations, the Project will result in emissions of particulate matter, primarily from coal handling activities at the Tooheys Road Site and the operation of upcast ventilation shafts at the Buttonderry Site.

Dust emissions during operations have been estimated by analysing the proposed activities for the Project. The estimated dust emissions during the operational stage of the Project are presented in **Table 6.2**.

In estimating dust emissions, consideration has been given to best practice management (BPM) and applicable controls have been applied to significant dust sources. An overview of BPM is provided in **Section 6.3**.

Table 6.2: Estimated Annual Dust Emission

ACTIVITY	TSP		PM_{10}		$PM_{2.5}$	
	Previous Assessment	Current Assessment	Previous Assessment	Current Assessment	Previous Assessment	Current Assessment
	kg/y					
Tooheys Road Site						
CL - Conveyor transfer @ Portal	828	828	392	392	59	59
CL - Conveyor transfer to ROM stockpile	828	248	392	118	59	18
CL - Loading ROM stockpile from conveyor	828	828	392	392	59	59
CL - Active ROM Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	13,324	13,324	6,662	6,662	999	999
CL - Conveyor transfer to Crushing Station	828	248	392	118	59	18
CL - Processing - Crushing Station	-	450	-	405	-	75
CL - Conveyor transfer between crusher and stockpile	828	124	392	118	59	18
CL - Conveyor transfer to Product stockpile	828	248	392	118	59	18
CL - Loading Product stockpile from conveyor gantry	828	828	392	392	59	59
CL - Active Product Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	48,171	48,171	24,068	24,086	3,613	3,613
CL - Loading from Product Stockpile to Conveyor	-	828	-	392	-	59
CL - Unloading material at transfer points	-	124	-	59	-	9
Conveying from stockpiles to train load out bin	-	248	-	118	-	18
Transfer from conveyor to train load out bin	-	248	-	118	-	18
CL - Loading Trains from Train Load Out Bin	828	828	392	392	59	59
Buttonderry Site						
Ventilation Shaft	23,337	23,337	23,227	23,337	23,227	23,337
Total Annual	**91,458**	**90,914**	**57,218**	**57,212**	**28,423**	**28,436**

6.2.1 Ventilation Shaft

The assumptions and modelling parameters detailed in **Section 7.2.1** of the previous AQGHGA remain valid (**PAEHolmes, 2012**) as no changes have been made to the modelling of the ventilation shaft from the previous assessment.

6.2.2 Flare and Gas Engine Emissions

The proposed flaring of methane and from gas engine emissions has not changed from the previous assessment; therefore NO_x emissions have not been reassessed.

6.3 Overview of Best Practice Dust Control

Table 6.3 provides an overview of the applicable BPM measures recommended by EPA and those adopted for the assessment. As noted in Section 3.6.3, the assumptions are based on information contained in the Best Practice Report (**Donnelly et al., 2011**).

When preparing the emission inventory for modelling the relevant percentage controls for the BPM adopted are shown in **Table 6.3**. Many of the BPM are not relevant for Project as they apply to open cut mining operations.

Table 6.3: Best Practice Dust Management

EPA best practice		Mining Activity	Best Practice Control		Applied at site (Y/N/Other)	Comment	Control Applied in Modelling
Section	Table						
9.2	66	Hauling on Unsealed Roads	Vehicle restrictions	Speed reduction from 75 km/h to 50 km/h	N/A	Not applicable to underground operations	
				Speed reduction from 65 km/h to 30 km/h	N/A	Not applicable to underground operations	
				Grader speed reduction from 16 km/h to 8 km/h	N/A	Not applicable to underground operations	
			Surface improvements	Pave the surface	N/A	Not applicable to underground operations	
				Low silt aggregate	N/A	Not applicable to underground operations	
				Oil and double chip surface	N/A	Not applicable to underground operations	
			Surface treatments	Watering (standard procedure)	N/A	Level 2 watering applied	
				Watering Level 1 (2 L/m2/h)	N/A	Level 2 watering applied	
				Watering Level 2 (>2 L/m2/h)	Y	Applied during construction. No hauling during operation of the Project	75%
				Watering grader routes	N		
				Watering twice a day for industrial unpaved road	N		
				Dust suppressants (please specify)	N		
			Other	Use of larger vehicles	N/A	Not applicable to underground operations	
				Conveyors	N/A	Not applicable to underground operations	
9.3	71	Wind Erosion on Exposed Areas & Overburden Emplacements	Avoidance	Minimise pre-strip	Y	Applied during construction. Not applicable during operation of the Project	
			Surface stabilisation	Watering	N/A	Not applicable to underground operations	
				Chemical suppressants	N/A	Not applicable to underground operations	
				Paving and cleaning	N/A	Not applicable to underground operations	
				Application of gravel to stabilise disturbed open areas	N/A	Not applicable to underground operations	
				Rehabilitation goals	Y	Applied during construction. Not applicable during operation of the Project	
			Wind speed reduction	Fencing, bunding, shelterbelts or in-pit dump	N/A	Not applicable to underground operations	
				Vegetative ground cover	N/A	Not applicable to underground operations	
9.3	72	Wind Erosion and Maintenance - Coal Stockpiles	Avoidance	Bypassing stockpiles	N/A	Not practical	
			Surface stabilisation	Water sprays	Y	Fixed water sprays on stockpiles	50%
				Chemical wetting agents	N		
				Surface crusting agent	N		
				Carry over wetting from load in	N		
			Enclosure	Silo with bag house	N		
				Cover storage pile with a tarp during high winds	N		
			Wind speed reduction	Vegetative windbreaks	N		
				Reduced pile height	N		
				Wind screens/fences	N		
				Pile shaping/orientation	N		
				Erect 3-sided enclosure around storage piles	N		
9.4	76	Bulldozers on OB	Minimise travel speeds and distance		Y	Applied during construction. Not applicable during operation of the Project	
			Travel routes and material kept moist		Y	Applied during construction. Not applicable during operation of the Project	

EPA best practice		Mining Activity	Best Practice Control		Applied at site (Y/N/Other)	Comment	Control Applied in Modelling
Section	Table						
9.5	81	Blasting and drilling	Blasting	Delay shot to avoid unfavourable weather conditions	N/A	Not applicable to underground operations	
				Minimise area blasted	N/A	Not applicable to underground operations	
	82		Drilling	Fabric filters	N/A	Not applicable to underground operations	
				Cyclone	N/A	Not applicable to underground operations	
				Water injection while drilling	N/A	Not applicable to underground operations	
9.6	85	Draglines	Minimise drop height		N/A	Not applicable to underground operations	
			Minimising drop height		N/A	Not applicable to underground operations	
			Modify activities in windy conditions		N/A	Not applicable to underground operations	
			Water sprays		N/A	Not applicable to underground operations	
			Minimise side casting		N/A	Not applicable to underground operations	
9.7	90	Loading and dumping overburden	Excavator	Minimise drop height	Y	Applied during construction. Not applicable during operation of the Project	
			Truck dumping	Minimise drop height	Y	Applied during construction. Not applicable during operation of the Project	
				Water application	Y	Applied during construction. Not applicable during operation of the Project	
				Modify activities in windy conditions	Y	Applied during construction. Not applicable during operation of the Project	
9.8	95	Loading and dumping ROM coal	Avoidance	Bypass ROM stockpiles	N		
			Truck or loader dumping coal	Minimise drop height	N/A	Not applicable to underground operations	
				Water sprays on ROM pad	N/A	Not applicable to underground operations	
			Truck or loader dumping to ROM bin	Water sprays on ROM bin or ROM pad	N/A	Not applicable to underground operations	
				Three sided and roofed enclosure of ROM bin	N/A	Not applicable to underground operations	
				Three sided and roofed enclosure of ROM bin + water sprays	N/A	Not applicable to underground operations	
				Enclosure with control device	N/A	Not applicable to underground operations	
9.9	96	Conveyors and transfers	Conveyors	Application of water at transfers	Y		50%
				Wind shielding - roof OR side wall	N/A	Higher level of control applied- roof AND side wall	
				Wind shielding - roof AND side wall	Y	3/4 shielded conveyors proposed	70%
				Belt cleaning and spillage minimisation	Y	No reduction applied to inventory	
			Transfers	Enclosure	Y		70%
9.10	97	Stacking and reclaiming product coal	Avoidance	Bypass coal stockpiles	N		
			Loading coal stockpiles	Variable height stack	Y		
				Boom tip water sprays	Y		
				Telescopic chute with water sprays	Y		
			Unloading coal stockpiles	Bucket-wheel, portal or bridge reclaimer with water application	N		
9.11	-	Train and truck load out and transportation	Limit load size to ensure coal is below sidewalls		Y	No reduction applied to inventory	
			Maintain a consistent profile		Y	No reduction applied to inventory	
			Use bedliners to minimise seepage		N		
			Cover load with tarpaulin		N/A	Not applicable to underground operations	
			Utilise truck wheel wash		N/A	Not applicable to underground operations	

7 IMPACT ASSESSMENT

The results of the predictions for the Project are presented in the sections below. Per the emissions detailed in **Section 6.2**, all activities from the Project have been assessed. The contour plots are indicative of the concentrations that could potentially be reached under the conditions modelled. A summary of the predicted pollutant concentrations at each of the assessment locations is presented in **Table 7.1**. The assessment locations are detailed in **Appendix A** and shown in **Figure 2.1**.

The following sections discuss the results for each of the relevant pollutants and averaging periods.

Table 7.1: Predicted Incremental Ground Level Concentrations at Assessment Locations

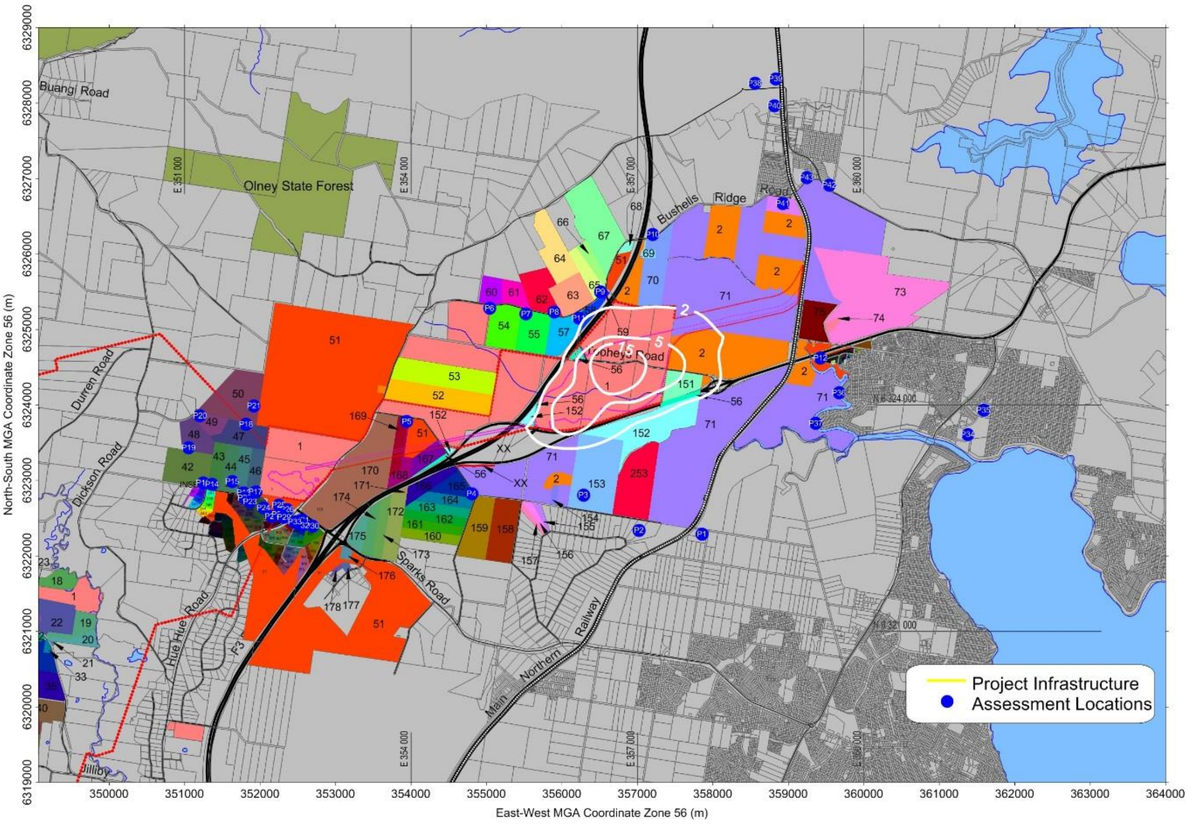
Receptor ID	Easting	Northing	$PM_{2.5}$						PM_{10}						TSP		Dust deposition	
			24 hour (max daily)		24 hour (average daily)		Annual		24 hour (max daily)		24 hour (average daily)		Annual		Annual		Annual	
			Previous	Current	Previous	Current	Previous	Current	Previous	Current	Previous	Current	Previous	Current	Previous	Current	Previous	Current
Units			µg/m³						µg/m³						µg/m³		g/m²/month	
Criteria			N/A		N/A		N/A		N/A		N/A		N/A		N/A		2	
P1	357855	6322289	0.37	0.38	0.32	0.32	0.03	0.03	1.74	2.22	1.35	1.72	0.1	0.2	0.2	0.2	0.02	0.01
P2	357021	6322338	0.83	0.81	0.64	0.62	0.04	0.05	3.80	4.07	3.00	3.21	0.2	0.2	0.2	0.3	0.01	0.01
P3	356284	6322807	1.14	1.14	0.83	0.82	0.08	0.09	6.04	6.64	4.84	5.32	0.4	0.5	0.6	0.7	0.03	0.03
P4	354803	6322823	0.69	0.68	0.49	0.49	0.07	0.07	3.45	3.96	2.71	3.11	0.2	0.3	0.3	0.4	0.06	0.06
P5	353943	6323781	0.65	0.64	0.47	0.46	0.05	0.05	3.32	3.70	2.62	2.91	0.1	0.1	0.2	0.2	0.03	0.02
P6	355040	6325280	0.75	0.75	0.67	0.67	0.06	0.06	3.27	3.86	2.55	3.01	0.2	0.2	0.2	0.3	0.02	0.02
P7	355524	6325206	1.10	1.08	0.81	0.79	0.09	0.09	5.85	6.21	4.61	4.90	0.4	0.4	0.5	0.6	0.04	0.04
P8	355898	6325231	2.28	2.06	1.58	1.43	0.15	0.14	12.97	12.71	9.44	9.25	0.7	0.8	1.0	1.1	0.06	0.06
P9	356509	6325499	2.85	2.93	2.05	2.11	0.22	0.22	13.66	16.33	10.91	13.04	1.1	1.3	1.5	1.9	0.09	0.09
P10	357203	6326257	1.34	1.31	0.98	0.95	0.08	0.08	5.99	7.05	4.67	5.50	0.4	0.5	0.4	0.6	0.03	0.03
P11	356222	6325149	5.02	4.89	3.78	3.68	0.30	0.28	27.16	29.53	22.14	24.08	1.6	1.7	2.4	2.6	0.14	0.13
P12	359426	6324622	0.63	0.66	0.46	0.48	0.06	0.06	2.88	3.77	2.30	3.01	0.3	0.4	0.3	0.5	0.04	0.05
P13	351245	6322968	0.96	0.96	0.94	0.94	0.08	0.08	1.37	1.50	1.20	1.31	0.1	0.1	0.1	0.1	0.01	0.01
P14	351364	6322948	0.99	0.99	0.97	0.97	0.10	0.10	1.67	1.80	1.48	1.59	0.1	0.1	0.1	0.1	0.02	0.02
P15	351632	6322985	1.56	1.57	1.54	1.55	0.19	0.19	2.37	2.54	2.15	2.30	0.2	0.2	0.2	0.2	0.03	0.03
P16	351783	6322837	3.33	3.23	3.33	3.23	0.32	0.32	3.33	3.28	3.32	3.26	0.3	0.3	0.3	0.4	0.05	0.05
P17	351940	6322848	4.92	5.22	4.92	5.22	0.46	0.47	4.87	5.22	4.87	5.22	0.5	0.5	0.5	0.5	0.06	0.06
P18	351815	6323743	3.71	3.68	3.71	3.68	0.15	0.15	3.54	3.67	3.54	3.67	0.2	0.2	0.2	0.2	0.02	0.02
P19	351054	6323433	0.79	0.79	0.78	0.78	0.07	0.07	1.01	1.10	0.90	0.97	0.1	0.1	0.1	0.1	0.01	0.01
P20	351205	6323857	0.76	0.74	0.76	0.74	0.07	0.07	1.20	1.32	1.01	1.11	0.1	0.1	0.1	0.1	0.01	0.01
P21	351920	6323989	0.93	0.99	0.93	0.99	0.10	0.10	1.62	1.83	1.27	1.43	0.1	0.1	0.1	0.1	0.01	0.01
P22	351795	6322769	3.26	3.06	3.26	3.05	0.28	0.28	3.21	3.05	3.21	3.05	0.3	0.3	0.3	0.3	0.04	0.04
P23	351869	6322717	2.30	2.46	2.30	2.46	0.23	0.24	2.26	2.46	2.26	2.46	0.2	0.3	0.2	0.3	0.03	0.03
P24	352046	6322637	2.72	2.73	2.72	2.73	0.20	0.20	2.68	2.72	2.68	2.72	0.2	0.2	0.2	0.3	0.02	0.02
P25	352248	6322672	2.07	2.10	2.07	2.10	0.16	0.17	2.00	2.09	2.00	2.09	0.2	0.2	0.2	0.2	0.03	0.03
P26	352359	6322615	1.84	1.85	1.84	1.85	0.13	0.13	1.77	1.84	1.77	1.84	0.2	0.2	0.2	0.2	0.03	0.03
P27	352154	6322523	1.46	1.47	1.45	1.47	0.11	0.11	1.42	1.48	1.42	1.48	0.1	0.2	0.1	0.2	0.02	0.02
P28	352245	6322549	1.25	1.29	1.25	1.29	0.11	0.11	1.27	1.37	1.21	1.30	0.1	0.1	0.1	0.2	0.02	0.02
P29	352319	6322512	1.22	1.24	1.22	1.24	0.09	0.10	1.23	1.30	1.16	1.23	0.1	0.1	0.1	0.2	0.02	0.02
P30	352693	6322395	0.78	0.77	0.78	0.77	0.08	0.08	1.30	1.65	1.01	1.28	0.1	0.1	0.1	0.2	0.02	0.01
P31	352562	6322475	0.96	0.97	0.96	0.97	0.09	0.09	1.18	1.48	0.91	1.15	0.1	0.1	0.1	0.2	0.02	0.02
P32	352562	6322404	0.94	0.95	0.94	0.95	0.08	0.08	1.23	1.55	0.95	1.20	0.1	0.1	0.1	0.1	0.01	0.01
P33	352462	6322452	1.15	1.17	1.15	1.17	0.08	0.08	1.13	1.20	1.10	1.17	0.1	0.1	0.1	0.1	0.02	0.02
P34*	361381	6323610	-	0.37	-	0.25	-	0.02	-	1.46	-	1.20	-	0.1	-	0.1	-	0.02
P35*	361587	6323932	-	0.36	-	0.24	-	0.02	-	1.55	-	1.27	-	0.1	-	0.1	-	0.02
P36*	359671	6324160	-	0.52	-	0.42	-	0.05	-	2.96	-	2.46	-	0.3	-	0.3	-	0.05
P37*	359364	6323755	-	0.58	-	0.48	-	0.05	-	3.35	-	2.75	-	0.3	-	0.4	-	0.05
P38*	358556	6328262	-	0.44	-	0.33	-	0.02	-	1.66	-	1.40	-	0.1	-	0.1	-	0.00
P39*	358831	6328322	-	0.28	-	0.28	-	0.02	-	1.44	-	1.18	-	0.1	-	0.1	-	0.00
P40*	358813	6327963	-	0.39	-	0.30	-	0.02	-	1.55	-	1.29	-	0.1	-	0.1	-	0.00
P41*	358926	6326668	-	0.53	-	0.42	-	0.04	-	2.15	-	1.77	-	0.2	-	0.2	-	0.01
P42*	359543	6326914	-	0.49	-	0.39	-	0.03	-	1.94	-	1.52	-	0.1	-	0.1	-	0.01
P43*	359243	6327014	-	0.38	-	0.38	-	0.03	-	1.73	-	1.36	-	0.1	-	0.1	-	0.01

*Receptor not previously assessed

7.1 Annual Average Concentrations

7.1.1 Annual Average Incremental Ground Level PM_{10} Concentrations

A contour plot of the predicted ground level concentrations (glcs) of PM_{10} due to the Project alone are presented in **Figure 7.1.** Annual average PM_{10} predictions are presented for the maximum annual production scenario. The relevant impact assessment criteria are shown by the red contour line. There are no privately owned receivers that are predicted to experience glcs of PM_{10} above the assessment criteria, due to emissions from the Project alone. The highest predicted glcs occur at the closest residence to the north of the site (P11). At this location, under the current assessment, the predicted annual average PM_{10} concentration is 1.7 µg/m³ compared to 1.6 µg/m³ under the previous assessment.



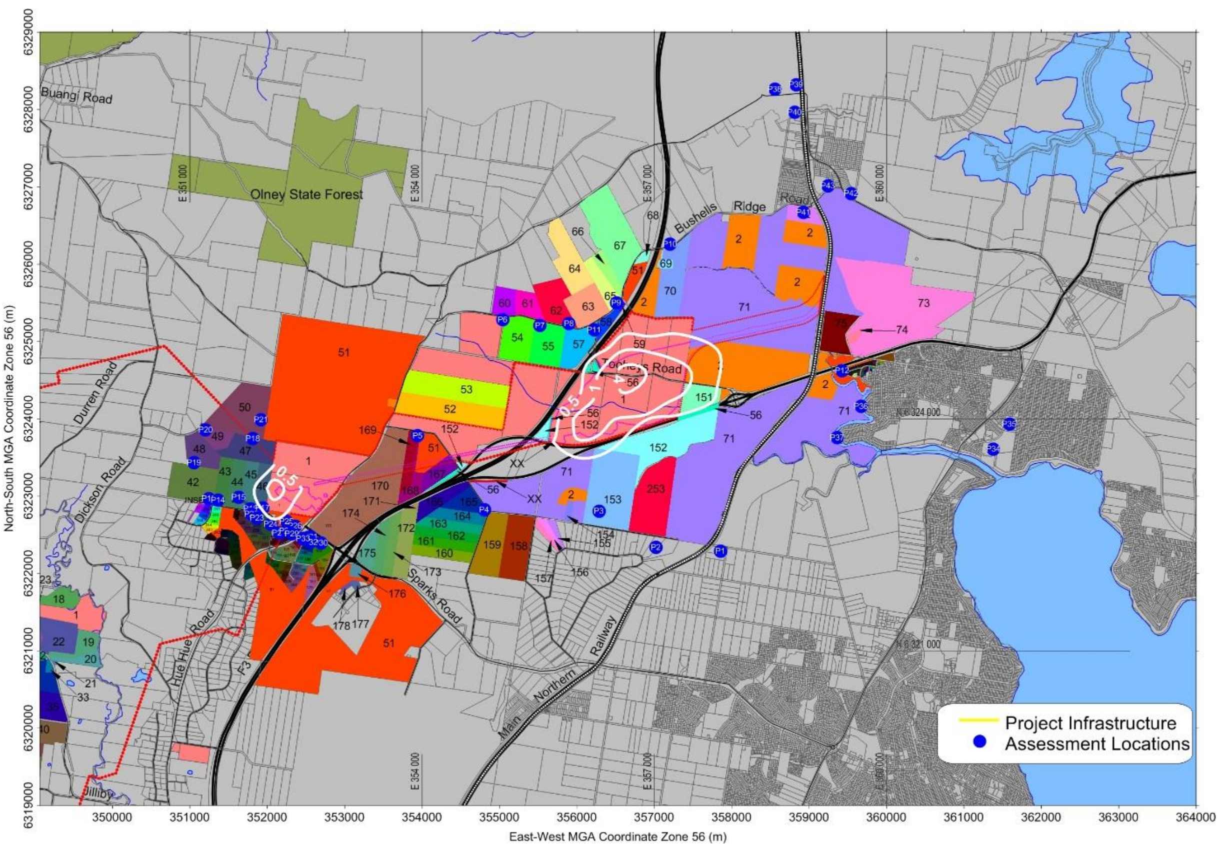
Species: PM_{10}	**Location:** Wyong	**Scenario:** Maximum Annual Production	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF v8.1.0	**Units:** µg/m³	**Assessment Criterion:** N/A	**Met Data:** CALMET	**Plot:** L. McDonough

Figure 7.1: Incremental Annual Average PM_{10} Concentration - Maximum Annual Production

7.1.2 Annual Average Incremental Ground Level $PM_{2.5}$ Concentrations

Contour plots for the predicted glcs of $PM_{2.5}$ due to the Project alone are presented in **Figure 7.2**. Annual average $PM_{2.5}$ predictions are presented for the maximum annual production scenario.

There are no privately owned receivers that are predicted to experience glcs of $PM_{2.5}$ above the assessment criteria, due to emissions from the Project alone. The highest predicted glcs occur at the closest residence to the south-west of the Buttonderry site (P17). At this location, the predicted incremental annual average $PM_{2.5}$ concentration is 0.47 µg/m³ compared to the 0.46 µg/m³ at the same receptor under the previous assessment.



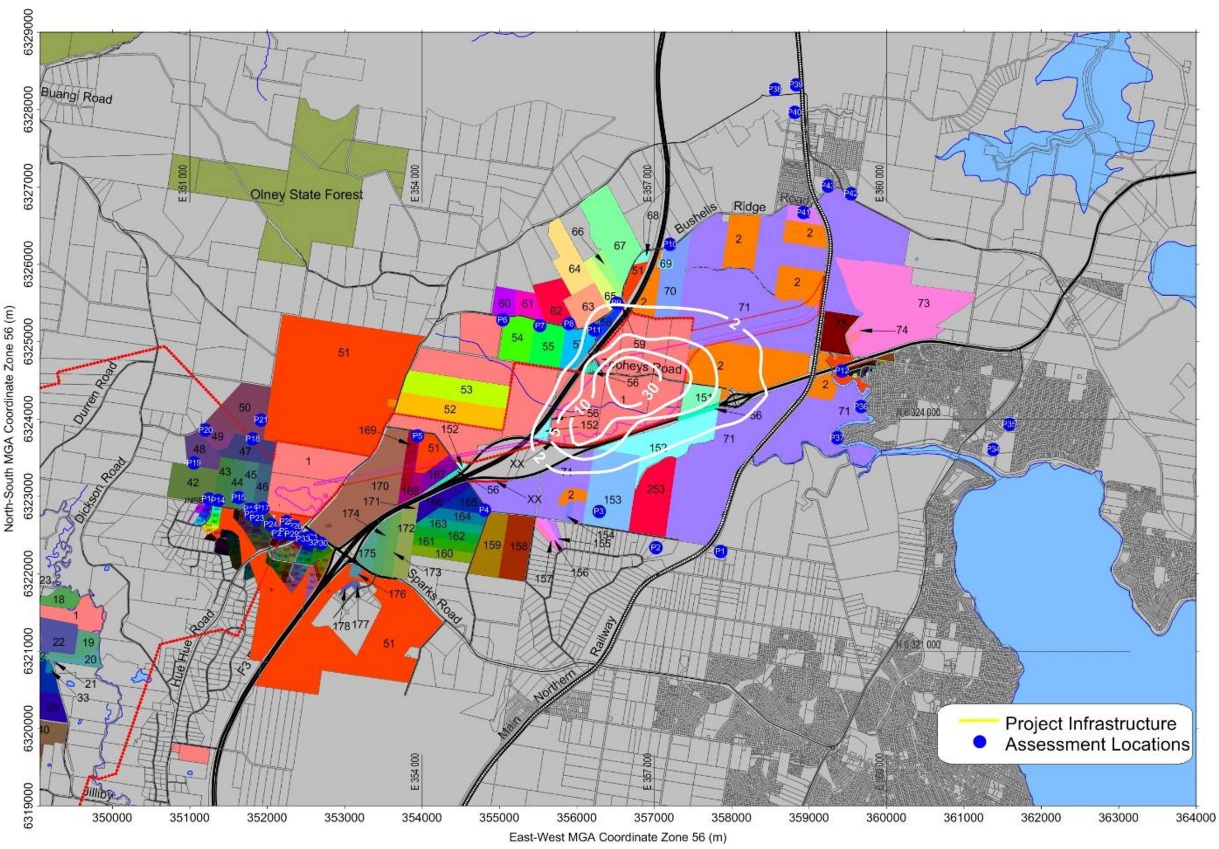
Species: $PM_{2.5}$	**Location:** Wyong	**Scenario:** Maximum Annual Production	**Percentile:** N/A	**Averaging Time:** Annual
Model Used: CALPUFF v8.1.0	**Units:** µg/m³	**Assessment Criterion:** N/A	**Met Data:** CALMET	**Plot:** L. McDonough

Figure 7.2: Incremental Annual Average $PM_{2.5}$ Concentration – Maximum Annual Production

7.1.3 Annual Average Incremental Ground Level TSP Concentrations

Contour plots for the predicted glcs of TSP due to the Project alone are presented in **Figure 7.3**. Annual average TSP predictions are presented for the maximum annual production scenario.

There are no privately owned receivers that are predicted to experience glcs of TSP above the assessment criteria, due to emissions from the Project alone. The highest predicted glcs occur at the closest residence to the north of the site (P11). At this location, the predicted incremental annual average TSP concentration is 2.6 µg/m^3 compared to 2.4 µg/m^3 at the same receptor under the previous assessment.



Species:	Location:	Scenario:	Percentile:	Averaging Time:
TSP	Wyong	Maximum Annual Production	N/A	Annual
Model Used:	**Units:**	**Assessment Criterion:**	**Met Data:**	**Plot:**
CALPUFF v8.1.0	µg/m^3	N/A	CALMET	L. McDonough

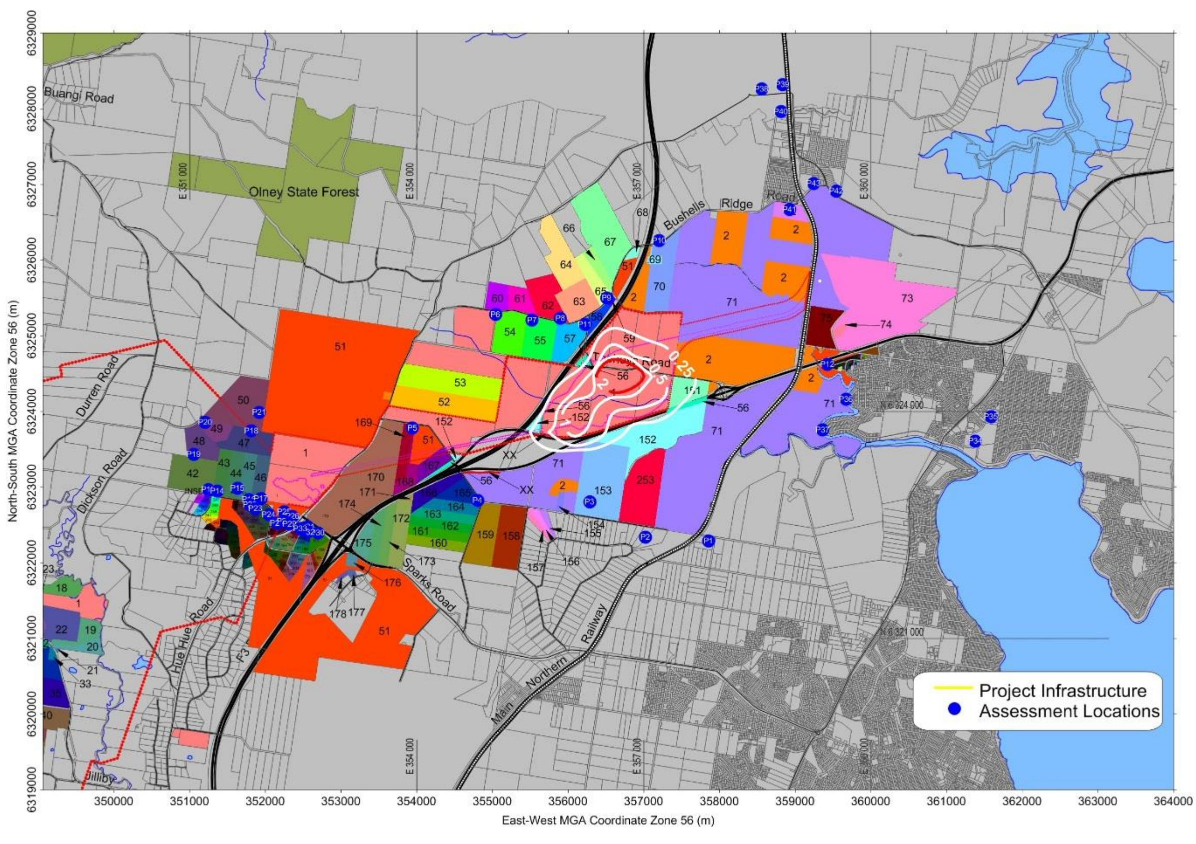
Figure 7.3: Incremental Annual Average TSP Concentration – Maximum Annual Production

7.1.4 Annual Average Incremental Ground Level Dust Deposition Level

Consistent with the previous assessment, deposited dust concentrations have been calculated by combining the modelled results from the dry deposition portion of $PM_{2.5}$, PM_{10} and TSP. These concentrations have been added together to obtain total incremental dust deposition rates due to the Project at each residence.

Contour plots for the predicted dust deposition levels due to the Project alone are presented in **Figure 7.4**. Annual average dust deposition predictions are presented for the maximum annual production scenario. The relevant impact assessment criterion is shown by the red contour line.

There are no privately owned receivers that are predicted to experience dust deposition above the assessment criteria, due to emissions from the Project alone. The highest predicted levels occur at the closest residence to the north of the site (P11). At this location, the predicted incremental annual average dust deposition under the current assessment is 0.13 g/m²/month compared to 0.14 g/m²/month at the same receptor under the previous assessment.



Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
Dust Deposition	Wyong	Maximum Annual Production	N/A	Annual
Model Used:	**Units:**	**Assessment Criterion:**	**Met Data:**	**Plot:**
CALPUFF v8.1.0	g/m²/month	2 g/m²/month (shown in red)	CALMET	L. McDonough

Figure 7.4: Incremental Annual Average Dust Deposition – Maximum Annual Production

7.2 Maximum Incremental 24-hour Average Concentrations

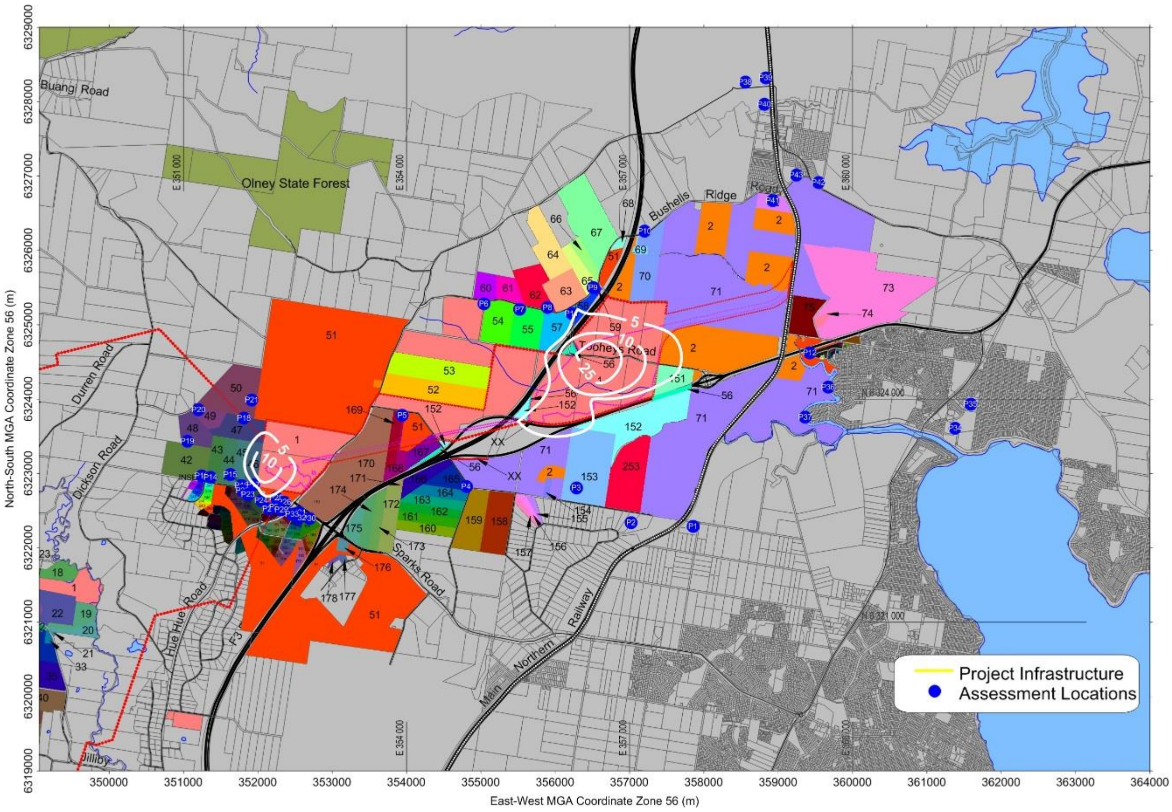
The current assessment has modelled the annual average and corresponding maximum 24-hour average concentrations at each receptor based on the maximum annual production scenario. In the previous assessment the maximum 24-hour average concentrations were based on modelling a maximum daily production scenario.

The ratio of maximum 24-hour average concentrations under a maximum annual production scenario and a maximum daily production scenario was determined from the modelled results for the previous assessment. In this assessment, the maximum 24-hour average concentrations under a maximum daily production scenario were estimated by applying this ratio to the modelled results for the maximum annual production scenario for this assessment.

These ratios have been applied at all receptor sites for PM_{10} and $PM_{2.5}$ under the current assessment. The maximum daily results are provided in **Table 7.1**.

7.2.1 Maximum 24-hour Average $PM_{2.5}$ Concentrations

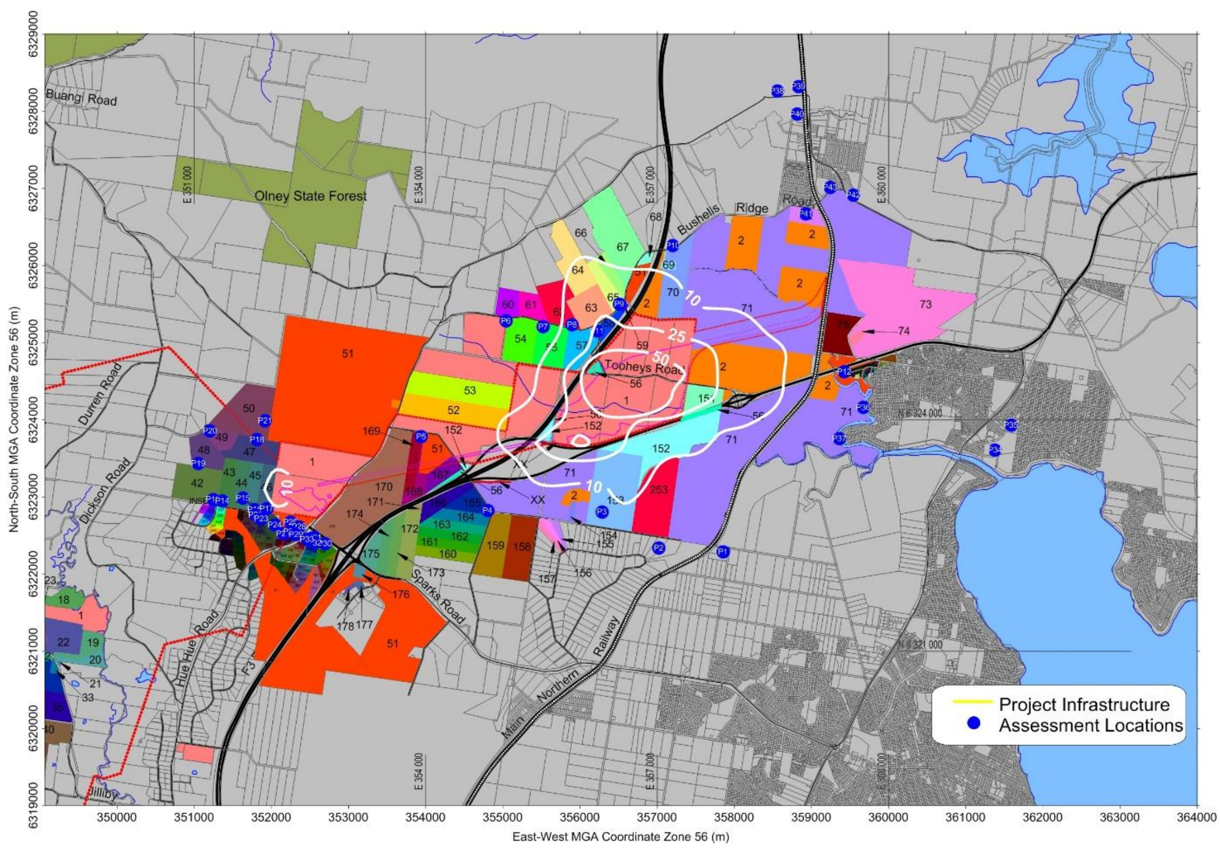
The contours for maximum 24-hour average $PM_{2.5}$ concentrations are shown in **Figure 7.5.** Individual results for each receptor are presented in **Table 7.1**. There are no privately owned receivers that are predicted to experience glcs of $PM_{2.5}$ above the assessment criteria, due to emissions from the Project alone. The highest predicted levels occur at the closest residence to the north-west of the Buttonderry Site (P17). At this location, the predicted incremental concentration due to maximum daily production is 5.3 µg/m^3 compared to 4.9 µg/m^3 under the previous assessment.



Species: PM2.5	Location: Wyong	Scenario: Maximum Daily Production	Percentile: N/A	Averaging Time: 24 hour
Model Used: CALPUFF v8.1.0	**Units:** µg/m³	**Assessment Criterion:** N/A	**Met Data:** CALMET	**Plot:** L. McDonough

Figure 7.5: Maximum 24-hour average $PM_{2.5}$ Concentration – Maximum Daily Production

Contour results for the maximum 24-hour average PM_{10} concentrations are presented in **Figure 7.6**. Results for individually assessed receptors are shown in **Table 7.1**. There are no privately owned receivers that are predicted to experience glcs of PM_{10} above the assessment criteria, due to emissions from the Project alone. The highest predicted levels occur at the closest residence to the north of the Tooheys Road Site (P11). At this location, the predicted incremental concentration due to maximum daily production is 29.5 µg/m³ compared to 27.2 µg/m³ under the previous assessment.



Species:	**Location:**	**Scenario:**	**Percentile:**	**Averaging Time:**
PM_{10}	Wyong	Maximum Daily Production	N/A	24 hour
Model Used:	**Units:**	**Assessment Criterion:**	**Met Data:**	**Plot:**
CALPUFF v8.1.0	µg/m³	N/A	CALMET	L. McDonough

Figure 7.6: Maximum 24-hour average PM_{10} Concentration – Maximum Daily Production

7.3 Cumulative Impact Assessment

7.3.1 24-Hour average PM_{10}

There are no available continuous 24-hour PM_{10} data for the area. HVAS data are available every sixth day, however, this is insufficient to provide a representative background for each day of the model simulation.

A statistical approach (using a Monte Carlo Simulation) is presented to investigate the potential for cumulative 24-hour PM_{10} impacts. The approach takes all of the available background monitoring data from HVAS C and HVAS E and randomly generates a daily 24-hour PM_{10}. This random daily background concentration is added to model predictions for each day of the year, at selected receptor locations. The addition of the random background to the model predicted 24-hour PM_{10} is repeated 250,000 times to generate a probability distribution of cumulative 24-hour PM_{10} concentrations. The Monte Carlo Simulation is run using the Oracle Crystal Ball software (version 11.1.1.2).

The process assumes that a randomly selected background value from the real dataset would have a chance equal to that of any other background value from the dataset of occurring on the given future day when the Project is operational. With sufficient repetition, this would yield a good statistical estimate of the combined and independent effects of varying background and Project contributions to total 24-hour PM_{10}.

The results of the simulation are extracted and the predicted number of days that cumulative 24-hour PM_{10} concentration would exceed certain 24-hour PM_{10} concentrations is determined for each residence.

This is shown in **Figure 7.7** for the worst impacted assessment location close to both the Buttonderry Site (P17) and the Tooheys Road Site (P11). The plots show the cumulative 24-hour PM_{10} concentration compared with the existing background, as discussed in **Section 4.2**.

As shown in **Figure 7.7** there is a very low probability that cumulative 24-hour PM_{10} concentrations would result in any additional days over 50 µg/m^3 compared with those which would occur regardless due to background in the absence of the Project.

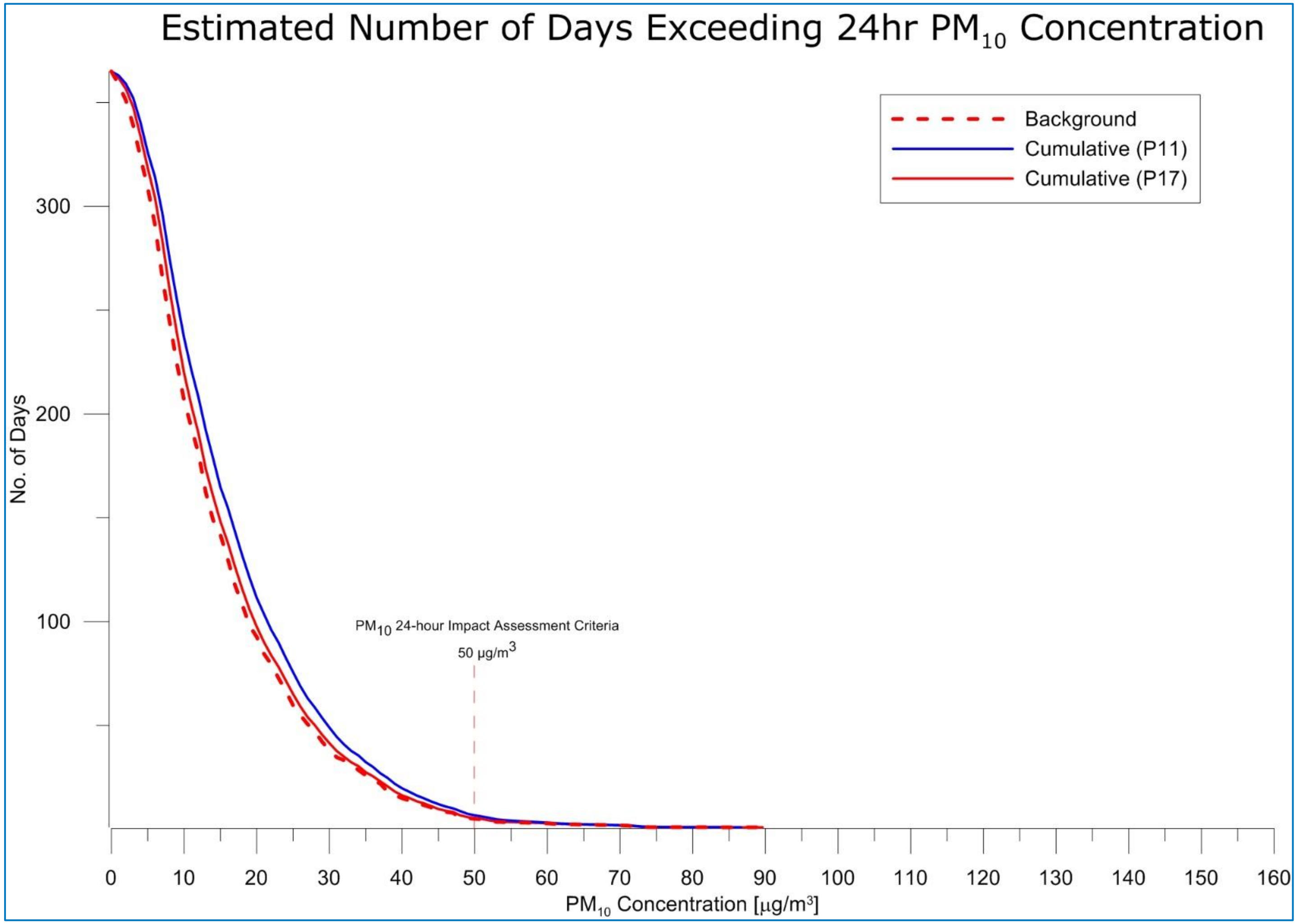


Figure 7.7: Predicted number of days over 24-Hour PM_{10} Concentration at worst impacted residences

7.3.2 Annual Average

The predicted annual average pollutant concentrations at each of the sensitive receptors are added to the adopted background levels calculated in **Section 4.3,** and are presented in **Table 7.2**.

There are no privately owned receivers that are predicted to exceed the annual average assessment criteria when existing background concentrations are included.

Table 7.2: Predicted Cumulative Ground Level Concentrations at Receptor Locations

Receptor ID	Easting	Northing	$PM_{2.5}$ Annual		PM_{10} Annual		TSP Annual		Dust deposition Annual	
			Previous	Current	Previous	Current	Previous	Current	Previous	Current
Units			µg/m³						g/m²/month	
Criteria			8		30		90		4	
P1	357855	6322289	5.0	7.0	18.1	17.2	31.2	33.2	1.6	1.6
P2	357021	6322338	5.0	7.0	18.2	17.2	31.2	33.3	1.6	1.6
P3	356284	6322807	5.1	7.1	18.4	17.5	31.6	33.7	1.6	1.6
P4	354803	6322823	5.1	7.1	18.2	17.3	31.3	33.4	1.7	1.7
P5	353943	6323781	5.0	7.0	18.1	17.1	31.2	33.2	1.6	1.6
P6	355040	6325280	5.1	7.1	18.2	17.2	31.2	33.3	1.6	1.6
P7	355524	6325206	5.1	7.1	18.4	17.4	31.5	33.6	1.6	1.6
P8	355898	6325231	5.1	7.1	18.7	17.8	32.0	34.1	1.7	1.7
P9	356509	6325499	5.2	7.2	19.1	18.3	32.5	34.9	1.7	1.7
P10	357203	6326257	5.1	7.1	18.4	17.5	31.4	33.6	1.6	1.6
P11	356222	6325149	5.3	7.3	19.6	18.7	33.4	35.6	1.7	1.7
P12	359426	6324622	5.1	7.1	18.3	17.4	31.3	33.5	1.6	1.7
P13	351245	6322968	5.1	7.1	18.1	17.1	31.1	33.1	1.6	1.6
P14	351364	6322948	5.1	7.1	18.1	17.1	31.1	33.1	1.6	1.6
P15	351632	6322985	5.2	7.2	18.2	17.2	31.2	33.2	1.6	1.6
P16	351783	6322837	5.3	7.3	18.3	17.3	31.3	33.4	1.6	1.7
P17	351940	6322848	5.5	7.5	18.5	17.5	31.5	33.5	1.7	1.7
P18	351815	6323743	5.2	7.1	18.2	17.2	31.2	33.2	1.6	1.6
P19	351054	6323433	5.1	7.1	18.1	17.1	31.1	33.1	1.6	1.6
P20	351205	6323857	5.1	7.1	18.1	17.1	31.1	33.1	1.6	1.6
P21	351920	6323989	5.1	7.1	18.1	17.1	31.1	33.1	1.6	1.6
P22	351795	6322769	5.3	7.3	18.3	17.3	31.3	33.3	1.6	1.6
P23	351869	6322717	5.2	7.2	18.2	17.3	31.2	33.3	1.6	1.6
P24	352046	6322637	5.2	7.2	18.2	17.2	31.2	33.3	1.6	1.6
P25	352248	6322672	5.2	7.2	18.2	17.2	31.2	33.2	1.6	1.6
P26	352359	6322615	5.1	7.1	18.2	17.2	31.2	33.2	1.6	1.6
P27	352154	6322523	5.1	7.1	18.1	17.2	31.1	33.2	1.6	1.6
P28	352245	6322549	5.1	7.1	18.1	17.1	31.1	33.2	1.6	1.6
P29	352319	6322512	5.1	7.1	18.1	17.1	31.1	33.2	1.6	1.6
P30	352693	6322395	5.1	7.1	18.1	17.1	31.1	33.2	1.6	1.6
P31	352562	6322475	5.1	7.1	18.1	17.1	31.1	33.2	1.6	1.6
P32	352562	6322404	5.1	7.1	18.1	17.1	31.1	33.1	1.6	1.6
P33	352462	6322452	5.1	7.1	18.1	17.1	31.1	33.1	1.6	1.6
P34*	361381	6323610	-	7.0	-	17.1	-	33.1	-	1.6
P35*	361587	6323932	-	7.0	-	17.1	-	33.1	-	1.6
P36*	359671	6324160	-	7.0	-	17.3	-	33.3	-	1.7
P37*	359364	6323755	-	7.0	-	17.3	-	33.4	-	1.7
P38*	358556	6328262	-	7.0	-	17.1	-	33.1	-	1.6
P39*	358831	6328322	-	7.0	-	17.1	-	33.1	-	1.6
P40*	358813	6327963	-	7.0	-	17.1	-	33.1	-	1.6
P41*	358926	6326668	-	7.0	-	17.2	-	33.2	-	1.6
P42*	359543	6326914	-	7.0	-	17.1	-	33.1	-	1.6
P43*	359243	6327014	-	7.0	-	17.1	-	33.1	-	1.6

*Receptor not previously assessed

7.4 Potential Impacts on Proposed Jilliby Subdivision

The Jilliby Stage 2 Land Owners Action Group are proposing a rural residential subdivision immediately west of the proposed Buttonderry Site. The subdivision would involve staged rezoning of approximately 400 hectares north of Sandra St, Jilliby.

Based on the modelling results presented in the sections above, it is not anticipated that the proposed rezoning would result in any significant impact for future residential dwellings as part of the subdivision. The expected air quality impacts on future residential dwellings are expected to be similar to the predictions presented in **Table 7.1** for assessment locations P13 to P21.

8 COAL TRANSPORTATION

The Amended Project will involve:

- Removal of the previously proposed rail loop;
- Re-location of the rail spur and train load out facility to the eastern side of the Main Northern Rail Line; and
- A conveyor system to deliver product coal from the stockpile to the new train load out facility which will facilitate the transportation of coal by rail to the Port of Newcastle.

Dust emissions associated with train loading have been included as part of the modelling assessment of mining operations as described in **Section 6**. Potential impacts from the fugitive dust emissions from coal wagons and diesel emissions from engines during rail transportation have not been quantitatively assessed within the modelling assessment and are discussed below.

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

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

The **Katestone 2012b** study concluded that loaded coal trains were not associated with a statistically significant difference in PM_{10} and $PM_{2.5}$ compared with concentrations when no train passed. Unloaded coal trains were associated with a statistically significant difference in PM_{10} and $PM_{2.5}$ compared with concentrations when no train passed.

A subsequent re-analysis of the data collected for **Katestone 2012b** (**Ryan and Wand, 2014**) found evidence that that particulate levels were elevated when all train types passed by the monitoring station, with the strongest correlation for loaded and unloaded coal trains, for all particle size fractions. **Ryan and Wand (2014)** note that since coal dust is likely to be reflected in the larger particle counts (TSP and PM_{10}) this finding suggested that other contaminants such as diesel may be of more concern than coal dust.

Subsequent to this, additional analysis was completed to incorporate further data in the form of precipitation data from Cessnock and Maitland, and the number of locomotives pulling each train (**Ryan, 2015**). The analysis showed that the number of locomotives had little influence on the increased particulate levels associated with various types of trains passing[b], which dispels, to some extent, the hypothesis that diesel exhaust explains a large proportion of the observed increases in particulate levels associated with train passings. The analysis did however show that particulate levels were significantly influenced by whether or not it had rained the day previous to sample collection at Maitland (but very

[b] Ryan 2015 does state an important caveat from ARTC that the information on the number of locomotives per train is likely to have been reported with some error.

little relationship to rainfall at Cessnock)[c] and this was the same irrespective of train type. Current day rainfall at Maitland was not strongly associated with particulate levels, nor was rainfall at Cessnock. The hypothesis here is that a key mechanism for the increased particulate levels is the resuspension by passing trains of dust particles that had previously settled on the tracks and nearby ground. Particulate levels are higher when any train is passing, as well as during the five minute period after the trains have passed. The magnitude of the increase was found to be similar for freight, loaded coal and unloaded coal trains, and roughly half that magnitude when passenger trains are passing.

For both studies (**Environ, 2012** and **Katestone, 2012b**), PM concentrations were recorded at short distances from the track and for short averaging periods to coincide with train passes, therefore no quantification of impact at residential areas can be inferred from the studies. Notwithstanding this, WACJV is committed to making sure exposed coal in loaded wagons is moistened when loaded to minimise the potential for wind erosion.

To put the potential fugitive emissions from loaded coal trains into context, an estimate has been made as to the levels of PM that may occur. Assuming a loaded train contains a maximum of 60 wagons, each 16.1 m in length and 2 m in width, the total surface area of exposed coal would be just over 1,930 m^2 (0.19 ha). **Katestone (2012a)** suggests that if the product coal is watered as it is loaded to trains, then emissions can be controlled by up to 99%. Assuming a conservative control factor of 50% (allowing time for the coal to dry somewhat en-route to Newcastle), and an emission factor of 0.1 kg/ha/h (**USEPA, 1985**), then the total windblown TSP emissions from loaded coal trains may be of the order of 85 kg/y. Even if no control factor was assumed, windblown TSP emissions would amount to approximately 170 kg/y (TSP), which constitutes less than 0.2 % of the total annual emissions for the worst-case operational year (Year 5), as calculated in **Section 6.2.** Since these emissions would be spread across a large area between the rail load-out and Newcastle, ground level concentrations due to this source would therefore be extremely low. Emissions from loaded coal trains are not considered further in this assessment.

In summary, the rail load-out facility would be designed such that:

- The surface of the product coal will be sprayed with water prior to transportation
- Load size will be limited to ensure that coal deposited into wagons is profiled such that it avoids overfilling and spillage.
- Loading will be such that a consistent profile is maintained.

As noted in **Ryan and Wand (2014),** the findings suggested that other contaminants, such as the products of combustion due to the use of diesel in the locomotives, may be of more concern than coal dust. Whilst it now appears (that the diesel emissions themselves are not a direct cause of the elevated particulate levels measured (**Ryan, 2015**) , Australia currently has no national exhaust standards for new or re-manufactured locomotives.

In order to start addressing this issue, the NSW EPA published a Diesel and Marine Emissions Strategy (the Strategy) in January 2015 (**NSW EPA, 2015**). The Strategy has the objective to '*progressively control and reduce diesel and marine emissions from priority sectors – shipping, locomotives and non-road equipment used by EPA- licensed activities*'.

The Strategy sets out actions that the EPA has implemented and further steps it is taking to ensure that NSW benefits from the availability of feasible and cost-effective approaches and technologies to reduce non-road diesel and marine emissions. With respect to rail locomotives, the Strategy sets the following goals:

- Investigate feasibility and support adoption of new emissions controls for locomotives

[c] It is stated in **Ryan 2015** that these results make sense as the Maitland meteorological station is quite close to the particulate monitoring site.

- Update the NSW regulatory framework to ensure accountability of diesel locomotive operators for improved emissions performance.

Table 8.1 presents a summary of the goals, associated milestones, the original timing for implementation, and the status at April 2016.

Table 8.1: Strategy overview for locomotives

Focus area	Goals	Milestones	Timing per NSW EPA, 2015	Status at April 2016
Rail – locomotives and rail construction	■ Investigate feasibility and support adoption of new emissions control technology for locomotives. ■ Update NSW regulatory framework to ensue accountability of diesel locomotive operators for improved emissions performance.	■ Proposed change to Schedule 1 of POEO Act.	■ 2nd quarter 2015	■ Consultation draft of an amendment expected to be exhibited on the EPA website in early 2016.
		■ Pilot locomotive emission upgrade program	■ Complete by 3rd quarter 2015	■ Preliminary work completed, Stage 2 due end April 2016
		■ Licensing of rolling stock operators and of rail construction activities as separate scheduled activities	■ Expected to commence 4th quarter 2015	■ Consultation draft of an amendment expected to be exhibited on the EPA website in early 2016.

In September 2015, the Hon. Mark Speakman MP, Minister for the Environment, requested the NSW Chief Scientist & Engineer, Professor Mary O'Kane, to undertake a review of rail coal dust emissions management practices in the NSW coal chain in line. The first phase was completed in November 2015 with the release of an Initial Report (**NSW Chief Scientist & Engineer, 2015**). This first phase focussed on scoping the problem and understanding the issues, including community concerns, scientific knowledge, initiatives in NSW and other jurisdictions, and gaps in knowledge. The Initial Review concluded that whilst it was evident that there has been a substantial amount of work over of number of years in the Hunter rail corridor to both measure and reduce dust and particulates, the available studies only provide partial information about specific issues, and no existing studies (or set of studies) can definitely determine if there is a problem. It was identified that the gaps in knowledge exist around localised emissions in or near the rail corridor. Whilst studies indicate that there are increased levels of dust in the rail corridor when some trains pass, there is insufficient knowledge around the composition of the dust, the source of the dust, the quality and concentration, and the dispersion of this dust from the rail corridor. The next phase of the Review has been focussing on how to better understand these unknowns. The final report is stated as being due on 31 March 2016. However, at the time of writing it had not yet been published.

9 GREENHOUSE GAS ASSESSMENT

9.1 Introduction

Greenhouse gas (GHG) emissions have been estimated based on 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**) (GHG Protocol).
- National Greenhouse and Energy Reporting (Measurement) Determination 2008.
- The Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) National Greenhouse Accounts (NGA) Factors August 2015 (**DCCEE, 2015**).

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 emissions from another facility.

A discussion of the types of activities associated with Scope 1, Scope 2 and Scope 3 emissions are detailed in **Section 10.1** of the previous AQGHGA (**PAEHolmes, 2012**).

9.2 Greenhouse Gas Emission Estimates

Emissions of carbon dioxide (CO_2) and 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 CH_4 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 (CO_2-e) emissions by applying the relevant global warming potential. The GHG assessment has been conducted using the National Greenhouse Account (NGA) Factors, published by the **DCCEE (2015)**.

Project-related GHG sources included in the assessment are detailed in **Section 10.2** of the previous AQGHGA (**PAEHolmes, 2012**)

A summary of the annual GHG emissions is provided in **Table 9.1**. Scope 1 emissions over the 28 years assessed remain very similar with to the previous AQGHGA (**PAEHolmes, 2012**). Scope 2 emissions have slightly increased from the previous assessment due to the addition of four conveyor motors which has led to an increase in electricity use. Scope 3 emissions have largely decreased slightly aside from a slight increase in emissions due to energy production.

Full details of all calculations are provided in **Appendix D**.

9.3 GHG Benefits from Flaring and Beneficial Re-Use

Consistent with the previous project design, a proportion of the gas (approximately 35%) will be released via the mine ventilation system (as MVA) as described above. However, the capture and flaring of the remaining CH_4 (pre and post mining) will have significant benefits in terms of reducing GHG emissions.

When compared to 100% fugitive emissions of CH_4, the flaring scenario results in a GHG saving of approximately 5.5 Mt CO_2-e over 28 years (8 Mt CO_2-e over the potential 38 year mine life) or 54% of Scope 1 emissions.

Additional GHG savings would be realised through the use of onsite power generation. Further details of this are provided in **Section 10.3** of the previous AQGHGA (**PAEHolmes, 2012**).

Table 9.1: Summary of Annual Greenhouse Gas Emissions

	Scope 1 Emissions (t CO_2-e)				Scope 2 Emissions (t CO_2-e)	Scope 3 Emissions (t CO_2-e)				
Year	**Diesel**	**Fugitive MVA**	**Flaring**	**Total**	**Electricity**	**Diesel**	**Electricity**	**Energy Production**	**Rail**	**Total**
Year 1	4,803	0	0	4,803	3,881	247	554	0	0	802
Year 2	4,803	0	0	4,803	3,881	247	554	0	0	802
Year 3	91	6,014	1,844	7,949	5,516	5	788	438,712	249	439,754
Year 4	294	19,503	5,980	25,778	9,185	15	1,312	1,422,716	806	1,424,850
Year 5	913	60,514	18,556	79,983	20,337	47	2,905	4,414,387	2,502	4,419,841
Year 6	1,994	132,172	40,530	174,696	39,824	103	5,689	9,641,754	5,464	9,653,010
Year 7	1,654	109,645	33,622	144,921	33,698	85	4,814	7,998,442	4,533	8,007,874
Year 8	1,972	130,677	40,071	172,720	39,418	102	5,631	9,532,696	5,402	9,543,831
Year 9	2,287	151,607	46,489	200,384	45,110	118	6,444	11,059,513	6,268	11,072,343
Year 10	2,050	135,876	41,665	179,591	40,832	106	5,833	9,911,921	5,617	9,923,477
Year 11	2,293	151,947	46,593	200,833	45,202	118	6,457	11,084,299	6,282	11,097,156
Year 12	2,353	155,956	47,823	206,132	46,292	121	6,613	11,376,774	6,447	11,389,956
Year 13	2,366	156,840	48,094	207,300	46,533	122	6,648	11,441,218	6,484	11,454,471
Year 14	2,126	140,904	43,207	186,238	42,199	109	6,028	10,278,754	5,825	10,290,717
Year 15	2,152	142,603	43,728	188,483	42,661	111	6,094	10,402,684	5,895	10,414,785
Year 16	2,050	135,876	41,665	179,591	40,832	106	5,833	9,911,921	5,617	9,923,477
Year 17	2,563	169,887	52,095	224,545	50,081	132	7,154	12,393,000	7,023	12,407,310
Year 18	2,563	169,887	52,095	224,545	50,081	132	7,154	12,393,000	7,023	12,407,310
Year 19	2,563	169,887	52,095	224,545	50,081	132	7,154	12,393,000	7,023	12,407,310
Year 20	2,467	163,499	50,136	216,102	48,344	127	6,906	11,927,023	6,759	11,940,816
Year 21	2,514	166,625	51,094	220,234	49,194	129	7,028	12,155,054	6,888	12,169,100
Year 22	2,461	163,092	50,011	215,563	48,233	127	6,890	11,897,280	6,742	11,911,039
Year 23	2,297	152,219	46,677	201,192	45,276	118	6,468	11,104,128	6,293	11,117,007
Year 24	2,222	147,258	45,156	194,636	43,927	114	6,275	10,742,252	6,088	10,754,730
Year 25	2,162	143,317	43,947	189,426	42,855	111	6,122	10,454,735	5,925	10,466,893
Year 26	2,184	144,744	44,385	191,312	43,243	112	6,178	10,558,836	5,984	10,571,110
Year 27	2,115	140,191	42,989	185,294	42,005	109	6,001	10,226,704	5,796	10,238,609
Year 28	2,185	144,846	44,416	191,447	43,271	113	6,182	10,566,272	5,988	10,578,554
Total	**62,497**	**3,505,584**	**1,074,963**	**4,643,044**	**1,061,990**	**3,219**	**151,713**	**255,727,076**	**144,924**	**256,026,932**

9.4 Impact on the Environment

According to the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report, global surface temperature has increased by 0.89°C ± 0.2°C during the 100 years ending 2012 (**IPCC, 2013**). 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, 2013**).

Climate change projections specific to Australia have been determined by the CSIRO and the Australian Bureau of Meteorology (BoM), based on global emissions scenarios predicted by the latest IPCC assessment (**CSIRO, 2015a**). These projections supersede those released by CSIRO and the BoM in 2007. Although the findings are similar to those of the 2007 projections, the range of emissions scenarios is broader than those used for the 2007 projections. The latest projections begin with concentration levels, rather than socio-economic assumptions followed by inferred emissions.

The projected changes have been prepared for four Representative Concentration Pathways (RCPs), which represent the following scenarios of emissions of greenhouse gases, aerosols and land-use change:

- RCP8.5 (high emissions) - represents a future with little curbing of emissions, with CO_2 concentrations continuing to rapidly rise, reaching 940 parts per million (ppm) by 2100.
- RCP6.0 (intermediate emissions) - represents lower emissions, achieved by application of some mitigation strategies and technologies. This scenario results in the CO_2 concentration rising less rapidly than RCP8.5, but still reaching 660 ppm by 2100.
- RCP4.5 (intermediate emissions) - represents a similar scenario to RCP6.0, but emissions peak earlier (around 2040), and the CO_2 concentration reaches 540 ppm in 2100.
- RCP2.6 (low emissions) - assumes a very strong emissions reductions from a peak at around 2020 to reach a CO_2 concentration at about 420 ppm by 2100. This pathway would require early participation from all emitters, including developing countries, as well as the application of technologies for actively removing carbon dioxide from the atmosphere.

For climate change projections, a regionalisation scheme using natural resource management regional boundaries has been used to divide Australia up into 8 clusters and 15 sub-clusters. For the projections described above, **Table 9.2** presents the changes in annual temperature relative to the 1986-2005 period for the Central Coast sub-cluster where the Project is located.

Table 9.2: Projected Changes in Annual Temperature (relative to the 1986-2005 period)

2030 – RCP2.6 (low emissions scenario)	2030 – RCP4.5 (intermediate emissions scenario)	2030 – RCP8.5 (high emissions scenario)	2090 – RCP2.6 (low emissions scenario)	290 – RCP4.5 (intermediate emissions scenario)	2090 – RCP8.5 (high emissions scenario)
Temperature (°C)					
0.9 (0.6 to 1.2)	1 (0.6 to 1.3)	1.1 (0.7 to 1.5)	1.1 (0.6 to 1.8)	2.1 (1.4 to 2.7)	4.2 (3 to 5.4)

Notes: The table gives the median (50th percentile) change with the 10th and 90th percentile range given within brackets. RCP6.0 is not included due to a smaller sample of model simulations available compared to the other RCPs. (**CSIRO, 2015a**).

Source: **CSIRO (2015b)** Climate Change in Australia – Projections for Australia's NRM Regions – Central Slopes Cluster Report, 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.
- 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 GHG emissions. Average annual scope 1 emissions from the Project (0.5 Mt CO_2-e) would represent approximately 0.1% of Australia's commitment under the original Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global GHG emissions, given that Australia contributed approximately 1.12% of global GHG emissions in 2012 (**PBL Netherlands Environmental Assessment Agency, 2015**).

A comparison of predicted annual GHG emissions from the Project with global, Australian and NSW emissions inventories are presented in **Table 9.3**.

Table 9.3: Comparison of Greenhouse Gas Emissions

Geographic coverage	Source coverage	Timescale	Emissions 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	2014	35,700	PBL Netherlands Environmental Assessment Agency, 2015
Australia	1990 Base	1990	547.7	United Nations Framework on Climate Change – Kyoto Protocol base year data http://unfccc.int/ghg_data/kp_data_unfccc/base_year_data/items/4354.php
Australia	Kyoto target	Average annual 2008 - 2012	591.5	Based on 1990 net emissions multiplied by 108% Australia's Kyoto emissions target.
Australia	Total	2013	538.0	Taken from the National Greenhouse Gas Inventory 2013 http://www.environment.gov.au/system/files/resources/7d7f7ef6-e028-462e-b15c-ede14e222e65/files/national-inventory-report-2013-vol1.pdf
NSW	Total	2013	151.5	Taken from the State and Territory National Greenhouse Gas Inventory (2013) http://www.environment.gov.au/system/files/resources/9e33b185-1fb6-44b7-9d72-6979f3427b94/files/state-territory-inventories-2013.pdf

The commitment from the Australian Government to reduce GHG emissions is proposed to be achieved through the introduction of the Australian Government's *Direct Action Plan*. The centrepiece of the plan is Emissions Reduction Fund which will provide incentives for emissions reduction activities across the Australian economy. The legislation to establish the Emissions Reduction Fund came into effect in December 2014.

9.5 Greenhouse Gas Emissions Intensity

The estimated GHG emissions intensity of the Project is approximately 0.045 t CO_2-e/t ROM coal (scope 1 emissions only). The estimated emissions intensity of the Project is similar to the majority of underground coal mines in Australia (0.05 t CO_2-e/t coal) (scope 1 emissions only) (**Deslandes, 1999**).

Figure 9.1 (derived from **Deslandes, 1999**) shows the GHG intensity of the Project compared to other Australian coal mines.

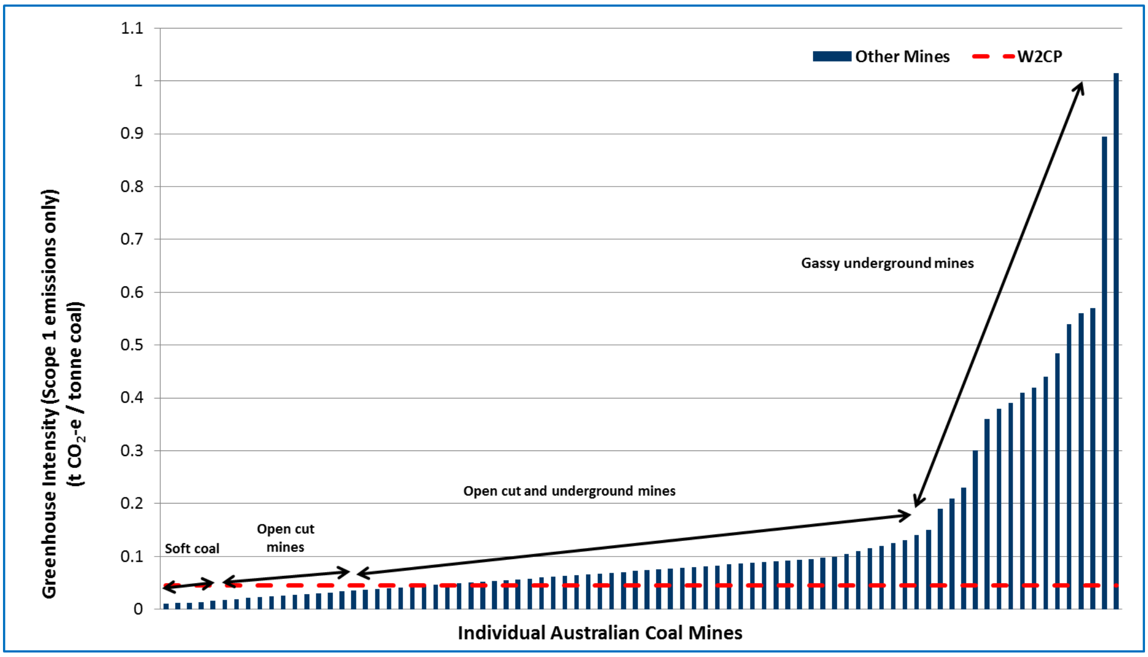


Figure 9.1: GHG Intensity Comparison

It is noted that the Project will not have a coal washery and associated reject emplacement, resulting in reduced demand for electricity and diesel.

9.6 Project Greenhouse Gas and Energy Reduction Measures

As proposed under the previous assessment, the Project will develop an Energy and Greenhouse Strategy within 2 years after the commencement of longwall coal extraction. Further details regarding the Strategy are provided in **Section 10.6** of the previous AQGHGA (**PAEHolmes, 2012**).

10 MANAGEMENT AND MONITORING

10.1 Construction Dust Management

The principal emissions from the construction phase of the Project will be dust and particulate matter, occurring from the following activities:

- Vegetation clearing and earthmoving during site preparation and access road construction;
- Excavation of portal and ventilation shafts and stockpiling of excavated material;
- Excavated material handling, shaping, and bund construction;
- Movement of heavy plant and machinery within the site;
- Graders / scrapers working access road construction; and
- Wind erosion from exposed surfaces.

Procedures for controlling dust impacts during construction have been discussed in **Section 11.1.1** to **Section 11.1.4** of the previous AQGHGA (**PAEHolmes, 2012**).

10.2 Operational Dust Control

Sources of emissions during operation of the Project are described in **Section 6.2** and **Table 6.3.**

Based on the predicted impacts from the Project, the proposed management measures, developed in accordance with the NSW EPA best practice document '*NSW Coal Mining Benchmarking Study: International Best Practice Measures to Prevent and/or Minimise Emissions of Particulate Matter from Coal Mining*' (**Donnelly et al., 2011**), are considered feasible and reasonable.

10.3 Monitoring

A discussion of the proposed monitoring activities to occur is provided in **Section 11.3** of the previous AQGHGA (**PAEHolmes, 2012**).

11 CONCLUSION

Pacific Environment has completed an Air Quality and Greenhouse Gas Assessment for the Amended Project in accordance with the requirements as identified throughout the planning approvals process.

The key air quality issues assessed are emissions of dust during the operation of the Project. During construction, fugitive dust emissions can also be expected, however the total estimated TSP emissions are less than 85% of the emissions estimated to occur during operation of the Project. Therefore compliance with air quality goals during the operation of the mine is assumed to represent compliance during mine construction.

Dispersion modelling was conducted for a maximum annual production scenario to predict the ground level concentrations for all relevant pollutants. Maximum daily emissions at each receiver assessed were estimated using the ratios from the maximum daily production scenario and maximum annual production scenarios at each receptor obtained from the previous modelling (**PAEHolmes, 2012**). This ratio was applied to the modelled results from the maximum production scenario at each receptor under the current modelling to assess the glcs resulting from maximum daily production.

The results of the modelling indicate that the predicted incremental PM_{10}, $PM_{2.5}$, TSP and dust deposition at the closest residential receptors are all below the impact assessment criteria. The highest predicted glcs occur at the closest residence to the north of the Tooheys Road Site (P11) and the receptor closest to the Buttonderry Site (P17).

A cumulative assessment, incorporating existing background levels, indicates that the Project is unlikely to result in any additional exceedances of relevant impact assessment criteria at the neighbouring receivers.

Emissions to air associated with the flaring of methane and use in power generation would not change from the previous assessment (see **Section 7.3** of the Air Quality and Greenhouse Gas Assessment (**PAEHolmes, 2012**). Additionally, odour impacts are not expected to significantly change as a result of the Amendment.

An assessment of the GHG emissions associated with the Project indicates that average annual scope 1 emissions would represent approximately 0.04% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small portion of global greenhouse emissions.

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Appendix A ASSESSMENT LOCATIONS AND LAND OWNERSHIP

Assessment Location ID	Easting	Northing	Owner Name
1	357855	6322289	STEVEN BARRY MCKEOGH & SIEW TING MCKEOGH
2	357021	6322338	ARTHUR ROBERT MUNROE & SUSAN JOAN MUNRO
3	356284	6322807	JT & KE HUTCHINSON
4	354803	6322823	STANDARD INDUSTRIES PTY LIMITED
5	353943	6323781	DELCARE CONSTRUCTIONS PTY LIMITED
6	355040	6325280	WYONG COAL PTY LIMITED
7	355524	6325206	BJ & KR DRAKE
8	355898	6325231	N & A IORDANIDIS
9	356509	6325499	DJC SUAREZ
10	357203	6326257	NORMAN JAMES HAWKINS & ADA MARIE HAWKINS
11	356222	6325149	KR DRAKE
12	351245	6322968	AT ETHELL
13	359426	6324622	N/A Representative of Bluehaven Residential Area
14	351364	6322948	ZS MUSLU
15	351632	6322985	C TOHAMY & MUSLIM COMMUNITY CO-OPERATIVE (AUSTRALIA) LTD
16	351783	6322837	S WONG & S LIN & PH LEE
17	351940	6322848	LA & R ATCHISON
18	351815	6323743	EM DUNN
19	351054	6323433	KG & KA MACDONALD
20	351205	6323857	MJ BAULCH
21	351920	6323989	F & EM MERCIECA
22	351795	6322769	CJ CAMPBELL & EI HINSON
23	351869	6322717	J EDINGTON
24	352046	6322637	RW & CP & BW IKIN
25	352248	6322672	WYONG COAL PTY LIMITED
26	352359	6322615	WYONG COAL PTY LIMITED
27	352154	6322523	CJ & L BAUERHUIT
28	352245	6322549	JF & AP RITCHIE
29	352319	6322512	ME & JE WALTERS
30	352693	6322395	HELI-AUST LAND HOLDINGS PTY LTD
31	352562	6322475	B & B MITROVIC
32	352562	6322404	J & R DIMIS
33	352462	6322452	RO & AE HOLLAND
34	361381	6323610	NORTHLAKES HIGH SCHOOL
35	361587	6323932	NORTHLAKES PUBLIC SCHOOL
36	359671	6324160	36 TURNER CLOSE, BLUE HAVEN
37	359364	6323755	109 BIRDWOOD DR, BLUE HAVEN
38	358556	6328262	WYEE PUBLIC SCHOOL
39	358831	6328322	WYEE UNION CHURCH
40	358813	6327963	SEVENTH-DAY ADVENTIST CHURCH WYEE
41	358926	6326668	555 BUSHELLS RIDGE ROAD, BUSHELLS RIDGE
42	359543	6326914	259 WYEE ROAD, WYEE
43	359243	6327014	16 GOSFORD ROAD, WYEE

Appendix B MODEL SET UP

Model Set Up

TAPM (v 4.0.4)	
Number of grids (spacing)	4 (30 km, 10 km, 3 km, 1 km)
Number of grid points	43 x 43 x 35
Year of analysis	Jul 2010 – Jun 2011
Centre of analysis (local coordinates)	354890, 6323821
CALMET (v. 6.42)	
Meteorological grid domain	30 km x 30 km
Meteorological grid resolution	250 m
Input data	Surface station data from Wallarah, Cooranbong, Norah Head and cloud cover and height from Williamtown. Prognostic 3D.dat extracted from TAPM at 1 km grid

CALMET Model Options used

Flag	Descriptor	Default	Value Used
IEXTRP	Extrapolate surface wind observations to upper layers	Similarity theory	Similarity theory
BIAS (NZ)	Relative weight given to vertically extrapolated surface observations versus upper air data	NZ * 0	-1, -0.5, -0.25, 0, 0, 0, 0
TERRAD	Radius of influence of terrain	No default (typically 5- 15km)	6 km
RMAX1 and RMAX2	Maximum radius of influence over land for observations in layer 1 and aloft	No Default	2.5 km
R1 and R2	Distance from observations in layer 1 and aloft at which observations and Step 1 wind fields are weighted equally	No Default	2.5 km

CALPUFF Model Options used

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

Appendix C ESTIMATED EMISSIONS

Wallarah 2 Coal Project

Estimated emissions are presented for all significant dust generating activities associated with the construction and operation of the Project.

Fugitive dust emissions can be expected during construction from the following activities:

- excavation of material for the box cut, ventilation shafts and ROM stockpile area;
- loading of material to trucks and transport within site;
- dozers on excavated material; and
- graders working road construction.

Fugitive dust emissions can be expected during operation from the following activities:

- loading stockpile from conveyor;
- wind erosion and maintenance on stockpiles; and
- upcast ventilation shafts.

Loading / dumping waste rock

Each tonne of material loaded will generate a quantity of particulate matter that will depend on the wind speed and the moisture content according to the US EPA emission factor equation (**US EPA, 1985 and updates**) shown below:

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

Where:

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

U – wind speed (m/s)

M – moisture content (%)

The moisture content of waste material is assumed to be 5% and the wind speed of 1.3 m/s is taken from the measured wind at the Wallarah AWS for the period July 2010 – June 2011.

Hauling material / coal on unsealed surfaces

The emission estimate of wheel generated dust associated with hauling at the pit top areas (i.e. for hauling of waste rock material during construction is based the US EPA AP42 emission equation for unpaved surfaces at industrial sites (**US EPA, 1985 and updates**) shown below:

$$E\ \ (kg/VKT) = 0.2819 \times k \times [\ \times (s/12)^\wedge 0.7 \times ((W \times 1.1023)/3)^\wedge 0.45]$$

Where:

k = 4.9 for TSP, 1.5 for PM_{10} and 0.015 for $PM_{2.5}$

s = silt content of road surface

W = mean vehicle weight

The silt content (s) for the haulage routes is assumed to be 4%.

The mean vehicle weight used in the emissions estimates is an average of the loaded and unloaded gross vehicle mass, to account for one empty trip and one loaded trip. Haul trucks carrying waste during construction are assumed to have a payload of 136 t and a tare weight of 181 t.

Dozers working on waste rock

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

$$E(kg/hr) = k \times \frac{s^{1.2}}{M^{1.3}}$$

Where:

k = 2.6 for TSP, 0.3375 for PM_{10} and 0.0273 for $PM_{2.5}$

s = silt content (assumed to be 10%)

M = moisture content (assumed to be 2%).

Active Stockpiles – Wind Erosion and Maintenance

The following **US EPA (1985 and updates)** emission factor equation has been used for wind erosion.

$$E_{TSP}\ (kg/ha/hr) = 1.8\ x\ U$$

Where:

U= mean wind speed (m/s) and is taken as 1.3 m/s from the Wallarah meteorological site.

For PM_{10} this is multiplied by a factor of 0.5 and for 0.075 for $PM_{2.5}$.

Estimated emissions of TSP during Operations

ACTIVITY - Operations (Annual)	TSP Emission kg/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Assumptions
Tooheys Road Site																		
CL - Conveyor transfer @ Portal	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA.
CL - Conveyor transfer to ROM stockpile	248	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	70% control to reflect two sides and a roof.
CL - Loading ROM stockpile from conveyor	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA
CL - Active ROM Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	13,324	1.3	ha	2.34	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.
CL - Conveyor transfer to Crushing Station	248	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 70% control to reflect 3 enclosed sides.
CL - Processing - Crushing Station	450	5000000	t/y	0.0006	kg/t											70	% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 70% control to reflect 3 enclosed sides.
CL - Conveyor transfer between crusher and stockpile	124	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 70% control to reflect 3 enclosed sides.
CL - Conveyor transfer to Product stockpile	248	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.4	5	moisture content in %							70	% control	70% control to reflect two sides and a roof plus 50% control from water sprays
CL - Loading Product stockpile from conveyor gantry	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA
CL - Active Product Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	48,171	4.7	ha	2.34	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.
CL - Loading from Product Stockpile to Conveyor	828.2902849	5000000	t/y	0.00016566	kg/t	0.50463	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA
CL - Unloading material at transfer points	124.2435427	5000000	t/y	0.00016566	kg/t	0.50463	average of (wind speed/2.2)^1.3	5	moisture content in %							85	% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. Control assumed for fully enclosed transfer points and the use of
Conveying from stockpiles to train load out bin	248.4870855	5000000	t/y	0.00016566	kg/t	0.50463	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. 70% control to reflect 2 sides and a roof.
Transfer from conveyor to train load out bin	248.4870855	5000000	t/y	0.00016566	kg/t	0.50463	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA; 70% control for enclosure
CL - Loading Trains from Train Load Out Bin	828	5,000,000	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. No controls for stockpile loading
Buttonderry Site																		
Ventilation Shaft	23,337	11,668	10^6 m3/yr	2.0000	TSP Conc. (mg/m3)	8760	h/y	3600	s/hour	370	Flow Rate (m3/s)						% control	Flow rate take from 2008 EA. Particulate concentration for Vent Shaft taken from measurements at Tasman Underground Mine (HAS, 2007)
Total Annual TSP (kg)	**90,914**																	

Estimated emissions of PM_{10} during Operations

ACTIVITY - Operations (Annual)	PM10 Emission kg/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Assumptions
Tooheys Road Site																		
CL - Conveyor transfer @ Portal	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.2	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA.
CL - Conveyor transfer to ROM stockpile	118	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	70% control to reflect two sides and a roof.
CL - Loading ROM stockpile from conveyor	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA
CL - Active ROM Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	6,662	1.3	ha	1.17	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.
CL - Conveyor transfer to Crushing Station	118	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 70% control to reflect 3 enclosed sides.
CL - Processing - Crushing Station	405	5,000,000	t/y	0.00027	kg/t											70	% control	70% ontrol assumed for full enclosure of crushing station. Wet supression emission factor used as water controls will be used.
CL - Conveyor transfer between crusher and stockpile	118	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.2	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 70% control to reflect 3 enclosed sides.
CL - Conveyor transfer to Product stockpile	118	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	70% control to reflect two sides and a roof.
CL - Loading Product stockpile from conveyor gantry	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA
CL - Active Product Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	24,086	4.7	ha	1.17	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.
CL - Loading from Product Stockpile to Conveyor	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA
CL - Unloading material at transfer points	59	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							85	% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. 70% control assumed for fully enclosed transfer points.
Conveying from stockpiles to train load out bin	118	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. 70% control to reflect 2 sides and a roof.
Transfer from conveyor to train load out bin	118	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA
CL - Loading Trains from Train Load Out Bin	392	5,000,000	t/y	0.0001	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. No controls for stockpile loading
Buttonderry Site																		
Ventilation Shaft	23,337	11,668	10^6 m3/yr	2.0000	TSP Conc. (mg/m3)	8760	h/y	3600	s/hour	370	Flow Rate (m3/s)						% control	Flow rate take from 2008 EA. Particulate concentration for Vent Shaft taken from measurements at Tasman Underground Mine (HAS, 2007)
Total Annual PM10 (kg)	**57,212**																	

Estimated emissions of $PM_{2.5}$ during Operations

ACTIVITY - Operations (Annual)	PM2.5 Emission kg/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Assumptions	Source type
Tooheys Road Site																			
CL - Conveyor transfer @ Portal	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA.	1
CL - Conveyor transfer to ROM stockpile	18	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	70% control to reflect 3 enclosed sides.	2
CL - Loading ROM stockpile from conveyor	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA	2
CL - Active ROM Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	999	1.3	ha	0.1755	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.	2
CL - Conveyor transfer to Crushing Station	18	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 70% control to reflect 3 enclosed sides.	2
CL - Processing - Crushing Station	75	5,000,000	t/y	0.00005	kg/t											70	% control	70% ontrol assumed for full enclosure of crushing station. Wet supression emission factor used as water controls will be used.	1
CL - Conveyor transfer between crusher and stockpile	18	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2009 EA. 70% control to reflect 3 enclosed sides.	1
CL - Conveyor transfer to Product stockpile	18	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	70% control to reflect 3 enclosed sides.	2
CL - Loading Product stockpile from conveyor gantry	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA	2
CL - Active Product Stockpiles (wind erosion and maintenance - assumes maintenance by FEL/Dozer)	3,613	4.7	ha	0.1755	kg/ha/hr	8760	h/y	1.3	average wind speed m/s							50	% control	Area of stockpile taken supplied DXF. Control assumed for fixed water sprays.	2
CL - Loading from Product Stockpile to Conveyor	59.32349338	5000000	t/y	1.1865E-05	kg/t	0.50463	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA	2
CL - Unloading material at transfer points	8.898524007	5000000	t/y	1.1865E-05	kg/t	0.50463	average of (wind speed/2.2)^1.3	5	moisture content in %							85	% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. 70% control assumed for fully enclosed transfer points.	2
Conveying from stockpiles to train load out bin	17.79704801	5000000	t/y	1.1865E-05	kg/t	0.50463	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. 70% control to reflect 2 sides and a roof.	2
Transfer from conveyor to train load out bin	17.79704801	5000000	t/y	1.1865E-05	kg/t	0.50463	average of (wind speed/2.2)^1.3	5	moisture content in %							70	% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA	2
CL - Loading Trains from Train Load Out Bin	59	5,000,000	t/y	0.000012	kg/t	0.50	average of (wind speed/2.2)^1.3	5	moisture content in %								% control	Intensity assumed for max production year. Moisture content of coal as per 2008 EA. No controls for stockpile loading	2
Buttonderry Site																			
Ventilation Shaft	23,337	11,668	10^6 m3/yr	2.0000	TSP Conc. (mg/m3)	8760	h/y	3600	s/hour	370	Flow Rate (m3/s)						% control	Flow rate take from 2008 EA. Particulate concentration for Vent Shaft taken from measurements at Tasman Underground Mine (HAS, 2007)	1
Total Annual PM2.5 (kg)	**28,436**																		

Estimated emissions of TSP during Construction

ACTIVITY - Construction	TSP Emission kg/year	Intensity	units	Emission factor	units	Variable 1	units	Variable 2	units	Variable 3	units	Variable 4	units	Variable 5	units	Variable 6	units	Assumptions	Source type
Tooheys Road Site																			
Dozer clearing vegetation	11,583	692	h/y	16.74	kg/h	10	silt content in %	2	moisture content in %									As per previous assessment - generally retained assumption from 2008 EA: - amounts of excavated material - dozer hours - moisture contents - trip distances Updated the following: - hauling emission equation -topsoil silt content - updated truck payload and vehicle gross mass based on CAT785. Drift material will now go from drift to crusher and conveyed to rail spur (per Andrew Wu email 8/3/16)	1
Loading of excavated material to trucks	69	304,550	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	4	moisture content in %										2
Hauling of excavated material to trucks	2,729	304,550	t/y	0.036	kg/t	28	t/truck load	38	Vehicle gross mass (t)	0.5	km/return trip	2.0	kg/VKT	4	% silt conten	75	% control		1
Hauling of drift material from drift to crusher by truck	3,431	382,883	t/y	0.036	kg/t	28	t/truck load	38	Vehicle gross mass (t)	0.5	km/return trip	0.3	kg/VKT	4	% silt conten	75	% control		2
CL - Processing - Crushing Station	69	382,883	t/y	0.0006	kg/t											70	% control		1
CL - Conveyor transfer of drift material from crusher to rail spur	87	382,883	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.2	4	moisture content in %								% control		1
Dumping of excavated material	156	687,433	t/y	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	4	moisture content in %										2
FEL / Dozer Shaping	6,525	960	t/y	6.8	kg/h	10	silt content in %	4	moisture content in %										1
Wind erosion - exposed areas	24,528	7	ha	0.4	kg/ha/hr														3
Buttonderry Site																			
Dozer clearing vegetation	4,820	288	h/y	16.74	kg/h	10	silt content in %	2	moisture content in %										1
Loading of excavated material to trucks	33	146,850	t	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	4	moisture content in %										2
Hauling of excavated material to trucks	1,316	146,850	t/y	0.036	kg/t	28	t/truck load	38	Vehicle gross mass (t)	0.5	km/return trip	2.0	kg/VKT	4	% silt conten	75	% control		1
Dumping of excavated material	33	146,850	t	0.0002	kg/t	0.50	average of (wind speed/2.2)^1.3	4	moisture content in %										2
FEL / Dozer Shaping	6,525	960	t/y	6.8	kg/h	10	silt content in %	4	moisture content in %										1
Wind erosion	14,016	4	ha	0.4	kg/ha/hr														3
Total Annual TSP (kg)	**75,919**																		

Appendix D ESTIMATION OF GREENHOUSE GAS EMISSIONS

D.1 FUEL CONSUMPTION

GHG 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 (Q) in each year is based on a diesel intensity rate of 0.19 L diesel/t ROM). Diesel consumption during construction (Year 1 and Year 2) is based on the assumption that 1780 kl/year is required. 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).

GHG emission factors and energy content for diesel were sourced from the NGA Factors (**DCCEE, 2015**). The estimated annual and Project total GHG emissions from diesel usage are presented in **Table D.1**.

Table D.1: Estimated CO_2-e (tonnes) for diesel consumption

Year	Diesel (kL)	Emissions (t CO_2-e)		
		Scope 1	Scope 3	Total
Year 1	1,780	4,803	247	5,050
Year 2	1,780	4,803	247	5,050
Year 3	34	91	5	95
Year 4	109	294	15	309
Year 5	338	913	47	960
Year 6	739	1,994	103	2,097
Year 7	613	1,654	85	1,740
Year 8	731	1,972	102	2,073
Year 9	848	2,287	118	2,405
Year 10	760	2,050	106	2,156
Year 11	850	2,293	118	2,411
Year 12	872	2,353	121	2,474
Year 13	877	2,366	122	2,488
Year 14	788	2,126	109	2,235
Year 15	797	2,152	111	2,262
Year 16	760	2,050	106	2,156
Year 17	950	2,563	132	2,695
Year 18	950	2,563	132	2,695
Year 19	950	2,563	132	2,695
Year 20	914	2,467	127	2,594
Year 21	932	2,514	129	2,643
Year 22	912	2,461	127	2,587
Year 23	851	2,297	118	2,415
Year 24	823	2,222	114	2,336
Year 25	801	2,162	111	2,274
Year 26	809	2,184	112	2,296
Year 27	784	2,115	109	2,224
Year 28	810	2,185	113	2,298
Total	**23,163**	**62,497**	**3,219**	**65,716**

D.2 ELECTRICITY

GHG emissions from electricity usage were estimated using the following equation:

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

where:

E_{CO2-e}	=	Emissions of GHG from electricity usage	(tCO_2-e/annum)
Q	=	Estimated electricity usage	(kWh/annum)[1]
EF	=	Emission factor (Scope 2 or Scope 3) for electricity usage	($kgCO_2$-e/kWh)[2]

[1] kWh/annum = kilowatt hours per annum

[2] $kgCO_2$-e/kWh = kilograms of carbon dioxide equivalents per kilowatt hour

The quantity of electricity used each year is based on an intensity rate of 11 kWh/tpa ROM. GHG emission factors were sourced from the NGA Factors (**DCCEE, 2015**). The estimated annual and Project total GHG emissions from electricity usage are presented in **Table D.2**.

TableD.2: Estimated CO_2-e (tonnes) for electricity

Year	Electricity (kWhr)	Emissions (t CO2-e)		
		Scope 2	Scope 3	Total
Year 1	4,620,000	3,881	554	4,435
Year 2	4,620,000	3,881	554	4,435
Year 3	6,567,000	5,516	788	6,304
Year 4	10,934,000	9,185	1,312	10,497
Year 5	24,211,000	20,337	2,905	23,243
Year 6	47,410,000	39,824	5,689	45,514
Year 7	40,117,000	33,698	4,814	38,512
Year 8	46,926,000	39,418	5,631	45,049
Year 9	53,702,000	45,110	6,444	51,554
Year 10	48,609,000	40,832	5,833	46,665
Year 11	53,812,000	45,202	6,457	51,660
Year 12	55,110,000	46,292	6,613	52,906
Year 13	55,396,000	46,533	6,648	53,180
Year 14	50,237,000	42,199	6,028	48,228
Year 15	50,787,000	42,661	6,094	48,756
Year 16	48,609,000	40,832	5,833	46,665
Year 17	59,620,000	50,081	7,154	57,235
Year 18	59,620,000	50,081	7,154	57,235
Year 19	59,620,000	50,081	7,154	57,235
Year 20	57,552,000	48,344	6,906	55,250
Year 21	58,564,000	49,194	7,028	56,221
Year 22	57,420,000	48,233	6,890	55,123
Year 23	53,900,000	45,276	6,468	51,744
Year 24	52,294,000	43,927	6,275	50,202
Year 25	51,018,000	42,855	6,122	48,977
Year 26	51,480,000	43,243	6,178	49,421
Year 27	50,006,000	42,005	6,001	48,006
Year 28	51,513,000	43,271	6,182	49,452
Total	**1,264,274,000**	**1,061,990**	**151,713**	**1,213,703**

D.3 FUGITIVE METHANE

Emissions from fugitive CH_4 were estimated using the following equation:

$$E_{co2-e} = Q \times EF$$

where:

E_{CO2-e}	=	Emissions of GHG 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)

A site specific emission factor (EF) of 0.1 t CO_2-e/tonne has been determined based on gas content testing (**GeoGas, 2002**). The measured average gas content of 7.6 m^3/t (**GeoGas, 2002**) was converted to CO_2-e based on the National Greenhouse and Energy Reporting System (NGERS) methodology (Division 3.2.2, Subdivision 3.2.2.2 Method 4) (**DCC, 2014**).

It is assumed that of the total measured gas content, approximately 35% would be emitted via mine ventilation air. The remaining 65% (pre drainage and post drainage) would be flared. The estimated annual and Project total GHG emissions from fugitive CH_4 are presented in **Table D.3.**

Table D.3: Estimated CO2-e (tonnes) for fugitive methane and flaring

Year	ROM (tpa)	Scope 1 Emissions (t CO2-e)	
	(tpa)	Flaring (Pre and Post Drainage)	Fugitive (MVA)
Year 1	0	0	0
Year 2	0	0	0
Year 3	177,000	1,844	6,014
Year 4	574,000	5,980	19,503
Year 5	1,781,000	18,556	60,514
Year 6	3,890,000	40,530	132,172
Year 7	3,227,000	33,622	109,645
Year 8	3,846,000	40,071	130,677
Year 9	4,462,000	46,489	151,607
Year 10	3,999,000	41,665	135,876
Year 11	4,472,000	46,593	151,947
Year 12	4,590,000	47,823	155,956
Year 13	4,616,000	48,094	156,840
Year 14	4,147,000	43,207	140,904
Year 15	4,197,000	43,728	142,603
Year 16	3,999,000	41,665	135,876
Year 17	5,000,000	52,095	169,887
Year 18	5,000,000	52,095	169,887
Year 19	5,000,000	52,095	169,887
Year 20	4,812,000	50,136	163,499
Year 21	4,904,000	51,094	166,625
Year 22	4,800,000	50,011	163,092
Year 23	4,480,000	46,677	152,219
Year 24	4,334,000	45,156	147,258
Year 25	4,218,000	43,947	143,317
Year 26	4,260,000	44,385	144,744
Year 27	4,126,000	42,989	140,191
Year 28	4,263,000	44,416	144,846
Total	**103,174,000**	**1,074,963**	**3,505,584**

D.4 VEGETATION CLEARING

There is minimal vegetation stripping required for the Project (restricted to small areas around the surface infrastructure) and there GHG emissions due to vegetation clearance have not been calculated. This is consistent with the previous assessment.

D.5 PRODUCT COAL TRANSPORTATION

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**). 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 120 km. The total estimated GHG emissions from rail transport of product coal are provided in **Table D.4.**

Table D.4: Estimated CO_2-e (tonnes) for product coal transportation

Year	Product Coal (tpa)	Scope 3 Emissions (t CO2-e)
Year 1	0	0
Year 2	0	0
Year 3	177,000	249
Year 4	574,000	806
Year 5	1,781,000	2,502
Year 6	3,890,000	5,464
Year 7	3,227,000	4,533
Year 8	3,846,000	5,402
Year 9	4,462,000	6,268
Year 10	3,999,000	5,617
Year 11	4,472,000	6,282
Year 12	4,590,000	6,447
Year 13	4,616,000	6,484
Year 14	4,147,000	5,825
Year 15	4,197,000	5,895
Year 16	3,999,000	5,617
Year 17	5,000,000	7,023
Year 18	5,000,000	7,023
Year 19	5,000,000	7,023
Year 20	4,812,000	6,759
Year 21	4,904,000	6,888
Year 22	4,800,000	6,742
Year 23	4,480,000	6,293
Year 24	4,334,000	6,088
Year 25	4,218,000	5,925
Year 26	4,260,000	5,984
Year 27	4,126,000	5,796
Year 28	4,263,000	5,988
Total	**103,174,000**	**144,924**

Consistent with the previous assessment, 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.

D.6 ENERGY PRODUCTION FROM PRODUCT 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 saleable coal is based on the production rate in tpa. This is converted to GJ using an energy content factor for black coal of 27 GJ/t. The GHG emission factor and energy content for coal were sourced from the NGA Factors (**DCCEE, 2015**).

The emissions associated with the use of the product coal are presented in **Table D.5**.

Table D.5: Scope 3 emissions for energy production from product coal

Year	Product Coal (tpa)	Scope 3 Emissions (t CO2-e)
Year 1	0	0
Year 2	0	0
Year 3	177,000	438,712
Year 4	574,000	1,422,716
Year 5	1,781,000	4,414,387
Year 6	3,890,000	9,641,754
Year 7	3,227,000	7,998,442
Year 8	3,846,000	9,532,696
Year 9	4,462,000	11,059,513
Year 10	3,999,000	9,911,921
Year 11	4,472,000	11,084,299
Year 12	4,590,000	11,376,774
Year 13	4,616,000	11,441,218
Year 14	4,147,000	10,278,754
Year 15	4,197,000	10,402,684
Year 16	3,999,000	9,911,921
Year 17	5,000,000	12,393,000
Year 18	5,000,000	12,393,000
Year 19	5,000,000	12,393,000
Year 20	4,812,000	11,927,023
Year 21	4,904,000	12,155,054
Year 22	4,800,000	11,897,280
Year 23	4,480,000	11,104,128
Year 24	4,334,000	10,742,252
Year 25	4,218,000	10,454,735
Year 26	4,260,000	10,558,836
Year 27	4,126,000	10,226,704
Year 28	4,263,000	10,566,272
	103,174,000	**255,727,076**