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**McArthur River Mine
Overburden Management Project**

Air Quality

Draft Environmental Impact Statement

13 Air Quality

13.1 Introduction

This chapter discusses the potential impacts on air quality associated with the McArthur River Mine (MRM) Overburden Management Project (the Project), and outlines the appropriate mitigation measures where required. The primary sources of the Project particulate emissions include the North Overburden Emplacement Facility (NOEF), Tailings Storage Facility (TSF), open cut mining operations, processing plant, mobile plant and vehicle movements. Potential sources of particulate emissions from the existing surrounding environment include agricultural activities, smoke from bushfires and controlled burns and wind-blown dust.

In accordance with the Terms of Reference (TOR), this assessment addresses the potential nuisance and human health issues associated with air quality, including members of the general public with the potential for exposure to these hazards as a consequence of the Project. The potential air quality impacts on environmental receptors (sensitive habitats, species of conservation significance) are discussed in **Chapter 9 – Biodiversity, Appendix W – Aquatic Ecology Impact Assessment Report and Appendix X– Terrestrial Ecology Impact Assessment Report**.

An Environmental Risk Assessment is presented in **Chapter 7 – Project Risk Assessment** which outlines the potential Project risks in relation to air quality. The risk assessment determines the likelihood and consequence of each risk and an overall risk rating (high, medium or low). Risk ratings are given for both risks assessed without mitigation strategies (inherent) and those with mitigation strategies (residual).

An air quality impact assessment technical report presents detailed information relating to the assessment of the Project and is provided in **Appendix AA – Air Quality Impact Assessment Report**.

13.1.1 Background

MRM has been operating for more the 20 years and currently operates in accordance with MRM air quality management, monitoring procedures and sampling regimes. The Project presents the future stages of the operation including the extraction and hauling of overburden and ore, handling and placement of topsoil, processing of ore and other activities which have the potential to generate air emissions that may have an impact on sensitive receptors.

The Project's potential air quality impacts have been assessed by:

- reviewing legislative requirements and ambient air quality goals;
- describing existing air quality and dispersion meteorology within and surrounding the Project;
- identifying the nearest sensitive receptors;
- modelling air dispersion to predict concentrations of particulate matter at the nearest sensitive receptors;
- determining the potential air quality impacts by comparing with air quality goals;
- identifying mitigation strategies to assist with the management of the potential air quality impacts from the Project;
- assessing the potential greenhouse gas emissions associated with the Project and climate change impacts; and
- reviewing and analysing site air quality monitoring data.

13.1.2 Regulatory Framework

13.1.2.1 National Environment Protection Council

The National Environment Protection Council (NEPC), comprising of the Federal Environment Minister and their counterpart from each State and Territory, takes a cooperative approach to ensure appropriate environmental management is in place to protect the Australian people.

The objectives of the NEPC are to ensure that:

- people enjoy the benefit of equivalent protection from air, water or soil pollution and from noise, wherever they live; and
- business decisions are neither distorted nor markets fragmented by variations in major environment protection initiatives between member governments.

NEPC has powers to develop National Environment Protection Measures (NEPMs) on:

- ambient air quality;
- ambient marine, estuarine and fresh water quality;
- protection of amenity in relation to noise (only if differences in environmental requirements; relating to noise would have an adverse effect on national markets for goods and services);
- general guidelines for the assessment of site contamination;
- environmental impacts associated with hazardous wastes;
- re-use and recycling of used materials; and
- motor vehicle noise and emissions (in consultation with the National Transport Commission).

Regarding air quality, two NEPMs exist, including the:

- Ambient Air Quality NEPM, which establishes ambient air quality standards, monitoring and reporting protocols for listed air pollutants; and
- Air Toxics NEPM, which establishes procedures to collect information regarding certain hazardous air pollutants in order to develop national standards eight years after its making.

As outlined in the NEPC 2014-2015 Annual Report, air toxics have been shown to be irrelevant to the Northern Territory (NT) airshed and have not been considered further in the air quality assessment of the Project.

The NEPM air quality standards are not designed to be applied to a specific project, with the standards applying to the average exposure to air pollutants of the general population, in each state/territory. The NEPM requires that the states/territories report to the Commonwealth on the trends in air quality by way of reference to the standards.

13.1.2.1.1 Ambient Air Quality NEPM

The Ambient Air Quality NEPM provides the following standards for emissions applicable for the Project:

Particles as PM₁₀

- PM₁₀ particles (often described as coarse particles) are smaller than 10 micrometres (µm) (0.01 millimetres (mm)) in diameter;
- high levels of PM₁₀ particles in the air can irritate the eyes and throat. People with existing heart or lung conditions (including asthma) can experience an increase in symptoms, including wheezing, chest tightness and difficulty breathing; and

- common sources of PM₁₀ particles include sea salt, pollen and combustion related activities associated with industrial processes and operation of motor vehicles. Dust from unsealed roads is also a major source of PM₁₀ particles.

Particles as PM_{2.5}

- PM_{2.5} particles are less than 2.5 µm (0.0025 mm) in diameter. Often described as fine particles, they are up to 30 times smaller than the width of a human hair;
- PM_{2.5} particles are small enough to be inhaled into the lungs. This can cause negative health effects. Children, people over 65, pregnant women and people with existing heart or lung conditions (including asthma) are more sensitive to the effects of breathing in fine particles. Symptoms may include wheezing, chest tightness and difficulty breathing; and
- PM_{2.5} particles result from the burning of fossil fuels (such as coal), organic matter (including wood and grass) and most other materials, such as rubber and plastic. Motor vehicle exhaust emissions, power plant emissions and bushfires are also major sources of fine particles.

Sulphur Dioxide

Sulphur dioxide can potentially be released from selected MRM materials and concentrates. Sulphur dioxide levels are more likely to be elevated in hot conditions where combustion is more readily able to occur. Sulphur dioxide is an irritant to the eyes, skin and mucous membranes. It reacts with the water content of these surfaces, rapidly forming sulphuric acid.

Lead

Lead can be absorbed into the body via:

- inhalation of lead dust particles and ingestion in food and drinks; and
- ingestion from contaminated hands, food, drinks, clothing and/or cigarettes.

The Ambient Air Quality NEPM was amended on 15 December 2015 after taking into consideration the latest scientific evidence about the potential health impacts of particles. The amending instrument took effect on 4 February 2016 with the following amendments worth noting for the MRM air quality study:

- amending the status of the annual average and 24 hour average PM_{2.5} 'advisory reporting standards' to 'standards';
- including an annual average PM₁₀ standard of 25 microgram per cubic metre (µg/m³);
- including an aim to move to annual average and 24 hour PM_{2.5} standards of 7 µg/m³ and 20 µg/m³ by 2025; and
- replacing the five-day exceedance form of the 24 hour PM_{2.5} and PM₁₀ standards with an exceptional event rule.

Table 13-1 outlines the relevant NEPM standards and goals.

Table 13-1 Ambient Air Quality NEPM: Standards and Goal for Pollutants

Pollutant	Averaging Period	Maximum Concentration	Maximum Allowable Exceedances
Particles as PM ₁₀	1 day	50 micrograms per cubic metre (µg/m ³)	None
	1 year	25 µg/m ³	None
Particles as PM _{2.5}	1 day	25 µg/m ³	None
	1 year	8 µg/m ³	None
Sulphur dioxide	1 hour	0.20 parts per million (ppm)	1 day per year
	1 day	0.08 ppm	1 day per year
	1 year	0.02 ppm	None
Lead	1 year	0.50 µg/m ³	None

13.1.2.2 Northern Territory EPA Impact Assessment Guidelines

The Northern Territory Environmental Protection Authority (NT EPA) applies the New South Wales (NSW) guidelines and impact assessment criteria for air quality. The NSW air quality criteria (*Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*) which are applicable to the Project are outlined in **Table 13-2**.

The air quality criteria for total impact needs to consider background dust levels along with the Project related dust levels to assess potential impacts.

Table 13-2 Air Quality Impact Assessment Criteria

Pollutant	Averaging Period	Impact	Criteria
Total Suspended Particles (TSP)	1 year	Total	90 µg/m ³
PM ₁₀	1 day	Total	50 µg/m ³
	1 year	Total	25 µg/m ³
PM _{2.5}	1 day	Total	25 µg/m ³
	1 year	Total	8 µg/m ³
Deposited dust	1 year	Incremental	2 g/m ² /month*
	1 year	Total	4 g/m ² /month
Sulphur Dioxide	10 minute	Total	0.25 ppm

*grams per square metre per month

13.1.2.3 Other Applicable Goals and Standards

Zinc is another air quality pollutant which is applicable to the Project. As zinc is not listed under the NEPM or NT EPA guidelines, another criterion was sought which has been used in similar parts of Australia. The Ontario Ministry of the Environment (MOE) Ambient Air Quality Criteria was adopted for the Project as this has been used by government departments for air quality assessments/monitoring in Northern Australia. The Ontario ambient air quality criterion for zinc is outlined in **Table 13-3**.

Table 13-3 Ontario MOE Standard for Zinc

Indicator	Environmental Value	Objective	Period
Zinc	Particulate	120 µg/m ³	1 day

13.1.2.4 Project Goals for Air Quality

Table 13-4 provides a summary of the standards and goals adopted for each of the applicable Project pollutants.

Table 13-4 Summary of Standards and Goals for Applicable Pollutants

Pollutant	Averaging Period	Project Goal	Guideline Source
TSP	1 year (total)	90 µg/m ³	NSW EPA
PM ₁₀	1 day (total)	50 µg/m ³	NEPM/NSW EPA
	1 year (total)	25 µg/m ³	NEPM/NSW EPA
PM _{2.5}	1 day (total)	25 µg/m ³	NEPM/NSW EPA
	1 year (total)	8 µg/m ³	NEPM/NSW EPA
Sulphur dioxide	10 minute (total)	712 µg/m ³ (0.25 ppm)	NSW EPA
	1 hour (total)	572 µg/m ³ (0.20 ppm)	NEPM
	1 day (total)	229 µg/m ³ (0.08 ppm)	NEPM
	1 year (total)	57 µg/m ³ (0.02 ppm)	NEPM
Lead	1 year (total)	0.50 µg/m ³	NEPM
Zinc	1 day (total)	120 µg/m ³	Ontario MOE
Dust deposition	1 year (total)	4 g/m ² /month	NSW EPA
	1 year (incremental)	2 g/m ² /month	NSW EPA

13.1.3 Greenhouse Gas Policies

Greenhouse gas (GHG) is present in the atmosphere and acts as an agent in absorbing and emitting radiation within the thermal infrared range causing a “greenhouse effect”. GHG’s within the Earth’s atmosphere comprise of water vapour, carbon dioxide, methane, nitrous oxide and ozone. Over the last century the amount of GHG within the atmosphere has risen significantly as a result of anthropogenic activity and subsequently has the potential to impact average patterns and intensity of global weather.

13.1.3.1 International Policy

The United Nations Framework Convention on Climate Change (UNFCCC) is the main global forum for climate change negotiations and aims to reduce potential impacts to the climate through stabilising GHG concentrations in the atmosphere through policies and agreements.

The Kyoto Protocol was the first international agreement under the UNFCCC, which encouraged developed countries to commit to setting internationally binding GHG reduction targets. The Kyoto Protocol began in 2008 and by 2012 when it had ended a number of countries had managed to reduce their GHG emissions to an average of 5% of 1990 levels of emissions. The second commitment period began in 2013 which set a target to developed countries to reduce their emissions by at least 18% below the 1990 emissions by 2020.

In December 2015 a historical global climate agreement was signed at the UNFCCC 21st Conference of the Parties (COP21) in Paris. This Paris Agreement set a framework for all countries (including developing countries) to take climate change action from 2020, building on existing international efforts in the period up to 2020. The agreement included commitments to:

- a global goal to keep the average temperature increase well below 2°C and pursue efforts to keep global warming below 1.5°C above pre-industrial levels;
- all countries to set mitigation targets from 2020 and review targets every five years to build ambition over time, informed by a global stocktake;
- robust transparency and accountability rules to provide confidence in countries’ actions and track progress towards targets;
- promoting action to adapt and build resilience to climate impacts; and
- financial, technological and capacity building support to help developing countries implement the Agreement.

13.1.3.2 Australian Policy

Australia is a party to the UNFCCC and has agreed to the Kyoto Protocol and the Paris Agreement, committing Australia to reduce its GHG emissions to 26-28% on 2005 levels by 2030. National policies to reduce emissions and adapt to changes as a result of climate change is being implemented in Australia in the context of coordinated global action. This includes Direct Action Plans as well as Emissions Reduction Funds to help outline the means to achieving reduction targets.

13.1.3.3 Glencore Approach

Glencore recognises the importance of global climate change as outlined by the Intergovernmental Panel on Climate Change (IPCC) and believes that (together with COP21 and public sentiment) decisions and policy developments to reduce emissions can be achieved. Glencore manages climate change issues through four broad areas, including:

1. internal risk and materiality assessment;
2. management of our energy and carbon footprint;
3. proactive engagement with a range of stakeholders; and
4. support for development of low-emission technologies.

(Glencore, 2017).

13.1.3.3.1 Glencore Emission Reduction Pilots and Projects

Glencore is committed to a role in reducing global GHG emissions. Systematic management of energy and carbon emissions across the business has been identified and Glencore has begun works to determine how an internal carbon target can be applied across the business. Additionally over several years Glencore has invested in a range of projects and initiatives to reduce emissions from operations and the use of products with low emissions. In addition to reducing GHG emissions, Glencore supports low-emission coal technology projects and GHG-related studies.

13.1.3.3.2 MRM Emission Reduction

Glencore's overall strategy around reducing GHG emissions filters down to all sites including MRM and targets are set with the intent of improving performance over consecutive years. These targets are incorporated into site annual plans and performance is tracked on a quarterly basis.

13.2 Existing Environment

13.2.1 Local Setting

The Project is located on the Carpentaria Highway in the Gulf region of the NT, approximately 45 kilometres (km) directly southwest of the township of Borroloola and 900 kilometres southeast of Darwin.

The area surrounding the mine is used predominantly for cattle grazing by large pastoral properties, whereby limited anthropogenic emissions are released other than the mining operations and processing facility. Bushfires and controlled burns occur throughout the year, however predominantly within the dry season and have a noticeable impact on air quality.

The topography surrounding the Project area is gently undulating and only mildly elevated in some areas to the northwest and west of the Project. The Project area is situated adjacent to the McArthur River which flows along a southwest to northeast axis in a depressed region of the terrain.

13.2.2 Sensitive Receptor Locations

Sensitive receptors are locations which have the potential to be impacted by air emissions from the Project. Air quality sensitive receptors include:

- residences;
- educational facilities (e.g. schools, kindergartens, child care centres and universities);
- medical institutions (e.g. hospitals and surgeries);
- public parks and recreational areas; and
- religious buildings.

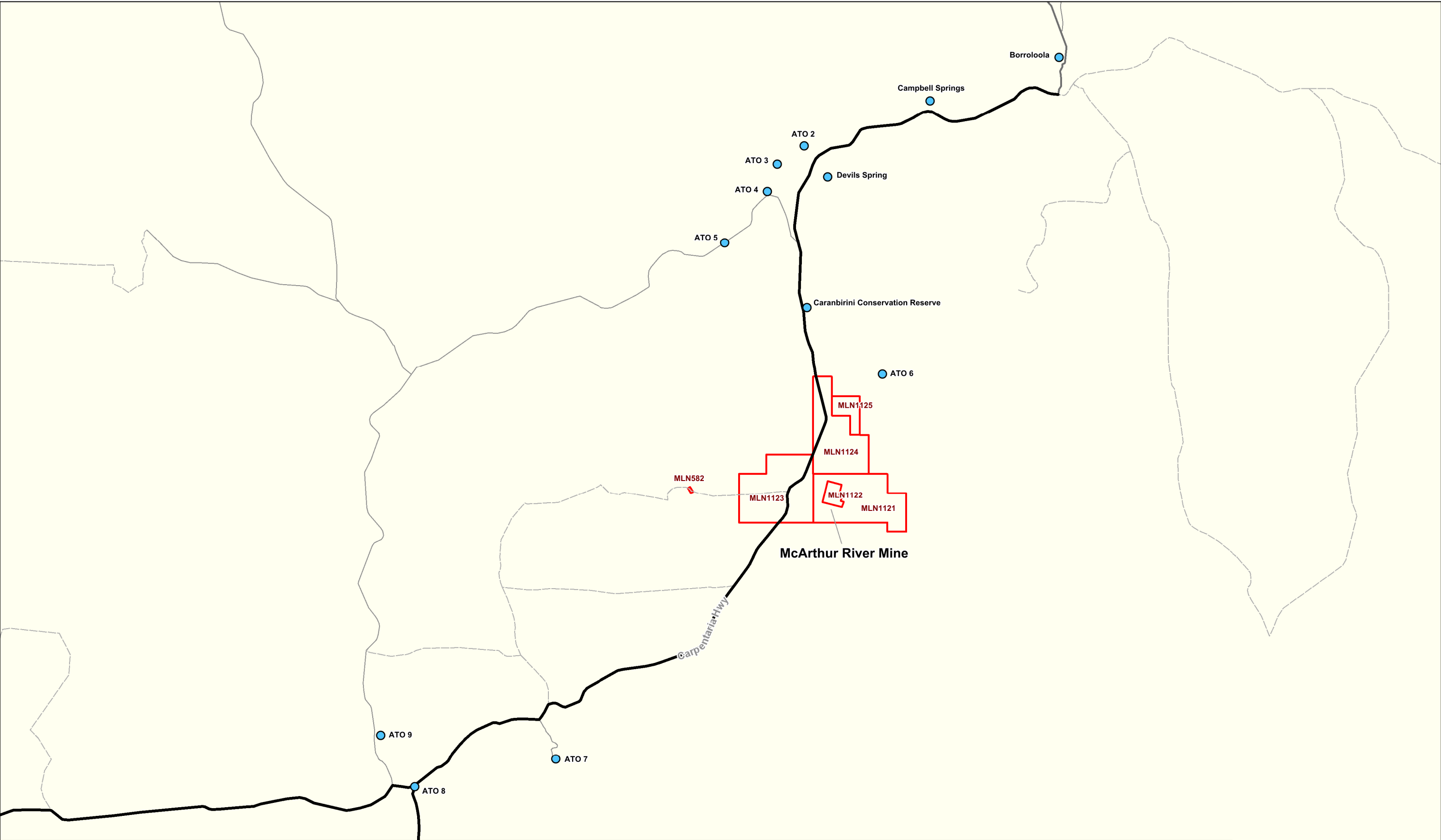
The Project is located in a remote region of the NT with no sensitive receptors in its immediate vicinity. The nearest townships of Borroloola (45 km directly to the northeast) and Devil Spring (28 km directly north) are located at significant distances from the Project.

Areas of Temporary Occupation (ATO), which include camps and areas used intermittently by the local population, are located both north and south of the Project however all are located more than 10 km from the Project area. Campbell Springs comprises of several privately-owned dwellings and the Caranbirini Conservation Reserve is a publicly accessible recreational area.

The Carpentaria Highway dissects the Project site. Whilst this is a public thoroughfare, users of the highway are considered to be transient and short term, and in most cases are inside a vehicle. These users are considered unlikely to be affected by the air quality emissions from the Project.

Sensitive receptor locations are defined in this assessment as off-site areas where people work and live. The potential risk of air pollutants on MRM employees at on-site operational areas and the accommodation village is managed by MRM's occupational health and safety protocols (e.g. hygiene management protocols for reducing potential for lead ingestion, conducting regular blood testing of employees, and personnel protective equipment requirements).

Sensitive receptors which have been identified as part of the Project are displayed in **Figure 13-1**.



	 A GLENCORE COMPANY	LEGEND ● Off-site Sensitive Receptors (ATO: Area of Temporary Occupation) — Highway — Road - - - Track □ Mining Leases Data Source: Sensitive Receptors - MetServe (Oct 2016); Tenements, Roads - NT Gov. (2012)	McArthur River Mine Overburden Management Project EIS Sensitive Receptors 50510 Kilometres Scale: 1:350,000 (A3) 03/03/2017  Datum: GDA94 Projection: MGA53 FIGURE 13-1
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13.2.3 Sources of Air Emissions

Potential sources of particulate emissions from the existing surrounding environment primarily comprise:

- farming and grazing activities;
- traffic on unsealed roads;
- existing mining operations;
- smoke from grass/bush fires (permitted or otherwise); and
- naturally occurring wind-blown dust.

13.2.4 Existing Air Quality Monitoring

Due to the fine-grained nature of the ore, dust generation is one of the environmental aspects closely managed at the existing mine. The existing monitoring program records data to assess potential contaminated particulate matter (dust particles) arising from mining activities. This data has been utilised to verify the air quality assessment model and provide greater accuracy for the assessment of impacts at the sensitive receptors (refer to **Section 13.2.2**). Exceedances are managed in accordance with MRM's Air Quality Management Plan and MRM's occupational health and safety protocols.

13.2.4.1 Low Volume Air Samplers

A total of 31 Low Volume Air Samplers (LVASs), including two control sites located at distances greater than 3 km from the Project, have been established to measure ambient particulate matter (PM₁₀), particulate lead and particulate zinc. Monitoring is conducted monthly at each of the locations over a 24 hour period, however due to site accessibility and other constraints, all of these sites are not able to be monitored every month. Consequently, when assessing annual compliance per the NEPM Ambient Air Quality Measure, the requirement to have a dataset at least 75% complete in each calendar quarter cannot be met (NEPC, 2002). Therefore, for the purposes of the analysis below, the annual compliance level is used as a guide for comparison with the measured levels. The air quality monitoring program is under review and new monitoring locations are being proposed (see **Section 13.4.1.1**).

Data captured from the LVASs have been summarised below for particulate matter, particulate lead and particulate zinc. The following analysis of data uses the annual compliance level as a guide only for comparison with the measured levels and available data.

13.2.4.1.1 Particulate Dust (PM₁₀)

Particulate matter (PM₁₀) levels for July 2014 to June 2015 and July 2015 to June 2016 are summarised in **Table 13-5**. A majority of the sites (17 out of 31), with sufficient data for annual average calculations exceeded the air quality criteria, with results ranging from 26 µg/m³ at LV45 to 92.1 µg/m³ at LV43. Maximum 24 hour average PM₁₀ concentrations reported 22 sites out of 31 above the 50 µg/m³ criteria. All of the sites capturing particulate matter data are located nearby to mining operations and are displayed in **Figure 13-2**.

Table 13-5 Summary of PM₁₀ Levels at MRM Monitoring Sites

Sites	Annual Average*			24 hour Average*		
	Air Quality Criteria (µg/m³)	July 2014 - June 2015 (µg/m³)	July 2015 - June 2016 (µg/m³)	Air Quality Criteria (µg/m³)	July 2014 - June 2015 (µg/m³)	July 2015 - June 2016 (µg/m³)
LV01 (control)	25	21.3	18.4	50	30.8	35.8
LV10 (control)	25	24.8	20.1	50	57.9	30.0
LV22	25	55.8	49.2	50	116.9	106.0
LV23	25	57.5	41.2	50	137.6	78.5
LV24	25	31.8	29.3	50	51.5	56.0
LV27	25	35.7	23.9	50	68.8	47.2
LV28	25	36.3	34.1	50	70.1	101.9
LV30	25	34.3	26.6	50	80.4	61.1
LV31	25	22.0	25.1	50	42.8	52.8
LV32	25	-	-	50	-	14.3
LV33	25	-	-	50	-	19.0
LV43	25	92.1	41.3	50	169.4	64.7
LV44	25	34.4	22.5	50	60.8	45.3
LV45	25	26.0	23.1	50	54.2	51.1
LV46	25	-	-	50	76.4	17.2
LV47	25	-	22.5	50	-	47.2
LV03	25	18.9	19.6	50	28.8	34.3
LV05	25	28.9	18.8	50	78.9	28.2
LV06	25	24.3	23.3	50	55.6	52.8
LV07	25	34.2	23.7	50	78.8	38.5
LV08	25	23.3	21.0	50	46.1	39.2
LV12	25	28.1	26.8	50	87.2	46.3
LV13	25	24.7	21.1	50	46.3	32.8
LV15	25	22.2	22.7	50	61.9	53.8
LV17	25	18.7	19.9	50	33.2	36.4
LV19	25	26.7	23.5	50	79.3	58.2
LV20	25	21.6	21.0	50	53.6	36.9
LV25	25	32.1	24.9	50	51.9	42.9
LV26	25	-	-	50	16.4	-
LV42	25	43.6	28.3	50	110.3	75.3
LV48	25	-	29.4	50	-	81.3

Source: Todoroski, 2017

*Bold indicates criteria exceeded



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METSERVE
Mining & Energy Technical Services Pty Ltd



LEGEND

- Control Site Location (LV)
- Dust Deposition Gauge (DD)
- Low Volume Air Samplers (LV)

Data Source: Monitoring Locations - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

**McArthur River Mine
Overburden Management Project EIS
Current Air Quality
Monitoring Locations**



Scale: 1:40,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-2

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13.2.4.1.2 Particulate Lead

No annual average data exist for comparison with the annual average criteria, and conversely there are no 24 hour average criteria for comparison with the available data. As such, the available 24 hour average data has been compared against annual average levels. The maximum measured 24 hour levels would generally be much higher than the actual annual average levels, meaning the comparison below is very conservative.

A summary of all the lead data captured by the LVASs is presented in **Table 13-6**. The maximum 24 hour average over the measured periods was above the annual NEPM criteria ($0.5 \mu\text{g}/\text{m}^3$) at seven out of the 31 sites. The LVASs which are located near the processing plant (LV22, LV23, LV24 and LV28) recorded levels above the lead criteria over both the July 2014 to June 2015 and July 2015 to June 2016 monitoring periods.

Monitoring of lead has indicated a decrease from July 2014 - June 2015 compared to July 2015 - June 2016, with the exception of LV28. Dust controls were implemented prior to the latter monitoring period (July 2015 - June 2016), indicating the controls have been successful in reducing lead levels.

As explained above, the comparison between measured 24 hour average data and the annual average NEPM criteria is conservative; therefore sites which have just gone above the criteria levels may potentially be within the recommended levels if required data was available.

13.2.4.1.3 Particulate Zinc

All 24 hour average concentrations presented in **Table 13-7** were recorded between July 2014 to June 2015 and July 2015 to June 2016 and are below the air quality criteria of $120 \mu\text{g}/\text{m}^3$ specified by the Ontario MOE.

13.2.4.2 Depositional Dust

Particles larger than $30 \mu\text{m}$ in diameter tend to settle out of the atmosphere quickly and are generally not considered a concern for human health. However, these larger particles have the capacity to cause nuisance to sensitive receptors. The potential for nuisance is measured through the depositional dust rate.

Depositional dust sampling is undertaken in accordance with *Australian/New Zealand Standard 3580.10.1.2003 Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method*. There are 18 depositional dust gauges located strategically around the mine (to capture fugitive dust sources) which are mounted on regulated height stands. Depositional dust which has been sampled, undergo laboratory analysis on a monthly basis.

The annual average dust deposition levels from 2009 until 2012 are presented in **Table 13-8**. The average dust deposition rate at most monitoring locations was below the dust nuisance goal recommended by the NSW EPA. Four of the dust deposition gauges (DD21, DD22, DD24 and DD28) are located in close proximity to the processing plant and have consistently recorded dust deposition rates above the NSW dust nuisance goal ($4 \text{ g}/\text{m}^2/\text{month}$) (refer to **Figure 13-2**). Dust deposition at these sites is considered to be influenced by the dust associated with processing.

Table 13-6 Summary of Maximum 24 hour Lead Levels at Monitoring Sites

Site	NEPM Criteria (Annual) ($\mu\text{g}/\text{m}^3$)	July 2014 - June 2015* ($\mu\text{g}/\text{m}^3$)	July 2015 - June 2016 ($\mu\text{g}/\text{m}^3$)
LV01 (control)	0.5	0.07	0.07
LV10 (control)	0.5	0.07	0.07
LV22	0.5	4.39	2.46
LV23	0.5	1.24	1.01
LV24	0.5	1.08	0.92
LV27	0.5	0.72	0.49
LV28	0.5	0.54	1.29
LV30	0.5	0.08	0.07
LV31	0.5	0.07	0.07
LV32	0.5	-	0.07
LV33	0.5	-	0.07
LV43	0.5	0.54	0.19
LV44	0.5	1.03	0.36
LV45	0.5	0.43	0.21
LV46	0.5	0.42	0.07
LV47	0.5	-	0.07
LV03	0.5	0.07	0.08
LV05	0.5	0.07	0.08
LV06	0.5	0.07	0.08
LV07	0.5	0.11	0.07
LV08	0.5	0.07	0.08
LV12	0.5	0.17	0.15
LV13	0.5	0.07	0.07
LV15	0.5	0.08	0.10
LV17	0.5	0.07	0.07
LV19	0.5	0.29	0.07
LV20	0.5	0.07	0.07
LV25	0.5	0.18	0.15
LV26	0.5	0.07	-
LV42	0.5	0.13	0.07
LV48	0.5	-	0.07

Source: Todoroski, 2017

*Bold indicates criteria exceeded

Table 13-7 Summary of Maximum 24 hour Zinc Levels at Monitoring Sites

Site	Ontario MOE Criteria (µg/m³)	July 2014 - June 2015 (µg/m³)	July 2015 - June 2016 (µg/m³)
LV01 (control)	120	0.10	0.18
LV10 (control)	120	0.17	0.17
LV22	120	7.15	5.57
LV23	120	3.35	2.04
LV24	120	2.00	2.28
LV27	120	1.88	1.01
LV28	120	1.82	2.01
LV30	120	0.17	0.14
LV31	120	0.17	0.18
LV32	120	-	0.08
LV33	120	-	0.13
LV43	120	1.15	0.40
LV44	120	3.60	1.13
LV45	120	0.74	0.42
LV46	120	1.00	0.14
LV47	120	-	0.17
LV03	120	0.15	0.17
LV05	120	0.08	0.14
LV06	120	0.17	0.24
LV07	120	0.24	0.26
LV08	120	0.13	0.21
LV12	120	0.50	0.46
LV13	120	0.19	0.22
LV15	120	0.22	0.17
LV17	120	0.14	0.13
LV19	120	0.71	0.10
LV20	120	0.15	0.21
LV25	120	0.65	0.47
LV26	120	0.07	-
LV42	120	0.32	0.17
LV48	120	-	0.17

Source: Todoroski, 2017

Table 13-8 Annual Average Dust Deposition

Site		Annual Average (g/m ² /month)			
	Criteria	2009	2010	2011	2012
DD03	4	0.8	0.8	0.5	0.7
DD05	4	0.6	0.4	0.3	0.3
DD06	4	1.0	0.4	0.3	0.4
DD08	4	2.2	2.2	0.6	0.9
DD12	4	1.2	1.1	0.4	0.8
DD13	4	0.9	0.8	0.7	0.9
DD15	4	1.5	1.3	1.1	1.1
DD17	4	0.8	0.5	0.7	0.9
DD19	4	0.6	0.5	0.4	0.4
DD20	4	0.8	0.6	0.4	0.4
DD21	4	4.2	8.0	3.1	2.2
DD22	4	8.4	6.3	5.7	7.0
DD23	4	2.6	2.5	2.3	2.7
DD24	4	8.9	7.5	10.1	4.7
DD25	4	0.8	0.7	0.6	0.5
DD26	4	0.7	0.7	0.5	0.7
DD27	4	2.8	2.0	1.6	1.0
DD28	4	15.3	10.9	10.6	7.9

Source: Todoroski 2017

*Bold indicates criteria exceeded

13.2.4.3 Sulphur Dioxide

Ambient sulphur dioxide monitoring was conducted in residential areas at Borroloola and Devil Spring between June 2015 and June 2016. The monitoring was undertaken in accordance with *Australian Standard 3580.4.1 – 2008 Methods for sampling and analysis of ambient air. Method 4.1: Determination of Sulphur dioxide – Direct reading instrumental method*.

This monitoring program collected representative air quality data including sulphur dioxide levels, wind speed and wind direction". Separate reports on the ambient air quality levels measured at these two locations were regularly prepared and made available to the public on the MRM website as monthly reports, weekly summary reports, and raw data.

The results of the sulphur dioxide monitoring at Borroloola and Devil Spring are outlined in **Table 13-9**. The sulphur dioxide levels for the period between July 2015 and June 2016 were well under the annual average and maximum 24 hour average criteria for both Borroloola and Devil Spring.

Table 13-9 Summary of Sulphur Dioxide Levels from MRM Monitoring

Site	Annual average Criteria Reading ($\mu\text{g}/\text{m}^3$)	Monitored Level ($\mu\text{g}/\text{m}^3$) July 2015 to June 2016	Max 24 hour average Criteria Reading ($\mu\text{g}/\text{m}^3$)	Monitored Level ($\mu\text{g}/\text{m}^3$) July 2015 to June 2016
Borroloola	57	1.1	229	12.2
Devil Spring	57	0.2	229	7.4

13.2.5 Climate

Meteorological data recorded by the Bureau of Meteorology (BoM) at the MRM Airport (station 014704) has been reviewed to describe the existing meteorological and climatological influences of the Project area.

The BoM station at MRM is located approximately 2 km southwest of the active open cut area and is considered representative of the study area for the air quality assessment. **Table 13-10** provides a summary of the temperature, humidity, and wind speed and rainfall data for the MRM meteorological station.

The climatic conditions in the area surrounding MRM are typical of northern Australia which is characterised by two seasons per year; the dry season occurring from April to November and the wet season from December to March. November is the warmest month with a mean maximum temperature of 38.6 degrees Celsius ($^{\circ}\text{C}$). Overnight temperatures drop sharply in the dry season with average minimum daily temperatures of 12.2 $^{\circ}\text{C}$ in June.

Mean 9 am relative humidity is generally greatest during the months from February to July and least during September to December. Mean 3 pm relative humidity is generally lower than 9 am through the year, ranging from 35% in September up to 48% in February. The lowest 3 pm relative humidity is experienced between August and October.

Highest rainfall is recorded during wet season months with January experiencing the highest monthly average of 210.7 mm. Mean monthly rainfall declines in the dry season months (April to November) dramatically with the lowest monthly average rainfall occurring in August with 0.3 mm.

Wind speeds during the warmer months tend to have a greater variance between the 9am and 3pm conditions compared to the colder months. The mean 9am wind speeds range from 5.5 kilometres per hour (km/h) in March to 9.4 km/h in September. The mean 3pm wind speeds vary from 9.4 km/h in February to 13.2 km/h in October.

Table 13-10 Monthly Climate Statistics Summary – McArthur River Mine Airport

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Annual
Mean Maximum Temperature (°C)	36.0	35.3	35.1	34.8	32.4	29.8	30.0	32.0	35.4	37.9	38.6	37.6	34.6
Mean Minimum Temperature (°C)	24.9	24.7	23.5	20.7	16.7	12.6	12.2	13.3	17.2	21.1	24.1	25.0	19.7
Rainfall (mm)	210.7	178.6	146.3	31.7	7.5	1.7	2.2	0.3	4.4	19.4	57.3	127.1	766.1
Mean no. of rain days (≥ 1 mm)	10.8	11.0	9.0	2.7	0.8	0.3	0.2	0.0	0.4	1.5	4.5	8.0	49.2
Mean 9 am Temperature (°C)	29.4	28.7	28.2	27.2	23.9	20.3	19.8	21.5	26.0	29.5	31.0	30.7	26.3
Mean 9 am relative humidity (%)	71	75	71	59	50	48	48	47	46	48	53	62	57
Mean 9 am wind speed (km/h)	6.9	5.9	5.5	6.9	8.7	8.7	8.1	8.6	9.4	9.3	8.2	7.2	7.8
Mean 3 pm Temperature (°C)	34.1	33.6	33.4	33.6	31.5	29.1	29.3	31.1	34.3	36.6	37.0	35.9	33.3
Mean 3 pm relative humidity (%)	50	53	47	34	28	25	24	21	21	23	30	39	33
Mean 3 pm wind speed (km/h)	10.2	9.4	10.1	10.7	10.2	10.5	11.0	11.8	13.1	13.2	12.5	11.4	11.2

Source: Todoroski 2017

Annual and seasonal windroses collected at the MRM Airport and Borroloola weather stations for the 2015 calendar period are presented in **Figure 13-3** and **Figure 13-4** respectively.

Analysis of the wind roses shows a dominant north to northeasterly component to the winds year round, although a pronounced southeasterly is evident during the dry season.

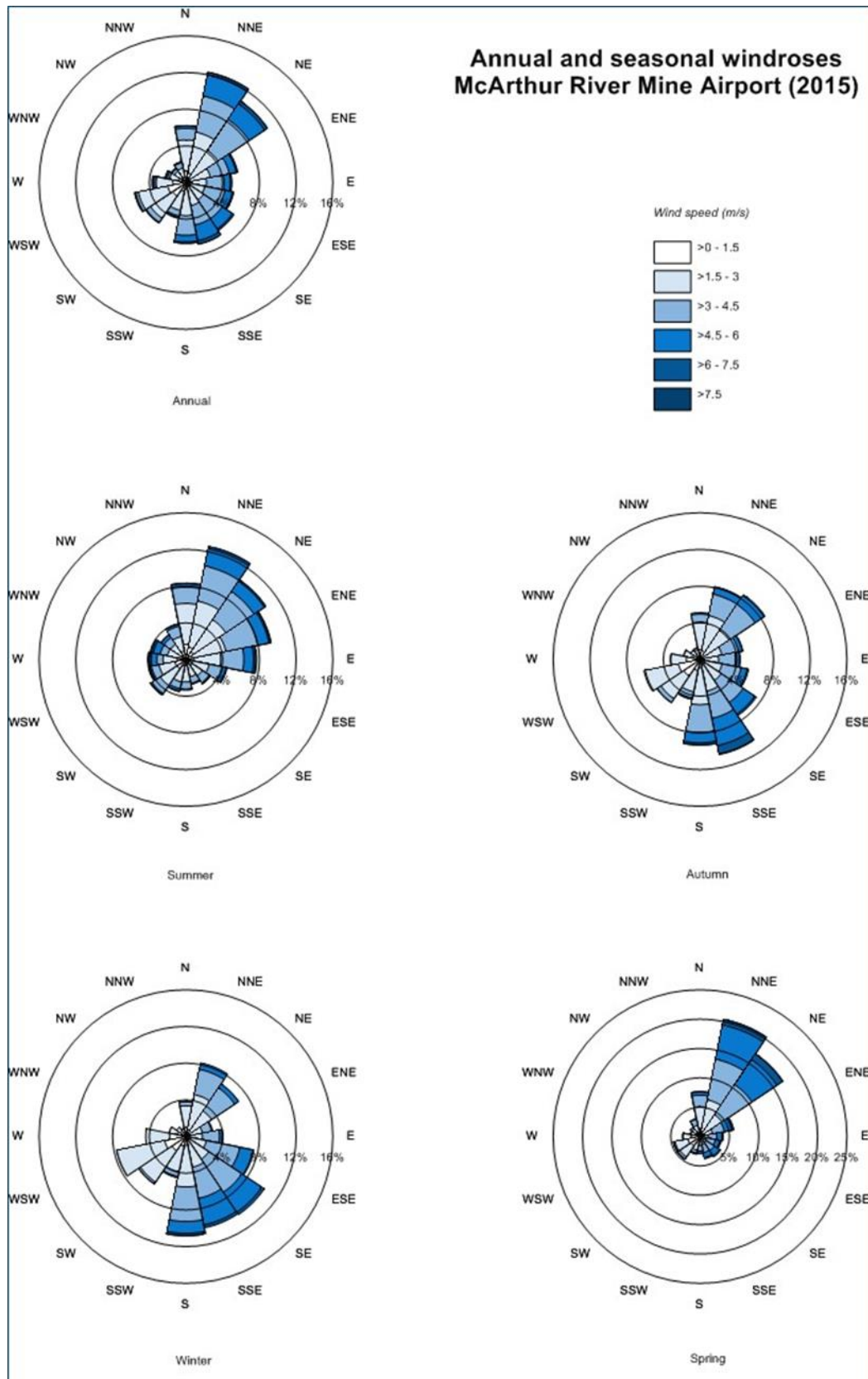


Figure 13-3 Annual and Seasonal Wind Roses for McArthur River Mine Airport (2015)

Source: Todoroski 2017.

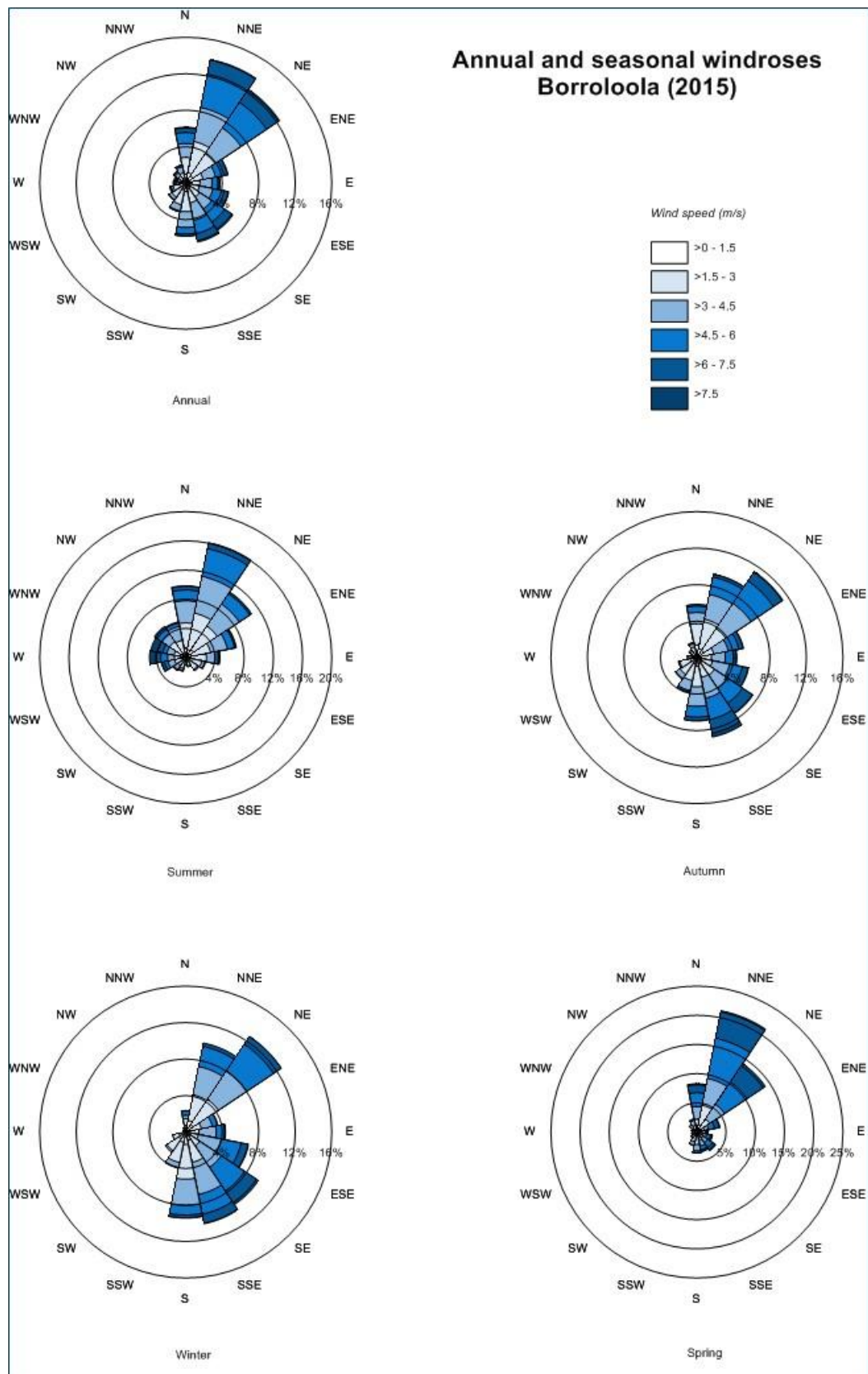


Figure 13-4 Annual and Seasonal Wind Roses for Borroloola (2015)

Source: Todoroski 2017.

13.3 Air Quality Impact Assessment

13.3.1 Risk Identification

The potential air quality risks/impacts associated with the Project have been assessed by:

- identifying sensitive receptors which may potentially be impacted upon by sources of air emissions from the Project;
- preparing an air emissions inventory for key air emissions sources from the Project;
- undertaking dispersion modelling on sources considered to have the potential to exceed the ambient air quality criteria;
- comparing predicted concentrations with ambient air quality criteria;
- recommending appropriate mitigation measures for the Project to achieve compliance with the ambient air quality goals; and
- assessing the potential risks associated with air quality from the Project.

13.3.1.1 Sources of Air Emissions and Potential for Impact

13.3.1.1.1 Particulate Matter

The primary sources of particulate emissions at the Project are likely to include:

- clearing of vegetation and removal of topsoil;
- drilling and blasting;
- in-pit loading;
- construction of Overburden Emplacement Facilities (OEFs);
- hauling waste and ore;
- movement of ore from ROM stockpiles to the primary crusher;
- ore processing, crushing and stockpiling;
- stockpiles and areas of bare topsoil;
- vehicle movement on unsealed roads and ramps (also partially wind generated); and
- road and windrow maintenance.

13.3.1.1.2 Sulphur Dioxide

A proportion of the overburden material proposed to be stored in the NOEF contains material which has the potential to oxidise in the presence of water and oxygen. The rapid oxidation of this material may cause self-heating to occur which may potentially result in spontaneous combustion.

The emissions resulting from the oxidation (spontaneous combustion) typically produce a visible smoke plume. Where a reactive part of the NOEF reaches a temperature of approximately 100°C, the oxidation reaction may accelerate and may no longer require water to be sustained (Todoroski 2016). When this occurs, the emissions may not necessarily be visible, but may be noticeable as a localised heat haze.

13.3.2 Risk Evaluation

13.3.2.1 Emission Estimates

13.3.2.1.1 Particulate Matter

Dust emission estimates have been calculated by analysing the various types of dust generating activities taking place and utilising suitable emission factors.

The Air Quality Impact Assessment Report assessed three of the most active Project stages (scenarios). Scenario 2 (mine year 2022) was considered to represent a worst case air quality scenario for the Project and provides a conservative representation of potential air quality impacts over the operational life of the Project. Therefore scenario 2 has been selected as the basis for discussion of potential air quality impacts and required management measures within this chapter. The assessment of scenario 1 (mine year 2019) and 3 (mine year 2027) is provided in **Appendix AA – Air Quality Report**. The estimated emissions for Scenario 2 are presented in **Table 13-11**.

Emission factors were derived from industry-standard emission factors that have been collated by the locally derived and United States Environmental Protection Agency (USEPA) AP-42 emissions estimation methodology. The factors applied were considered to be the most applicable for determining dust generation for the Project and associated activities.

The emission estimates outlined in **Table 13-11** include current dust mitigation measures applied at the Project, however many additional controls cannot be included in the modelling due to constraints of the model. The detailed emission inventories and emission estimation calculations which show the mitigation measures that were explicitly included in the modelling are presented in **Appendix AA – Air Quality Report**.

Table 13-11 Estimated Emissions for MRM Incorporating Scenario 2

Category	Activity	Scenario 2
Topsoil	Topsoil removal Loading topsoil to haul truck Hauling topsoil to emplacement area Emplacing topsoil at emplacement area	9 tonnes (t) of TSP/year
Overburden	Drilling overburden Blasting overburden Loading overburden to haul truck Hauling to emplacement area (Alluvium) Hauling to emplacement area Emplacing at area (Alluvium) Emplacing at area Dozers in open cut Dozers on dump and rehab	1,820 t of TSP/year
Run of Mine	Drilling ROM Blasting ROM Loading ROM to haul truck Hauling ROM to hopper	153 t of TSP/year
Processing Plant	Unloading ROM to ROM pad and/or crusher Rehandle ROM at hopper Primary crushing Convey to screen Screening Convey to secondary and tertiary crushers Secondary crushing Screening Conveying Tertiary crushing Screening Convey to transfer point Transfer point Unloading to HMP feed stockpile Convey to HMP Unloading to Ore stockpile Processing ore (enclosed and wet - no emissions) Loading Product to trucks for dispatch Hauling Product off-site Dozer on stockpiles Unloading rejects to stockpile Loading rejects to haul truck Hauling rejects to emplacement Unloading rejects at emplacement	873 t of TSP/year
Wind Erosion	Overburden emplacement areas TSF Domain Open cut Stockpiles	464 t of TSP/year
Roads	Grading roads	47 t of TSP/year
Total		3,367 t of TSP/year

Note: Totals may vary slightly due to rounding.

Source: Todoroski 2017

13.3.2.1.2 Lead and Zinc

The fraction of lead and zinc in the TSP emissions outlined in **Table 13-11** have been determined by the available monitoring data regarding overburden and ore feed compositions (Todoroski 2017). These fractions have been used to estimate emissions of particulate lead and zinc and are presented in **Table 13-12**.

Table 13-12 Estimated Project Emissions of Lead and Zinc

Type	Scenario 2
Lead tonnes per year (t/yr)	45
Zinc (t/yr)	113

Source: Todoroski 2017

13.3.2.2 Modelling Methodology

Modelling was undertaken using a combination of TAPM and the CALPUFF Modelling System. The CALPUFF Modelling System includes three main components: CALMET, CALPUFF and CALPOST and a large set of pre-processing programs designed to interface the model to standard, routinely available meteorological and geophysical datasets. Modelling systems are described in greater detail in **Appendix AA – Air Quality Report**.

13.3.2.2.1 Meteorology Modelling

The TAPM model was used to generate a three dimensional upper air data file for use in CALMET. The model predicted the flows important to local scale air pollution, such as sea breezes and terrain induced flows, against a background of larger scale meteorology data provided by synoptic analysis (Todoroski 2017).

The CALMET model was used to develop a three dimensional grid of meteorology for the model domain. This model generated hourly atmospheric parameters such as wind speed and direction (three dimensional), atmospheric mixing heights and stability conditions.

The CALMET modelling results were consistent with the observed monitoring data captured at the MRM Airport weather station (**Table 13-10**). This reflects the modelled wind distribution patterns of the area based and the predicted terrain effects on the prevailing winds.

13.3.2.2.2 Dispersion Modelling

Dust concentrations from Project related mining activities were predicted using the CALPUFF model, which was able to simulate the effects of complex local terrain on the dispersion meteorology over the entire modelling domain (Todoroski 2017).

Meteorological conditions associated with dust generation (such as wind speed) and levels of dust generating activity were considered in calculating the hourly varying emission rate for each source. However, as a conservative assessment, the air quality modelling did not take into consideration the effect of precipitation rate (rainfall) in reducing dust emissions, which may potentially reduce the level of emissions more than modelled outcomes.

13.3.2.2.3 Background Pollutant Levels

Non-mining sources of particulate matter in the wider area (wind erosion of land, smoke from fires etc.) have not been accounted for in the dispersion model as it is impracticable to do so, however, an allowance from their contribution to the total dust levels has been made to fully account for the total potential impact. The estimated annual average contribution from other non-modelled background dust sources is presented in **Table 13-13**.

Table 13-13 Estimated Contribution from other Background Dust Sources

Pollutant	Averaging period	Unit	Estimated Contribution
TSP	Annual	µg/m ³	38.4
PM ₁₀	Annual	µg/m ³	15.0
Dust deposition	Annual	g/m ² /month	0.6

Source: Todoroski 2017

13.3.2.2.4 Modelling Scenarios

The Project's proposed mine production schedule was analysed to determine those periods where material extraction was at a maximum, and thus the potential for dust generation would also be at a maximum. These periods were then matched with the nearest available mine plan year for use in the dispersion modelling.

Three mine plan years were chosen for the assessment to nominally represent year 2019 (Scenario 1), 2022 (Scenario 2) and 2027 (Scenario 3). Indicative mine plans for each of the respective years are presented in **Figure 13-5** to **Figure 13-7**. Further information on activities undertaken during these stages is provided in **Chapter 3 – Project Description**. The plans presented in the Project Description present minor insignificant changes (e.g. stockpile and borrow pit re-alignments) to the stages assessed in the air quality technical assessment. These small changes were completed after the air quality assessment was conducted and have not changed the level of disturbance significantly to influence the modelling results.

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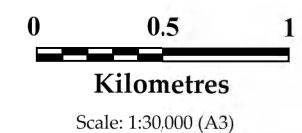
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LEGEND

- | | | |
|-------------------------------|---------------------------------------|---------------------------------------|
| TSF Interception Trench | North Overburden Emplacement Facility | Open Cut |
| Tailings Storage Facility | Benign Material Stockpile | South Overburden Emplacement Facility |
| Borrow Area (Benign Material) | Runoff Dam | Cell 3 Water Management Dams |
| Haul Roads | Flood Protection | |

Data Source: Hillshade Rasters - Glencore (Jun 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

**McArthur River Mine
Overburden Management Project EIS
Indicative Mine Plan
Scenario 1 (2019)**



09/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-5



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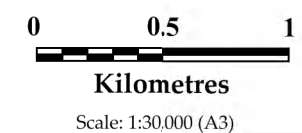
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LEGEND

- | | | | |
|-------------------------------|---------------------------------------|---------------------------------------|--|
| TSF Interception Trench | North Overburden Emplacement Facility | Open Cut | Runoff Drain |
| Tailings Storage Facility | Benign Material Stockpile | South Overburden Emplacement Facility | East Overburden Emplacement Facility Low Grade Ore Stockpile |
| Borrow Area (Benign Material) | Runoff Dam | Cell 3 Water Management Dams | EOEF Runoff Sump |
| Haul Roads | | Flood Protection | |

Data Source: Hillshade Rasters - Glencore (Jun 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

**McArthur River Mine
Overburden Management Project EIS
Indicative Mine Plan
Scenario 2 (2022)**



09/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-6



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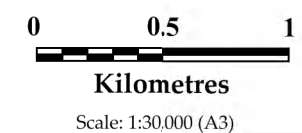
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LEGEND

- | | | | |
|-------------------------------|---------------------------------------|--|--|
| TSF Interception Trench | North Overburden Emplacement Facility | Open Cut | Runoff Drain |
| Tailings Storage Facility | Benign Material Stockpile | South Overburden Emplacement Facility | East Overburden Emplacement Facility Low Grade Ore Stockpile |
| Borrow Area (Benign Material) | Runoff Dam | Cell 3 Water Management Dams | EOEf Runoff Sump |
| Haul Roads | | East Overburden Emplacement Facility PAF(HW) Stockpile | Rehabilitation Commenced |

Data Source: Hillshade Rasters - Glencore (Jun 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

**McArthur River Mine
Overburden Management Project EIS
Indicative Mine Plan
Scenario 3 (2027)**



03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-7

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13.3.2.3 Dispersion Modelling Results

The dispersion model predictions have been reviewed to understand the risk of potential Project impacts on the air quality environment and sensitive receptors. Scenario 2 is the worst case stage of the modelled operational periods (**Table 13-11** and **Table 13-12**) as a large amount of material is proposed to be handled (highest amount of ore). As such, Scenario 2 was used to determine the Project's potential impacts at sensitive receptors. Further detail on the operational/mining activities for each domain during Scenario 2 stage is provided in **Chapter 3 - Project Description and Justification**.

The results presented include those for the operation in isolation (incremental impact) as well as operating with other sources (total (cumulative) impact) and show the estimated:

- maximum 24 hour average PM_{2.5} and PM₁₀ concentrations;
- annual average PM_{2.5} and PM₁₀ concentrations;
- annual average TSP concentrations;
- annual average dust (insoluble solids) deposition rates;
- annual average lead concentrations; and
- maximum 24 hour average zinc concentrations.

13.3.2.3.1 Predicted Particulate Matter Levels

The model predictions for particulate matter levels at each of the sensitive receptor locations have been presented in **Table 13-14**.

Table 13-14 Modelling Predictions for Particulate Matter (Scenario 2)

Receptor ID	PM _{2.5} (µg/m³)		PM ₁₀ (µg/m³)		TSP (µg/m³)	DD (g/m²/month)	PM ₁₀ (µg/m³)	TSP (µg/m³)	DD (g/m²/month)
	Incremental impact						Total impact		
	24 hour average	Annual average	24 hour average	Annual average	Annual average	Annual average	Annual average	Annual average	Annual average
	Air Quality Criteria								
	25	8	50	-	-	2	25	90	4
Borroloola ⁽¹⁾	< 1	< 1	< 1	< 1	< 1	< 0.1	15	38	< 1
Devil Spring ⁽¹⁾	< 1	< 1	5	< 1	< 1	< 0.1	15	38	< 1
Campbell Springs	< 1	< 1	2	< 1	< 1	< 0.1	15	38	< 1
ATO 2	< 1	< 1	5	< 1	< 1	< 0.1	15	38	< 1
ATO 3	< 1	< 1	4	< 1	< 1	< 0.1	15	38	< 1
ATO 4	< 1	< 1	7	< 1	< 1	< 0.1	15	38	< 1
ATO 5	1	< 1	7	< 1	1	< 0.1	15	39	< 1
ATO 6	2	< 1	15	2	3	< 0.1	17	41	< 1
ATO 7	< 1	< 1	3	< 1	< 1	< 0.1	15	38	< 1
ATO 8	< 1	< 1	3	< 1	< 1	< 0.1	15	38	< 1
ATO 9	< 1	< 1	3	< 1	< 1	< 0.1	15	38	< 1
Caranbirini Conservation Reserve ⁽²⁾	2	< 1	15	2	3	< 0.1	17	41	< 1

1. These locations would have additional dust due to activity in the village.

2. Approximate model predictions based on the predicted levels within the reserve.

ATO = Area of Temporary Occupation

Bold indicate predicted values above the relevant criteria

Source: Todoroski 2017

The incremental modelling is visually presented in the Isopleth diagrams for each of the assessed dust metrics in Scenario 2 (**Figure 13-8** to **Figure 13-13**).



LEGEND

— Concentration Contour ($\mu\text{g}/\text{m}^3$)

McArthur River Mine
Overburden Management Project EIS
Predicted Maximum 24 Hour Average
PM_{2.5} Concentrations Due to Emissions
from the Project in Scenario 2 ($\mu\text{g}/\text{m}^3$)

0.5 0 0.5 1

Kilometres

Scale: 1:35,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-8

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

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LEGEND

— Concentration Contour ($\mu\text{g}/\text{m}^3$)

McArthur River Mine
Overburden Management Project EIS
Predicted Annual Average
PM_{2.5} Concentrations Due to Emissions
from the Project in Scenario 2 ($\mu\text{g}/\text{m}^3$)

0.5 0 0.5 1

Kilometres

Scale: 1:35,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-9

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

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LEGEND

— Concentration Contour ($\mu\text{g}/\text{m}^3$)

McArthur River Mine
Overburden Management Project EIS
Predicted Maximum 24 Hour Average
PM₁₀ Concentrations Due to Emissions
from the Project in Scenario 2 ($\mu\text{g}/\text{m}^3$)

0.75 0 0.75 1.5



Kilometres

Scale: 1:40,000 (A3)

03/03/2017



Datum: GDA94
Projection: MGA53

FIGURE 13-10

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Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)



LEGEND

— Concentration Contour ($\mu\text{g}/\text{m}^3$)

McArthur River Mine
Overburden Management Project EIS
Predicted Annual Average PM_{10}
Concentrations Due to Emissions
from the Project in Scenario 2 ($\mu\text{g}/\text{m}^3$)

0.75 0 0.75 1.5



Kilometres

Scale: 1:40,000 (A3)

03/03/2017



Datum: GDA94
Projection: MGA53

FIGURE 13-11

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

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LEGEND

— Concentration Contour ($\mu\text{g}/\text{m}^3$)

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

**McArthur River Mine
Overburden Management Project EIS
Predicted Annual Average TSP
Concentrations Due to Emissions
from the Project in Scenario 2 ($\mu\text{g}/\text{m}^3$)**

0.75 0 0.75 1.5



Kilometres

Scale: 1:40,000 (A3)

03/03/2017

 Datum: GDA94
Projection: MGA53

FIGURE 13-12



LEGEND

— Concentration Contour ($\mu\text{g}/\text{m}^3$)

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

**McArthur River Mine
Overburden Management Project EIS
Predicted Annual Average Dust Deposition
Levels Due to Emissions from the Project in
Scenario 2 ($\text{g}/\text{m}^2/\text{Month}$)**

250 0 250 500 750 1000

Metres

Scale: 1:25,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-13

13.3.2.3.1.1 Further Analysis of 24 hour Average PM₁₀ Concentrations

Time series plots, which provide the predicted 24 hour average PM₁₀ concentrations, have been considered (for the worst case Scenario 2) at four locations around the site to better understand the nature of the emissions in the short term (24 hour) basis. The four locations considered are shown in **Figure 13-14** and the time series plots showing the 24 hour PM₁₀ level predicted for each day of the year are presented in **Figure 13-15**.

Modelling results indicated that Locations 1 and 2, which are located north of the NOEF, experience their highest 24 hour average dust levels in the dry season when dominant winds tend to be towards the north (**Figure 13-14**). These sites are located closest to the largest dust sources at the site (haul roads) and exposed bare surfaces (NOEF).

Conversely, locations 3 and 4, which are located further south of the mine activities, experience their highest 24 hour average levels during the wet season. This may be attributed to the dominate wind direction being southwest in the wet season (**Figure 13-14**); although proximity to the processing plant could also be a contributing factor. Emissions from the processing plant are not significantly influenced by rainfall as is the case with haul roads and other bare surfaces.

As a conservative measure, the effect of rainfall in reducing dust emissions has not been considered in the dispersion modelling. It is likely that the incorporation of rainfall data would have a positive effect on reducing dust emissions and hence the extent of potential impacts.

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McArthur
River
Mining

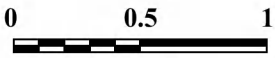
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LEGEND

● Receptor Location

Data Source: Dust Monitoring Locations - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

**McArthur River Mine
Overburden Management Project EIS
Receptor Locations used for
Examination of Daily Dust Effects**



Scale: 1:30,000 (A3)

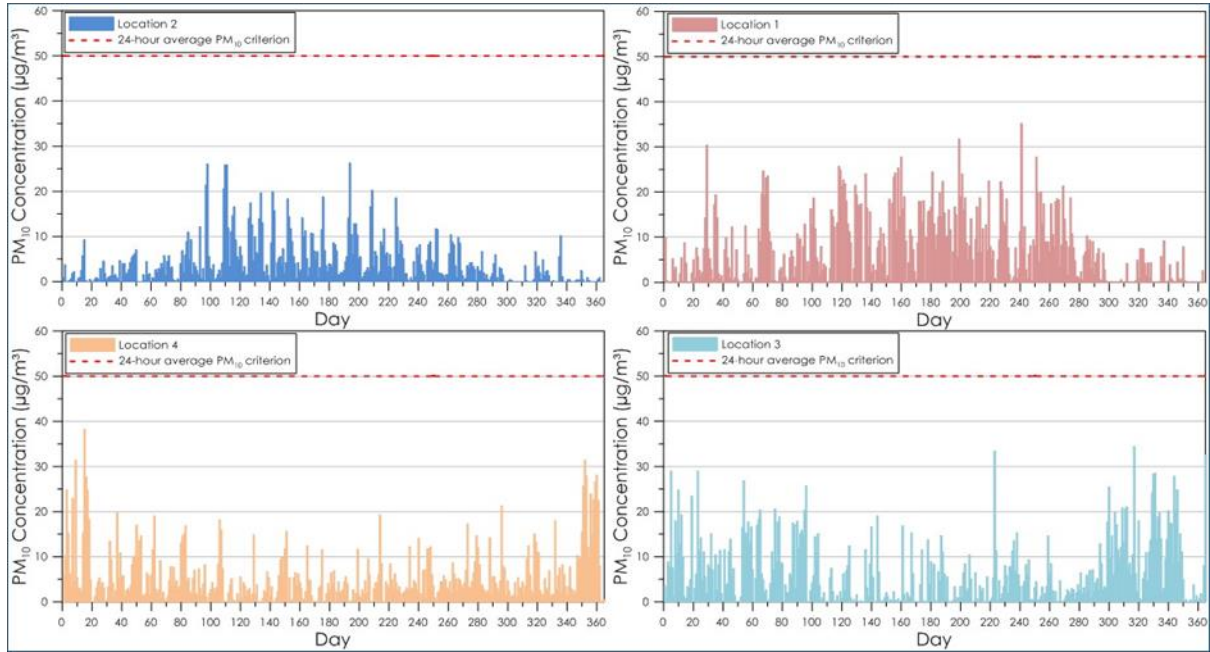
03/03/2017



Datum: GDA94
Projection: MGA53

FIGURE 13-14

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Source: Todoroski 2017

Figure 13-15 Time-series Plots for Predicted 24 hour Average PM₁₀ Concentrations for Scenario 2

13.3.2.3.2 Predicted Lead Concentrations

The model predictions for lead concentrations at each of the sensitive receptor locations for Scenario 2 have been presented in **Table 13-15**.

Table 13-15 Incremental Modelling Predictions for Annual Average Lead Concentrations for Scenario 2

Receptor Name	Scenario 2($\mu\text{g}/\text{m}^3$)
	Air Quality Criteria
	0.5
Borrooloola	< 0.1
Devil Spring	< 0.1
Campbell Springs	< 0.1
ATO 2	< 0.1
ATO 3	< 0.1
ATO 4	< 0.1
ATO 5	< 0.1
ATO 6	< 0.1
ATO 7	< 0.1
ATO 8	< 0.1
ATO 9	< 0.1
Caranbirini Conservation Reserve*	< 0.1

* Approximate model predictions based on the predicted levels within the reserve.

ATO- Area of Temporary Occupation

Source: Todoroski 2017

The results indicate that the predicted lead concentrations would be well below the adopted criteria of $0.5 \mu\text{g}/\text{m}^3$.

The incremental modelling is presented in the Isopleth diagrams for annual average lead concentrations associated with Scenario 2 (**Figure 13-16**).



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LEGEND

— Concentration Contour ($\mu\text{g}/\text{m}^3$)

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

McArthur River Mine
Overburden Management Project EIS
Predicted Annual Average Lead
Concentrations Due to Emissions
from the Project in Scenario 2 ($\mu\text{g}/\text{m}^3$)

0 0.5 1
Kilometres
Scale: 1:30,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-16

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13.3.2.3.3 Predicted Zinc Concentrations

The model predictions for zinc concentrations at each of the sensitive receptor locations for Scenario 2 have been presented in **Table 13-16**.

Table 13-16 Incremental Modelling Predictions for 24 Hour Average Zinc Concentrations for Scenario 2

Receptor name	Scenario 2 ($\mu\text{g}/\text{m}^3$)
	Air Quality Criteria
	120
Borroloola	< 1
Devil Spring	< 1
Campbell Springs	< 1
ATO 2	< 1
ATO 3	< 1
ATO 4	< 1
ATO 5	< 1
ATO 6	< 1
ATO 7	< 1
ATO 8	< 1
ATO 9	< 1
Caranbirini Conservation Reserve*	< 1

* Approximate model predictions based on the predicted levels within the reserve.

ATO = Area of Temporary Occupation

Source: Todoroski 2017

The results indicate that predicted zinc concentrations would be well below the adopted criteria of $120 \mu\text{g}/\text{m}^3$.

The incremental modelling is presented in the Isopleth diagrams for annual average zinc concentrations associated with Scenario 2 (**Figure 13-17**).

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	 A GLENORE COMPANY	LEGEND — Concentration Contour ($\mu\text{g}/\text{m}^3$) Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)	<table><tr><td colspan="2" data-bbox="2258 1696 2718 1871"> McArthur River Mine Overburden Management Project EIS Predicted Maximum 24 Hour Average Zinc Concentrations Due to Emissions from the Project in Scenario 2 ($\mu\text{g}/\text{m}^3$) </td></tr><tr><td data-bbox="2258 1871 2718 2030"> 0 0.5 1 Kilometres Scale: 1:30,000 (A3) </td><td data-bbox="2718 1871 2908 2030"> 03/03/2017  Datum: GDA94 Projection: MGA53 FIGURE 13-17 </td></tr></table>	McArthur River Mine Overburden Management Project EIS Predicted Maximum 24 Hour Average Zinc Concentrations Due to Emissions from the Project in Scenario 2 ($\mu\text{g}/\text{m}^3$)		0 0.5 1 Kilometres Scale: 1:30,000 (A3)	03/03/2017  Datum: GDA94 Projection: MGA53 FIGURE 13-17
McArthur River Mine Overburden Management Project EIS Predicted Maximum 24 Hour Average Zinc Concentrations Due to Emissions from the Project in Scenario 2 ($\mu\text{g}/\text{m}^3$)							
0 0.5 1 Kilometres Scale: 1:30,000 (A3)	03/03/2017  Datum: GDA94 Projection: MGA53 FIGURE 13-17						

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13.3.2.3.4 Sulphur Dioxide

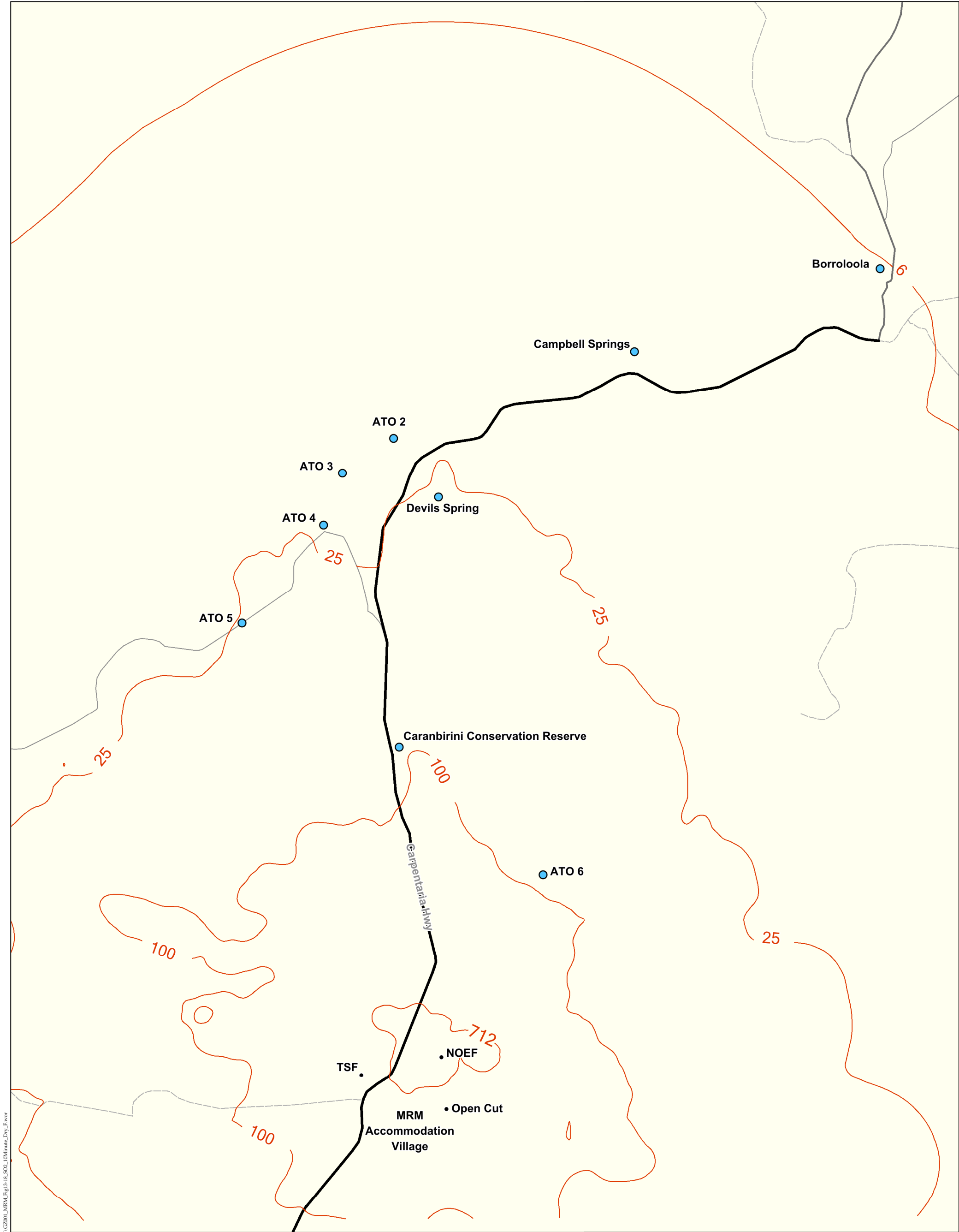
In April 2015, the NT EPA issued McArthur River Mining Pty. Ltd. (McArthur River Mining) with an Environmental Audit Program to identify any potential off-site environmental impacts caused by NOEF related air emissions. The Environmental Audit Program required dry and wet season modelling and detailed reporting, and a discussion of the potential risks associated with NOEF emissions. An overview of the Audit Program report is outlined in **Appendix AA – Air Quality Report**.

The sulphur dioxide dispersion modelling results for the dry (conducted on 28 to 30 July 2015) and wet season (conducted on 19 to 21 February 2016) monitoring campaigns are presented in **Figure 13-18 to Figure 13-25**.

The dry season modelling results indicate the potential for 10 minute and 1 hour average sulphur dioxide levels to be above the relevant criteria alongside the NOEF beside the Carpentaria Highway, however it is unlikely for levels to exceed relevant criteria at the nearest permanent residences in Devil Spring, Campbell Springs and Borroloola.

The wet season modelling results indicate that no impact in any publicly accessible area or permanent residences in Devil Spring, Campbell Springs and Borroloola is predicted to arise, and that the impact is confined to the vicinity of the NOEF.

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LEGEND

- Off-site Sensitive Receptor
- Concentration Contour ($\mu\text{g}/\text{m}^3$)
- Highway
- Road
- Track

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Localities/Sensitive Receptors - MetServe (Oct 2016); Roads - Geoscience Australia (2008)

McArthur River Mine
Overburden Management Project EIS
Validated Modelling Results
10 Minute Average SO_2 - Dry Season ($\mu\text{g}/\text{m}^3$)

3036

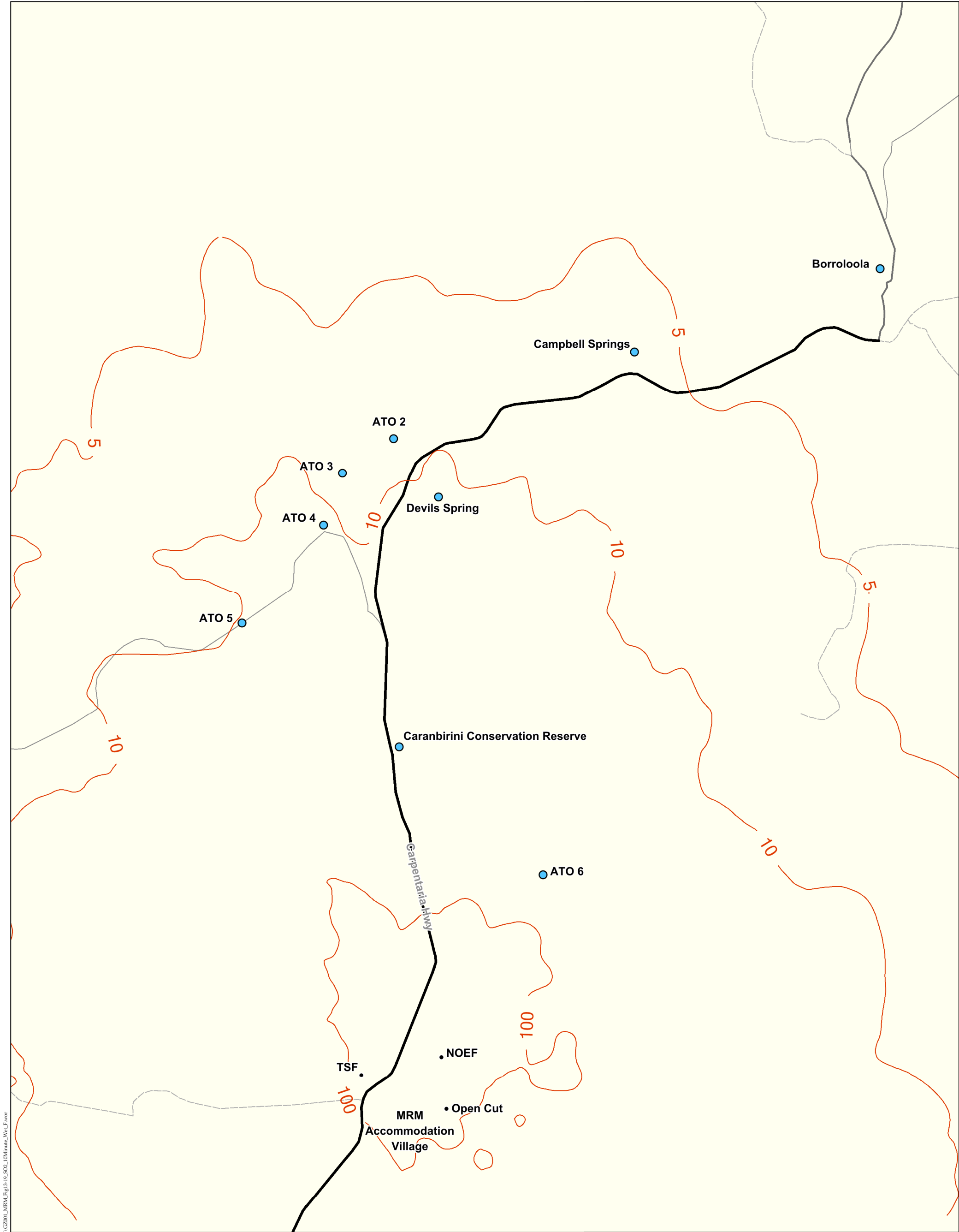
Kilometres

Scale: 1:175,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-18



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LEGEND

- Off-site Sensitive Receptor
- Concentration Contour ($\mu\text{g}/\text{m}^3$)
- Highway
- Road
- Track

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Localities/Sensitive Receptors - MetServe (Oct 2016); Roads - Geoscience Australia (2008)

**McArthur River Mine
Overburden Management Project EIS
Validated Modelling Results
10 Minute Average SO_2 - Wet Season ($\mu\text{g}/\text{m}^3$)**



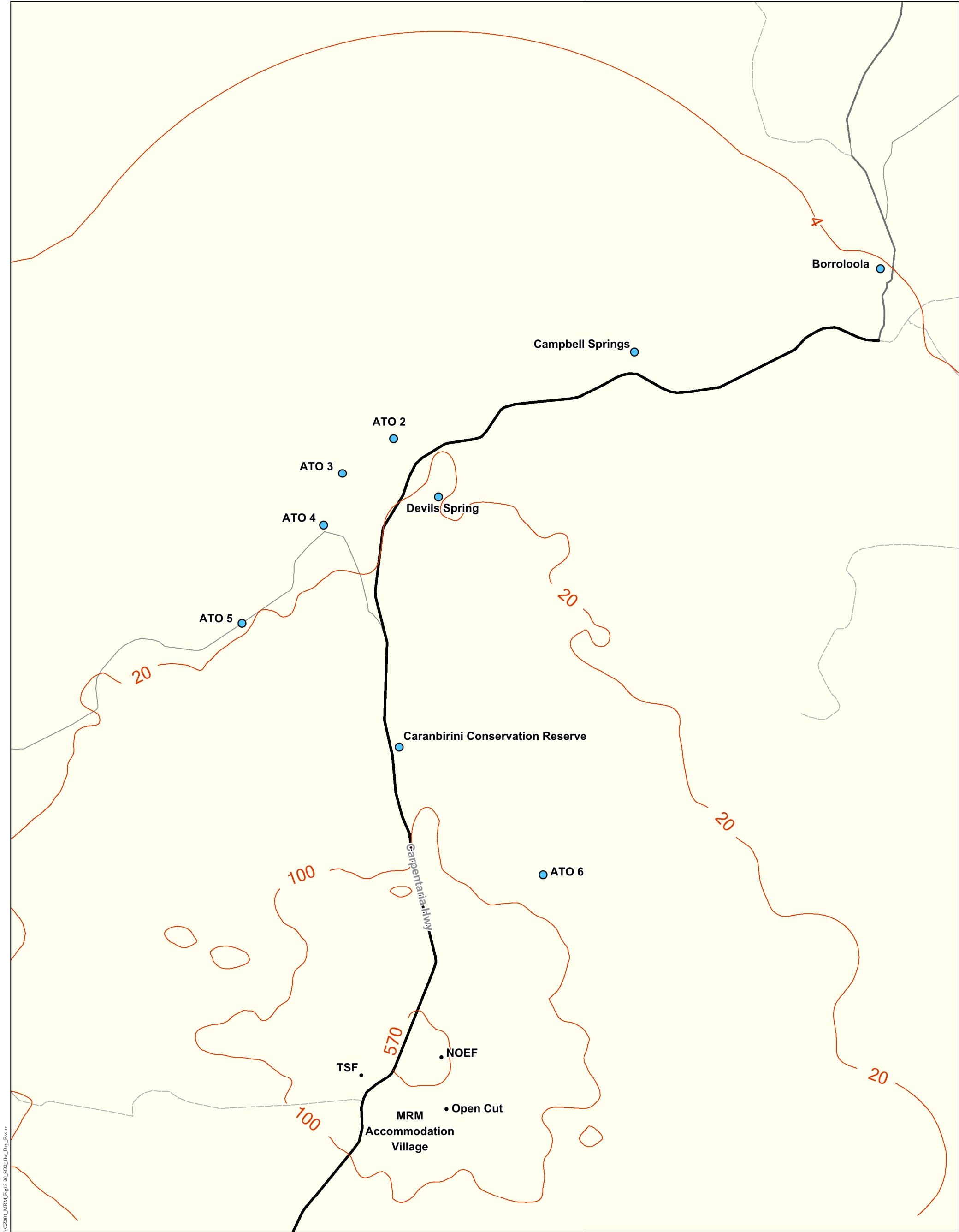
Scale: 1:175,000 (A3)

03/03/2017



Datum: GDA94
Projection: MGA53

FIGURE 13-19



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METSERVE
Mining & Energy Technical Services Pty Ltd



LEGEND

- Off-site Sensitive Receptor
- Concentration Contour ($\mu\text{g}/\text{m}^3$)
- Highway
- Road
- Track

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Localities/Sensitive Receptors - MetServe (Oct 2016); Roads - Geoscience Australia (2008)

**McArthur River Mine
Overburden Management Project EIS
Validated Modelling Results
1 Hour Average SO_2 - Dry Season ($\mu\text{g}/\text{m}^3$)**

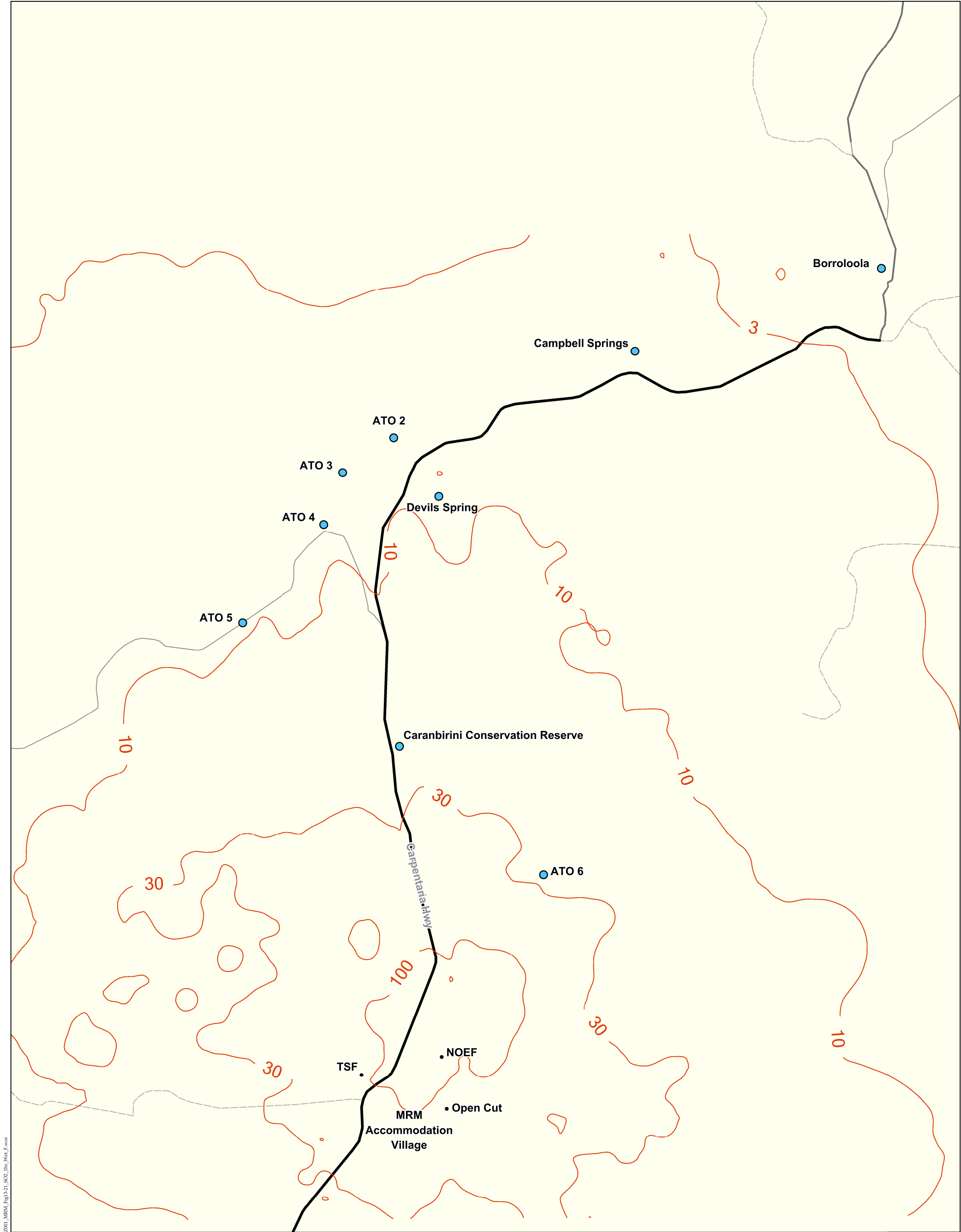


Scale: 1:175,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-20



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Mining & Energy Technical Services Pty Ltd



LEGEND

- Off-site Sensitive Receptor
- Concentration Contour ($\mu\text{g}/\text{m}^3$)
- Highway
- Road
- Track

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Localities/Sensitive Receptors - MetServe (Oct 2016); Roads - Geoscience Australia (2008)

**McArthur River Mine
Overburden Management Project EIS
Validated Modelling Results
1 Hour Average SO_2 - Wet Season ($\mu\text{g}/\text{m}^3$)**

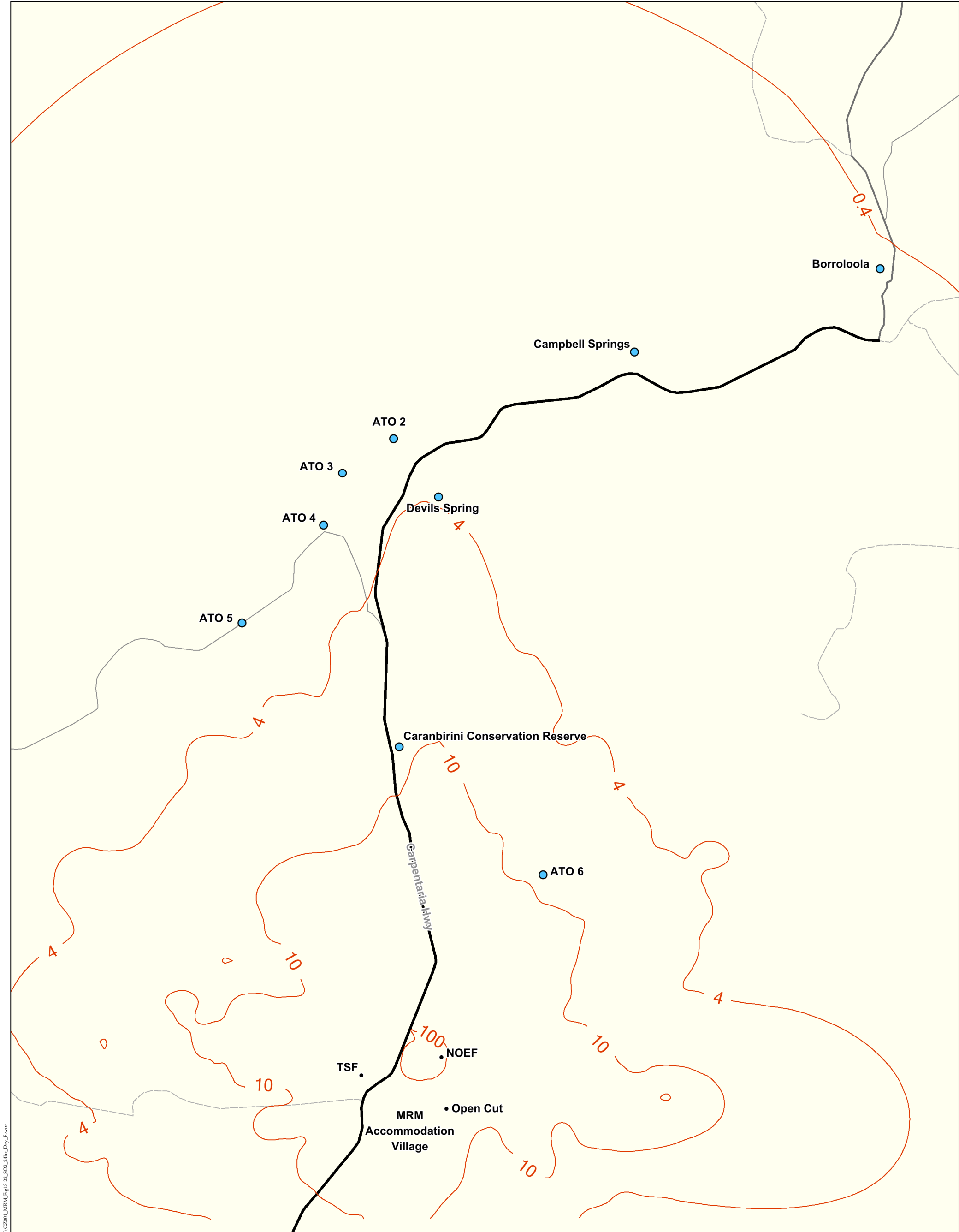


Scale: 1:175,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-21



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LEGEND

- Off-site Sensitive Receptor
- Concentration Contour ($\mu\text{g}/\text{m}^3$)
- Highway
- Road
- Track

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Localities/Sensitive Receptors - MetServe (Oct 2016); Roads - Geoscience Australia (2008)

**McArthur River Mine
Overburden Management Project EIS
Validated Modelling Results
24 Hour Average SO_2 - Dry Season ($\mu\text{g}/\text{m}^3$)**

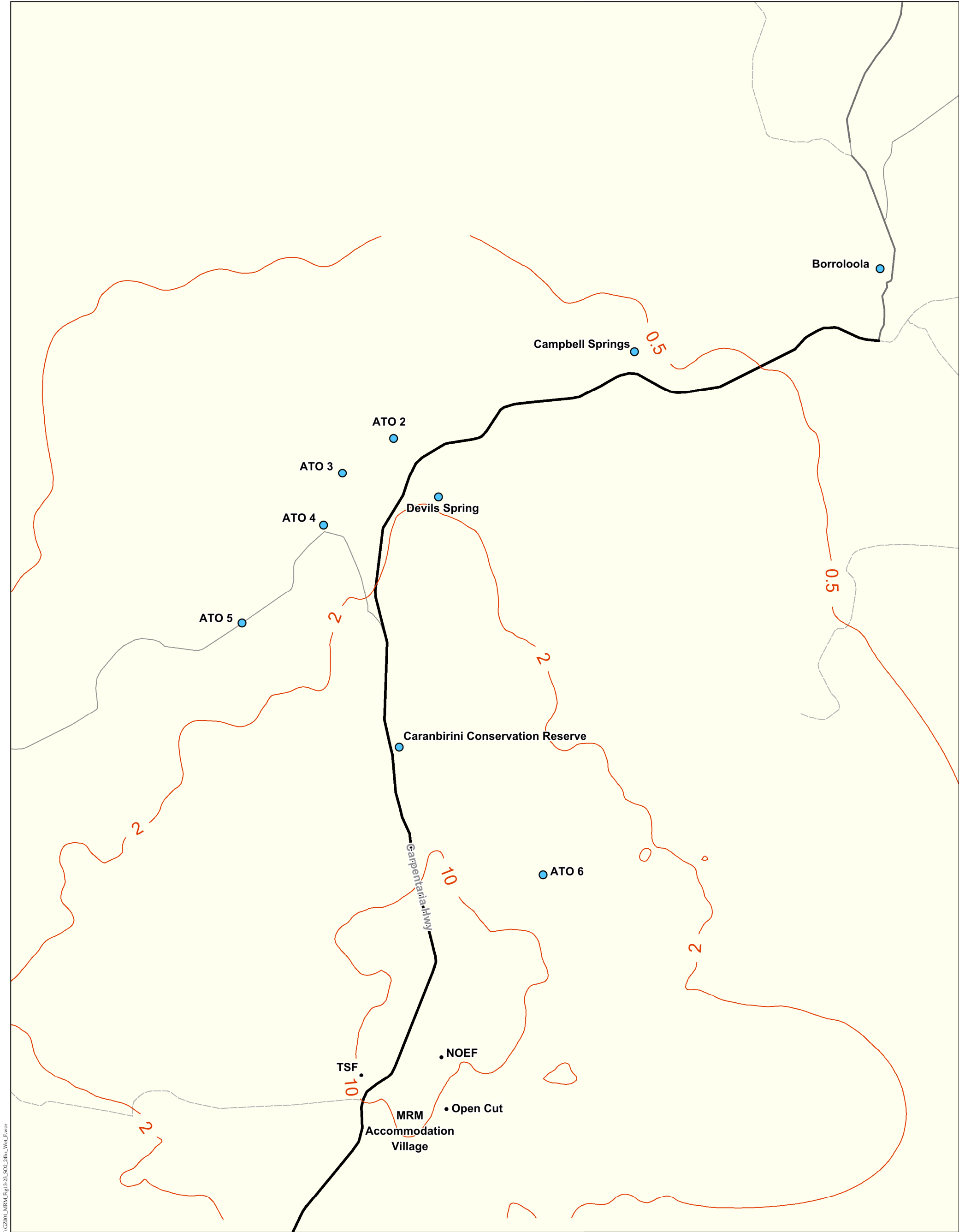


Scale: 1:175,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-22



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LEGEND

- Off-site Sensitive Receptor
- Concentration Contour ($\mu\text{g}/\text{m}^3$)
- Highway
- Road
- Track

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Localities/Sensitive Receptors - MetServe (Oct 2016); Roads - Geoscience Australia (2008)

**McArthur River Mine
Overburden Management Project EIS
Validated Modelling Results
24 Hour Average SO_2 - Wet Season ($\mu\text{g}/\text{m}^3$)**

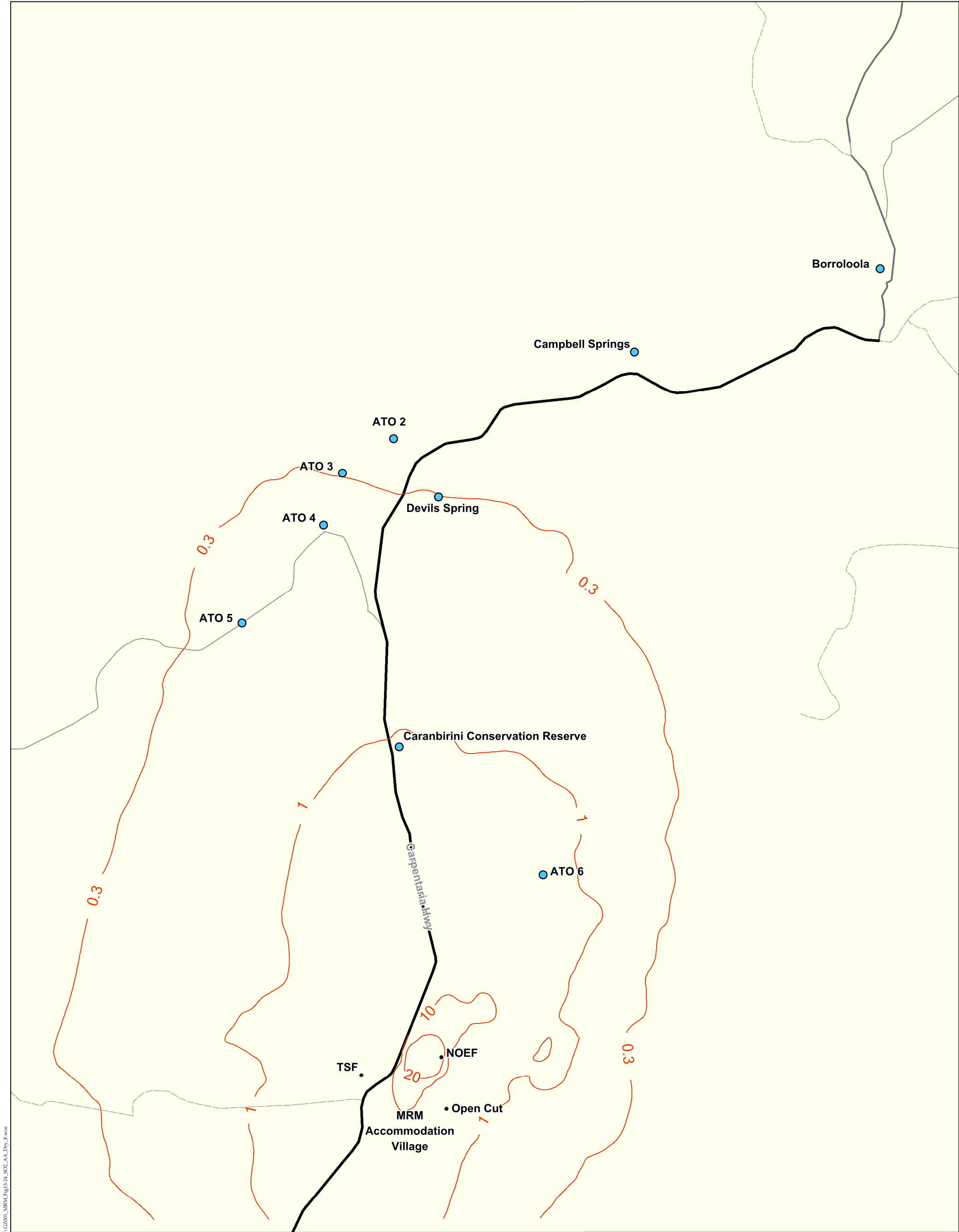


Scale: 1:175,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-23



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LEGEND

- Off-site Sensitive Receptor
- Concentration Contour ($\mu\text{g}/\text{m}^3$)
- Highway
- Road
- Track

Data Source: Concentration Contour - Todoroski Air Sciences (Nov 2016); Localities/Sensitive Receptors - MetServe (Oct 2016); Roads - Geoscience Australia (2008)

**McArthur River Mine
Overburden Management Project EIS
Validated Modelling Results
Annual Average SO_2 - Dry Season ($\mu\text{g}/\text{m}^3$)**



Scale: 1:175,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-24

13.4 Risk Mitigation Measures

13.4.1 Particulate Matter

The MRM operations incorporate a range of air quality mitigation measures designed to limit the potential impact of nuisance dust. A summary of the key dust mitigation measures are outlined in **Table 13-17**. Not all of these mitigation measures can be included in the dispersion model, but where applicable these measures have been applied to the emissions estimates outlined in **Table 13-11**.

Table 13-17 Summary of Dust Mitigation Measures at MRM

Activity	Dust Mitigation Measure
General	• Site induction is to include additional air quality requirements to ensure employee awareness of visual dust plumes and potential for dust impacts.
Hauling on unsealed and sealed roads	• When applicable (via dust monitoring) watering of haul road surfaces; • prevent material being deposited/spilled on haul roads as much as possible; • speed limits on all roads to be adhered to; • trafficable areas clearly marked, minimised, and vehicle movements restricted to these areas; • trafficable areas and vehicle manoeuvring areas regularly maintained; • disused roads are rehabilitated as soon as practicable; and • visual monitoring and inspections of dust from unsealed roads to determine control effectiveness.
Material extraction/unloading	• Application of water using sprinklers on areas prior to extraction where dusty conditions are observed; • water truck with water cannon to supply selective dust suppression when required; • limit double handling and stockpiling of material; • fall distance of materials during loading and unloading limited; and • operations relocated/rescheduled during high dust periods, where practicable.
Dozer and grader operation	• Avoid use during unfavourable conditions (i.e. high wind speeds); • travel speed limited in dusty conditions; • travel on defined routes between work areas, pre-water route where feasible; • visual monitoring and inspections of dust levels from dozer operations; and • water haul roads immediately after grading, where possible.
Exposed areas	• Only the minimum area necessary for mining will be disturbed; • overburden emplacement areas will be rehabilitated as soon as feasible; • stabilisation on areas inactive for long periods; and • regular watering of cleared areas where appropriate.

Activity	Dust Mitigation Measure
Mill	• Water sprays to limit dust when unloading ROM to hopper; • slower tipping at ROM hopper during adverse weather conditions; • use visual triggers for implementation of further dust mitigation; • enclosed facility with internal water sprays at feeder, crusher, conveyor and transfer points as necessary; • enclosed conveyors and transfer points; • all conveyors to be fitted with appropriate cleaning and collection devices; • regularly clean areas where spilt material can build up, e.g. under transfer chutes and conveyors; and • water sprays, enclosures and wind breaks for crushers and screens.
ROM Stockpiles	• Limit drop heights when stacking; • manual implementation of water sprays and/or water cart during dusty periods; and • visual surveillance of dust plumes during activity.
TSF	• Capping of TSF Cell 1 with clay layer to limit generation of tailings dust; and • tailings deposition via 47 spigots around the periphery of Cell 2, where these spigots are operated on a rotation/cycle of approximately 35 to 40 days to keep the exposed tailings surface at least periodically damp, thereby reducing dust generation.

13.4.1.1 Monitoring

The air quality monitoring program at MRM is currently under review and will be presented in the Air Quality Management Plan which is being developed in consultation with the relevant government agencies and operational departments. The Air Quality Management Plan is scheduled to be implemented in early 2017. The review of the monitoring program is based on the dispersion modelling results presented in **Section 13.3.2.3**, along with field observations at the site. The locations of proposed Project air quality monitoring equipment are presented in **Figure 13-26**.



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LEGEND

- SO₂ Monitor
- TEOM Monitor
- High Volume Air Sampler
- Low Volume Air Samplers
- Real-Time Dust Monitor (E-sampler)
- Dust Deposition Gauge
- McArthur River BoM (Weather Station)

Data Source: Dust Monitoring Locations - Todoroski Air Sciences (Nov 2016); Aerial - McArthur River Mining Pty Ltd (Jul 2016)

McArthur River Mine
Overburden Management Project EIS

Proposed Dust Monitoring Locations



Scale: 1:40,000 (A3)

03/03/2017

Datum: GDA94
Projection: MGA53

FIGURE 13-26

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Monthly assessments will be undertaken to validate the monitoring data. Alternatively, assessments will be undertaken in response to any measured exceedance of criteria (i.e. to confirm whether or not the exceedance is a non-compliance). This will be done in accordance with the three escalating response levels outlined below (Level 2 and 3 are applied as necessary).

Level 1: A first pass assessment that includes a check that all calibration and maintenance work due in that month was completed, and an examination of the data. For example, using a plot of the last month's data on a trend line spanning at least 12 months (where available) or similar other simple and effective means to identify potentially erroneous or outlier data (e.g. windroses for meteorological data), or tables showing variability and deviation from the average.

Level 2: Where data has been assessed to be potentially invalid, a detailed examination of the available field records, laboratory notes, calibrations etc. shall be made. This may require a site inspection of the monitoring equipment to assess that it is not damaged, dirty, corroded or compromised by insects, spider webs etc.

Level 3: Where anomalous or potentially invalid data is found and the issue is significant (e.g. may indicate an exceedance or equipment fault) and a level 1 or 2 evaluation cannot determine the cause, a professional air quality expert will be engaged to investigate the issue.

Monitoring records will be retained for at least five years and will include the following information:

- the date and time of sampling;
- the sampling location; and
- the name of the person collecting the sample.

13.4.2 Sulphur Dioxide

Sulphur dioxide is managed at MRM through a protocol for selective handling and emplacement of overburden material. The protocol has been implemented to limit the potential for water and oxygen to enter the NOEF and come into contact with the encapsulated pyritic material, thereby reducing the risk of spontaneous combustion.

A number of additional monitoring techniques have also been implemented to reduce the risk of spontaneous combustion, as outlined below.

In-pit Monitoring

Thermal monitoring is undertaken prior to and during drill and blast operations enabling the early detection of potentially problematic material.

Daily NOEF Inspections

Daily visual and thermal inspections are conducted by Mining personnel to enable early detection of reacting material. The aim is to identify areas showing early signs of increased reactivity (e.g. abnormal surface moisture, elevated temperatures, cracks, heaving or efflorescent salts) prior to the onset of spontaneous combustion.

Gas Monitoring

Daily gas measurements including sulphur dioxide levels are undertaken on the NOEF to identify potential hazards and areas requiring remediation/intervention.

Hazard Maps

Weekly hazard maps of the NOEF are generated showing areas of concern with regards to temperatures and gas levels.

Where sources of sulphur dioxide are identified, management measures include capping and/or excavation, cooling and capping of emission sources will be implemented. Personal monitors and PPE are utilised for workers working near areas of potential sulphur dioxide emission.

13.5 Greenhouse Gas Assessment

The National Greenhouse Accounts (NGA) factors document, which is published by the Department of the Environment and Energy (DEE), defines direct and indirect emissions factors as follows:

- Scope 1: Direct (or point source) GHG emissions are those sources from within an organisation's boundary as a direct result of the activities of the organisation (i.e. fuel use, energy use etc.) (DEE, 2016); and
- Scope 2 and 3: Indirect GHG emissions factors are emissions generated in the wider economy as a consequence of an organisation's activities but are physically produced by another organisation (DEE, 2016).

Scope 3 emissions can also arise from a number of various other sources indirectly associated with the Project's operation including emissions generated by employees travelling to and from the site. These relatively minor individual contributions are difficult to accurately quantify due to the diversity and nature of the sources, and therefore have not been considered further in this assessment.

13.5.1 Greenhouse Gas Emissions

Project related GHG emissions will be generated primarily from electricity generation, and fuel and explosives use. The following GHG's have been considered in the assessment:

- carbon dioxide (CO₂);
- methane (CH₄); and
- nitrous oxide (N₂O).

Estimated quantities of materials that have the potential to emit Scope 1, 2 and 3 GHG emissions have been summarised in **Table 13-18** below. These estimates are based on an annual average use for the life of the Project (up to 2037). Different GHG's have different potential impacts so for comparison they have been converted to equivalent carbon dioxide emissions (CO₂-e).

Table 13-18 Summary of Quantities of Materials Estimated for the Project (2037)

Period	Diesel (kilolitres)	Electricity (megawatt hours)	Explosives (t)
Annual	26,824	320,865	6,273
Total	536,479	6,417,303	125,453

Todoroski 2017

A summary of the Project's Scope 1, 2 and 3 emissions is presented in **Table 13-19**.

Table 13-19 Summary of CO₂-e Emissions per Scope

Period	Scope 1 (t CO ₂ -e)	Scope 2 (t CO ₂ -e)	Scope 3 (t CO ₂ -e)
Annual	74,125	214,980	35,814
Total	1,482,502	4,299,593	716,279

Todoroski 2017

The estimated annual average greenhouse emission for the Project is 0.29 million tonnes of carbon dioxide equivalent (Mt CO₂-e) (Scope 1 and 2). When compared with the estimated annual greenhouse emission at a federal level (535.7 Mt CO₂-e), the Project's annual contribution to Australian greenhouse emissions in 2015 was approximately 0.05% (Todoroski 2017).

If the Project is compared with the NT's greenhouse emissions (12.4 Mt CO₂-e), the annual contribution from the Project in 2014 was approximately 2.33% (Todoroski 2017).

13.5.2 Greenhouse Gas Minimisation measures

Direct means of reducing GHG emissions include such measures as:

- minimising clearing at the site where possible;
- integrating transport for the Project with other local industries, so that GHG emissions from the construction and running of transport are limited;
- maintenance of heavy mobile equipment (including tyres) and roads;
- using renewable energy sources where practicable;
- replacing some diesel powered light towers with mains connected LEDs at the mine and installing timers to control lighting across the site;
- upgrading to more efficient heavy equipment in the mining fleet to reduce diesel derived GHG emissions; and
- using driver simulation software for bulldozers and loaders instead of equipment when training personnel.

13.5.3 Climate Impact Assessment

Potential climate change impacts on the Project have been considered across all relevant technical disciplines using an agreed climate change impact assessment approach, as outlined in **Appendix D – Approach for Assessing Climate Change Impacts**.

A review of the projections of future climate for the Monsoonal North (CSIRO, 2015) indicates that:

- future substantial warming is projected with very high confidence for mean, maximum and minimum temperature;
- there is high confidence that natural climate variability will be the major driver of annual mean rainfall changes in the short term (by 2030); however the direction (increase or decrease) of the annual rainfall change is uncertain. There is generally a low confidence in long term (2090) annual rainfall projections;
- small changes are projected to mean surface wind speed with high confidence in the short term. In the long term little change is projected with medium confidence;

- the projections indicate that there is high confidence in both short term and long term periods and that the potential evapotranspiration will increase in all seasons. The level of increase is less certain as there is only medium confidence in the magnitude of the projections; and
- there is high confidence in little changes to solar radiation and relative humidity in the short term. In the long term there is low confidence in solar radiation projections (models projecting both increases and decreases) and medium confidence in a decrease to relative humidity.

13.5.3.1 Methodology

Three global climate model (GCM) future scenarios, which include best case, worst case and maximum consensus (most likely), were selected to provide a range of projected changes to the relevant climate variables for the short term (2030) and long term (2090). Details of the methodology are set out in the WRM climate change document outlined in **Appendix D – Approach for Assessing Climate Change Impacts**.

The climate variables which were determined to be applicable to the assessment of climate change from an air quality perspective are:

- rainfall;
- wind speed;
- maximum daily temperature;
- humidity;
- solar radiation; and
- evapotranspiration.

To determine the likely changes in climate variables at the Project location, the results from the three short term and long term GCM scenario projections were then adjusted to account for the difference between the historical baseline dataset (1889 to 2015) and GCM reference dataset (1986 to 2005).

13.5.3.2 Results

The sensitivity ranges in climate variables relevant to air quality from the three short term and long term GCM scenario projections, adjusted with the SILO baseline at the Project location, are presented in **Table 13-20**.

Table 13-20 Climate Impact Sensitivity Analysis Range

Scenario	Representative Model	Model Consensus	Rainfall (%)	Maximum Daily Temperature (°C)	Solar Radiation (%)	Evapotranspiration (%)
SILO* Drill Data – annual average historical baseline and GCM differences						
N/A	N/A	N/A	-4.0%	-0.19	2.4%	1.7%
Short term GCM data (2030) minus historical baseline and GCM differences						
Best Case	MIROC5	Very Low	10.4%	0.84	-2.7%	1.1%
Worst Case	GFDL-ESM2M	Low	-6.2%	1.13	-0.4%	-0.2%
Maximum Consensus	CanESM2	High	4.2%	0.41	-2.1%	2.7%
Long term GCM data (2090) minus historical baseline and GCM differences						
Best Case	MIROC5	Very Low	9.5%	1.98	-2.2%	4.1%
Worst Case	HadGEM2-CC	Low	-3.1%	2.36	-2.9%	4.9%
Maximum Consensus	CanESM2	Moderate	6.7%	2.58	-2.2%	6.8%

*Scientific Information for Land Owners
Todoroski 2017

Table 13-20 indicates that the maximum consensus (most likely) scenario for both the short and long term would result in increases to annual rainfall, maximum daily temperatures and evapotranspiration. Annual average solar radiation is projected to decrease in both the short and long terms.

Changes to these variables would likely have some impact on the Project's annual dust emissions. For example, the increase in annual average rainfall and decrease in solar radiation would likely favour a reduction of dust emissions. However, warmer daily maximum temperatures and increased evapotranspiration may on the other hand tend to increase daily maximum dust emissions.

The effect of potential changes in climate variables upon Project generated dust emissions is overall likely to be relatively balanced by small increases and decreases in emissions on any given day. However such dust emissions occur over relatively short time frames (hours to days), and would be managed accordingly (e.g. increased watering on hotter days with higher rates of evaporation).

13.6 Conclusions and Residual Risk

A risk assessment has been completed to determine the residual risk profile by considering the effectiveness of proposed mitigations on unmitigated scenarios. The key risks were assessed in two stages including:

- risks assessed with current control measures (inherent risk); and
- risks assessed with proposed additional control measures (residual risk).

The Glencore Corporate Risk Framework, which considers the likelihood and consequence of potential impacts has been utilised. For each hazard, a likelihood and consequence score is generated, which combine to determine the category of risk (high, medium or low).

The Project's potential air quality related risks have been assessed and are outlined below in **Table 13-21**. These risks have been identified as part of the Project risk assessment process and are documented in **Chapter 7 – Project Risk Assessment** and **Appendix AA – Air Quality Impact Assessment Report**.

The risk of potential air quality impacts is considered low at all off-site receptors. The likelihood of any air quality impacts is assessed as “unlikely” and the severity of any consequence is considered to be “minor”, indicating that the Project would not lead to any off-site impacts at Borroloola, Devil Springs, Campbell Springs or the identified areas of temporary occupation.

The assessment of sulphur dioxide identifies that potential impacts may arise from the NOEF, and that there is potential for impacts along a stretch of the Carpentaria Highway if emissions are not well managed at all times. The consequences are considered to be low as there is very little traffic on this stretch of road, and it is unlikely for any person to be present for a sufficient length of time to experience any negative effects.

The Project's estimated annual average GHG emissions based on an annual average level of production is calculated to be 0.29 Mt CO₂-e material. This is equivalent to approximately 0.05 per cent of Australian greenhouse emissions for the year to December 2015 and approximately 2.33 per cent of the NT's greenhouse emissions for the 2014 period.

The climate change assessment indicates that for the assessed long term and short term scenarios, there would be increases to annual rainfall, maximum daily temperatures and evapotranspiration. Annual average solar radiation is projected to decrease in both the short and long terms. The projected changes to these climate variables would have some effect on Project generated dust emissions, both increasing and decreasing emissions on any given day, however it is intended that any potential additional dust impacts would be managed on a daily basis and thus any influence of climatic changes on dust impacts would be negligible.

The potential air quality risk to MRM employees is managed by MRM's Air Quality Management Plan and also MRM's occupational health and safety protocols. The Air Quality Management Plan outlines operational measures to mitigate air pollutants along with real-time air quality trigger limits to assist with management of daily dust levels at on-site receptors such as the accommodation village. Occupational health and safety protocols include hygiene management protocols for reducing potential for lead ingestion, conducting regular blood testing of employees, and personnel protective equipment requirements.

Table 13-21 Residual Risk Assessment

Hazard	Potential impact	Existing mitigation	Inherent Risk	Proposed Mitigation	Residual Risk
Spontaneous combustion of overburden within the NOEF	Release of sulphur dioxide from the NOEF and affecting nearby receptors.	Covering of OEFs with alluvial material and clay. Compacted batters and alluvial blanket. Monitoring and communication strategy. Dust management plan.	H-17	Development and implementation of Site Air Quality Management Plan which will include the 'Visual Dust Triggers and Associated Actions'.	L-6
Spontaneous combustion of tailings due to improper handling during tailings dam construction	Spontaneous combustion and release of sulphur dioxide from tailings due to improper handling potentially resulting in impacts to nearby receptors.	Work method statement for conduct of tailings construction activities (e.g. avoiding loose tailings being left in stockpiles). Tailings being rehandled are track rolled (as per Operation, Maintenance and Surveillance Manual for the Tailings Storage Facility). Safety Management System - identification of hazards and application of work methods to avoid exposure or to be protected whilst working in proximity to hazards (cabins, PPE, etc.).	M-7	Development and implementation of Site Air Quality Management Plan which will include the 'Visual Dust Triggers and Associated Actions'.	L-6
NOEF - general operations/failure of dust suppression/air quality	Potential nuisance and human health issues associated with air quality, including dust and air pollutants such as sulphur dioxide	Dust Management Plan - use of water carts and fixed sprays to suppress dust - applied during construction of the NOEF and other OEFs and as required elsewhere. Safety Management System - identification of hazards and application of work methods to avoid exposure or to be protected whilst working in proximity to hazards (cabins, PPE, etc.).	M-7	Development and implementation of updated Air Quality Management Plan which will include the 'Visual Dust Triggers and Associated Actions'.	L-2