Federation Project

Air Quality and Greenhouse Gas Assessment

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Federation Project

Air Quality and Greenhouse Gas Assessment

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Acronyms and Abbreviations

Name	Description
AAQ NEPM	National Environment Protection (Ambient Air Quality) Measure
ADP	Automated Data Processing
AERMAP	Terrain pre-processor for AERMOD
AERMET	Meteorological data pre-processor for AERMOD
AERMOD	Air Quality Dispersion Modelling
AWS	Automatic Weather Station
BoM	Bureau of Meteorology
CALMET	Meteorological model for CALPUFF
EIS	Environmental Impact Statement
ECMWF	European Centre for Medium-Range Weather Forecasts
EP&A Act	Environmental Planning and Assessment Act
DLCD	Dynamic Land Cover Dataset
DoEE	Department of Environment and Energy
DPIE	Department of Planning, Industry and Environment
HHRA	Human Health Risk Assessment
IPCC	Intergovernmental Panel on Climate Change
LCC	Lambert conformal conic
MMIF	Mesoscale Model Interface
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NEPC	National Environment Protection Council Service Corporation
NEPM	National Environment Protection Measures
NGA	National Greenhouse Accounts
NGER	National Greenhouse and Energy Reporting
NSW	New South Wales
NSW EPA	(NSW) Environment Protection Authority
PAF	Potentially Acid Forming
PM_{10}	Airborne particulate matter with an aerodynamic diameter of less than 10 µm
$PM_{2.5}$	Airborne particulate matter with an aerodynamic diameter of less than 2.5 µm
SEARs	Secretary’s Environmental Assessment Requirements
SPCC	State Pollution Control Commission of NSW
SRTM	Shuttle Radar Topography Mission
SSD	State Significant Development
ROM	Run of Mine
TSF	Tailings Storage Facility
TSP	Total Suspended Particulate (matter)
Tpa	Tonnes per annum
UCAR	University Corporation for Atmospheric Research
US EPA	United States Environmental Protection Agency
VLAMP	Voluntary Land Acquisition and Mitigation Policy
WBCSD	World Business Council for Sustainable Development

WE	Wind erosion
WHO	World Health Organisation
WRF	Weather Research and Forecasting model
WRI	World Resources Institute
$\mu g/m^3$	Micrograms per cubic metre

EXECUTIVE SUMMARY

Hera Resources Pty Limited (Hera Resources), a wholly owned subsidiary of Aurelia Metals Ltd (Aurelia Metals), has commissioned ERM Australia Pacific Pty Ltd (ERM) to prepare an Air Quality and Greenhouse Gas Assessment for the Federation Project (the Project). The assessment will form part of an Environmental Impact Statement (EIS) that will be prepared for the State Significant Development (SSD) application.

The Project is a proposed underground mine development which will establish and operate underground gold, silver and metalliferous mining activities with a projected 7 million tonnes (Mt) of ore extracted over a period of 12 to 14 years.

This Air Quality and Greenhouse Gas Assessment addresses the Secretary's Environmental Assessment Requirements (SEARs) and the outputs of the air quality assessment are used as part of the human health risk assessment (HHRA).

The air quality assessment has focused on emissions of particulate matter (TSP, PM_{10} and $PM_{2.5}$). The assessment has used the computer-based dispersion model (AERMOD) to predict off-site particulate matter concentrations across a model domain and at sensitive receptor locations. To assess the effect that potential emissions could have on existing air quality, the dispersion model predictions are compared to relevant regulatory air quality criteria. The assessment follows a conventional approach using the procedures outlined in the NSW Environment Protection Authority's (EPA) document titled *"Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW"* (Approved Methods) (NSW EPA, 2016).

The results show that there are no predicted exceedances at sensitive receptor locations of the NSW EPA impact assessment criteria for any of the annual average parameters. For 24-hour average $PM_{2.5}$, there are no predicted exceedances at sensitive receptor locations of the NSW EPA impact assessment criteria. For 24-hour average PM_{10}, there is one predicted exceedance of the NSW EPA impact assessment criteria, experienced at all sensitive receptor locations. This exceedance is due to background concentrations already exceeding the criteria. There are no additional exceedances at sensitive receptor locations of the 24-hour average PM_{10} criterion caused by Project contributions.

The Project's contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions. Average annual scope 1 emissions from the Project (approximately 0.02 Mt CO_2-e) would represent approximately 0.005% of Australia's commitment under the Paris Agreement. The proponent has proposed a solar farm to supplement power supply and reduce GHG emissions.

Overall, this quantitative air quality assessment concludes that the operation of the proposed Project activities is not anticipated to result in adverse air quality impacts under normal operating conditions.

1. INTRODUCTION

Hera Resources Pty Limited (Hera Resources), a wholly owned subsidiary of Aurelia Metals Ltd (Aurelia Metals), has commissioned ERM Australia Pacific Pty Ltd (ERM) to prepare an Air Quality and Greenhouse Gas Assessment for the Federation Project (the Project). The assessment will form part of an Environmental Impact Statement (EIS) that will be prepared for the State Significant Development (SSD) application.

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The air quality assessment has focused on emissions of particulate matter (TSP, PM_{10} and $PM_{2.5}$). The assessment has used the computer-based dispersion model (AERMOD) to predict off-site particulate matter concentrations across a model domain and at sensitive receptor locations. To assess the effect that potential emissions could have on existing air quality, the dispersion model predictions are compared to relevant regulatory air quality criteria. The assessment follows a conventional approach using the procedures outlined in the NSW Environment Protection Authority's (EPA) document titled *"Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW"* (Approved Methods) (NSW EPA, 2016).

The report comprises the following components:

- Local setting and Project description;
- Legislative setting and criteria;
- Existing environment;
- Modelling approach;
- Emissions to air;
- Assessment of impacts;
- Greenhouse gas assessment; and
- Conclusions.

2. PROJECT DESCRIPTION

2.1 Overview

The Project is a proposed underground mine development located in central-western NSW, approximately 15 km south of Nymagee and 10 km south of Hera Mine. The Hera Mine is also owned and operated by Hera Resources.

The Project comprises:

- The establishment and operation of underground gold and metalliferous mining activities, with supporting surface infrastructure, mining approximately 6.95 million tonnes (Mt) of ore over a period of 12 to 14 years, referred to as the Federation Site.
- Amendments at the Hera Mine to facilitate mining and processing of Federation deposit ore, including new process plant and disposal of tailings in the Hera Mine tailings storage facility (TSF).
- Services Corridor between the Federation Site and Hera Mine, including powerline, water pipeline, and access track and potentially a tailings pipeline.

The majority of ore produced will be sent to Hera Mine for processing. However up to 200 ktpa will be transported to PGM during the initial four years of processing (total of 750 kt over this period), whilst the new processing plant at Hera Mine is being commissioned and ramped up.

Access to the underground mine will be via a portal developed through the base of a box cut. The main decline will be developed to gain access to all production levels, where stopes will be excavated. The loosened ore from the stopes will be brought to the surface via underground truck and placed on the Federation Site Run of Mine (ROM) ore stockpile near the boxcut. Ore will then be transported by surface trucks via Burthong Road to the Hera Mine ROM stockpile at the Hera Mine process plant.

Figure 2-1 shows the local area, the location of the existing Hera Mine and the proposed location of the Federation Site.

This assessment has considered activities conducted for the Project which includes activities at Federation Site (namely hauling, loading, unloading and wind erosion), activities at Hera Mine for the processing of Federation deposit ore (including the new processing plant and disposal of tailings in the TSF), and haulage between Federation Site and Hera Mine. For a cumulative assessment, background concentrations have been added to predicted contributions from the Project. Further details are provided in the following sections of this chapter. The estimation of emissions related to these activities are provided in Section 6.

2.2 Federation Site

The Federation Site will utilise a surface box cut and decline to address the underground workings, with the mining method comprising a mix of longhole stoping and transverse longhole stoping.

Ore from the Federation Site is proposed to be transported approximately 10 km along Burthong Road and will be processed at Hera Mine. Ore proposed to be processed at Peak Mine will be transported in trucks of an approximate 50 t payload along Burthong Road, Priory tank Road and Kidman Way.

Figure 2-2 shows the Federation Site plan and on-site features.

2.3 Hera Mine

Hera Mine infrastructure is proposed to be modified to facilitate the Federation Project. The following activities at Hera Mine have been proposed:

- Amendments to facilitate mining and processing of Federation ore, including new process plant and disposal of tailings in the approved Hera Mine tailings storage facility (TSF).

- The new process plant will recover gold in doré and produce separate copper, lead and zinc concentrates. Up to 750 kt of ore will be processed annually at the new plant. Up to 200 kt of ore will be processed annually at Peak Mine.
- Sixty percent of the total tailings from Hera Mine process plant will be used for paste backfilling of the stope voids at Federation Site. The remaining tailings will be disposed within the approved TSF at Hera Mine.
- Approximately 100-150 ktpa of concentrate from Hera Mine will be transported by road trains to Hermidale Siding, approximately 100 km north of Hera Mine, via Hermidale Nymagee Road.

Figure 2-3 presents the Hera Mine site plan.

2.4 Transitional Period

It is anticipated that approval for the Project will be obtained in early 2023. Prior to the construction and operation of the Federation Project, an Exploration Decline Program will be undertaken. This activity will be undertaken under a separate approval to that being sought for the Project. The main objectives of the Exploration Decline Program are to further define the mineral resources associated with the Federation deposit, including permitting drilling of exploration drill holes from underground.

Key components of the Exploration Decline Program include:

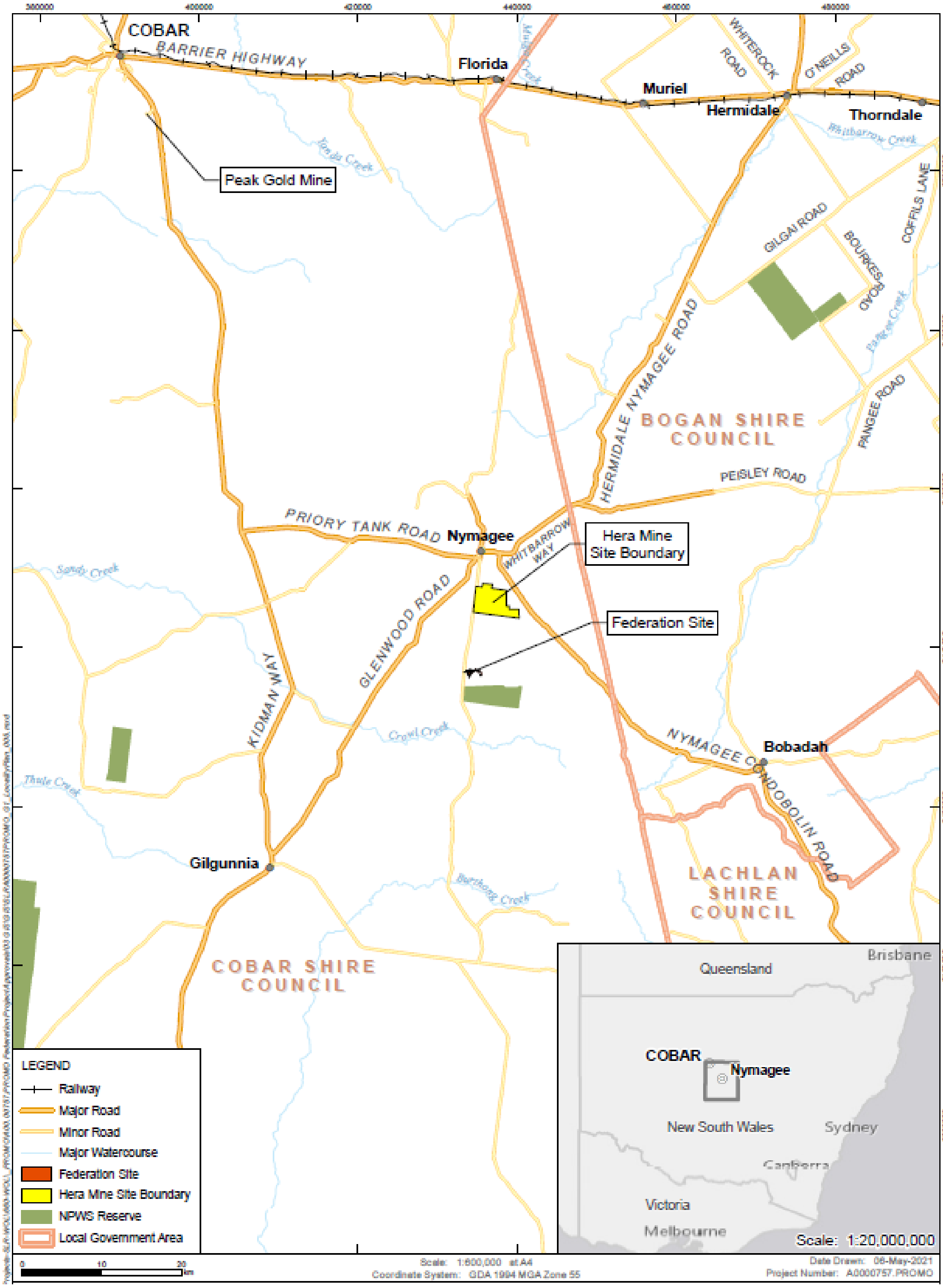
- Establishment of a Surface Infrastructure Area required to support the exploration decline.
- Development of a box cut, portal, exploration decline, two ventilation rises and one escapeway.
- Transportation to and storage of waste rock within the Surface Infrastructure Area, with subsequent transport of waste rock to Hera Mine.
- Establishment and use of an approximately 14.8 km surface pipeline to transfer water from the exploration decline to Hera Mine.
- Exploration drilling from the exploration decline.
- Extraction of one or more bulk samples together totalling no more than 20,000 t and transportation of that material to Hera Mine processing plant via Burthong Road.

It is anticipated that the Exploration Decline Program will commence in November 2021 with the Surface Infrastructure Area established and waste rock being generated from the decline. It is anticipated that ore from the bulk sample will be extracted and processed between the third quarter of 2022 and first quarter of 2023. Based on the current schedule for the Project, there will be a transitional period between Exploration Decline Program activities, mining operations at Hera Mine, and Project construction and operations. Following approval of the Project:

- Construction of Project infrastructure (including the new process plant) will commence in the first half of 2023.
- Exploration Decline Program activities will transition into mining operations at the Federation Site.
- Hera Mine operations may continue over a period of 6 to 12 months.

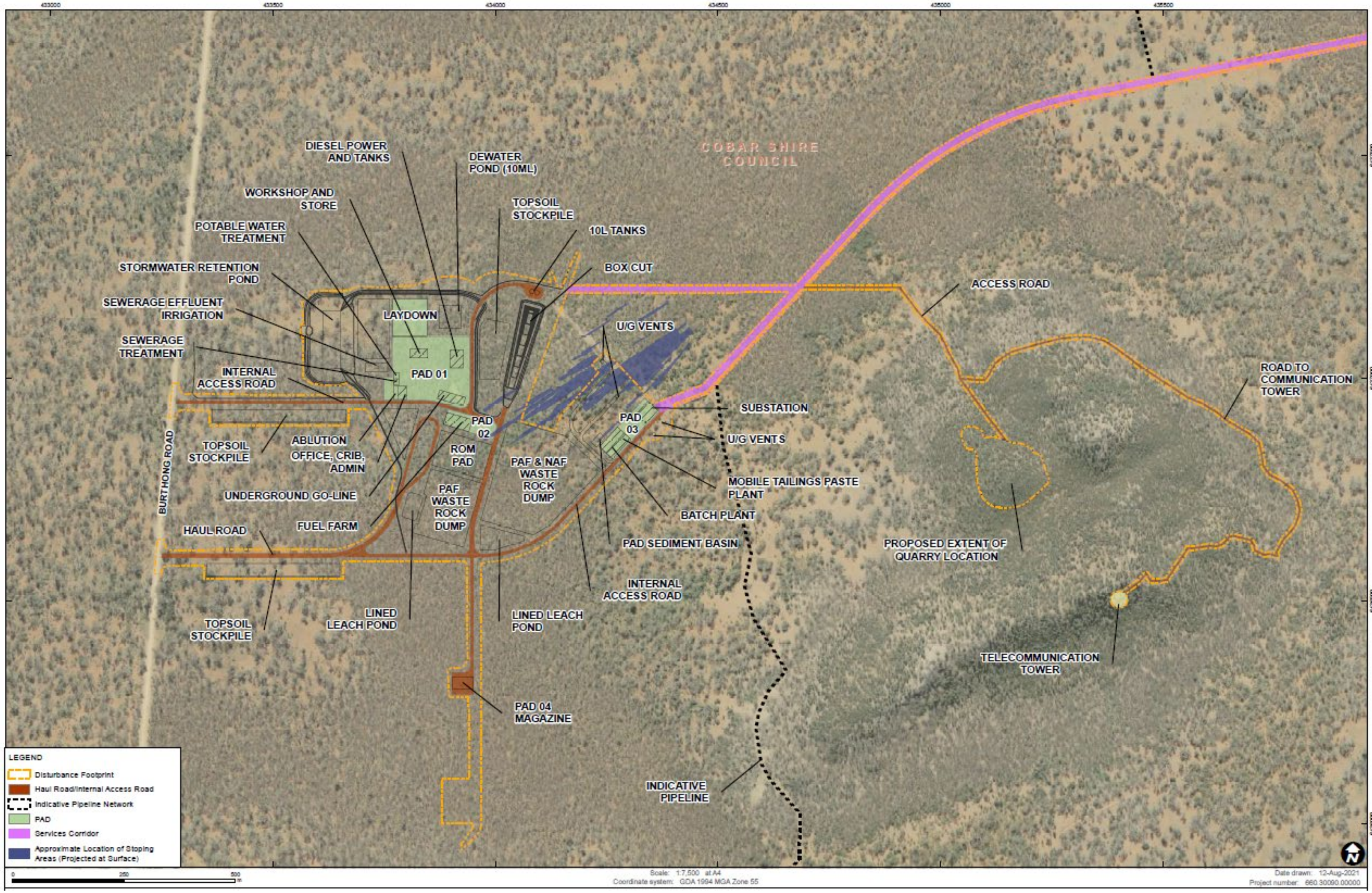
From early 2024, it is anticipated that all activities will be related to the Project operations. The operational workforce numbers will be transitioned from Hera Mine operations to Project operations.

For this assessment, the worst-case scenario for emissions is FY28 and not the transitional period. FY28 will have higher emissions, in particular from wheel generated dust from on internal haul roads. FY28 has been chosen as the year for this assessment. The transitional period is therefore not considered further in this report. The selection of assessment scenarios is discussed further in Section 5.3.



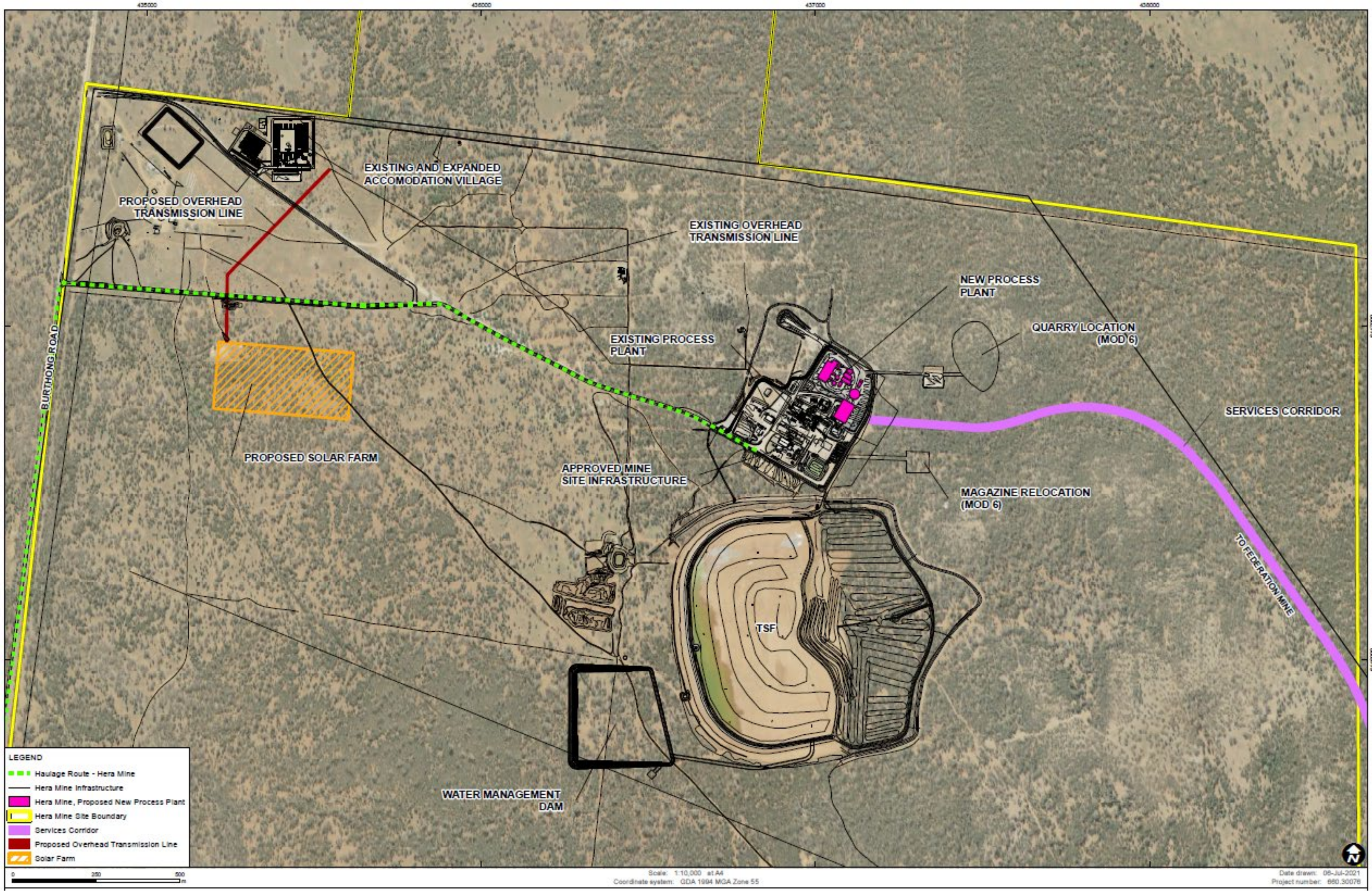
Source: SLR

Figure 2-1: Location of Federation and Hera Mine Sites



Source: SLR

Figure 2-2: Federation Site Plan



Source: SLR

Figure 2-3: Hera Mine Site Plan

2.5 Sensitive Receptors

There are sensitive receptors within the immediate vicinity of the Hera Mine and along haul routes between Federation Site and Hera Mine. The closest sensitive receptors to Hera Mine are receptors R3 and R2/R1, which are located approximately 2.5 km north west of the mine infrastructure area and 3.0 – 3.5 km south west of the mine infrastructure area, respectively.

Figure 2-4 presents the location of nearby sensitive receptors. Table 2-1 presents the detailed list of sensitive receptors.

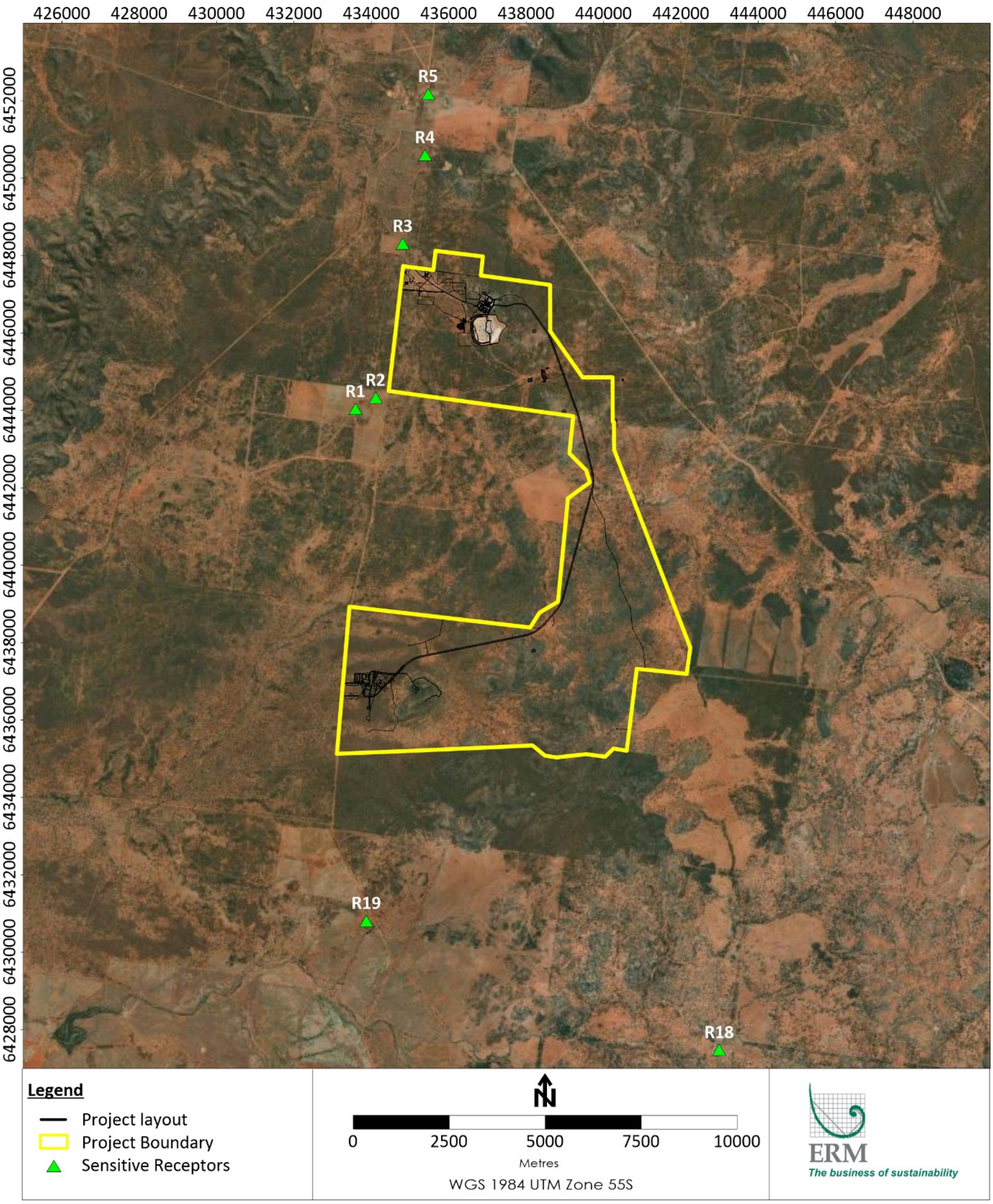


Figure 2-4: Location of sensitive receptors

Table 2-1: Sensitive receptor locations

Receptor ID	Easting (mE, MGA94)	Northing (mN, MGA94)
R1	433589	6444039
R2	434110	6444329
R3	434812	6448309
R4	435384	6450597
R5	435468	6452177
R18	442991	6427477
R19	433869	6430813

3. LEGISLATIVE SETTING AND AIR QUALITY ASSESSMENT CRITERIA

3.1 Overview

Mining activities proposed (as described in Section 2) have the potential to generate fugitive dust emissions in the form of particulate matter described as total suspended particulate matter (TSP), particulate matter with an equivalent aerodynamic diameter of 10 micrometres (µm) or less (PM_{10}), particulate matter with an equivalent aerodynamic diameter of 2.5 micrometres (µm) or less ($PM_{2.5}$) and deposited dust.

The following sections provide information on the relevant government requirement guidelines and air quality criteria used to assess the impact of pollutant emissions. Some background discussion has been provided to assist in interpreting the predicted pollutant levels.

3.2 Air quality issues and effects

From an air quality perspective, it is important to consider the potential emissions that would occur during the operation of the mining activities. There are many potential sources of dust emissions from the proposed Project activities including in particular from wheel generated dust from haulage of material on internal haul roads.

Modelling of lead emissions has not been included as part of this assessment report. Predicted concentrations of PM_{10} have been scaled based on the lead and other metals content to determine likely lead and other metals concentrations at sensitive receptors and across the modelled domain. These have been assessed in the human health risk assessment for the Project.

There will be an approximate 10 MW gas-fired power plant at Hera Mine. Any emissions from this plant will likely be small and can be considered to be negligible. In terms of total emissions, mining activities are not significant sources of NO_2 and SO_2, in comparison to pollutants such as particulate matter. On that basis, the focus of this assessment is particulate matter – TSP, PM_{10}, $PM_{2.5}$ and deposited dust.

Particulate matter has the capacity to affect health and to cause nuisance effects, and is categorised by size and/or by chemical composition. The potential for harmful effects depends on both. The particulate size ranges are commonly described as:

- Total Suspended Particulates (TSP) – refers to all suspended particles in the air. In practice, the upper size range is typically 30 µm.
- PM10 – refers to all particles with equivalent aerodynamic diameters of less than 10 µm, that is, all particles that behave aerodynamically in the same way as spherical particles with diameters less than 10 µm and with a unit density. PM10 are a sub-component of TSP.
- PM2.5 – refers to all particles with equivalent aerodynamic diameters of less than 2.5 µm diameter (a subset of PM10). These are often referred to as the fine particles and are a sub-component of PM10.
- PM2.5-10 – defined as the difference between PM10 and PM2.5 mass concentrations. These are often referred to as coarse particles.

Evidence suggests that health effects from exposure to airborne particulate matter are predominantly related to the respiratory and cardiovascular systems (WHO, 2011). The human respiratory system has in-built defensive systems that prevent larger particles from reaching the more sensitive parts of the respiratory system. Particles larger than 10 µm, while not able to affect health, can soil materials and generally degrade aesthetic elements of the environment. For this reason, air quality goals make reference to measures of the total mass of all particles suspended in the air, referred to as TSP. In practice particles larger than 30 to 50 µm settle out of the atmosphere too quickly to be regarded as air pollutants. The upper size range for TSP is usually taken to be 30 µm.

Both natural and anthropogenic processes contribute to the atmospheric load of particulate matter. Coarse particles ($PM_{2.5-10}$) are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal materials from roads, farming, mining and dust storms.

Fine particles or $PM_{2.5}$ are derived primarily from combustion processes, such as vehicle emissions, wood burning and natural processes such as bush fires. Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosol from volatile organic compound emissions. $PM_{2.5}$ may penetrate beyond the larynx and into the thoracic respiratory tract and evidence suggests that particles in this size range are more harmful than the coarser component of PM_{10}.

The size of particles determine their behaviour in the respiratory system, including how far the particles are able to penetrate, where they deposit, and how effective the body's clearance mechanisms are in removing them.

3.3 Secretary Environmental Assessment Requirements (SEARs)

The Secretary's Environmental Assessment Requirements (SEARs) for the Project were issued on 17 August 2021. Those specific to air quality, and the section in which they are address in this report, have been provided in Table 3-1:

Table 3-1: Secretary's Environmental Assessment Requirements (SEARs)

Requirement	Section addressed
An assessment of the likely air quality impacts of the development, including cumulative impacts from nearby developments, in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (2016), and having regard to the NSW Government's Voluntary Land Acquisition and Mitigation Policy	Section 7
Demonstrated ability to comply with the relevant regulatory framework, specifically the Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations (Clean Air) Regulation 2010	Section 3.4, Section 3.5 Section 3.6 & Section 7
Identification of strategies to minimise point and/or fugitive and/or odour emissions/impacts (with proposed timing), including monitoring, in line with relevant guidance/standards	Section 6.3 and Section 8.3
An assessment of the likely greenhouse gas impacts of the development	Section 8
A description of the feasibility of measures that would be implemented to monitor and report on the emissions (including fugitive dust and greenhouse gases) of the development	Section 9

3.4 Impact assessment criteria

An ambient air quality standard defines a metric relating to the concentration of an air pollutant in the ambient air. Standards are usually designed to protect human health, including sensitive populations such as children, the elderly, and individuals suffering from respiratory disease, but may relate to other adverse effects such as damage to buildings and vegetation. The form of an air quality standard is typically a concentration limit for a given averaging period (e.g. annual mean, 24-hour mean), which may be stated as a 'not-to-be-exceeded' value or with some exceedances permitted. Several different averaging periods may be used for the same pollutant to address long-term and short-term exposure. Each metric is often combined with a goal, such as a requirement for the limit to be achieved by a specified date.

In 1998, Australia adopted a National Environmental Protection (Ambient Air Quality) Measure (AAQ NEPM) that established national standards for six criteria pollutants (NEPC, 1998). The AAQ NEPM was extended in 2003 to include advisory reporting standards for PM with an aerodynamic diameter of less than 2.5 µm ($PM_{2.5}$) (NEPC, 2003). The standards for PM were further amended in February 2016 (NEPC, 2016).

In 2016 the National Environment Protection Council (NEPC) approved a variation to the NEPM AAQ for particles to reflect the latest scientific understanding of health risks. On 15 April 2021, the National Environment Protection Council (NEPC) agreed to vary the NEPM AAQ, approving an amending instrument to incorporate more stringent standards for $PM_{2.5}$ amongst others.

At the time of preparation of this report, the amending instrument is yet to be registered on the Federal Register of Legislative Instruments, at which point it will become legally enforceable. Accordingly, the standards within the 2021 NEPM variation are referred to as 'pending NEPM AAQ' standards.

Table 3-2 presents NSW impact assessment criteria and pending NEPM AAQ standards. For $PM_{2.5}$, it is considered prudent to compare the results in this assessment with the pending NEPM AAQ standards.

Table 3-2: NSW impact assessment criteria and pending NEPM AAQ standards

Pollutant	Maximum concentration		Averaging Period
	Criterion (NSW EPA, 2016)	Pending NEPM AAQ standards	
TSP	90 µg/m^3	No change	Annual
PM_{10}	25 µg/m^3	No change	Annual
	50 µg/m^3		24-hour
$PM_{2.5}$	8 µg/m^3	7 µg/m^3	Annual
	25 µg/m^3	20 µg/m^3	24-hour

Note: µg/m^3 = micrograms per cubic metre

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

Table 3-3 shows the maximum acceptable increase in dust deposition over the existing dust levels from an amenity perspective. These criteria for dust fallout levels are set to protect against nuisance impacts (NSW EPA, 2016).

Table 3-3: NSW EPA air quality criteria for deposited dust

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

g/m^2/month = grams per square metre per month.

3.5 NSW Department of Planning, Industry and Environment Voluntary Land Acquisition and Mitigation Policy (VLAMP)

In December 2014, the NSW Department of Planning and Environment (now Department of Planning, Industry and Environment (DPIE)) released a policy relating to Mining, Petroleum Production and Extractive Industries and including the identification of voluntary mitigation and land acquisition criteria for air quality and noise (NSW Government, 2014). This is reflected in State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 (the Mining SEPP) at Clause 12A.

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

The DPIE voluntary mitigation and acquisition criteria are summarised in Table 3-4 and Table 3-5, respectively. The Project has been assessed against these criteria, in addition to the NSW EPA impact assessment criteria discussed in Section 3.3.

The VLAMP was revised by DPIE and reissued in September 2018.

Table 3-4: DPIE particulate matter mitigation criteria

Pollutant	Criterion	Averaging Period	Application
$PM_{2.5}$	8 µg/m^3 25 µg/m^3	Annual 24-hour	Total impact* Incremental impact**
PM_{10}	30 µg/m^3 50 µg/m^3	Annual 24-hour	Total impact* Incremental impact**
TSP	90 µg/m^3	Annual	Total impact
Deposited dust	2 g/m^2/month 4 g/m^2/month	Annual Annual	Incremental impact** Total impact*

Notes:
* Cumulative impact (i.e. increase in concentrations due to the development plus background concentrations due to all other sources)
**Incremental impact (i.e. increase in concentrations due to the development alone), with zero allowable exceedances of the criteria over the life of the development.

Table 3-5: DPIE particulate matter acquisition criteria

Pollutant	Criterion	Averaging Period	Application
$PM_{2.5}$	8 µg/m^3 25 µg/m^3	Annual 24-hour	Total impact* Incremental impact**
PM_{10}	30 µg/m^3 50 µg/m^3	Annual 24-hour	Total impact* Incremental impact**
TSP	90 µg/m^3	Annual	Total impact
Deposited dust	2 g/m^2/month 4 g/m^2/month	Annual Annual	Incremental impact** Total impact*

Notes:
* Cumulative impact (i.e. increase in concentrations due to the development plus background concentrations due to all other sources)
**Incremental impact (i.e. increase in concentrations due to the development alone), with up to five allowable exceedances of the criteria over the life of the development.

Voluntary acquisition rights apply where the Project contributes to exceedances of the acquisition criteria at any residence or workplace on privately-owned land, or, on more than 25% of any privately-owned land, and a dwelling could be built on that land under existing planning controls.

Total impact includes the impact of the Project and all other sources, whilst incremental impact refers to the impact of the Project considered in isolation. The incremental impact for the DPIE mitigation criteria also applies to areas where more than 25% of the land has been predicted to exceed.

At Clause 12AB(4), the Mining SEPP also sets a non-discretionary development standard of cumulative annual average PM_{10} concentration for private dwellings of 30 µg/m^3.

3.6 Protection of the Environment Operations Act

If approved, the Project will be issued an Environmental Protection Licence (EPL) issued under the *Protection of the Environment (Operations) Act 1997* (POEO Act) which will require the operation to minimise dust emissions. In addition, the *NSW POEO (Clean Air) Regulation 2010* prescribes requirements for domestic solid fuel heaters, control of burning, motor vehicle emissions and industrial emissions (such as Volatile Organic Carbons). Motor vehicle emissions would be addressed by regular maintenance of all vehicles associated with the Project.

4. EXISTING ENVIRONMENT

4.1 Dispersion meteorology

The primary meteorological parameters influencing plume dispersion for ground based, non-buoyant sources are wind direction and wind speed.

The closest Bureau of Meteorology (BoM) meteorological station to the Project is the Cobar MO Automatic Weather Station (AWS) 048027, located approximately 90 km to the northwest. It should also be noted that there is an on-site weather station at Hera Mine. However there are some concerns regarding the validity of the wind direction data and on that basis, data from the on-site weather station have not been used. Given the separation distance from the Cobar MO AWS, an alternative approach (prognostic meteorological modelling using WRF) has been adopted to produce the meteorological data used in the dispersion model. These data are described in Section 4.2.

The Cobar MO AWS data have still been used to understand the inter-annual variability meteorological data. The annual wind roses for six years from 2015 – 2020 are presented in Appendix A. It can be seen that the annual wind roses are consistent across the six year period with winds from the south/south west and east being the most dominant. There is some variability in the wind directions across the seasons, but this is expected. Table 4-1 presents the average wind speeds and percentage calms showing that the average wind speed is consistent across all analysed years. The percentage of calms (wind speeds less than 0.5 m/s) is generally between 0.2 and 0.5%, with the exception of 2019. Taking into consideration the annual and seasonal wind roses, the average wind speeds and percentage calms, it is considered that 2017 is representative year for modelling. Furthermore this supports the year chosen from the analysis of background data discussed further in Section 4.3.

Table 4-1: Average wind speeds and percentage calms at Cobar MO AWS from 2015 to 2020

Year	Average wind speed (m/s)	Calms (%)
2015	3.8	0.2
2016	3.7	0.5
2017	3.8	0.3
2018	3.9	0.3
2019	3.8	1.2
2020	3.7	0.4
Period average	3.8	0.5

4.2 Weather Research and Forecasting Model (WRF)

With the meteorological year chosen, meteorological modelling was first undertaken using Weather Research and Forecasting model (WRF). WRF is a three-dimensional numerical meteorological model which can be used to generate three-dimensional gridded meteorological data through the treatment and assimilation of available surface/upper air/precipitation observations in addition to very specific and local land use characteristics.

WRF modelling was initially conducted for 2017 simulate meteorological conditions across the modelling domain. The process of developing the WRF datasets involved a nested approach as described below. Initially, a broader geographical domain was selected to span the State of NSW and VIC at a horizontal grid resolution (spacing) of 27 kilometres (km). The next two iterations of the WRF modelling was conducted to reduce the horizontal resolution to 9 km and 3 km. The model was centred at 32.201°S and 146.354°E and a Lambert conformal conic (LCC) map projection was used to account for the curvature (degree of distortion) of the earth.

4.2.1 Initialisation Datasets

WRF meteorological datasets were developed for the period using data ERA5 dataset published by the European Centre for Medium-Range Weather Forecasts (ECMWF) as the initial guess and boundary fields. ERA5 data are available every three hours on a 30 km grid and resolves the atmosphere from the surface up to a height of 80 km at 137 levels.

4.2.2 Geospatial WRF Inputs

WRF inputs are available from NCAR with default sets of static geospatial data for terrain, vegetation/land use and soil type. At the latitude of the site, the datasets have a resolution of about 0.45 km. These data were assigned to ERM's WRF simulations based on the resolution of the simulation domain. In addition to the above inputs, other features available from the University Corporation for Atmospheric Research (UCAR) were used in the prognostic modelling (UCAR, 2018).

4.2.3 Land Use

In addition to the default databases, for this study for the inner grids at resolution of 9 km and 3 km, an approach to utilise land use at 50 m resolution was developed. Land use inputs to the WRF model were obtained from the Dynamic Land Cover Dataset (DLCD) published by Geoscience Australia.

4.2.4 Terrain

For terrain, the terrain data at 30 m for the final refined grid (Domain-03 at 3 km) was utilised. Terrain inputs into the WRF model at 30-m resolution were obtained from the SRTM elevation model.

4.2.5 Observational Data

The NCEP ADP Global Surface Observational Weather Data and CEP ADP Global Upper Air Observational Weather Data were incorporated to the WRF run to nudge the model towards the available observations within the dataset using the Obsgrid program. The intent of this approach is to provide WRF with additional information to improve the modelled result.

4.2.6 WRF Options

In addition to the domain-wide characteristics noted above, the following discussion describes the physical schemes available within the WRF system and how they were adapted for use by ERM in the modelling analysis. The WRF model user has the choice of numerous options for running the model and its pre-processors.

4.2.7 WRF Post Processing

Following completion of the WRF modelling, the data was processed through the Mesoscale Model Interface (MMIF) program to translate the WRF output into a format compatible with AERMET. The default settings within the MMIF program were used and the entire 3 km resolution grid output for incorporation into CALMET.

Figure 4-1 presents the annual wind roses from WRF for 2017. Figure 4-2 presents the seasonal wind roses from WRF for 2017.

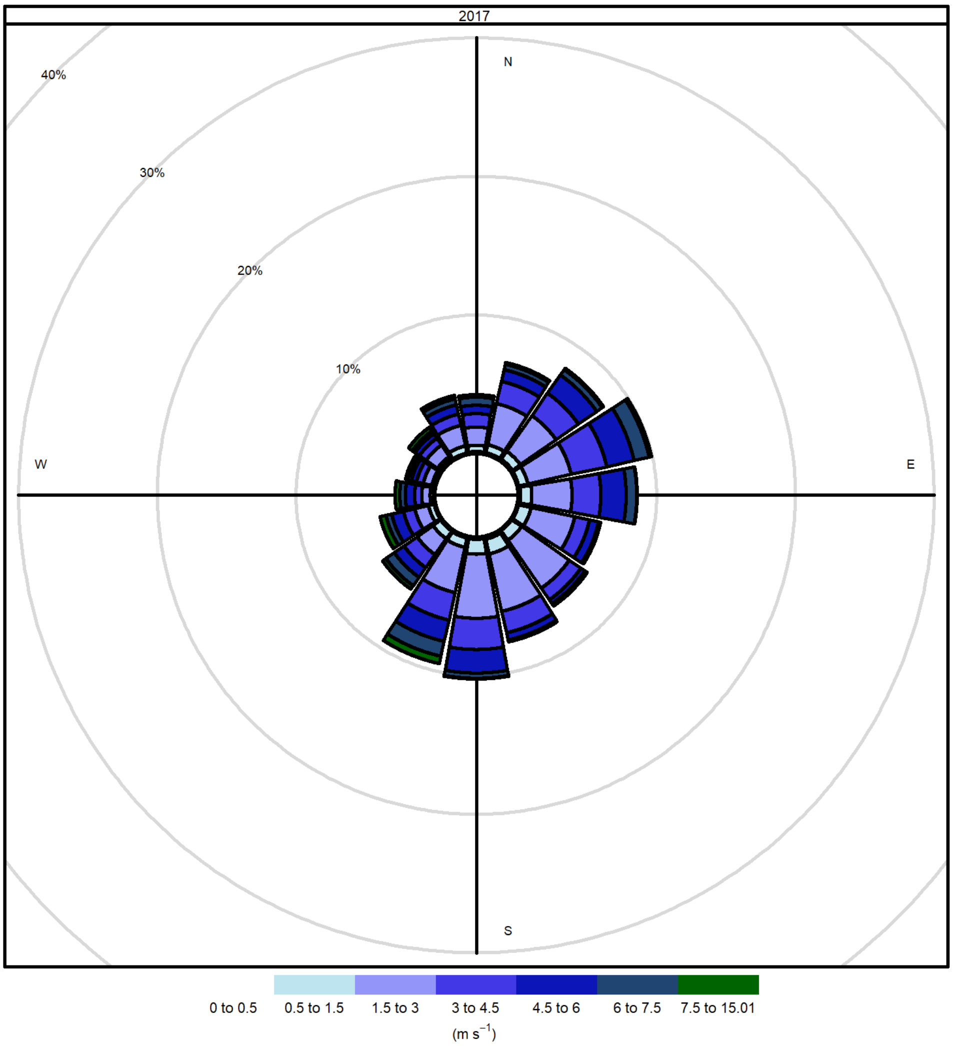


Figure 4-1: Annual wind rose for WRF output for 2017

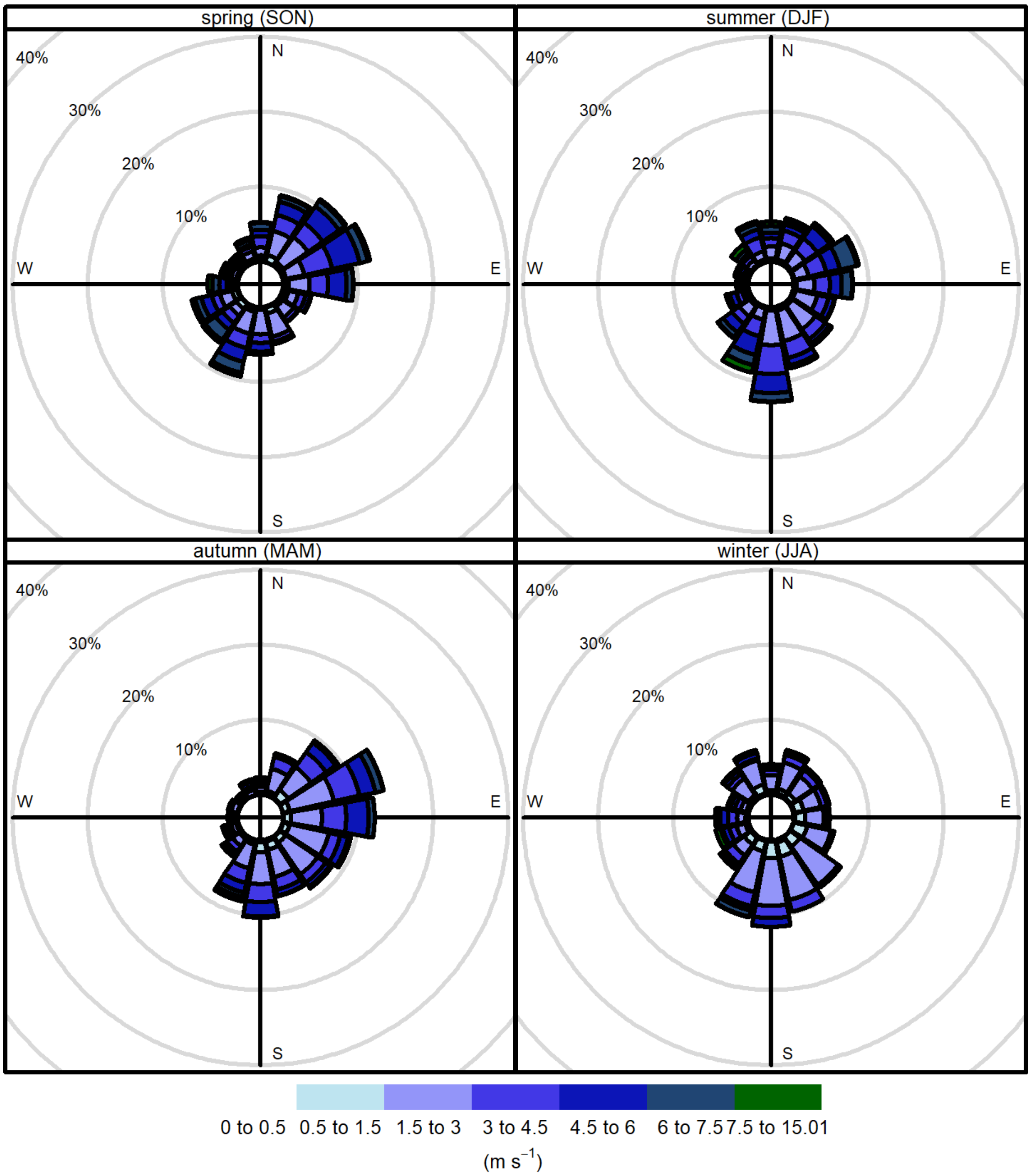


Figure 4-2: Seasonal wind rose for WRF output for 2017

4.3 Existing air quality

4.3.1 Overview

At Hera Mine, there is a High Volume Air Sampler (HVAS) which records TSP and PM_{10} concentrations. The HVAS is located within the mining lease and in close proximity to haul roads. Data for this monitor has been provided, however it cannot be used as an indicator of background concentrations.

At Hera Mine, there are also two dust deposition gauges. Again, the dust deposition gauges are located in close proximity to haul roads and therefore cannot be used as an indicator of background concentrations.

Figure 4-3 presents the location of the HVAS and dust deposition gauges in relation to Hera Mine. Presentation of data collected at the HVAS and dust deposition gauges is provided later in this section.

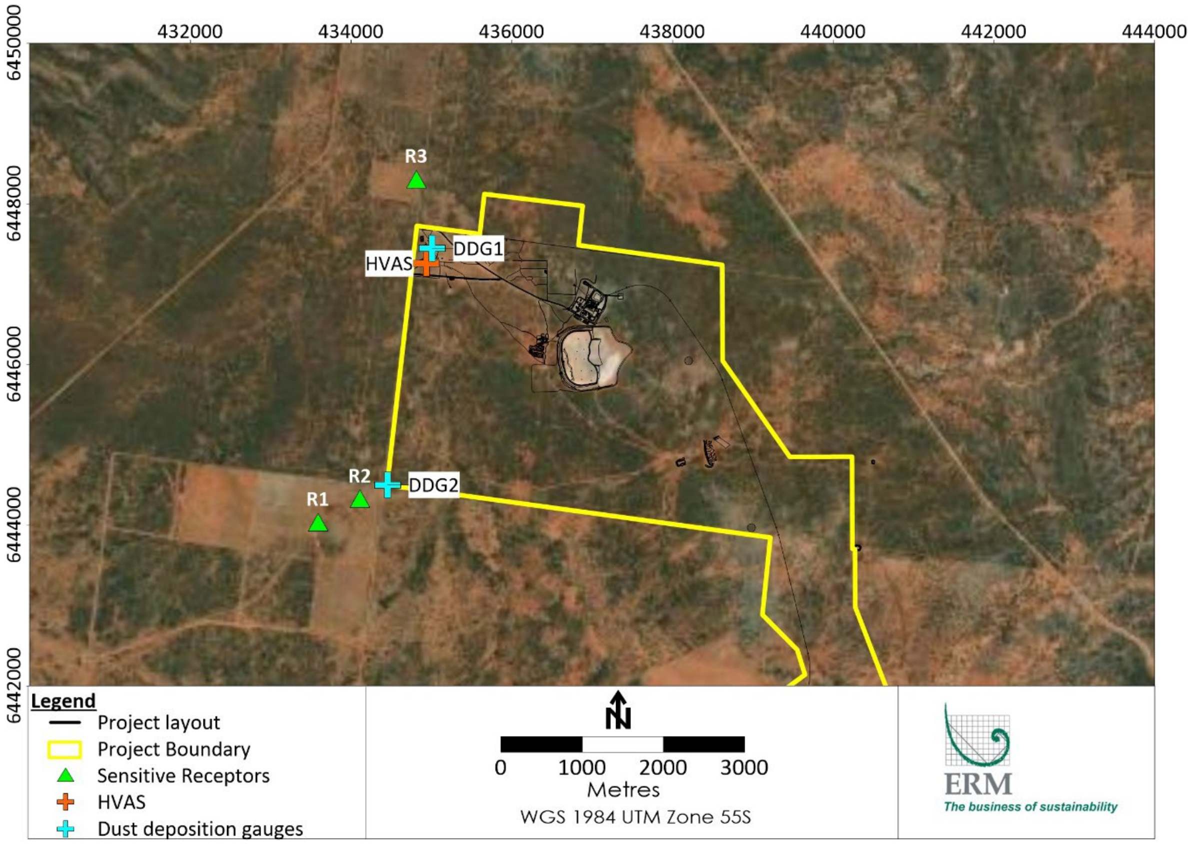


Figure 4-3: Location of HVAS and dust deposition gauges in relation to Hera Mine

In order to gather background concentrations, the closest monitoring stations with publicly available data are from the Department of Planning, Industry and Environment (DPIE) monitors located at Wagga Wagga and Bathurst, both more than 300 km away from the site.

In the absence of site-specific or local data, a review of all regional data from the DPIE's rural monitoring stations located in Tamworth, Bathurst, Albury and Wagga Wagga North has been completed.

It is noted that although these DPIE monitoring stations are located in rural areas of NSW, they are located within densely populated towns in those areas (population between approximately 35,000 and 63,000), compared to the much smaller population of the town of Nymagee (anticipated to be less than 100). It is therefore considered that these monitors would include a higher contribution of PM (particularly $PM_{2.5}$) from sources related to urban areas such as vehicle emissions and wood smoke and thus represent a conservative assumption of existing air quality in the vicinity of the Project. This is despite the more arid conditions experienced at the Project location.

4.3.2 PM_{10} concentrations

4.3.2.1 DPIE Monitoring Stations

Table 4-2 presents the annual average PM_{10} concentrations recorded at DPIE monitoring stations at Tamworth, Albury (both ~450 km distant), Bathurst and Wagga Wagga North (both ~350 km distant) from 2015 to 2020.

Table 4-2: Annual average PM_{10} concentrations at DPIE stations from 2015 to 2020

Year	Tamworth ($\mu g/m^3$)	Albury ($\mu g/m^3$)	Bathurst ($\mu g/m^3$)	Wagga Wagga Nth ($\mu g/m^3$)	All sites average ($\mu g/m^3$)	Criterion ($\mu g/m^3$)
2015	14.1	14.6	13.4	19.9	15.5	25
2016	15.3	15.1	13.3	20.6	16.1	
2017	15.3	15.8	14.1	20.6	16.5	
2018	20.1	19.8	18.8	27.4	21.5	
2019	33.7	23.4	27.4	35.3	30.0	
2020	16.8	20.1	17.0	23.2	19.3	
Period Average (excluding 2019)	**16.2**	**16.3**	**14.9**	**22.1**	**17.8**	
Period Average (2015-2020)	**19.2**	**18.1**	**17.3**	**24.5**	**19.8**	

The highest annual average concentration for all the DPIE stations was recorded in 2019. Years 2018 and 2019 were affected by higher prevalence of both dust storms and bushfires leading to higher annual average concentrations. The year 2019 was highly affected by intense bushfires during the last quarter of the year. The year 2020 was affected by the bushfires from 2019 during the first months of the year.

Annual averages for year 2017 are lower than the average six-year period (2015-2020) shown but are closest to the mentioned five-year averaged period (2015-2018, 2020). The 'all sites' average for 2017 of 16.5 $\mu g/m^3$ is higher than the five-year averaged period for all sites except Wagga Waga North. This supports the selection of 2017 as a representative year for modelling, noting that years 2019-2020 are exceptional.

The annual average PM_{10} concentration across all four data sets for 2017 is 16.5 $\mu g/m^3$ and has been adopted as a conservative representation of the annual average PM_{10} background for this assessment. This value is deemed representative of a regional -rural location such as the Project Site.

Figure 4-4 to Figure 4-11 presents the 24-hour average PM_{10} concentrations at the closest DPIE stations.

The data shows that measured 24-hour average PM_{10} concentrations at the Tamworth, Albury, Bathurst and Wagga Wagga North DPIE's monitoring stations have been predominantly below the NSW EPA's 24-hour average impact assessment criterion of 50 $\mu g/m^3$ from 2015 to 2018 and 2020. The exception is Wagga Wagga North during 2018. The year 2019, as already mentioned, was subject to intense bushfires so the PM_{10} concentrations were higher than the criterion throughout that year for all the sites except for Albury.

It is also noted that due to prevailing regional drought conditions, the Wagga Wagga North monitoring station shows consistently higher concentrations compared with the other sites. From October 2019 until February 2020 all the DPIE stations were generally above the NSW EPA's impact assessment criterion due to the drought / bushfire situation.

There were a total of 346 occasions over the 2015-2020 period where the impact assessment criterion was exceeded at the DPIE stations, including 73 occasions at the Tamworth station, 54 occasions at the Albury station, 64 occasions at the Bathurst station, and 155 occasions at the Wagga Wagga North station.

Figure 4-8 to Figure 4-11 presents the 24-hour average PM_{10} data for the DPIE stations for 2017 only, as these data will be used in the 24-hour average cumulative assessment.

Figure 4-8 to Figure 4-11 shows that the Wagga Wagga North DPIE monitoring station data appears to be consistently higher than other stations throughout the year, with peaks observed in January, March, April and December that are significantly higher than those recorded at the other sites. The annual average concentrations also reflect this fact with Wagga Wagga North recording an annual average PM_{10} concentration of 20.6 $\mu g/m^3$ in 2017, compared to the other regional sites which are all below 16 $\mu g/m^3$ in 2017.

Given the lack of site-specific data and the analysis shown above, the 24-hour PM_{10} background dataset for the site has been developed by taking an average of all four regional DPIE stations for every day of the modelled year (2017) to develop a daily varying profile for that year. As discussed previously, the population of Nymagee is much smaller than the population of the regional towns where the other DPIE monitors are located, and therefore likely to be less affected by urban levels of PM concentrations as the DPIE monitors may be. Therefore this dataset is deemed to be a conservative estimation of background PM_{10} within the Project Site, even when considering the more arid environment within the Project locality.

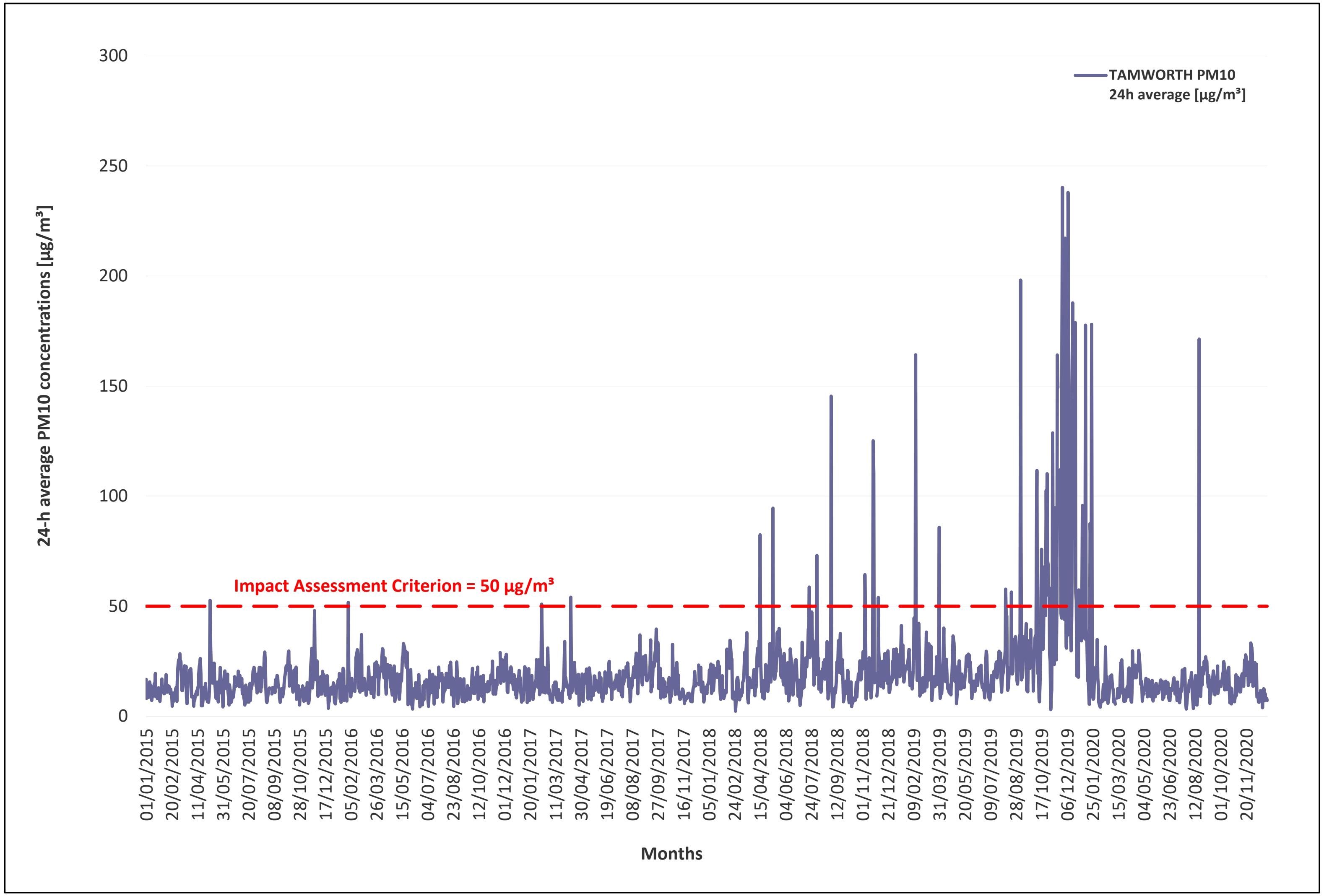


Figure 4-4: 24-hour average PM_{10} concentrations – DPIE Tamworth (2015 to 2020)

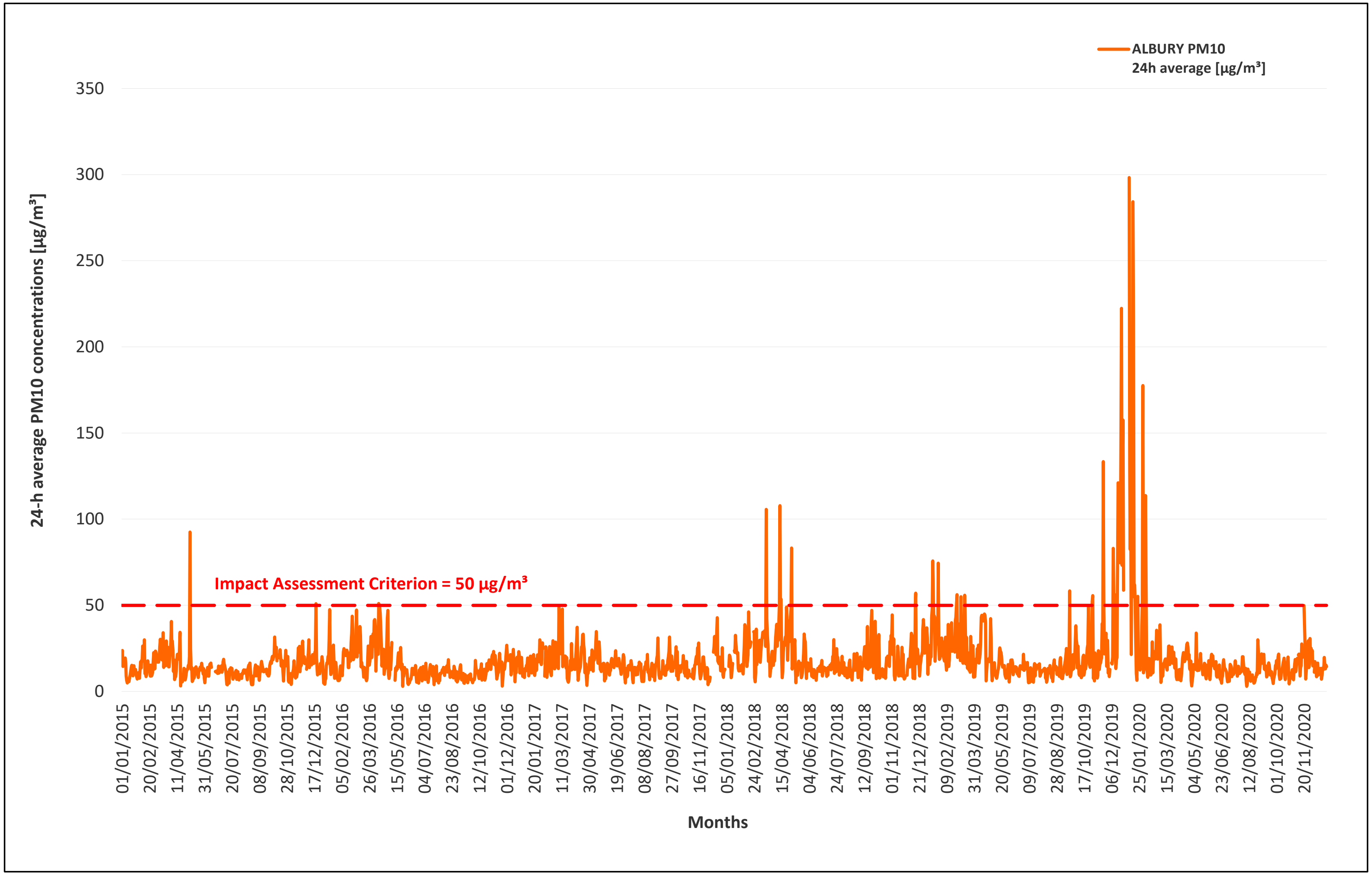


Figure 4-5: 24-hour average PM_{10} concentrations – DPIE Albury (2015 to 2020)

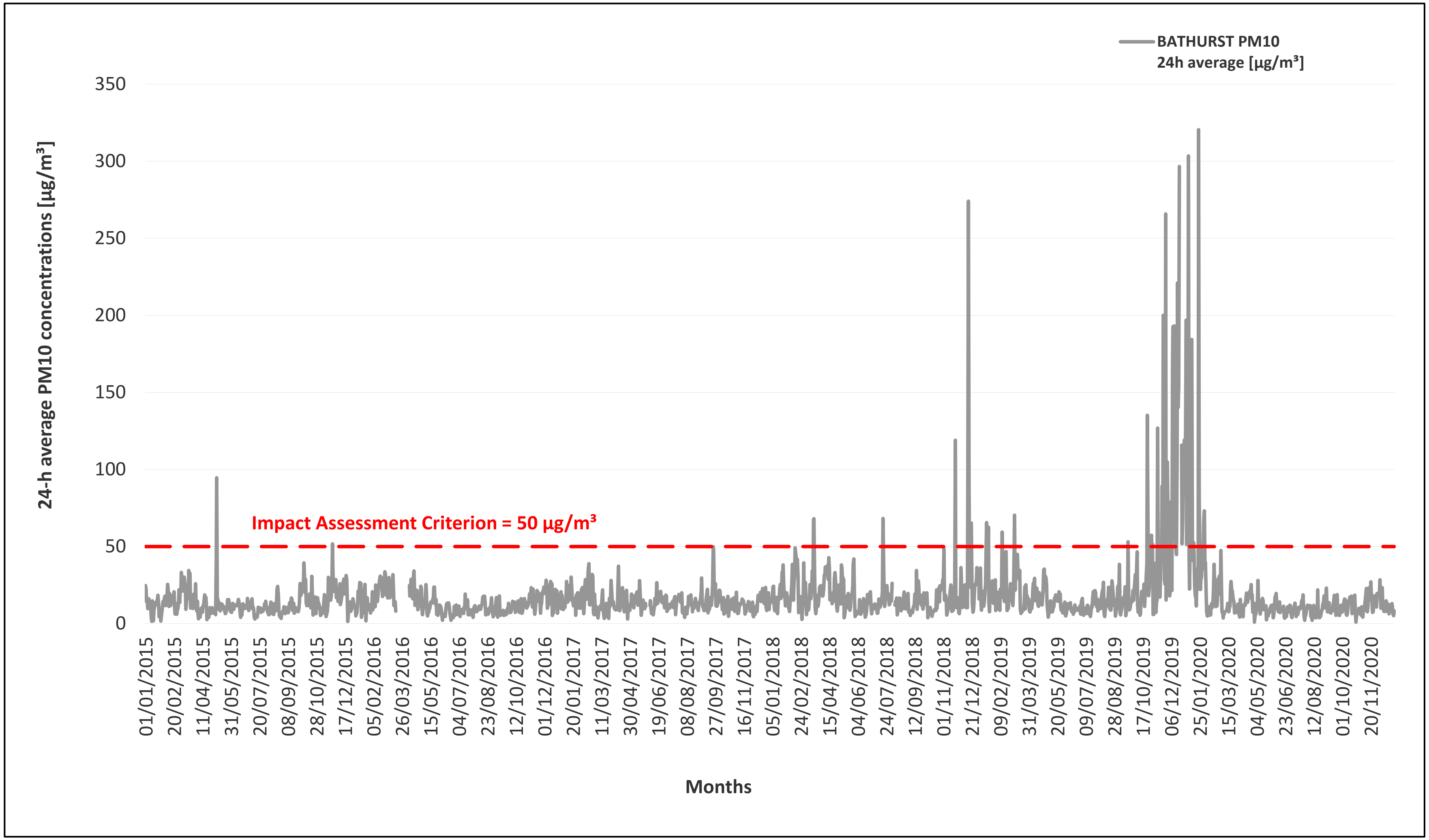


Figure 4-6: 24-hour average PM_{10} concentrations – DPIE Bathurst (2015 to 2020)

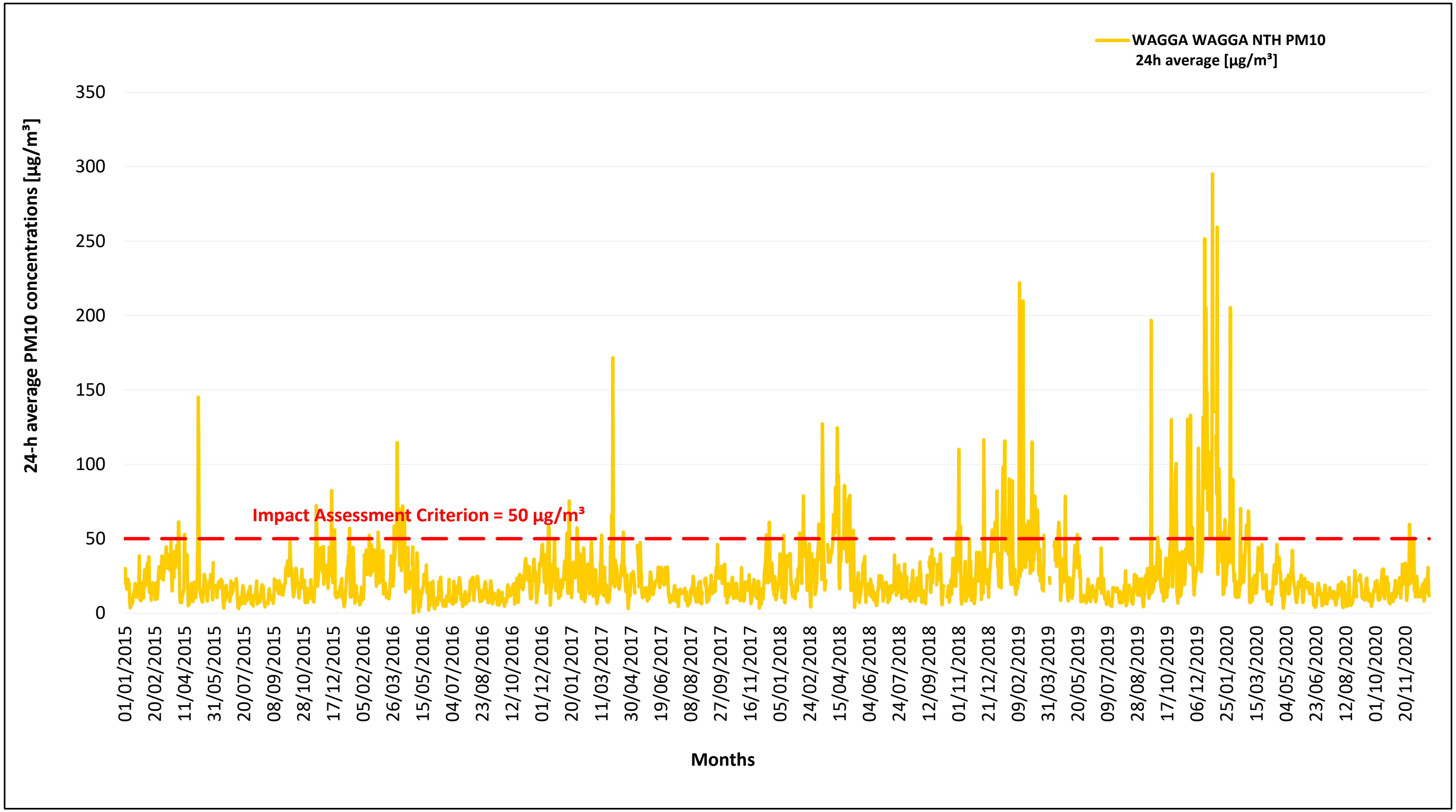


Figure 4-7: 24-hour average PM_{10} concentrations – DPIE Wagga Wagga North (2015 to 2020)

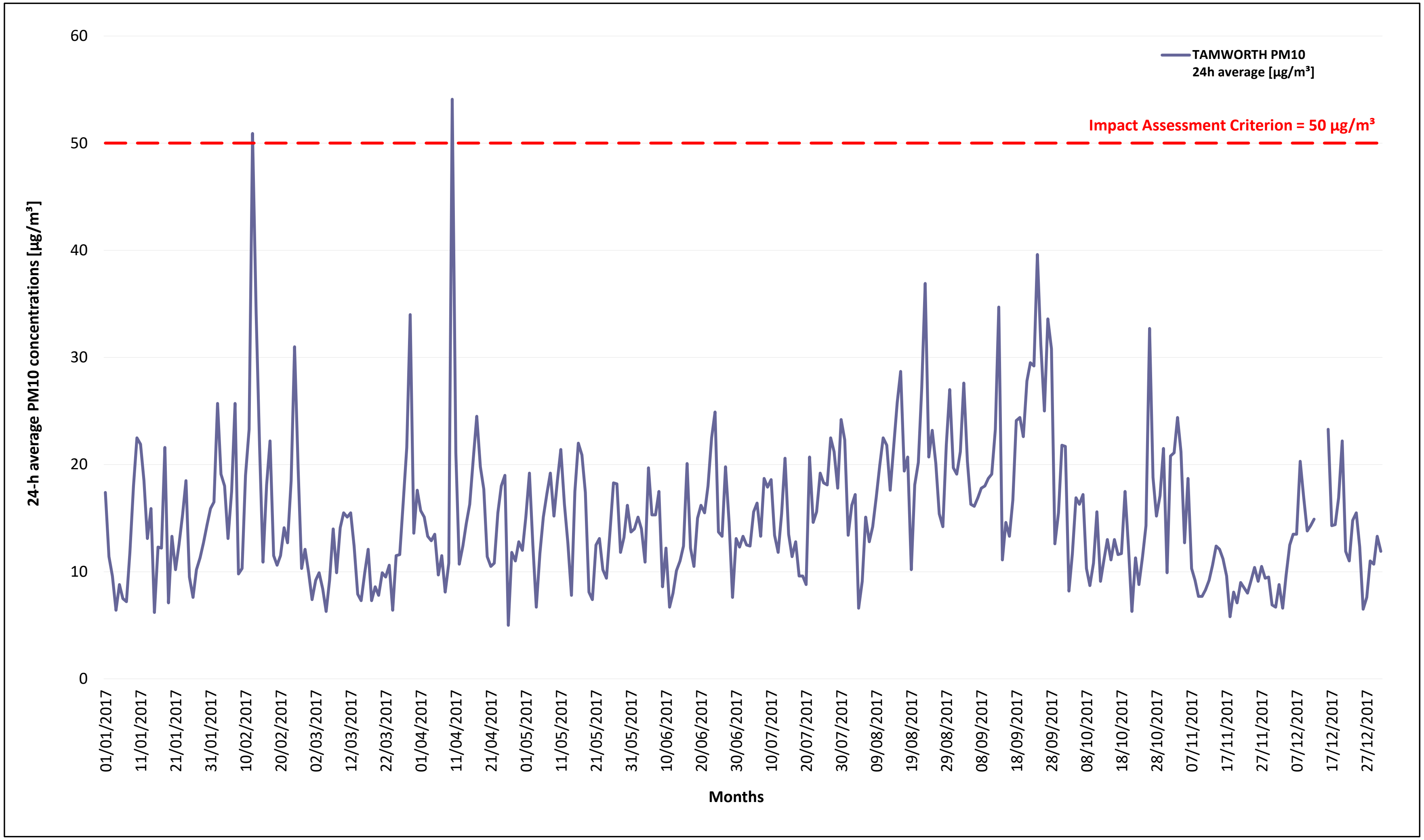


Figure 4-8: 24-hour average PM_{10} concentrations – DPIE Tamworth (2017)

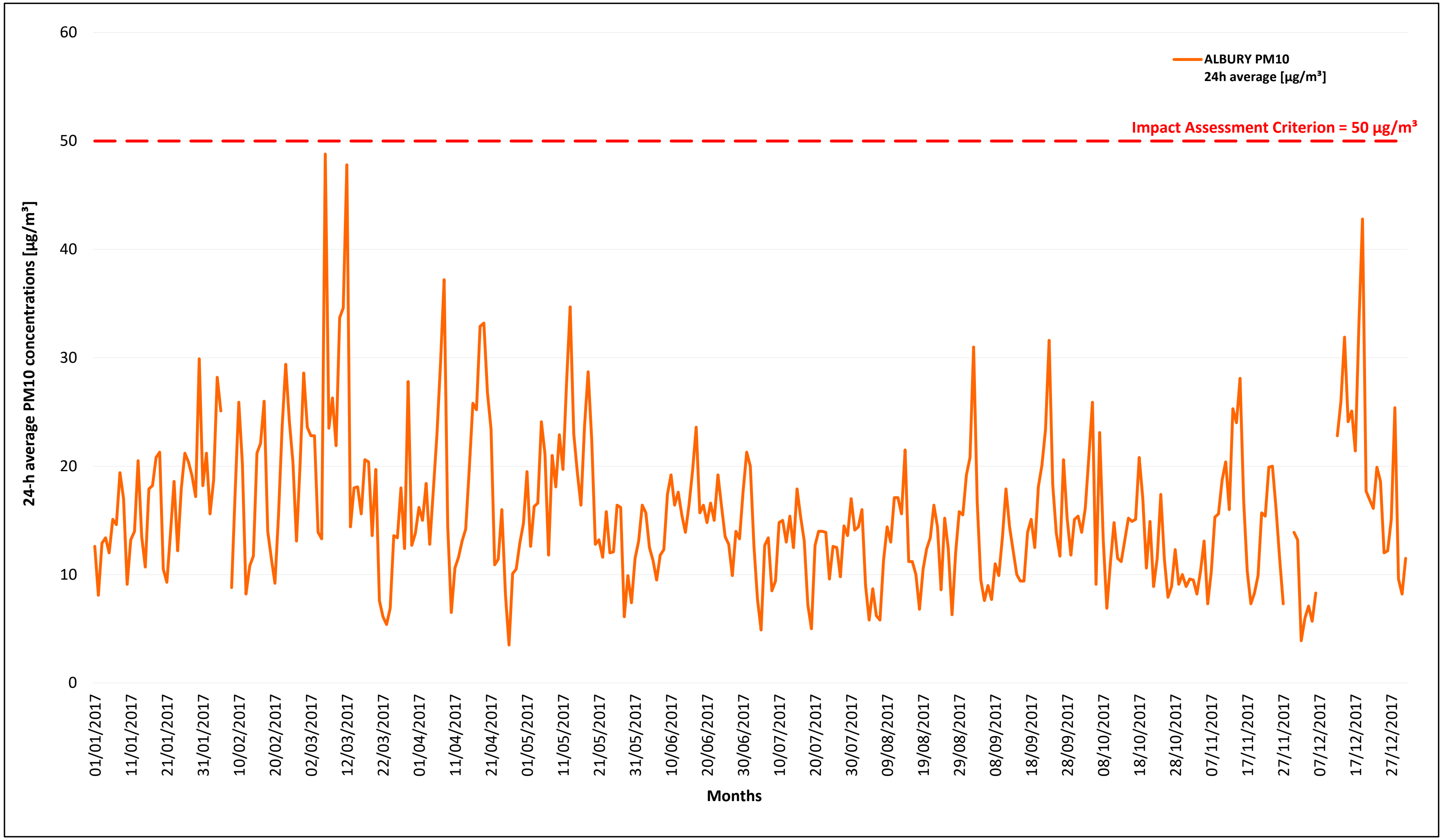


Figure 4-9: 24-hour average PM_{10} concentrations – DPIE Albury (2017)

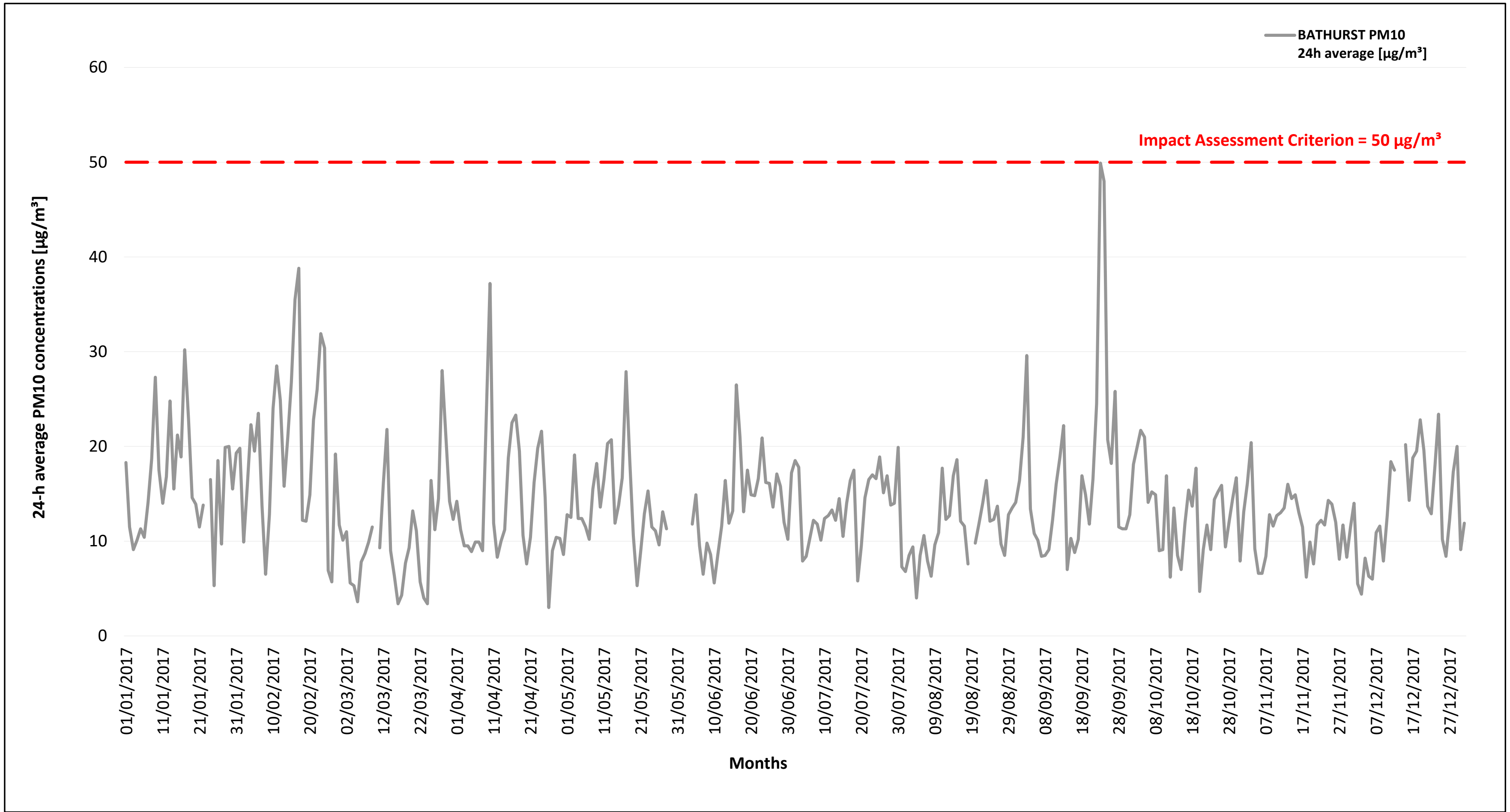


Figure 4-10: 24-hour average PM_{10} concentrations – DPIE Bathurst (2017)

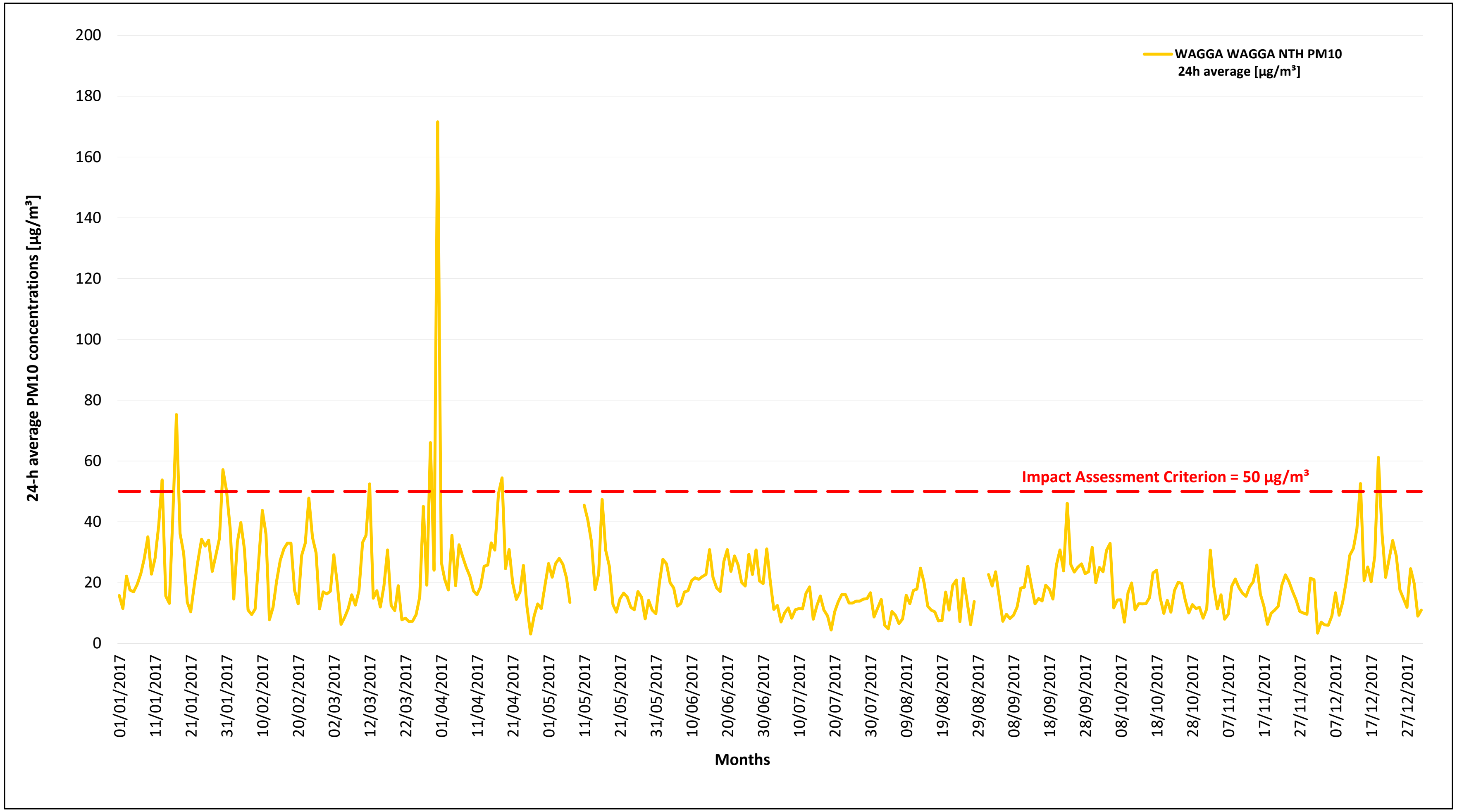


Figure 4-11: 24-hour average PM_{10} concentrations – DPIE Wagga Wagga North (2017)

4.3.2.2 Hera Mine

Table 4-3 presents the annual average PM_{10} concentrations recorded at the Hera Mine HVAS from 2015 to 2020. Data for this monitor was provided by SLR/Aurelia Metals. The results over this period show concentrations increasing from 2016 to 2019 with highest concentrations identified during 2019.

Table 4-3: Annual average PM_{10} concentrations – Hera Mine HVAS 2015 to 2020

Year	HVAS (µg/m^3)
2015	17.2
2016	15.1
2017	19.9
2018	26.8
2019	30.7
2020	18.9

4.3.3 $PM_{2.5}$ concentrations

Table 4-4 presents the annual average $PM_{2.5}$ concentrations recorded at DPIE monitoring stations at Tamworth, Albury, Bathurst and Wagga Wagga North monitoring stations from 2015 to 2020.

Table 4-4: Annual average $PM_{2.5}$ concentrations – DPIE stations 2015 to 2020

Year	Tamworth (µg/m^3)	Albury (µg/m^3)	Bathurst (µg/m^3)	Wagga Wagga Nth (µg/m^3)	All sites average (µg/m^3)	Criterion
2015	No data	No data	No data	7.6	7.6	8
2016	7.6	No data	5.9	7.4	7.0	
2017	7.8	7.3	6.1	8.1	7.3	
2018	8.3	7.3	7.0	8.4	7.8	
2019	14.4	10.1	11.3	11.3	11.8	
2020	6.8	11.1	7.6	10.7	9.1	
Period Average (excluding 2019)	**7.6**	**8.6**	**6.7**	**8.4**	**7.8**	
Period Average (2015-2020)	**9.0**	**9.0**	**7.6**	**8.9**	**8.6**	

The highest annual average concentration for all the DPIE stations was recorded in 2019. As noted above and previously for PM_{10}, years 2018 and 2019 were affected by higher prevalence of both dust storms and bushfires leading to higher annual average concentrations. The year 2019 was highly affected by intense bushfires during the last quarter of the year. The year 2020 was affected by the bushfires from 2019 and was also affected by the COVID outbreak during the next three quarters of the year.

The combined average over the six-year period from 2015 to 2020 is 8.6 µg/m^3 which is largely influenced by the high concentrations recorded in 2019. When excluding 2019, the combined average is reduced to 7.8 µg/m^3. The combined average when excluding both the exceptional years 2019 and 2020, is 7.4 µg/m^3. This is also similar to the combined average for 2017 which is 7.3 µg/m^3. The value of 7.3 µg/m^3 is therefore likely to be more representative of the annual average $PM_{2.5}$ concentration for a regional -rural location such as the Project Site.

The data in Figure 4-12 to Figure 4-15 shows that measured 24-hour average $PM_{2.5}$ concentrations at the Tamworth, Albury, Bathurst and Wagga Wagga North DPIE's monitoring stations have been predominantly well below the NSW EPA's impact assessment criterion of 25 µg/m^3 from 2015 to 2018 inclusive, with the exceptions of Tamworth in 2018 and Wagga Wagga North during both 2017 and 2018 due to both drought and bushfire conditions. The Wagga Wagga North monitoring station shows consistently higher concentrations compared with the other sites. During 2020, the concentrations at Albury and Wagga Wagga North were above the NSW EPA's annual average criterion of 8 µg/m^3 due to the bushfire activity in the region. As with PM_{10}, from October 2019 to February 2020 all the DPIE stations were generally above the NSW EPA's impact assessment criterion due to the high number of bushfires across NSW.

There were a total of 148 occasions over the last six years where the impact assessment criterion was exceeded at the DPIE stations, including 15 occasions at the Tamworth station, 18 occasions at the Albury station, 16 occasions at the Bathurst station, and 16 occasions at the Wagga Wagga North station.

Figure 4-16 to Figure 4-19 presents the 24-hour average $PM_{2.5}$ concentrations for the DPIE stations for 2017 only, as these data will be used in the 24-hour average cumulative assessment.

Figure 4-16 to Figure 4-19 shows that the Wagga Wagga North DPIE monitoring station data appears to be consistently higher than other stations throughout the year with peaks observed from April to June that are significantly higher than those recorded at the other sites. The annual average concentrations also reflect this with Wagga Wagga North recording an annual average $PM_{2.5}$ concentration of 8.1 µg/m^3 in 2017, compared to the other regional sites which are all below 8 µg/m^3 in 2017.

Given the lack of site-specific data and the analysis shown above, the 24-hour $PM_{2.5}$ background dataset was developed by taking an average of all four regional DPIE stations for every day of the modelled year (2017) to develop a daily varying profile for that year. As discussed previously, the population of Nymagee is much smaller than the population of the regional towns where the other DPIE monitors are located, and therefore likely to be less affected by urban levels of PM concentrations than the DPIE monitors may be.

Further, $PM_{2.5}$ is a marker of combustion emissions, which will likely be greater at the monitoring locations selected (both associated with biomass burning and vehicle emissions). Therefore this dataset is deemed to be conservative to represent the Project Site.

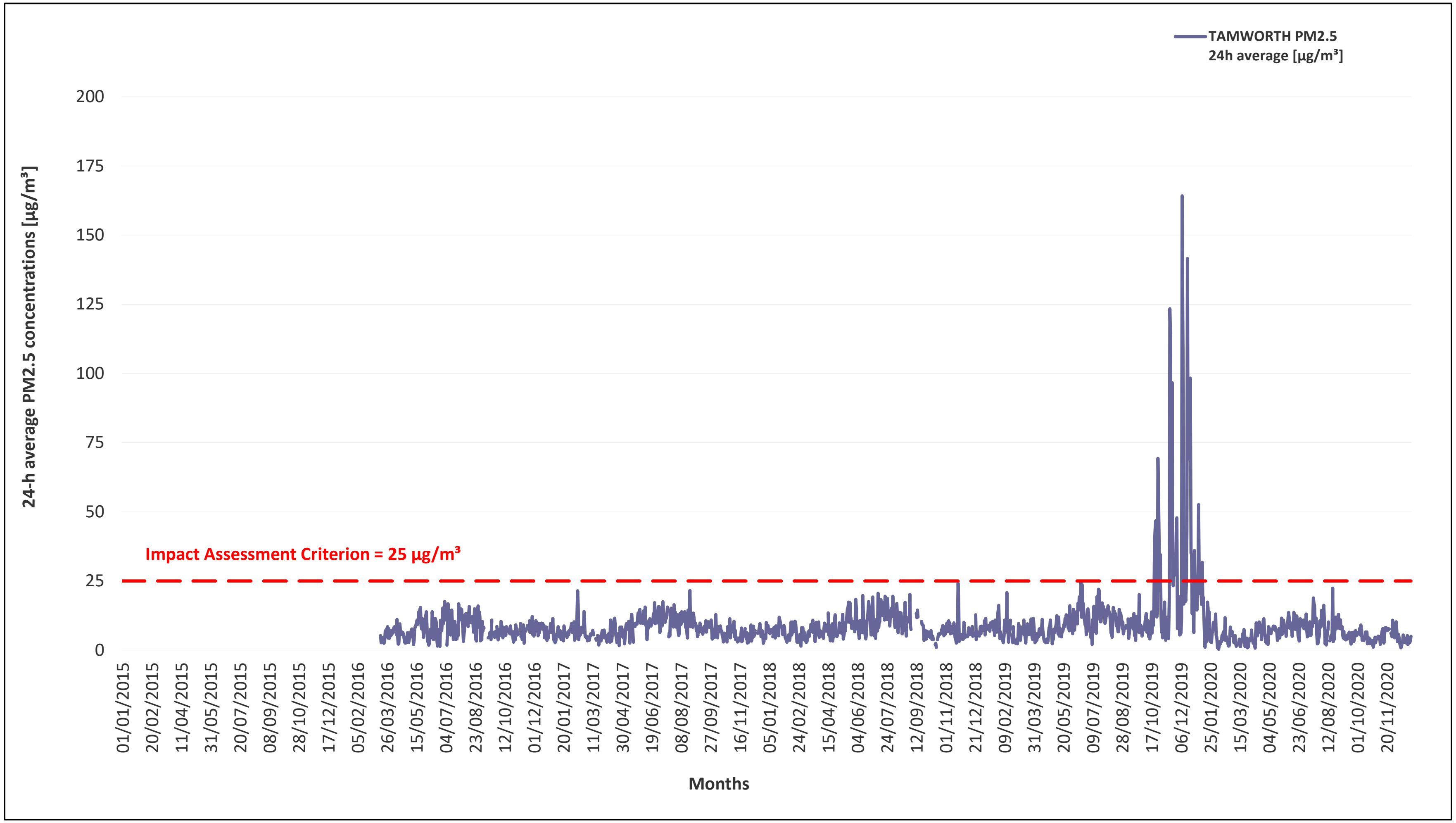


Figure 4-12: 24-hour average $PM_{2.5}$ concentrations – DPIE Tamworth (2015 to 2020)

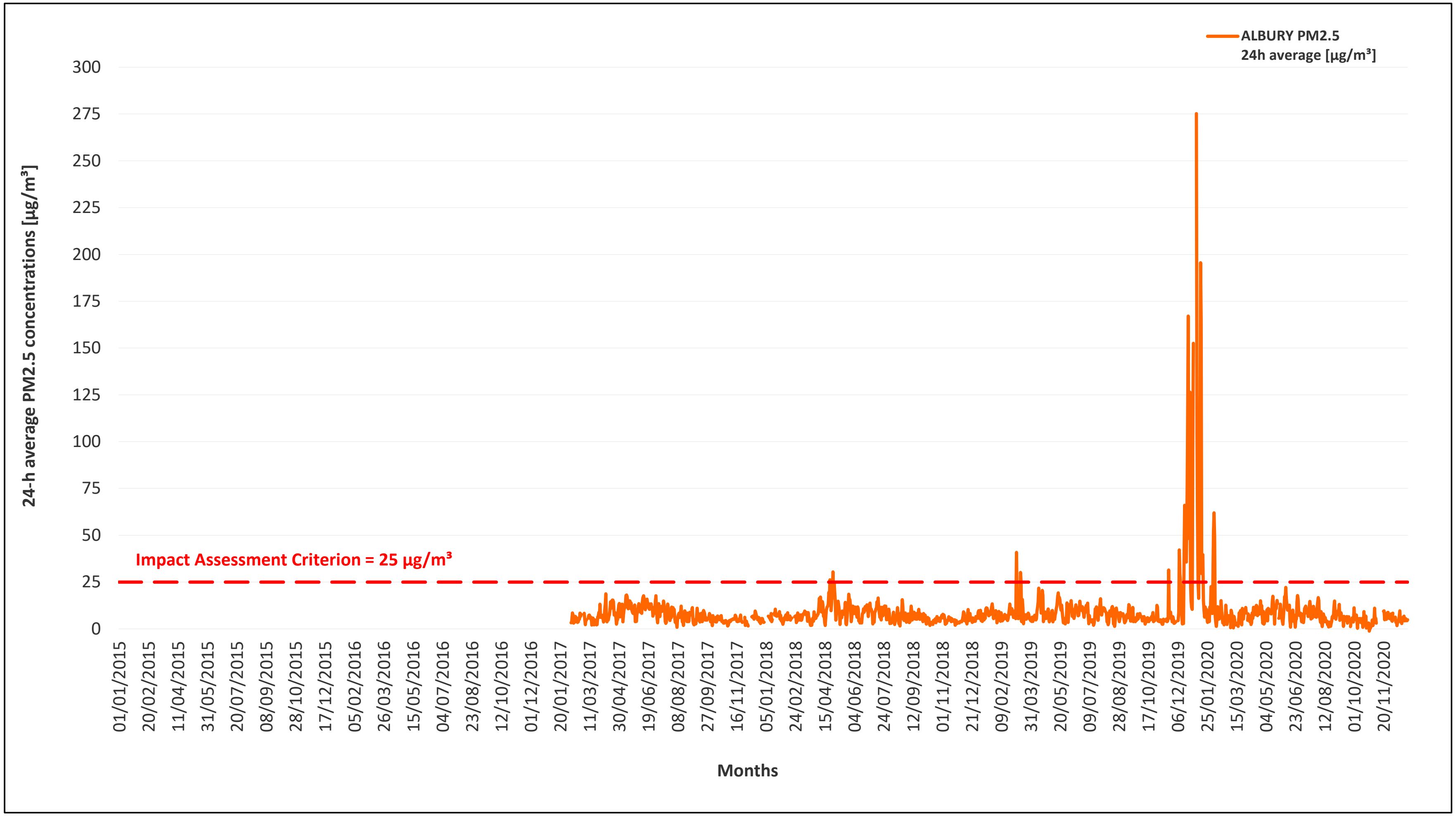


Figure 4-13: 24-hour average $PM_{2.5}$ concentrations – DPIE Albury (2015 to 2020)

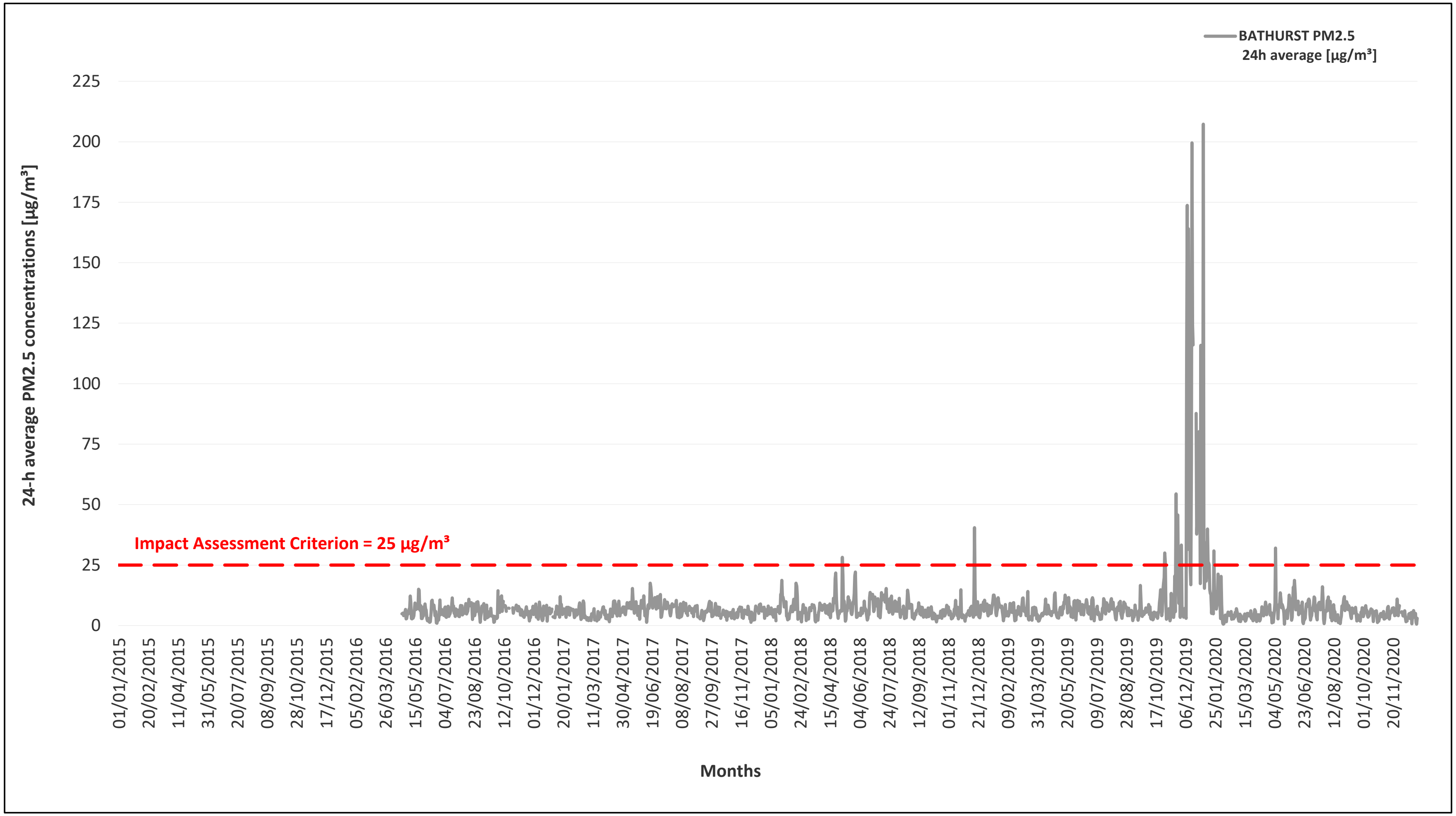


Figure 4-14: 24-hour average $PM_{2.5}$ concentrations – DPIE Bathurst (2015 to 2020)

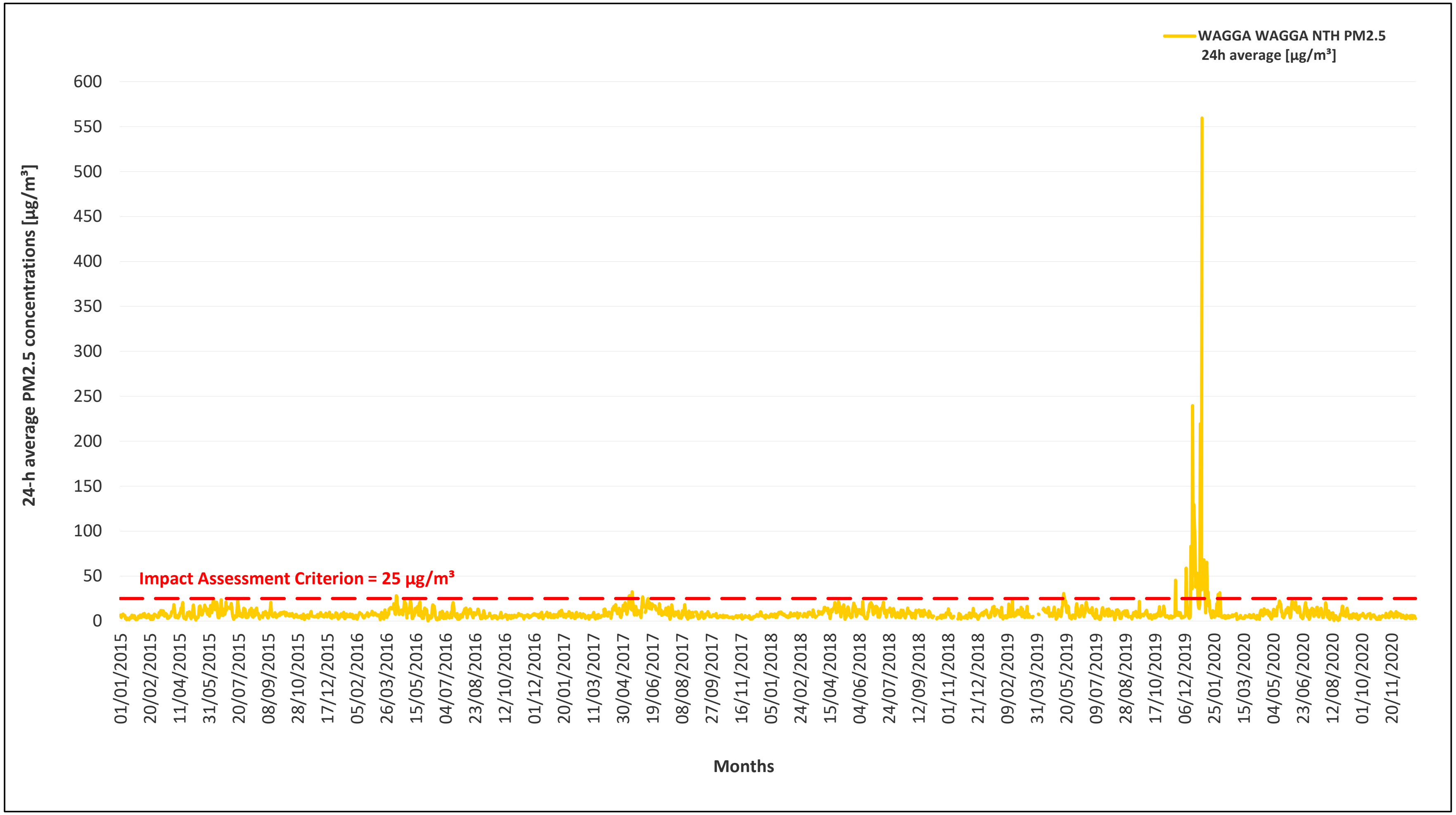


Figure 4-15: 24-hour average $PM_{2.5}$ concentrations – DPIE Wagga Wagga North (2015 to 2020)

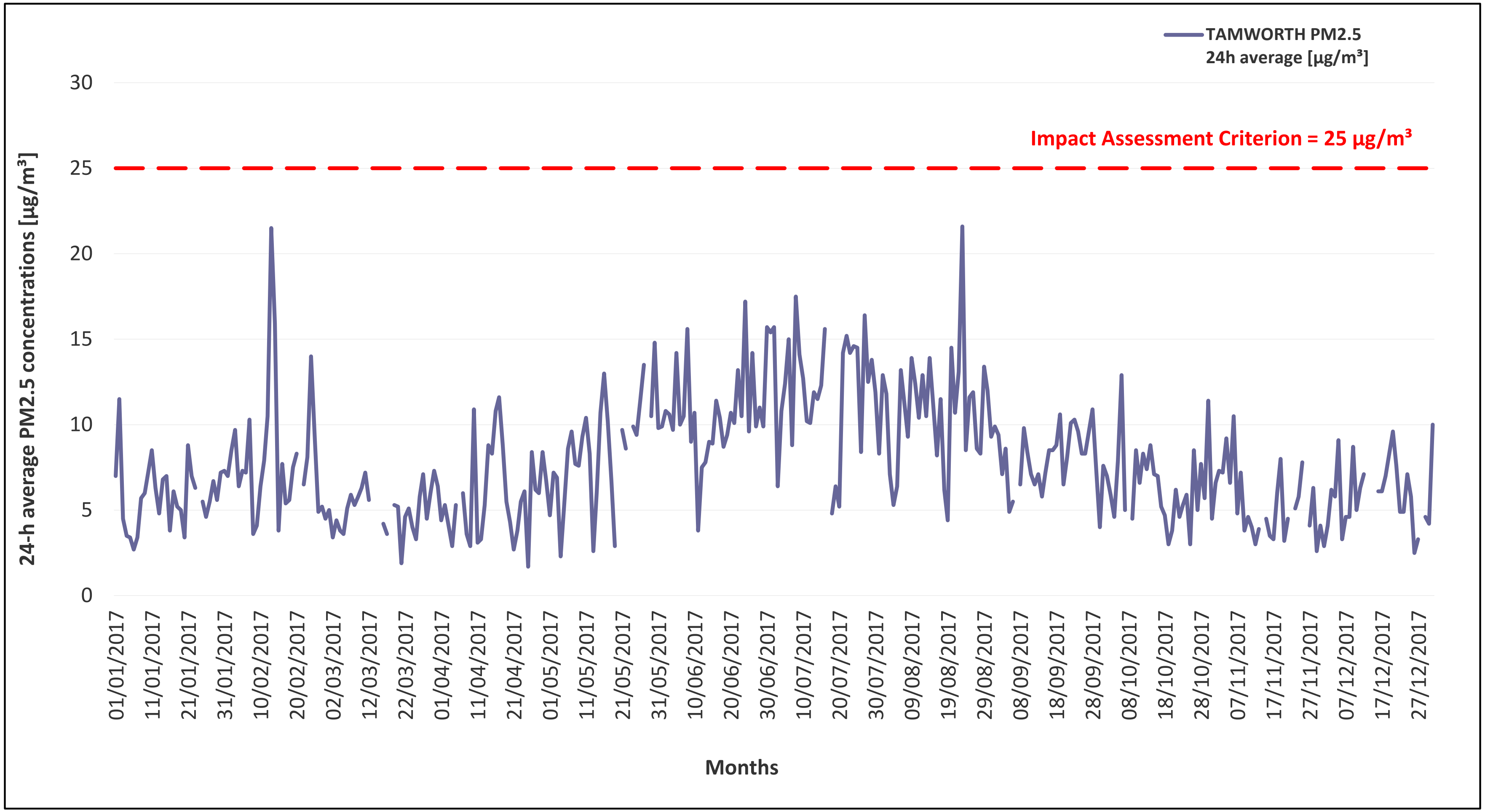


Figure 4-16: 24-hour average $PM_{2.5}$ concentrations – DPIE Tamworth (2017)

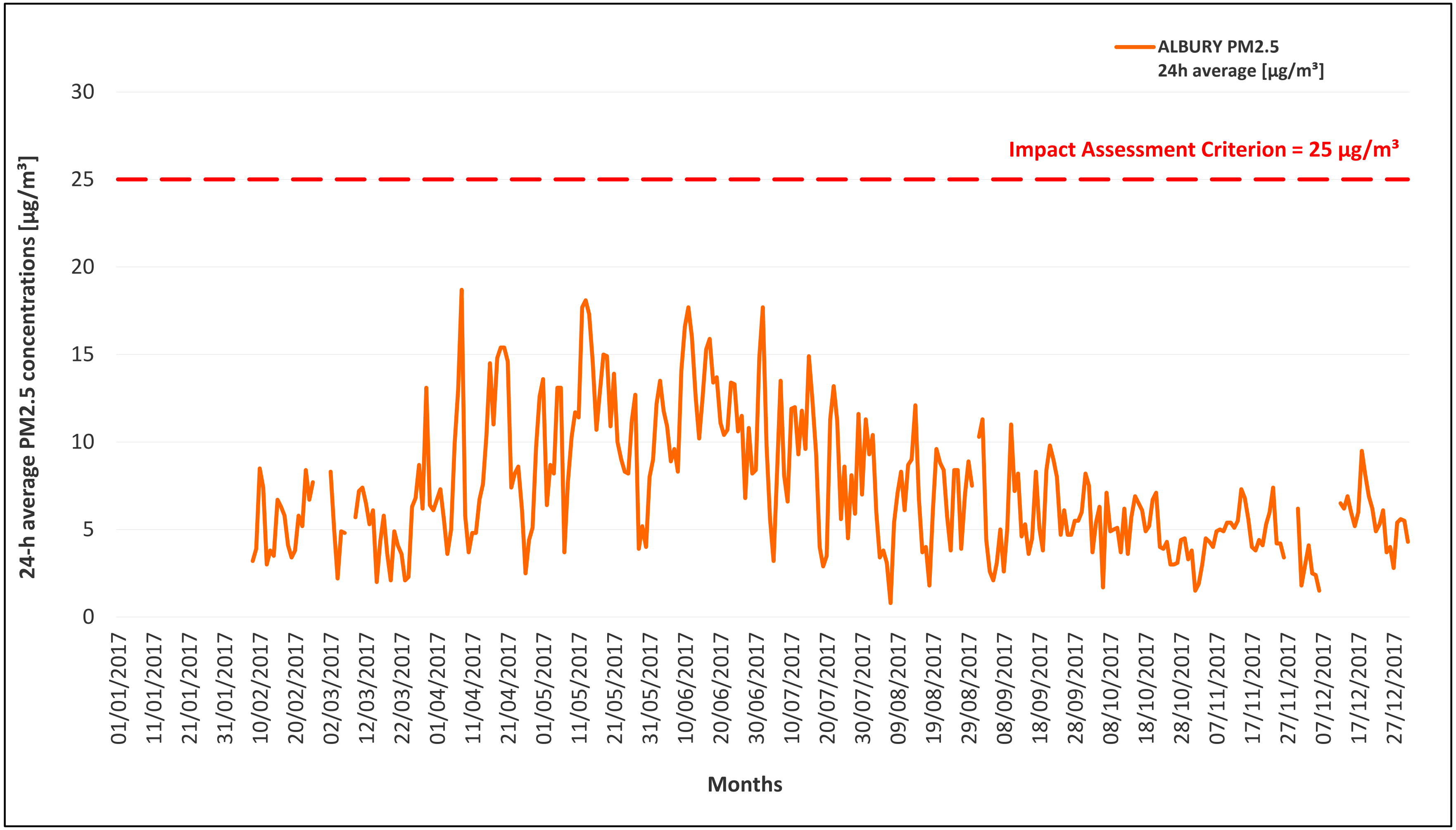


Figure 4-17: 24-hour average $PM_{2.5}$ concentrations – DPIE Albury (2017)

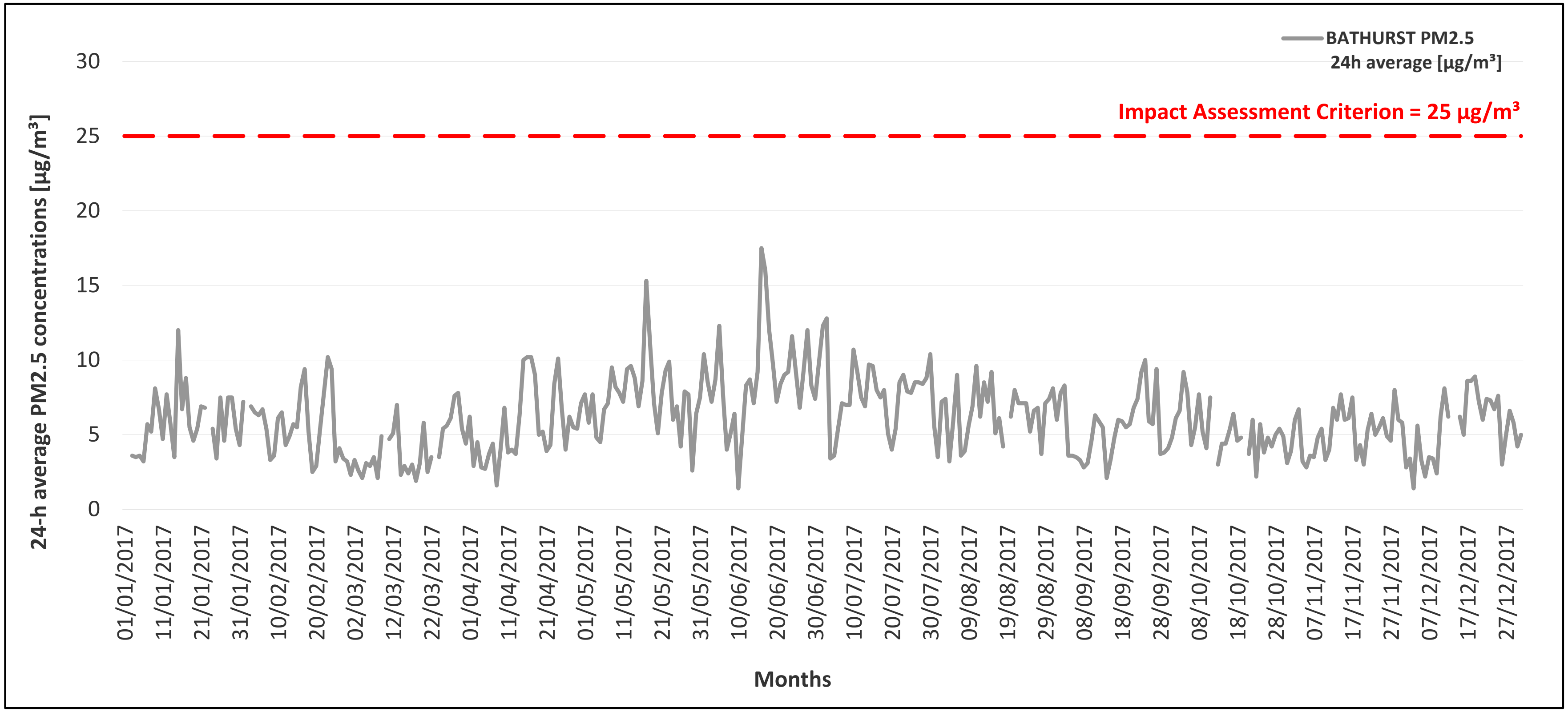


Figure 4-18: 24-hour average $PM_{2.5}$ concentrations – DPIE Bathurst (2017)

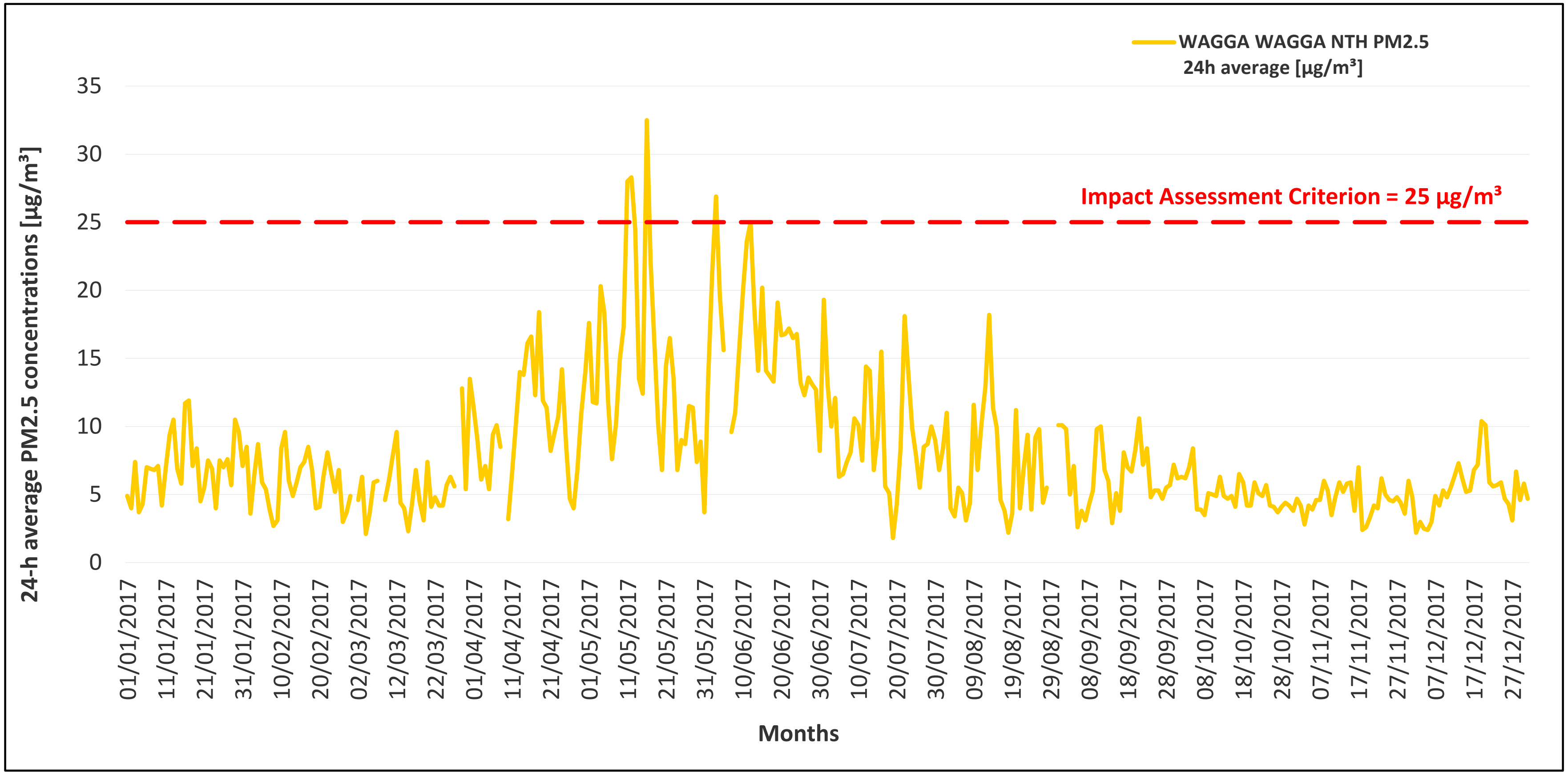


Figure 4-19: 24-hour average $PM_{2.5}$ concentrations – DPIE Wagga Wagga North (2017)

4.3.4 TSP concentrations

Table 4-5 presents the annual average TSP concentrations recorded at the Hera Mine HVAS from 2015 to 2020. Data for this monitor was provided by SLR/Aurelia Metals. The results over this period show concentrations increasing from 2016 to 2019 with highest concentrations identified during 2019.

Table 4-5: Annual average TSP concentrations – Hera Mine HVAS 2015 to 2020

Year	HVAS (µg/m^3)
2015	36.5
2016	28.2
2017	42.1
2018	52.4
2019	74.3
2020	48.2

As previously mentioned, the on-site HVAS will not be used to provide background concentrations. In the absence of any site-specific or DPIE data on TSP concentrations, a common approach to estimating TSP background values has been applied using the assumption that ~40% of TSP comprises PM_{10}. This assumption is based on monitoring data from areas in the Hunter Valley, NSW, where co-located TSP and PM_{10} monitors have been operated for reasonably long periods of time indicate that long-term average PM_{10} concentrations are approximately 40% of the corresponding long-term TSP concentration (NSW Minerals Council, 2000). Using this approach, and based on the assumption made in Section 4.3.2 that background annual average PM_{10} concentrations are 16.5 µg/m^3, it assumed that background annual average TSP concentrations are thus 41 µg/m^3.

4.3.5 Dust deposition rates

Table 4-6 presents the annual average dust deposition levels recorded at Hera Mine from 2015 to 2020. Data for this monitor was provided by SLR/Aurelia Metals. The concentrations vary across the dust deposition gauges and there is no clear pattern in the data presented.

Table 4-6: Annual average dust deposition levels – Hera Mine HVAS 2015 to 2020

Year	DDG1 (g/m^2/month)	DDG2 (g/m^2/month)
2015	4.9	4.5
2016	2.2	1.3
2017	1.9	2.1
2018	4.1	3.6
2019	3.1	4.2
2020	2.5	3.5

As mentioned previously, the on-site dust deposition gauges will not be used to provide background concentrations. In the absence of site-specific dust deposition data it is assumed existing annual dust deposition rates are 2.0 g/m^2/month which is typical of arid rural areas.

4.3.6 Summary of background data

The background concentrations adopted for this assessment, based on the available monitoring data described above, are presented in Table 4-7. Of note, the adopted annual average background concentration for $PM_{2.5}$ of 7.3 µg/m^3 is considered to be highly conservative given the data are from largely populated rural centres.

Table 4-7: Adopted background concentrations and assessment criteria

Air Quality Parameter	Averaging Period	Adopted Background Concentration	Cumulative NSW EPA Assessment Criteria
TSP	Annual	41 µg/m^3	90 µg/m^3
PM_{10}	Annual	16.5 µg/m^3	25 µg/m^3
	24-hour	Daily varying	50 µg/m^3
$PM_{2.5}$	Annual	7.3 µg/m^3	8 µg/m^3
	24-hour	Daily varying	25 µg/m^3
Dust deposition	Annual	2 g/m^2/month	2 g/m^2/month* 4 g/m^2/month

*Incremental criteria (maximum increase in deposited dust level)

It is noted that the goals for $PM_{2.5}$ have recently been adopted in the National Environment Protection Measure (NEPM), reducing from 25 µg/m^3 to 20 µg/m^3 for the maximum 24-hour average and from 8 µg/m^3 to 7 µg/m^3 for annual average. They are not yet adopted into the Approved Methods as assessment criteria, but are noted here for completeness.

5. APPROACH TO ASSESSMENT

5.1 Overview

The overall approach to the assessment follows the Approved Methods (NSW EPA, 2016) using the Level 2 assessment methodology. The Approved Methods specifies how assessments based on the use of air dispersion models should be completed. It includes guidelines for the preparation of meteorological data to be used in dispersion models and the relevant air quality criteria for assessing the significance of predicted concentrations and deposition rates from a project.

5.2 Dispersion Model

The air dispersion modelling conducted for this assessment represents an advanced modelling system using the AERMET/AERMOD modelling scheme. AERMOD is the American Meteorological Society/Environmental Protection Agency Regulatory Model and AERMET is the meteorological data pre-processor. AERMOD was chosen as a suitable dispersion model due to the source type, location of nearest receiver and nature of local topography. AERMOD is the United States Environmental Protection Agency's (US EPA) recommended steady-state plume dispersion model for regulatory purposes. The AERMOD model was developed, and is supported by the US EPA and is now the model of choice for nearfield (less than 50 km from an emission source) applications in the US (US EPA, 2017). It has undergone many formal validation studies to confirm model performance.

A significant feature of AERMOD is the Pasquill-Gifford stability based dispersion is replaced with a turbulence-based approach that uses the Monin-Obukhov length scale to account for the effects of atmospheric turbulence based dispersion.

The AERMOD system includes AERMET, used for the preparation of meteorological input files and AERMAP, used for the preparation of terrain data. Ground level concentrations were modelled across two grids. The first grid was a large grid of 14.5 km (east to west) by 29.5 km (north to south) at 500 m spacing. The second grid was a smaller grid of 4 km (east to west) by 18 km (north to south) at 200 m spacing focusing along Burthong Road. The size of the modelling domain is considered adequate to capture the maximum predicted ground level concentrations associated with the Project, including the activities at the Federation Site and Hera Mine as well as the movement of trucks on Burthong Road in the immediate vicinity, which is assumed to be sealed.

Terrain data was sourced from NASA's Shuttle Radar Topography Mission Data (3 arc second [~30m] resolution) and processed to create the necessary input files.

AERMET requires surface and upper air meteorological data as input. As previously mentioned WRF was used to generate meteorological data.

5.3 Assessment Scenarios

Ore production rates, which gives rise to concentrate and tailings have been provided for each individual financial year. Figure 5-1 presents the tailings and concentration production for each year. It was identified that FY28 had the highest amount of ore mined (tailings and concentrate). This year has therefore been the focus on the air quality assessment.

Figure 5-1: Tailings and concentrate production for each financial year

6. EMISSIONS ESTIMATION

There are many potential sources of dust emissions from the proposed Project activities. Activities have been reviewed and estimates of dust emissions for the key dust generating activities have been made. The assessment has considered activities conducted for the Project which includes activities at Federation Site, activities at Hera Mine for the processing of Federation deposit ore, and haulage between Federation Site and Hera Mine. For a cumulative assessment, background concentrations have been added to predicted contributions from the Project.

This section describes the calculation of the emissions for the operations associated with the Project for the worst case year, financial year 2028 (FY28). Conservatively, the air quality emission estimation has assumed concurrent operation of the following which are the major dust generating activities:

- Transportation of material from the Federation Site to the Hera Mine along the sealed Burthong Road;
- Processing of Federation deposit ore at the processing plant at Hera Mine;
- Disposal of approximately 40% of the tailings at TSF at Hera Mine;
- Transportation of approximately 60% of the tailings to the Federation Site for paste backfill of underground stopes; and
- Transportation of concentrate to Hermidale Siding via Hermidale Nymagee Road.

A full list of the activities included in the emissions inventory is provided in Table 6-1.

A detailed emissions inventory has been prepared for the proposed activities, as shown in Appendix B.

For the evaluation of cumulative concentrations, the increment from the Project has been added to the background concentrations.

6.1 Particle size categories

Emission rates of TSP, PM_{10} and $PM_{2.5}$ have been calculated using emission factors developed both within NSW and by the US EPA. Modelling of TSP, PM_{10} and $PM_{2.5}$ was undertaken using the particle size specific inventories and was assumed to emit any deposit from the plume in accordance with the deposition rate appropriate for particles with an aerodynamic diameter equal to the geometric mass of the particle size range.

Modelling was completed for three particle size categories; TSP, PM_{10} and $PM_{2.5}$. The particle mass mean diameters were determined from particle size distribution data for various mining activities (presented in SPCC, 1986).

6.2 Emissions estimates from Federation Project

Estimates of emissions for each source were developed on an hourly time step taking into account the activities that would take place at that location. Thus, for each source and for each hour, an emission rate was determined which depended on the level of activity and the wind speed. Dust generating activities were represented by a series of volume sources situated according to the location of activities for the modelled scenarios.

Figure 6-1 and Figure 6-2 show the locations of the volume sources used to represent site activities and associated haulage in the vicinity of Hera Mine and the Federation Site, respectively. Table 6-1 shows the allocation of sources for each activity.

There are four ventilation rises at the Federation Site and only one of these is an operational exhaust air rise at any one time. Table 6-2 provides the ventilation rise parameters.

Detailed emissions tables are provided in Appendix C.

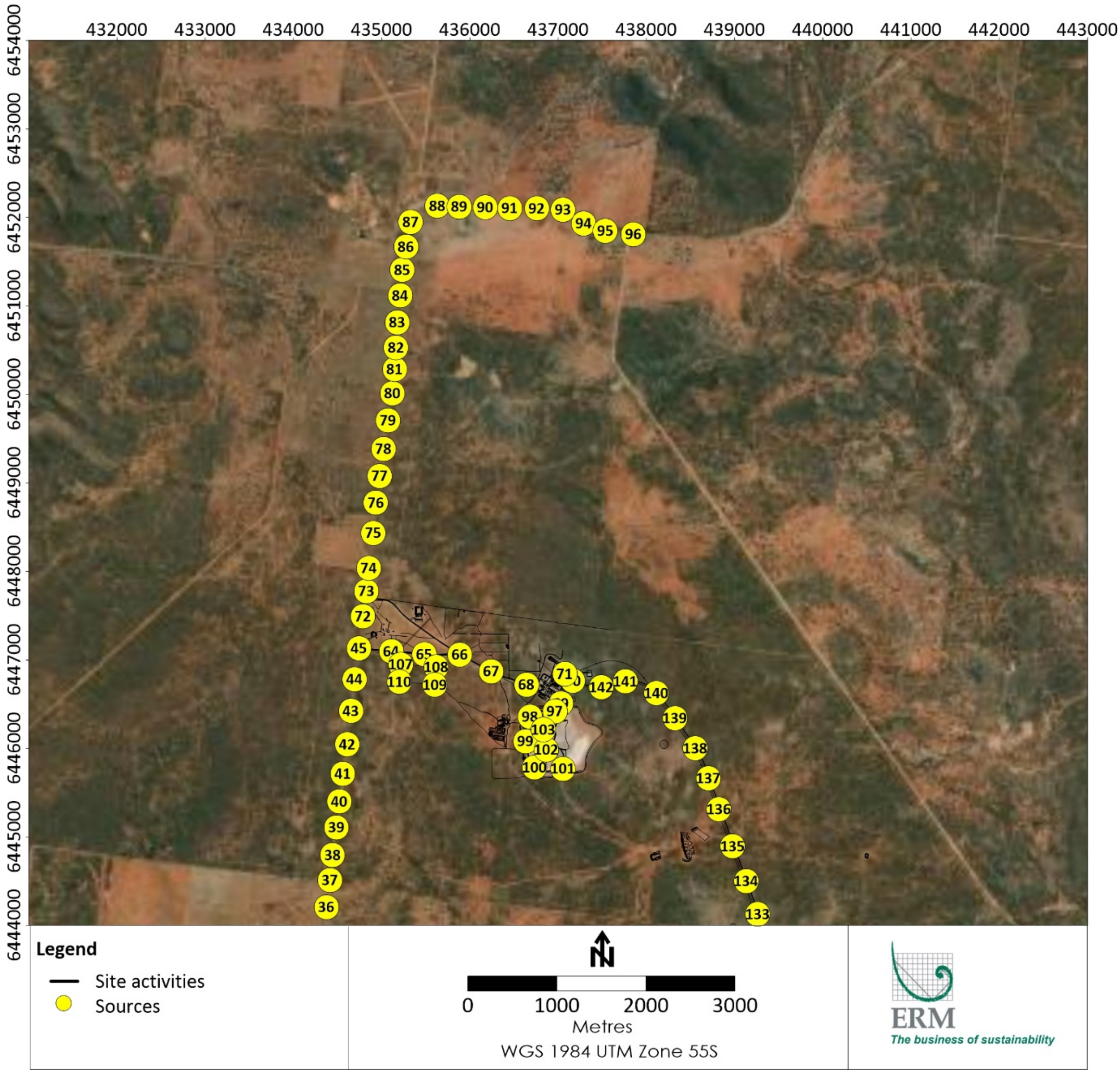


Figure 6-1: Location of emission sources(a) – Hera Mine

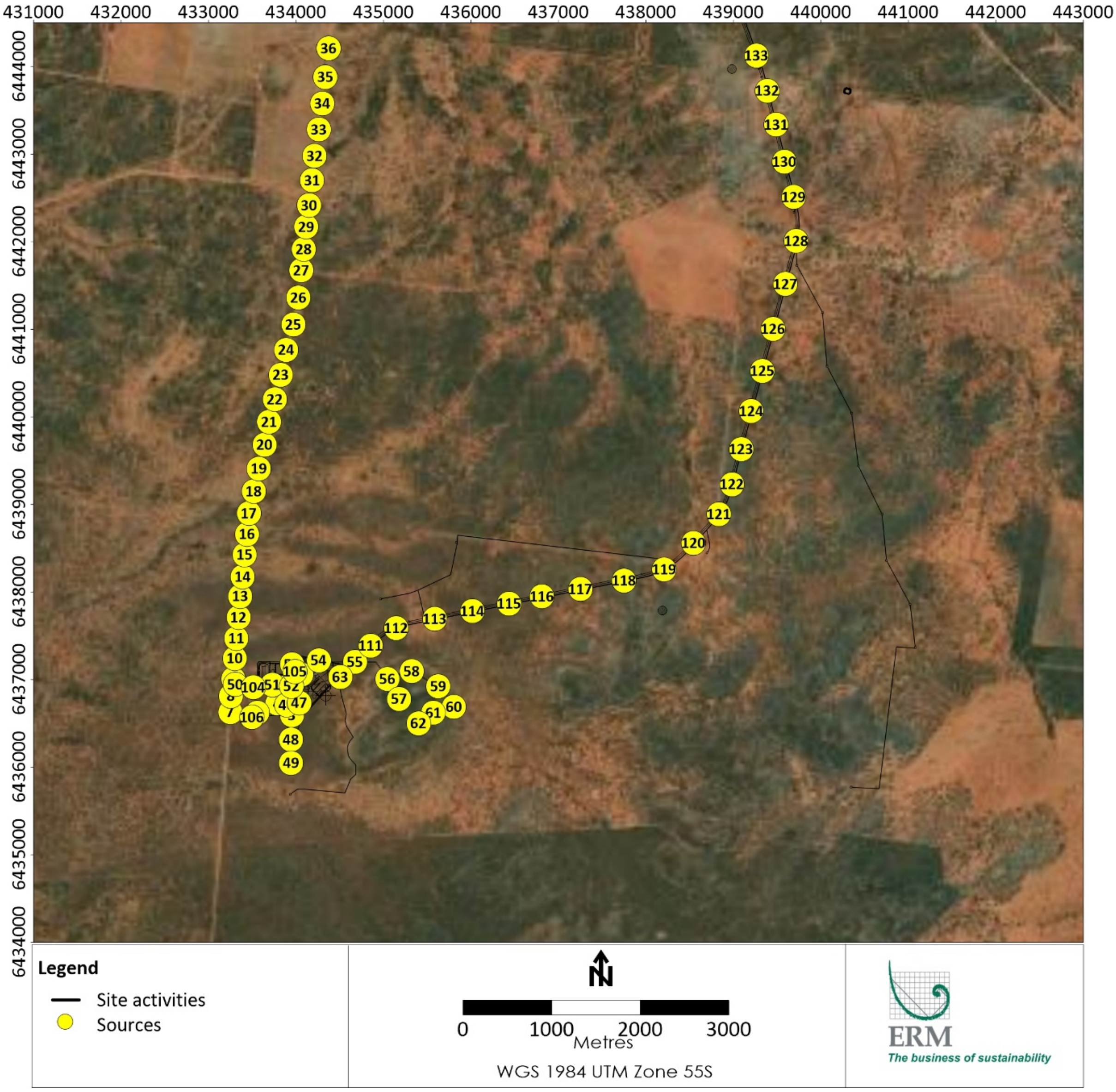


Figure 6-2: Location of emission sources(b) – Federation Site

Table 6-1: Inventory activity and allocated source number

Activity	Source number
Hauling of underground ore to Federation Site ROM pad (unsealed roads)	1-2
Unloading of underground ore to Federation Site ROM pad	2
Loading of ore at Federation Site ROM pad	2
Hauling of ore to Federation Site boundary (unsealed roads)	2-7
Hauling of ore from Federation Site boundary to Hera Mine boundary (sealed roads) via Burthong Road	8-45
Hauling of underground waste rock to PAF stockpile (unsealed roads)	1,46-47
Unloading of underground waste rock at PAF stockpile	46-47
Grader at Federation Site unsealed roads	1,3-7, 48-63
Hauling of ore from Hera Mine boundary to Processing Plant (unsealed roads)	64-71
Unloading of ore at Processing Plant	71
Crushing of ore at Processing Plant	71
Screening of crushed material at Processing Plant	71
Front End Loader at Processing Plant	71
Loading of concentrate at Processing Plant into trucks	71
Hauling of concentrate from Hera Mine Processing Plant to Hera Mine Site boundary (unsealed roads)	64-71
Hauling of concentrate from Hera Mine Site Boundary to Hermidale by truck (sealed roads)	72-96
Loading of tailings at Processing Plant for trip to the TSF	71
Hauling of tailings from Processing Plant to TSF (unsealed roads)	69-71,97-103
Unloading of tailings at TSF	102-103
Front End Loader at TSF	102-103
Loading of tailings at Processing Plant to return to Federation Site	71
Hauling of tailings from Hera Mine Processing Plant to Hera Mine Site boundary (unsealed roads)	64-71
Hauling of taillings from Hera Mine Site boundary to Federation Site boundary via Burthong Road (sealed roads)	8-45
Hauling of tailings from Federation Site boundary to underground	1,3-7
Grader at Solar Farm unsealed roads	107-110
Grader at Services Corridor unsealed roads	111-142
WE - ROM Pad	2
WE - PAF waste rock stockpile	46-47
WE - Topsoil stockpile 1 (west of boxcut)	105
WE - Topsoil stockpile 2 (south of internal access road)	104
WE - Topsoil stockpile 3 (south of internal haul road)	106
WE - Tailings Storage Facility	102-103

Notes: ROM – Run of Mine, PAF – Potentially Acid Forming, TSF - Tailings Storage Facility, WE - Wind Erosion

Table 6-2: Ventilation rise parameters

Parameter	Value for Ventilation Rise 1	Units
Stack height	Ground level	-
Stack diameter	5.0	m
Flow rate	390	m^3/s
Exit temperature	295.15	Kelvin
Coordinates	434273, 6436960	-
Emission rates		
TSP	0.867	g/s
PM_{10}	0.433	g/s
$PM_{2.5}$	0.289	g/s

The information used for developing the inventories is based on the operational descriptions and Project drawings which were used to determine haul road distances and routes, activity operating hours, anticipated truck sizes and other details that are necessary to estimate PM emissions.

Table 6-3 summarises the quantities of TSP, PM_{10} and $PM_{2.5}$ estimated to be released by each activity of the Project.

Table 6-3: Estimated TSP, PM_{10} and $PM_{2.5}$ emissions for the Federation Project

Activity	TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)	$PM_{2.5}$ Emissions (kg/y)
Hauling of underground ore to ROM pad (unsealed roads)	13,605	3,360	336
Unloading of underground ore to ROM pad	325	154	23
Loading of ore at ROM pad	325	154	23
Hauling of ore to Federation Site boundary (unsealed roads)	72,560	17,919	1,792
Hauling of ore from Federation Site boundary to Hera Mine boundary (sealed roads)	101,585	25,087	2,509
Hauling of underground waste rock to PAF stockpile (unsealed roads)	5,271	1,302	130
Unloading of underground waste rock at PAF stockpile	94	45	7
Grader at Federation Site unsealed roads	5,515	1,927	171
Hauling of ore from Hera Mine boundary to Processing Plant (unsealed roads)	136,051	33,598	3,360
Unloading of ore at Processing Plant	325	154	23
Crushing of ore at Processing Plant	2,031	902	902
Screening of crushed material at Processing Plant	9,401	3,234	3,234
Front End Loader at Processing Plant	3,161	544	332
Loading of concentrate at Processing Plant into trucks	62	29	4

Activity	TSP Emissions (kg/y)	PM_{10} Emissions (kg/y)	$PM_{2.5}$ Emissions (kg/y)
Hauling of concentrate from Hera Mine Processing Plant to Hera Mine Site boundary (unsealed roads)	25,767	6,363	636
Hauling of concentrate from Hera Mine Site Boundary to Tritton Copper Mines (Hermidale) by truck (sealed roads)	9,448	2,333	233
Loading of tailings at Processing Plant for trip to the TSF	105	50	8
Hauling of tailings from Processing Plant to TSF (unsealed roads)	26,468	6,536	654
Unloading of tailings at TSF	105	50	8
Front End Loader at TSF	3,161	544	332
Loading of tailings at Processing Plant to return to Federation Site	158	75	11
Hauling of tailings from Hera Mine Processing Plant to Hera Mine Site boundary (unsealed roads)	66,171	16,341	1,634
Hauling of taillings from Hera Mine Site boundary to Federation Site boundary via Burthong Road (sealed roads)	49,407	12,201	1,220
Hauling of tailings from Federation Site boundary to underground	37,497	9,260	926
Grader at Solar Farm unsealed roads	5,515	1,927	171
Grader at Services Corridor unsealed roads	5,515	1,927	171
WE - ROM Pad	213	106	16
WE - PAF waste rock stockpile	765	383	57
WE - Topsoil stockpile 1 (west of boxcut)	170	85	13
WE - Topsoil stockpile 2 (south of internal access road)	213	106	16
WE - Topsoil stockpile 3 (south of internal haul road)	213	106	16
WE - Tailings Storage Facility	446	223	33
TOTAL EMISSIONS	**581,645**	**146,741**	**18,959**

Notes: ROM – Run of Mine, PAF – Potentially Acid Forming, TSF - Tailings Storage Facility, WE - Wind Erosion

6.3 Overview of dust control measures

Dust control measures to be employed for the Project and assumed as part of this assessment include the following:

- Use of additional water application, if required, on active unsealed haul roads (50% control applied);
- Use of additional water sprays, if required, on activities such as loading, unloading, front end loader operations, stockpiles and pads, tailings storage facility (50% control applied); and
- Use of sealed road, Burthong Road (90% control applied).

Incorporation of the abovementioned dust control measures will reduce particulate matter emissions and have been included in the calculation of emissions shown in Table 6-3.

7. ASSESSMENT OF IMPACTS

The modelling predictions for the Project are presented in the sections below. The contour plots are indicative of the concentrations that could potentially be reached under the conditions modelled. It is important to note that the isopleth figures are presented to provide a visual representation of the predicted impacts. To produce the isopleths, it is necessary to make interpolations between predicted concentrations, and as a result the isopleths will not always match exactly with predicted impacts at any specific location.

In the case of maximum 24-hour average concentrations, it is also important to note that individual contour plots do not represent one moment in time, but rather the maximum 24-hour average that could potentially occur at a sensitive receiver on any given day over the period of a year. For this reason, contours are not presented for the cumulative 24-hour PM_{10} and $PM_{2.5}$ concentrations. Rather than showing cumulative contours plots for 24-hour average, timeseries plots have been prepared and are presented further in this section.

As noted in Section 2, there are sensitive receptors within the vicinity of the Hera Mine and along haul routes between Federation Site and Hera Mine. The closest sensitive receptors to the Hera Mine Site are approximately 2.5 km north west of the mine infrastructure area (R3) and 3.0 – 3.5 km south west of the mine infrastructure area (R2 and R1).

During the assessment year of FY28, with regards to R3, to the north of Hera Mine via Burthong Road, there is no effect due to haulage of tailings from Hera Mine to the Federation Site. During FY28, impacts at R3, R4 and R5 can therefore be assumed due to the haulage of concentrate to the Hermidale Siding Site. The roads used for transport in the vicinity of R3, R4 and R5 are sealed.

As Burthong Rd has been assessed as sealed, impacts are significantly reduced compared to an unsealed road, During FY28, receptors R2 and R1, to the south of Hera Mine and to the north of Federation Site along Burthong Road, are not predicted to be materially impacted by dust emissions from ore and tailings haulage, as Burthong Rd is proposed to be sealed..

Table 7-1 presents the predicted annual average Project contribution and cumulative concentrations at the selected sensitive receptors. There are no predicted exceedances of the annual average TSP criterion of 90 µg/m³ or the annual average PM_{10} criterion of 25 µg/m³. For $PM_{2.5}$, there are no predicted exceedances of the NSW EPA impact assessment criterion of 8 µg/m³, however there are exceedances of the pending NEPM AAQ standard of 7 µg/m³. It should be noted that the exceedance would be due to the background concentration which is already exceeding 7 µg/m³, and not due to the Project. When considering the Project contribution, these concentrations are low and range between 0.1 and 2.7% of the cumulative concentration.

Table 7-1: Predicted annual average Project contribution and cumulative concentrations at sensitive receptors for TSP, PM_{10} and $PM_{2.5}$

Receptor ID	TSP (µg/m³)		PM_{10} (µg/m³)		$PM_{2.5}$ (µg/m³)	
	Project contribution	Cumulative	Project contribution	Cumulative	Project contribution	Cumulative
R1	3.6	44.6	0.8	17.3	0.1	7.4
R2	6.3	47.3	1.3	17.8	0.2	7.5
R3	5.3	46.3	1.1	17.6	0.2	7.5
R4	2.4	43.4	0.5	17.0	0.1	7.4
R5	1.9	42.9	0.4	16.9	0.1	7.4
R18	0.2	41.2	<0.1	16.5	<0.1	7.3
R19	0.5	41.5	0.1	16.6	<0.1	7.3

Table 7-2 presents the predicted maximum 24-hour average concentrations for the Project contribution and cumulative concentrations at sensitive receptors for PM_{10} and $PM_{2.5}$. There are predicted exceedances of the maximum 24-hour average criterion for PM_{10} of 50 µg/m^3 at all receptors. The exceedance is due to a high background concentration of 53.8 µg/m^3. There are no additional exceedances caused by the Project. For $PM_{2.5}$, there are no predicted exceedances of the maximum 24-hour average NSW impact assessment criteria of 25 µg/m^3 or the pending NEPM AAQ standards of 20 µg/m^3.

Table 7-2: Predicted maximum 24-hour average concentrations for Project contribution and cumulative concentrations at sensitive receptors for PM_{10} and $PM_{2.5}$

Receptor ID	PM_{10} (µg/m^3)			$PM_{2.5}$ (µg/m^3)		
	Maximum Project contribution	Maximum Cumulative	Days of additional exceedances	Maximum Project contribution	Maximum Cumulative	Days of additional exceedances
R1	4.5	54.6	0	0.9	17.0	0
R2	7.2	55.8	0	1.2	17.1	0
R3	10.2	56.6	0	1.6	17.1	0
R4	3.4	55.5	0	0.7	16.8	0
R5	2.9	55.2	0	0.7	16.6	0
R18	0.7	53.8	0	0.2	16.2	0
R19	2.0	53.8	0	0.7	16.3	0

Table 7-2 shows that the highest PM_{10} (24-hour) concentrations are predicted at R3. Figure 7-1 presents the time series for 24-hour average PM_{10} concentrations at R3. Figure 7-2 presents the time series for 24-hour average $PM_{2.5}$ concentrations at R3. The figures show the background concentrations and the Project contribution and comparison with the NSW EPA impact assessment criteria. As mentioned previously there is one predicted exceedance for 24-hour average PM_{10} concentrations, and no exceedances of the 24-hour average $PM_{2.5}$ concentrations, with this one exceedance caused by the high background concentration and is not caused by the Project.

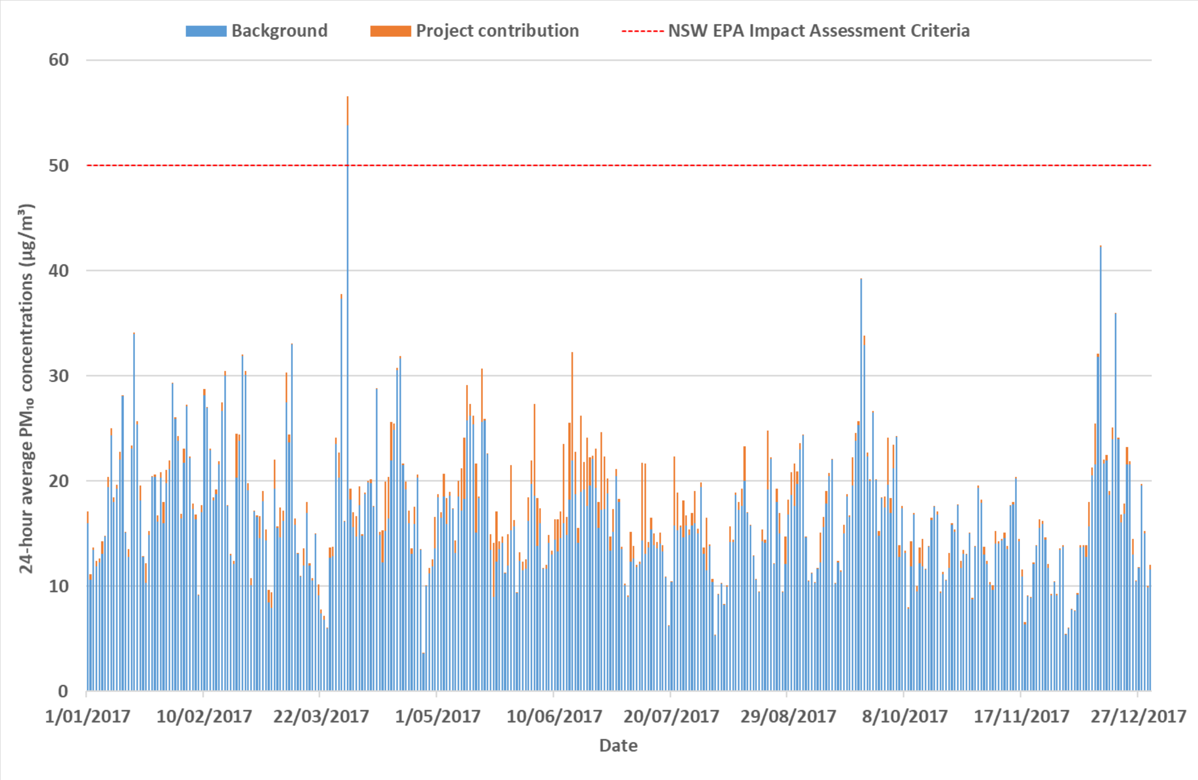


Figure 7-1: Time series results for 24-hour average PM_{10} at R3

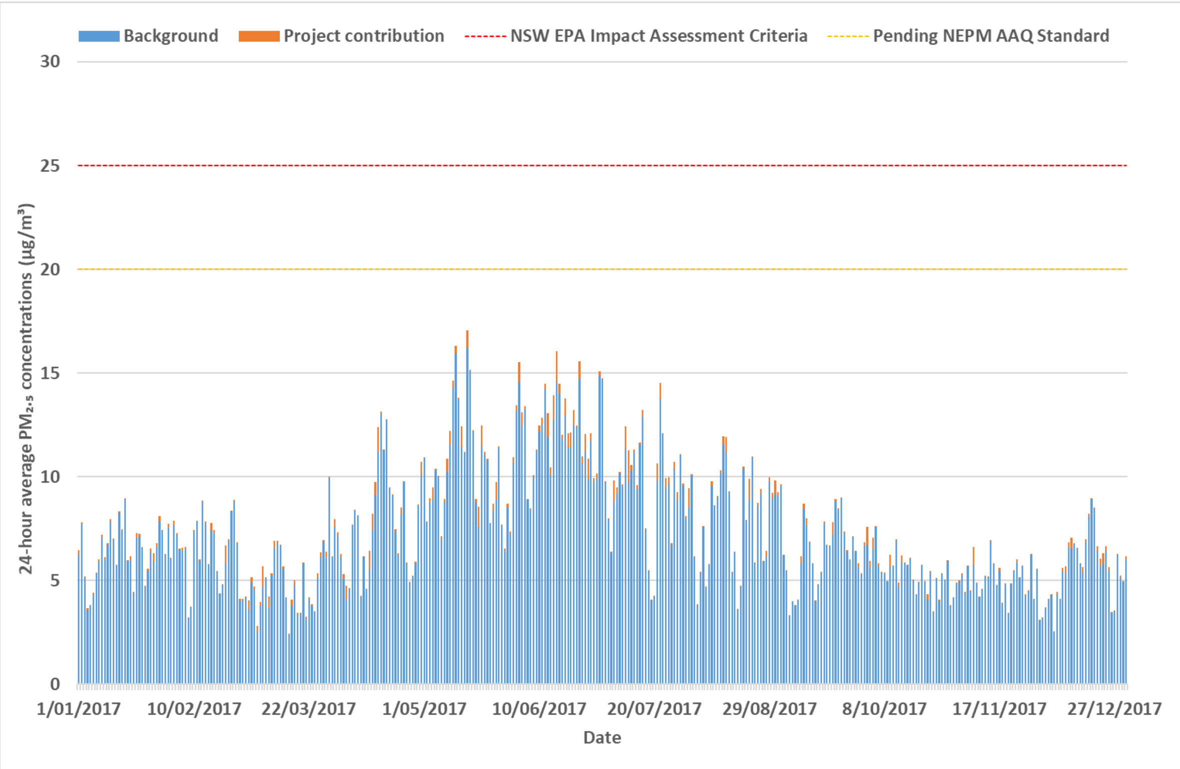


Figure 7-2: Time series results for 24-hour average $PM_{2.5}$ at R3

Table 7-3 presents the predicted monthly average Project contribution and cumulative dust deposition levels. There are no predicted exceedances of the NSW EPA impact assessment criteria.

Table 7-3: Predicted monthly average Project contribution and cumulative dust deposition levels

Receptor ID	Dust deposition ($g/m^2/month$)	
	Project contribution	Cumulative
R1	0.1	2.1
R2	0.2	2.2
R3	0.1	2.1
R4	0.1	2.1
R5	0.1	2.1
R18	<0.1	2.0
R19	<0.1	2.0

Figure 7-3 to Figure 7-6 presents the annual average Project contribution and cumulative concentrations for TSP, PM_{10}, $PM_{2.5}$ and dust deposition.

Figure 7-7 and Figure 7-8 present the maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations, for the Project contribution. Cumulative 24-hour predictions are presented earlier as time-series for the most effected receptor (R3) in Figure 7-1 and Figure 7-2.

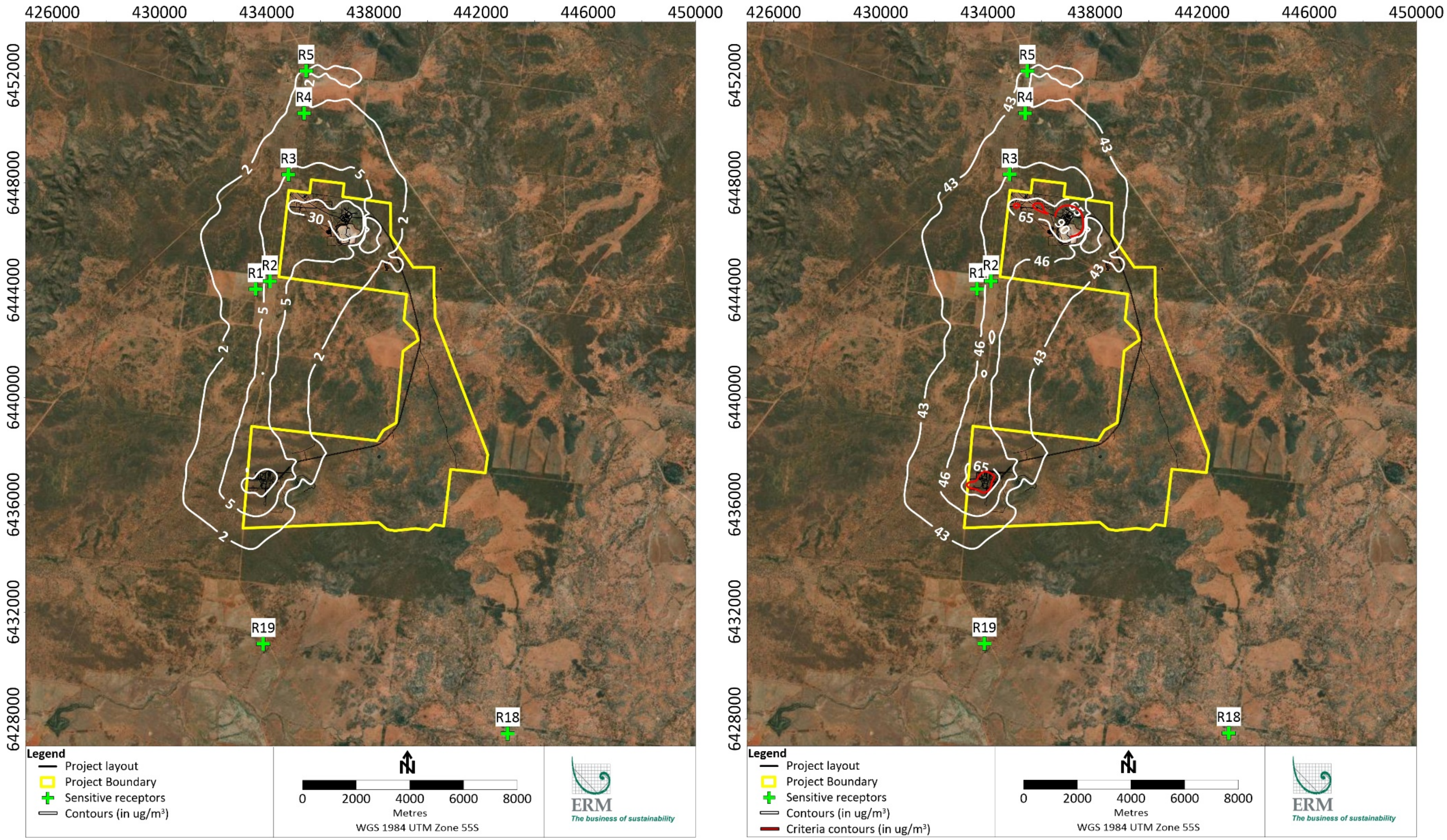


Figure 7-3: Predicted annual average TSP concentrations (µg/m^3) Project contribution (left) and cumulative (right)

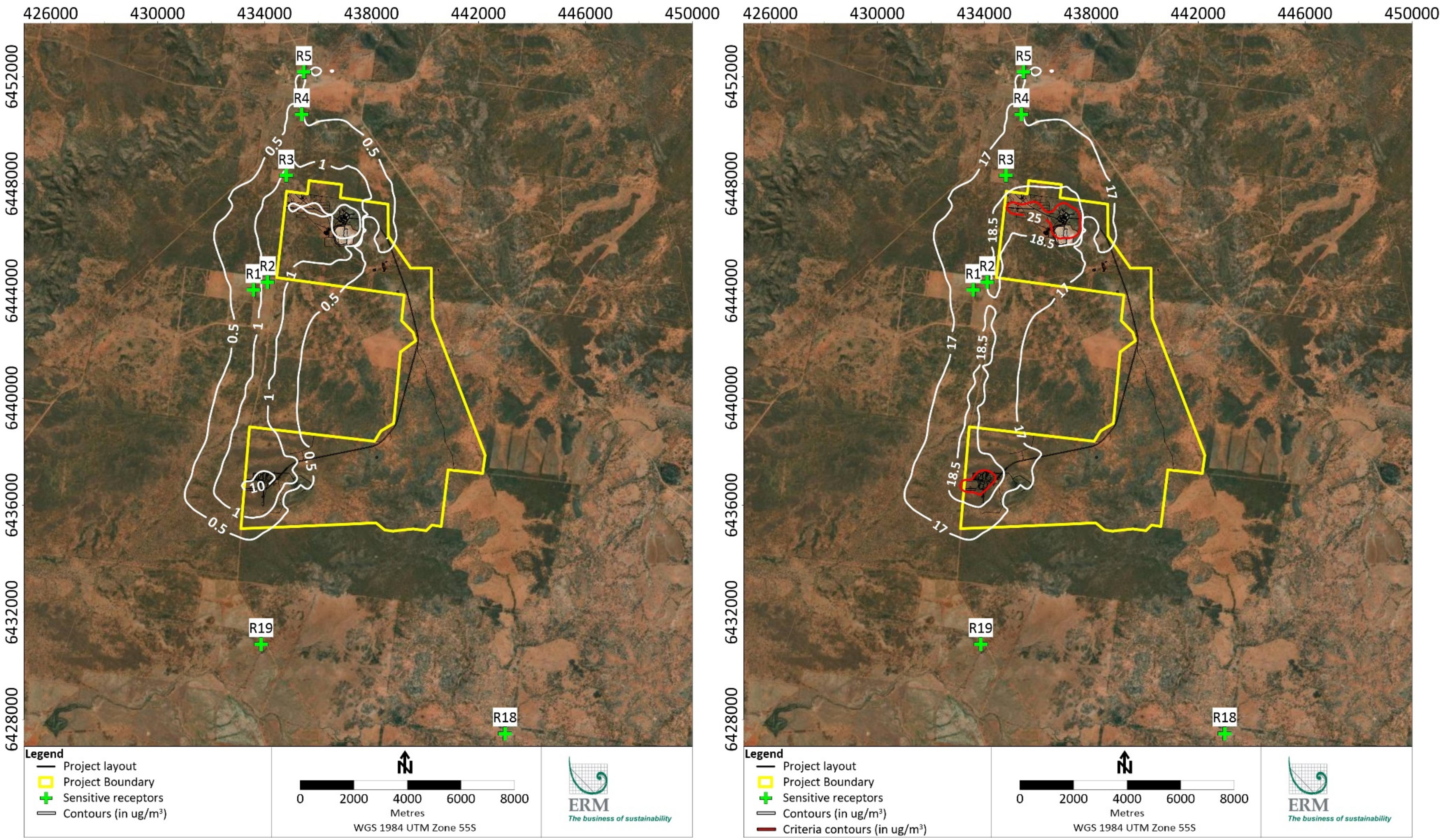


Figure 7-4: Predicted annual average PM_{10} concentrations (µg/m³) Project contribution (left) and cumulative (right)

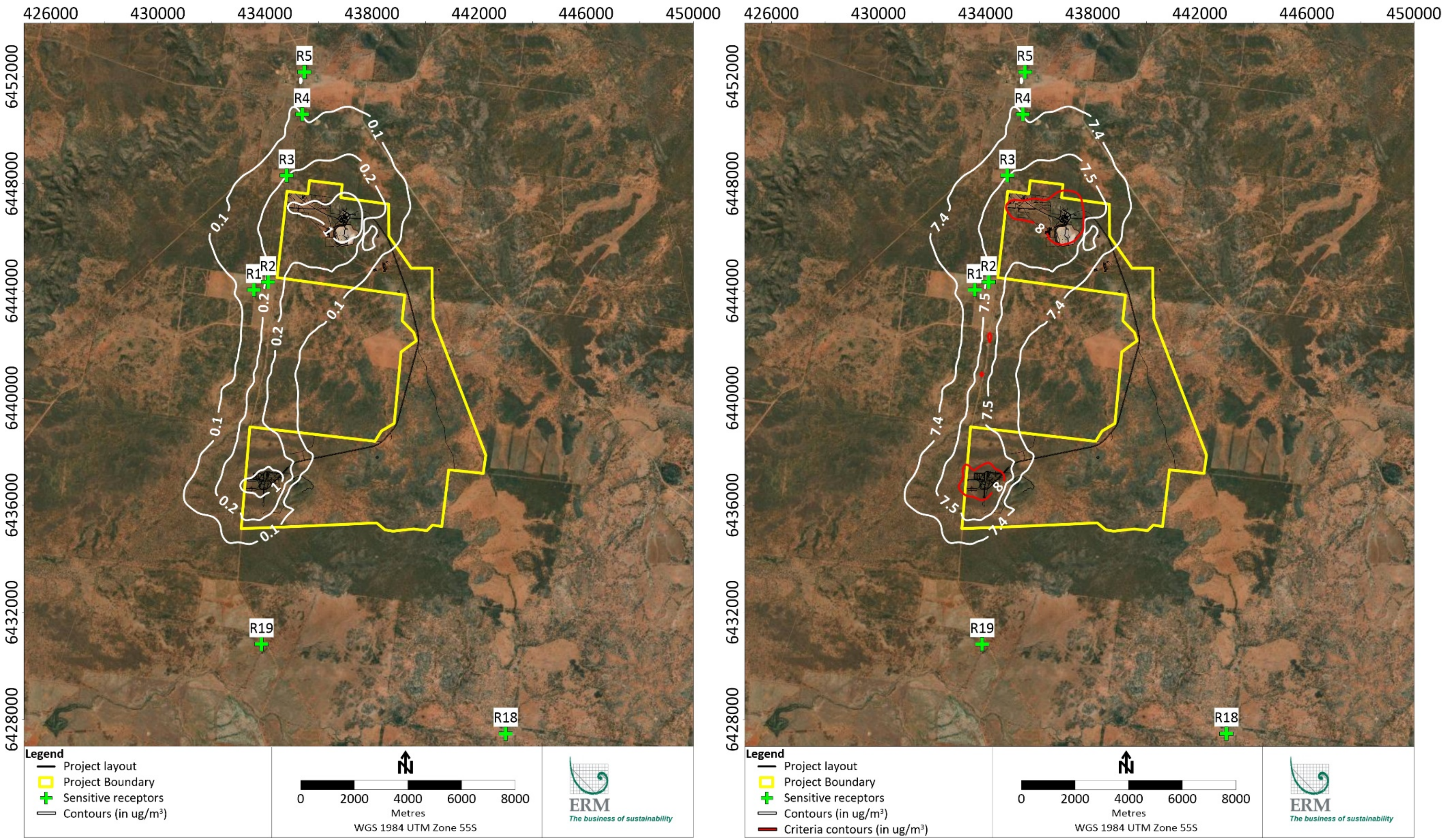


Figure 7-5: Predicted annual average $PM_{2.5}$ concentrations (μg/m³) Project contribution (left) and cumulative (right)

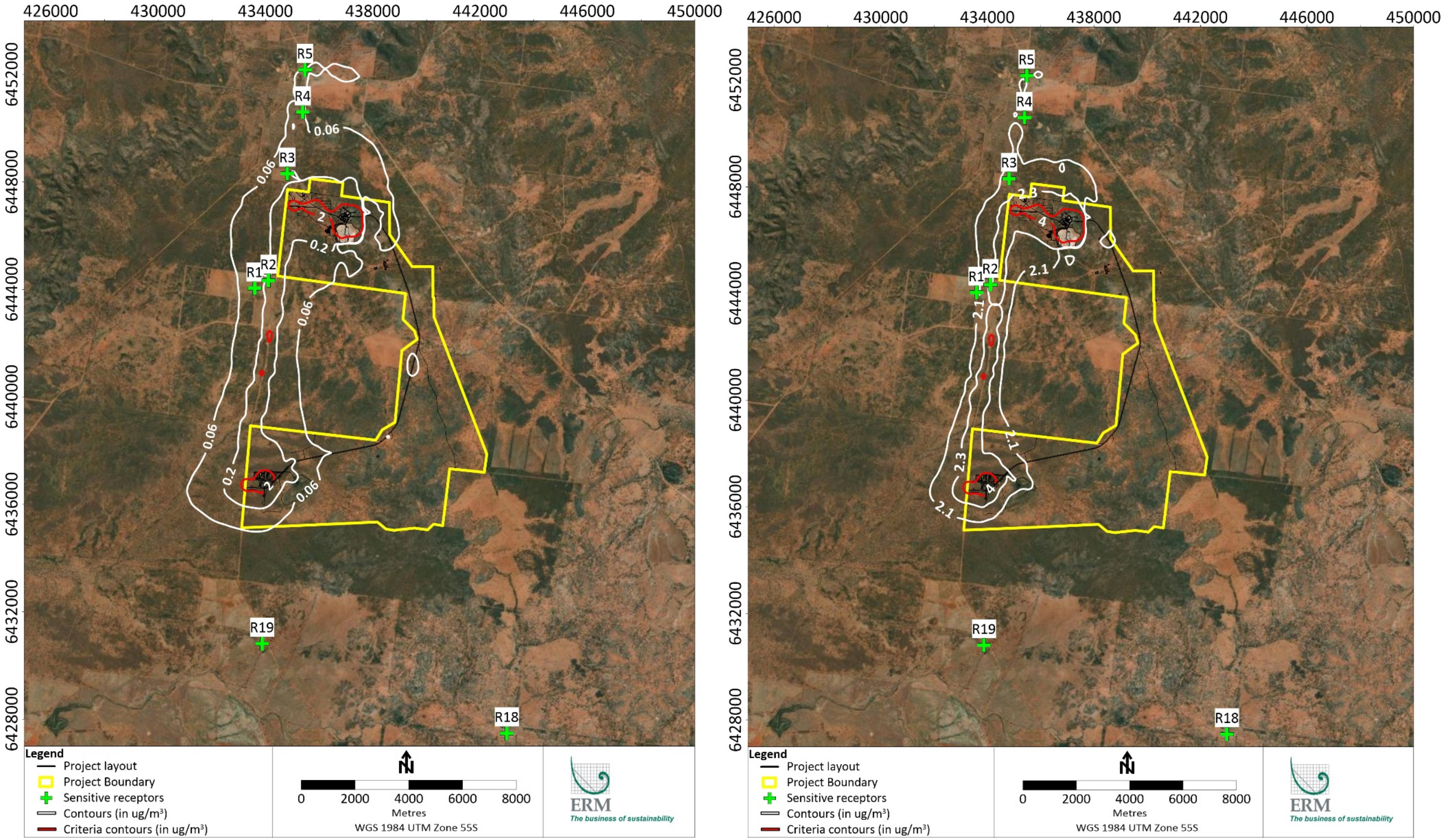


Figure 7-6: Predicted monthly average dust deposition levels (g/m^2/month) Project contribution (left) and cumulative (right)

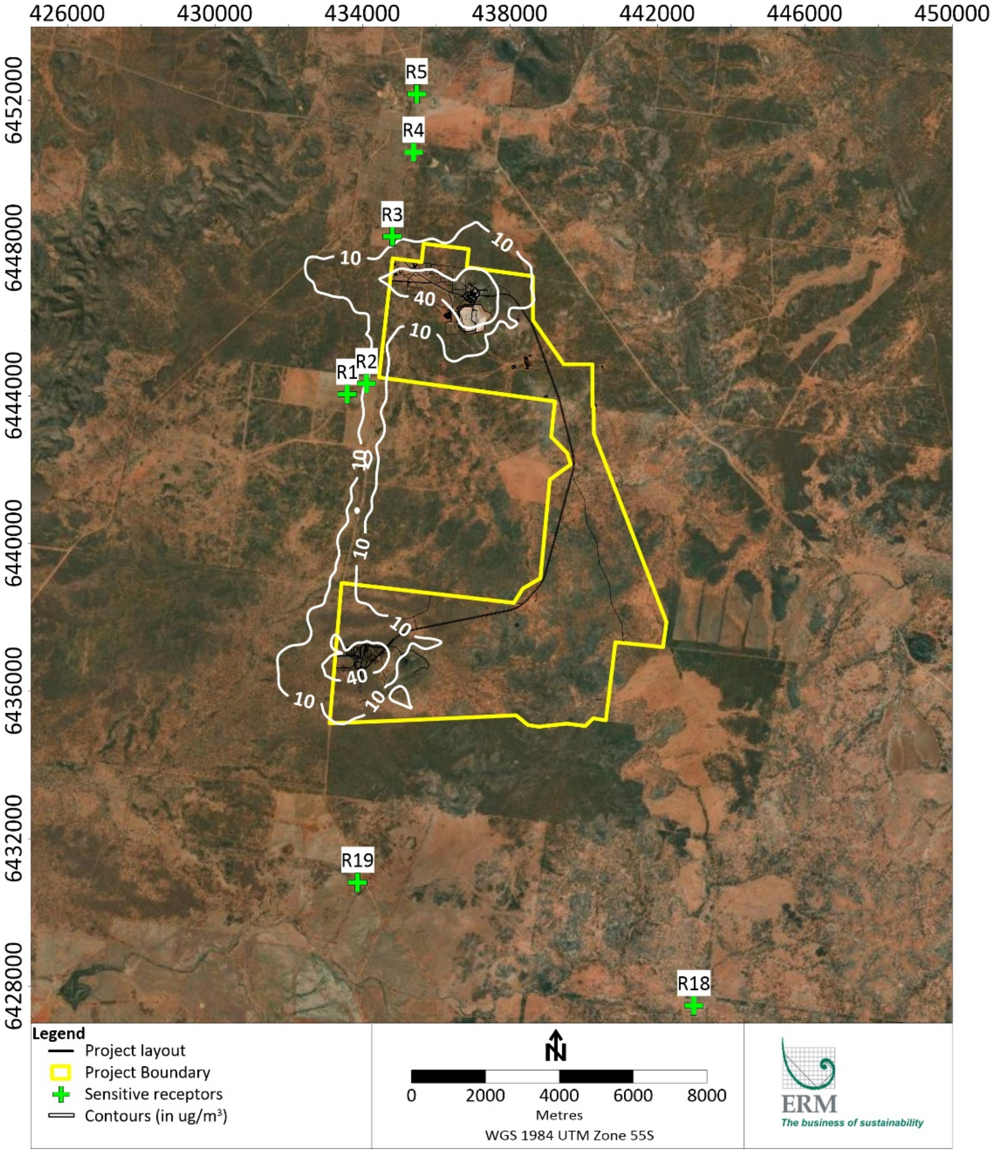


Figure 7-7: Predicted 24-hour average PM_{10} concentrations ($\mu g/m^3$) Project contribution

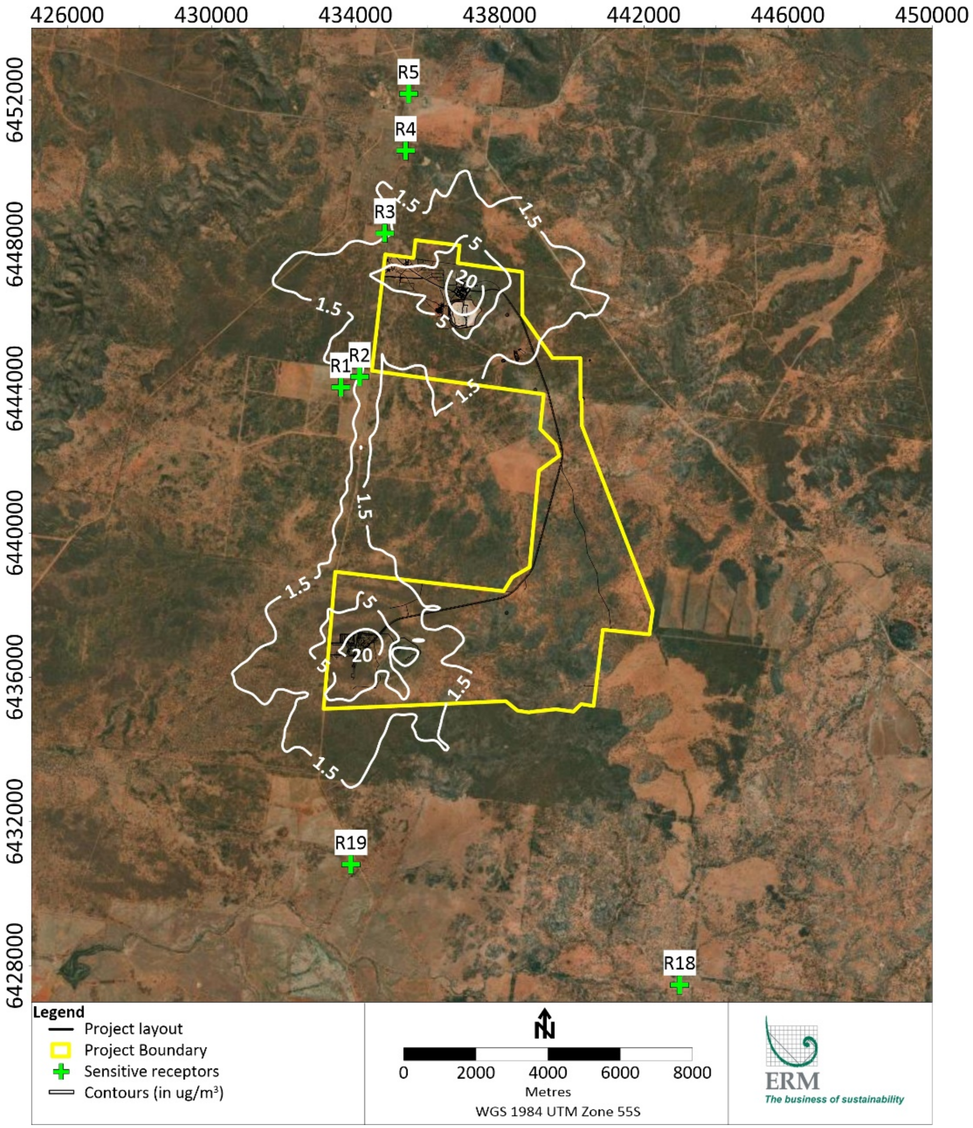


Figure 7-8: Predicted 24-hour average $PM_{2.5}$ concentrations (µg/m^3) Project contribution

8. GREENHOUSE GAS ASSESSMENT

8.1 Methodology

Quantification of GHG emissions has been completed in accordance with the GHG Protocol (WRI & WBCSD, 2004), IPCC and Australian Government GHG accounting/classification systems.

This GHGA is also guided by the emission estimation methodologies endorsed under the National Greenhouse and Energy Reporting Regulations 2008 (the NGER Regulations) (as amended in 2019). These describe the detailed requirements for reporting under the NGER framework and also provide a basis for estimating emissions from proposed activities.

The Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia (the NGER Guidelines) (DoEE, 2019) support reporting under the NGER Act. They have been designed to assist corporations in understanding and applying the NGER Measurement Determination.

The NGER Guidelines are reporting year specific, and outline calculation methods and criteria for determining GHG emissions, energy production, energy consumption and potential GHG emissions embodied in combusted fuels. The latest published NGER Guidelines (at the time of writing) have been referenced.

8.1.1 The GHG protocol

The GHG Protocol establishes an international standard for accounting and reporting of GHG emissions. The GHG Protocol has been adopted by the International Organization for Standardisation, endorsed by GHG initiatives (such as the Carbon Disclosure Project) and is compatible with existing GHG trading schemes.

Under this protocol, three "scopes" of emissions (scope 1, scope 2 and scope 3) are defined for GHG accounting and reporting purposes. This terminology has been adopted in Australian GHG reporting and measurement methods and has been employed in this assessment. These are represented visually in Figure 8-1. Reporting of scope 3 is not required so only scopes 1 and 2 are addressed. The definitions for scope 1 and scope 2 are provided in the following sections.

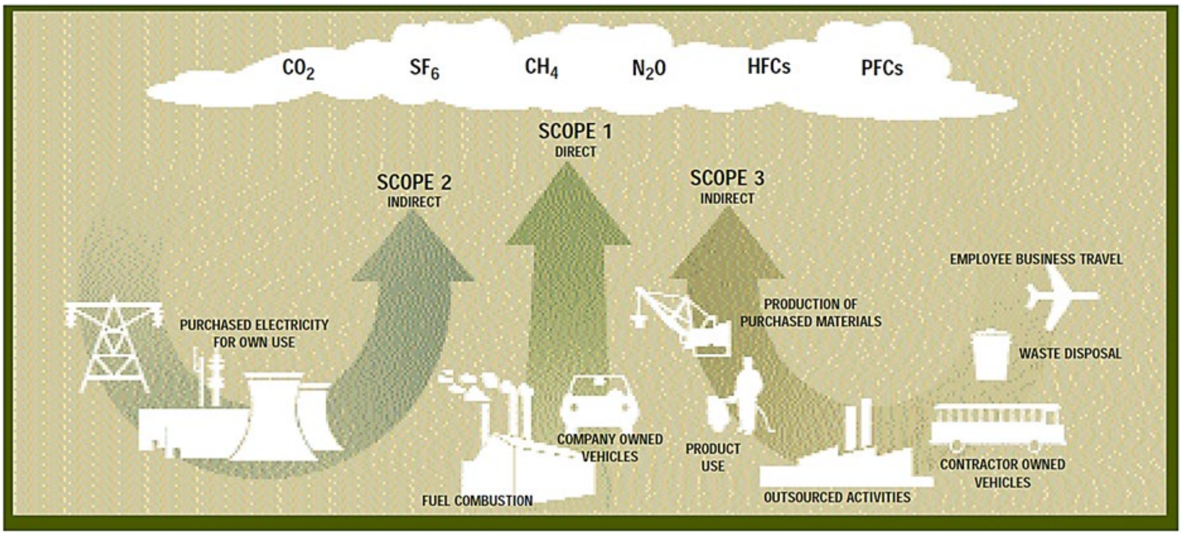


Figure 8-1: Overview of scope and emissions across a reporting entity

8.1.1.1 Scope 1: Direct greenhouse gas emissions

Direct GHG emissions are defined as those emissions that occur from sources that are owned or controlled by the reporting entity. Direct GHG gas emissions are those emissions that are principally the result of the following types of activities undertaken by an entity. For example:

- Generation of electricity, heat or steam. These emissions result from combustion of fuels in stationary sources;
- Physical or chemical processing. Most of these emissions result from manufacture or processing of chemicals and materials, e.g., the manufacture of cement, aluminium, etc;
- Transportation of materials, products, waste and employees. These emissions result from the combustion of fuels in entity owned/controlled mobile combustion sources, e.g., trucks, trains, ships, aeroplanes, buses and cars; and
- Fugitive emissions. These emissions result from intentional or unintentional releases, e.g., equipment leaks from joints, seals, packing, and gaskets; methane emissions from coal mines and venting; HFC emissions during the use of refrigeration and air conditioning equipment; and methane leakages from gas transport.

8.1.1.2 Scope 2: Energy product use indirect greenhouse gas emissions

Scope 2 emissions are a category of indirect emissions that accounts for GHG emissions from the generation of purchased energy products (principally, electricity, steam/heat and reduction materials used for smelting) by the entity.

Scope 2 covers purchased electricity defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity. Scope 2 emissions physically occur at the facility where electricity is generated. Entities report the emissions from the generation of purchased electricity that is consumed in its owned or controlled equipment or operations as scope 2.

The Project will not generate any scope 2 emissions as there will be no electricity purchased from the grid. All electricity will be generated onsite from either the solar farm or the LNG power plant.

8.1.2 Assessment approach

GHG emissions have been estimated for the Project based upon the methods outlined in the following documents:

- The National Greenhouse and Energy Reporting (Measurement) Amendment Determination 2008 (as amended 2019);
- Site specific information;
- The NGER Guidelines; and
- The NGA Factors.

8.2 Greenhouse gas emission estimates

Inventories of GHG emissions can be calculated using published emission factors. Different gases have different greenhouse warming effects (referred to as global warming potentials) and emission factors take into account the global warming potentials of the gases created during combustion. The estimated emissions are referred to in terms of carbon dioxide equivalent, or CO2-e, emissions by applying the relevant global warming potential. The greenhouse gas assessment has been conducted using the National Greenhouse Accounts (NGA) Factors, published by the DEE (2016).

Project related GHG sources included in the assessment are all for Scope 1 for fuel consumption and are as follows:

- Liquefied natural gas (LNG);
- Diesel;
- Lubricants/oil;
- Liquefied petroleum gas (LPG);
- Diesel (light duty vehicles); and
- Diesel (heavy duty vehicles).

The mining operations will last 14 years (FY23 to FY36). Fuel usage values have been provided by Aurelia Metals. It is assumed that fuel consumption will be fairly consistent across all years of operation relative to extraction and production rates.

A summary of annual average GHG emissions is provided in Table 8-1. The method for presenting emissions is for an annual average. Detailed information on the calculation of greenhouse gas emissions from the Project are provided in Appendix C.

Table 8-1: Summary of estimated annual average CO_2-e (tonnes)

Type of fuel	Scope 1
LNG	13,299
Diesel	7,688
Lubricants/oil	55
LPG	130
Diesel (light duty vehicles)	25
Diesel (heavy duty vehicles)	1,186
Total	**22,382**

The Project's contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions. Average annual scope 1 emissions from the Project (approximately 0.02 Mt CO_2-e) would represent approximately 0.005% of Australia's commitment under the Paris Agreement.

8.3 Greenhouse gas emission savings

Electricity at Federation Site will be provided by the power plant at Hera Mine (75% of the total power requirements) and the solar farm at Hera Mine (25% of the total power requirements). To calculate emission savings, greenhouse gas emissions have been calculated if electricity was to be provided by the grid compared with emissions from the LNG used for the power plant (this notes 25% of power is provided by the solar farm, which therefore displaces the requirement for gas consumption at the power plant). Table 8-2 presents the comparison of total (life of Project) greenhouse gas emissions for power sourced from the grid and the proposed combination of the power plant and solar farm. Table 8-3 presents the comparison of total (life of Project) greenhouse gas emissions if 100% of electricity was generated from the power plant and the savings that are achieved from the solar farm providing 25% of electricity needs.

Table 8-2: Summary of estimated greenhouse gas savings from using the power plant and solar farm compared with the grid (t CO_2-e)

Scope 2 emissions (t CO_2-e) if generated from grid	Scope 1 emissions (t CO_2-e) from LNG (used for power plant at 75%)	t CO_2-e savings from power plant and solar farm
278,476	186,180	92,296

Table 8-3: Summary of estimated greenhouse gas savings from the solar farm (t CO_2-e)

Scope 1 emissions (t CO_2-e) from LNG (if 100% from power plant)	Scope 1 emissions (t CO_2-e) from LNG (used for power plant at 75%)	t CO_2-e savings from solar farm
248,240	186,180	62,060

It can be seen from Table 8-2 that by using the on-site power plant and solar farm, rather than taking electricity from the grid, has saved 92,296 t CO_2-e over the life of the Project. Table 8-3 shows that by having the power plant provide 75% of electricity needs and the solar farm providing 25%, compared with 100% of the power plant, this has saved 62,060 t CO_2-e over the life of the Project. Overall, the combination of solar farm and power plant is making a significant saving to greenhouse gas emissions for the Project.

9. MONITORING AND REPORTING

9.1 Air Quality

Post approval, an Air Quality Management Plan (AQMP) will be prepared to detail any proposed mitigation and monitoring at the Project. Proposed monitoring is likely to include some or all of the following:

- High Volume Air Sampler (HVAS) to monitor TSP and/or PM10 concentrations; and
- Dust deposition gauges to monitor the monthly dust deposition levels.

The concentrations and deposition levels recorded by the monitors mentioned above will be reported annually as part of an annual review. The annual review is distributed to DPIE, Resources Regulator, Natural Resources Access Regulator (NRAR), Environment Protection Authority (EPA), NSW Environment, Energy and Science (EES) (formally the Office of Environment and Heritage [OEH]), Central West Local Land Services (LLS), Department of Industry – Crown Lands (DoI Crown Lands), Cobar Shire Council, Bogan Shire Council, and local mining companies. Additionally, a copy will be made available on the Aurelia Metals website for the general public. From an air quality perspective, the annual review will make commentary on compliance with air quality criteria.

9.2 Greenhouse Gas

Greenhouse gas emissions will be reported as part of the National Greenhouse and Energy Reporting (NGER) Act 2007. The reports are required to be submitted to the Clean Energy Regulator by 31 October each year. The reports will detail the following from the operation of facilities under the operational control of the corporation and entities that are members of the corporation’s group, during that financial year:

- Greenhouse gas emissions;
- Energy production;
- Energy consumption; and
- Energy savings from use of renewable sources.

10. CONCLUSIONS

Hera Resources Pty Limited (Hera Resources), a wholly owned subsidiary of Aurelia Metals Ltd (Aurelia Metals) has commissioned ERM Australia Pacific Pty Ltd (ERM) to prepare an Air Quality and Greenhouse Gas Assessment for the Federation Project. The assessment will form part of an Environmental Impact Statement (EIS) that will be prepared for the State Significant Development (SSD) application.

The Project is a proposed underground mine development which will establish and operate underground gold, silver and metalliferous mining activities with a projected 7 million tonnes (Mt) of ore extracted over a period of 12 to 14 years.

The Air Quality and Greenhouse Gas Assessment addresses the Secretary's Environmental Assessment Requirements (SEARs) and the outputs of the air quality assessment are used as part of the human health risk assessment.

The air quality assessment has focused on emissions of particulate matter (TSP, PM_{10} and $PM_{2.5}$) and lead. The assessment has used the computer-based dispersion model (AERMOD) to predict off-site particulate matter concentrations across a model domain and at sensitive receptor locations. To assess the effect that potential emissions could have on existing air quality, the dispersion model predictions are compared to relevant regulatory air quality criteria. The assessment follows a conventional approach using the procedures outlined in the NSW Environment Protection Authority's (EPA) document titled *"Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW"* (Approved Methods) (NSW EPA, 2016).

The results show that there are no predicted exceedances at sensitive receptor locations of the NSW EPA impact assessment criteria for any of the annual average parameters. For 24-hour average $PM_{2.5}$, there are no predicted exceedances at sensitive receptor locations of the NSW EPA impact assessment criteria. For 24-hour average PM_{10}, there is one predicted exceedance of the NSW EPA impact assessment criteria, experienced at all sensitive receptor locations. This exceedance is due to background concentrations already exceeding the criteria. There are no additional exceedances at sensitive receptor locations of the 24-hour average PM_{10} criterion caused by Project contributions.

The Project's contribution to projected climate change, and the associated impacts, would be in proportion with its contribution to global GHG emissions. Average annual scope 1 emissions from the Project (approximately 0.02 Mt CO_2-e) would represent approximately 0.005% of Australia's commitment under the Paris Agreement. The proponent has proposed a solar farm to supplement power supply and reduce GHG emissions.

Overall, this quantitative air quality assessment concludes that the operation of the proposed Federation Project activities is not anticipated to result in adverse air quality impacts under normal operating conditions.

11. REFERENCES

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Appendix A ANNUAL AND SEASONAL WIND ROSES FOR COBAR MO AWS FOR 2015-2019

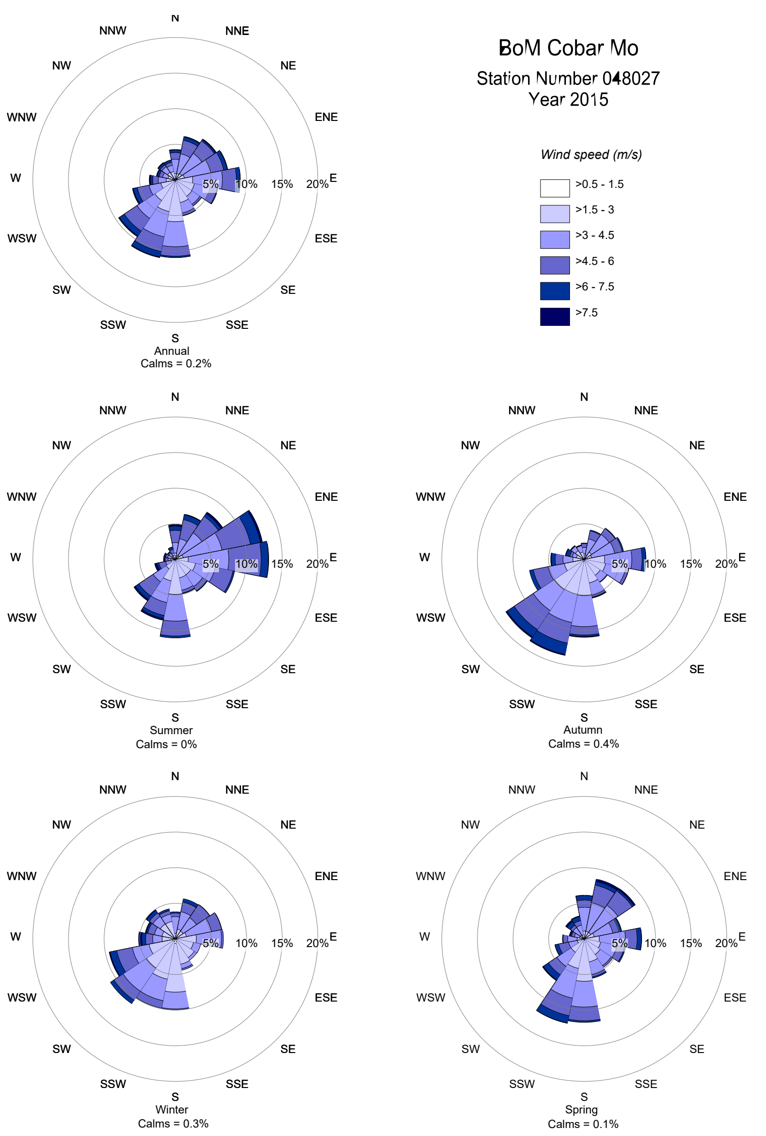

Figure A-1: Annual wind roses for Cobar MO Now Ran AWS for 2015

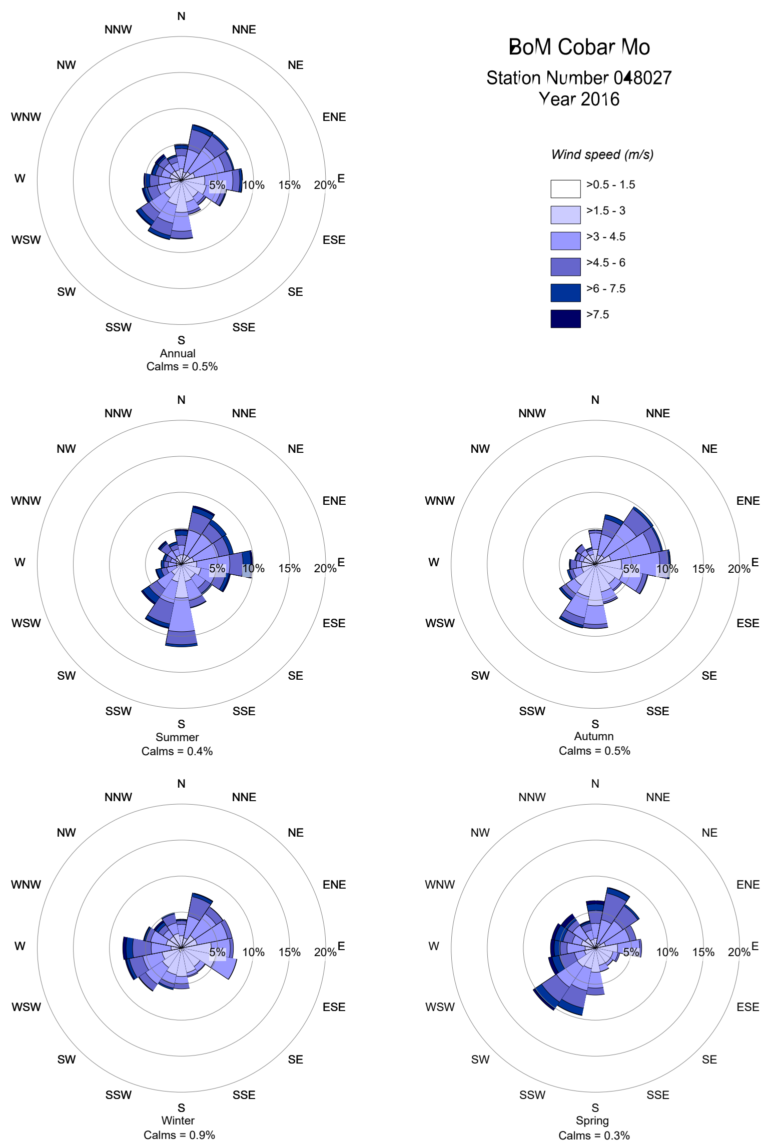

Figure A-2: Annual wind roses for Cobar MO Now Ran AWS for 2016

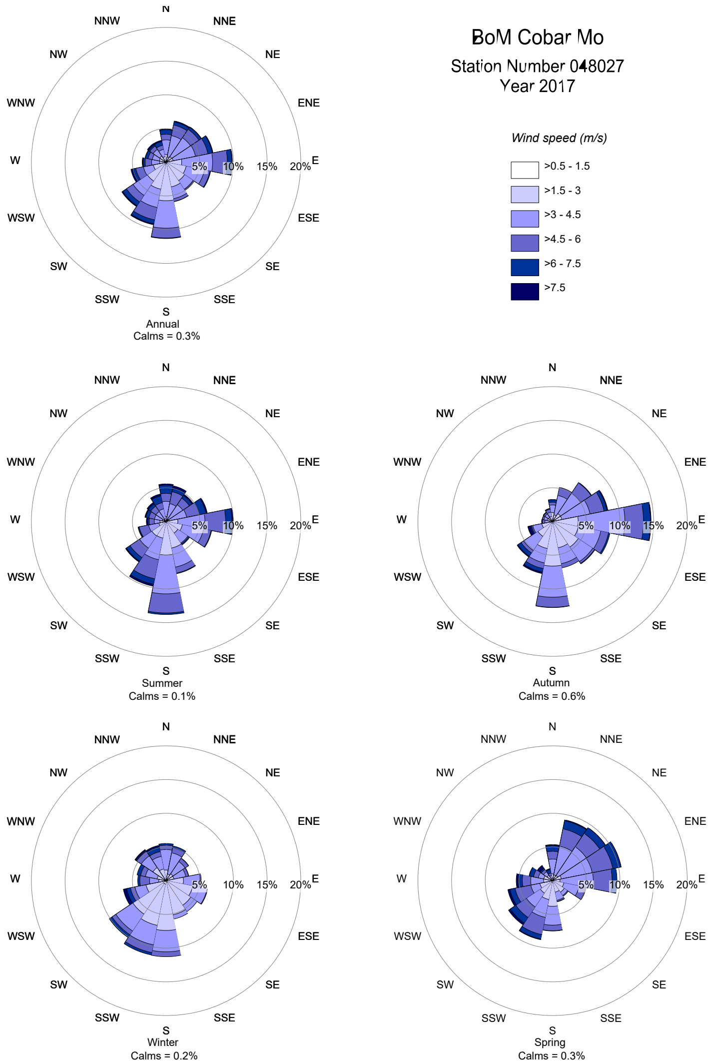

Figure A-3: Annual wind roses for Cobar MO Now Ran AWS for 2017

Figure A-4: Annual wind roses for Cobar MO Now Ran AWS for 2018

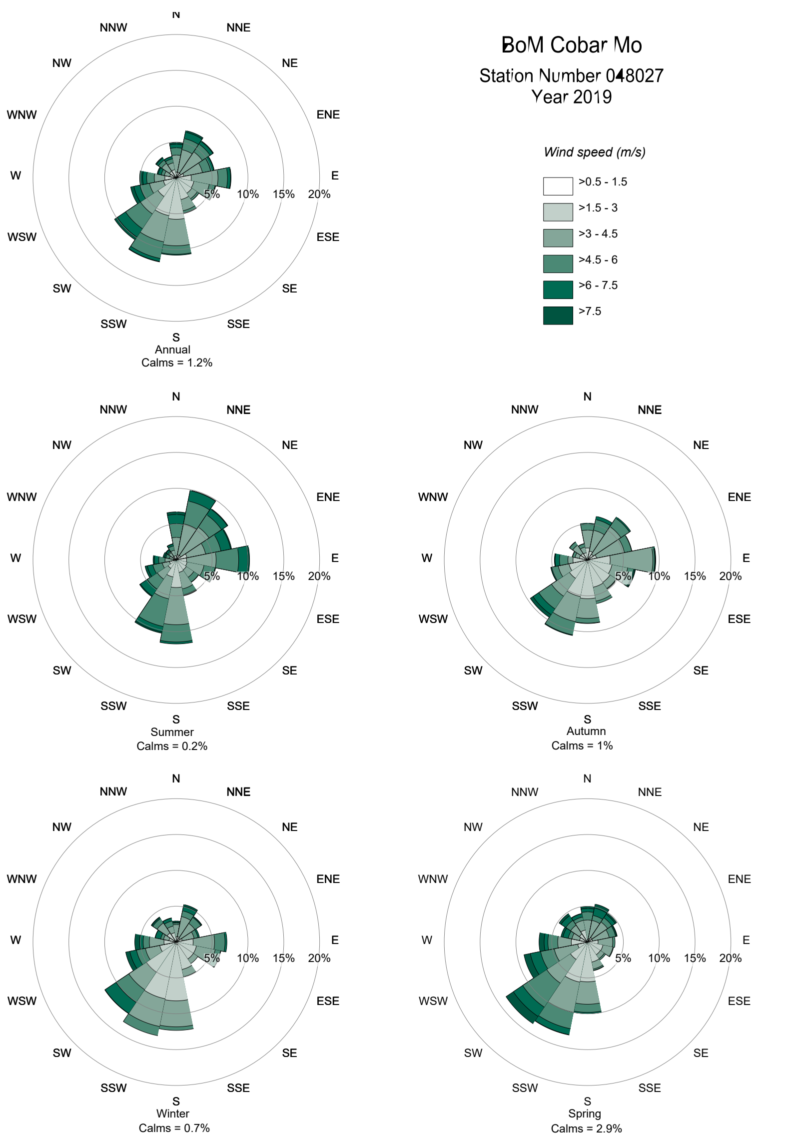

Figure A-5: Annual wind roses for Cobar MO Now Ran AWS for 2019

Figure A-4: Annual wind roses for Cobar MO Now Ran AWS for 2020

Appendix B EMISSIONS INVENTORIES

Activity	TSP (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Control assumed	Type
Federation Site																			
Ore																			
Hauling of underground ore to ROM pad (unsealed roads)	13,605	752,055	t/y	0.036	kg/t	50	t/load	82	Vehicle gross mass (t)	0.6	km/return trip	3.02	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of underground ore to ROM pad	325	752,055	t/y	0.001	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Loading of ore at ROM pad	325	752,055	t/y	0.001	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of ore to Federation Site boundary (unsealed roads)	72,560	752,055	t/y	0.193	kg/t	50	t/load	82	Vehicle gross mass (t)	3.2	km/return trip	3.02	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hauling of ore from Federation Site boundary to Hera Mine boundary (sealed roads)	101,585	752,055	t/y	1.351	kg/t	50	t/load	82	Vehicle gross mass (t)	22.4	km/return trip	3.02	kg/VKT	4.1	% silt content	90	% control	Sealed	1
Waste Rock																			
Hauling of underground waste rock to PAF stockpile (unsealed roads)	5,271	218,528	t/y	0.048	kg/t	50	t/load	82	Vehicle gross mass (t)	0.8	km/return trip	3.02	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of underground waste rock at PAF stockpile	94	218,528	t/y	0.001	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Grader																			
Grader at Federation Site unsealed roads	5,515	17,920	km	0.615	kg/km	8	speed of graders in km/h	2240	grader hours							50	% control	Watering	1
Hera Mine																			
Ore																			
Hauling of ore from Hera Mine boundary to Processing Plant (unsealed roads)	136,051	752,055	t/y	0.362	kg/t	50	t/load	82	Vehicle gross mass (t)	6	km/return trip	3.02	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of ore at Processing Plant	325	752,055	t/y	0.001	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Crushing of ore at Processing Plant	2,031	752,055	t/y	0.003	kg/t											0	% control	No controls	1
Screening of crushed material at Processing Plant	9,401	752,055	t/y	0.013	kg/t											0	% control	No controls	1
Front End Loader at Processing Plant	3,161	2,800	h/y	2.258	kg/t	4.1	% silt content	4	moisture content in %							50	% control	Water sprays	1
Concentrate																			
Loading of concentrate at Processing Plant into trucks	62	142,432	t/y	0.001	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of concentrate from Hera Mine Processing Plant to Hera Mine Site boundary (unsealed roads)	25,767	142,432	t/y	0.362	kg/t	50	t/load	82	Vehicle gross mass (t)	6	km/return trip	3.02	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hauling of concentrate from Hera Mine Site Boundary to Tritton Copper Mines (Hermidale) by truck (sealed roads)	9,448	142,432	t/y	0.663	kg/t	50	t/load	82	Vehicle gross mass (t)	11	km/return trip	3.02	kg/VKT	4.1	% silt content	90	% control	Sealed	1
Tailings for Hera																			
Loading of tailings at Processing Plant for trip to the TSF	105	243,849	t/y	0.001	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of tailings from Processing Plant to TSF (unsealed roads)	26,468	243,849	t/y	0.217	kg/t	50	t/load	82	Vehicle gross mass (t)	3.6	km/return trip	3.02	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of tailings at TSF	105	243,849	t/y	0.001	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Front End Loader at TSF	3,161	2,800	h/y	2.258	kg/t	4	% silt content	4	moisture content in %							50	% control	Water sprays	1
Tailings for Federation																			
Loading of tailings at Processing Plant to return to Federation Site	158	365,774	t/y	0.001	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of tailings from Hera Mine Processing Plant to Hera Mine Site boundary (unsealed roads)	66,171	365,774	t/y	0.362	kg/t	50	t/load	82	Vehicle gross mass (t)	6	km/return trip	3.02	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hauling of taillings from Hera Mine Site boundary to Federation Site boundary via Burthong Road (sealed roads)	49,407	365,774	t/y	1.351	kg/t	50	t/load	82	Vehicle gross mass (t)	22.4	km/return trip	3.02	kg/VKT	4.1	% silt content	90	% control	Sealed	1
Federation Site																			
Hauling of tailings from Federation Site boundary to underground	37,497	365,774	t/y	0.205	kg/t	50	t/load	82	Vehicle gross mass (t)	3.4	km/return trip	3.02	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hera Mine - Solar Farm																			
Grader at Solar Farm unsealed roads	5,515	17,920	km	0.615	kg/km	8	speed of graders in km/h	2240	grader hours							50	% control	Watering	1
Services Corridor - connecting Federation Site with Hera Mine Site																			
Grader at Services Corridor unsealed roads	5,515	17,920	km	0.615	kg/km	8	speed of graders in km/h	2240	grader hours							50	% control	Watering	1
Wind Erosion (WE) at Federation Site																			
WE - ROM Pad	213	1.00	ha	850	kg/ha/y											50	% control	Water sprays	3
WE - PAF waste rock stockpile	765	3.60	ha	850	kg/ha/y											50	% control	Water sprays	3
WE - Topsoil stockpile 1 (west of boxcut)	170	0.80	ha	850	kg/ha/y											50	% control	Water sprays	3
WE - Topsoil stockpile 2 (south of internal access road)	213	1.00	ha	850	kg/ha/y											50	% control	Water sprays	3
WE - Topsoil stockpile 3 (south of internal haul road)	213	1.00	ha	850	kg/ha/y											50	% control	Water sprays	3
WE at Hera Mine																			
WE - Tailings Storage Facility	446	2.10	ha	850	kg/ha/y											50	% control	Water sprays	3
TOTAL TSP EMISSIONS	**581,645**																		

Figure B-1: TSP emission inventory

Activity	PM10 (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Control assumed	Type
Federation Site																			
Ore																			
Hauling of underground ore to ROM pad (unsealed roads)	3,360	752,055	t/y	0.009	kg/t	50	t/load	82	Vehicle gross mass (t)	0.6	km/return trip	0.74	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of underground ore to ROM pad	154	752,055	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Loading of ore at ROM pad	154	752,055	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of ore to Federation Site boundary (unsealed roads)	17,919	752,055	t/y	0.048	kg/t	50	t/load	82	Vehicle gross mass (t)	3.2	km/return trip	0.74	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hauling of ore from Federation Site boundary to Hera Mine boundary (sealed roads)	25,087	752,055	t/y	0.334	kg/t	50	t/load	82	Vehicle gross mass (t)	22.4	km/return trip	0.74	kg/VKT	4.1	% silt content	90	% control	Sealed	1
Waste Rock																			
Hauling of underground waste rock to PAF stockpile (unsealed roads)	1,302	218,528	t/y	0.012	kg/t	50	t/load	82	Vehicle gross mass (t)	0.8	km/return trip	0.74	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of underground waste rock at PAF stockpile	45	218,528	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Grader																			
Grader at Federation Site unsealed roads	1,927	17,920	km	0.215	kg/km	8	speed of graders in km/h	2240	grader hours							50	% control	Watering	1
Hera Mine																			
Ore																			
Hauling of ore from Hera Mine boundary to Processing Plant (unsealed roads)	33,598	752,055	t/y	0.089	kg/t	50	t/load	82	Vehicle gross mass (t)	6	km/return trip	0.74	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of ore at Processing Plant	154	752,055	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Crushing of ore at Processing Plant	902	752,055	t/y	0.001	kg/t											0	% control	No controls	1
Screening of crushed material at Processing Plant	3,234	752,055	t/y	0.004	kg/t											0	% control	No controls	1
Front End Loader at Processing Plant	544	2,800	h/y	0.389	kg/t	4.1	% silt content	4	moisture content in %							50	% control	Water sprays	1
Concentrate																			
Loading of concentrate at Processing Plant into trucks	29	142,432	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of concentrate from Hera Mine Processing Plant to Hera Mine Site boundary (unsealed roads)	6,363	142,432	t/y	0.089	kg/t	50	t/load	82	Vehicle gross mass (t)	6	km/return trip	0.74	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hauling of concentrate from Hera Mine Site Boundary to Tritton Copper Mines (Hermidale) by truck (sealed roads)	2,333	142,432	t/y	0.164	kg/t	50	t/load	82	Vehicle gross mass (t)	11	km/return trip	0.74	kg/VKT	4.1	% silt content	90	% control	Sealed	1
Tailings for Hera																			
Loading of tailings at Processing Plant for trip to the TSF	50	243,849	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of tailings from Processing Plant to TSF (unsealed roads)	6,536	243,849	t/y	0.054	kg/t	50	t/load	82	Vehicle gross mass (t)	3.6	km/return trip	0.74	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of tailings at TSF	50	243,849	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Front End Loader at TSF	544	2,800	h/y	0.389	kg/t	4	% silt content	4	moisture content in %							50	% control	Water sprays	1
Tailings for Federation																			
Loading of tailings at Processing Plant to return to Federation Site	75	365,774	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of tailings from Hera Mine Processing Plant to Hera Mine Site boundary (unsealed roads)	16,341	365,774	t/y	0.089	kg/t	50	t/load	82	Vehicle gross mass (t)	6	km/return trip	0.74	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hauling of taillings from Hera Mine Site boundary to Federation Site boundary via Burthong Road (sealed roads)	12,201	365,774	t/y	0.334	kg/t	50	t/load	82	Vehicle gross mass (t)	22.4	km/return trip	0.74	kg/VKT	4.1	% silt content	90	% control	Sealed	1
Federation Site																			
Hauling of tailings from Federation Site boundary to underground	9,260	365,774	t/y	0.051	kg/t	50	t/load	82	Vehicle gross mass (t)	3.4	km/return trip	0.74	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hera Mine - Solar Farm																			
Grader at Solar Farm unsealed roads	1,927	17,920	km	0.215	kg/km	8	speed of graders in km/h	2240	grader hours							50	% control	Watering	1
Services Corridor - connecting Federation Site with Hera Mine Site																			
Grader at Services Corridor unsealed roads	1,927	17,920	km	0.215	kg/km	8	speed of graders in km/h	2240	grader hours							50	% control	Watering	1
Wind Erosion (WE) at Federation Site																			
WE - ROM Pad	106	1.00	ha	425	kg/ha/y											50	% control	Water sprays	3
WE - NAF waste rock stockpile	383	3.60	ha	425	kg/ha/y											50	% control	Water sprays	3
WE - Topsoil stockpile 1 (west of boxcut)	85	0.80	ha	425	kg/ha/y											50	% control	Water sprays	3
WE - Topsoil stockpile 2 (south of NAF waste rock stockpile)	106	1.00	ha	425	kg/ha/y											50	% control	Water sprays	3
WE - Topsoil stockpile 3 (south of internal haul road)	106	1.00	ha	425	kg/ha/y											50	% control	Water sprays	3
WE at Hera Mine																			
WE - Tailings Storage Facility	223	2.10	ha	425	kg/ha/y											50	% control	Water sprays	3
TOTAL TSP EMISSIONS	**147,024**																		

Figure B-2: PM_{10} emission inventory

Activity	PM10 (kg/y)	Intensity	Units	Emission factor	Units	Variable 1	Units	Variable 2	Units	Variable 3	Units	Variable 4	Units	Variable 5	Units	Control	Units	Control assumed	Type
Federation Site																			
Ore																			
Hauling of underground ore to ROM pad (unsealed roads)	336	752,055	t/y	0.001	kg/t	50	t/load	82	Vehicle gross mass (t)	0.6	km/return trip	0.07	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of underground ore to ROM pad	23	752,055	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Loading of ore at ROM pad	23	752,055	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of ore to Federation Site boundary (unsealed roads)	1,792	752,055	t/y	0.005	kg/t	50	t/load	82	Vehicle gross mass (t)	3.2	km/return trip	0.07	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hauling of ore from Federation Site boundary to Hera Mine boundary (sealed roads)	2,509	752,055	t/y	0.033	kg/t	50	t/load	82	Vehicle gross mass (t)	22.4	km/return trip	0.07	kg/VKT	4.1	% silt content	90	% control	Sealed	1
Waste Rock																			
Hauling of underground waste rock to PAF stockpile (unsealed roads)	130	218,528	t/y	0.001	kg/t	50	t/load	82	Vehicle gross mass (t)	0.8	km/return trip	0.07	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of underground waste rock at PAF stockpile	7	218,528	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Grader																			
Grader at Federation Site unsealed roads	171	17,920	km	0.019	kg/km	8	speed of graders in km/h	2240	grader hours							50	% control	Watering	1
Hera Mine																			
Ore																			
Hauling of ore from Hera Mine boundary to Processing Plant (unsealed roads)	3,360	752,055	t/y	0.009	kg/t	50	t/load	82	Vehicle gross mass (t)	6	km/return trip	0.07	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of ore at Processing Plant	23	752,055	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Crushing of ore at Processing Plant	902	752,055	t/y	0.001	kg/t											0	% control	No controls	1
Screening of crushed material at Processing Plant	3,234	752,055	t/y	0.004	kg/t											0	% control	No controls	1
Front End Loader at Processing Plant	332	2,800	h/y	0.237	kg/t	4.1	% silt content	4	moisture content in %							50	% control	Water sprays	1
Concentrate																			
Loading of concentrate at Processing Plant into trucks	4	142,432	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of concentrate from Hera Mine Processing Plant to Hera Mine Site boundary (unsealed roads)	636	142,432	t/y	0.009	kg/t	50	t/load	82	Vehicle gross mass (t)	6	km/return trip	0.07	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hauling of concentrate from Hera Mine Site Boundary to Tritton Copper Mines (Hermidale) by truck (sealed roads)	233	142,432	t/y	0.016	kg/t	50	t/load	82	Vehicle gross mass (t)	11	km/return trip	0.07	kg/VKT	4.1	% silt content	90	% control	Sealed	1
Tailings for Hera																			
Loading of tailings at Processing Plant for trip to the TSF	8	243,849	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of tailings from Processing Plant to TSF (unsealed roads)	654	243,849	t/y	0.005	kg/t	50	t/load	82	Vehicle gross mass (t)	3.6	km/return trip	0.07	kg/VKT	4.1	% silt content	50	% control	Watering	1
Unloading of tailings at TSF	8	243,849	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Front End Loader at TSF	332	2,800	h/y	0.237	kg/t	4	% silt content	4	moisture content in %							50	% control	Water sprays	1
Tailings for Federation																			
Loading of tailings at Processing Plant to return to Federation Site	11	365,774	t/y	0.000	kg/t	2	average of (wind speed/2.2)^1.3 in m/s	4	moisture content in %							50	% control	Water sprays	2
Hauling of tailings from Hera Mine Processing Plant to Hera Mine Site boundary (unsealed roads)	1,634	365,774	t/y	0.009	kg/t	50	t/load	82	Vehicle gross mass (t)	6	km/return trip	0.07	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hauling of taillings from Hera Mine Site boundary to Federation Site boundary via Burthong Road (sealed roads)	1,220	365,774	t/y	0.033	kg/t	50	t/load	82	Vehicle gross mass (t)	22.4	km/return trip	0.07	kg/VKT	4.1	% silt content	90	% control	Sealed	1
Federation Site																			
Hauling of tailings from Federation Site boundary to underground	926	365,774	t/y	0.005	kg/t	50	t/load	82	Vehicle gross mass (t)	3.4	km/return trip	0.07	kg/VKT	4.1	% silt content	50	% control	Watering	1
Hera Mine - Solar Farm																			
Grader at Solar Farm unsealed roads	171	17,920	km	0.019	kg/km	8	speed of graders in km/h	2240	grader hours							50	% control	Watering	1
Services Corridor - connecting Federation Site with Hera Mine Site																			
Grader at Services Corridor unsealed roads	171	17,920	km	0.019	kg/km	8	speed of graders in km/h	2240	grader hours							50	% control	Watering	1
Wind Erosion (WE) at Federation Site																			
WE - ROM Pad	16	1.00	ha	64	kg/ha/y											50	% control	Water sprays	3
WE - NAF waste rock stockpile	57	3.60	ha	64	kg/ha/y											50	% control	Water sprays	3
WE - Topsoil stockpile 1 (west of boxcut)	13	0.80	ha	64	kg/ha/y											50	% control	Water sprays	3
WE - Topsoil stockpile 2 (south of NAF waste rock stockpile)	16	1.00	ha	64	kg/ha/y											50	% control	Water sprays	3
WE - Topsoil stockpile 3 (south of internal haul road)	16	1.00	ha	64	kg/ha/y											50	% control	Water sprays	3
WE at Hera Mine																			
WE - Tailings Storage Facility	33	2.10	ha	64	kg/ha/y											50	% control	Water sprays	3
TOTAL TSP EMISSIONS	**19,002**																		

Figure B-3: $PM_{2.5}$ emission inventory

Note: Ventilation rise has been modelled consistent with the parameters detailed in Table 6-2.

Appendix C GREENHOUSE GAS EMISSION CALCULATIONS

Fuel consumption

Liquefied Natural Gas (LNG)

Greenhouse gas (GHG) emissions from LNG consumption were estimated using the following equation:

Equation 1: $$E_{CO_2-e} = \frac{Q \times EF}{1000}$$

Where:

$E_{CO2\text{-}e}$	Emissions of GHG from LNG combustion	(t CO2-e)[1]
Q	Estimated combustion of LNG	(GJ)[2]
EF	Emission factor (scope 1) for LNG combustion	(kg CO2-e/GJ)[3]

[1] tCO2-e = tonnes of carbon dioxide equivalent
[2] GJ = gigajoules
[3] kg CO2-e/GJ = kilograms of carbon dioxide equivalents per gigajoule

The quantity of LNG consumed (Q) each year is based on usage numbers provided by Aurelia Metals. The quantity of LNG consumed in GJ is calculated using an energy content factor for LNG of 25.3 gigajoules per kilolitre (GJ/kL). The Scope 1 emission factor is 51.5 kg CO2 e/GJ (DISER, 2021). The estimated annual and total life of mine GHG emissions from LNG usage are presented in the table below.

Table C-1: Estimated scope 1 CO_2-e (tonnes) for LNG consumption

Financial Year	Usage (kL)	Emissions (t CO_2-e)
FY23	0	0
FY24	3,921	5,111
FY25	8,295	10,814
FY26	8,401	10,952
FY27	11,131	14,512
FY28	17,332	22,596
FY29	17,285	22,534
FY30	16,598	21,639
FY31	17,282	22,531
FY32	16,877	22,003
FY33	14,851	19,362
FY34	7,776	10,138
FY35	2,261	2,948
FY36	798	1,041
Total	**142,808**	**186,180**
Annual average	**10,201**	**13,299**

Diesel

GHG emissions from diesel consumption from underground equipment, were estimated using Equation 1 as above.

The quantity of diesel consumed (Q) each year is based on usage numbers provided by Aurelia Metals. The quantity of diesel consumed in GJ is calculated using an energy content factor for diesel of 38.6 gigajoules per kilolitre (GJ/kL). The Scope 1 emission factor is 70.2 kg CO2 e/GJ (DISER, 2021). The estimated annual and total life of mine GHG emissions from diesel usage are presented in the table below.

Table C-2: Estimated scope 1 CO_2-e (tonnes) for diesel consumption

Financial Year	Usage (kL)	Emissions (t CO_2-e)
FY23	4,391	11,900
FY24	2,541	6,886
FY25	2,677	7,254
FY26	2,871	7,781
FY27	2,723	7,378
FY28	2,813	7,622
FY29	2,903	7,865
FY30	3,027	8,201
FY31	3,051	8,269
FY32	3,051	8,269
FY33	3,051	8,269
FY34	2,799	7,586
FY35	2,547	6,903
FY36	1,274	3,451
Total	**39,721**	**107,633**
Annual average	**2,837**	**7,688**

Lubricants/oil

GHG emissions from lubricants/oil consumption were estimated using Equation 1 as above.

The quantity of lubricants/oil consumed (Q) each year is based on usage numbers provided by Aurelia Metals. The quantity of lubricants/oil consumed in GJ is calculated using an energy content factor for petroleum based oils of 38.8 gigajoules per kilolitre (GJ/kL). The Scope 1 emission factor is 13.9 kg CO2 e/GJ (DISER, 2021). The estimated annual and total life of mine GHG emissions from lubricants/oil usage are presented in the table below.

Table C-3: Estimated scope 1 CO_2-e (tonnes) for lubricant/oils consumption

Financial Year	Usage (kL)	Emissions (t CO_2-e)
FY23	55	30
FY24	105	57
FY25	110	59
FY26	110	59
FY27	110	59
FY28	110	59
FY29	110	59
FY30	110	59
FY31	110	59
FY32	110	59
FY33	110	59
FY34	110	59
FY35	110	59
FY36	55	30
Total	**1,425**	**769**
Annual average	**102**	**55**

Liquefied Petroleum Gas (LPG)

GHG emissions from LPG consumption were estimated using Equation 1 as above.

The quantity of LPG consumed (Q) each year is based on usage numbers provided by Aurelia Metals. The quantity of LPG consumed in GJ is calculated using an energy content factor for Propane (as LPG) of 25.7 gigajoules per kilolitre (GJ/kL). The Scope 1 emission factor is 60.6 kg CO2 e/GJ (DISER, 2021). The estimated annual and total life of mine GHG emissions from LPG usage are presented in the table below.

Table C-4: Estimated scope 1 CO_2-e (tonnes) for LPG consumption

Financial Year	Usage (kL)	Emissions (t CO_2-e)
FY23	101	157
FY24	108	168
FY25	83	130
FY26	83	130
FY27	83	130
FY28	83	130
FY29	83	130
FY30	83	130
FY31	83	130
FY32	83	130
FY33	83	130
FY34	83	130
FY35	83	130
FY36	42	65
Total	**1,169**	**1,820**
Annual average	**83**	**130**

Diesel (light duty vehicles)

GHG emissions from diesel (light duty vehicles) consumption were estimated using Equation 1 as above.

The quantity of diesel consumed (Q) each year is based on usage numbers provided by Aurelia Metals. The quantity of diesel consumed in GJ is calculated using an energy content factor for diesel of 38.6 gigajoules per kilolitre (GJ/kL). The Scope 1 emission factor is 70.4 kg CO2 e/GJ (DISER, 2021). The estimated annual and total life of mine GHG emissions from diesel usage are presented in the table below.

Table C-5: Estimated scope 1 CO_2-e (tonnes) for diesel (light duty vehicles) consumption

Financial Year	Usage (kL)	Emissions (t CO_2-e)
FY23	0	0
FY24	4	12
FY25	11	29
FY26	11	29
FY27	11	29
FY28	11	29
FY29	11	29
FY30	11	29
FY31	11	29
FY32	11	29
7FY33	11	29
FY34	11	29
FY35	11	29
FY36	5	14
Total	**127**	**345**
Annual average	**9**	**25**

Diesel (heavy duty vehicles)

GHG emissions from diesel (heavy duty vehicles) consumption were estimated using Equation 1 as above.

The quantity of diesel consumed (Q) each year is based on usage numbers provided by Aurelia Metals. The quantity of diesel consumed in GJ is calculated using an energy content factor for diesel of 38.6 gigajoules per kilolitre (GJ/kL). The Scope 1 emission factor is 70.4 kg CO2 e/GJ (DISER, 2021). The estimated annual and total life of mine GHG emissions from diesel usage are presented in the table below.

Table C-6: Estimated scope 1 CO_2-e (tonnes) for diesel (heavy duty vehicles) consumption

Financial Year	Usage (kL)	Emissions (t CO_2-e)
FY23	0	0
FY24	173	469
FY25	365	993
FY26	407	1,105
FY27	512	1,391
FY28	757	2,058
FY29	782	2,125
FY30	659	1,790
FY31	708	1,924
FY32	752	2,045
FY33	592	1,609
FY34	291	792
FY35	81	220
FY36	30	82
Total	**6,109**	**16,601**
Annual average	**436**	**1,186**

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