BHP Mitsubishi Alliance

Appendix C

Air Quality Assessment

Advanced Environmental Dynamics

Specialist Consultants

CAVAL RIDGE MINE

HORSE PIT EXTENSION PROJECT

AIR QUALITY ASSESSMENT

Report # 101020.2

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Executive Summary

Advanced Environmental Dynamics Pty Ltd (AED) was commissioned by SLR Consulting on behalf of BM Alliance Coal Operations Pty Ltd (BMA) to undertake an air quality assessment of Caval Ridge Mine (CVM) Horse Pit Extension Project (The Project) in support of a major Environmental Authority (EA) amendment application.

Caval Ridge Mine Environmental Authority Conditions

CVM's Environmental Authority (EA) (Permit Number EPML00562013) specifies ambient air quality objectives for Caval Ridge Mine (Table A). Objectives are included for dust deposition, total suspended particulates (TSP) and particulate matter with an aerodynamic diameter less than 10 micrometres (PM_{10}).

Table A: CVM EA Air Quality Objectives

Pollutant	Averaging Period	Project Goal	Allowable Exceedances	Source
Dust deposition	Monthly	120 mg/m2/day	None	CVM EA condition (B5(a))
TSP	Annual	90 µg/m^3	None	CVM EA condition (B5(b))
PM_{10} (1)	24 hour	50 µg/m^3	None	CVM EA condition (B6) (2)

Note (1): Condition (B6) of Environmental Authority Permit Number EPML00562013 states that: *The holder must take all reasonable and practical measures to meet the objective of the concentration of particulate matter generated by the mining activities with an aerodynamic diameter of less than 10 micrometres (PM_{10}) of 50 micrograms per cubic metre (50 µg/m^3) suspended in the atmosphere over a 24 hour averaging time at any sensitive or commercial place.*
Note (2): Interpreted as the incremental contribution of CVM mining activities as assessed by the methodology incorporated into the CVM Dust Control System.

Dust Management at CVM

A state-of-the-air ambient air monitoring network, Dust Control System (DCS) and supporting Trigger Action Response Plan (TARP) form the foundation of dust management practices at CVM.

As part of recent and planned upgrades, operational dust management at CVM is being improved through a number of initiatives including:

- *The upgrading of the DCS to include improved sensor data analysis and proactive dust mitigation functionality.*
- *The commissioning of three temperature inversion towers for the improved detection and response to high risk environmental conditions.*

- *The optimisation of mine schedules to reduce the inherent risk due to planned mining activity/location/intensity.*

Dispersion Modelling

Specifically, two mining scenarios for the Horse Pit Extension Project based on Business as Usual (BAU) dust management practices were assessed:

- ***Project Without (BAU) Case:*** *The mining of Caval Ridge Mine as permitted under current mining approvals; and*
- ***Project With (BAU) Case:*** *The mining of Caval Ridge Mine that includes the Horse Pit Extension 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 based on 2019 meteorology during which time, CVM was experiencing severe drought conditions.

Conclusions

The findings of the air quality assessment suggests that there will be a net increase in the frequency of alarms generated by the site's Dust Control System (DSC) and the requirement to implement additional dust mitigation strategies under the site's TARP associated with monitoring stations located to the north and east of CVM.

The development and adherence to a strict continual improvement plan for CVM that includes key triggers for review and refinement of the plan will assist in minimising operational risk.

Noting the ongoing upgrades to the CVM DCS, no specific additional changes to the range of dust management strategies that form part of site's dust management practices that have been designed to meet the site's EA condition requirements are suggested as a result of the assessment.

Nonetheless, 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.

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Abbreviations

AED	Advanced Environmental Dynamics Pty Ltd
BM	BHP Billiton Mitsubishi
BMA	BM Coal Alliance Operations Pty Ltd
BMC	BHP Billiton Mitsui Coal
BoM	Bureau of Meteorology
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
CVM	Caval Ridge Mine
DCS	Dust Control System
EA	Environmental Authority
EPA	Environmental Protection Authority
EPBC	Environmental Protection and Biodiversity Conservation Act
FY	Financial year
LOM	Life of mine
MIA	Mine industrial area
ML	Mine Lease
MM	Millennium Mine
NASA	National Aeronautics and Space Administration
OOPD	Out of pit dump
PDM	Peak Downs Mine
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
TEOM	Tapered element oscillating microbalance
TIS	Total Insoluble Solids
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 on behalf of BM Alliance Coal Operations Pty Ltd (BMA) to undertake an air quality assessment of the Caval Ridge Mine (CVM) Horse Pit 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 Background

CVM is located within Mining Lease (ML) 1775 with associated infrastructure in ML 70403 and ML 70462. CVM operates under the conditions of Environmental Authority (EA) EPML00562013 and EPBC Approval (2008/4417).

The mine is located five kilometres southwest of the township of Moranbah and approximately 200 km southwest of Mackay. The Moranbah airport forms the boundary of the Project to the north-northeast. The Peak Downs Highway intersects CVM between the Horse Pit and Heyford Pit. The area surrounding CVM to the east is relatively flat with a gentle slope upwards from the south at 230 m elevation to north at 270 m elevation. There is a mountain range to the west of the site that slopes up to a peak just over 500 m elevation (Mt Dilingen). Most of the land surrounding CVM is relatively cleared land.

There are several open cut mines in the vicinity of CVM including: Peak Downs Mine (BMA) located c.12 km southeast; Poitrel Mine (BMC), Daunia Mine (BMA) and Millennium mine (Peabody) located c.14 km to the northeast; Isaac Plains Mine c.20 km to the east-northeast; and Goonyella Riverside mine c.30 km to the north.

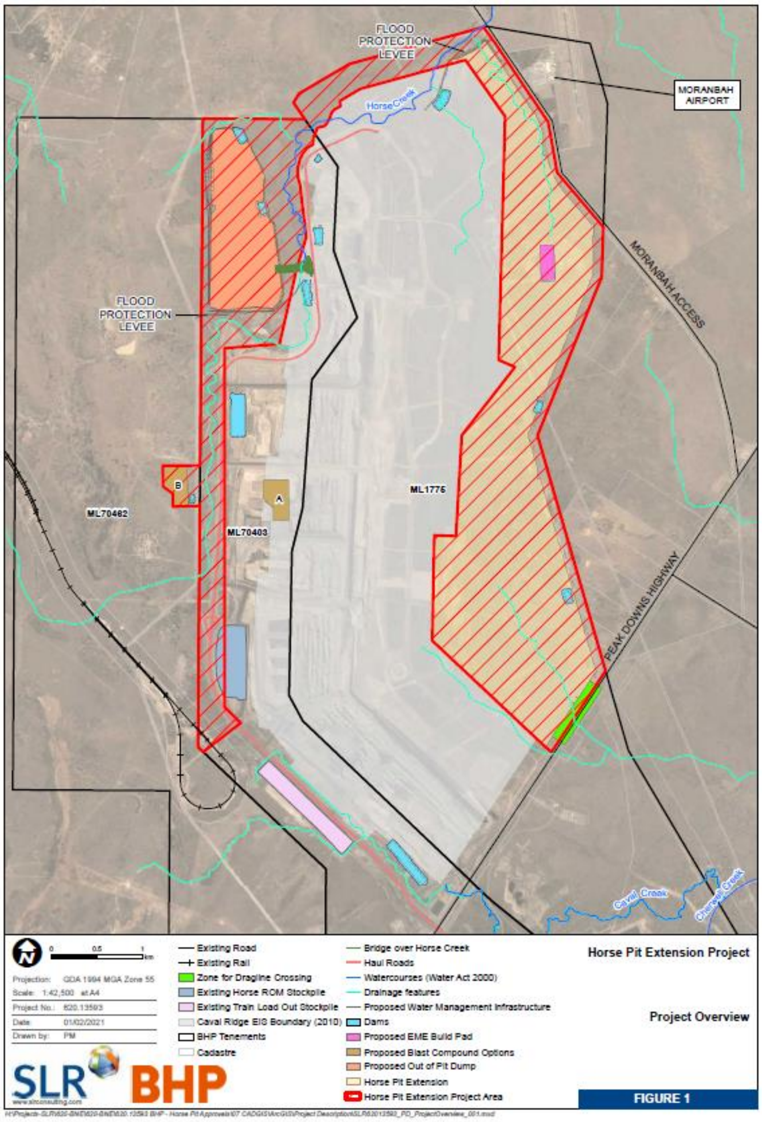
2.1 Project Description

CVM operates using open cut mining techniques using dragline and truck and shovel equipment to produce up to 15 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal. The CVM CHPP also receives via conveyors between 5 and 11 Mtpa of ROM for processing from Peak Downs Mine (PDM). CVM operates in two pits, Horse Pit and Heyford Pit. As a result of identifying efficiencies in mining and mine sequencing an extension into mining from the existing Horse Pit footprint is required. This extension will extend the life of the mine for an additional c.20 years.

The Project will not affect the rate of mine production (c. 15 Mtpa ROM) and will continue to operate in a similar manner to the present operations. An out of pit dump (OOPD) will be added to the northwest of ML 70403. Some of the existing infrastructure will be relocated including power lines and back-access roads, relocation of the mine water dams and pipelines, the blast compound, as well as the relocation of the Peak Downs Highway dragline crossing. The modifications include an extension of the haul road to the proposed OOPD, construction of new sediment dams and the expansion of existing sediment dams as well as the inclusion of two flood levees. The coal handling and processing plant (CHPP), existing conveyors from PDM and rail loading facilities will remain unchanged.

The layout of the site and proposed extension location is shown in Figure 1.

Figure 1: Project Overview



2.2 Environmental Authority Conditions

Environmental Authority (EA) (Permit Number EPML00562013) specifies ambient air quality objectives for CVM under *Schedule B: Air*. Objectives are included for dust deposition (Condition B5(a)), total suspended particulates (TSP) (Condition B5(b)) and particulate matter with an aerodynamic diameter less than 10 micrometres (PM_{10}) (Condition B6). A summary of the CVM EA Condition objectives is presented in Table 1.

It is noted that EA Condition B6 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}. Compliance is based on an interpretation of data recorded by the CVM ambient air monitoring network with mine contribution calculated by the CVM Dust Control System (DCS).

Table 1: CVM Ambient Air Quality Objectives

Pollutant	Averaging Period	Project Goal	Allowable Exceedances	Source
TSP	Annual	90 µg/m^3	None	CVM EA condition (B5(b))
PM_{10} (1)	24 hour	50 µg/m^3	None	CVM EA condition (B6) (2)
Dust deposition	Monthly	120 mg/m2/day	None	CVM EA condition (B5(a))

Note (1): Condition (B6) of Environmental Authority Permit Number EPML00562013 states that: *The holder must take all reasonable and practical measures to meet the objective of the concentration of particulate matter generated by the mining activities with an aerodynamic diameter of less than 10 micrometres (PM_{10}) of 50 micrograms per cubic metre (50 µg/m^3) suspended in the atmosphere over a 24 hour averaging time at any sensitive or commercial place.*
Note (2): Interpreted as the incremental contribution of CVM mining activities as assessed by the methodology incorporated into the CVM DCS.

2.2.1 Reported Dust Levels above EA Condition Objectives

Based on information provided by BMA dust levels above the relevant objectives stated in EA condition (B5) or (B6) have been reported to the regulating authority:

- On c. six occasion in relation to the Condition (B5a) objective for dust deposition.
- On c. 24 occasions in relation to 21 days associated with exceedances of the Condition (B6) objective for PM_{10}

Of the c. 24 reported exceedances of the Condition (B6) objective of 50 µg/m^3 for the 24 hour average concentration of PM_{10}, one was reported in 2015, four in 2017, five in 2018, twelve in 2019 and two in 2020. The elevated levels of dust during 2018 and 2019 (in particular) highlight the increased level of operational risk due to the severe drought conditions experienced during this period.

It is further noted that the 24 reported exceedances included elevated levels of dust above the Condition (B6) objective at all monitoring stations.

Recent (regulatory approved) changes to the data processing methodology used to calculate mine contribution, as well as the consideration of both local and regional dust emission source contributions, suggests that the number of CVM-related exceedances may be significantly reduced from that reported to date (Section 3.1.3).

2.3 Assessment Locations

The CVM EA EPML00562013 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 CVM EA EPML00562013 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

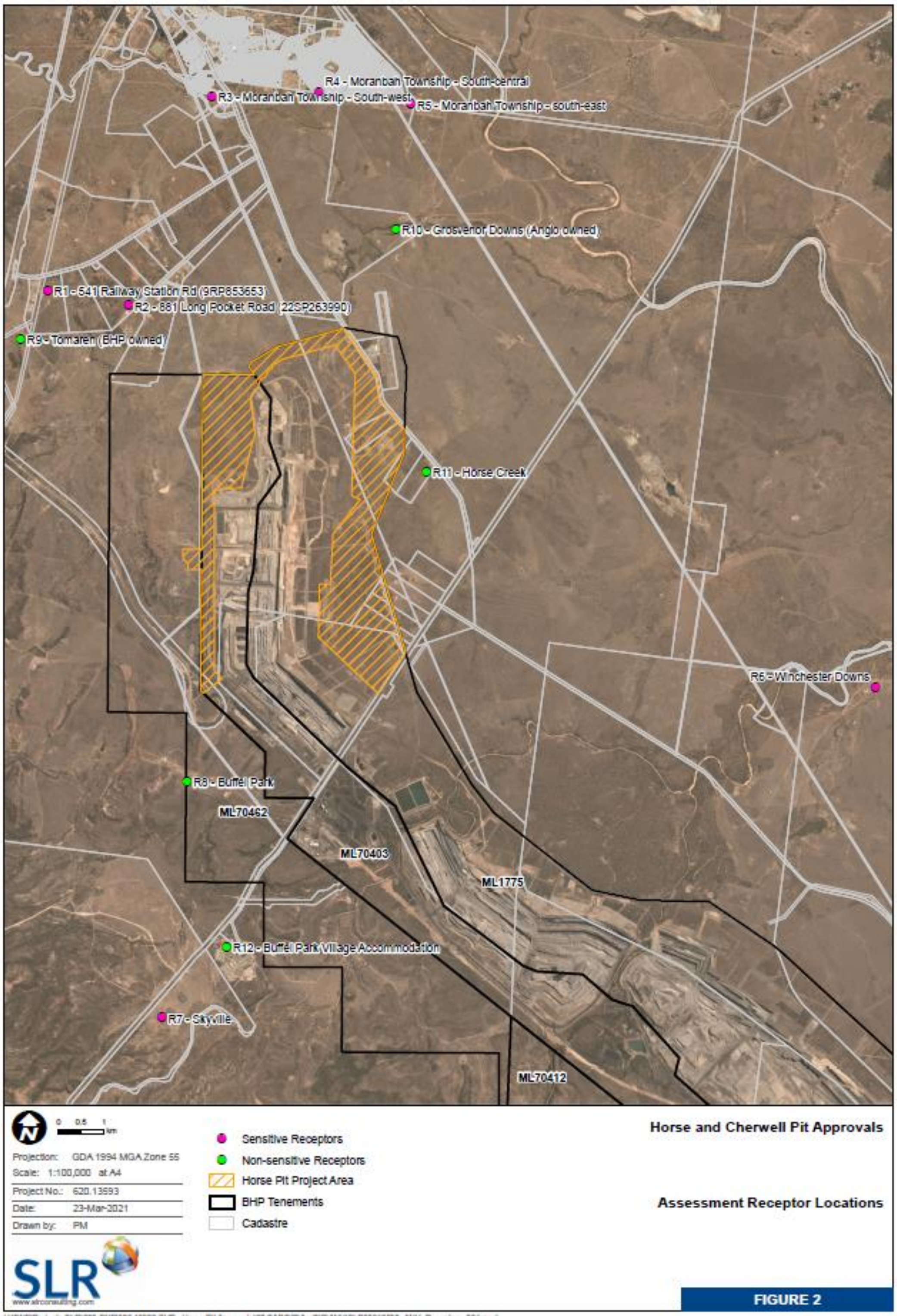
iv. *A property owned or leased by one or more of the environmental authority holders, or a related company whether or not is subject to an alternative arrangement*

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.

The nearest sensitive and commercial places to the Project include Winchester Downs to the east, Skyville homestead to the west of Buffel Park Accommodation Village, homesteads along Long Pocket Road to the north, as well as Moranbah Township (Figure 2).

To date the regulating authority has expressed particular interest in air quality outcomes in association with receptor locations in the vicinity of the CVM Site 2, Site 6 and Site 8 monitoring stations (Section 3) located to the north and northeast of mining operations. This assessment has focused on the presentation of results in relation to these three locations in particular.

Figure 2: Assessment Locations



3. The CVM Ambient Air Monitoring Network

The CVM DCS is informed by an ambient air monitoring network consisting of six continuous monitoring locations, i.e. Site 2, Site 6, Site 8, Site 13, Site 15 and Site 14 (Figure 3). Whilst a range of dust (TSP, PM_{10} and $PM_{2.5}$) and meteorological parameters are measured on a continuous basis at Site 2, Site 6, Site 8, Site 13 and Site 15, only meteorological parameters are measured at Site 14. More recently (2021/2022) CVM has commissioned 3 temperature inversion towers (MIA, North, East) at the locations indicated in Figure 3.

Monthly dust deposition sampling is undertaken at the 12 locations indicated in Figure 3 (EA Condition B5(a)).

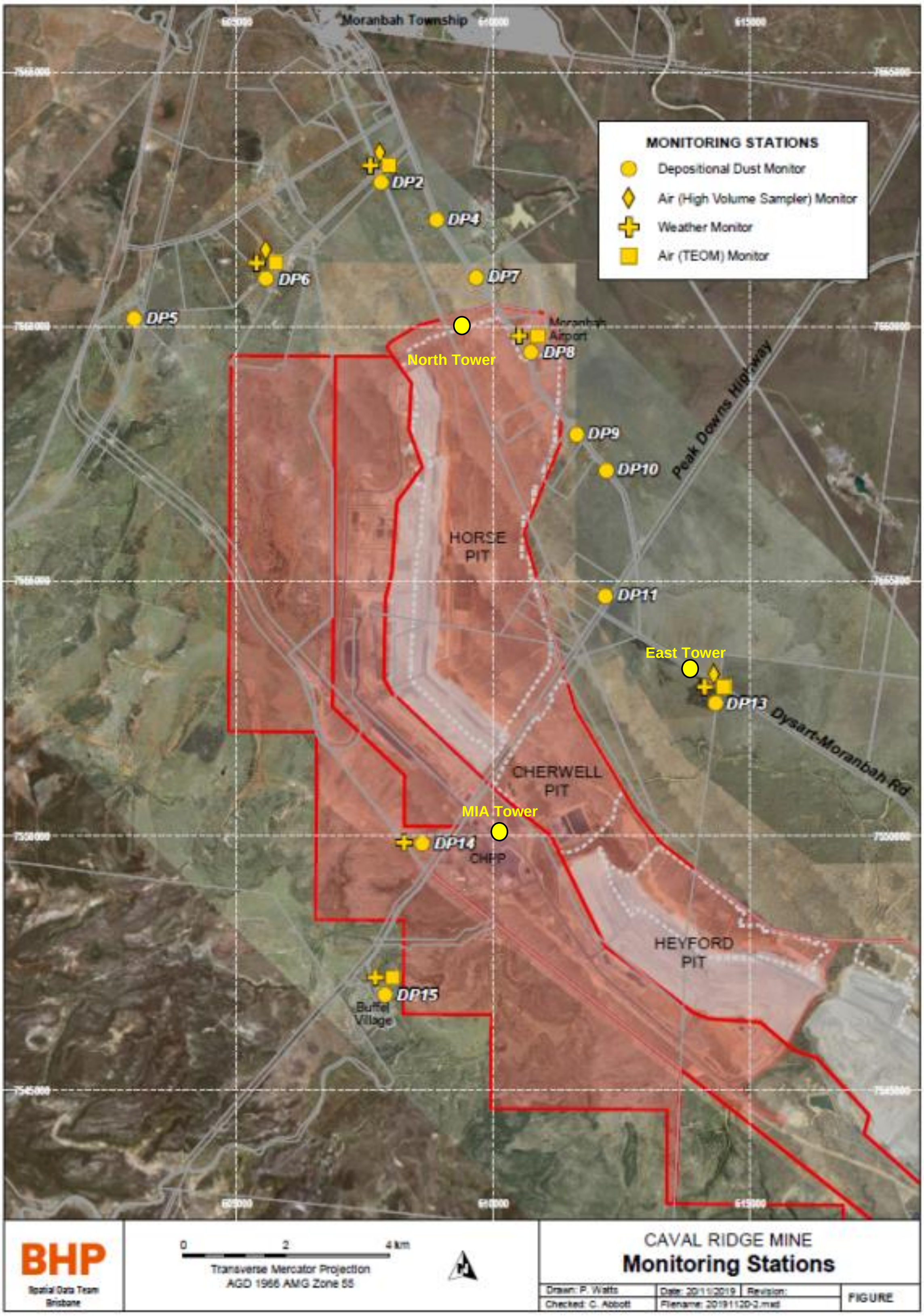
It is noted that BMA consider Site 2 (Long Pocket Road east) and Site 6 (Long Pocket Road west) and Site 8 (Moranbah Airport) to be representative of a sensitive or commercial place whilst Site 13 is used to inform background estimates and Site 15 is located at BMA's Buffel Park Accommodation Village.

AED (2021) presents a summary of the results of the analysis of data from the commencement of monitoring in c. October 2010 through 2020. Some of the findings of this report have been included here. Additional data analysis has been undertaken to develop estimates of CVM's contribution to PM_{10} dust levels recorded at the monitoring locations for comparison with the results from the dispersion modelling.

With reference to Figure 2 and Figure 3, it is noted that the CVM monitoring network includes stations that are located in closer proximity to mining activities than the neighbouring sensitive or commercial place(s).

As compliance or otherwise with the EA Conditions is informed by the CVM ambient air monitoring network, for the purposes of this assessment, the focus of the presentation of the results from the dispersion modelling are for those associated with the locations of the continuous dust monitoring stations.

Figure 3: CVM Monitoring Stations



3.1 Analysis of Data from the CVM Monitoring Network

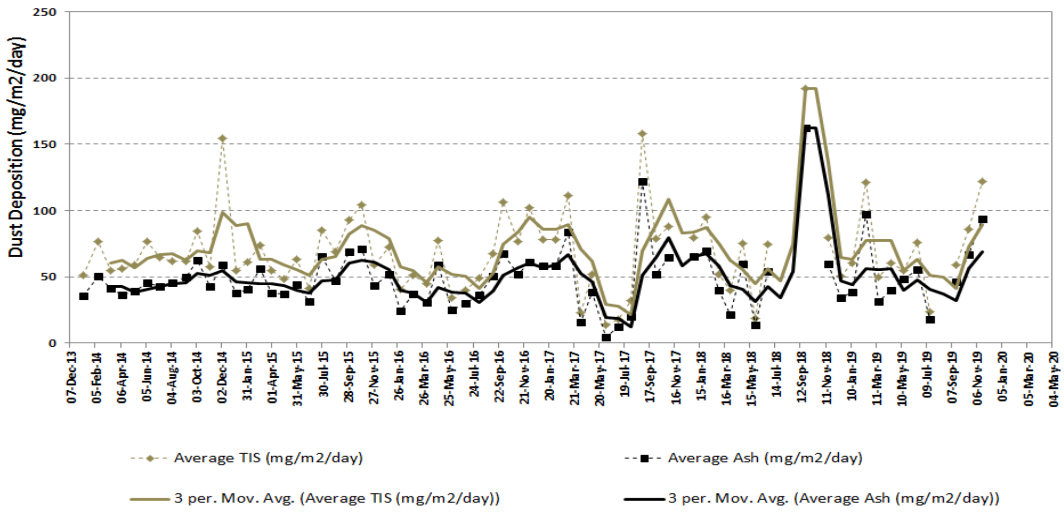
This section provides a summary of the findings of a review of data from the CVM ambient air monitoring network including estimates of background levels of TSP and dust deposition as well as estimates of mine contribution to the 24 hour average concentration of PM_{10}.

3.1.1 Results for Dust Deposition

Results of the analysis of dust deposition data from the period January 2014 through December 2019 is presented in Figure 4. Presented in the figure is a time series of airshed loading which is calculated as an average of the data from all available sites for each month. Time series for both Total Insoluble Solid (TIS) and Ash are presented. Noting that reporting of dust deposition is based on the value of TIS whilst the ash component provides an indication of the amount of combustible matter that was contained within the sample and may aid data interpretation.

Of particular note is the seasonal variability in the results presented with elevated levels of dust recorded during the September through January periods. In general, the winter months are associated with lower levels of deposited dust than during the summer months. As noted in Section 3.3.3 these fall and summer months are more likely to be associated with elevated wind speeds and thus a potential for an increase in windblown dust and a resultant increase in deposited dust. Lower wind speeds typically experienced during the winter period (Section 3.3.3) are less likely to be associated with windblown dust and thus there is a corresponding reduction in deposited dust.

Figure 4: Analysis Results for Dust Deposition (January 2014 through December 2019)



3.1.2 Results for TSP

Presented in Table 2 is a summary of the annual average concentration of TSP based on TEOM data from the period 01/01/2015 through 31/12/2020 (AED 2021). Results indicate that (with the exception of the atypical value during 2019 for Site 15) TSP levels were well below the EA Condition (B5b) objective of 90 µg/m^3 for the annual average concentration of TSP.

Table 2: Summary of Annual Average TSP Data (01/01/2015 through 31/12/2020)

Year	Site 2	Site 6	Site 8	Site 13	Site 15
2015	36.8	52.7	46.6	42.3	50.2
2016	31.0	33.9	30.6	33.5	40.0
2017	40.3	43.7	38.5	35.1	47.0
2018	55.6	59.5	52.2	40.6	63.4
2019	53.4	59.7	54.0	53.3	**90.5**
2020	41.9	63.5	42.2	38.6	44.8

Note: Data capture rates vary from site to site and year to year. Additional information is provided in AED (2021).

3.1.3 Results for the Estimates of Mine Contribution to PM_{10}

A review of data from the CVM monitoring network has been undertaken focusing on the period from 01/04/2015 through 31/12/2020. This data has been processed in accordance with the recently approved methodology for calculating mine contribution for comparison with output from the dispersion modelling (AED, 2020).

The revised background calculation methodology is based on an interpretation of sensor data from the CVM monitoring network and includes an approach for estimating both regional and localised background dust levels with the average used to represent the station background. The mine contribution is then calculated as the difference between the station's 24 hour average PM_{10} background concentration and the station's absolute 24 hour average concentration of PM_{10}.

The revised methodology was developed to quantify the influence of local dust emission sources on air quality at the monitoring stations. Although considered an improvement over the use of a single value as used to represent regional background dust levels, the revised methodology is still limited by:

- Off-site dust emission sources that exist within the CVM arc of influence (i.e. within wind directions attributed to mining operations)

- Situations where the deviation in the local and regional background estimates is significant enough that the average value may result in an under-representation of the potential impact of localised sources.

Based on the three monitoring stations considered by BMA to be representative of a *sensitive or commercial place* i.e. (Site 2, Site 6 and Site 8), a total of seven days were identified as being associated with estimated mine contributions that exceeded the EA Condition (B6) objective of 50 µg/m^3 for the 24 hour average concentration of PM_{10} (Table 3) at the location of one or more monitoring stations (as indicated by the blue highlighted cells and bold font).

Included in Table 3 are comments provided by AED based on a review of the local and regional background estimates which suggest that:

- A regional event may have influenced the mine estimates on 08/09/2019 with all monitoring stations affected.
- There were very high local background levels calculated at Site 2 on 09/12/2019. Using an average of local and regional background estimates may have resulted in an under-estimation of the impacts of local dust emission sources at this location on this day. A more detailed investigation was not undertaken.
- There were very high local background levels calculated at Site 6 on 22/04/2020 and 23/04/2020. Using an average of local and regional background estimates may have resulted in an under-estimation of the impacts of local dust emission sources at this location on these days. A more detailed investigation was not undertaken.

Note that results from the data analysis from all monitoring locations will be used to inform the interpretation of results from the dispersion modelling and thus for completeness, days that exceed the EA Condition (B6) objective for PM_{10} as recorded at the Site 13 and Site 15 monitoring location have been included in Table 3.

(*It is noted that Section 2.2.1 referred to a total of 24 reported exceedances. However initially, the reported exceedances included estimates for mine contributions at the Site 13 monitoring station and not just those associated with Site 2, Site 6 and Site 8. Nonetheless, expanding the conclusions of the re-analysis of monitoring data to include Site 13, suggests a total of eleven (c.f. seven) days with dust levels of above the Condition (B6) objective (Table 3).)*

Table 3: Mine Contribution Estimates that Exceed Condition (B6) Objective based on data from 01/04/2015 through 31/12/2020

Date	Site 2	Site 6	Site 8	Site 13	Site 15	Comments
03/01/2017	N/D	**56.2**	N/D	N/D	N/D	*Site 6 Likely attributable to CVM*
10/10/2017	0.0	0.0	0.0	0.0	**75.9**	*Site 15: High local background (68) + Lower regional (29) + absolute (124) - Levels above 50 likely attributable to CVM*
21/09/2018	0.0	**61.6**	0.0	15.0	0.0	*Site 6: Likely attributable to CVM*
26/11/2018	2.4	0.0	47.7	**68.6**	0.1	*Site 13: Likely attributable to CVM*
20/08/2019	7.4	**65.8**	0.0	25.9	0.0	*Site 6: Regional influences combined with low local background estimate - Likely attributable to CVM*
3/09/2019	10.4	3.0	26.9	**55.2**	0.0	*Site 13 Likely attributable to CVM*
4/09/2019	0.1	0.0	18.9	**62.9**	3.4	*Site 13: Likely attributable to CVM*
08/09/2019	**71.3**	**115.4**	0.0	**73.8**	13.5	*Regional Event – all sites affected (all sites removed from following table)*
14/09/2019	5.0	0.0	21.9	**64.2**	4.0	*Site 13: Likely attributable to CVM*
09/12/2019	**74.8**	0.0	0.0	0.0	0.0	*Site 2: High local background (149) + Lower regional (61)+ absolute (180) – Levels above 50 likely not attributable to CVM (removed in following table)*
22/04/2020	0.0	**150.2**	0.0	0.0	0.0	*Site 6: Very high local background (366) + Lower regional(74) + absolute (362) – Levels above 50 likely not attributable to CVM (removed in following table)*
23/04/2020	0.0	**63.2**	0.0	0.0	0.0	*Site 6: Very high local background (317) + Lower regional(34) + absolute(259) – Levels above 50 likely not attributable to CVM (removed in following table)*

Presented in Table 4 is a summary of the results for the estimated mine contribution to the 24 hour average concentration of PM_{10} for the period 01/04/2015 through 31/12/2020. The table presents a yearly breakdown of a range of percentiles including the maximum (i.e. the 100th percentile) estimated mine contribution. The table includes two sets of analysis results; one for the entire data set and the second with the events noted in Table 3 removed.

Included as Table 5 is a summary of the number of days when exceedances of Condition B6 objective of a mine contribution of 50 µg/m^3 may have occurred. Results are presented for both of the data sets presented in Table 4 (i.e. including and excluding the dust events noted in Table 3.)

Focusing on the analysis based on the filtered data (i.e. with the dust events in Table 3 removed), results suggest that over the period of data considered (01/04/2015 through 31/12/2020), a total of eight exceedances of the EA Condition (B6) objective for PM_{10} (with two exceedances recorded on 08/09/2019 i.e. Site 2 and Site 6) were likely attributable to CVM mining operations.

- As discussed, three of the exceedances occurred at Site 6. It is further noted however, significant localised dust generating emission sources exist in close proximity to Site 6 that have been found to have a significant impact on dust levels at this location.
- Four exceedances are suggested at the location of the Site 13 monitoring station which is used to inform background calculations within the CVM DCS.
- Finally, a single exceedance is suggested at Site 15 (BMA's Buffel Village) on 10/10/2017.This was an atypical occurrence with CVM mine contributions estimated to not exceed c. 35 µg/m^3 during any other year analysed. An investigation into data from the day in question has not been undertaken.

In summary, results of the data analysis based on the filtered data set suggest that to date, the estimated maximum mine contribution to the 24 hour average concentration of PM_{10} at each of the monitoring locations has been less than: c. 35 µg/m^3 at Site 2, c. 70 µg/m^3 at Site 6, c. 50 µg/m^3 at Site 8, c. 70 µg/m^3 at Site 13 and c. 75 µg/m^3 at Site 15.

Results presented for the 70th percentile may be considered representative of 'background creep' with values varying from location to location and from year to year, but on averaging ranging from 0.7 µg/m^3 at Site 8 to c. 4.7 µg/m^3 at Site 6.

Table 4: Summary of PM_{10} Mine Contribution Estimates (01/04/2015 through 31/12/2020)

Year	Percentiles	Results based on Original Data				
		Site 2	Site 6	Site 8	Site 13	Site 15
2015[(1)]	100%	21.5	45.5	47.6	34.9	15.7
	99%	14.0	37.7	35.5	25.0	14.1
	95%	5.9	22.6	23.6	8.1	10.9
	90%	4.7	16.2	13.3	5.0	8.8
	70%	1.3	8.0	2.2	1.2	4.7
2016	100%	18.5	16.1	21.2	18.9	20.8
	99%	13.5	13.6	11.4	14.6	13.3
	95%	7.3	9.3	6.0	12.0	8.5
	90%	5.0	7.5	3.0	8.6	7.0
	70%	1.5	3.5	0.1	2.8	3.1
2017	100%	26.8	**56.2**	31.5	26.7	**75.9**
	99%	15.9	25.9	23.4	22.1	17.1
	95%	9.4	13.6	11.3	12.2	11.8
	90%	7.5	10.2	6.7	8.8	9.1
	70%	2.6	5.2	0.7	2.3	4.0

Year	Percentiles	Results with Dust Events Removed				
		Site 2	Site 6	Site 8	Site 13	Site 15
2015[(1)]	100%	21.5	45.5	47.6	34.9	15.7
	99%	14.0	37.7	35.5	25.0	14.1
	95%	5.9	22.6	23.6	8.1	10.9
	90%	4.7	16.2	13.3	4.7	8.8
	70%	1.3	8.0	2.2	1.2	4.7
2016	100%	18.5	16.1	21.2	18.9	20.8
	99%	13.5	13.6	11.4	14.6	13.3
	95%	7.3	9.3	6.0	12.0	8.5
	90%	5.0	7.5	3.0	8.6	7.0
	70%	1.5	3.5	0.1	2.8	3.1
2017	100%	26.8	**56.2**	31.5	26.7	**75.9**
	99%	15.9	25.9	23.4	22.1	17.1
	95%	9.4	13.6	11.3	12.2	11.8
	90%	7.5	10.2	6.7	8.8	9.1
	70%	2.6	5.2	0.7	2.3	4.0

Year	Percentiles	Results based on Original Data				
		Site 2	Site 6	Site 8	Site 13	Site 15
2018	100%	30.9	**61.6**	47.7	**68.6**	26.3
	99%	23.7	29.8	32.6	32.3	18.0
	95%	16.6	21.8	19.4	22.7	13.0
	90%	13.6	16.8	12.8	16.9	11.1
	70%	4.1	7.9	2.0	6.4	6.1
2019	100%	**74.8**	**115.4**	27.5	**73.8**	25.7
	99%	18.0	26.4	25.3	**50.7**	19.8
	95%	12.5	17.2	14.1	27.5	13.5
	90%	9.8	14.6	8.0	20.5	10.9
	70%	2.8	5.8	0.0	5.9	5.7
2020	100%	22.0	**150.2**	34.5	45.8	35.2
	99%	18.5	23.4	25.4	27.3	18.3
	95%	9.2	12.4	16.2	13.2	13.5
	90%	6.0	9.5	11.9	9.7	10.3
	70%	1.8	4.4	0.9	2.2	5.0

Year	Percentiles	Results with Dust Events Removed				
		Site 2	Site 6	Site 8	Site 13	Site 15
2018	100%	30.9	**61.6**	47.7	**68.6**	26.3
	99%	23.7	29.8	32.6	32.3	18.0
	95%	16.6	21.8	19.4	22.7	13.0
	90%	13.6	16.8	12.8	16.9	11.1
	70%	4.1	7.9	2.0	6.4	6.1
2019	100%	20.3	**65.8**	27.5	**64.2**	25.7
	99%	16.5	25.9	25.3	43.6	19.8
	95%	12.3	17.0	14.1	27.0	13.5
	90%	9.6	14.3	8.0	20.3	10.9
	70%	2.7	5.8	0.0	5.7	5.6
2020	100%	22.0	28.4	34.5	45.8	35.2
	99%	18.5	19.2	25.4	27.3	18.3
	95%	9.2	12.0	16.2	13.2	13.5
	90%	6.0	9.4	11.9	9.7	10.3
	70%	1.8	4.4	0.9	2.2	5.0

Year	Percentiles	Results based on Original Data				
		Site 2	Site 6	Site 8	Site 13	Site 15
2015[1]-2020	100%	**74.8**	**150.2**	47.7	**73.8**	**75.9**
	99%	20.1	28.5	27.4	31.7	18.3
	95%	11.9	16.9	15.1	18.5	12.8
	90%	7.9	12.3	8.9	12.5	9.8
	70%	2.4	5.5	0.7	3.1	4.8

Note (1): Data from 1/4/2015 where available

Year	Percentiles	Results with Dust Events Removed				
		Site 2	Site 6	Site 8	Site 13	Site 15
2015[1]-2020	100%	30.9	**65.8**	47.7	**68.6**	**75.9**
	99%	18.7	27.9	27.4	31.2	18.3
	95%	11.8	16.8	15.1	18.5	12.8
	90%	7.8	12.2	8.9	12.5	9.7
	70%	2.4	5.4	0.7	3.1	4.8

Note (1): Data from 1/4/2015 where available

Table 5: Summary of Exceedances of Condition B6 Objective for PM_{10} (01/04/2015 through 31/12/2020)

Year	Results based on Original Data				
	Site 2	Site 6	Site 8	Site 13	Site 15
2015[1]	0	0	0	0	0
2016	0	0	0	0	0
2017	0	**1**	0	0	**1**
2018	0	**1**	0	**1**	0
2019	**2**	**2**	0	**4**	0
2020	0	**2**	0	0	0
Total 2015-2020	**2**	**6**	0	**5**	**1**

Note (1): Data from 1/4/2015 where available

Year	Results with Dust Events Removed				
	Site 2	Site 6	Site 8	Site 13	Site 15
2015[1]	0	0	0	0	0
2016	0	0	0	0	0
2017	0	**1**	0	0	**1**
2018	0	**1**	0	**1**	0
2019	0	**1**	0	**3**	0
2020	0	0	0	0	0
Total 2015-2020	0	**3**	0	**4**	**1**

Note (1): Data from 1/4/2015 where available

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, data from the CVM Site 2 monitoring station has been used to estimate background levels of TSP and dust deposition for comparison with EA Condition (B5a) and (B5b) objectives.

The Site 2 monitoring station includes continuous monitoring of particulate matter as well as the monitoring of meteorological parameters. Data for the period 12/11/2013 through 31/03/2015 (AED 2015) were analysed to estimate background levels of TSP. This period is considered to be representative of pre-mining dust levels.

The adopted background levels are summarised in Table 6.

Table 6: Estimate of Background Levels

Pollutant	Averaging Period	Estimated Background Level	Source
TSP	Annual	39 µg/m^3	BMA CVM Site 2
Dust deposition	Monthly	44 mg/m^2/day	BMA CVM Site 2

3.3 Meteorological Environment

Presented in Appendix A is a summary of:

- Climate statistics from the Bureau of Meteorology's Moranbah Water Treatment Plant monitoring station (1972-2012) including: temperature; relative humidity and rainfall.
- Wind speed and wind direction data presented as wind roses based on numerically simulated data and data from the CVM DCS Site 2 monitoring station.
- Atmospheric stability based on numerically simulated data.

Include in this Section is a summary of Site 2 wind data, Site 2 rainfall data and a description of worst-case meteorological conditions.

3.3.1 Wind Roses

Presented in Figure 5 is a wind rose based on hourly averaged data from Site 2 for 2019. The wind rose highlights the predominance of southeast winds at this location.

The seasonal variability in the wind speed and direction is highlighted by the wind roses presented in Figure 6. The wind roses provided in Figure 7 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 5: Wind Rose Based on Site 2 Hourly Averaged Data (2019)

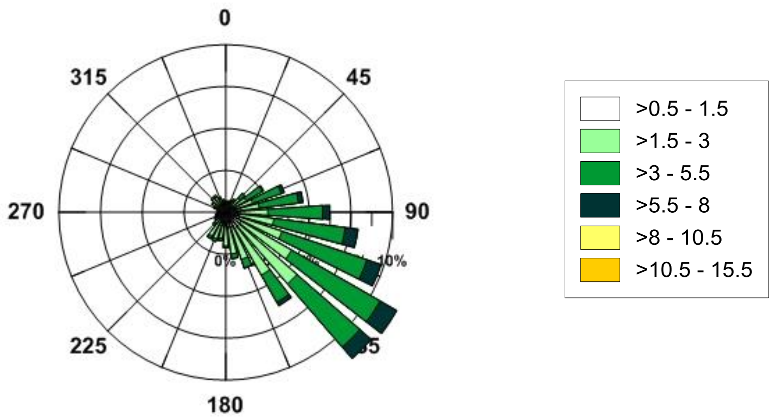


Figure 6: Seasonal Wind Roses Based on Site 2 Hourly Averaged Data (2019)

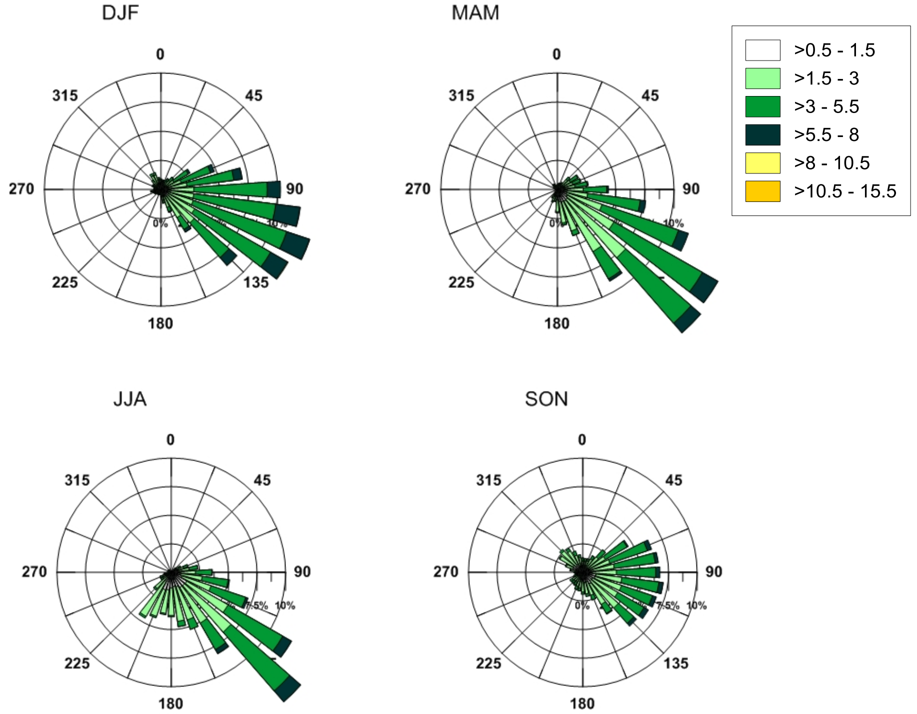
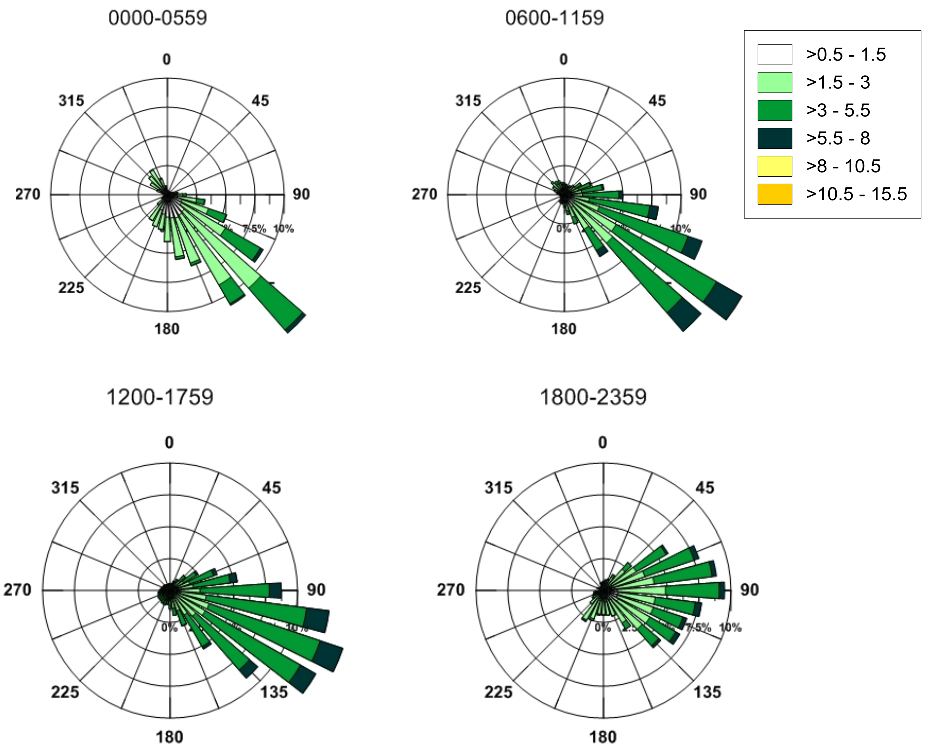


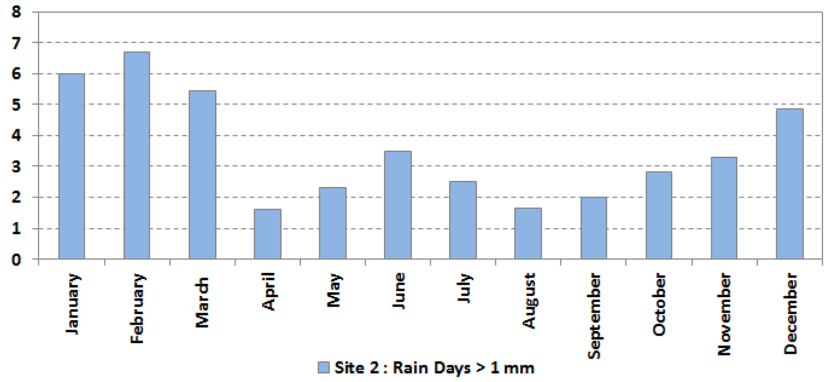
Figure 7: Hour of Day Wind Roses Based on Site 2 Hourly Averaged Data (2019)



3.3.2 Rainfall Days

Presented in Figure 8 is the monthly average number of days with rainfall greater than 1 mm based on data from the Site 2 monitoring station for the period 2014 through 2020. Increased rainfall during the months of December through March is suggested with drier conditions experienced during the winter months.

Figure 8: Site 2 - Number of Days with >1 mm of Rainfall (2014 through 2020)



3.3.3 Worst Case Meteorological Conditions

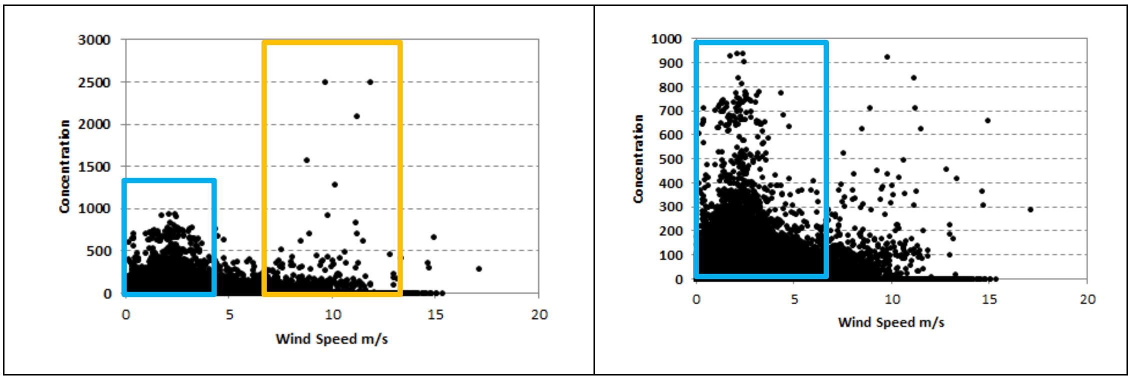
In order to effectively manage CVM's dust emissions, a detailed understanding of the meteorological conditions that lead to an increased risk of elevated levels of dust is required. In general, worst-case meteorological conditions for open cut mining operations fall into two categories:

- 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 (Section 3.1.1). 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). With reference to the figures presented in 3.3.1, wind speeds above 5.4 m/s are an infrequent occurrence in this area and are more likely to occur during the daytime hours.

Presented in Figure 9 is a scatter plot of 5 minute average PM_{10} data as a function of wind speed based on data from the Site 13 monitoring system. 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).

Figure 9: Site 13 Five Minute Average Concentration of PM_{10} as a Function of Wind Direction (01/04/2015 through 31/12/2020)



The correlation between the strength of the low level temperature inversion and elevated levels of dust was highlighted in a field study undertaken at CVM (AED, 2018). These findings have led to the commissioning of the CVM MIA Tower (2021), the East Tower adjacent to Site 13 (2022) and the North Tower within the CVM ML, on the north side of Horse Creek in the vicinity of Site 2 (2022) (Figure 3).

4. Dust Management Practices at CVM

Dust management practices at CVM are continually improving. Increased operational pressure was experienced during the recent period of prolonged drought throughout central Queensland. Calendar years 2018 and 2019 were more challenging operationally than during any other period in the mine's history as indicated by the number of times when dust levels elevated above the EA objectives were reported to the regulating authority during this period (Section 2.2.1).

The state-of-the-art ambient air monitoring network, the real time DCS and the supporting trigger action response plan (TARP) form the foundation of dust management at CVM.

As part of a continual improvement plan for CVM, operational dust management decisions is being improved through:

- The upgrading of the DCS to include improved sensor data analysis and proactive dust mitigation functionality.
- The recent upgrade of the CVM ambient air monitoring network to include 2D ultra sonic sensors for improved data reliability under light wind conditions.
- The commissioning of temperature inversion towers for the improved detection and response to high risk environmental conditions.
- Studies investigating the optimisation of the 90 day and/or 5 year mine schedules in order to reduce the inherent risk due to planned mining activity/location/intensity thereby decreasing the residual burden of the management of dust risk on a day to day basis by operations.

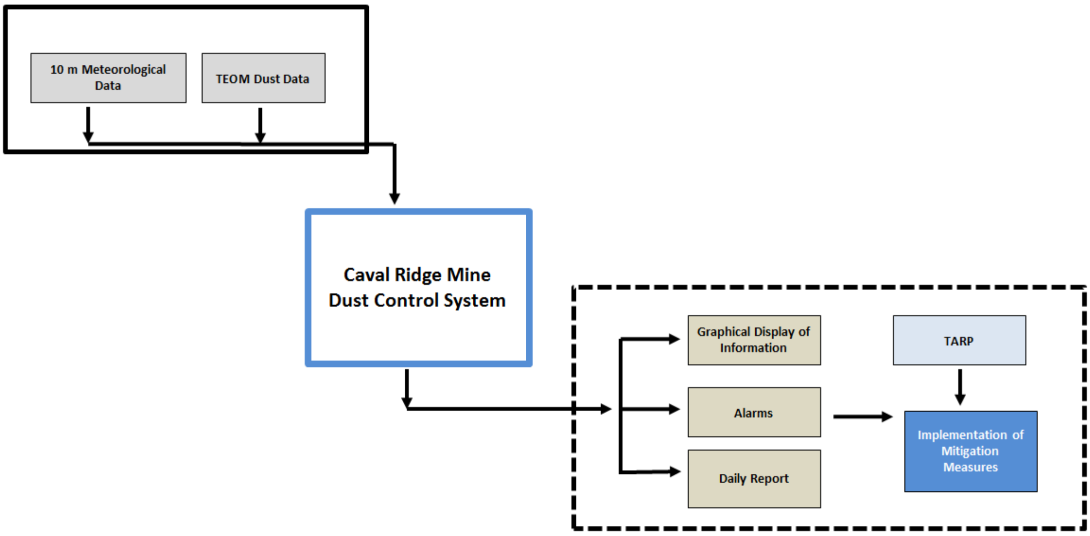
4.1 The CVM Dust Control System

As previously noted, the DCS forms an integral part of dust management at CVM. Commissioned in c. 2014, the CVM DCS has historically been based solely on the interpretation of a range of field sensor data from the ambient air monitoring stations (Figure 10).

The partitioning of the continuous PM_{10} (TEOM) 5-minute average data based on wind angles formed the basis of an estimate of background levels of dust by the DCS. Data eligibility for use in the background estimate was informed by a critical wind speed cut off value below which the wind direction data was considered to be unreliable. By default, the DCS allocated mine contribution as the difference between the background estimate and the local PM_{10} measurement.

The CVM DCS alarming procedure includes trigger levels based on the calculated mine contribution. The associated range of mitigation measures/strategies/requirements is outlined in the site's TARP. Dust mitigation measures/actions that are required to be implemented under the CVM TARP range from the raising of awareness to the cessation of mining activities.

Figure 10: CVM DCS (2014) High Level Flow Diagram



4.2 Site Mitigation Options

Specific dust mitigation measures incorporated into the TARP include (but may not be limited to):

- Truck/Excavator/Shovel Operations:
  - Prioritise water carts to high dust emitting operations
  - Ensure all available watercarts are being used, hot seat water carts and reduce grading to only essential work
  - Reduce vehicle speeds to reduce visible dust
  - Reduce number of active trucks
  - Change dig/dump method
  - Cessation of activities

- Dragline:
  - Ensure drop height does not exceed 6m
  - Partial filling of dragline bucket (below crest)
  - Avoid over-dragging the bucket during fill
  - Lift bucket cleanly away from the face, and hoist up with minimum spillage
  - When emptying the bucket, restrict the drop height as far as practical and especially during windy conditions
  - Ongoing visual monitoring for dust emissions by trained personnel, with operations modified or stopped to restrict visible dust from leaving the mine site
  - Avoid bucket rotation during emptying
  - Cessation of activities
- Dozer Push/Grader:
  - Relocate dozer to sheltered area and modify task to lower emission activity
  - Cessation of activities
- Drill and Blast:
  - Drill rigs will be equipped with effective dust suppression systems which are available and activated during drilling.
- Coal Mining:
  - Prioritise water carts to areas generating dust
  - Drive to conditions
  - Minimise haul distances and traffic volumes
  - Maintain a consistent profile of loaded material to reduce spillage and the potential for wind entrainment of material being hauled
  - Cessation of activities
- CHPP and Stockpile Coal:
  - Visual inspection
  - Water sprays on stacker/reclaimer units
  - Dust suppression sprays on all transfer points where conveyors are running

- Operation of fogging systems on outlets from sizing stations

4.3 CVM DCS Upgrade Project

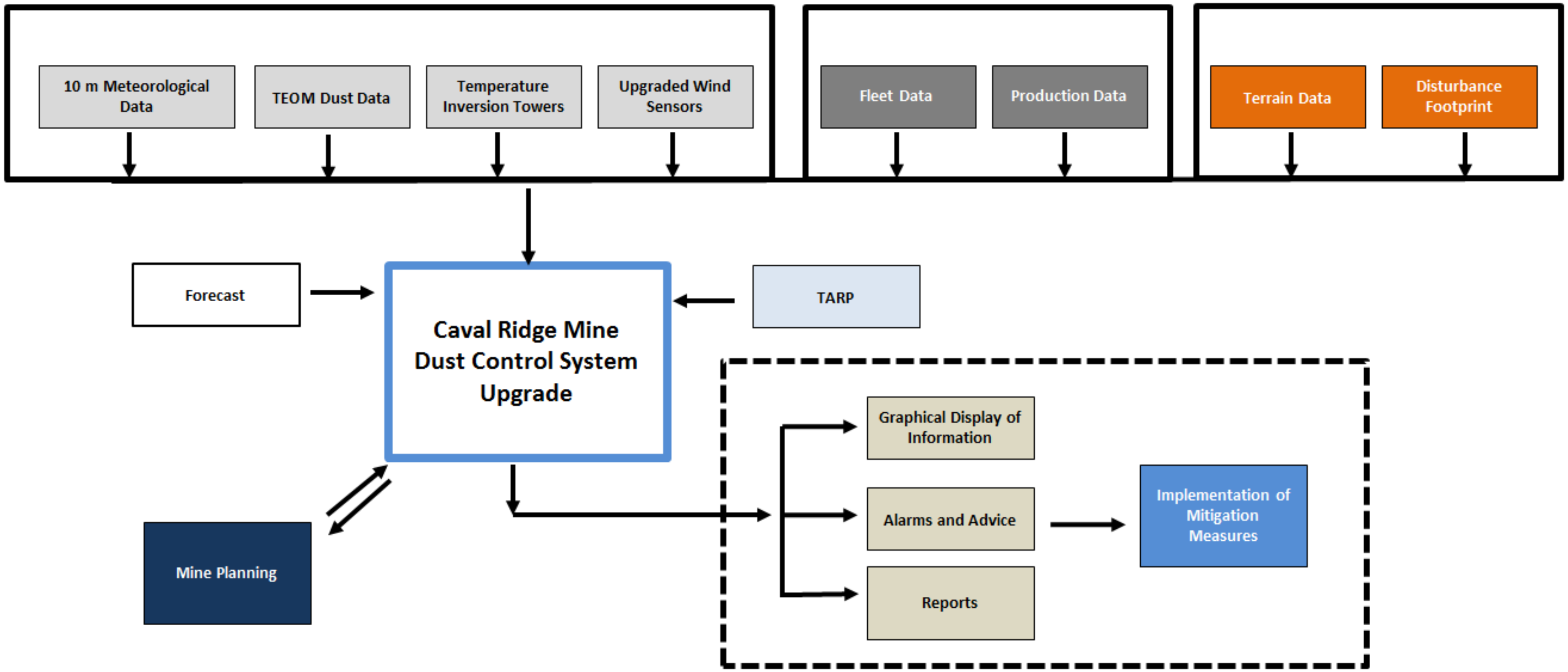
One of the key limitations of the DCS identified by BMA was the solely reactive nature of the system with no supporting information provided by the DCS in relation to the key source(s) of dust or when to implement actions.

In recognition of the need for an improved correlation between the implementation of mitigation actions and environmental outcomes, the CVM DCS Upgrade Project commenced in 2021 with the DCS scheduled to undergo a significant upgrade and expansion of key functionality including:

- Improved sensor data analysis.
- Use of 2D ultrasonic wind sensors to improve wind direction data reliability under low wind speed conditions.
- New methodology for calculating regional, local and site background dust levels.
- Improved representation of mine contribution estimates based on sensor data.
- Interpretation of detailed mine activity and production information to inform estimates of mine contribution and source identification.
- Use of weather forecast data to inform proactive dust management.
- Inclusion of temperature and wind data obtained at 10 m intervals on c. 50 m towers to monitor the development of low level temperature inversions and inform the DCS trigger levels.

One of the key goals of the upgrade to the DCS is to shift the basis of the system from solely reactive to increasingly proactive.

Figure 11: CVM DCS Upgrade Project High Level Flow Diagram



5. Overview of Assessment Methodology

5.1 Dust Emission Sources

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

- 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
- Activities associated with the transport of coal via conveyor from PDM to the CVM CHPP for processing.

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)
- 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.

5.2 Dust Emission Scenarios

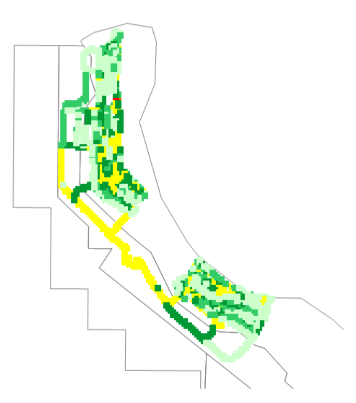
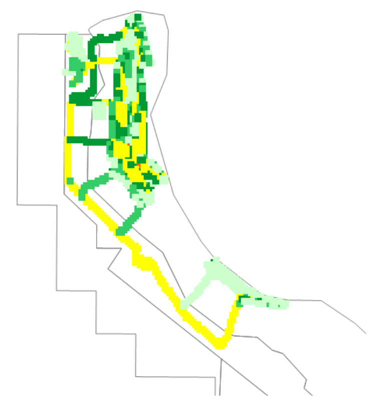
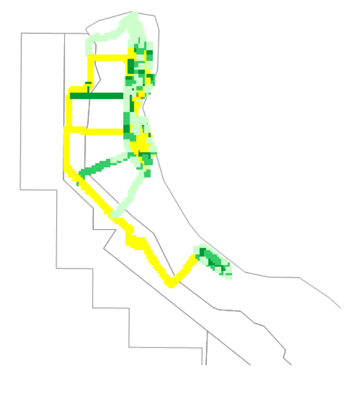
Two mining scenarios for the Project based on Business as Usual (BAU) dust management practices have been assessed:

- **Project Without (BAU) Case:** The mining of Caval Ridge Mine as permitted under current mining approvals; and
- **Project With (BAU) Case:** The mining of Caval Ridge Mine that includes the Horse Pit Extension 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, truck and shovel and dozer activities for the Project With (BAU) case are provided in Figure 12.

Additionally, a series of mitigation scenarios have also been investigated for the Project With (BAU) case (Section 6.7). 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 access of BAU practices.

Figure 12: Project With (BAU) Case: Dragline and Truck & Shovel Activities

FY30	FY40	FY50
		

5.3 Dust Management and Reduction Measures

As discussed in Section 4, compliance with EA conditions is managed in accordance with CVM's Environmental Management Plan which is informed by the DCS and TARP.

In practice, routine dust control focuses on the application of water for dust suppression i.e. on haul routes, at ROM dumps, whilst crushing etc. Additional dust reduction measures such as those outlined in Section 4.2 are implemented as required based on the information available to operations (e.g. via the DCS) at the time when conditions at a monitoring station(s) suggest that an alteration to activities is required.

Dust reduction measures that have been incorporated into the dust dispersion modelling include and are limited to:

- Watering of haul roads of more than 2 litres/m^2/hour (i.e. level 2 watering);
- The limiting of the dragline drop height to 6 m.
- Use of water sprays at the ROM dump
- Use of water sprays whilst crushing
- Use of variable height stacker
- Use of water sprays on stockpiles

5.4 Dust Emissions Inventory

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

For this assessment, the NPI Emission Estimation Technique Manual 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 on the mine site 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.

5.4.1 The Project Without (BAU) Case

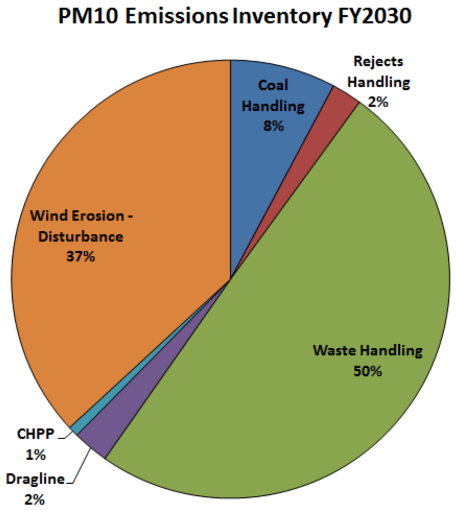
The PM_{10} and TSP emissions inventory for the Project Without (BAU) case for selected years of mining is presented in Table 7.

The breakdown of the emissions inventory by activity Figure 13 highlights waste handling and wind erosion as key sources of dust.

Table 7: Project Without (BAU) Case: Emissions Inventory for Selected Years of Mining

Activity	Units	FY2030	FY2040	FY2050
PM10				
Coal Handling	kg/year	565,995	-	-
Rejects Handling	kg/year	162,135	-	-
Waste Handling	kg/year	3,613,112	-	-
Dragline	kg/year	192,595	-	-
CHPP	kg/year	55,699	-	-
Wind Erosion - Disturbance	kg/year	2,678,808	-	-
Subtotal (No WSD)		4,589,536	-	-
Total		7,268,344	-	-
TSP				
Coal Handling	kg/year	1,796,981	-	-
Rejects Handling	kg/year	597,230	-	-
Waste Handling	kg/year	10,525,409	-	-
Dragline	kg/year	832,166	-	-
CHPP	kg/year	132,071	-	-
Wind Erosion - Disturbance	kg/year	5,357,616	-	-
Subtotal (No WSD)		13,883,856	-	-
Total		19,241,472	-	-

Figure 13: Project Without (BAU) Case: Breakdown of Emissions Inventory



5.4.2 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 8.

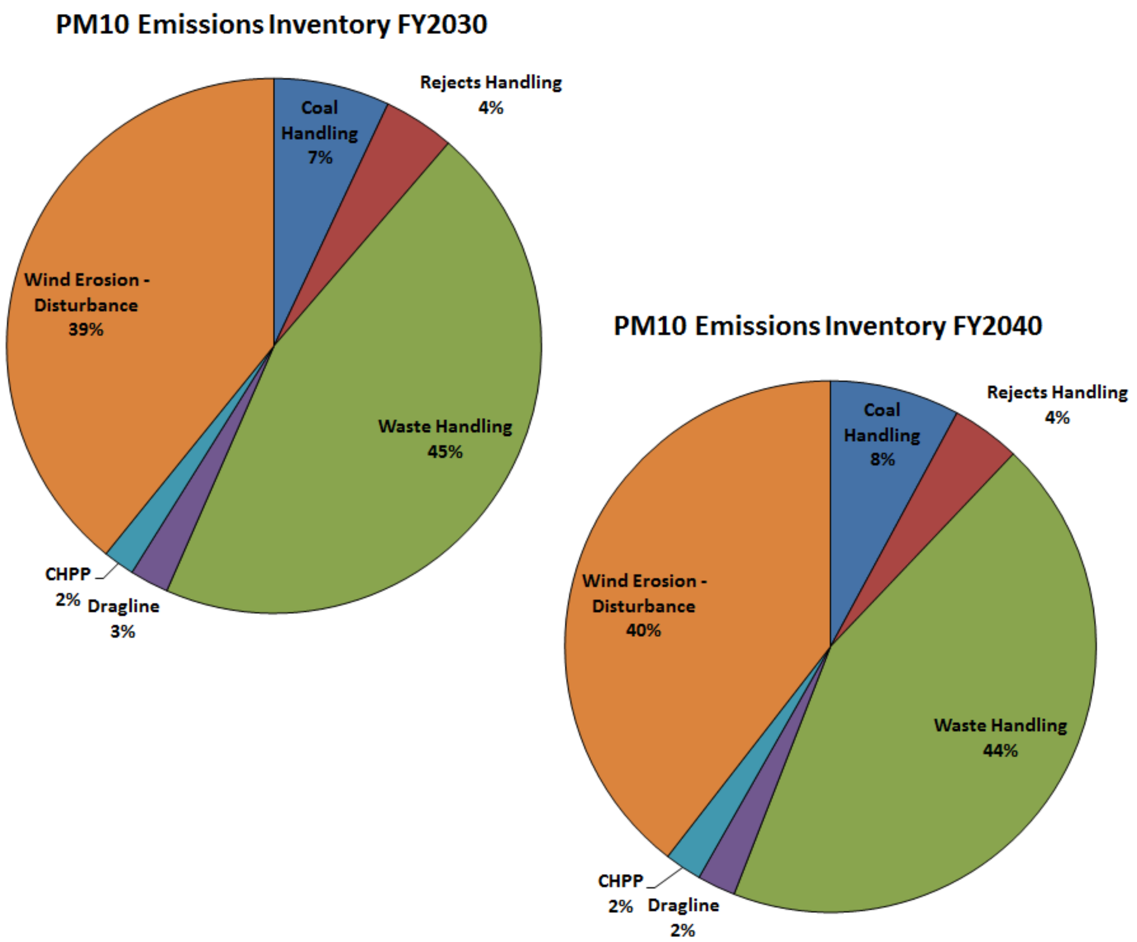
The breakdown of the emissions inventory by activity presented in Figure 14 highlights waste handling and wind erosion as key sources of dust.

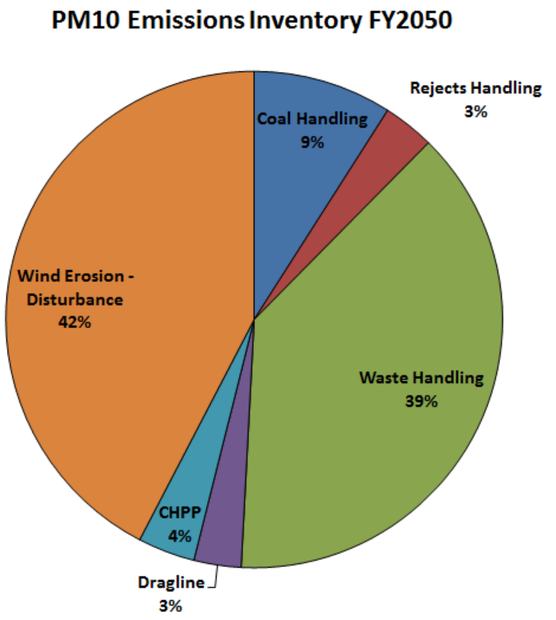
Table 8: Project With (BAU) Case: Emissions Inventory for Selected Years of Mining

Activity	Units	FY2030	FY2040	FY2050
PM10				
Coal Handling	kg/year	551,749	522,141	363,792
Rejects Handling	kg/year	338,368	277,196	134,960
Waste Handling	kg/year	3,564,939	2,898,824	1,548,590
Dragline	kg/year	184,784	153,975	123,669
CHPP	kg/year	149,652	149,652	149,652
Wind Erosion - Disturbance	kg/year	3,085,272	2,612,232	1,706,448
Subtotal (no WSD)	kg/year	4,789,492	4,001,788	2,320,662
Total	kg/year	7,874,764	6,614,020	4,027,110

TSP				
Coal Handling	kg/year	1,734,589	1,680,279	1,184,815
Rejects Handling	kg/year	1,246,388	1,021,059	497,127
Waste Handling	kg/year	10,068,466	8,235,709	4,250,940
Dragline	kg/year	799,808	665,611	533,589
CHPP	kg/year	396,454	396,454	396,454
Wind Erosion - Disturbance	kg/year	6,170,544	5,224,464	3,412,896
Subtotal (no WSD)	kg/year	14,245,705	11,999,111	6,862,926
Total	kg/year	20,416,249	17,223,575	10,275,822

Figure 14: Project With (BAU) Case: Breakdown of Emissions Inventory




PM10 Emissions Inventory FY2050
Rejects Handling
3%
Coal Handling
9%
Wind Erosion -
Disturbance
42%
Waste Handling
39%
CHPP
4%
Dragline
3%

5.5 Dispersion Modelling Methodology

Regional, 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 12 with additional figures provided in Appendix D.

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

5.5.1 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 9.

Table 9: 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 of TSP and dust deposition masks the spatial and temporal variability particularly of these parameters e.g Figure 4.
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 Figure 8 is the monthly average number of rain days with rainfall greater than 1 mm based on data from the CVM Site 2 monitoring station for the period (2014 through 2020). The NPI EETM for Mining (Appendix 1.1.17) (NPI, 2012) suggests that each day with a rainfall

Category	Assumption	Implication and Comments
		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 in 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 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 there was no site-specific data 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 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.

Category	Assumption	Implication and Comments
Estimates of mine contribution	Mine contribution estimates are based on the analysis of background levels in accordance with the methodology outlined in AED (2020).	The methodology outlined in AED (2020) for calculating background levels of dust based on the CVM ambient air monitoring network has been used to estimate mine contribution to the 24 hour average concentration of PM_{10} at the location of the monitoring stations. By default, the mine contribution is the difference between the 24 hour average concentration and background levels.
Corrections for the dispersion model output for PM_{10}	The findings of the analysis based on c. 15 months of data are sufficiently robust for the purposes intended.	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 the CVM monitoring network including data from the site' temperature inversion towers. The exclusion of significant wind events was based on the limitations of the methodology for locations for which wind conditions are infrequently above the critical wind speed of 5.4 m/s.

6. 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 has included BAU dust management practices. Thus the results provide an indication of how frequently implementation of additional dust control measures as informed by the site's TARP 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 6.7.
- 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 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 an indication of the increased frequency by which additional dust management strategies may need to be implemented, and represents increased operational risk.
- Results of the dispersion modelling for PM_{10} have been corrected based on data from the ambient air monitoring stations (Section 6.3.1) and the MIA Tower. Due to the use of station-specific corrections, contour plots have not been presented as a single correction factor was not applied across the study area.
- Tabulated results are presented for the monitoring locations as compliance or otherwise with the site's EA Conditions are reported in relation to these locations.

6.1 Results for Dust Deposition

CVM EA Condition B5(a) specifies an objective for the monthly average dust deposition of 120 mg/m^2/day.

Presented in Table 10 are the results for the maximum monthly average dust deposition at the location of the monitoring stations. Results include a background level of 44 mg/m^2/day (Section 3.2).

The predicted number of exceedances of the EA Condition B5(a) objective for dust deposition is presented in Table 11. A result of 0.1 (for example Site 8, Project Without case) is interpreted as predicting one exceedance of the EA Condition B5(a) objective in 10 years of mining.

Table 10: The Maximum Monthly Average Dust Deposition (mg/m²/day)

Receptor	Project Without Case (BAU)				Project With Case (BAU)			
	FY30	FY40	FY50	Average LOM	FY30	FY40	FY50	Average LOM
Mine years assessed	1	-	-	18	1	1	1	36
Background	*44*	*44*	*44*	*44*	*44*	*44*	*44*	*44*
Site 2	101	-	-	61	86	106	96	84
Site 6	**150**	-	-	**122**	**131**	**165**	**127**	**123**
Site 8	87	-	-	75	71	**121**	**157**	96
Site 13	87	-	-	68	75	61	58	63
Site 15	112	-	-	94	104	71	63	80

Result highlight Site 6 as the highest risk location based on an average over the LOM with the Project Without (BAU) case predicted to be associated with on average 1.3 exceedances per year, increasing to 1.8 exceedances per year for the Project With (BAU) case (Table 11).

Table 11: Annual exceedances of the Monthly Average Dust Deposition (mg/m²/day)

Receptor	Project Without Case (BAU)				Project With Case (BAU)			
	FY30	FY40	FY50	Average LOM	FY30	FY40	FY50	Average LOM
Mine years assessed	1	-	-	18	1	1	1	36
Site 2	0	-	-	0	0	0	0	0
Site 6	4.0	-	-	**1.3**	0.8	4.0	1.2	**1.8**
Site 8	0	-	-	0	0	1.0	2.0	0.4
Site 13	0	-	-	0	0	0	0	0
Site 15	0	-	-	0	0	0	0	0

(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.)

6.2 Results for TSP

CVM EA Condition B5(b) specifies an objective for the annual average concentration of TSP of 90 µg/m^3. Presented in Table 12 are the results for the annual average concentration of TSP at the monitoring locations. Results presented in the Table include a background level of 39 µg/m^3.

Results suggest that there will be no significant change in operational risk associated with the Project with the average over the LOM for the Project With (BAU) case not differing significantly from that of the Project Without (BAU) case.

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

Table 12: The Annual Average Concentration of TSP (µg/m³)

Location	Project Without Case (BAU)				Project With Case (BAU)			
	FY30	FY40	FY50	Average LOM	FY30	FY40	FY50	Average LOM
Mine years assessed	1	-	-	18	1	1	1	36
Background	*39*	*39*	*39*	*39*	*39*	*39*	*39*	*39*
Site 2	68	-	-	56	60	70	66	59
Site 6	**96**	-	-	74	79	**99**	82	78
Site 8	53	-	-	61	54	69	76	60
Site 13	52	-	-	62	55	49	46	49
Site 15	73	-	-	62	66	55	50	57

Table 13: The Predicted Number of Exceedances of the Annual Average Concentration of TSP of 90 µg/m^3

Location	Project Without Case (BAU)				Project With Case (BAU)			
	FY30	FY40	FY50	Average LOM	FY30	FY40	FY50	Average LOM
Mine years assessed	1	-	-	18	1	1	1	36
Site 2	0	-	-	0	0	0	0	0
Site 6	**1**	-	-	**0.11**	0	**1**	0	**0.14**
Site 8	0	-	-	0	0	0	0	0
Site 13	0	-	-	0	0	0	0	0
Site 15	0	-	-	0	0	0	0	0

6.3 Results for PM_{10}

The results presented in this section focus on quantifying changes in operational risk attributable to the Project in relation to the EA Condition B6 of 50 µg/m^3 for the 24 hour average concentration of PM_{10}.

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

Model output correction factors were developed to account for differences in the identified relationships between the strength of low level temperature inversions (i.e. from ground level to c. 60 m high):

- And predicted dust impacts based on output from the CALPUFF dispersion model;
- And dust impacts based on c. 15 months' worth of observational data (17.02.2021 through 30.06.2022) from the CVM MIA Tower, Site 2, Site 8 and Site 13 monitoring stations.

6.3.2 Results based on the Corrected Dispersion Model Output

Presented in Table 14 are the results for the maximum mine contribution to the 24 hour average concentration of PM_{10} at the location of the monitoring stations based on the model output correction methodology developed for PM_{10} .

Results for three specific years of mining are included as well as an average over the life of mine i.e. 18 years of mining for the Project Without (BAU) case and 36 years for the Project With (BAU) case.

A summary of results for the predicted number of exceedance days is presented in Table 15.

Table 14: The Maximum 24 Hour Average Concentration of PM_{10} ($\mu g/m^3$)

Location	Project Without (BAU) Case				Project With (BAU) Case			
	FY30	FY40	FY50	Average LOM	FY30	FY40	FY50	Average LOM
Number of mine years	1	-	-	18	1	1	1	36
Site 2	**62**	-	-	38	49	57	46	41
Site 6	**87**	-	-	**53**	65	89	74	**59**
Site 8	47	-	-	36	34	63	83	44
Site 13	44	-	-	24	29	29	23	23
Site 15	**54**	-	-	39	52	52	36	42

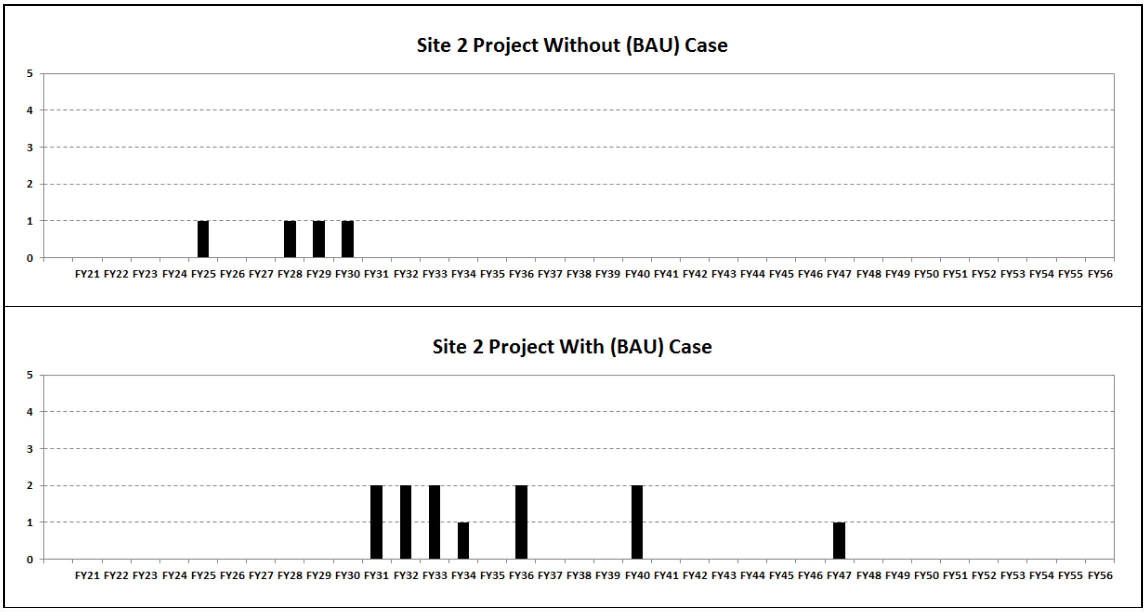
Table 15: The Predicted Number of PM_{10} Exceedance Days

Location	Project Without (BAU) Case					Project With (BAU) Case				
	FY30	FY40	FY50	Avg/yr LOM	Total LOM	FY30	FY40	FY50	Avg/yr LOM	Total LOM
Number of mine years	1	-	-	18	18	1	1	1	36	36
Site 2	1	-	-	0.2	4	1	8	2	1.4	12
Site 6	10	-	-	2.4	43	3	12	4	3.9	142
Site 8	0	-	-	0.2	4	0	2	8	1.4	50
Site 13	0	-	-	0	0	0	0	0	0	0
Site 15	2	-	-	0.6	11	1	1	0	0.5	18

Presented in Figure 15 through Figure 19 are plots of the number of predicted PM_{10} exceedance days for each year of the life of the mine for both the Project Without (BAU) case and the Project With (BAU) case.

Results for Site 2 (Long Pocket Road east) presented in Figure 15 suggest a marginal increase in the number of exceedance days per year (from c. 1 to c. 2) that will have to be managed by operations as a result of the Project. To date, mining operations at CVM have not been significantly impacted by dust levels at this location.

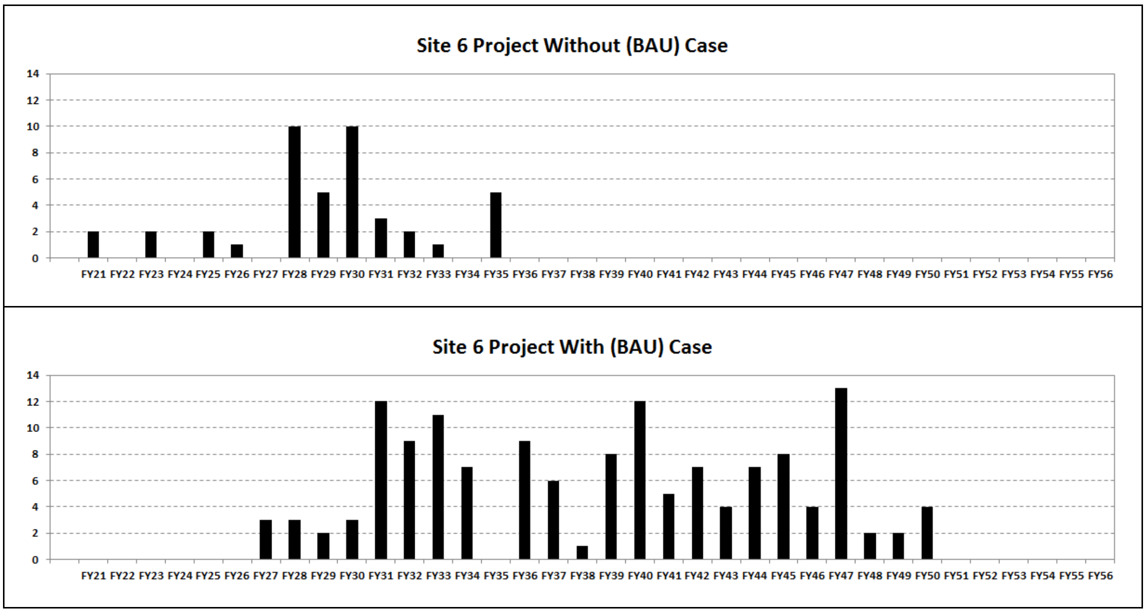
Figure 15: Site 2 Variation in Predicted Exceedance Days over the LOM



Results presented in Figure 16 for Site 6 (Long Pocket Road west) suggest that the peak predicted number of dust exceedance days is comparable between the two cases with just the duration for which additional operational dust management strategies may need to be implemented, extending for a longer period due to the Project. It is further noted that for both cases, dust risk levels are predicted to increase from c. 2 exceedance day per year to c. 12 exceedance days in c. 7 to 10 years.

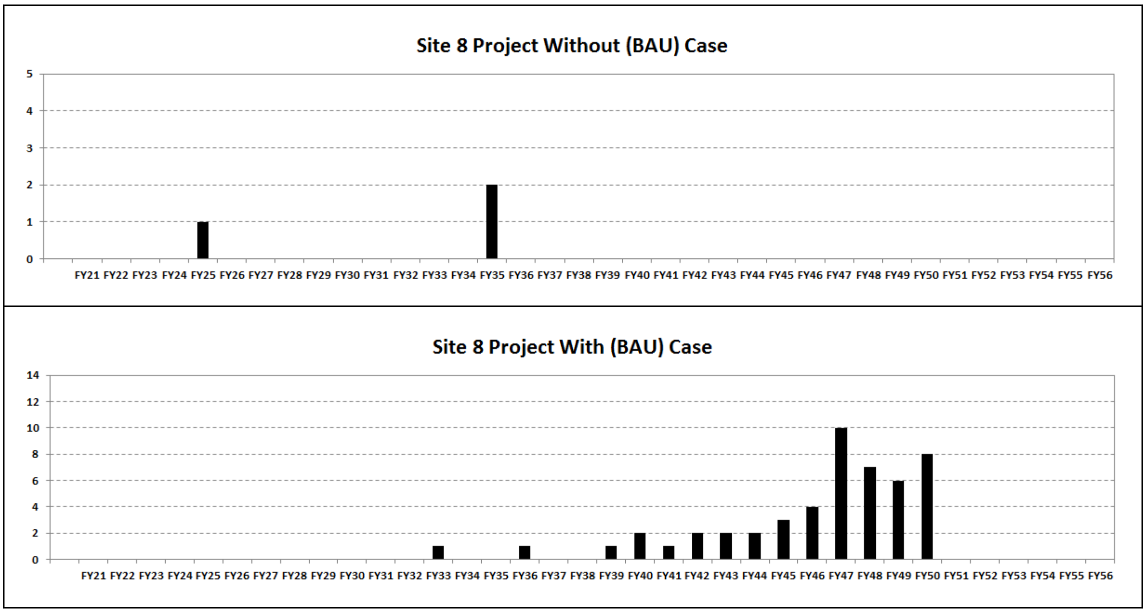
Results presented in Table 14 for the maximum 24 hour average concentration of PM_{10} suggest that the magnitude of the predicted exceedance days in both cases is comparable. This suggests that a similar level of operational dust management strategies will be required to be implemented in order to comply with the EA Condition B6 objective for both cases.

Figure 16: Site 6 Variation in Predicted Exceedance Days over the LOM



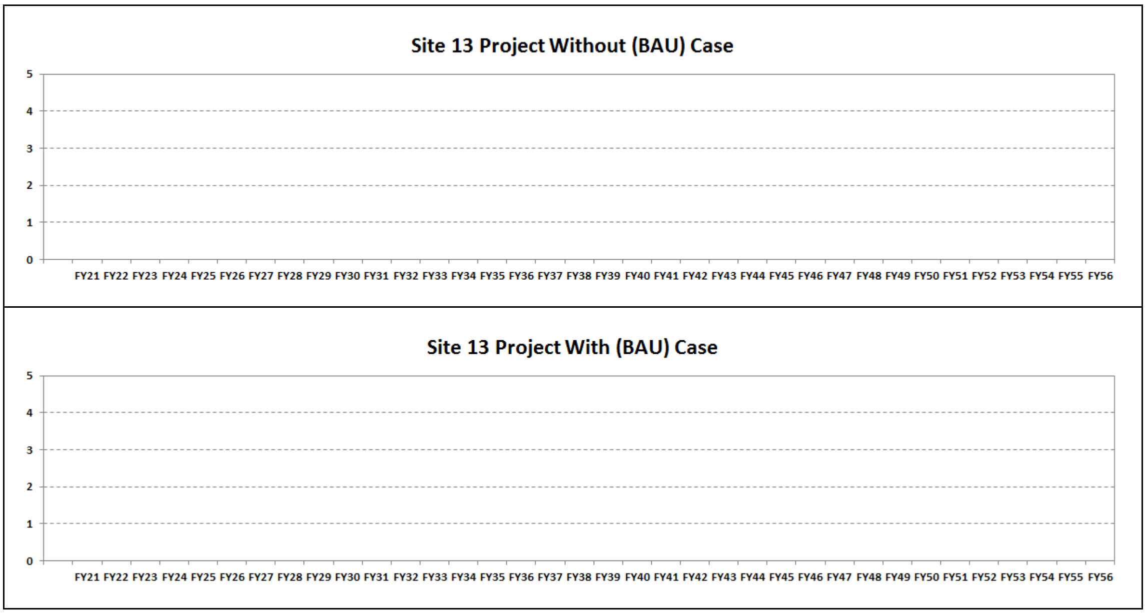
Results presented in Figure 17 for Site 8 (Moranbah Airport) suggest a slight increase in operational dust risk due to dust levels at this location towards the end of the life of the Project. As mining activities progress eastward the number of dust exceedance days per year is predicted to peak at c. 10 for the BAU case.

Figure 17: Site 8 Variation in Predicted Exceedance Days over the LOM



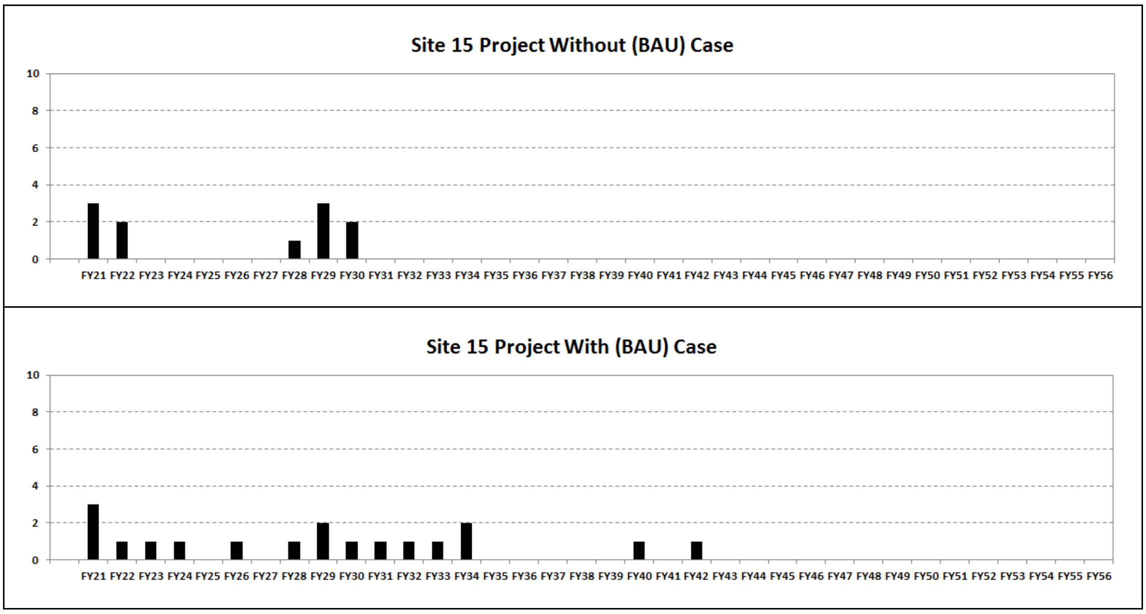
Results presented in Figure 18 for Site 13 (background site) suggest that potential changes to operational risk will be immaterial over the life of the project.

Figure 18: Site 13 Annual Variation in Predicted Exceedance Days over the LOM



Results presented in Figure 19 for Site 15 (BMA Buffel Park Accommodation Village) suggest comparable levels of operational risk associated with both cases.

Figure 19: Site 15 Variation in Predicted Exceedance Days over the LOM



6.4 Summary of Results for the BAU Cases

Presented in Table 16 is a summary of the average number of predicted exceedances per year of the relevant CVM EA condition objectives.

For the Project Without (BAU) case, the values presented are based on an average of the total number of exceedances predicted for each of the 18 years of mining assessed, with 36 years of mining informing the values presented for the Project With (BAU) case.

When interpreting the results presented in the table, the value of 1.4 for the PM_{10} Project With (BAU) case for Site 2 (for example) is interpreted as (on average over the LOM) a total of 14 exceedance days per every 10 years of mining is suggested.

Table 16: Average Number of Predicted Dust Exceedances per Year over the LOM

Location	TSP		PM_{10}		Dust deposition	
	Without	With	Without	With	Without	With
Number of mine years assessed	18	36	18	36	18	36
Site 2	0	0	0.2	1.4	0	0
Site 6	0.11	0.14	2.4	3.9	1.3	1.8
Site 8	0	0	0.2	1.4	0	0
Site 13	0	0	0	0	0	0
Site 15	0	0	0.6	0.5	0	0

Presented in Table 17 is a summary of the results for the average over the LOM of the maximum value of the relevant EA Condition objective, i.e. 18 years for the Project Without Case and 36 years for the Project With Case.

When interpreting the results presented in the table, the value of 59 for the PM_{10} Project With (BAU) case for Site 6 (for example,) is interpreted as: *on average over the LOM, a maximum value of 57 µg/m^3 for the mine contribution to the 24 hour average concentration of PM_{10} is suggested by the results of the dispersion modelling*.

Table 17: The Average of the Maximum over the LOM

Location	TSP		PM_{10}		Dust deposition	
	Without	With	Without	With	Without	With
Number of mine years assessed	18	36	18	36	18	36
Averaging period	annual	annual	24 hour	24 hour	Monthly	Monthly
Units	µg/m³	µg/m³	µg/m³	µg/m³	mg/m²/day	mg/m²/day
Background level	39.4	39.4	na	na	43.6	43.6
EA Condition Objective	90	90	50	50	120	120
Site 2	56	59	38	41	61	84
Site 6	74	78	**53**	**59**	**122**	**123**
Site 8	61	60	36	44	75	96
Site 13	62	49	24	23	68	63
Site 15	62	57	39	42	94	80

Notes: na – not applicable. Mine contribution only.
: values in bold exceed the relevant EA Condition Objective

In general, when interpreting results presented in the tables, the difference between the values presented for the Project With (BAU) case and the Project Without (BAU) case is attributable to the Project with the magnitude of the difference between the values indicative of the average increase or decrease operational risk over the life of the mine.

Results of the assessment suggest that dust impacts at the location of the Site 6 monitoring station pose the most operational risk to CVM for both cases.

6.5 Correlation with Neighbouring Receptor Locations

Presented in Table 18 are the results from the dispersion modelling for the Site 2, Site 6 and Site 8 monitoring stations as well as for a selection of receptors located at the Airport, on Long Pocket Road, on Railway Siding Road and/or on the fringe of Moranbah (Figure 20). Results presented in the table include:

- The average (over the LoM) of the maximum 24 hour average concentration of PM_{10} for comparison against EA Condition B6 for each monitoring station location and each of the noted receptors.

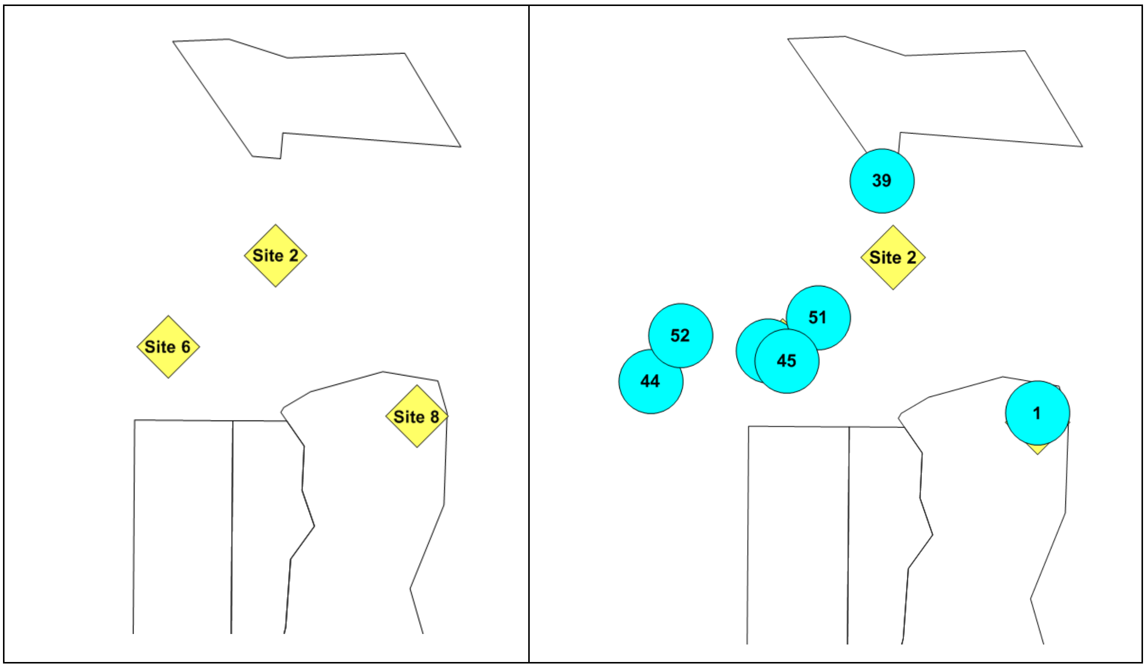
- The average (over the LoM) of the predicted number of exceedances per year of the EA Condition B6 objective for each monitoring station location and each of the relevant receptors.
- The percentage difference values presented in the table highlight the increase/decrease in predicted impacts compared to those for the "representative" monitoring station. Values in green font are improved outcomes relative to the 'representative" station, whilst those presented in red font indicate a worse outcome (on average over the LoM).

Results suggest that the management of dust emissions in accordance with EA Condition B6 requirements as indicated by dust levels recorded at the location of the CVM monitoring stations and as demonstrated in Section 6.7 will be sufficient to manage dust risk at the noted receptor locations.

Table 18: Project With (BAU) Case: Results for the 24 Hour Average Concentration of PM_{10}

Location	Reference Monitoring Station	Description	Average of 24 Hour Maximum PM_{10} (LoM) LoM	Average Number of EA Exceedance Days per year (LoM)	Percentage Difference in the Average Maximum (LoM)
Site 8	Site 8	Monitoring station	43	**1.4**	n/a
R1	Site 8	Airport	41	**1.0**	**-5%**
Site 2	Site 2	Monitoring station	41	**1.4**	n/a
R39	Site 2	Commercial	26	0.0	**-36%**
Site 6	Site 6	Monitoring station	**59**	**3.9**	n/a
R44	Site 6	Railway Siding Road	**53**	**1.9**	**-11%**
R45	Site 6	Long Pocket Road	**61**	**4.7**	**+3%**
R50	Site 6	Long Pocket Road	**59**	**3.9**	**+1%**
R51	Site 6	Long Pocket Road	**51**	**2.3**	**-14%**
R52	Site 6	Railway Siding Road	47	**1.1**	**-21%**

Figure 20: Monitoring Stations and Selected Receptor Locations and IDs



6.6 Key Drivers of PM_{10}

In order to develop an understanding of the nature and extent to which additional mitigation measures (i.e. in excess of BAU dust management practices) may be required in order to achieve compliance with EA condition B6 objective for 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 21 is a summary of the identified key drivers at the location of the Site 2, Site 6 and Site 8 monitoring stations for the Project With (BAU) case based on an average over the life of the mine.

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.

Note that these findings are not unexpected as waste handling by truck and shovel mining methods was found to be the most significant contributor to the site based emissions inventory (Section 5.4.2)

Additional results for selected years of mining (Table 19) highlight the relative consistency of these findings over the life of the mine.

Figure 21: Project With (BAU) Case: Key Drivers based on an Average over the Life of the Mine

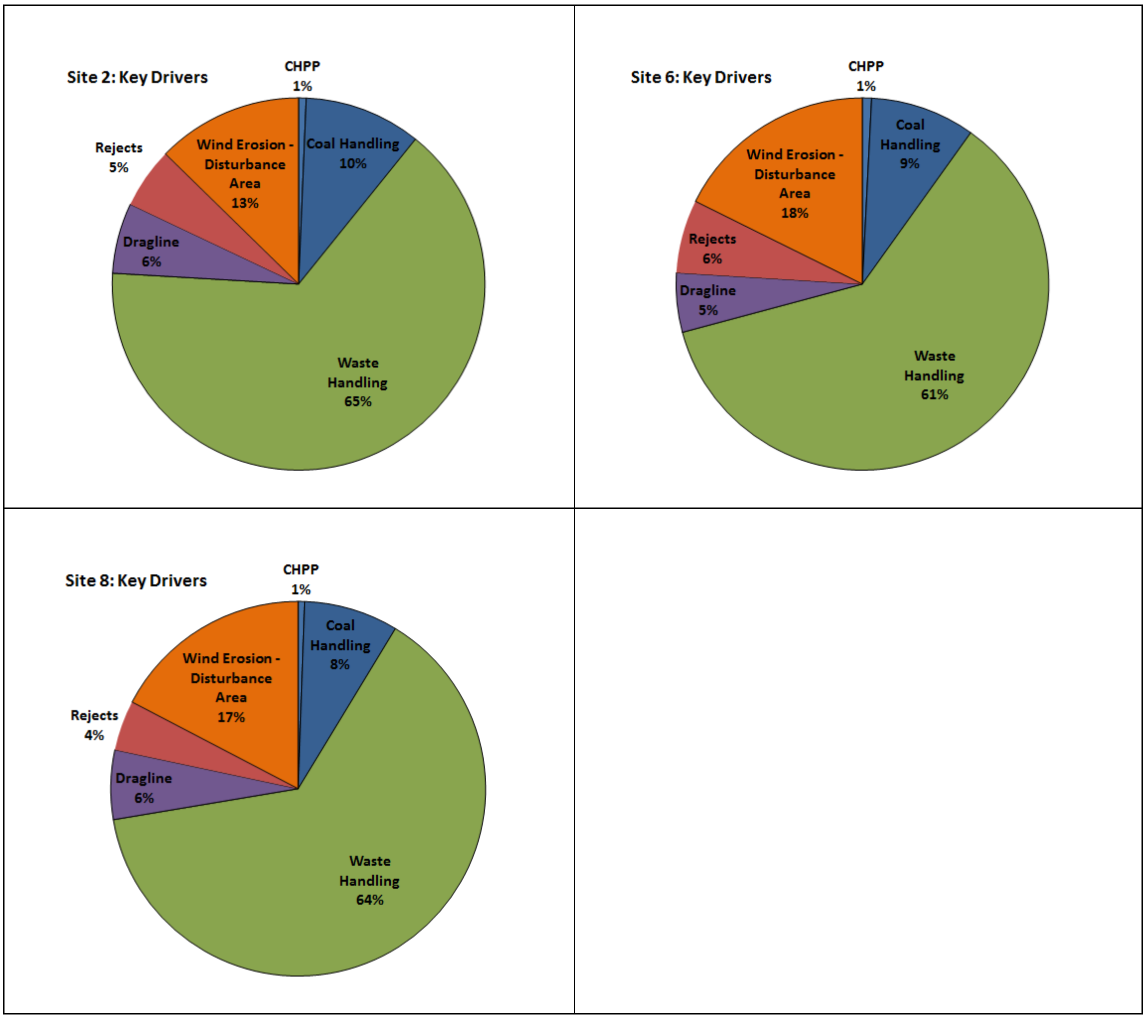


Table 19: Source Contributions to Worse Case 24 Hour Average Concentration of PM_{10} for Selected Years of Mining

Station	Source	LoM	FY2030	FY2040	FY2050
Site 2	CHPP	1%	0%	1%	1%
	Coal Handling	10%	8%	11%	11%
	Waste Handling	65%	67%	64%	55%
	Dragline	6%	4%	5%	8%
	Rejects	5%	13%	5%	6%
	Wind Erosion - Disturbance Area	13%	8%	15%	18%
Site 6	CHPP	1%	1%	1%	1%
	Coal Handling	9%	8%	9%	9%
	Waste Handling	61%	60%	60%	61%
	Dragline	5%	4%	5%	8%
	Rejects	6%	13%	6%	8%
	Wind Erosion - Disturbance Area	18%	14%	20%	13%
Site 8	CHPP	1%	1%	0%	1%
	Coal Handling	8%	6%	8%	12%
	Waste Handling	64%	62%	64%	67%
	Dragline	6%	4%	5%	6%
	Rejects	4%	8%	4%	5%
	Wind Erosion - Disturbance Area	17%	19%	19%	10%

6.7 Modelled Mitigation Scenarios

Results presented in Section 6.6 highlighted waste material handling by truck and shovel mining methods as being the key driver to predicted impacts at Site 2, Site 6 and Site 8. Therefore 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 20.

It is noted that the percentage reduction for the scenarios listed in the table may be achieved using one or more of a combination of dust mitigation options (which in practice will be informed by the TARP) 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 20 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.

(Note that in practice high risk areas and high risk days will be as identified by the DCS.)

Table 20: Project With (BAU) Case - Mitigation Scenarios

Scenario	Description	Comments
25% Reduction in Waste Material Handling	• A reduction in 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
50% Reduction in Waste Material Handling	• A reduction in 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
75% Reduction in Waste Material Handling	• A reduction in 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

Scenario	Description	Comments
100% Reduction in Waste Material Handling	• 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.

6.7.1 Results from the Mitigation Scenarios

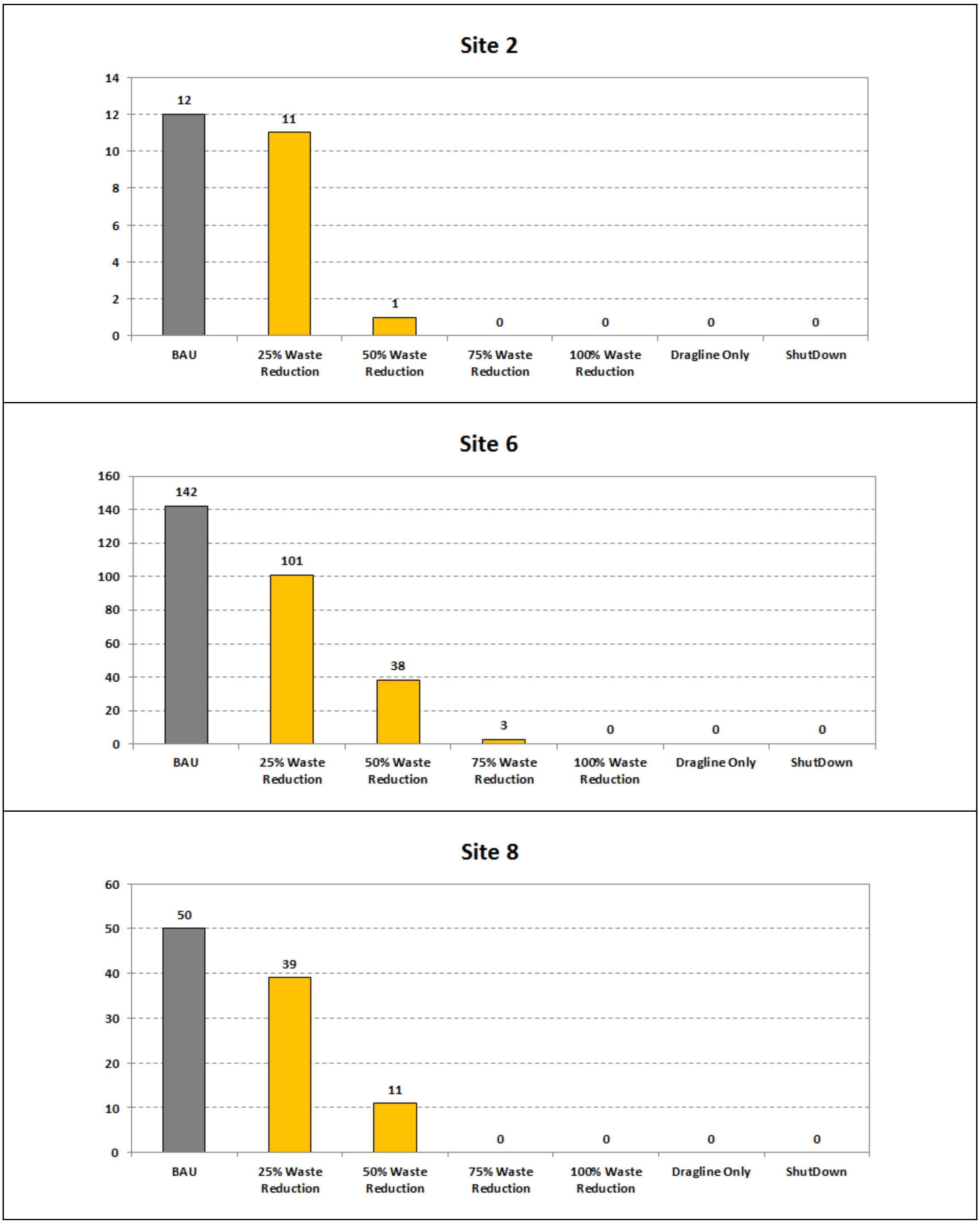
Presented in Figure 22 are the results from the dispersion modelling for the PM_{10} mitigation scenarios as outlined in Table 20 highlighting the extent to which additional dust control measures are predicted to be required to mitigate EA Condition B6 exceedance days. When interpreting the results presented in the figure, the following are noted:

- The number above the grey column associated with the BAU case indicates the total number of exceedances of the CVM EA condition B6 that are predicted to occur over the LoM.
- The value above the remaining columns highlights the number of exceedances days that are **mitigated** by implementing the noted mitigation measure when required.
- For example, 12 exceedance days are predicted to occur in total over the LOM at the location of the Site 2 monitoring station. A total of 11 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. The remaining exceedance day is predicted to be mitigated through the implementation of a strategy that is associated with a 50% reduction in waste handling by truck and shovel.

Results suggest that the range of mitigation measures available to site (as informed by the TARP) will be sufficient to adequately manage operational dust risk in accordance with CVM's current EA requirements.

The extent to which mitigation measures are required to achieve compliance with EA Condition B6 is referred to herein as the Project With (Fully Mitigated) case.

Figure 22: Mitigation of Predicted EA Condition B6 Exceedance Days (Total over LOM)



6.7.2 Summary of Results for the Project With Cases

Presented in

Table 15 is a comparison of the predicted number of EA Condition B6 (PM_{10}) exceedance days for the Project With (BAU) case (Section 6.4), and the Project With (Fully Mitigated) case for the mitigation scenarios presented in Section 6.7.

Results presented in the table suggest that the range of mitigation measures available to site (as informed by the TARP) will be sufficient to adequately manage operational dust risk in accordance with CVM's current EA requirements.

Table 21: The Predicted Number of PM_{10} Exceedance Days (EA Condition B6)

Location	Project With (BAU) Case					Project With (Fully Mitigated) Case	
	FY30	FY40	FY50	Avg/yr LOM	Total LOM	Avg/yr LOM	Total LOM
Number of mine years	1	1	1	36	36	36	36
Site 2	1	8	2	1.4	12	0	0
Site 6	3	12	4	3.9	142	0	0
Site 8	0	2	8	1.4	50	0	0
Site 13	0	0	0	0	0	0	0
Site 15	1	1	0	0.5	18	0	0

7. Conclusion

AED has undertaken a dust assessment of Caval Ridge Mine's Horse Pit Extension Project in support of a major EA Amendment application. The objective of the assessment was to determine the change in operational risk attributable to the Project.

Of particular interest were predicted air quality impacts at the location of the CVM ambient air monitoring network as data collected at these locations inform compliance or otherwise with:

- EA Condition B5(a) objective of 120 $mg/m^2/day$ for the monthly average dust deposition;
- EA Condition B5(b) objective of 90 $\mu g/m^3$ for the annual average concentration of TSP; and
- EA Condition B6 objective 50 $\mu g/m^3$ for the mine contribution to the 24 hour average concentration of PM_{10}.

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

- **Project Without (BAU) Case:** The mining of Caval Ridge Mine 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 Caval Ridge Mine with the inclusion of the Horse Pit Extension project, extending the life of mine by an additional c. 20 years.

In order to demonstrate that the CVM dust management options are sufficient to meet its obligations under EA Condition B6, mitigation scenarios were investigated for the Project With (BAU) case. Results of 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 access of BAU practices.

Results of the assessment suggest that dust impacts due to mining operations will be able to be managed in accordance with CVM EA Condition B6 objective for PM_{10}.

Results of the assessment suggest that both the Project With (BAU) case and the Project Without (BAU) case may lead to potential infrequent exceedances of EA Condition B5 objectives for TSP and dust deposition. However, it is noted that quantification of the potential for improved TSP and dust deposition outcomes that may result in association with the mitigation scenarios that have been investigated in relation to PM_{10} has not been undertaken due in part to the significant differences in associated timescales i.e. 30 day average for dust deposition and annual average for TSP. Furthermore, the lack of a real time monitoring option for dust deposition means that the assessment of compliance (or otherwise) with EA condition B5(a) will not be able to be assessed in a manner which will allow for the development of alarms within the real time DCS. It is further noted that the dispersion model output correction methodology has only been applied to results for PM_{10}. Similar correction factors for TSP (in particular) and potential correction factors for dust deposition have not been developed as part of this assessment. However, it is reasonable to assume that the strict management of dust in accordance with EA Condition B6 will be associated with improved air quality outcomes for TSP and dust deposition as well.

As mining operations progress eastward, the findings of the assessment suggests that there will be a net increase in the frequency of alarms generated by the site's DCS and the requirement to implement additional dust mitigation strategies (e.g. Section 4.2) under the site's TARP.

The development and adherence to a strict continual improvement plan for CVM that includes key triggers for review and refinement of the plan will assist to minimise operational risk.

It is noted that the CVM DCS is currently undergoing an upgrade that includes the implementation of additional functionality designed to improve site's ability to manage dust more proactively.

No specific changes to the range of dust management strategies that form part of CVM's dust management practices that have been designed to meet current EA condition requirements are suggested as a result of Project-related air quality impacts.

Nonetheless, 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.

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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.

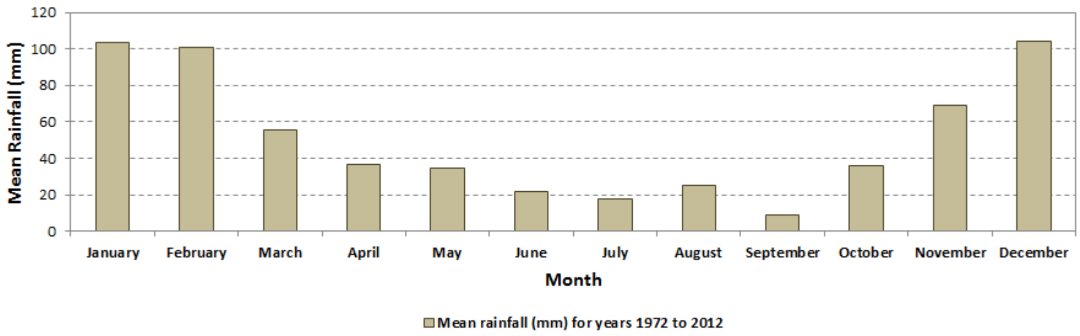
Data for long term climate statistics have been sourced from the Bureau of Meteorology (BoM) climate statistics for the Moranbah Water Treatment Plant. Monitoring commenced at this site in 1972 and ended in April 2012.

BoM data was supplemented by numerically simulated data developed using CALMET. The modelled data were used to generate hourly records of wind speed and wind direction, because the BoM data from the Moranbah Water Treatment Plant has only recorded these parameters twice daily: 9.00am and 3.00pm. Additionally, the numerically simulated data provide site-specific parameters that cannot be directly measured, such as stability class.

Rainfall Patterns

The mean annual rainfall at Moranbah is approximately 600 mm of which c. 50% is received between the months of November through to March. Monthly mean rainfall values for the period January 1972 through to March 2012 are presented in Figure 23.

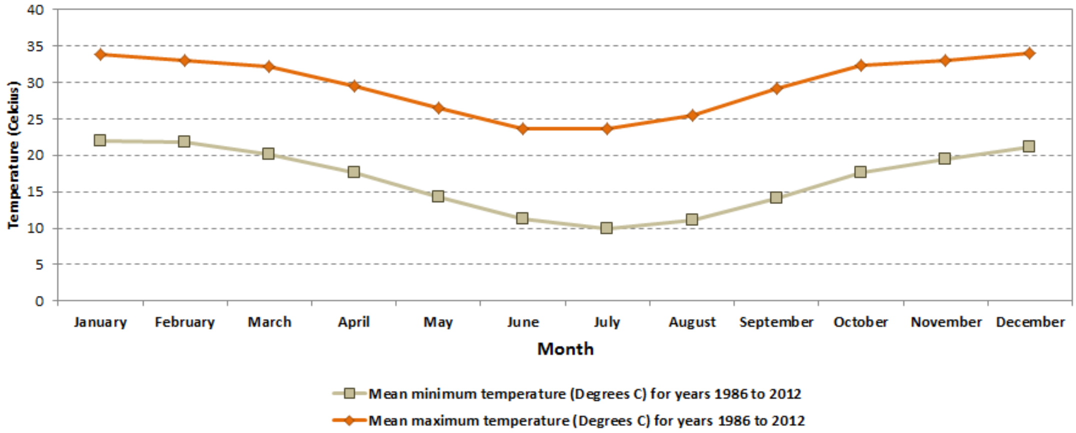
Figure 23: Mean Rainfall Statistics, Moranbah Water Treatment Plant (1972-2012)



Air Temperature

Long term ambient air temperature statistics for the mean maximum and mean minimum from Moranbah Water Treatment Plant suggest that the maximum daily temperatures in summer average between 33.1°C and 34°C, with overnight minimums averaging between 21.1°C and 21.9°C. During winter, the maximum daily temperatures average between 23.7°C and 25.5°C, with overnight minimums averaging between 9.9°C and 11.2°C (Figure 24).

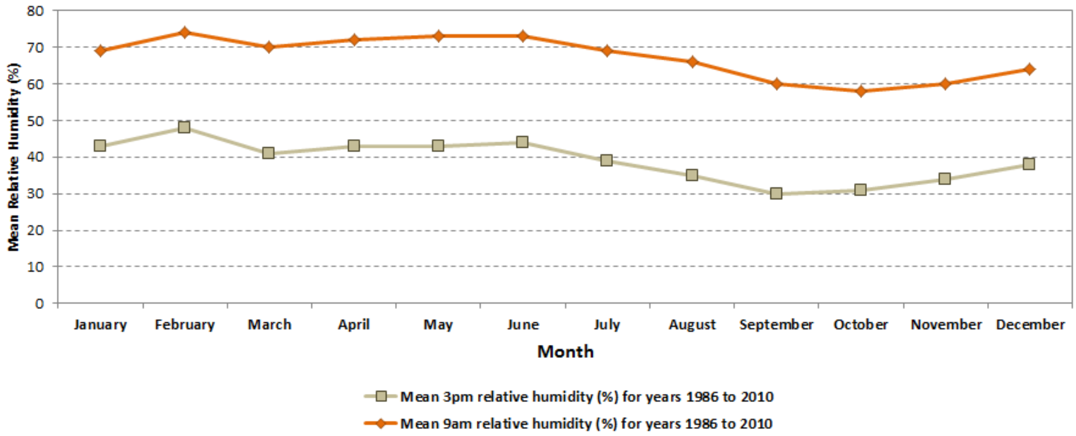
Figure 24: Mean Air Temperature Statistics, Moranbah Water Treatment Plant (1986-2012)



Humidity

The mean relative humidity measured at 9am and 3pm at the Moranbah Water Treatment Plant are presented in Figure 25. The mean monthly relative humidity at 9am ranges from 58% (in October) to 74% (in February). Records of mean relative humidity at 3pm indicate that humidity is lowest in September (30%) and highest in February (48%).

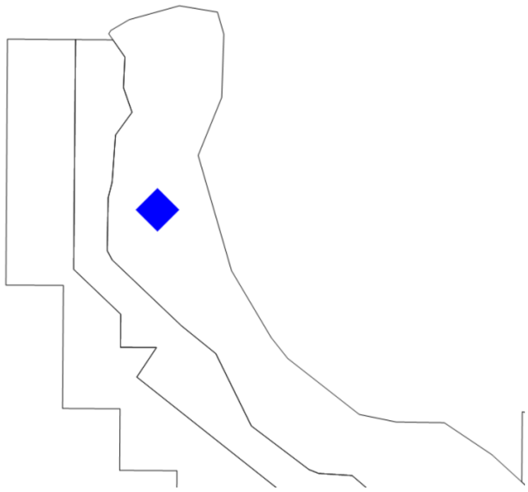
Figure 25: Mean Relative Humidity Statistics, Moranbah Water Treatment Plant (1986-2010)



Wind Speed and Direction

In order to present a more complete picture of the temporal and seasonal variability in the wind fields within the study region, numerically simulated wind fields (CALMET) for 2019 were developed. The location of the extracted CALMET wind data within Horse Pit is shown in Figure 26.

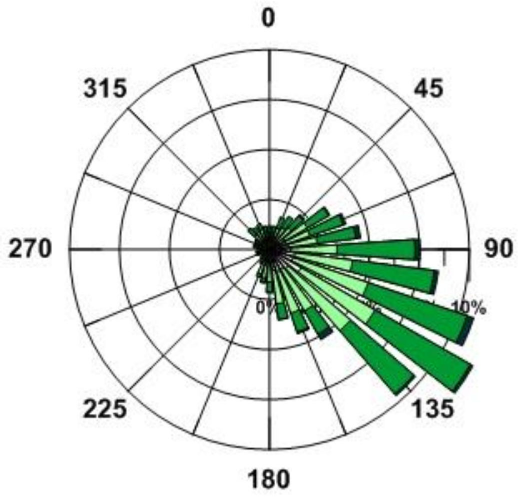
Figure 26 Location of CALMET Extracted Time Series Data



The wind rose for 2019 is presented in Figure 27. The wind directions in the vicinity of the Project are predominantly from the east through southeast with light to moderate wind speeds. Inter-annual variability in wind speed and wind direction is shown in Figure 27. These figures show little variability in the dominant winds. Seasonal variations and variations as a function of the time of day are highlighted in Figure 28. These seasonal figures show a dominant easterly wind through spring and summer while a southeast component dominates in autumn and winter. The diurnal variation in the winds shows from midnight to midday to be dominated by southeast winds while the afternoons are dominated by an easterly component and evenings a northeast to southeast component. These plots also show winds to be lighter at night time (6 pm to 6 am) then during the day time (6 am to 6 pm).

Wind roses based on hourly averaged data from the CVM Site 2 monitoring station were provided in Section 3.3.1. For ease of comparison, the Ste 2 wind roses are provided in Figure 27 and Figure 29 showing good agreement between observations and the numerically simulated wind fields.

Figure 27: Annual Wind Rose 2019 (Left – CALMET, Right – Site 2)



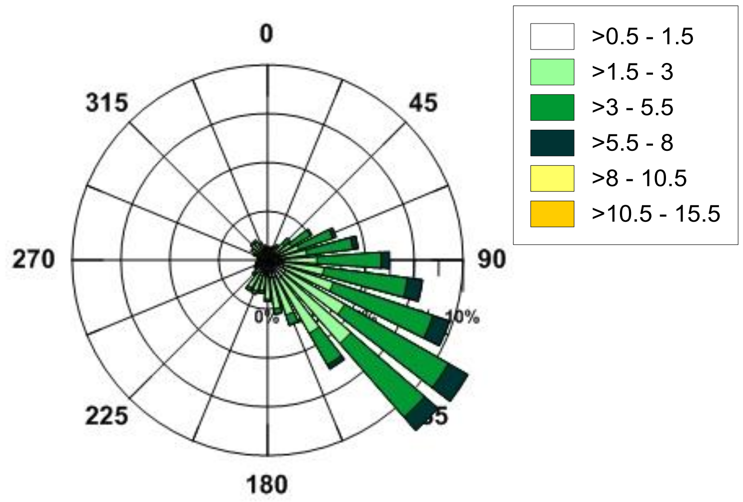


Figure 28: Wind Roses as a Function of the Season (upper) and Time of Day (lower) (CALMET 2019)

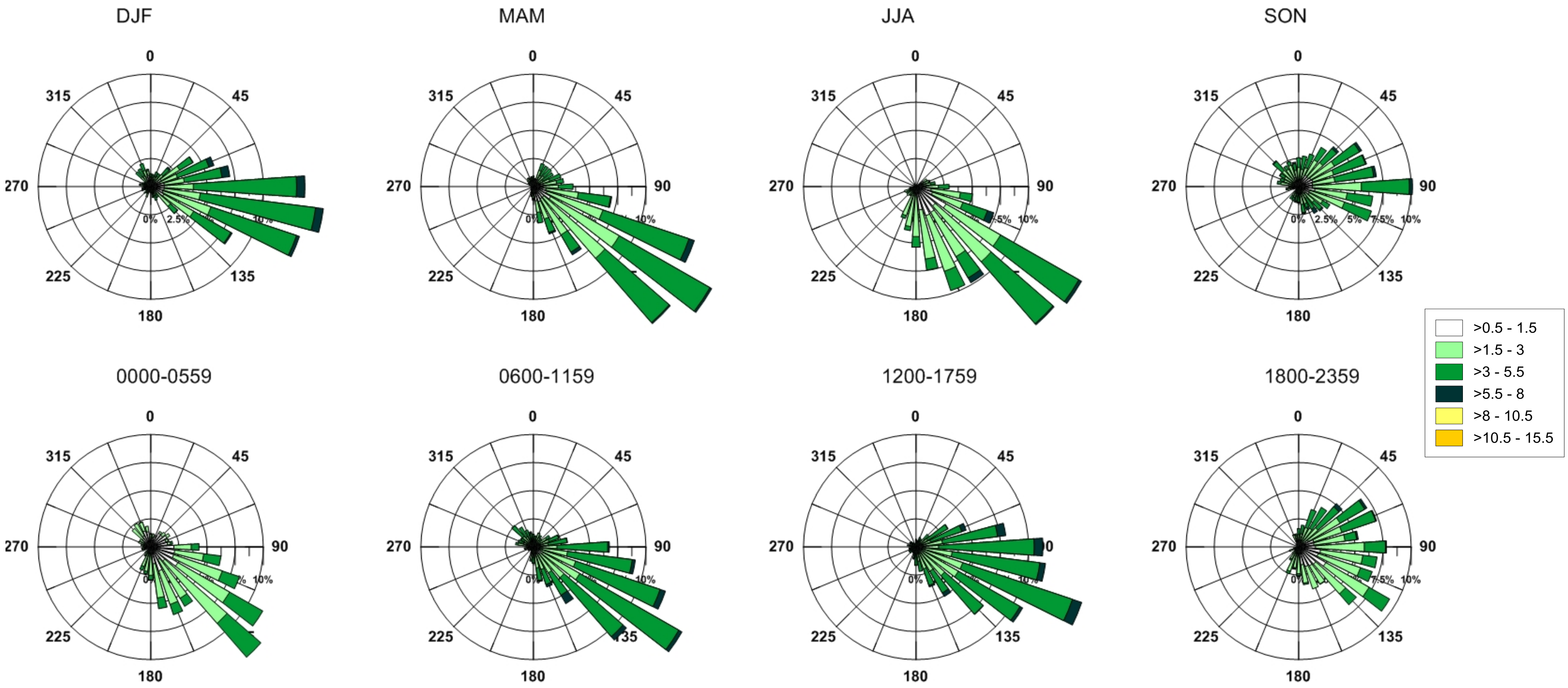
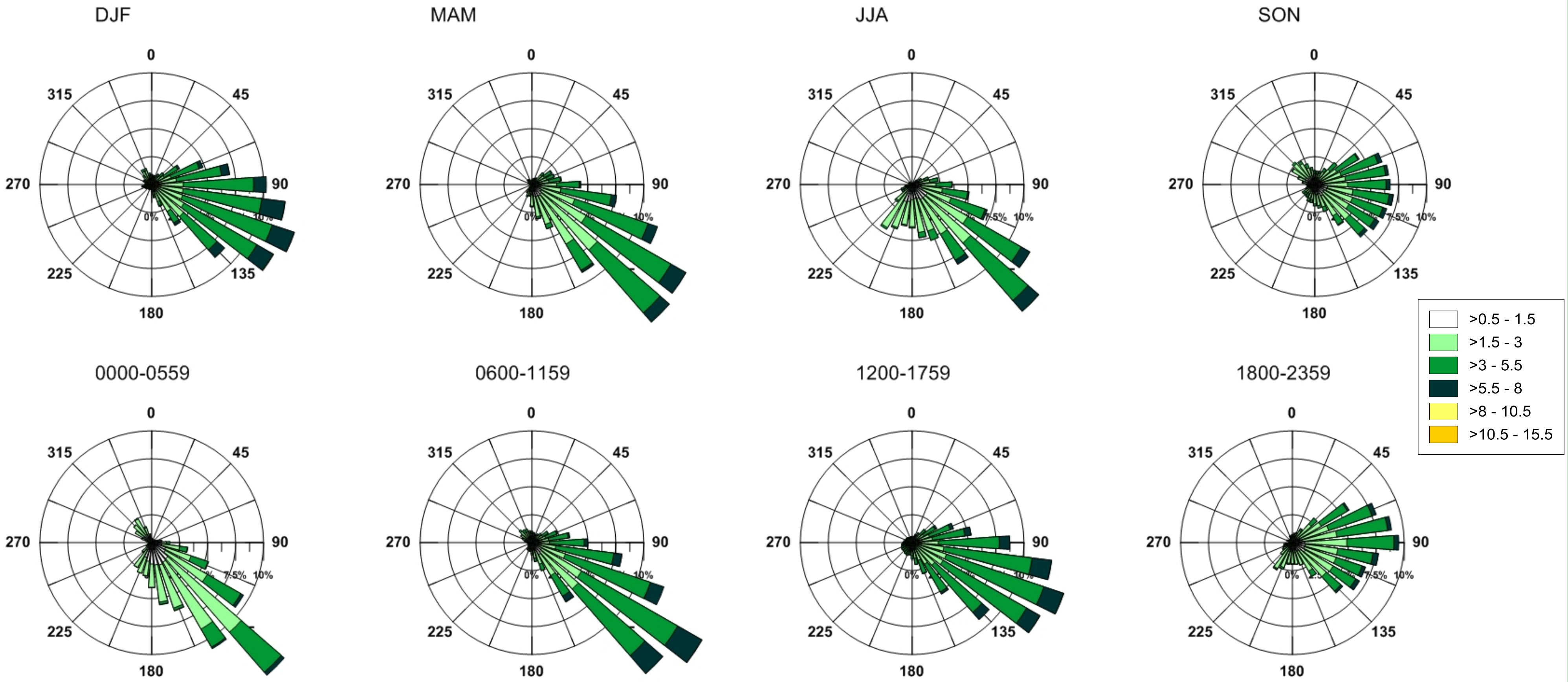


Figure 29: Wind Roses as a Function of the Season (upper) and Time of Day (lower). (Site 2, 2019)



Atmospheric Stability Class

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 2019 is presented in Figure 30 and Figure 31. Stability class D is predicted to occur most frequently (37.9%). Stability class D conditions are considered neutral conditions that typically occur during moderate wind speeds with little or no solar radiation (night time or cloudy periods). Stability class F is predicted to occur second most frequently (30.6%), indicating that a high percentage of conditions are moderately to very stable, with very little lateral and vertical diffusion.

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

Frequency of stability class data for the individual years presented in Figure 30 suggests very little inter-annual variability.

Figure 30: Frequency of Stability Class (CALMET 2019)

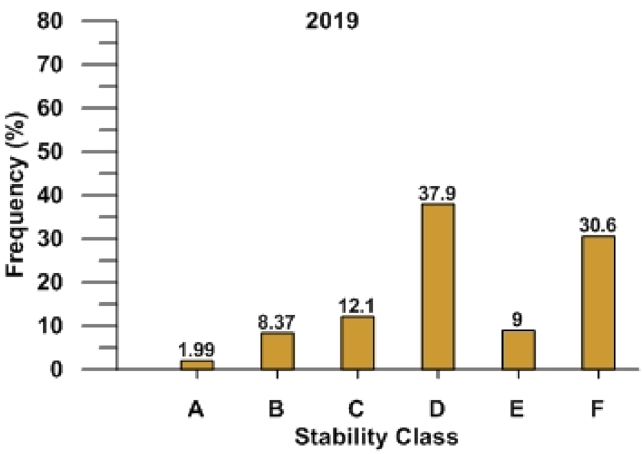
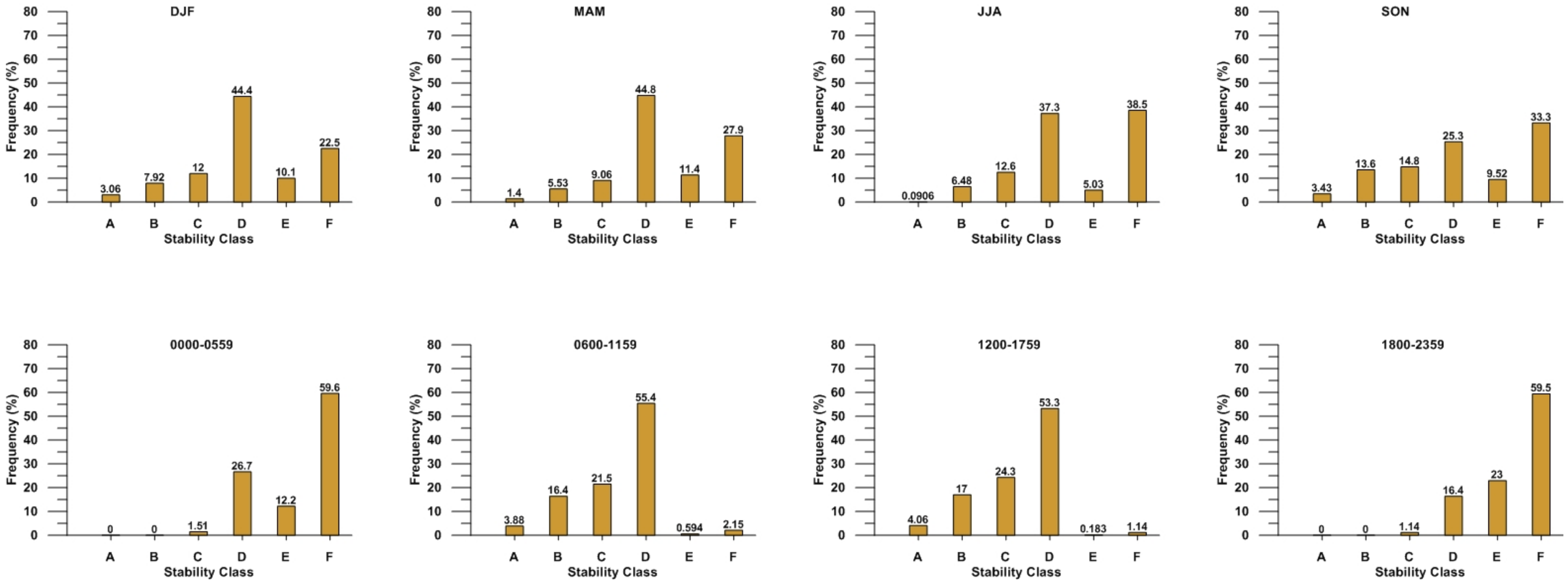


Figure 31: Seasonal Variation in the Stability Class Frequency (upper) and Variation as a Function of the Time of Day (lower) (CALMET 2019)



Appendix B. Dispersion Modelling Methodology

Development of Representative Meteorological Wind Fields

Dispersion modelling typically requires a meteorological dataset representative of the local airshed on an hourly timescale. 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 modelling scheme 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 22.

Table 22: TAPM Configuration

Parameter	Units	Value
TAPM version	-	v4.0.5
Years modelled	-	2019
Grid centre	Lat.(degrees), Lon. (degrees)	-22.45833, 148.225
Local centre coordinates	UTM zone 55 S (m)	626042, 7515926
Number of nested grids	-	3
Grid dimensions (nx, ny)	-	41,41
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:

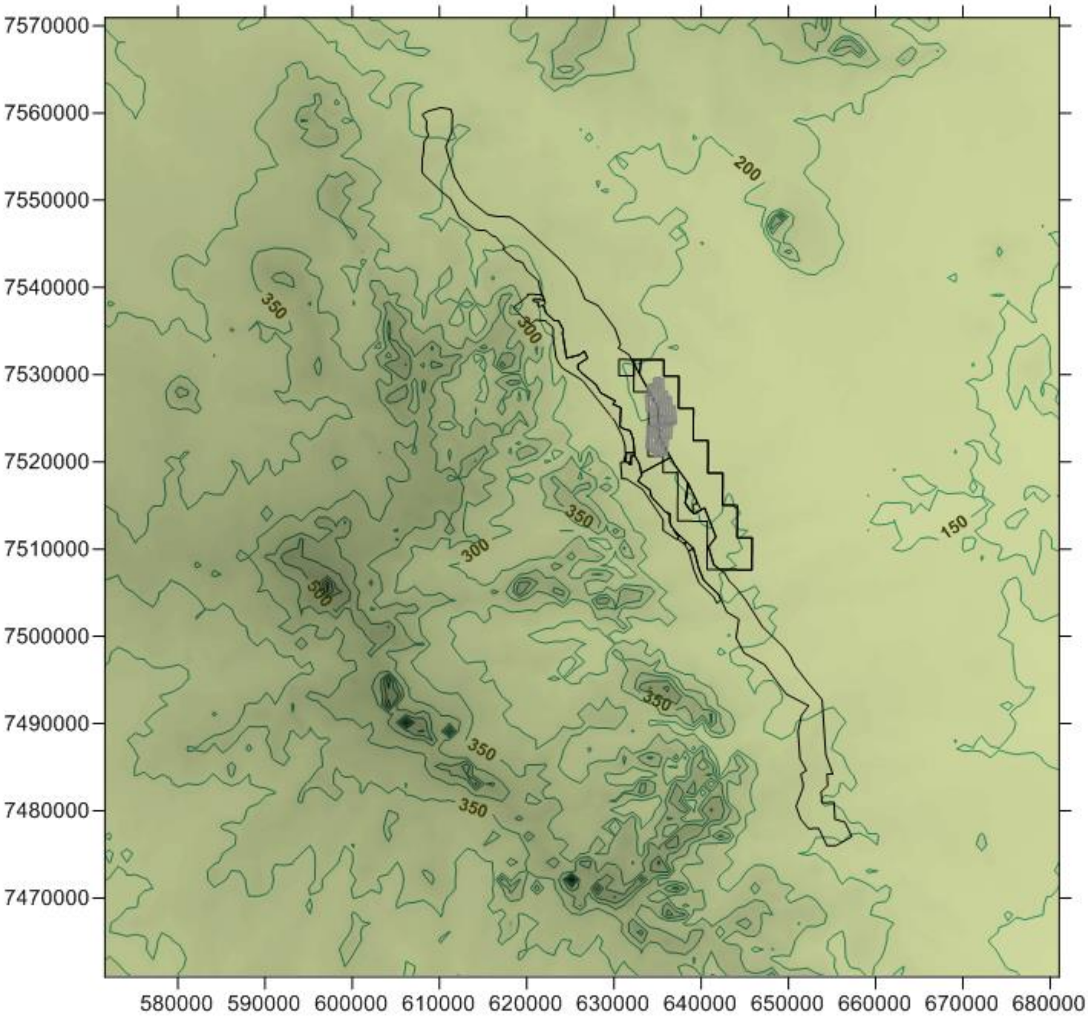
- Geophysical data;
- Upper air meteorological data; and
- Surface meteorological data.

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 32.

Figure 32: 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 33 and summarised in Table 23.

Figure 33: Land use classification included in CALMET

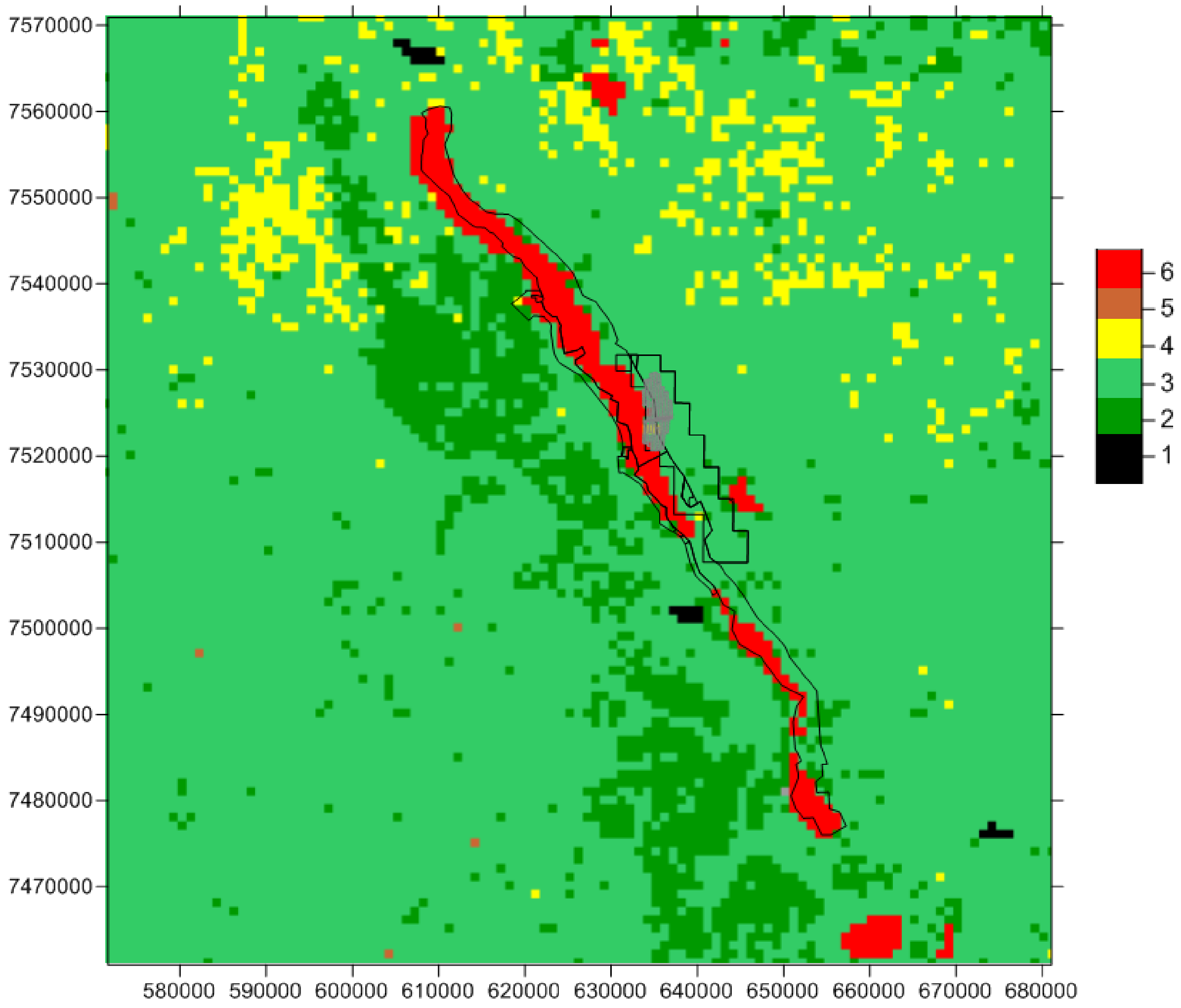


Table 23: CALMET Land use categories included in the assessment

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,	

CALMET User defined Category	ESA Category	AERMET Category
	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) (50-70%)/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 24.

Table 24: CALMET Configuration

Parameter	Units	Value
CALMET version	-	V6.326
Years modelled	-	2019
No. X grid cells (NX)	-	121
No. Y grid cells (NY)	-	121
Grid spacing (DGRIDKM)	km	1
X coordinate (XORIGKM)	km	570.000
Y coordinate (YORIGKM)	km	7460.000
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

Parameter	Units	Value
		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 (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 25. Defaults were used for all other options.

Table 25: 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 26 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 26: 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.

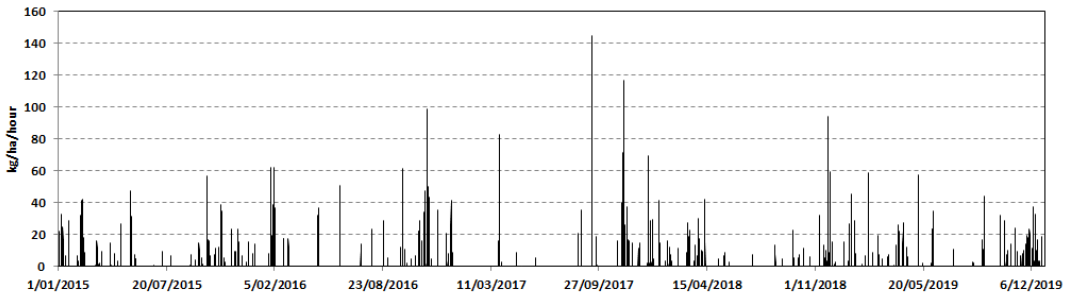
$$u_o = 5.4ln\left(\frac{10-z_0}{z-z_0}\right) \qquad \text{(Equation 2)}$$

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 34 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 34: Example of Wind Speed Dependent Emission Factor



Emission Factors

Presented in Table 27 and Table 28 is a summary of the uncontrolled and controlled TSP and PM_{10} adopted for this assessment.

Table 27: Emission Factors Used to Develop Emissions Inventory Estimates

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	Cat 793F C Coal	0.029	0.0100	4.7856	0%	50%	75%	0.0290	0.0050	1.1964
kg/tonne	kg/tonne	kg/VKT	Rejects	Cat 793F C Reject	0.029	0.0100	4.6925	100%	100%	75%	0.0000	0.0000	1.1731
kg/tonne	kg/tonne	kg/VKT	OB Waste	Cat 793F W - Average	0.0250	0.0120	4.8765	0%	0%	75%	0.0250	0.0120	1.2191
kg/tonne	kg/tonne	kg/VKT	OB Waste	CAT797F W	0.0250	0.0120	6.0502	0%	0%	75%	0.0250	0.0120	1.5125
n/a	kg/bcm	n/a	DRE Waste	Dragline	0	0.0233	0	0%	0%	0	0.0000	0.0233	0.0000

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	Cat 793F C Coal	0.014	0.0042	1.2992	0%	50%	75%	0.0140	0.0021	0.3248
kg/tonne	kg/tonne	kg/VKT	Rejects	Cat 793F C Reject	0.014	0.0042	1.2739	100%	100%	75%	0.0000	0.0000	0.3185
kg/tonne	kg/tonne	kg/VKT	OB Waste	Cat 793F W - Average	0.012	0.0043	1.3239	0%	0%	75%	0.0120	0.0043	0.3310
kg/tonne	kg/tonne	kg/VKT	OB Waste	CAT797F W	0.012	0.0043	1.6425	0%	0%	75%	0.0120	0.0043	0.4106
n/a	kg/bcm	n/a	DRE Waste	Dragline	0	0.00544	0	0%	0%	0	0.0000	0.00544	0.0000

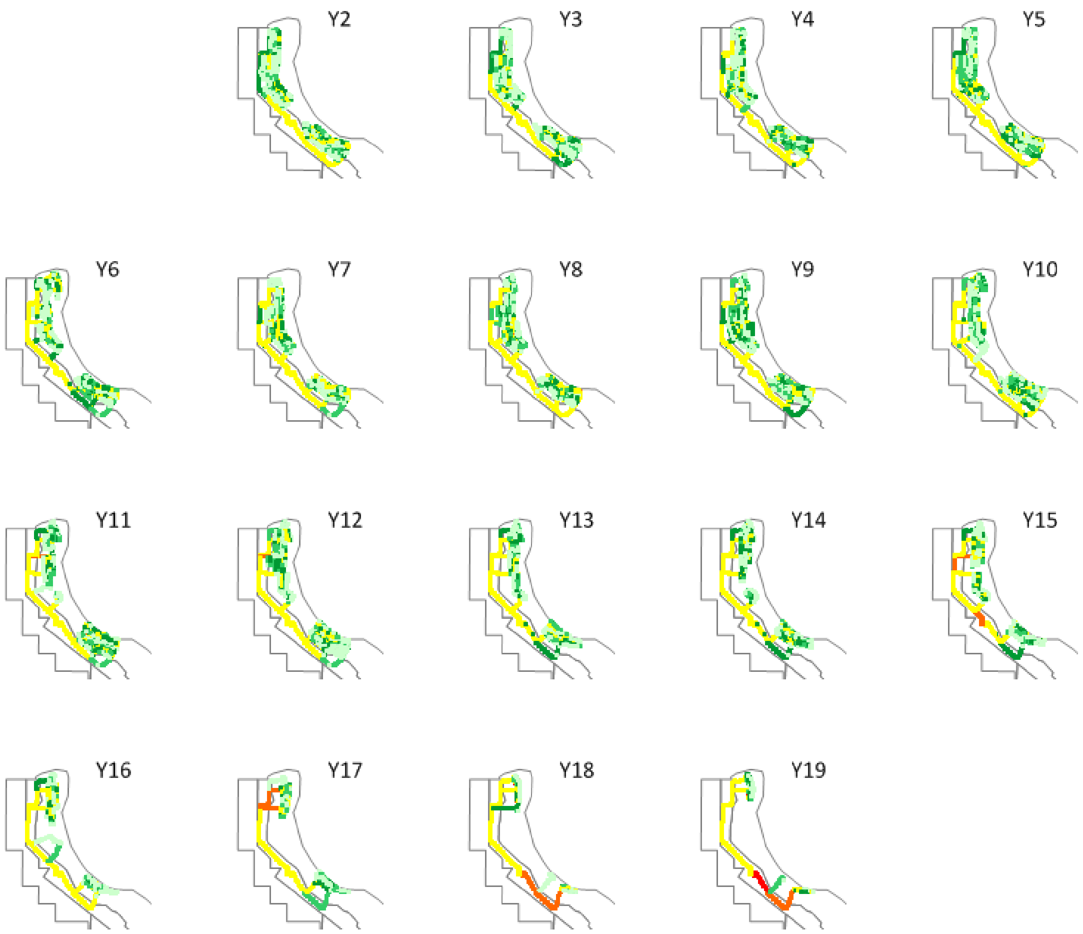
Table 28: Emission Factors Used to Develop Emissions Inventory Estimates (Continued)

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

Appendix D. Dust Emission Sources for the Project With (BAU) Case

The location of key dust emission sources (dragline, truck & shovel and dozer activities) used in the dispersion modelling for selected years of mining are indicated in Figure 35. Note that Y2 in the figure corresponds to FY21. The variations in colour highlight dust emission intensity using a stop light approach.

Figure 35: Location of the Dust Emission Sources for the Project Without (BAU) Case



Project With (BAU) Case

The location of key dust emission sources (dragline, truck & shovel and dozer activities) used in the dispersion modelling for all years of mining are indicated in Figure 36 and Figure 37. Note that Y2 in the figure corresponds to FY21. The variations in colour highlight dust emission intensity using a stop light approach.

Figure 36: Location of the Dust Emission Sources for the Project With (BAU) Case

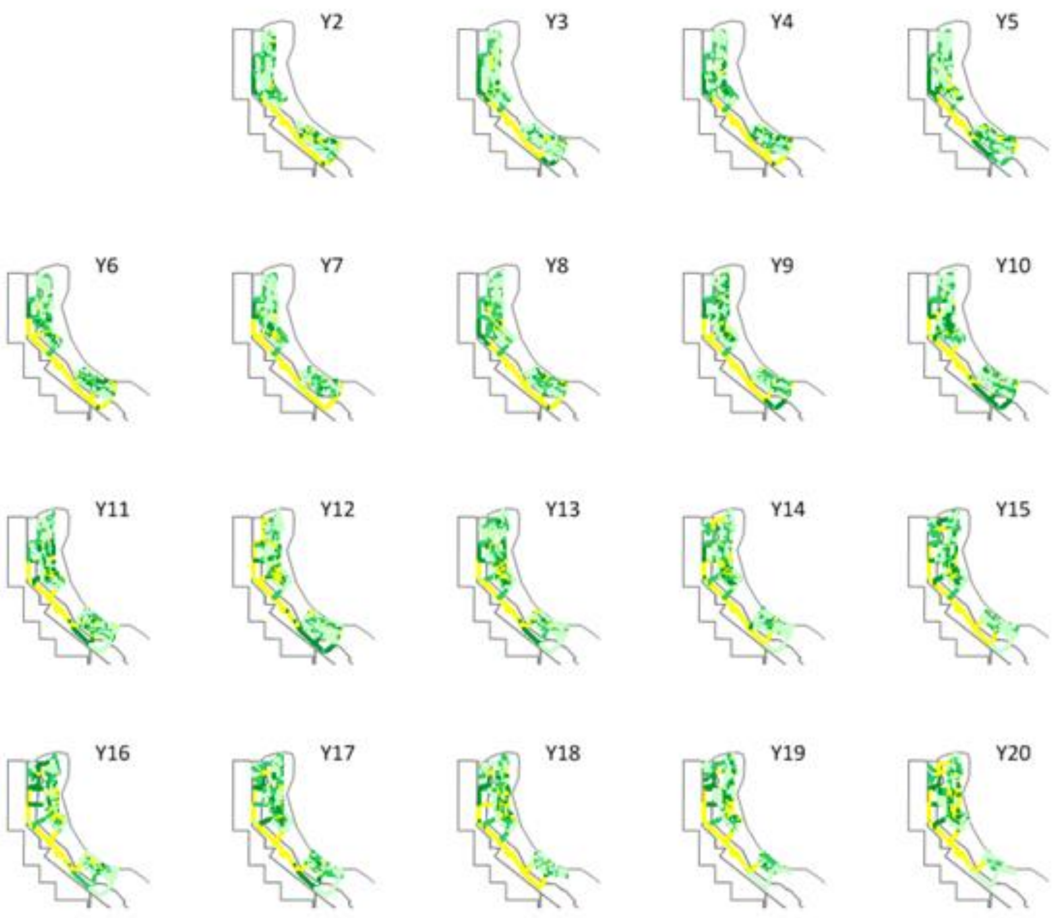
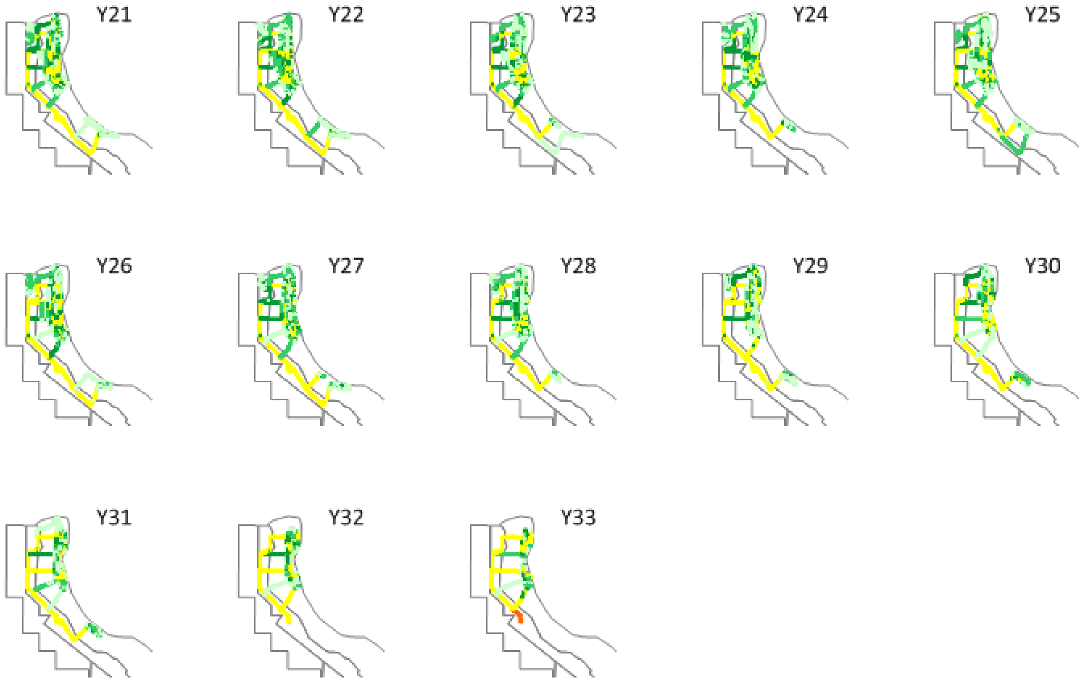


Figure 37: Location of the Dust Emission Sources for the Project With (BAU) Case (continued)



Appendix E. Out of Pit Dump

The nature and extent of potential impacts associated with the proposed out of pit (OoP) dump (Figure 38) has been of expressed interest to the regulating authority.

It is noted that the Project With (BAU) case includes the OoP dump (Figure 38) whilst the Project Without (BAU) case excludes the OoP dump.

Activities related to the OoP dump will include truck hauling and dumping of waste and stockpile shaping by dozer. These activities are explicitly accounted for within the mine plan which is the basis of the air quality assessment for the Project With (BAU) case. Results presented in Section 6.4 highlighted the difference in predicted impacts associated with the Project With (BAU) case and the Project Without (BAU) case. The contribution of all aspects of the OoP (formation, shaping, wind erosion) are included in the results presented. It is AED’s opinion that it is not practicable to isolate waste haulage, dumping and shaping of the OoP from other site based activities as the exclusion of an OoP dump as an option, would require a site-wide reconfiguration of planned mine activities, for example that represented by the Project Without (BAU) case.

The preceding point noted, it is practicable to isolate the predicted contribution to air quality outcomes associated with wind erosion that is attributable to the OoP dump. Presented in Table 29 are the results from the dispersion modelling that isolate worst case impacts due to wind erosion associated with the OoP dump. Results suggest that on average over the life of the project, wind erosion associated with the OoP dump (in isolation) would contribute a maximum of c. 0.3 $\mu g/m^3$ (Site 2) to 2.7 $\mu g/m^3$ (Site 6) to the 24 hour average concentration of PM_{10}.

Based on the information presented in Section 6.6, waste material handling by Truck and Shovel mining methods (and not wind erosion) was identified as the key driver to air quality impacts at Site 2, Site 6 and Site 8. Thus, in general, increasing haul distances (i.e. to haul waste to an in-pit location if available) will have a negative impact on air quality outcomes, so it is plausible that a mine plan that excludes the OoP dump will require longer distance waste hauling and may result in dust impacts that are greater than those indicated for the Project With (BAU) case (Section 6).

Figure 38: Location of Out of Pit Dump

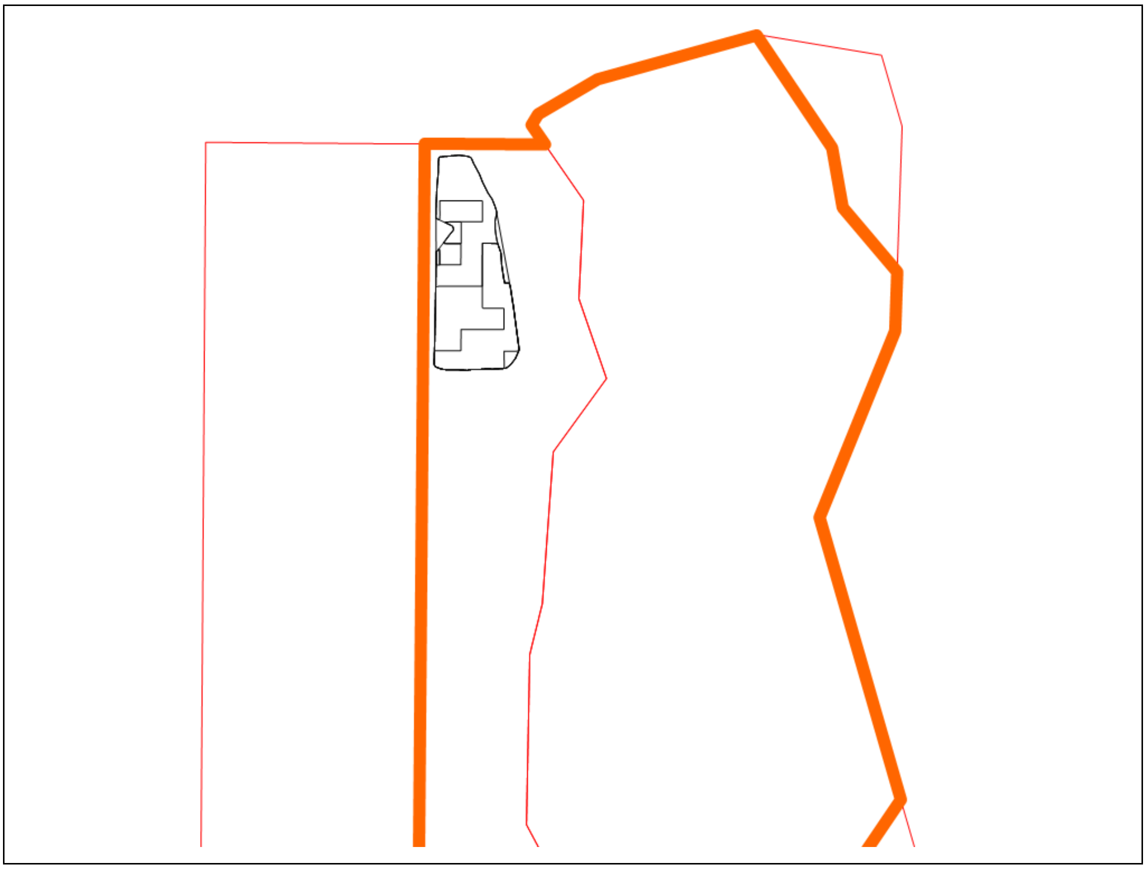


Table 29: Worst Case Predicted Contribution from OoP Dump – Wind Erosion

Station	Average of 24 Hour Maximum PM_{10}	
	Project Without Case (18 Years)	Project With Case (36 years)
Site 2	0.0	0.3
Site 6	0.0	2.7
Site 8	0.0	2.1