BHP Mitsubishi Alliance

Appendix C

Air Quality Assessment

Advanced Environmental Dynamics

Specialist Consultants

BLACKWATER MINE

NORTH EXTENSION PROJECT

AIR QUALITY ASSESSMENT

Report # 105009

Prepared for:

SLR Consulting Australia Pty Ltd

L16, 175 Eagle Street

Brisbane QLD 4000

On behalf of:

BM Alliance Coal Operations Pty Ltd

L14, 480 Queen Street

Brisbane QLD 4000

7 December 2023

Advanced Environmental Dynamics Pty Ltd (ACN 147 226 060)

The Trustee for AED Trust (ABN: 68 934 621 946)

www.aedconsultants.com.au

Advanced Environmental Dynamics Pty Ltd (ACN 147 226 060)
The Trustee for AED Trust (ABN: 68 934 621 946)
Tel: +61 400 661 182
Email: enquiries@aedconsultants.com.au
www.aedconsultants.com.au

SPECIALIST CONSULTANTS

Client	**Client's Representative**
SLR Consulting Australia Pty Ltd	Peter Allen (SLR)
Client Address L16, 175 Eagle Street, Brisbane Qld 4000	

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Authors	**Date**
Dr Darlene Heuff	07/12/2023
	Approved By Dr Darlene Heuff

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Executive Summary

Advanced Environmental Dynamics Pty Ltd (AED) was commissioned by SLR Consulting Australia Pty Ltd on behalf of BM Alliance Coal Operations Pty Ltd (BMA) to undertake an air quality assessment of the Blackwater Mine (BWM) North Extension Project (the Project) in support of an Environmental Authority (EA) amendment application.

Project Background

Key elements of the Project include: the extension of mining activities within an area to the east of currently approved mining operations, specifically extending mining into SA10 on ML1759 and SA7 on ML1762; and the increase in peak coal production from 16 million tonnes per annum (Mtpa) to 17.6 Mtpa.

Blackwater Mine Environmental Authority Conditions

Under BWM's Environmental Authority (EA) (Permit Number EPML00717813), the requirement to demonstrate compliance with air quality objectives specified in Schedule B of the EA is triggered by a request from the administering authority (Condition A14). Specifically, Schedule B includes ambient air quality objectives for the monthly average of dust deposition (Condition B4(a)) and the 24 hour average concentration of particulate matter with an aerodynamic diameter less than 10 micrometres (PM_{10}) (Condition B4(b)) (Table A). To date, AED understands that in relation to air quality, Condition A14 has not been triggered.

Additional pollutants and/or averaging periods of interest to the administering authority that have been considered in this assessment include the annual average of total suspended particulates (TSP) and the annual average of PM_{10} (Table A).

Table A: Air Quality Assessment Objectives

Pollutant	Averaging Period	Assessment Objectives	Source
Dust deposition	Monthly	120 mg/m^2/day	EA condition B4(a) (1,2)
TSP	Annual	90 µg/m^3	QLD Environmental Protection (Air) Policy
PM_{10}	24 hour	50 µg/m^3	EA condition B4(b) (1,2)
	Annual	25 µg/m^3	QLD Environmental Protection (Air) Policy

Note: (1): Monitoring required *when triggered by EA Condition A14.*
(2): *Exceedances due to events that cannot be managed by the environmental authority holder, such as bush fires, fuel reduction burning for fire management purposes or dust storms, would not be considered to be in breach of condition B4 if the environmental authority holder can demonstrate that the exceedance was caused by such events.*

Dust Management at BWM

Dust management at BWM is supported by a real-time Dust Monitoring System and a Trigger Action Response Plan (TARP). The TARP outlines a suite of specific dust mitigation options that may be implemented in response to elevated levels of dust recorded by the BMA ambient air monitoring stations.

Dispersion Modelling

Two mining scenarios for the Project based on Business as Usual (BAU) dust management practices were assessed:

- ***Project Without (BAU) Case:*** *The mining of BWM as permitted under current mining approvals; and*
- ***Project With (BAU) Case:*** *The mining of BWM that includes the Project.*

Additional mitigation scenarios have been investigated for the Project With (BAU) Case. The results from these scenarios have been used to demonstrate the nature and extent of improved air quality outcomes that may be achieved through the implementation of dust mitigation measures in excess of BAU practices.

Dust dispersion modelling was undertaken using the CALMET/CALPUFF suite of modelling tools. Aligning with worst-case background dust conditions, hourly varying meteorology was developed for 2019 during which time BWM was experiencing severe drought conditions.

Summary of Results

Incremental changes in air quality outcomes that are attributed to the Project were calculated as the difference in the results for the Project With (BAU) Case compared with those of the Project Without (BAU) Case over the life of the mine (LOM). Results for the Project are summarised in Table B and Table C for the key assessment locations indicated in (Figure A).

The results presented highlight R5 located to the west of the Project as the most affected location assessed.

Figure A: Key Assessment Locations

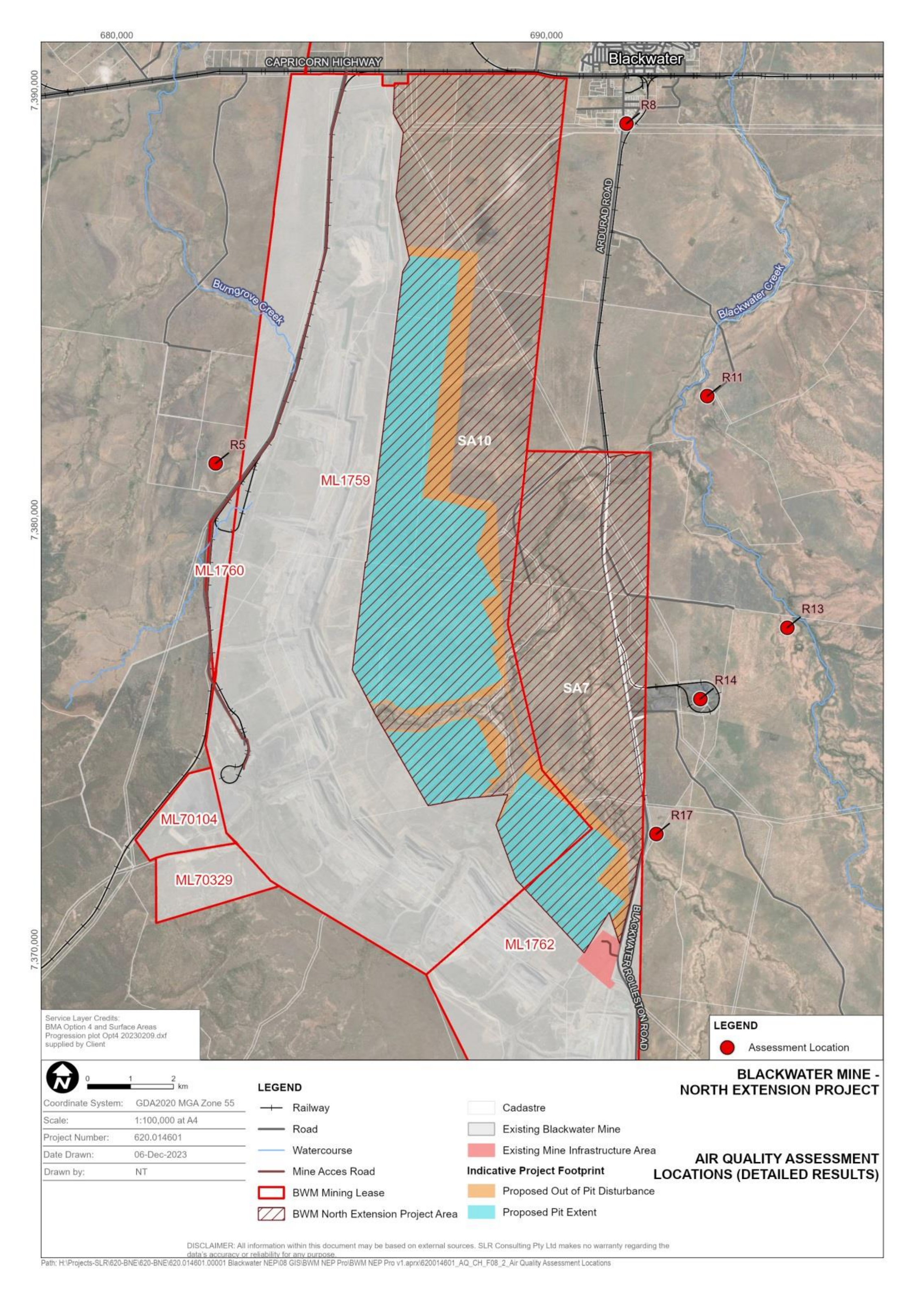

Table B: Changes in Predicted Air Quality Outcomes Attributed to the Project

Receptor	Dust Deposition Monthly Average ($mg/m^2/day$)	TSP Annual Average ($\mu g/m^3$)	PM_{10} 24hr Average ($\mu g/m^3$)	PM_{10} Annual Average ($\mu g/m^3$)
	Change in Average of Maximum over LOM	Change in Annual Average over LOM	Change in Average of Maximum over LOM	Change in Annual Average over LOM
Mine years assessed	61	61	61	61
R5 – private residence	+149.4	+45.5	+67.6	+11.2
R8 – private residence	+8.6	+5.9	+12.3	+1.4
R11 – private residence	+8.7	+4.9	+14.5	+1.3
R13 – private residence	+6.4	+3.4	+8.9	+1.0
R14 – industrial	+15.7	+6.9	+16.9	+1.9
R17 – private residence	+21.9	+9.8	+25.4	+2.8

Table C: Changes in Predicted Exceedances Attributed to the Project

Location	Dust Deposition Exceedance Months	TSP Annual Average Exceedance years	PM_{10} 24hr Average Exceedance days	PM_{10} Annual Average Exceedance years
	Change in Average over LOM(1)	Change in Average over LOM(1)	Change in Average over LOM(1)	Change in Average over LOM(1)
Number of mine years	61	61	61	61
R5 – private residence	+1.4	0	+13.9	0
R8 – private residence	0	0	+0.1	0
R11 – private residence	0	0	0.0	0
R13 – private residence	0	0	+0.3	0
R14 – industrial	0	0	+1.7	0
R17 – private residence	0	0	+4.8	0

Note (1): Results presented exclude background levels of dust

Conclusions

The findings of the air quality assessment suggest that there will be a requirement to implement additional dust mitigation strategies in excess of BAU if BWM is to achieve air quality outcomes in accordance with the assessment objectives.

Recommendations include:

- *The implementation of a network of regulatory-compliant ambient air monitoring stations and temperature inversion towers*
- *The extension of the features and functionality of the BWM Dust Monitoring System to include: estimates of background levels, estimates of mine contribution, increased visibility on key dust emission sources, increased visibility on resource utilisation, and real-time dust forecasting*
- *The optimisation of mine plans to reduce operational dust risk*
- *The development of a Continual Improvement Plan*

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Abbreviations

AED	Advanced Environmental Dynamics Pty Ltd
BM	BHP Billiton Mitsubishi
BMA	BM Alliance Coal Operations Pty Ltd
BoM	Bureau of Meteorology
BWM	Blackwater Mine
c.	Circa (approximately)
CALMET	California Meteorological Model
CALPUFF	California Plume Dispersion Model
CHPP	Coal handling and processing plant
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCS	Dust Control System
DES	Department of Environment and Science
EA	Environmental Authority
EPA	Environmental Protection Authority
EPP(Air)	Environmental Protection (Air) Policy
FY	Financial year
LOM	Life of mine
MIA	Mine industrial area
ML	Mine Lease
NASA	National Aeronautics and Space Administration
PM_{10}	Particulate matter with an aerodynamic diameter less than 10 microns
$PM_{2.5}$	Particulate matter with an aerodynamic diameter less than 2.5 microns
QLD	Queensland
RoM	Run-of-mine
SRTM	Shuttle Radar Topography Mission
TAPM	The Air Pollution Model
TARP	Trigger Action Response Plan
TCP	Thermal Coal Plant
TSP	Total suspended particulates
Y	Year

Units

%	per cent
ºC	degrees Celsius
g/cm^3	grams per cubic centimetre
h	hour
m	metre
mm	millimetre
Mtpa	Million tonnes per annum
µg	micrograms
$\mu g/m^3$	micrograms per cubic metre

1. Introduction

Advanced Environmental Dynamics Pty Ltd (AED) was commissioned by SLR Consulting Australia Pty Ltd on behalf of BM Alliance Coal Operations Pty Ltd (BMA) to undertake an air quality assessment of the Blackwater Mine (BWM) North Extension Project in support of an Environmental Authority (EA) amendment application.

This report contains a summary of the assessment methodology and findings. Additional detail can be found in the supporting appendices.

2. Project Summary

Blackwater Mine (BWM) is located approximately 20 kilometres (km) south-west of Blackwater in the Bowen Basin, Queensland (Figure 1). BWM's Mining Leases (MLs) include ML1759, ML1760, ML1761, ML1762, ML1767, ML1771, ML1772, ML1773, ML1792, ML1800, ML1812, ML1829, ML1860, ML1862, ML1907, ML70091, ML70103, ML70104, ML70139, ML70167 and ML70329 (Figure 1, Figure 2).

BWM has been in operation since 1967 and operates in accordance with, amongst other authorisations, Environmental Authority (EA) EPML00717813, granted under the Environmental Protection Act 1994 (Qld) (EP Act). BWM produces up to 16 million tonnes per annum (Mtpa) of product coal.

BMA seek relevant State and Federal approvals to extend the current mining operation through the BWM – North Extension Project (the Project). The Project would extend the mining area of the existing BWM to within Surface Area (SA)10 on ML1759 and SA7 on ML1762 (Figure 1, Figure 2) and increase BWM production to up to 17.6 Mtpa (product coal). Importantly, the Project should be viewed in the context that it is an extension and continuation of ongoing mining operations on a portion of the significantly larger BWM mining operation.

The key elements of the Project include, but are not limited to, the following:

- vegetation clearing, the removal and stockpiling of topsoil material, drilling and blasting of overburden and interburden material;
- removal of overburden and interburden material (dragline and truck and shovel/excavator methods) to uncover coal, which is placed as back fill in the mined-out pit voids (in-pit spoil dumps) as mining advances;

- open cut mining (truck and shovel/excavator methods) of RoM coal from the coal measures in SA10 on ML1759 and SA7 on ML1762;
- continued use of BWM infrastructure (e.g. Coal Handling and Preparation Plant (CHPP), Thermal Coal Plant (TCP), RoM and product stockpiles, train load-out, water management system and other supporting infrastructure);
- continued disposal of rejects and tailings in accordance with the EA;
- construction and operation of new or relocated infrastructure within SA10 on ML1759 and SA7 on ML1762 to facilitate and/or support the open cut mining extension such as back access roads, access tracks, water management infrastructure and powerlines, laydown areas and build pads;
- a new dragline crossing across Deep Creek;
- ongoing exploration activities within ML1759 and ML1762; and
- progressive rehabilitation of the mine site.

Surface Area SA7 on ML1762 and SA10 on ML1759 cover a total area of approximately 9,010 hectares (ha). The extent of the proposed Project open cut mining area and out of pit disturbance areas is approximately 3,761 ha. If approved, and subject to customer demand, the extension is projected to extend mining at the BWM to within SA7 on ML1762 and SA10 on ML1759 from 2025 to 2085.

Figure 1: Project Location

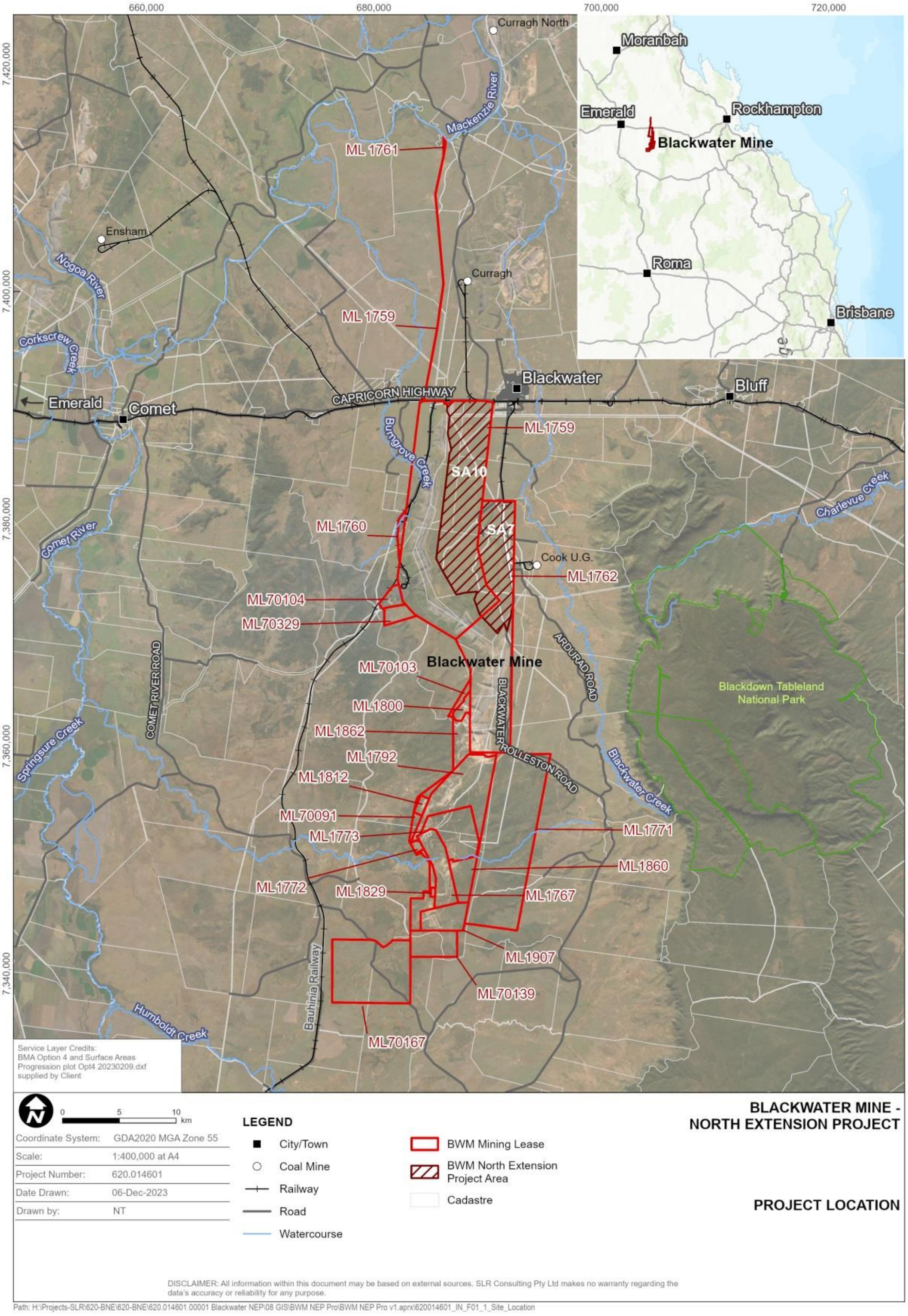
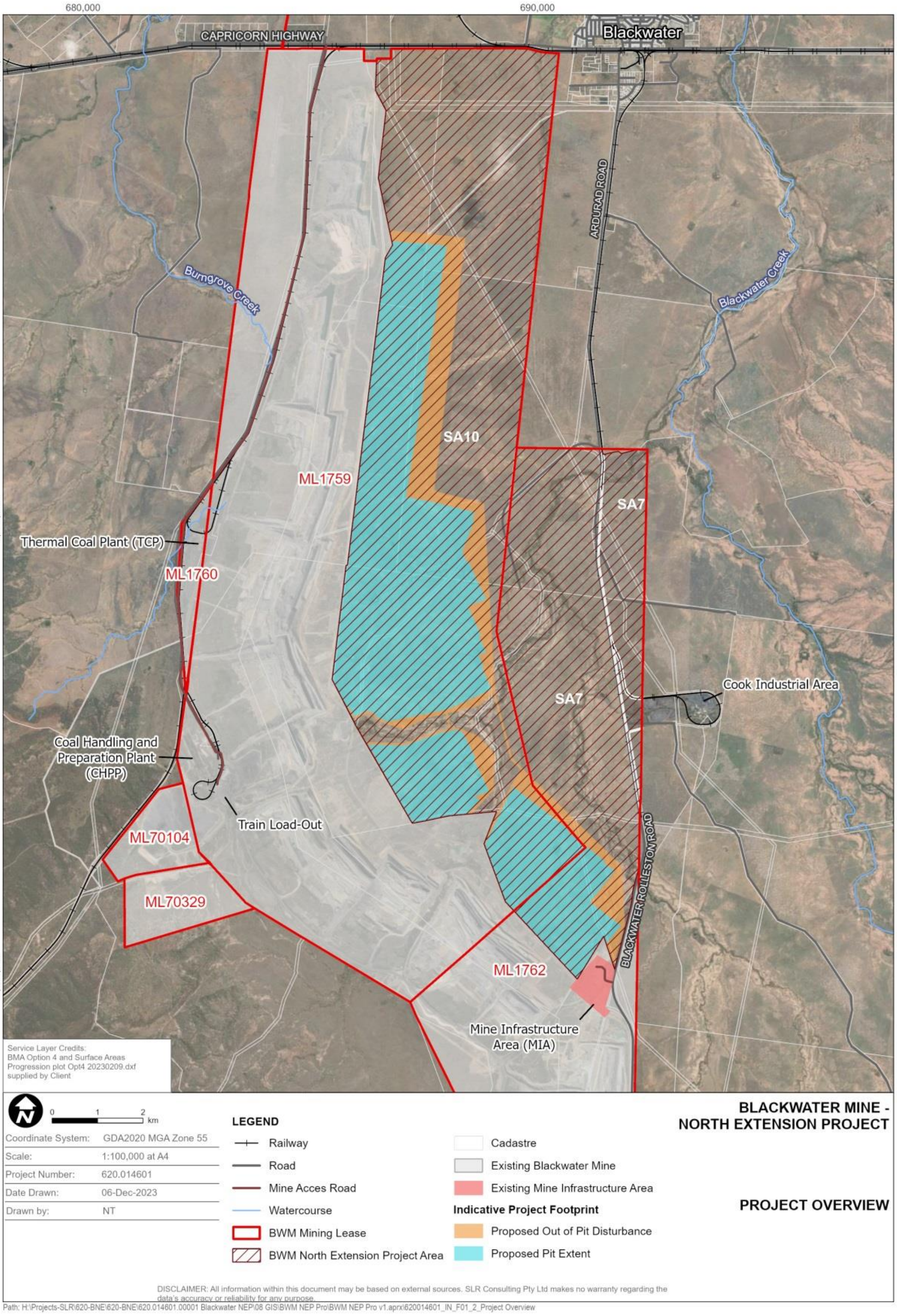


Figure 2: Project Overview



2.1 Environmental Authority Conditions

BWM operates under Environmental Authority (EA) (Permit Number EPML00717813). In relation to dust, EA Condition A14, Condition B3 and Condition B4 are of particular interest to this assessment:

A14	**Monitoring on request** When requested by the administering authority, the environmental authority holder must investigate any nuisance, or contaminant release, or environmental harm, or complaint that is neither frivolous nor vexatious in the opinion of the authorised person, by: a) undertaking the monitoring specified by the administering authority; b) undertaking the monitoring in the timeframe nominated or agreed to by the administering authority; c) completing an analysis and interpretation of the monitoring results; and d) implementing abatement measures, where required.

B3	**Dust nuisance** The release of dust or particulate matter or both resulting from the mining activities must not cause an environmental nuisance, at any sensitive place or commercial place.
B4	Monitoring of dust and particulate matter resulting from the mining activities, undertaken in accordance with condition **A14**, must be carried out at a place relevant to the potentially affected sensitive place or commercial place and must not exceed the following levels when measured at any sensitive place or commercial place: a) dust deposition, measured as total insoluble matter, of 120 milligrams per square metre per day, averaged over one month, when monitored in accordance with the most recent version of Australian Standard *AS3580.10.1 Methods for sampling and analysis of ambient air – Determination of particulate matter – Deposited matter – Gravimetric method.* b) a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometre (PM10) suspended in the atmosphere of 50 micrograms per cubic metre over a 24-hour averaging time, when monitored in accordance with the most recent version of either: i. Australian Standard *AS3580.9.6 Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM10 high volume sampler with size selective inlet – Gravimetric method*; or ii. Australian Standard *AS3580.9.8 Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM10 continuous direct mass method using a tapered element oscillating microbalance analyser*; or iii. Australian Standard *AS3580.9.9 Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM10 low volume sampler – Gravimetric method*; or iv. Australian Standard *AS3580.9.11 Methods for sampling and analysis of ambient air – Determination of suspended particulate matter – PM10 beta attenuation monitors.* *NOTE: Exceedances due to events that cannot be managed by the environmental authority holder, such as bushfires, fuel reduction burning for fire management purposes or dust storms, would not be considered to be in breach of condition **B4** if the environmental authority holder can demonstrate that the exceedance was caused by such events.*

Based on information provided by BMA, AED understands that to date, operations have not received a request from the administering authority (Condition A14) to assess the mine's performance against the air quality objectives specified in *Schedule B Condition B4* for the monthly average deposition of dust nor for the 24 hour average concentration of particulate matter with an aerodynamic diameter less than 10 microns (PM_{10}) (Table 1).

EA Condition B4 is interpreted by BMA as allowing for a mine contribution of 50 µg/m^3 to the 24 hour average ground level concentration of PM_{10} when it is able to be demonstrated that events outside the control of BWM was the cause of an exceedance event.

Table 1: BWM Environmental Authority Air Quality Objectives

Pollutant	Averaging Period	EA Objectives	Source
Dust deposition	Monthly	120 mg/m^2/day	BWM EA Condition B4(a)(1)
PM_{10}	24 hour	50 µg/m^3	BWM EA Condition B4(b) (1)

Note (1): *Exceedances due to events that cannot be managed by the environmental authority holder, such as bush fires, fuel reduction burning for fire management purposes or dust storms, would not be considered to be in breach of condition B4 if the environmental authority holder can demonstrate that the exceedance was caused by such events.*

2.1.1 Summary of Air Quality Assessment Objectives

Pollutants considered in this assessment have been expanded to include total suspended particulates (TSP) which is of interest to the regulating authority and is relevant to mining activities.

Due to the primarily mechanical means by which dust is generated by open cut mining activities (as opposed to combustion processes), particulate matter with an aerodynamic diameter less than 2.5 microns ($PM_{2.5}$) has not been considered in this assessment.

Table 2: Summary of Air Quality Assessment Objectives

Pollutant	Averaging Period	Assessment Objectives	Source
Dust deposition	Monthly	120 mg/m^2/day	BWM EA condition B4(a)(1,2)
TSP	Annual	90 µg/m^3	QLD Environmental Protection (Air) Policy
PM_{10}	24 hour	50 µg/m^3	BWM EA condition B4(b) (1,2)
	Annual	25 µg/m^3	QLD Environmental Protection (Air) Policy

Note: (1): Monitoring required when triggered by EA Condition A14.
(2): Exceedances due to events that cannot be managed by the environmental authority holder, such as bush fires, fuel reduction burning for fire management purposes or dust storms, would not be considered to be in breach of condition B4 if the environmental authority holder can demonstrate that the exceedance was caused by such events.

2.2 Assessment Locations

The BWM EA defines a sensitive place as:

Sensitive place *means;*

- ***a)*** *Any of the following :*
  - *i.* *A dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises; or*
  - *ii.* *A motel, hotel or hostel; or*
  - *iii.* *A medical centre or hospital; or*
  - *iv.* *A protected area; or*
  - *v.* *A public park or gardens.*
- ***b)*** *Despite paragraph (a), the following places are not sensitive places:*
  - *i.* *subject to paragraph (c) , a place that is the subject of an alternative arrangement; or*
  - *ii.* *a mining camp (i.e. accommodation and ancillary facilities for mine employees or contractors or both, associated with the mine the subject of the environmental authority), whether or not the mining camp is located within a mining tenement that is part of the mining project the subject of the environmental authority. For example, the mining camp might be located on the neighbouring land owned or leased by the same company as one of the environmental authority holders for the mining project or related company; or*
  - *iii.* *a property owned or leased by one or more of the environmental authority holder, or a related company whether or not is subject to an alternative arrangement.*
- ***c)*** *A place that is the subject of a current alternative arrangement in relation to a particular type(s) of environmental nuisance, is not a sensitive place for the purpose of that type(s) of environmental nuisance, however remains a sensitive place for the purposes of other types of environmental nuisances.*

The BWM EA also defines:

Commercial place *means:*

- *a)* *A work place that is used as:*
  - *i.* *An office; or*
  - *ii.* *A place of business ; or*

   iii. *A place used for commercial purposes.*

b) *Despite paragraph (a). the following places are not commercial places:*

   i. *Subject to paragraph (c), a place that is the subject of an alternative arrangement; or*

   ii. *Places that are part of the mining activity; or*

   iii. *Employee accommodation or public roads; or*

   iv. *A property owned or leased by one or more of the environmental authority holders, or a related company whether or not is subject to an alternative arrangement*

c) *A place that is the subject of a current alternative arrangement in relation to a particular type(s) of environmental nuisance, is not a sensitive place for the purpose of that type(s) of environmental nuisance, however remains a sensitive place for the purposes of other types of environmental nuisances.*

Based on the above definitions, locations listed in Table 3 and depicted in Figure 3 were identified as being of potential interest.

Highlighted rows within the table indicate that the receptor is not considered 'sensitive' as defined in the EA.

Table 3: Receptor Locations

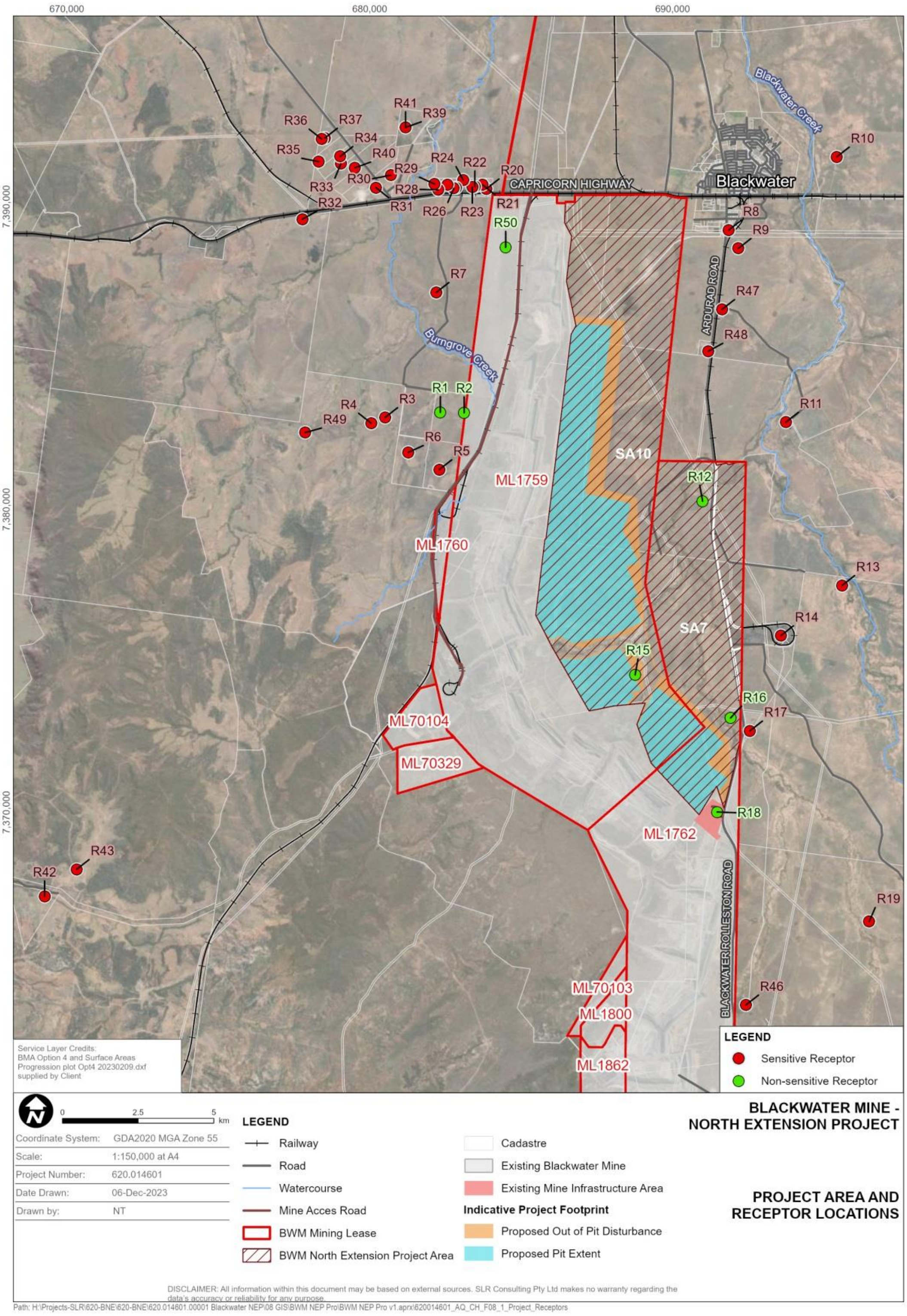
ID	Easting (m) (1)	Northing (m) (1)	Description
R1	682,332	7,383,198	BMA
R2	683,118	7,383,184	BMA
R3	680,506	7,383,036	Private - Tolmies Creek Homestead (HS)
R4	680,046	7,382,848	Private - Tolmies Creek HS
R5	682,295	7,381,314	Private - Ausbute HS
R6	681,271	7,381,884	Private
R7	682,199	7,387,165	Private - Burngrove HS
R8	691,856	7,389,223	Private – edge of Blackwater township
R9	692,174	7,388,618	Private - Minyango HS
R10	695,420	7,391,637	Private - Cardona HS
R11	693,741	7,382,883	Private - Tantallon HS
R12	690,992	7,380,267	BMA
R13	695,598	7,377,492	Private - Yarrawonga HS
R14(2)	693,576	7,375,833	Qcoal (Cook Colliery - north)

ID	Easting (m) [(1)]	Northing (m) [(1)]	Description
R15	688,762	7,374,534	Private - Taurus HS
R16	691,913	7,373,114	Private - Stewarton HS
R17	692,554	7,372,690	Private - Retreat HS
R18	691,468	7,370,011	BMA - BWM MIA Administration
R19	696,492	7,366,393	Private - Tannyfoil HS
R20	683,854	7,390,585	Private
R21	683,725	7,390,717	Private
R22	683,471	7,390,656	Private
R23	683,386	7,390,637	Private
R24	683,088	7,390,869	Private
R25	682,852	7,390,613	Private
R26	682,776	7,390,604	Private
R27	682,564	7,390,721	Private
R28	682,268	7,390,548	Private
R29	682,136	7,390,744	Private
R30	680,696	7,391,034	Private - Tulloch Ard HS
R31	680,210	7,390,623	Private
R32	677,776	7,389,581	Private - Maryvale HS
R33	679,048	7,391,412	Private - Malamy HS
R34	679,029	7,391,655	Private - Malamy HS
R35	678,311	7,391,482	Private - Sherborne HS
R36	678,413	7,392,228	Private
R37	678,517	7,392,258	Private
R39	681,182	7,392,608	Private
R40	679,512	7,391,279	Private
R41	681,184	7,392,609	Private
R42	669,266	7,367,221	Private - Monash HS
R43	670,323	7,368,118	Private
R46	692,423	7,363,643	Qcoal (Cook Colliery - south)
R47	691,633	7,386,604	Blackwater Cemetery
R48[(2)]	691,184	7,385,223	Resource recovery centre
R49	677,869	7,382,537	Quarry
R50	684,392	7,388,504	BWM Airport

Note: (1) Based on GDA 2020 MGA Zone 55 coordinate reference.

(2) *The Cook Colliery meets the definition of 'commercial place' in the current BWM EA, however, is an operating coal mine with its own EA.*

Figure 3: Project area and Receptor Locations



3. Existing Environment

This section presents data from a variety of sources including:

- The BWM ambient air monitoring network.
- The Queensland Department of Environment and Science's (DES) Blackwater monitoring station which was commissioned in 04/2019.
- The Bureau of Meteorology's (BoM) Blackwater Airport monitoring station (01/2014 – 12/2022).
- Output from the CALMET meteorological model (2019).

Climate statistics from the BoM Emerald Airport monitoring station (1992 – 2023) are presented in Appendix A.

3.1 The BWM Ambient Air Monitoring Network

As noted in Section 2.1, in relation to air quality, AED understands that EA Condition A14 has not been invoked by the administering authority. Nonetheless, BWM operates four optical (OSIRIS) continuous dust monitors (Figure 4) that collect: total suspended particulate (TSP), PM_{10}, and $PM_{2.5}$ data. To support the interpretation of dust impacts, wind speed and wind direction data is also collected at these same four locations. All parameters are sampled at 10 minute intervals.

Additionally, BWM undertakes dust deposition gauge monitoring at a number of locations focusing primarily on the area to the north east of mining operations (Figure 5). Due to its location to the south of mining operations, location DB9 is considered to be most representative of background levels of dust deposition.

Figure 4: OSIRIS Monitoring Locations

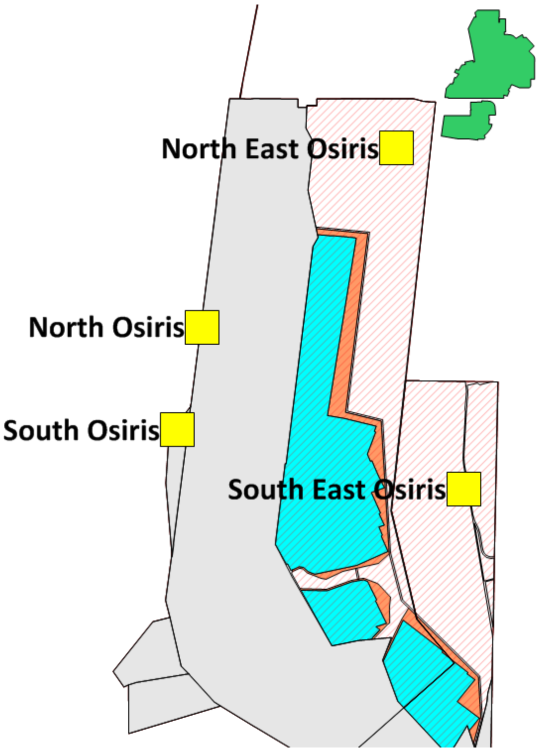
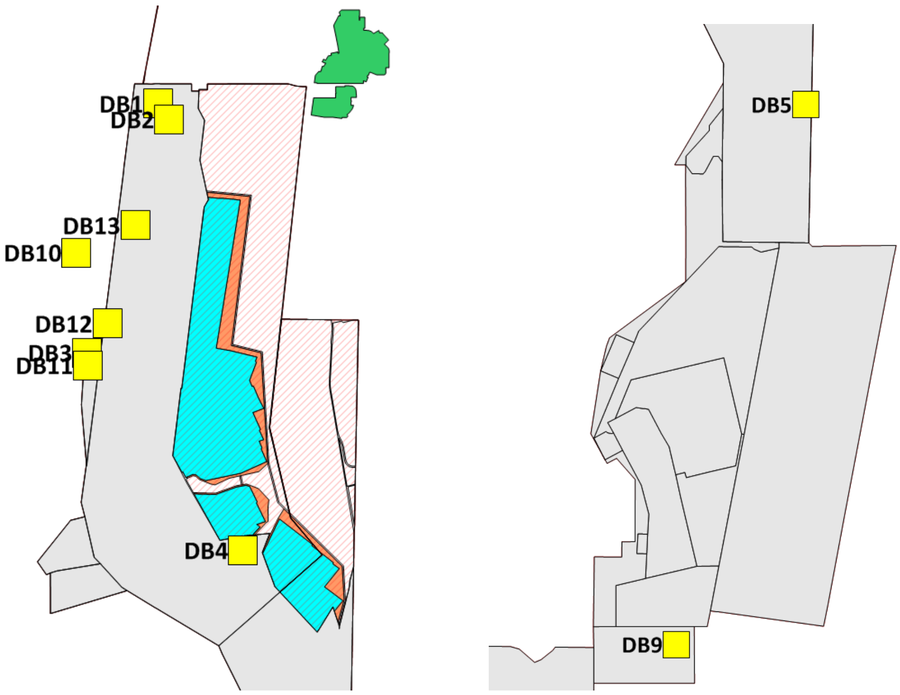


Figure 5: Dust Deposition Monitoring Locations (Left: Northern Locations, Right: Southern Locations)



3.2 Estimates of Background Levels

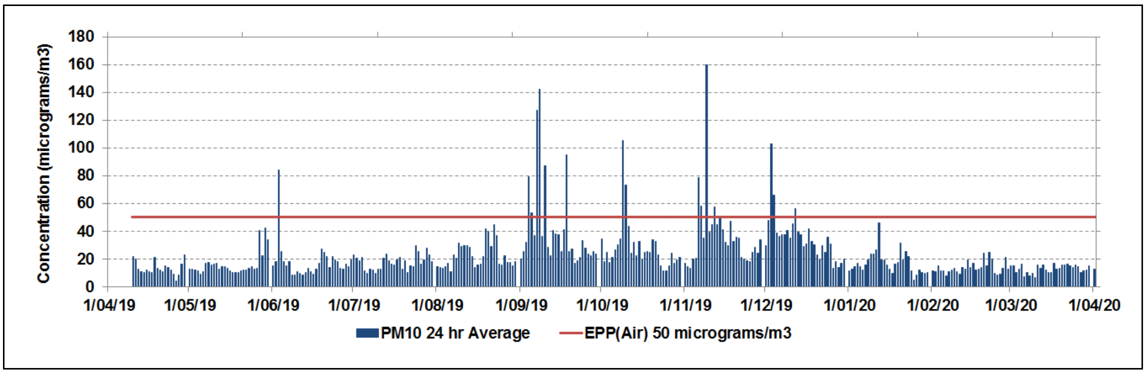
In theory, background levels of pollutants are the concentrations that would occur in the absence of anthropogenic emission sources. In practice, the practicalities and limitations associated with the establishment of ambient air monitoring stations means that they are rarely sited at locations which are not influenced to some degree by anthropogenic emission sources.

Estimating background levels is further complicated by the fact that, although the Victorian EPA recommend the use of the 70th percentile as an estimate for the background level, in reality background levels will be spatially and temporally varying as the emission rate of pollutants from natural sources are often functions of a number of factors including for example, frequency of rain, wind speed, atmospheric stability etc.

These limitations noted however, for the purposes of this assessment, a background dust deposition value of 36 mg/m^2/day has been estimated based on the 70th percentile of 82 rounds of monthly sampling from the BWM dust deposition monitoring location DB9 (Figure 5).

For the purposes of estimating background levels of PM_{10}, hourly averaged data from the DES monitoring station in the township of Blackwater has been used. Commissioned in 04/2019, the 70th percentile 24 hour average concentration of PM_{10} for the period 10/04/2019 through 09/04/2020 (Figure 6) was 23.7 µg/m^3. The annual average concentration of PM_{10} for this same period was 22.6 µg/m^3. It is noted that although the use of a single value as an estimate of background levels across the study region is common practice, this approach masks the spatial and temporal variability that may exist within the data set. For example, during the period presented there were a total of 18 exceedances of the EPP(Air) objective of 50 µg/m^3 for the 24 hour average concentration of PM_{10}.

Figure 6: DES Blackwater Monitoring Station Data 24 Hour Average Concentration of PM_{10}



An estimate for the annual average concentration of TSP has been developed based on an assumption that 50% of TSP is in the form of PM_{10}.

Estimates of background levels are summarised in Table 4.

Table 4: Estimate of Background Levels

Pollutant	Averaging Period	Estimated Background Level	Source
Dust deposition	Monthly	36 $mg/m^2/day$	BWM DDG Data(1)
TSP	annual	45.2 $\mu g/m^3$	Inferred from DES Blackwater data(3)
PM_{10}	24 hour	23.7 $\mu g/m^3$	DES Blackwater Monitoring Station(2)
	annual	22.6 $\mu g/m^3$	DES Blackwater Monitoring Station(2)

Note: (1) Data collected over the period 06/2014 through 12/2021 has been used.

(2) Data collected over the period 04/2019 to 04/2022 has been used.

(3) Based on an assumption that 50% of TSP is in the form of PM_{10}.

3.3 Meteorological Environment

3.3.1 Wind Roses

Presented in Figure 7 is a wind rose based on hourly averaged data from the DES Blackwater monitoring station. The wind rose highlights the predominance of easterly winds at this location.

The seasonal variability in the wind speed and direction is highlighted by the wind roses presented in Figure 8. The wind roses provided in Figure 9 highlight the variation in wind conditions as a function of the time of day. Of particular note is the increased frequency of light winds during the night and an increased frequency of elevated winds during the day time hours.

Additional figures are presented in Appendix A.

Figure 7: Wind Rose (m/s) based on Hourly Averaged Data

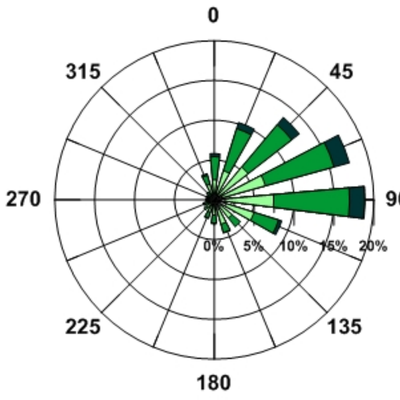
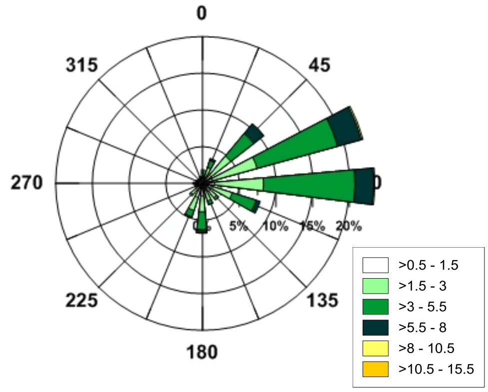
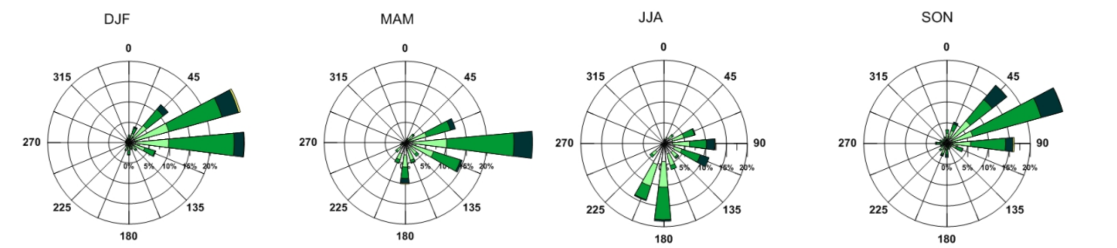
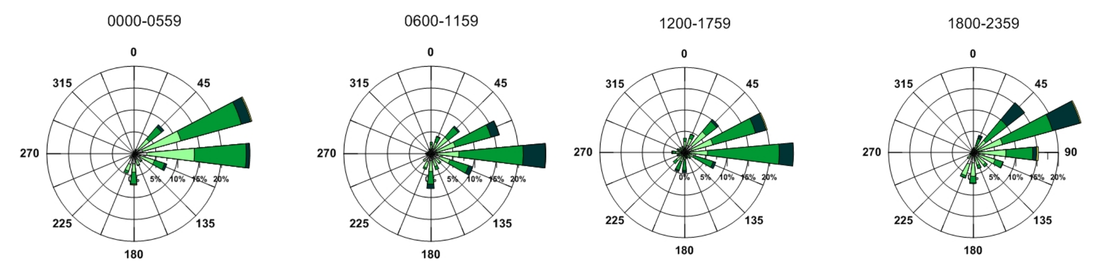
DES Blackwater Monitoring Station (10/04/2019 – 09/04/2020)	CALMET Numerically Simulated (2019)
	

Figure 8: Seasonal Wind Roses (m/s) based on DES Blackwater Monitoring Station Hourly Averaged Data (m/s) (10/04/2019 – 09/04/2020)



Note: DJF – December, January, February, MAM – March April May, JJA – June, July, August, SON – September, October, November

Figure 9: Hour of Day Wind Roses (m/s) based on DES Blackwater Monitoring Station Hourly Averaged Data (m/s) (10/04/2019 – 09/04/2020)

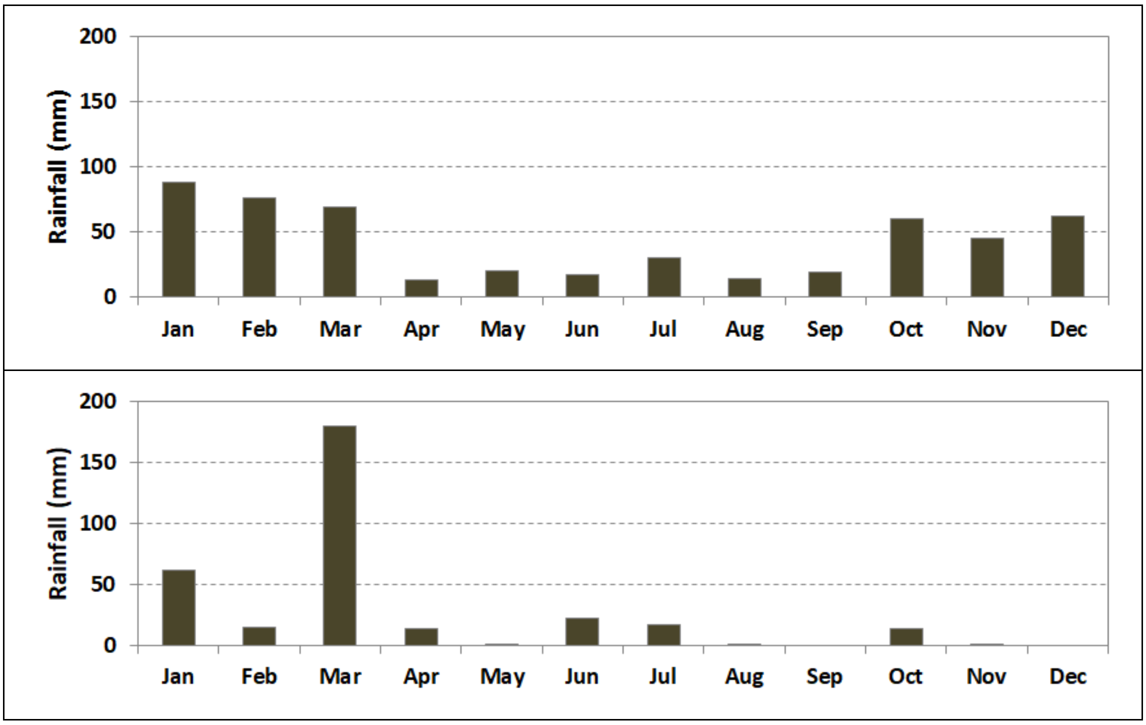


3.3.2 Rainfall Data

Rainfall data has been sourced from the BoM Blackwater Airport monitoring station. Monthly average values are presented in Figure 10 for the period 01/2014 through 12/2022. Data specific to 2019 is included in Figure 10.

Based on data for the period 2014-2022, the average annual rainfall was 548 mm, whilst an annual total of 327 mm was recorded in 2019. With c. 180 mm recorded in March 2019, the balance of the year experienced significantly less than average rainfall.

Figure 10: Monthly Average Rainfall Data, BoM Blackwater Airport (Upper: 01/2014 through 12/2022, Lower: 2019)



3.3.3 Worst Case Meteorological Conditions

In order to effectively manage BWM's dust emissions, a detailed understanding of the meteorological conditions that lead to an increased risk of elevated levels of dust is required. In general, worst-case meteorological conditions for open cut mining operations fall into two categories:

- Temperature Inversions: Characterised by calm conditions and the development of low level temperature inversions (typically in winter) that trap dust close to the Earth's surface. Dust levels under these conditions have been observed to increase rapidly over very short periods of time. Inhibiting the dispersion of dust away from the source, the strength and duration of a temperature inversion event can be very difficult to forecast. The collapse of the inversion layer (typically just after sunrise) is associated with a rapid rate of dispersion of the trapped dust and an associated reduction in ground level concentrations.

- Wind Events: Elevated wind conditions that lead to the generation of significant windblown dust, particularly from exposed areas. Wind events are typically associated with elevated levels of visible dust and an increase in dust deposition. Wind events in the Bowen Basin are likely associated with summer storms or a synoptic front associated with a regional weather system. The minimum wind speed required to initiate wind erosion will vary depending on the properties of the exposed material, however, in general a lift off velocity of c. 5.4 m/s is suggested by the literature (e.g. NPI, 2012). Based on data from the DES Blackwater monitoring station, for the period 10/04/2019 through 09/04/2022, winds above 5.4 m/s were recorded c. 11.3% of the time. Based on numerically simulated data from locations associated with BWM (Figure 31 through Figure 33), wind speeds above 5.4 m/s are more likely to occur during daytime hours.

Presented in Figure 11 is a scatter plot of 10 minute average PM_{10} data as a function of wind speed based on data from the Southern OSIRIS monitoring station. The figure highlights the occurrence of both categories of worst-case meteorological conditions: infrequent elevated levels of dust associated with high wind speeds (orange box); and frequent elevated levels of dust associated with low wind speeds (blue box).

Data presented in Figure 12 highlights the elevated risk of dust during the evening and early morning hours (indicative of temperature inversion conditions) with reduced dust risk during the afternoon (i.e. between 12:00 and 16:00).

The correlation between the strength of the low level temperature inversion and elevated levels of dust was highlighted in a field study undertaken at BMA's Caval Ridge Mine (AED 2018).

Figure 11: Southern OSIRIS 10 Minute Average Concentration of PM_{10} as a Function of Wind Direction (01/06/2018 through 31/12/2019)

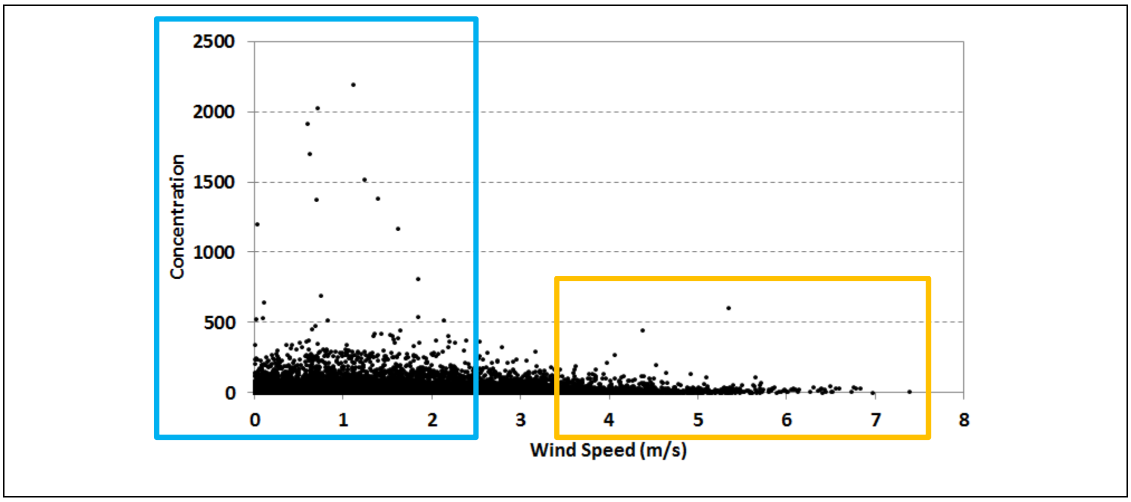
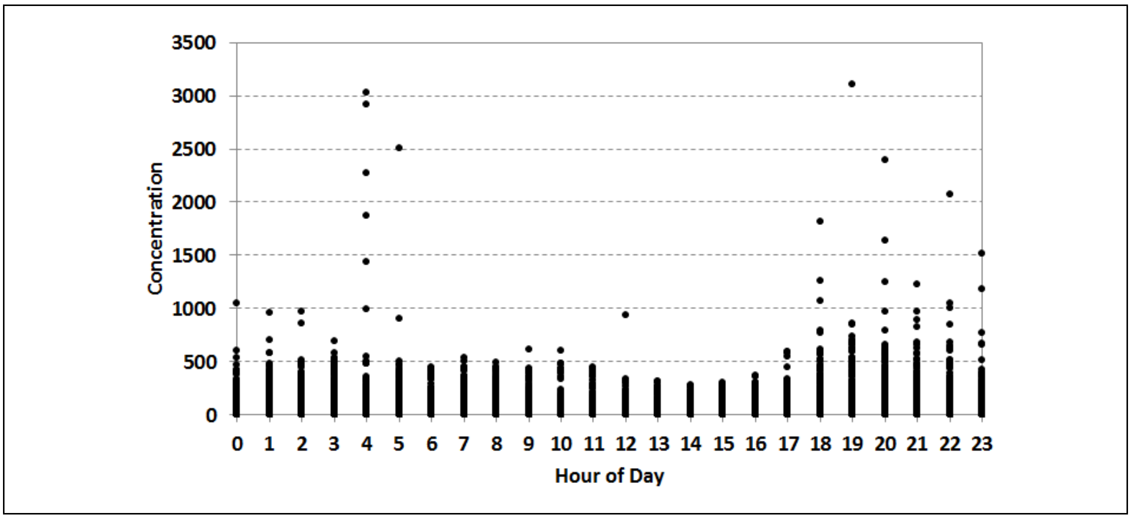


Figure 12: Southern OSIRIS 10 Minute Average Concentration of PM_{10} as a Function of the Hour of Day (01/06/2018 through 31/12/2019)



4. Overview of Assessment Methodology

4.1 Dust Emission Sources

A number of dust generating activities are associated with mining operations at BWM:

- Topsoil stripping
- Drilling and blasting of both overburden and coal
- Truck loading and dumping and shovel operations both overburden and coal
- Dragline operations
- Wheel generated dust from coal hauling to CHPP
- Wheel generated dust from transport of overburden to dumps
- Dozers operating on coal and waste material
- Stacking and reclaiming at raw coal stockpiles
- Stacking and reclaiming at product stockpiles
- Wind erosion from exposed areas including overburden dumps
- Wind erosion from coal stockpiles
- CHPP activities
- TCP activities

Dust emission sources that have been explicitly modelled include (and are limited to):

- Coal mining, hauling and dumping
- Waste removal by dragline
- Waste removal by Truck and Shovel fleets including the loading of trucks, hauling and truck dumping
- Reject haulage
- Dozer dragline support
- Dozer operations in support of in-pit coal operations
- Dozer operations in support of waste handling

- CHPP activities (crushing, stacking, reclaiming)
- TCP activities (crushing, stacking, reclaiming)
- Wind erosion of exposed areas.

The incorporated dust emission sources is considered to represent the majority of significant site-based dust generating emissions sources with those excluded considered to be immaterial.

4.2 Dust Emission Scenarios

Two mining scenarios for the Project based on Business as Usual (BAU) dust management practices have been assessed:

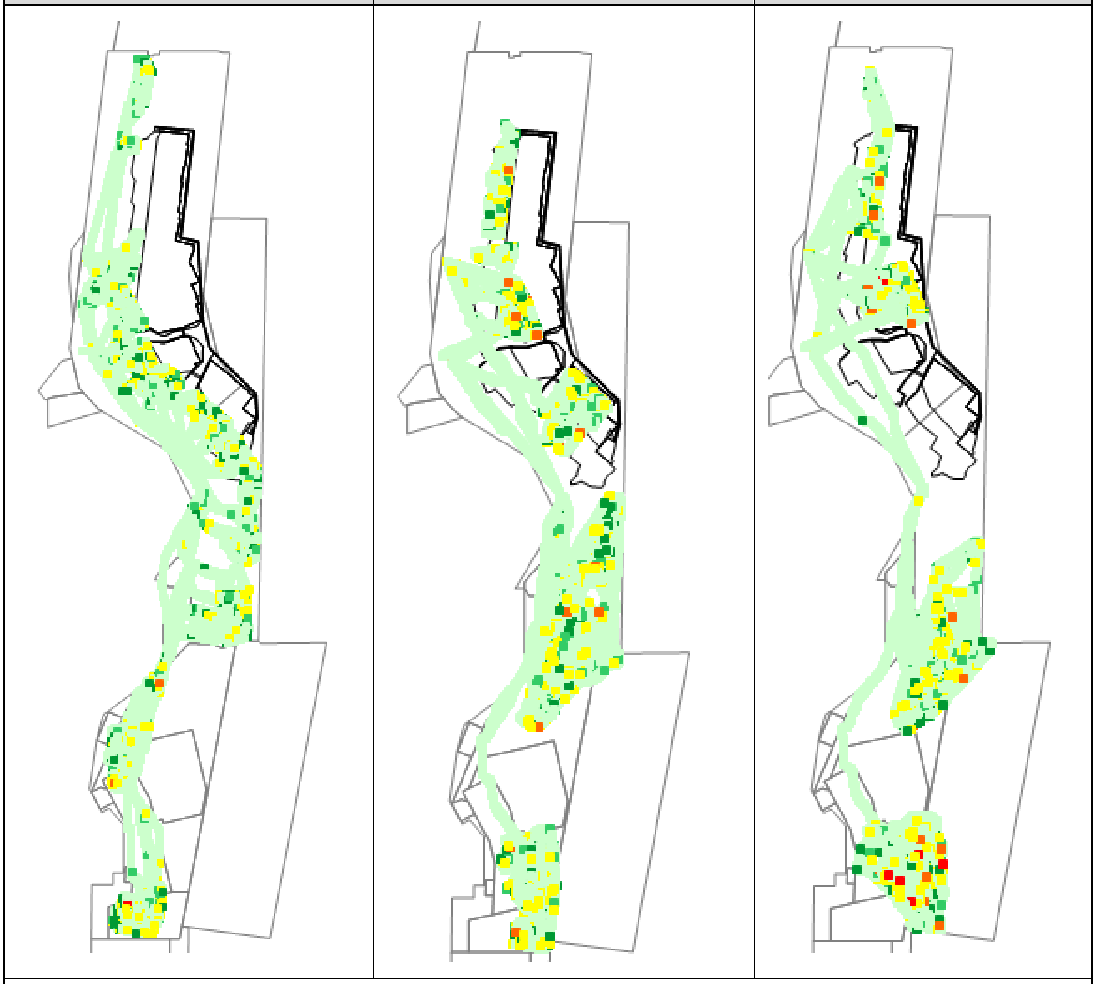
- **Project Without (BAU) Case:** The mining of BWM as permitted under current mining approvals; and
- **Project With (BAU) Case:** The mining of BWM including the Project.

Detailed mine schedule and haulage model output was provided by BMA for both cases. An example of dust emission source locations associated with dragline, waste handling by truck and shovel, coaling, rejects and dozer activities for the Project With (BAU) case are provided in Figure 13. Results are presented as a percentage of the annual total emissions associated with these activities highlighting the variability in mining intensity.

Additionally, a series of mitigation scenarios have been investigated for the Project With (BAU) Case (Section 5.5). The results from these scenarios have been used to demonstrate the nature and extent of improved air quality outcomes that may be achieved through the implementation of dust mitigation measures in excess of BAU practices.

Figure 13: Project With (BAU) Case: PM_{10} Emissions Intensity as Percentage of Annual Total based on Dragline, Truck & Shovel, Coaling, Rejects and Dozer Activities

FY30	FY50	FY70



Minimum	Maximum
>0.000%	0.005%
0.005%	0.0125%
0.0125%	0.025%
0.0250%	0.250%
0.2500%	0.500%
>0.500%	n/a

4.3 Dust Reduction Measures

4.3.1 Dust Management Practices at BWM

Dust management practices at BWM are informed by:

- An Air Emissions Management Plan: *BWM-PLN-1034 BWM Plan Air Emissions Management Plan*
- A Trigger Action Response Plan (TARP): *BWM-TAR-1012 BWM Trigger Action Response Plan (TARP) PM10 Dust Management for Sensitive Receptors*
- A Dust Control Work Instruction: *BWM-SWI-2079 BWM Instruction Dust Control Work Instruction*
- A Dust Monitoring System that includes a dashboard displaying the location of the dust monitoring stations and a dashboard displaying real-time sensor date from the BWM ambient air monitoring network.

Current TARP trigger levels are:

- Level 1 response (yellow TARP – *Increase Awareness and Investigate*): No 'PM_{10} Average' dust monitor readings above 70 µg/m^3.
- Level 2 response (orange TARP – *Increase Monitoring and Prepare Contingencies*): 2 x 'PM_{10} Average' dust monitor readings above 70 µg/m^3 and or climb in the rolling 24 hr average PM_{10} dust levels to 40 µg/m^3
- Level 3 response (red TARP – *Stop Normal Operations and Treat the Problem Directly*): Rolling 24hr average PM_{10} dust levels reading above 45 µg/m^3.

Specific dust mitigation measures specified in the TARP include:

- Pre-Strip:
  - Prioritise water carts to areas impacting dust monitors
  - Increase watercarts, hot seat water carts and reduce grading
  - Drive to conditions to reduce dust
  - Reduce quantity of active trucks hauling
  - Change dig/dump method
  - Stop circuit
  - Shut down work area

- Dragline:
  - Reduce dumping height
  - Consider alternate dig/dump locations/methodology
  - Lift bucket cleanly away from the face, and hoist up with minimum spillage
  - Do not dump with swinging boom
  - Slow cycle time down
  - Shut down work area
- Dozer Push/Grader:
  - Drive to conditions to reduce dust
  - Attempt to spread work area out
  - Relocate dozer
  - Shut down work area
- Drilling:
  - Identify specific drills with compromised dust controls
  - Prioritise compromised controls
  - Shut down work area
- Blasting
  - Management of the pattern
  - Shut down work area
- Coal Mining:
  - Prioritise water carts
  - Drive to conditions
  - Divert trucks from pits
  - Shut down work area
- Coal Processing:
  - Visual inspection
  - TCP turn on water sprays if not currently operating

- TCP turn off stacker
- TCP stockpile dozer to be relocated if required
- Shut down work area

4.3.2 Dust Reduction Measures Included in the Dispersion Modelling

BWM dust reduction measures that have been incorporated into the dust dispersion modelling include:

- Use of water sprays at the RoM dump
- Use of water sprays whilst crushing
- Use of a ply stacker to reduce the coal drop height

Additional mitigation measures that have been incorporated into the dispersion modelling for the purposes of this assessment that may not typically form part of BWM BAU dust management practices but are available to operations if required, include:

- The limiting of the dragline drop height to 6 m
- Watering of haul roads at a rate of more than 2 litres/m^2/hour (i.e. level 2 watering)

4.4 Dust Emissions Inventory

The National Pollutant Inventory (NPI) has produced a series of Emission Estimation Technique Manuals (EETM) that are intended to provide data on emissions of air pollutants from a wide variety of industries/activities.

For this assessment, the NPI EETM for Mining V3.1 (NPI, 2012) has been used to develop estimates of the amount of TSP and PM_{10} emitted from the various dust generating activities and incorporating site-specific information where available. Emission factors from the NPI EETM for Mining were supplemented with those from the US EPA's AP42 (USEPA, 1995) as required and/or considered appropriate. Details of the development of the emission factors used in this assessment are provided in Appendix C.

4.4.1 The Project Without (BAU) Case

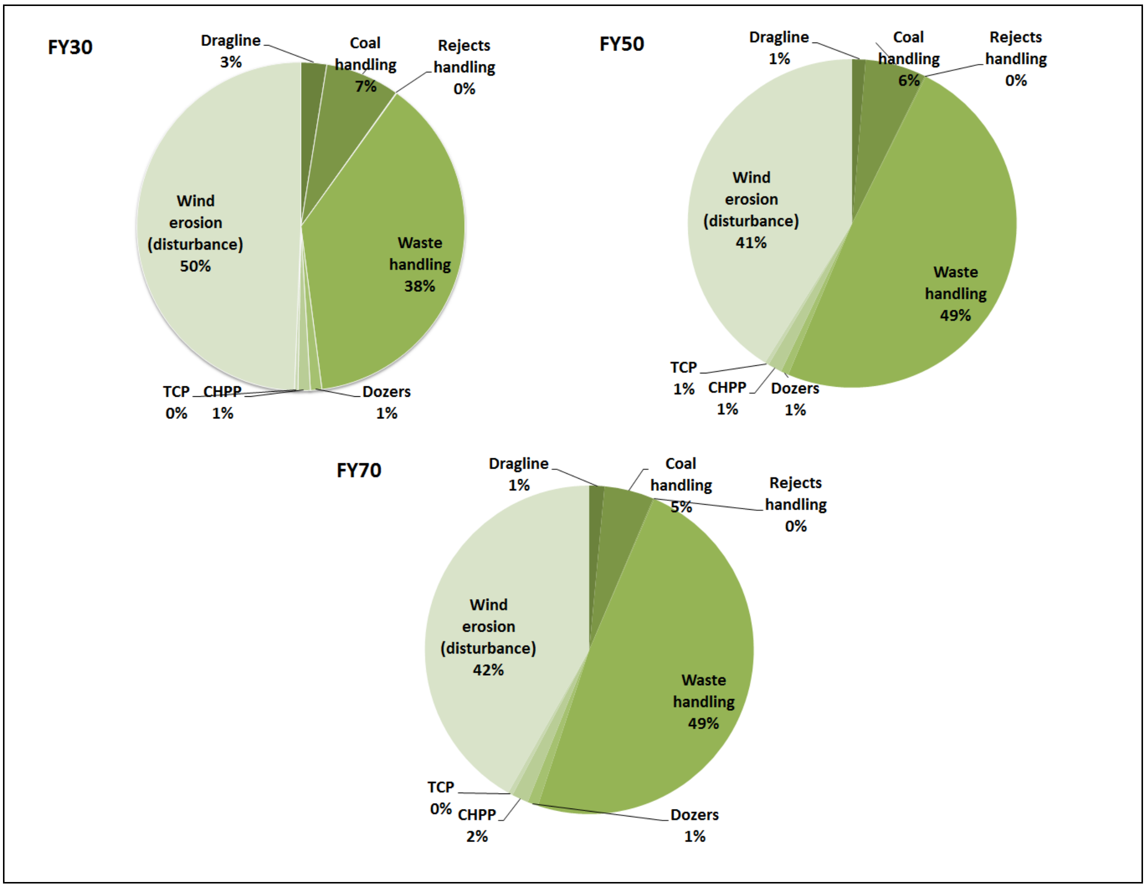
The PM_{10} and TSP emissions inventory for the Project Without (BAU) case for selected years of mining is presented in Table 5.

The breakdown of the emissions inventory by activity Figure 14 highlights waste handling and wind erosion as key sources of dust.

Table 5: Project Without (BAU) Case: Emissions Inventories

Activity	TSP (t/year)			PM10 (t/year)		
	FY30	FY50	FY70	FY30	FY50	FY70
Dragline	1,597	734	695	487	224	212
Coal handling	1,455	1,037	708	1,405	1,014	695
Rejects handling	13	17	15	13	17	15
Waste handling by truck & shovel	13,424	16,289	13,529	7,304	8,308	6,920
Dozers	816	497	567	214	130	149
CHPP	233	233	233	233	233	233
TCP	66	66	66	66	66	66
Wind erosion (disturbance)	18,960	13,953	11,903	9,480	6,976	5,952
Subtotal (excluding wind erosion)	17,604	18,872	15,813	9,722	9,992	8,289
Total	**36,564**	**32,825**	**27,716**	**19,202**	**16,969**	**14,241**

Figure 14: Project Without (BAU) Case: Breakdown of Emissions Inventory



4.4.2 The Project With (BAU) Case

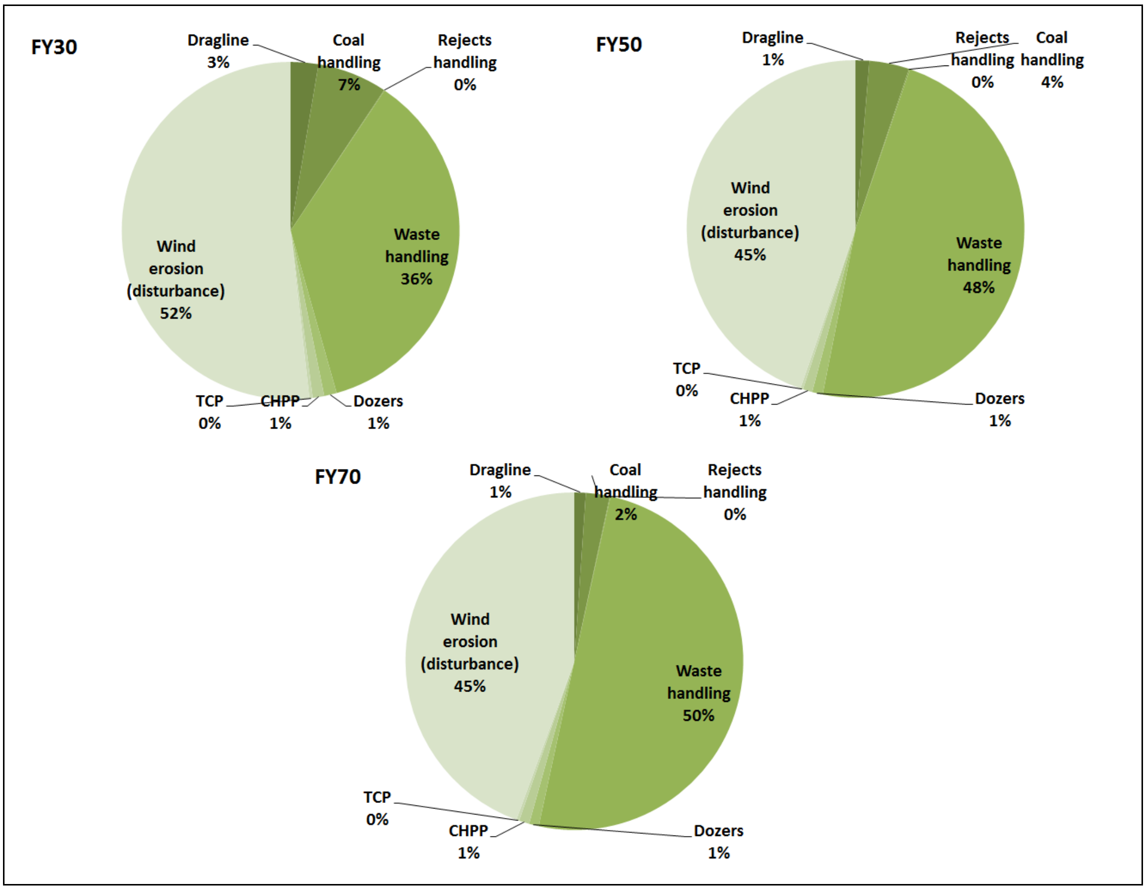
The PM_{10} and TSP emissions inventory for the Project With (BAU) case for selected years of mining is presented in Table 6.

The breakdown of the emissions inventory by activity presented in Figure 15 highlights waste handling and wind erosion as key sources of dust.

Table 6: Project With (BAU) Case: Emissions Inventories

	TSP (t/year)			PM10 (t/year)		
Activity	**FY30**	**FY50**	**FY70**	**FY30**	**FY50**	**FY70**
Dragline	1,833	1,110	844	559	338	257
Coal handling	1,467	1,013	560	1,412	980	542
Rejects handling	14	28	16	14	28	16
Waste handling by truck & shovel	13,352	24,254	24,100	7,646	12,322	11,846
Dozers	973	993	841	255	260	221
CHPP	233	233	233	233	233	233
TCP	66	66	66	66	66	66
Wind erosion (disturbance)	21,868	23,004	21,066	10,934	11,502	10,533
Subtotal (excluding wind erosion)	17,937	27,696	26,660	10,184	14,228	13,180
Total	**39,805**	**50,700**	**47,726**	**21,118**	**25,730**	**23,713**

Figure 15: Project With (BAU) Case: Breakdown of Emissions Inventory



4.5 Dispersion Modelling Methodology

Three-dimensional wind fields that are used as input into the dispersion model were prepared using a combination of The Air Pollution Model (TAPM) developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Hurley, 2008), CALMET, the meteorological pre-cursor for CALPUFF (Scirer, 2000).

Aligning with worst-case background dust conditions, hourly varying meteorology was developed corresponding to 2019.

Dust dispersion modelling was undertaken using CALPUFF. Examples of the locations of dust emission sources incorporated into the dispersion modelling were indicated in Figure 13.

Details of the model set up are provided in Appendix B.

4.5.1 Modelling Assumptions and Implications

A necessary component of any air quality assessment is the need to incorporate a wide range of assumptions, the consequence(s) of which can be difficult to quantify. Nonetheless, a summary of some of the key assumptions that have been incorporated into the dust dispersion modelling methodology utilised for this assessment, the implication(s) of these assumptions and comments are summarised in Table 7.

Table 7: Modelling Assumptions and Implications

Category	Assumption	Implication and Comments
Background levels	Single value applicable for all locations and all times of the year	The use of a single value for background levels masks the spatial and temporal variability.
Impact of rain days	Rainfall not included	The dust dispersion model methodology adopted for this assessment does not explicitly include rainfall as the validation of rainfall frequency and intensity would add another level of uncertainty when interpreting results. The omission of rainfall from the assessment methodology would suggest that results presented are likely to be more representative of drier years and conservative during periods of above average rainfall. Nonetheless, in order to highlight the potential reduction in the number of days during which additional mitigation measures may be required as a result of natural precipitation a review of rainfall climate data has been undertaken. Presented in Appendix A is the monthly average number of rain days with rainfall greater than 1 mm based on data from the BoM Emerald monitoring station for the period (1992 through 2023). The NPI EETM for Mining (Appendix 1.1.17) (NPI, 2012) suggests that each day with a rainfall amount greater than 0.25 mm will have an 0.78% reduction on the annual total emission of dust associated with wind erosion. This statistic could be used to estimate the improvement in air quality outcomes that could be achieved as a result of the mitigating effect of rainfall. However, such an estimate is likely to underestimate the influence of rainfall as well since soil recharge would not be taken into account using this approach. The lack of incorporation of wet/dry season influences within the dispersion model. In general, the wet/dry season may affect the number of predicted exceedances via: • The reduction/elevation of background levels of dust. • The reduction/elevation of the potential for windblown dust from exposed areas. • The seasonal variation of topsoil moisture content. • (To a lesser extent) the potential for seasonal variation

Category	Assumption	Implication and Comments
		in overburden moisture content although dust generation from the material handling of overburden is likely to be highly influenced by material type as well as any possible seasonal variation in moisture content.
Emission Factors	Based on the NPI Emission Estimation Technique Manual for Mining V3.1 (NPI EETM)	The NPI EETM (NPI, 2012) has been used to estimate the amount of PM_{10} emitted from the various mining activities and were supplemented with those from the US EPA's AP42 (USEPA, 1995) as required and/or considered appropriate. Important parameters that are used in the NPI EETM emission factor formulas associated with material handling include silt and moisture content. However, as a comprehensive site-specific data set pertaining to these parameters for overburden (as an example), adopted values have been assumed based on information contained in the US EPA AP42 (1995). It is acknowledged that the lack of comprehensive site-specific material parameter information may limit the representativeness of the emission factors developed for this assessment. A seasonal site-based sampling program could be implemented however, a robust data set would require several seasons worth of data and good data/meteorological correlation.
Corrections for the dispersion model output for PM_{10}	The Correction Methodology developed for BMA's Caval Ridge Mine (Moranbah) is applicable to BWM.	The development of correction factors for temperature inversion that were applied to the results of the dispersion modelling of PM_{10} impacts, is based on the results of an analysis of data from BMA's Caval Ridge Mine monitoring network including data from the site's temperature inversion towers. Significant wind events within the CALMET data set for BWM have not been excluded from the results presented.

5. Interpretation of Results from the Dispersion Modelling

When interpreting results from the dispersion modelling presented in this section it is important to note the following:

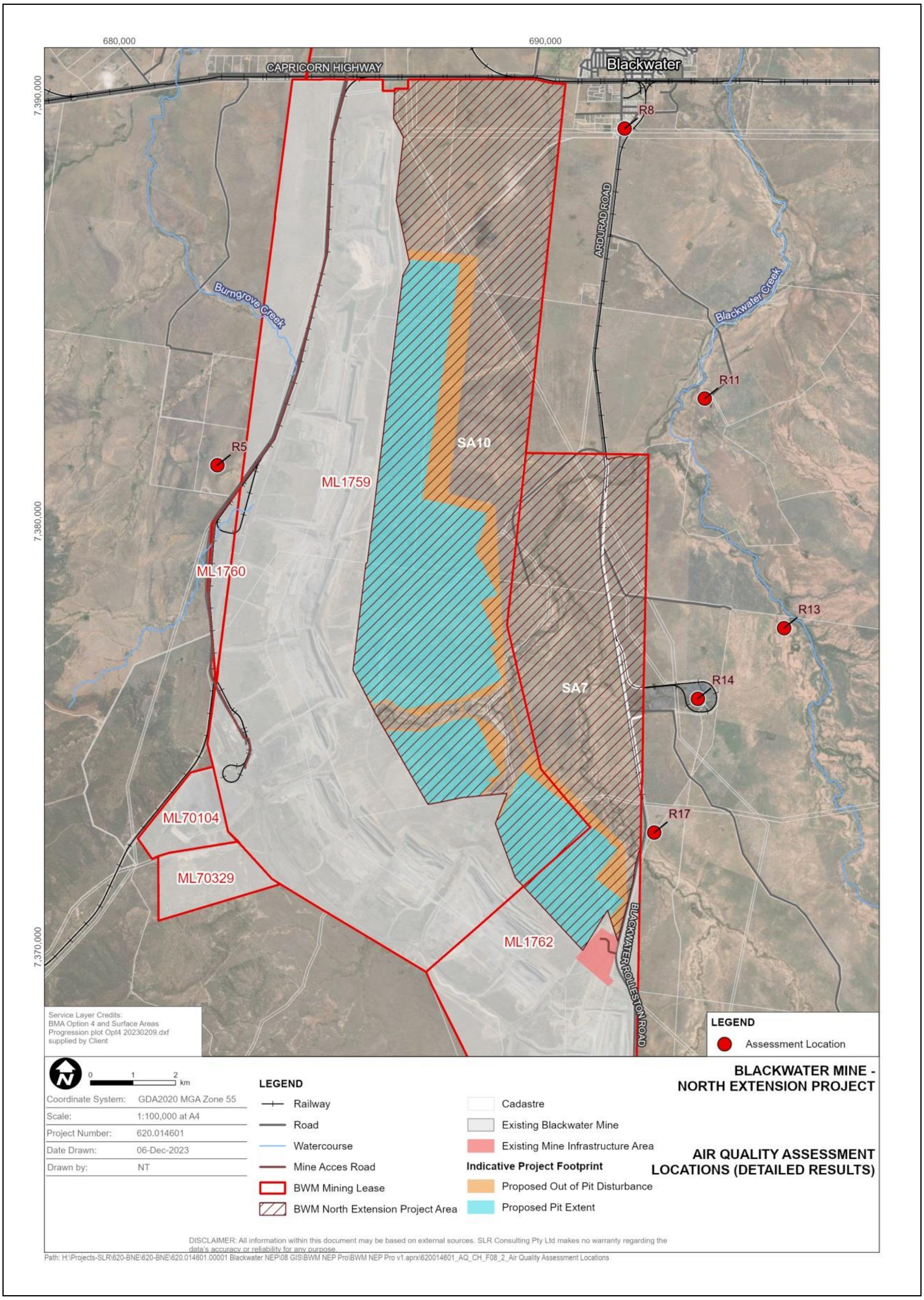
- Modelling presented as the BAU Case includes the dust reduction measures specified in Section 4.3. Thus the results provide an indication of how frequently implementation of additional dust control measures may need to be implemented. Modelling of additional scenarios to investigate the extent to which additional mitigation measures may be required has been undertaken with results presented in Section 5.5.
- Results should not be interpreted as being indicative of environmental outcomes as operations will be required to modify activities in order to comply with the site's current and/or future EA Conditions. Instead, an increase in the predicted number of days for which BAU dust management strategies may be insufficient to ensure compliance with EA requirements (for example), is interpreted as an indication of the increased frequency by which additional dust management strategies may need to be implemented, and therefore represents an increase in operational risk.
- Results of the dispersion modelling for PM_{10} have been corrected based on the temperature inversion correction methodology developed by AED following the findings of the ACARP study (AED 2018). Due to the use of assessment location-specific corrections, contour plots have not been presented as a single correction factor was not applied across the study area.
- A preliminary screening assessment of results for the 24 hour average concentration of PM_{10} for a total of 86 assessment locations was undertaken (results not presented). The findings of this assessment were used to identify a sub-set of worst case representative receptor(s) for clusters of receptor locations and/or individual locations (Table 3). Results for receptors that were significantly less than those presented here have not been explicitly included. Tabulated results for the six representative locations in Table 8 and depicted in Figure 16 are presented in this report.

  The management of dust by BWM in accordance with its EA Conditions at these locations is considered to be sufficient to ensure compliance with EA Conditions at locations for which results are not explicitly provided in this report.

Table 8: Dispersion Modelling Assessment Locations

ID	Easting (m) [(1)]	Northing (m) [(1)]	Assessment Location Type
R5	682,295	7,381,314	Private residence
R8	681,271	7,381,884	Private residence
R11	693,741	7,382,883	Private residence
R13	695,598	7,377,492	Private residence
R14	693,576	7,375,833	Industrial
R17	692,554	7,372,690	Private residence

Figure 16: Air Quality Assessment Locations (Detailed Results)



5.1 Results for Dust Deposition

Presented in Table 9 are the results from the dispersion modelling for the average over the LOM of the maximum monthly averaged dust deposition for comparison with the assessment objective of 120 mg/m^2/day (Table 2).

Results highlight assessment location R5 as being associated with the greatest increase in operational risk with the Project's contribution to the maximum monthly dust deposition predicted to exceed the assessment goal on average over the LOM.

Results presented do not include a background level of 36 mg/m^2/day (Section 3.2).

The predicted number of exceedances of the assessment objective for dust deposition is presented in Table 10. A result of 1.4 (for example R5, Project Impacts) is interpreted as predicting fourteen exceedances of the assessment objective for dust deposition over a 10 year period (or 120 months).

(It is noted, that correction factors for the dispersion model output in relation to dust deposition has not been developed as part of this study.)

Table 9: Maximum Monthly Average Dust Deposition (mg/m²/day)

Receptor	Project Without Case(1) (BAU)				Project With Case(1) (BAU)				Project Impacts
	FY30	FY50	FY70	Average LOM	FY30	FY50	FY70	Average LOM	Change in Average LOM
Mine years assessed	1	1	1	61	1	1	1	61	61
R5	431.6	13.5	9.8	55.5	78.7	167.8	238.4	204.9	+149.4
R8	15.2	11.4	6.9	9.1	14.4	20.1	16.7	17.7	+8.6
R11	17.0	12.5	7.3	9.7	18.9	22.7	17.7	18.4	+8.7
R13	15.0	21.0	11.4	14.5	21.2	25.3	18.9	20.9	+6.4
R14	2.9	30.5	13.9	21.1	41.6	46.0	30.4	36.8	+15.7
R17	47.9	51.8	21.2	34.3	43.2	64.8	66.7	56.2	+21.9

Note (1): Background levels are excluded from the results presented

Table 10: Annual exceedances of the Monthly Average Dust Deposition

Receptor	Project Without Case[1] (BAU)				Project With Case[1] (BAU)				Project Impacts
	FY30	FY50	FY70	Average LOM	FY30	FY50	FY70	Average LOM	Change in Average LOM
Mine years assessed	1	1	1	61	1	1	1	61	61
R5	2	0	0	0.3	0	1	1	1.7	+1.4
R8	0	0	0	0	0	0	0	0	0
R11	0	0	0	0	0	0	0	0	0
R13	0	0	0	0	0	0	0	0	0
R14	0	0	0	0	0	0	0	0	0
R17	0	0	0	0	0	0	0	0	0

Note (1): Background levels are excluded from the results presented

5.2 Results for TSP

Presented in Table 11 are the results from the dispersion modelling for the annual average concentration of TSP for comparison against the assessment objective of 90 µg/m^3 (Table 2).

Results suggest that there will be an increase in operational risk associated with all assessment locations considered with location R5 predicted to experience the largest increase in Project-related impacts of 45.5 µg/m^3 per year on average over the LOM.

Note that results presented in the table do not include a background level of 45.2 µg/m^3.

(It is noted, that temperature inversion correction factors for the dispersion model output in relation to TSP have not been developed as part of this study.)

Table 11: Annual Average Concentration of TSP (µg/m³)

Location	Project Without Case[1] (BAU)				Project With Case[1] (BAU)				Project Impacts
	FY30	FY50	FY70	Average LOM	FY30	FY50	FY70	Average LOM	Change in Average LOM
Mine years assessed	1	1	1	61	1	1	1	61	61
R5	79.9	8.8	6.2	16.4	28.1	65.6	57.6	61.9	+45.5
R8	7.7	3.6	2.4	3.5	6.3	10.4	9.7	9.4	+5.9
R11	6.6	5.1	3.0	4.2	8.0	11.2	9.3	9.1	+4.9
R13	6.0	6.1	3.6	4.9	8.9	10.4	7.9	8.3	+3.4
R14	10.5	11.1	5.4	8.0	17.1	19.7	10.9	14.9	+6.9
R17	14.4	15.4	6.0	10.4	25.4	26.6	13.2	20.2	+9.8

Note (1): Background levels are excluded from the results presented

5.3 Results for PM_{10}

5.3.1 Development of Dispersion Model Correction Methodology for PM_{10}

The AED Temperature Inversion Correction methodology that was motivated by the findings of the ACARP study (AED 2018) has been applied to the output from the CALPUFF dispersion model.

The correction methodology is computationally intensive and is applied on a location by location basis, i.e. a single value is not applied across the domain. Thus results are presented in a tabulated format only. Contour plots are not presented.

5.3.2 Results based on the Corrected Dispersion Model Output

Presented in Table 12 are the results for the mine contribution to the maximum 24 hour average concentration of PM_{10} at the selected assessment locations for comparison against the assessment objective of 50 µg/m^3 (Table 2).

Results for three specific years of mining are included as well as an average over the life of mine (i.e. 61 years, FY25 through FY85) for both the Project Without (BAU) Case and the Project With (BAU) Case.

It is noted that the background estimate of 23.7 µg/m^3 for the 24 hour average concentration of PM_{10} (Section 3.2) is not included in the results presented.

Results from the dispersion modelling highlight R5 as the most affected assessment location with an increase in the maximum predicted 24 hour average concentration of PM_{10} on average over the LOM of 67.6 µg/m^3.

Table 12: Maximum 24 Hour Average Concentration of PM_{10} (µg/m³)

Location	Project Without(1) (BAU) Case				Project With(1) (BAU) Case				Project Impacts
	FY30	FY50	FY70	Average LOM	FY30	FY50	FY70	Average LOM	Change in Average LOM
Number of mine years	1	1	1	61	1	1	1	61	61
R5	184.4	18.7	11.9	34.2	95.3	78.4	106.0	101.8	+67.6
R8	53.2	79.4	52.1	59.8	84.0	104.3	64.2	72.1	+12.3
R11	34.3	22.9	14.5	20.5	35.9	38.7	34.6	35.0	+14.5
R13	27.6	43.8	26.5	32.3	43.6	52.3	36.9	41.2	+8.9
R14	34.4	40.9	23.4	33.3	60.3	63.3	42.4	50.2	+16.9
R17	51.3	53.3	28.1	45.1	81.5	102.5	53.1	70.5	+25.4

Note (1): Background levels are excluded from the results presented

A summary of the predicted number of exceedance days is presented in Table 13.

Results of the assessment highlight location R5 located to the west of the Project, as the most affected assessment location with an additional 13.9 predicted PM_{10} exceedance days per year attributed to the Project on average over the LOM. It is noted that these results are based on the BAU cases. Results for the mitigated cases are presented in Section 5.5.1.

The annual variability in the predicted number of exceedance days over the LOM for both the Project Without (BAU) Case and the Project With (BAU) Case is evident in the results presented in Figure 17 through Figure 21.

Table 13: Number of PM_{10} Exceedance Days

Location	Project Without[1] (BAU) Case				Project With[1] (BAU) Case				Project Impacts
	FY30	FY50	FY70	Average LOM	FY30	FY50	FY70	Average LOM	Change in Average LOM
Number of mine years	1	1	1	61	1	1	1	61	61
R5	18	0	0	2.3	4	12	12	16.2	+13.9
R8	1	1	1	0.7	1	1	1	0.8	+0.1
R11	0	0	0	0	0	0	0	0	0.0
R13	0	0	0	0.1	0	1	0	0.4	+0.3
R14	0	0	0	0.1	1	4	0	1.8	+1.7
R17	1	1	0	0.7	5	12	1	5.5	+4.8

Note (1): Background levels are excluded from the results presented

Results for R5 presented in Figure 17 suggest minimal change in the maximum number of exceedance days per year that will have to be managed by operations as a result of the Project. However, there is a significant increase in the number of years that are predicted to be associated with exceedances of the assessment objective of 50 µg/m^3 for the 24 hour average concentration of PM_{10} (Table 13).

Results for R8 presented in Figure 18 suggest minimal change in impacts associated with the Project. It is noted that the single predicted exceedance at this location is attributed to a significant wind event within the meteorological data set.

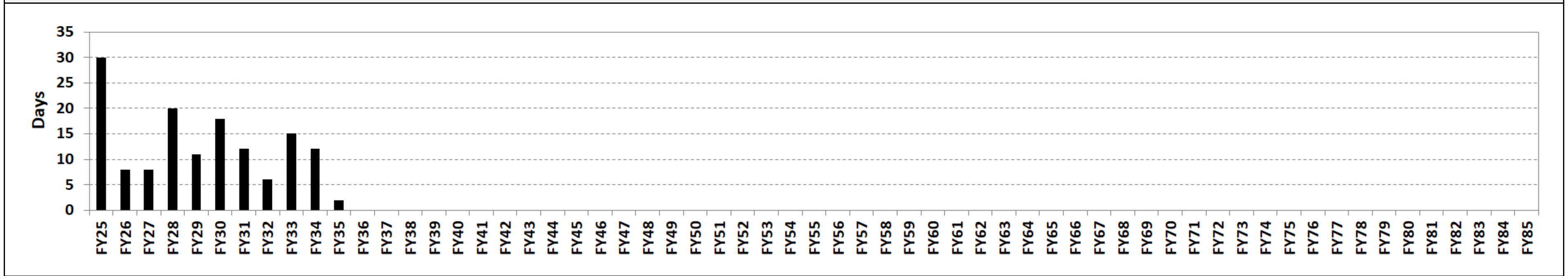
Results presented in Figure 19 for R13 suggest that potential changes to operational risk will be minimal over the life of the project.

Results presented in Figure 20 for R14 highlights the predicted increase in both the number of exceedances per year and the number of mine years that are associated with predicted exceedances.

Results presented in Figure 21 for R17 highlights the predicted increase in both the number of exceedances per year and the number of mine years that are associated with predicted exceedances.

Figure 17: R5 Variation in Predicted Exceedance Days over the LOM

R5 – Project Without (BAU) Case



R5 – Project With (BAU) Case

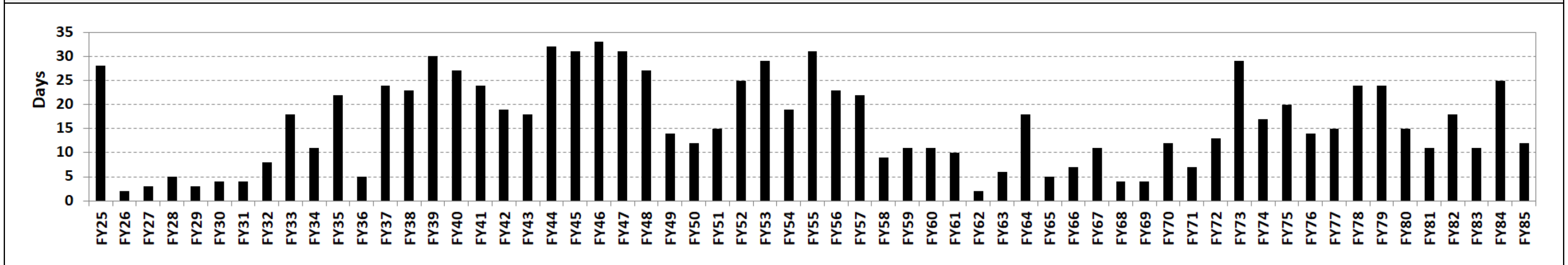
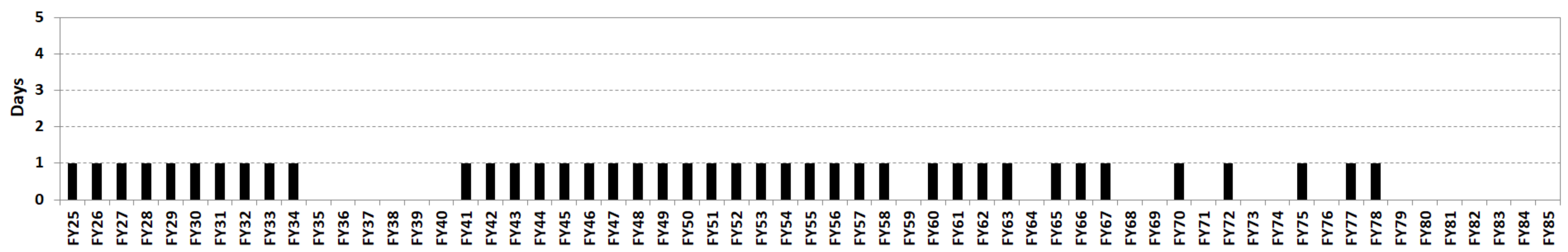


Figure 18: R8 Variation in Predicted Exceedance Days over the LOM

R8 – Project Without (BAU) Case



R8 – Project With (BAU) Case

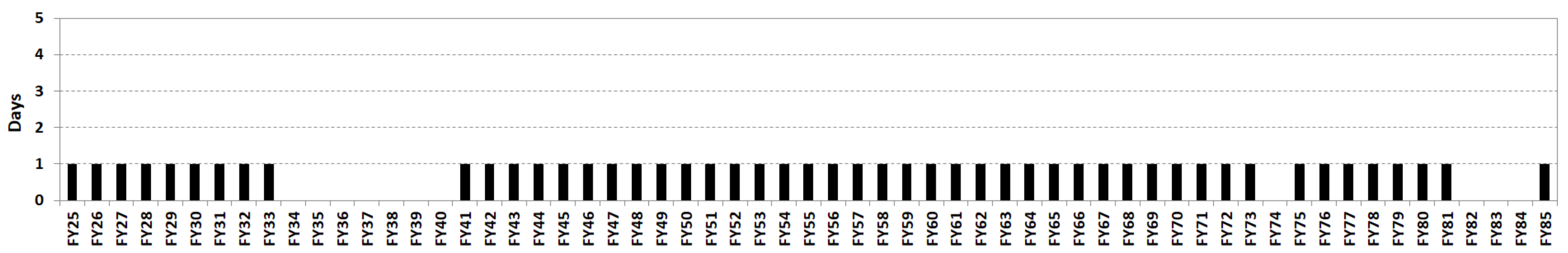
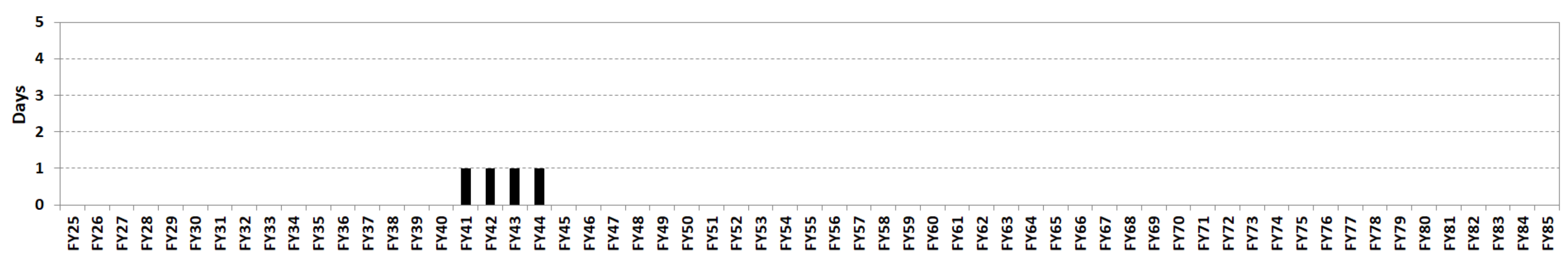


Figure 19: R13 Annual Variation in Predicted Exceedance Days over the LOM

R13 – Project Without (BAU) Case



R13 – Project With (BAU) Case

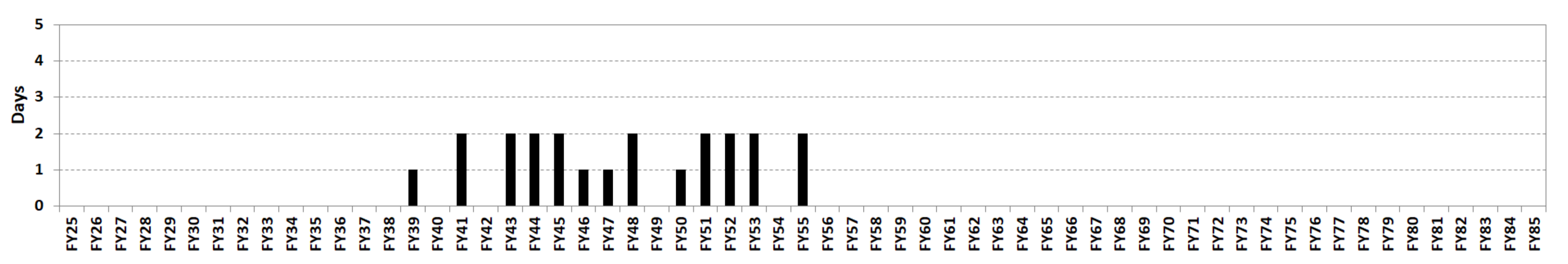
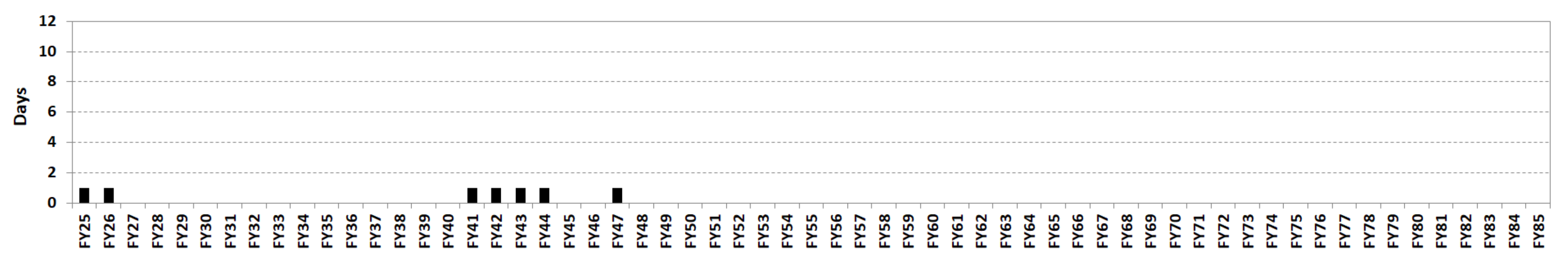


Figure 20: R14 Variation in Predicted Exceedance Days over the LOM

R14 – Project Without (BAU) Case



R14 – Project With (BAU) Case

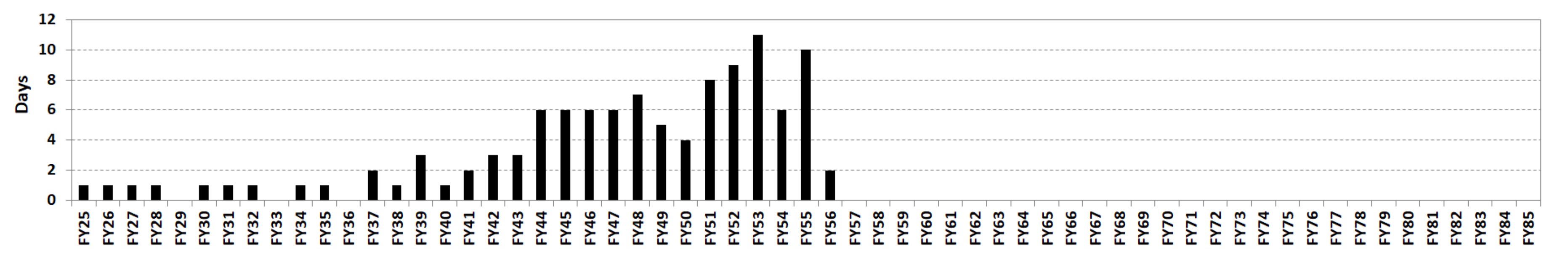
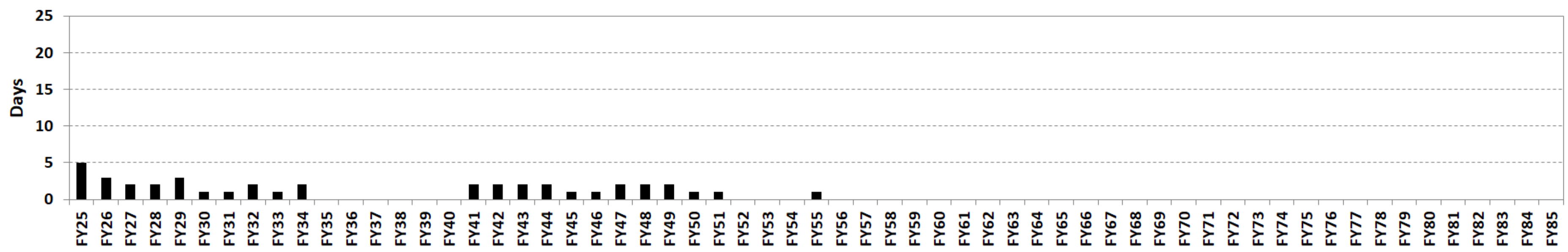
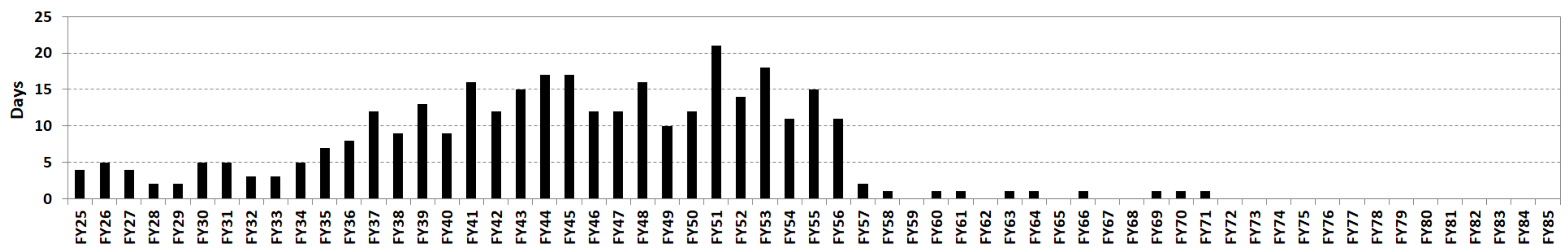


Figure 21: R17 Variation in Predicted Exceedance Days over the LOM

R17 – Project Without (BAU) Case



R17 – Project With (BAU) Case



Presented in Table 14 is a summary of the results for the contribution to the annual average concentration of PM_{10} at selected assessment locations for both the Project Without (BAU) Case and the Project With (BAU) Case for comparison with the assessment objective of 25 µg/m^3.

Results highlight R5 as being the most affected location presented with an estimated increase in the mine's contribution to the annual average concentration of PM_{10} over the LOM of c. 11.2 µg/m^3.

Note that the estimated background concentration of 22.6 µg/m^3 (Section 3.2) has not been added to the results presented in the table.

There are no predicted exceedances of the assessment objective of 25 µg/m^3 for the annual average concentration of PM_{10}.

Table 14: Annual Average Concentration of PM_{10} (µg/m³)

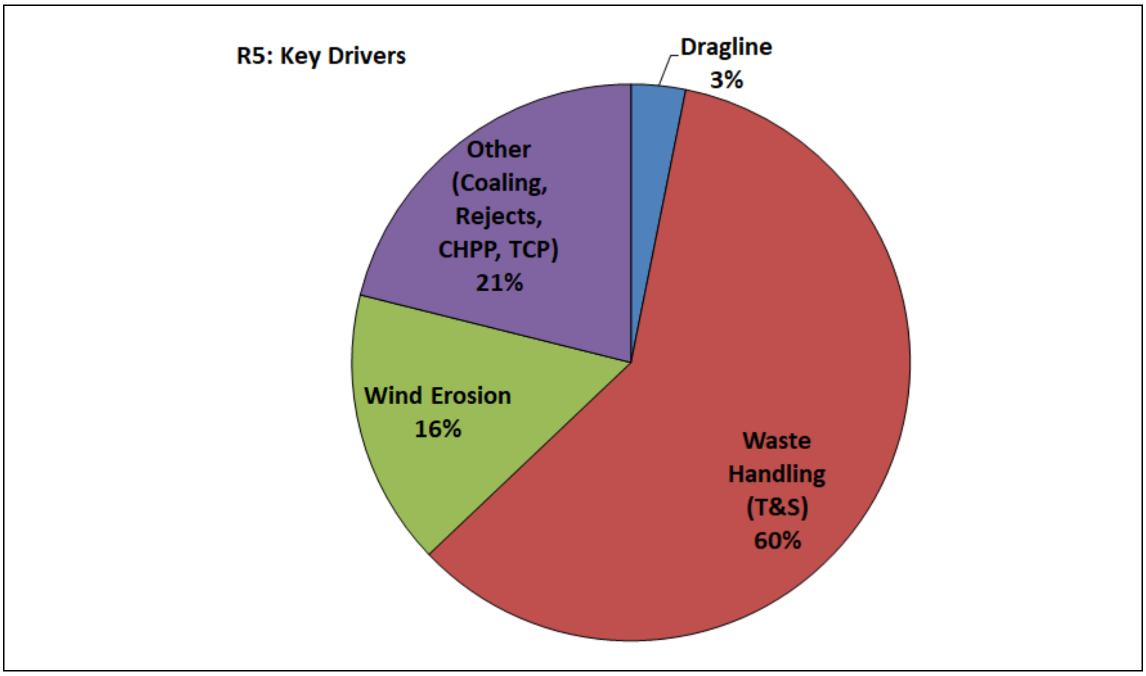
Location	Project Without Case (BAU)				Project With Case (BAU)				Project Impacts
	FY30	FY50	FY70	Average LOM	FY30	FY50	FY70	Average LOM	Change in Average LOM
Mine years assessed	1	1	1	61	1	1	1	61	61
R5	19.5	1.8	1.1	3.8	7.6	15.5	14.5	15.0	+11.2
R8	2.1	1.2	0.9	1.2	2.1	3.0	2.6	2.6	+1.4
R11	2.0	1.4	1.0	1.3	2.3	3.1	2.6	2.6	+1.3
R13	1.9	1.7	1.1	1.5	2.7	3.1	2.4	2.5	+1.0
R14	3.0	2.7	1.5	2.2	4.6	5.4	3.2	4.1	+1.9
R17	3.9	3.5	1.7	2.7	6.6	7.4	3.8	5.5	+2.8

5.4 Key Drivers of PM_{10}

In order to develop an understanding of the nature and extent to which additional mitigation measures in excess of BAU dust management practices may be required in order to achieve compliance with the assessment objective of 50 µg/m^3 for the 24 hour average concentration of PM_{10}, this section presents the findings of an investigation into the key drivers of predicted dust impacts based on dispersion modelling output.

Presented in Figure 22 is a summary of the identified key drivers at the location of R5 (as the most affected assessment location) for the Project With (BAU) case based on an average over the LOM. Results suggest that waste handling by truck and shovel mining methods (including loading, hauling and dumping) will be the most significant contributor to dust risk. These findings are not unexpected as waste handling by truck and shovel mining methods was found to be the most significant contributor to the PM_{10} emissions inventory (Section 4.4).

Figure 22: Project With (BAU) Case: Key Drivers at R5 based on an Average over the LOM



5.5 Modelled Mitigation Scenarios

Results presented in Section 5.4 highlighted waste material handling by truck and shovel mining methods as being the key driver to predicted impacts at the location of R5.

Thus modelled dust reduction scenarios focused on mitigation measures that target waste handling by truck shovel mining methods. A summary of the mitigation scenarios that were investigated is provided in Table 15.

It is noted that the percentage dust reduction for the scenarios listed in the table may be achieved using one or more of a combination of dust mitigation options for example:

- Reducing haul distances where possible
- Reducing vehicle speed and thus vehicle kilometres travelled (VKT) per hour
- Reducing the number of operating trucks

Two additional mitigation scenarios have been included in Table 15 that focus on dust mitigation strategies other than truck and shovel mining methods:

- Draglines only operation in key areas on high risk days.
- The cessation of all mining activities.

Table 15: Project With (BAU) Case - Mitigation Scenarios

Scenario	Description	Comments
Dust 25% Reduction (T&S)	• A reduction in dust emissions associated with Truck & Shovel activity (including loading, hauling and dumping of waste material) by 25% in key source areas on high risk days	• Assumes all other activities are operating as per BAU in key source areas on high risk days
Dust 50% Reduction (T&S)	• A reduction in dust emissions associated with Truck & Shovel activity (including loading, hauling and dumping of waste material) by 50% in key source areas on high risk days	• Assumes all other activities are operating as per BAU in key source areas on high risk days
Dust 75% Reduction (T&S)	• A reduction in dust emissions associated with Truck & Shovel activity (including loading, hauling and dumping of waste material) by 75% in key source areas on high risk days	• Assumes all other activities are operating as per BAU in key source areas on high risk days
Dust 100% Reduction (T&S)	• A reduction in Truck & Shovel activity by 100% (i.e. stopped operating) in key source areas on high risk days	• Assumes all other activities are operating as per BAU in key source areas on high risk days
Dragline Only	• Dragline operations as per BAU • All other activities have ceased in key source areas on high risk days	• Assumes all other activities are operating as per BAU in other areas of site on high risk days
Shutdown	• All mining activities have ceased.	• Assumes all activities in key source areas on high risk days have ceased operating.

5.5.1 Results from the Mitigation Scenarios

Presented in Table 16 are the results from the dispersion modelling for the PM_{10} mitigation scenarios (Table 15) highlighting the extent to which additional dust control measures may be required to mitigate the predicted PM_{10} exceedance days. When interpreting the results presented in the figures the following are noted:

- The number in the first column associated with the BAU Case indicates the average number of exceedance days per year of the assessment objective of 50 µg/m^3 for the 24 hour average concentration of PM_{10} that are predicted to occur over the LOM.
- The value above the remaining columns highlights the number of exceedances days per year that are mitigated by implementing the noted mitigation measure when required.
- For example, 16 exceedance days per year are predicted to occur over the LOM at the location of R5. A total of 8.6 of these days are predicted to be mitigated by implementing a strategy that is associated with a 25% reduction in waste handling by truck and shovel mining methods. An additional 3.8 exceedance days are predicted to be mitigated through the implementation of a 50% reduction in waste handling by truck shovel mining methods. Note that due to the scale of the BWM disturbance footprint, a residual of 2.3 exceedance days on average per year are predicted to result even if mining operations shutdown on these days due to wind erosion.

Results suggest that with the exception of significant wind events, the range of mitigation measures available to site will in general be sufficient to adequately manage operational dust risk.

These scenarios are referred to herein as the Project With (Fully Mitigated) Case.

Table 16: Results from the Project With Case Mitigation Scenarios

Location	BAU	Dust 25% Reduction (T&S)	Dust 50% Reduction (T&S)	Dust 75% Reduction (T&S)	Dust 100% Reduction (T&S)	Dragline Only	Shutdown	Residual (BWM)
R5	16.0	8.6	3.8	1.3	0.1	0.0	0.0	2.3
R8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.8
R11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13	0.4	0.2	0.0	0.1	0.0	0.0	0.0	0.0
R14	1.8	1.1	0.3	0.0	0.0	0.0	0.0	0.3
R17	5.5	2.1	1.3	0.4	0.1	0.1	0.0	1.4

Note (1): Background levels are excluded from the results presented

5.5.2 Summary of Results for the Project With Cases

Presented in Table 17 is a comparison of the predicted number of PM_{10} exceedance days for the Project With (BAU) Case and the Project With (Fully Mitigated) Cases presented in Section 5.5.

Results presented in the table suggest that with the exception of significant wind events, the range of mitigation measures available to site will in general be sufficient to adequately manage operational dust risk.

Table 17: Comparison of BAU and Fully Mitigated Cases - PM_{10} Exceedance Days

Location	Project With (BAU) Case(2)				Project With (Fully Mitigated) Case(2)
	FY30	FY40	FY50	Average LOM	Average LOM(1)
Number of mine years	1	1	1	61	61
R5	4	12	12	16.2	2.3
R8	1	1	1	0.8	0.8
R11	0	0	0	0	0.0
R13	0	1	0	0.4	0.0
R14	1	4	0	1.8	0.3
R17	5	12	1	5.5	1.4

Note: (1) Residual exceedance days are attributed to significant wind events

(2) Background levels are excluded from the results presented

6. Recommendations

In support of the Blackwater North Extension Project the following are recommended:

Recommendation (1): Implementation of an ambient air monitoring network

The implementation of a network of ambient air monitoring stations that measure dust and meteorological parameters on a continuous basis is recommended.

It is recommended the number of ground stations commissioned be sufficient to monitor air quality outcomes at locations that are representative of, or surrogate for, sensitive receptor location(s) and/or are required for informing background dust estimates.

It is also recommended that the ground stations be complimented by temperature inversion towers.

A summary of the recommended parameters to be sampled is provided in Table 18.

Table 18: Sampled Parameters

Station	Parameters sampled	Sampling Frequency	Sampling Method	Comment
Ground station	TSP, PM_{10}, Meteorology(1)	5 minute	Continuous	Representative of, or surrogate for, a sensitive receptor location and/or required for informing background estimates
BWM Tower #1	Meteorology(2)	5 minute	Continuous	Temperature Inversion Tower

Notes:

(1) Meteorology includes:

- *Wind speed, wind direction, standard deviation of wind direction using ultrasonic wind sensors sampled at a height of 10 m;*
- *Rainfall, solar radiation, relative humidity, pressure and temperature.*

(2) Meteorology Includes:

- *The measurement of temperature at heights of 2 m, 10 m, 20 m, 30 m, 40 m, 50 m and 60 m.*
- *The measurement of wind speed and wind direction using ultrasonic wind sensors at heights of 2 m, 10 m, 20 m, 30 m, 40 m, 50 m and 60 m.*

Recommendation (2): Expanding the Functionality of the BWM Dust Monitoring System

Expanding of features and functionality of the Dust Monitoring System that is currently used by BWM to inform dust management practices is recommended.

It is recommended the additional features and functionality:

- Include sensor data analysis that provides estimates of:

  - Background levels of dust at the location of the ground monitoring stations
  - Mine contribution to dust impacts at the location of the ground monitoring stations
- Raise alarms in response to trigger levels based on sensor data analysis.
- Include alarms and/or notifications that are informed by temperature inversion conditions.
- Include alarms and/or notifications that are informed by meteorological forecasts.
- Includes alarms and/or notifications that are informed by a real-time dust forecast
- Provides for the capturing of dust mitigation actions via a User Interface
- Produce a Daily Report that includes as a minimum: the site's performance against EA Conditions; estimates of background levels of dust; estimates of mine contribution as well as alarms raised and actions taken
- Provides visibility on key dust emission sources
- Provides visibility on resource utilisation (such as water trucks)
- Aligns with the BWM Trigger Action Response Plan (TARP)

Recommendation (3): Implementation of a continual improvement plan for dust management

The development of a continual improvement plan for dust management at BWM that includes key triggers for review, auditing against, and refinement of the plan will assist in minimising operational risk, is recommended.

Recommendation (4): Mine plan optimisation

Seeking opportunities to reduce operational risk by incorporating dust reduction strategies into mine planning practices over all planned timeline horizons (e.g. LOM, 5-year, 90-day, and weekly) is recommended.

7. Conclusion

AED has undertaken an air quality assessment of the Blackwater Mine North Extension Project in support of an EA Amendment application. The Project involves the extension of current open cut mining operations into SA10 (ML1759) and SA7(ML1762) (Figure 2). The objective of the air quality assessment was to determine the change in operational risk attributable to the Project.

Of particular interest were changes in air quality outcomes at neighbouring locations due to emissions of TSP, PM_{10} and dust deposition associated with the Project. The quantification of air quality impacts was based on a comparison of predictions from dispersion modelling and the assessment air quality objectives (Table 2).

Two dust emission scenarios for BWM were considered based on Business as Usual (BAU) dust management practices:

- **Project Without (BAU) Case:** The mining of BWM as permitted under current mining approvals. This case forms the Project Base Case and is associated with the exhausting of the currently approved-to-mine resource; and
- **Project With (BAU) Case:** The mining of BWM with the inclusion of the Project.

Mitigation scenarios were investigated for the Project With (BAU) case. Results from these scenarios have been used to demonstrate the nature and extent of improved air quality outcomes that may be achieved through the implementation of a range of dust mitigation measures.

Results of the air quality assessment suggest that the implementation of dust management strategies above BAU will be required to effectively manage the impact of air quality outcomes attributable to the Project at neighbouring sensitive receptor locations. Of particular note is the increased duration of predicted dust impacts at locations to the west of the Project.

To support effective dust management at BWM a number of recommendations have been provided including:

- The implementation of a continuous ambient air monitoring program
- Expanding the features and functionality of the BWM Dust Monitoring System used to inform current dust management practices
- The implementation of a continual improvement plan for dust management
- Mine plan optimisation on long term and short term time horizons

8. Document Limitations

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Appendix A. Local Meteorology

This appendix describes rainfall patterns, air temperature, humidity, wind speed and direction, as well as stability class characteristics in the region.

Data for long term climate statistics have been sourced from the Bureau of Meteorology (BoM) climate statistics for the Emerald Airport. Available climate data varies, starting in 1992 and ending in 2010, or continuing to date depending on the parameter.

BoM data was supplemented by numerically simulated data developed using CALMET to provide site-specific parameters that cannot be directly measured, such as stability class.

Rainfall Patterns

The mean annual rainfall at Emerald Airport is approximately 560 mm. Monthly mean rainfall values for the period 1992 through 2023 are presented in Figure 23.

Figure 23: Mean Rainfall Statistics, Emerald (1992-2023)

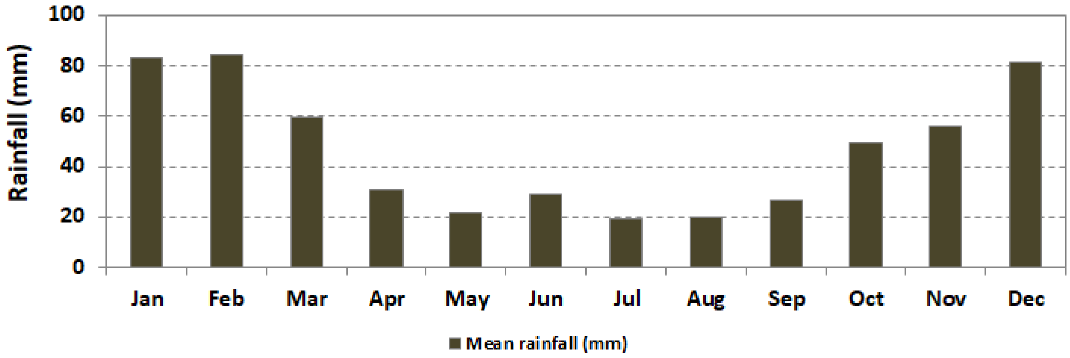
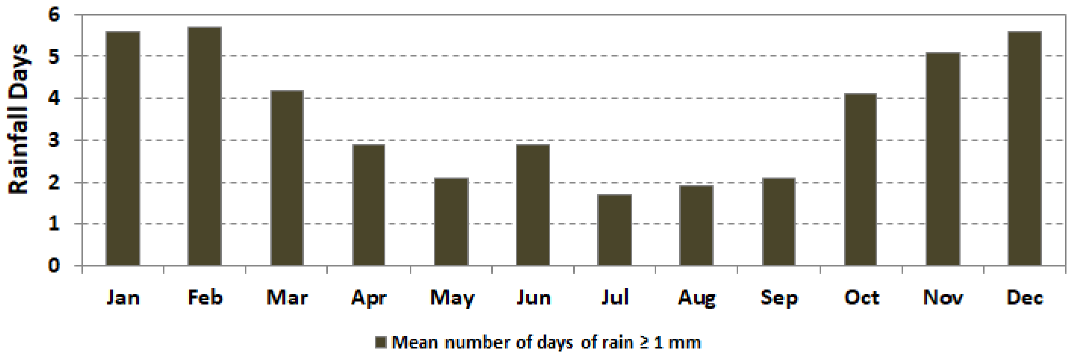


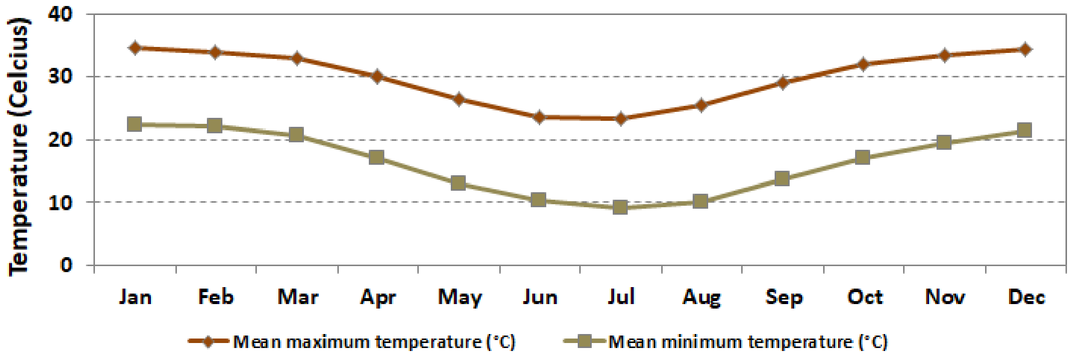
Figure 24: Mean Rainfall Days, Emerald Airport (1992-2023)



Air Temperature

Long term ambient air temperature statistics for the mean maximum and mean minimum from Emerald Airport for the period 1992 through 2023 is presented in Figure 25.

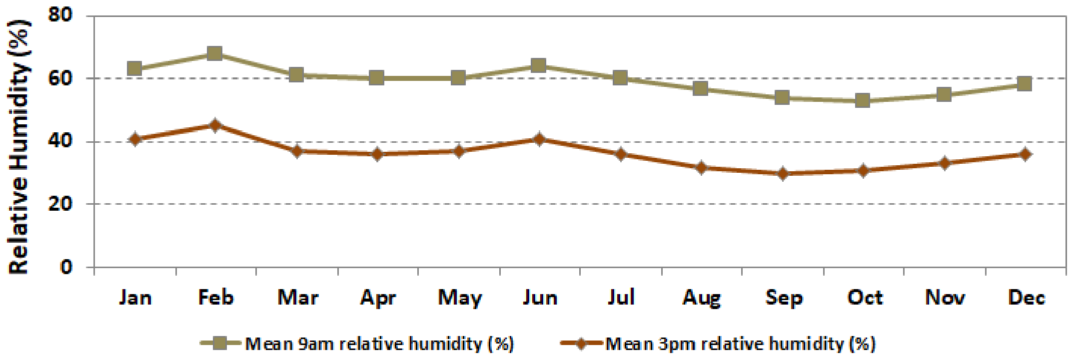
Figure 25: Mean Air Temperature Statistics, Emerald Airport (1992-2023)



Humidity

The mean relative humidity measured at 9am and 3pm as recorded at the BoM Emerald Airport monitoring station are presented in Figure 26 for the period 1992 through 2010.

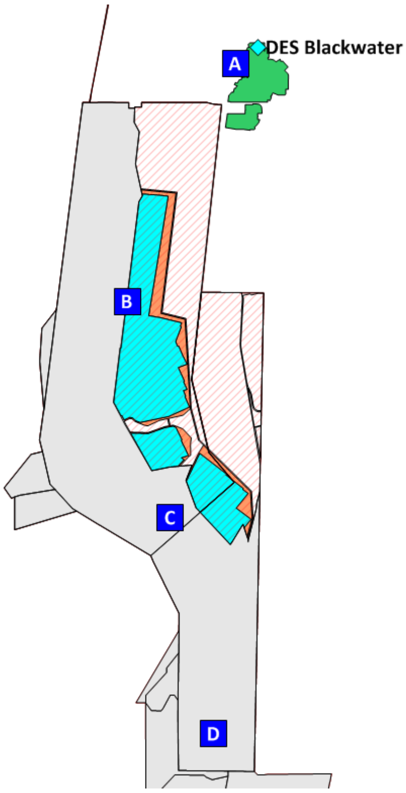
Figure 26: Mean Relative Humidity Statistics, Emerald Airport (1992-2010)



Wind Speed and Direction

In order to present a more complete picture of the variability in the wind fields within the study region, numerically simulated wind fields from 4 locations were extracted from the CALMET 2019 output. The location of the extracted CALMET wind data as well as the DES Blackwater Monitoring Station is depicted in Figure 27.

Figure 27: Location of CALMET Data Extracts (A through D) and the DES Blackwater Monitoring Station

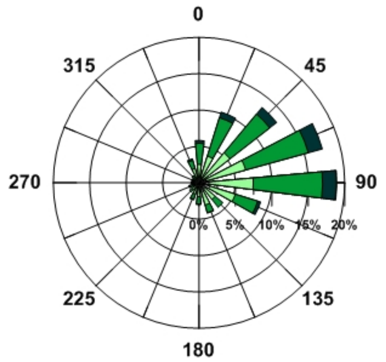


The annual wind roses for the CALMET locations (A through D) and the DES Blackwater monitoring station are presented in Figure 28. The wind directions in the vicinity of the Project are predominantly from the northeast through southeast. Seasonal variations and variations as a function of the time of day are highlighted in Figure 29. These plots also show winds to be lighter at night time (6 pm to 6 am) then during the daytime (6 am to 6 pm).

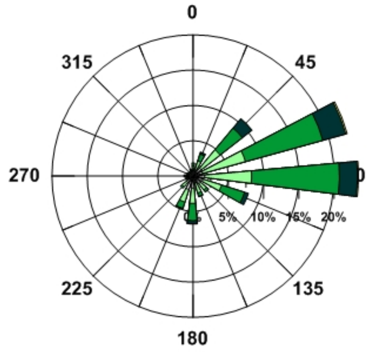
Wind roses based on hourly averaged data from the DES Blackwater monitoring station were provided in Section 3.3.1. For ease of comparison, these wind roses are provided in Figure 28 and Figure 30 showing good agreement between observations and the numerically simulated wind fields.

Figure 28: Annual Wind Roses (m/s)

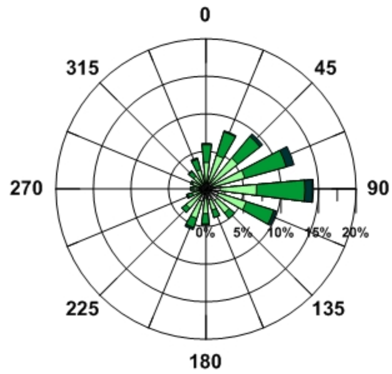
DES Blackwater (04/2019 – 04/2020)



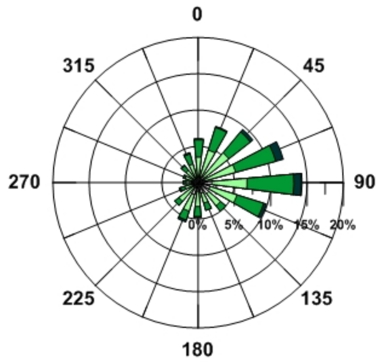
CALMET (Location A) (2019)



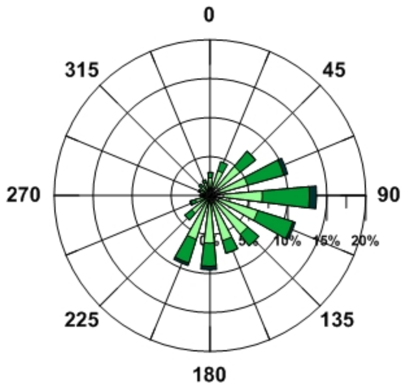
CALMET (Location B) (2019)



CALMET (Location C) (2019)



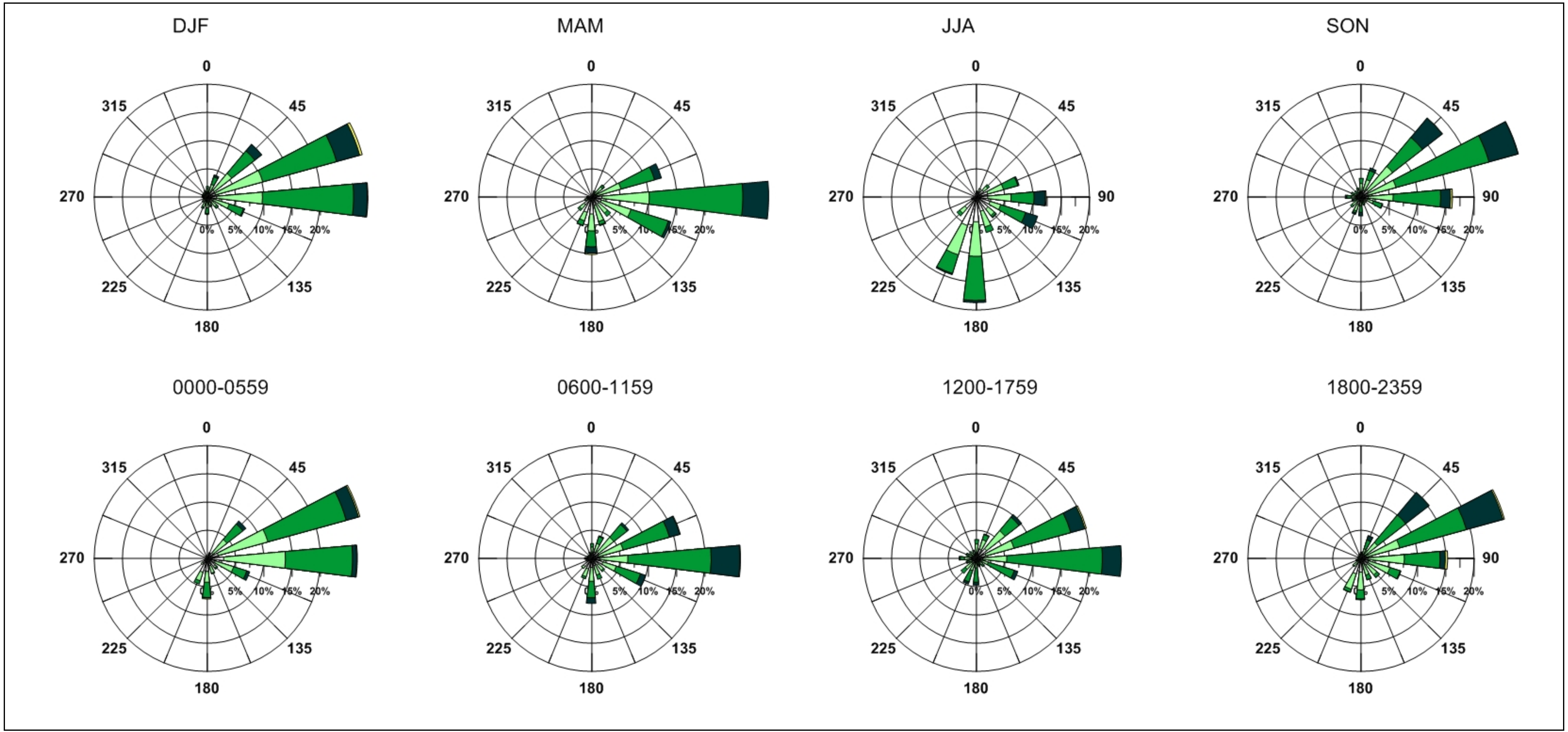
CALMET (Location D) (2019)



Legend (m/s)

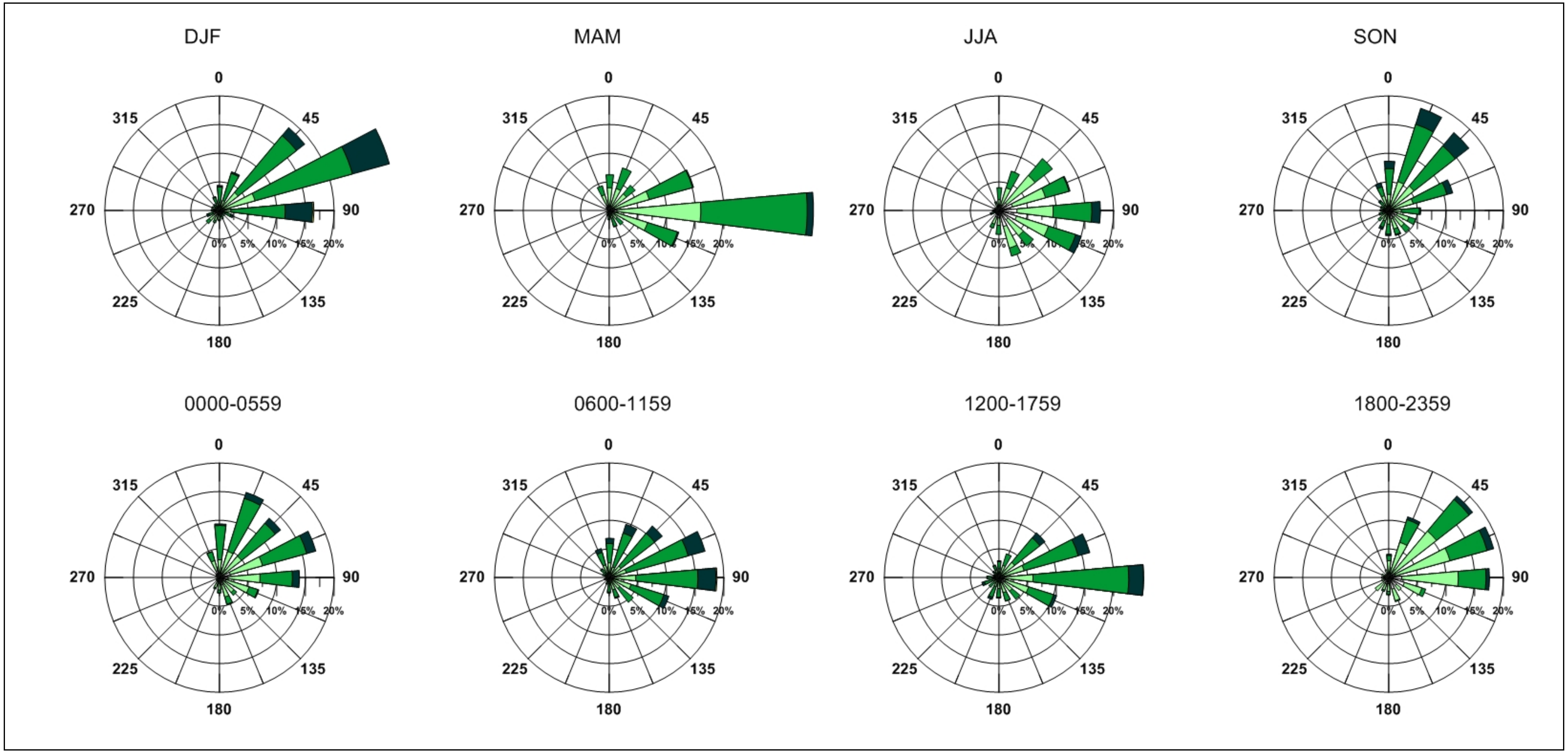
- >0.5 - 1.5
- >1.5 - 3
- >3 - 5.5
- >5.5 - 8
- >8 - 10.5
- >10.5 - 15.5

Figure 29: Wind Roses (m/s) as a Function of the Season (upper) and Time of Day (lower) (DES, Blackwater 04/2019 – 04/2020)



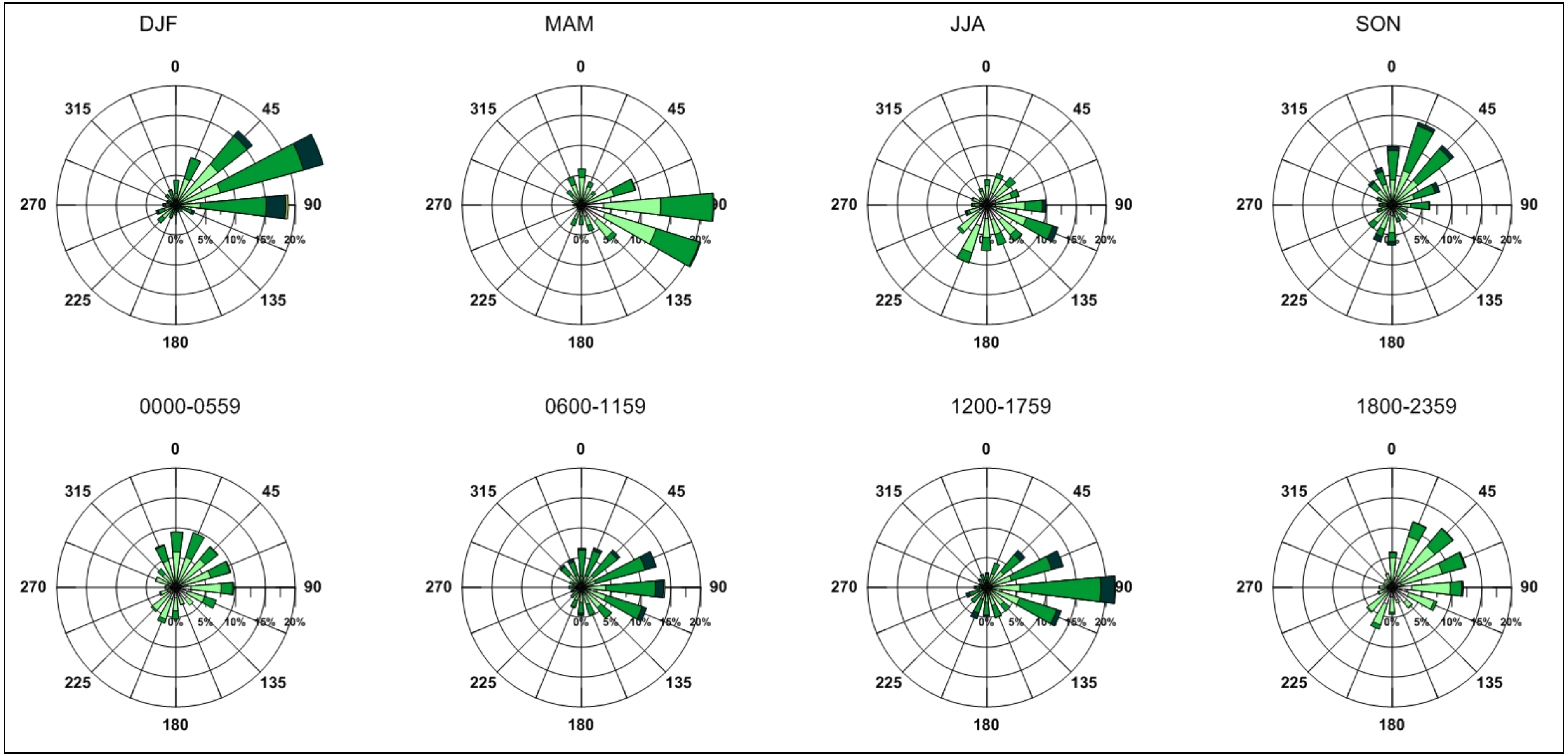
Note: DJF – December, January, February, MAM – March April May, JJA – June, July, August, SON – September, October, November

Figure 30: Wind Roses (m/s) as a Function of the Season (upper) and Time of Day (lower). (CALMET Location A, 2019)



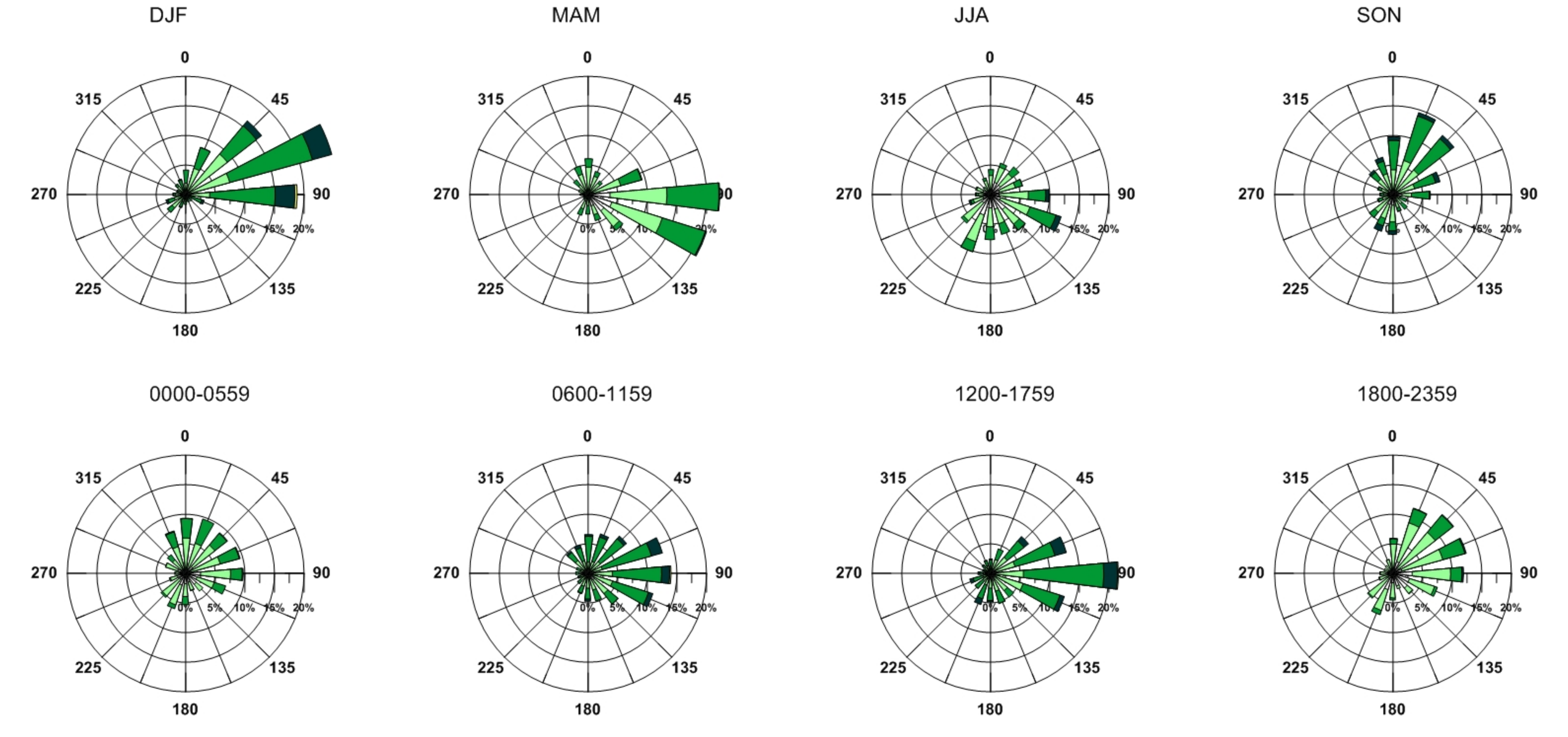
Note: DJF – December, January, February, MAM – March April May, JJA – June, July, August, SON – September, October, November

Figure 31: Wind Roses (m/s) as a Function of the Season (upper) and Time of Day (lower). (CALMET Location B, 2019)



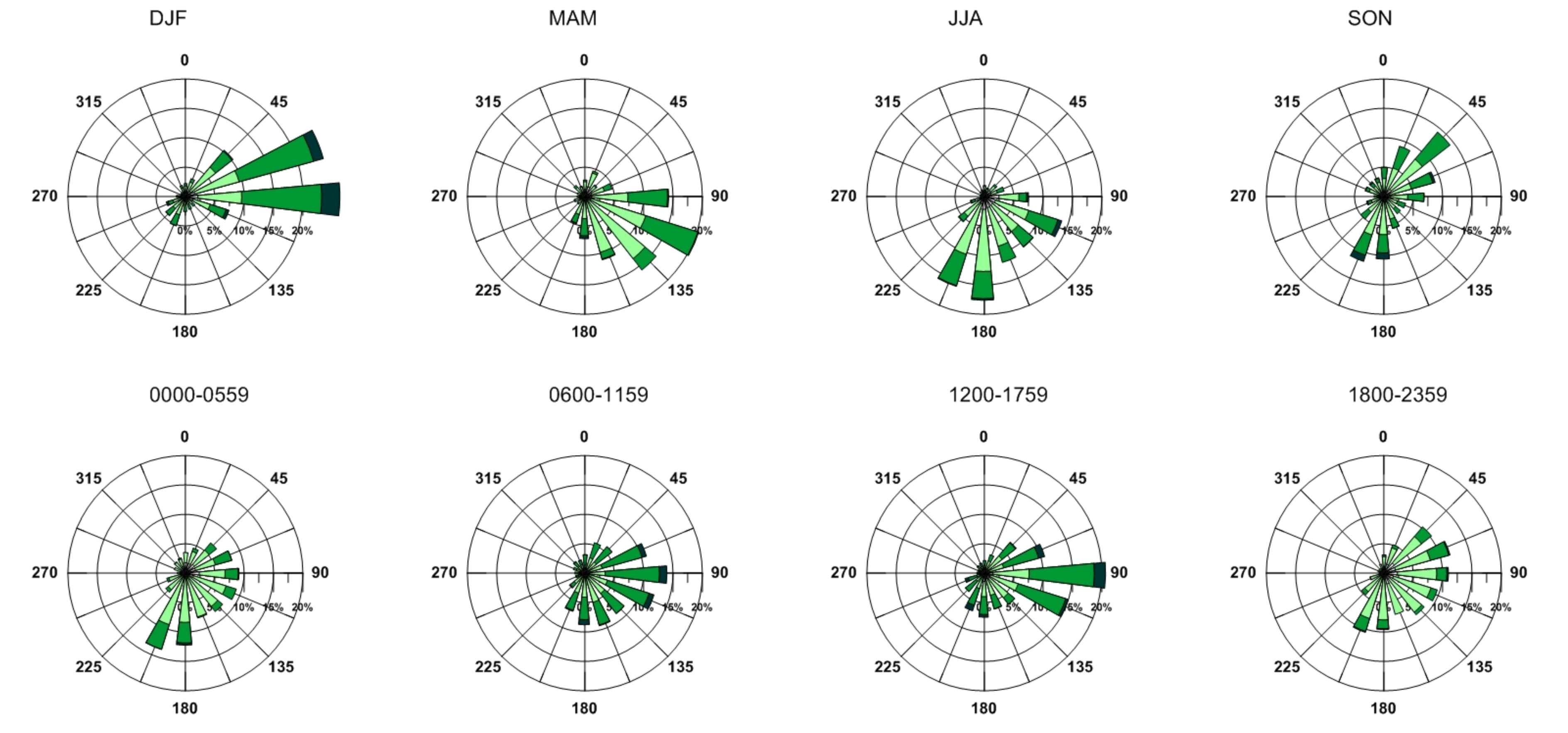
Note: DJF – December, January, February, MAM – March April May, JJA – June, July, August, SON – September, October, November

Figure 32: Wind Roses (m/s) as a Function of the Season (upper) and Time of Day (lower). (CALMET Location C, 2019)



Note: DJF – December, January, February, MAM – March April May, JJA – June, July, August, SON – September, October, November

Figure 33: Wind Roses (m/s) as a Function of the Season (upper) and Time of Day (lower). (CALMET Location D, 2019)



Note: DJF – December, January, February, MAM – March April May, JJA – June, July, August, SON – September, October, November

Atmospheric Stability

Stability of the atmosphere is determined by a combination of horizontal turbulence caused by the wind and vertical turbulence caused by the solar heating of the ground surface. Stability cannot be measured directly; instead it must be inferred from available data, either measured or numerically simulated.

The Pasquill-Gifford scale defines stability on a scale from A to G, with stability class A being the least stable, occurring during strong daytime sun and stability class G being the most stable condition, occurring during low wind speeds at night. For any given wind speed the stability category may be characterised by two or three categories depending on the time of day and the amount of cloud present. In meteorological models such as CALMET, the stability classes F and G are combined.

A summary of the numerically simulated hourly stability class data for CALMET location B (2019) is presented in Figure 34 and Figure 35. Stability class F is predicted to occur most frequently (35.3%) indicating that a high percentage of conditions are moderately to very stable, with very little lateral and vertical diffusion. Stability class D conditions are predicted to occur second most frequently (22%). Stability Class D are neutral conditions that typically occur during moderate wind speeds with little or no solar radiation (night time or cloudy periods).

The frequency of strongly convective (unstable) conditions at the study area, represented by stability class A, is relatively low at c.2% of hours.

Figure 34: Frequency of Stability Class (CALMET Location B 2019)

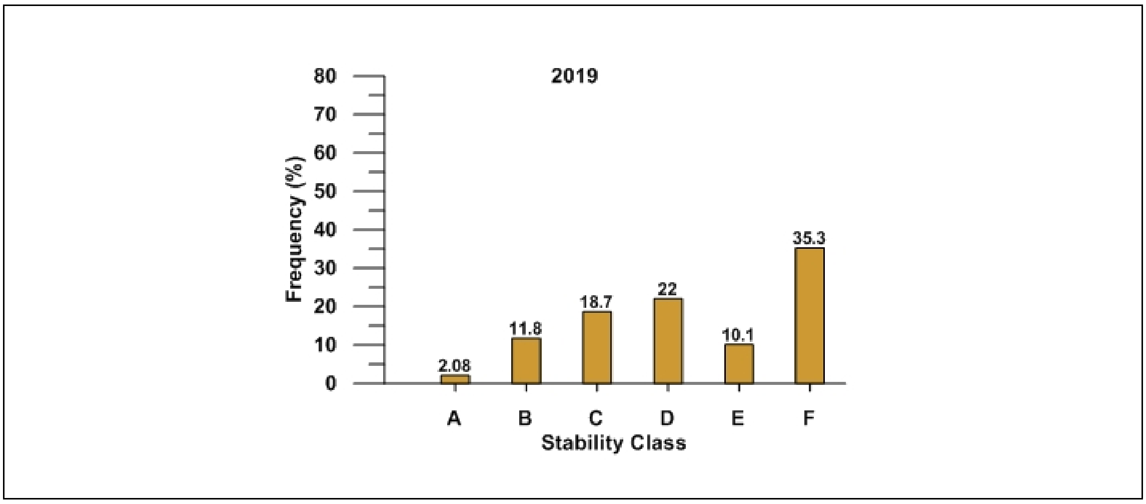
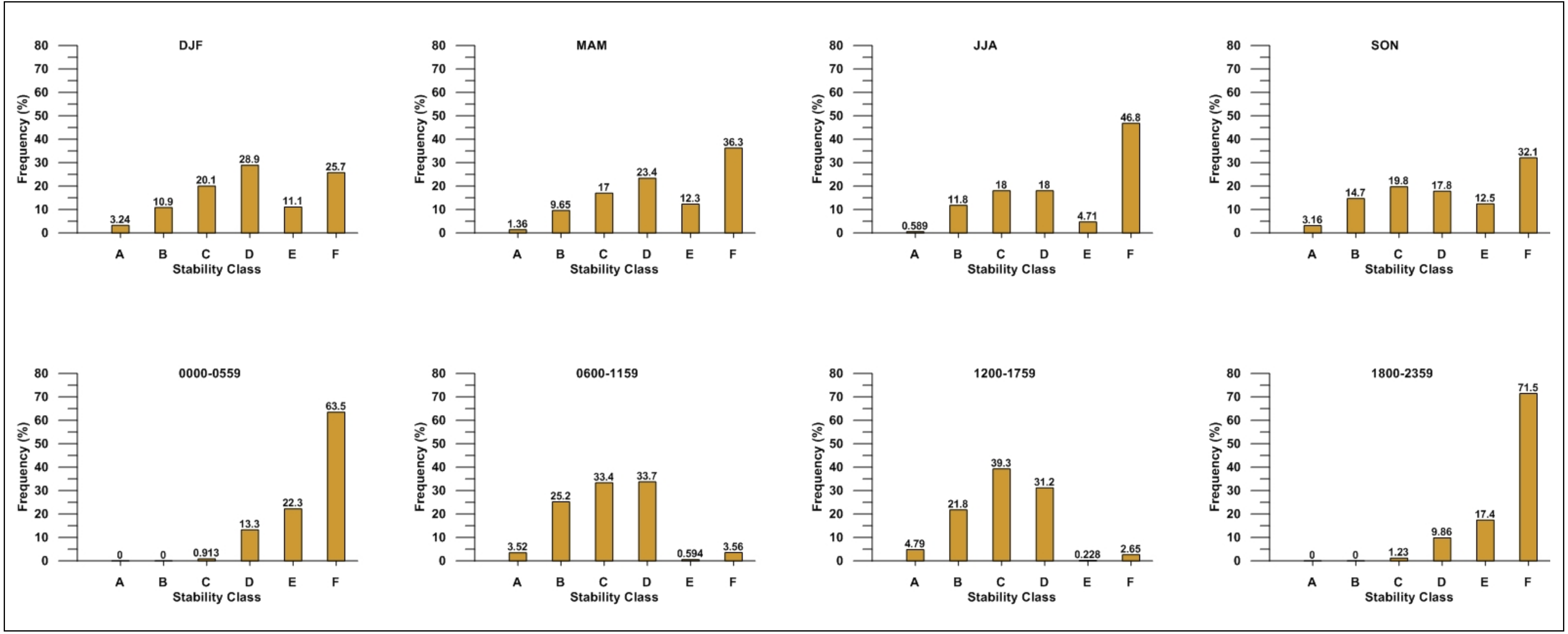


Figure 35: Seasonal Variation in the Stability Class Frequency (upper) and Variation as a Function of the Time of Day (lower) (CALMET 2019)



Note: DJF – December, January, February, MAM – March April May, JJA – June, July, August, SON – September, October, November

Appendix B. Dispersion Modelling Methodology

Development of Representative Meteorological Wind Fields

Dispersion modelling typically requires a meteorological dataset representative of the local region based on hourly averages. Parameters required include wind speed, wind direction, temperature, atmospheric stability and mixing height. In general, meteorological observations typically include hourly wind speed, wind direction, temperature, rainfall and humidity. However additional parameters, such as atmospheric stability class and mixing height, are difficult to measure and are often generated through the use of meteorological models. For this assessment the TAPM and CALMET/CALPUFF suite of modelling tools has been used.

TAPM

The meteorological model 'The Air Pollution Model' (TAPM) developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) was used to predict initial three-dimensional meteorology for the local airshed. TAPM is a prognostic model used to predict three dimensional meteorological observations, with no local inputs required. The model predicts meteorological datasets consisting of parameters like wind speed, wind direction, temperature, water vapour, cloud, rain, mixing height, atmospheric stability classes etc. that are required for dispersion modelling.

Technical details of the model equations, parameterisations and numerical methods are described in the technical paper by Hurley (2008).

The details of TAPM configuration are summarised in Table 19.

Table 19: TAPM Configuration

Parameter	Units	Value
TAPM version	-	v4.0.5
Years modelled	-	2019
Grid centre	Lat.(degrees), Lon. (degrees)	-23.84167, 146.85
Local centre coordinates	UTM zone 55 S (m)	688429, 7362996
Number of nested grids	-	3
Grid dimensions (nx, ny)	-	31,31
Number of vertical grid levels (nz)	-	25
Grid 1 spacing (dx, dy)	km	30,30
Grid 2 spacing (dx, dy)	km	10,10
Grid 3 spacing (dx, dy)	km	3,3
Local hour	-	GMT + 10

Parameter	Units	Value
Synoptic wind speed maximum	m/s	30
Local met assimilation	-	No
Surface vegetation database	-	Default TAPM V4 database at 3-minute grid spacing (Australian vegetation and soil type data provided by CSIRO Wildlife and Ecology).
Terrain database	-	Default TAPM V4 database at 9-second grid spacing (Australian terrain height data from Geoscience Australia)

CALMET

CALMET (version 6.326) was used to simulate meteorological conditions for the local airshed. CALMET is a diagnostic three dimensional meteorological pre-processor for the CALPUFF modelling system (developed by Earth Tech, Inc.).

Prognostic output from TAPM was used as an initial guess field for the CALMET model. Using high resolution geophysical datasets CALMET then adjusts the initial guess field for the kinematic effects of terrain, slope flows, blocking effects and 3-dimensional divergence minimisation, as well as differential heating and surface roughness associated with different land uses across the modelling domain.

The CALMET model requires three input files along with the control file where the CALMET run parameters are specified and involve:

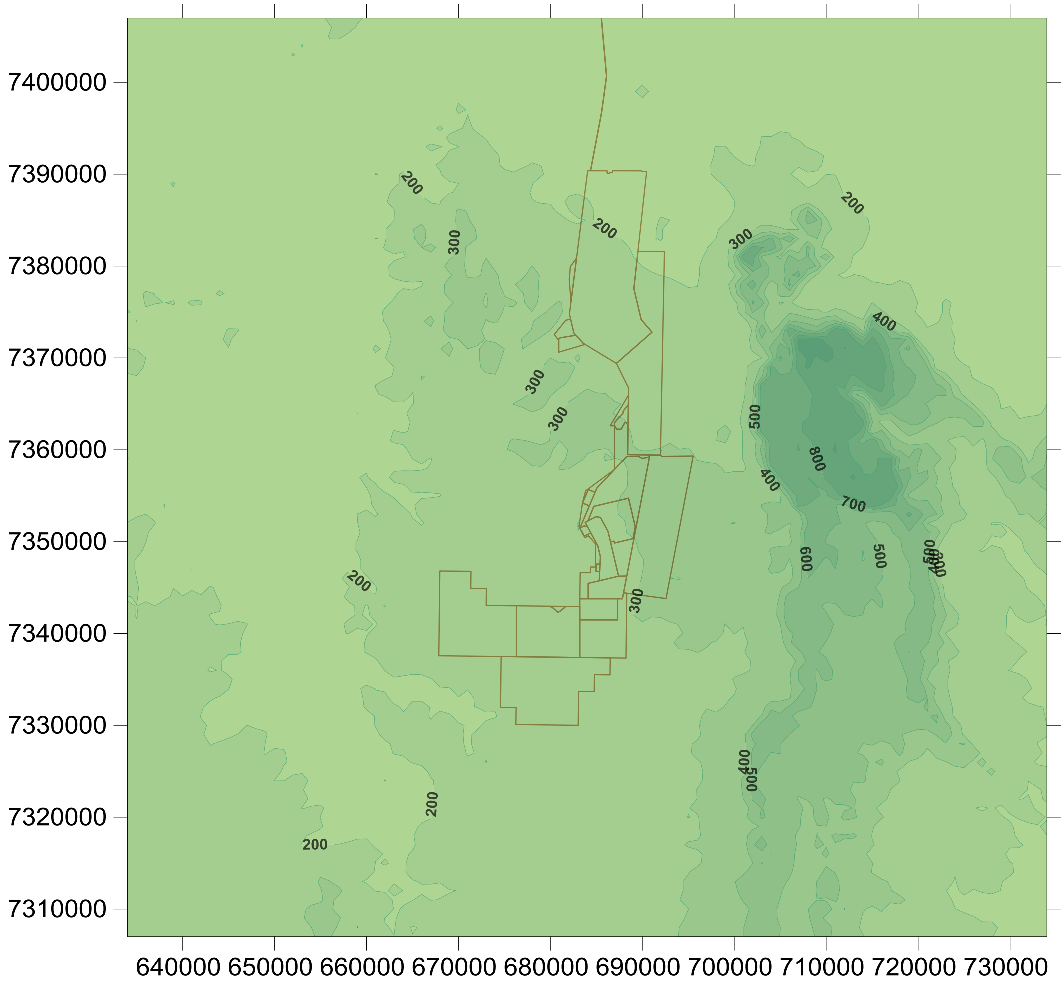
- Geophysical data;
- Upper air meteorological data; and
- Surface meteorological data.

The Geophysical dataset contain terrain and land use information for the modelling domain.

The terrain information for the project was extracted from 3-arc second (90m) spaced elevation data obtained via NASA's Shuttle Radar Topography Mission (SRTM) in 2000. (Downloaded from USGS website http://dds.cr.usgs.gov/srtm/version2_1/SRTM3/Australia/)

Final terrain data for Geophysical dataset for CALMET is shown in Figure 36.

Figure 36: Terrain data for CALMET Geophysical Dataset



The land use or land cover data for the modelling domain was derived from 300 m resolution Globcover land cover map (© ESA 2010 and UCLouvain, published by European Space science, Dec 2010). Manual edits were performed to take into account the latest mine progressions and urban development within the modelling domain. The ESA classification system was mapped to adopt the user defined CALMET classification system. The Geotechnical parameters for the user defined land use classification were adopted from a combination of closest CALMET and AERMET land use categories.

User defined land use classification and geotechnical parameters used in CALMET are shown in Figure 37 and summarised in Table 20.

Figure 37: Land use classification included in CALMET

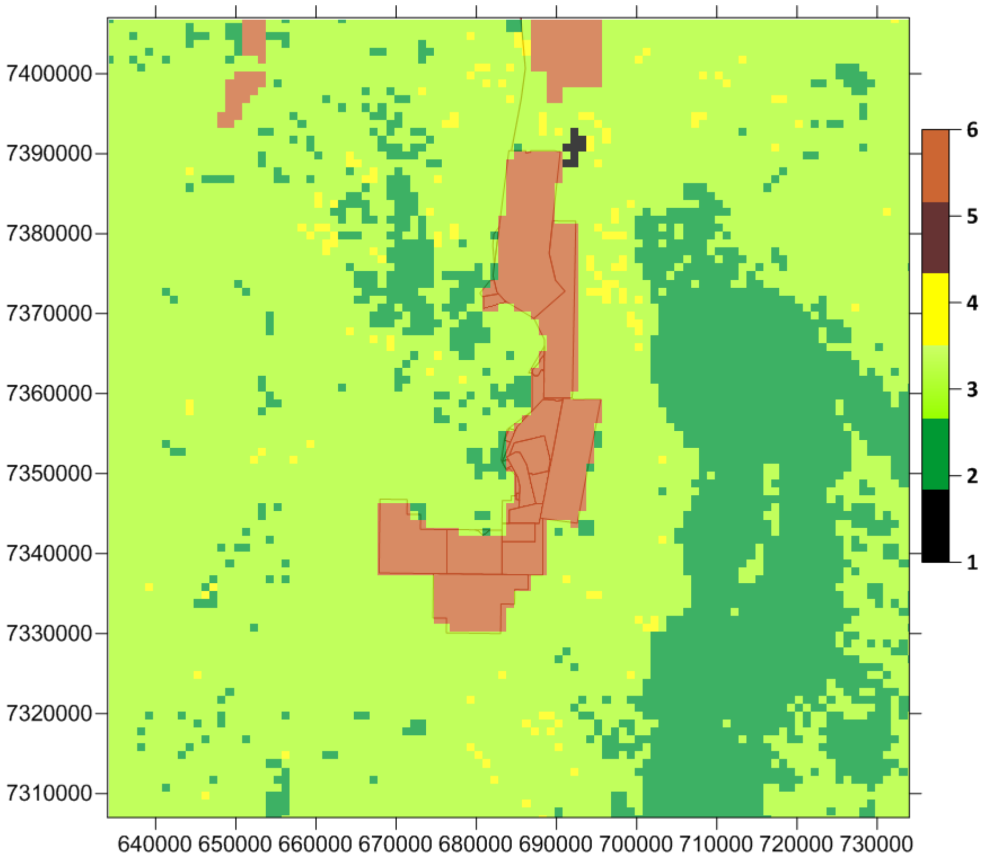


Table 20: CALMET Land use categories included in the assessment

CALMET User defined Category	ESA Category	AERMET Category
1	17 Artificial surfaces and associated areas (Urban areas >50%)	Low intensity residential
2	3 Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)	Mixed Forest
	5 Open (15-40%) broadleaved deciduous forest/woodland (>5m)	
3	9 Mosaic forest or shrub land (50-70%) / grassland (20-50%)	Shrub land (Non-arid)
	10 Mosaic grassland (50-70%) / forest or shrub land (20-50%)	
	11 Closed to open (>15%) (broadleaved or needle leaved, evergreen or deciduous) shrub land (<5m)	
	12 Closed to open (>15%) herbaceous vegetation (Grassland, savannas or lichens/mosses)	
	2 Mosaic vegetation (grassland/shrub land/forest) (50-	

CALMET User defined Category	ESA Category	AERMET Category
	70%)/cropland (20-50%)	
4	13 Sparse (<15%) vegetation	Grassland/Herbaceous
5	1 Mosaic cropland (50-70%) / vegetation (grassland/shrub land/forest) (20-50%)	Small grains
	0 Rain fed croplands	
6	-	Quarries/strip mine/gravel

Details of the CALMET configuration are presented in Table 21.

Table 21: CALMET Configuration

Parameter	Units	Value
CALMET version	-	V6.326
Years modelled	-	2019
No. X grid cells (NX)	-	101
No. Y grid cells (NY)	-	101
Grid spacing (DGRIDKM)	km	1
X coordinate (XORIGKM)	km	634.000
Y coordinate (YORIGKM)	km	7,307.000
No. of vertical layers (NZ)	-	10
Number of surface stations	-	0
Number of upper air stations	-	0
Maximum radius of influence over land in the surface layer (RMAX1)	km	3
Maximum radius of influence over land aloft (RMAX2)	km	30
Maximum radius of influence over water (RMAX3)	km	10
Radius of influence of terrain features (TERRAD)	km	1
Land use database	-	Manually edited 300 m resolution Globcover land cover map (© ESA 2010 and UCLouvain, published by European Space science, Dec 2010).
Terrain database	-	Manually edited 3-arc second (90m) spaced elevation data obtained via NASA's Shuttle Radar Topography Mission

Parameter	Units	Value
		(SRTM) in 2000
Minimum overland mixing height (ZIMIN)	m	50
Maximum overland mixing height (ZIMAX)	m	3000
UTC time zone (ABTZ)	Hours	UTC+1000

CALPUFF

Dust dispersion modelling was undertaken using the US EPA approved CALPUFF model for 2019 meteorological conditions at 100 m resolution using wind fields developed by CALMET. General run control parameters and technical options that were selected are presented in Table 22. Defaults were used for all other options.

Table 22: CALPUFF Configuration

Parameter	Units	Value
CALPUFF version	-	V6.263
Years modelled	-	2019
No. of vertical layers (NZ)	-	10
UTC time zone (XBTZ)	Hours	UTC+1000
Method used to compute dispersion coefficient (MDISP)	-	2 (internally calculated sigma v, sigma w using micrometeorology)
Computational grid size and resolution	-	Identical to CALMET grid
Sampling grid size and resolution	-	Identical to CALMET grid
Discrete receptors height above ground	m	1.5
Wet deposition		False
Dry deposition		True

Appendix C. Emissions Estimates

The National Pollutant Inventory (NPI) has a series of Emission Estimation Technique Manuals that are intended to provide data on emissions of air pollutants during typical operations. The NPI Emission Estimation Technique Manual (EETM) for Mining V3.1 (NPI, 2012) has been used to provide data to estimate the amount of TSP and PM_{10} emitted from the various activities on a mine site, based on the amount of coal and overburden material mined as provided by the Proponent. Emission factors from the NPI EETM for Mining were supplemented with those from the US EPA's AP42 (USEPA, 1995) as required and/or when considered appropriate.

Presented in Table 23 is a summary of the assumed values for the moisture content, silt content and density of coal, overburden and topsoil as required as input in the development of the emission factors. Note that there was no site-specific data pertaining to the silt and moisture content of overburden at the time of the assessment. Values have been assumed based on information contained in the US EPA AP42 (1995). It is acknowledged that the lack of site-specific material parameter information may limit the representativeness of the emission factors developed for this study.

Table 23: Material Parameters

Material	units	Value	Reference
Moisture Content			
Overburden	%	3.2	Assumed based on US EPA AP42 table 11.9.3
Coal – RoM	%	4	BMA
Coal - Raw	%	6	BMA
Coal - Product	%	9	BMA
Silt Content			
Overburden	%	6.9	Assumed based on US EPA AP42 table 11.9.3
Road	%	4.3	Assumed based on US EPA AP42 table 11.9.3
Coal	%	5	BMA
exposed areas	%	6.9	Assumed based on overburden silt content
Density			
Overburden	g/cm3	2.2	BMA
Coal	g/cm3	1.51	BMA

Wind Speed Dependent Wind Erosion

For the purposes of estimating wind erosion from exposed areas the default emission factor of 0.4 kg/ha/hr for TSP recommended in NPI (2012) has been used. The annual total emissions of TSP was distributed on an hourly basis in accordance with Equation 1 (SKM, 2005)

$$F = ku^3\left(1 - \frac{u^2}{u_0^2}\right) \text{ when } u > u_o\text{, otherwise } F = 0 \qquad \text{(Equation 1)}$$

Where 'k' is a constant, 'u' is hourly average wind speed at root mean square height of the stockpile (m), 'u_0' is a wind speed threshold velocity.

The critical wind speed 'u_0' is calculated based on a critical wind speed of 5.4 m/s at the root mean square height of source (e.g. stockpile), corrected to 10 m based on a logarithmic wind speed profile as shown in Equation 2.

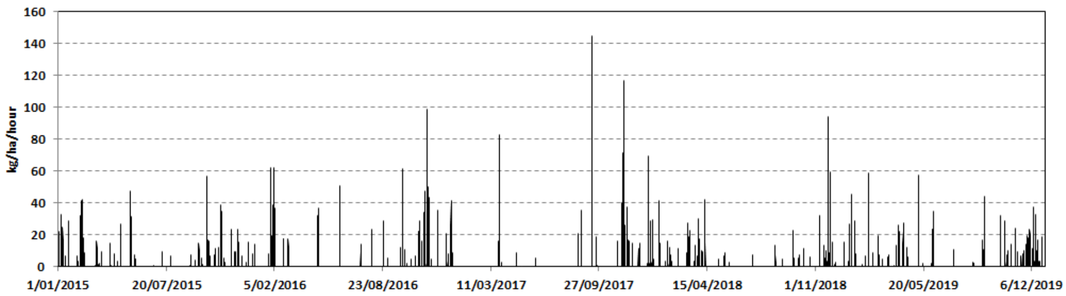
$$u_o = 5.4 ln\left(\frac{10 - z_0}{z - z_0}\right) \qquad \text{(Equation 2)}$$

Where 'z' is the root mean square height of a stockpile (m), 'z_0' is the surface roughness (0.3 m). The constant 'k' in Equation 3 is obtained based on the relationship that the cumulative hourly emissions calculated from Equation 1 are equal to the total annual emissions.

Presented in Figure 38 is an example of wind speed dependent wind erosion emission factors for the five year period 2015 through to 2019.

For PM_{10} an emission factor of 0.2 kg/ha/hour was adopted based on the assumption that 50% of TSP is in the form of PM_{10}.

Figure 38: Example of Wind Speed Dependent Emission Factor



Emission Factors

Presented in Table 24 and Table 25 is a summary of the uncontrolled and controlled TSP and PM_{10} emission factors adopted for this assessment.

Table 24: Emission Factors Used to Develop the Emissions Inventories

TSP

EF Units					Uncontrolled EF			Control			Controlled EF		
Dig	**Dump**	**Haul**	**Material**	**Description**	**Dig**	**Dump**	**Haul**	**Dig**	**Dump**	**Haul**	**Dig**	**Dump**	**Haul**
kg/tonne	**kg/tonne**	**kg/VKT**	Coal	Komatsu 830E-AC	0.03	0.01	4.84	0%	50%	75%	0.029	0.005	1.209
kg/tonne	**kg/tonne**	**kg/VKT**	Rejects	Komatsu 830E-AC	0.03	0.01	4.84	100%	100%	75%	0.000	0.000	1.209
kg/tonne	**kg/tonne**	**kg/VKT**	OB Waste	Komatsu 930E-4SE	0.03	0.01	5.45	0%	0%	75%	0.025	0.009	1.362
n/a	**kg/bcm**	**n/a**	DRE Waste	Dragline	0	0.02	0	0%	0%	0	0.000	0.023	0.000

PM 10

EF Units					Uncontrolled EF			Control			Controlled EF		
Dig	**Dump**	**Haul**	**Material**	**Description**	**Dig**	**Dump**	**Haul**	**Dig**	**Dump**	**Haul**	**Dig**	**Dump**	**Haul**
kg/tonne	**kg/tonne**	**kg/VKT**	Coal	Komatsu 830E-AC	0.01	0.004	1.3	0%	50%	75%	0.014	0.002	0.328
kg/tonne	**kg/tonne**	**kg/VKT**	Rejects	Komatsu 830E-AC	0.01	0.004	1.3	100%	100%	75%	0.000	0.000	0.328
kg/tonne	**kg/tonne**	**kg/VKT**	OB Waste	Komatsu 930E-4SE	0.01	0.004	1.5	0%	0%	75%	0.012	0.004	0.370
n/a	**kg/bcm**	**n/a**	DRE Waste	Dragline	0.00	0.001	0	0%	0%	0	0.000	0.0054	0.000

Table 25: Emission Factors Used to Develop the Emissions Inventories (Continued)

Units	Activity	TSP EF	PM10 EF
kg/hr	Dozer (DRE assist)	5.82	1.2093
kg/hr	Dozer (In pit - coal)	5.82	1.2093
kg/hr	Dozer (In pit - OB)	5.82	1.2093
kg/hr	Dozer (OB Dumps)	5.82	1.2093