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AIR QUALITY REPORT



Air Quality Assessment for the Big Vein South Gold Project

Prepared for:

**Hansen Environmental Consulting on behalf of
Strategic Minerals Corporation Pty Ltd**

November 2025

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Abbreviation, Units and Glossary

Term	Definition
$\mu\text{g}/\text{m}^3$	micrograms per cubic metre
$^{\circ}\text{C}$	degrees Celsius
g/s	grams per second
ha	hectare
kg/Mg	Kilogram per megagram
km	kilometre
km/h	kilometre per hour
m	metre
m/s	metres per second
m^2	square metres
$\text{mg}/\text{m}^2/\text{day}$	milligrams per square metre per day
$\text{g}/\text{m}^2/\text{month}$	grams per square metre per month
Mtpa	million tonnes per annum
MW	megawatts
mm	millilitre
ppm	parts per million
Nomenclature	Definition
CO_2	carbon dioxide
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
PM_{10}	particulate matter with a diameter less than 10 micrometres
$\text{PM}_{2.5}$	particulate matter with a diameter less than 2.5 micrometres
SO_x	sulfur oxide
SO_2	sulfur dioxide
TSP	Total suspended particulate
Abbreviations	Definition
AHD	Australian Height Datum
Air EPP	<i>Environmental Protection (Air) Policy 2019 (Qld)</i>
Air NEPM	<i>National Environment Protection (Ambient Air Quality) Measure</i>
Application Requirements	<i>Application requirements for activities with impacts to air</i>
BoM	Bureau of Meteorology
CIL	Carbon-In-Leach
CSIRO	<i>Commonwealth Scientific and Industrial Research Organisation</i>
DETSI	Department of Environment, Tourism, Science and Innovation
EAR	<i>Environmental Assessment Report</i>
EF	Emission factor
EP Act	<i>Environmental Protection Act 1994 (Qld)</i>
MLA	<i>Mining Lease Application</i>
NPI	National Pollutant Inventory database
ROM	Run of Mine
TCEQ ESL	Texas Commission on Environmental Quality Effects Screening Level
USEPA	United States Environmental Protection Agency
Vic EPA	Environment Protection Authority Victoria
WRD	Waste Rock Dump

Term	Definition
Ambient Air	Ambient air is the outdoor air in which humans and other organisms live and breathe.
Averaging period	Length of time over which an average of that data is taken. For example; if temperatures are measured once every minute over a day, a 1-hour averaging period is obtained by averaging sixty consecutive 1-minute measurements.
Background levels	Existing concentrations of pollutants in ambient air.
CALMET	Meteorological model used in conjunction with the CALPUFF dispersion model. CALMET produces 1-hour average wind and temperature fields on a three-dimensional gridded domain.
CALPUFF	A model that characterises the dispersion and deposition of air pollutants in the atmosphere.
Concentration	Concentration is the mass of a pollutant such as particulate matter that is suspended per unit volume of air. Suspended particulate matter in ambient air is usually measured in micrograms per cubic metre ($\mu\text{g}/\text{m}^3$).
Dispersion modelling	Computer based software package used to mathematically simulate plume dispersion under varying atmospheric conditions; used to calculate spatial and temporal fields of concentrations due to emissions from various source types.
Dust deposition rate	Deposition is the mass of particulate matter that settles per unit surface area. Deposited particulate matter is usually measured in grams per square metre per month ($\text{g}/\text{m}^2/\text{month}$) or milligrams per square metre per day ($\text{mg}/\text{m}^2/\text{day}$).
Dust or particulate matter	Dust or particulate matter are terms used to define solid or liquid particles that may be suspended in the atmosphere. Particulate matter is a generic term that is commonly used interchangeably with other terms such as smoke, soot, haze and dust. The potential effect of particulate matter on the environment, human health and amenity depends on the size of the particles, the concentration of particulate matter in the atmosphere and the rate of deposition.
Mixing height	The layer of air through which pollutants are presumed to be mixed, due to convection caused by daytime heating of the earth's surface. The height of this layer of air is measured from the ground to the height of the lowest inversion.
Relative humidity	The amount of water vapour present in air (measured as vapour density or pressure) as a percentage of the maximum amount of vapour that the air could hold at the same temperature. Its maximum value is 100%.
Stability class	Stability is a term applied to the properties of the atmosphere that govern the acceleration of the vertical motion of an air parcel. The acceleration is positive in an unstable atmosphere (turbulence increases), zero when the atmosphere is neutral and negative (deceleration) when the atmosphere is stable (turbulence is suppressed). Atmospheric stability is typically classified under the Pasquill-Gifford scheme, with six main categories designated as A (highly unstable or convective), B (moderately unstable), C (slightly unstable), D (neutral), E (slightly stable) and F (stable).

Term	Definition
Wind speed	The rate of movement of wind in distance per unit of time. When measured by an anemometer, this is a short-term average reading of horizontal wind vector magnitude, usually cited for measurement heights of 10 m.
Wind direction	Australian convention is to report wind direction by the direction from which it originates. For example, wind from the east is reported with a wind direction = 90°.

1. INTRODUCTION

1.1 Project description

Katestone Environmental Pty Ltd (Katestone) was commissioned by Strategic Minerals Corporation to complete an air quality assessment as part of the Environmental Assessment Report (EAR) for the Big Vein South Gold Project (the project).

The project involves the construction and operation of an open cut gold mine on a greenfield site in North Queensland. The project site covers an area of approximately 2,281 ha and is located approximately 100 km north of Richmond and 380 km west of Townsville (Figure 1).

Open cut mining will be conducted using excavators and trucks. Gold ore will be processed on site to produce gold dore (solid bars containing gold alloy). The mine's peak production rate will be up to 1.95 million tonnes per annum (Mtpa) of run of mine (ROM) gold ore, yielding up to approximately 100,000 ounces of gold dore per annum. The mine life will be approximately 11 years.

The following mining and ore processing activities will be undertaken as part of the project:

- Developing three open cut pits, as follows:
 - The main Big Vein South Pit (BVS Pit) located in the centre of the project site (Figure 2). Waste rock from this pit will be hauled by truck and stored in the Central and Southern Waste Rock Dumps (WRDs).
 - Two small satellite pits, BV1 Pit and BV2 Pit, located in the northern part of the project site (Figure 2). Waste rock from these pits will be stored in the Northern WRD.
- Transporting mined ore in haul trucks from the open cut pits to the ROM area ore stockpiles located near the mine processing facilities at the southern end of the project site (Figure 2).
- Processing ore from the BV1 and BV2 Pits in the first 2 years of mining using Heap Leach Pads and gold elution. Processing ore mined from the BVS Pit in an on-site Carbon In-Leach (CIL) Plant from Year 3 onwards. The heap leaching process will generate spent heap leach residues. These residues will be reprocessed in the CIL Plant over the life of the mine. The CIL Plant will generate wet tailings and dewatered tailings. Wet tailings will be pumped to a Tailings Storage Cell. Dewatered tailings will be stored with waste rock in the Central and Southern WRDs.
- Transporting dore bars from the site via plane to a refinery.

The majority of the mine infrastructure will be located at the southern end of the project site (Figure 2). Key mine infrastructure will include ore processing facilities, workshop, warehouse, administration buildings, haul roads and access roads, vehicle servicing, refuelling and wash down facilities, fuel storage facilities, diesel and solar power station, water supply and water management infrastructure. Workforce accommodation and a private airstrip will also be located at the southern end of the project site.

1.2 Scope of works

This study summarises the aspects of the project that may result in emissions to the atmosphere, as well as the legislation, policies and guidelines that are relevant to the management of air emissions in Queensland and Australia.

The key emission to the atmosphere likely to be generated by the project is dust. Heavy metals may be present in small quantities..

Dust emissions would occur as a result of the construction and operation of the project. Combustion gases would also be emitted due to the use of diesel generators, and to a lesser extent, the mining fleet. Elevated levels of these pollutants have the potential to adversely impact the amenity and health of any people living nearby. Dispersion modelling has been conducted to estimate ground-level concentrations of dust, heavy metals and combustion gases associated with the project for assessment against amenity and health objectives.

The report also describes the measures that would be in place to monitor and manage dust emissions from the project.

2. CONSIDERATIONS FOR ASSESSING EMISSIONS TO AIR

Particulate matter (i.e. dust) would be the key air emission generated by activities on the project site. Particulate matter is discussed further in Section 2.1, and other potential pollutants are discussed in Section 2.2. The legislative context, and air quality standards and criteria used in the assessment are presented in Section 2.3.

2.1 Particulate matter

Elevated concentrations of dust have the potential to cause adverse impacts on the amenity and health of people living in the vicinity of the mine.

Dust can affect communities in various ways, depending upon the source and size of particles present. Dust typically emitted as a result of mining operations is assessed in terms of total suspended particulates (TSP), dust deposition and particulate matter with an aerodynamic diameter less than 10 micrometres (PM₁₀).

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

Smaller particles such as PM₁₀ can also be generated through mining activities. Elevated levels of PM₁₀ have the potential to affect human health as these particles can be trapped in the nose, mouth or throat, or be drawn into the lungs.

Very fine particles such as particulate matter with an aerodynamic diameter less than 2.5 micrometres (PM_{2.5}), are mostly generated through combustion processes and vehicle exhaust rather than through mining activities. The PM_{2.5} emissions anticipated to be generated by the project would be due to the exhaust emissions from the generators, and to a lesser extent, the mining vehicle fleet. The emissions of PM_{2.5} that may be generated by the mining fleet are considered negligible and have not been considered further.

2.2 Other pollutants

There are trace amounts of boron, cobalt, lead, manganese, nickel, arsenic, hexavalent chromium, copper, selenium, zinc and cadmium in the ore, waste rock, tailings and heap leach. Whilst the emissions of the metals due to the project are expected to be small, emissions of metals have been included in this assessment for completeness.

The use of diesel for power generation would give rise to emissions of pollutants due to the combustion of diesel fuel. Key pollutants that have been considered in this assessment include oxides of nitrogen (NO_x), oxides of sulfur (SO_x), carbon monoxide (CO), and particulates.

Trace emissions of these pollutants would also occur due to the combustion of fuels in vehicles on the project site. These emissions are expected to be negligible and have not been considered further in this assessment.

2.3 Air quality objectives

The *Environmental Protection Act 1994* (EP Act) provides for the management of the air environment in Queensland. The EP Act gives the Department of Environment, Tourism, Science and Innovation (DETSI) the power to create Environmental Protection Policies that identify, and aim to protect, environmental values of the atmosphere that are conducive to the health and well-being of humans and biological integrity. The *Environmental Protection (Air) Policy* (Air EPP) was made under the EP Act and gazetted in 1997; the Air EPP was revised and reissued in 2019. An amendment to the Air EPP was introduced in 2024 as the *Environmental Protection (Air)*

Amendment Policy 2024, that updates air quality objectives to align with variations to the National Environment Protection Council's (NEPC's) Ambient Air Quality National Environment Protection Measure (Air NEPM).

The objective of the Air EPP is to identify the environmental values of the air environment to be enhanced or protected and to achieve the objective of the EP Act, that is, ecologically sustainable development.

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

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

The administering authority must consider the requirements of the Air EPP when it decides an application for an environmental authority, amendment of a licence or approval of a draft environmental management plan. Schedule 1 of the Air EPP specifies air quality indicators and objectives for a range of contaminants that may be present in the air environment.

The NEPC defines national ambient air quality standards and goals in consultation, and with agreement from all Australian state and territory governments. These were first published in 1998 in the Air NEPM and last varied in 2021. The NEPM contains, amongst other parameters, standards for particulates and combustion products. Compliance with the Air NEPM standards is determined by ambient air quality monitoring undertaken at locations prescribed by the Air NEPM and that are representative of large urban populations. The goal of the Air NEPM is to monitor and improve ambient air quality. Whilst the Air NEPM is relevant to ambient air quality levels rather than the assessment of emissions from individual facilities, a number of Australian states have adopted the Air NEPM standards as assessment criteria for air quality objectives. The air quality objectives contained in Queensland's Air EPP are consistent with those in the Air NEPM.

Also relevant is the *Application requirements for activities with impacts to air* (DETSI, 2025) (Application Requirements) which specifies the information to be provided to DETSI as part of the application process for environmentally relevant activities and how the information is used. The Application Requirements outlines how the proposed activity would be assessed by comparison with the requirements stipulated in the EP Act. In particular an application should include, if applicable:

- description of the site and surrounding areas, including topography, prevailing winds and ambient air quality (Section 4.1, 4.3 and 4.4);
- identification of any nearby sensitive places must be identified and assessed appropriately (Section 4.2);
- identification and evaluation of possible impacts on air quality (Section 6); and
- proposed management (Section 6.3)

The Application Requirements also indicates that if a guideline is known of for pollutants not covered by the Air EPP that guideline should be applied. In this instance, for metals not covered by the Air EPP, objectives have been adopted from the Environmental Protection Authority (EPA) Victoria Publication 1961 and the Texas Commission on Environmental Quality (TCEQ) Effects Screening Levels (ESL) (<https://www.tceq.texas.gov/toxicology/esl>). This air quality assessment has been conducted in accordance with these requirements.

The air quality objectives relevant to the key air pollutants that may be generated from the project are presented in Table 1.

Table 1 Air quality objectives used in the assessment

Pollutant	Environmental value	Averaging period	Air quality objective ^a (µg/m ³)
TSP	Health and wellbeing	1-year	90
PM ₁₀	Health and wellbeing	24-hour	50
		1-year	25
PM _{2.5}	Health and wellbeing	24-hour	20
		1-year	7
Dust deposition	Amenity	1-month	120 mg/m ² /day ^b
Nitrogen dioxide (NO ₂)	Health and wellbeing	1-hour	164
		1-year	31
	Health and biodiversity of ecosystems	1-year	33
Sulfur dioxide (SO ₂)	Health and wellbeing	1-hour	214
		24-hour	57
	Protecting agriculture	1-year	31
	Health and biodiversity of ecosystems (for forests and natural vegetation)	1-year	21
Carbon monoxide (CO)	Health and wellbeing	8-hour	11,000
Heavy metals ^c			
Arsenic	Health and wellbeing	1-year	6 ng/m ³
Boron	Health	1-hour	50 ^e
		1-year	5 ^e
Cadmium	Health and wellbeing	1-year	5 ng/m ³
Chromium (VI)	Human health impacts	1-hour	1.3 ^d
		1-year	0.005 ^d
Cobalt	Health	1-hour	0.21 ^e
		1-year	0.0017 ^e
Copper	Human health impacts	1-hour	10 ^d
Manganese	Health and wellbeing	1-year	0.16
Nickel	Health and wellbeing	1-year	22 ng/m ³
Lead (measured as total metal content in TSP)	Health and wellbeing	1-year	0.5
Selenium	Health	1-hour	2 ^e
		1-year	0.2 ^e
Zinc	Human health impacts	1-hour	20 ^d
		1-year	2 ^d

Note:

^a Air EPP objective, unless otherwise specified

^b The dust deposition guideline is not defined in the Air EPP. DES's Model Mining Conditions (DES, 2017) contains this guideline for dust deposition, which applies to total insoluble solids.

^c Heavy metals are measured as the total metal content in PM₁₀, unless otherwise specified

^d Environment Protection Authority Victoria (Vic EPA) air pollution assessment criteria, from *Guideline for assessing and minimising air pollution in Victoria*

^e Texas Commission Environmental Quality (TCEQ) Effects Screening Levels (ESLs) – interim levels

3. AIR QUALITY ASSESSMENT METHODOLOGY

3.1 Meteorology

The prognostic model TAPM (The Air Pollution Model) (CSIRO, 2006) was used in conjunction with local observations of meteorological data to represent wind flows in the region. The CALMET model was then used to generate a finer resolution dataset for use in the dispersion modelling.

Appendix A provides details of the generation of the site-specific meteorological dataset, including:

1. Selection of a modelling time period;
2. TAPM and CALMET model configurations; and
3. Discussion of meteorological parameters that drive the dispersion model (i.e. wind speed and direction, mixing heights, atmospheric stability).

3.2 Assessment scenarios

Based on a review of the proposed mining schedule, annual production schedule and the relative location of the closest sensitive receptors, Project Years 1, 5 and 11 were identified as being likely to generate the worst case potential for dust impacts over the life of the project. Project year 11 is a proxy of the year 10 mining volumes and the year 11 operational areas, to ensure that a high mining rate was paired with highest exposed operational areas.

In summary, Project Years 1, 5 and 11 were selected for detailed consideration for the following reasons:

Project Year 1

- Involves the highest waste rock removal volumes, and associated truck movements in the first two years when the BV1 and BV2 pits are being mined;
- Mining operations occur in BV1 pit the northern most pit meaning that this year is likely to be representative of the worst case potential impacts for the Middle Park Homestead located to the northwest; and
- Involves the highest transport of waste rock to the Northern WRD, also impacting the Middle Park Homestead.

Project Year 5

- Involves the highest ore removal volumes over the life of the project;
- Mining operations are occurring only in the BVS pit, with a relatively large waste rock removal volume, meaning that this year is likely to be representative of the worst case potential impacts for the Mt Norman Homestead to the south; and
- Involves 100% transport of waste rock to the Central WRD, also impacting the Mt Norman Homestead.

Project Year 11

- Involves 100% transport of waste rock to the Southern WRD; and
- Has the largest area of active waste rock emplacements over the life of the project exposed to wind erosion.

Detailed dust emissions inventories were prepared for Project Years 1, 5 and 11 (Section 5.2). It is expected that other years would have reduced dust levels at sensitive receptors, compared to the selected project years.

Heavy metals emissions and results were presented based on the Year 5 dust inventory, deemed as the worst-case scenario in terms of impacts at receptors. Compliance with the heavy metals objectives for Year 5 operations will demonstrate compliance across all project years.

3.3 Emission rates

Emission rates of dust associated with mining activities have been estimated, accounting for proposed emission controls, using emission factors published in authoritative sources including the National Pollutant Inventory (NPI) Handbooks or the USEPA AP42 Emission Estimation Manuals (NPI, 2012; USEPA, 1998). Emission rates of key exhaust pollutants due to combustion of diesel in the generators have also been estimated using emission factors for stationary large (greater than 450 kW) diesel engines from the NPI (NPI, 2008), with the total generator capacity being 8,750 kW. Emission rates associated with gold ore processing have been estimated using emission factors from the NPI (NPI, 2006).

Emission rates of heavy metals considered in the assessment have been estimated using multi-element testing results from sampling of the different material types associated with the project, presented in the document *Geochemistry Report for the Big Vein South Gold Project* (the geochemistry report) (RGS, 2022).

Operating parameters such as throughputs, location of equipment and utilisation rates, were based on information provided by the proponent, as detailed in Appendix B. Details of the methodology and the emission factors used for estimating dust emissions are provided in Appendix C.

Section 5 provides a comprehensive discussion of the sources of dust that were included in the assessment.

3.4 Dispersion modelling

Source characteristics and dust emission rates for each scenario were incorporated into a dispersion modelling study. This was conducted using the CALPUFF dispersion model.

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

Details of the CALPUFF model configuration are provided in Appendix A.

3.5 Limitations of dispersion modelling

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

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

It is important to note that numerical models are based on an approximation of governing equations and will inherently be associated with some degree of uncertainty. The more complex the physical model, the greater the number of physical processes that must be included.

There will be physical processes that are not explicitly accounted for in the model and, in general, these approximations tend to lead to an over-prediction of air pollutant levels. For example, in the real world when a plume of dust reaches an area of sloping terrain, mass from the plume will be removed through impaction on the surface. However, in a dust model, the dust plume is treated as a gas and the plume will pass over or around the

obstacle with no loss of mass. This difference in characterisation can lead to an over-prediction of dust levels downwind from the source.

3.6 Presentation of results

Modelling results have been presented as ground-level concentrations or dust deposition rates at sensitive receptors as well as contours across the modelling domain.

3.7 Impact assessment

The dispersion modelling results have been added to ambient background concentrations (where applicable) and then assessed against the relevant air quality criteria.

4. EXISTING ENVIRONMENT

4.1 Local terrain and land-use

Figure 3 illustrates terrain in the vicinity of the project. The terrain of the project site rises gently from the southwest towards the Blackbraes National Park to the northeast. As a consequence, there is a gentle rise across the project site increasing towards the northern extents of the project boundary with elevations ranging from 375 to 425 m Australian Height Datum (AHD). The key significant terrain feature within the vicinity of the project is the Woolgar River that runs along the western edge of the project site boundary.

4.2 Sensitive receptors

There are three sensitive receptors in the vicinity of the project, and these have been included as discrete receptors in the dispersion modelling. The locations of the sensitive receptors are presented in Table 2 and Figure 4.

Table 2 **Nearest sensitive receptors to the Big Vein South Gold Project**

ID	Description	Easting (m)	Northing (m)	Distance and direction from the project site
R1	Barns House	744,624	7,812,087	3 km NE
R2	Middle Park Homestead	739,457	7,810,681	1.1 km NW
R3	Mt Norman Homestead	728,026	7,801,787	8.4km SW

4.3 Climate and meteorology

The local meteorological conditions are important for an assessment of potential air quality impacts associated with a project as they dictate the direction of transport, the magnitude of pollutant concentrations, and where and when the higher concentrations are likely to occur. The Big Vein South Gold Project is located approximately 100 km north of Richmond, Queensland. The Bureau of Meteorology (BoM) station at Richmond airport, located approximately 115 km from the project site, is the closest meteorological station with hourly measurements of wind speed and direction.

The climate in the project region is tropical with distinct wet and dry seasons. The active phases of the monsoon play a role in the seasons and climate of the region. The monsoon occurs from November to April, resulting from a seasonal reversal of winds that occurs over parts of the tropics. The monsoon results in a zone of low pressure and rising air, bringing heavy rainfall to northern Australia.

4.3.1 Temperature

The mean daily temperature recorded at the Richmond Airport BoM station for the years 1998 to 2021, is presented in Figure 5 and Table 3. The mean recorded daily maximum temperature ranges from 26.7 to 38.5°C. The mean minimum temperature ranges from 9.1 to 23.7°C.

Table 3 Mean daily maximum and minimum temperatures at the Richmond Airport BoM station (1998 to 2021)

Mean maximum temperature (°C)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
37.0	36.2	35.6	33.5	29.7	26.7	27.0	29.2	33.4	36.7	38.0	38.5	33.4
Mean minimum temperature (°C)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
23.7	22.9	21.3	17.9	13.2	10.2	9.1	10.0	14.8	19.0	21.8	23.5	17.2

4.3.2 Relative humidity

The availability of atmospheric moisture is an important factor that influences the climate by affecting the transfer of heat in the atmosphere through the balance between sensible and latent heat fluxes, and the occurrence of precipitation. Relative humidity is one of several measures used to describe the quantity of moisture in the atmosphere and is the ratio of the actual amount of moisture in the atmosphere to the maximum amount that could be held, at a given temperature.

The mean monthly 9am and 3pm relative humidity recorded at the Richmond Airport BoM station for the years 1998 to 2010, are presented in Figure 6 and Table 4. The 9am relative humidity ranges from 32% in October to 60% in February. The mean relative humidity for 3pm ranges from 17% in October to 40% in February.

Table 4 Mean recorded 9am and 3pm relative humidity at the Richmond Airport BoM station (1998 to 2010)

Mean 9am relative humidity (%)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
59	60	53	51	51	55	50	44	37	32	39	44	48
Mean 3pm relative humidity (%)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
38	40	30	30	27	29	24	21	18	17	23	27	27

4.3.3 Rainfall

The mean and maximum monthly rainfall recorded at the Richmond Airport BoM station for the years 1998 to 2021, are presented in Figure 7 and Table 5. The mean monthly rainfall ranges from 3.8 mm in September to 122.7 mm in January. The highest monthly rainfall of 496 mm was recorded in February 2019.

Table 5 Mean and highest recorded rainfall at the Richmond Airport BoM station (1998 to 2021)

Mean rainfall (mm)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
122.7	99.8	61.2	25.6	7.5	14.8	10.0	4.0	3.8	10.2	44.7	63.2	463.0
Highest rainfall (mm)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
324.6	496.0	181.2	190.6	36.0	146.0	127.8	39.6	38.6	69.8	183.4	213.8	854.6

4.3.4 Wind speed and wind direction

The wind speed distributions recorded at the Richmond Airport BoM site between 2013 and 2020 are presented in Figure 8.

On average, during the wet season 60% of winds at the Richmond Airport BoM station are from the southeast quartile. The winds are predominately moderate between 3 and 7 m/s, averaging 4.3 m/s, with a maximum 30-minute average of 16.6 m/s.

4.4 Existing air quality

4.4.1 Existing sources of emissions

The project site is remote and located within large cattle grazing properties. The region is sparsely populated with only three homesteads located within 10 km of the project site. Ambient levels of air pollutants across the area will therefore be predominately influenced by wind erosion and bushfires.

A review of NPI database for the 2023/2024 reporting year indicated that no reporting facilities were within 100km of the project site. It is unlikely that surrounding facilities outside of this radius will have influence on the air quality for sensitive receptors surrounding the project site.

4.4.2 Existing ambient air quality

DETSI operates a network of ambient air quality monitoring stations throughout Queensland. The project is located at a greenfield site in Woolgar and there are no existing industrial facilities within 100 km. The nearest monitoring sites to the project are located in Townsville and Mt Isa. Given that Mt Isa is surrounded by large mining operations it is not representative of the project site. Similarly, other outback sites like Emerald, Moranbah, Bluff and Blackwater have also been excluded due to the heavy presence of mining operations. Within the Townsville monitoring network, the North Ward monitoring station has been selected as it is not located to monitor industrial activities. The validated datasets were downloaded from DETSI's Open Data Portal (<https://www.data.qld.gov.au/dataset?q=%22air%20quality%20monitoring%22>). This site been considered as the most representative of the project site. The North Ward monitoring station has been established by DETSI as an Air NEPM reporting station and therefore monitoring must be conducted in accordance with the requirements of the NEPM. This site is expected to provide a conservative estimate of ambient background as it is located in residential areas that would have higher levels of air pollutants due to anthropogenic activities such as motor vehicle use than would occur in the project area.

Ambient concentrations of NO₂, SO₂, PM_{2.5} and PM₁₀ measured at North Ward from 2017 to 2024 are presented in Table 6 to Table 9, respectively. Heavy metals are not monitored.

Table 6 Concentrations of nitrogen dioxide measured in the surrounding environment

Year	Nitrogen dioxide (µg/m³)			
	1-hour average			Annual average
	Maximum	95 th percentile	70 th percentile	
2017	10.3	7.4	3.28	NA
2018	47.2	14.4	4.1	4.6
2019	84.1	14.4	6.15	5.3
2020	49.2	12.3	4.1	4.5
2021	53.3	12.3	6.15	5.3
2022	49.2	14.4	6.15	5.5
2023	55.4	12.3	6.15	5.0
2024	51.3	12.3	6.15	4.9
Air EPP objective	164 ^a			31 ^a / 33 ^b
Table note:				
NA – not available. Data capture during 2016 and 2017 was low.				
^a Objective for health and wellbeing, Air EPP 2019/Air NEPM 2021				
^b Objective for health and biodiversity of ecosystems, Air EPP 2019.				

Table 7 Concentrations of sulfur dioxide measured in the surrounding environment

Year	Sulfur dioxide (µg/m ³)						
	1-hour average			24-hour average			Annual average
	Maximum	95 th percentile	70 th percentile	Maximum	95 th percentile	70 th percentile	
2017	11.4	2.9	0.0	2.4	1.8	0.7	NA
2018	25.7	2.9	2.9	5.3	3.2	2.2	1.5
2019	28.6	2.9	2.9	5.8	2.9	1.5	1.1
2020	8.6	2.9	2.9	3.1	2.6	1.7	1.0
2021	25.7	2.9	0.0	2.6	1.5	0.5	0.4
2022	17.2	2.9	0.0	2.3	1.3	0.5	0.4
2023	14.3	2.9	0.0	3.3	2.2	0.8	0.7
2024	14.3	2.9	0.0	2.6	1.1	0.2	0.2
Air EPP objective	214 ^a			57 ^a			31 ^b / 21 ^c
Table note: NA – not available. Data capture during 2016 and 2017 was low. ^a Objective for health and wellbeing, Air EPP 2019/Air NEPM 2021 ^b Objective for protecting agriculture, Air EPP 2019. ^c Objective for health and biodiversity of ecosystems (for forests and natural vegetation). Air EPP 2019.							

Table 8 Concentrations of PM_{2.5} measured in the surrounding environment

Year	PM _{2.5} (µg/m ³)			
	24-hour average			Annual average
	Maximum	95 th percentile	70 th percentile	
2017	7.6	6.5	5.2	NA
2018	30.7	9.2	5.9	5.6
2019	51.5	13.7	7.5	7.1
2020	17.4	9.4	6.6	5.8
2021	15.3	9.0	6.7	5.8
2022	26.3	8.8	6.6	5.8
2023	27.2	10.6	6.5	6.2
2024	14.5	8.5	6.4	5.6
Air EPP objective	20 ^a			7 ^a
Table note: NA – not available. Data capture during 2016 and 2017 was low. ^a Objective for health and wellbeing.				

Table 9 **Concentrations of PM₁₀ measured in the surrounding environment**

Year	PM ₁₀ (µg/m ³)			
	24-hour average			Annual average
	Maximum	95 th percentile	70 th percentile	
2017	20.8	17.8	14.5	NA
2018	42.3	23.4	16.3	15.0
2019	277.4	33.2	21.1	20.2
2020	35.6	26.8	18.3	16.1
2021	60.0	25.8	18.7	16.3
2022	41.1	23.8	17.5	15.2
2023	47.3	26.7	18.1	16.2
2024	39.9	24.0	17.7	15.6
Air EPP objective	50 ^a			25 ^a
Table note: NA – not available. Data capture during 2016 and 2017 was low. ^a Objective for health and wellbeing.				

4.4.3 Summary of ambient air quality

Ambient background concentrations selected for use in the air quality assessment are presented in Table 10. It is noted that 2019 data is excluded from the selection of representative backgrounds for annual and 24-hour PM₁₀ and PM_{2.5}, as this was an atypical year whereby concentrations of particulates were elevated due to bushfire events and regional windblown dust.

Table 10 Ambient background concentrations selected for use in the air quality assessment

Pollutant	Averaging period	Ambient background (ug/m ³)	Source
PM ₁₀	24-hour	18.7	Highest 70 th percentile from 2017 to 2024, from North Ward monitoring station (excluding 2019)
	Annual	16.3	Highest annual average from 2017 to 2024, from North Ward monitoring station (excluding 2019)
PM _{2.5}	24-hour	6.7	Highest, 70 th percentile from 2017 to 2024, from North Ward monitoring station (excluding 2019)
	Annual	6.2	Highest annual average from 2017 to 2024, from North Ward monitoring station (excluding 2019)
TSP	Annual	32.5	Derived from PM ₁₀ using PM ₁₀ to TSP ratio of 0.5 for rural areas
Dust deposition	Monthly	40 mg/m ² /day	Based on experience
NO ₂	1-hour	14.4	Highest, 95 th percentile from 2017 to 2024, from North Ward monitoring station
	Annual	5.5	Highest annual from 2017 to 2024, from North Ward monitoring station
SO ₂	1-hour	2.9	Highest, 95 th percentile from 2017 to 2024, from North Ward monitoring station
	24-hour	2.2	Highest, 70 th percentile from 2017 to 2024, from North Ward monitoring station
	Annual	1.5	Highest annual average from 2017 to 2024, from North Ward monitoring station

5. EMISSIONS TO THE ATMOSPHERE

5.1 Construction phase activities

The construction phase of the project has the potential to cause elevated levels of dust if not managed appropriately. Construction phase activities at the project site can be broadly described as:

- Site clearance of areas, including vegetation clearance;
- Excavation and stockpiling of topsoil and subsoil;
- Earthworks associated with the construction of the haul roads, mine infrastructure and mine water dams;
- Civil works including temporary and permanent drainage works; and
- Structure and plant erection and installation.

5.2 Operation phase activities

The operational phase of the project would generate dust emissions and combustion related air pollutants. Key activities include:

- Waste rock and ore excavation, dozing and handling;
- Wheel generated dust due to transport of material across the mine site on unsealed haul roads;
- Wind erosion of exposed areas, including pits, WRDs and stockpiles;
- Transfer of ore to the processing plant, heap leach pads, tailings storage cell; and
- Crushing and sag milling of ore in the processing plant.

5.3 Emissions inventory

Emissions of dust to the atmosphere are likely to be produced during the construction and operation of the project. Dust emissions will be generated through handling and transportation of waste rock and ore, as well as gold ore processing. Wind erosion of exposed areas including cleared areas, WRDs and stockpiles will also generate dust emissions. The project involves limited and relatively minor construction activities including haul road construction, stockpile pad construction, drainage and water management infrastructure construction, and construction of an airstrip. Dust emissions associated with construction activities will be significantly lower than operational emissions from open cut mining and, consequently, construction emissions have not been explicitly quantified.

The project is expected to operate for 11 years with a peak extraction rate of approximately 1.95 Mtpa of Gold ore. The emissions inventory has been constructed for three operational years: Project Years 1, 5 and 11, presented in Table 11 to Table 13. The layout plans for the project in each of these years are shown in Figure 9 to Figure 11.

Emissions from the generators have been assumed to occur continuously at maximum load, presented in Table 14. Stack characteristics used in the dispersion modelling of emissions from the generators were assumed based on Katestone's experience with similar generators, and are shown in Table 15.

Heavy metal emissions have been quantified based on the Year 5 dust inventory. Emissions were calculated as the metal content in PM₁₀ emissions (excluding lead, which is calculated as the total metal content in TSP as per the Air EPP), derived from sampling concentrations of metals within the different material types (waste rock, tailings, spent heap leach residue and high-grade ore) presented in the geochemistry report (RGS, 2022) and summarised in Table B3. The heavy metals emissions inventory is presented in Table 16.

The key measures to control emissions of dust include watering of all haul roads and progressive rehabilitation of exposed areas. Consequently, the following control measures and reduction factors have been accounted for when estimating dust emissions:

- 50% reduction in wheel generated dust due to Level 1 watering on all haul routes;
- 40% reduction in wind erosion from areas with partial rehabilitation;
- 40% reduction in emission due to crushing as the operation is partially enclosed; and
- 99% reduction in emissions generated from drilling due to the application of fabric filters.

Operating parameters, such as extraction rates, equipment locations and utilisation rates were based on information provided by the proponent. These are detailed in Appendix B. Other factors that determine dust emissions are the ore and waste rock moisture and silt contents as well as the mitigation measures that may be employed. These key factors have been accounted for in estimating the dust emissions for the project.

Further details of the methodology and the emission factors used for estimating dust emissions are provided in Appendix C.

Table 11 Project Year 1 - Estimated dust emission rates

Activity	Emission Rate (g/s)		
	TSP	PM ₁₀	PM _{2.5}
BV1 Pit			
<i>Drilling / Blasting</i>	0.2	0.1	0.005
<i>Waste rock excavation</i>	0.006	0.003	0.0004
<i>Waste rock dozing</i>	0.09	0.02	0.010
<i>Waste rock haulage to dump</i>	0.6	0.2	0.02
<i>Ore excavation</i>	0.0007	0.0003	0.0001
<i>Ore haulage to plant</i>	0.39	0.11	0.01
BVS Pit			
<i>Drilling / Blasting</i>	3.8	2.0	0.1
<i>Waste rock excavation</i>	0.15	0.07	0.01
<i>Waste rock dozing</i>	0.4	0.07	0.04
<i>Waste rock haulage to dump</i>	27.8	7.9	0.8
<i>Ore excavation</i>	0.002	0.001	0.0002
<i>Ore haulage to plant</i>	0.6	0.2	0.02
Beneficiation plant			
<i>Product handling</i>	0.12	0.02	0.01
<i>Crushing</i>	0.6	0.2	0.05
Grading of ore/waste rock haul	0.6	0.2	0.02
Wind erosion			
<i>Exposed areas pits and dumps</i>	2.9	1.4	0.2
<i>Stockpiles</i>	3.3	1.7	0.2
<i>Heap leach pads</i>	0.2	0.1	0.01
<i>Tailings storage cell</i>	0.2	0.1	0.02
<i>ROM</i>	0.3	0.2	0.02
Power generation			
<i>Diesel generators</i>	1.0	1.0	1.0
TOTAL	43.1	15.5	2.6

Table 12 **Project Year 5 - Estimated dust emission rates**

Activity	Emission Rate (g/s)		
	TSP	PM ₁₀	PM _{2.5}
BVS Pit			
<i>Drilling / Blasting</i>	3.9	2.0	0.1
<i>Waste rock excavation</i>	0.1	0.1	0.01
<i>Waste rock dozing</i>	0.4	0.07	0.04
<i>Waste rock haulage to dump</i>	35.0	10.0	1.0
<i>Ore excavation</i>	0.01	0.01	0.001
<i>Ore haulage to plant</i>	4.3	1.2	0.1
Beneficiation plant			
<i>Product handling</i>	0.12	0.02	0.01
<i>Crushing</i>	2.6	1.0	0.22
Grading of ore/waste rock haul	0.6	0.2	0.02
Wind erosion			
<i>Exposed areas pits and dumps</i>	4.3	2.1	0.3
<i>Stockpiles</i>	4.4	2.2	0.3
<i>Heap leach pads</i>	0.2	0.1	0.01
<i>Tailings storage cell</i>	0.2	0.1	0.02
<i>ROM</i>	0.3	0.2	0.02
<i>Rehabilitated (40%)</i>	0.3	0.1	0.02
Power generation			
<i>Diesel generators</i>	1.0	1.0	1.0
TOTAL	57.7	20.4	3.2

Table 13 Project Year 11 - Estimated dust emission rates

Activity	Emission Rate (g/s)		
	TSP	PM ₁₀	PM _{2.5}
BVS Pit			
<i>Drilling / Blasting</i>	3.9	2.0	0.1
<i>Waste rock excavation</i>	0.02	0.01	0.001
<i>Waste rock dozing</i>	0.2	0.03	0.02
<i>Waste rock haulage to dump</i>	6.2	1.8	0.2
<i>Ore excavation</i>	0.012	0.006	0.001
<i>Ore haulage to plant</i>	4.9	1.4	0.14
Beneficiation plant			
<i>Product handling</i>	0.12	0.02	0.013
<i>Crushing</i>	2.6	1.0	0.22
Grading of ore/waste rock haul	0.4	0.1	0.01
Wind erosion			
<i>Exposed areas pits and dumps</i>	6.7	3.4	0.5
<i>Stockpiles</i>	2.5	1.3	0.2
<i>Heap leach pads</i>	0.2	0.1	0.01
<i>Tailings storage cell</i>	0.2	0.1	0.02
<i>ROM</i>	0.3	0.2	0.02
<i>Rehabilitated (40%)</i>	2.3	1.1	0.2
Power generation			
<i>Diesel generators</i>	1.0	1.0	1.0
TOTAL	31.6	13.6	2.7

Table 14 Emission rates for combustion gases

Location	Emission rate (g/s)		
	NO _x	SO ₂	CO
<i>Diesel generators (total)</i>	36.5	0.012	8.0

Table 15 Stack characteristics for diesel generators

Parameter	Generators	
	Value	Units
<i>Stack height</i>	5.5	m
<i>Exit temperature</i>	462	°C
<i>Exit velocity</i>	30	m/s
<i>Stack diameter</i>	0.5	m

Table 16 Estimated heavy metals emission rates

Activity	Emission Rate (g/s)										
	Arsenic	Boron	Cadmium	Chromium (VI)	Cobalt	Copper	Manganese	Nickel	Lead	Selenium	Zinc
BVS Pit											
<i>Drilling / Blasting</i>	5.7E-05	2.2E-05	1.1E-05	5.6E-05	2.9E-05	7.6E-05	1.5E-03	5.7E-05	7.9E-04	4.8E-07	4.5E-04
<i>Waste rock excavation</i>	1.5E-06	5.8E-07	2.8E-07	1.5E-06	7.6E-07	2.0E-06	4.0E-05	1.5E-06	2.3E-05	1.2E-08	1.2E-05
<i>Waste rock dozing</i>	1.9E-06	7.1E-07	3.4E-07	1.8E-06	9.4E-07	2.5E-06	5.0E-05	1.9E-06	7.4E-05	1.5E-08	1.5E-05
<i>Waste rock haulage (dump)</i>	2.8E-04	1.1E-04	5.2E-05	2.7E-04	1.4E-04	3.7E-04	7.5E-03	2.8E-04	7.0E-03	2.3E-06	2.2E-03
<i>Ore excavation</i>	4.9E-07	5.8E-08	2.6E-08	5.2E-08	7.5E-08	3.1E-07	1.8E-06	1.6E-07	2.5E-06	1.2E-09	1.5E-06
<i>Ore haulage to plant</i>	3.5E-05	1.3E-05	6.4E-06	3.4E-05	1.8E-05	4.6E-05	9.3E-04	3.5E-05	8.7E-04	2.9E-07	2.7E-04
Beneficiation plant											
<i>Product handling</i>	2.1E-06	2.5E-07	1.1E-07	3.1E-07	3.2E-07	1.3E-06	7.8E-06	7.1E-07	2.6E-05	4.9E-09	6.6E-06
<i>Crushing</i>	8.1E-05	9.6E-06	4.4E-06	8.7E-06	1.2E-05	5.2E-05	3.0E-04	2.6E-05	5.3E-04	1.9E-07	2.5E-04
Grading of ore/waste rock haul	5.5E-06	2.1E-06	1.0E-06	5.4E-06	2.8E-06	7.3E-06	1.5E-04	5.5E-06	1.1E-04	4.6E-08	4.3E-05
Wind erosion											
<i>Exposed areas</i>	6.0E-05	2.3E-05	1.1E-05	5.8E-05	3.0E-05	7.9E-05	1.6E-03	6.0E-05	8.4E-04	5.0E-07	4.7E-04
<i>Stockpiles</i>	4.2E-05	1.6E-05	7.8E-06	4.1E-05	2.1E-05	5.6E-05	1.1E-03	4.2E-05	6.0E-04	3.5E-07	3.3E-04
<i>Heap leach pads</i>	1.2E-05	9.5E-07	2.9E-07	2.9E-06	1.3E-06	2.7E-06	7.8E-05	2.4E-06	8.1E-05	2.8E-08	2.2E-05
<i>Tailings storage cell</i>	7.3E-06	1.1E-06	9.6E-07	2.1E-05	9.5E-07	5.6E-06	4.8E-05	1.2E-05	9.7E-05	2.1E-08	5.3E-05
<i>ROM</i>	7.2E-05	8.6E-06	3.9E-06	7.7E-06	1.1E-05	4.6E-05	2.7E-04	2.3E-05	3.5E-04	1.7E-07	2.3E-04
<i>Rehabilitated (40%)</i>	3.2E-06	1.4E-06	2.6E-08	4.6E-06	1.6E-06	3.1E-06	6.0E-05	3.4E-06	5.1E-06	3.2E-08	1.7E-05
TOTAL	6.6E-04	2.1E-04	9.8E-05	5.2E-04	2.7E-04	7.5E-04	1.4E-02	5.5E-04	1.1E-02	4.5E-06	4.4E-03

6. IMPACT ASSESSMENT

6.1 Project and ambient background

The CALPUFF dispersion model has been used to quantify the incremental change in air pollutants and dust associated with the project during Years 1, 5 and 11. Ground-level concentrations of dust associated with the project have been predicted at the sensitive receptors. Ambient background dust levels have been added to the incremental model predictions to obtain an estimate of the potential cumulative impact of the project with existing sources of dust. Air pollutant levels have been assessed by comparing the predicted concentrations and dust deposition rates with the relevant air quality objectives.

Ground-level concentrations of dust and dust deposition rates were also predicted at a network of evenly spaced grid points covering the study region. Contour plots indicative of ground-level concentrations or dust deposition rates due to the project and the ambient background levels are presented in the following sections.

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

6.1.1 Project Year 1

Table 17 and Table 18 provide the predicted ground-level concentrations of key air pollutants and dust deposition rates due to Year 1 of the project in isolation, and due to the project plus ambient background concentration, respectively.

Contour plots of the predicted ground-level concentrations of dust and dust deposition rates are presented in Plate 1 to Plate 6. Predicted ground-level concentrations of NO₂ and SO₂ are presented in Plate 7 to Plate 11.

The results show that ground-level concentrations of all air pollutants and dust deposition rates due to the project plus ambient background levels are predicted to **comply** at all sensitive receptors.

Table 17 Project Year 1 - Predicted ground-level concentrations of dust due to the project in isolation

Receptor		TSP (µg/m³)	PM ₁₀ (µg/m³)		PM _{2.5} (µg/m³)		Dust deposition (mg/m²/day)	NO ₂ (µg/m³)		SO ₂ (µg/m³)		
ID	Description	Annual average	Maximum 24-hour	Annual Average	Maximum 24-hour	Annual Average	Maximum Monthly	Maximum 1-hour	Annual average	Maximum 1-hour	Maximum 24-hour	Annual Average
1	Barnes House	0.1	3.3	0.05	0.6	0.01	0.2	19.0	0.02	0.02	0.001	0.00002
2	Middle Park Homestead	0.7	15.7	0.5	2.3	0.1	1.8	21.9	0.03	0.02	0.001	0.00003
3	Mt Norman Homestead	1.0	10.0	0.8	1.4	0.1	1.7	30.2	0.1	0.03	0.002	0.0001
Objective ^a		90	50	25	20	7	120	164	31	214	57	21 ^b

Table note:

^a Objective for health and wellbeing, Air EPP / Air NEPM 2021.

^b Objective for health and biodiversity of ecosystems (for forests and natural vegetation), Air EPP

Table 18 Project Year 1 - Predicted ground-level concentrations of dust due to the project plus ambient background concentrations

Receptor		TSP (µg/m³)	PM ₁₀ (µg/m³)		PM _{2.5} (µg/m³)		Dust deposition (mg/m²/day)	NO ₂ (µg/m³)		SO ₂ (µg/m³)		
ID	Description	Annual average	Maximum 24-hour	Annual Average	Maximum 24-hour	Annual Average	Maximum Monthly	Maximum 1-hour	Annual average	Maximum 1-hour	Maximum 24-hour	Annual Average
1	Barnes House	32.6	22.0	16.3	7.3	6.2	40.2	33.4	5.52	2.92	2.20	1.50
2	Middle Park Homestead	33.2	34.4	16.8	9.0	6.3	41.8	36.3	5.53	2.92	2.20	1.50
3	Mt Norman Homestead	33.5	28.7	17.1	8.1	6.3	41.7	44.6	5.60	2.93	2.20	1.50
Objective ^a		90	50	25	20	7	120	164	31	214	57	21 ^b

Table note:

^a Objective for health and wellbeing, Air EPP / Air NEPM 2021.

^b Objective for health and biodiversity of ecosystems (for forests and natural vegetation), Air EPP .

6.1.2 Project Year 5

Table 19 and Table 20 provide the predicted ground-level concentrations of key air pollutants and dust deposition rates due to Year 5 of the project in isolation, and due to the project plus ambient background concentration, respectively.

Contour plots of the predicted ground-level concentrations of dust and dust deposition rates are presented in Plate 12 to Plate 17. Contour plots of NO₂ and SO₂ have not been presented as the results are identical to Year 1.

The results show that ground-level concentrations of all air pollutants and dust deposition rates due to the project plus ambient background levels are predicted to **comply** at all sensitive receptors.

Table 19 Project Year 5 - Predicted ground-level concentrations of dust due to the project in isolation

Receptor		TSP (µg/m³)	PM ₁₀ (µg/m³)		PM _{2.5} (µg/m³)		Dust deposition (mg/m²/day)	NO ₂ (µg/m³)		SO ₂ (µg/m³)		
ID	Description	Annual average	Maximum 24-hour	Annual Average	Maximum 24-hour	Annual Average	Maximum Monthly	Maximum 1-hour	Annual average	Maximum 1-hour	Maximum 24-hour	Annual Average
1	Barnes House	0.1	3.9	0.1	0.8	0.01	0.3	19.0	0.02	0.02	0.001	0.00002
2	Middle Park Homestead	0.7	19.6	0.5	3.0	0.1	1.7	21.9	0.03	0.02	0.001	0.00003
3	Mt Norman Homestead	1.4	15.0	1.2	2.3	0.2	2.3	30.2	0.1	0.03	0.002	0.0001
Objective ^a		90	50	25	20	7	120	164	31	214	57	21 ^b

Table note:

^a Objective for health and wellbeing, Air EPP / Air NEPM 2021.

^b Objective for health and biodiversity of ecosystems (for forests and natural vegetation), Air EPP.

Table 20 Project Year 5 - Predicted ground-level concentrations of dust due to the project plus ambient background concentrations

Receptor		TSP (µg/m³)	PM ₁₀ (µg/m³)		PM _{2.5} (µg/m³)		Dust deposition (mg/m²/day)	NO ₂ (µg/m³)		SO ₂ (µg/m³)		
ID	Description	Annual average	Maximum 24-hour	Annual Average	Maximum 24-hour	Annual Average	Maximum Monthly	Maximum 1-hour	Annual average	Maximum 1-hour	Maximum 24-hour	Annual Average
1	Barnes House	32.6	22.6	16.4	7.5	6.2	40.3	33.4	5.52	2.92	2.20	1.50
2	Middle Park Homestead	33.2	38.3	16.8	9.7	6.3	41.7	36.3	5.53	2.92	2.20	1.50
3	Mt Norman Homestead	33.9	33.7	17.5	9.0	6.4	42.3	44.6	5.60	2.93	2.20	1.50
Objective ^a		90	50	25	20	7	120	164	31	214	57	21 ^b

Table note:

^a Objective for health and wellbeing, Air EPP / Air NEPM 2021.

^b Objective for health and biodiversity of ecosystems (for forests and natural vegetation), Air EPP 2019.

6.1.3 Project Year 11

Table 21 and Table 22 provide the predicted ground-level concentrations of key air pollutants and dust deposition rates due to Year 11 of the project in isolation, and due to the project plus ambient background concentration, respectively.

Contour plots of the predicted ground-level concentrations of dust and dust deposition rates are presented in Plate 18 to Plate 23. Contour plots of NO₂ and SO₂ have not been presented as the results are identical to Year 1.

The results show that ground-level concentrations of all air pollutants and dust deposition rates due to the project plus ambient background levels are predicted to **comply** at all sensitive receptors.

Table 21 Project Year 11 - Predicted ground-level concentrations of dust due to the project in isolation

Receptor		TSP (µg/m³)	PM ₁₀ (µg/m³)		PM _{2.5} (µg/m³)		Dust deposition (mg/m²/day)	NO ₂ (µg/m³)		SO ₂ (µg/m³)		
ID	Description	Annual average	Maximum 24-hour	Annual Average	Maximum 24-hour	Annual Average	Maximum Monthly	Maximum 1-hour	Annual average	Maximum 1-hour	Maximum 24-hour	Annual Average
1	Barnes House	0.03	1.5	0.02	0.3	0.01	0.1	19.0	0.02	0.02	0.001	0.00002
2	Middle Park Homestead	0.3	5.2	0.2	1.0	0.03	0.6	21.9	0.03	0.02	0.001	0.00003
3	Mt Norman Homestead	0.5	6.3	0.4	1.2	0.1	0.8	30.2	0.1	0.03	0.002	0.0001
Objective ^a		90	50	25	20	7	120	164	31	214	57	21 ^b

Table note:

^a Objective for health and wellbeing, Air EPP / Air NEPM 2021.

^b Objective for health and biodiversity of ecosystems (for forests and natural vegetation), Air EPP 2019.

Table 22 Project Year 11 - Predicted ground-level concentrations of dust due to the project plus ambient background concentrations

Receptor		TSP (µg/m³)	PM ₁₀ (µg/m³)		PM _{2.5} (µg/m³)		Dust deposition (mg/m²/day)	NO ₂ (µg/m³)		SO ₂ (µg/m³)		
ID	Description	Annual average	Maximum 24-hour	Annual Average	Maximum 24-hour	Annual Average	Maximum Monthly	Maximum 1-hour	Annual average	Maximum 1-hour	Maximum 24-hour	Annual Average
1	Barnes House	32.5	20.2	16.3	7.0	6.2	40.1	33.4	5.52	2.92	2.20	1.50
2	Middle Park Homestead	32.8	23.9	16.5	7.7	6.2	40.6	36.3	5.53	2.92	2.20	1.50
3	Mt Norman Homestead	33.0	25.0	16.7	7.9	6.3	40.8	44.6	5.60	2.93	2.20	1.50
Objective ^a		90	50	25	20	7	120	164	31	214	57	21 ^b

Table note:

^a Objective for health and wellbeing, Air EPP / Air NEPM 2021.

^b Objective for health and biodiversity of ecosystems (for forests and natural vegetation), Air EPP 2019.

6.2 Heavy metals

Table 23 and Table 24 present the predicted ground-level concentrations of key heavy metals due to Year 5 of the project in isolation.

The results show that ground-level concentrations of all heavy metals due to the project are predicted to **comply** at all sensitive receptors.

Predicted concentrations of heavy metals are at most 1.3% of the relevant air quality objectives, for maximum 1-hour average concentrations of cobalt predicted at sensitive receptors. The contour plot for maximum 1-hour cobalt is presented in Plate 24.

Table 23 Project Year 5 - Predicted ground-level concentrations of heavy metals due to the project in isolation

Receptor		Arsenic	Boron	Cadmium	Chromium (VI)		Cobalt	
ID	Description	Annual average	Annual Average	Annual Average	Maximum 1-hour	Annual Average	Maximum 1-hour	Annual Average
1	Barnes House	0.002	0.0000006	0.0003	0.002	0.000002	0.001	0.0000008
2	Middle Park Homestead	0.02	0.000006	0.003	0.005	0.00001	0.003	0.000008
3	Mt Norman Homestead	0.04	0.00001	0.006	0.002	0.00003	0.001	0.00002
Objective ^a		6 ng/m ³	5 µg/m ³ ^b	5 ng/m ³	1.3 µg/m ³ ^c	0.005 µg/m ³ ^c	0.21 ^b	0.0017 ^b
Table note: ^a Objectives for health and wellbeing, Air EPP 2019 unless otherwise stated ^b Texas Commission on Environmental Quality (TCEQ) interim toxicity effect screening level for health ^c Environment Protection Authority Victoria (Vic EPA) air pollution assessment criteria, from <i>Guideline for assessing and minimising air pollution in Victoria</i>								

Table 24 Project Year 5 – Predicted ground-level concentrations of heavy metals due to the project in isolation

Receptor		Copper	Manganese	Nickel	Lead	Selenium		Zinc	
ID	Description	Maximum 1-hour	Annual average	Annual average	Annual average	Maximum 1-hour	Annual average	Maximum 1-hour	Annual Average
1	Barnes House	0.003	0.00004	0.002	0.00002	0.00002	0.00000001	0.02	0.00001
2	Middle Park Homestead	0.007	0.0004	0.01	0.0001	0.00004	0.0000001	0.04	0.0001
3	Mt Norman Homestead	0.003	0.0008	0.03	0.0003	0.00002	0.0000003	0.02	0.0003
Objective ^a		10 µg/m ³ ^c	0.16 µg/m ³	22 ng/m ³	0.5 µg/m ³	2 µg/m ³ ^b	0.2 µg/m ³ ^b	20 µg/m ³ ^c	2 µg/m ³ ^c
Table note: ^a Objectives for health and wellbeing, Air EPP unless otherwise stated ^b Texas Commission on Environmental Quality (TCEQ) interim toxicity effect screening level for health ^c Environment Protection Authority Victoria (Vic EPA) air pollution assessment criteria, from <i>Guideline for assessing and minimising air pollution in Victoria</i>									

6.3 Mitigation and management

The air quality assessment has taken into account a range of mitigation measures, including:

- Watering on all mine truck haul roads;
- Watering of active pit areas;
- The use of fabric filters when drilling;
- Crushing activities are partially enclosed; and
- Progressive rehabilitation.

The assessment predicts that dust emissions from the project can be adequately managed using the above mitigation measures to prevent adverse impacts at sensitive receptors.

7. CONCLUSIONS

Katestone Environmental Pty Ltd (Katestone) was commissioned by Hansen Environmental Consulting on behalf of Strategic Minerals Corporation Pty Ltd to complete an air quality assessment for the Big Vein South Gold Project (the project) as part of the Environmental Assessment Report (EAR).

This assessment was conducted in accordance with recognised techniques for dispersion modelling and emission estimation in order to determine potential impacts to identified sensitive receptors and the surrounding environment.

Potential impacts on air quality were assessed for Project Years 1, 5 and 11, to understand the worst-impacts from the project. The assessment of potential impacts on air quality was conducted based on a dispersion modelling study that incorporates source characteristics, estimated emissions, local meteorology, terrain, land use and the geographical location of sensitive receivers.

The air quality assessment has shown that predicted ground-level concentrations of all air pollutants and dust deposition rates due to the project plus ambient background levels are predicted to **comply** with the relevant air quality objectives at all sensitive receptors for all years modelled.

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9. FIGURES

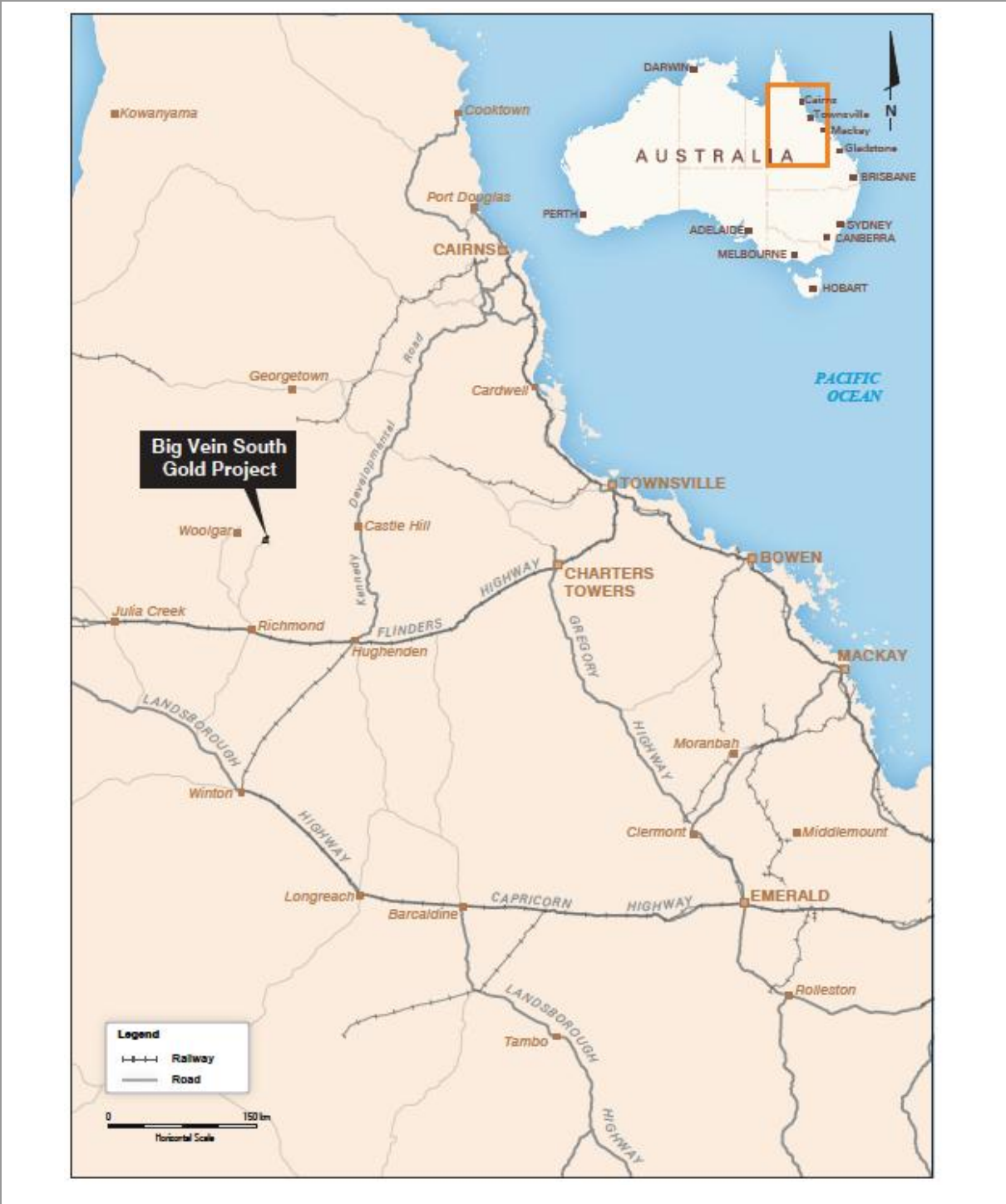


Figure 1 **Big Vein South Gold Project – Overall Project Layout**

Location: Queensland	Data source: Hansen Environmental Consulting	Date: June 2022
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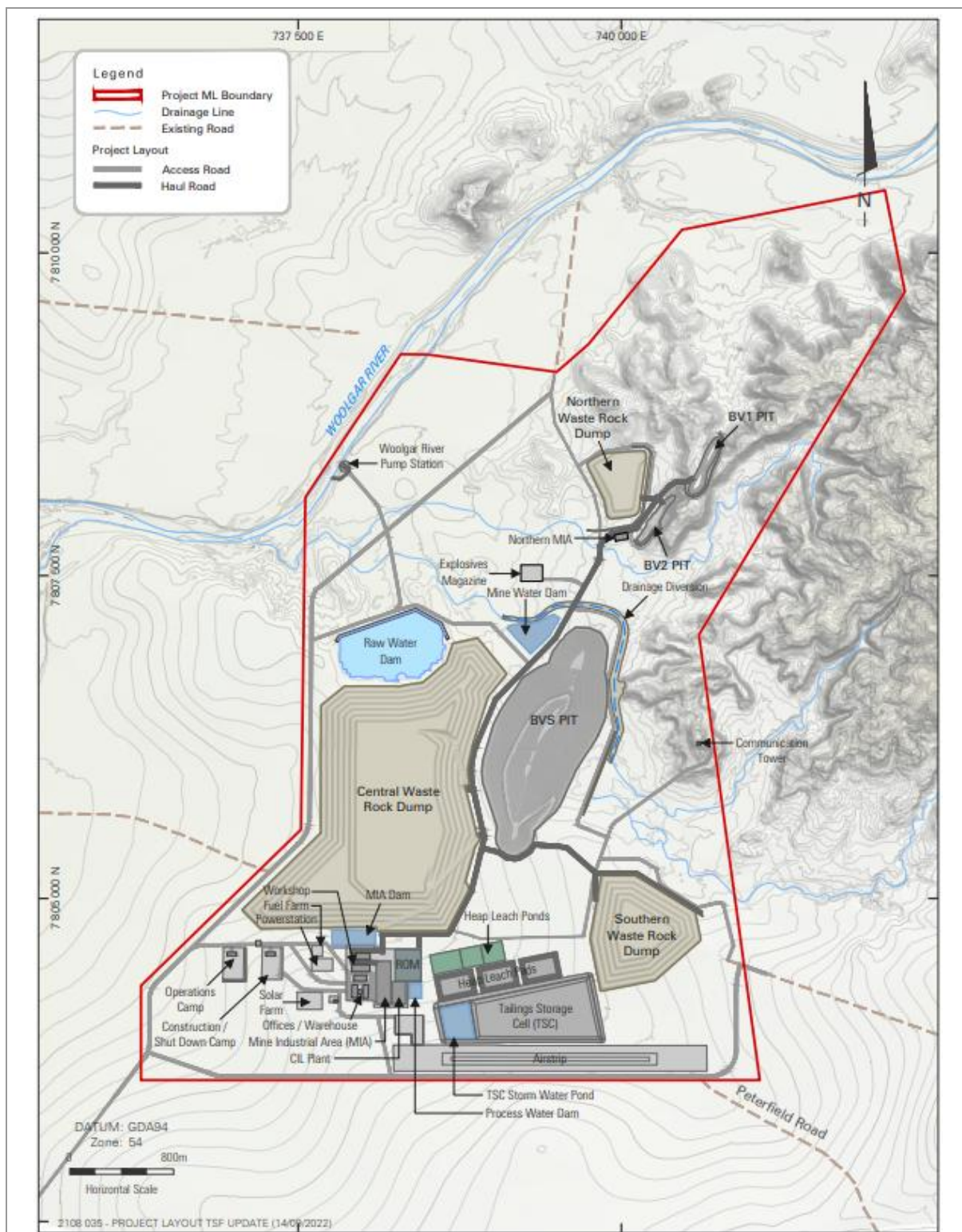


Figure 2 Big Vein South Gold Project – Detailed Project Layout

Location:
Queensland

Data source:
Hansen Environmental Consulting

Date:
June 2022

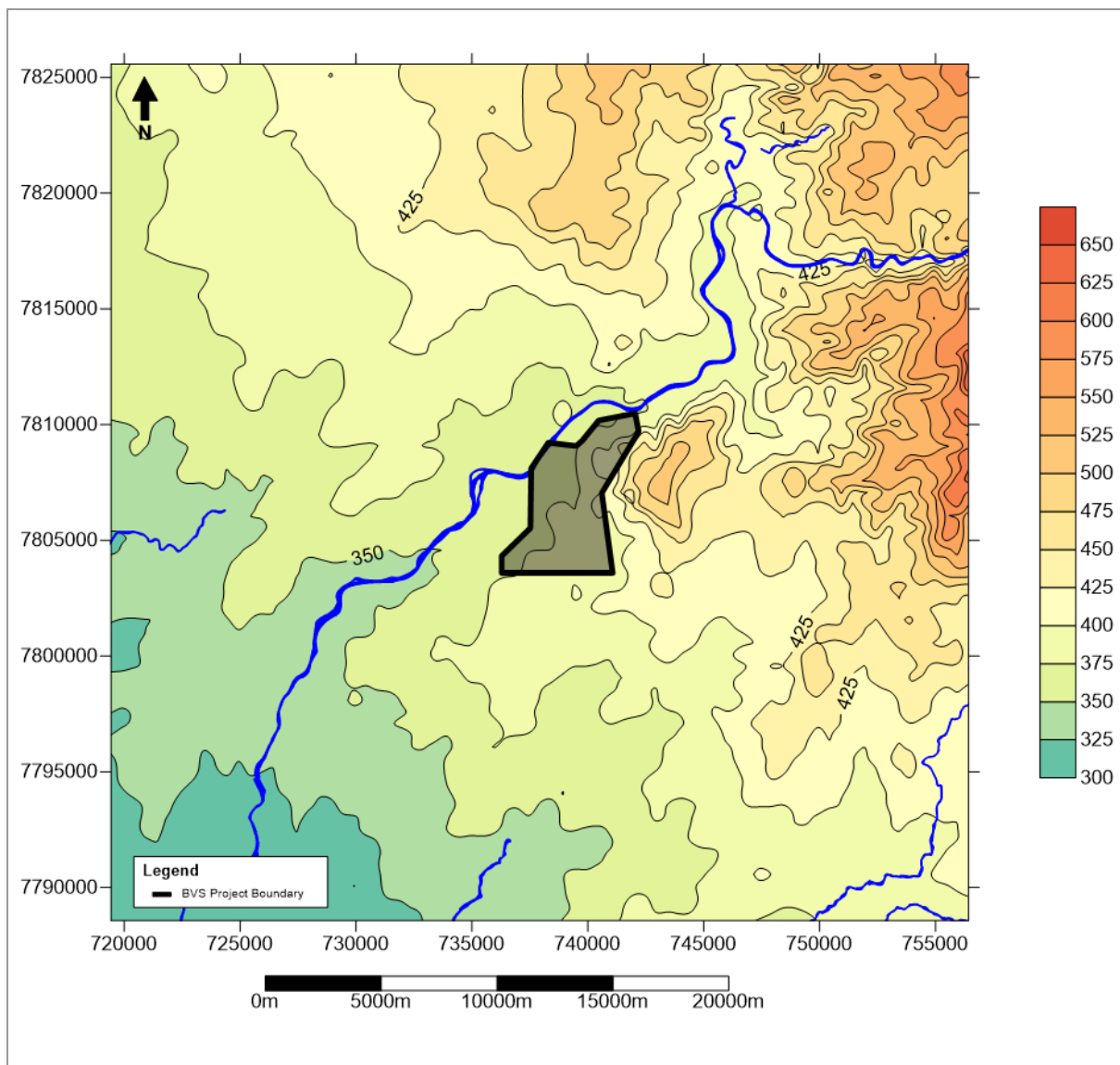


Figure 3 Terrain surrounding the Project

Location: Woolgar, QLD	Data source: SRTM1 database	Units: Metres, GDA-94 zone 54S
Type: Contour map	Prepared by: Padraig McDowell	Date: June 2022

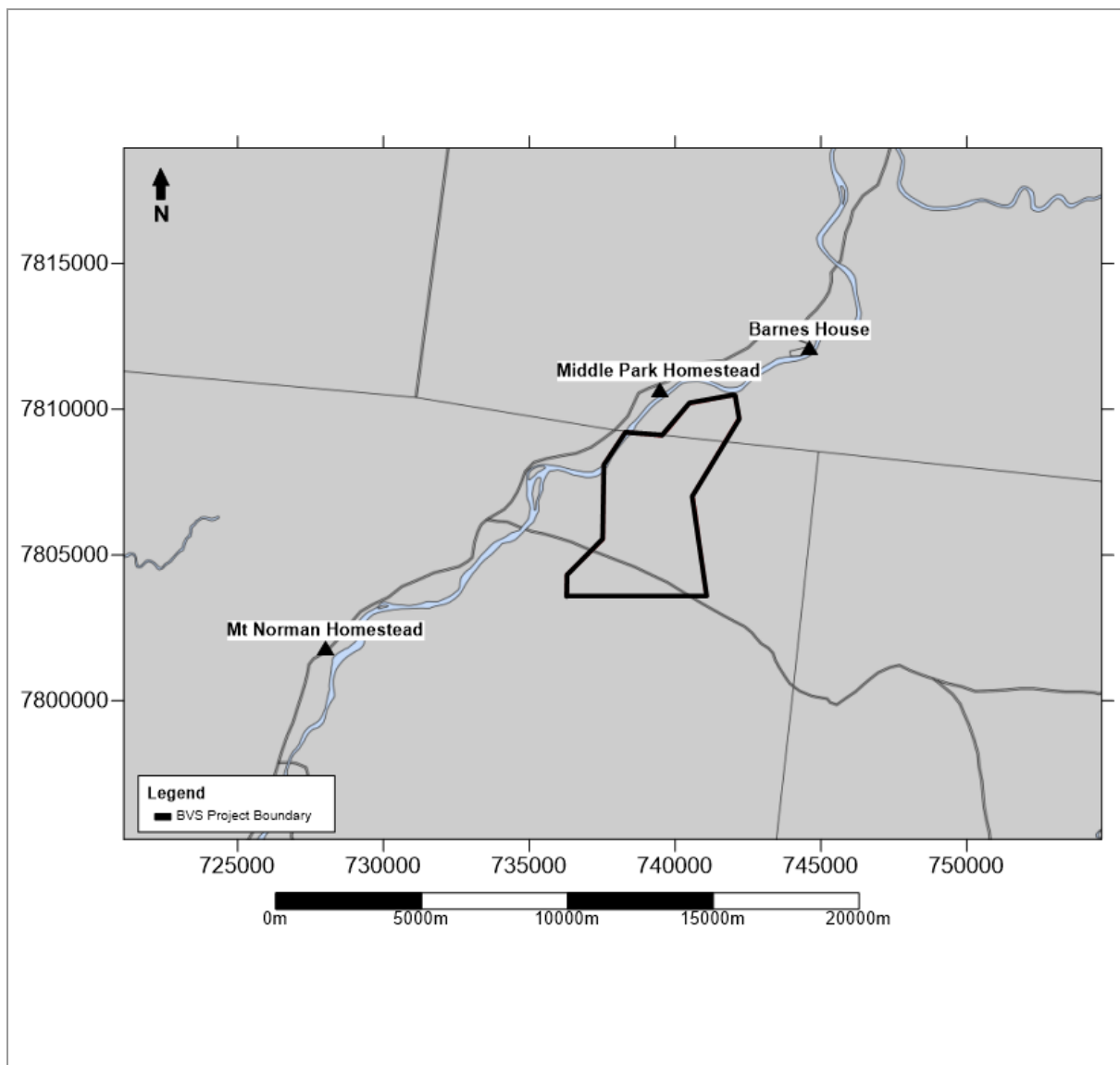


Figure 4 **Nearest sensitive receptors to the Project**

Location: Woolgar, QLD	Data source: Hansen Environmental Consulting	Units: Metres, GDA-94 zone 54S
Type: Map	Prepared by: Padraig McDowell	Date: June 2022

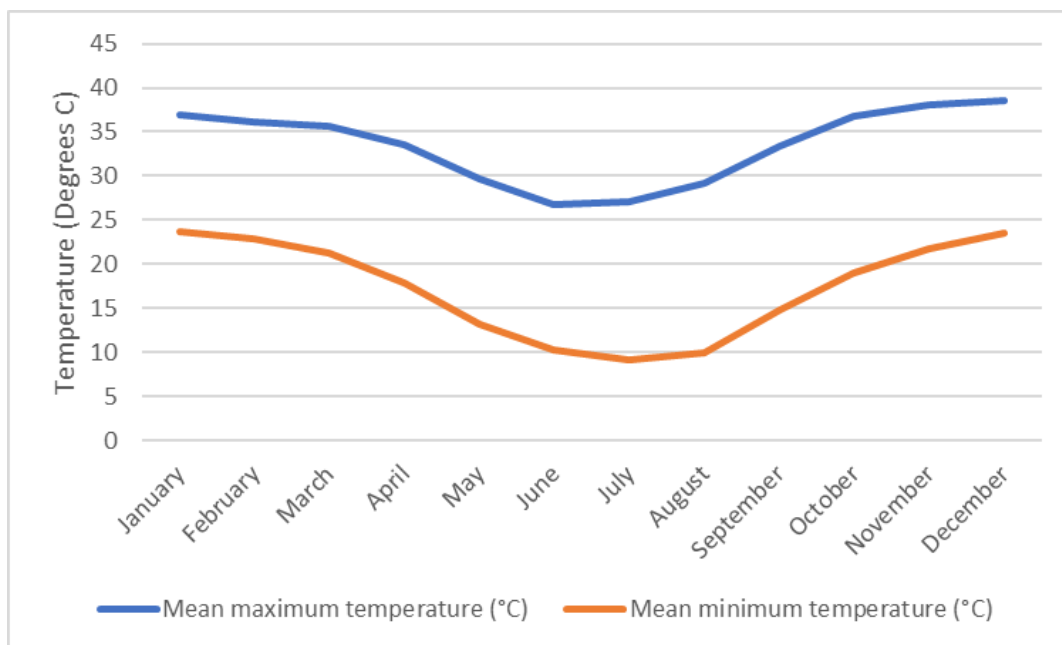


Figure 5 Mean daily maximum and minimum temperatures at the BoM's Richmond station (1998 - 2021)

Location: Richmond, Qld	Data source: BoM	Units: Degrees Celsius
Type: Time-series	Prepared by: Padraig McDowell	Date: February 2022

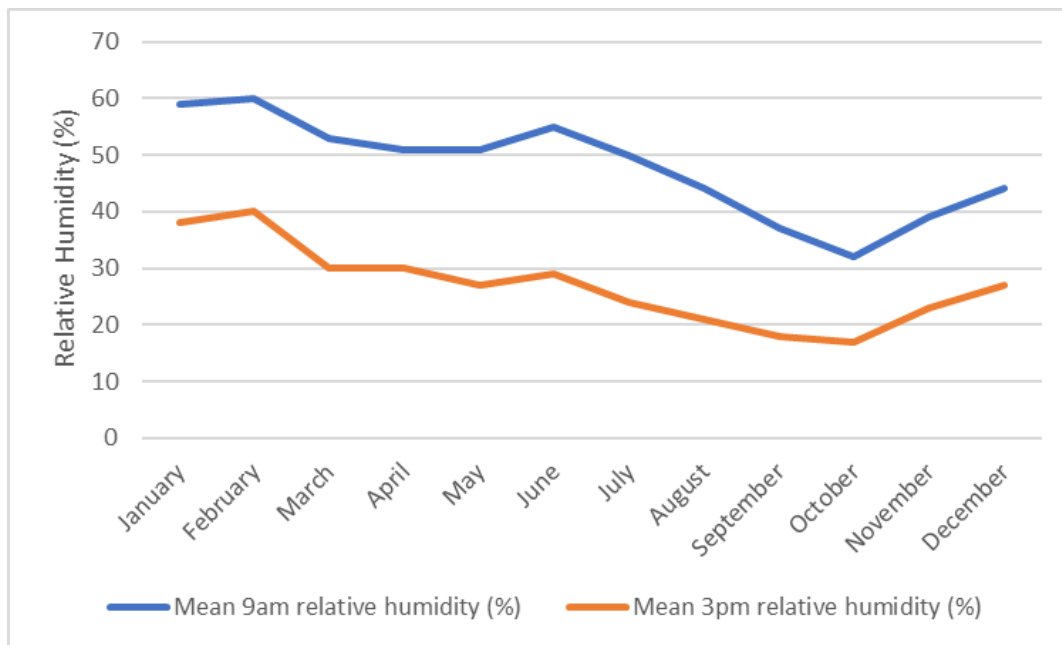


Figure 6 Mean recorded 9am and 3pm relative humidity at the BoM's Richmond station (1998 - 2021)

Location: Richmond, Qld	Data source: BoM	Units: Percentage
Type: Time-series	Prepared by: Padraig McDowell	Date: February 2022

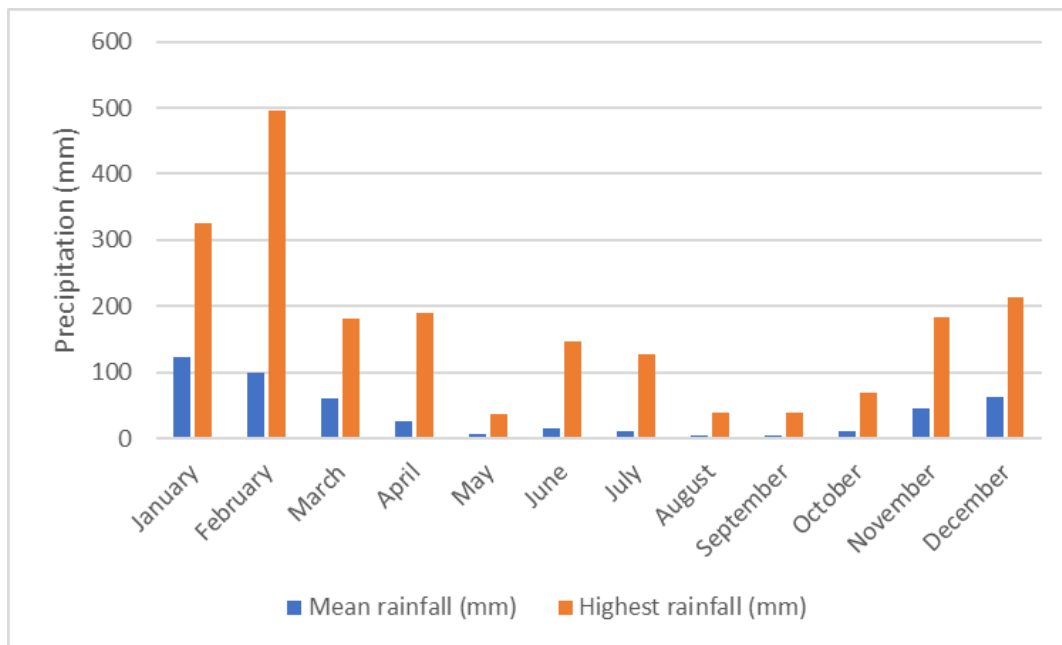
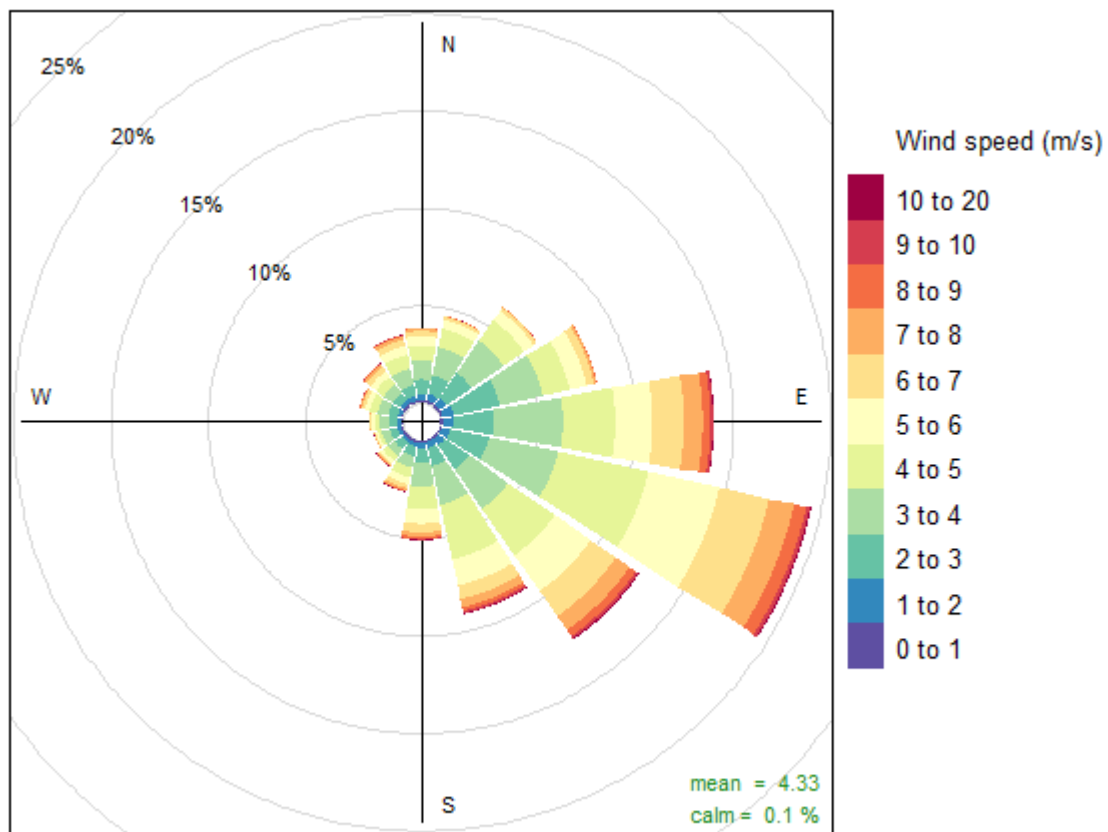


Figure 7 Mean and highest recorded rainfall at the BoM's Richmond station (1998 - 2021)

Location: Richmond, Qld	Data source: BoM	Units: Millimetres
Type: Column chart	Prepared by: Padraig McDowell	Date: February 2022



Frequency of counts by wind direction (%)

Figure 8 Distribution of winds at BoM's Richmond Airport station (2011 - 2020)

Location: Richmond, Qld	Data source: BoM	Units: m/s and °
Type: Wind rose	Prepared by: Padraig McDowell	Date: February 2022

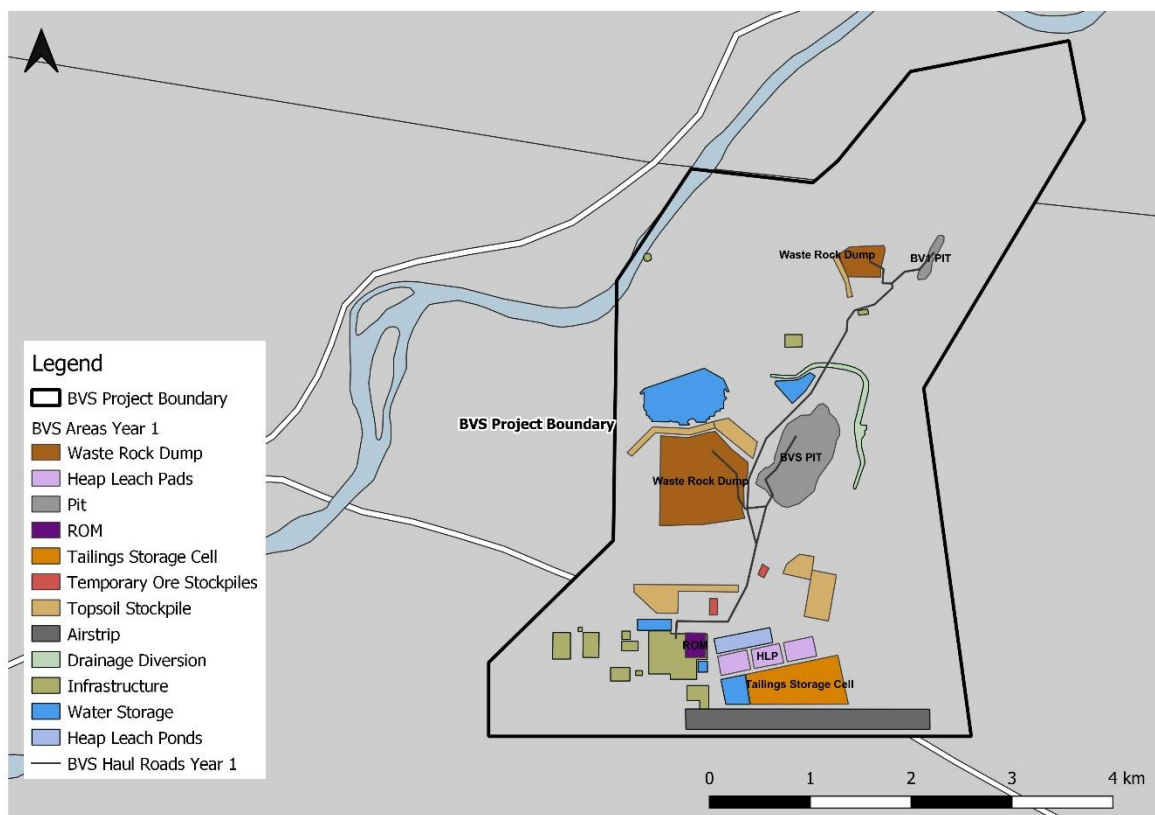


Figure 9 Project Year 1 – Big Vein South Gold Project Layout

Location: Woolgar, QLD	Data source: Hansen Environmental Consulting	Units: Metres, GDA-94 zone 54S
Type: Map	Prepared by: Padraig McDowell	Date: June 2022

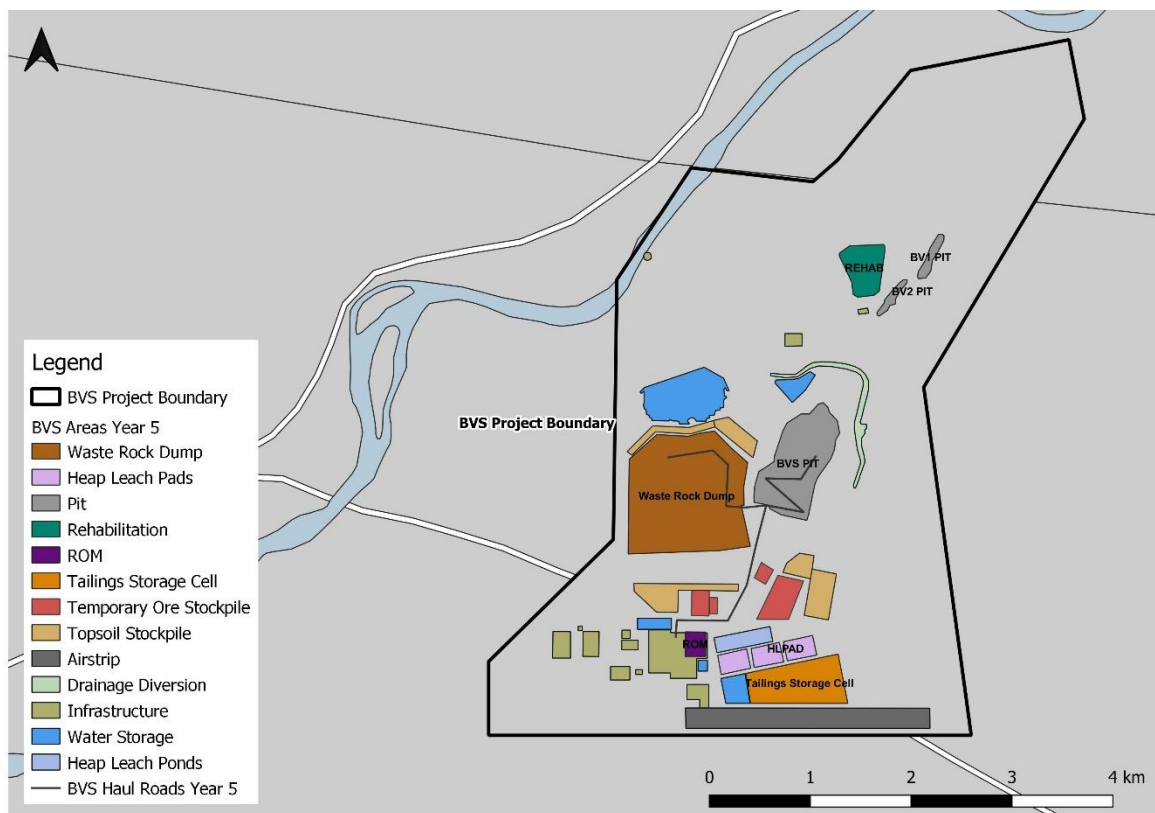


Figure 10 **Project Year 5 – Big Vein South Gold Project Layout**

Location: Woolgar, QLD	Data source: Hansen Environmental Consulting	Units: Metres, GDA-94 zone 54S
Type: Map	Prepared by: Padraig McDowell	Date: June 2022

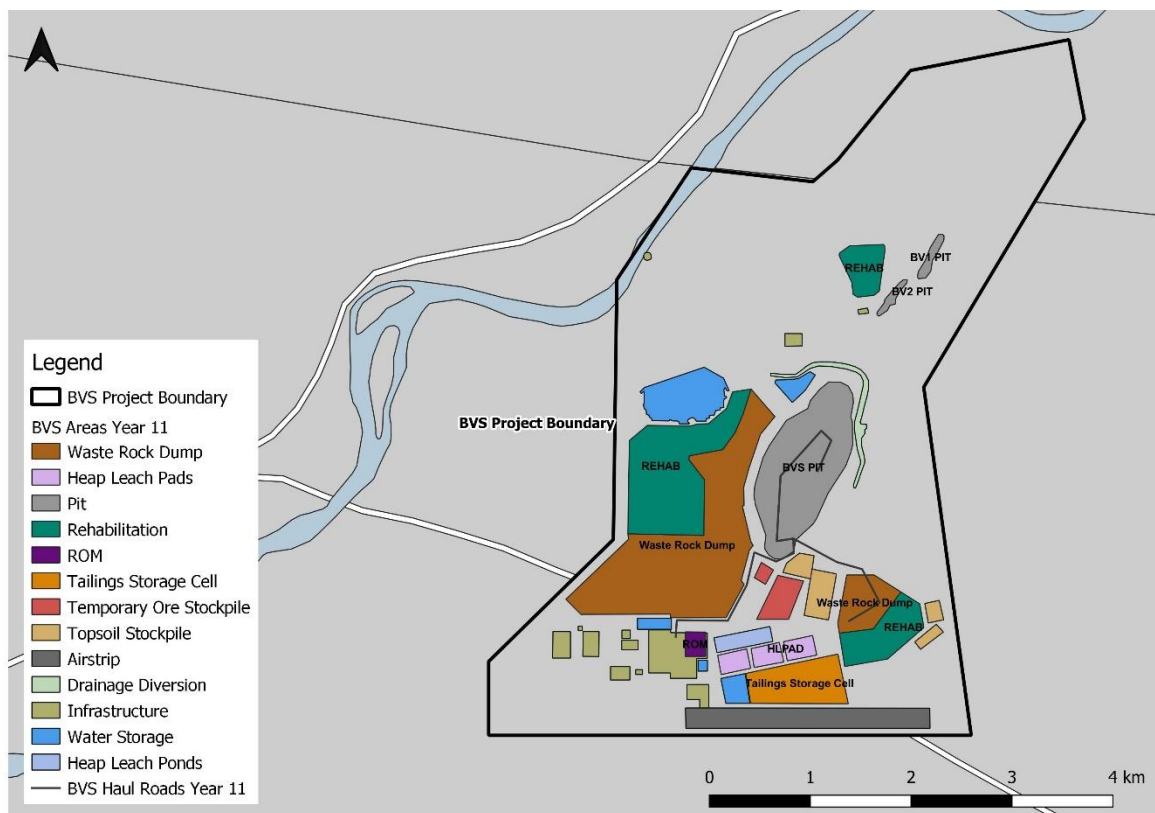


Figure 11 Project Year 11 – Big Vein South Gold Project Layout

Location: Woolgar, QLD	Data source: Hansen Environmental Consulting	Units: Metres, GDA-94 zone 54S
Type: Map	Prepared by: Padraig McDowell	Date: June 2022

10. CONTOUR PLATES

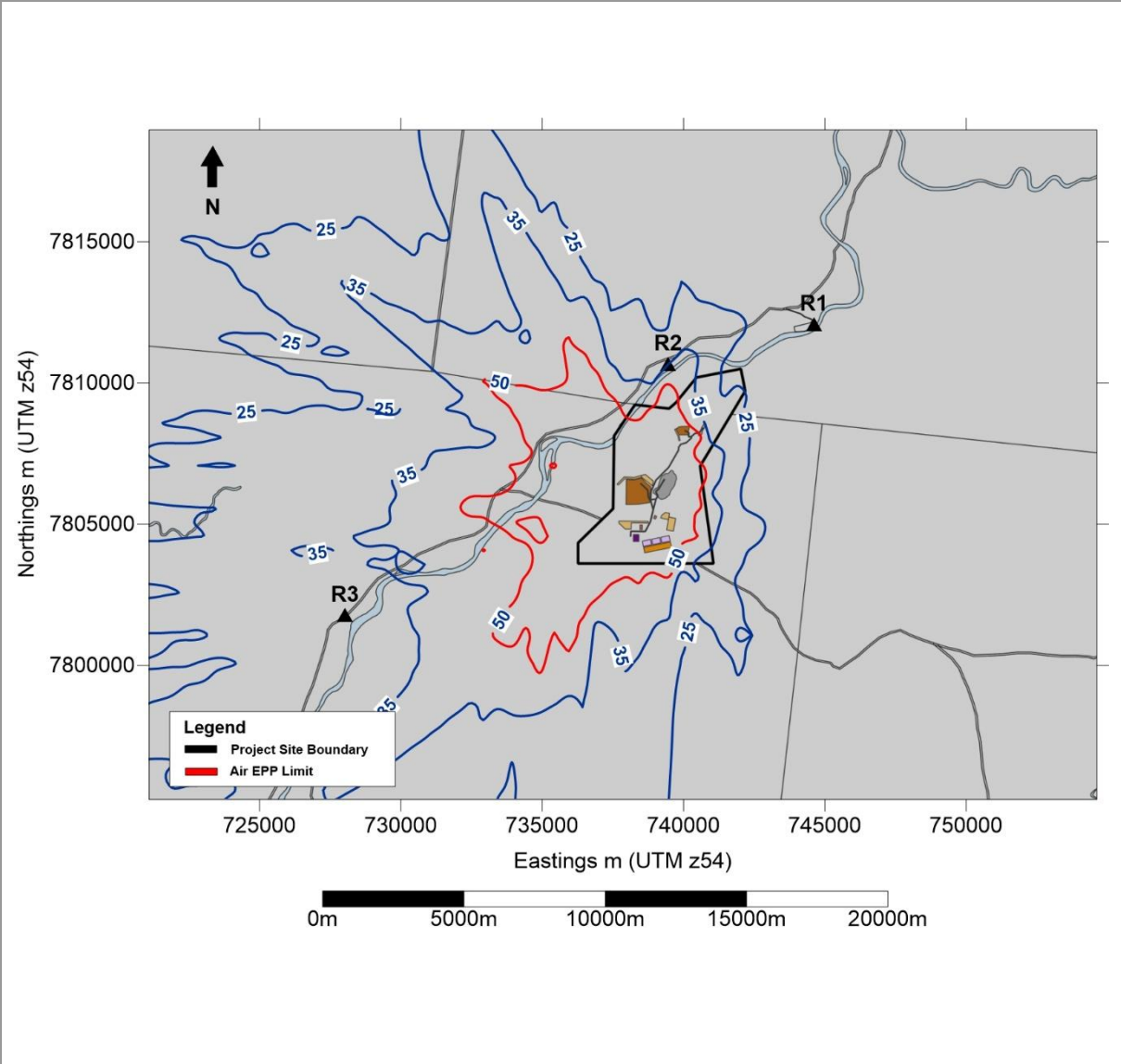


Plate 1 Project Year 1 - Predicted maximum 24-hour average ground-level concentrations of PM₁₀ due to the project including background levels of dust			
Location: Woolgar, Qld	Averaging period: 24-hour	Data source: CALPUFF	Units: µg/m ³
Type: Maximum contour	Objective: 50 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

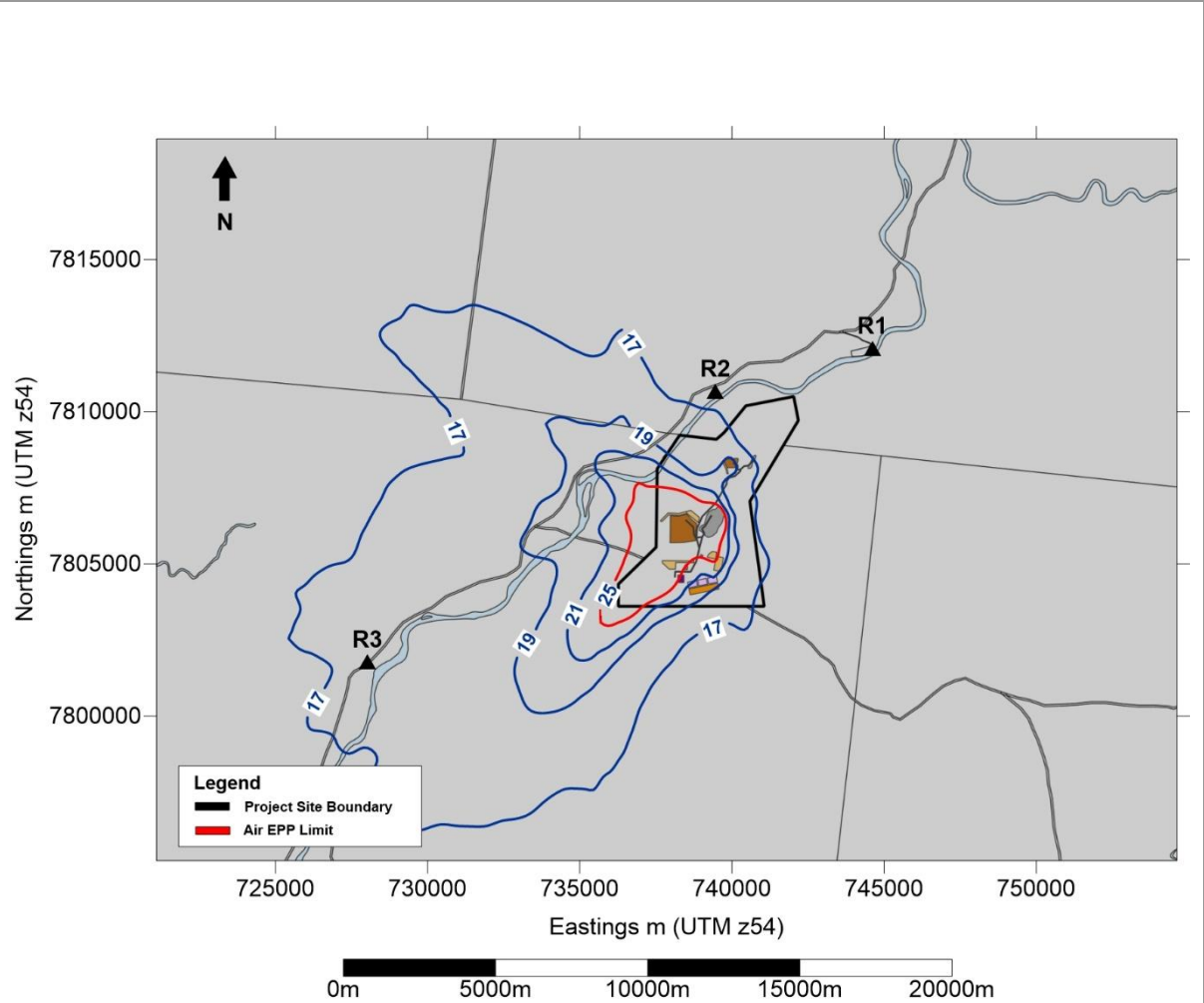


Plate 2 Project Year 1 - Predicted annual average ground-level concentrations of PM₁₀ due to the project including background levels of dust

Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: µg/m ³
Type: Average contour	Objective: 25 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

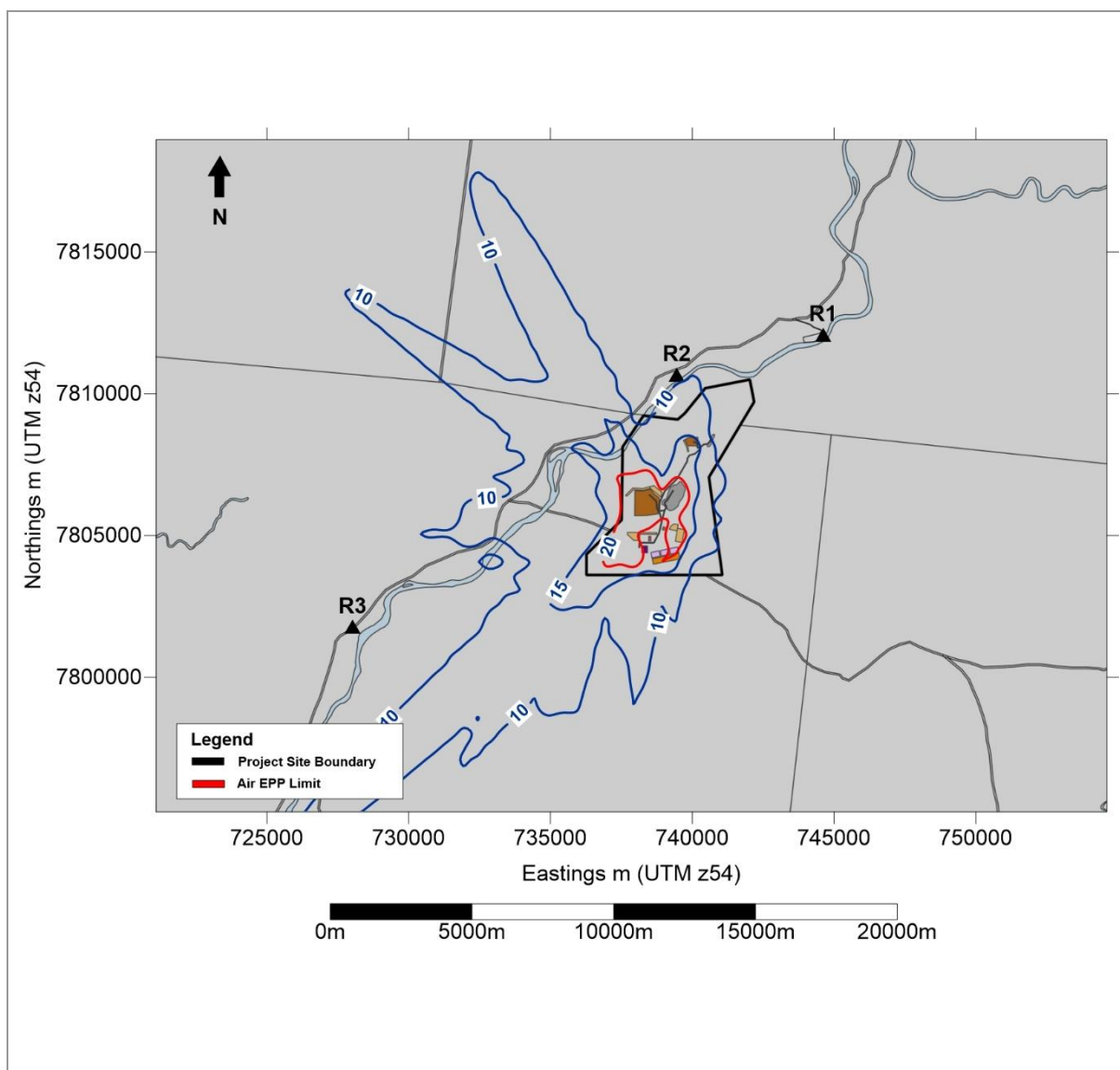


Plate 3 **Project Year 1 - Predicted maximum 24-hour average ground-level concentrations of PM_{2.5} due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 24-hour	Data source: CALPUFF	Units: µg/m ³
Type: Maximum contour	Objective: 20 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

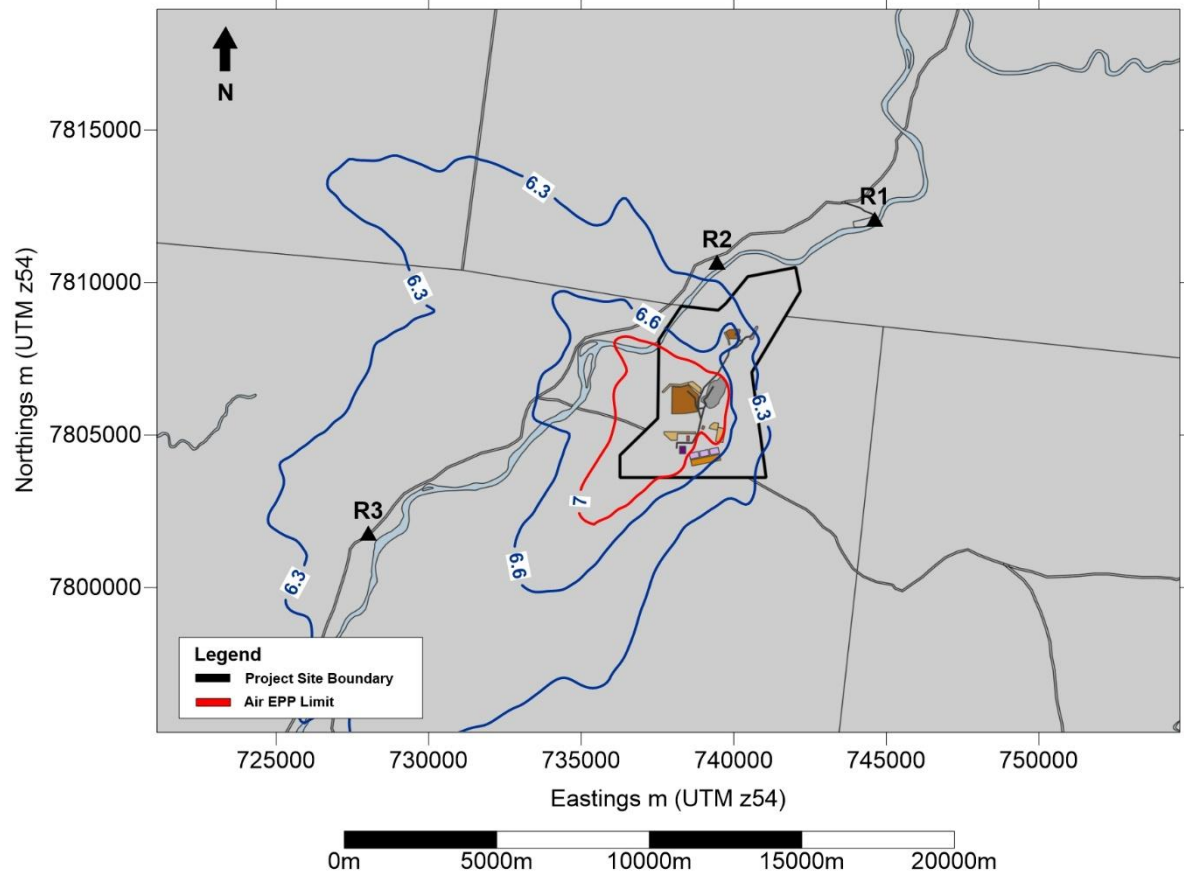


Plate 4 **Project Year 1 - Predicted annual average ground-level concentrations of PM_{2.5} due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: µg/m ³
Type: Average contour	Objective: 7 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

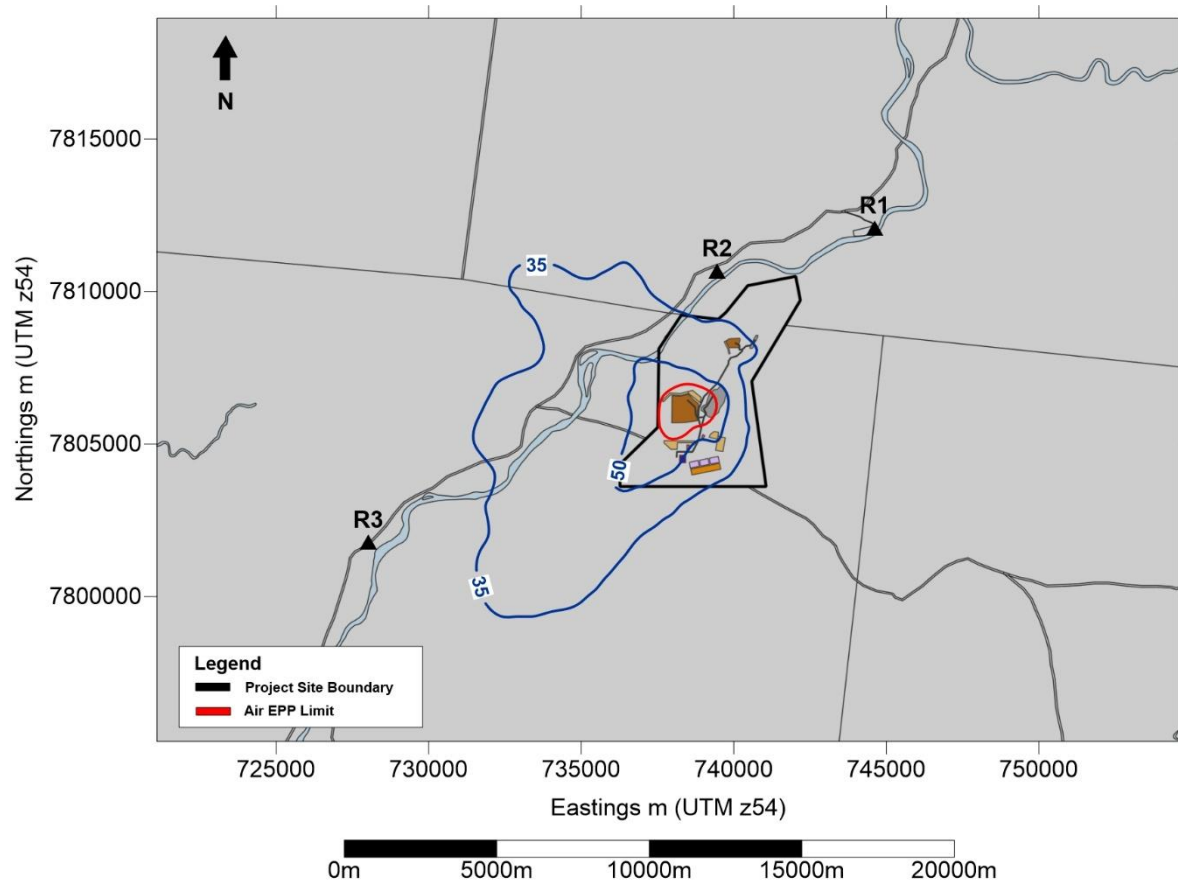


Plate 5 Project Year 1 - Predicted annual average ground-level concentrations of TSP due to the project including background levels of dust

Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: $\mu\text{g}/\text{m}^3$
Type: Average contour	Objective: $90 \mu\text{g}/\text{m}^3$	Prepared by: Sathya Roysmith	Date: 2025

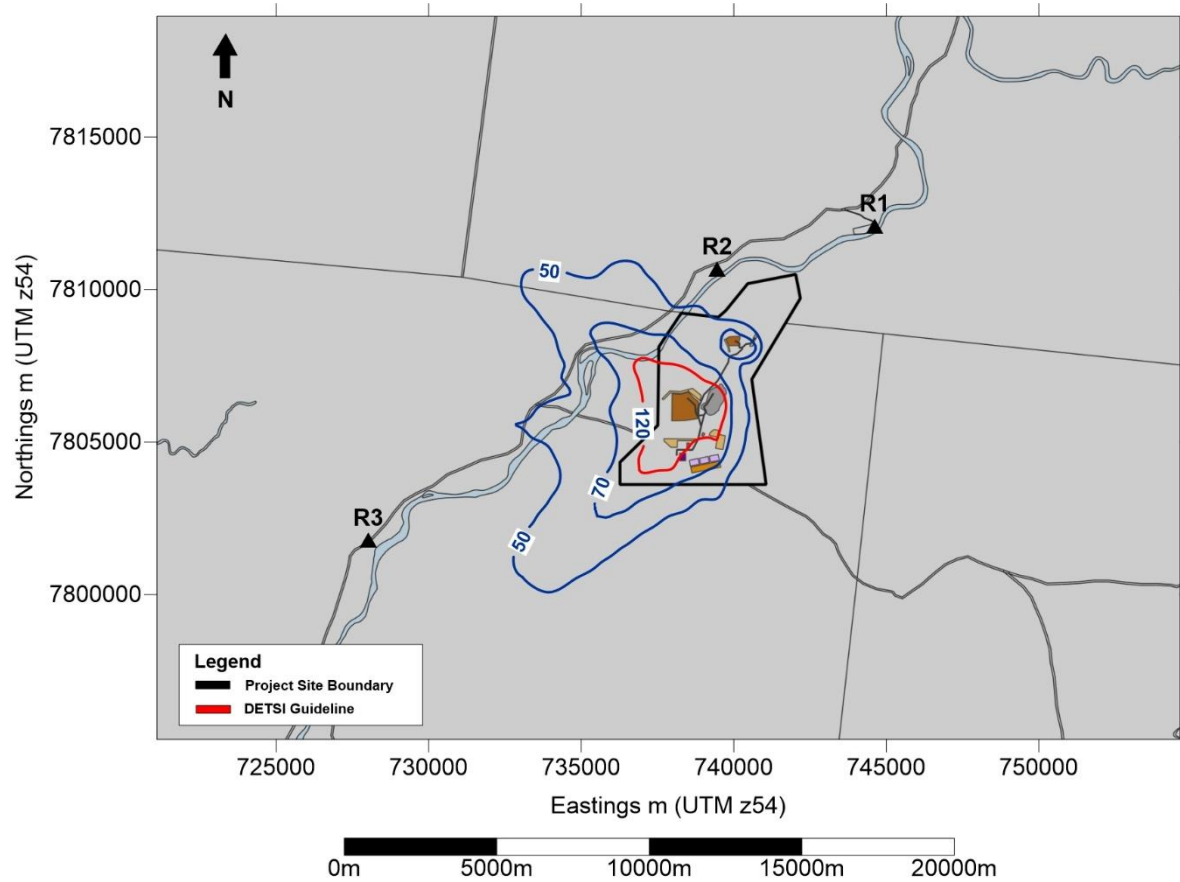


Plate 6 **Project Year 1 - Predicted maximum monthly dust deposition rate due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 1-month	Data source: CALPUFF	Units: mg/m ² /day
Type: Maximum contour	Objective: 120 mg/m ² /day	Prepared by: Sathya Roysmith	Date: 2025

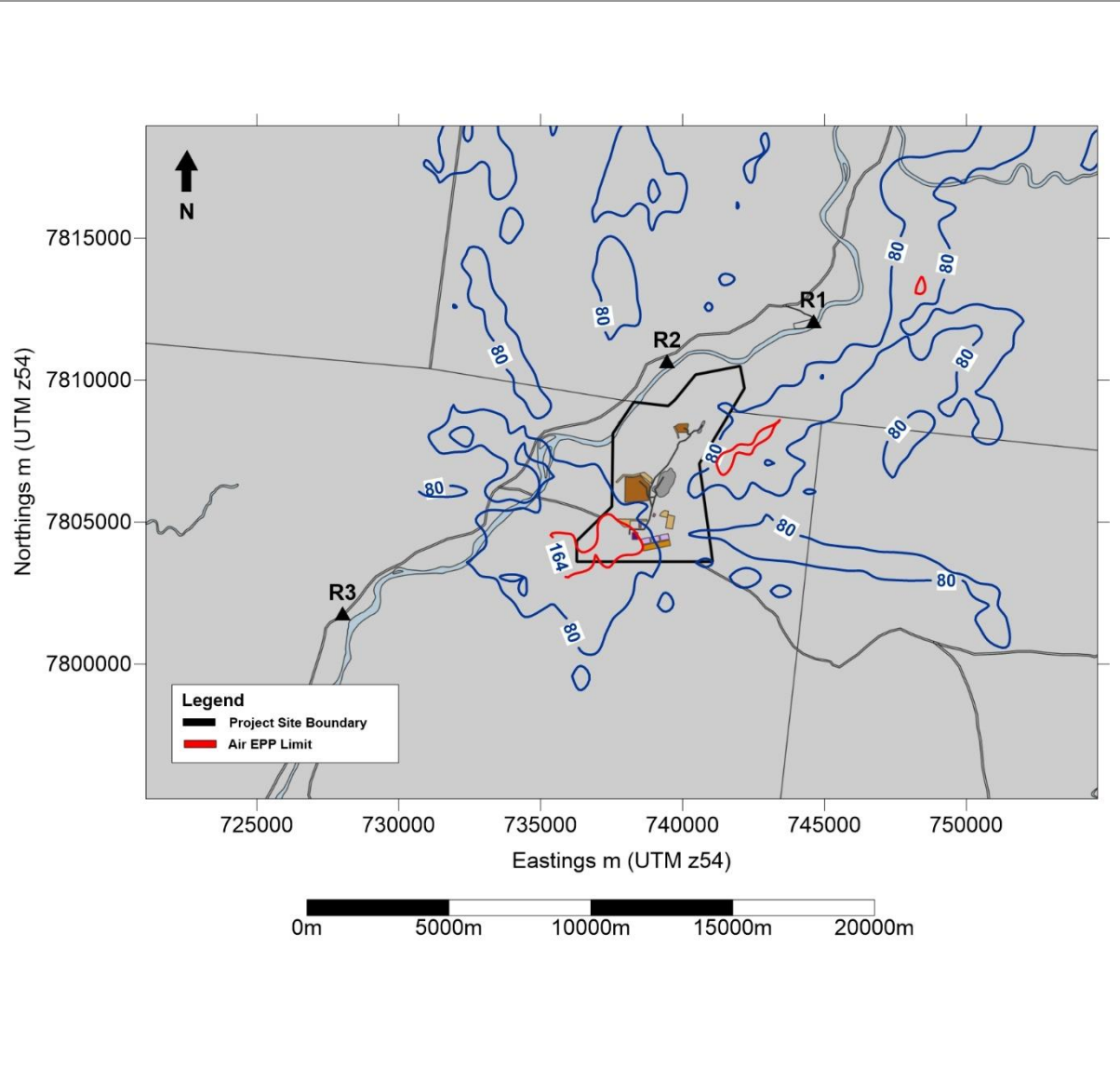


Plate 7 **Project Year 1 - Predicted maximum 1-hour average ground-level concentrations of NO2 due to the project including background levels**

Location: Woolgar, Qld	Averaging period: 1-hour	Data source: CALPUFF	Units: µg/m ³
Type: Maximum contour	Objective: 164 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

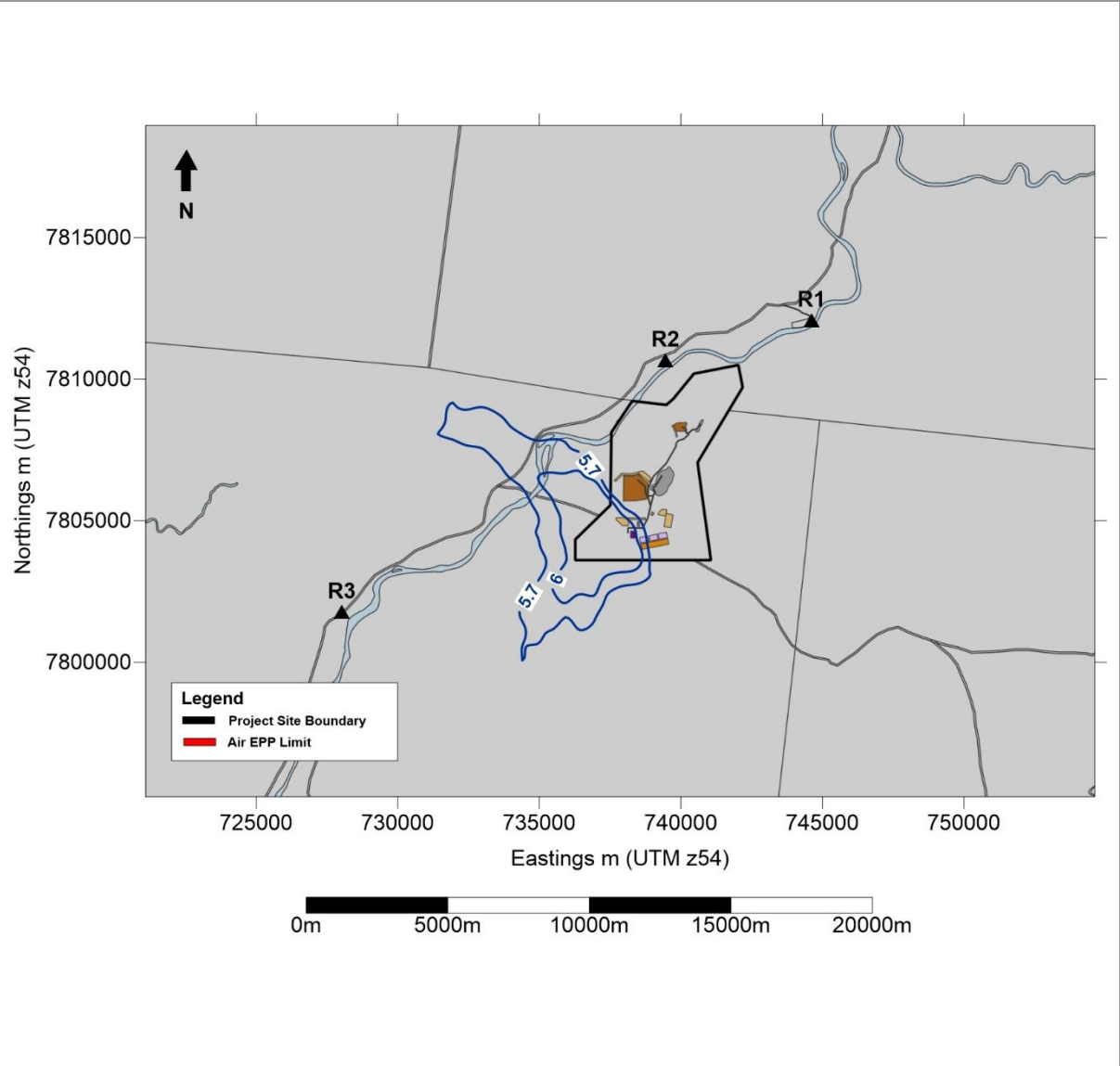


Plate 8 Project Year 1 - Predicted annual average ground-level concentrations of NO2 due to the project including background levels			
Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: µg/m³
Type: Average contour	Objective: 31 µg/m³	Prepared by: Sathya Roysmith	Date: 2025

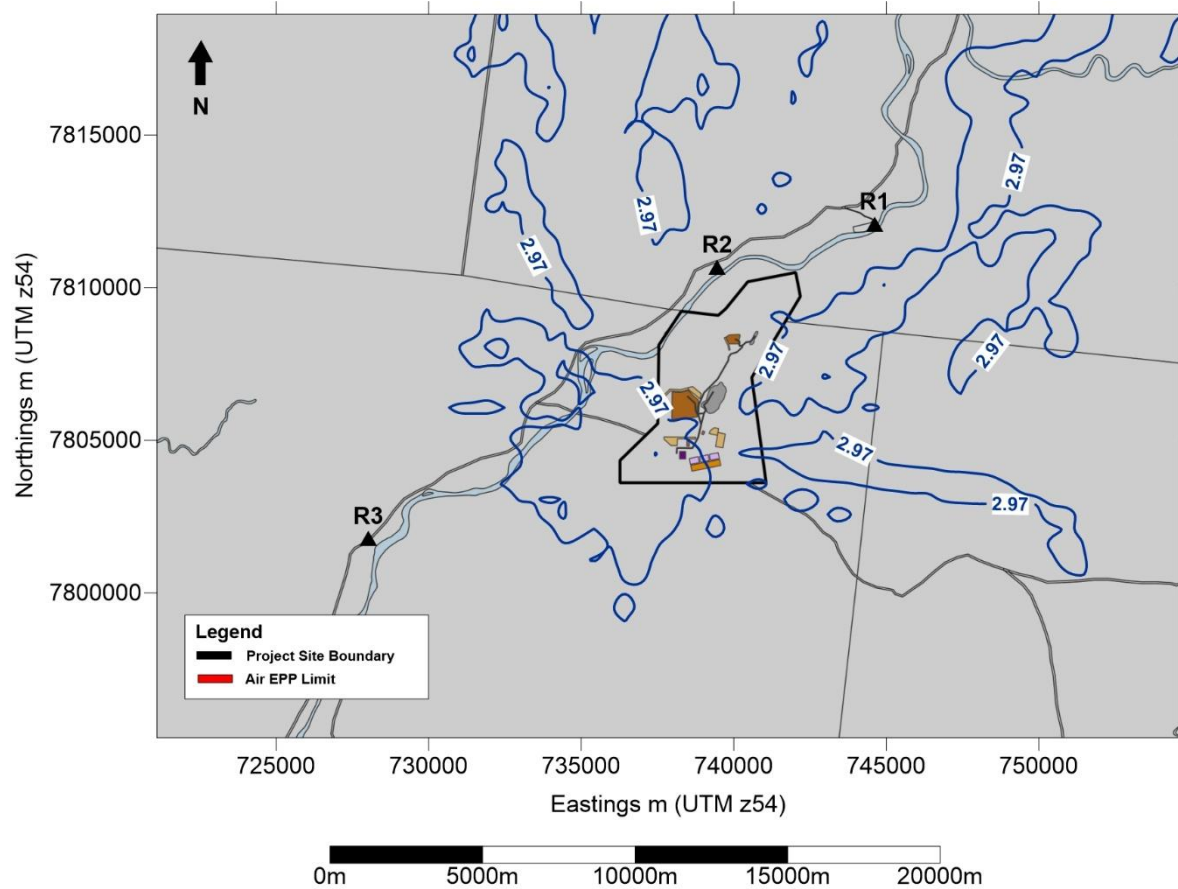


Plate 9 **Project Year 1- Predicted maximum 1-hour average ground-level concentrations of SO₂ due to the project including background levels**

Location: Woolgar, Qld	Averaging period: 1-hour	Data source: CALPUFF	Units: µg/m ³
Type: Maximum contour	Objective: 214 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

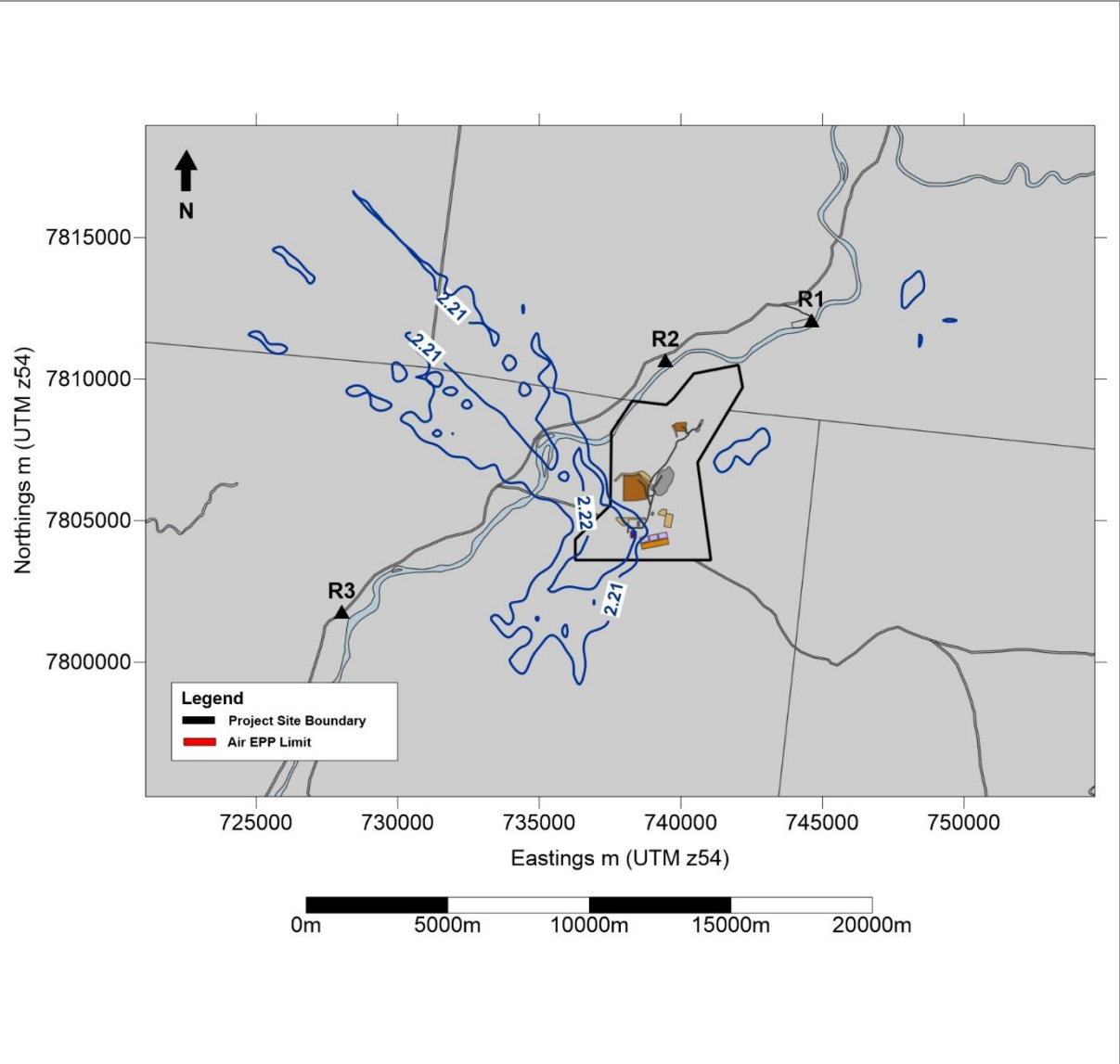


Plate 10 Project Year 1 - Predicted maximum 24-hour average ground-level concentrations of SO₂ due to the project including background levels

Location: Woolgar, Qld	Averaging period: 24-hour	Data source: CALPUFF	Units: $\mu\text{g}/\text{m}^3$
Type: Maximum contour	Objective: 57 $\mu\text{g}/\text{m}^3$	Prepared by: Sathya Roysmith	Date: 2025

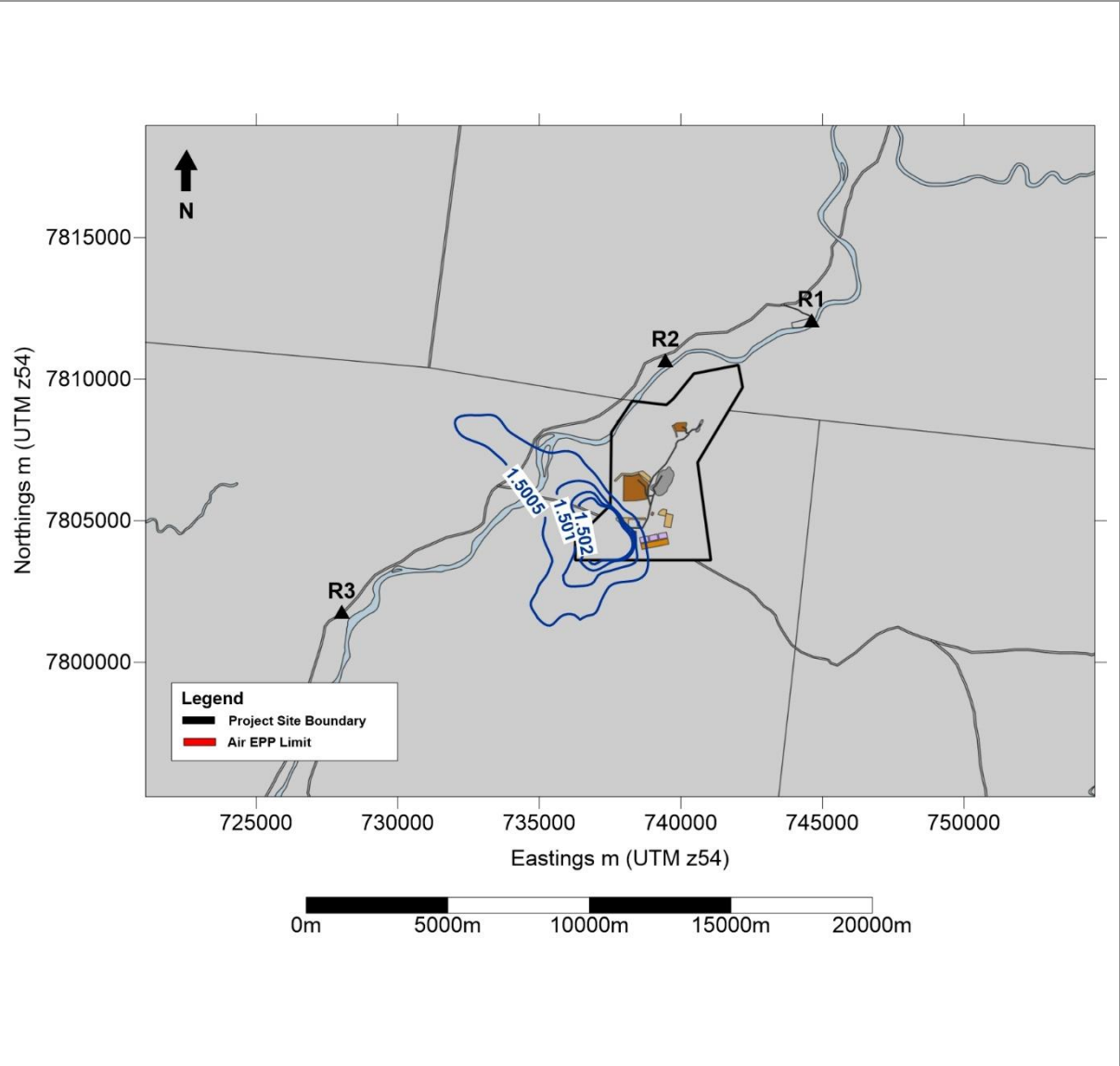


Plate 11 **Project Year 1 - Predicted annual average ground-level concentrations of SO₂ due to the project including background levels**

Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: µg/m ³
Type: Average contour	Objective: NA	Prepared by: Sathya Roysmith	Date: 2025

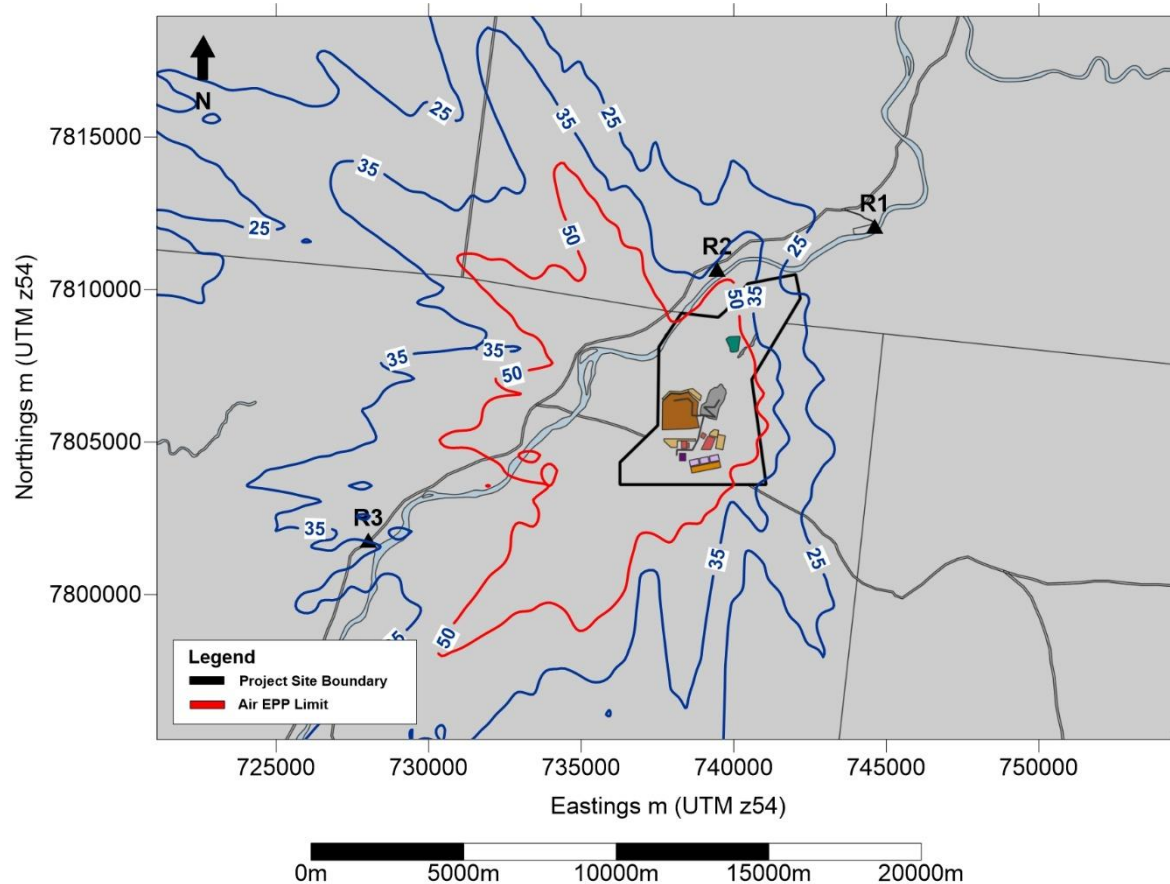


Plate 12 Project Year 5 - Predicted maximum 24-hour average ground-level concentrations of PM₁₀ due to the project including background levels of dust

Location: Woolgar, Qld	Averaging period: 24-hour	Data source: CALPUFF	Units: µg/m ³
Type: Maximum contour	Objective: 50 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

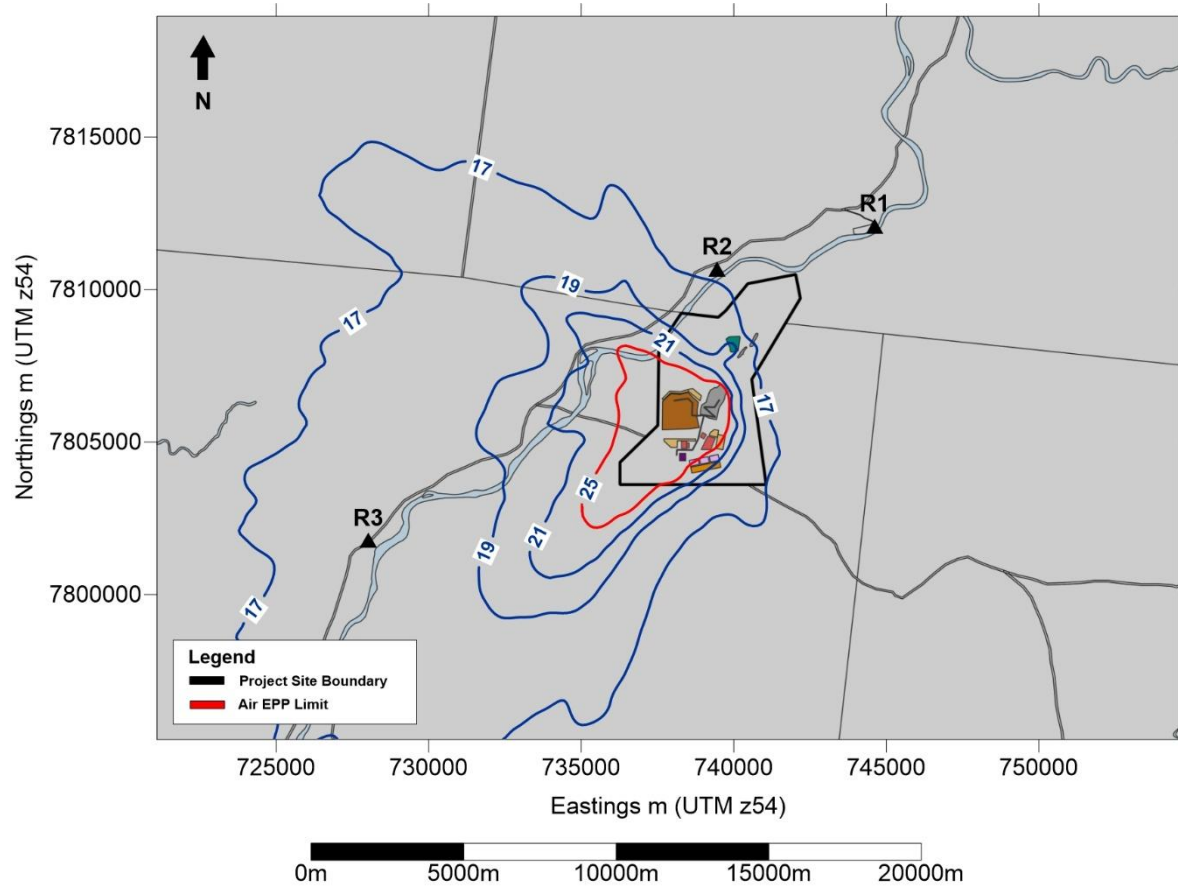


Plate 13 **Project Year 5 - Predicted annual average ground-level concentrations of PM₁₀ due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: µg/m ³
Type: Average contour	Objective: 25 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

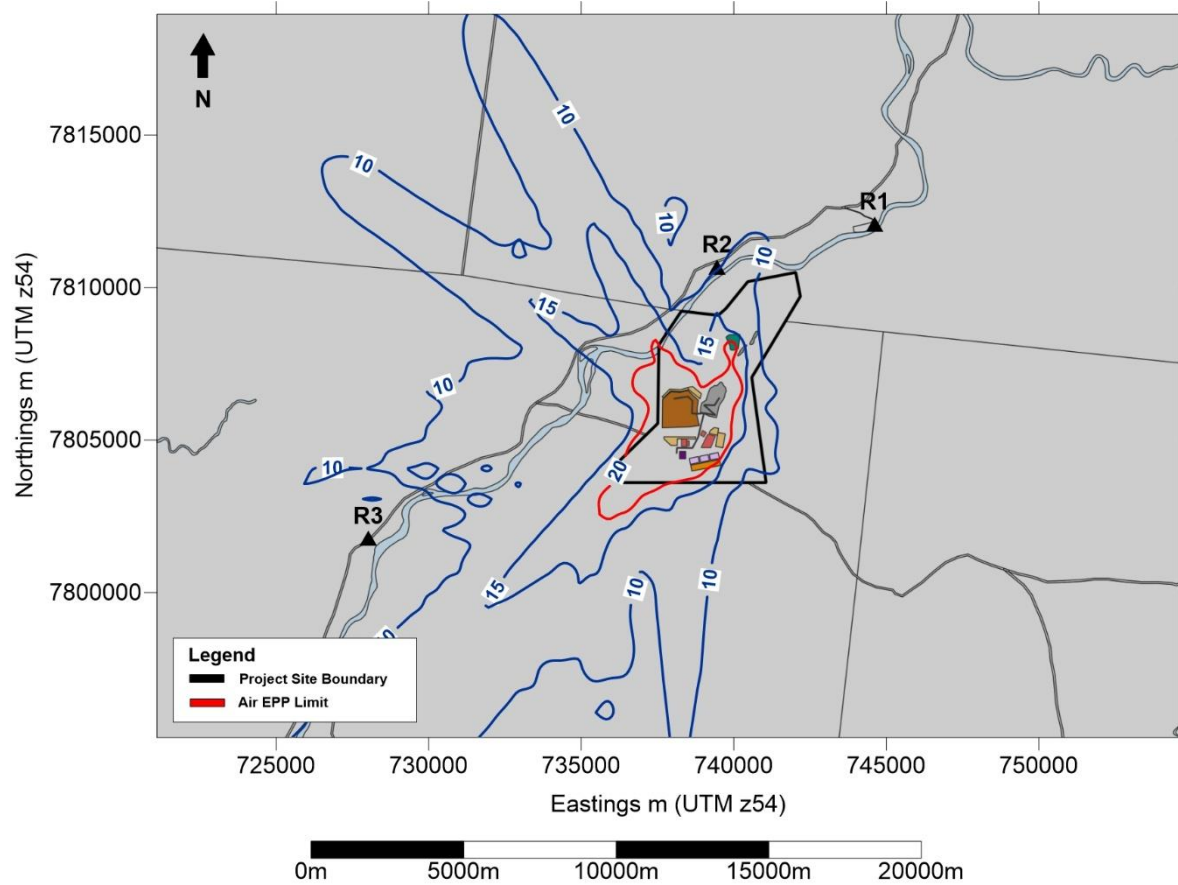


Plate 14 **Project Year 5 - Predicted maximum 24-hour average ground-level concentrations of PM_{2.5} due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 24-hour	Data source: CALPUFF	Units: µg/m ³
Type: Maximum contour	Objective: 20 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

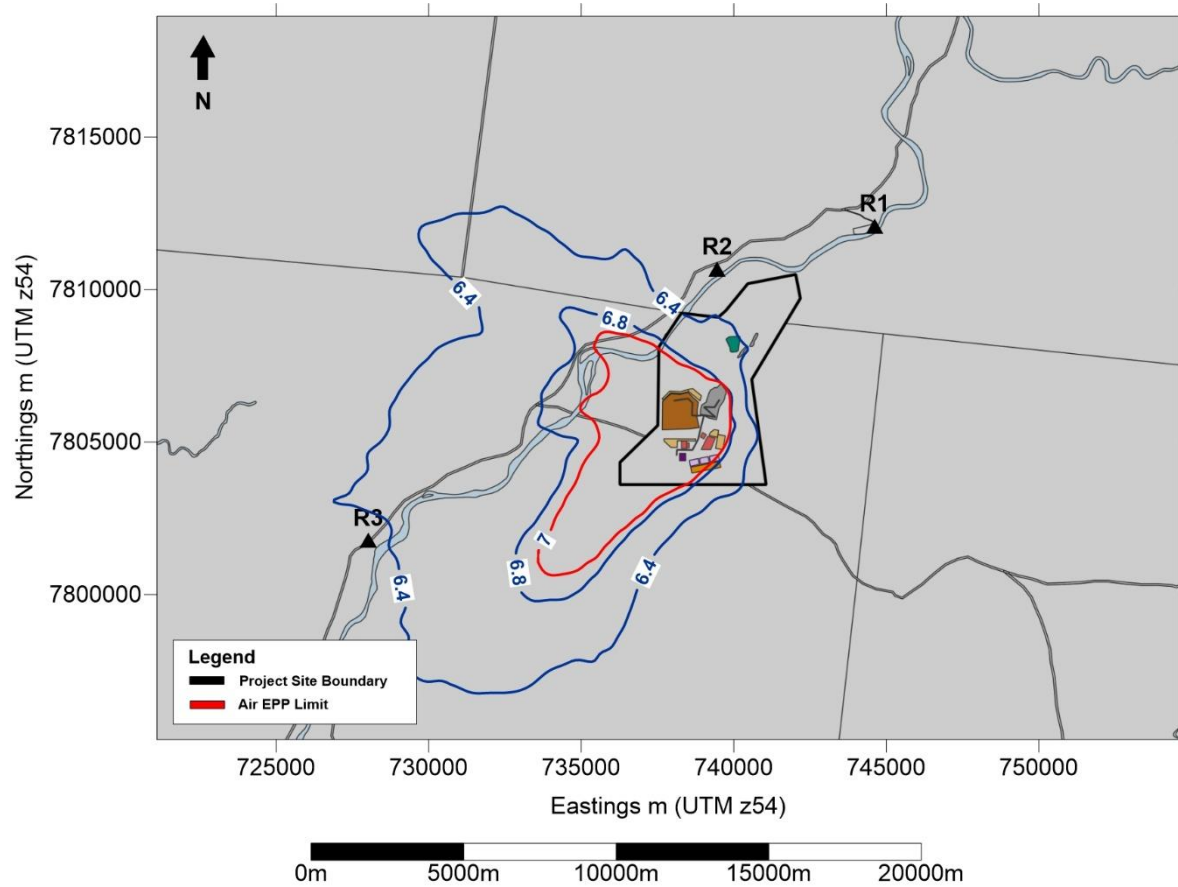


Plate 15 Project Year 5 - Predicted annual average ground-level concentrations of PM_{2.5} due to the project including background levels of dust

Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: µg/m ³
Type: Average contour	Objective: 7 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

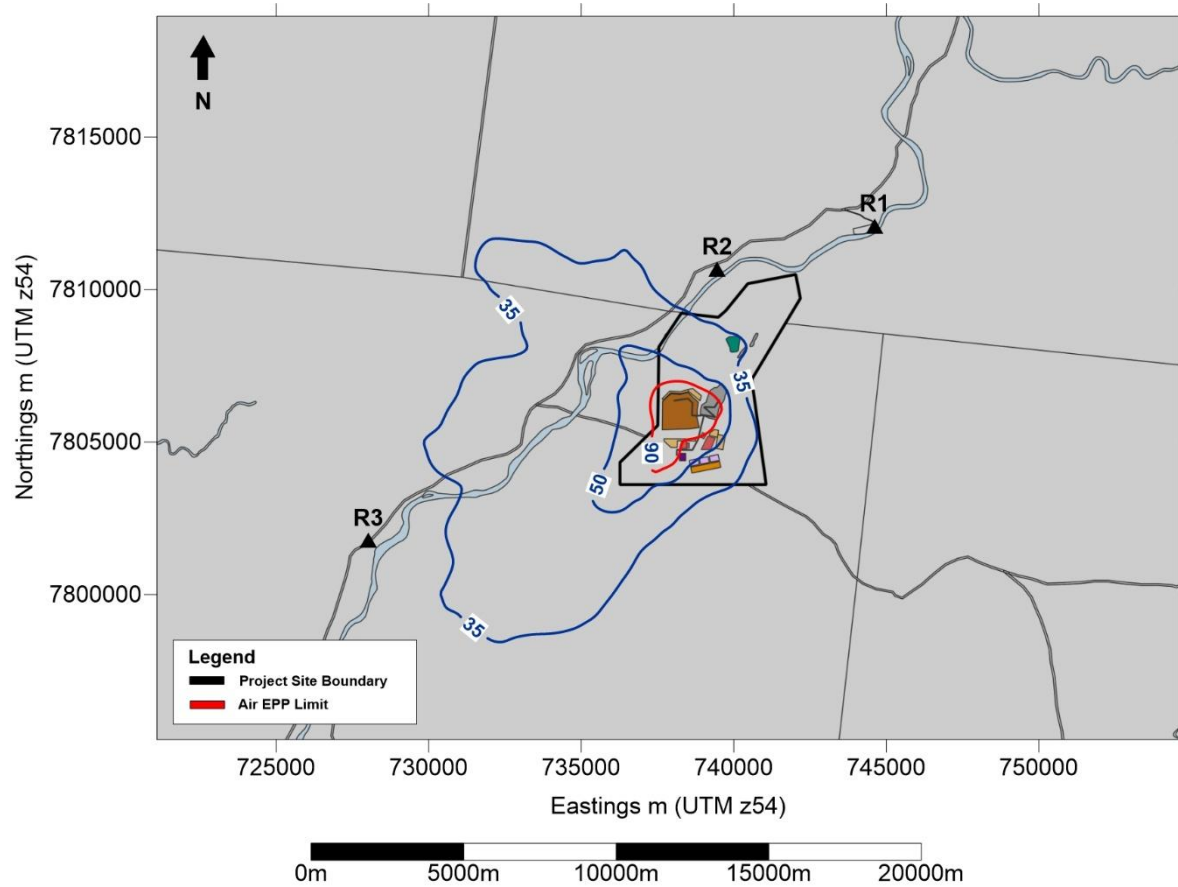


Plate 16 Project Year 5 - Predicted annual average ground-level concentrations of TSP due to the project including background levels of dust

Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: $\mu\text{g}/\text{m}^3$
Type: Average contour	Objective: 90 $\mu\text{g}/\text{m}^3$	Prepared by: Sathya Roysmith	Date: 2025

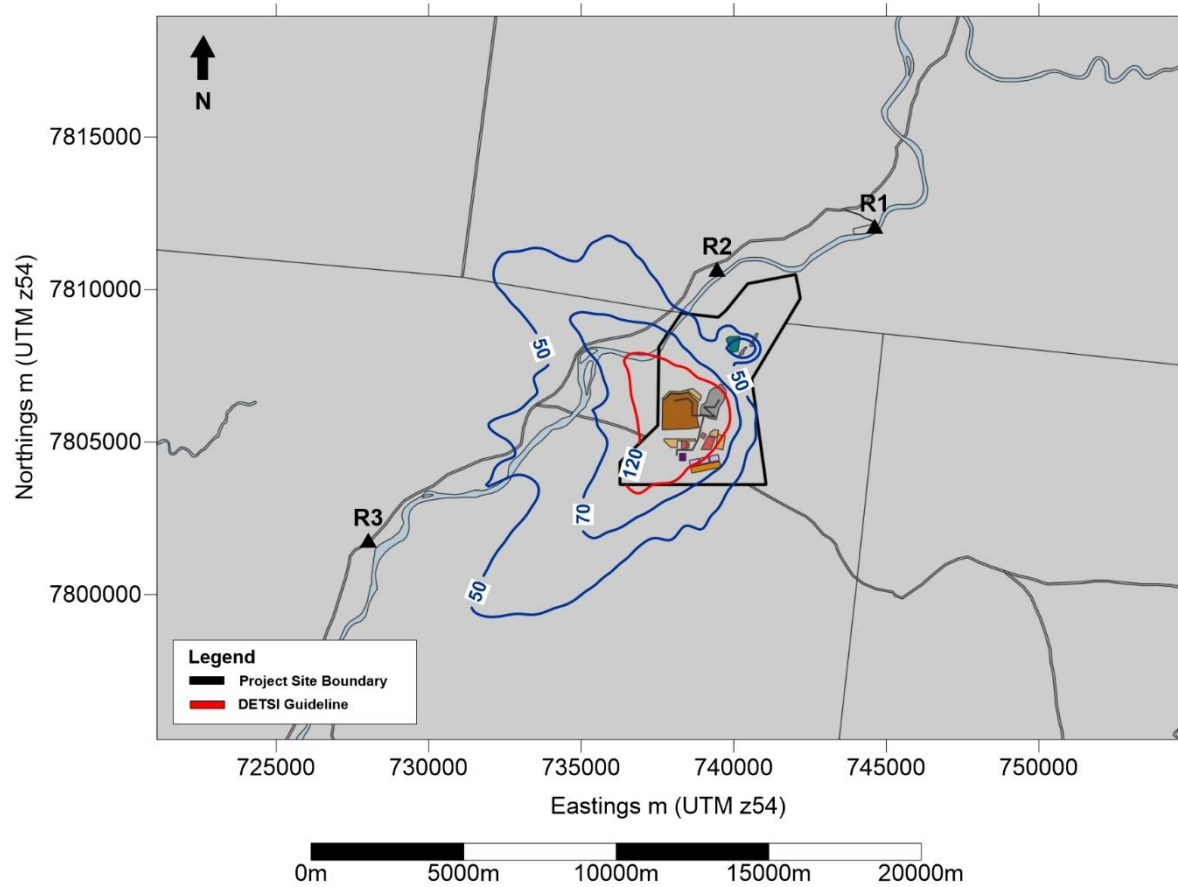


Plate 17 **Project Year 5 - Predicted maximum monthly dust deposition rate due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 1-month	Data source: CALPUFF	Units: mg/m ² /day
Type: Maximum contour	Objective: 120 mg/m ² /day	Prepared by: Sathya Roysmith	Date: 2025

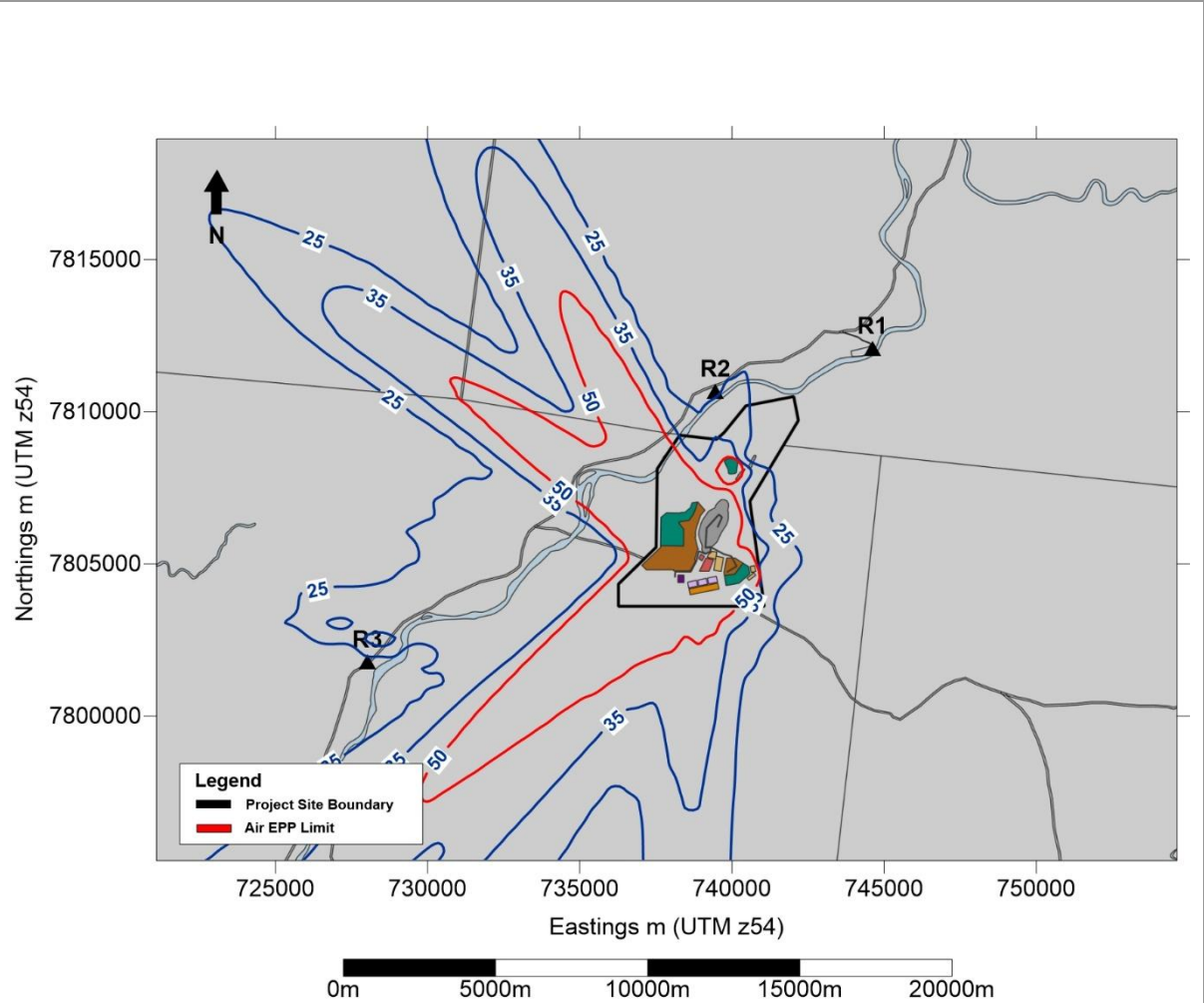


Plate 18 **Project Year 11 - Predicted maximum 24-hour average ground-level concentrations of PM₁₀ due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 24-hour	Data source: CALPUFF	Units: µg/m ³
Type: Maximum contour	Objective: 50 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

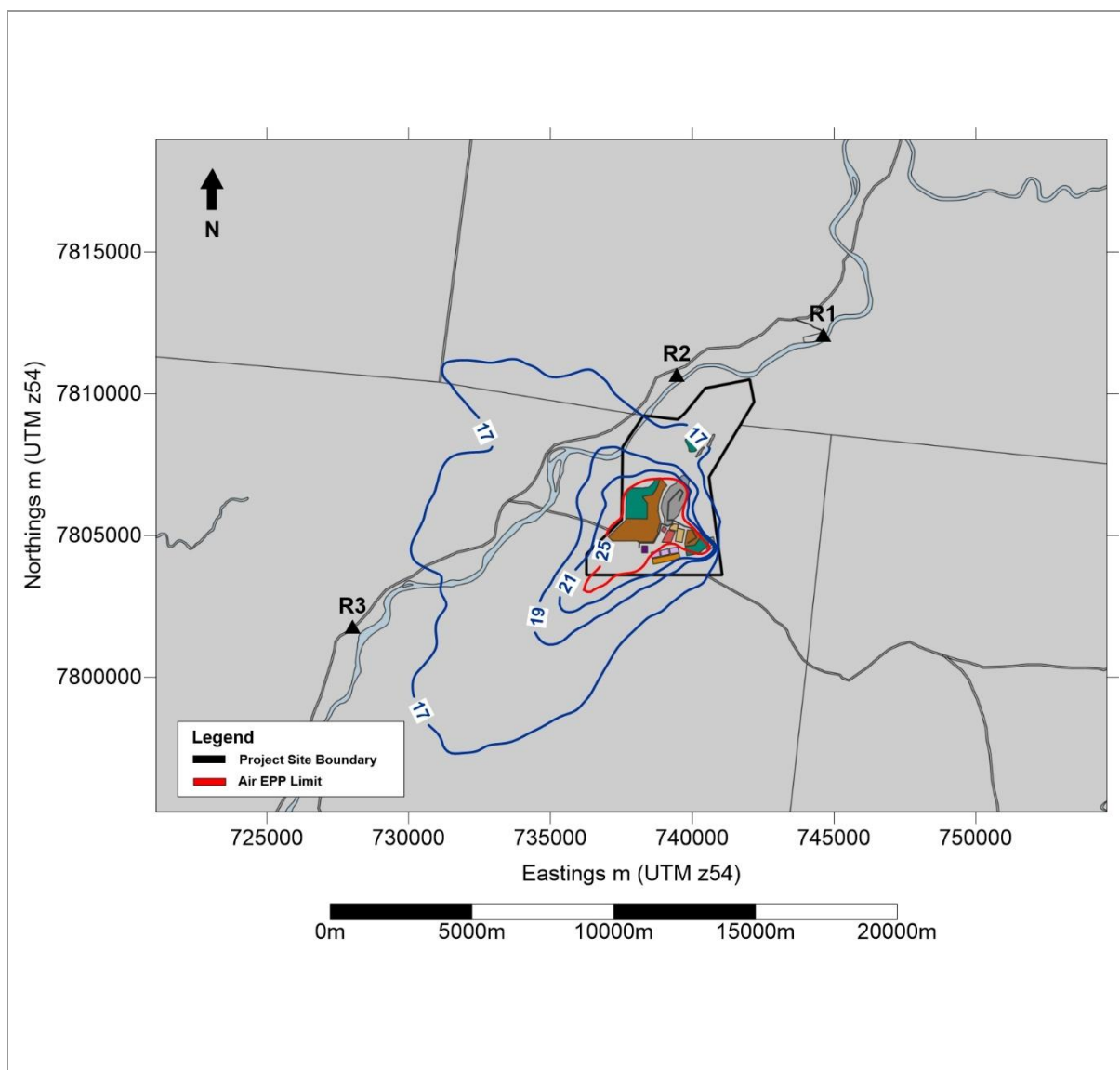


Plate 19 Project Year 11 - Predicted annual average ground-level concentrations of PM₁₀ due to the project including background levels of dust

Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: µg/m ³
Type: Average contour	Objective: 25 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

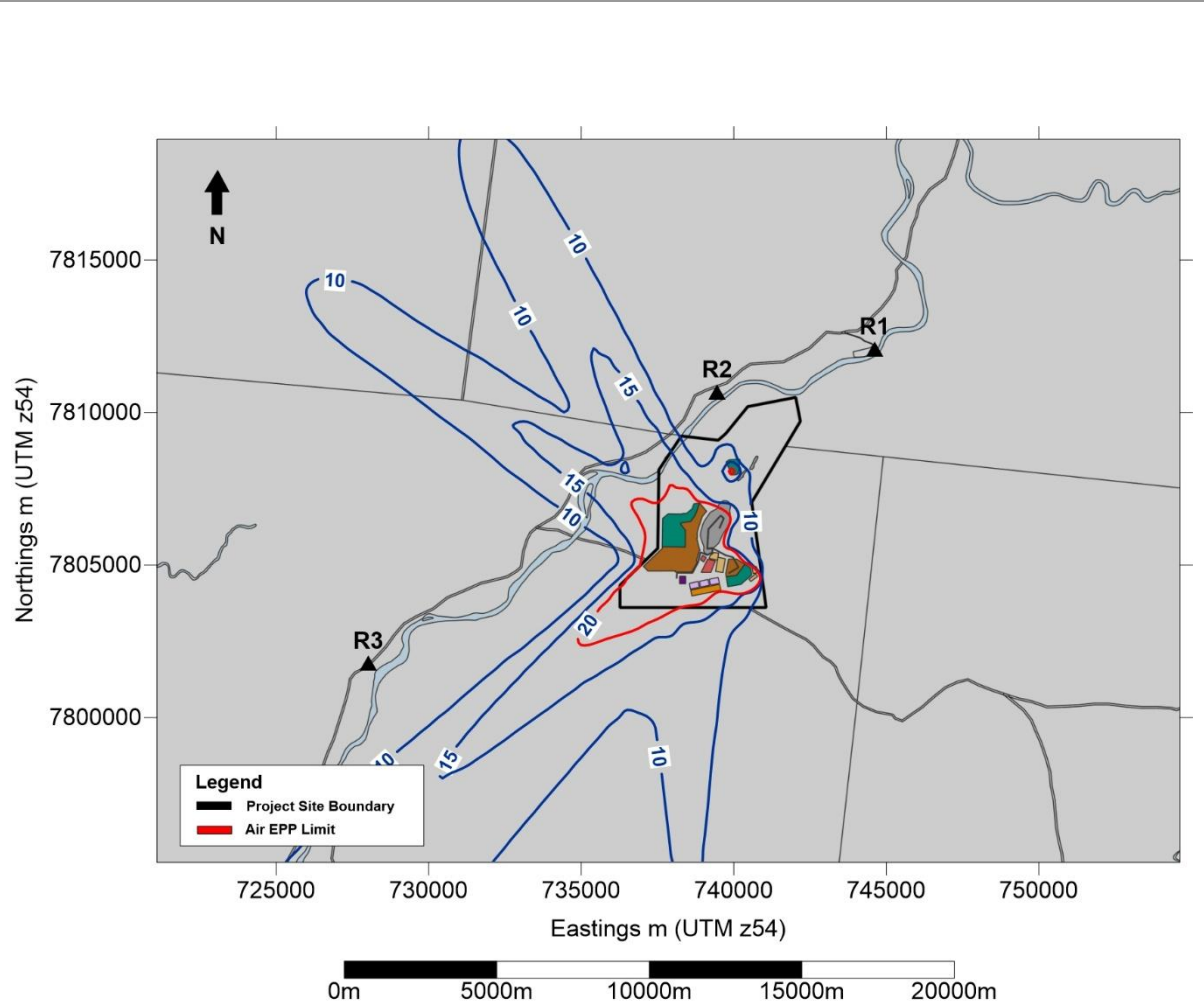


Plate 20 **Project Year 11 - Predicted maximum 24-hour average ground-level concentrations of PM_{2.5} due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 24-hour	Data source: CALPUFF	Units: µg/m ³
Type: Maximum contour	Objective: 20 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

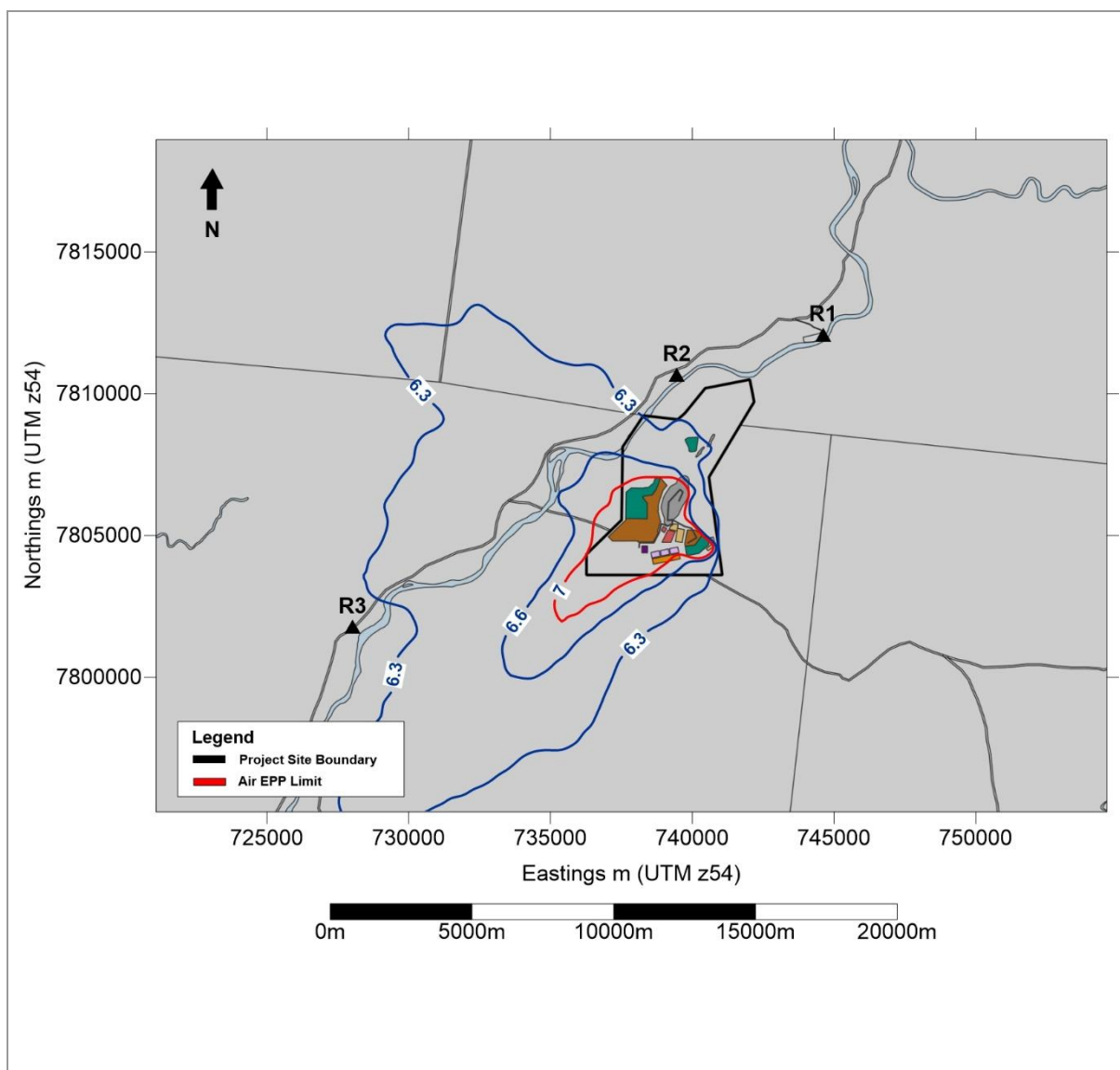


Plate 21 **Project Year 11 - Predicted annual average ground-level concentrations of PM_{2.5} due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: µg/m ³
Type: Average contour	Objective: 7 µg/m ³	Prepared by: Sathya Roysmith	Date: 2025

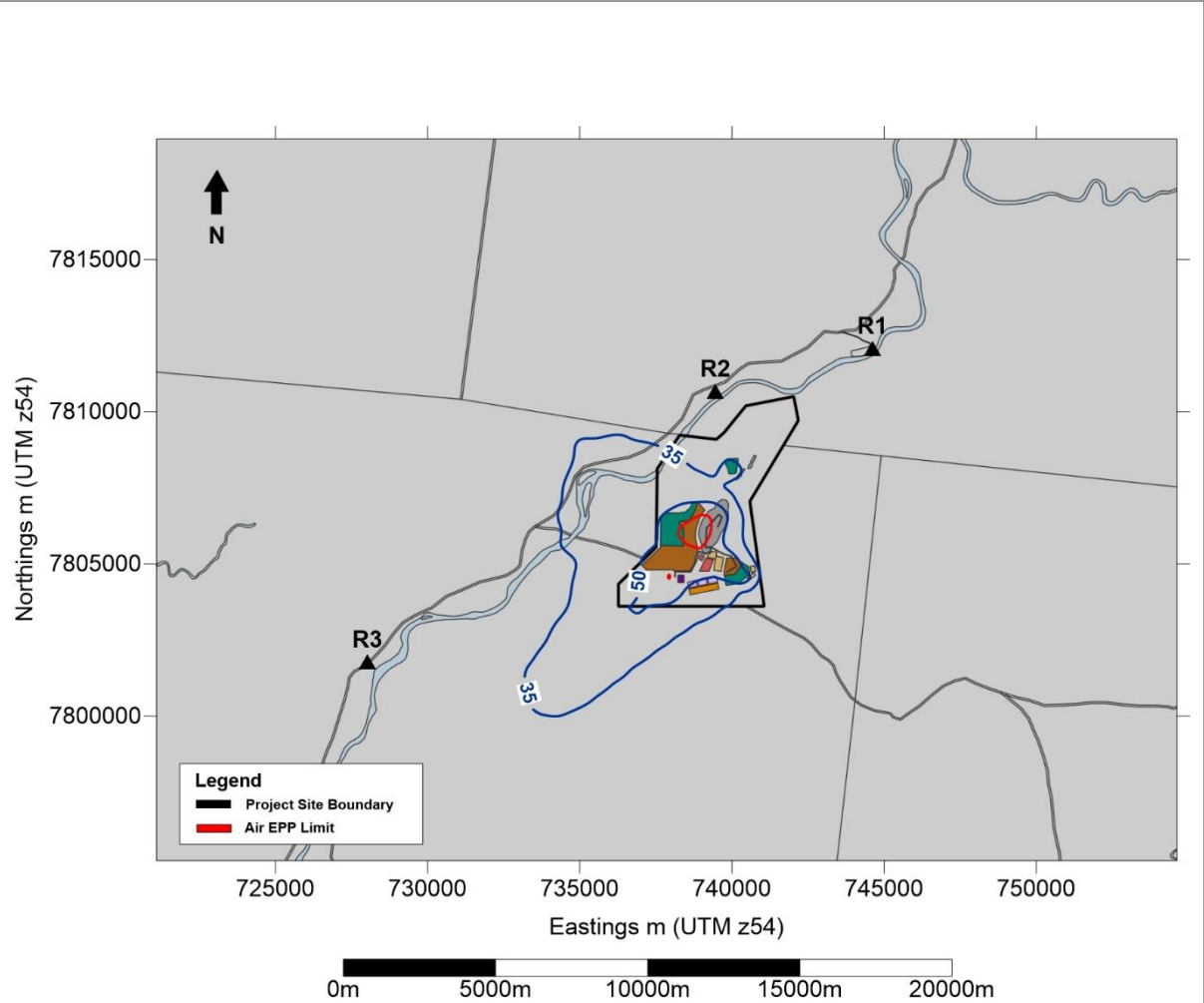


Plate 22 **Project Year 11 - Predicted annual average ground-level concentrations of TSP due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 1-year	Data source: CALPUFF	Units: $\mu\text{g}/\text{m}^3$
Type: Average contour	Objective: $90 \mu\text{g}/\text{m}^3$	Prepared by: Sathya Roysmith	Date: 2025

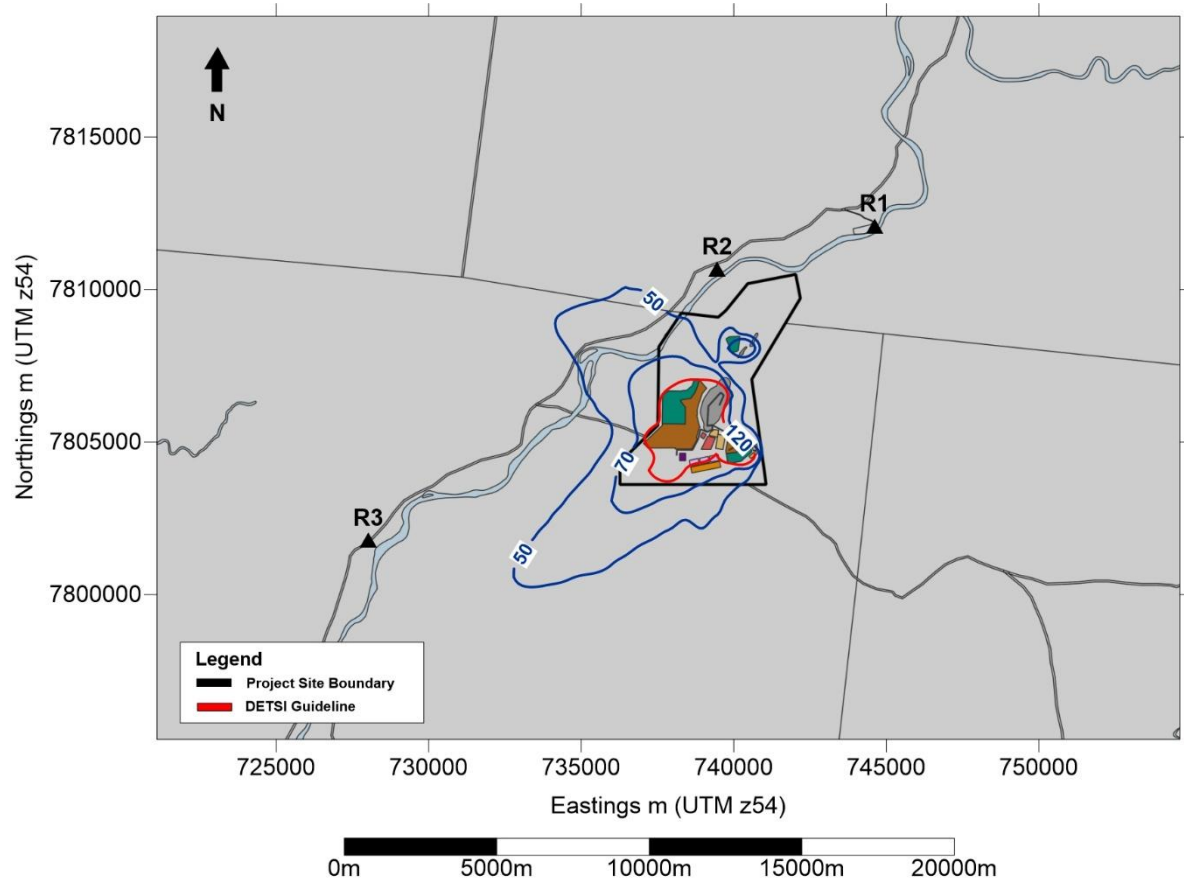


Plate 23 **Project Year 11 - Predicted maximum monthly dust deposition rate due to the project including background levels of dust**

Location: Woolgar, Qld	Averaging period: 1-month	Data source: CALPUFF	Units: mg/m²/day
Type: Maximum contour	Objective: 120 mg/m²/day	Prepared by: Sathya Roysmith	Date: 2025

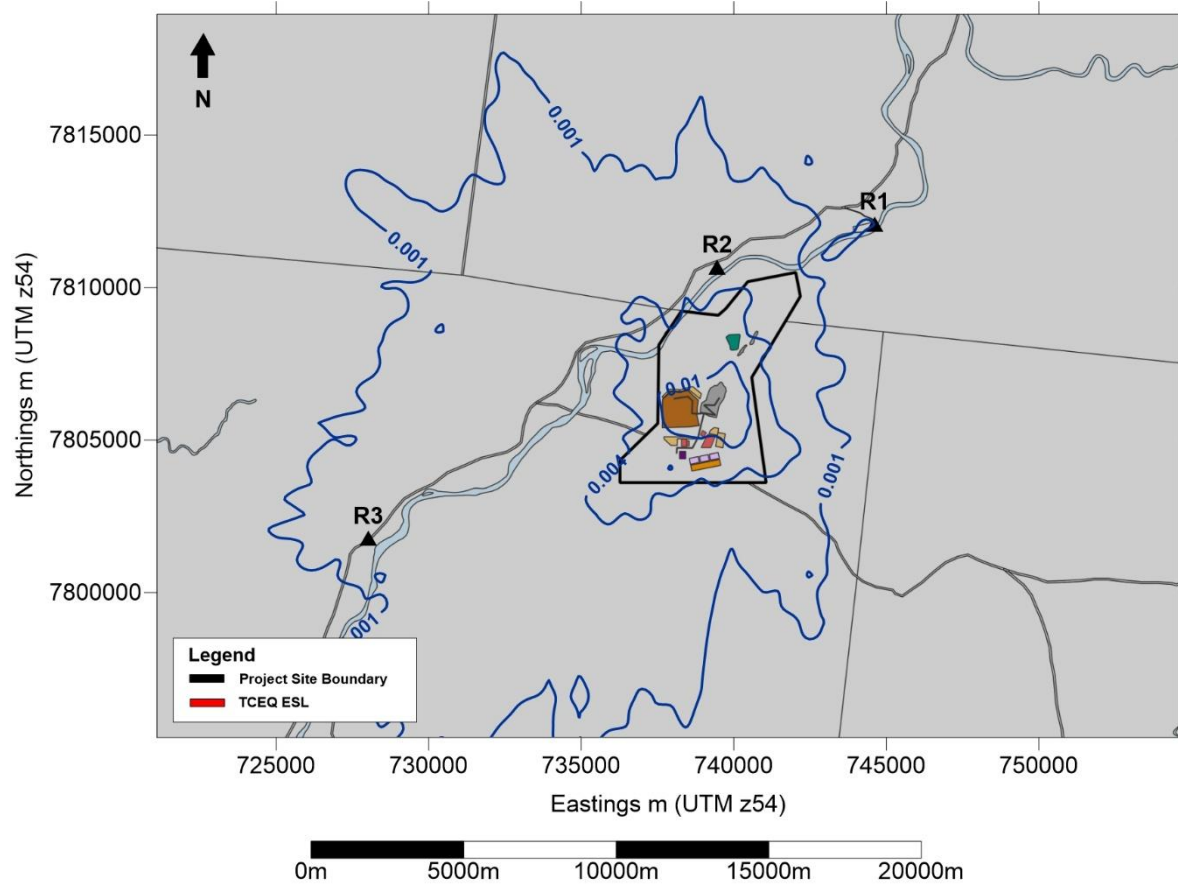


Plate 24 Predicted maximum 1-hour average ground-level concentrations of cobalt due to the project

Location: Woolgar, Qld	Averaging period: 1-hour	Data source: CALPUFF	Units: $\mu\text{g}/\text{m}^3$
Type: Average contour	Objective: $0.21 \mu\text{g}/\text{m}^3$	Prepared by: Sathya Roysmith	Date: 2025

APPENDIX A METEOROLOGICAL AND DISPERSION MODELLING METHODOLOGY

A1 Meteorology

A1.1 Selection of modelling time period

Meteorological data measured between 2013 and 2020 at the Richmond Airport BoM station was analysed to determine a representative year. Figure A1 presents probability distribution functions of meteorology conditions for each of the eight years from 2013 and 2020.

All years displayed a wind direction probability distribution similar to the average. The year 2020 was selected as the most recent of the years that is generally representative of the wind speed, wind direction, humidity and temperature over the period.

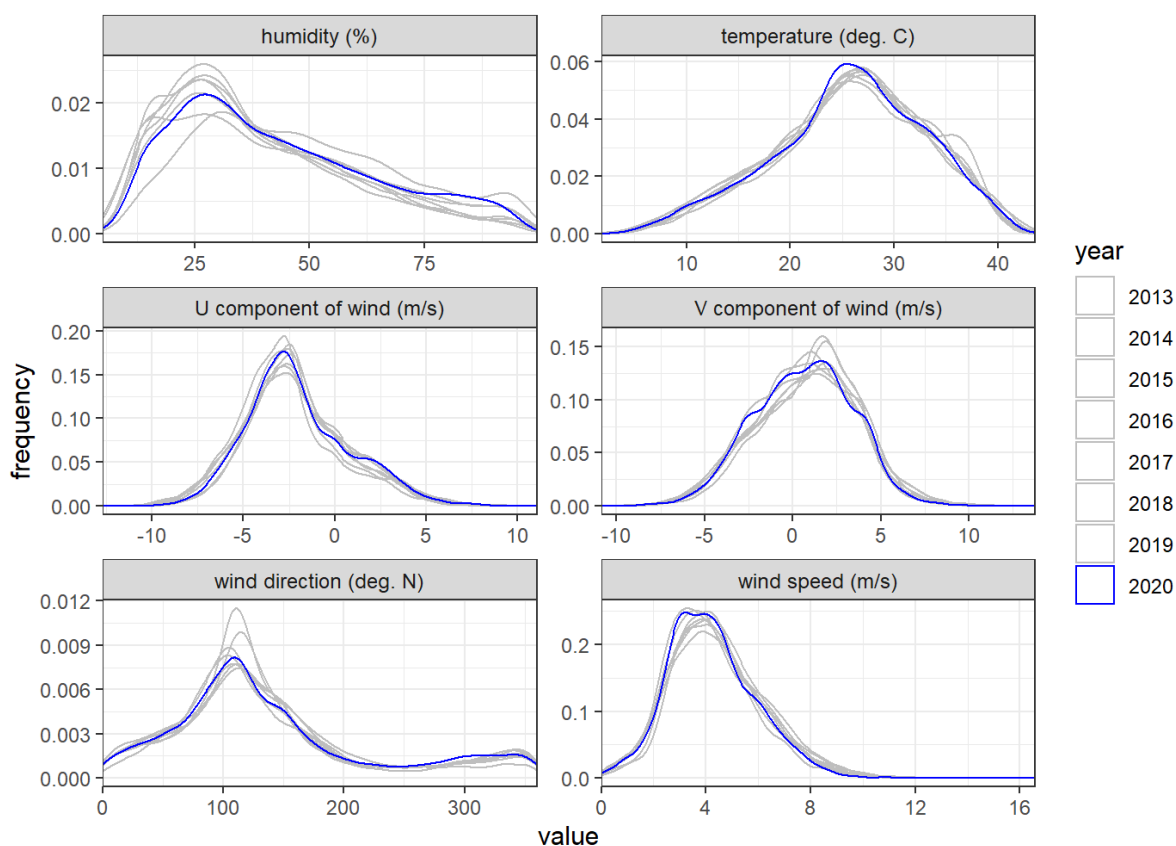


Figure A1 Probability distribution functions of meteorology conditions at BoM's Richmond Airport site (2013-2020)

A1.2 TAPM meteorology

TAPM (The Air Pollution Model) was developed by the CSIRO and has been validated by the CSIRO, Katestone and others for many locations in Australia, in south-east Asia and in North America (CSIRO, 2008). Katestone has extensive experience with TAPM for sites throughout Australia and in parts of America, Bangladesh, New Caledonia, Thailand and Vietnam. The model performs well in simulating regional wind patterns and has proven to be a useful tool for simulating meteorology in locations where monitoring data is unavailable.

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

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

TAPM version 4.0.4 was configured with the following parameters:

- 65 x 65 grid point domain with an outer grid of 30 kilometres and nesting grids of 10 kilometres, 3 kilometres and 1 kilometre;
- 365 days modelled (from 1 January 2020 to 31 December 2020);
- Grid centred near the Project site at latitude -19.900005° and longitude 143.274998°;
- Geoscience Australia 9-second digital elevation model terrain data;
- Land use edited to be consistent with aerial imagery; and
- 25 vertical grid levels.

The TAPM configuration is consistent with the guidance provided in the TAPM user manual and the *NSW Office of Environment and Heritage's (OEH) Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*.

A1.3 CALMET meteorological modelling

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

CALMET version 6.5.0 was used to simulate meteorological conditions in the region. The CALMET simulation was initialised with the gridded TAPM 3D wind field data from the 1km grid. CALMET treats the prognostic model output as the initial guess field for the CALMET diagnostic model wind fields. The initial guess field is then adjusted for the kinematic effects of terrain, slope flows, blocking effects and 3D divergence minimisation.

CALMET was configured in accordance with Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into The Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia (TRC, 2011). This includes default options and parameters, with the following exceptions:

- Modelling period from 1 January to 31 December 2020;
- 75 x 75 grid point domain with 0.5km resolution, nested within the TAPM inner domain;
- 12 vertical levels at heights of 20, 60, 100, 150, 200, 250, 350, 500, 800, 1600, 2600 and 4600 metres;
- Prognostic wind fields generated by TAPM input as MM5/3D.DAT at surface and upper air for “initial guess” field (no-observations mode);
- Gridded cloud cover from prognostic relative humidity at all levels;
- No extrapolation of surface wind observations to upper layers; and
- Terrain radius of influence of 8km.

The geophysical data (land use) was generated to be consistent with the geophysical dataset for TAPM. Terrain data was generated from the 30m resolution SRTM1 dataset.

A1.4 Site-specific meteorology

A1.4.1 Wind speed and direction

Wind speed and wind direction can determine the rate of dispersion of dust emissions from sources such as material transfers, material processing and wind erosion. Wind speed also determines the amount of dust lifted into the air by wind erosion. The annual, seasonal and diurnal frequency of winds at the Project site is shown as wind roses in Figure A2, Figure A3 and Figure A4 respectively.

Northeasterly to southeasterly winds are dominant at the project site, the wind are generally light to moderate with an average wind speed of 2.65 m/s. There is a variation in wind direction throughout the seasons of the year Spring and summer being characterised by predominant north easterly winds. During autumn, winds are predominantly from the southeast.

There is a diurnal variation in wind direction at the Project site. From (midnight – 6am) northeasterlies dominate, during the (6am - midday) period southeasterlies become more prevalent. From (midday - 6pm) the southeasterlies dominate, during the late afternoon (6pm - midnight) the southeasterlies reduce and easterly winds become the predominate winds.

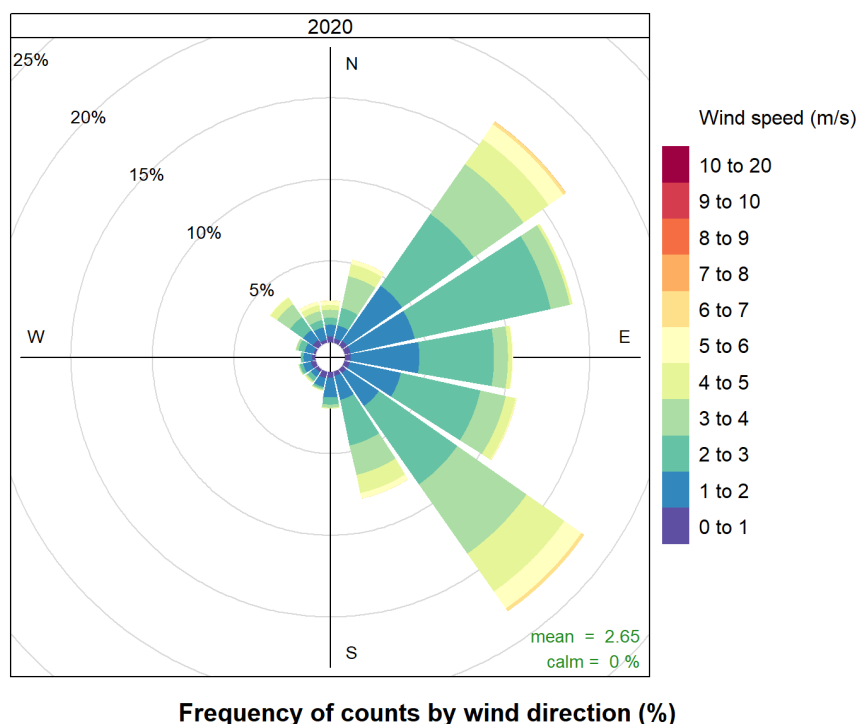


Figure A2 Annual wind distribution predicted by TAPM/CALMET at the project site (2020)

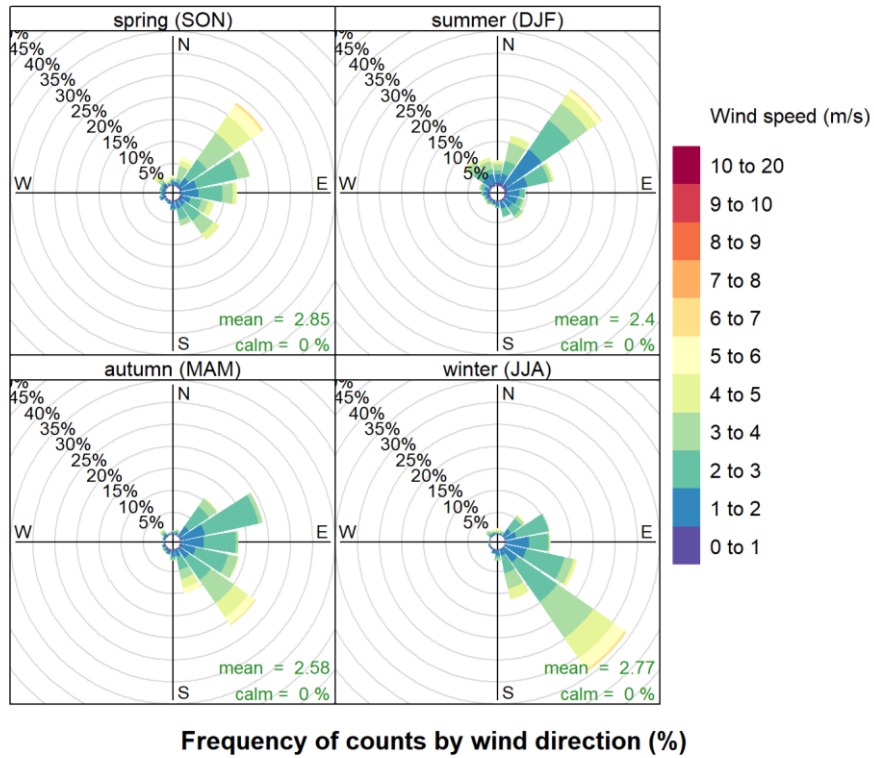


Figure A3 Seasonal wind distribution predicted by TAPM/CALMET at the project site (2020)

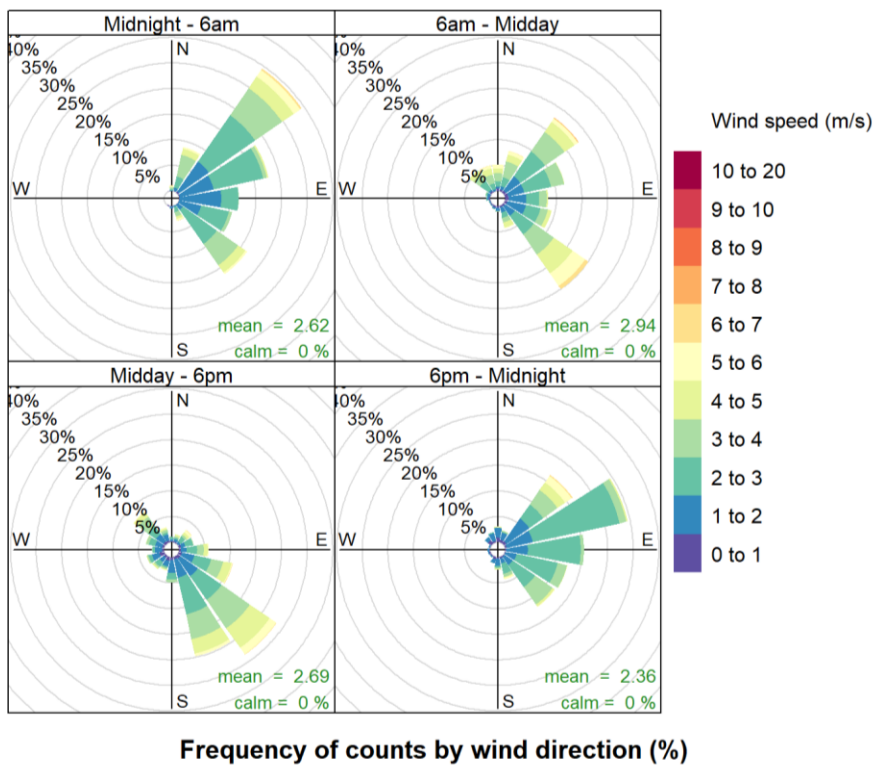


Figure A4 Diurnal wind distribution predicted by TAPM/CALMET at the Project site, 2020

A1.4.2 Mixing height

The mixing height refers to the height above ground within which particulates or other pollutants released at or near ground can mix with ambient air. During stable atmospheric conditions, the mixing height is often quite low and particulate dispersion is limited to within this layer. During the day, solar radiation heats the air at the ground level and causes the mixing height to rise. This results in the better dispersion as pollutants can travel longer distances before reaching ground-level, and lower ground-level concentrations typically occur. The air above the mixing height during the day is generally cooler. The growth of the mixing height is dependent on how well the air can mix with the cooler upper level air and therefore depends on meteorological factors such as the intensity of solar radiation and wind speed. During strong wind speed conditions the air will be well mixed, resulting in a high mixing height.

Mixing height information for the project has been extracted from the TAPM simulation and is presented in Figure A5. The data shows that the mixing height develops around 7 am, increases to a peak at 3 pm before descending rapidly between 4 pm and 6 pm

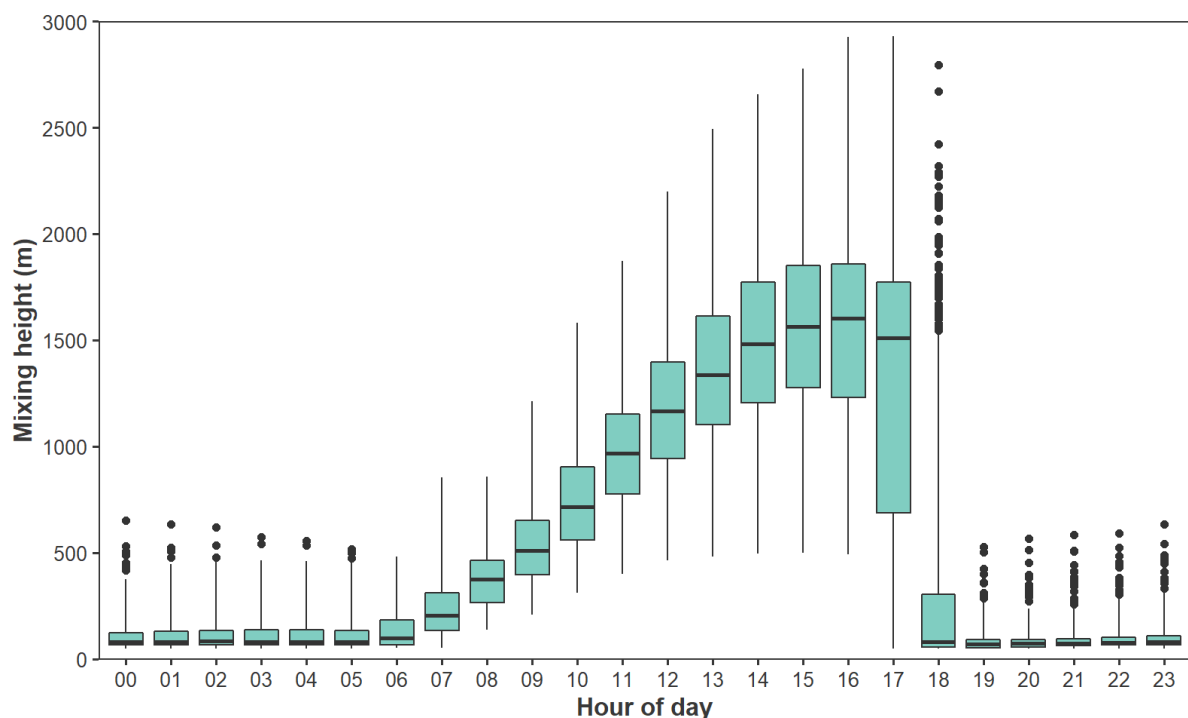


Figure A5 Box and whisker plot of the mixing height data extracted from CALMET at the project site by hour of day

A1.4.3 Atmospheric stability

Atmospheric stability is classified under the Pasquill-Gifford scheme and ranges from Class A, which represents very unstable atmospheric conditions that may typically occur on a sunny day, to Class F which represents very stable atmospheric conditions that typically occur during light wind conditions at night. Unstable conditions (Class A-C) are characterised by strong solar heating of the ground that induces turbulent mixing in the atmosphere close to the ground, which usually results in material from a plume reaching the ground closer to the source than it does for neutral conditions or stable conditions.

This turbulent mixing is the main driver of dispersion during unstable conditions. Dispersion processes for stable conditions (Class F), which are most frequent at the project site, tend to suppress vertical updrafts and reduce

turbulence intensity. During night time, the atmospheric conditions are generally neutral or stable (Class D, E and F) with cloud cover reducing solar heating and enhancing stability. Stability refers to the vertical movement of the atmosphere and is therefore an important factor in the dispersion and transport of particulates within the boundary layer.

Stability class is calculated by CALMET and has been extracted at the site and presented in Figure A6. Table A1 shows the distribution of stability classes for the site.

Table A1 Frequency distribution of surface atmospheric stability conditions at the project site

Pasquil-Gifford Stability Class	Frequency (%)	Classification
A	4%	Extremely unstable
B	17%	Unstable
C	18%	Slightly unstable
D	14%	Neutral
E	10%	Slightly stable
F	37%	Stable

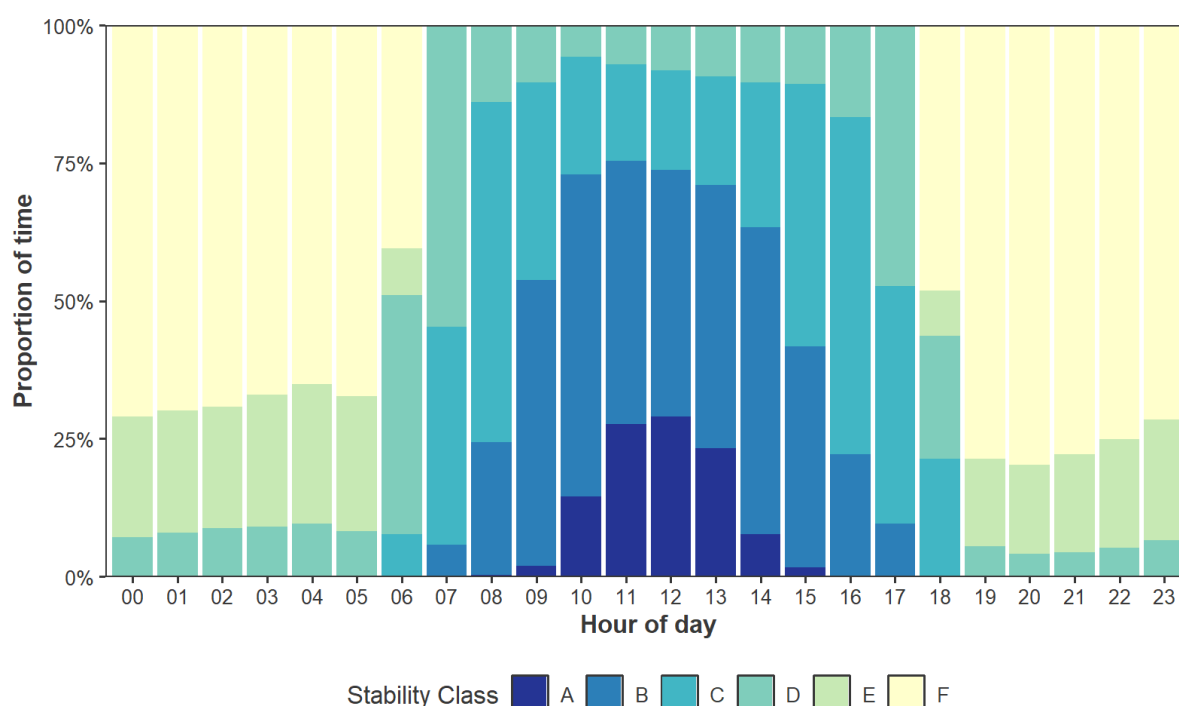


Figure A6 Proportion of stability class predicted by TAPM/CALMET at the Project site by hour of day, 2020

A2 CALPUFF dispersion modelling

CALPUFF simulates the dispersion of air pollutants to predict ground-level concentration and deposition rates across a network of receptors spaced at regular intervals, and at identified discrete locations. CALPUFF is a non-steady-state Lagrangian Gaussian puff model containing parameterisations for complex terrain effects, overwater transport, coastal interaction effects, building downwash, wet and dry removal, and simple chemical transformation. CALPUFF employs the 3D meteorological fields generated from the CALMET model by simulating the effects of time and space varying meteorological conditions on pollutant transport, transformation and removal. CALPUFF takes into account the geophysical features of the study area that affects dispersion of pollutants and ground-level concentrations of those pollutants in identified regions of interest. CALPUFF contains algorithms that can resolve near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub-grid scale terrain interactions, as well as the long range effects of removal, transformation, vertical wind shear, overwater transport and coastal interactions. Emission sources can be characterised as arbitrarily-varying point, area, volume and lines or any combination of those sources within the modelling domain.

Key features of CALPUFF used to simulate dispersion:

- Domain area of 75 by 75 grids at 500 m spacing;
- 366 days modelled (1 January 2020 to 31 December 2020);
- Gridded 3D hourly-varying meteorological conditions generated by CALMET;
- Partial plume path adjustment for terrain modelled;
- Dispersion coefficients calculated internally from sigma v and sigma w using micrometeorological variables; and
- Stack tip downwash, transitional plume rise and PDF used for dispersion under convective conditions.

All other options set to default.

APPENDIX B ACTIVITY DATA

Table B1 Activity data for the Big Vein South Gold Project mining operations

Activity	Year 1	Year 5	Year 11	Units	Source
Operating hours	24	24	24	hrs/day	Proponent
Blasting hours	12	12	12	hrs/day	
Throughputs					
BV1 - Ore	115	0	0	Kt (wet)	Proponent
BV1 - Waste rock	1,000	0	0	Kt (wet)	
BV2 - Ore	0	0	0	Kt (wet)	Calculated
BV2 - Waste rock	0	0	0	Kt (wet)	Proponent
BVS - Ore	350	1,950	1,940	Kt (wet)	
BVS - Waste rock	24,600	18,000	2,800	Kt (wet)	
Waste dump split – BV1					
North waste rock dump	100%	100%	100%	%	Proponent
Southern waste rock dump	0%	0%	0%	%	
BVS waste rock dump	0%	0%	0%	%	
Waste dump split – BV2					
North waste rock dump	100%	100%	100%	%	Proponent
Southern waste rock dump	0%	0%	0%	%	
BVS waste rock dump	0%	0%	0%	%	
Waste dump split – BVS					
North waste rock dump	0%	0%	0%	%	Proponent
Southern waste rock dump	0%	0%	100%	%	
BVS waste rock dump	100%	100%	0%	%	
Process Volumes					
Heap Leach	465	0	0	Kt (wet)	Proponent
Carbon in Leach	0	1,950	1,940	Kt (wet)	
Tailings	0	1,950	1,940	Kt (wet)	
Material characteristics					
Waste rock - Silt content	6.9	6.9	6.9	%	AP42 Ch11.9
Waste rock - Moisture content	14	14	14	%	Proponent
Ore - Silt content	6.9	6.9	6.9	%	AP42 Ch11.9
Ore - Moisture content	14	14	14	%	Proponent
Met parameters					
Ave wind speed	2.65	2.65	2.65	m/s	CALMET wind field
Haul characteristics					
Grader speed	8	8	8	km/h	AP42 Ch13.2
Mine site haul road silt content	8.4	8.4	8.4	%	
Vehicle details - CAT 789D					
Empty weight	126	126	126	tonnes	CAT 789D
Payload	194	194	194	tonnes	
Average weight	245.8	245.8	245.8	tons	Calculated
Haulage – trip length					

Activity	Year 1	Year 5	Year 11	Units	Source
BV1 Waste rock Haul	915.3	-	-	m	Measured from GIS
BV1 Ore Haul	5,188	-	-	m	
BV2 Waste rock Haul	-	-	-	m	
BV2 Ore Haul	-	-	-	m	
BVS Waste rock Haul	1,723	2,969	3,366	m	
BVS Ore Haul	2,708	3,393	3,864	m	
Haulage – No. of trips					
BV1 Waste rock Haul	5,155	0	0	#	Calculated
BV1 Ore Haul	593	0	0	#	
BV2 Waste rock Haul	0	0	0	#	
BV2 Ore Haul	0	0	0	#	
BVS Waste rock Haul	126,804	92,784	14,433	#	
BVS Ore Haul	1,804	10,052	10,000	#	
Haulage – VKT					
BV1 Waste rock Haul	4,718	-	-	VKT	Calculated
BV1 Ore Haul	3,076	-	-	VKT	
BV2 Waste rock Haul	-	-	-	VKT	
BV2 Ore Haul	-	-	-	VKT	
BVS Waste rock Haul	218,440	275,479	48,582	VKT	
BVS Ore Haul	4,886	34,108	38,636	VKT	
Grader					
Number of Graders	2	2	1	#	Proponent
Total Hours operation	7121	7121	5340	hrs.op/yr	
BV1 Waste rock Haul	273	0	0	hrs.op/yr	Calculated
BV1 Ore Haul	31	0	0	hrs.op/yr	
BV2 Waste rock Haul	0	0	0	hrs.op/yr	
BV2 Ore Haul	0	0	0	hrs.op/yr	
BVS Waste rock Haul	6720	6425	3155	hrs.op/yr	
BVS Ore Haul	96	696	2186	hrs.op/yr	
Dozers					
Total Dozers	6	5	2	#	Proponent
Avg hours of op for the year	20,475	17,882	9,529	hrs.op/yr	
Avg hours of op per dozer per year	3,413	3,576	3,176	hrs.op/yr	Calculated
Daily hours op for Processing Dozer	12	12	12	hrs.op	
Avg hours of op for Processing Dozer	4,380	4,380	4,380	hrs.op/yr	
Excavators					
Total Excavators	3	2	1	#	Proponent
Drilling and blasting					
Total blasts per year	183	183	183	blasts/yr	Proponent
Total holes drilled per blast	323	323	323	holes/blast	
Total holes drilled per year	59,109	59,109	59,109	holes/yr	
Area per blasts	13,333	13,333	13,333	m2	
Stockpile Areas					
Rom Stockpile area	4.8	4.8	4.8	ha	Measured from GIS
Rom Stockpile height	10	10	10	m	
Ore Stockpile area	2.1	20.0	14.3	ha	

Activity	Year 1	Year 5	Year 11	Units	Source
Ore Stockpile height	10	10	10	m	
Topsoil Stockpile area	45.8	43.7	22.3	ha	
Topsoil Stockpile height	10	10	10	m	
Heap Leach Pad area	18.3	18.3	18.3	ha	
Heap Leach Pad height	10	10	10	m	
Tailings Storage Cell area	20.4	20.4	20.4	ha	
Tailings Storage Cell height	10	10	10	m	
Exposed Areas					
BV1 Pit	3.9	3.9	3.9	ha	Measured from GIS
BV2 Pit	-	2.9	2.9	ha	
BVS Pit	47.5	55.7	102.6	ha	
North WRD	11.8	-	-	ha	
BVS waste rock dump	70.0	127.1	169.5	ha	
Southern waste Rock dump	-	-	24.8	ha	
Rehabbed Area	-	17.4	139.9	ha	

Table B2 Combustion activity data

Activity	Value	Units
Operating hours	24	hrs/day
Total generating capacity	8,750	kW

Table B3 Metal analysis

Metal	Waste Rock (mg/kg)			High Grade Ore (ppm)	Tailings (mg/kg)	Heap Leach (mg/kg)
	BV1	BV2	BVS			
Arsenic	24.5	21	28.0	83.9	69.0	126.5
Boron	10	10	10.8	10	10.0	10.0
Cadmium	0.06	0.305	5.2	4.52	9.1	3.1
Chromium (VI)	22.5	43.5	27.3	9	203.0	31.0
Cobalt	6.45	16.85	14.2	12.9	9.0	13.4
Copper	8.35	36.25	37.3	53.8	53.5	28.2
Manganese	333.5	522	753.6	313	459.7	825.5
Nickel	14.4	34	28.0	27.2	113.3	25.5
Lead	10.5	26	200.7	203	459.3	425.0
Selenium	0.2	0.25	0.2	0.2	0.2	0.3
Zinc	36.5	199	220.9	264	503.0	233.5

APPENDIX C METHODOLOGIES FOR CALCULATING EMISSIONS

C1 Material handling

Locations throughout the mining and processing areas involve the transfer of material from one location to another. Emissions are dependent on amount of materials transferred (kg/tonne of material).

Emission rates for material transfers were calculated using the following equation (US EPA, 2006):

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

where:

k : 0.74 for particles less than 30 μm
0.35 for particles less than 10 μm
0.053 for particles less than 2.5 μm

U : Mean wind speed in m/s

M : Material moisture content

C2 Wheel generated dust from unpaved haul roads

Wheel-generated dust from haulage of material around the site along unpaved haul routes was estimated using the emission factor defined in AP42 for haulage of materials through unpaved roads. The emission factor for wheel-generated dust on haul roads is dependent on the size of the truck and the silt content of the road. In equation form, the emission factors (g/VKT) for dust are defined using the following equations:

$$EF_{TSP} = 281.9 \times 4.9 \times \left(\frac{S}{12}\right)^{0.7} \times \left(\frac{W}{3}\right)^{0.45}$$

$$EF_{PM10} = 281.9 \times 1.5 \times \left(\frac{S}{12}\right)^{0.9} \times \left(\frac{W}{3}\right)^{0.45}$$

$$EF_{PM2.5} = 281.9 \times 0.15 \times \left(\frac{S}{12}\right)^{0.9} \times \left(\frac{W}{3}\right)^{0.45}$$

where:

s : Silt content of the road

W : mean vehicle weight in tons

The total emissions are dependent on the total distance travelled by the truck, which is based on truck capacity and the length of the haul road to be travelled.

C3 Grading

Maintenance of unpaved haul roads would be achieved with the use of a grader. Emissions of TSP during grading were estimated using the equation defined in AP42:

$$EF_{TSP} = 0.0034 \times (S)^{2.5}$$

$$EF_{PM10} = 0.0034 \times (S)^2$$

10.5% of TSP emissions are estimated to be PM_{2.5}.

C4 Drilling

Dust emitted during drilling was estimated based on the emission factor defined in the NPI. The TSP emission factor is 0.59 kg/hole and the PM₁₀ emission factor is 0.31 kg/hole. The ratio of PM_{2.5} to TSP emissions is 3%.

C5 Blasting

The emission rate for blasting has been calculated using the following equations (NPI, 2012):

$$EF_{TSP} = 0.00022 \times A^{1.5}$$

$$EF_{PM10} = 0.000114 \times A^{1.5}$$

where:

EF_{TSP} : TSP blasting emission factor (kg/blast)

EF_{PM10} : PM₁₀ blasting emission factor (kg/blast)

A: Area blasted (m²)

Blasting was assumed to occur during daylight hours and was modelled between 6am and 6pm. Of TSP emissions, 3.0% are estimated to be PM_{2.5}. The particulate matter distribution is based on size particle distribution for blasting as defined in the AP42.

C6 Crushing

The emission factor for TSP and PM₁₀ due to the primary and secondary crushing is based on the US EPA AP42 document, chapter 11.19.2 (August 2004). For primary crushing the TSP and PM₁₀ emission factors are estimated to be 0.01 and 0.004 kg/tonne of material crushed, respectively. For secondary crushing the TSP and PM₁₀ emission factors are estimated to be 0.03 and 0.012 kg/tonne of material crushed, respectively. The emission factor for PM_{2.5} has been estimated from the emission factor for PM₁₀, and the ratio of the PM_{2.5} and PM₁₀ emission factors for controlled crushing.

C7 Wet grinding

The emission factors for TSP and PM₁₀ for wet grinding (milling) is based on the NPI emission estimation technique manual for gold ore processing (December 2006). TSP and PM₁₀ emission factors are estimated to be 0, due to the wet nature of the process.

C8 Bulldozing

The TSP and PM₁₀ emission factors for bulldozing of topsoil, subsoil and ore were calculated using the equation for materials other than coal, as defined in the NPI and AP42 (NPI, 2012):

$$EF_{TSP} = 2.6 \times \frac{S^{1.2}}{M^{1.3}}$$

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

where

s: Silt content

M: Moisture content

PM_{2.5} emissions were assumed to be 10.5% of TSP emissions, based on the PM_{2.5} to TSP ratio for dozing materials other than coal defined in AP42 Ch. 11.9.

C9 Wind erosion of active stockpiles

Emissions of dust from wind erosion of stockpiles are dependent on the surface area of the stockpiles (kg/ha/hr). The emission rate of dust from the ore and product stockpiles has been calculated using the emission factor for active storage piles from the AP42 Chapter 11.9. In equation form, the emission factor for TSP is defined as:

$$EF_{TSP} = 1.8 \times u$$

where

u: Wind speed (m/s)

Of TSP emissions, 50% are estimated to be PM₁₀ and 7.5% of TSP emissions are estimated to be PM_{2.5}. The particulate matter distribution is based on size particle distribution for wind erosion as defined in the AP42 and the NPI.

Emissions of dust from wind erosion of active stockpiles have been modelled as hourly varying, using a threshold wind speed of 5.4 m/s so that emissions occur during hours when the wind speed is greater than the threshold wind speed, and the magnitude of dust emissions is proportional to the square of the wind speed.

C10 Wind erosion of exposed areas

Emissions of dust from wind erosion of exposed areas are dependent on the size of the exposed areas (Mg/ha/yr). The emission rate is based on the equation defined in the AP42 for estimating emissions of wind exposed areas. A rain factor was not applied. The TSP emission factor was estimated using the following equation:

$$EF_{TSP} = 0.85$$

Of TSP emissions, 50% are estimated to be PM₁₀ and 7.5% are estimated to be PM_{2.5}. The particulate matter distribution is based on the size particle distribution for wind erosion as defined in the AP42 and the NPI.

Emissions of dust from wind erosion of exposed areas have been modelled as hourly varying, using a threshold wind speed of 5.4 m/s so that emissions occur during hours when the wind speed is greater than the threshold wind speed, and the magnitude of dust emissions is proportional to the square of the wind speed.