BHP – Whaleback OB29/30/35 Significant Amendment

Air Quality Assessment

Final Report
Version 3

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BHP – Whaleback OB29/30/35 Significant Amendment

Final Report

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Executive Summary

BHP Billiton Iron Ore (BHP) operate the Mt Whaleback and Eastern Ridge mining and processing operations within the region surrounding the town of Newman in the Pilbara district of Western Australia. BHP are proposing to expand the existing mining operations at Newman through the development of the Ore Body 29/30/35 Significant Amendment (OB29/30/35 SA) project (the Project) located within the existing Whaleback operations immediately to the west of the Newman townsite in the Pilbara region of Western Australia.

Overview of assessment

An air quality assessment was conducted to determine potential air quality impacts of particulates (as TSP, PM_{10} and $PM_{2.5}$) associated with the progressive development of the Project. Emission rates were estimated using recognised and accepted methods of emissions estimation, which included published emission factors from the National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining (EA, 2012). Emissions were estimated for the mining year 2036 based on the high forecast tonnages for this year. Background concentrations were incorporated into the model results to provide an indication of the potential cumulative impact.

Modelling impacts of TSP, $PM_{10,}$ and $PM_{2.5}$ emissions was undertaken using the CALMET/CALPUFF modelling suite. In the absence of onsite meteorological measurements, the Weather Research and Forecast (WRF) model was used to simulate the meteorology over the region for a representative meteorological year and then as input to the CALMET model to generate fine-resolution three-dimensional meteorological fields. Fine resolution terrain elevation (Shuttle Radar Topography Mission (SRTM)) data with 90 metre (m) resolution was used in conjunction with European Space Agency Climate Change Initiative Land Cover (ESACCI-LU) land-use data to characterise the geophysical environment.

Ground-level particulates (as TSP, PM_{10}, and $PM_{2.5}$ concentrations) predicted at sensitive receptor locations and the surrounding environment were compared with the relevant air quality assessment criteria (relevant to human amenity and health). Sensitive receptors are consistent with those used in other BHP mine modelling assessments in the immediate region.

The modelling assessment considered the following scenarios:

- Scenario 1: Current operations – Mt Whaleback (includes existing OB29/30/35) & Eastern Ridge (as outlined in ETA, 2022)
- Scenario 2: Future project – OB29/30/35 Significant amendment in isolation (includes BWT and AWT) (Project)
- Scenario 3: Future project – OB29/30/35 operations including both approved and amendment in isolation.
- Scenario 4: Future cumulative – Proposed OB29/30/35, Mt Whaleback, Eastern Ridge and future Western Ridge plus background concentrations.

Key findings

The key findings of the assessment, in relation to human amenity and health assessment criteria adopted, are:

- For the Project in isolation of other emission sources:
  - For TSP, PM_{10} and $PM_{2.5}$ -The predicted maximum concentrations are well within the applicable criteria at the Town and Newman East monitors.
- For the Project with the cumulative scenario (proposed OB29/30/35, Mt Whaleback, Eastern Ridge and future Western Ridge plus background concentrations):
  - For TSP the introduction of both the proposed Western Ridge and the Project results in a predicted increase in ground level concentrations of TSP at all receptors.
  - For PM_{10}:
    - The modelling indicates that there will be a slight increase in the maximum PM_{10} concentrations at the Town and Newman East monitors.
    - The lower statistics at these two residential monitors indicates that there will be an overall reduction predicted ground level concentrations.
    - The modelling predicts that there will be a reduction in the number of excursions of the criteria (70 µg/m^3) at both residential monitors.
  - For $PM_{2.5}$:
    - The modelling indicates that there will be a slight increase in the maximum $PM_{2.5}$ concentrations at the Town and Newman East monitors.
    - The lower statistics at these two residential monitors indicates that the overall ground level concentrations of $PM_{2.5}$ are predicted to be similar.

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1 Introduction

1.1 Background

BHP Billiton Iron Ore (BHP) propose to expand the existing mining operations at Newman through the development of the Ore Body 29/30/35 Significant Amendment (OB29/30/35 SA) project (the Project) located within the existing Whaleback operations immediately to the west of the Newman townsite in the Pilbara region of Western Australia (Figure 1-1).

1.2 Scope of work

Environmental Technologies & Analytics Pty Ltd (ETA) was engaged by BHP to undertake an air quality assessment for the Project. The scope of work included:

- Determining the study approach and methodology in Section 2.
- Generation of site-specific meteorological data and atmospheric dispersion modelling using the WRF-CALMET/CALPUFF model suite in Section 5.
- Project emission estimation and inventory in Section 6.
- An evaluation of the predicted ground-level concentrations of particulates and interpretation of the potential impact of the Project (Section 7).
- Conclusions of the assessment presented in Section 8.

The appendices contain supporting information.

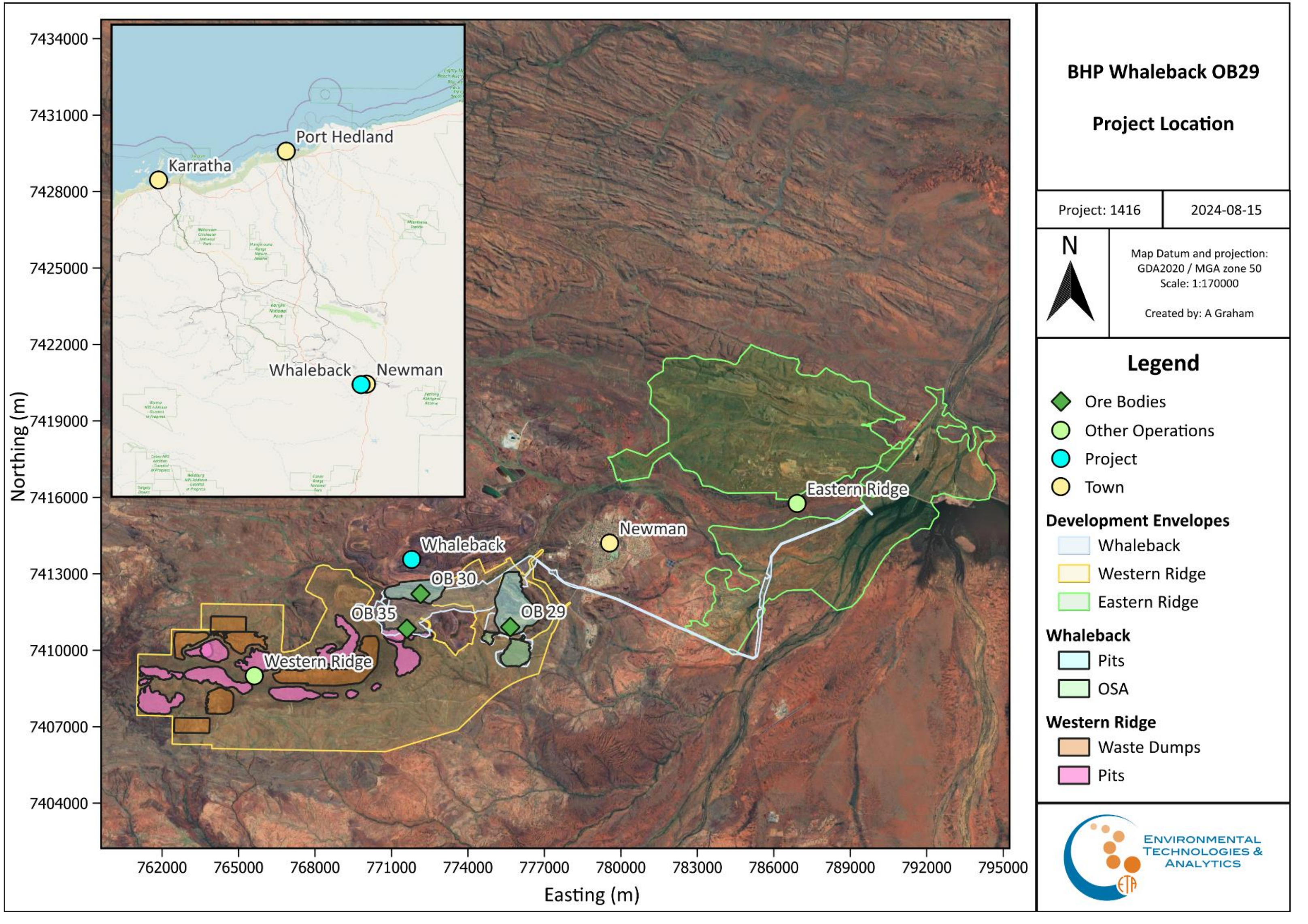

Figure 1-1: Project location and setting.

2 Assessment methodology

This section outlines the air quality study and assessment approach. It includes the methodology applied to define the meteorological characteristics of the project area relevant to the assessment, the emission estimation, the dispersion, and the ambient assessment criteria selected for the purposes of determining the significance of the dispersion model results, and therefore the potential impact.

The study structure is shown in Figure 2-1.

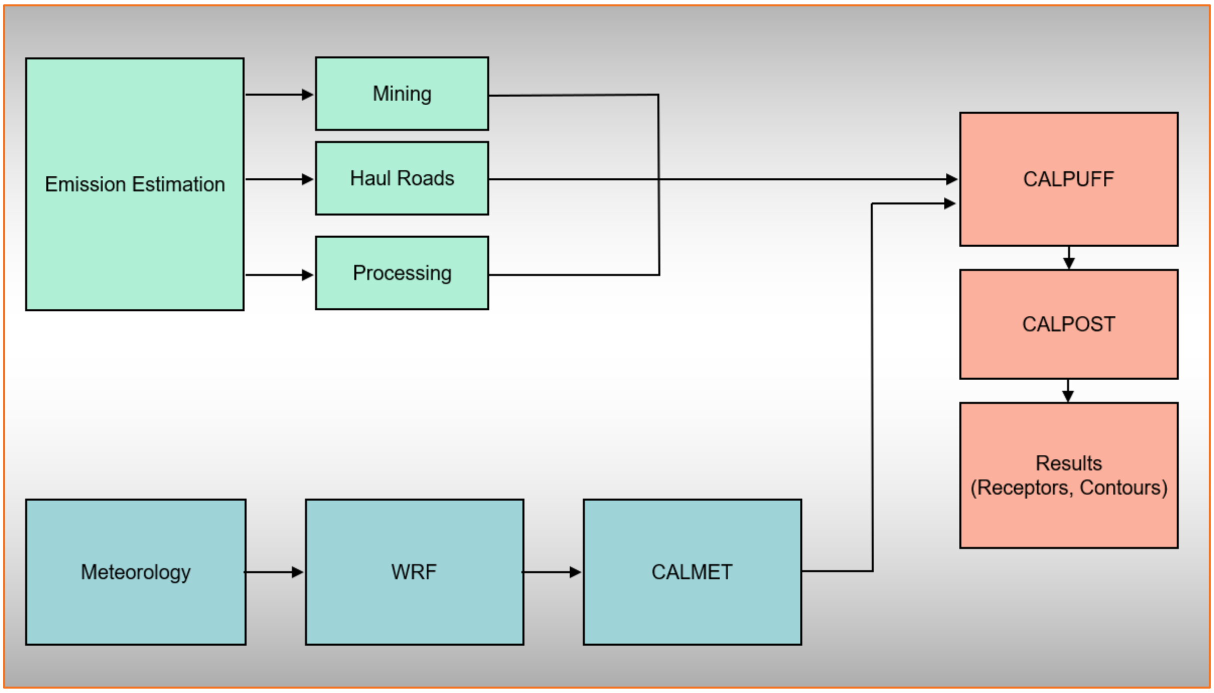

Figure 2-1: Air quality assessment – study approach

Comparison of the modelled results to the assessment criteria is intended to provide an objective evaluation of the potential impact of the operations at the nearest sensitive receptors. Modelled ground-level concentrations for key air pollutants have been compared to ambient air quality assessment criteria.

2.1 Meteorology

The meteorology component of a dispersion model is a key element for the effectiveness or representativeness of the dispersion model outputs. Both upper air and surface information are needed for modelling. In the absence of adequate onsite meteorological data, the Weather Research and Forecast (WRF V3.7) model (http://wrf-model.org/index.php) was used to generate hourly 3-dimensional data for the region. The 3-Dimensional meteorological data generated by WRF was input to CALMET for further processing to the finer resolution used in the dispersion modelling. This procedure will be referred to as the 'WRF-CALMET methodology'. The output from the CALMET meteorological model is then used to drive the pollution dispersion in the CALPUFF model.

2.2 Emissions estimation

Emission rates were estimated using national and internationally recognised and accepted methods of emissions estimation, which included published emission factors from the NPI Emission Estimation Technique Manual for Mining (EA, 2012) and components of the United States Environmental Protection Agency (USEPA) AP-42 contained with Chapter 13, Miscellaneous Sources.

2.3 Modelling

Air dispersion modelling has been conducted using CALPUFF - the dispersion module of the CALMET/CALPUFF suite of models. The model has been used to predict ground level concentrations across the model domain and at identified sensitive receptor locations. The potential air quality impacts associated with the Project have been considered in isolation of other emission sources as well as cumulatively with future operations and background concentrations.

2.4 Impact Assessment

Ground-level particulates (concentrations) predicted at sensitive receptors and the surrounding environment were compared with the relevant air quality assessment criteria. This assessment has considered the potential impact attributable to the Project, as well as the cumulative (background) impact (i.e. in conjunction with the existing emission sources in the area). The assessment has been made across the model domain, as well as at key sensitive receptor locations identified as being representative or important for assessment.

The ambient air quality and potential impacts are assessed in terms of the following particulate sizes:

- Total Suspended Particulates (TSP)
- PM_{10} (particulate matter with an aerodynamic diameter of 10 µm or less)
- $PM_{2.5}$ (particulate matter with an aerodynamic diameter of 2.5 µm or less).

3 Existing Environment

The climate and meteorological characteristics of the region control the dispersion, transformation and removal (or deposition) of pollutants from the atmosphere. This section outlines the key climate and meteorological characteristics of the region important for the dispersion, transformation and removal (or deposition) of pollutants from the atmosphere, and therefore ambient air quality.

3.1 Climate

According to the Koppen-Geiger climate system the Newman region is classified as a Hot Desert Climate, 'BWh', where evaporation exceeds rainfall. The following sections outline the long-term meteorological statistics from the Bureau of Meteorology (BoM) automatic weather station (AWS) at Newman Airport, located approximately 9 km to the southeast of Newman. This AWS has been collecting meteorological data since 1998.

3.1.1 Local meteorology

The Pilbara region of Western Australia is characterised as semi-arid and has two primary seasons – wet and dry. The wet season, from October to April, is dominated by high temperatures and evaporation rates with isolated intense convective rainfall (thunderstorms) and cyclonic activity. The dry season, from May to September, is relatively dry with mild temperatures.

The long-term temperature statistics from the BoM AWS in Newman are presented in Figure 3-1. From this figure it is apparent that the wet season (summer) period has very warm to hot days and warm nights while the dry season (winter) has warm days with cool, and occasionally cold, nights. Mean monthly maximum temperatures ranging from a high of 43.0°C in January to 27.6°C in July. The mean monthly minimum temperatures range from 20.6°C in January down to 2.0°C in July.

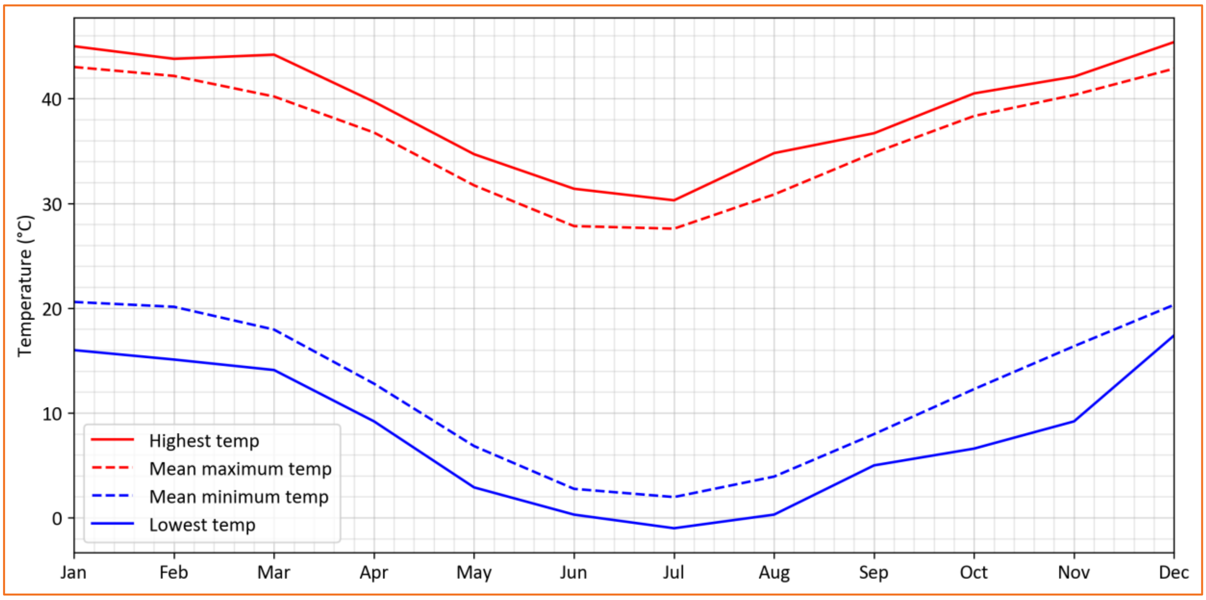

Figure 3-1: Long term temperature statistics, 2010 to 2022 (BoM, 2022).

The long term annual average rainfall at Newman is 330 millimetres (mm). While rainfall is mainly associated with the formation of the occasional afternoon thunderstorms, the impact of cyclonic rainfall is evident in Figure 3-2 where the maximum monthly rainfall is significantly greater than the average rainfall, particularly during the cyclone period from December to March.

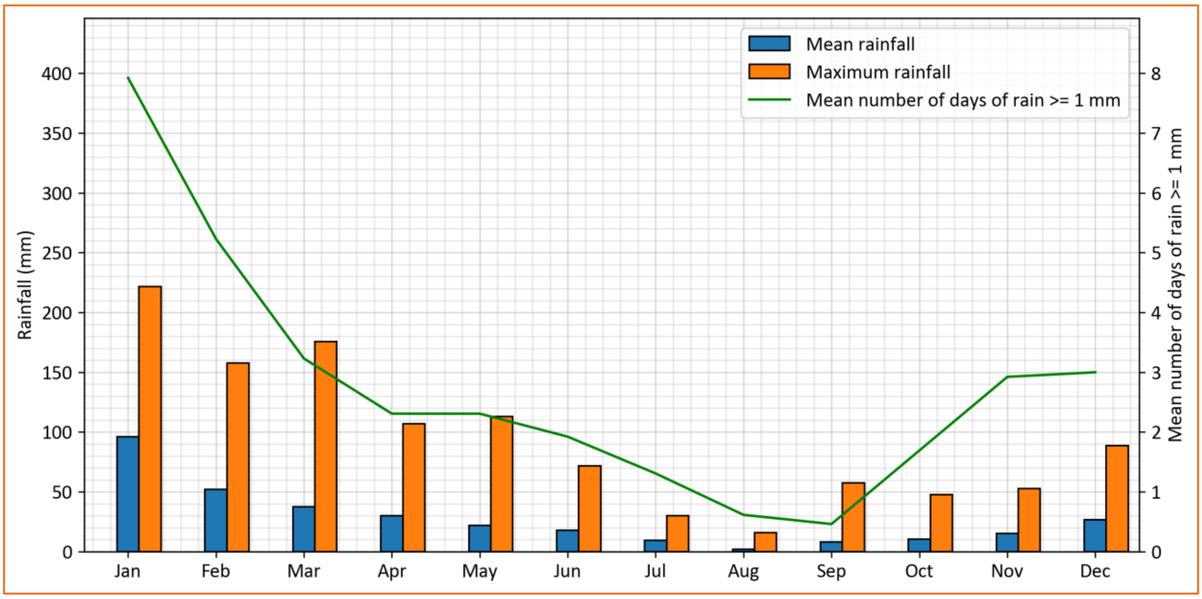

Figure 3-2: Long term rainfall statistics, 2010 to 2022 (BoM, 2022).

3.1.2 Wind speed/direction

As shown in Figure 3-3, the wind characteristics at the BoM Newman Aero AWS is characterised by variable winds throughout the year including:

- Summer winds come from the northeast to southeast along with a southwest component, the mean wind speed is 3.9 m/s.
- In Autumn winds come from the southeast and east, the mean wind speed is 3.2 m/s.
- In Winter winds come from the southeast and South-west, the mean wind speed is 3.0 m/s.
- In Spring winds come from the southwest, the mean wind speed is 3.8 m/s.

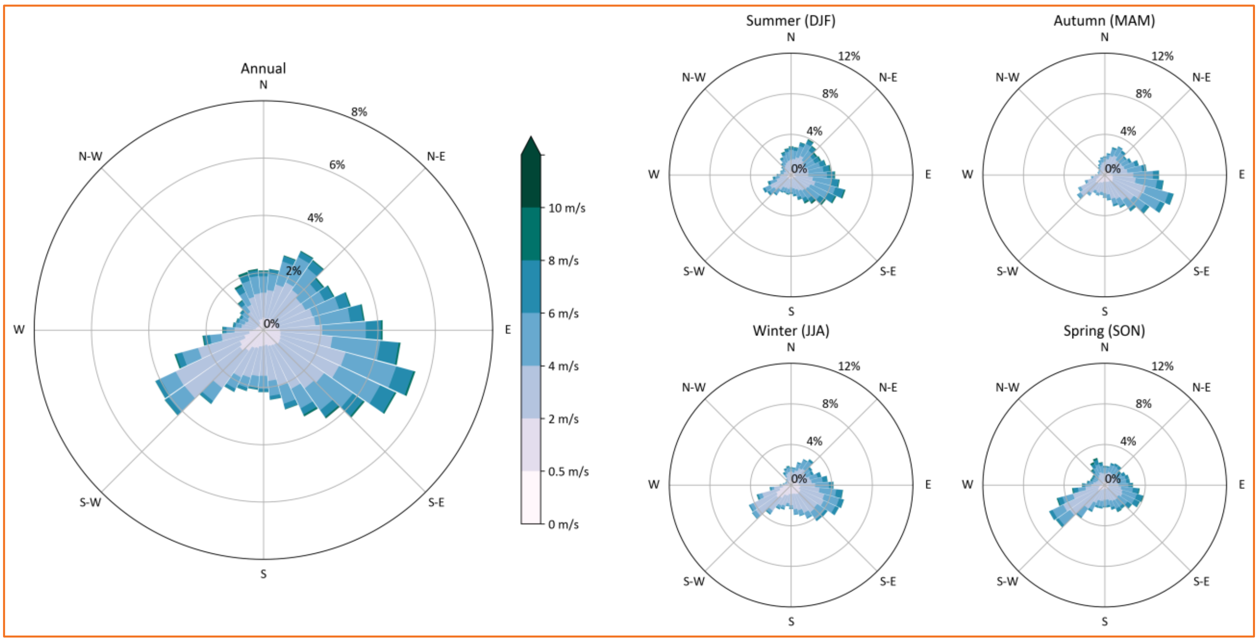

Figure 3-3: Annual and seasonal windrose from 2010 to 2022 (BoM Newman Aero).

3.2 Local Air quality

The Pilbara region is a naturally dusty environment with wind-blown dust being a significant contributor to the particulate loading. Within the aggregated emission inventory for the Pilbara, undertaken by SKM in 2000 for the 1999/2000 financial year, it was calculated that approximately 170,000 tonnes of particulate material were emitted as a result of wind erosion (SKM, 2003). Wildfires also account for a significant amount of the emissions with approximately 195,000 tonnes of particulates emitted. Note that these are calculated values (i.e. not monitored data) and will vary on an annual basis depending on a range of factors including the extent of erodible areas, area burnt, rainfall and wind speed.

4 Air quality assessment criteria

4.1 Definitions

Suspended solids or liquids in air are referred to as Particulate Matter (PM). Concentrations of particles suspended in air can be classified by an aerodynamic diameter, which describes the behaviour of the particle in the air based on its size and shape:

- Total Suspended Particulate (TSP) – refers to the total amount of the PM suspended in air (regardless of size). These larger particles are primarily associated with amenity or visibility issues and are likely to be removed by gravitational settling within a short time of being emitted (i.e. they settle to the ground or other surfaces fairly quickly).
- PM_{10} – refers to the total of suspended particulate matter less than 10 µm in aerodynamic diameter. Particles in this size range can enter bronchial and pulmonary regions of the respiratory tract and can impact human health. Particles in this size range can remain suspended for many days in the atmosphere.
- $PM_{2.5}$ – refers to the total of suspended particulate matter less than 2.5 µm in aerodynamic diameter. Epidemiological studies have shown that particles in this size range are associated with greater health impacts on humans than other particle sizes due to their ability to enter further into the lungs and into the alveoli. Particles in this size tend to be derived from combustion sources such as combustion of fossil fuels and biomass burning (WHO, 2005). These particles can remain suspended for months to years.

An example of the relative particle sizes is presented in Figure 4-1.

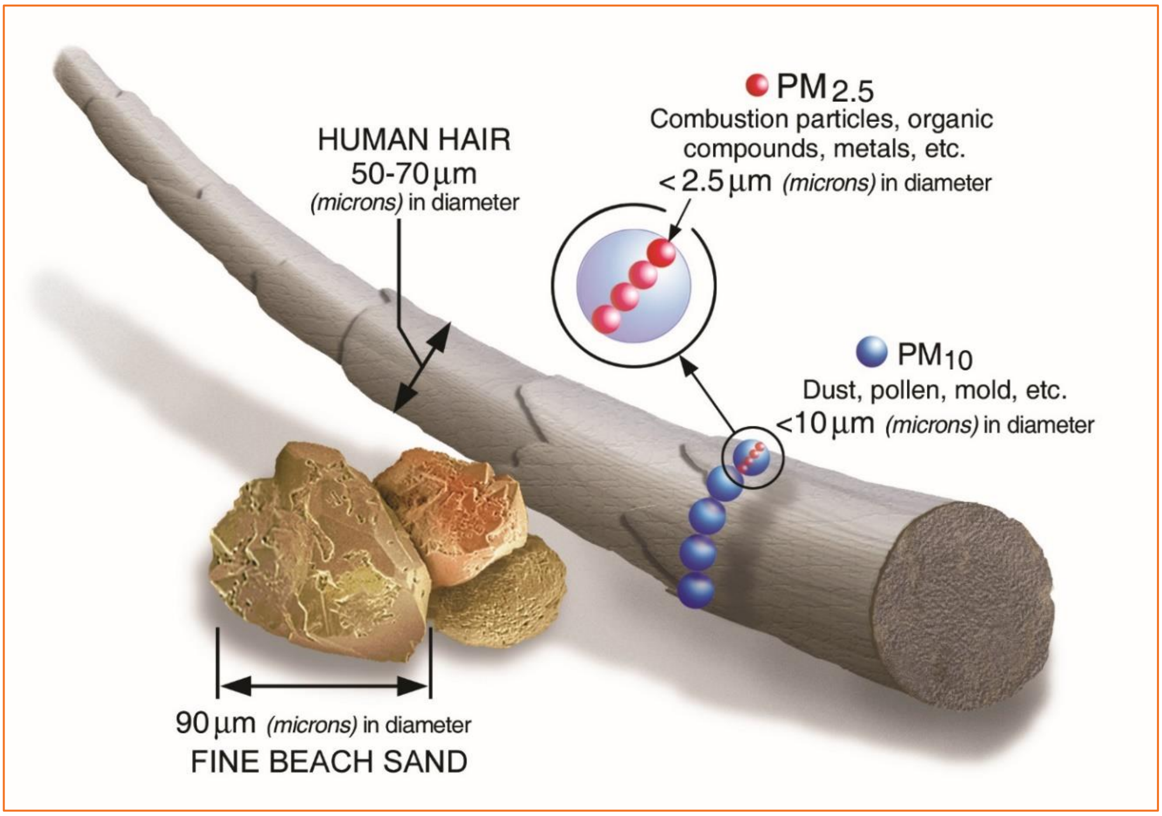

Figure 4-1: Example of particle sizes (USEPA, 2021)

4.2 Human Health Assessment and Amenity Criteria

Modelled ground level concentrations for particulates have been compared to ambient air quality assessment criteria to determine the potential changes in impact resulting from the Project.

The assessment criteria adopted for this study (for particulates) are primarily based on the DWER (2019; 2021) guidelines, which also reference the numerical values from the ambient air quality standards specified in the Ambient Air Quality NEPM (NEPC, 2021).

In their current draft form, the DWER (2019) guidelines for TSP/PM_{10}/$PM_{2.5}$ (defined as *criteria pollutants* in the guideline) require the criteria to generally be '…met at all existing and future offsite sensitive receptors in the modelling domain'. DWER (2021) draft guidelines address the settling or deposition of dust, noting that at time of this assessment the guideline is draft and subject to public consultation. The guidelines also state that the department may approve deviations to the assessment criteria on a case-by-case basis.

Within Port Hedland the Port Hedland Dust Management Taskforce (Taskforce), in their final report to government (DSD, 2016), recommended that the interim guideline of 70 µg/m^3 for PM_{10} (24-hour average and excluding natural events) continue to be applied to residential areas. This value is used to assess the potential health impact on community receptors within the project model domain. In its response to the final recommendations of the Taskforce, in October 2018 the State Government agreed that the air guideline value of 70 µg/m^3 should apply to residential areas, wherever people live on a permanent basis in Port Hedland. In addition, the DoH agreed to the continuation of the 10 exceedances per year of the air guideline value, as measured at Taplin Street, on the understanding that the overall population for the Port Hedland peninsula does not exceed 17,000 (ie the modelled population in the Health Risk Assessment). Consistent with the approach adopted by the NEPM, there is no limit on exceedances solely as a result of natural events.

The ambient air quality assessment criteria adopted in this study are shown in Table 4-1.

Table 4-1: Summary of Adopted Assessment Criteria

Pollutant	Air quality assessment criteria					Reference
	Concentration [1]	Concentration [2]	Averaging Period	Allowable Exceedances	Environmental value protected	
PM_{10}	25 µg/m^3	23 µg/m^3	annual	none	Human health	DWER (2021) consistent with NEPM (NEPC, 2021)
PM_{10}	70 µg/m^3	-	24-hour average	Not more than 10 days a year	Human health	Taskforce criteria (DSD, 2016)
$PM_{2.5}$	25 µg/m^3	23 µg/m^3	24-hour	exception event	Human health	DWER (2021) consistent with NEPM (NEPC, 2021)
$PM_{2.5}$	8 µg/m^3	8 µg/m^3	annual	none	Human health	DWER (2021) consistent with NEPM (NEPC, 2021)
TSP	90 µg/m^3	82 µg/m^3	24-hour	none	Human health and amenity Proxy for protection of	DWER (2019)

Pollutant	Air quality assessment criteria					Reference
	Concentration [1]	Concentration [2]	Averaging Period	Allowable Exceedances	Environmental value protected	
					ecological values	

Notes:
1 Concentrations referenced to 0ºC
2 Concentrations referenced to 25ºC

5 Model Assessment

For this assessment, air dispersion modelling has been conducted using CALPUFF. The model has been used to predict ground level concentrations across the model domain and at identified sensitive receptor locations. The potential air quality impacts associated with the Project have been considered in isolation of other emission sources, as well as cumulatively with existing air quality of the region. The model was configured to predict the ground-level concentrations on a rectangular grid. The model domain was defined with the Southwest corner of the grid cell at 760.0 km Easting and 7404.0 km Northing (UTM Zone 50 S). Specifics for the modelling configuration are described further in this section.

5.1 Pilbara Strategic Environmental Assessment

During 2015 BHP undertook a Strategic Environmental Assessment (SEA) of potential cumulative impacts of operations within the Pilbara region, inclusive of all iron ore operations. As part of this assessment a Cumulative Air Quality Assessment was completed with one of the aims being to develop a base model for the region using the dispersion model CALPUFF. The assessment included identifying a representative model year, emissions estimation of sources within the study area, and modelling of the emission sources.

The components of the SEA that are relevant to this study include:

- The representative meteorological year was determined to be 2010
- The WRF model was utilised to generate 3-dimensional meteorology for the model domain
- Emission estimation was undertaken using emission factors from the National Pollutant Inventory (NPI) Emission Estimation Technique Manual for Mining Version 3.1 (EETM for Mining)
- Constant background concentrations, based off the BHP monitoring network, were incorporated for TSP and PM_{10}.

Where possible this assessment has utilised either an identical or similar approach to that outlined in the SEA with the following exceptions:

- Modelled year has been updated to 2020 (Appendix A)
- The background file was updated to the 2020 and now consists of a 24-hour varying file (Section 5.5).

5.2 Meteorological model

The meteorology component of a dispersion model is a key element for the effectiveness or representativeness of the dispersion model outputs. Both upper air and surface information are needed for modelling.

The following sections outline the process for the development of the meteorological file for this assessment.

5.2.1 WRF Model

The Weather Research and Forecast (WRF V3.7) model (http://wrf-model.org/index.php) was used to generate hourly 3-dimensional data for the region. WRF is the next-generation mesoscale numerical weather prediction system. The model was primarily designed to serve both operational forecasting and atmospheric research. WRF features multiple dynamical cores, a 3-dimensional variational data assimilation system and a software architecture allowing for computational parallelism and system extensibility. Further details on WRF are provided in Appendix B.

5.2.2 CALMET

The 3-Dimensional meteorological data generated by WRF was input to CALMET for further processing to the finer resolution used in the dispersion modelling. This procedure will be referred to as the 'WRF-CALMET methodology'. The output from the CALMET meteorological model is then used to drive the pollution dispersion in the CALPUFF model.

CALMET is a three-dimensional meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain blocking effects. The pre-processor produces fields of wind components, air temperature, relative humidity, mixing height and other micro-meteorological variables to produce the three-dimensional, spatially and temporally varying meteorological fields that are utilised in the CALPUFF dispersion model.

CALMET utilised several datasets to resolve the surface and upper air meteorology occurring for each hour of the year:

- surface observations (Whaleback and Jimblebar) and gridded prognostic meteorological model (WRF) data.
- land use and topographical data.

CALMET was run for a 250 x 133 grid domain at a spatial resolution of 130 m. Vertically, the model consisted of 11 levels extending to 3,000 m. The southwest corner coordinates of the domain were 760.0 km Easting and 7405.0 km Northing (UTM Zone 50 S).

Shuttle Radar Topography Mission (SRTM) data with 90 m resolution was input into the CALMET model to indicate terrain heights within the model domain (Figure 5-1). This is an identical approach to that outlined in the SEA (BHP, 2015).

CALMET also requires geophysical data including gridded fields of land use categories. The default United States Geological Survey (USGS) land use classification system (14 category system) was substituted with a more up to date, finer resolution data obtained from the European Space Agency Climate Change Initiative Land Cover (ESACCI-LC) dataset. This is a similar approach to that outlined with the SEA, however improvements were made to account for the finer spatial resolution used in this assessment.

The CALMET results are provided in Appendix B.

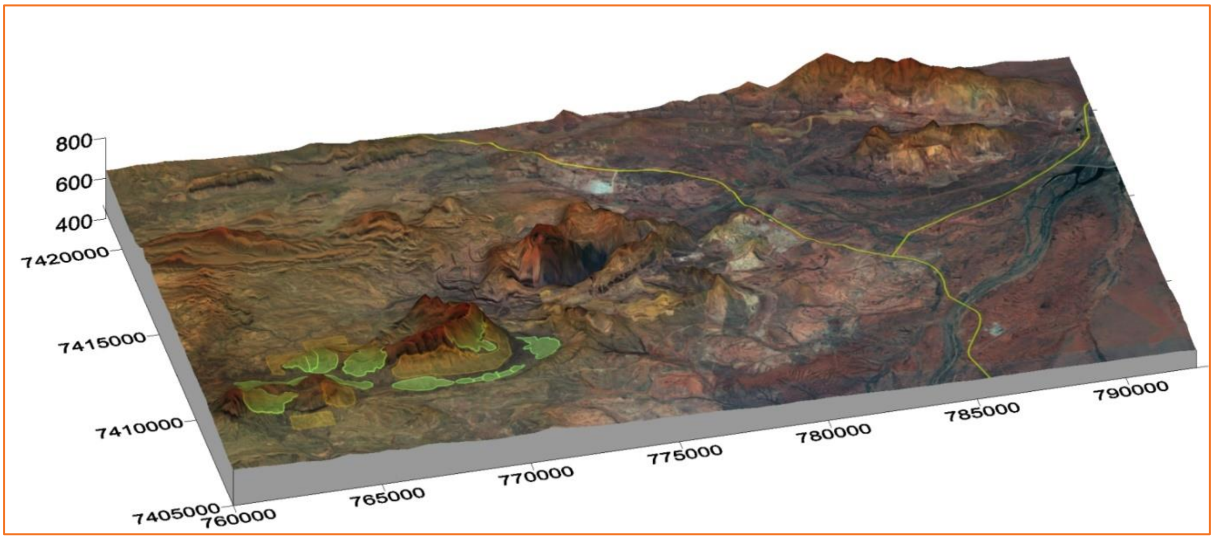

Figure 5-1: Image of SRTM terrain elevation used in CALMET (vertical height is exaggerated)

5.3 CALPUFF

CALPUFF is the dispersion module of the CALMET/CALPUFF suite of models. It is a multi-layer, multi species, non-steady-state puff dispersion model that can simulate the effects of time-varying and space-varying meteorological conditions on pollutant transport, transformation and removal. The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction effects. The model employs dispersion equations based on a Gaussian distribution of pollutants across released puffs and considers the complex arrangement of emissions from point, area, volume and line sources (Scire et al., 2000).

The CALPUFF model was set to calculate concentrations both on a set grid (gridded receptors) and at six specified locations (discrete receptors). The model domain was defined as 32.5 km in the east–west direction and 17.3 km in the north-south direction at a spacing of 130 m.

5.3.1 Emission sources

Each emission source for the Project was characterised as either area sources or volume sources in the dispersion model. Area sources were assigned to open areas while volume sources were assigned to mining activities in the pits and haul roads following the USEPA recommendations (USEPA, 2012). The locations of sources are presented in Appendix D as coordinates (GDA94, zone 50).

This approach varies slightly from the SEA (BHP, 2015) which, due to its large regional scale modelling, used a single area source which incorporated all predicted emissions for each mining operation. The modelling approach adopted for this assessment allows for each emission source to be modelled separately, which is appropriate given the smaller spatial size of the modelled grid.

For the cumulative assessment, the estimated emissions from the Whaleback/Eastern Ridge and proposed Western Ridge mining operations were included.

5.3.2 Particle size distribution

CALPUFF was set up to model depletion of the dust plume concentration through deposition. Since dust is subject to gravitation settling as well as deposition, information on particle size is critical. A particle size distribution for TSP, PM_{10} and $PM_{2.5}$ was estimated using a composite from the USEPA AP-42 manuals for 'aggregated handling and storage piles', 'industrial wind erosion' and 'unpaved roads'. These are shown in Table 5.1. The size distribution for the particulates has been modified since the previous air quality assessment of the BHP Western Ridge operations (ETA, 2022) to both simplify the modelling process and bring the PM_{10}:$PM_{2.5}$ ratios in line with those outlined in WRAP (2006).

Table 5-1: Particle size distribution (%)

Size range (µm)	TSP Cumulative (%)	PM_{10} Cumulative (%)	$PM_{2.5}$ Cumulative (%)
<2.5	6	15	100
2.5 – 5.0	14	36	-
5.0 – 10.0	19	48	-
10.0 – 15.0	14	-	-
15.0 – 30.0	29	-	-
30.0 – 50.0	18	-	-

5.4 Receptors

The discrete receptor locations used in the assessment are listed in Table 5.2, and are shown in Figure 5-2. These locations are existing ambient air quality monitoring locations, are used for interpreting the model results and are consistent with those used in previous air quality assessments of the BHP Western Ridge operations (ETA, 2022).

It is important to note that of these six locations only the Town Monitor (R1) and Newman East (R2) are classified as 'sensitive receptors' in that they are within residential areas. The other four locations are BHP boundary monitors and are located outside of residential areas.

Table 5-2: Discrete receptor locations

ID	Location	Easting (m)	Northing (m)
R1	Town Monitor	779,414	7,414,521
R2	Newman East	781,232	7,413,739
R3	Newman Boundary 1	778,826	7,415,669
R4	Newman Boundary 2	777,239	7,413,124
R5	Newman Boundary 3	783,590	7,415,881
R6	Newman ER OB32	780,714	7,417,256

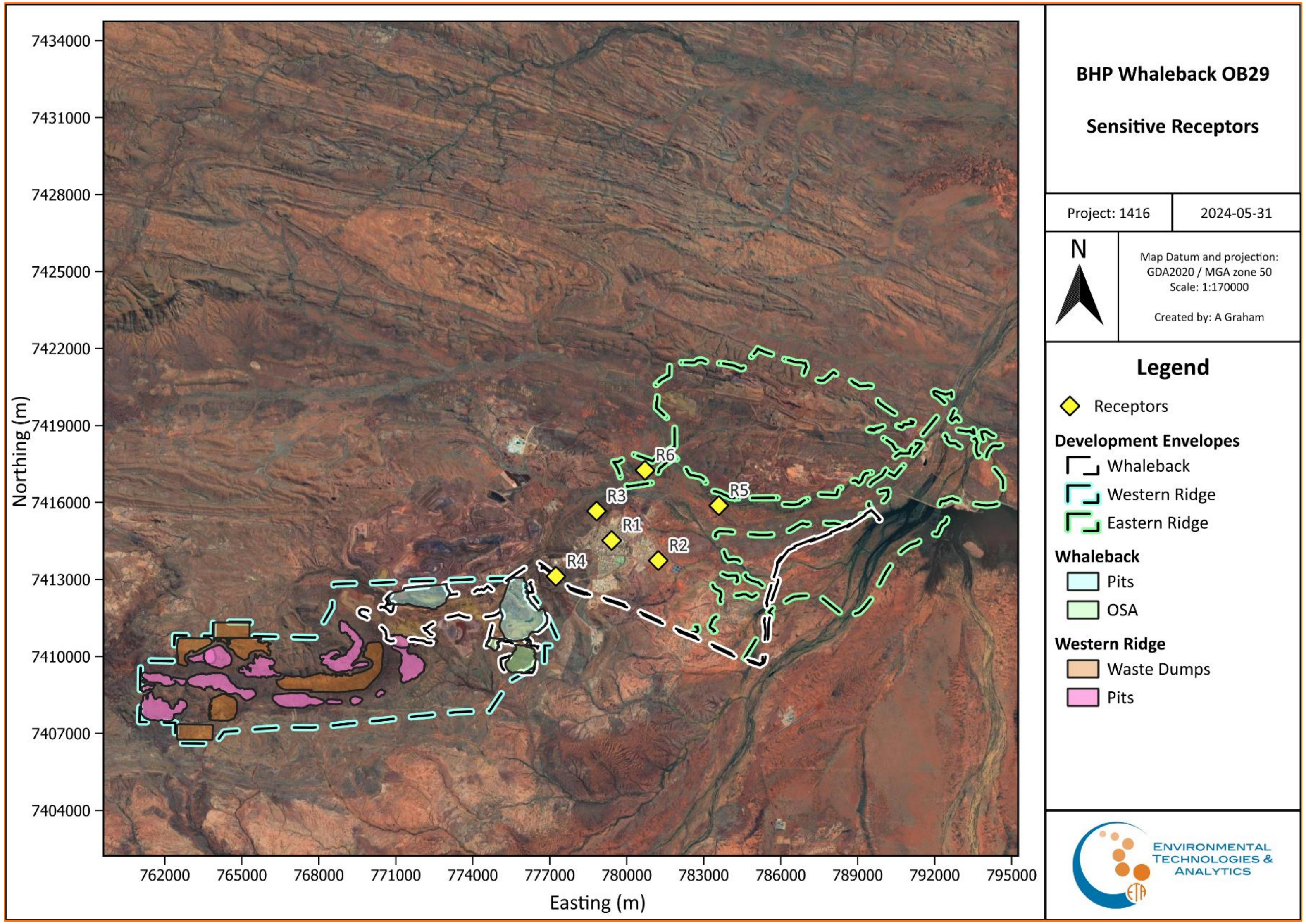

Figure 5-2: Discrete sensitive receptor locations

5.5 Background Air Quality

As outlined in Section 3.2 the Pilbara region is naturally dusty with wind-blown dust and wildfires being a significant contributor to dust emissions. To account for these additional particulate sources in the region a 24-hour variable PM_{10} background file was created.

Within the Newman region BHP operate a series of BAM1020 monitors (Figure 5-3) with the majority of these monitors being located between the Township of Newman and the mining and processing operations at either Eastern Ridge or Mt Whaleback. However four of the monitoring locations can be considered to be background monitors based on their distance from the operations. These monitors include:

- Background East BAM
- Background 2 South BAM
- Background West BAM
- Background 3 BAM north.

The 2020 hourly PM_{10} monitoring data for each of these four BAM monitors was obtained from BHP and the background file was derived using the following methodology:

- Indicative wind arcs were assigned to each monitor to ensure that the monitor was 'upwind' and the hourly PM_{10} concentration was not influenced by emissions from the mining or processing operations as well as potential emissions from within the Township of Newman. The assigned arcs are presented in Table 5-3.
- The hourly wind direction was based on the data recorded at the BHP Ophthalmia meteorological station.
- The hourly background PM_{10} concentration was determined by assigning the hourly PM_{10} data from the BAM1020 that was within the arc of influence.
- Note that the monitoring data from the Background West BAM monitor was only available from 26 March 2020 onwards. As can be seen from Table 5-3 the arc of influence for this monitor overlaps with that for the Background 3 BAM North monitor. When data for both monitors was available within the overlapping arc of influence the minimum hourly PM_{10} concentration was utilised.

The derived hourly data was then averaged to obtain a 24-hour average background concentration. The statistics of this 24-hour are tabulated in Table 5-4 and presented in Figure 5-4 as a time series graph. The 24-hour PM_{10} data was:

- doubled to derive an indicative background TSP file.
- reduced by 70% to derive an indicative $PM_{2.5}$ background file.

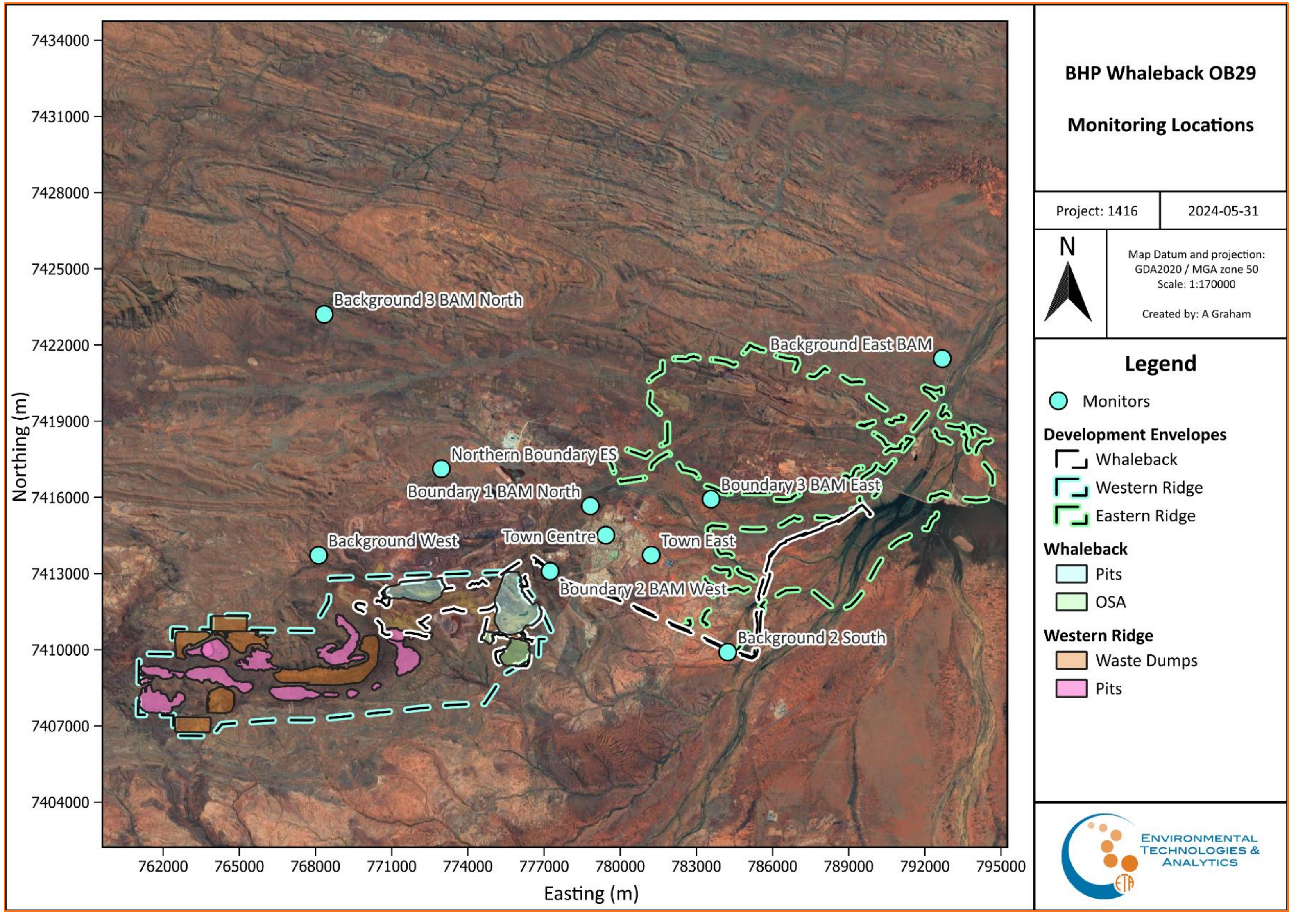

Figure 5-3: BHP ambient monitoring locations within the Newman region.

Table 5-3: Arcs of influence for determining background concentrations

Monitor	From	To
Background East BAM	320°	75°
Background 2 South BAM	75°	225°
Background West BAM	225°	310°
Background 3 BAM north	225°	320°

Table 5-4: Statistics of 24-hour averaged PM_{10} background file

Statistic	Concentration (µg/m³)
Maximum	79.9
99 Percentile	49.0
95 Percentile	28.9
90 Percentile	23.7
70 Percentile	15.3
Average	14.5
Number greater than 50 µg/m³	4
Number greater than 70 µg/m³	2

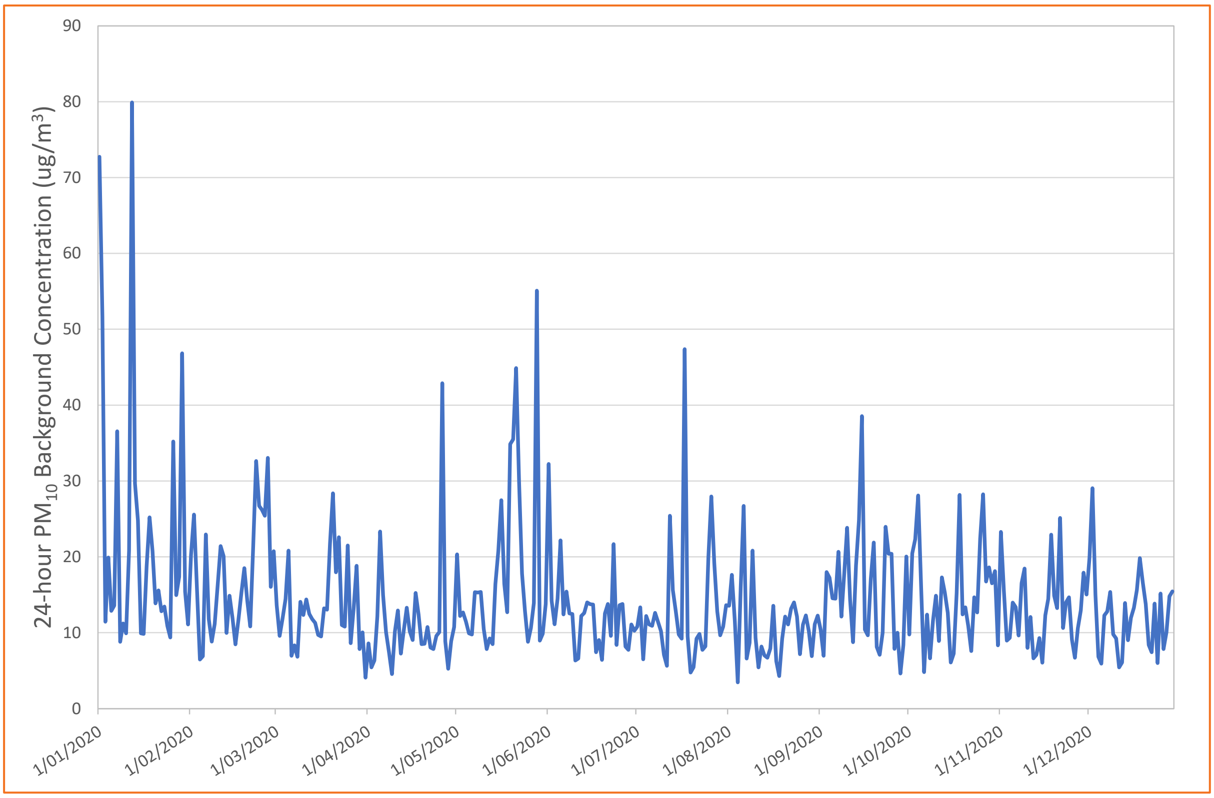

Figure 5-4: Time series graph of the 24-hour PM_{10} background file for the Newman region

6 Emissions to air estimation

When determining the potential impact of a facility, either existing or proposed, one of the critical inputs is the source emission file. The following sections outline the process whereby potential sources are identified, and quantified, based on the forecast throughput tonnage of the facility. For this assessment there are three modelled scenarios:

- Scenario 1: Current operations – Mt Whaleback (includes existing OB29/30/35) & Eastern Ridge (as outlined in ETA, 2022)
- Scenario 2: Future project – OB29/30/35 Significant amendment in isolation (Project)
- Scenario 3: Future project – OB29/30/35 operations including both approved and significant amendment in isolation.
- Scenario 4: Future cumulative – Proposed OB29/30/35, Mt Whaleback, Eastern Ridge and future Western Ridge plus background concentrations.

The emission estimation process for Scenario 1 and the future Western Ridge operations are outlined in ETA (2022). The following sections outline the emission estimation process for the Project.

6.1 Emission Source Inventory

The key emission sources for the operating phase (mining only) of the Project are associated with:

- drilling and blasting
- material handling from loading and unloading activities involving;
    - loading trucks
    - unloading trucks
    - bulldozing
- wheel generated dust from roads and haul roads
- wind erosion from stockpiles and open areas.

A summary of the estimated annual mining tonnages for the life of the Project, as supplied by BHP, are presented in Table 6.1. From this table the Mining Year 2036 was chosen for this assessment as it represents the maximum mining tonnage, along with a 50:50 mix of waste being directed either the new OB29 OSA or backfilling in-pit.

Table 6-1: Forecast mining tonnages (Mtpa)

Pit	Type	2025	2027	2028	2032	2033	2034	2035	2036	2037	2038	2039
OB29/30/35	Waste	6.75	2.57	21.59	13.05	0.79	5.39	3.82	22.61	11.89	7.39	16.39
	Ore	6.79	11.44	6.06	5.84	0.96	11.00	8.66	11.26	7.02	7.36	17.60
TOTAL		**13.54**	**14.01**	**27.65**	**18.89**	**1.75**	**16.39**	**12.48**	**33.88**	**18.91**	**14.76**	**33.99**

Pit	Type	2040	2055	2056	2057
OB29/30/35	Waste	0.03	11.24	4.21	0.20
	Ore	0.10	2.31	8.12	0.87
TOTAL		**0.13**	**13.55**	**12.33**	**1.07**

6.2 Emission estimates – OB29/30/35 SA

This section outlines the emission estimation process for the Project. Emission estimates are sourced from this inventory for inclusion in the dispersion model. It includes the emissions from mine operations, facilities and associated infrastructure including the road network. Emissions from all key sources have been identified according to accepted methods and, in accordance with the SEA (BHP, 2015), the NPI EETM for Mining (EA, 2012a) has been referenced for emission equations and values.

The emphasis of the emission estimation and modelling is on the potential impact from the operating phase of the various operations within the Project. Emission estimation of construction activities is excluded from the assessment due to their intermittent nature over the life of the Project.

The emission estimation process for the Mt Whaleback, Eastern Ridge and proposed Western Ridge operations, for both the existing and future scenarios are outlined in ETA (2022).

6.2.1 Drilling

Emissions for drilling have been calculated using the default emissions contained within the EETM for Mining (EA, 2012a). The default values are:

- TSP: 0.59 kg/hole
- PM_{10}: 0.31 kg/hole
- $PM_{2.5}$: 15% of PM_{10} emissions

The statistics of the annual PM_{10} emissions from drilling for PM_{10} are contained in Appendix E.

6.2.2 Blasting

Emissions for blasting have been calculated using Equation 19 contained in Appendix A of the EETM for Mining. This is represented by Equation 1:

Equation 1: $$EF_{TSP\ (kg/blast)} = 0.00022 \times A^{1.5}$$

Where A = blast area (m^2)

The emission factor for PM_{10} is taken as 52% of the TSP emission and the $PM_{2.5}$ emissions are taken as 15% of the PM_{10} emissions. The statistics of the annual PM_{10} emissions for blasting for PM_{10} are contained in Appendix D.

Within the model blasting was assumed to occur approximately twice per week within each pit area with blasting times at either 11am or 1pm.

6.2.3 Loading ore/waste

Emissions for loading ore and waste have been calculated using the default value for excavators and front end loaders on overburden of:

- TSP: 0.025 kg/t
- PM_{10}: 0.012 kg/t

The emission factor for $PM_{2.5}$ emissions is taken as 15% of the PM_{10} emissions. The statistics of the annual emissions for loading for PM_{10} are contained in Appendix E.

6.2.4 Unloading ore/waste

Emissions for unloading ore and waste have been calculated using the default values of:

- TSP: 0.012 kg/t
- PM_{10}: 0.0043 kg/t

The emission factor for $PM_{2.5}$ emissions is taken as 15% of the PM_{10} emissions. The statistics of the annual emissions for loading for PM_{10} are contained in Appendix E.

6.2.5 Bulldozing

Emissions for the operation of bulldozers on both ore and waste have been determined using Equation 16 and Equation 17 outlined in Appendix A of the EETM for Mining (EA, 2012) and presented below as Equation 2 for TSP and Equation 3 for PM_{10}. The silt and moisture contents used were the defaults listed in the manual (2% moisture, 10% silt).

Equation 2:

$$EF_{TSP\ (kg/hr)} = 2.6 \times \frac{s^{1.2}{}_{(\%)}}{M^{1.3}{}_{(\%)}}$$

Equation 3:

$$EF_{PM_{10}\ (kg/hr)} = 0.34 \times \frac{s^{1.5}{}_{(\%)}}{M^{1.4}{}_{(\%)}}$$

Where: s = silt content (%)
M = moisture (%)

The emission factor for $PM_{2.5}$ emissions is taken as 15% of the PM_{10} emissions. The statistics of the annual PM_{10} emissions for bulldozing are contained in Appendix E.

6.2.6 Haul Roads

To determine emissions from wheel generated dust along the haul roads the default equation for 'unpaved roads from wheels' was utilised (Equation 4). The weight of the haul trucks was taken as 272 tonnes – being the average of an empty and fully laden CAT793E haul truck and the default silt content of 10% was utilised.

Equation 4:

$$EF_{(kg/VKT)} = \frac{0.4536}{1.6093} \times k \times \left(\frac{s_{(\%)}}{12}\right)^a \times \left(\frac{W_{(t)}}{3}\right)^b$$

Where: *k* = constant (TSP = 4.9, PM_{10} = 1.5)
$s_{(\%)}$ = silt content (%)
$W_{(t)}$ = vehicle mass (t)
a = constant (TSP = 0.7, PM_{10} = 0.9)
b = constant (0.45)

The emission factor for $PM_{2.5}$ emissions is taken as 15% of the PM_{10} emissions. The statistics of the annual emissions for loading for PM_{10} are contained in Appendix E.

6.2.7 Wind erosion

The default emission factor for wind erosion in the EETM for Mining is a constant emission of 0.2 kg/ha/hr which, while potentially suitable for the calculation of annual emissions, is not suitable for inclusion in atmospheric modelling. This assessment used the modified Shao equation outlined in SKM (2005) which is represented as Equation 5:

Equation 5:

$$PM_{10\,(g/m^2/s)} = k \times \left\{WS^3 \times \left(1 - \left(WS_0^{\,2}/WS^2\right)\right)\right\} \qquad WS > WS_0$$

$$PM_{10\,(g/m^2/s)} = 0 \qquad WS < WS_0$$

Where: WS = wind speed (m/s)
WS_0 = threshold for particulate matter lift off (m/s)
k is a constant

For this assessment the wind speed threshold was set at 5.4 m/s and the k constants were set at 6.3 x 10^{-6}, resulting in an overall emission rate of 0.4 kg/ha/hr for PM_{10} from open areas. This is higher than the emission rate of 0.2 kg/ha/hr specified in the EETM for Mining (EA, 2012) which, as outlined in SKM (2005), is derived for the Hunter Valley region of New South Wales (NSW). The SKM (2005) report notes that an applicable rate for the Pilbara region is 0.4 kg/ha/hr for PM_{10} which is the value used in this assessment. This increase in wind erosion emissions is based on a range of factors including increased wind speed, lower rainfall and higher evaporation rates in the Pilbara region.

The emission factor for TSP is taken as twice that of the PM_{10} emissions while $PM_{2.5}$ emissions are taken as 15% of the PM_{10} emissions (Table 5-1).

6.3 Emission Controls

Emissions controls (for dust abatement) were included in the emissions estimation and these controls are summarised in Table 6.2, along with the percentage reduction applied to each source type.

Table 6-2: Dust abatement in place (included in model)

	Equipment	Dust abatement description	Emission reduction
Mining	Bulldozing	None	0%
	Loading ore and waste	In pit reduction	5% (PM_{10}) 50% (TSP)
	Unloading waste	None	0%
	Unloading ore at ROM pad	None	0%
	Drilling	In pit reduction	5% (PM_{10}) 50% (TSP)
	Blasting	In pit reduction	5% (PM_{10}) 50% (TSP)
	Wind erosion (OSA and ROM pad)	Watering	15%
Haul road	Hauling	Level 1 watering	50% (75% availability) 25% (25% availability)

6.4 Emission summary

A summary of the estimated annual emissions from the Project is shown in Table 6.3.

Table 6-3: Estimate of TSP, PM_{10} and $PM_{2.5}$ annual particulate emissions from the Project (kg/yr)

Source	Process	2036		
		TSP	PM_{10}	$PM_{2.5}$
Mining	Drilling	1,086	1,084	163
	Blasting	47,755	47,182	7,077
	Loading	257,000	234,384	35,158
	Unloading	138,989	49,804	7,471
	Bulldozers	130,770	41,358	6,204
Wind Erosion	Wind Erosion	96806	57,168	8,575
Haul Roads	Haul Roads	1,479,749	436,764	65,515
Total		2,152,155	867,744	130,163

7 Predicted air quality impact

Comparison of the modelled results to the assessment criteria is intended to provide an objective evaluation of the potential impact of the operations at the nearest sensitive receptors. Modelled ground-level concentrations for key air pollutants have been compared to ambient air quality assessment criteria to determine the potential impacts.

The results of the modelling, for PM_{10} and $PM_{2.5}$, are presented for four scenarios:

- Scenario 1: Current operations – Mt Whaleback (includes existing OB29/30/35) & Eastern Ridge (i.e. as defined in ETA (2022) and presented in Appendix C)
- Scenario 2: Future project – OB29/30/35 Significant amendment in isolation (Project)
- Scenario 3: Future project – OB29/30/35 operations including both approved and amendment in isolation.
- Scenario 4: Future cumulative – Proposed OB29/30/35, Mt Whaleback, Eastern Ridge and future Western Ridge plus background concentrations.

The model results for TSP, for these four scenarios, are presented in Appendix F.

7.1 Particulates as PM_{10}

To assess the potential air quality impact, modelled PM_{10} concentrations are compared to the assessment criteria of 70 μg/m^3 as discussed in Section 4.2. The predicted ground level concentrations at the key sensitive receptor locations are presented for each scenario. The modelled concentration statistics are provided in tabulated form for each scenario and, where applicable, include the background air quality estimate for the region. Figures demonstrating the ground level concentration contours are also presented.

7.1.1 Scenario 1

The statistics of the PM_{10} model results, for Scenario 1, with background concentrations, are presented in Table 7-1.

Table 7-1: Statistics of 24-hour PM_{10} concentration at sensitive receptors – Scenario 1 (μg/m^3) (with background)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >70
1	Town Monitor	121	93	77	74	63	57	39	31	12
2	Newman East	112	91	77	75	63	54	36	29	11
3	Newman Boundary 1	120	95	84	77	67	59	40	32	15
4	Newman Boundary 2	177	142	114	110	91	77	44	37	45
5	Newman Boundary 3	170	168	141	120	106	85	54	43	65
6	Newman ER OB32	114	93	82	80	67	61	45	35	12

The isopleths of the annual average PM_{10} concentrations (with background) are presented in Figure 7-1 while the isopleths for the predicted maximum 24-hour PM_{10} concentrations are presented Figure 7-2.

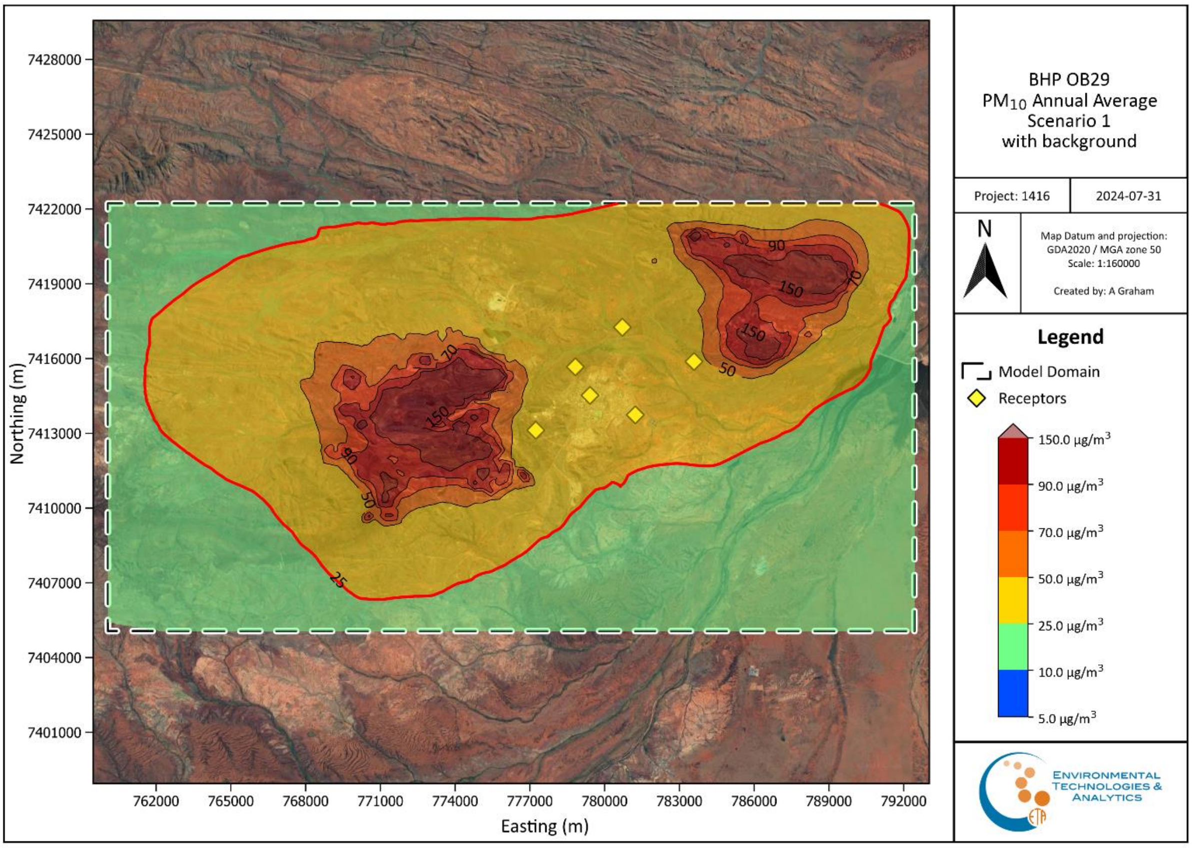

Figure 7-1: Maximum predicted annual PM_{10} concentrations – Scenario 1 (with background)

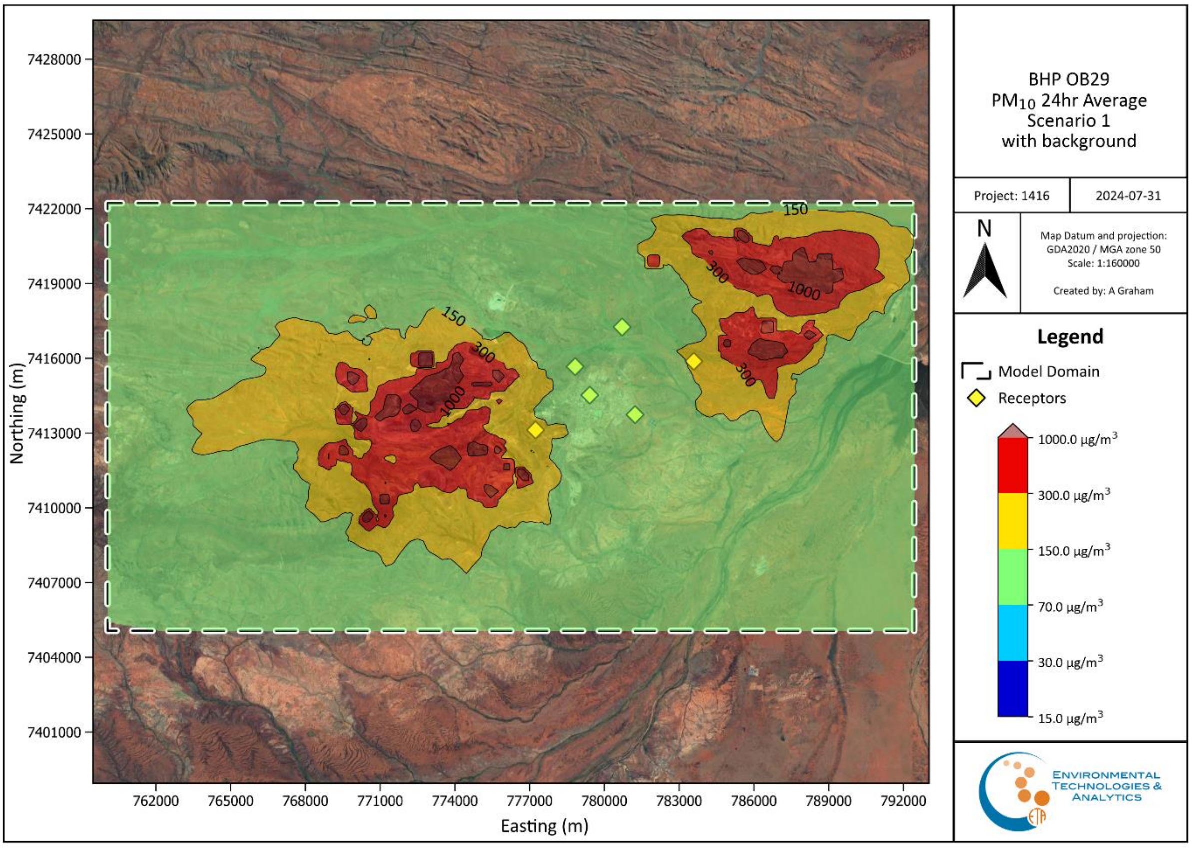

Figure 7-2: Maximum predicted 24-hour PM_{10} concentrations – Scenario 1 (with background)

7.1.2 Scenario 2

The statistics of the 24-hour predicted PM_{10} concentrations for the Project (OB29/30/35 significant amendment), in isolation of other sources, are presented in are presented in Table 7-2. The results indicate that:

- The closest receptor (Newman Boundary 2) is predicted to have the highest 24-hour concentrations of PM_{10}, primarily due its relatively close distance to the proposed operations.
- For the remaining receptors the predicted ground level 24-hour concentrations of PM_{10} are expected to reduce from the maximum down through the lower statistics and once below the 90th percentile the predicted impacts are expected to be negligible.

Table 7-2: Statistics of 24-hour PM_{10} concentration at sensitive receptors – Scenario 2 (µg/m³) (in isolation)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >70
1	Town Monitor	19	14	12	11	8	6	1	2	0
2	Newman East	10	8	7	6	5	3	1	1	0
3	Newman Boundary 1	13	9	9	8	7	5	1	1	0
4	Newman Boundary 2	33	30	28	28	22	18	7	5	0

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >70
5	Newman Boundary 3	5	5	4	4	3	2	0	1	0
6	Newman ER OB32	9	7	6	5	4	3	0	1	0

The isopleths of the predicted annual PM_{10} concentrations (in isolation), for Scenario 2, are presented in Figure 7-3, while the isopleths for the maximum predicted 24-hour PM_{10} concentrations are presented in Figure 7-4.

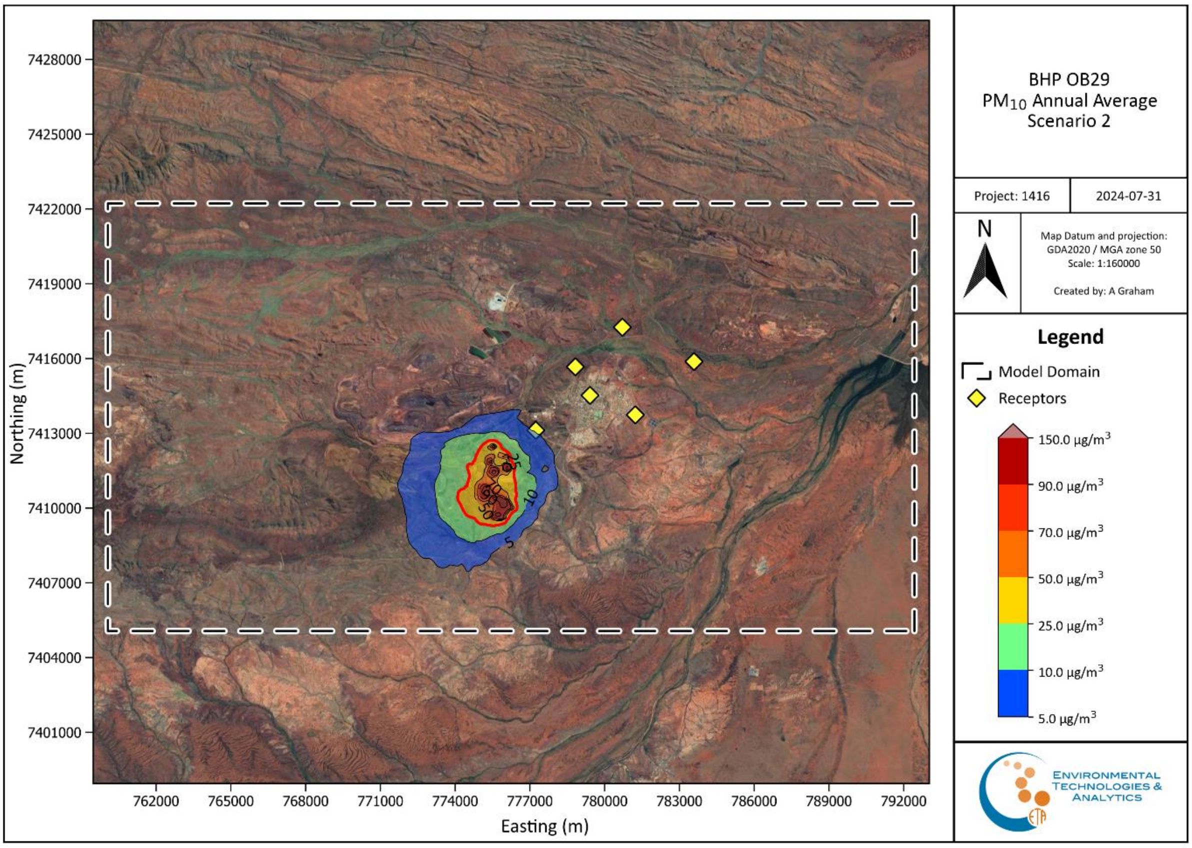

Figure 7-3: Maximum predicted annual PM_{10} concentrations – Scenario 2 (in isolation)

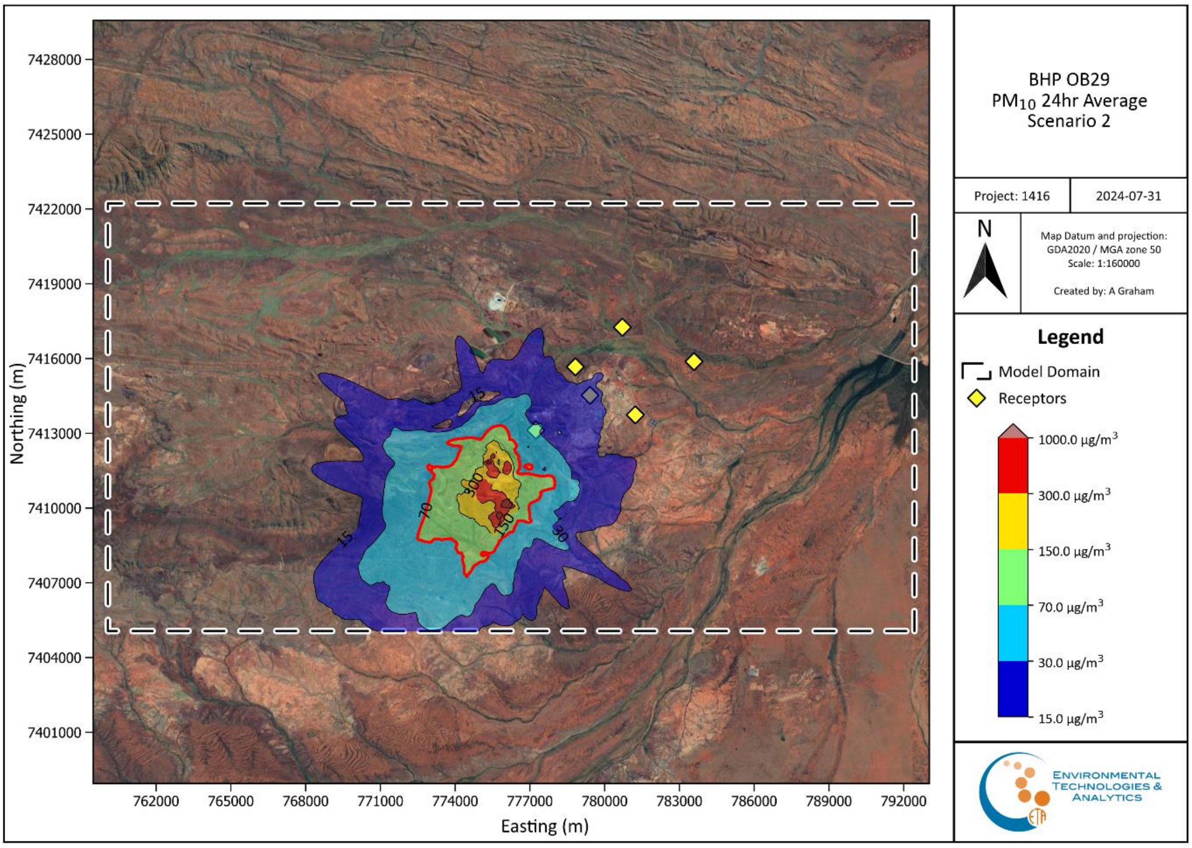

Figure 7-4: Maximum predicted 24-hour PM_{10} concentrations – Scenario 2 (in isolation).

7.1.3 Scenario 3

The statistics of the 24-hour predicted PM_{10} concentrations for the Project (OB29/30 operations including both approved and significant amendment in isolation), in isolation of other sources, are presented in are presented in Table 7-3. The results indicate that:

- The closest receptor (Newman Boundary 2) is predicted to have the highest 24-hour concentrations of PM_{10}, primarily due its relatively close distance to the proposed operations.
- For the remaining receptors the predicted ground level 24-hour concentrations of PM_{10} are expected to reduce from the maximum down through the lower statistics and once below the 90th percentile the predicted impacts are expected to be negligible.

Table 7-3: Statistics of 24-hour PM_{10} concentration at sensitive receptors – Scenario 3 (µg/m^3) (in isolation)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >70
1	Town Monitor	29	24	20	17	17	10	3	3	0
2	Newman East	16	16	11	10	10	5	1	2	0
3	Newman Boundary 1	19	15	13	13	13	7	2	2	0

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >70
4	Newman Boundary 2	48	47	42	40	40	27	11	8	0
5	Newman Boundary 3	10	9	7	7	7	3	0	1	0
6	Newman ER OB32	14	13	9	8	8	4	1	1	0

The isopleths of the predicted annual PM_{10} concentrations (in isolation), for Scenario 3, are presented in Figure 7-5, while the isopleths for the maximum predicted 24-hour PM_{10} concentrations are presented in Figure 7-6.

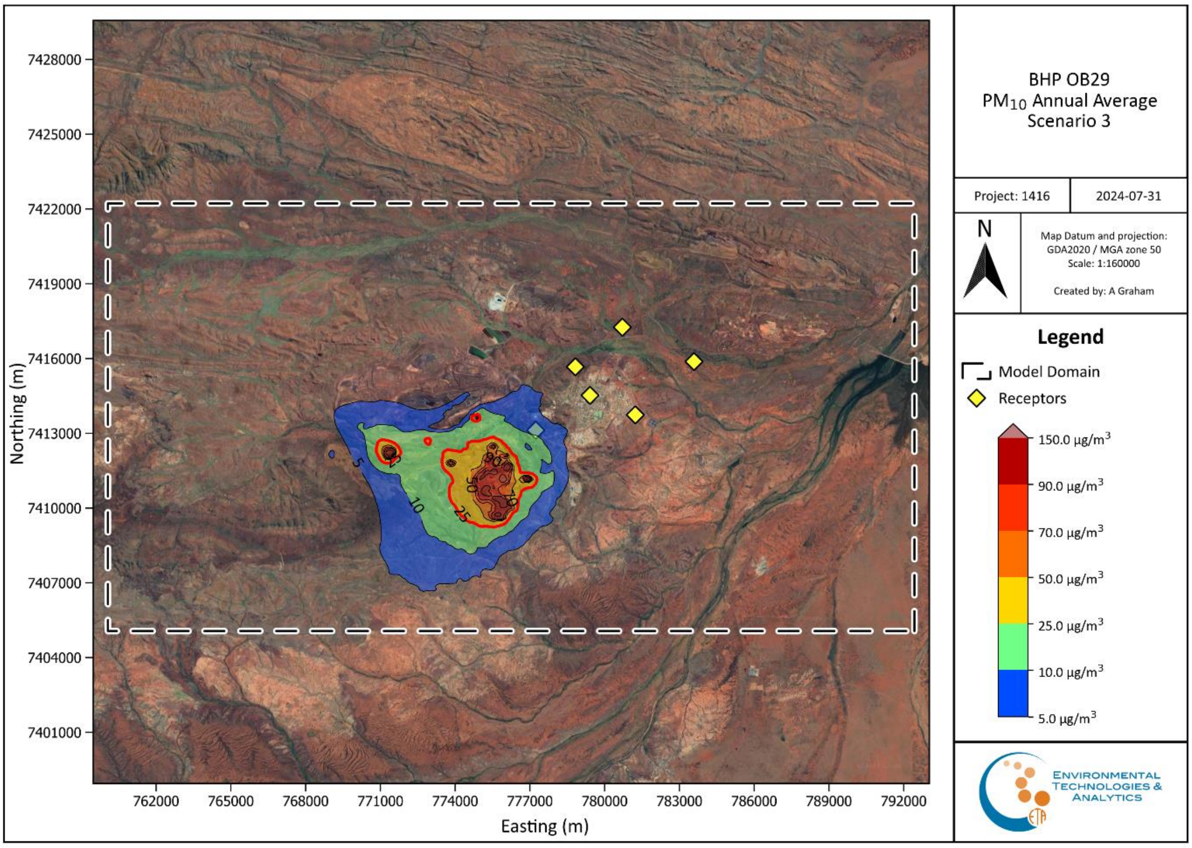

Figure 7-5: Maximum predicted annual PM_{10} concentrations – Scenario 3 (in isolation)

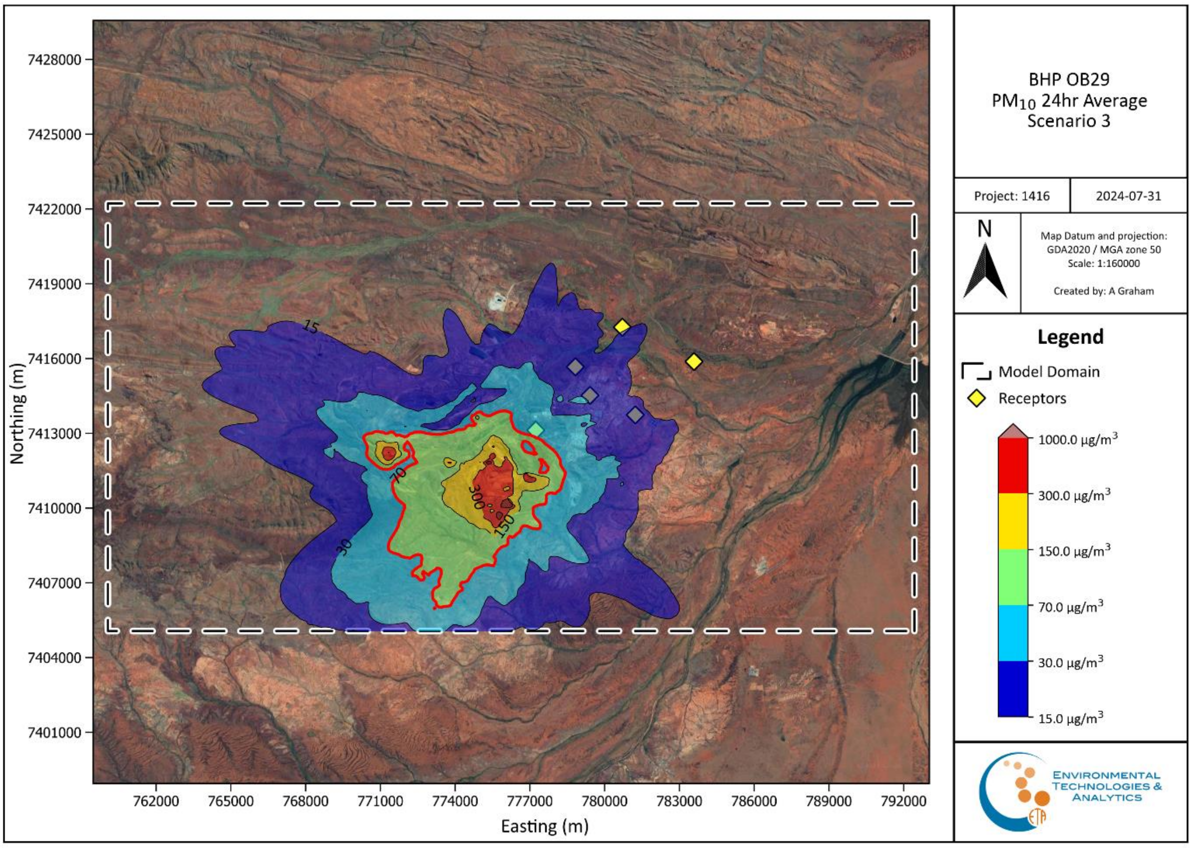

Figure 7-6: Maximum predicted 24-hour PM_{10} concentrations – Scenario 3 (in isolation).

7.1.4 Scenario 4

The statistics of the 24-hour predicted PM_{10} concentrations for Scenario 4 (Proposed OB29/30/35, Mt Whaleback (includes existing OB29/30/35), Eastern Ridge and future Western Ridge) with background are presented in Table 7-4. From this table it is apparent that, when compared to the results for the existing scenario (Scenario 1), the introduction of both the proposed Western Ridge and the Project:

- The modelling indicates that there will be a slight increase in the maximum PM_{10} concentrations at the Town and Newman East monitors.
- The lower statistics at these two residential monitors indicates that there will be an overall reduction predicted ground level concentrations.
- The modelling predicts that there will be a reduction in the number of excursions of the criteria (70 μg/m^3) at both residential monitors.
- Although the modelling is indicating a decrease in overall PM_{10} concentrations the annual average at the Town Monitor is still predicting to be above the annual criteria (Table 4-1).

Table 7-4: Statistics of 24-hour PM_{10} concentration at sensitive receptors – Scenario 4 with background (µg/m³)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >70
1	Town Monitor	126	83	64	62	62	44	33	26.8	4
2	Newman East	114	82	59	56	55	43	29	24.8	3
3	Newman Boundary 1	109	78	59	55	55	43	32	26.7	2
4	Newman Boundary 2	190	132	109	106	104	63	40	33.5	26
5	Newman Boundary 3	126	123	107	103	102	65	42	34.6	31
6	Newman ER OB32	100	77	70	63	61	47	36	29.5	6

The isopleths of the annual average PM_{10} concentrations (with background) for Scenario 4 are presented in Figure 7-7 while the isopleths for the predicted maximum 24-hour PM_{10} concentrations are presented Figure 7-8.

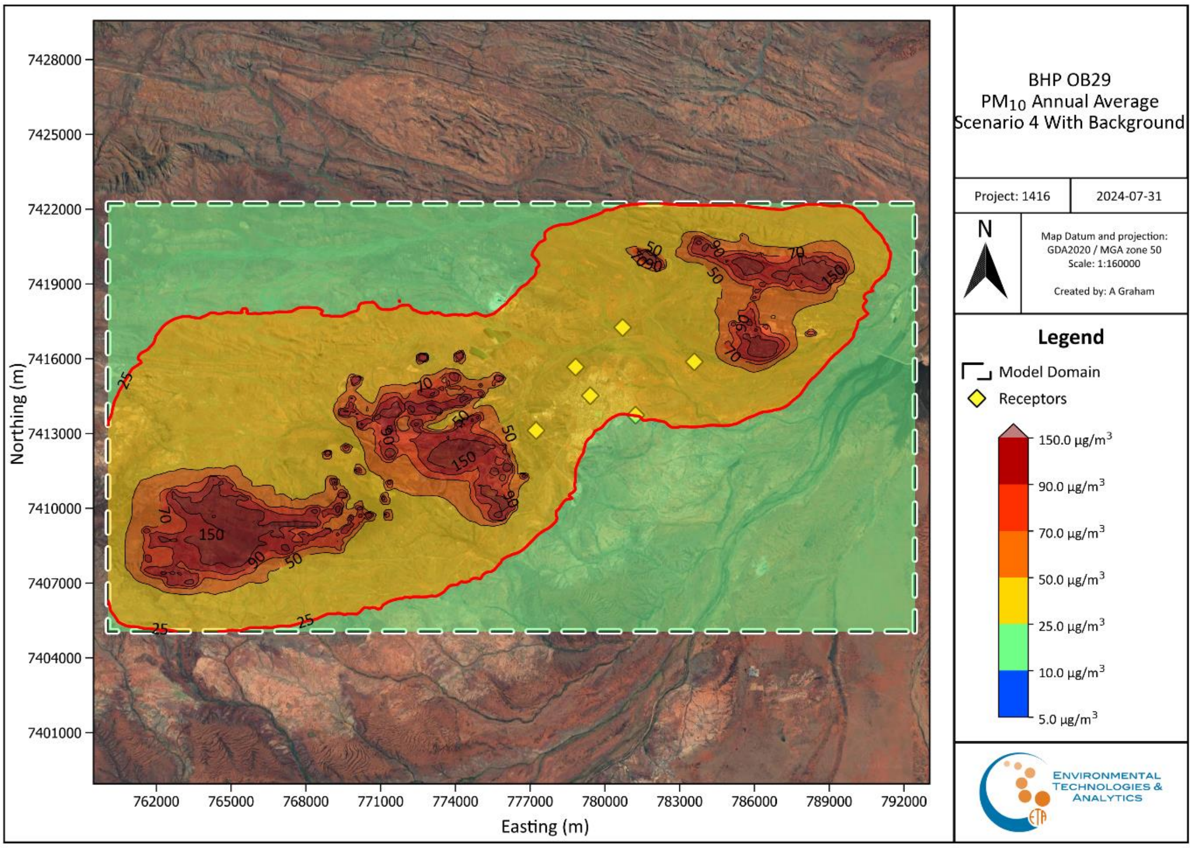

Figure 7-7: Predicted annual PM_{10} concentrations – Scenario 4 with background

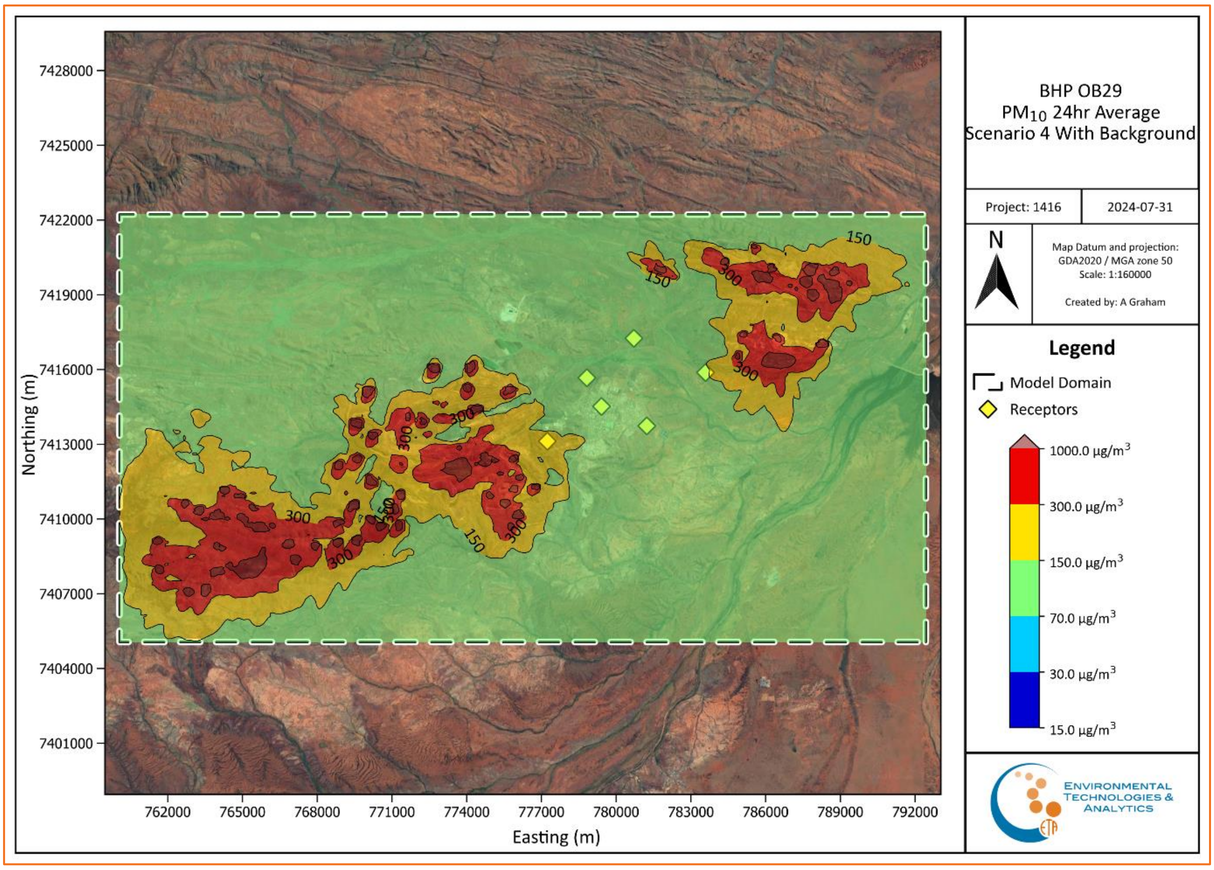

Figure 7-8: Maximum predicted 24-hour PM_{10} concentrations – Scenario 4 with background

7.2 Particulates as $PM_{2.5}$

To assess the potential air quality impact, modelled $PM_{2.5}$ concentrations are compared to the assessment criteria of 25 µg/m^3 as discussed in Section 4.2. The predicted ground level concentrations at the key sensitive receptor locations are presented for each scenario. The modelled concentration statistics are provided in tabulated form for each scenario and include the background air quality estimate for the region. Figures demonstrating the ground level concentration contours are also presented.

7.2.1 Scenario 1

The statistics of the $PM_{2.5}$ model results, for the Scenario 1, with background concentrations, are presented in Table 7-5.

Table 7-5: Statistics of 24-hour $PM_{2.5}$ concentration at sensitive receptors – Scenario 1 (µg/m^3)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
1	Town Monitor	17	12	8	7	7	6	4	3.5	0

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
2	Newman East	15	12	9	8	8	6	4	3.4	0
3	Newman Boundary 1	15	11	8	8	8	6	4	3.6	0
4	Newman Boundary 2	24	15	13	11	11	7	4	3.9	0
5	Newman Boundary 3	19	18	16	15	15	10	6	5.0	0
6	Newman ER OB32	14	11	11	9	9	7	5	4.1	0

The isopleths of the maximum predicted 24-hour $PM_{2.5}$ concentrations for scenario 1 are presented in Figure 7-9, and Figure 7-10.

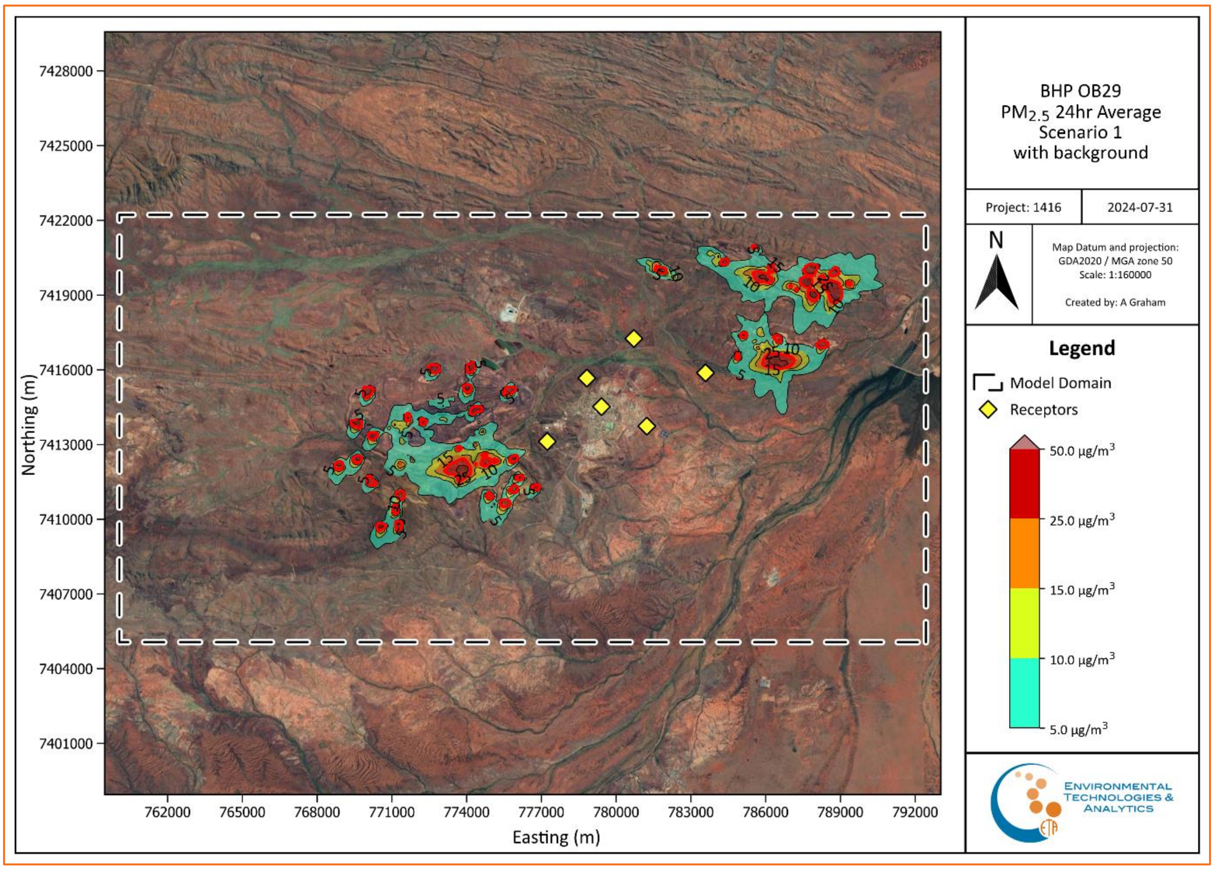

Figure 7-9: Maximum predicted 24-hour $PM_{2.5}$ concentrations – Scenario 1

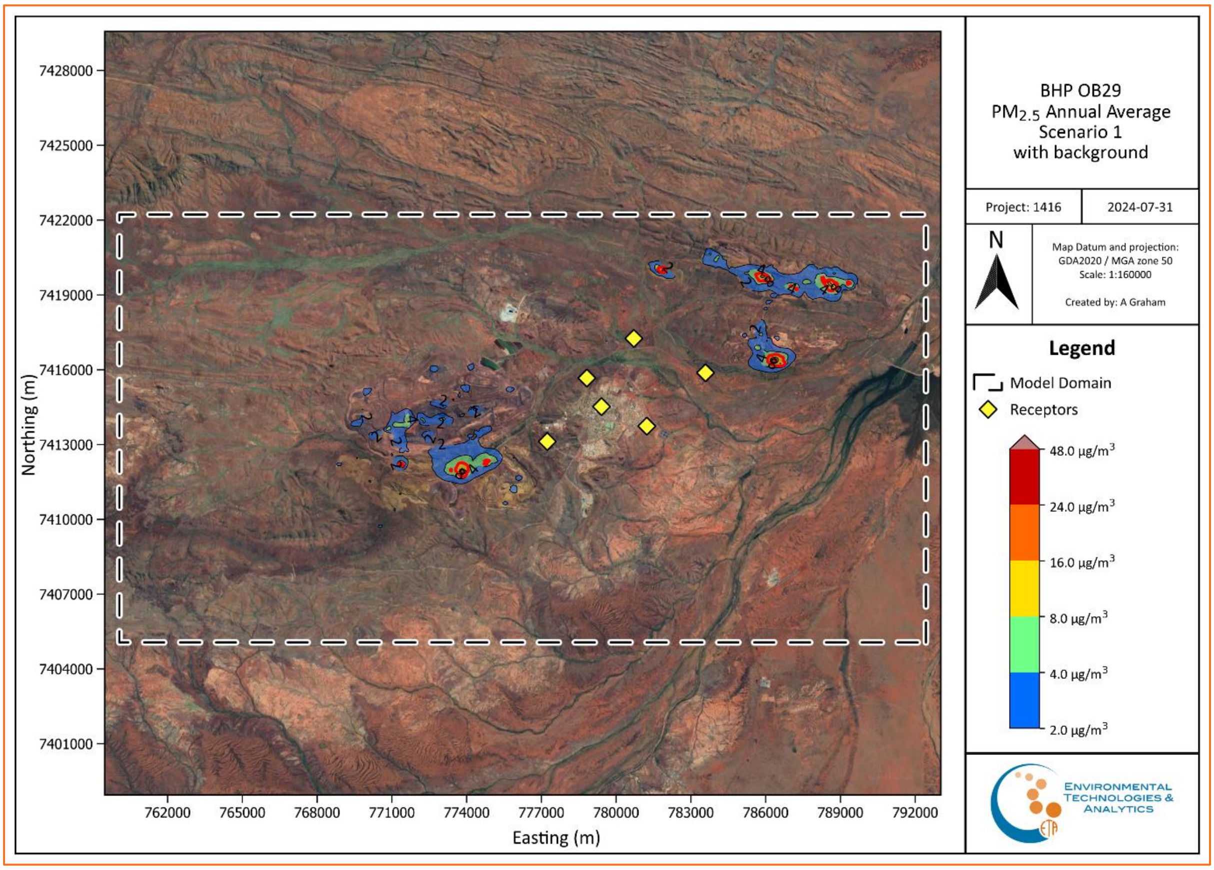

Figure 7-10: Maximum predicted annual $PM_{2.5}$ concentrations – Scenario 1

7.2.2 Scenario 2

The statistics of the 24-hour predicted $PM_{2.5}$ concentrations for the Project (OB29/30/35 significant amendment), in isolation of other sources, are presented in Table 7-6. The results indicate that:

- The closest receptor (Newman Boundary 2) is predicted to have the highest 24-hour concentrations of $PM_{2.5}$, primarily due its relatively close distance to the proposed operations.
- For all of the receptors the predicted ground level 24-hour concentrations of $PM_{2.5}$ are expected to be well below the criteria and once below the 95th percentile the predicted impacts are expected to be negligible.

Table 7-6: Statistics of 24-hour $PM_{2.5}$ concentration at sensitive receptors – Scenario 2 (µg/m^3) (in isolation)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
1	Town Monitor	2.9	2.1	1.8	1.7	1.2	0.9	0.2	0.3	0
2	Newman East	1.5	1.2	1.1	0.9	0.8	0.5	0.2	0.2	0
3	Newman Boundary 1	2.0	1.4	1.4	1.2	1.1	0.8	0.2	0.2	0

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
4	Newman Boundary 2	5.0	4.5	4.2	4.2	3.3	2.7	1.1	0.8	0
5	Newman Boundary 3	0.8	0.8	0.6	0.6	0.5	0.3	0.0	0.2	0
6	Newman ER OB32	1.4	1.1	0.9	0.8	0.6	0.5	0.0	0.2	0

The isopleths of the maximum predicted 24-hour $PM_{2.5}$ concentrations, in isolation, for Scenario 2 are presented in Figure 7-11, and Figure 7-12.

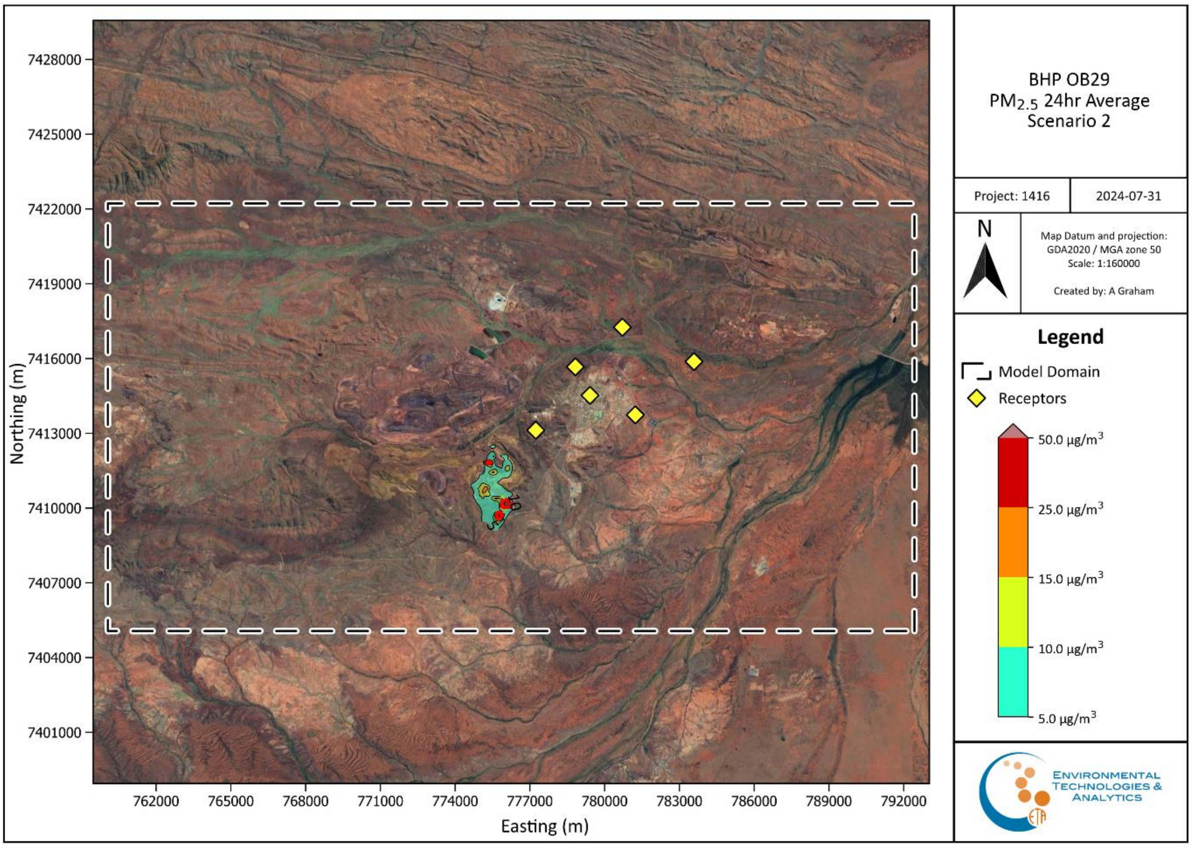

Figure 7-11: Maximum predicted 24-hour $PM_{2.5}$ concentrations – Scenario 2 (in isolation)

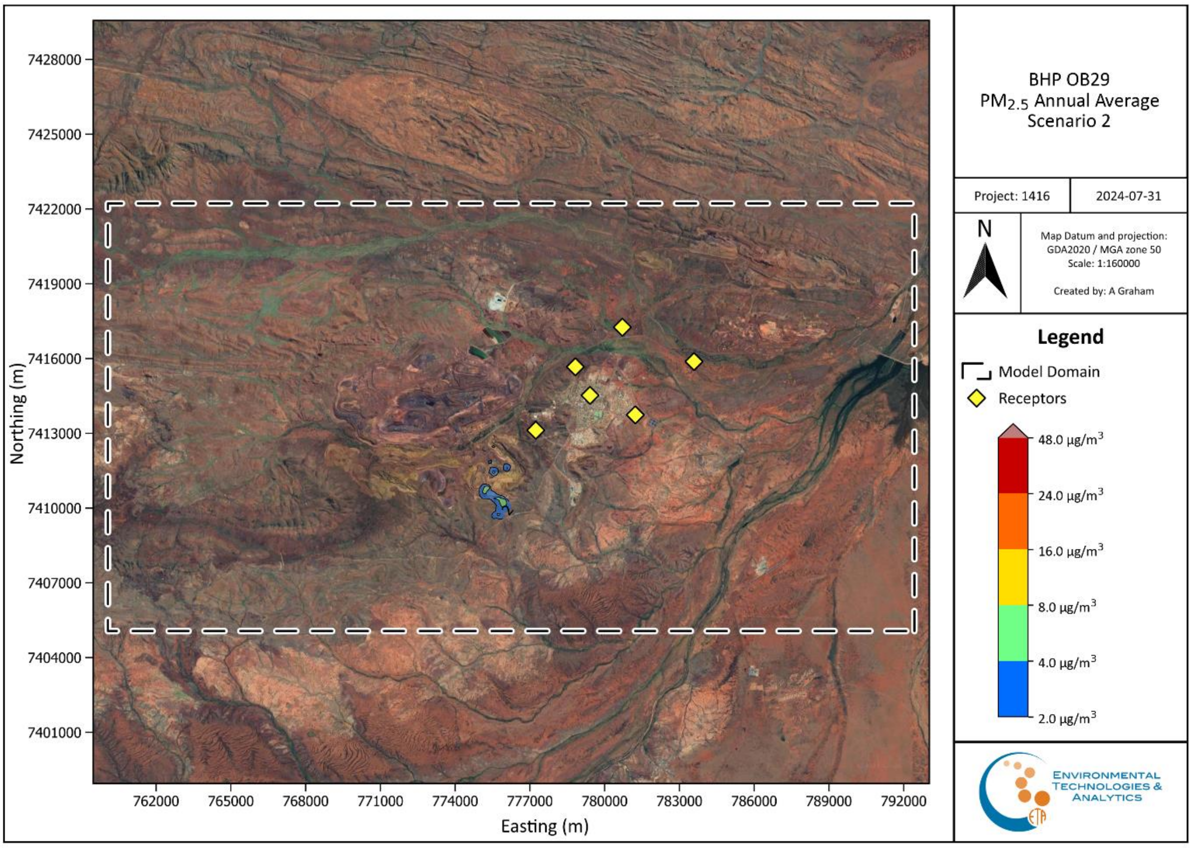

Figure 7-12: Maximum predicted annual $PM_{2.5}$ concentrations – Scenario 2

7.2.3 Scenario 3

The statistics of the 24-hour predicted $PM_{2.5}$ concentrations for the Project (OB29/30/35 operations including both approved and amendment in isolation), in isolation of other sources, are presented Table 7-7. The results indicate that:

- The closest receptor (Newman Boundary 2) is predicted to have the highest 24-hour concentrations of $PM_{2.5}$, primarily due its relatively close distance to the proposed operations.
- For all of the receptors the predicted ground level 24-hour concentrations of $PM_{2.5}$ are expected to be well below the criteria and once below the 95th percentile the predicted impacts are expected to be negligible.

Table 7-7: Statistics of 24-hour $PM_{2.5}$ concentration at sensitive receptors – Scenario 3 (µg/m^3) (in isolation)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
1	Town Monitor	4.3	3.6	3.0	2.5	2.5	1.5	0.4	0.4	0
2	Newman East	2.5	2.4	1.7	1.6	1.5	0.8	0.2	0.2	0

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
3	Newman Boundary 1	2.9	2.2	2.0	1.9	1.9	1.1	0.3	0.3	0
4	Newman Boundary 2	7.2	7.1	6.3	6.0	6.0	4.0	1.7	1.2	0
5	Newman Boundary 3	1.5	1.3	1.0	1.0	1.0	0.5	0.1	0.1	0
6	Newman ER OB32	2.1	1.9	1.3	1.2	1.2	0.6	0.1	0.2	0

The isopleths of the maximum predicted 24-hour $PM_{2.5}$ concentrations for Scenario 2 are presented in Figure 7-13, and Figure 7-14.

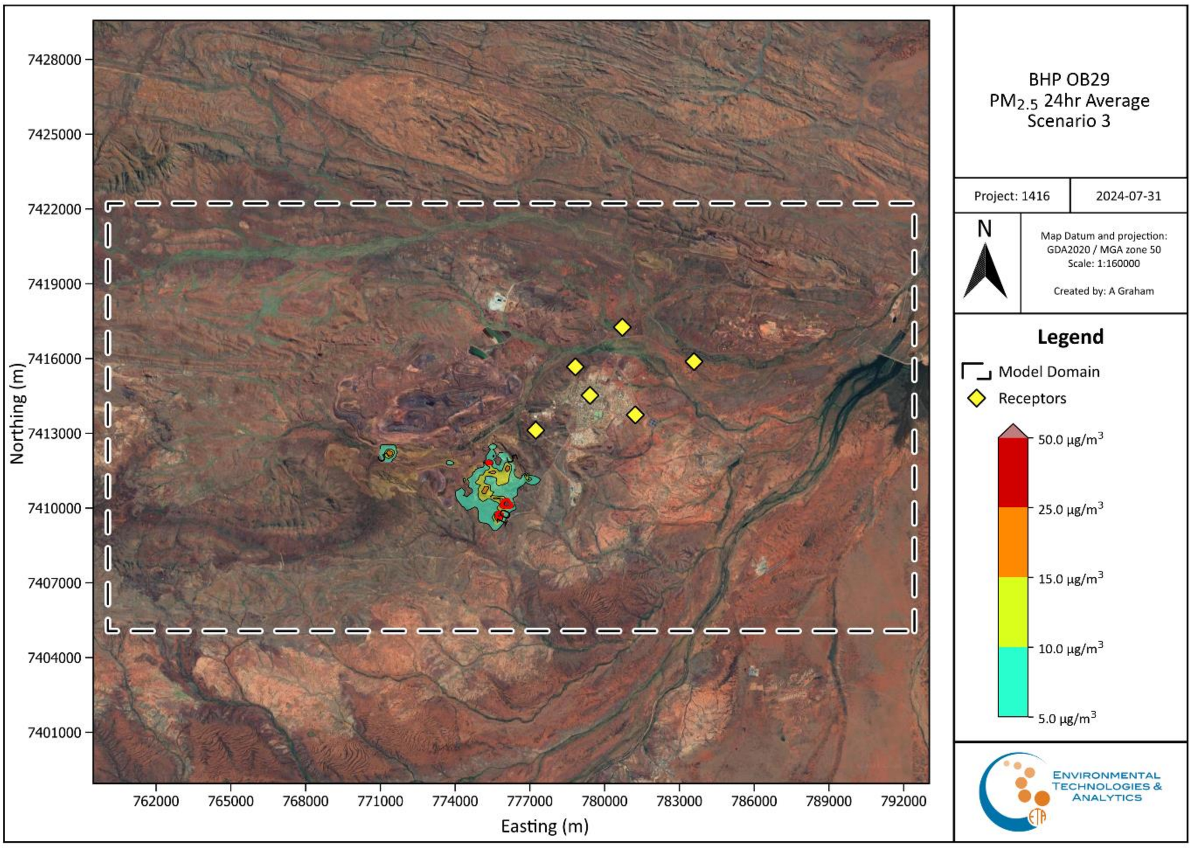

Figure 7-13: Maximum predicted 24-hour $PM_{2.5}$ concentrations – Scenario 3 (in isolation)

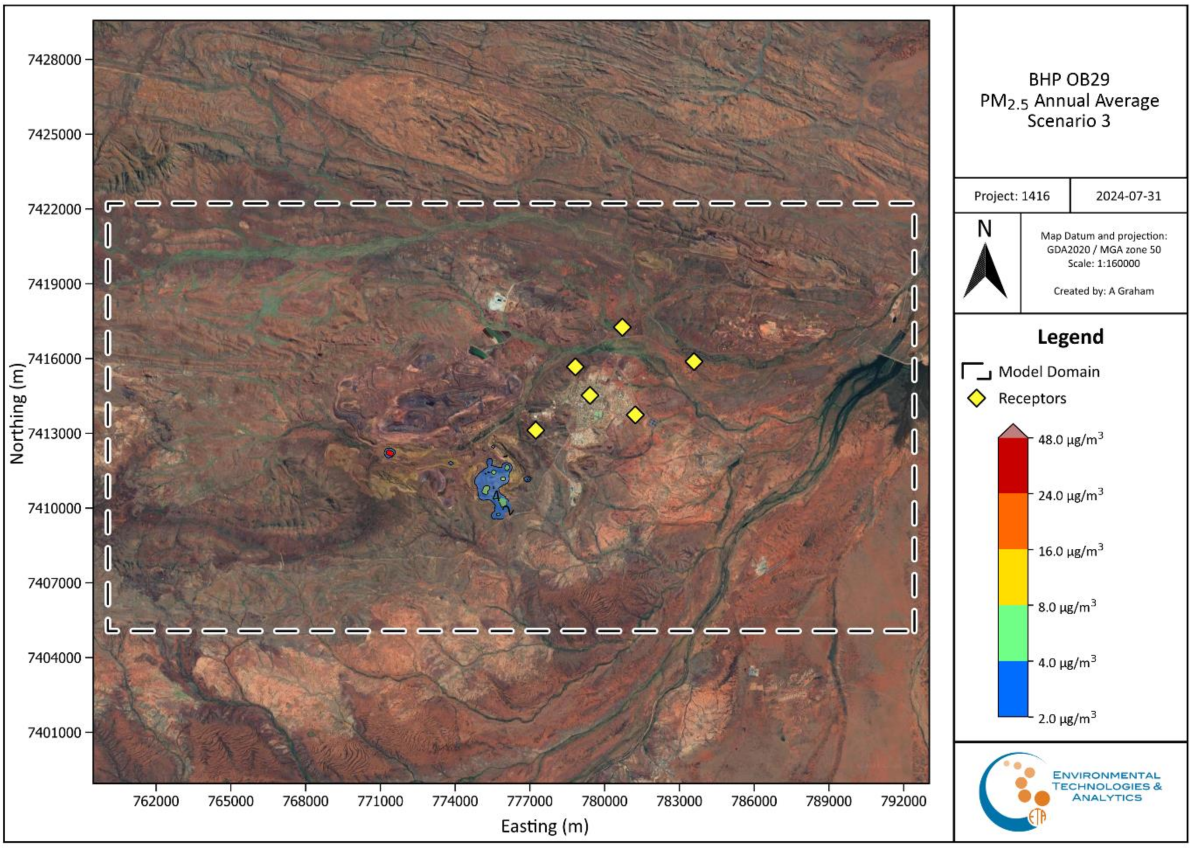

Figure 7-14: Maximum predicted annual $PM_{2.5}$ concentrations – Scenario 3 (in isolation)

7.2.4 Scenario 4

The statistics of the 24-hour predicted $PM_{2.5}$ concentrations for Scenario 4 (Proposed OB29/30/35, Mt Whaleback (includes existing OB29/30/35), Eastern Ridge and future Western Ridge) with background are presented in Table 7-8. From this table it is apparent that, when compared to the results for the existing scenario (Scenario 1), the introduction of both the proposed Western Ridge and this Project:

- The modelling indicates that there will be a slight increase in the maximum $PM_{2.5}$ concentrations at the Town and Newman East monitors.
- The lower statistics at these two residential monitors indicates that the overall ground level concentrations of $PM_{2.5}$ are predicted to be similar.
- There is only one predicted excursion of the 24-hour $PM_{2.5}$ criteria (25 µg/m^3), though this is at the Newman Boundary 2 receptor which is not located within Newman.

Table 7-8: Statistics of 24-hour $PM_{2.5}$ concentration at sensitive receptors – Scenario 4 (µg/m^3)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
1	Town Monitor	19	12	10	9	9	7	5	4.0	0
2	Newman East	17	12	9	8	8	7	4	3.7	0

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >25
3	Newman Boundary 1	16	12	9	8	8	6	5	4.0	0
4	Newman Boundary 2	29	20	16	16	16	9	6	5.0	1
5	Newman Boundary 3	19	18	16	15	15	10	6	5.2	0
6	Newman ER OB32	15	12	11	9	9	7	5	4.4	0

The isopleths of the annual average $PM_{2.5}$ concentrations for Scenario 4 are presented in Figure 7-15 while the maximum predicted 24-hour $PM_{2.5}$ concentrations for Scenario 4 are presented in Figure 7-16.

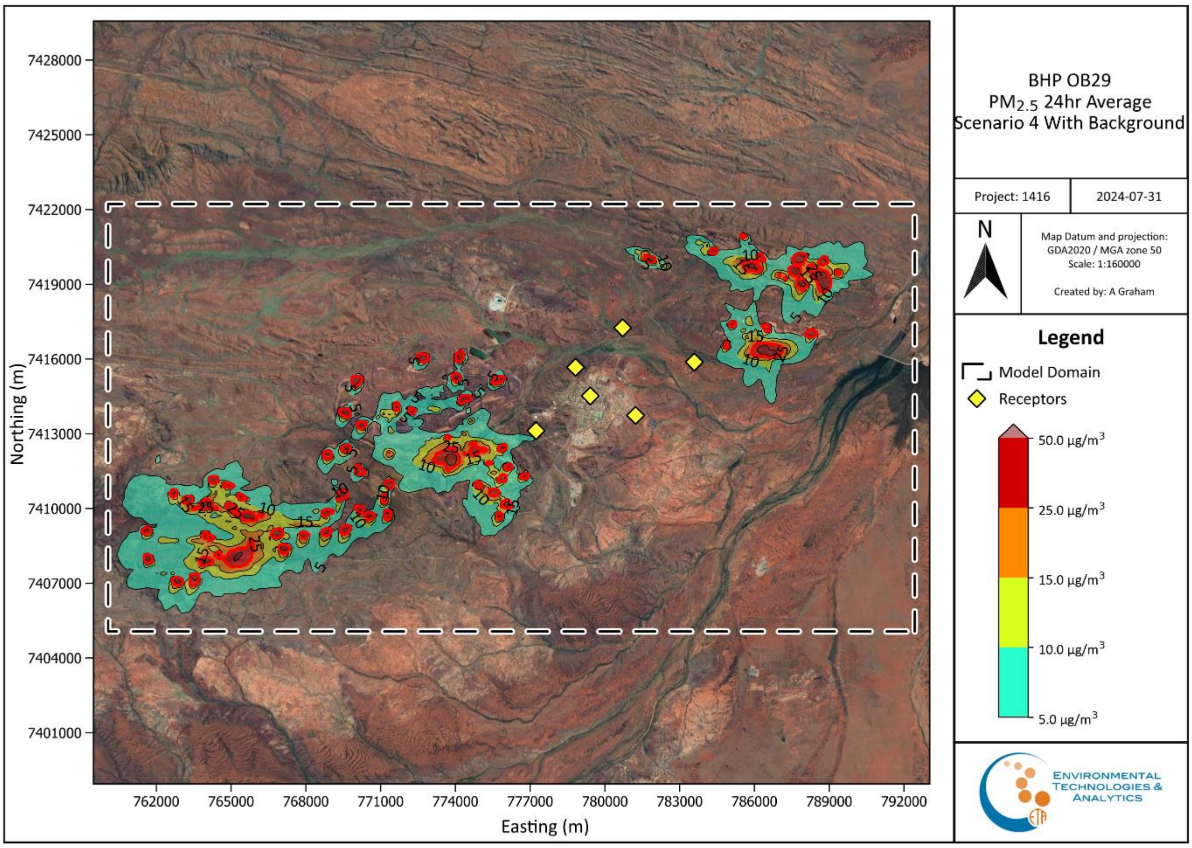

Figure 7-15: Maximum predicted annual $PM_{2.5}$ concentrations – Scenario 4 with background

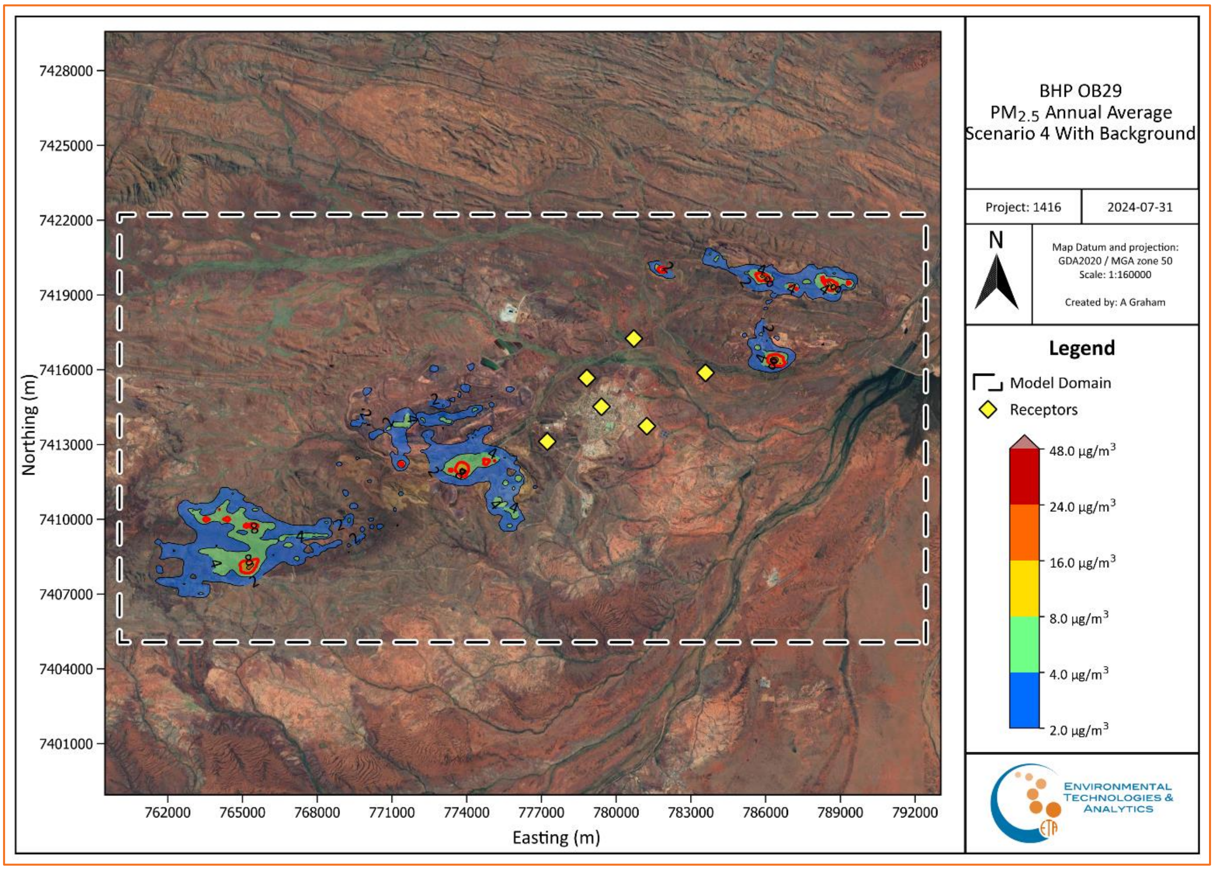

Figure 7-16: Maximum predicted 24-hour $PM_{2.5}$ concentrations – Scenario 4 with background

8 Conclusions

This assessment has assessed the potential air quality impacts associated with mining, hauling and processing activities from the development of the Ore Body 29 Below Water Table (OB29 BWT) project located within the existing Whaleback operations.

The modelling assessment, using CALPUFF/CALMET has considered the following scenarios:

- Scenario 1: Current operations – Mt Whaleback (includes existing OB29/30/35) & Eastern Ridge (i.e. as defined in ETA (2022) and presented in Appendix C)
- Scenario 2: Future project – OB29/30/35 Significant amendment in isolation (Project)
- Scenario 3: Future project – OB29/30/35 operations including both approved and significant amendment in isolation.
- Scenario 4: Future cumulative – Proposed OB29/30/35, Mt Whaleback, Eastern Ridge and future Western Ridge plus background concentrations.

For the proposed OB29/30/35 significant amendment operation, emissions were estimated for mining year 2036 as it represents the maximum mining tonnage, along with a 50:50 mix of waste being directed either the new OB29 OSA or backfilling in-pit. The emission estimation was calculated utilising emission factors from the EETM for Mining (EA, 2012) and input into the CALPUFF dispersion model as volume sources to simulate mining, haulage and processing, and area sources to simulate wind-blown dust. Background concentrations were also included to provide an indication of the potential cumulative impact from the existing operations.

Ground-level particulates (concentrations for TSP, PM_{10} and $PM_{2.5}$) are predicted at sensitive receptors and the surrounding environment. Results are compared with the relevant air quality assessment criteria at the sensitive receptors, as an indicator of potential impact.

The key findings of the assessment are:

- For the Project in isolation of other emission sources;
  - For TSP, PM_{10} and $PM_{2.5}$ - The model predicts the maximum concentrations will remain below the applicable criteria at residential receptors.
- For the Project with the cumulative scenario (OB29/30/35, Mt Whaleback, Eastern Ridge and future Western Ridge plus background concentrations);
  - For PM_{10}
    - The modelling indicates that there will be a slight increase in the maximum PM_{10} concentrations at the Town and Newman East monitors. The lower statistics at these two residential monitors indicates that there will be an overall reduction predicted ground level concentrations.
    - The modelling predicts that there will be a reduction in the number of excursions of the criteria (70 µg/m^3) at both residential monitors.
    - Although the modelling is indicating a decrease in overall PM_{10} concentrations the annual average at the Town Monitor is still predicting to be above the annual criteria.
  - For $PM_{2.5}$ -
    - The modelling indicates that there will be a slight increase in the maximum $PM_{2.5}$ concentrations at the Town and Newman East monitors.
    - The lower statistics at these two residential monitors indicates that the overall ground level concentrations of $PM_{2.5}$ are predicted to be similar.

- There is only one predicted excursion of the 24-hour $PM_{2.5}$ criteria (25 µg/m^3), though this is at the Newman Boundary 2 receptor which is not located within Newman.

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10 Acronyms and Glossary

Acronym	Description
AWS	Automatic Weather Station
BHP	BHP Billiton Iron Ore
BoM	Bureau of Meteorology
BWS	Belt wash station
C	Degrees Celsius (temperature)
CV	Conveyor
DSD	Department of State Development, Western Australia, Australia
DWER	Department of Water and Environmental Regulation
EA	Environment Australia
EE	Emissions estimation
EET	Emissions Estimation Technique
EF	Emission factor
EPA	Environmental Protection Authority Western Australia, Australia
EPAV	Environmental Protection Authority Victoria, Australia
EPP	Environmental Protection Policy
ESACCI-LC	European Space Agency Climate Change Initiative Land Cover dataset
ETA	Environmental Technologies& Analytics Pty Ltd
FEL	Front end loader
GDA94	Geocentric Datum of Australia 1994
GLC	Ground Level Concentration
$g/m^2/month$	Grams per square metre per month
g/s	grams per second
h/yr	Hours per year
kg	kilogram
kg/ha/yr	kilograms per hectare per year
kg/t	kilogram per tonne
kg/yr	kilograms per year
kPa	kiloPascals
km	kilometre
m	metre
m/s	metres per second
mm	millimetre
Mt	Million tonnes
Mtpa	Million tonnes per annum
NEPC	National Environment Protection Council
NEPM	National Environmental Protection Measure
NPI	National Pollutant Inventory
NSW	New South Wales
OSA	Overburden Storage Area
PM	Particulate matter, small particles and liquid droplets that can remain suspended in air.
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of 10 µm or less.
PM_{10}	Particulate matter with an aerodynamic diameter of 2.5 µm or less.
Qld EPA	Queensland Environmental Protection Authority
ROM	Run of mine
SRTM	Shuttle Radar Topography Mission
t	Tonnes
t/h	Tonnes per hour
tpa	tonnes per annum
tph	tonnes per hour
TS	Transfer station
TSP	Total suspended particulates
UTM	Universal Transverse Mercator
$\mu g/m^3$	micro grams (one millionth of a gram) per cubic metre

Acronym	Description
µm	micrometre
USEPA	United States Environment Protection Agency
USGS	United States Geological Survey
WRF	Weather Research and Forecast (WRF V3.7) model

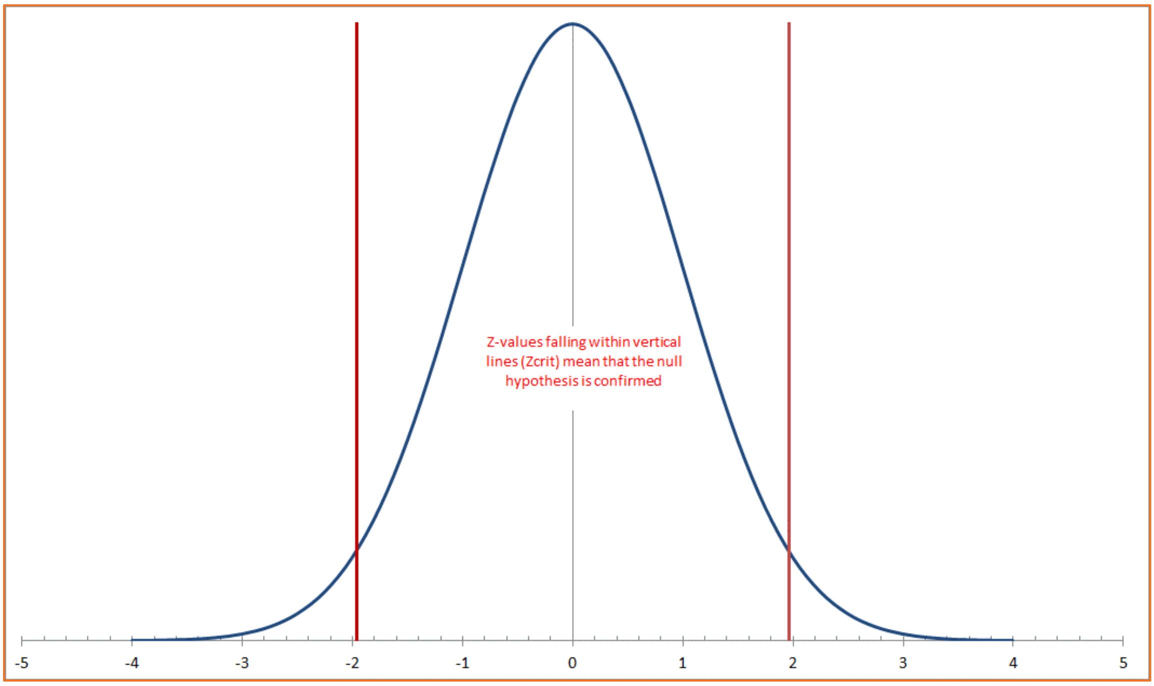
11 Appendices

Appendix A – Selection of Representative Meteorological Year for Modelling

Generally, a minimum of one year of meteorological data is acceptable for dispersion modelling in Australia and New Zealand. The data must, however, adequately represent worst-case meteorological conditions and the data should be assessed in terms of representativeness against climatic averages. In other words, the meteorology for selected years must be deemed representative of the "normal" range of conditions in the area.

To determine the year of meteorological data to use for the dispersion modelling, 10-years of historical surface observations from BoM station at Newman Airport (2010 to 2020 inclusive) were reviewed. The Chi-squared goodness of fit test was used to statistically identify the representative modelling year based on recorded scalar meteorological parameters including wind speed and temperature.

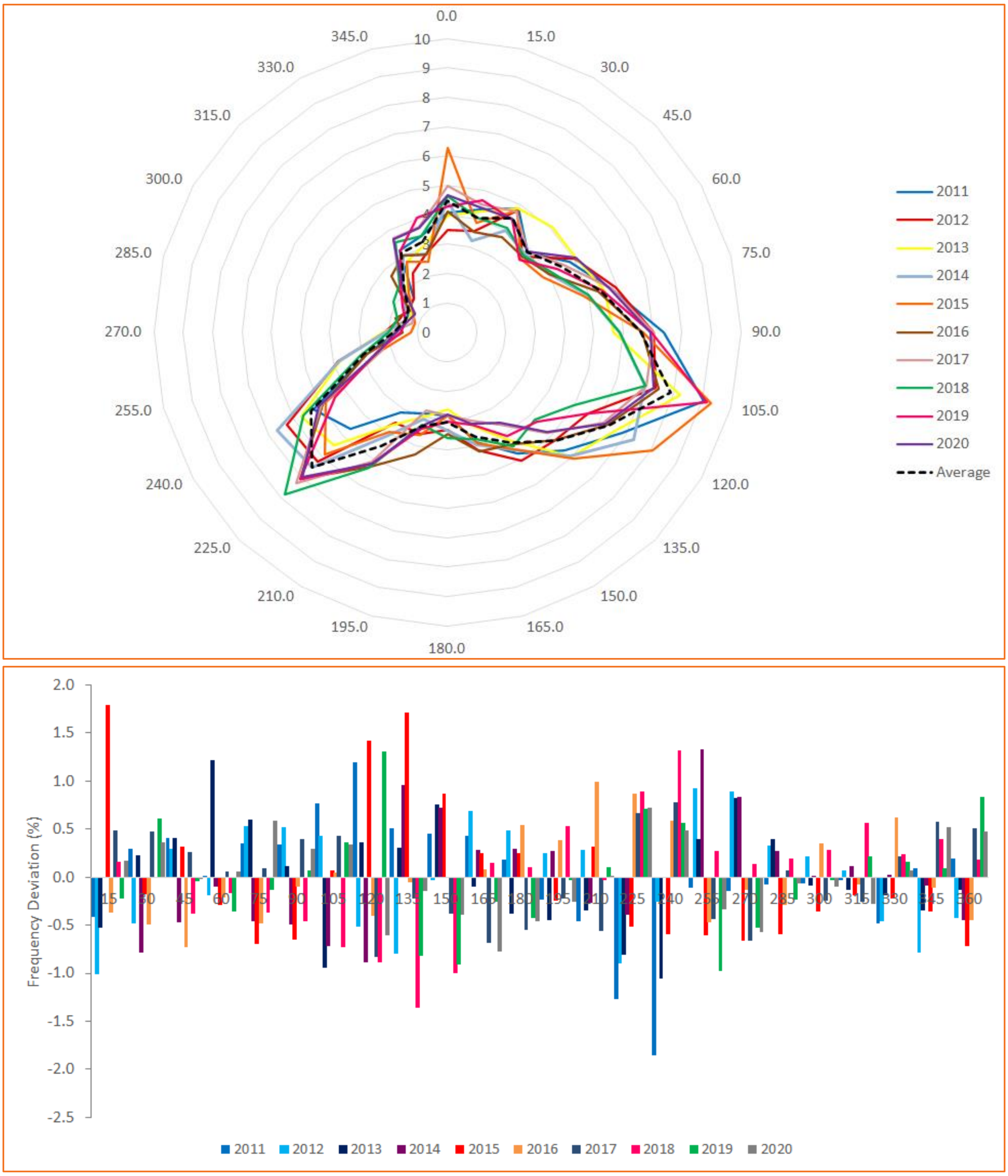
The null hypothesis is that there is no significant difference between hourly values in an individual year and the hourly averages for long term average values. If values fall within the vertical lines, then accept the null hypothesis (Appendix Figure 1). The null hypothesis is that there is no significant difference between percentage frequencies in an individual year and the percentage frequencies for long term average values. Note that only scalars were assessed (i.e., temperature and wind speed). Wind direction was assessed through radar plots.



Appendix Figure 1: Null Hypothesis

A.1: Wind Direction and Speed

The average wind direction radar plots for 2010 to 2020 at Newman Airport are compared in Appendix Figure 2 (upper). Except for 2011, the wind direction pattern is generally consistent across all years. There are only minor inter-annual differences in wind direction for years 2011, 2012, 2014 and 2015 show the greatest deviation from long term wind directions, with values of greater 1% from the average for various directions (Appendix Figure 2, lower).



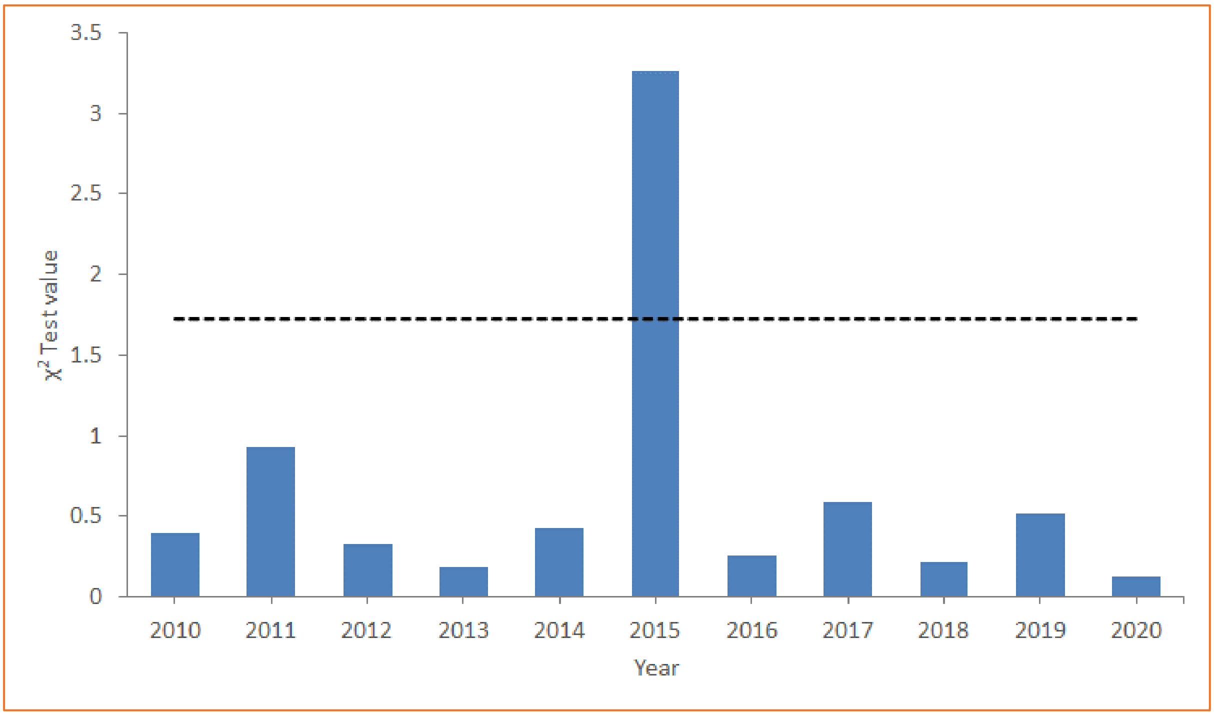
Appendix Figure 2: Wind direction radar plot (upper) and frequency deviation from the 11-year mean (lower) for Newman (2010-2020)

Appendix Table 1 shows the annual and long-term wind statistics at Newman Airport. For the 10th percentiles, 2010, 2016, 2018 and 2019 are closest to long-term averages. For average wind speeds, 2012, 2018, 2019 and 2020 are closest to long-term average conditions. The 90th percentiles show that 2014, 2016, 2019 and 2020 are closest to long-term averages.

Chi-squared goodness of fit test results for wind speed indicate that percentage frequencies for all years, except 2015 were representative of 10 year mean percentage frequencies at the 99.5% confidence interval (Appendix Figure 3).

Appendix Table 1: Wind speed statistics for Newman Airport for 2010-2020. (km/h).

	10th Percentile	Average	90th Percentile
2010	4.8	12.7	21.6
2011	4.9	13.4	22.9
2012	4.1	12.5	22.3
2013	4.4	12.7	21.9
2014	3.8	11.9	20.7
2015	3.0	11.6	20.0
2016	4.7	12.1	20.4
2017	4.0	11.8	20.3
2018	4.7	12.5	21.7
2019	4.9	12.5	21.4
2020	4.5	12.4	21.4
Average	4.7	12.4	20.9



Appendix Figure 3: Chi-squared goodness of fit test result for wind speed. Dashed line indicates 0.995 significance level.

A.2: Temperature

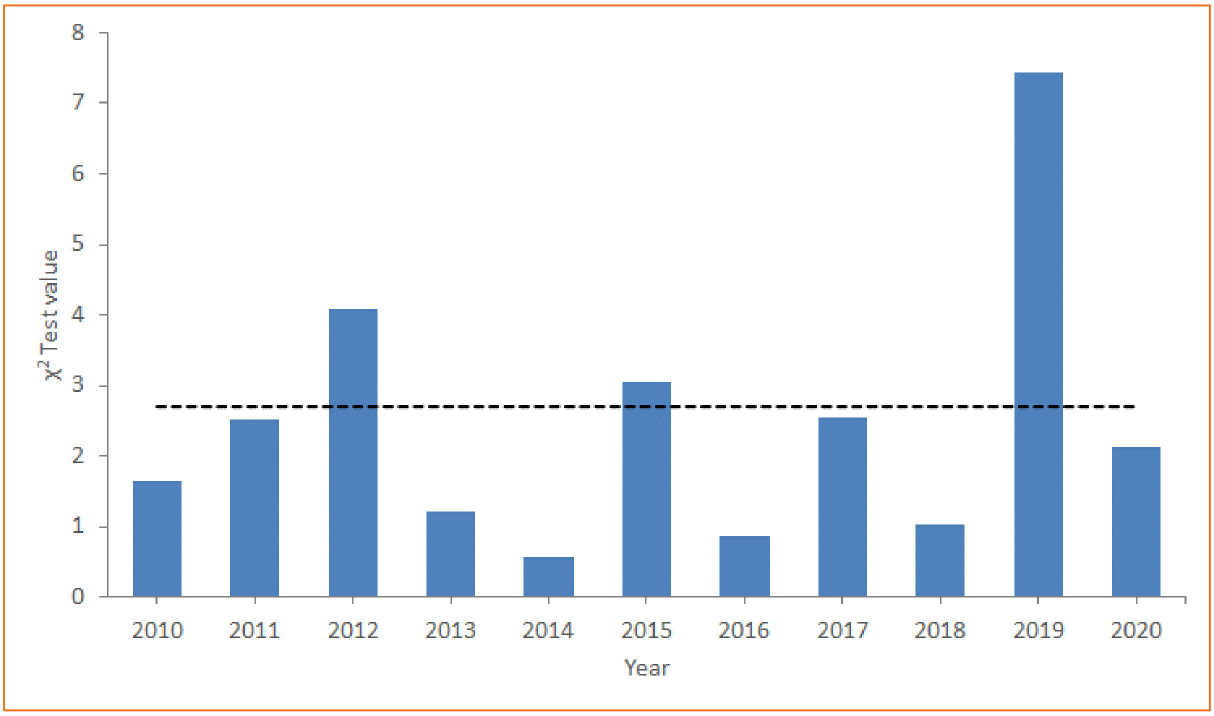
Appendix Table 2 shows the annual and long-term temperature statistics at Newman Airport. For the 10th percentiles, 2010, 2011, 2015, 2016, 2017 and 2020 are closest to long-term averages. For average temperatures, 2010, 2016 and 2018 are closest to long-term average conditions. The 90th percentiles show that 2014, 2016 and 2020 are closest to long-term averages.

The Chi-squared goodness of fit test results for temperature indicate that temperature frequency percentage values during 2012, 2015 and 2019 were significantly different to long term averages (Appendix Figure 4).

Appendix Table 2: Temperature statistics for Newman Airport for 2010-2020

	10th Percentile	Average	90th Percentile
2010	12.6	24.9	36.6
2011	12.9	24.0	34.0
2012	11.9	23.7	34.0
2013	13.5	24.8	35.6
2014	12.3	24.8	35.9
2015	12.4	24.5	36.7
2016	13.0	24.7	35.8
2017	12.5	24.1	34.6
2018	11.9	24.8	36.0

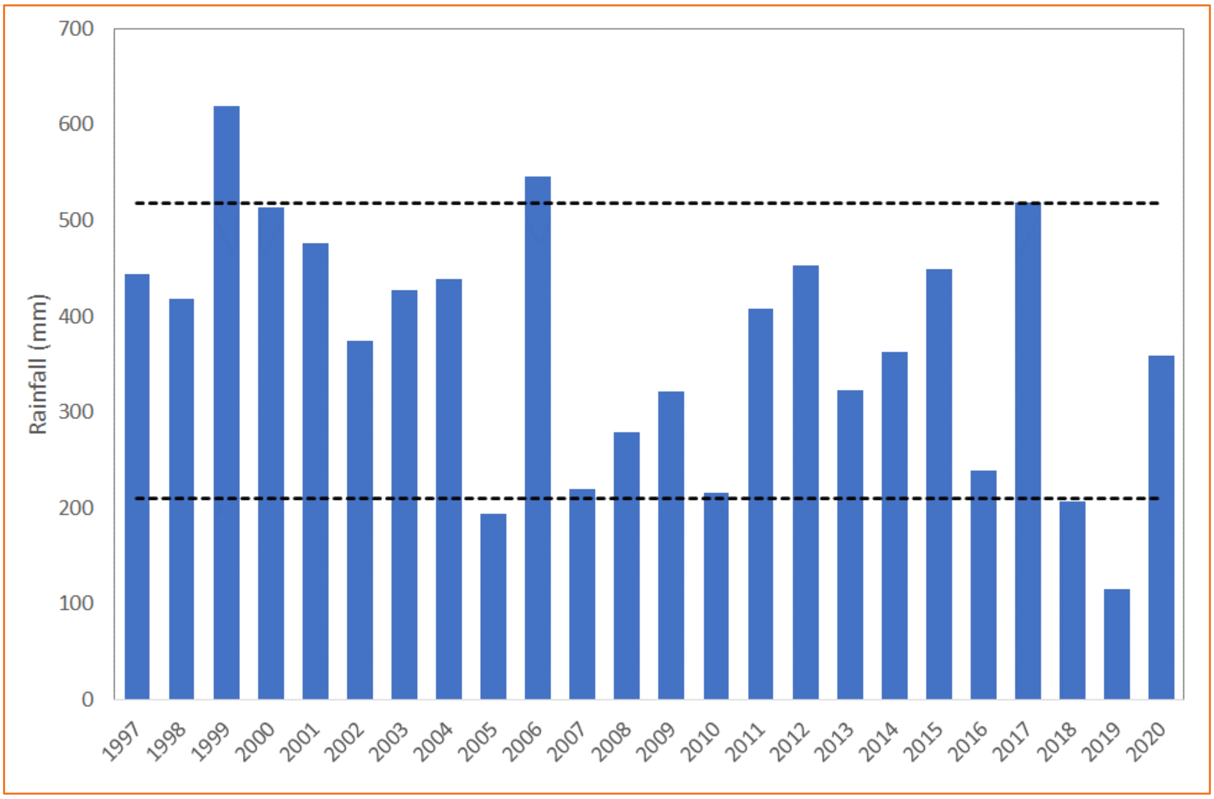
	10th Percentile	Average	90th Percentile
2019	13.1	26.1	37.8
2020	13.0	25.3	35.8
Average	12.7	24.9	35.8



Appendix Figure 4: Chi-squared goodness of fit test result for temperature. Dashed line indicates 0.975 significance level.

A.3: Rainfall

The annual rainfall at Newman for the 23-year period (1997-2020) is displayed in Appendix Figure 5. There is a significant variation of rainfall between each year. During the 23-year period, all years except 1999, 2005, 2006, 2007, 2010, 2017, 2018 and 2019 all fall within the 10th and 90th percentile long-term rainfall totals. This indicates that the remaining years had no major "outlier" annual rainfall totals, notwithstanding the highly variable nature of rainfall over the region.



Appendix Figure 5: Median annual rainfall at Newman Airport between 1997 and 2020. Dotted lines indicate 23-year 10th and 90th percentile rainfall values.

In summary:

- For wind speed only 2015 was statistically different to longer term conditions.
- For temperature 2012, 2015 and 2019 were significantly different to longer term average values.
- Wind direction displayed highest interannual variability for 2011, 2012, 2014 and 2015.
- Rainfall, although highly variable, showed that over the most recent 10-year period, that 2011 to 2016, and 2020 fell within the 10th and 90th percentile 23-year rainfall totals.

Based on the above analysis, the years that are consistently closest to long-term average conditions are 2010, 2013, 2016 and 2020. Given that the most complete ambient monitoring data is for 2020, it was decided that dispersion modelling be performed for that year.

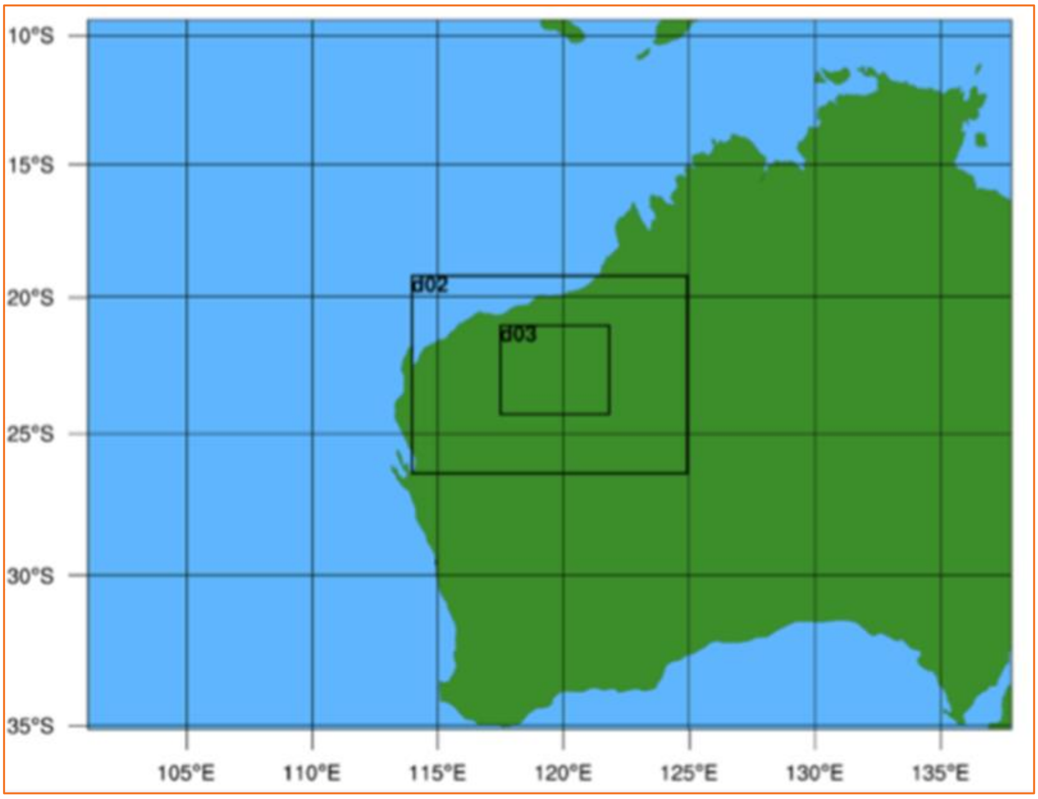
Appendix B– Meteorology

B.1: WRF

WRF was developed (and continues to be developed) in the United States by a collaborative partnership including the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (the National Center for Environmental Prediction (NCEP), the Forecast Systems Laboratory (FSL), the Air Force Weather Agency (AFWA), the Naval Research Laboratory, the University of Oklahoma, the Federal Aviation Administration (FAA) and others. (WRF, 2019).

WRF is a fully compressible, Eulerian, non-hydrostatic meso-scale numerical model developed by the National Center for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration (NOAA) in the United States. WRF is suitable for a broad spectrum of applications across scales ranging from metres to thousands of kilometres. The model utilises global reanalysis data to produce fine-scale 3-dimensional meteorological fields that considers local terrain and land-use effects.

WRF was run with a three-nest structure (40 km, 13.3 km and 4.4 km horizontal grid space resolution) centred on 23.055°S and 119.25°E. This is shown in Appendix Figure 6. The model vertical resolution consists of 28 pressure levels.[1].



Appendix Figure 6: Three nest structure, WRF model

[1] Eta levels are terrain-following vertical coordinates

Physics options in WRF are to represent atmospheric radiation, surface and boundary layer as well as cloud and precipitation processes. The physics options selected for the modelling are summarised in Appendix Table 3.

Appendix Table 3: WRF Physics Options Selected for Model

	Domain 1	Domain 2	Domain 3	Explanatory Notes
mp_physics	3	3	3	WRF single moment 3-class scheme
ra_lw_physics	1	1	1	Rapid radiative transfer model scheme
ra_sw_physics	1	1	1	Dudhia scheme for cloud and clear sky absorption and scattering
Radt	30	15	5	Time step for radiation schemes
sf_sfclay_physics	1	1	1	MM5 based on MOST
sf_surface_physics	2	2	2	Noah land surface model with 6 soil layers
bl_pbl_physics	1	1	1	Non-local K-scheme with entrainment layer
bldt	0	0	0	Boundary layer time step (0=every time step)
cu_physics	1	1	1	Kain-Fritch scheme using mass flux approach for domain 1 only.
cudt	5	5	5	Cumulus physics time step (minutes)

Six-hourly global final analysis synoptic data (from http://nomads.ncdc.noaa.gov/data/gfsanl/) was used to initialise the model and provide boundary conditions.

Land-use and terrain data was sourced from the United State Geological Services (USGS) database. Inspection of the land-use indicates an acceptable resolution and category for the model area with shrub land being the dominant vegetation type. A review of the Vegparm.tbl[2] reveals that these are based on North American parameterisations, with marked seasonal differences to allow for winter snow cover. These are clearly inappropriate for the Pilbara region. A non-seasonally varying roughness length value of 0.4 m was assigned to the shrub land category based on a study by Peel *et al*. (2005) for Spinifex vegetation in the Pilbara. Albedo was also set to 0.2 based on values cited in Peel *et al*. (2005). Other parameters such as Bowen ratio were adjusted to allow for the drier climate of the Pilbara.

The selection of an appropriate Land Surface Model (LSM) is critically important to provide the boundary conditions at the land-atmosphere interface because:

- The Planetary Boundary Layer (PBL) schemes are sensitive to surface fluxes.
- The cloud/cumulus schemes are sensitive to the PBL structures.

[2] A table consisting of land-use specific surface roughness, albedo and Bowen ratio.

- There is a need to capture mesoscale circulations forced by surface variability in albedo, soil moisture/temperature and land use.

The Noah Land-Surface Model was selected in this case to account for the sub-grid-scale fluxes. This sophisticated scheme provides four quantities to the parent atmospheric model (WRF), namely:

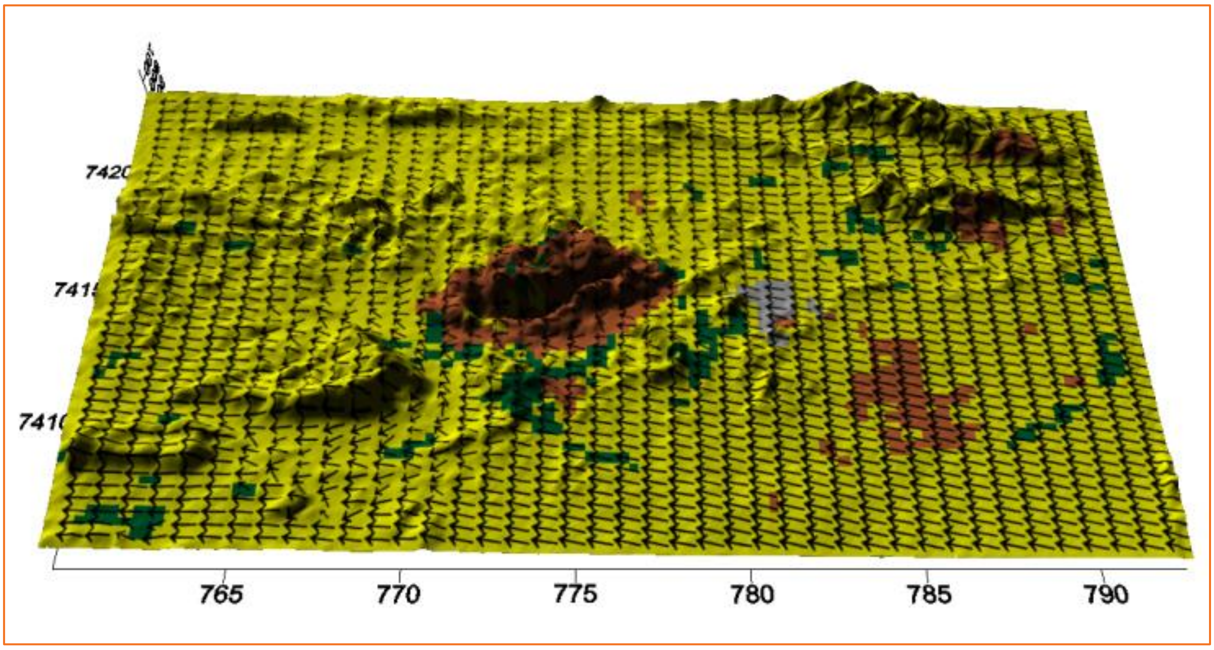
- surface sensible heat flux
- surface latent heat flux
- upward longwave radiation
- upward (reflected) shortwave radiation.

B.2: CALMET

CALMET Results

Wind

An example of early morning surface wind fields generated by CALMET for the model domain is shown in Appendix Figure 2. Colours depict dominant land cover (yellow = range land, grey = urban, brown = barren land, green=forest), and arrows depict wind flow direction. The existence of non-steady state meteorology as depicted by the flow along valleys and deflection around terrain is clearly demonstrated in Appendix Figure 7.

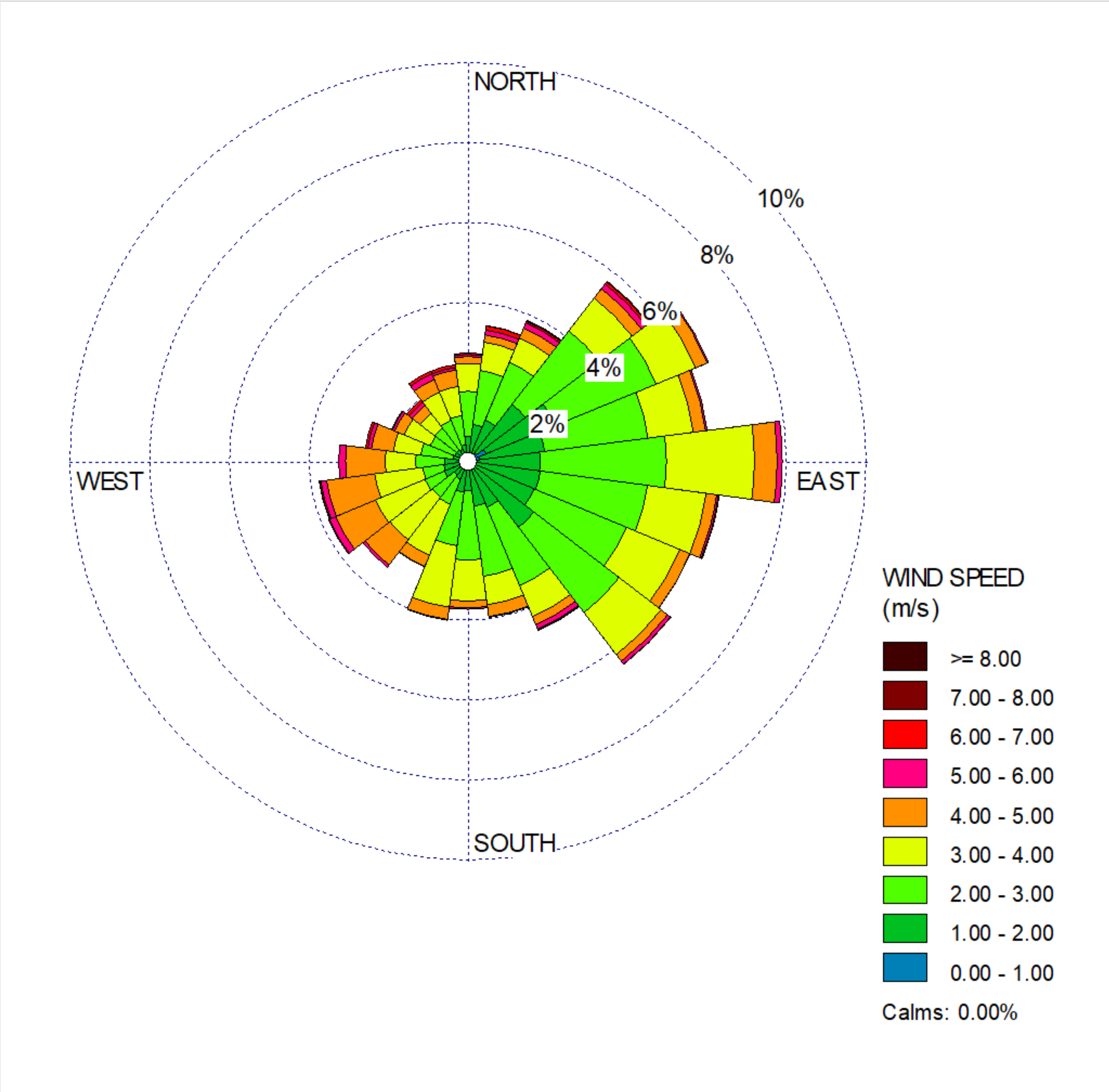


Appendix Figure 7: Example of surface wind vectors generated by CALMET.

Selected meteorological variables were extracted from the gridded CALMET output for three points corresponding to Western Ridge. The characteristics of the 10 m winds are illustrated in the annual wind rose diagrams the 12-month period from January 2020 – December 2020. These are shown in Appendix Figure 8. The wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points – N, NNE, NE, etc. The bar at the top of each wind rose diagram represents winds blowing from the north (i.e., northerly winds), and so on. The length of the bar represents the frequency of occurrence of winds from that direction, and the widths of the bar sections correspond to wind speed categories, the narrowest representing the lightest winds.

The major features of the wind rose is as follows:

- Prevailing wind directions at all three locations are predominantly north easterly to south-easterly.
- Strongest winds are from the northeast.
- Winds from the northwest are relatively rare.
- Calm conditions (<0.5 m/s) occur for less than 1% of the year.



Appendix Figure 8: Annual wind rose for Western Ridge mine.

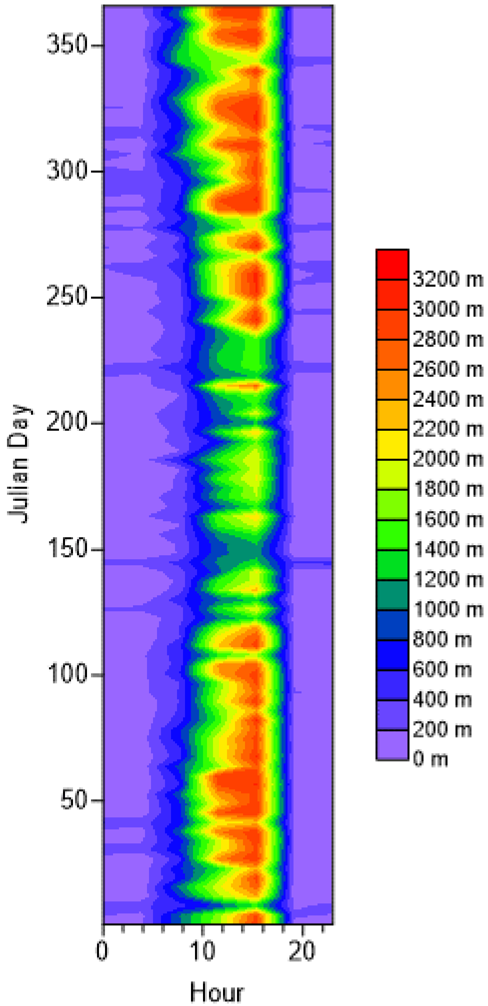
Mixing Height

Mixing height is the depth of the atmospheric surface layer beneath an elevated temperature inversion. It is an important parameter within air pollution meteorology. Vertical diffusion or mixing of a plume is limited by the mixing height, as the air above this layer tends to be stable, with restricted vertical motion.

A series of internal algorithms within CALMET is used to calculate mixing heights for the subject site where it is assumed that mixing height is formed through mechanical means (wind speed) at night and through a mixture of mechanical and convective means (wind speed and solar radiation) during the day (Scire et al. 2008). During the night and early morning when the convective mixed layer is absent or small, the full depth of the planetary boundary layer (PBL) may be controlled by mechanical turbulence. During the day, the height of the PBL during convective conditions is then taken as the maximum of the estimated (or measured if available) convective boundary layer height and the estimated (or measured if available) mechanical mixing height. It is calculated from the early morning potential temperature sounding (prior to sunrise), and the time varying surface heat flux to calculate the time evolution of the convective boundary layer.

The seasonal and hourly variation of mixing height at Western Ridge is summarised as a Hovmöller plot[3] in Appendix Figure 9. Highest mixing heights occur during the mid-afternoon and during the spring to late summer when solar insolation is at its highest. Winter months generally have lower maximum mixing heights.

[3] The Hovmöller plot is a way of representing data on two axes: in this case hour of day on x- and Julian day on y-axis.



Appendix Figure 9: Hovmöller plot of hourly mixing heights

Stability

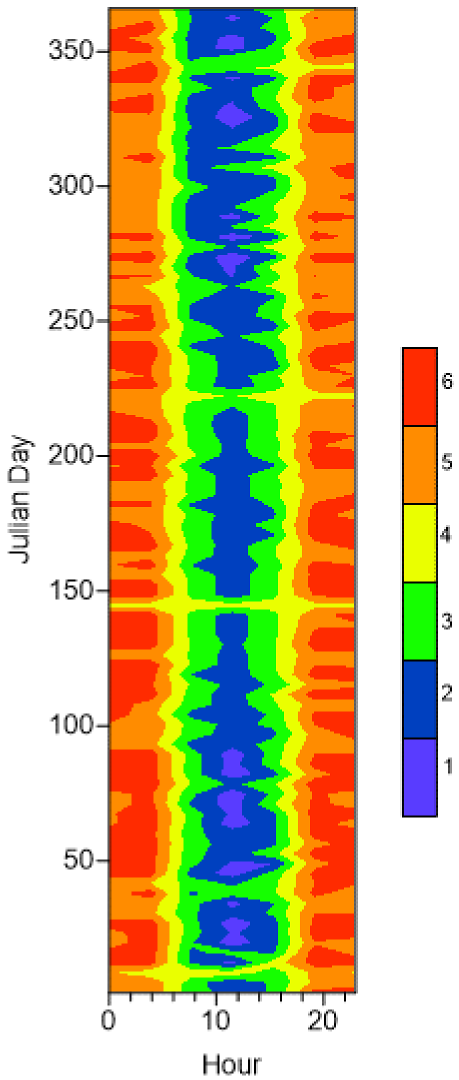
An important aspect of pollutant dispersion is the level of turbulence in the lowest 1 km or so of the atmosphere, known as the planetary boundary layer (PBL). Turbulence controls how effectively a plume is diffused into the surrounding air and hence diluted. It acts by increasing the cross-sectional area of the plume due to random motions. With stronger turbulence, the rate of plume diffusion increases. Weak turbulence limits diffusion and contributes to high plume concentrations downwind of a source.

Turbulence is generated by both thermal and mechanical effects to varying degrees. Thermally driven turbulence occurs when the surface is being heated, in turn transferring heat to the air above by convection. Mechanical turbulence is caused by the frictional effects of wind moving over the earth's surface and depends on the roughness of the surface as well as the flow characteristics.

Turbulence in the boundary layer is influenced by the vertical temperature gradient, which is one of several indicators of stability. Plume models use indicators of atmospheric stability in conjunction with other meteorological data to estimate the dispersion conditions in the atmosphere.

Stability can be described across a spectrum ranging from highly unstable through neutral to highly stable. A highly unstable boundary layer is characterised by strong surface heating and relatively light winds, leading to intense convective turbulence and enhanced plume diffusion. At the other extreme, very stable conditions are often associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in the early morning. Under these conditions, plumes can remain relatively undiluted for considerable distances downwind. Neutral conditions are linked to windy and/or cloudy weather, and short periods around sunset and sunrise, when surface rates of heating or cooling are very low.

The hourly averaged Pasquill-Gifford stability, computed from all data in the CALMET surface file, are presented in Appendix Figure 10. This plot indicates that the atmosphere is stable overnight and reaches maximum instability around midday. The unstable conditions occur as radiation from the sun heats the surface layer of the atmosphere and drives convection. Instability is slightly reduced during the winter months in response to reduced solar insolation.



Appendix Figure 10: Hovmöller plot of hourly stability.

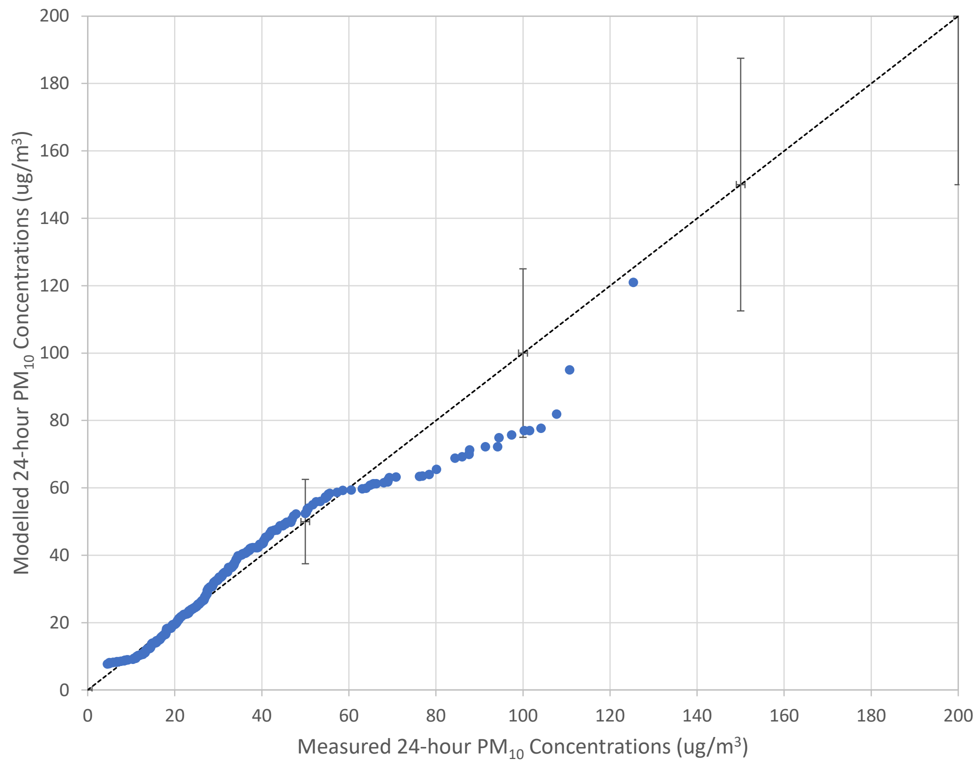
Appendix C – Model Validation

As outlined in Section 5.1 the modelled year was converted from 2010, which was the modelled year in the SEA, to 2020. To verify the performance of the model for this updated annual period a brief model verification study was undertaken. For this study the following steps were taken:

- Emission estimation was undertaken for the Mt Whaleback and Eastern Ridge operations for the FY22 period (Appendix F). This period was utilised as the forecast mining tonnages were similar to those in 2020.
- The CALPUFF model was run and the background PM_{10} file for 2020 (Section 5.5) was added to the model results.
- The modelled results were compared to the 24-hour PM_{10} monitoring data from 2020 at the Town Centre and Newman East monitors as a quantile/quantile graph (highest to lowest).

The Q:Q comparison plot at Town Centre is presented in Appendix Figure 11 where it can be seen that:

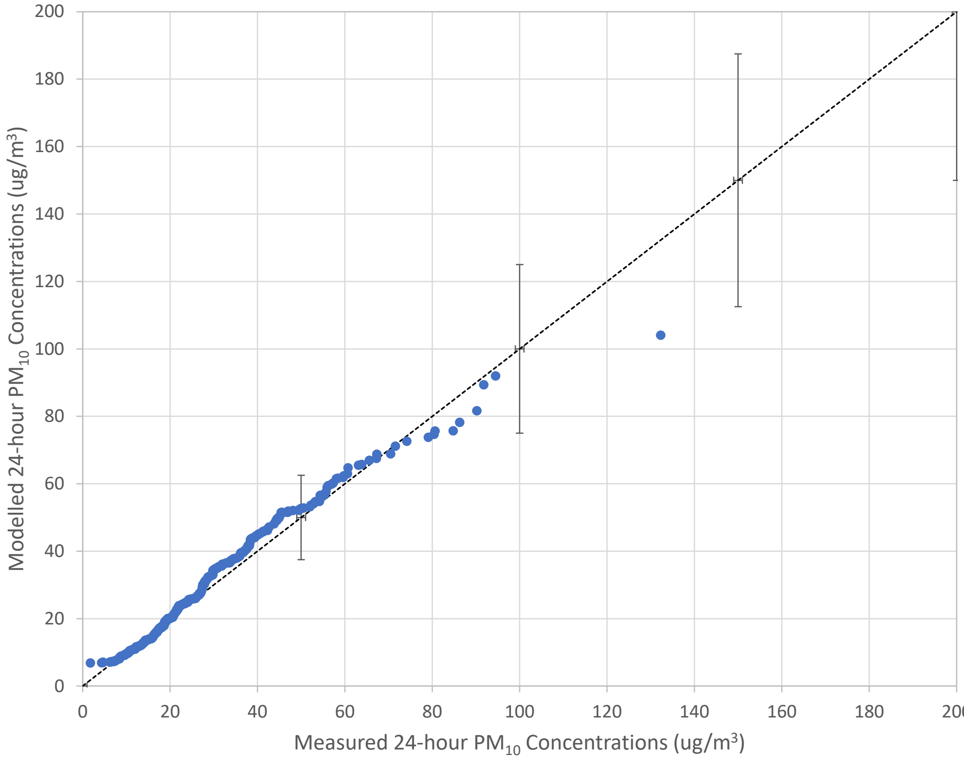
- The modelled and measured concentrations closely align up to around 60 µg/m^3.
- Beyond 60 µg/m^3 the model underpredicts the measured concentrations.
- The model does predict the maximum monitored concentration.



Appendix Figure 11: Quantile/quantile plot of measured versus modelled 24-hour PM_{10} concentrations at the Town Centre monitor

The Q:Q comparison plot for the Newman East monitor is presented in Appendix Figure 12 where it can be seen that:

- Nearly all the modelled and measured concentrations closely align.
- The model does underpredict the maximum monitored concentration.



Appendix Figure 12: Quantile/quantile plot of measured versus modelled 24-hour PM_{10} concentrations at the Newman East monitor

The statistics of the 2020 24-hour PM_{10} monitored and modelled concentrations are presented in Appendix Table 4. From this table the following can be inferred:

- At the Town Centre Monitor;
  - The underprediction of the model at the upper percentiles is very apparent (99 and 95 percentile) while there is good agreement at the lower percentiles (90 and 70 percentile).
  - The model is slightly underpredicting the annual average.
  - The model is underpredicting the number of excursions of 70 µg/m^3.
- At the Newman East Monitor;
  - The model underpredicts the maximum and 99 percentile concentrations.
  - The model predicts the lower percentiles (95, 90 and 70) very well.
  - There is effectively no difference in the annual average concentration between the model and monitored data.
  - The model accurately predicts the number of excursions of 70 µg/m^3.

Appendix Table 4: Statistics of monitored and modelled concentrations (µg/m³)

Statistic	Town Centre		Newman East	
	Monitored	Modelled	Monitored	Modelled
Maximum	125	121	132	104
99 Percentile	103	77	88	79
95 Percentile	77	63	61	63
90 Percentile	55	57	53	54
70 Percentile	35	39	34	36
Average	31.9	30.6	28.6	28.5
Number greater than 50 µg/m³	46	52	40	50
Number greater than 70 µg/m³	20	12	12	11

Appendix D– Emission Sources and Parameters

Appendix Table 5: OB29 BWT mining sources and parameters

Source Id	Easting	Northing	Effective Height (m)	Sigma Y	Sigma Z
BWT_D1	775625	7411932	1.5	75	0.70
BWT_D2	776212	7411697	1.5	75	0.70
BWT_D3	775464	7411596	1.5	75	0.70
BWT_B1	775556	7412094	20	22.0	9.30
BWT_B2	776125	7411781	20	22.0	9.30
BWT_B3	775395	7411411	20	22.0	9.30
BWT_L1	776075	7411668	6	75	2.79
BWT_L2	775630	7411467	6	75	2.79
BWT_L3	775400	7412004	6	75	2.79
BWT_UW1	775599	7412482	2	75	0.93
BWT_UW2	776035	7412091	2	75	0.93
BWT_UW3	776212	7409975	2	75	0.93
BWT_UW4	775596	7409655	2	75	0.93
BWT_Bull1	775487	7412448	2	75	0.93
BWT_Bull2	775860	7412147	2	75	0.93
BWT_Bull3	775985	7410213	2	75	0.93
BWT_Bull4	775929	7409594	2	75	0.93

Appendix Table 6: OB29 BWT Haul Roads

Source Id	Easting	Northing	Effective Height (m)	Sigma Y	Sigma Z
HR301	775300	7410783	8.5	16.7	7.9
HR302	775214	7410660	8.5	16.7	7.9
HR303	775366	7410513	8.5	16.7	7.9
HR304	775583	7410440	8.5	16.7	7.9
HR305	775763	7410354	8.5	16.7	7.9
HR306	775909	7410258	8.5	16.7	7.9
HR307	776001	7410090	8.5	16.7	7.9
HR308	775997	7409876	8.5	16.7	7.9
HR309	775854	7409768	8.5	16.7	7.9
HR310	775658	7409708	8.5	16.7	7.9

Appendix E – Emission Rates

Appendix Table 7: OB29 BWT PM_{10} Mining Emission Rates (g/s)

Source Id	Maximum	99th Percentile	95th Percentile	90th Percentile	75th Percentile	Average
BWT_D1	0.03	0.03	0.03	0.03	0.00	0.01
BWT_D2	0.03	0.03	0.03	0.03	0.03	0.02
BWT_D3	0.03	0.03	0.03	0.03	0.00	0.01
BWT_B1	91.96	0.00	0.00	0.00	0.00	0.55
BWT_B2	91.96	0.00	0.00	0.00	0.00	0.55
BWT_B3	68.12	0.00	0.00	0.00	0.00	0.40
BWT_L1	3.16	3.16	3.16	3.16	3.16	3.16
BWT_L2	3.16	3.16	3.16	3.16	3.16	3.16
BWT_L3	1.11	1.11	1.11	1.11	1.11	1.11
BWT_UW1	0.28	0.28	0.28	0.28	0.28	0.28
BWT_UW2	0.47	0.47	0.47	0.47	0.47	0.47
BWT_UW3	0.36	0.36	0.36	0.36	0.36	0.36
BWT_UW4	0.47	0.47	0.47	0.47	0.47	0.47
BWT_Bull1	1.08	1.08	1.08	1.08	1.08	0.32
BWT_Bull2	1.08	1.08	1.08	1.08	1.08	0.32
BWT_Bull3	1.13	1.13	1.13	1.13	1.13	0.34
BWT_Bull4	1.13	1.13	1.13	1.13	1.13	0.34

Appendix Table 8: OB29 BWT PM_{10} wind erosion emissions (g/s)

Source Id	Maximum	99th Percentile	95th Percentile	90th Percentile	75th Percentile	Average
BWT_WE1	126.76	19.74	0.00	0.00	0.00	0.59
BWT_WE2	128.52	20.01	0.00	0.00	0.00	0.61
BWT_WE3	113.42	20.90	0.00	0.00	0.00	0.61

Appendix Table 9: OB29 BWT haul road emissions (g/s)

Source Id	Maximum	99th Percentile	95th Percentile	90th Percentile	75th Percentile	Average
HR301	6.79	6.79	6.79	6.79	6.79	5.53
HR302	6.79	6.79	6.79	6.79	6.79	5.53
HR303	6.79	6.79	6.79	6.79	6.79	5.53
HR304	6.79	6.79	6.79	6.79	5.09	5.52
HR305	6.79	6.79	6.79	6.79	5.09	5.52
HR306	6.79	6.79	6.79	6.79	5.09	5.52
HR307	6.79	6.79	6.79	6.79	5.09	5.52
HR308	3.40	3.40	3.40	3.40	2.55	2.76
HR309	3.40	3.40	3.40	3.40	2.55	2.76
HR310	3.40	3.40	3.40	3.40	2.55	2.76

Appendix F – Particulates as TSP

To assess the potential air quality impact, modelled TSP concentrations are compared to the assessment criteria of 90 µg/m^3 as discussed in Section 4.2. The predicted ground level concentrations at the key sensitive receptor locations are presented for each scenario. The modelled concentration statistics are provided in tabulated form for each scenario and include, where applicable, the background air quality estimate for the region. Figures demonstrating the ground level concentration contours are also presented.

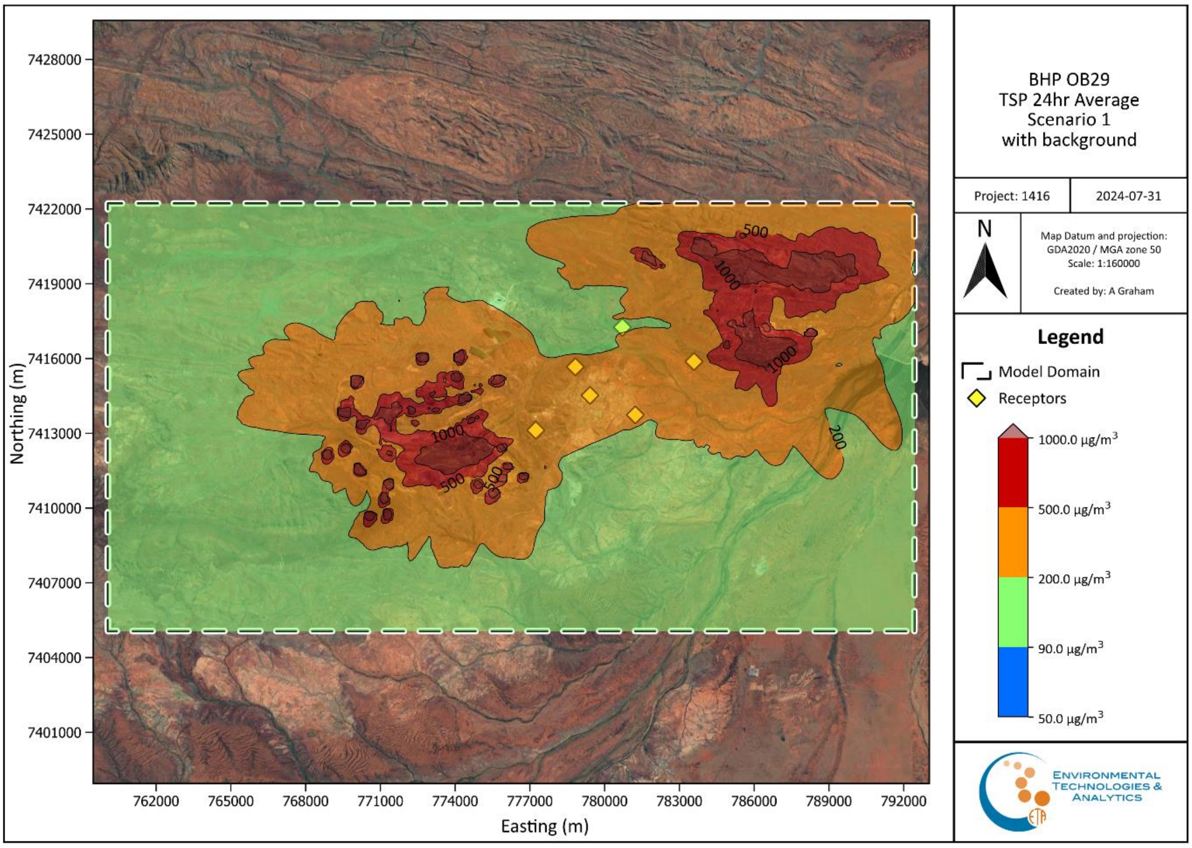
11.1.1 Scenario 1

The statistics of the TSP model results, for the existing scenario (Whaleback and Eastern Ridge for 2022 with current controls and with background concentrations), are presented in Appendix Table 10. These results indicate the model is predicting that both the Town Centre and Newman East monitors have elevated concentrations with up to 59 predicted excursions of the relevant criteria.

Appendix Table 10: Statistics of 24-hour TSP concentration at sensitive receptors – Scenario 1 (µg/m^3) (including background)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >90
1	Town Monitor	233	188	149	144	121	107	72	58	59
2	Newman East	204	173	137	136	113	100	65	53	49
3	Newman Boundary 1	224	195	170	167	125	108	75	61	70
4	Newman Boundary 2	306	281	210	204	179	144	85	71	102
5	Newman Boundary 3	292	286	224	216	196	155	101	78	129
6	Newman ER OB32	217	161	154	149	129	115	83	66	89

The isopleths of the maximum predicted 24-hour TSP concentrations for Scenario 1 (with background) are presented in Appendix Figure 13.



Appendix Figure 13: Maximum predicted 24-hour TSP concentrations – Scenario 1 (with background concentrations).

11.1.2 Scenario 2

The statistics of the 24-hour predicted TSP concentrations for the Project (OB29/30/35 significant amendment), in isolation of other sources, are presented in are presented in Appendix Table 11. The results indicate that:

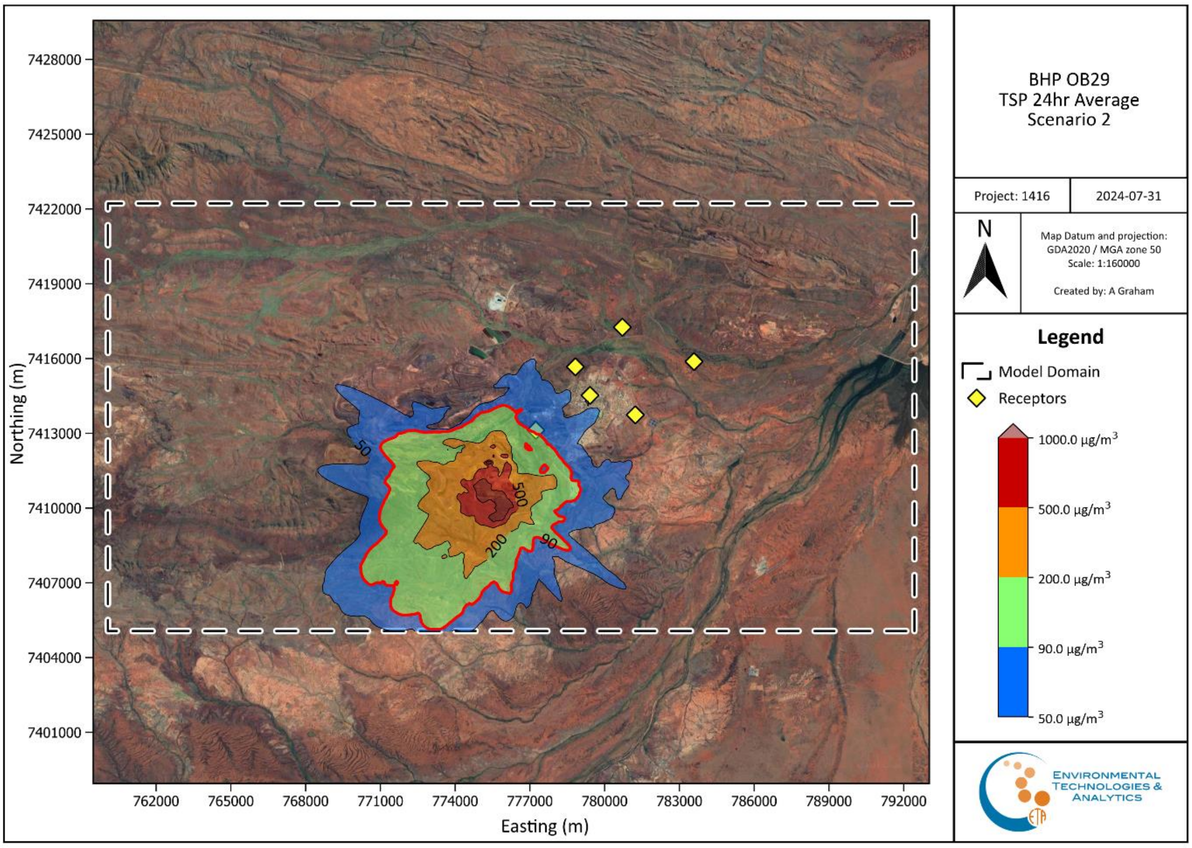
- The closest receptor (Newman Boundary 2) is predicted to have elevated 24-hour concentrations of TSP, primarily due its relatively close distance to the proposed operations.
- For the remaining receptors the predicted ground level 24-hour concentrations of TSP are expected to reduce from the maximum down through the lower statistics and once below the 90th percentile the predicted impacts are expected to be negligible.

Appendix Table 11: Statistics of 24-hour TSP concentration at sensitive receptors – Scenario 2 (µg/m³) (in isolation)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >90
1	Town Monitor	46	40	30	29	23	16	3	4	0
2	Newman East	26	21	18	16	13	9	2	2	0
3	Newman Boundary 1	35	25	23	21	16	12	2	3	0

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >90
4	Newman Boundary 2	88	82	69	66	56	43	14	13	0
5	Newman Boundary 3	14	12	11	10	8	5	1	1	0
6	Newman ER OB32	22	21	16	15	11	7	1	2	0

The isopleths of the maximum predicted 24-hour TSP concentrations for the Scenario 2, in isolation of other sources, are presented in Appendix Figure 14.



Appendix Figure 14: Maximum predicted 24-hour TSP concentrations – Scenario 2 (in isolation)

11.1.3 Scenario 3

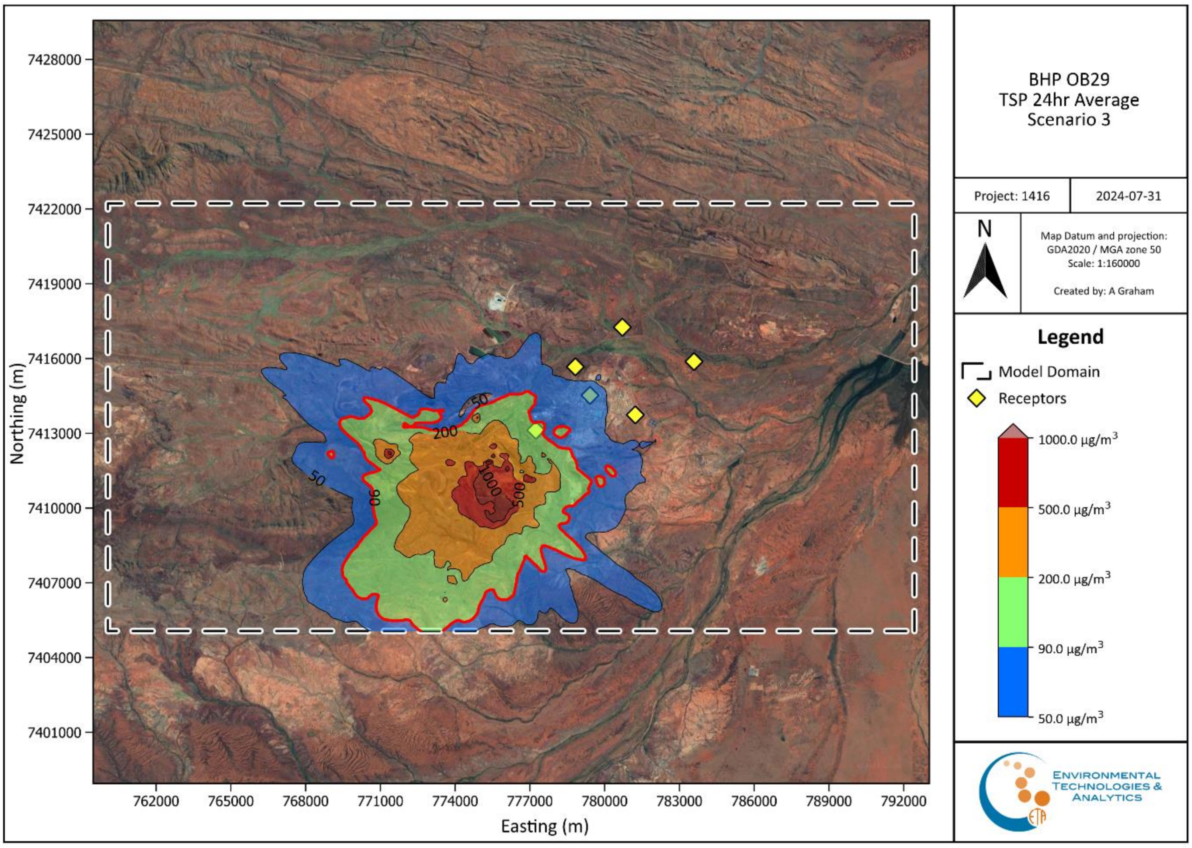
The statistics of the 24-hour predicted TSP concentrations for the Project (OB29/30/35 operations including both approved and amendment in isolation), in isolation of other sources, are presented in Appendix Table 12. The results indicate that:

- The closest receptor (Newman Boundary 2) is predicted to have elevated 24-hour concentrations of TSP, primarily due its relatively close distance to the proposed operations.
- For the remaining receptors the predicted ground level 24-hour concentrations of TSP are expected to reduce from the maximum down through the lower statistics and once below the 90th percentile the predicted impacts are expected to be negligible.

Appendix Table 12: Statistics of 24-hour TSP concentration at sensitive receptors – Scenario 3 (µg/m³) (in isolation)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >90
1	Town Monitor	65	54	43	40	39	23	7	7	0
2	Newman East	37	36	26	24	24	13	3	4	0
3	Newman Boundary 1	45	33	30	30	29	17	4	5	0
4	Newman Boundary 2	107	106	91	88	88	58	24	18	7
5	Newman Boundary 3	22	20	16	15	15	8	1	2	0
6	Newman ER OB32	32	29	21	19	19	9	2	3	0

The isopleths of the maximum predicted 24-hour TSP concentrations for Scenario 3, in isolation of other sources, are presented in Appendix Figure 15.



Appendix Figure 15: Maximum predicted 24-hour TSP concentrations – Scenario 3 (in isolation)

11.1.4 Scenario 4

The statistics of the 24-hour predicted TSP concentrations for Scenario 4 (Proposed OB29/30/35, Mt Whaleback (includes existing OB29/30/35), Eastern Ridge and future Western Ridge) with background are presented in Appendix Table 13. From this table it is apparent that:

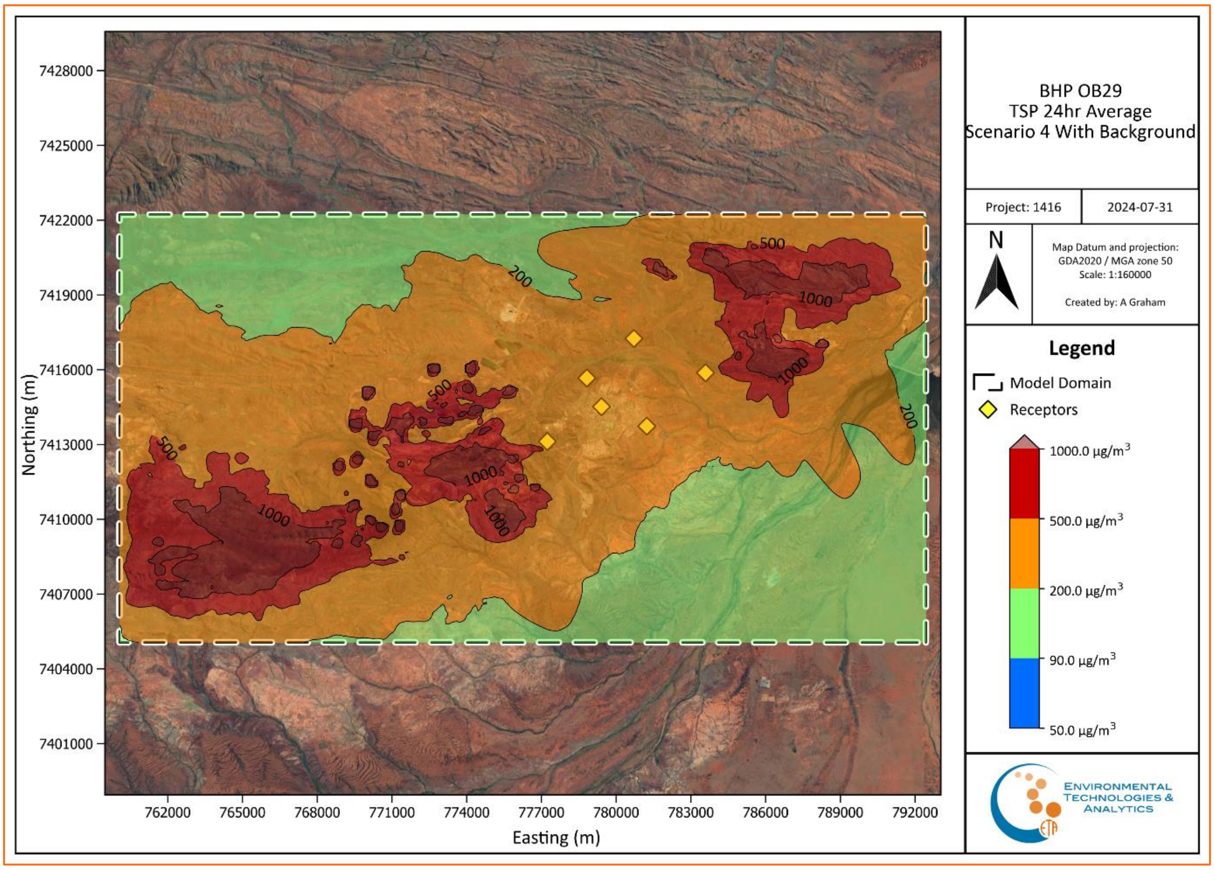
- The introduction of both the proposed Western Ridge and the Project does result in a predicted increase in ground level concentrations of TSP at all receptors.

Appendix Table 13: Statistics of 24-hour TSP concentration at sensitive receptors – Scenario 4 with background (µg/m³)

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >90
1	Town Monitor	277	173	152	143	143	111	77	62.7	77
2	Newman East	245	176	147	146	143	110	71	57.9	67
3	Newman Boundary 1	239	161	131	129	128	107	78	62.6	71

Receptor No.	Receptor Name	Max	2nd	6th	8th	95th	90th	70th	Ann	Days >90
4	Newman Boundary 2	419	305	256	236	233	147	92	76.9	116
5	Newman Boundary 3	340	337	289	262	261	172	108	86.5	140
6	Newman ER OB32	216	191	173	161	160	121	89	71.5	107

The isopleths of the maximum predicted 24-hour TSP concentrations for Scenario 4 are presented in Appendix Figure 16.



Appendix Figure 16: Maximum predicted 24-hour TSP concentrations – Scenario 4 with background.

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