PEMBROKE

Olive Downs Coking Coal Project

Draft Environmental Impact Statement

Appendix G

Air Quality and Greenhouse Gas Assessment

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Air Quality and Greenhouse Gas Assessment of the Olive Downs Coking Coal Project

Prepared for:

Pembroke Olive Downs Pty Ltd

July 2018

Final

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Glossary

Term	Definition
µg/m³	micrograms per cubic metre
µm	microns
°C	degrees Celsius
g/s	grams per second
km	kilometres
km/h	kilometres per hour
m	metres
mm	millimetres
m/s	metres per second
m²	square metres
m³	cubic metres
mg/m²/day	milligrams per square metre per day
m³/s	cubic metres per second
Mtpa	million tonnes per annum
t/year	tonnes per year
Nomenclature	**Definition**
PM_{10}	particulate matter with a diameter less than 10 micrometres
$PM_{2.5}$	particulate matter with a diameter less than 2.5 micrometres
TSP	total suspended particles
Abbreviations	**Definition**
Air EPP	*Environmental Protection (Air) Policy 2008*
BoM	Bureau of Meteorology
DES	Department of Environment and Science
EIS	Environmental Impact Statement
EF	Emission Factor
EP Act	*Environmental Protection Act 1994*
ER	Emission Rate
GHG	Greenhouse Gas
ML	Mine Lease
NGER Act	*National Greenhouse and Energy Reporting Act 2007*
NPI	National Pollutant Inventory database
Pembroke	Pembroke Olive Downs Pty Ltd
ROM	Run of Mine
TAPM	The Air Pollution Model
ToR	Terms of Reference

EXECUTIVE SUMMARY

Katestone Environmental Pty Ltd (Katestone) was commissioned by Pembroke Olive Downs Pty Ltd (Pembroke) to complete an air quality and greenhouse gas assessment for the Olive Downs Coking Coal Project (the Project), a proposed open-cut coal mine located 40 km south-east of Moranbah in central Queensland.

The Project comprises the Olive Downs and Willunga domains, which contain high quality metallurgical coal resources within the Bowen Basin mining precinct. Up to 20 Mtpa of Run of Mine (ROM) coal would be extracted through open cut methods over the anticipated operational life of 79 years.

An air quality assessment has investigated the potential for the Project to affect air quality in the region. Four scenarios (Years 2027, 2043, 2066 and 2085) have been considered that represent worst-case emission scenarios over four distinct years during the life of the Project. Selection of the four scenarios was based on the proposed mining schedule and the proximity of sensitive receptors to critical emissions generating activities. The assessment has used meteorological and dispersion models to assess the effect of emissions of particulate matter on concentrations of TSP[1], PM_{10}[2], $PM_{2.5}$[3] and dust deposition rate on the surrounding region due to the Project.

Air quality levels due to operations of the Project in isolation, and with the inclusion of background levels of dust, were determined at identified sensitive receptors and on a grid of evenly-spaced receptors covering the region. Predicted ground-level concentrations and deposition rates were compared with the relevant air quality objectives and guidelines.

The air quality assessment of the Project found the following:

TSP

- Predicted concentrations of TSP ***comply*** with the relevant air quality objective at all sensitive receptors, in all modelled Project scenarios, in isolation and cumulatively.

PM_{10}

- Predicted concentrations of PM_{10} due to the Project ***comply*** with the relevant air quality objective at all sensitive receptors in all Project scenarios, in isolation and cumulatively, with the application of standard mitigation measures and the proposed proactive and reactive mitigation measures.

$PM_{2.5}$

- Predicted 24-hour average concentrations of $PM_{2.5}$ due to the Project ***comply*** with the relevant air quality objective at all sensitive receptors, for all modelled Project scenarios, in isolation and cumulatively.

- Predicted annual average concentrations of $PM_{2.5}$ due to the Project ***comply*** with the relevant air quality objective at all sensitive receptors, for all modelled Project scenarios, in isolation and cumulatively.

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1 Total suspended particles.

2 Particulate matter with an equivalent aerodynamic diameter 10 micrometres or less.

3 Particulate matter with an equivalent aerodynamic diameter 2.5 micrometres or less.

Dust Deposition

- Predicted dust deposition rates due to the Project ***comply*** with the guideline at all sensitive receptors, for all modelled Project scenarios, in isolation and cumulatively.

The greenhouse gas assessment of the Project found the following:

- Maximum annual greenhouse gas emissions associated with the Project are estimated to be 2,249 kt CO2-e (Year 2035), while average annual GHG emission have been estimated to be 910 kt CO2-e over the life of mine.
- Greenhouse gas emissions from the Project are predominantly due to diesel use (66%), electricity generation (indirect emissions) (17%) and fugitive methane releases (17%).
- Compared to national and state greenhouse gas inventory levels, the maximum annual GHG emissions from the Project would account for approximately 0.4% and 2.2%, respectively.

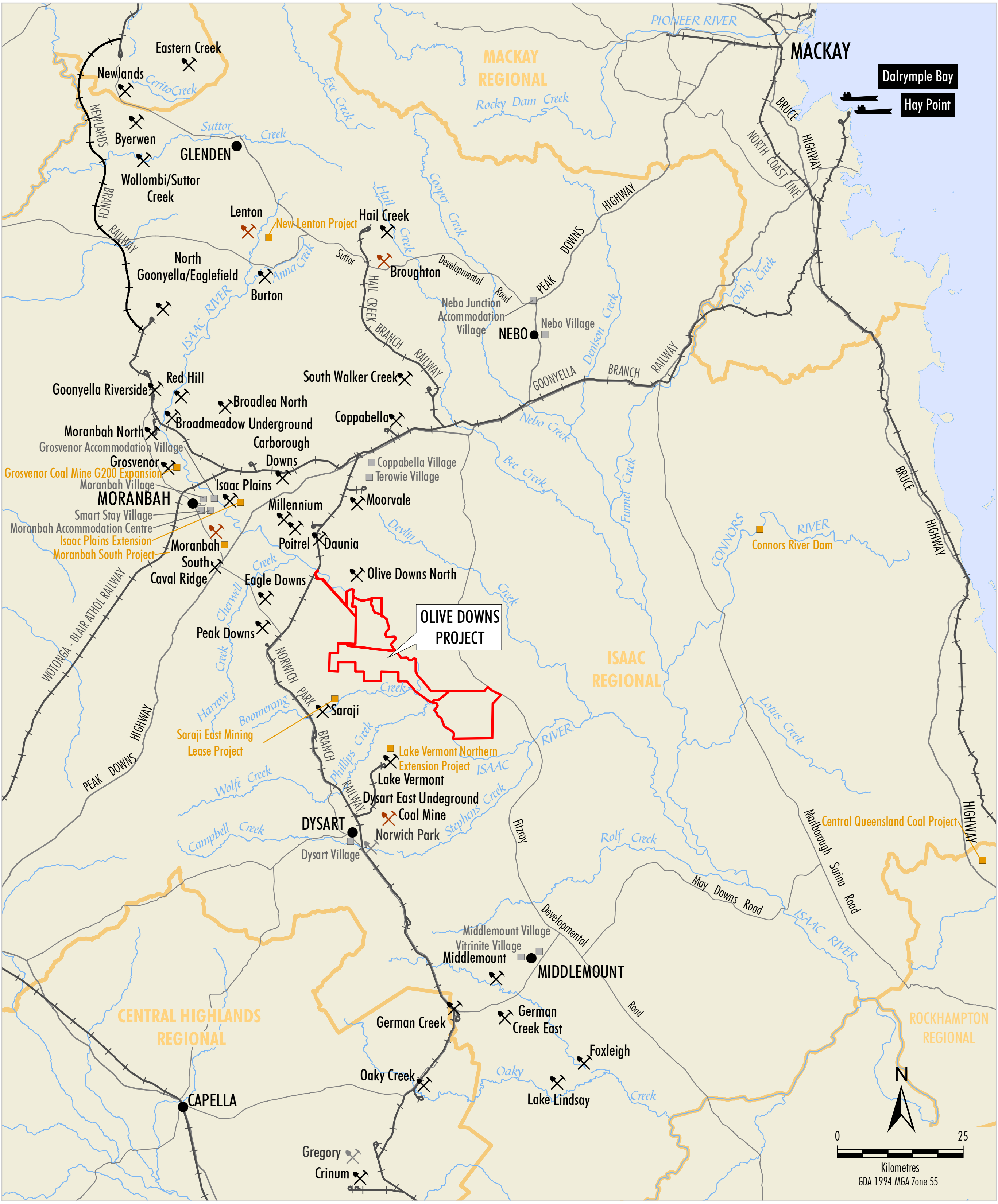
1. INTRODUCTION

Pembroke Olive Downs Pty Ltd (Pembroke) proposes to develop the Olive Downs Coking Coal Project (the Project), a metallurgical coal mine and associated infrastructure, located approximately 40 kilometres (km) south-east of Moranbah in Queensland's Bowen Basin (as shown in Figure 1). The Project provides an opportunity to develop an open cut metallurgical coal resource that can deliver up to 14 million tonnes per annum (Mtpa) of product coal.

The Project comprises the Olive Downs South and Willunga domains and associated linear infrastructure corridors, including a rail spur connecting to the Norwich Park Branch Railway, a water pipeline connecting to the Eungella pipeline network, an electricity transmission line (ETL) and access roads. The coal resource would be mined by conventional open cut mining methods, with product coal to be transported by rail to the Dalrymple Bay Coal Terminal. Up to 20 Mtpa of run-of-mine (ROM) coal would be extracted over the anticipated operational life of approximately 79 years. The Project's general arrangement is shown in Figure 2.

In February 2017, following submission of the Project's Initial Advice Statement (IAS), the Queensland Coordinator-General declared the Project as a *coordinated project* and issued Terms of Reference (ToR). The declaration triggered the requirement for Pembroke to prepare an Environmental Impact Statement (EIS).

Katestone Environmental Pty Ltd (Katestone) was commissioned by Pembroke to complete an Air Quality and Greenhouse Gas Assessment of the Project for inclusion in the EIS. The air quality and greenhouse gas assessments have been carried out in accordance with the Queensland Coordinator-General's ToR and the Queensland Department of Environment and Science (DES) (formerly the Department of Environment and Heritage Protection [DEHP]) document titled *Application requirements for activities with impacts to air* (DEHP, 2017a).



LEGEND

- Mining Lease Application Boundary
- Local Government Area
- Major Road
- Railway
- Port
- Approved/Operating Coal Mine
- Proposed Coal Mine
- Under Care and Maintenance
- Workforce Accommodation Facility
- Coordinated, Major and Other Relevant Project

Source: Geoscience Australia - Topographical Data 250K (2006); Department of Natural Resources and Mines (2016)

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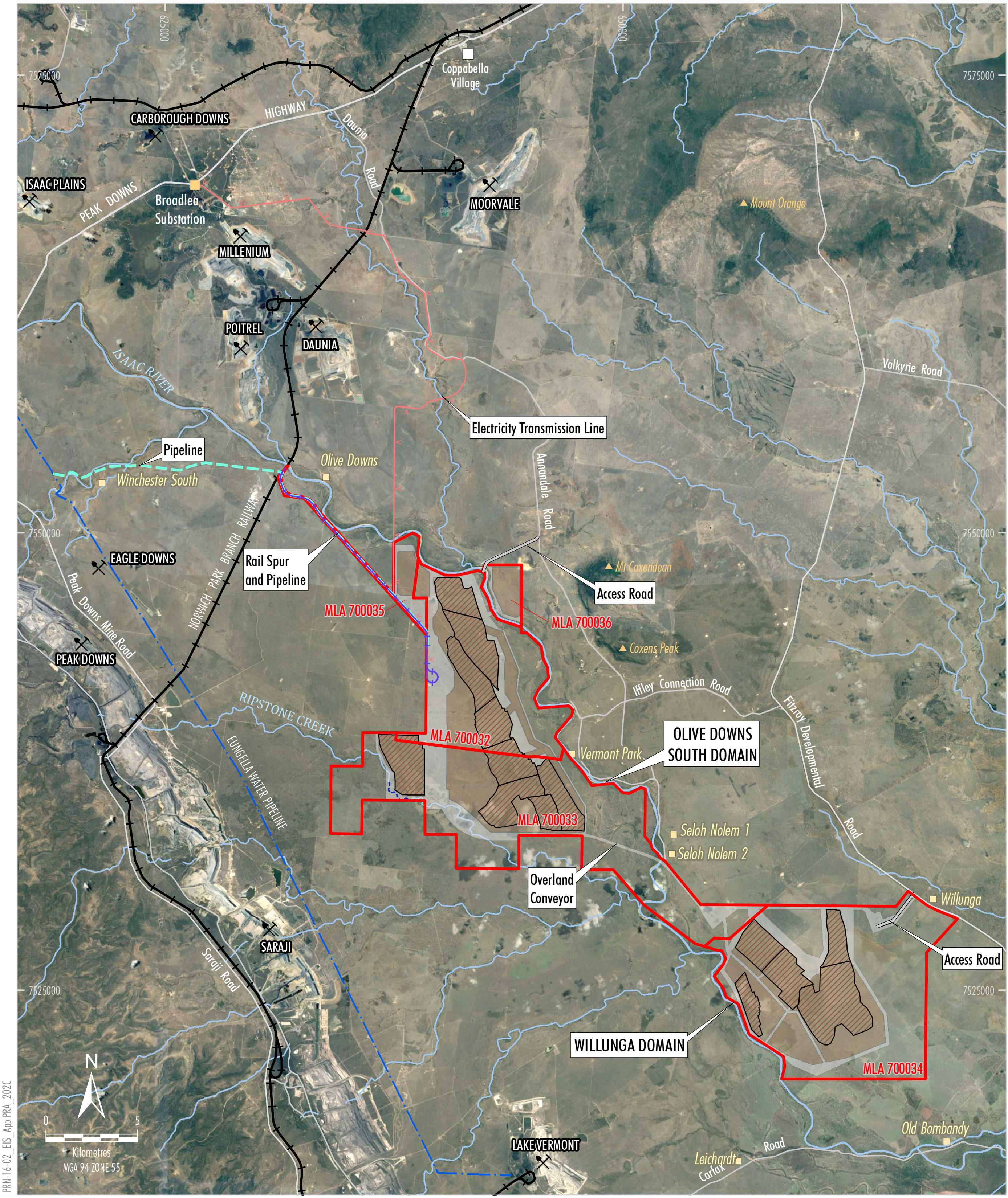
OLIVE DOWNS COKING COAL PROJECT

Regional Location

Figure 1



LEGEND

- Mining Lease Application Boundary
- Approved/Operating Coal Mine
- Dwelling
- Eungella Pipeline Network
- Railway
- Proposed Access Road
- Proposed Electricity Transmission Line
- Proposed Rail
- Proposed Water Pipeline
- Proposed Creek Diversion
- Open Cut Pit Extent
- Out-of-Pit and In-Pit Waste Rock Emplacement
- Infrastructure Area

Source: Geoscience Australia - Topographical Data 250K (2006)
Department of Natural Resources and Mines (2016)
Orthophotography: Google Image (2016)

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OLIVE DOWNS COKING COAL PROJECT

Project General Arrangement

Figure 2

2. OVERVIEW OF THE ASSESSMENT METHODOLOGY

The purpose of this air quality and greenhouse gas assessment is to address the requirements of the Project's ToR and the DES' *Application requirements for activities with impacts to air.* The assessments will form part of the Project's EIS.

The following sections outline the methodologies adopted for the air quality and greenhouse gas assessments.

2.1 Air Quality Assessment

2.1.1 Assessment scenarios

The air quality assessment has considered the following four scenarios associated with the Project:

- Year 2027.
- Year 2043.
- Year 2066.
- Year 2085.

The four scenarios represent worst-case emission scenarios over four distinct years during the life of the Project. A quantitative assessment of each year has been undertaken. Selection of the four scenarios was based on the proposed mining schedule and the proximity of sensitive receptors to critical emissions generating activities. The schedule for each scenario is provided in Table 1 and the general arrangement of the mine for each scenario is provided in Figure 3 to Figure 6.

Table 1 Project schedule for assessment scenarios (tonnes per annum)

Project Year	Mining Domain	Run of Mine (ROM)	Product Coal	Overburden
2027	Olive Downs South	6,000,000	4,424,943	129,732,044
	Willunga	0	0	0
2043	Olive Downs South	11,140,894	8,392,756	430,890,033
	Willunga	8,000,000	5,688,679	225,407,776
2066	Olive Downs South	2,620,894	1,996,642	84,067,366
	Willunga	4,312,210	3,259,816	122,513,138
2085	Olive Downs South	1,393,326	1,062,291	42,768,018
	Willunga	1,688,303	1,254,793	62,285,733

Figure 3 Year 2027 - Project General Arrangement

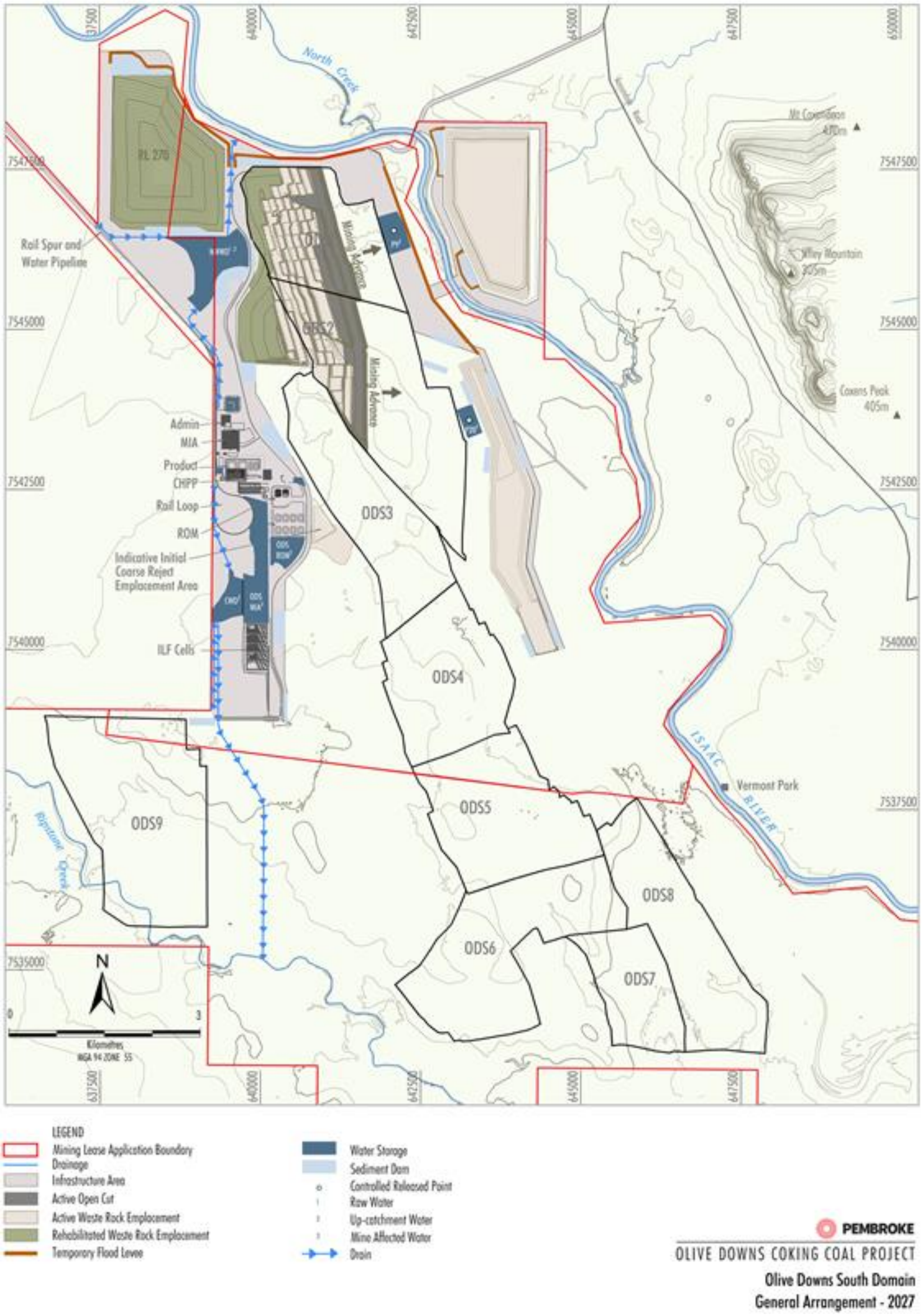


Figure 4 **Year 2043 - Project General Arrangement (left: Olive Downs South Domain, right: Willunga domain)**

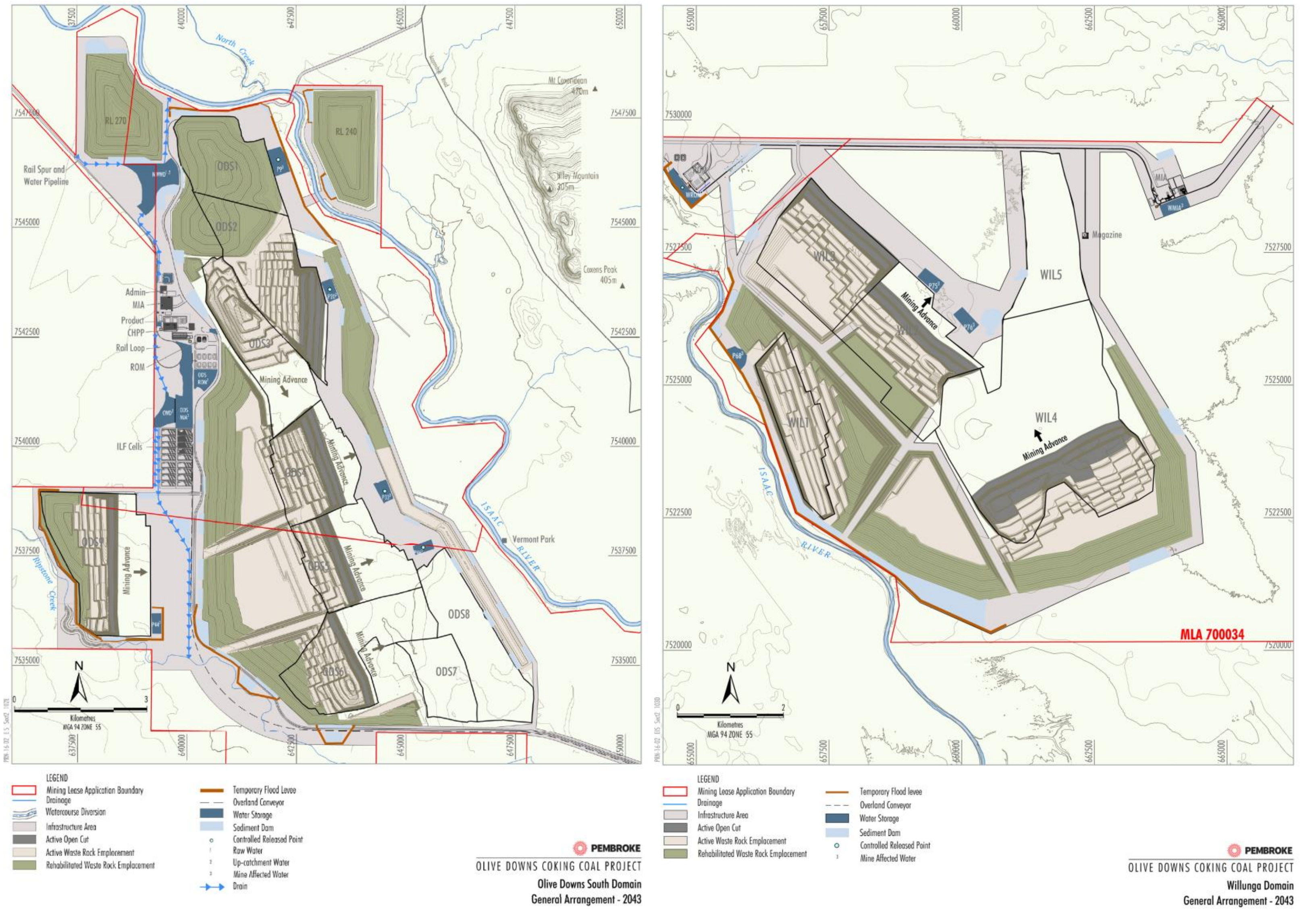


Figure 5 Year 2066 - Project General Arrangement (left: Olive Downs South Domain, right: Willunga domain)

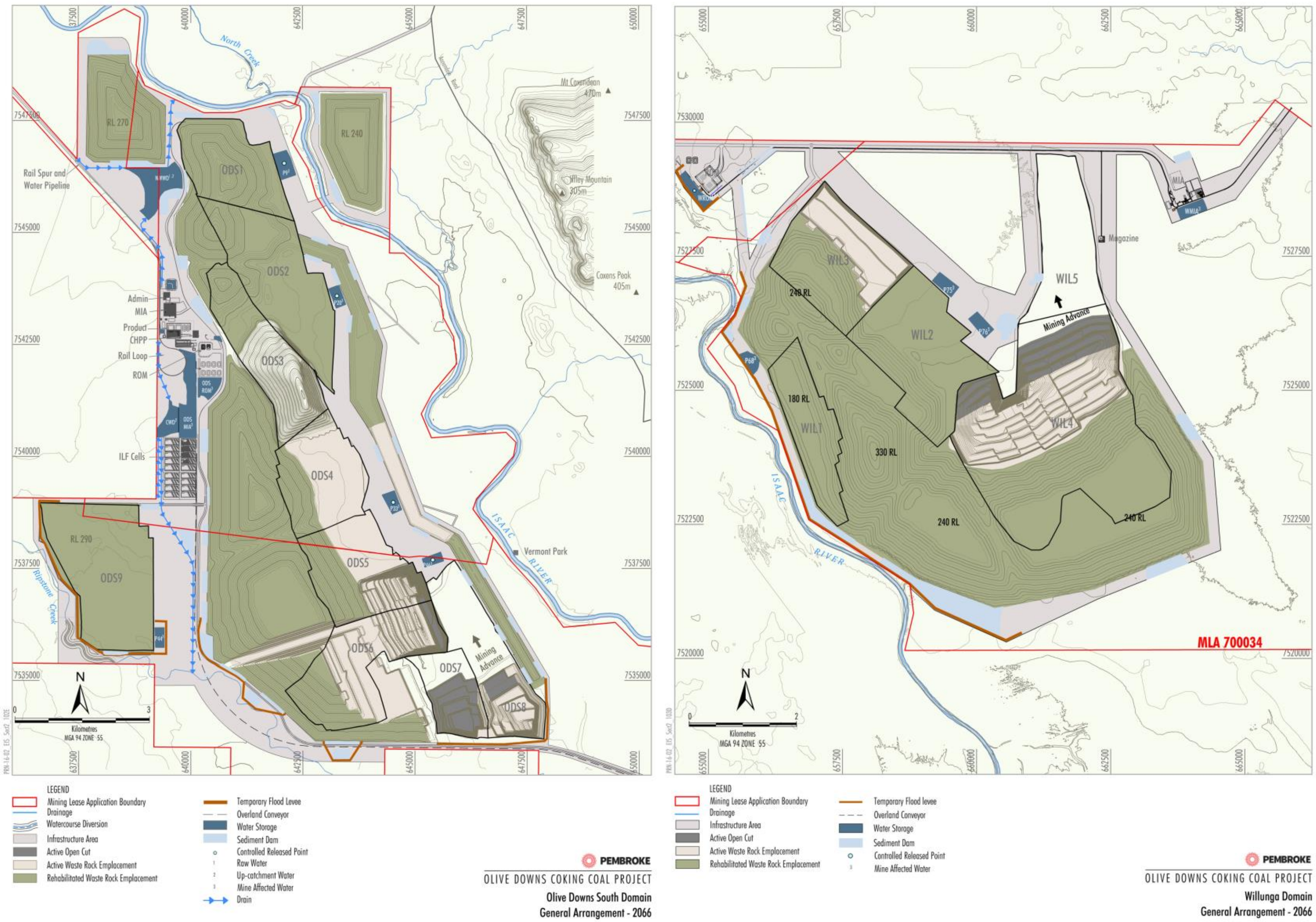
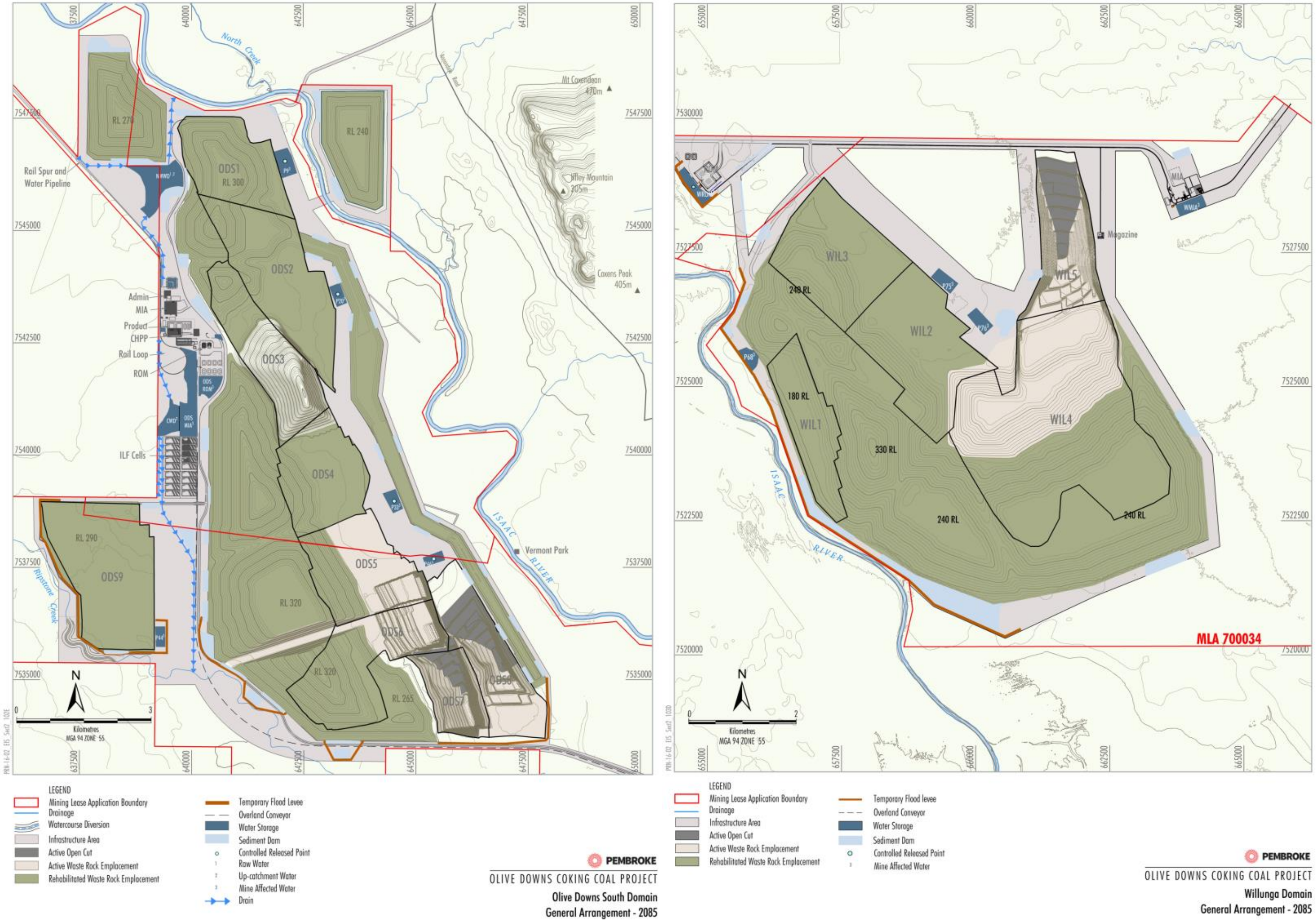


Figure 6 Year 2085 - Project General Arrangement (left: Olive Downs South Domain, right: Willunga domain)



2.1.2 Considerations for assessing air quality

Air pollutants likely to be emitted from the Project have been identified and the current regulatory requirements pertaining to these air pollutants in Queensland have been reviewed and relevant objectives presented. Results of the dispersion modelling of air emissions from the Project have been assessed against the identified air quality objectives.

2.1.3 Existing environment

The assessment includes an analysis of the characteristics of the existing environment in the Project area that are important for the dispersion of air pollutants from the site and that may influence the level of air pollutants in the surrounding area. Characteristics include the climate and local meteorology (temperature, wind, humidity and rainfall), any terrain features, the neighbouring land uses and the location of sensitive receptors. The existing air quality in the Project region has been quantified through analysis of available ambient air quality monitoring data. Existing sources of similar air pollutants to the air pollutants released by the Project have been identified.

2.1.4 Emissions

Emissions to the atmosphere associated with the four Project scenarios have been estimated. The primary air pollutant emitted from mining operations is particulate matter (PM) made up of various sized particles, including: TSP (total suspended particulates), PM_{10} (particulate matter with an aerodynamic diameter less than 10 microns) and $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 microns).

2.1.5 Impact assessment

The potential of the Project to impact air quality has been assessed through a dispersion modelling study and comparison with the air quality assessment criteria.

Dispersion modelling for each scenario has been carried out using the TAPM/CALMET/CALPUFF suite of meteorological and dispersion models.

A cumulative assessment has been undertaken to account for existing mines in the Project area that includes addition of a representative ambient background.

The impact assessment presents results at identified sensitive receptor locations and across a grid centred on the Project's Mining Lease Applications (MLAs).

2.2 Greenhouse Gas Assessment

A greenhouse gas assessment has been undertaken for the Project in accordance with relevant legislation. The approach to the greenhouse gas assessment and results are presented in the Greenhouse Gas Assessment section of the report (Section 8).

3. CONSIDERATIONS FOR ASSESSING AIR QUALITY

3.1 Pollutants

Particulate matter (i.e. dust) will be the key air pollutant generated by activities on the Project site. Particulate matter is discussed further in Section 3.1.1, and other potential pollutants are discussed in Section 3.1.2.

3.1.1 Particulate matter

Mining can give rise to dust that, in elevated concentrations, has the potential to cause adverse impacts on the amenity and health of people living in the vicinity.

Dust can affect communities in various ways, depending upon the source and size of particles present. Dust typically emitted as a result of coal mining operations is assessed in terms of TSP, dust deposition, PM_{10} and $PM_{2.5}$.

Dust from mining consists primarily of larger particles generated through the handling of rock and soil, as well as through wind erosion of stockpiles and exposed ground. Larger particles (measured as dust deposition) are mostly associated with dust nuisance or amenity impacts in residential areas, through settling or deposition of the particles. Elevated dust deposition rates can reduce public amenity, through soiling of clothes, buildings and other surfaces in the area.

Smaller particles such as PM_{10} and $PM_{2.5}$ can also be generated through mining activities. Elevated levels of PM_{10} and $PM_{2.5}$ have the potential to affect human health as these particles can be trapped in the nose, mouth or throat, or be drawn into the lungs. Fine particles (i.e. $PM_{2.5}$) are typically generated through combustion processes.

3.1.2 Other pollutants

Quantities of other air pollutants, such as oxides of nitrogen (NO_x), carbon monoxide (CO) and sulfur dioxide (SO_2), may also be emitted from vehicle traffic and blasting within the Project site. The emission rates of these air pollutants are low compared to the emission rates of particulate matter from mining activities. These air pollutants are transient in nature and are likely to have negligible impact outside of the roads and open-cut pits within the Project site. Hence, particulate matter is considered the critical air pollutant for this assessment.

Compliance with air quality objectives for particulate matter at the nearest sensitive receptors will, as a consequence, demonstrate compliance with air quality standards for NO_x, CO and SO_2. Therefore, these air pollutants do not require further assessment.

Odour is unlikely to be emitted from typical mining activities. Spontaneous combustion is a potential source of odour from mining activities but the potential for this is low and, therefore, odour has not been assessed further in this assessment.

3.2 Legislative Framework for Air Quality in Queensland

The *Environmental Protection Act 1994* (EP Act) provides for the management of the air environment in Queensland. The EP Act gives the DES the power to create Environmental Protection Policies that identify, and aim to protect, environmental values of the atmosphere that are conducive to the health and wellbeing of humans and biological integrity. *The Environmental Protection (Air) Policy* (Air EPP) was made under the EP Act and gazetted in 1997; the Air EPP was revised and reissued in 2008.

The purpose of the Air EPP is to identify the environmental values of the air environment to be enhanced or protected and to achieve the objective of the *Environmental Protection Act 1994*, i.e. ecologically sustainable development.

The environmental values to be enhanced or protected under the Air EPP are the qualities of the environment that are conducive to:

- protecting health and biodiversity of ecosystems;
- human health and wellbeing;
- protecting the aesthetics of the environment, including the appearance of building structures and other property; and
- protecting agricultural use of the environment.

The Air EPP defines air quality objectives for enhancing or protecting the environmental values. The objectives that are relevant to the key air pollutants that may be generated from the Project are presented in Table 2.

Table 2 also shows the dust deposition guideline commonly used in Queensland as a benchmark for avoiding amenity impacts due to dust. The dust deposition guideline is not defined in the Air EPP but is contained within the DES' *Model Mining Conditions* guideline (DEHP, 2017b), and is therefore adopted for this Project.

Table 2 Ambient air quality objectives for the Project

Pollutant	Environmental Value	Averaging Period	Air Quality Objective (µg/m³)	Number of Days of Exceedance Allowed per Year
$PM_{2.5}$[1]	Health and wellbeing	24-hour	25	N/A
		1-year	8	N/A
PM_{10}[2]		24-hour	50[3]	5
TSP		1-year	90	N/A
Dust deposition rate for total insoluble solids	Amenity guideline[4]	1-month	120 mg/m²/day	N/A

Note:
[1] $PM_{2.5}$ are particles that have aerodynamic diameters that are less than 2.5 µm.
[2] PM_{10} are particles that have aerodynamic diameters that are less than 10 µm.
[3] Not more than 5 days per year above objective.
[4] DES' *Model Mining Conditions* guideline, not an air quality objective from the Air EPP.

4. EXISTING ENVIRONMENT

4.1 Climate

The Project region of central Queensland has a sub-tropical continental climate characterised by high variability in rainfall, temperature and evaporation. The region can experience droughts, floods, heatwaves and frosts. In general, winter days are warm and nights are cool, while summer days are hot and nights are warm. Rainfall is summer dominant with almost half of the average annual rainfall occurring from December to February due to storms and tropical lows associated with cyclones.

The Bureau of Meteorology (BoM) weather monitoring station nearest to the Project is located at Moranbah Airport, approximately 30 km north-west. However, this weather station has only been in operation since 2012. Long-term climate data in the Project region, from 1972 to 2012, has been collected from the (now decommissioned) BoM weather monitoring station located at Moranbah Water Treatment Plant. These data are described in the sections below.

4.1.1 Temperature and solar exposure

The mean daily maximum and minimum temperatures by month are presented in Figure 7. The analysis identifies a seasonal temperature profile typical of the sub-tropical Queensland climate, with cooler winter months of June to August and warmer summer months of December to February. The mean maximum daily temperature at the Moranbah monitoring station was 33.8 degrees Celsius (°C), recorded during the summer season. The mean minimum daily temperature at the monitoring station is 9.9°C, recorded during winter.

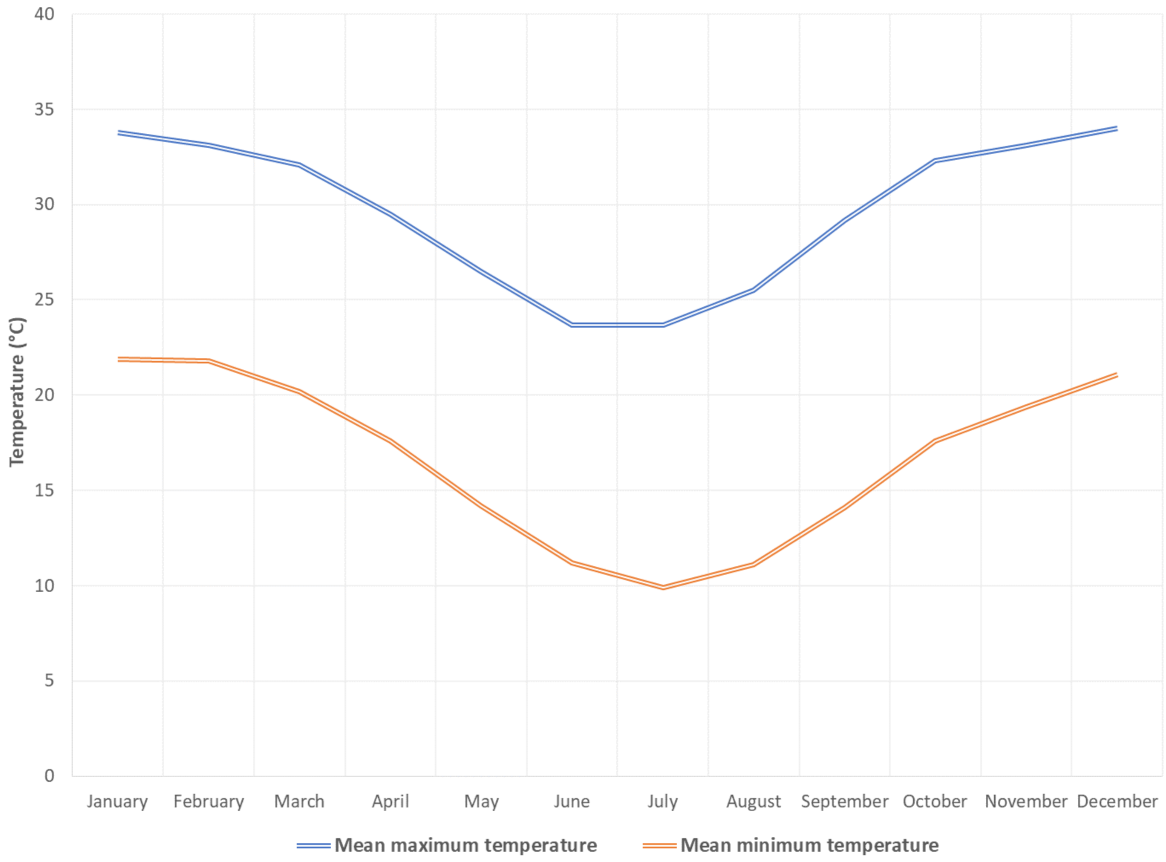


Figure 7 Monthly mean temperature (°C) measured at Moranbah Water Treatment Plant (1986-2012)

The amount of solar radiation received at ground-level is a primary driver for the weather patterns and climatic cycles that influence the Central Queensland region. The average daily solar radiation in megajoules per square metre (MJ/m²) by month is presented in Figure 8. This figure illustrates a clear seasonal pattern whereby summer solar radiation is much greater than during the winter months.

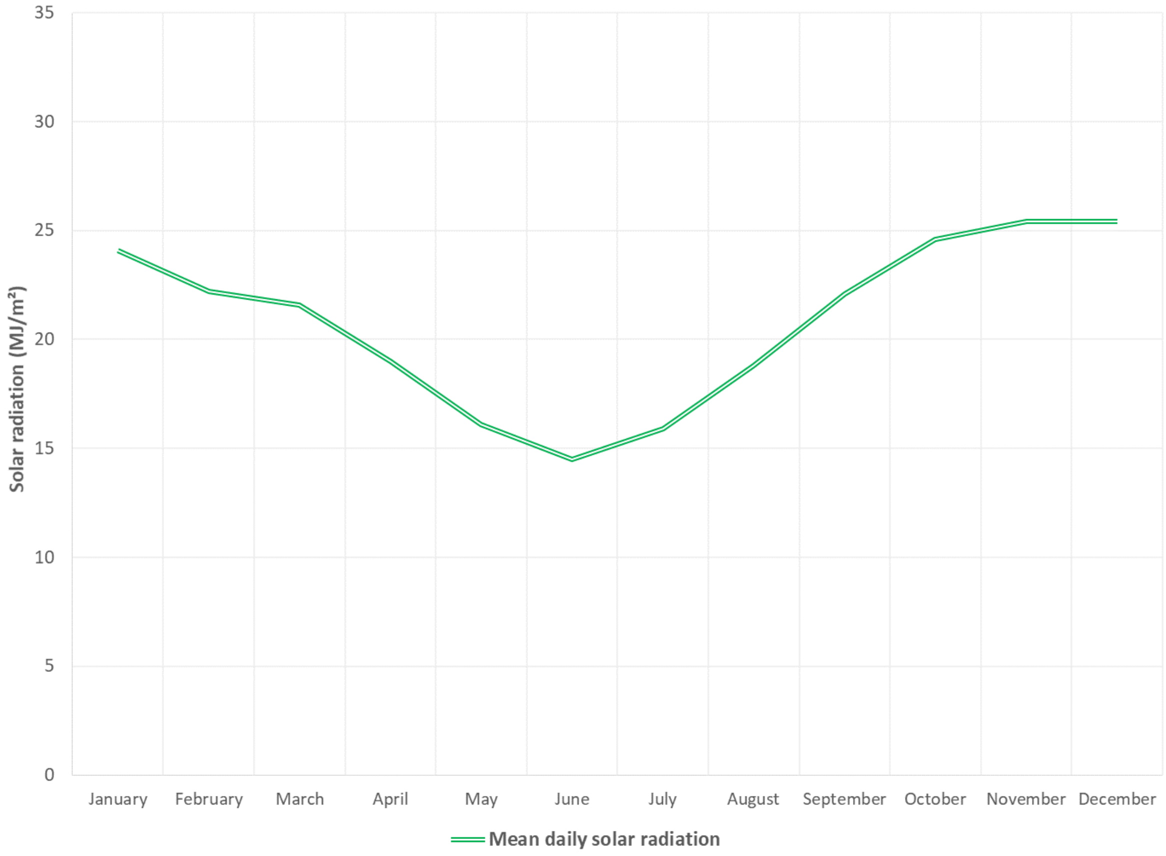


Figure 8 **Mean daily solar radiation (MJ/m²) by month at Moranbah Water Treatment Plant (1986-2012)**

4.1.2 Rainfall

The range of total monthly rainfall (mean and highest) at the Moranbah Water Treatment Plant for 1986-2012 is illustrated in Figure 9. The annual average rainfall is 614 millimetres (mm), with the wettest period occurring during the warmer months from December to February when, on average, 50% of the annual rainfall occurs.

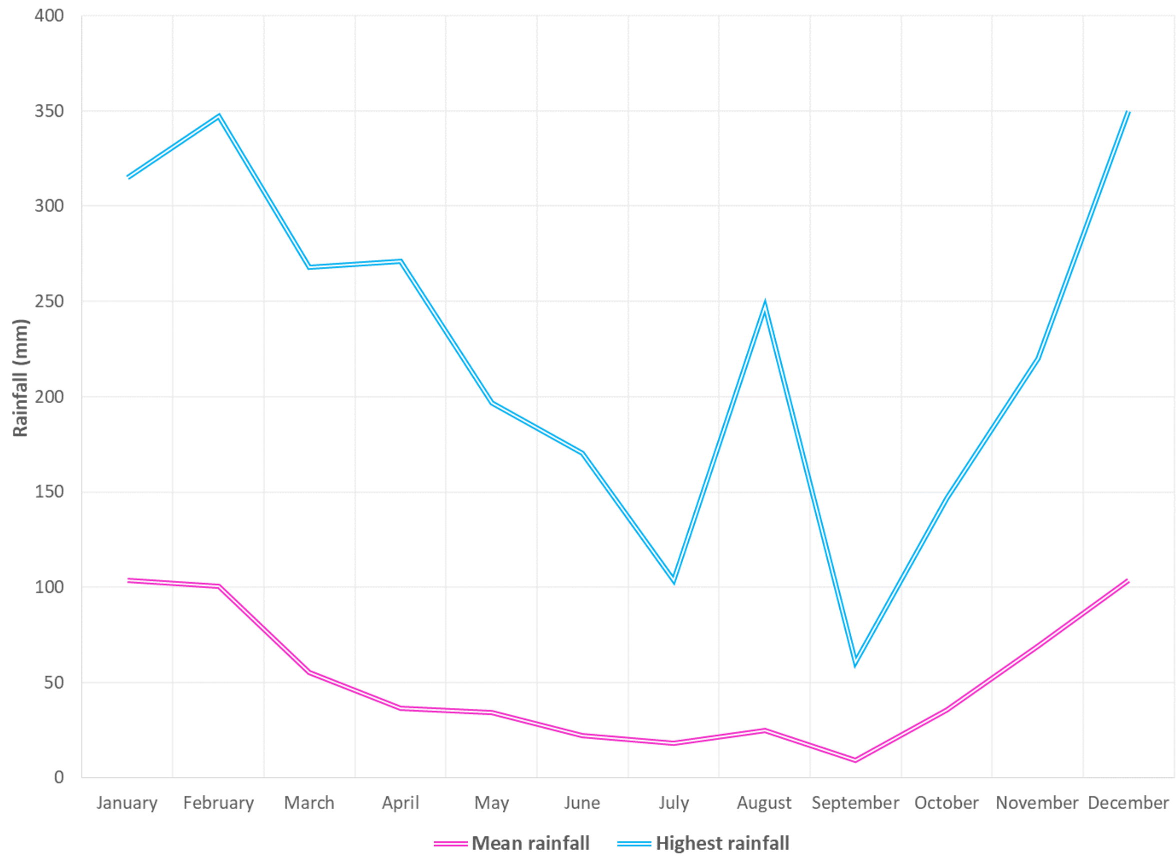


Figure 9 **Range of total monthly rainfall measured at Moranbah Water Treatment Plant (1986-2012)**

4.2 Local Meteorology

The following sections describe the local meteorology of the Project area, focusing on parameters that are important for dispersion of air pollutants, namely wind speed, wind direction, atmospheric stability and boundary layer mixing height.

This local meteorological data has been generated for the year 2015 by the coupled The Air Pollution Model (TAPM)/CALMET meteorological models at the location of the Project and used in the dispersion model assessment, as described in Section 5.2. It is noted that Pembroke installed a weather station at the Project site in March 2017. However, at the time of this assessment, the amount of data collected was not sufficient to use.

4.2.1 Wind speed and wind direction

Wind speed and wind direction influence the rate of dispersion of dust emissions from sources such as wheel generated dust, material transfers, material processing and wind erosion. Wind speed also determines the amount of dust lifted into the air by wind erosion. The 2015 annual, seasonal and diurnal frequencies of winds at the Project site are shown as wind roses in Figure 10, Figure 11 and Figure 12, respectively.

On average, 70% of winds at the site are from the north-east through to the south-east. During the year winds vary with season, with south-easterlies most frequent during autumn and winter, and north-easterlies most frequent during spring. The highest frequency of winds above 6 m/s occurs during summer, from the east and east-south-east which are also the most frequent wind directions. There is a diurnal variation in the wind distribution, with a higher frequency of light winds occurring overnight (6 pm to 6 am) compared to the day. Winds from the east and east-south-east are most frequent during the afternoon (midday to 6 pm), whilst winds from the north-east quadrant are most frequent during the evening. Winds from midnight to midday are predominantly from the south-east.

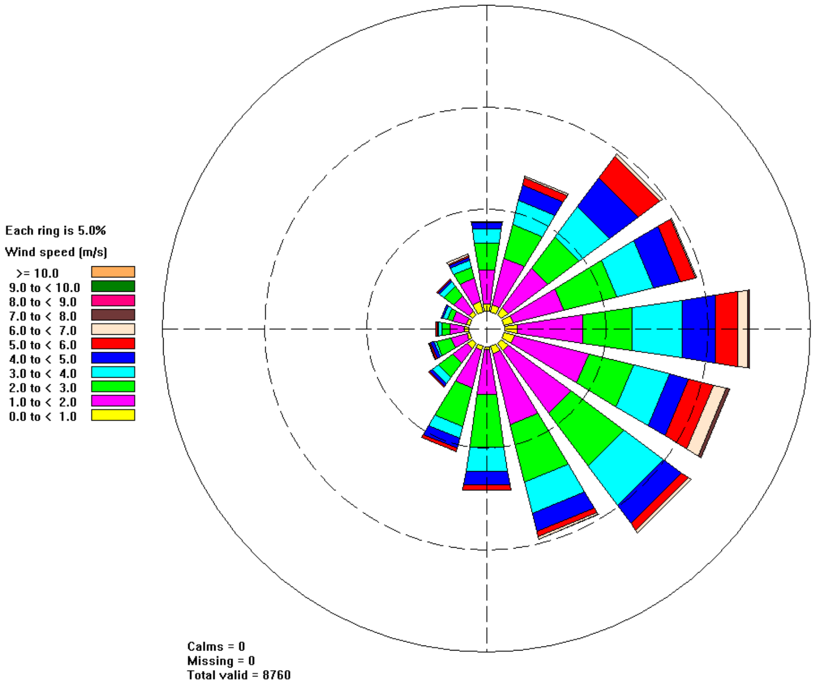


Figure 10 Annual wind rose for the Project site (extracted from CALMET) - 2015

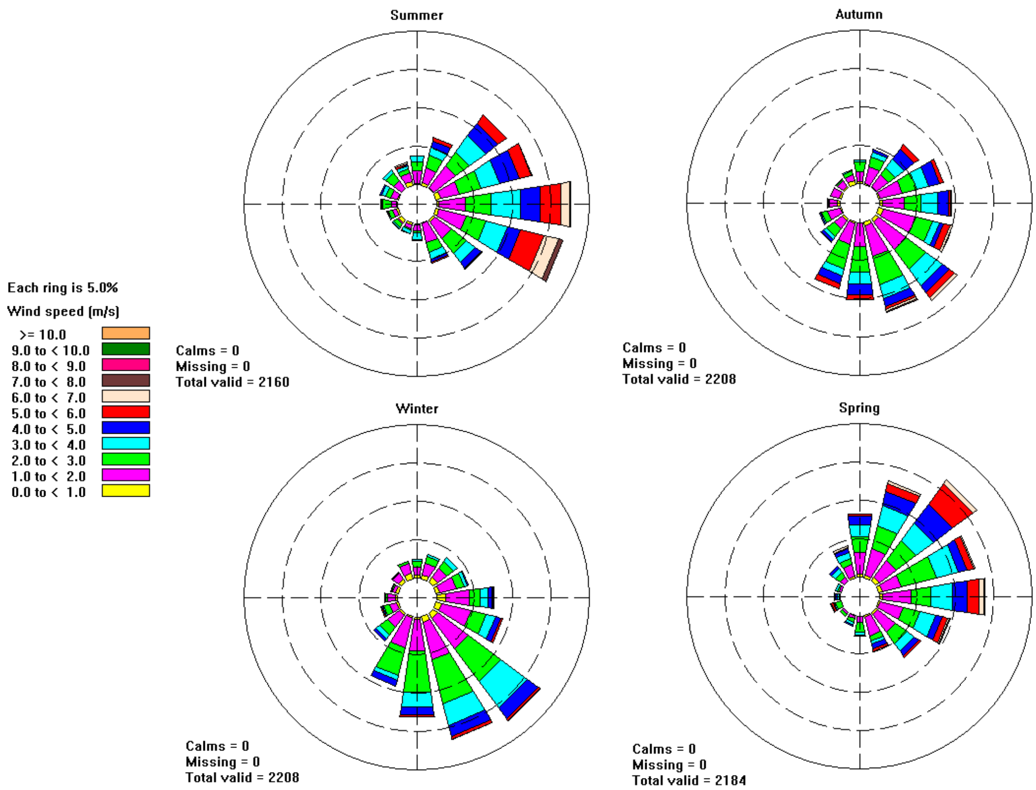


Figure 11 Seasonal wind roses for the Project site (extracted from CALMET) - 2015

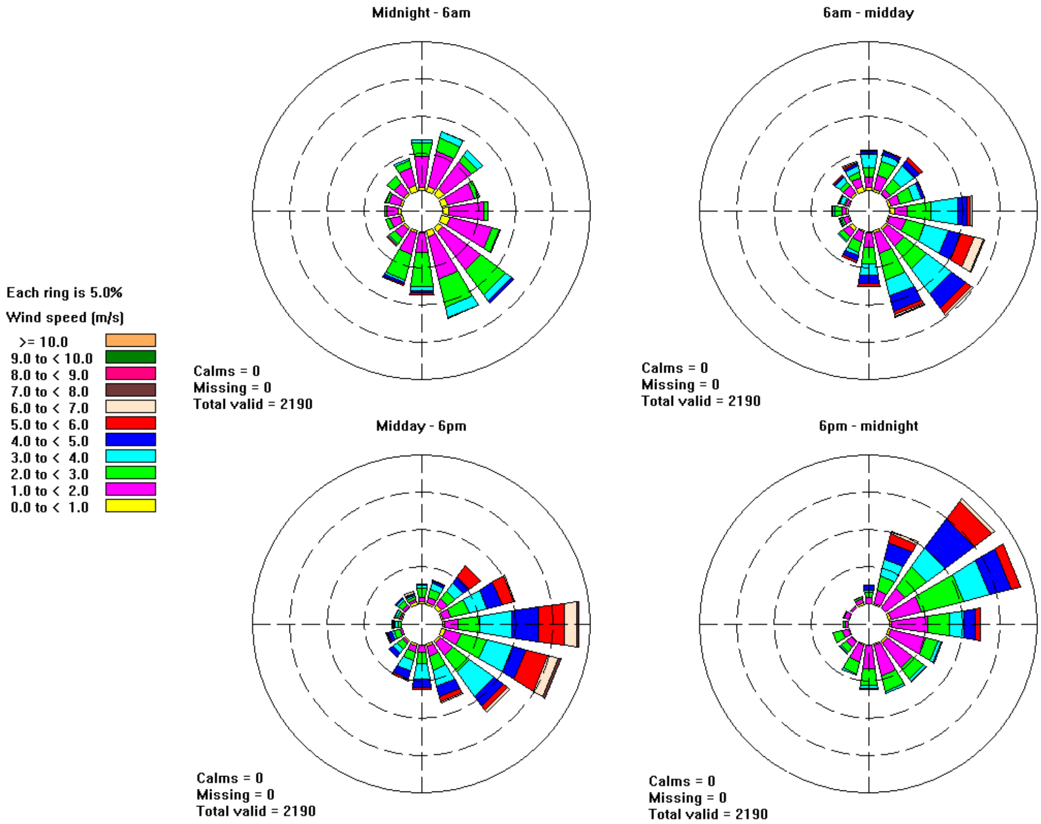


Figure 12 Diurnal wind roses for the Project site (extracted from CALMET) - 2015

4.2.2 Atmospheric stability and mixing height

Atmospheric stability class is a measure of the stability of the atmosphere. Stability classes range from A class to F class. Figure 13 shows the predicted annual frequency of stability classes in the Project area (taken from the meteorological dataset generated by the TAPM/CALMET models).

Class A represents the most unstable conditions and Class F the most stable conditions. Unstable conditions (Classes A to C) are characterised by strong to moderate solar heating of the ground. This induces turbulent mixing in the atmosphere close to the ground. This turbulent mixing is the main driver of dispersion during unstable conditions. Dispersion processes for the most frequently occurring Class D conditions are dominated by mechanical turbulence, generated as the wind passes over irregularities in the local surface. During light wind and clear sky conditions at night, the atmosphere is generally stable (classes E and F). Strong winds and/or overcast conditions at night lead to Class D conditions.

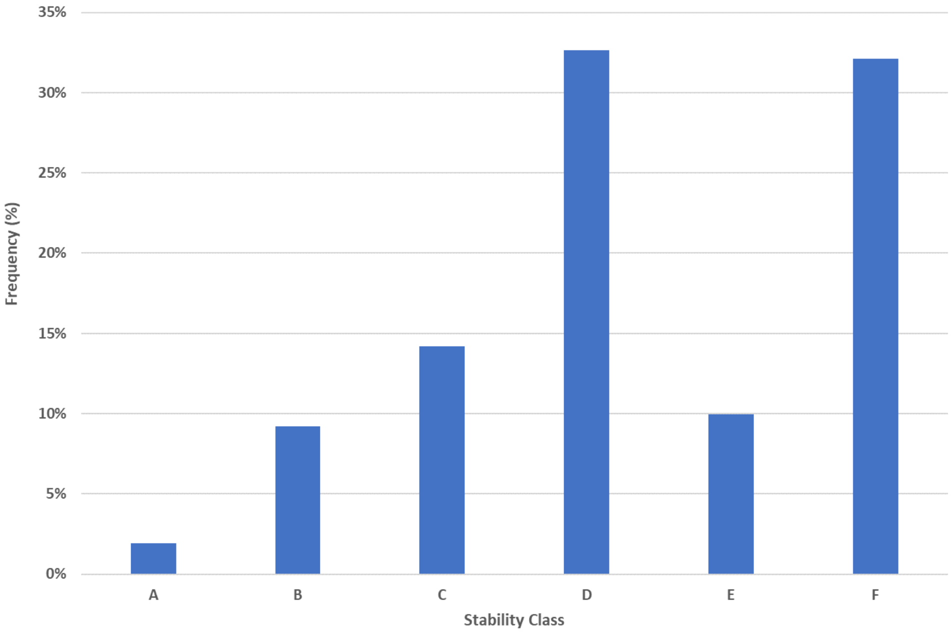


Figure 13 Stability class frequency for the Project site (extracted from CALMET) - 2015

The mixing height defines the height of the mixed atmosphere above the ground (mixed layer), which varies diurnally. Particulate matter, or other pollutants released at or near the ground, will become dispersed within the mixed layer. During stable atmospheric conditions, the mixing height is often quite low and particulate dispersion is limited to within this layer. During the day, solar radiation heats the ground and causes the air above it to warm, resulting in convection and an increase to the mixing height. The growth of the mixing height is dependent on how well the warmer air from the ground can mix with the cooler upper level air and, therefore, depends on meteorological factors such as the intensity of solar radiation and wind speed. During strong wind speeds, the air will be well mixed, resulting in a high mixing height.

Hourly mixing height information in 2015 has been extracted from the CALMET simulation over the Project area and is presented in Figure 14 as a diurnal frequency plot. The data shows that, on average (blue dots), the mixing height develops around 7 am, increases to a peak at 3 to 4 pm before descending rapidly until 6 pm.

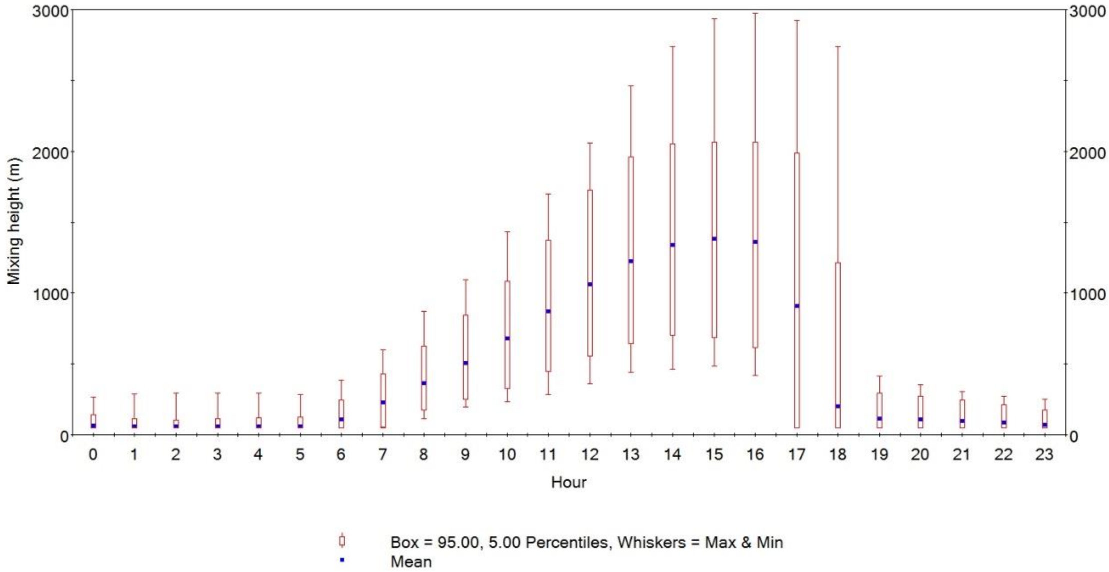


Figure 14 **Diurnal variation in mixing height at the Project site (extracted from CALMET) - 2015**

4.3 Local Terrain and Land-Use

The Project area is located approximately 40 km to the south-east of Moranbah in central Queensland's Bowen Basin. The Project is located on the relatively flat plains adjacent to (west of) the Isaac River, approximately 200 metres (m) above sea level. The terrain rises gently to the north-west and slopes slightly downwards to the south-east and is relatively flat with the exception of two terrain features to the north-east, known as Mt Coxendean and Coxens Peak.

The broader vicinity of the Project area is bordered by the Peak Downs Range, a ridge of hills located 20 km to the west with a maximum elevation of approximately 500 m above sea level. The region is predominantly rural, with the township of Moranbah located to the north-west of the Project site. Low intensity cattle grazing and coal mining are the dominant land uses in the vicinity of the Project.

4.4 Sensitive Receptors

The region surrounding the Project is sparsely populated. There are seven sensitive receptors (isolated homesteads) located in the Project area. These are shown in Table 3 and Figure 15.

Table 3 **Nearest sensitive receptors to the Project**

Receptor ID	Description	Easting (km)	Northing (km)	Distance and Direction from Closest Point of Project Component
R1	Leichardt	656.328	7515.670	6 km south
R2	Old Bombandy	667.554	7516.681	6 km south-east
R3	Willunga	666.964	7529.964	3.4 km east
R4	Seloh Nolem 1	652.712	7532.467	0.7 km north-east
R5	Seloh Nolem 2	652.771	7533.482	1.2 km north-east
R6	Vermont Park	647.213	7537.867	0.8 km east
R7	Olive Downs	633.806	7553.033	5.7 km north-west

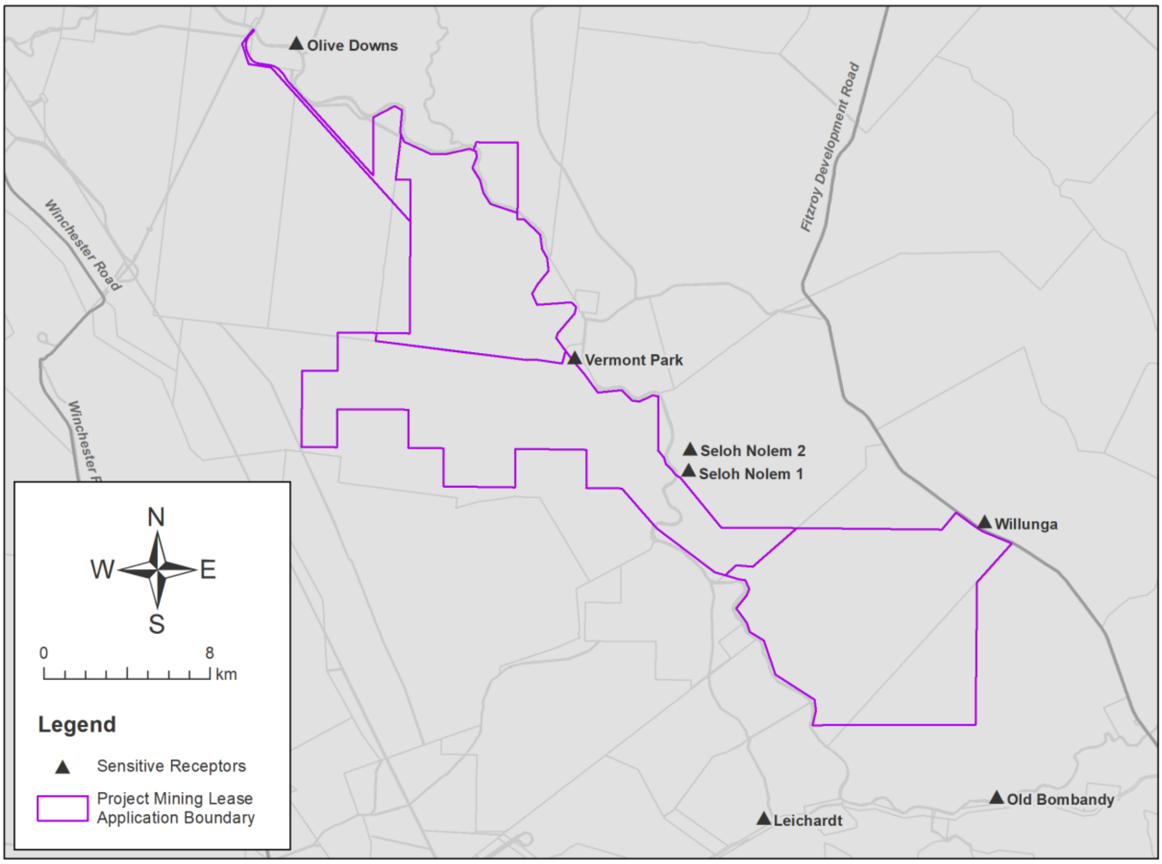


Figure 15 Sensitive receptors identified in the assessment

4.5 Ambient Air Quality

There are several sources of dust in the vicinity of the Project, including naturally generated dust in the environment such as pollen and grass seeds; dust from the use of dirt roads; agricultural activities; wind erosion of non-vegetated areas as well as contributions from a number of existing mines in the region. Activities in the township of Moranbah, such as construction, will also contribute to the ambient air quality levels in the Project region.

The existing air quality is characterised to indicate dust levels prior to operation of the Project, including the influence of natural dust sources and any dust arising from operations at the nearby mines. This has been characterised from a review of available information on dust emissions and representative ambient air quality monitoring data in the region.

4.5.1 Existing sources of air pollutants

Industries within 50 km of the Project with dust emissions (PM_{10} and $PM_{2.5}$) have been identified through a review of the National Pollutant Inventory (NPI) database (NPI, 2017). The types of industries include:

- Mining;
- Burning of coal seam gas (CSG) to produce electricity;
- Gas extraction, production and processing; and
- Gun cotton (explosive) manufacturing.

Table 4 details the dust emissions (PM_{10} and $PM_{2.5}$) reported to the NPI for 2015/16 from identified industries in the Project region.

Table 4 Dust emissions reported to NPI for 2015/2016

Facility Name	Main Activities	Distance and Direction from Project Boundary	PM_{10} (tonnes/year)	$PM_{2.5}$ (tonnes/year)
Saraji Mine	Coal Mining	10 km south-west	20,919	130
Peak Downs Mine	Coal Mining	12 km west	30,576	137
Poitrel Coal Mine	Coal Mining	14 km north-west	3,286	34
Daunia Mine	Coal Mining	14 km north-west	5,382	66
Lake Vermont	Coal Mining	15 km south-west	11,939	584
Millenium Coal Mine	Coal Mining	17 km north-west	3,587	57
Moorvale Coal Mine	Coal Mining	18 km north	6,193	37
Caval Ridge Mine	Coal Mining	20 km north-west	10,349	78
Red Mountain Infrastructure Joint Venture	Coal Mining Support	20 km north	292	1
Coppabella Coal Mine	Coal Mining	25 km north	8,131	39
Norwich Park Mine	Coal Mining	30 km south-west		
South Walker Creek Mine	Coal Mining	30 km north	4,615	35
Isaac Plains Coal Mine	Coal Mining	35 km north-west	747	10
Moranbah Power Station	Electricity production (CSG)	40 km north-west	0.01	0.01
Dyno Noble Moranbah	Gun cotton manufacturing	40 km north-west	15	10
Carborough Downs Coal Mine	Coal Mining	40 km north-west	1,201	4
Moranbah Operations	Oil and gas extraction	40 km north-west	7	0.1
Grosvenor	Coal Mining	45 km north-west	986	8
Moranbah North	Coal Mining	50 km north-west	0.2	0.2

4.5.2 Existing ambient air quality

An air quality monitoring station was installed at the Project site to measure TSP, PM_{10}, $PM_{2.5}$ and meteorology. The monitoring station was installed on 2 March 2017 and data collection is ongoing. The monitoring station was impacted by a severe weather event (Cyclone Debbie) at the end of March 2017 and the equipment was out of order until July 2017. Data from the ambient air quality monitoring station was provided for the period 18 July 2017 to 15 December 2017 (approximately 5 months) for analysis and use in this air quality assessment. Due to the relatively low amount of data from the on-site station it has not been used in this assessment to characterise existing air quality.

4.5.2.1 PM_{10}

Long-term continuous PM_{10} monitoring data in the Project area is available from the DES monitoring station located in Moranbah. Data measured from 2011 to 2016 is presented in Table 5 (Queensland Data, 2017). The data shows that on a few occasions the Moranbah monitoring station recorded 24-hour average PM_{10} concentrations greater than 50 µg/m³. In particular, in 2012 there were 36 days when the 24-hour average was greater than 50 µg/m³. Review of DES monitoring reports advised that for a period of 4 months, housing construction work was occurring within 100 m of the monitoring station and was the likely cause of the high number of exceedances.

The ambient background level of PM_{10} used in the cumulative assessment for the Project has been taken as the highest 70th percentile over the 6 years of monitoring data. The year 2012 has been excluded for this dataset due to the localised source that affected the data. Accordingly, the background level of PM_{10} used in this assessment is 27.2 µg/m³ (taken from 2016). Using the 70th percentile value from long-term data to represent ambient background levels is accepted in Queensland and is based on the methodology published by EPA Victoria.

Table 5 Concentrations of PM_{10} at Moranbah monitoring station from 2011 to 2016

Year	PM_{10} (µg/m³)			
	24-hour average (Maximum)	No. days above 50 µg/m³	24-hour average (70th percentile)	Annual average
2011	67.6	5	23.4	20.3
2012	492.8	36	29.5	27.9
2013	99.9	1	26.5	22.4
2014	49.9	0	24.0	20.4
2015	91.9	4	25.3	21.3
2016	49.5	0	27.2	22.1

4.5.2.2 TSP and $PM_{2.5}$

DES does not conduct monitoring for TSP and $PM_{2.5}$ at its Moranbah site. Publicly available information on ambient air quality monitoring in Moranbah is limited, however, a review of available data, including the Moranbah South EIS (2015) and Caval Ridge EIS (BHP Billiton Mitsubishi Alliance [BMA], 2010), provides information on available ambient air quality monitoring of TSP and $PM_{2.5}$ that can be used to represent background in this assessment.

BMA conducted monitoring of TSP and $PM_{2.5}$ at the corner of Jackson Avenue and Clements Street, Moranbah, using a Hi-volume air sampler in accordance with the Australian Standards for measurements of TSP and $PM_{2.5}$. Nine months of monitoring data is publicly available from this site from 1 January 2012 to 31 September 2012.

This data has been used to represent background levels of TSP and $PM_{2.5}$ in the Project region, namely:

- TSP
  - 27.5 µg/m³ - Annual average:
- $PM_{2.5}$
  - 4.3 µg/m³ - 24-hour average (70th percentile)
  - 3.6 µg/m³ - Annual average.

4.5.2.3 Dust deposition rate

Dust deposition monitoring is not undertaken by Pembroke or DES in the Project region. However, as detailed in the Moranbah South EIS (2015), Anglo American has undertaken dust deposition monitoring at its Golf Course deposition monitoring station every month from April 2009 to October 2012. The maximum rolling annual average from this site of 71 mg/m²/day has been applied to represent the background dust deposition rate for the Project.

4.5.3 Summary of background dust levels

Background levels of TSP, PM_{10}, $PM_{2.5}$ and dust deposition that have been derived from data presented in the previous sections and used in this assessment are summarised in Table 6.

Table 6 Ambient background concentrations used to assess cumulative impacts

Pollutant	Averaging Period	Concentration
TSP	Annual	27.5 µg/m³
PM_{10}	24-hour	27.2 µg/m³
$PM_{2.5}$	Annual	3.6 µg/m³
	24-hour	4.3 µg/m³
Dust deposition	Annual average	71 mg/m²/day

5. AIR QUALITY ASSESSMENT MODELLING METHODOLOGY

The following section describes the modelling methodology that was adopted for the air quality assessment. The methodology uses standard industry dispersion models suitable for use in Australia and regulatory approved assessment techniques to predict ground-level concentrations of air pollutants in the areas surrounding the Project.

5.1 Emissions Estimation

To assess potential air quality impacts due to the Project, potential dust emissions from individual mining activities in each scenario were accounted for and have been explicitly modelled. Specific activity information used to calculate dust emission rates associated with individual mining activities were provided or confirmed by Pembroke.

Dust emission rates were estimated using the base equation:

$$ER = A \times EF \times (1 - CF)$$

where:

ER	emission rate
A	activity / operations data
EF	emission factor
CF	reduction in emissions due to the implementation of control measures.

Emissions of TSP, PM_{10} and $PM_{2.5}$ from mining activities in each scenario were estimated using recognised and accepted methods of dust emissions estimation. These include approximation of emission rates from NPI emissions estimation technique handbooks and the United States Environmental Protection Agency (US EPA) AP42 emission handbooks (US EPA, 1998; US EPA, 2004; US EPA, 2006a; US EPA, 2006b; NPI, 2012).

The emissions estimation techniques applied in this assessment are based on standard methods that are applied throughout Australia and in the United States. These methods are consistent with those adopted for other air quality assessments conducted for other coal mines in Australia. The size distribution of dust particles was derived from the emission rates estimated for TSP, PM_{10}, and $PM_{2.5}$.

A dust emission inventory for each assessment scenario is detailed in Section 6. The activity data and emission factor equations used in estimating dust emissions are detailed in Appendix A.

5.2 Site-specific Meteorology

The prognostic model TAPM (2008) (developed by the Commonwealth Scientific and Industrial Research Organisation [CSIRO]) and the diagnostic meteorological model CALMET (developed by Earth Tech, Inc.) were used to generate the three-dimensional meteorological dataset for the Project area.

The year 2015 was selected as a representative year for meteorological modelling based on analysis of the last five complete years (2012 to 2016) of observations at the BoM Moranbah Airport monitoring station. The year 2015 was selected as representative, as observations of wind speed, wind direction and temperature in 2015 were closest to the average of the 2012 to 2016 period.

The three-dimensional wind field for 2015 produced by TAPM/CALMET was then used to create a meteorological file suitable for use with the CALPUFF dispersion model.

Details of the TAPM/CALMET model configuration and evaluation are discussed in Appendix B.

5.3 Dispersion Modelling

Source characteristics and dust emission rates for each scenario were incorporated into a dispersion modelling study. This was conducted using a standard and regulated model developed by Earth Tech, Inc., the CALPUFF dispersion model.

CALPUFF is an advanced non-steady-state air quality modelling system. The meteorological data for 2015 generated by the TAPM/CALMET model was used as input for the dispersion model in order to include all weather conditions likely to be experienced in the region during a typical year. The modelling has been used to predict maximum ground-level concentrations and deposition rates of dust across a Cartesian grid of the Project region and at the locations of the identified sensitive receptors.

Dust emissions have been modelled over a full year assuming 24 hours/day mining activities, except for blasting, which has been modelled between 6 am and 6 pm.

Technical details of the configuration of the CALPUFF model are discussed in Appendix B.

5.4 Cumulative Impacts

To determine the impact of the Project upon the surrounding environment a representative background concentration for relevant air pollutants is required. Background levels of TSP, PM_{10}, $PM_{2.5}$ and dust deposition have been added to the dispersion modelling results of each scenario to provide a cumulative impact. The background levels that have been used in the assessment are summarised in Section 4.5.3.

5.5 Limitations of Dispersion Modelling

This study relies on the accuracy of a number of datasets including, but not limited to:

- Meteorological information; and
- Calculation of emission rates from mining activities.

It is important to note that numerical models are based on an approximation of governing equations that represent complex natural processes. These will inherently be associated with some degree of uncertainty. The more complex the physical model, the greater the number of physical processes that must be included. Where uncertainty exists in characterising important properties of the environment or activities associated with the Project, this study has erred on the side of caution and selected conservative inputs.

6. DUST EMISSIONS INVENTORY

Dust emissions will be produced over the life of the Project. The Project will generate dust emissions from the extraction, handling, transportation and processing of material from the Project's open-cut pits, as well as from wind erosion of exposed areas and material stockpiles.

In addition to dust emissions, emissions of NO_X, SO_X and CO would occur due to blasting activities and the combustion of fuels on site. These emissions are transient, contained within the haul road corridor and open-cut pits and low in magnitude compared to dust emissions and have not been considered further in this assessment.

Dust mitigation measures proposed by Pembroke and a dust emissions inventory for each assessment scenario of the Project are provided in the following sections.

6.1 Overview

The key dust-generating activities over the life of the Project would be:

- Drilling and blasting;
- Haulage of overburden and ROM coal;
- Wind erosion of stockpiles, exposed and rehabilitated areas;
- On-site Coal Handling and Preparation Plant operation;
- Dozers;
- Material handling
- Road grading; and
- Train loading.

6.2 Mitigation Measures - Standard

Dust mitigation and operational controls have been included in the Project design to limit dust emissions from mining activities, including:

- Chemical suppressant application on all major haul routes in the Olive Downs South and Willunga domains
- Water application at the CHPP including at:
    - Stockpiles
    - Conveyor transfer points
    - Train loading
- Progressive rehabilitation of areas that have been mined.

These standard dust mitigation measures proposed by Pembroke have been accounted for in the dust emissions inventory. The effectiveness of each control measure is presented in Table 7. An additional control factor of 50% for TSP and 5% for PM_{10} has been applied in the dispersion modelling of in-pit activities to account for pit retention (NPI, 2012 – Table 4).

Table 7 Standard dust control measures and relative reduction in emissions

Activity	Control measure	Reduction (%)
Wheel-generated dust and grading	Chemical suppressant	95
Drilling	Dust collectors / watering	70
Wind erosion	Rehabilitated areas	40
Wind erosion from ROM coal and rejects stockpiles	Water sprays	50
Product stockpile - dozers, wind erosion and stacking and reclaiming	Material is wet due to processing	50
CHPP processing	Water application	50
Train loadout	Water application	50

6.3 Mitigation Measures – Proactive

Pembroke also intends to operate a proactive dust management system to ensure dust generation during times of high potential for impact is minimised as far as practicable. The system would include the use of weather forecasting and real-time measurement of dust levels and meteorological conditions to modify mining operations as required to achieve compliance with applicable air quality objectives at the nearest sensitive receptors.

PM_{10} and meteorological data would continue to be monitored on an ongoing basis at Pembroke's existing monitoring station. PM_{10} monitoring would also be undertaken at locations representative of the closest sensitive receptors to the site.

When air quality monitoring and meteorological forecasting indicate the potential for upcoming exceedances of the applicable air quality objectives, mining operations would be modified in accordance with an Air Quality Management Plan. A range of proactive mitigative actions would be available to Pembroke to reduce potential impacts, such as:

- Applying additional dust controls;
- Increasing the intensity of dust controls;
- Moving operations;
- Reducing the intensity of certain operations; and/or
- Halting certain operations.

If monitoring indicates any unexpected exceedances of air quality objectives, an investigation would be conducted by Pembroke.

In addition to the proactive dust management and monitoring system described above, Pembroke intends to develop and operate a complaint handling procedure. Community complaints that relate to air quality impacts would be logged and responded to in an appropriate and timely manner. A complaints procedure will be developed as part of the Project's environmental management plan.

6.4 Emission Inventory

A summary of the total dust emission rates estimated for Years 2027, 2043, 2066 and 2085 are presented in Table 8. A detailed breakdown of the dust inventory for each year is then provided in Table 9 to Table 12.

Emissions have been estimated as described in Section 2.1.4 and Appendix A. These inventories include all Project mining activities up to and including loading of product coal at the rail loop. Schematics illustrating the location of emission sources for each operating year are presented in Figure 16 to Figure 19.

Table 8 Estimated TSP, PM_{10} and $PM_{2.5}$ emission rates for the Project (kg/annum)

Scenario	TSP	PM_{10}	$PM_{2.5}$
Year 2027	2,022,500	681,600	77,400
Year 2043	11,631,500	3,680,700	398,072
Year 2066	5,116,600	1,668,200	193,430
Year 2085	3,311,900	1,098,000	125,600

Table 9 Year 2027 – breakdown of TSP, PM_{10} and $PM_{2.5}$ emission rates for the Project (g/s)

Activity	TSP	PM_{10}	$PM_{2.5}$
Pit activities			
Drilling and blasting	3.34	1.74	0.10
Bulldozing ROM coal	1.97	0.67	0.04
Bulldozing overburden	2.00	0.38	0.21
Loading/Dumping ROM coal	0.04	0.02	0.002
Loading/Dumping overburden	1.40	0.66	0.07
Haulage			
ROM coal haulage	5.00	1.43	0.14
Overburden haulage	31.28	8.92	0.89
Grading haul roads	5.67	1.68	0.18
Processing			
Sizing and crushing	3.82	1.34	0.10
Conveying and transfers	0.65	0.31	0.04
Wind erosion			
Stockpiles	3.96	1.98	0.30
Exposed areas	3.75	1.87	0.28
Rehabilitated areas	1.25	0.63	0.09
Total (g/s)	**64.13**	**21.61**	**2.46**

Table 10 **Year 2043 – breakdown TSP, PM_{10} and $PM_{2.5}$ emission rates for the Project (g/s)**

Activity	TSP	PM_{10}	$PM_{2.5}$
Pit activities			
Drilling and blasting	11.80	6.14	0.35
Bulldozing ROM coal	9.86	3.34	0.22
Bulldozing overburden	6.99	1.33	0.73
Loading/Dumping ROM coal	0.14	0.07	0.01
Loading/Dumping overburden	7.09	3.35	0.38
Haulage			
ROM coal haulage	26.81	7.64	0.76
Overburden haulage	243.72	69.47	6.95
Grading haul roads	18.90	5.60	0.59
Processing			
Sizing and crushing	12.20	4.28	0.33
Conveying and transfers	5.53	2.60	0.38
Wind erosion			
Stockpiles	4.95	2.47	0.37
Exposed areas	13.92	6.96	1.04
Rehabilitated areas	6.92	3.46	0.52
Total (g/s)	**368.83**	**116.72**	**12.62**

Table 11 Year 2066 – breakdown TSP, PM_{10} and $PM_{2.5}$ emission rates for the Project (g/s)

Activity	TSP	PM_{10}	$PM_{2.5}$
Pit activities			
Drilling and blasting	3.34	1.74	0.10
Bulldozing ROM coal	4.44	1.51	0.10
Bulldozing overburden	4.33	0.82	0.46
Loading/Dumping ROM coal	0.05	0.03	0.001
Loading/Dumping overburden	2.39	1.13	0.13
Haulage			
ROM coal haulage	15.29	4.36	0.44
Overburden haulage	86.54	24.67	2.47
Grading haul roads	17.01	5.04	0.53
Processing			
Sizing and crushing	4.42	1.55	0.12
Conveying and transfers	5.12	2.41	0.35
Wind erosion			
Stockpiles	3.96	1.98	0.30
Exposed areas	6.67	3.33	0.50
Rehabilitated areas	8.69	4.34	0.65
Total	**162.5**	**52.90**	**6.13**

Table 12 Year 2085 – breakdown TSP, PM_{10} and $PM_{2.5}$ emission rates for the Project (g/s)

Activity	TSP	PM_{10}	$PM_{2.5}$
Pit activities			
Drilling and blasting	3.41	1.78	0.10
Bulldozing ROM coal	5.73	1.94	0.13
Bulldozing overburden	2.60	0.49	0.27
Loading/Dumping ROM coal	0.03	0.01	0.001
Loading/Dumping overburden	1.29	0.61	0.07
Haulage			
ROM coal haulage	6.98	1.99	0.20
Overburden haulage	53.45	15.23	1.52
Grading haul roads	12.60	3.73	0.39
Processing			
Sizing and crushing	1.96	0.69	0.05
Conveying and transfers	4.99	2.35	0.35
Wind erosion			
Stockpiles	4.95	2.47	0.37
Exposed areas	3.84	1.92	0.29
Rehabilitated areas	3.20	1.60	0.24
Total (g/s)	**105.02**	**34.82**	**3.98**

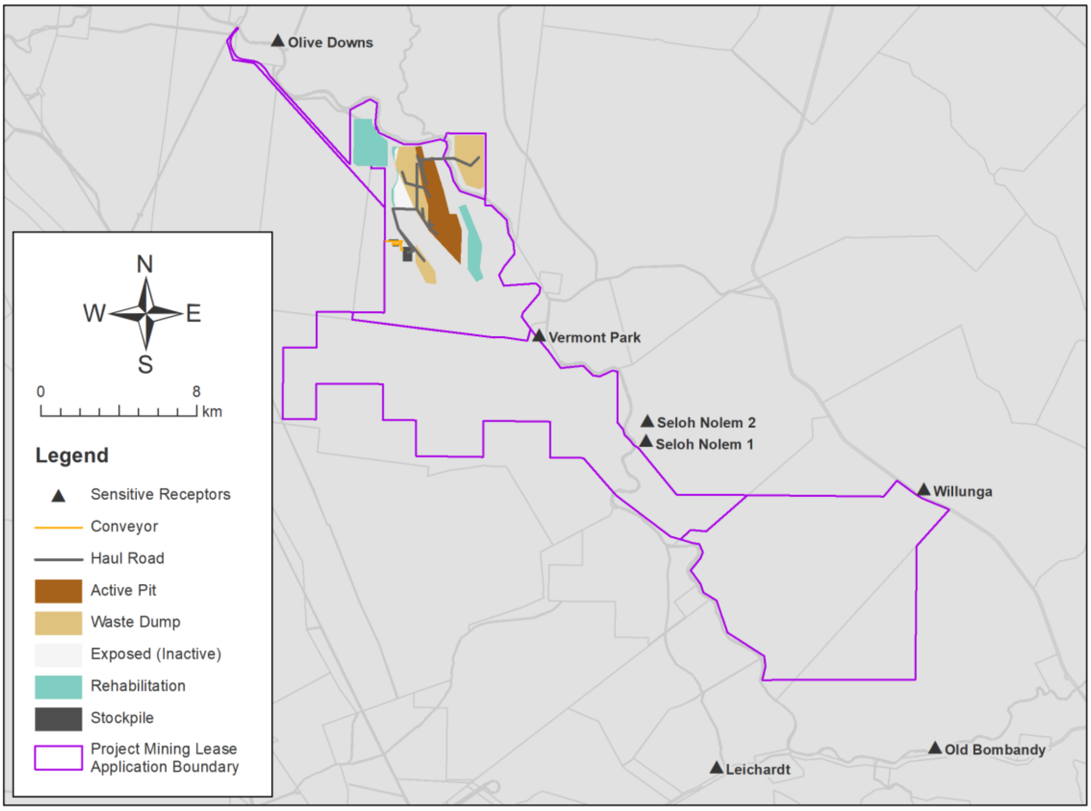


Figure 16 Year 2027 – Location of dust emission sources at the Project

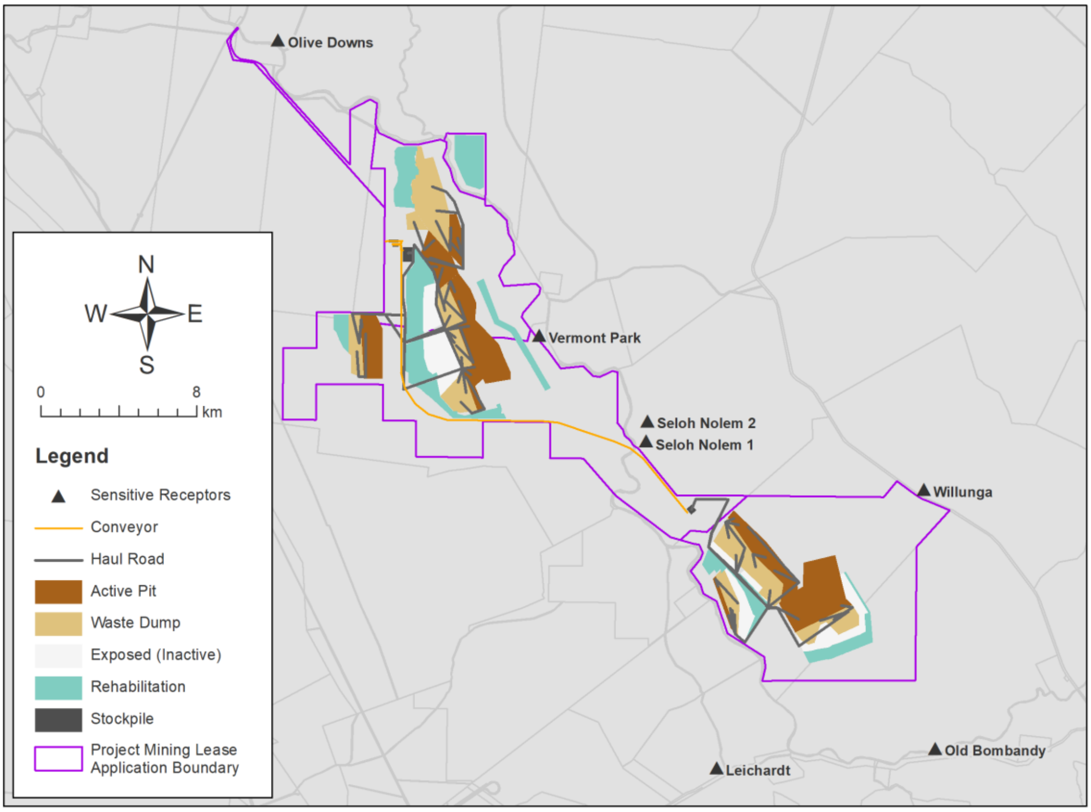


Figure 17 Year 2043 – Location of dust emission sources at the Project

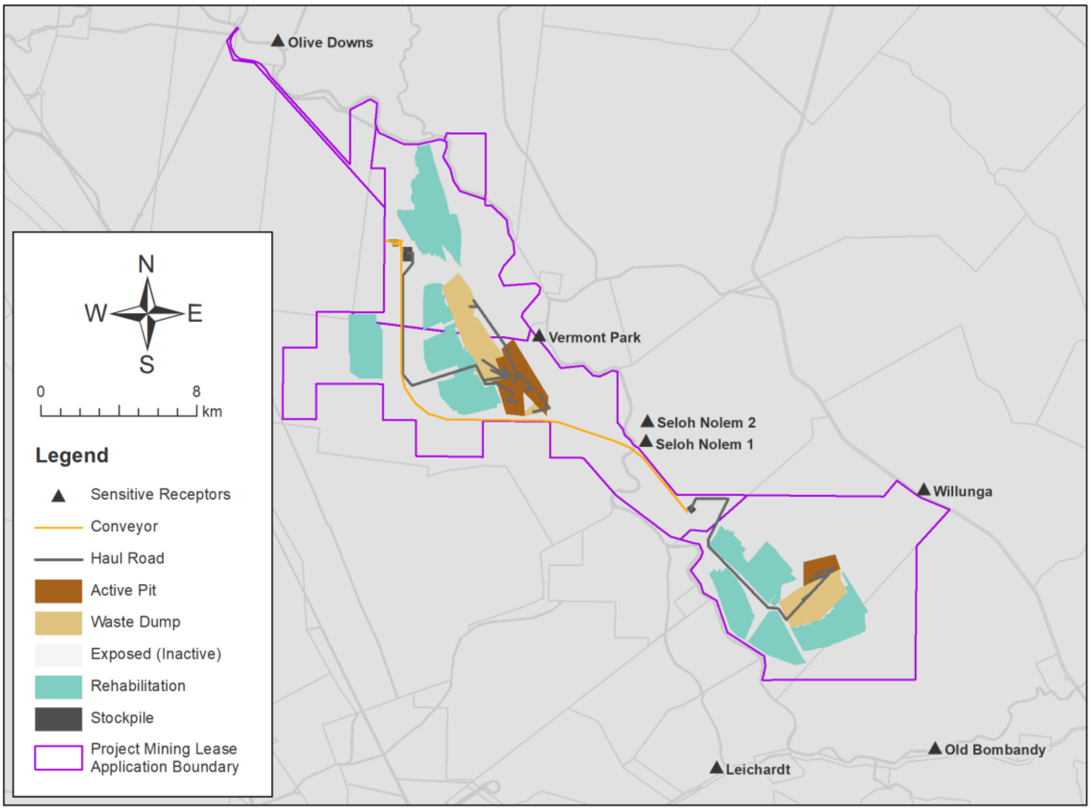


Figure 18 Year 2066 – Location of dust emission sources at the Project

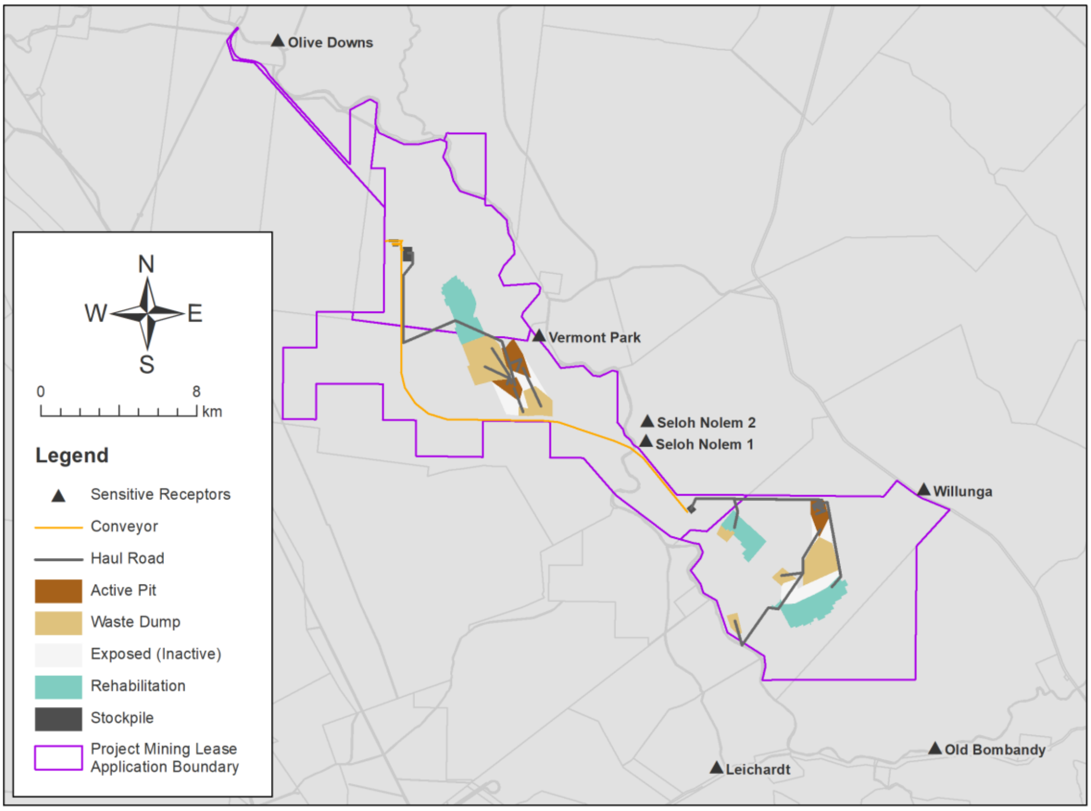


Figure 19 Year 2085 – Location of dust emission sources at the Project

7. AIR QUALITY IMPACT ASSESSMENT

This section presents the results of the dispersion modelling assessment of the Project. Modelling results associated with each scenario have been presented as ground-level concentrations or dust deposition rates at sensitive receptors as well as contours across the modelling domain.

Background dust levels have been added to the incremental model predictions in order to obtain an estimate of the potential cumulative impacts of the Project. Results have been assessed by comparing the predicted concentrations and dust deposition rates with the relevant air quality objectives.

When considering the results, it is important to note the 24-hour average dispersion modelling results are based on the concentration of each pollutant predicted at the receptors over the one-year period and thus represent a peak-impact scenario. The contour plots are constructed such that the highest value is obtained and stored from each point in the modelled domain. As these values may occur at different times at different grid points, these figures do not represent a single snapshot of conditions at any given time.

7.1 TSP

Table 13 provides the predicted annual average ground-level TSP concentrations for each Project scenario in isolation (i.e. without the background) and with background levels applied.

Contours of the predicted annual average ground-level TSP concentrations for each Project scenario are presented in Plate 1 to Plate 4 and provide the results of the cumulative assessment.

The results show that:

- Predicted concentrations of TSP ***comply*** with the relevant air quality objective at all sensitive receptors, in all modelled Project scenarios, in isolation and cumulatively.

Table 13 Predicted annual average ground-level concentrations of TSP (µg/m³)

Receptor	Year 2027		Year 2043		Year 2066		Year 2085	
	Project	Cumulative	Project	Cumulative	Project	Cumulative	Project	Cumulative
Leichardt	0.03	27.5	4.4	31.9	1.9	29.4	1.4	28.9
Old Bombandy	0.02	27.5	0.5	28.0	0.2	27.7	0.2	27.7
Willunga	0.03	27.5	1.1	28.6	0.7	28.2	0.6	28.1
Seloh Nolem 1	0.1	27.6	8.2	35.7	3.7	31.2	3.2	30.7
Vermont Park	0.4	27.9	7.3	34.8	5.5	33.0	2.9	30.4
Seloh Nolem 2	0.2	27.7	6.4	33.9	2.8	30.3	2.4	29.9
Olive Downs	2.1	29.6	4.3	31.8	0.7	28.2	0.3	27.8
Objective	**90 µg/m³**							

7.2 PM_{10}

The predicted 6th highest 24-hour average ground-level PM_{10} concentrations for each Project scenario in isolation (i.e. without the background) and with background levels applied (cumulative assessment) are presented in Table 14. Contours of the predicted 6th highest 24-hour average ground-level PM_{10} concentrations for all Project scenarios are presented in Plate 5 to Plate 8.

For the 2027 and 2085 Project scenarios the results account for the application of the standard mitigation measures described in Section 6.2. For the 2043 and 2066 scenarios the results account for both the application of standard mitigation measures and also the proactive mitigation measures discussed in Section 6.3.

The results show that:

- Predicted concentrations of PM_{10} due to the Project ***comply*** with the relevant air quality objective at all sensitive receptors in all Project scenarios, in isolation and cumulatively, with the application of standard mitigation measures and the proposed proactive and reactive mitigation measures.

Table 14 Predicted 6th high 24-hour average ground-level concentrations of PM_{10} ($\mu g/m^3$)

Receptor	Year 2027		Year 2043		Year 2066		Year 2085	
	Project	Cumulative	Project	Cumulative	Project	Cumulative	Project	Cumulative
Leichardt	0.4	27.6	32.5	47.6 A	17.2	44.4	10.1	37.3
Old Bombandy	0.2	27.4	7.4	34.6	3.4	30.6	2.2	29.4
Willunga	0.4	27.6	11.9	39.1	9.2	36.4	9.6	36.8
Seloh Nolem 1	1.9	29.1	36.5	48.9 A	13.8	41.0	10.9	38.1
Vermont Park	5.8	33.0	36.8	48.8 A	24.6	47.9 A	10.3	37.5
Seloh Nolem 2	2.3	29.5	32.2	47.8 A	11.2	38.4	8.4	35.6
Olive Downs	12.3	39.5	24.6	45.6A	5.3	32.5	2.1	29.3
Objective	**50 $\mu g/m^3$**							

Note:
A Includes proactive mitigation.

Predicted maximum 24-hour average PM_{10} concentrations at the sensitive receptors for each Project scenario are shown in Appendix C.

Further analysis of 24-hour average PM_{10} predictions for 2043 and 2066 indicates:

- Proposed proactive and reactive mitigations measures may be required when elevated PM_{10} concentrations would otherwise occur. The meteorological data and associated modelling results suggest such measures would be triggered relatively infrequently and would be unlikely to materially affect mine scheduling.
- Modifying night-time waste haulage operations is predicted to reduce the 24-hour average concentrations of PM_{10} (including background) at Vermont Park, Seloh Nolem 1 & 2, Leichardt and Olive Downs, resulting in compliance with the air quality objective (as shown in Figure 20 to Figure 24 for the 2043 Project scenario).
- Whilst this analysis has assumed modification of night-time haulage, there is a range of other proactive mitigative actions that would be available to Pembroke to reduce potential impacts if trigger levels are reached, as described in Section 6.3.

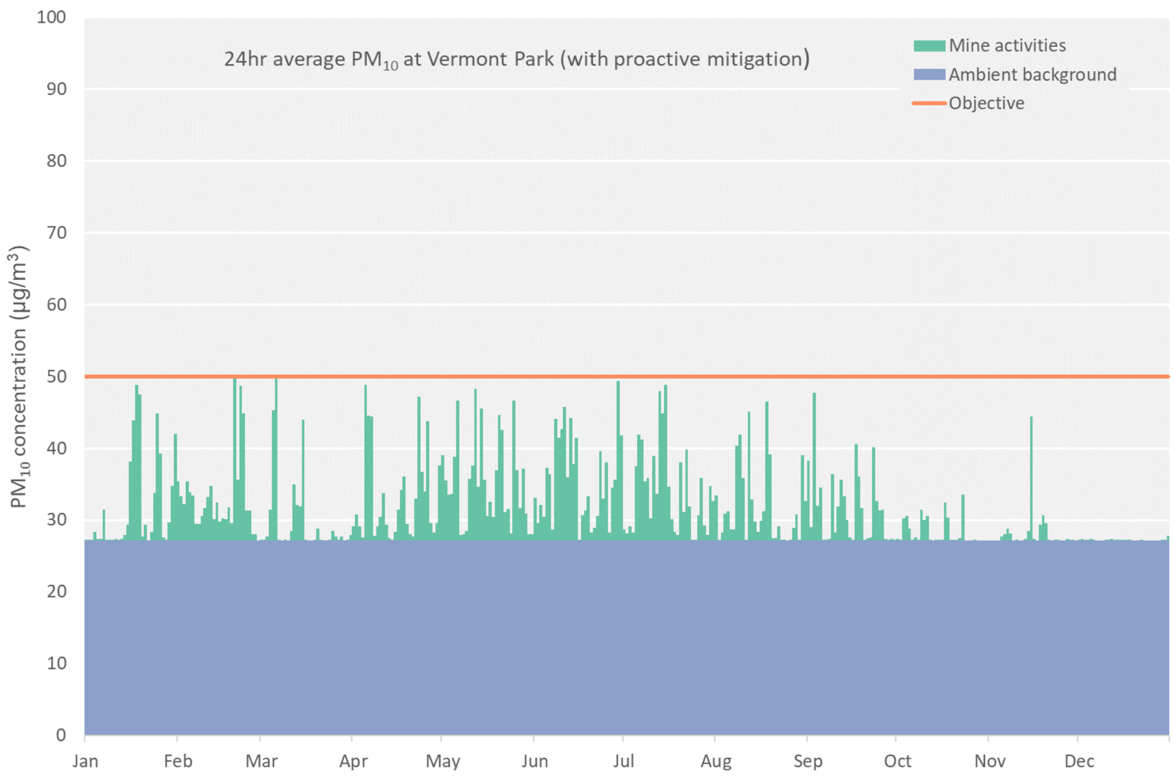


Figure 20 **Timeseries of the 2043 24-hour average PM_{10} at Vermont Park including proactive mitigation (when required)**

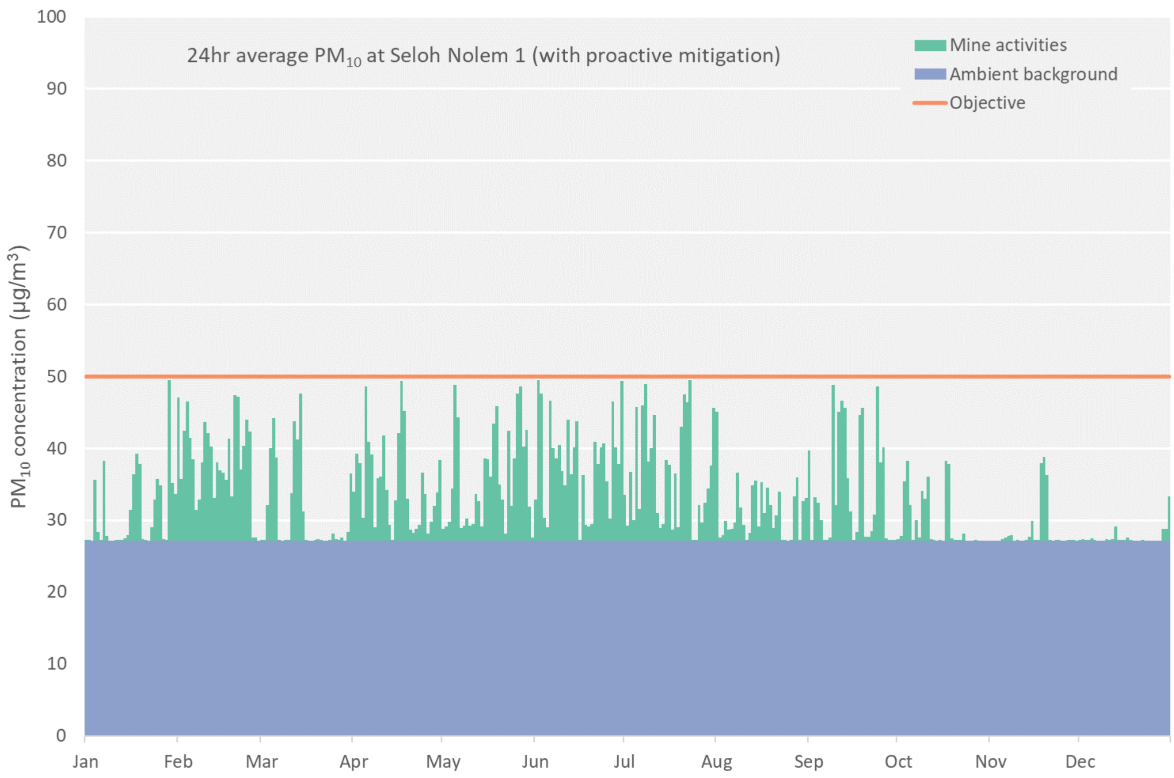


Figure 21 **Timeseries of the 2043 24-hour average PM_{10} at Seloh Nolem 1 including proactive mitigation (when required)**

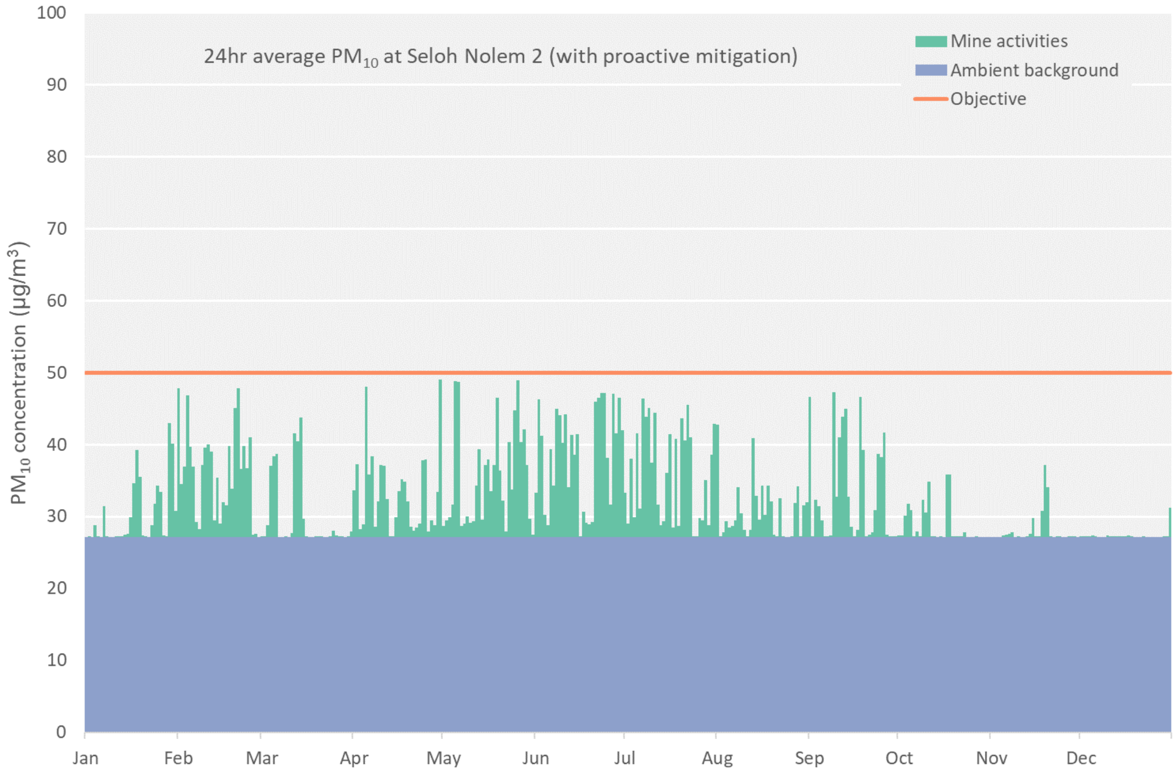


Figure 22 **Timeseries of the 2043 24-hour average PM_{10} at Seloh Nolem 2 including proactive mitigation (when required)**

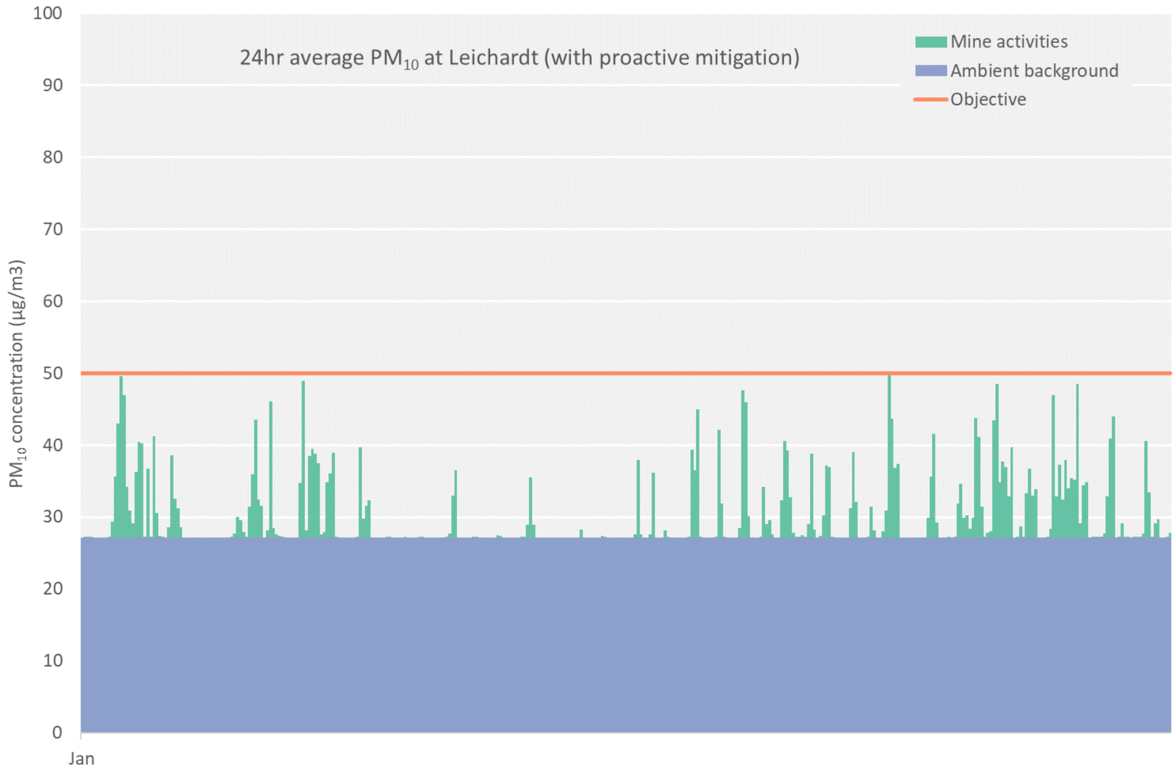


Figure 23 **Timeseries of the 2043 24-hour average PM_{10} at Leichardt including proactive mitigation (when required)**

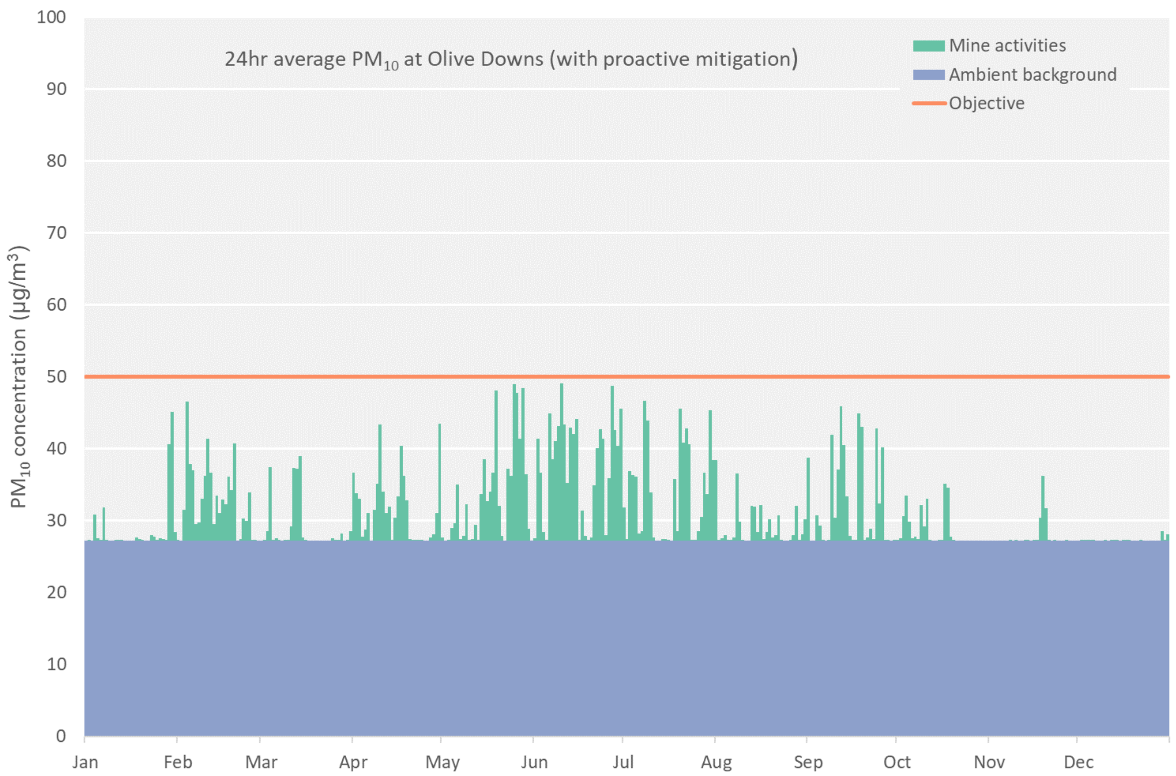


Figure 24 Timeseries of the 2043 24-hour average PM_{10} at Olive Downs including proactive mitigation (when required)

7.3 $PM_{2.5}$

Table 15 and Table 16 provide the predicted 24-hour average and annual average ground-level $PM_{2.5}$ concentrations for each Project scenario in isolation (i.e. without the background) and with background levels applied (cumulative assessment).

Contours of the predicted 24-hour average and annual average ground-level $PM_{2.5}$ concentrations for each Project scenario are presented in Plate 9 to Plate 16 and provide the results of the cumulative assessment.

The results show that:

- Predicted 24-hour average concentrations of $PM_{2.5}$ due to the Project ***comply*** with the relevant air quality objective at all sensitive receptors, in all modelled Project scenarios, in isolation and cumulatively.
- Predicted annual average concentrations of $PM_{2.5}$ due to the Project ***comply*** with the relevant air quality objective at all sensitive receptors, in all modelled Project scenarios, in isolation and cumulatively.

Table 15 Predicted 24-hour average ground-level concentrations of $PM_{2.5}$ ($\mu g/m^3$)

Receptor	Year 2027		Year 2043		Year 2066		Year 2085	
	Project	Cumulative	Project	Cumulative	Project	Cumulative	Project	Cumulative
Leichardt	0.3	4.6	7.4	11.7	3.7	8.0	2.4	6.7
Old Bombandy	0.1	4.4	2.7	7.0	1.2	5.5	0.7	5.0
Willunga	0.3	4.6	3.5	7.8	4.0	8.3	1.8	6.1
Seloh Nolem 1	0.6	4.9	11.0	15.3	5.8	10.1	2.9	7.2
Vermont Park	1.8	6.1	9.0	13.3	5.5	9.8	1.9	6.2
Seloh Nolem 2	1.0	5.3	10.8	15.1	4.4	8.7	2.4	6.7
Olive Downs	3.7	8.0	9.0	13.3	1.8	6.1	1.0	5.3
Objective	**25 µg/m³**							

Table 16 Predicted annual average ground-level concentrations of $PM_{2.5}$ ($\mu g/m^3$)

Receptor	Year 2027		Year 2043		Year 2066		Year 2085	
	Project	Cumulative	Project	Cumulative	Project	Cumulative	Project	Cumulative
Leichardt	0.01	3.61	0.65	4.25	0.31	3.91	0.22	3.82
Old Bombandy	0.004	3.60	0.10	3.70	0.05	3.65	0.03	3.63
Willunga	0.01	3.61	0.18	3.78	0.10	3.70	0.09	3.69
Seloh Nolem 1	0.02	3.62	1.33	4.93	0.59	4.19	0.53	4.13
Vermont Park	0.07	3.67	1.04	4.64	0.57	4.17	0.39	3.99
Seloh Nolem 2	0.03	3.63	1.11	4.71	0.50	4.10	0.44	4.04
Olive Downs	0.42	4.02	0.93	4.53	0.16	3.76	0.08	3.68
Objective	**8 µg/m³**							

7.4 Dust Deposition

Table 17 provides the predicted maximum monthly dust deposition rates for each Project scenario in isolation (i.e. without the background) and with background levels applied (cumulative assessment).

Contours of the predicted maximum monthly dust deposition rates for each Project scenario are presented in Plate 17 to Plate 20 and provide the results of the cumulative assessment.

The results show that:

- Predicted dust deposition rates due to the Project ***comply*** with the guideline at all sensitive receptors, in all modelled Project scenarios, in isolation and cumulatively.

Table 17 **Predicted maximum monthly dust deposition rates (mg/m²/day)**

Receptor	Year 2027		Year 2043		Year 2066		Year 2085	
	Project	Cumulative	Project	Cumulative	Project	Cumulative	Project	Cumulative
Leichardt	0.1	71.1	9.6	80.6	8.5	79.5	3.6	74.6
Old Bombandy	0.0	71.0	0.9	71.9	0.5	71.5	0.3	71.3
Willunga	0.0	71.0	1.6	72.6	1.7	72.7	1.2	72.2
Seloh Nolem 1	0.3	71.3	13.0	84.0	5.8	76.8	4.3	75.3
Vermont Park	1.1	72.1	12.7	83.7	15.2	86.2	7.3	78.3
Seloh Nolem 2	0.3	71.3	9.0	80.0	4.1	75.1	3.2	74.2
Olive Downs	3.3	74.3	6.0	77.0	1.3	72.3	0.6	71.6
Objective	**120 mg/m²/day**							

7.5 Railway operations

Rail operations, from mine site to port, can give rise to localised dust along the rail corridor. Sources of dust emissions from coal train operations include:

- The exposed coal surface of loaded wagons;
- Leakage of coal from unloading doors in the bottom of wagons;
- Wind erosion of spilled coal in the corridor; and
- Leakage of residual coal from doors of unloaded wagons.

For the majority of dust producing activities, the dust emission rate is dependent on the speed of the air passing over the coal surface, which is influenced by the ambient wind speed and the train speed. Other factors are also important, such as: coal moisture content, particle size distribution, dustiness of the coal, wagon vibration, frequency of train movements, the profile of the coal load, rainfall and distance travelled.

Katestone has conducted several studies involving both ambient air quality monitoring and modelling of emissions from coal trains (Katestone, 2008a; Katestone, 2008b). These studies focused on railway corridors that transport between 10 and 125 Mtpa of coal, which is associated with 5 to 35 trains per day (travelling to the unloading facilities and returning to the mines).

These studies found the influence of coal trains on ambient dust levels is very localised. Monitoring and modelling at distances of 50 to 100 metres from railway lines failed to find evidence of significant dust levels. Dust measurements found the increase in dust levels from passing trains was short-lived and dependent on the type of train and meteorological conditions.

In addition, several monitoring studies have been undertaken by the Queensland Government to investigate coal dust from rail transport. For example, pre and post-veneering monitoring programs were conducted in 2013 (Department of Science, Information Technology, Innovation and the Arts, 2013) that measured particle levels along the Western and Metropolitan Rail Systems of Brisbane. These studies showed that ambient particle concentrations did not exceed air quality objectives at the monitoring sites, and that urban activities were the primary contribution to particle levels, not rail transport emissions. A continuous monitoring program is also being conducted at the Cannon Hill Railway Station to monitor particle levels along the Brisbane Metropolitan rail line. Whilst this monitoring is ongoing, the 2014 to 2015 peer reviewed monitoring report (Department of Science, Information Technology and Innovation, 2016) concluded that rail transport emissions were a minor contributor to overall particle levels at the monitoring site.

Notwithstanding the above, a number of management measures to minimise the generation of coal dust from rail loading and transport will be implemented by Pembroke, consistent with the dust mitigation activities presented in the *Coal Dust Management Plan* (QR Network, 2010), including:

- Automated loading of train wagons to prevent overloading;
- Sill beam brushes to remove coal on the outside faces of the train wagons;
- Veneering system to prevent coal dust generation during transit to port;
- Water sprays on the train load out to minimise dust generation; and
- Use of a spill pit to recover split coal under the train load out.

8. GREENHOUSE GAS ASSESSMENT

8.1 Background

The term greenhouse gases (GHG) comes from the 'greenhouse effect', which refers to the natural process that warms the Earth's surface. GHG in the atmosphere absorb the solar radiation released by the Earth's surface and then radiate some heat back towards the ground, increasing the surface temperature. Human activity, especially burning fossil fuels and deforestation, is increasing the concentration of GHG in the atmosphere and hence increasing the absorption of outgoing heat energy. Even a small increase in long-term average surface temperatures has numerous direct and indirect consequences for climate.

Australia is a signatory to United Nations Framework Convention on Climate Change (UNFCCC), the associated Kyoto Protocol signalling its commitment to reducing GHG emissions at a national level. Under the Paris Agreement, the most recent progression of the UNFCCC, Australia has set an ambitious target to reduce emissions by 26-28 per cent below 2005 levels by 2030, building on the 2020 target of reducing emissions by five per cent below 2000 levels.

The main GHG associated with the Project is carbon dioxide (CO_2), with smaller contributions from methane (CH_4) and nitrous oxide (N_2O). These gases vary in effect and longevity in the atmosphere, however a parameter referred to as the Global Warming Potential (GWP) allows each gas to be described in terms of CO_2 (the most prevalent greenhouse gas). Thus a given quantity of CH_4 or N_2O can be expressed in terms of carbon dioxide equivalents (CO_2-e). A unit of one tonne of CO_2-e is the basic unit used in carbon accounting. In simple terms the greenhouse gas emissions associated with the Project can be expressed as the sum of the emission rate of each greenhouse gas multiplied by its associated GWP (denoted in squares). For example:

$$\text{tonnes } \mathbf{CO_2\text{-}e} = \text{tonnes } \mathbf{CO_2} \times \boxed{\mathbf{1}} + \text{tonnes } \mathbf{CH_4} \times \boxed{\mathbf{25}} + \text{tonnes } \mathbf{N_2O} \times \boxed{\mathbf{310}}$$

While few, if any, individual Projects would make a noticeable change to the Earth's climate, the summation of human activities increasing the concentrations of GHG in the atmosphere does. Climate change is an environmental concern at a global level. Governments and the global scientific community have established conventions for accounting for GHG emissions to enable the transparent and verifiable assessment of GHG emissions among all global jurisdictions. This assessment employs these established conventions so that the relative impact of the Project can be assessed and understood.

8.2 Regulatory Framework for Greenhouse Gas Emissions

8.2.1 National policy

Australia will meet its targets through the Government's Direct Action Plan. The Emissions Reduction Fund (ERF) is a central component of the Direct Action policies, and comprises emission reduction credits, a fund to purchase emission reductions, and a Safeguard Mechanism.

The Safeguard Mechanism has been put in place to ensure that emissions reductions purchased by the Government through the ERF are not offset by significant increases in emissions by large emitters elsewhere in the economy. The Safeguard Mechanism commenced on 1 July 2016 and requires Australia's largest emitters to keep emissions within baseline levels. It applies to around 140 large businesses that have facilities with direct emissions (Scope 1 Emissions) of more than 100,000 tonnes of carbon dioxide equivalent (t CO_2-e) a year and is expected to cover approximately half of Australia's emissions.

Direct emissions associated with the Project are anticipated to exceed 100,000 t CO_2-e for all years with the exception of the first year of operation (2020). As a result, the Project will be subject to the requirements of the Safeguard Mechanism.

8.2.2 National Greenhouse and Energy Reporting (NGER)

The *National Greenhouse and Energy Reporting Act 2007* (NGER Act) established a national framework for corporations to report GHG emissions and energy consumption.

The NGER Regulation recognises Scope 1 and Scope 2 emissions as follows:

- Scope 1 emissions – in relation to a facility, means the release of GHG into the atmosphere as a direct result of an activity or series of activities (including ancillary activities) that constitute the facility.
- Scope 2 emissions – in relation to a facility, means the release of GHG into the atmosphere as a direct result of one or more activities that generate electricity, heating, cooling or steam that is consumed by the facility but that do not form part of the facility.

Registration and reporting is mandatory for corporations that have energy production, energy use or GHG emissions that exceed specified thresholds. GHG emission thresholds include Scope 1 and Scope 2 emissions. NGER reporting thresholds are summarised in Table 18.

Table 18 NGER annual reporting thresholds – greenhouse gas emissions and energy use

Threshold level	Threshold type	
	GHG (kt CO_2-e)	Energy consumption (TJ)
Facility	25	100
Corporate	50	200

Note:
kt CO_2-e = kilotonnes of carbon dioxide equivalent. TJ = terajoules.

With annual emissions (Scope 1 + Scope 2) ranging from 141 kt CO_2-e to 1,410 kt CO_2-e, Pembroke will have reporting obligations associated with the Project under the NGER Scheme, including estimating and reporting their GHG emissions on an annual basis.

8.3 Methodology

Pollutants of importance to climate change, associated with the Project, are carbon dioxide, methane and nitrous oxide. This study will assess the emissions of greenhouse gases from the Project during construction and operation based on activity data representative of the proposed activities and the methods described in the following documents:

- The National Greenhouse Accounts, July 2017 (Commonwealth Department of the Environment and Energy, 2017)
- *National Greenhouse and Energy Reporting (Measurement) Determination 2008*
- The Greenhouse Gas Protocol
- FullCAM – Full Carbon Accounting Model (used to account for GHG emissions from land clearing).

8.3.1 Emissions

Scope 1 and 2 greenhouse gas emissions will be estimated on an annual basis for the Project. This will include emissions from:

Scope 1 GHG emissions

- Diesel combustion
  - Heavy machinery and site vehicles

- Haulage vehicles
- Diesel generators.

- Use of explosives.
- Fugitive methane emissions from the coal seams.

Scope 2 GHG Emissions

- Electricity usage
  - Conveyors
  - Coal processing plant
  - Amenities.

Land clearing was also considered. During the construction and initial mining operations some land clearing will take place. However, as mining operations progress, spent pits and waste emplacement landforms will be progressively rehabilitated, resulting in offsetting any previous GHG emissions from land clearing. GHG emissions originating from land clearing and the offset from subsequent rehabilitation have not been included as they are not significant compared to the annual Scope 1 and Scope 2 GHG emissions associated with the Project.

8.3.2 Emissions estimation

GHG emissions associated with the Project have been considered on an annual basis for the life of the Project. A summary of estimated emissions associated with mining operations, expressed as tonnes per annum expressed in terms of CO_2-e is presented. Reporting obligations based on a conservative estimate of annual GHG emissions are summarised, along with measures to mitigate GHG emissions through avoidance and minimisation.

The methodologies used to estimate the GHG emissions resulting from the Project are consistent with:

1. *National Greenhouse and Energy Reporting (Measurement) Determination 2008*
2. The National Greenhouse Accounts, July 2017 (Commonwealth Department of the Environment and Energy, 2017)
3. The Greenhouse Gas Protocol.

In particular, the methodology is consistent with a Method 1 approach as detailed in the *National Greenhouse and Energy Reporting (Measurement) Determination*.

The emission factors and energy content for each of the emissions sources that have been used in the assessment are summarised in Table 19.

Table 19 Emission factors and energy content for GHG emission sources

Emission source	Scope	Energy content	Units	Emission factor	Units
Diesel	1	38.6	GJ/kL	70.5	kg CO_2-e/GJ
Fugitive methane (Qld – open cut)	1	-	-	0.02	t CO_2-e/t ROM
Explosives (Ammonium Nitrate Fuel Oil [ANFO])	1	2.4	GJ/t	0.17	t CO_2-e/t ANFO
Electricity (Queensland)	2	3.6	MJ/kWh	0.79	kg CO_2-e/kWh

Sources: *National Greenhouse and Energy Reporting (Measurement) Determination*, National Greenhouse Accounts Factors (July 2017), NGA Workbook (January 2008).

Note:
GJ/kL = gigajoules per kilolitre. GJ/t = gigajoules per tonne. MJ/kWh = megajoules per kilowatt hour.
kg CO_2-e/GJ = kilograms of carbon dioxide equivalent per gigajoule. t CO_2-e/t ROM = tonnes of carbon dioxide equivalent per tonne of ROM coal. t CO_2-e/t ANFO = tonnes of carbon dioxide equivalent per tonne of ANFO.
kg CO_2-e/kWh = kilograms of carbon dioxide equivalent per kilowatt hour.

8.4 Results

8.4.1 GHG emissions and energy use summary

Operations at the mine are forecast to commence in 2020. With coal being produced by the mine for a 66-year period. For the purposes of the air quality and greenhouse gas assessment mining operations have been considered as occurring in roughly four stages, coinciding with changing production rates and mining locations across the Olive Downs South domain and Willunga domain. An approximate summary of the four stages in terms of timing and ROM production rates is provided in Table 20.

Table 20 Summary of ROM production by stage of operations for the life of mining operations

Stage	ROM (kilotonnes/year)			
	Minimum	Maximum	Average	TOTAL
2020-2030	1,000	6,000	5,155	56,707
2031-2051	10,384	20,000	17,541	368,3527
2052-2072	888	10,155	6,518	136,874
2072-2098	376	3,334	1,905	49,531
Life of mine	**376**	**20,000**	**7,740**	**611,465**

A summary of anticipated annual GHG emissions, by scope, along with estimated energy consumption corresponding with the nominated stages are summarised in Table 21 and Table 22.

Table 21 Summary of GHG emissions by stage of operations for the life of mining operations

Scope	Stage	GHG (kt CO_2-e/yr)			
		Minimum	Maximum	Average	TOTAL
Scope 1	2020-2030	87	735	439	4,831
	2031-2051	1,021	1,989	1,681	35,292
	2052-2072	283	949	678	14,232
	2072-2098	61	323	199	5,163
	Life of mine	61	1,989	753	**59,518**
Scope 2	2020-2030	89	89	89	977
	2031-2051	89	260	246	5,166
	2052-2072	143	143	143	3,013
	2072-2098	89	143	125	3,239
	Life of mine	89	260	157	**12,395**
TOTAL	2020-2030	176	823	528	5,808
	2031-2051	1,164	2,249	1,927	40,458
	2052-2072	427	1,092	821	17,246
	2072-2098	150	467	323	8,401
	Life of mine	150	2,249	910	**71,912**

Table 22 Summary of energy use by stage of operations for the life of mining operations

Stage	Energy use (TJ/yr)			
	Minimum	Maximum	Average	TOTAL
2020-2030	1,362	9,233	5,197	57,167
2031-2051	12,114	23,953	20,078	421,633
2052-2072	4,408	730,828	8,460	177,651
2072-2098	936	6,830	3,393	108,567
Life of mine	936	23,953	9,251	**765,017**

The relative influence of the emissions sources on GHG emissions over the Project life is summarised in Figure 25. A similar breakdown of GHG by emissions scopes and emission sources is observed for individual years of operations. Over half of the GHG emissions associated with the Project are associated with diesel combustion for heavy machinery, mining equipment, haulage and other onsite vehicles as well as supplementary electricity generation. Fugitive methane and electricity have also been identified as significant sources of GHG emissions.

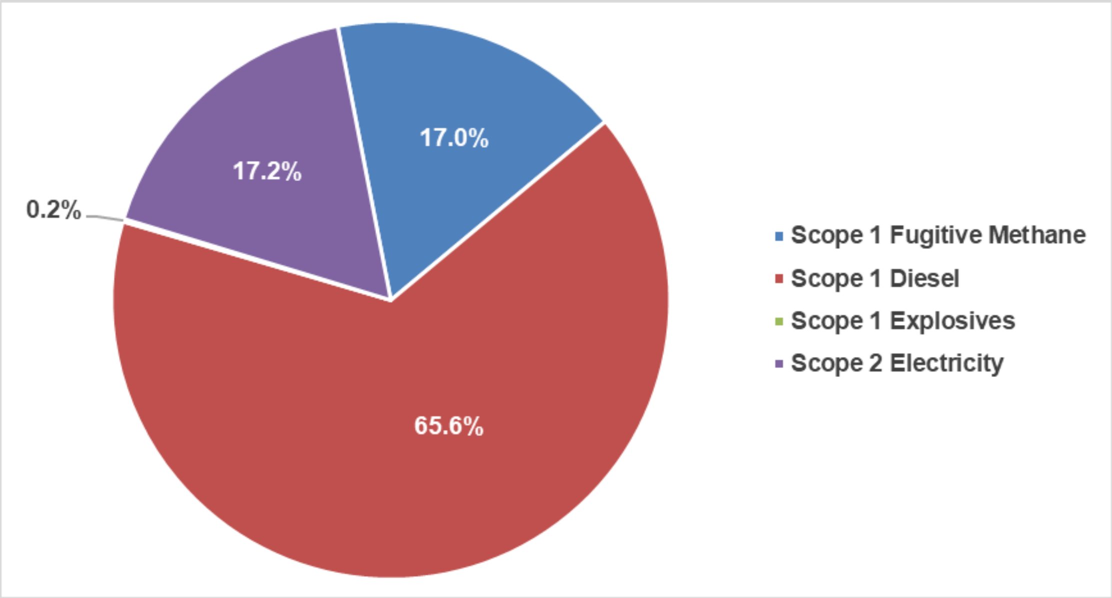


Figure 25 Summary of GHG emissions by scope over the life of mining operations (2020-2098)

For comparative purposes the latest GHG inventory estimates for Australia and Queensland (excluding emissions from Land Use, Land Use Change and Forestry [LULUCF]) are 550 Mt CO_2-e and 101 Mt CO_2-e, respectively (Commonwealth of Australia, 2017a and Commonwealth of Australia, 2017b). With maximum annual GHG emissions of 2,249 kt CO2-e in 2035, the Project could contribute up to 0.4% of national emissions and 2.2% of state emissions.

8.4.2 Regulatory obligations – NGER and the Safeguard Mechanism

As detailed in Table 21, the annual GHG emissions of the Project range from:

- Scope 1: 61 – 1,989 kt CO_2-e/y
- Total: 150 – 12,249 kt CO_2-e/y

Based on the NGER Reporting thresholds detailed in Table 18, Pembroke will have ongoing reporting obligations associated with the Project including annual assessment of GHG emissions as set out by the *NGER Act* and the *National Greenhouse and Energy Reporting (Measurement) Determination*.

In all years apart from the first year of operation (2020) Scope 1 emissions exceed 100 kt CO_2-e/y. Under the current Safeguard Mechanism facilities with Scope 1 emissions of more than 100 kt CO2-e/y are required to keep their emissions within baseline levels. This Safeguard Mechanism would apply to the Project, however the exact implications of this would need to be reviewed on an annual basis in communication with the regulator.

8.4.3 GHG mitigation and management

A range of options for Pembroke to manage Project-related GHG emissions include:

General

- Continuous improvement approach through ongoing monitoring and reporting GHG emissions and identifying opportunities to reduce GHG emissions
- Use of solar photovoltaic (PV) cells to supplement electricity requirements

Diesel

- Reduce mine equipment diesel consumption through equipment selection, load optimisation, route optimisation and production scheduling as well as reduced idle time
- Maintain equipment based on manufacturer/supplier guidelines and recommendations
- Reduce generator diesel consumption through selecting a flexible configuration that allows for electricity output to be adjusted in line with demand

Electricity

- On site power factor correction should be optimised to minimise the usage of grid electricity
- Consider using solar-powered lighting to reduce electricity demand
- Adjust peak demand through production scheduling to allow for optimal and well utilised diesel power generation capacity.

9. CONCLUSIONS

Air quality and greenhouse assessments were undertaken for the Olive Downs South Project, a proposed open-cut coal mine located 40 km south-east of Moranbah with a life of mine of approximately 78 years. The assessments were conducted to meet the Project's ToR and prepared in accordance with regulatory guidelines.

An air quality assessment has investigated the potential for the Project to affect air quality in the region. Four scenarios (Years 2027, 2043, 2066 and 2085) have been considered. These represent worst-case emission scenarios over four distinct years during the life of the Project. Selection of the four scenarios was based on the proposed mining schedule and the proximity of sensitive receptors to critical emissions generating activities. The assessment has used meteorological and dispersion models to assess the effect of emissions of particulate matter on concentrations of TSP, PM_{10}, $PM_{2.5}$ and dust deposition rate on the surrounding region due to the Project.

Air quality levels due to operations of the Project in isolation, and with the inclusion of background levels of dust, were determined at identified sensitive receptors and on a grid of evenly-spaced receptors covering the region. Predicted ground-level concentrations and deposition rates were compared with the relevant air quality objectives and guidelines.

The air quality assessment of the Project found the following:

TSP

- Predicted concentrations of TSP ***comply*** with the relevant air quality objective at all sensitive receptors, in all modelled Project scenarios, in isolation and cumulatively.

PM_{10}

- Predicted concentrations of PM_{10} due to the Project ***comply*** with the relevant air quality objective at all sensitive receptors in all Project scenarios, in isolation and cumulatively, with the application of standard mitigation measures and the proposed proactive and reactive mitigation measures.

$PM_{2.5}$

- Predicted 24-hour average concentrations of $PM_{2.5}$ due to the Project ***comply*** with the relevant air quality objective at all sensitive receptors, for all modelled Project scenarios, in isolation and cumulatively.
- Predicted annual average concentrations of $PM_{2.5}$ due to the Project ***comply*** with the relevant air quality objective at all sensitive receptors, for all modelled Project scenarios, in isolation and cumulatively.

Dust Deposition

- Predicted dust deposition rates due to the Project ***comply*** with the guideline at all sensitive receptors, for all modelled Project scenarios, in isolation and cumulatively.

The greenhouse gas assessment of the Project found the following:

- Maximum annual greenhouse gas emissions associated with the Project are estimated to be 2,249 kt CO2-e (Year 2035), while average annual GHG emission have been estimated to be 910 kt CO2-e over the life of mine.
- Greenhouse gas emissions from the Project are predominantly due to diesel use (66%), electricity generation (indirect emissions) (17%) and fugitive methane releases (17%).

Compared to national and state greenhouse gas inventory levels, the maximum annual GHG emissions from the Project would account for approximately 0.4% and 2.2%, respectively.

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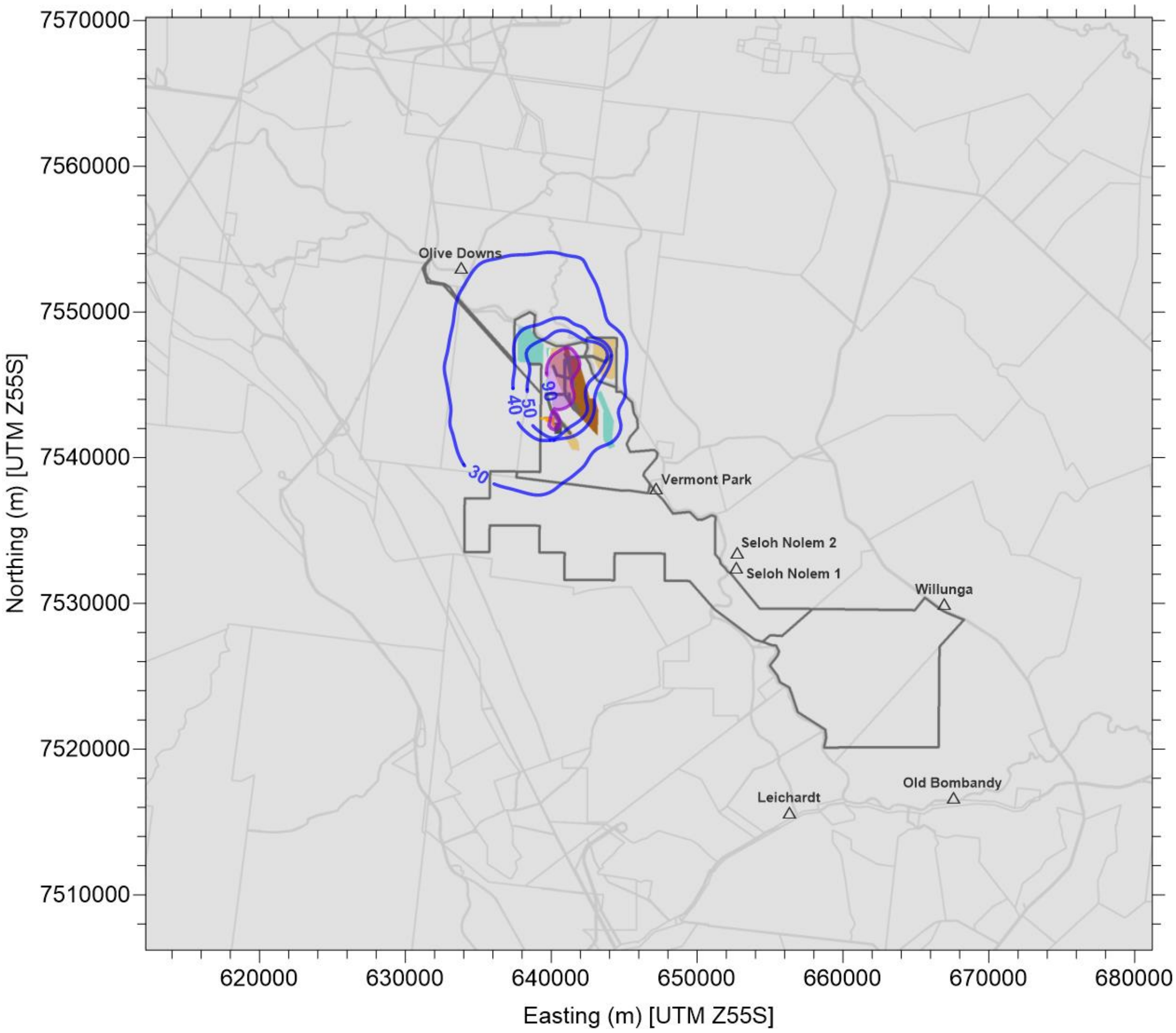

Plate 1	**Year 2027 predicted annual average ground-level concentrations of TSP for the cumulative assessment**

Location: Olive Downs Coking Coal Project, Moranbah, QLD	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Average contours	**Objective:** 90 µg/m³ (purple)	**Prepared by:** Manning Young	**Date:** July 2018

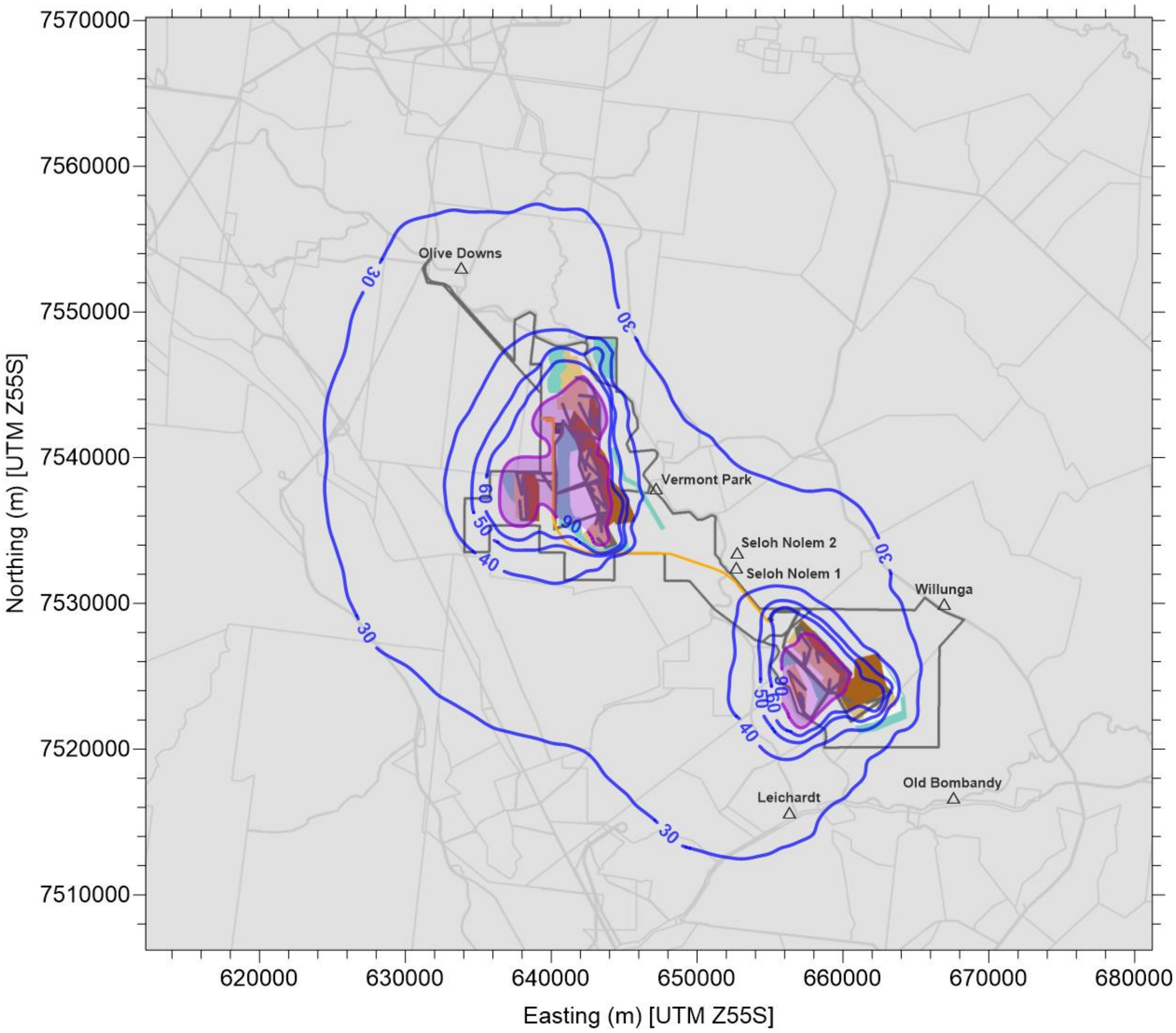

Plate 2 **Year 2043 predicted annual average ground-level concentrations of TSP for the cumulative assessment**

Location:	**Averaging period:**	**Data source:**	**Units:**
Olive Downs Coking Coal Project, Moranbah, QLD	Annual	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Average contours	90 µg/m³ (purple)	Manning Young	July 2018

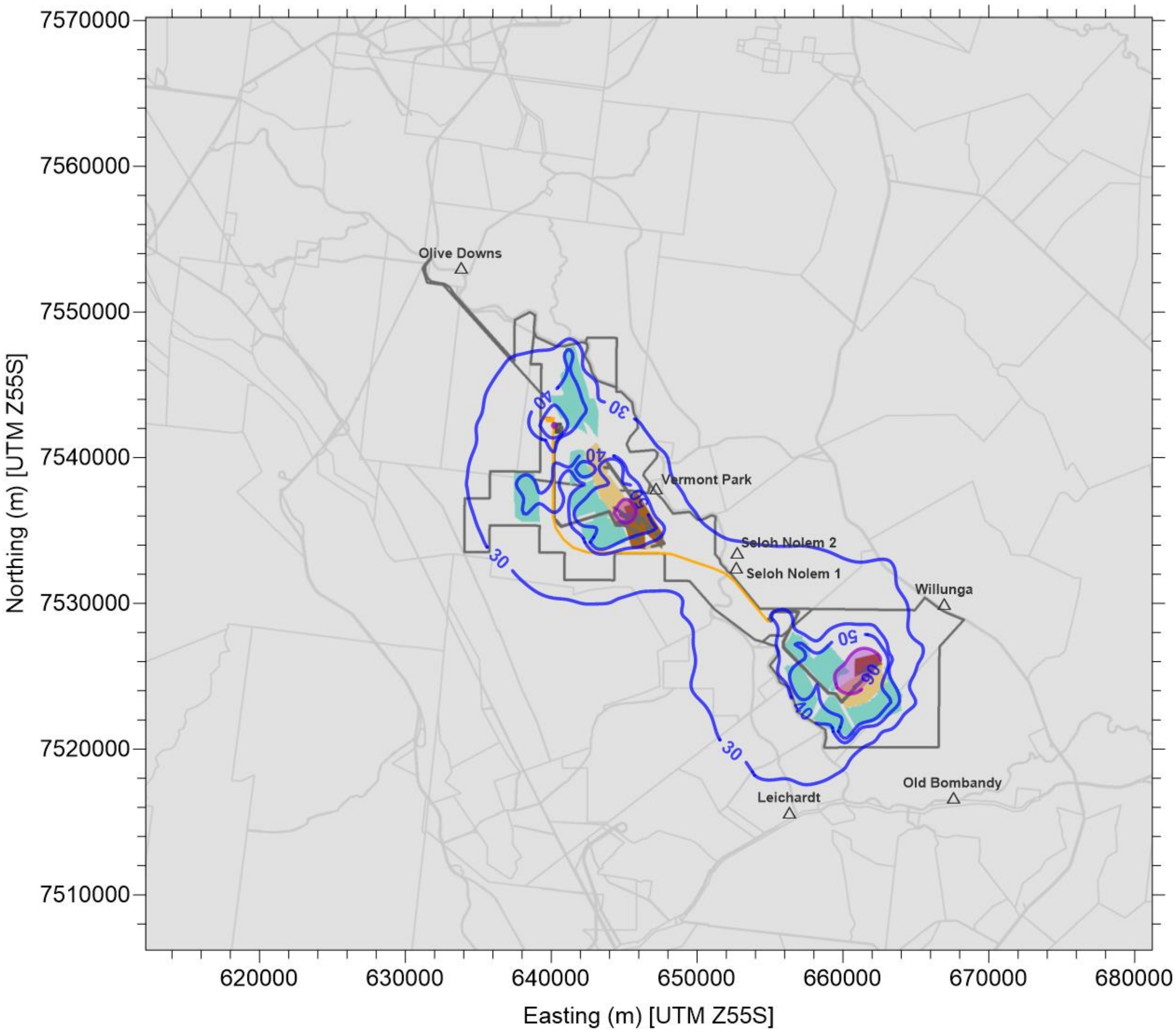

Plate 3	**Year 2066 predicted annual average ground-level concentrations of TSP for the cumulative assessment**		
Location: Olive Downs Coking Coal Project, Moranbah, QLD	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Average contours	**Objective:** 90 µg/m³ (purple)	**Prepared by:** Manning Young	**Date:** July 2018

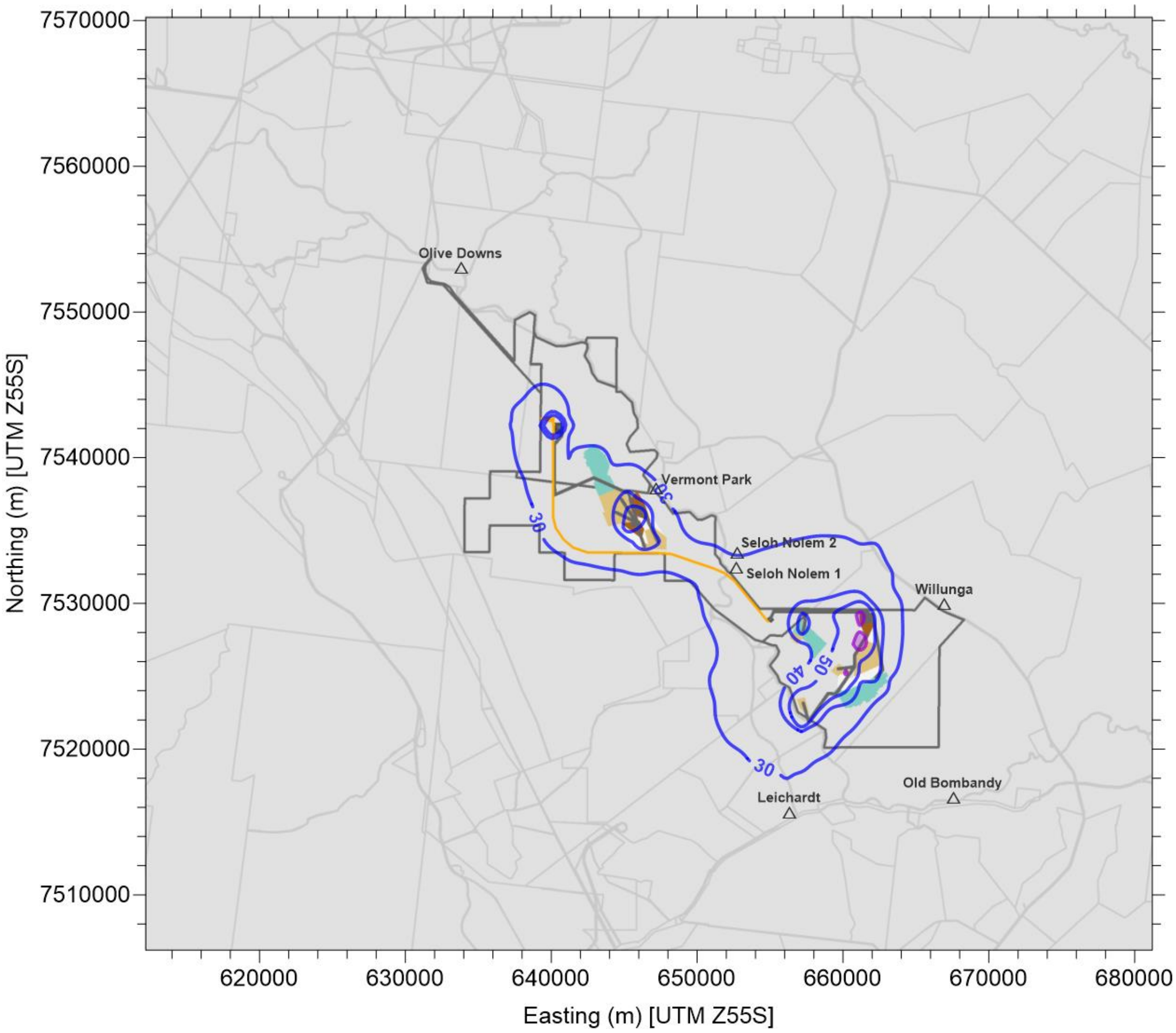

Plate 4	**Year 2085 predicted annual average ground-level concentrations of TSP for the cumulative assessment**

Location: Olive Downs Coking Coal Project, Moranbah, QLD	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Average contours	**Objective:** 90 µg/m³ (purple)	**Prepared by:** Manning Young	**Date:** July 2018

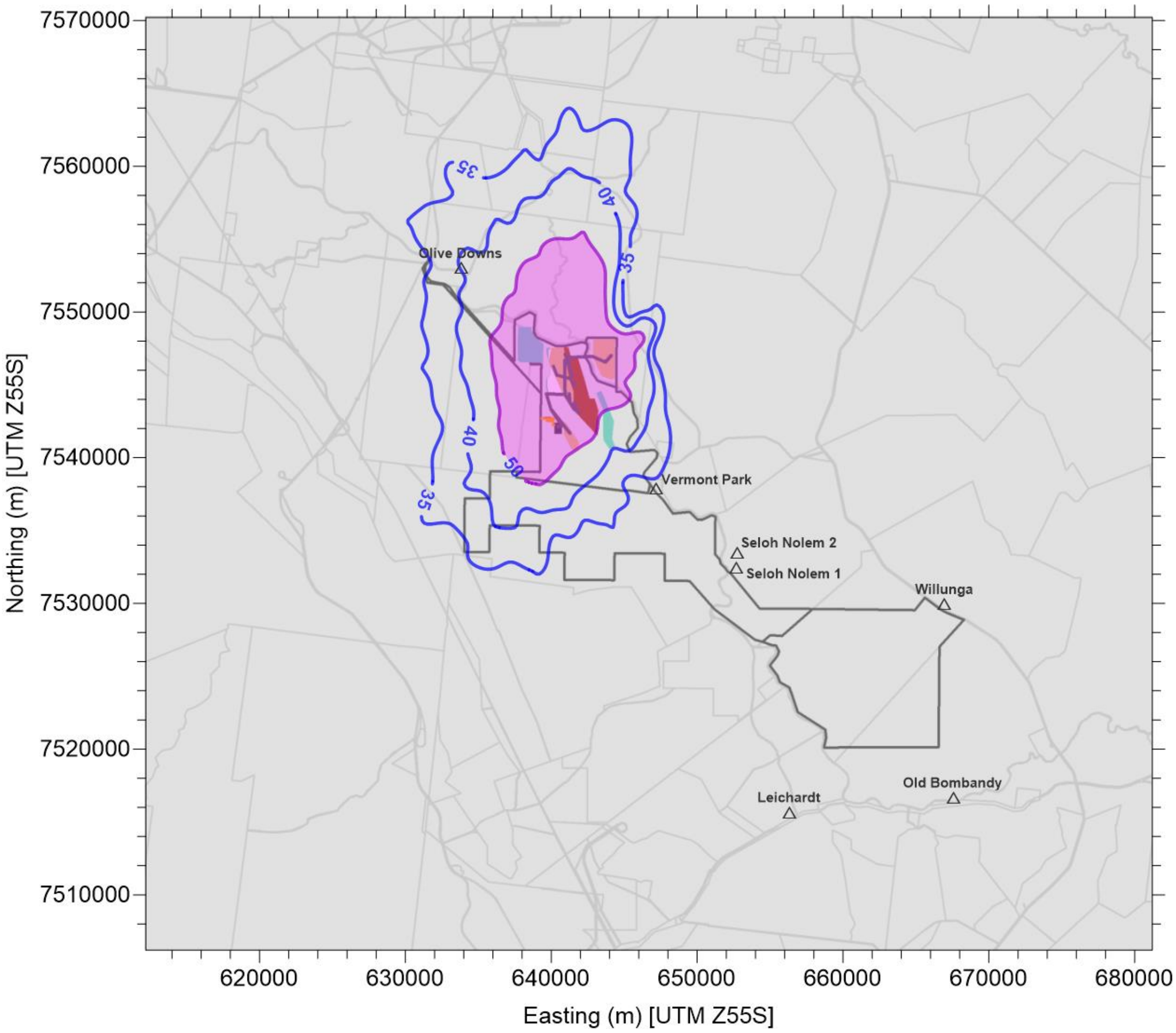

Plate 5 **Year 2027 predicted 6th highest 24-hour average ground-level concentrations of PM_{10} for the cumulative assessment**

Location:	**Averaging period:**	**Data source:**	**Units:**
Olive Downs Coking Coal Project, Moranbah, QLD	24-hour	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
6th highest contours	50 µg/m³ (purple)	Manning Young	July 2018

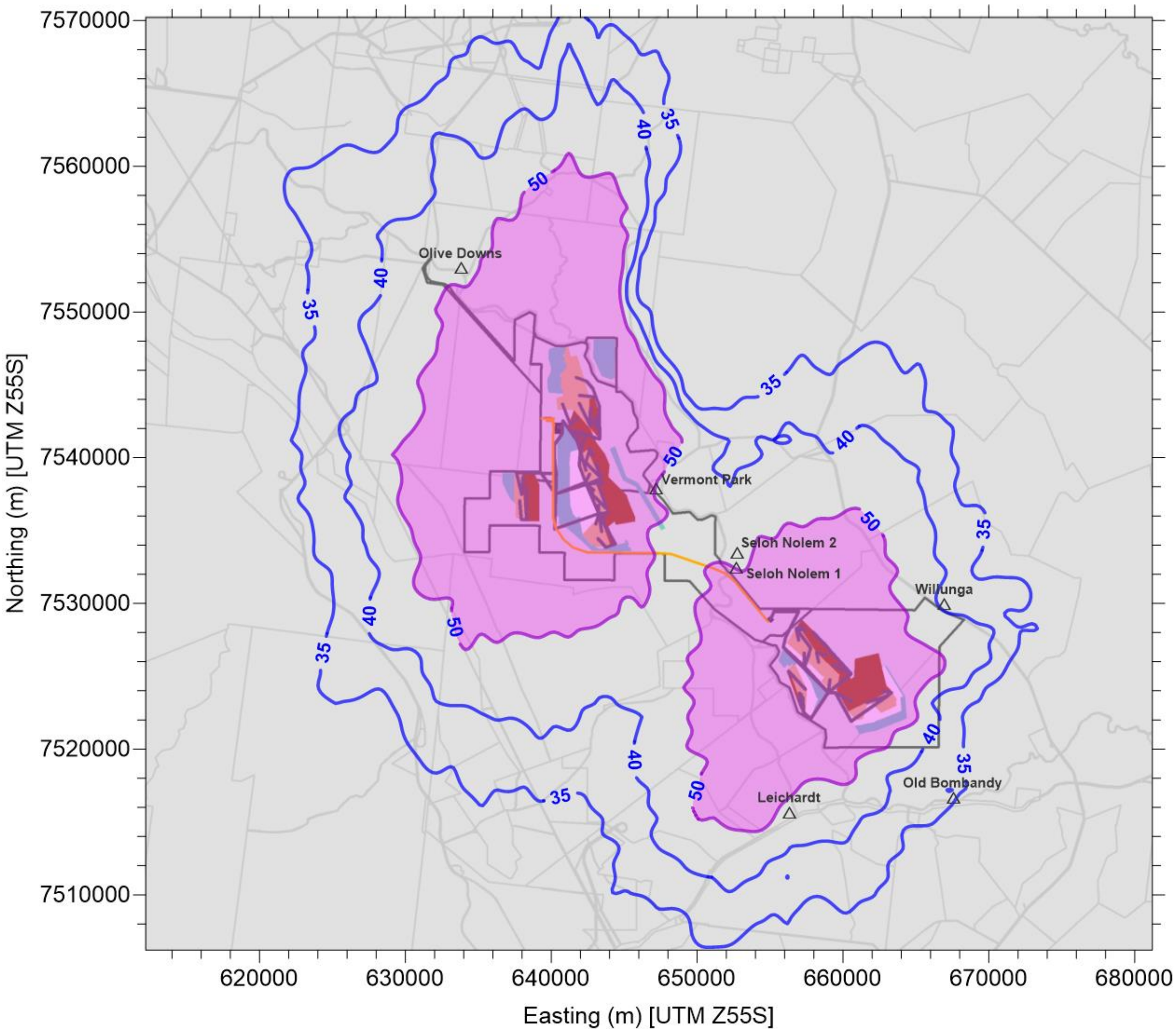

Plate 6	Year 2043 predicted 6th highest 24-hour average ground-level concentrations of PM_{10} for the cumulative assessment including the effects of proactive mitigation measures		
Location: Olive Downs Coking Coal Project, Moranbah, QLD	**Averaging period:** 24-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: 6th highest contours	**Objective:** 50 µg/m³ (purple)	**Prepared by:** Manning Young	**Date:** July 2018

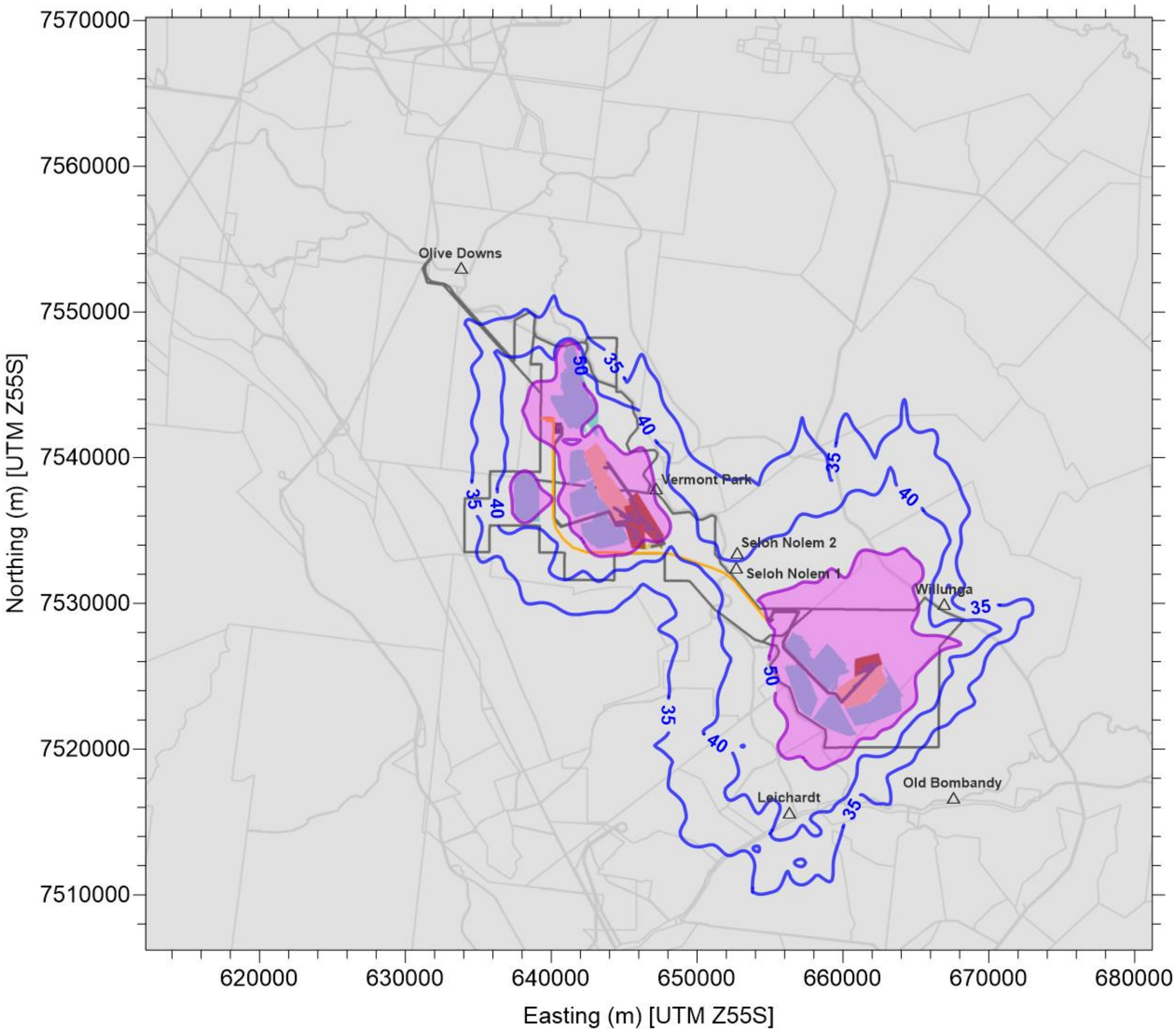

Plate 7	**Year 2066 predicted 6th highest 24-hour average ground-level concentrations of PM_{10} for the cumulative assessment including the effects of proactive mitigation measures**

Location:	**Averaging period:**	**Data source:**	**Units:**
Olive Downs Coking Coal Project, Moranbah, QLD	24-hour	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
6th highest contours	50 µg/m³ (purple)	Manning Young	July 2018

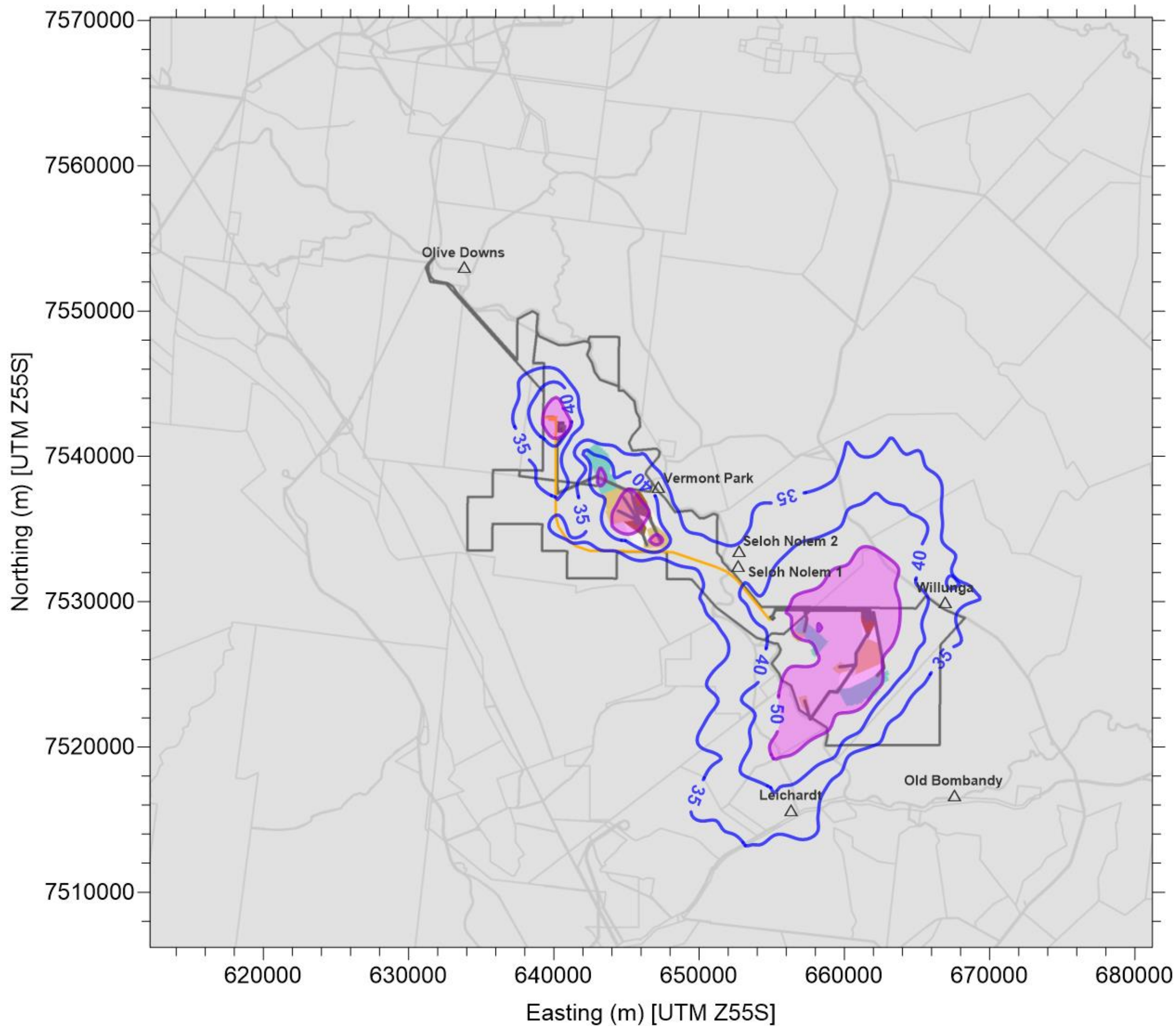

Plate 8	**Year 2085 predicted 6th highest 24-hour average ground-level concentrations of PM_{10} for the cumulative assessment**

Location:	**Averaging period:**	**Data source:**	**Units:**
Olive Downs Coking Coal Project, Moranbah, QLD	24-hour	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
6th highest contours	50 µg/m³ (purple)	Manning Young	July 2018

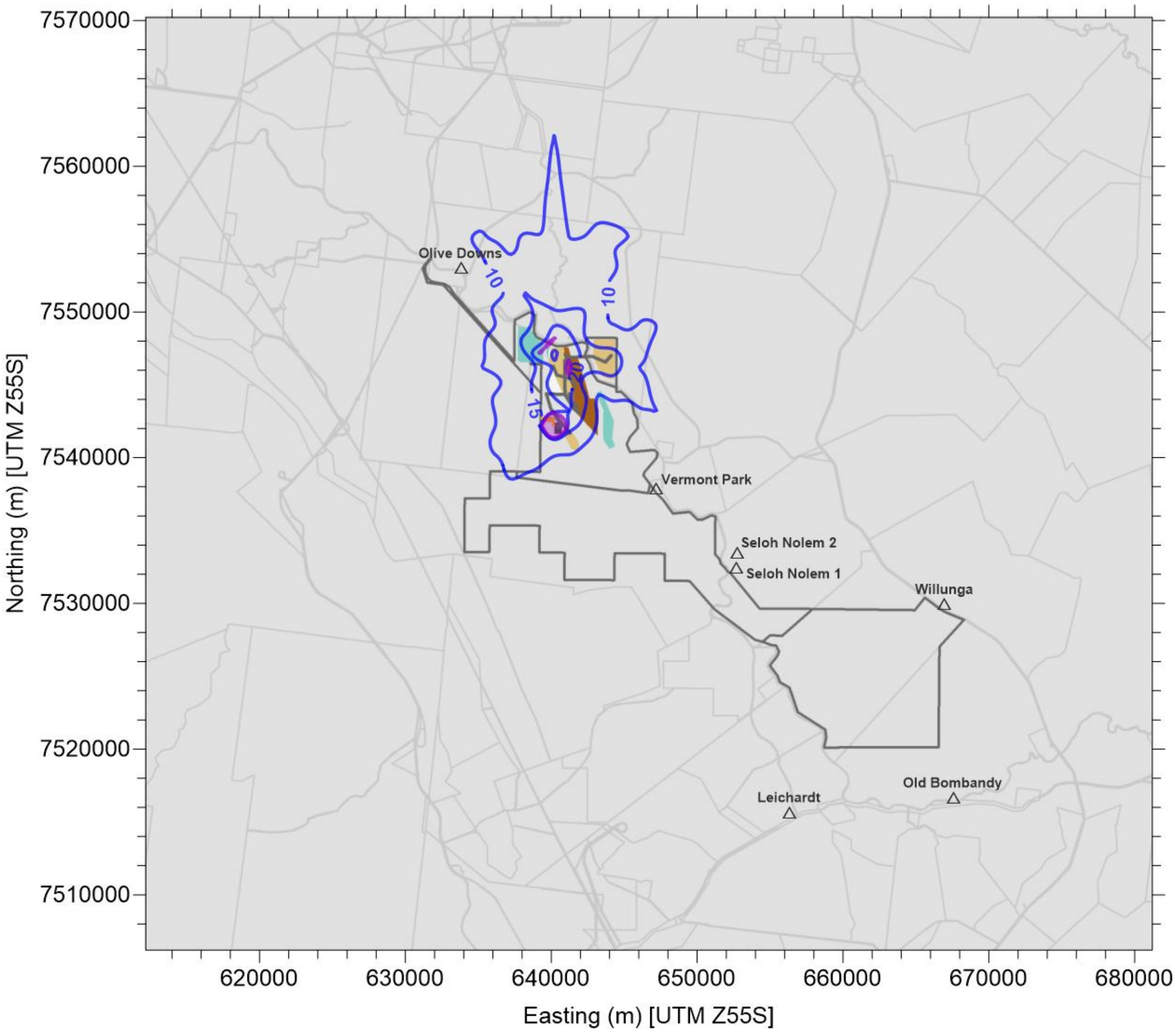

Plate 9 **Year 2027 predicted maximum 24-hour average ground-level concentrations of $PM_{2.5}$ for the cumulative assessment**

Location:	**Averaging period:**	**Data source:**	**Units:**
Olive Downs Coking Coal Project, Moranbah, QLD	24-hour	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Maximum contours	25 µg/m³ (purple)	Manning Young	July 2018

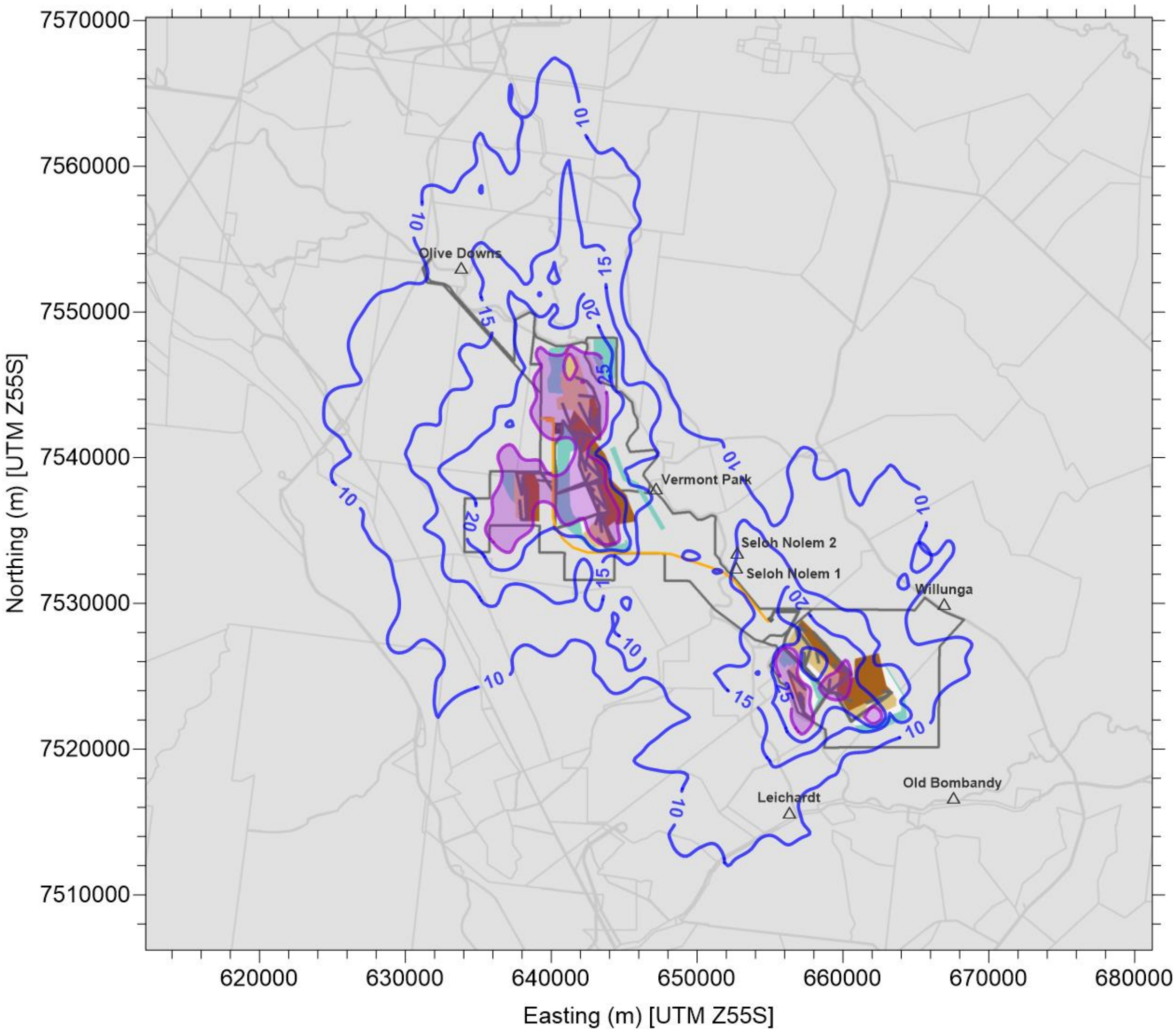

Plate 10	**Year 2043 predicted maximum 24-hour average ground-level concentrations of $PM_{2.5}$ for the cumulative assessment**		
Location: Olive Downs Coking Coal Project, Moranbah, QLD	**Averaging period:** 24-hour	**Data source:** CALPUFF	**Units:** µg/m³
Type: Maximum contours	**Objective:** 25 µg/m³ (purple)	**Prepared by:** Manning Young	**Date:** July 2018

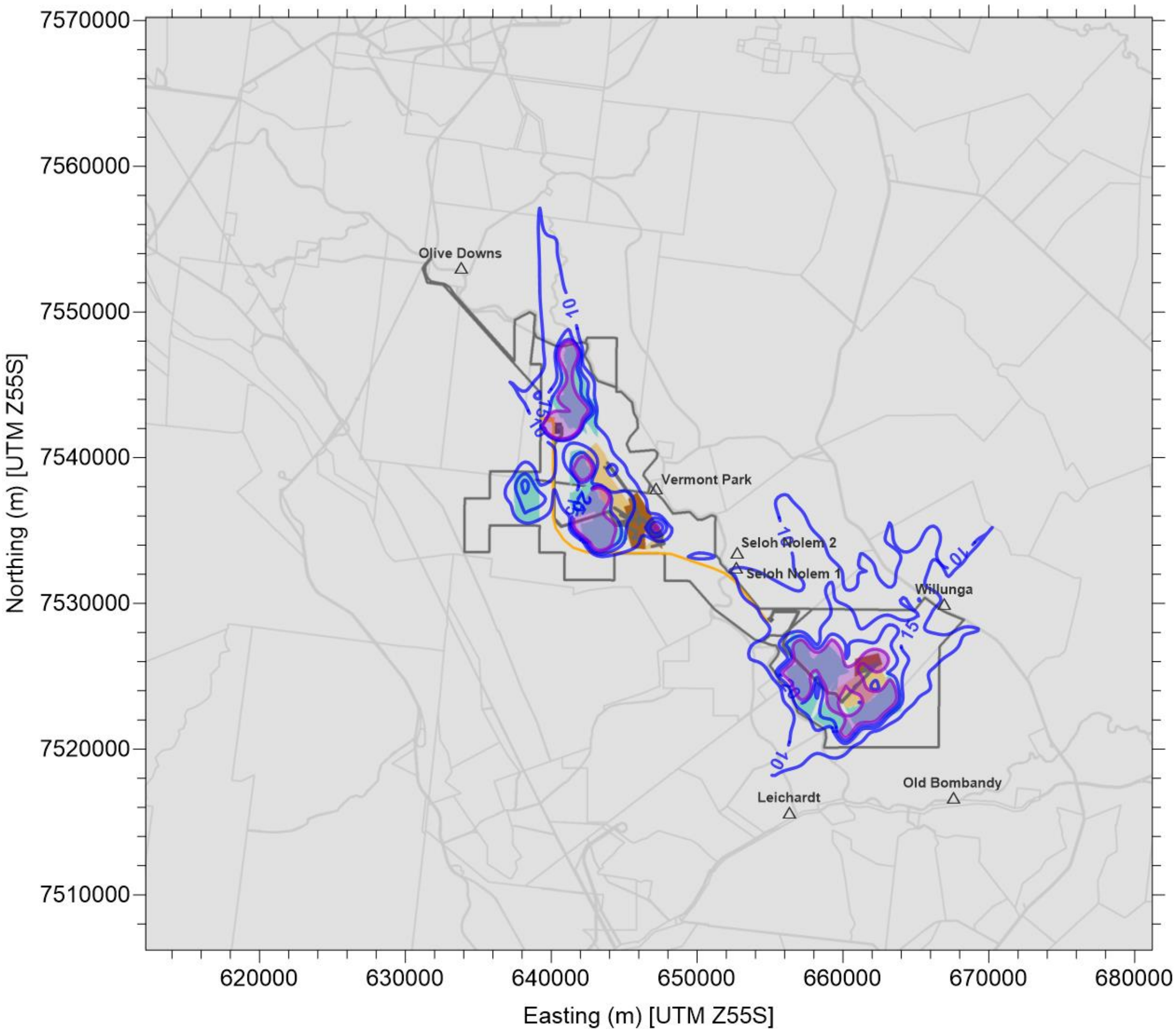

Plate 11	**Year 2066 predicted maximum 24-hour average ground-level concentrations of $PM_{2.5}$ for the cumulative assessment**

Location:	**Averaging period:**	**Data source:**	**Units:**
Olive Downs Coking Coal Project, Moranbah, QLD	24-hour	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Maximum contours	25 µg/m³ (purple)	Manning Young	July 2018

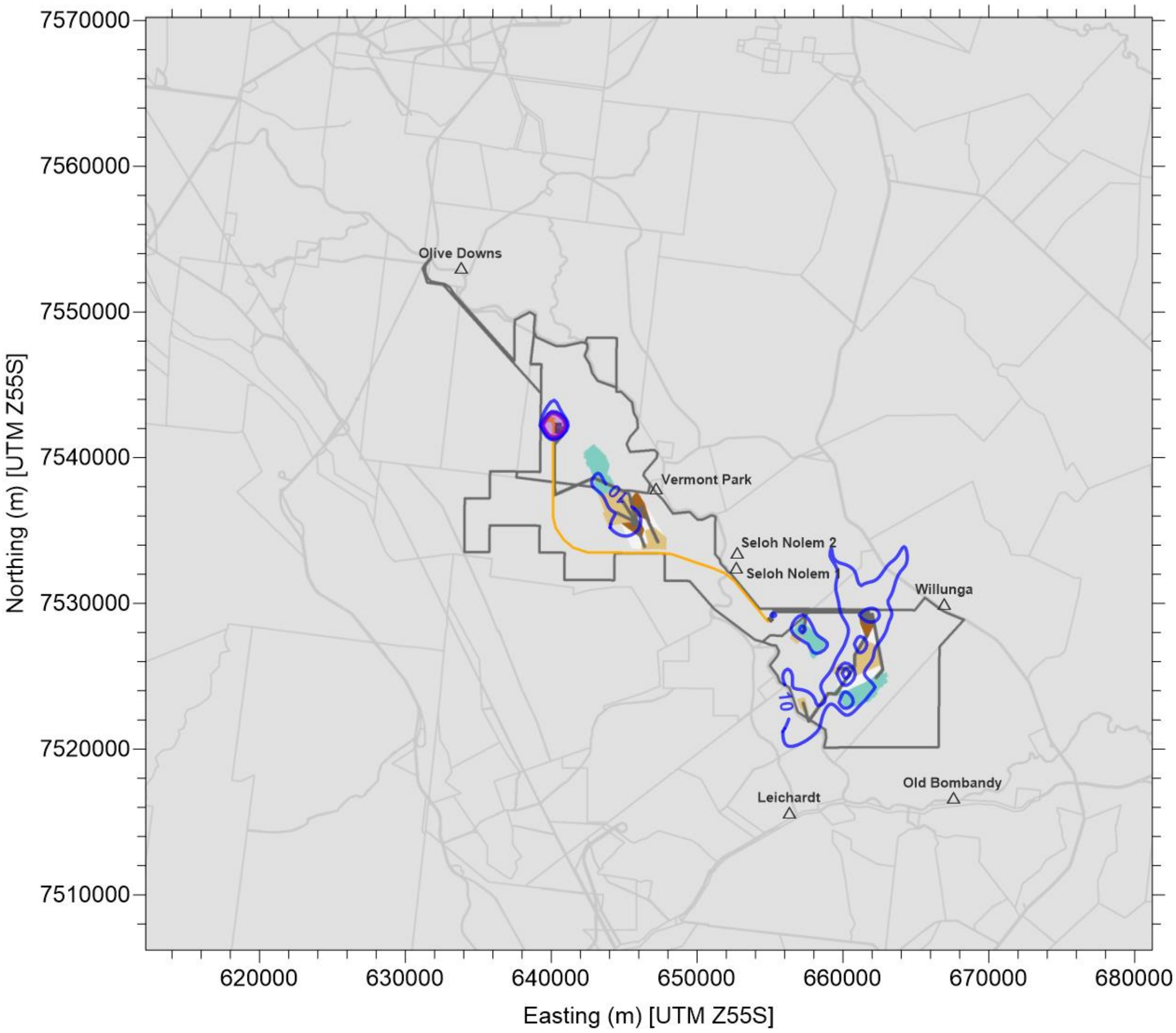

Plate 12	**Year 2085 predicted maximum 24-hour average ground-level concentrations of $PM_{2.5}$ for the cumulative assessment**

Location:	**Averaging period:**	**Data source:**	**Units:**
Olive Downs Coking Coal Project, Moranbah, QLD	24-hour	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Maximum contours	25 µg/m³ (purple)	Manning Young	July 2018

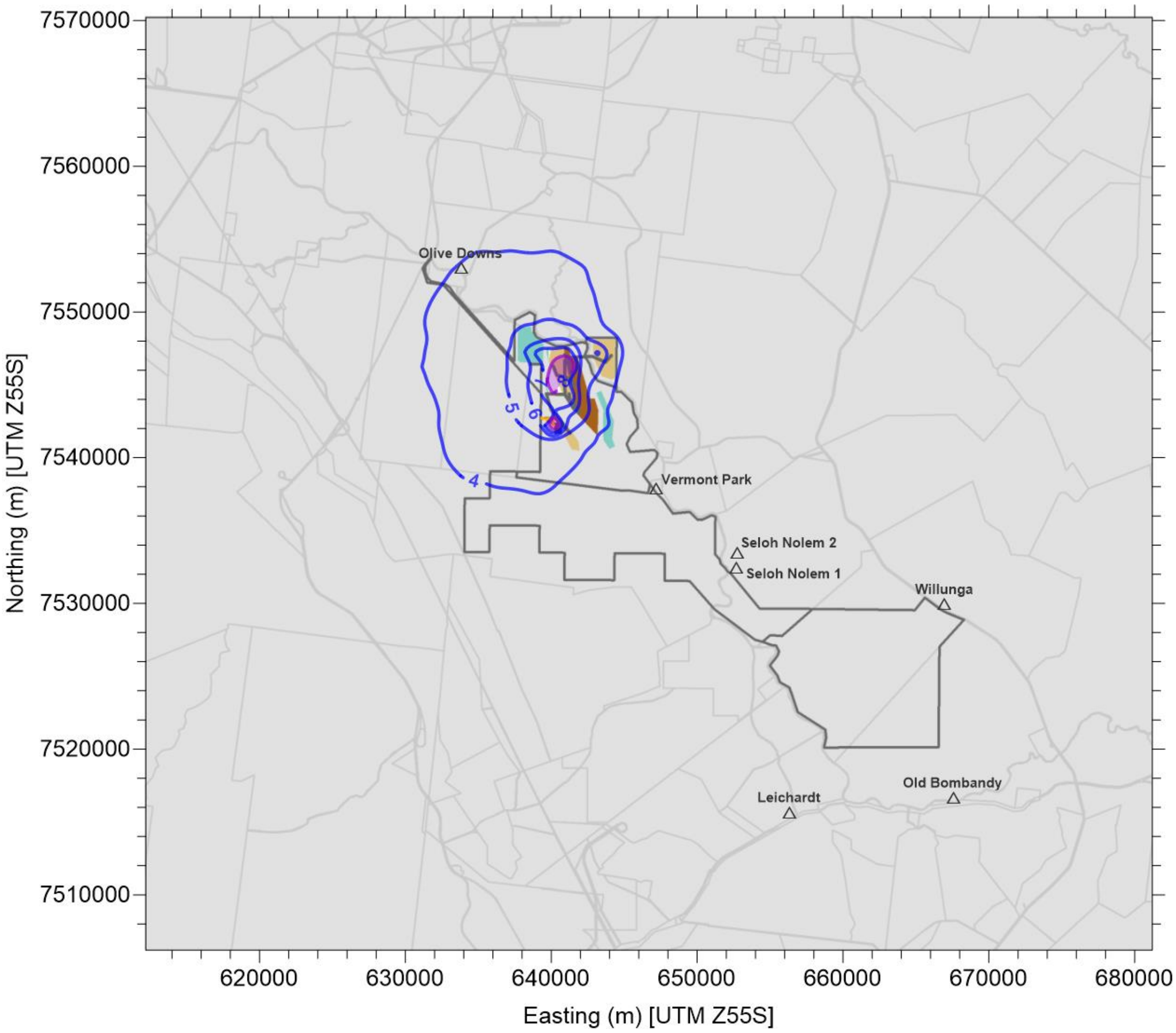

Plate 13	**Year 2027 predicted annual average ground-level concentrations of $PM_{2.5}$ for the cumulative assessment**		
Location: Olive Downs Coking Coal Project, Moranbah, QLD	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Average contours	**Objective:** 8 µg/m³ (purple)	**Prepared by:** Manning Young	**Date:** July 2018

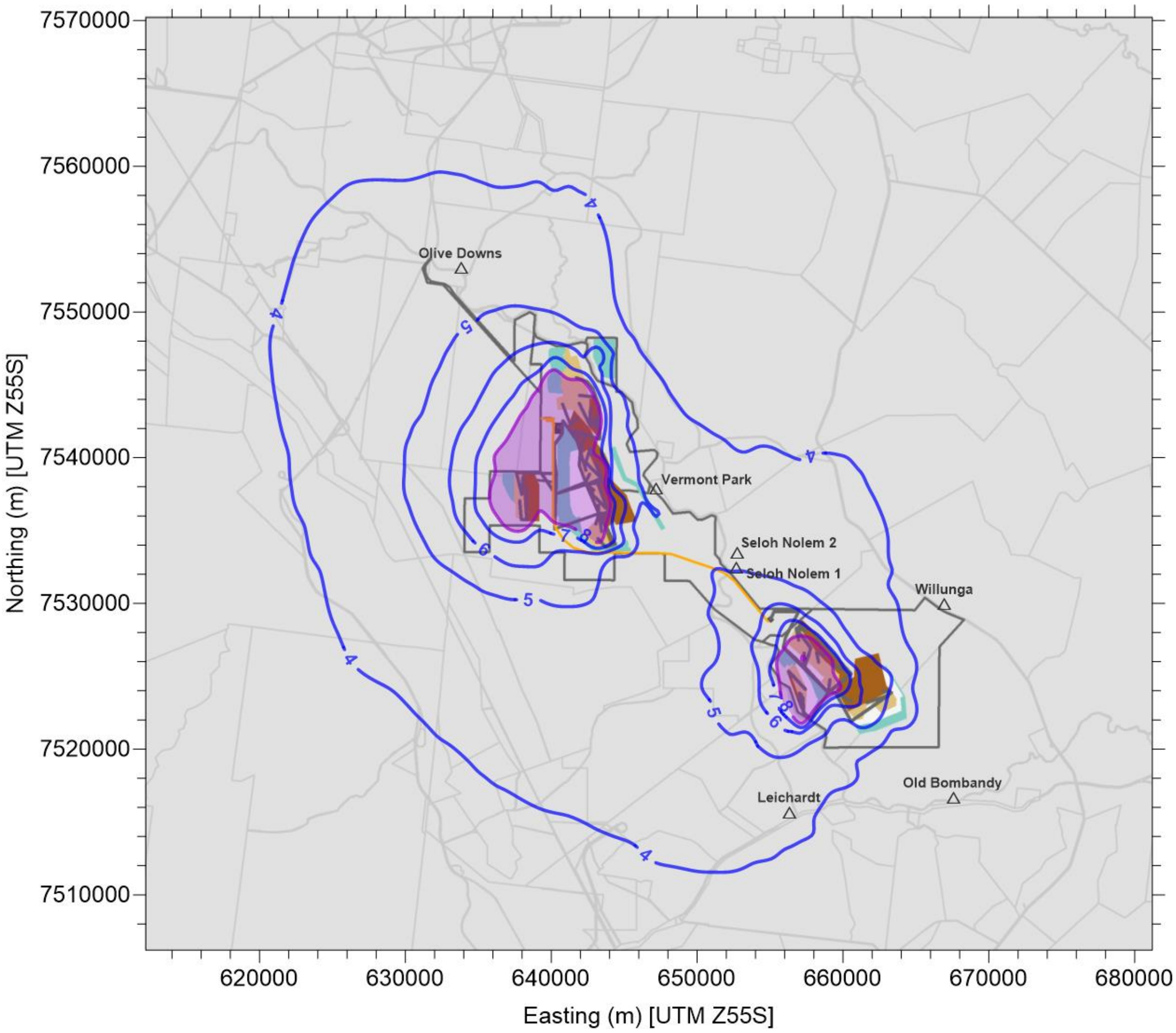

Plate 14	**Year 2043 predicted annual average ground-level concentrations of $PM_{2.5}$ for the cumulative assessment**

Location:	**Averaging period:**	**Data source:**	**Units:**
Olive Downs Coking Coal Project, Moranbah, QLD	Annual	CALPUFF	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Average contours	8 µg/m³ (purple)	Manning Young	July 2018

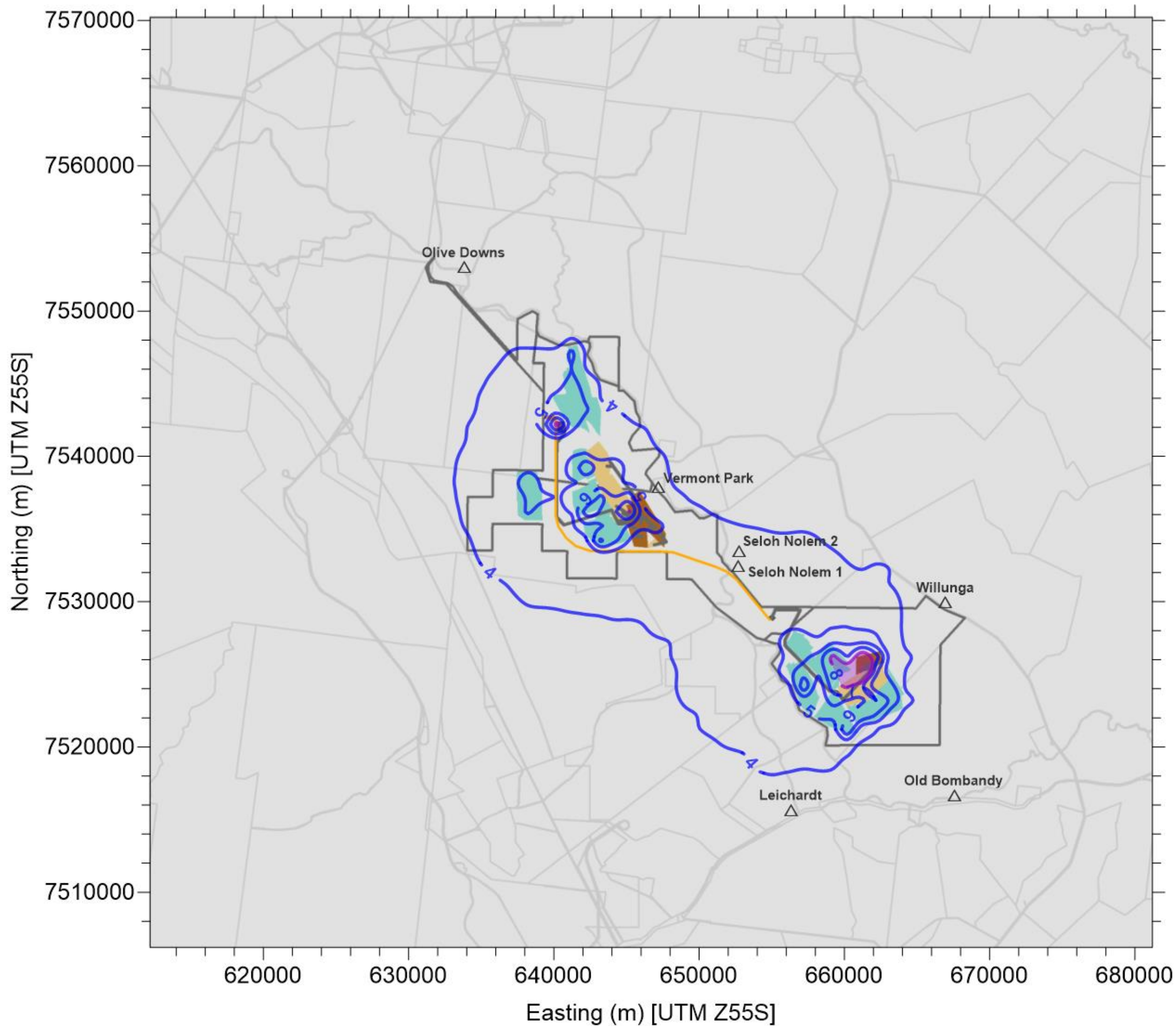

Plate 15 **Year 2066 predicted annual average ground-level concentrations of $PM_{2.5}$ for the cumulative assessment**

Location: Olive Downs Coking Coal Project, Moranbah, QLD	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Average contours	**Objective:** 8 µg/m³ (purple)	**Prepared by:** Manning Young	**Date:** July 2018

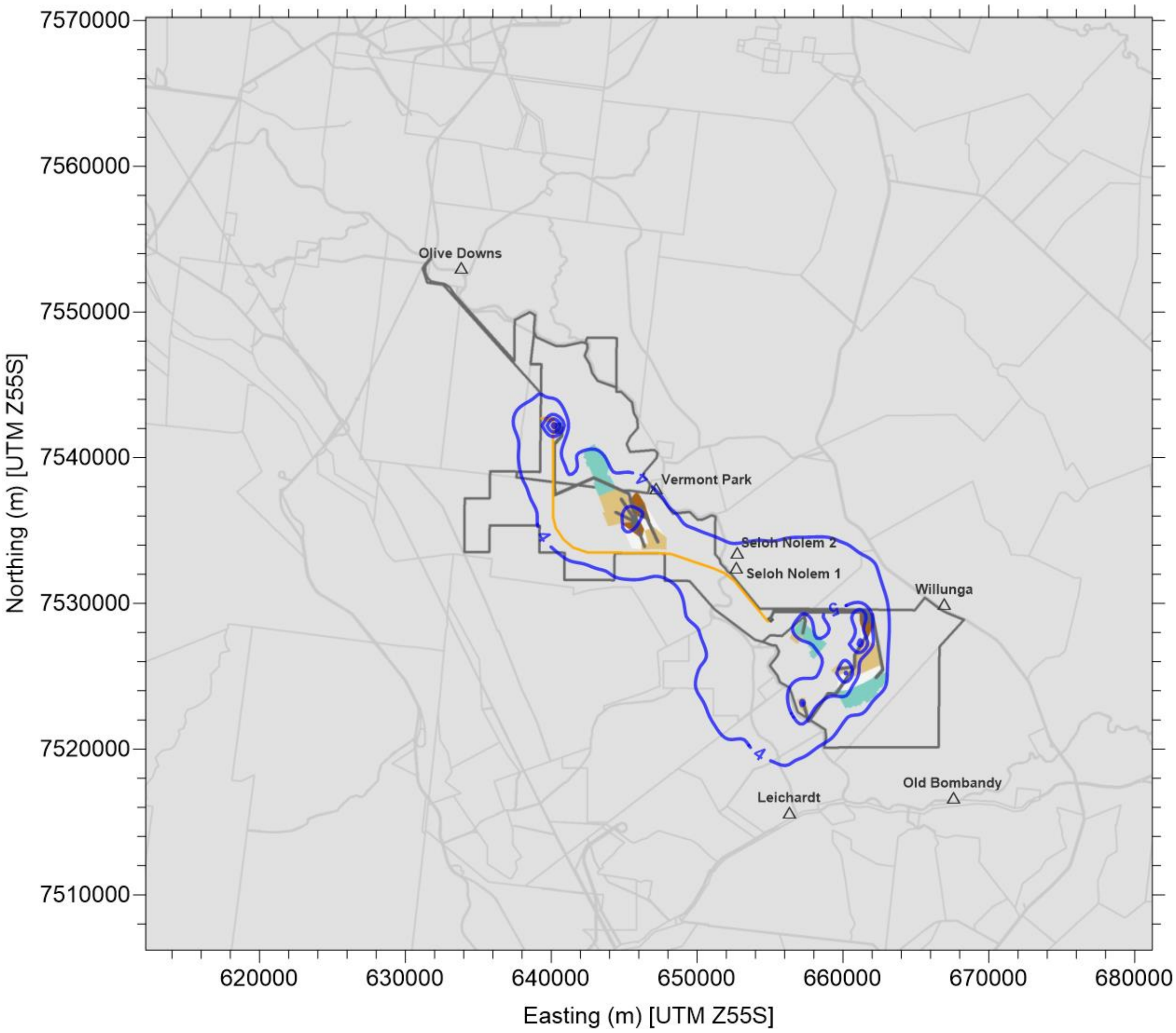

Plate 16 **Year 2085 predicted annual average ground-level concentrations of $PM_{2.5}$ for the cumulative assessment**

Location: Olive Downs Coking Coal Project, Moranbah, QLD	**Averaging period:** Annual	**Data source:** CALPUFF	**Units:** µg/m³
Type: Average contours	**Objective:** 8 µg/m³ (purple)	**Prepared by:** Manning Young	**Date:** July 2018

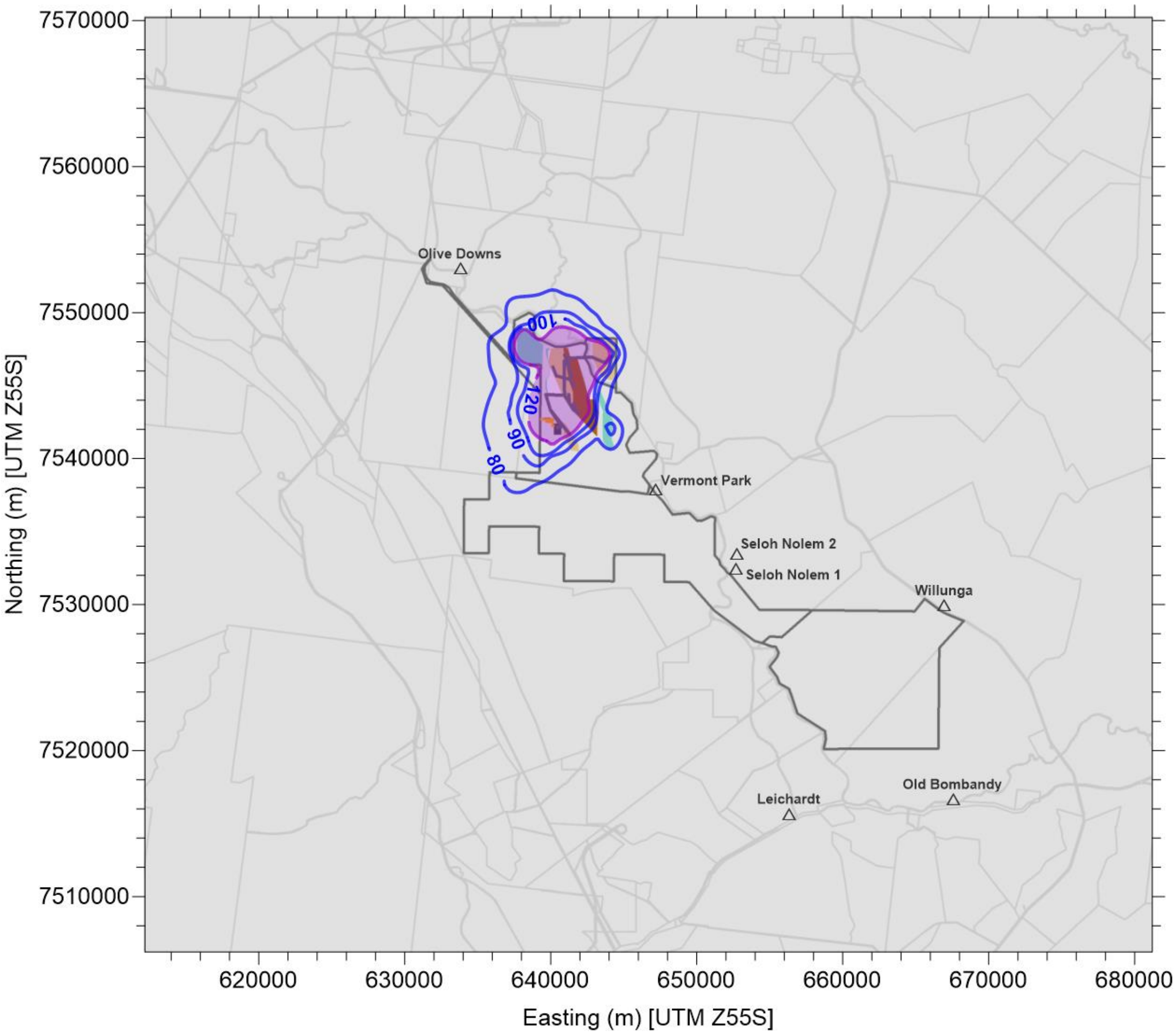

Plate 17	**Year 2027 predicted maximum monthly dust deposition rate for the cumulative assessment**

Location:	**Averaging period:**	**Data source:**	**Units:**
Olive Downs Coking Coal Project, Moranbah, QLD	Monthly	CALPUFF	mg/m²/day
Type:	**Guideline:**	**Prepared by:**	**Date:**
Maximum contours	120 mg/m²/day (purple)	Manning Young	July 2018

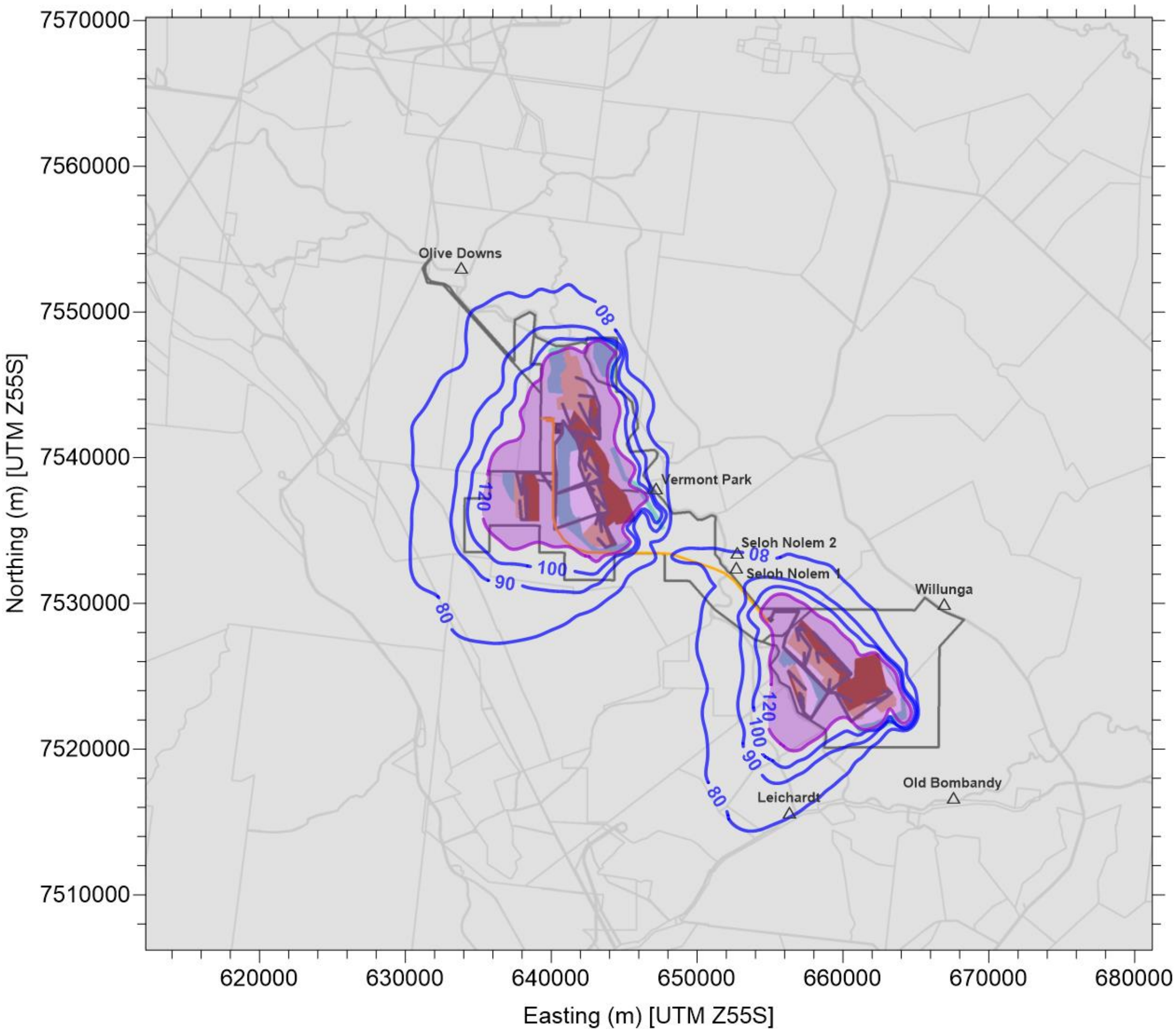

Plate 18	**Year 2043 predicted maximum monthly dust deposition rate for the cumulative assessment**		
Location: Olive Downs Coking Coal Project, Moranbah, QLD	**Averaging period:** Monthly	**Data source:** CALPUFF	**Units:** mg/m²/day
Type: Maximum contours	**Guideline:** 120 mg/m²/day (purple)	**Prepared by:** Manning Young	**Date:** July 2018

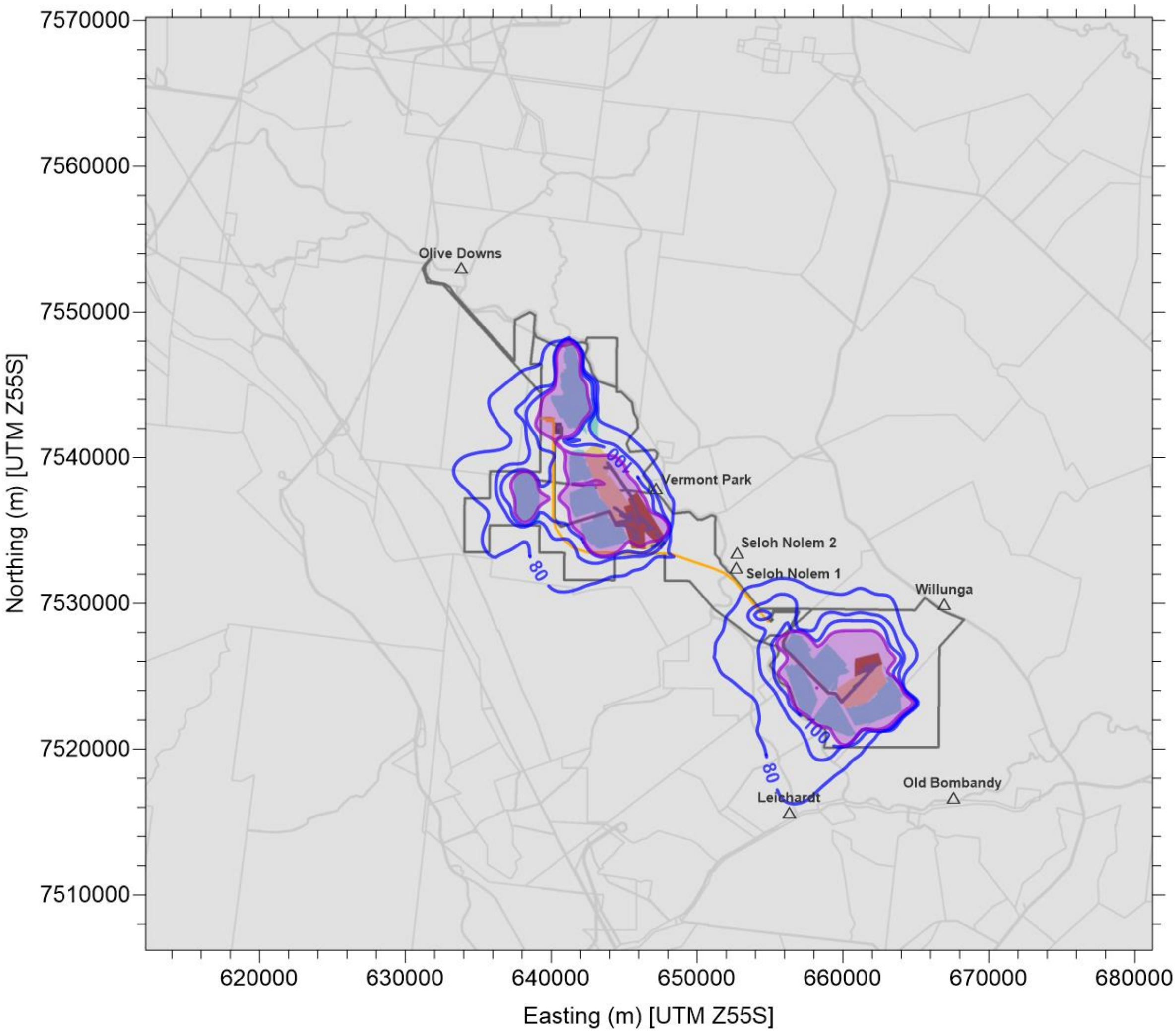

Plate 19	Year 2066 predicted maximum monthly dust deposition rate for the cumulative assessment

Location:	Averaging period:	Data source:	Units:
Olive Downs Coking Coal Project, Moranbah, QLD	Monthly	CALPUFF	mg/m²/day
Type:	**Guideline:**	**Prepared by:**	**Date:**
Maximum contours	120 mg/m²/day (purple)	Manning Young	July 2018

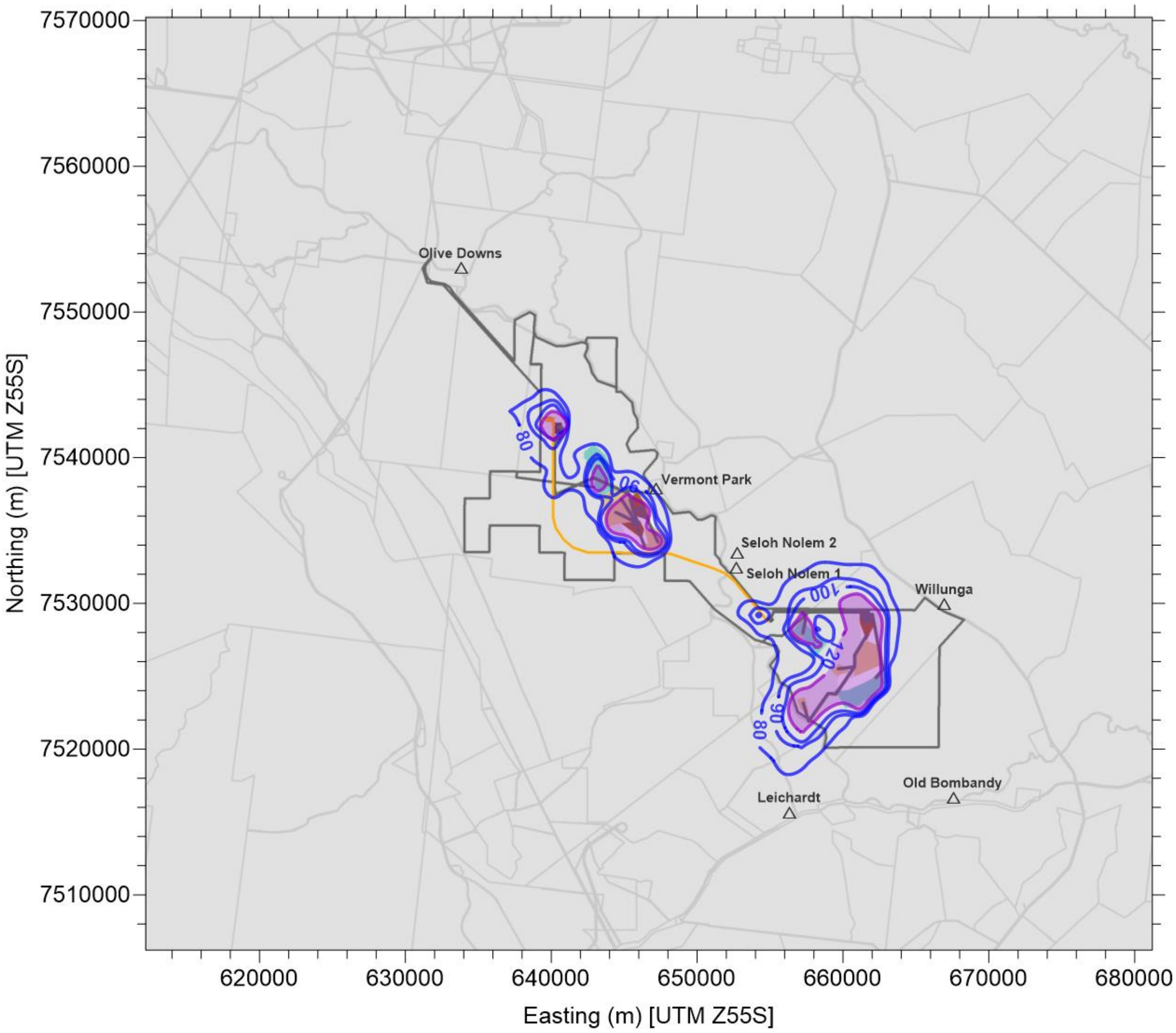

Plate 20 **Year 2085 predicted maximum monthly dust deposition rate for the cumulative assessment**

Location:	**Averaging period:**	**Data source:**	**Units:**
Olive Downs Coking Coal Project, Moranbah, QLD	Monthly	CALPUFF	mg/m²/day
Type:	**Guideline:**	**Prepared by:**	**Date:**
Maximum contours	120 mg/m²/day (purple)	Manning Young	July 2018

APPENDIX A DETAILED DUST EMISSIONS INVENTORY DATA

A1 ACTIVITY DATA

The activity data presented in Table A1 are based on the following information:

- Information provided by Pembroke/Resource Strategies, including site layouts, operational details, mining methods, throughput and fleet specifications; and
- Typical emissions characteristics documented in the US EPA Compilation of Air Pollutant Emission Factors (AP-42).

Overburden and ROM extraction volumes, drilling activity, and dozer and grader utilisation have been determined based on the relative spatial extent of the active mining areas indicated in the supplied site plans. Where suitable values were not available from Resource Strategies or the AP-42, conservative assumptions have been used.

Table A1 Mine operations and activities data

Activity	Units	2027	2043	2066	2085	Information Source
Hours of operation (except blasting and Pits 7 and 8)	hours/day days/year	24 365	24 365	24 365	24 365	Resource Strategies
Blasting hours	hours/day	12	12	12	12	Resource Strategies
Pit 7 and 8 activities	hours/day	24	24	12 (daytime)	12 (daytime)	Resource Strategies
Material characteristics						
Overburden						
Moisture content	%	7.9	7.9	7.9	7.9	AP-42 Chapter 11.9-3, default value
Silt content	%	6.9	6.9	6.9	6.9	AP-42 Chapter 11.9-3, default value
Coal (ROM and product)						
Moisture content	%	10.4	10.4	10.4	10.4	AP-42 Chapter 11.9-3, default value
Silt content	%	8.6	8.6	8.6	8.6	AP-42 Chapter 11.9-3, default value
Road surface silt content	%	8.4	8.4	8.4	8.4	AP-42 Chapter 13.2.2, mean value for pit haul
Throughputs						
Overburden						
Total overburden	Mtpa	129.7	656.3	206.6	105.1	Resource Strategies
Overburden from ODS	Mtpa	129.7	430.9	84.1	42.8	Resource Strategies
Overburden from Willunga	Mtpa	0.0	225.4	122.5	62.3	Resource Strategies
Coal						
ROM coal total	Mtpa	6.0	19.1	6.9	3.1	Resource Strategies
ROM coal from ODS	Mtpa	6.0	11.1	2.6	1.4	Resource Strategies
ROM coal from Willunga	Mtpa	0.0	8.0	4.3	1.7	Resource Strategies
Product coal total	Mtpa	4.4	14.1	5.3	2.3	Resource Strategies
Product coal from ODS	Mtpa	4.4	8.4	2.0	1.1	Resource Strategies

Activity	Units	2027	2043	2066	2085	Information Source
Product coal from Willunga	Mtpa	0.0	5.7	3.3	1.3	Resource Strategies
Drilling and blasting						
Maximum number of blasts per day in ODS	blasts/day	1	1	0.5	0.5	Resource Strategies
Maximum number of blasts per day in Willunga	blasts/day	0	1	0.5	0.5	Resource Strategies
Horizontal area of blast	m^2	15,000	22,000	15,000	15,000	Resource Strategies
Number of holes drilled per blast	holes/blast	200	300	200	200	Resource Strategies
Total holes drilled per year	holes/year	50,000	150,000	50,000	50,000	Calculated assuming maximum of 250 blasting days per year (Resource Strategies)
Areas						
Total active pit area	ha	584	2,830	801	366	Measured from site layouts provided by Resource Strategies
Total overburden dump area	ha	806	2,336	1,306	1,057	
Total inactive, unrehabilitated area	ha	107	1,191	0	533	
Total rehabilitation area	ha	596	2,296	5,371	1,089	
Total ROM coal stockpile area	ha	37	49	49	49	
Raw coal stockpile area	ha	5	5	5	5	
Product coal stockpile area	ha	8	8	8	8	
Distances						
Haulage						
Total waste haulage	VKT/year	1,901,512	4,817,622	3,940,791	2,806,972	Calculated using site layouts provided by Resource Strategies
Total ROM coal haulage	VKT/year	400,972	2,148,508	1,090,502	360,686	
Total grader travel	VKT/year	239,674	798,912	479,347	319,565	Calculated from operating hours
Conveyors						
Overland transport conveyor length	km	N/A	24.2	24.2	24.2	Measured from site layouts provided by Resource Strategies
Total processing conveyor length	km	2.4	2.4	2.4	2.4	
Fleet specifications						

Activity	Units	2027	2043	2066	2085	Information Source
Waste trucks (Leibherr T284)						
Empty weight	tonnes	237	237	237	237	Manufacturer specification
Maximum payload	tonnes	363	363	363	363	Manufacturer specification
Average weight	tonnes	419	419	419	419	Calculated
ROM coal trucks (Cat 789)						
Empty weight	tonnes	136	136	136	136	Manufacturer specification
Maximum payload	tonnes	182	182	182	182	Manufacturer specification
Average weight	tonnes	227	227	227	227	Calculated
Bulldozers (Cat D10T/D11T)						
Utilisation rate	%	80	80	80	80	Assumed (typical value)
Number on dump support	-	3	10	6	3	Resource Strategies
Number on coal and partings prep.	-	1	5	2	2	
Number on drill prep. and pit support	-	1	5	2	2	
Number on excavator support	-	3	10	6	3	
Graders (Cat 24M)						
Number in operation	-	3	10	6	4	Resource Strategies
Average speed	km/h	11.4	11.4	11.4	11.4	AP-42 Chapter 11.9-3, default value
Meteorological parameters						
Mean wind speed	m/s	2.7	2.7	2.7	2.7	CALMET modelling
Proportion of winds faster than 5.4m/s	%	5.2	5.2	5.2	5.2	CALMET modelling
Coal processing and export						
Average conveyor speed	m/s	6	6	6	6	Assumed (typical value)
Number of ROM coal transfers in processing area	-	5	5	5	5	Assumed based on site layouts provided by Resource Strategies
Number of product coal transfers in processing area	-	2	2	2	2	

Activity	Units	2027	2043	2066	2085	Information Source
Coal wagon exposed area	ha	0.7	0.7	0.7	0.7	Calculated assuming one train consisting of 200 wagons, each with 36m^2 exposed (typical values)
Coal wagon height	m	3.5	3.5	3.5	3.5	Assumed (typical value)
Coal stockpile height	m	16	16	16	16	Assumed (typical value)

A2 CALCULATION OF EMISSION FACTORS

A2.1 Drilling

Emission factors for drilling were calculated according to AP-42 Chapter 11.9. The default TSP emission factor of 0.59 kg/hole was used, with PM10 and PM2.5 fractions of 52.5% (0.31 kg/hole) and 3% (0.02 kg/hole), respectively, according to AP-42 Chapter 11.9.

A2.2 Blasting

Emission factors for blasting were calculated according to AP-42 Chapter 11.9. The TSP emission factor is given by

$$\mathrm{EF_{TSP}} = 0.00022\,A^{1.5}$$

where:

$\mathrm{EF_{TSP}}$	=	TSP emission factor (kg/blast)
A	=	horizontal blast area (m^2)

PM_{10} and $PM_{2.5}$ emission factors were calculated using fractions of 52.5% and 3%, respectively, according to AP-42 Chapter 11.9.

A2.3 Bulldozing on overburden

Emission factors for dozers operating on overburden were calculated according to NPI Mining. The TSP and PM_{10} emission factors are given by

$$\mathrm{EF_{TSP}} = \frac{2.6\,s^{1.2}}{M^{1.3}}$$

$$\mathrm{EF_{PM10}} = \frac{0.34\,s^{1.5}}{M^{1.4}}$$

where:

$\mathrm{EF_{TSP}}$	=	TSP emission factor (kg/ hr)
$\mathrm{EF_{PM10}}$	=	PM_{10} emission factor (kg//hr)
s	=	overburden silt content (%)
M	=	overburden moisture content (%)

The $PM_{2.5}$ emission factor was calculated from TSP using a fraction of 10.5% according to AP-42 Chapter 11.9.

A2.4 Bulldozing on coal

Emission factors for dozers operating on overburden were calculated according to NPI Mining. The TSP and PM_{10} emission factors are given by

$$\mathrm{EF_{TSP}} = \frac{35.6\,s^{1.2}}{M^{1.4}}$$

$$\mathrm{EF_{PM10}} = \frac{6.33\,s^{1.5}}{M^{1.4}}$$

where:

$\mathrm{EF_{TSP}}$	=	TSP emission factor (kg/ hr)

EF_{PM10}	=	PM_{10} emission factor (kg//hr)
s	=	coal silt content (%)
M	=	coal moisture content (%)

The PM2.5 emission factor was calculated from TSP using a fraction of 2.2% according to AP-42 Chapter 11.9.

A2.5 Material transfers and handling

Materials handling and transfers include truck loading, dumping, conveyor transfers and train load-out. These emission factors were calculated according to AP-42 Chapter 13.2.4 using the following equation:

$$\mathrm{EF} = k(0.0016)\left(\frac{U}{2.2}\right)^{1.3}\left(\frac{M}{2}\right)^{-1.4}$$

where:

EF	=	emission factor (kg/Mg)
k	=	particle size multiplier
U	=	mean wind speed (m/s)
M	=	material moisture content (%)

The particle size multiplier k varies with aerodynamic particle size range as follows:

$k = 0.74$	Particle size < 30 µm (TSP)
$k = 0.35$	Particle size < 10 µm (PM_{10})
$k = 0.053$	Particle size < 2.5 µm ($PM_{2.5}$)

A2.6 Grading

Emission factors for grading were calculated according to AP-42 Chapter 11.9. The TSP and PM_{10} emission factors are given by

$$\mathrm{EF}_{\mathrm{TSP}} = 0.0034\, S^{2.5}$$

$$\mathrm{EF}_{\mathrm{PM10}} = 0.0034\, S^{2}$$

where:

EF_{TSP}	=	TSP emission factor (kg/VKT)
EF_{PM10}	=	PM_{10} emission factor (kg/VKT)
S	=	grader average speed (km/h)

The PM2.5 emission factor was calculated from TSP using a fraction of 3.1% according to AP-42 Chapter 11.9.

A2.7 Wind erosion from active stockpiles

Emission factors for wind erosion of active stockpiles were calculated on an hourly basis using the emission factor for active storage piles from AP-42 Chapter 11.9. The TSP emission factor is given by

$$\mathrm{EF}_{\mathrm{TSP}} = 1.8u$$

Where:

EF_{TSP}	=	TSP emission factor (kg/ha/hr)
u	=	hourly-average wind speed (m/s)

PM_{10} and $PM_{2.5}$ emission factors were calculated using fractions of 50% and 7.5%, respectively, according to AP-42 Chapter 11.9.

A2.8 Wind erosion from exposed areas

Emission factors for wind erosion of exposed areas were calculated on an hourly basis using the emission factor for exposed areas from AP-42 Chapter 11.9 and adapted to include a threshold for dust lift-off.

The default TSP emission factor of 0.85 Mg/ha/yr was used, with the annual emissions apportioned into hourly emissions according to the square of the hourly wind speed compared with the threshold of $(5.4\ \mathrm{m/s})^2$. This reflects the tendency for stronger winds to generate more dust lift-off (if above the threshold for lift-off) and yields worse emissions during hours of strong winds.

PM_{10} and $PM_{2.5}$ emission factors were calculated using fractions of 50% and 7.5%, respectively, according to AP-42 Chapter 11.9.

A2.9 Wheel-generated dust

Emission factors for wheel-generated dust on unpaved roads were calculated according to AP-42 Chapter 13.2.2 via the following equation:

$$\mathrm{EF} = k(281.9)\left(\frac{s}{12}\right)^a \left(\frac{W}{3}\right)^b$$

where

EF	=	emission factor (g/VKT)
k	=	particle size multiplier
s	=	surface material silt content (%)
W	=	mean vehicle weight (tons)
a, b	=	empirical constants

A factor of 1.10231 was used to convert the vehicle weights in Table A1 to imperial tons. The particle size multiplier and empirical constants vary with aerodynamic particle size range as defined in Table A2.

Table A2 Constants used in calculating emissions from wheel-generated dust

Constant	TSP (assumed from PM_{30})	PM_{10}	$PM_{2.5}$
k	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

A2.10 Conveyors

Emission factors for coal transport via conveyors were calculated according to the study by GHD and Oceanics Australia. The TSP emission factor is given by

$$\mathrm{EF_{TSP}} = (0.031)(0.2)\frac{0.00006(U+U_{\mathrm{conv}})^2 - 0.0002(U+U_{\mathrm{conv}}) + 0.0001}{0.00006(10+U_{\mathrm{conv}})^2 - 0.0002(10+U_{\mathrm{conv}}) + 0.0001}$$

where:

EF_{TSP} = TSP emission factor (g/m/s)

U = mean wind speed (m/s)

U_{conv} = conveyor speed (m/s)

TSP emissions are therefore based on the combined speed of prevailing winds and the conveyor, using the reference emission rate of 0.031 g/s/m at a base wind velocity of 10 m/s. The factor 0.2 was used to account for the difference in particle size distribution between particulate matter sampled in the GHD Oceanics study and the normal TSP size fraction of PM_{30-50}.

PM_{10} and $PM_{2.5}$ emission factors were calculated using fractions of 47.2% and 7.2%, respectively, according to AP-42 Chapter 13.2.4.

A2.11 Crushing

Emission factors for the crushing of coal were calculated according to AP-42 Chapter 11.19.2. The default TSP and PM_{10} emission factors were used, equal to 0.0027 kg/tonne and 0.0012 kg/tonne of coal crushed, respectively. The $PM_{2.5}$ emission factor was calculated from TSP using a ratio of 8.33% according to AP-42 Chapter 11.19.2.

A2.12 Screening

Emission factors for the screening of coal were calculated according to AP-42 Chapter 11.19.2. The default TSP and PM_{10} emission factors were used, equal to 0.0125 kg/tonne and 0.0043 kg/tonne of coal screened, respectively. The $PM_{2.5}$ emission factor was calculated from TSP using a ratio of 2.27% according to AP-42 Chapter 11.19.2.

APPENDIX B METEOROLOGICAL AND DISPERSION MODELLING METHODOLOGY

B1 METEOROLOGY

The meteorological modelling methodology for the Project included the following steps:

- Selection of a representative year
- TAPM modelling
- CALMET modelling

The following sections describe each step of the meteorological modelling conducted for the Project.

B1.1 Selection of representative year

A representative year is required to be selected at the beginning of the meteorological modelling process. Using a representative year in the air quality assessment ensures that the conditions experienced at the Project site are reflected in the model.

Selection of a representative year has been done through statistical analysis of historical meteorological observations at BoM Moranbah Airport weather station. Meteorological observations from the past five years at Moranbah Airport were analysed in order to assess the inter-annual variability.

The annual frequency distributions of wind direction, wind speed and temperature for the period 20012 to 2016 were analysed and compared to the average distribution for the same five-year period. The analysis indicated that there was not a significant amount of variation in the distributions of wind direction, wind speed or temperature as illustrated graphically in Figure B1 to Figure B3. Based on the analysis, the year 2015 was selected as the year for modelling as this year presented as the closest representation of the five-year average.

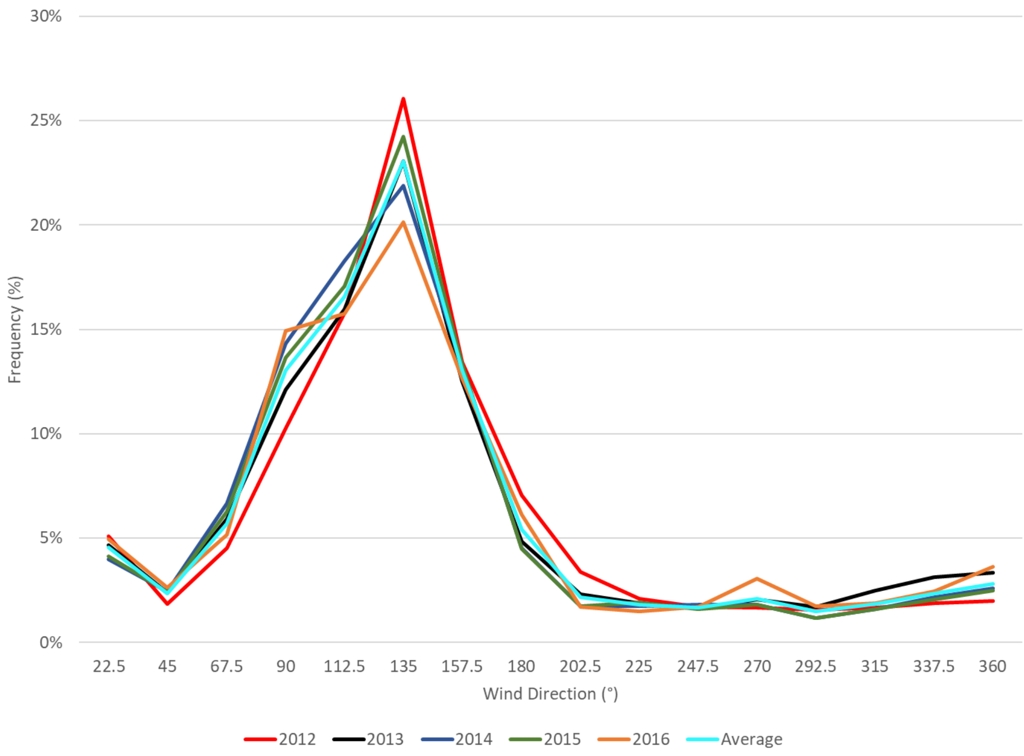

Figure B1 Annual Wind Direction Frequency Distribution at Moranbah Airport

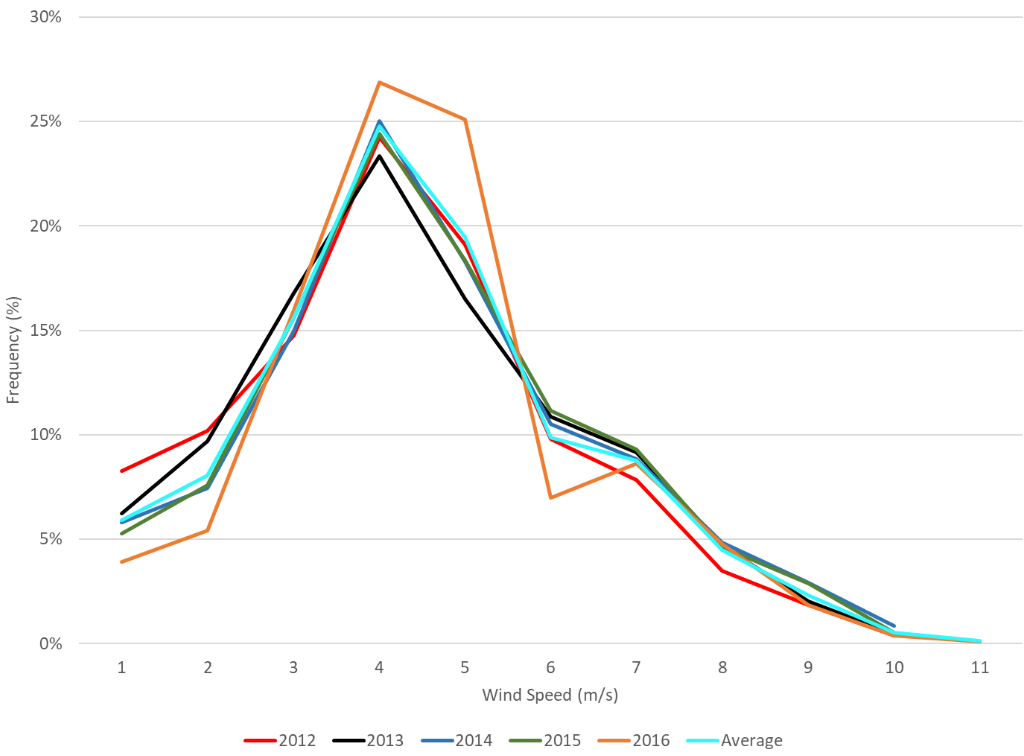

Figure B2 Annual Wind Speed Frequency Distribution at Moranbah Airport

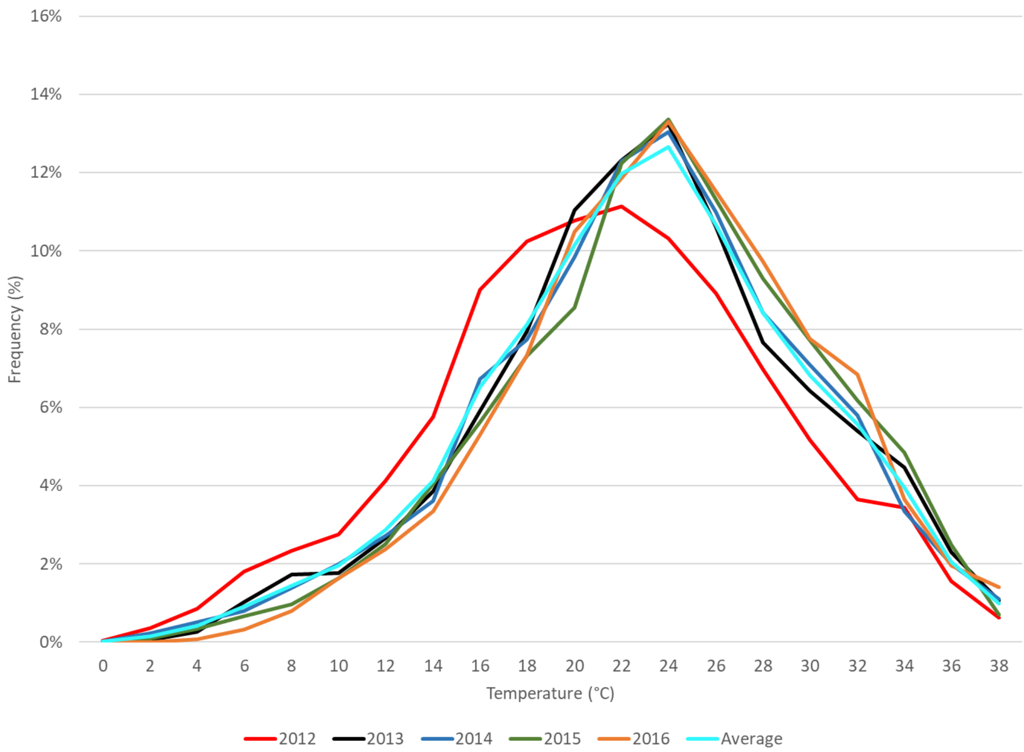

Figure B3 **Annual Temperature Frequency Distribution at Moranbah Airport**

B1.2 TAPM meteorology

The meteorological model, TAPM has been validated by the CSIRO, Katestone and others for many locations in Australia, in south-east Asia and in North America (CSIRO, 2008). Katestone has used the TAPM model throughout Australia as well as in parts of America, Bangladesh, New Caledonia and Vietnam. This model has performed well for simulating regional winds patterns. TAPM has proven to be a useful model for simulating meteorology in locations where monitoring data is unavailable.

TAPM is a prognostic meteorological model which predicts the flows important to regional and local scale meteorology, such as sea breezes and terrain-induced flows from the larger-scale meteorology provided by the synoptic analyses. TAPM solves the fundamental fluid dynamics equations to predict meteorology at a mesoscale (20 km to 200 km) and at a local scale (down to a few hundred metres (m)). TAPM includes parameterisations for cloud/rain micro-physical processes, urban/vegetation canopy and soil, and radiative fluxes.

TAPM requires synoptic meteorological information for the region. This information is generated by a global model similar to the large-scale models used to forecast the weather. The data were supplied on a grid resolution of approximately 75km, and at elevations of 100m to 5km above the ground. TAPM uses this synoptic information, along with specific details of the location such as surrounding terrain, land-use, soil moisture content and soil type to simulate the meteorology of a region as well as at a specific location.

Landcover data for TAPM are sourced from the US Geological Survey, Earth Resources Observation Systems (EROS) Data Center Distributed Active Archive Center (EDC DAAC) at 30-second (approximately 1 km) grid spacing.

TAPM was configured as follows:

- Modelling period for one year from 1 January to 31 December 2015
- 30 x 30 grid point domain with an outer grid of 30 km and nesting grids of 10 km and 3 km
- 25 vertical levels
- Grid centred near the Project (latitude –22° 14.0', longitude 148° 22.5')
- Geoscience Australia 9 second DEM terrain data
- Land cover data based on TAPM's default land-use database
- Default options selected for advanced meteorological inputs
- No data assimilation.

B1.3 CALMET meteorological modelling

CALMET is an advanced non-steady-state diagnostic 3D meteorological model with micro-meteorological modules for overwater and overland boundary layers. The model is the meteorological pre-processor for the CALPUFF modelling system. CALMET can read hourly meteorological data as data assimilation from multiple sites within the modelling domain; it can also be initialised with the gridded three-dimensional prognostic output from other meteorological models such as TAPM. This can improve dispersion model output, particularly over complex terrain as the near surface meteorological conditions are calculated for each grid point.

CALMET (version 6.5) was used to simulate meteorological conditions in the region. The CALMET simulation was initialised with the gridded TAPM 3D wind field data from the 3km grid. CALMET treats the prognostic model output as the initial guess field for the CALMET diagnostic model wind fields. The initial guess field is then adjusted for the kinematic effects of terrain, slope flows, blocking effects and 3D divergence minimisation.

CALMET was set up with twelve vertical levels with heights at 20, 60, 100, 150, 200, 250, 350, 500, 800, 1600, 2600, 4600 metres at each grid point.

Key features of CALMET used to generate the wind fields are as follows:

- Domain area of 60 by 60 grid points at 1 km spacing
- Twelve vertical levels set at 20 m, 60 m, 100 m, 150 m, 200 m, 250 m, 350 m, 500 m, 800 m, 1600 m, 2600 m and 4600 m
- 365 days (1 January to 31 December 2015)
- No observations mode, with prognostic wind fields generated by TAPM input as MM5/3D.dat at surface and upper air for "initial guess" field
- Gridded cloud cover from prognostic relative humidity at all levels
- No extrapolation of surface winds observations
- All other wind field options set as default
- Terrain radius of influence set at 5 kilometres
- Mixing height parameters all set as default
- 3D Relative humidity and temperature from prognostic data
- No data assimilation

All other options and factors were set to default.

B2 DISPERSION MODELLING

CALPUFF simulates the dispersion of air pollutants to predict ground-level concentration and deposition rates across a network of receptors spaced at regular intervals, and at identified discrete locations. CALPUFF is a non-steady-state Lagrangian Gaussian puff model containing parameterisations for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation.

CALPUFF employs the 3D meteorological fields generated from the CALMET model by simulating the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal. CALPUFF takes into account the geophysical features of the study area that affects dispersion of pollutants and ground-level concentrations of those pollutants in identified regions of interest. CALPUFF contains algorithms that can resolve near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub-grid scale terrain interactions, as well as the long-range effects of removal, transformation, vertical wind shear, overwater transport and coastal interactions. Emission sources can be characterised as arbitrarily-varying point, area, volume and lines or any combination of those sources within the modelling domain.

Key features of CALPUFF v7.2.1 used to simulate dispersion:

- Domain area of 60 km by 60 km equivalent to the domain defined in CALMET;
- 365 days modelled (1 January to 31 December 2015);
- Gridded 3D hourly-varying meteorological conditions generated by CALMET;
- Partial plume path adjustment and transitional plume rise modelled;
- No chemical transformation or wet removal modelled;
- PDF used for dispersion under convective conditions; and
- Dispersion coefficients calculated internally from sigma v and sigma w using micrometeorological variables.

All other options set to default.

B2.1 Source configuration

Characteristics for modelled sources are summarised in Table B1.

Emissions from all source types (haul roads, extraction and material handling, wind erosion, conveyors and processing area) were modelled as area sources. Wind erosion was modelled as an hourly-varying emission source. Emissions from blasting were modelled to reflect daytime operations only from 6am to 6pm.

An additional control factor of 50% for TSP and 5% for PM_{10} has been applied to in-pit activities to account for pit retention.

Table B1 Characteristics of modelled area sources

Source Type	Effective height	Initial vertical dispersion coefficient (σ_z)
	m	m
Haul roads	10	2.5
All extraction and material handling activities	10	2.5
Blasting	8	2
Wind erosion of ROM, product and rejects stockpiles	5	1.25
Wind erosion of exposed and rehabilitated areas	1	0.25
Conveyors	5	1.25
Processing area (including CHPP, transfer points and train loadout	10	2.5

APPENDIX C MAXIMUM 24-HOUR AVERAGE PM_{10} RESULTS

Predicted maximum 24-hour average concentrations of PM_{10} at each sensitive receptor for each Project scenario in isolation (i.e. without the background) and with background levels applied (cumulative assessment) are presented in Table C1. The results include the application of standard mitigation measures for 2027 and 2085 scenarios, and both standard and proactive mitigation measures for 2043 and 2066.

Table C1 Predicted maximum 24-hour average PM_{10} concentrations (µg/m³)

Receptor	Year 2027		Year 2043		Year 2066		Year 2085	
	Project	Cumulative	Project	Cumulative	Project	Cumulative	Project	Cumulative
Leichardt	1.4	28.6	42.4	49.8[A]	20.0	47.2	12.9	40.1
Old Bombandy	0.4	27.6	12.4	39.6	5.8	33.0	3.2	30.4
Willunga	1.2	28.4	23.6	49	26.7	46.6[A]	11.8	39.0
Seloh Nolem 1	2.9	30.1	43.1	49.5[A]	25.5	49.5[A]	12.6	39.8
Vermont Par	8.4	35.6	43.5[A]	49.7[A]	37.6	49.7[A]	12.1	39.3
Seloh Nolem 2	5.4	32.6	41.6	49.7[A]	18.6	45.8	11.5	38.7
Olive Downs	17.0	44.2	31.0	49.1[A]	6.0	33.2	3.1	30.3

Table note:
[A] Includes proactive mitigation measures