Air Quality Impact Assessment for the South32 Mamatwan Mine Project

Project done for **SLR Consulting (Africa) (Pty) Ltd**

Report compiled by:
Rochelle Bornman

Project Manager:
Hanlie Liebenberg-Enslin

Report No: 18SLR23 Rev1 | **Date:** August 2021

Address: 480 Smuts Drive, Halfway Gardens | Postal: P O Box 5260, Halfway House, 1685
Tel: +27 (0)11 805 1940 | Fax: +27 (0)11 805 7010
www.airshed.co.za

Report Details

Report Title	Air Quality Impact Assessment for the South32 Mamatwan Mine Project
Client	SLR Consulting (Africa) (Pty) Ltd
Report Number	18SLR23
Report Version	Rev 1
Date	August 2021
Prepared by	Rochelle Bornman, MPhil. GIS and Remote Sensing (University of Cambridge)
	Hanlie Liebenberg-Enslin, PhD (University of Johannesburg)
Reviewed by	Reneé von Gruenewaldt *(Pr. Sci. Nat.)*, MSc (University of Pretoria)
Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.
Copyright Warning	Unless otherwise noted, the copyright in all text and other matter (including the manner of presentation) is the exclusive property of Airshed Planning Professionals (Pty) Ltd. It is a criminal offence to reproduce and/or use, without written consent, any matter, technical procedure and/or technique contained in this document.

Revision Record

Version	Date	Comments
Rev 0	September 2020	For client review
Rev 1	August 2021	Addressed client comments and updated GHG Statement

Competency Profiles

Report author: R Bornman (M.Phil in GIS and Remote Sensing, University of Cambridge)

Rochelle Bornman started her professional career in Air Quality in 2008 when she joined Airshed Planning Professionals (Pty) Ltd after having worked in malaria research at the Medical Research Council in Durban. Rochelle has worked on several air quality specialist studies between 2008 and 2020. She has experience on the various components including emissions quantification for a range of source types, simulations using a range of dispersion models and impact assessments. Whilst most of her working experience has been in South Africa, a number of investigations were made in countries elsewhere, including Mozambique, Namibia, Saudi Arabia and Mali.

Report author: H Liebenberg-Enslin, PhD Geography (University of Johannesburg).

Hanlie Liebenberg-Enslin started her professional career in Air Quality Management in 2000 when she joined Environmental Management Services (EMS) after completing her MSc degree at the University of Johannesburg (then RAU) in the same field. She is one of the founding members of Airshed Planning Professionals in 2003 where she has worked as a company Director until she took over as Managing Director in May 2013.

She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, using different dispersion models, and conducting impact assessments and health risk screening assessments. Hanlie was the project manager on a number of ground-breaking air quality management plan (AQMP) projects and the principal air quality specialist on regional environmental assessments. Her work experience, although mostly in South Africa, range over various countries in Africa, including extensive experience in Namibia, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality.

Hanlie has lectured several Air Quality Management Courses and is actively involved in the International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA) and the South African National Association for Clean Air (NACA), where she served as President for both organisations. Being an avid student, she received her PhD from the University of Johannesburg in June 2014, specialising in Aeolian dust transport.

NEMA Regulation (2017), Appendix 6

NEMA Regulations (2017) - Appendix 6		Relevant section in report
1.a)	Details of the specialist who prepared the report.	Report details (page ii)
	The expertise of that person to compile a specialist report including curriculum vitae.	Report details (page ii) Appendix A
1.b)	A declaration that the person is independent in a form as may be specified by the competent authority.	Report details (page i)
1.c)	An indication of the scope of, and the purpose for which, the report was prepared.	Introduction and background (Executive Summary) Section 1.2: Scope of Work Section 1.3: Approach and Methodology
	An indication of the quality and age of base data used for the specialist report.	Section 3.2: Atmospheric Dispersion Modelling Section 4.3: Baseline Air Quality
	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change.	Section 5: Impact Significance Rating
1.d)	The duration date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Section 3.2: Influencing Meteorological Conditions Section 3.4: Baseline Air Quality
1.e)	A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used.	Section 1.3: Approach and Methodology Section 1.4: Limitations and Assumptions
1.f)	Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternative.	Section 3.1: receiving Environment Section 4: Impact Assessment Section 5: Impact Significance Rating
1.g)	An identification of any areas to be avoided, including buffers.	Not applicable
1.h)	A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Section 3.1: Receiving Environment Section 4.3: Atmospheric Dispersion Modelling
1.i)	A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.3: Limitations and Assumptions
1.j)	A description of the findings and potential implications of such findings on the impact of the proposed activity or activities.	Section 4: Impact Assessment
1.k)	Any mitigation measures for inclusion in the environmental management programme report	Section 6: Air Quality Management Measures
1.l)	Any conditions for inclusion in the environmental authorisation	Section 8: Conclusions and Recommendations
1.m)	Any monitoring requirements for inclusion in the environmental management programme report or environmental authorisation.	Section 6.3: Performance Indicators
1.n)	A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised.	Section 8: Conclusions and Recommendations
	A reasoned opinion regarding the acceptability of the proposed activity or activities.	Section 8: Conclusions and Recommendations
	If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the environmental management programme report, and where applicable, the closure plan.	Section 8: Conclusions and Recommendations
1.o)	A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable
1.p)	A summary and copies if any comments that were received during any consultation process.	Not applicable
1.q)	Any other information requested by the competent authority.	Not applicable.

Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
APPA	Air Pollution Prevention Act
AQSR	Air Quality Sensitive Receptors
AR5	IPCC Fifth Assessment Report
ASTM	American Standard Testing Method
CCRA	Climate Change Reference Atlas
CCS	Carbon Capture and Sequestration (or Carbon Capture and Storage)
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DFFE	Department of Forestry, Fisheries and Environment (previously DEA)
EHS	Environmental, Health, and Safety (IFC)
EIA	Environmental Impact Assessment
FOLU	Forestry and Other Land Use
GCMs	Global Climate Change Models
GHG	Greenhouse gas
GHGIP	Greenhouse Gas Improvement Programme
GLC	Ground Level Concentration
GWP	Global Warming Potential
HFO	Heavy Fuel Oil
I&APs	Interested and Affected Parties
IFC	International Finance Corporation
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IPPU	Industrial Process and Product Use
IRP	Integrated Resource Plan
LPG	Liquified Petroleum Gas
Ltd	Limited
NAAQS	National Ambient Air Quality Standards
NAEIS	National Atmospheric Emissions Inventory System
NCCRP	National Climate Change Response Plan
NDC	Nationally Determined Contribution
NDCR	National Dust Control Regulations
NEMAQA	National Environment Management Air Quality Act
NPI	National Pollutant Inventory (Australia)
PV	Photovoltaic
RCA4	Rossby Centre Regional Model

RCP	Representative Concentration Pathways
REI4P	Renewable Energy Independent Power Producer Procurement Programme
ROM	Run-of-mine
SAAELIP	South African Atmospheric Emission Licencing and Inventory Portal
SAAQIS	South African Air Quality Information System
SAGERS	South African Greenhouse Gas Emission Reporting System
SABS	South African Bureau of Standards
SANS	South African National Standards
SAWS	South African Weather Services
SoW	Scope of Work
UNFCCC	United Nations Framework Convention on Climate Change
US EPA	United States Environmental Protection Agency
WBG	World Bank Group
WHO	World Health Organisation

Symbols and Units

°C	Degrees Celsius
µg	Microgram(s)
µg/m³	Micrograms per cubic meter
L_{MO}	Monin-Obukhov Length
m/s	Meters per second
m^2	Metres squared
masl	Meters above sea level
mg	Milligram(s)
mg/m²/day	Milligram per metre squared per day
mm	Millimeters
mtpa	million tons per annum
PM	Particulate Matter
PM_{10}	Thoracic particulate matter
$PM_{2.5}$	Respirable particulate matter
TSP	Total Suspended Particulate
%	Percentage

Glossary

Air pollution	This means any change in the composition of the air caused by smoke, soot, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances
Ambient Air	This is defined as any area not regulated by Occupational Health and Safety regulations
Atmospheric emission or emission	Any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution
Averaging period	This implies a period of time over which an average value is determined
Dispersion	The spreading of atmospheric constituents, such as air pollutants
Dust	Solid materials suspended in the atmosphere in the form of small irregular particles, many of which are microscopic in size
Frequency of Exceedance	A frequency (number/time) related to a limit value representing the tolerated exceedance of that limit value, i.e. if exceedances of limit value are within the tolerances, then there is still compliance with the standard
Mechanical mixing	Any mixing process that utilizes the kinetic energy of relative fluid motion
Particulate Matter (PM)	These comprise a mixture of organic and inorganic substances, ranging in size and shape. These can be divided into coarse and fine particulate matter. The former is called Total Suspended Particulates (TSP), whilst PM_{10} and $PM_{2.5}$ fall in the finer fraction.
PM_{10}	Particulate Matter with an aerodynamic diameter less than or equal to 10 µm. it is also referred to as thoracic particulates and is associated with health impacts due to its tendency to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter less than or equal to 2.5 µm. it is also referred to as respirable particulates. It is associated with health impacts due to its high tendency to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung
Vehicle Entrainment	This is the lifting and dropping of particles by the rolling wheels leaving the road surface exposed to strong air current in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed

Executive Summary

South32 Mamatwan Mine is situated approximately 38 km south of Hotazel and 54 km north of Kuruman and is an opencast manganese mine which is proposing to undertake an integrated regulatory process to cater for layout/activity changes that have already taken place at the mine, as well as proposed layout/activity changes (hereafter referred to as the project).

The proposed layout/activity changes associated with the project that may have an impact on ambient air quality will consist of:

- The establishment of a top-cut stockpile and associated crushing and screening plant;
- Establishment of stormwater management infrastructure;
- Changes to waste rock dump height;
- Establishment of a pipeline to transport abstracted water from the decommissioned Middelplaats Mine to Mamatwan Mine;
- Upgrading the railway and railway loadout station;
- Sale of waste rock as aggregate; and
- Re-processing of material located in Adams pit.

The proposed mining and processing activities will result in air quality impacts in the study area. Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by SLR Consulting (South Africa) (Pty) Ltd to conduct an air quality impact assessment for the project. The main objective of the air quality specialist study was to determine the potential impact on ambient air quality and air quality sensitive receptors (AQSRs) as a result of the project and to recommend suitable mitigation and management measures.

Typical of specialist investigations the air quality study comprises both a baseline and an impact assessment. The baseline study included the review of the site-specific atmospheric dispersion potential, relevant air quality standards and guidelines and baseline dustfall levels and annual emissions monitoring data.

In assessing the impacts associated with the operations at the site, an emissions inventory was compiled, atmospheric dispersion modelling undertaken, and modelled concentrations evaluated. Dispersion modelling was conducted using the US EPA AERMOD model over an area of 10 km east-west by 8.5 km north-south. The evaluation of simulated concentrations and dustfall levels was compared against National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR) respectively.

Main Findings

The findings from the baseline assessment can be summarised as follows:

- The prevailing wind direction is from the south-southeast. During the day, winds are more frequent from the westerly and the northerly sectors. The predominant wind direction during the night-time is from the south-southeast. Day-time calms occurred for 8% of the time, with night-time calms for 28% of the time.

- Mining activities, farming and residential land-uses occur in the region. These land-uses contribute to baseline pollutant concentrations via vehicle tailpipe emissions, household fuel combustion, biomass burning and various fugitive dust sources.
- Six (6) AQSRs around the project site were identified, four of which are farmsteads, the other two being a farmworkers residence and the nearby Solar Plant Management Office.
- A dustfall monitoring network is in place at Mamatwan Mine, comprising of eight (8) single dustfall units (one has been decommissioned) that can be compared to the NDCR limits. Dustfall results for the single units were made available for the period January to December 2018, and January to December 2019. The dustfall over the year 2018 was low and well below the NDCR for residential and non-residential areas. The highest dustfall rates were recorded at MMT07 for most of the months. The annual average deposition rates ranged between 48 mg/m²/day (MMT05) to 151 mg/m²/day (MMT07).
- MMT does not undertake ambient air quality monitoring of PM_{10}[1] concentration levels.

The findings from the impact assessment can be summarised as follows:

PM_{10}

Baseline: Simulated PM_{10} daily ground level concentrations (GLCs), with no mitigation in place, are in non-compliance with the NAAQS for distances up to 4 km from the mining rights boundary. The simulated number of exceedances of the daily PM_{10} NAAQS at AQSR 5 and 6 are in non-compliance with the standard for unmitigated activities. Over an annual average the GLCs are within the NAAQS at all AQSRs. The significance of impacts is considered High.

With mitigation in place[2], simulated daily and annual PM_{10} concentrations are within NAAQS at all AQSRs. The significance of impacts is considered Low.

Project: PM_{10} daily GLCs, for unmitigated activities, are likely to exceed the NAAQS for a distance of up to 6 km from the mining rights boundary. The simulated number of exceedances of the daily PM_{10} NAAQS at five AQSRs are not in compliance with the standard. The footprint of exceedance of the annual NAAQS is much larger than that of the baseline scenario, but the annual GLCs are in compliance with the standard. The significance of impacts is considered High.

With mitigation in place, the area of exceedances of the PM_{10} daily NAAQS is reduced and no exceedances of the daily PM_{10} NAAQS were simulated at any of the AQSRs. Over an annual average the GLCs are within the NAAQS at all AQSRs. The significance of impacts is considered Low.

[1] Particulate matter less than 10 µm in diameter

[2] Mitigation measures were assumed as water suppression on unpaved roads with a control efficiency (CE) of 75%, 50% CE on in-pit crushing and at the new mobile crusher (project) through water suppression; 50% CE on all tipping and materials handling activities through water suppression; and 50% on conveyors through roofing and covering of one side of the conveyor. It was assumed that even under unmitigated conditions the crushers at the processing plant and sinter plant are enclosed (with a control efficiency of 83%).

$PM_{2.5}$

Baseline: Simulated daily $PM_{2.5}$ GLCs, with no mitigation in place, are likely to be in non-compliance with the NAAQS applicable from 1 January 2030 for distances of up to 2 km from the mining rights boundary. No exceedances of the daily $PM_{2.5}$ NAAQS were simulated at any of the AQSRs. With mitigation in place, the footprint of exceedances of the $PM_{2.5}$ daily NAAQS is reduced to within the site. Over an annual average the GLCs are within the NAAQS at all AQSRs.

Project: Simulated daily $PM_{2.5}$ GLCs, for unmitigated activities, are likely to exceed the NAAQS applicable from 1 January 2030 for distances up to 3.5 km from the mining rights boundary. The daily $PM_{2.5}$ NAAQS was exceeded at AQSR 6. The maximum distance of exceedance of the annual NAAQS is approximately 800 m from the northern mining rights boundary. Annual average simulated GLCs are within the standard at all receptors. The significance of impacts is considered High.

With mitigation in place, the area of exceedance of the $PM_{2.5}$ daily NAAQS is reduced and no exceedances of the daily $PM_{2.5}$ NAAQS were simulated at any of the AQSRs. Over an annual average, simulated exceedances of the 2030 NAAQS are largely confined to site. Annual average simulated GLCs are within the standard at all receptors. The significance of impacts is considered Low.

Dustfall

Simulated maximum daily dustfall rates for baseline and project operations (unmitigated and design mitigated operations) are in compliance with the NDCR residential limit (600 mg/m²/day). The significance of impacts is considered Low for both unmitigated and mitigated baseline operations, and Low for unmitigated and mitigated project operations.

Greenhouse Gas Emissions

The total GHG emission for the project is assumed to be the same as for the actual operations during the period Jul'2021 to Jun'2020 of 104 232 tCO_2-e. Based on the published 2015 National GHG Inventory, the total CO_2-e emissions from the project, would contribute approximately 0.02% to the total South African GHG inventory emissions of 512.38 million metric tonnes CO_2-e. The annual MMT GHG emissions exceeds the 0.1 Mt threshold which requires a pollution prevention plan to be submitted to the Minister for approval.

Conclusions

The impacts due to the proposed project were assessed with respect to the establishment of a new top-cut stockpile and crusher and changes to the railway infrastructure at the sinter plant. It was assumed that approximately half of the top-cut material would be hauled to the new stockpile per annum via unpaved road and that all of it would be crushed.

No significant differences in air quality impacts were found with respect to the options for railway loadout for the project scenario. However, simulated ground level concentrations due to the project scenario were much higher than for the baseline. The contribution of source groups to overall impact was analysed and showed unpaved roads and in-pit sources to be the largest contributors.

Exceedances of the NAAQS were predicted at five AQSRs for PM_{10} and at one AQSR for $PM_{2.5}$ under unmitigated conditions[2], project scenario. With design mitigation measures in place, no exceedances of the NAAQS at AQSRs were simulated. For baseline operations no exceedances of the NAAQS for either PM_{10} or $PM_{2.5}$ were simulated. Simulated dustfall levels were within the NDCR at all AQSRs for baseline and project operations.

The proposed project operations should not result in significant ground level concentrations or dustfall levels at the nearby receptors provided the design mitigation measures are applied effectively, and that the assumptions as to what current mitigation measures are in place are correct. From an air quality perspective, the proposed project can be authorised permitted the recommended mitigation and monitoring measures are applied.

Recommendations

A summary of the recommendations and management measures is given below:

- Construction and closure phases:
  - Air quality impacts during construction would be reduced through basic control measures such as limiting the speed of haul trucks and to apply water sprays on regularly travelled unpaved road sections.
  - When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and the material transported must be covered to minimise windblown dust.
- Operational phases:
  - In controlling dust due to drilling operations, dust suppression must be fitted on drill rigs to achieve an emission reduction efficiency of 97%.
  - For the control of vehicle entrained dust it is recommended that water sprays be applied to ensure a control efficiency of 75%. Literature indicates an application rate >2 litres/m²/hour should achieve this.
  - In controlling dust from mobile crushing operations, it is recommended that water sprays be applied to keep the ore wet, to achieve a control efficiency of up to 50%.
  - Mitigation of materials transfer points should be done using water sprays at the tip points. This should result in a 50% control efficiency. Also, regular clean-up at loading points is recommended. In-pit transfer points can be controlled through reducing excavator drop heights into haul trucks.
  - In minimizing windblown dust from stockpile areas, water sprays should be used to keep surface material moist. A mitigation efficiency of 50 % is anticipated. In addition, reshaping disturbed areas to natural contours, vegetation cover and rock cladding would limit wind erosion potential.
  - In minimizing windblown dust from the conveyors, roofing and covering of one side of the conveyor should be installed to achieve a mitigation efficiency of 50 %.
  - To ensure that mitigation is effective, it is recommended that the dustfall monitoring network at the mine be expanded to include single dust buckets at AQSR 4 and AQSR 5 and also that PM_{10} sampling be conducted at AQSR 5 (or AQSR 6 if it is more secure). This can be done as an annual campaign before the project commences (as part of the baseline) and again once mitigated project operations are in place.

- Greenhouse Gas Emissions:
    - MMT quantify GHG emissions monthly and quarterly, and it is assumed that it is reported annually on the SAAELIP system.
    - GHG emissions from the MMT operations, including the proposed project, are in excess of the 0.1 Mt threshold, *a pollution prevention plan* must be submitted to the Minister for approval, if this has not been done to date.

Table of Contents

List of Tables

List of Figures

1 Introduction

South32 Mamatwan Mine is an opencast manganese mine located approximately 25km to the south of Hotazel in the John Taolo Gaetsewe District Municipality and Joe Morolong Local Municipality of the Northern Cape Province of South Africa (Figure 1). The mine is located adjacent to the R380 road and railway with the Tshipi Borwa Manganese Mine situated immediately to the west. The mine is surrounded by farmland used for grazing.

Mamatwan Mine is proposing to undertake an integrated regulatory process to cater for layout/activity changes that have already taken place at the mine as well as layout/activity changes that are proposed (hereafter referred to as the project). These changes are as follows:

- Layout changes already taken place:
  - Expansion of the north eastern and south eastern waste rock dump;
  - Changes to the rehabilitation criteria of waste rock dumps;
  - Expansion of an existing road;
  - Expansion of the product stockyard; and
  - Establishment of potable and process water storage facilities.
- Activities that already taken place:
  - Irrigation using treated sewage effluent.
- Proposed layout changes:
  - Establishment of a top-cut stockpile and associated crushing and screening plant;
  - Establishment of stormwater management infrastructure;
  - Changes to waste rock dump height;
  - Establishment of a pipeline to transport abstracted water from the decommissioned Middelplaats Mine to Mamatwan Mine; and
  - Upgrading the railway and railway loadout station.
- Proposed activity changes:
  - Sale of waste rock as aggregate; and
  - Re-processing of material located in Adams pit. .

The proposed mining and processing activities will result in air quality impacts in the study area. Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by SLR Consulting (South Africa) (Pty) Ltd to conduct an air quality impact assessment for the project.

1.1 Study Objective

The main objective of the investigation is to quantify the potential impacts resulting from the proposed activities on the surrounding environment and human health. As part of the air quality assessment, a good understanding of the regional climate and local dispersion potential of the site is necessary and subsequently an understanding of existing sources of air pollution in the region and the current and potential future air quality.

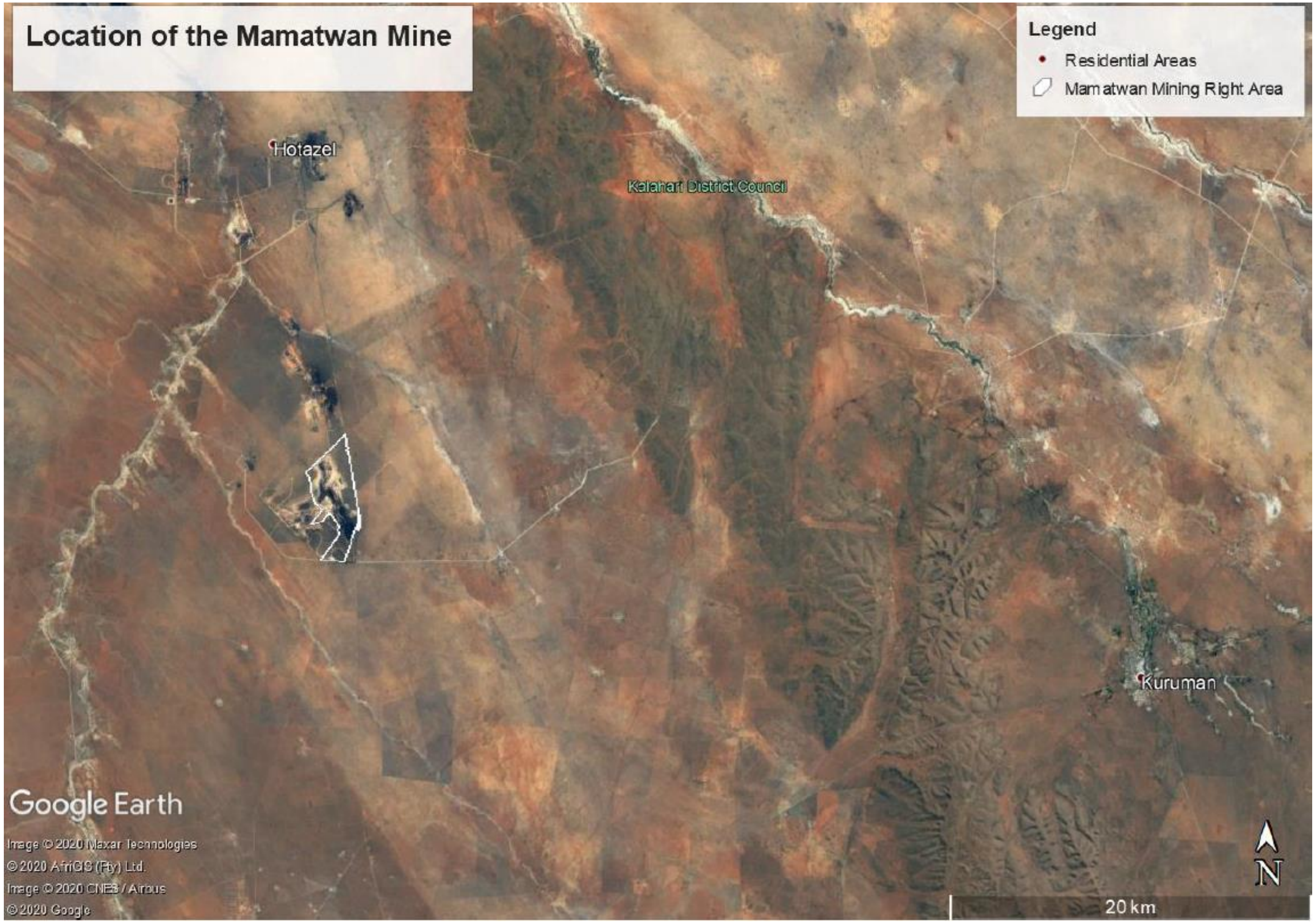

Figure 1: Location of Mamatwan Mine

1.2 Scope of Work

To meet the above objective, the following tasks were included in the Scope of Work (SoW):

1. A review of available project information.
2. A review of the legislative framework within which air quality is regulated in South Africa.
3. A study of the affected atmospheric environment, including:
   a. The identification of air quality sensitive receptors (AQSRs);
   b. An analysis of the atmospheric dispersion potential around Mamatwan Mine; and
   c. A review of available data to determine the status of current air quality in the study area.
4. An impact assessment, including:
   a. The establishment of a source inventory for proposed activities;
   b. Atmospheric dispersion simulations to determine potential air quality impacts as a result of the project activities;
   c. The screening of simulated results against relevant environmental standards;
   d. A qualitative cumulative air quality assessment.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. A Tier 1 (if required Tier 2) greenhouse gas inventory and qualitative discussion on climate change impacts.
7. The preparation of comprehensive air quality assessment report in the prescribed specialist report format.

1.3 Approach and Methodology

The air quality study includes the assessment of both baseline and proposed project operations. The approach to, and methodology followed in the completion of tasks (or scope of work) are discussed below.

1.3.1 Project Information and Activity Review

An information requirements list was sent to SLR Consulting (South Africa) (Pty) Ltd at the onset of the project. In response to the request, the following information was supplied:

- Layout maps;
- Process descriptions;
- Annual throughputs (current activities); and
- Stack emissions data

Documentation reviewed included the following:

- Golder Associates Africa, 2019. South32: Hotazel Manganese Mines (Pty) Limited. Atmospheric Emissions Impact Report for Mamatwan Sinter Plant Application for Postponement of Compliance Timeframes.
- SLR Consulting, and. Mamatwan Mine – Integrated Regulatory Process.
- SOUTH32 Mamatwan Hotazel Manganese Mines (MMT): Mamatwan Sinter Plant Atmospheric Emission Licence (AEL), number NC/AEL/JTG/MAM01/2012 (Valid until 31 January 2025), issued by the Department of Environment and Nature Conservation;

- SOUTH32 Mamatwan Hotazel Manganese Mines (MMT): Mamatwan Sinter Plant Atmospheric Emission Licence (AEL), number NC/AEL/NDM/ZRH01/2014 (Valid until 01 January 2020), issued by the Department of Environment and Nature Conservation;
- SOUTH32 Mamatwan Mine, 2015. Mamatwan Mine Gemco Visit, 12 October 2015.
- SOUTH32 Mamatwan Mine, 2016. Mamatwan Mine Investor Site Tour, 26 September 2016.
- SOUTH32 Wessels & Mamatwan Mines, 2019. Project Raptor Pre-Feasibility Study, 3 October 2019.

1.3.2 The Identification of Regulatory Requirements and Health Thresholds

In the evaluation of ambient air quality impacts and dustfall rates reference was made to:

- South African National Ambient Air Quality Standards (NAAQS); and
- National Dust Control Regulations (NDCR) as set out in the National Environmental Management Air Quality Act (Act No. 39 of 2004) (NEMAQA).

In the evaluation of GHG emissions and climate change reference was made to:

- The National GHG Emissions Inventory;
- GHG Emissions Inventory for the Sector; and
- The 2017 Climate Change Reference Atlas (CCRA) as published by SAWS.

1.3.3 Study of the Receiving Environment

Air quality sensitive receptors generally include private residences, community buildings such as schools, hospitals and any publicly accessible areas outside an industrial facility's property.

As part of the air quality assessment, a good understanding of the regional climate and local dispersion potential of the site is necessary, as well as an understanding of existing sources of air pollution in the region and the current and potential future air quality. Physical environmental parameters that influence the dispersion of pollutants in the atmosphere include terrain, land cover and meteorology.

Mamatwan Mine does not have a weather station and use was made of the South African Weather Services (SAWS) Kuruman Weather Station (located approximately 43 km to the southwest of the mine). Data for the period 1 January 2016 – 31 December 2018 were used to (a) describe the dispersion potential of the site and (b) as input into the AERMOD modelling suite.

Dustfall results from the Mamatwan Mine monitoring network was analysed for the period January to December 2018, and January to December 2019. Measured emission concentrations from the most recent annual stack emissions monitoring campaigns (October 2017 to January 2018, and March 2019 to October 2019) were provided.

1.3.4 Determining the Impact of the Project on the Receiving Environment

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts from the project's emissions on the receiving environment. In the quantification of emissions, use was made of emission factors which associate the quantity of release of a pollutant to the activity. Emissions were calculated using emission factors and equations published by the United States Environmental Protection Agency (US EPA) and Environment Australia (EA) in their National Pollutant Inventory (NPI) Emission Estimation Technique Manuals (EETMs).

The impact of proposed operations on the atmospheric environment was determined through the simulation of ambient pollutant concentrations. As per the National Code of Practice for Air Dispersion Modelling use was made of the US EPA approved AERMOD atmospheric dispersion modelling suite for the simulation of ambient air pollutant concentrations and dustfall rates.

The dispersion model uses the specific input data to run various algorithms to estimate the dispersion of pollutants between the source and receptor. The model output is in the form of a simulated time-averaged concentration at the receptor. These simulated concentrations are added to suitable background concentrations and compared with the relevant ambient air quality standard or guideline.

Ground level concentration (GLC) isopleths plots presented in this report depict interpolated values from the concentrations simulated by AERMOD for each of the receptor grid points specified. Plots reflecting daily averaging periods contain only the 99.73th percentile of simulated ground level concentrations, for those averaging periods, over the entire period for which simulations were undertaken. It is therefore possible that even though a high daily average concentration is simulated at certain locations, this may only be true for one day during the period. Typically, NAAQS apply to areas where the Occupational Health and Safety regulations do not apply, thus outside the mine property or lease area. Ambient air quality guidelines and standards are therefore not occupational health indicators but applicable to areas where the general public has access i.e. off-site.

1.3.5 Compliance Assessment

The legislative and regulatory context, including emission limits and guidelines, ambient air quality guidelines and dustfall classifications were used to assess the impact and recommend additional emission controls, mitigation measures and air quality management plans to maintain the impact of air pollution to acceptable limits in the study area. The model results were analysed against the NAAQS and dustfall criteria.

1.3.6 Impact Significance

Potential impacts of the proposed project were identified based on the baseline data, project description, review of other studies for similar projects and professional experience. The significance of the impacts was assessed using the prescribed SLR impact rating methodology provided. The significance of an impact is defined as a combination of the consequence of the impact occurring and the probability that the impact will occur. The impact significance was rated for unmitigated operations and assuming the effective implementation of design mitigation measures.

1.3.7 The Development of an Air Quality Management Plan

The findings of the above components informed recommendations of air quality management measures, including mitigation and monitoring.

1.4 Limitations and Assumptions

The main assumptions, exclusions and limitations are summarized below:

- Meteorological data: no onsite meteorological data was available. Data from the South African Weather Services (SAWS) Kuruman Weather Station (located approximately 43 km to the southeast of the mine) was obtained for the period January 2016 – December 2018.
- Operational hours for the processing plant were provided as 7920 hours per year. Operational hours for mining activities were calculated from provided annual and hourly throughputs as 12 hours per day, 7 days a week. It was assumed that this information is correct.
- Emissions:
  - The quantification of sources of emission was for project activities only. Background sources were not included.
  - Information required for the calculation of emissions from fugitive dust sources for the facility's operations were provided in the form of run-of-mine (ROM), top-cut, overburden, and product tonnages.
  - Throughputs were provided for current activities only. Since no other information was available, it was assumed that project operations will have the same throughput as baseline operations.
  - Only routine emissions were estimated and modelled. This was done for the provided operational hours.
  - Gaseous emissions from vehicle exhaust and other auxiliary equipment were not quantified as the impacts from these sources are usually localized and unlikely to exceed health screening limits outside the project area. The main pollutant of concern from the operations at the study site is particulate matter and hence formed the focus of the study.
  - Particle size distribution for ROM, overburden, topsoil, discard and product material was based on information from similar mining processes.
  - Greenhouse gas emissions (GHG) were based on August 2020 to July 2021 information, and since the impact assessment assumed project operations to have the same throughput as baseline operations, GHG emissions were also assumed to remain similar to the period August 2020 to July 2021.
- Impact assessment:
  - Impacts due to two operational phases (baseline and project) were assessed quantitatively, whilst the construction, closure and decommissioning phases were assessed qualitatively due to the limited information available.

- The impact assessment was limited to airborne particulate (including TSP[3], PM_{10}[1] and $PM_{2.5}$[4]).
- There will always be some degree of uncertainty in any geophysical model, but it is desirable to structure the model in such a way to minimize the total error. A model represents the most likely outcome of an ensemble of experimental results. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model physics; the uncertainty due to data errors; and the uncertainty due to stochastic processes (turbulence) in the atmosphere. Nevertheless, dispersion modelling is generally accepted as a necessary and valuable tool in air quality management and typically provides a conservative prediction of emission concentrations.

[3] Total suspended particulates
[4] Particulate matter less than 2.5 µm in diameter

2 Regulatory Requirements and Impact Assessment Criteria

The last issued and approved EMP was in November 2005 (Reference number: NC 6/2/2/118). Subsequently, there have been additions and changes to the National Environmental Management: Air Quality Act (Act no.39 of 2004). The Act commenced with on 11 September 2005 as published in the Government Gazette on 9 September 2005 with sections omitted from the implementation (Sections 21, 22, 36 to 49, 51(1)(e),51(1)(f), 51(3), 60 and 61). The Act was fully implemented on 1 April 2010, including Section 21 on the Listed Activities and Minimum National Emission Standards (MES) with the revised MES published on 22 November 2013 (Government Gazette 37054, Notice No. 893). Amendments to the Act, primarily pertaining to administrative aspects, were published in 2014 (Government Gazette 37666, Notice No. 390 on 14 May 2014). Air quality legislation that came into play after 2005 that is relevant to the project is provided in Table 1.

Table 1: Legislation applicable to the project

Air Quality Legislation	Implementation/ revision dates	Reference	Affected Project Activity
National Framework	Updated Dec 2012	Government Gazette 37078, 29 Nov 2013	Industry legal responsibilities
Section 21 – Listed Activities	Implemented: 1 April 2010 Revised: 2013 Amendments: 2015	Government Gazette 37054, 22 Nov 2013 Government Gazette 38863, 12 Jun 2015	Sinter Plant
National Ambient Air Quality Standards (NAAQS)	24 December 2009 29 July 2012	Government Gazette 32816, 24 Dec 2009 Government Gazette 35463, 29 Jun 2012	PM_{10} and $PM_{2.5}$ ground level concentrations as a result of the mining activities
National Dust Control Regula**tions (NDCR)**	1 November 2013	Government Gazette 37054, 22 Nov 2013	Dust fallout rates as a result of the mining activities
National Atmospheric Emission Reporting Regulations **(NAERR)**	2 April 2015	Government Gazette 3863, 2 Apr 2015	Emissions reporting on mining operations Emissions reporting on Listed Activity
Regulation on Administrative Fines and Air quality offsets guideline	18 March 2016	Government Gazette 39833, 18 Mar 2016	Sinter Plant has a valid AEL until 31 March 2020
Declaration of Greenhouse Gases (GHG) as Priority Air Pollutants	Draft in 2016	Government Gazette 40996, 21 Jul 2017	N.A.[(a)]
National Pollution Prevention Plans (PPP) **Regulations**	Draft in 2016	Government Gazette 40996, 21 July 2017	N.A.[(a)]
National Greenhouse Gas (GHG) Emission Reporting Regulations	3 April 2017	Government Gazette 40762, 3 April 2017	Mining and quarrying to report on all stationary combustion emissions above 10 MW(th)

Notes: [(a)] only apply to direct emission of GHG in excess of 0.1 Megatonnes (Mt) annually measured as carbon dioxide equivalents (CO_2-eq)

2.1 National Framework

The National Framework (first published in Government Gazette Notice No. 30284 of 11 September 2007) was updated in 2013) and provides national norms and standards for air quality management to ensure compliance. The National Framework states that aside from the various spheres of government's responsibility towards good air quality, industry too has a responsibility not to impinge on everyone's right to air that is not harmful to health and well-being. Industries therefore should take reasonable measures to prevent such pollution order degradation from occurring, continuing or recurring.

In terms of AQA, certain industries have further responsibilities, including:

- Compliance with any relevant national standards for emissions from point, non-point or mobile sources in respect of substances or mixtures of substances identified by the Minister, MEC or municipality.
- Compliance with the measurement requirements of identified emissions from point, non-point or mobile sources and the form in which such measurements must be reported and the organs of state to whom such measurements must be reported.
- Compliance with relevant emission standards in respect of controlled emitters if an activity undertaken by the industry and/or an appliance used by the industry is identified as a controlled emitter.
- Compliance with any usage, manufacture or sale and/or emissions standards or prohibitions in respect of controlled fuels if such fuels are manufactured, sold or used by the industry.
- Comply with the Minister's requirement for the implementation of a pollution prevention plan in respect of a substance declared as a priority air pollutant.
- Comply with an Air Quality Officer's legal request to submit an atmospheric impact report in a prescribed form.
- Taking reasonable steps to prevent the emission of any offensive odour caused by any activity on their premises.
- Furthermore, industries identified as Listed Activities have further responsibilities, including:
- Making application for an AEL and complying with its provisions.
- Compliance with any minimum emission standards in respect of a substance or mixture of substances identified as resulting from a listed activity.
- Designate an Emission Control Officer **if** required to do so.
- Section 51 of the Air Quality Act lists possible offences according to the requirements of the Act with Section 52 providing for penalties in the case of offences.

2.2 Emission Standards

The NEMAQA (Act No. 39 of 2004 as amended) (DEA, 2005) mandates the Minister of Environment to publish a list of activities which result in atmospheric emissions and consequently cause significant detrimental effects on the environment, human health and social welfare. All scheduled processes as previously stipulated under the Air Pollution Prevention Act (APPA) (Dept of Labour, 1993) are included as listed activities with additional activities added to the list. The updated Listed Activities and Minimum National Emission Standards (MES) were published on the 22nd November 2013 (Government Gazette No. 37054). An amendment to this Act was published in June 2015.

Sinter Plants fall under Category 4: Metallurgical Industry, Sub-category 4.5: Sinter Plants. An Atmospheric Emission License (AEL) has been issued in March 2020 and is valid until 31 January 2025.

The Minimum Emission Standards (MES) as set out for the Sinter Plant operations are provided in Table 2. There are two sets of MES applicable to:

- *New Plants* (plant or process where the application in terms of NEMA was made on or after 1 April 2010); and
- *Existing Plants* (plant or process that was legally authorized to operate before 1 April 2010 or where an application in terms of NEMA was made before 1 April 2010).

Mamatwan Sinter Plant must comply with the New Plants standards[5].

Table 2: Applicable Listed Activity for Sinter Plant Operations

Category 4 - Metallurgical Industry; Subcategory 4.5 – Sinter Plants			
Description:	Sinter plants for the agglomeration of fine ore using heating process, including sinter cooling where applicable		
Application:	All installations		
Substance or Mixture of Substances		**Plant Status**	**mg/Nm³ under normal conditions of 6% O_2, 273 Kelvin and 101.3 kPa**
Common Name	**Chemical Symbol**		
Particulate matter	N/A	New	50
		Existing	100
Sulphur dioxide	SO_2	New	500
		Existing	1000
Oxides of nitrogen	NO_x expressed as NO_2	New	700
		Existing	1200

2.3 Ambient Air Quality Standards for Criteria Pollutants

The South African Bureau of Standards (SABS) assisted the Department of Environmental Affairs (DEA) in the development of ambient air quality standards. National Ambient Air Quality Standards (NAAQS) were determined based on international best practice for $PM_{2.5}$ PM_{10}, SO_2, NO_2, ozone (O_3), CO, lead (Pb) and benzene. The NAAQS were published in the Government Gazette (no. 32816) on 24 December 2009, thus after the 2009 EIA was competed. NAAQS for $PM_{2.5}$ was published on 29 July 2012. The NAAQS are listed in Table 3. The pollutants of concern for this assessment are provided in bold.

[5] All Listed Activities must comply with new plant standards by 1 April 2020

Table 3: South African National Ambient Air Quality Standards (Government Gazette 32816, 2009)

Substance	Molecular formula / notation	Averaging period	Concentration limit (µg m^{-3})	Frequency of exceedance[a]	Compliance date[b]
Sulfur dioxide	SO_2	10 minutes	500	526	Currently enforceable
		1 hour	350	88	Currently enforceable
		24 hours	125	4	Currently enforceable
		1 year	50	-	Currently enforceable
Nitrogen dioxide	NO_2	1 hour	200	88	Currently enforceable
		1 year	40	-	Currently enforceable
Particulate matter	PM_{10}	24 hours	75	4	Currently enforceable
		1 year	40	-	Currently enforceable
Fine particulate matter	$PM_{2.5}$	24 hours	40	4	1 Jan 2016 – 31 Dec 2029
			25		1 Jan 2030
		1 year	20	-	1 Jan 2016 – 31 Dec 2029
			15		1 Jan 2030
Ozone	O_3	8 hours (running)	120	11	Currently enforceable
Benzene	C_6H_6	1 year	5	-	Currently enforceable
Lead	Pb	1 year	0.5	-	Currently enforceable
Carbon monoxide	CO	1 hour	30 000	88	Currently enforceable
		8 hours (based on 1-hourly averages)	10 000	11	Currently enforceable

Notes: [a] The number of averaging periods where exceedance of limit is acceptable.

[b] Date after which concentration limits become enforceable.

2.4 National Dust Control Regulations

South Africa's Draft National Dust Control Regulations were published on the 27 May 2011 with the dust fallout standards passed and subsequently published on the 1st of November 2013 (Government Gazette No. 36974) with changes in regulations published in 2018 (Notice 517 GG 41650 of 25 May 2018). These are called the National Dust Control Regulations (NDCR). The purpose of the regulations is to prescribe general measures for the control of dust in all areas including residential and light commercial areas. SA NDCRs that were published on the 1st of November 2013. Acceptable dustfall rates according to the regulation are summarised in Table 4.

Table 4: Acceptable dustfall rates

Restriction areas	Dustfall rate (D) in mg/m^2-day over a 30 day average	Permitted frequency of exceedance
Residential areas	D < 600	Two within a year, not sequential months.
Non-residential areas	600 < D < 1 200	Two within a year, not sequential months.

The regulation also specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be American Standard Testing Method (ASTM, 1970)[6], or equivalent method approved by any internationally recognized body. It is important to note that dustfall is assessed for nuisance impact and not inhalation health impact.

2.5 National Atmospheric Emission Reporting Regulations (NAERR)

The National Atmospheric Emission Reporting Regulations (NAERR) was published on the 2nd of April 2015 by the Minister of Environmental Affairs. The regulation aims to standardize the reporting of data and information from an identified point, non-point and mobile sources of atmospheric emissions to an internet-based National Atmospheric Emissions Inventory System (NAEIS), towards the compilation of atmospheric emission inventories (DEA , 2015).

Annexure 1 of the NAERR classify **mines** (holders of a mining right or permit in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)) as a data provider under **Group C**. **Listed Activities** as published in terms of Section 21(1) of the AQA falls under **Group A**.

Sections of the regulation that applies to data providers are summarized below.

With regards to registration, the regulation stipulates that:

(a) A person classified as a data provider must register on the NAEIS within 30 days from the date upon which these Regulations came into effect;
(b) A person classified as a data provider and who commences with an activity or activities classified as emission source in terms of the regulation 4(1) after the commencement of these Regulations, must register on the NAEIS within 30 days after commencing with such an activity or activities.

With regards to reporting and record keeping, the regulation stipulates that:

(a) A data provider must submit the required information for the preceding calendar year, as specified in Annexure 1 to the Regulations, to the NAEIS by 31 March of each calendar year.
(b) A data provider must keep a record of the information submitted to the NAEIS for five years and such record must, on request, be made available for inspection by the relevant authority.

With regards to verification of information, the regulation requires data providers to verify requested information within 60 days after receiving the written request from the relevant authority.

[6] ASTM 1739:70 is a previous version of ASTM 1739 which did not prescribe a wind shield around the opening of the bucket; the addition of a wind shield is intended to deflect wind away from the lip of the container, allowing for a more laminar flow across the top of the collecting container (Kornelius *et al*., 2015). SANS 1929-2004 does however refer to ASTM 1739-98 (ASTM, 1998), which has a wind shield.

2.6 Greenhouse Gas Emissions

Greenhouse gases – CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 – have been declared priority pollutants under Section 29(1) of the Air Quality Act (Government Gazette 37421 of 14 March 2014). The declaration provides a list of sources and activities including (i) fuel combustion (both stationary and mobile), (ii) fugitive emission from fuels, (iii) industrial processes and other product use, (iv) agriculture; forestry and other land use and (v) waste management. GHGs in excess of 0.1 Megatons or more, measured as CO_2-e, is required to submit a pollution prevention plan to the Minister for approval.

Regulations pertaining to GHG reporting using the NAEIS was published on 3 April 2017 (Government Gazette 40762, Notice 275 of 2017). The South African mandatory reporting guidelines focus on the reporting of Scope 1 emissions only. The three broad scopes for estimating GHG are:

- Scope 1: All direct GHG emissions.
- Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.
- Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc.

The South African Greenhouse Gas Emission Reporting System (SAGERS) web-based monitoring and reporting system is used to collect GHG information in a standard format for comparison and analyses. The system forms part of the national atmospheric emission inventory component of South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP).

The DFFE is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the Intergovernmental Panel on Climate Change's (IPCC) default emission figures may be used to populate the SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. Technical guidelines for GHG emission estimation have been issued.

Also, the Carbon Tax Act (Act 15 of 2019) includes details on the imposition of a tax on the CO_2-e of GHG emissions. Certain production processes indicated in Annexure A of the Declaration of Greenhouse Gases as Priority Pollutants (GN 710 in GG 40966, 21 July 2017) with GHG in excess of 0.1 Mt, measured as CO_2-e, are required to submit a pollution prevention plan to the Minister for approval.

2.7 Screening Criteria for Animals and Vegetation

Limited information is available on the impact of dust on vegetation and grazing quality. While there is little direct evidence of the impact of dustfall on vegetation in the South African context, a review of European studies has shown the potential for reduced growth and photosynthetic activity in sunflower and cotton plants exposed to dustfall rates greater than 400 mg/m²/day (Farmer, 1993). In addition, there is anecdotal evidence to indicate that over extended periods, high dustfall levels in grazing lands can soil vegetation and this can impact the teeth of livestock (Farmer, 1993).

2.8 Regulations regarding Air Dispersion Modelling

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to assess compliance with the relevant ambient air quality standards. Regulations regarding Air Dispersion Modelling were promulgated in Government Gazette No. 37804 vol. 589; 11 July 2014, (DEA, 2014) and recommend a suite of dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. The Regulations regarding Air Dispersion Modelling are applicable –

a) in the development of an air quality management plan, as contemplated in Chapter 3 of the NEMAQA;
b) in the development of a priority area air quality management plan, as contemplated in section 19 of the NEMAQA;
c) in the development of an atmospheric impact report, as contemplated in section 30 of the NEMAQA; and,
d) in the development of a specialist air quality impact assessment study, as contemplated in Chapter 5 of the NEMAQA.

The Regulations have been applied to the development of this report. The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise and thereby gives clear direction to the choice of the dispersion model most suited for the purpose. Chapter 2 of the Regulations present the typical levels of assessments, technical summaries of the prescribed models (SCREEN3, AERSCREEN, AERMOD, SCIPUFF, and CALPUFF) and good practice steps to be taken for modelling applications. The project falls under a Level 2 assessment – which is described as follows:

- The distribution of pollutant concentrations and deposition are required in time and space.
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. The model specifically to be used in the air quality impact assessment of the proposed operation is AERMOD.
- Emissions are from sources where the greatest impacts are in the order of a few kilometers (less than 50 km) downwind)

Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Chapter 3 of the Regulation prescribe the source data input to be used in the model. Dispersion models are particularly useful under circumstances where the maximum ambient concentration approaches the ambient air quality limit value and provide a means for establishing the preferred combination of mitigation measures that may be required.

Chapter 4 of the Regulations prescribe meteorological data input from onsite observations to simulated meteorological data. The chapter also gives information on how missing data and calm conditions are to be treated in modelling applications. Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determining the diluting effect of the atmosphere.

Topography is also an important geophysical parameter. The presence of terrain can lead to significantly higher ambient concentrations than would occur in the absence of the terrain feature. In particular, where there is a significant relative difference in elevation between the source and off-site receptors large ground level concentrations can result.

The modelling domain would normally be decided on the expected zone of influence; the extent being defined by simulated ground level concentrations from initial model runs. The modelling domain must include all areas where the ground level concentration is significant when compared to the air quality limit value (or other guideline). Air dispersion models require a receptor grid at which ground-level concentrations can be calculated. The receptor grid size should include the entire modelling domain to ensure that the maximum ground-level concentration is captured and the grid resolution (distance between grid points) sufficiently small to ensure that areas of maximum impact adequately covered. No receptors should however be located within the property line as health and safety legislation (rather than ambient air quality standards) is applicable within the site.

Chapter 5 provides general guidance on geophysical data, model domain and coordinates system requirements, whereas Chapter 6 elaborates more on these parameters as well as the inclusion of background air pollutant concentration data. Chapter 6 also provides guidance on the treatment of NO_2 formation from NOx emissions, chemical transformation of SO_2 into sulphates and deposition processes.

Chapter 7 of the Regulation outlines how the plan of study and modelling assessment reports are to be presented to authorities.

3 Description of the Receiving Environment

This chapter provides details of the receiving environment which is described in terms of:

- The identification of Air Quality Sensitive Receptors (AQSRs) from available maps and Google Earth imagery;
- A study of the atmospheric dispersion potential of the area taking into consideration local meteorology, land-use and topography;
- The identification of existing sources of emissions in the study area; and
- The analysis of all available ambient air quality information/data to determine pre-development ambient pollutant levels and dustfall rates.

3.1 Receiving Environment

AQSRs primarily refer to places where people reside; however, it may also refer to other sensitive environments that may adversely be affected by air pollutants. Ambient air quality guidelines and standards, as discussed under Section 2.2, have been developed to protect human health. Ambient air quality, in contrast to occupation exposure, pertains to areas outside of an industrial site/mine boundary where the public has access to and according to the NEMAQA, excludes areas regulated under the Occupational Health and Safety Act (Act No 85 of 1993) (Dept of Labour, 1993).

Mamatwan Mine is adjacent to the R380 road and railway (Figure 2). The Tshipi Borwa Manganese Mine is located immediately to the west of Mamatwan Mine. The mine is surrounded by farmland used for grazing. Air quality sensitive receptors (AQSRs) in the vicinity of the mine include a farmhouse (N Fourie) 4.2 km southwest of the sinter plant, a farmhouse (M Kruger) 1.8 km southeast of the sinter plant and the Operations and Management Offices for the Solar PV Plant located approximately 1.3 km to the east of the nearest mine boundary. Receptors that are further afield include a farmhouse (D van den Berg) located 3.2 km to the southwest of the mine boundary, farmworkers housing approximately 4 km to the northwest of the central pit and a farmhouse (A Pyper) located 4.7 km to the west of the central pit.

Table 5: Nearest AQSRs in the vicinity of the mine

ID	Description
AQSR1	Farmstead (A Pyper)
AQSR2	Farmstead (Farm workers)
AQSR3	Farmstead (D van den Bergh)
AQSR4	Farmstead (N Fourie)
AQSR5	Farmstead (M Kruger)
AQSR6	Operations and Management Offices for the Solar PV Plant

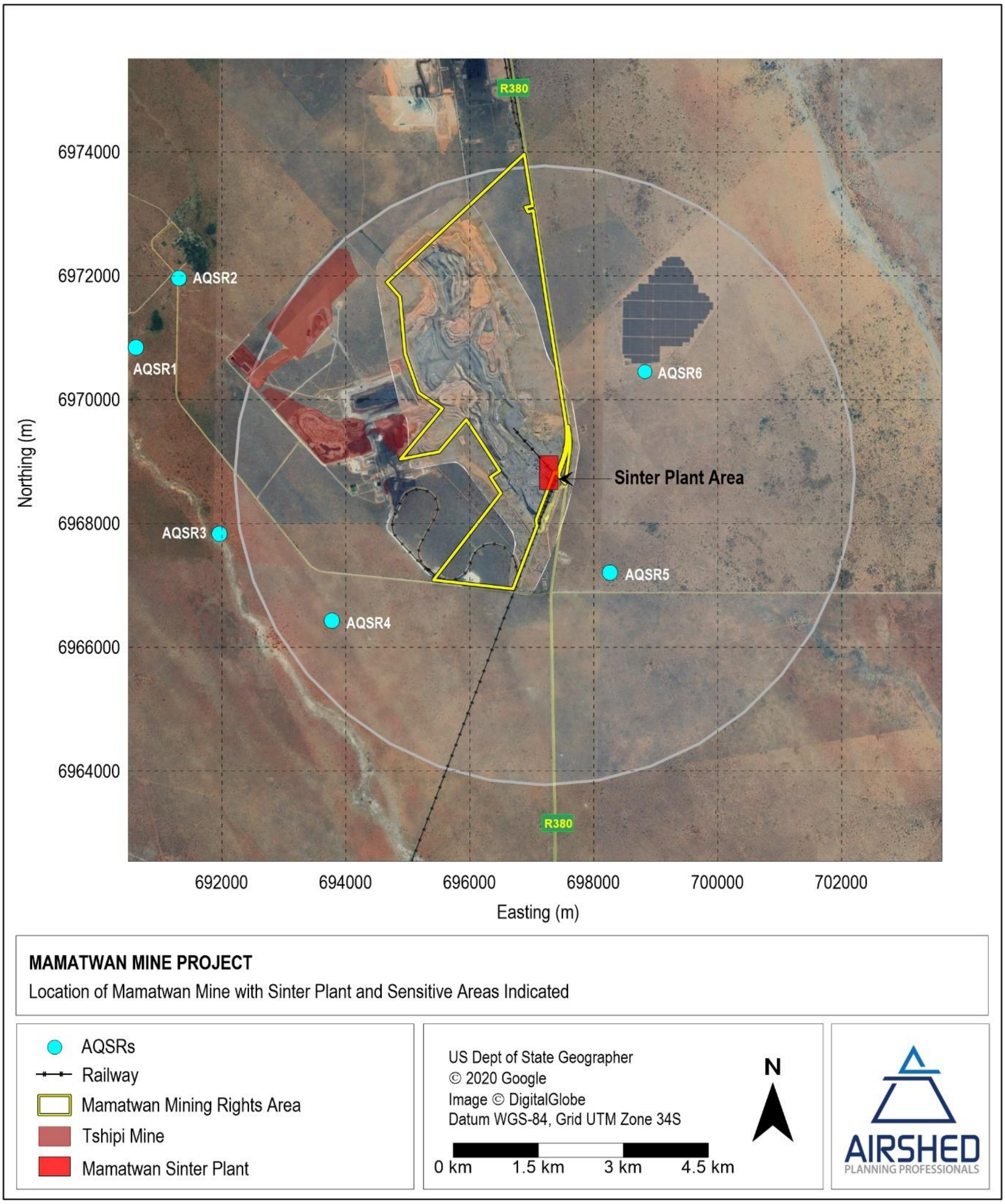

Figure 2: Location of Mamatwan Mine and sinter plant with AQSRs within a 5km radius indicated

3.2 Atmospheric Dispersion Potential

Physical and meteorological mechanisms govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere. The analysis of hourly average meteorological data is necessary to facilitate a comprehensive understanding of the dispersion potential of the site. Parameters useful in describing the dispersion and dilution potential of the site i.e. wind speed, wind direction, temperature and atmospheric stability, are subsequently discussed.

Mamatwan Mine does not have a weather station and use was made of the South African Weather Services (SAWS) Kuruman Weather Station (located approximately 43 km to the southeast of the mine). Data for the period 1 January 2016 – 31 December 2018 was obtained for inclusion in the report. The data availability varied slightly between the years with good data availability of 99%, 99% and 95% for 2016, 2017 and 2018, respectively.

3.2.1 Surface Wind Field

The wind field determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is a function of the wind speed, in combination with the surface roughness. The wind field for the study area is described with the use of wind roses. Wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the yellow area, for example, representing winds in between 4 and 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. Calm conditions are periods when the wind speed was below 1 m/s. These low values can be due to “meteorological” calm conditions when there is no air movement; or, when there may be wind, but it is below the anemometer starting threshold.

The annual average wind roses for the years 2016, 2017 and 2018 are shown in Figure 3 with the period average wind field (2016-2018) and diurnal variability in the wind field provided in Figure 4. The predominant wind direction is from the south-southeast. Winds occur less frequently from the easterly sector.

As shown in Figure 4, during the day winds are more frequent from the westerly and the northerly sectors. The wind during the night-time is predominantly from the south-southeast. Day-time calms occurred for 8% of the time, with night-time calms for 28% of the time.

The prevailing wind field is similar to the data used in the 2009 study (Krause & Liebenberg-Enslin, 2009), with a slight shift in the overall wind field from south-east and south-southeast (2001-2005 data) to the south-southeast and south (2016-2018). Similarly, the 2001-2005 Kuruman data had more prevalent north-westerly winds with a shift to more westerly winds in the later dataset.

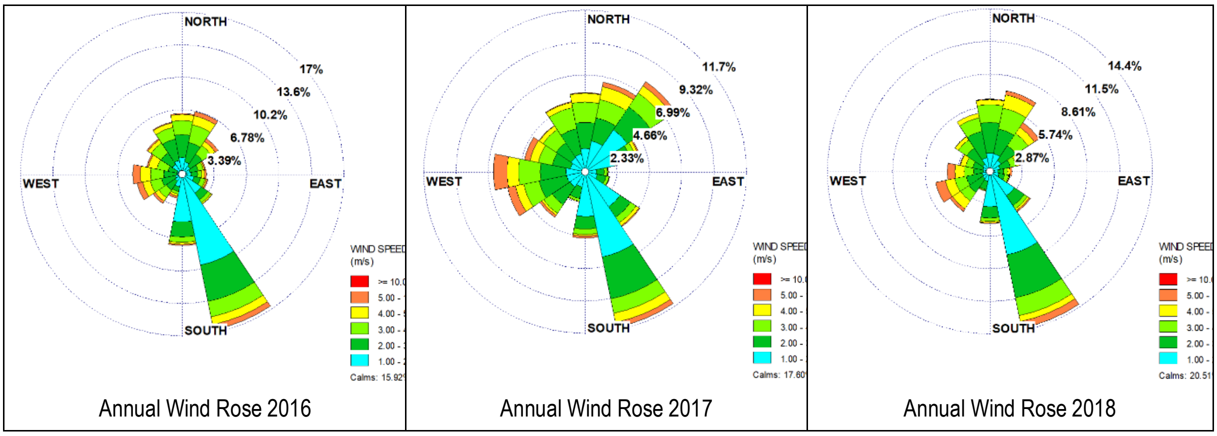

Figure 3: Annual wind roses (SAWS Kuruman data; 2016, 2017 and 2018)

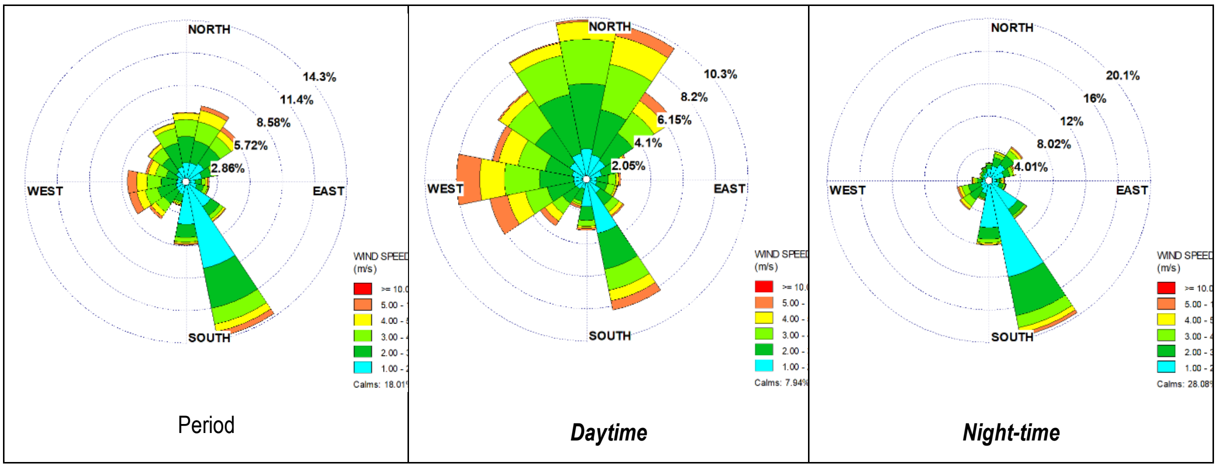

Figure 4: Period, daytime and night-time wind roses (SAWS Kuruman data; 2016 to 2018)

According to the Beaufort wind force scale (https://www.metoffice.gov.uk/guide/weather/marine/beaufort-scale), wind speeds between 6-8 m/s equates to a moderate breeze, with wind speeds between 14-17 m/s near gale force winds. Based on the three years of SAWS data, wind speeds exceeding 6 m/s occurred for only 1% of the time, with a maximum wind speed of 10 m/s. The average wind speed over the three years was 2.04 m/s. Calm conditions (wind speeds < 1 m/s) occurred for 18% of the time (Figure 5). The US EPA indicates a friction velocity of 5.4 m/s to initiate erosion from a coal storage piles (US EPA, 2006) and (Mian & Yanful, 2003). Thus, the likelihood exists for wind erosion to occur from open and exposed surfaces, with loose fine material, when the wind speed exceeds at least 5.4 m/s. Wind speeds exceeding 5.4 m/s occurred only for 2% over the three years (2016 -2018).

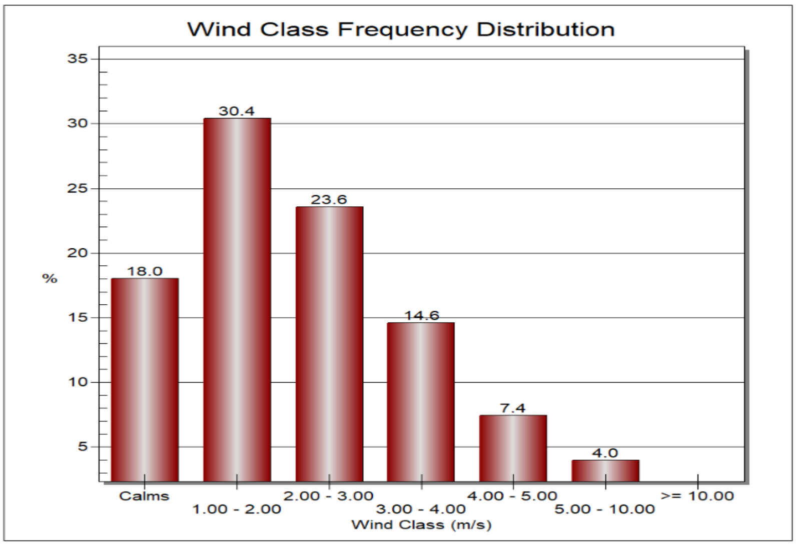

Figure 5: Wind speed categories (SAWS Kuruman data; 2016 to 2018)

3.2.2 Ambient Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher a pollution plume is able to rise and determining the development of the mixing and inversion layers). The monthly temperature pattern is provided in Table 6. The area experiences hot temperatures during summer, with maximum of 42.6°C for the month of January. Winter temperatures are relatively low especially in the months of June to August. Maximum temperatures range between 42.6°C in January to 25°C in June, with minima between -5.3°C in July to 10.9°C in February.

Table 6: Minimum, average and maximum temperatures (SAWS Kuruman data; 2016 to 2018)

	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Min	10.7	10.9	6.4	5	1.2	-2.3	-5.3	-4.4	-2.7	2.7	4.3	9.6
Ave	25.1	24.0	21.8	18.0	13.2	10.7	10.5	12.8	17.7	20.6	23.7	25.9
Max	42.6	38.4	35.6	35.3	26.5	25	27.1	30.5	34.5	38.5	39.5	38.7

3.2.3 Atmospheric Stability and Mixing Depth

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. This layer is directly affected by the earth's surface, either through the retardation of flow due to the frictional drag of the earth's surface, or as result of the heat and moisture exchanges that take place at the surface. During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated inversion. The radiative flux divergence during the night usually results in the establishment of ground-based inversions and the erosion of the mixing layer. The night times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds, hence less dilution potential.

The mixed layer ranges in depth from a few metres (i.e. stable or neutral layers) during night times, to the base of the lowest-level elevated inversion during unstable, daytime conditions. Elevated inversions may occur for a variety of reasons and on some occasions as many as five may occur in the first 1000 m above the surface.

Atmospheric stability is frequently categorised into one of six stability classes – these are briefly described in Table 7 with the percentage time each class occurred at the study site. The most commonly occurring stability class calculated for Kuruman is Class C and F, representing Unstable and Very Stable conditions respectively. Diurnal variation in atmospheric stability described by the inverse Monin-Obukhov length and the mixing height is provided in Figure 6. For elevated releases (e.g. from the plant stack), the highest ground level concentrations would occur during unstable, daytime conditions, which relates to 22% of the time at the study site. For low level releases, such as vehicle and materials handling activities, the highest ground level concentrations would occur during weak wind speeds and stable (night-time) atmospheric conditions, which relates to 49% of the time at the study site. Windblown dust is likely to occur under high winds (neutral conditions) but is not relevant in this case (frequency of occurrence 0%), which relates to 3% of the time at the study site.

Table 7: Atmospheric stability classes

Designation	Stability Class	Atmospheric Condition	Frequency of occurrence
A	Very unstable	calm wind, clear skies, hot daytime conditions	7%
B	Moderately unstable	clear skies, daytime conditions	19%
C	Unstable	moderate wind, slightly overcast daytime conditions	22%
D	Neutral	high winds or cloudy days and nights	3%
E	Stable	moderate wind, slightly overcast night-time conditions	5%
F	Very stable	low winds, clear skies, cold night-time conditions	44%

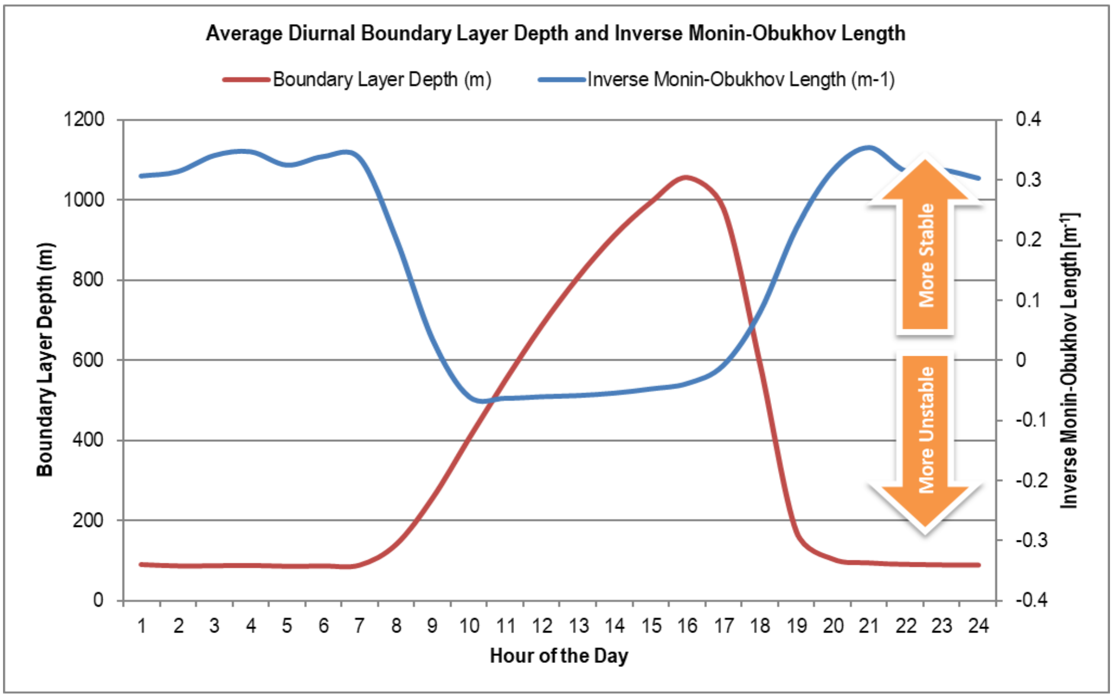

Figure 6: Diurnal atmospheric stability graph for Kuruman (January 2016 – December 2018).

3.3 Existing Sources of Emissions near the Project Site

Mining activities, farming and residential land-uses occur in the region. These land-uses contribute to baseline pollutant concentrations via vehicle tailpipe emissions, household fuel combustion, biomass burning and various fugitive dust sources. Long-range transport of particulates, emitted from remote tall stacks and from large-scale biomass burning in countries to the north of South Africa, has been found to contribute to background fine particulate concentrations within the South African boundary (Andreae, et al., 1996; Garstang, Tyson, Swap, & Edwards, 1996; Piketh, Annegarn, & Kneen, 1996).

3.3.1 Mining Operations

Fugitive emissions from opencast and underground mining operations mainly comprise of land clearing operations (i.e. scraping, dozing and excavating), materials handling operations (i.e. tipping, off-loading and loading, conveyor transfer points), vehicle entrainment from haul roads, wind erosion from open areas, drilling and blasting. These activities mainly result in particulates and dust emissions, with small amounts of oxides of nitrogen (NO_x), carbon monoxide (CO), SO_2, methane and CO_2 being released during blasting operations. Operating mines include the neighbouring Tshipi Borwa Manganese Mine and United Manganese of Kalahari (UMK) Mine approximately 2 km to the north. UMK also has onsite sintering (Krause & Liebenberg-Enslin, 2009). Other large opencast mines in the area include Wessels Mine and Sishen Iron Ore Mine, respectively located 30 km to the north-northwest and 33 km to the south of Mamatwan Mine. Closed or dormant mines include Middelplaats, Adams, Smartt and Perth.

3.3.2 Agricultural operations

Agriculture is a land-use within the area surrounding the site. Particulate matter is the main pollutant of concern from agricultural activities deriving from windblown dust, biomass burning, and dust entrainment as a result of vehicles travelling along dirt roads. The quantity of windblown dust is a function of the wind speed, the extent of exposed areas and the moisture and silt content of such areas.

The major agricultural activities in the region comprise low density commercial farming of goats, sheep, cattle and game farms. These types of agricultural activities are not likely to have a significant influence on the air quality in the area. Seasonal wildfires during the winter period may result in increased particulate emissions.

3.3.3 Unpaved Roads

Vehicle entrained dust emissions from paved and unpaved roads represent a potentially significant source of fugitive dust in the area surrounding MMT. Unpaved roads include industrial, mine, local farming and township access roads (Golder Associates Africa, 2019). The extent of particulate emissions from the main roads will depend on the number of vehicles using the roads and the silt loading on the roadways. The extent, nature and duration of road-use activity and the moisture and silt content of soils are required to be known in order to quantify fugitive emissions from this source.

Vehicle entrained dust emissions from paved and unpaved roads represent a potentially significant source of fugitive dust in the region. Identified sources of fugitive road dust emissions include unpaved: industrial; mine; local farming; and township access roads. Vehicle entrainments of particulates from unpaved access and haul roads are anticipated to be one of the dominant emissions from MMT.

3.3.4 Vehicle Tailpipe Emissions

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. Notable primary pollutants emitted by vehicles include CO_2, CO, hydrocarbons (HCs), SO_2, NO_x, DPM and Pb. Secondary pollutants include: NO_2, photochemical oxidants (e.g. ozone), HCs, sulphur acid, sulphates, nitric acid, nitric acid and nitrate aerosols. Hydrocarbons emitted include benzene, 1.2-butadiene, aldehydes and polycyclic aromatic hydrocarbons (PAH). Benzene represents an aromatic HC present in petrol, with 85% to 90% of benzene emissions emanating from the exhaust and the remainder from evaporative losses. Vehicle tailpipe emissions are localised sources and unlikely to impact far-field.

Both small and heavy private and industrial vehicles travelling along the R31 (public) road as well as the unpaved R380 (public) and private roads, are notable sources of vehicle tailpipe emissions.

3.3.5 Household Fuel Burning

Domestic households are known to have the potential to be one the most significant sources that contribute to poor air quality within residential areas. Pollutants arising from the combustion of wood include respirable particulates, CO and SO_2 with trace amounts of polycyclic aromatic hydrocarbons (PAHs), in particular benzo(a)pyrene and formaldehyde. Particulate emissions from wood burning have been found to contain about 50% elemental carbon and about 50% condensed hydrocarbons.

Coal burning emits a large amount of gaseous and particulate pollutants including SO_2, heavy metals, PM including heavy metals and inorganic ash, CO, PAHs (recognized carcinogens), NO_2 and various toxins. The main pollutants emitted from the combustion of paraffin are NO_2, particulates, CO and PAHs.

It is likely that households within the local communities or settlements utilize coal, paraffin and/or wood for cooking and/or space heating (mainly during winter) purposes. The contribution of household fuel burning to the ambient air quality in the area is not likely to be significant however, due to the relatively low density of housing and their widely spread-out nature in the region.

3.4 Baseline Air Quality

Particulates represent the main pollutant of concern in the assessment of mining operations. The particulates in the atmosphere may contribute to visibility reduction, pose a threat to human health, or simply be a nuisance due to their soiling potential.

3.4.1 Air Quality Monitoring Data

3.4.1.1 Monitored Ambient Concentrations

MMT does not undertake ambient air quality monitoring of PM_{10} concentration levels and thus the baseline concentration levels are yet to be established for the site. MMT only undertakes dust fallout monitoring which monitors Total Suspended Particulates (TSP) in the form of nuisance dust.

3.4.1.2 Dustfall Monitoring network

A dustfall monitoring network is in place at Mamatwan Mine, comprising of eight (8) single dustfall units (one has been decommissioned) and three (3) directional dustfall units. Since the NDCRs are based on single dustfall units following the ASTM D1739 method, the directional units cannot be compared to the NDCR limits. Dustfall results for the single units for the period January to December 2018, and January to December 2019 are provided in Table 8 and Table 9. The dustfall locations are shown in Figure 7.

The dustfall over the year 2018 was low and well below the NDCR for residential (600 mg/m²/day) and non-residential areas (1 200 mg/m²/day). The highest dustfall rates were recorded at MMT07 for most of the months. The annual average ranged between 48 mg/m²/day (MMT05) to 151 mg/m²/day (MMT07).

Dustfall over the year 2019 was below the NDCR for residential (600 mg/m²/day) areas at all dustfall units apart from MMT01 (December 2019) and was well below the NDCR for non-residential (1 200 mg/m²/day) areas at all dustfall units. The highest dustfall rates were recorded at MMT01 for most of the months. The annual average ranged between 60 mg/m²/day (MMT8) to 255 mg/m²/day (MMT01).

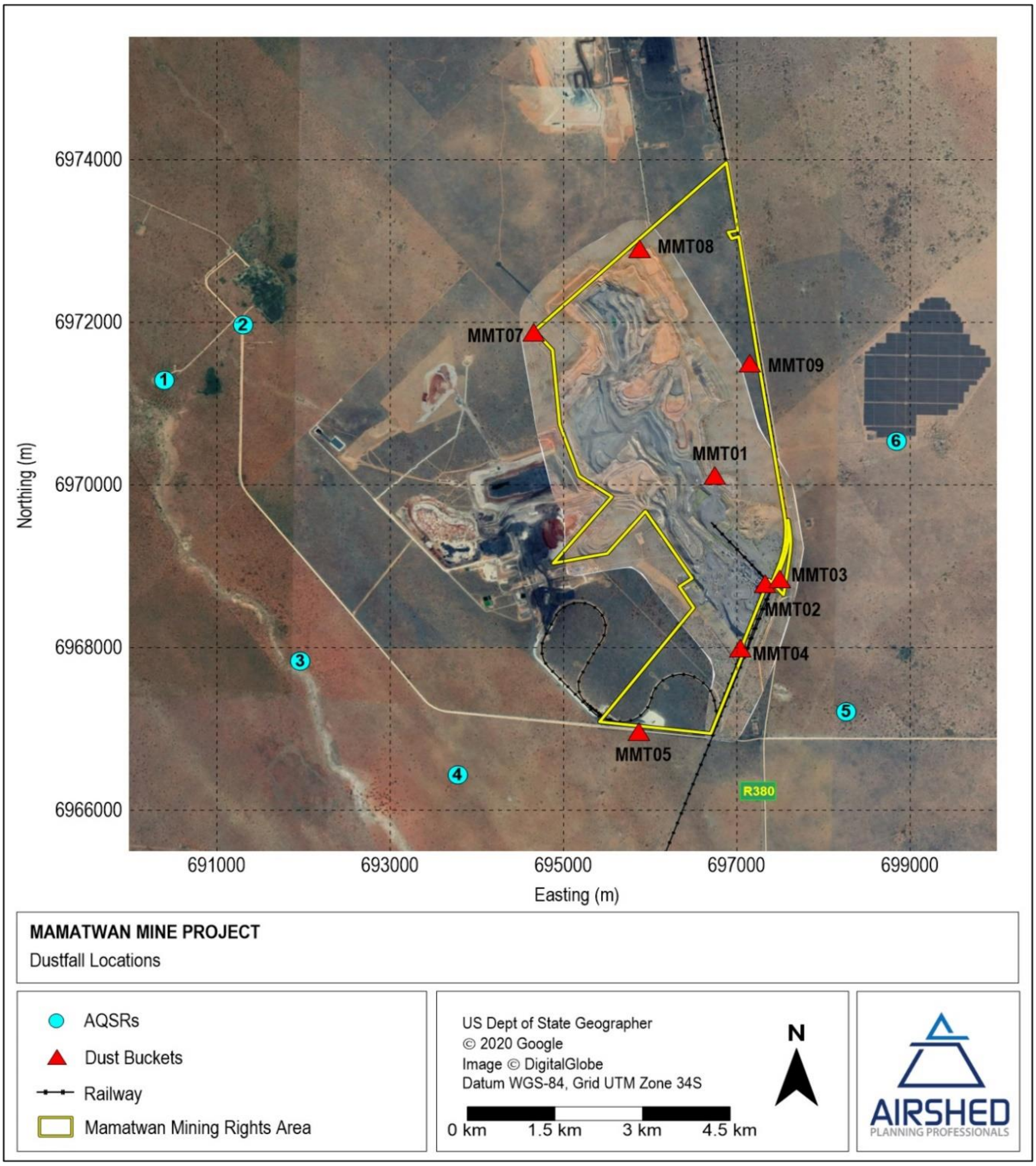

Figure 7: Monitoring network at Mamatwan Mine

Table 8: Dustfall rates from the single dustfall units at Mamatwan Mine (2018)

	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18[(a)]	Aug-18	Sep-18[(a)]	Oct-18[(b)]	Nov-18	Dec-18[(a)]
MMT01	180	150	26	94	111	126	196	ND	27	124	ND	108
MMT02	128	127	54	39	44	56	57	ND	45	80	80	123
MMT03	87	74	57	89	60	84	147	ND	134	118	67	207
MMT04	63	52	19	84	119	39	35	ND	50	124	33	30
MMT05	131	38	18	16	33	8	67	ND	59	81	45	32
MMT06	Decommissioned											
MMT07	252	241	109	97	228	147	75	ND	101	201	173	38
MMT08	153	68	47	118	212	90	49	ND	58	62	58	57
MMT09	58	97	41	51	74	24	214	ND	69	136	82	175

Notes: [(a)] Samples were over exposed (more than the allowable 30(±2) days
[(b)] Samples were under exposed (less than the allowable 30(±2) days
ND – No Data

Table 9: Dustfall rates from the single dustfall units at Mamatwan Mine (2019)

	Jan-19[(b)]	Feb-19[(b)]	Mar-19	Apr-19[(a)]	May-19	Jun-19	Jul-19[(a)]	Aug-19[(a)]	Sep-19[(a)]	Oct-19	Nov-19	Dec-19[(a)]
MMT01	98	49	205	89	248	95	271	464	162	196	339	843
MMT02	51	ND	233	102	126	87	107	223	135	166	188	144
MMT03	87	68	124	47	18	39	71	143	76	ND	119	98
MMT04	40	111	76	20	149	84	98	109	64	21	90	47
MMT05	63	137	108	29	169	76	92	164	51	61	170	76
MMT06	Decommissioned											
MMT07	86	85	119	60	119	34	83	220	38	99	122	38
MMT08	102	79	89	32	73	16	46	58	56	48	52	66
MMT09	94	80	ND	87	88	76	117	146	ND	65	124	35

Notes: [(a)] Samples were over exposed (more than the allowable 30(±2) days
[(b)] Samples were under exposed (less than the allowable 30(±2) days
ND – No Data

To assess or identify trends in dustfall rates, box-and-whisker plots of on-site dustfall rates samples for the calendar year 2018 and 2019 are included in Figure 8 and Figure 9. A box-and-whisker plot shows the median, the upper quartile (25% of data greater than the median), lower quartile (25% of data less than the median), and the minimum and maximum values.

Dustfall rates for 2018 varied throughout the year with the highest rates collected during the summer months (Jan, Feb and Dec) as well as during May and July. For 2019 the highest rates were recorded during the months of August and December. There is no clear seasonal trend, which indicates varying operations at and around the mine.

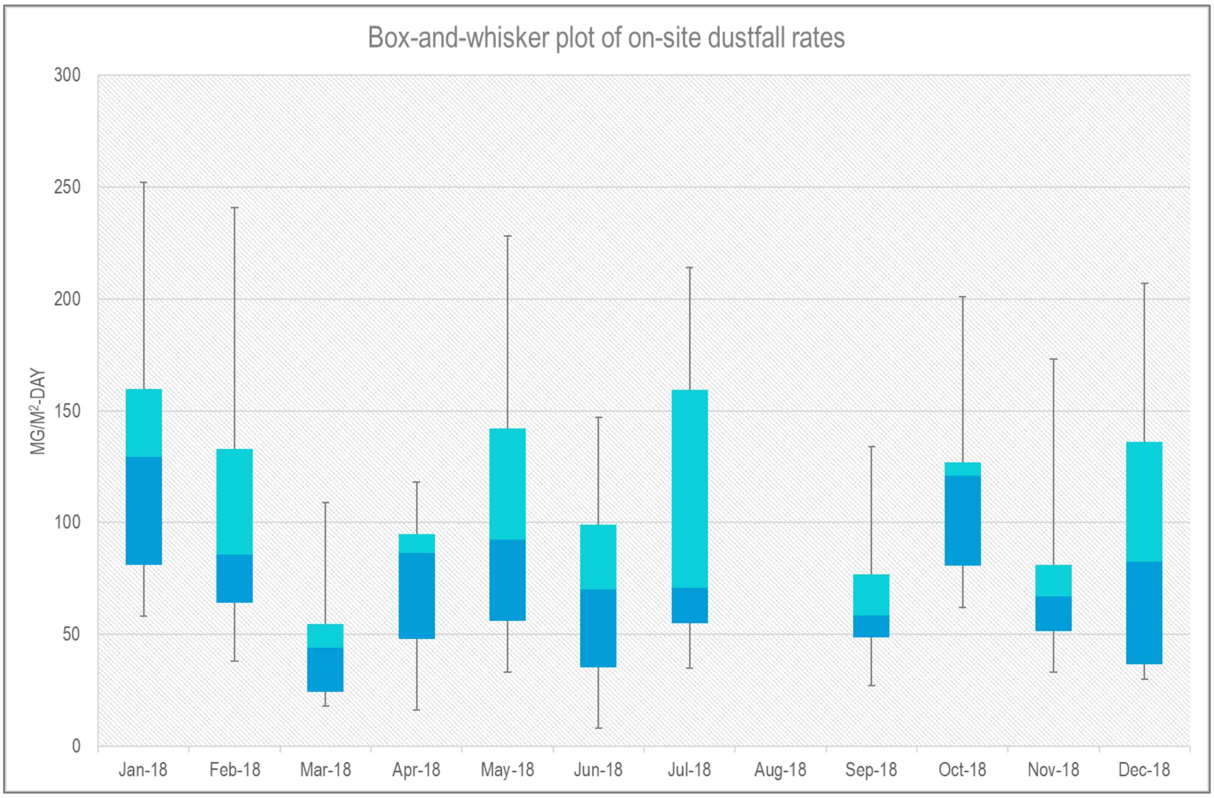

Figure 8: Box-and-whisker plot of on-site dustfall for the year 2018

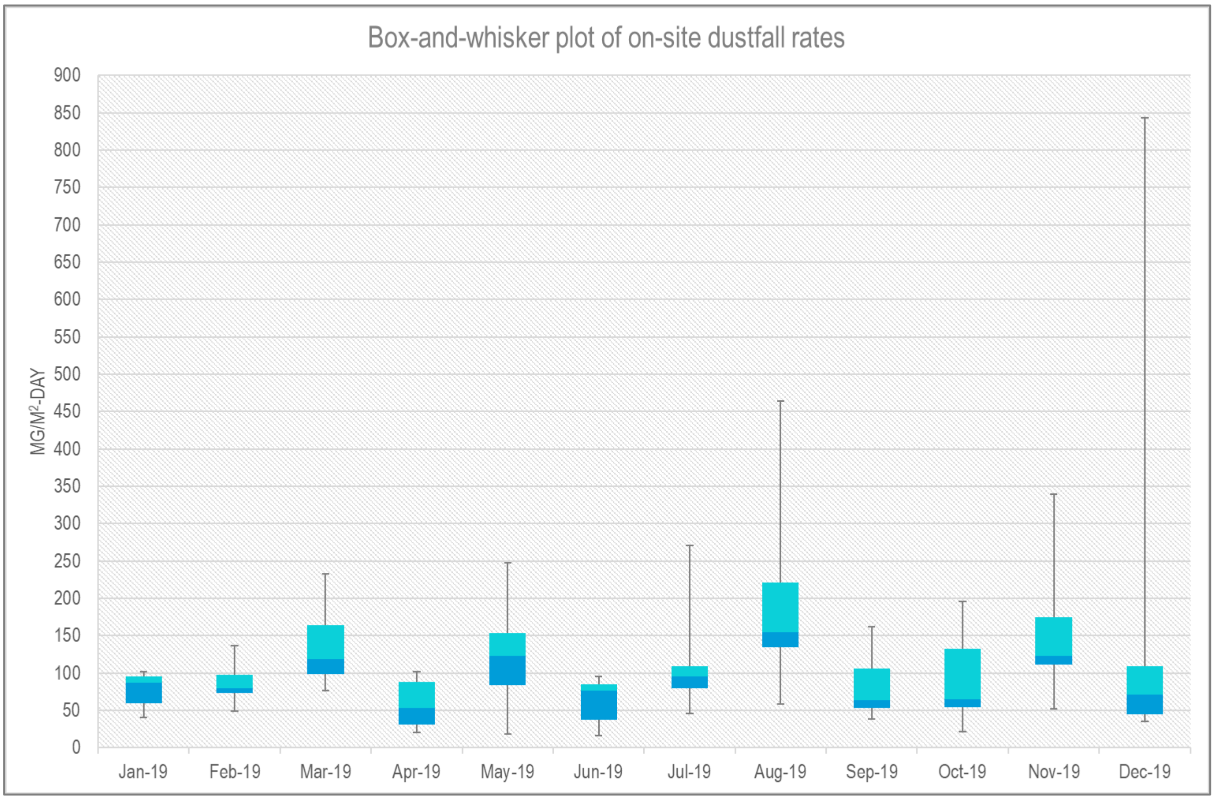

Figure 9: Box-and-whisker plot of on-site dustfall for the year 2019

3.4.1.3 Annual Emissions Monitoring

MMT is classified as a Subcategory 4.6 (Sinter Plants) listed activity in terms of Section 21 of the NEM: AQA. As part of the plant's Environmental Authorisation and as a condition of its Atmospheric Emission Licence (AEL), the facility is required to undertake annual stack emission testing for: PM, SO_2 and NO_x.

The most recent annual emissions monitoring campaigns are:

- October 2017 to January 2018; and
- March 2019 to November 2019.

All emissions monitoring campaigns were undertaken during normal operating conditions and in accordance with Government Notice 893 of 22 November 2013 (commonly known as the Minimum Emission Standards).

Emissions monitoring results

Table 10 contains a list of all the measured emission concentrations from the monitored sources at the facility, in addition to the relevant emissions limits and an indication of whether there was compliance with the standards for Existing and New plants as required under the NEM: AQA.

Based on the monitoring data (2017 and 2019), it is clear that MMT faces a significant challenge regarding meeting the new plant emission limit for PM_{10} by 1 April 2020 as several of the sources display year on year exceedances well above the 50 mg/Nm^3 limit value hence the need for this postponement application.

Note: An exceedance was noted in the NO_x concentration levels of the Sinter waste gas stack in 2016 however the monitored concentrations were ten orders of magnitude lower in 2017. The 2016 NO_x concentration may be related to an upset condition leading to higher than normal NO_x concentration levels in the stack during the monitoring.

Table 10: Annual emissions monitoring and compliance with set emissions limits

Chemical symbol	Plant status	Emission limit	2017**								2019***							
			SWS		De-dust1		De-dust2		De-dust3		SWS		De-dust1		De-dust2		De-dust3	
			Emission average (mg/Nm[3])	Compliance	Emission average (mg/Nm[3])	Compliance	Emission average (mg/Nm[3])	Compliance	Emission average (mg/Nm[3])	Compliance	Emission average (mg/Nm[3])	Compliance	Emission average (mg/Nm[3])	Compliance	Emission average (mg/Nm[3])	Compliance	Emission average (mg/Nm[3])	Compliance
PM_{10}	New	50	69.92	N	67.06	N	1.57	Y	1.28	Y	33.69	Y	38.45	Y	95.6	N	2.44	Y
	Existing	100		Y		Y		Y		Y		Y		Y		Y		Y
SO_2	New	500	275.3	Y	BDL	Y	BDL	Y	1.16	Y	593.4	N	0.57	Y	15.67	Y	BDL	Y
	Existing	1000		Y		Y		Y		Y		Y		Y		Y		Y
NO_x expresses as NO_2	New	700	228.9	Y	15.46	Y	35.24	Y	BDL	Y	317.3	Y	BDL	Y	0.53	Y	BDL	Y
	Existing	1200		Y		Y		Y		Y		Y		Y		Y		Y

Note: * mg/Nm^3 under normal conditions of 273 Kelvin and 101.3 kPa

** Sampling conducted between October 2017 to January 2018

*** Sampling conducted between March 2019 to November 2019

BDL: Below detection level of method

4 Impact Assessment

The emissions inventory, dispersion modelling and results are discussed in Section 4.2 and Section 4.3 respectively.

4.1 Project Description

4.1.1 Current Mining and Process Description

The MMT site layout is shown in Figure 10. The MMT mining, beneficiation and sintering processes are depicted in a flow diagram in Figure 11. The following project description was made available:

- Stripping and stockpiling of topsoil and waste rock
  - MMT is a conventional opencast operation in that topsoil and waste rock is removed to uncover the manganese ore body using truck and shovel methods.
  - Topsoil is transported via truck to designated topsoil stockpile areas for later use as part of rehabilitation.
  - Waste rock is stripped and transported to one of the designated WRDs at the MMT. Waste rock is either backfilled into the open pit or used to flatten the slopes of existing dumps.
  - Designated WRDs are shown in Figure 10.
- Access to opencast workings
  - Ore is drilled, blasted and hauled using front end loaders and shovels to the "in-pit" primary crusher. Crushed ore is conveyed to a product stockpile area (ROM stockpile) near the mineral processing plant. Excess ore is stored and crushed as required.
- In-pit crushing and screening
  - Oversize ore is crushed using an “in-pit” jaw crusher to reduce the size of the ore for further downstream processes. The crushed ore is conveyed to a designated Run of Mine (ROM) stockpile area.
- Crushing, screening and washing (ore processing)
  - Ore from the ROM stockpile is conveyed to two parallel circuits comprising scalping screens, cone crushers and double-deck sizing screens and a horizontal dewatering screen at the processing plant.
  - Lumpy material (– 75 +6 MM) from the processing plant is stockpiled in marked allocated lumpy product stockpile area (Gantry 7) prior to being sent to the load out station using front end loaders. The product is conveyed to railway trucks via the load out section for sale to third parties.
  - Slimes material from the processing plant is sent to the tailings dam for disposal.
- DMS processing
  - The natural Mamatwan ore ideally lends itself to upgrading by technologically advanced beneficiation processes. In this regard, the -40+6MM feed from the ore processing plant is stockpiled (KAWA product stockpile Gantry 6) prior to being sent to the Dense Medium Separation Plant (DMS) via conveyer.

- o The dense medium separation plant can be used to beneficiate the ore prior to sintering by recovering the upgradeable portion of the ore body. The product (low grade and high grade) from the DMS is stored on the sinter feed stockpiles prior to being subjected to the sinter plant process. Correctly graded material and size (M1FT product) from the DMS is stockpiled prior to be sent to the loading and dispatch. Fines (-6+1MM) from the ore processing plant is conveyed directly to the sinter plant. Material that is not sent to the sinter plant is stockpiled for rework.
- Sintering process
  - o During the sintering process calcium carbonate and other impurities are driven off resulting in an increase in the grade. In this regard, the sinter plant generates a high and standard grade sinter product which is conveyed to loading and dispatching of MMT products. Fugitive dust is extracted from the process through a series of extraction ducts with the particulate matter being captured in bag houses. Dust from the baghouses are either recycled back into the sinter process or captured in bulk bags for sale. Off gas and particulate matter is extracted and scrubbed.

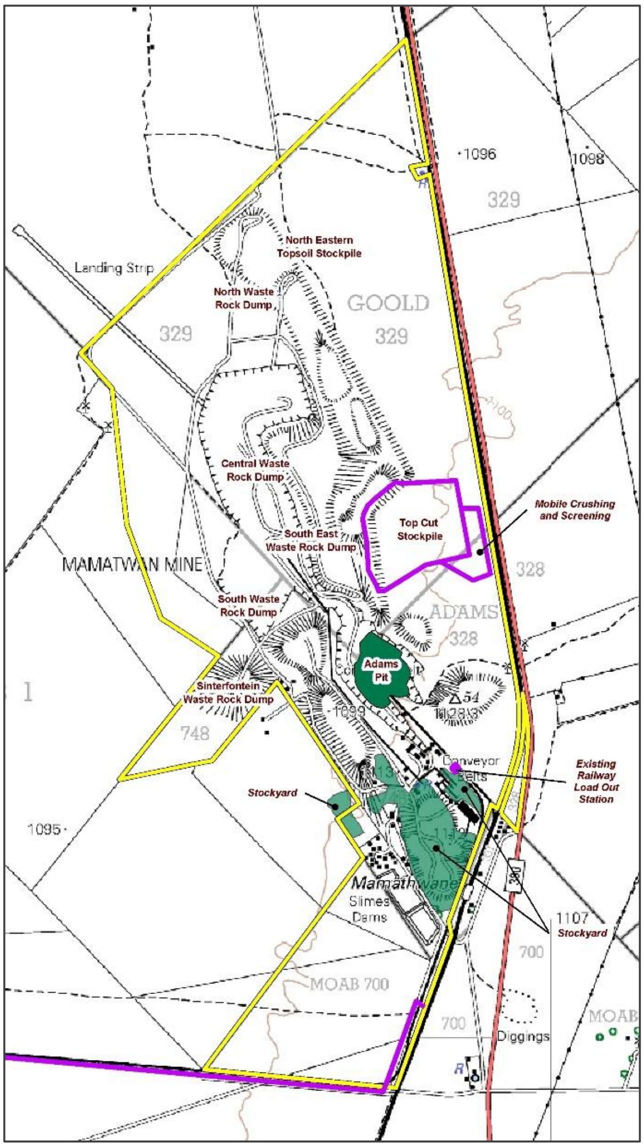

Figure 10: MMT site layout and position of top-cut stockpile

The potential air emissions and impacts due to current mining and processing activities are listed in Table 11.

Table 11: Potential sources of air emissions and impacts associated with MMT activities

Description	Comments
In-pit operations: drilling and blasting, excavation of ROM ore, top-cut ore, and waste rock, storage of top-cut on in-pit stockpile	Mostly PM, gaseous emissions from mining equipment (PM, sulfur dioxide (SO_2) oxides of nitrogen (NOx); carbon monoxide (CO); and carbon dioxide (CO_2))
In-pit operations: removal and stockpiling of topsoil.	Mostly PM, gaseous emissions from excavation equipment (PM, SO_2; NOx; CO; CO_2)
In-pit primary crushing	Mostly PM, gaseous emissions from diesel powered machinery (PM, SO_2; NOx; CO; CO_2)
In-pit operations: haulage of ROM ore, top-cut ore to in-pit crusher, waste rock and topsoil to stockpiles; haulage of discard to discard dump	PM from road surfaces, tipping, windblown dust from trucks, windblown dust from conveyors, gaseous emissions from truck exhaust (PM, SO_2; NOx; CO; CO_2)
ROM feed conveyor (in-pit and surface)	Mostly PM from tipping and windblown dust, gaseous emissions from machinery (PM, SO_2; NOx; CO; CO_2)
ROM, discard, waste rock, topsoil, and product stockpiles	PM from tipping, windblown dust, gaseous emissions from truck exhaust (PM, SO_2; NOx; CO; CO_2)
Processing operations: ROM transfer point and reclaim system; primary, secondary and tertiary ROM crushing and screening; stockpiling of lumpy product and fines product and reclaiming to load to trains, stockpiling, and loadout operations, storage of sinter de-dust fines on Adams pit storage area	Mostly PM, gaseous emissions from diesel powered machinery (PM, SO_2; NOx; CO; CO_2) Current loadout operations include a loading time of 18 hours to load to train, with underutilisation of 260 000 tpa.
DMS plant, sinter plant	PM, SO_2; NOx; CO; and CO_2

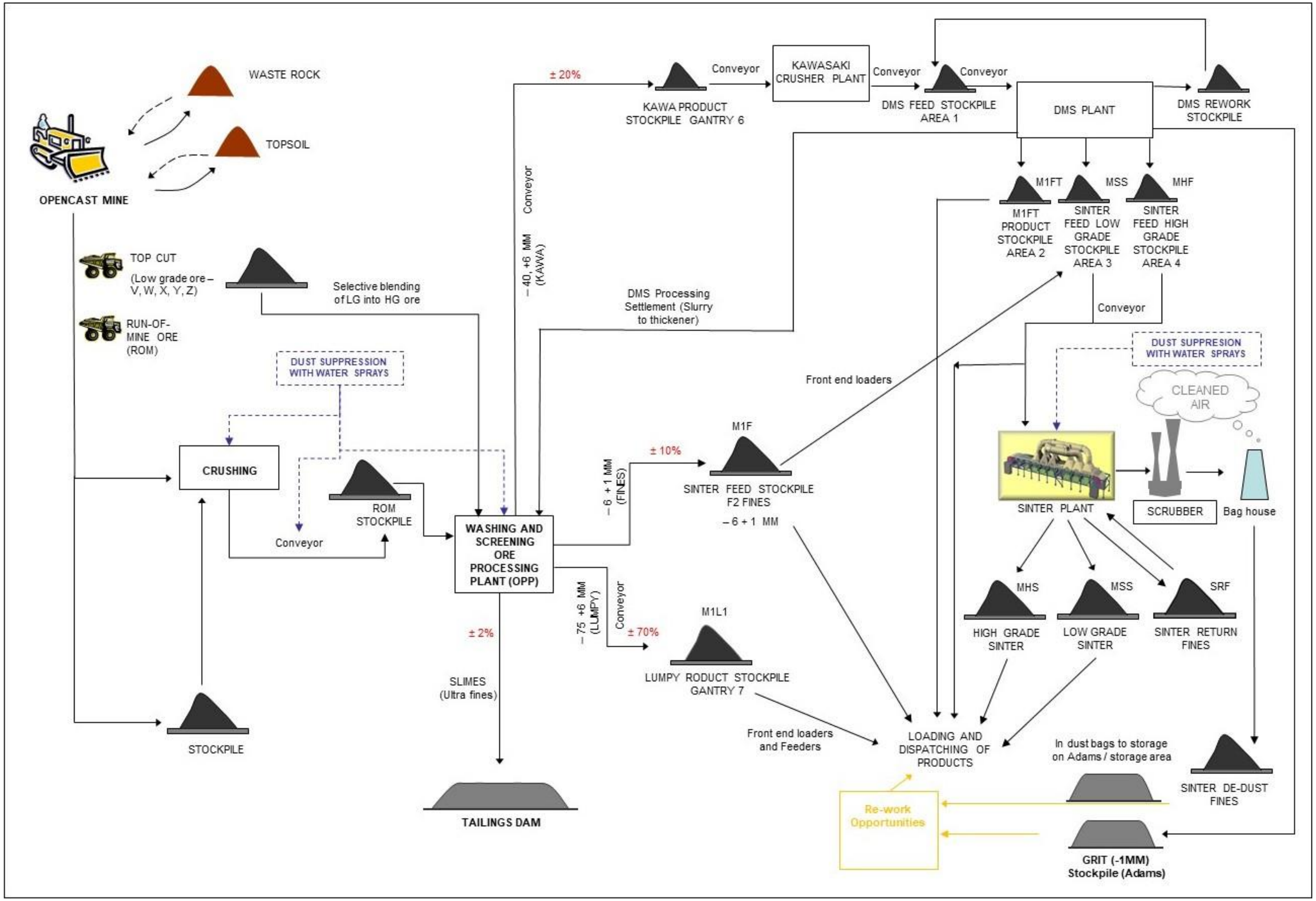

Figure 11: Process flow diagram

4.1.2 Proposed Layout and Activity Changes

The potential sources of air emissions due to proposed layout and activity changes are provided in Table 12. The position of the proposed top-cut stockpile and mobile crushing plant is shown in Figure 10. The proposed new infrastructure (loadout option 2) is shown in Figure 12.

Table 12: Potential sources of air emissions associated with MMT project activities

	Description	Sources	Comments
Proposed Layout Changes			
1	Establishment of a top-cut stockpile and associated crushing and screening plant, requiring additional storage space to stockpile top-cut material prior to processing at the sinter plant, and crushing and screening via a mobile crusher prior to being sent to the sinter plant.	Clearing of indigenous vegetation, crushing and screening, materials handling	The proposed activities are expected to result in an increase in air quality impacts at sensitive receptors to the east of the MMT mining rights boundary and are assessed in the accompanying AQIA.
2	Changes to waste rock dump height from the approved 2005 EMPr height from 50m to 80m.	Materials handling, vehicle entrained dust, bulldozing etc.	Changes in air quality impacts due to the change in waste rock dump height are expected to be minimal, and as such this source was not included in the modelling for the current assessment.
3	Upgrading the railway and railway loadout station. Transnet Freight Rail (TFR) plans to increase the capacity of the Manganese rail line, and in order to meet the TFR expansion requirements the loading rate of trains at MMT needs to be increased. This can be achieved by upgrading the existing loadout station and related railway.	Stacker, reclaimer operations, materials handling including conveyor transfer	Three proposed options were provided: Option 1: The reduction of the loading time from 18 to 12 hours to load a train with 125 wagons, requiring the reconfiguration of the train station. Option 2: The reduction of the loading time to 8 hours to load a train with 125 wagons, requiring upgrading the existing loadout station and conveyor system. Option 3: The reduction of the loading time to 4 hours to load a train with 125 wagons. This option requires the establishment of a new railway loop, new loadout station, product stockpile areas, stackers and reclaimers. The location of the proposed infrastructure for Option 2 is indicated in Figure 12.
Proposed Activity Changes			
1	Sale of waste rock as aggregate: MMT is proposing selling some of the waste rock that would have remained on the surface in perpetuity.	Possible crushing of the waste rock prior to being sold, vehicle entrainment of dust in transporting waste rock to crusher and off-site.	Not enough information was made available as to this activity, and as such the source was not included in the AQIA.
2	Re-processing of material located in Adams pit.	Materials handling at stockpiles, crushing and screening	The re-processing of material located in the Adams pit was included in the source inventory and impact assessment.

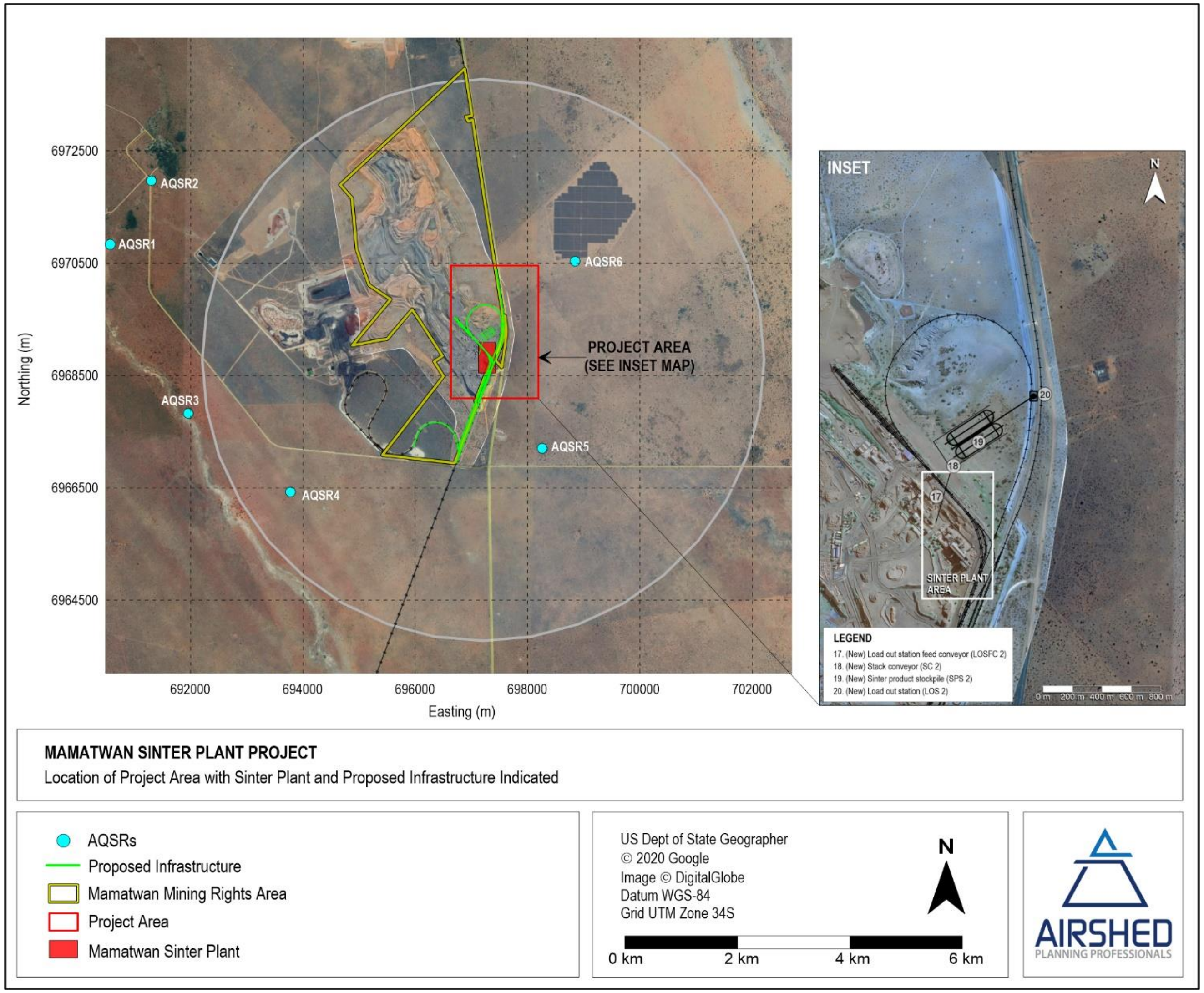

Figure 12: Location of project area with proposed infrastructure layout change (loadout option 2) indicated

4.2 Atmospheric Emissions

4.2.1 Construction Phase

Construction activities include the three options for the planned upgrading of the railway and railway loadout station, and the establishment of stormwater management infrastructure as well as a top-cut stockpile and mobile crusher plant.

The main pollutant of concern from construction operations is particulate matter, including PM_{10}, $PM_{2.5}$ and TSP. PM_{10} and $PM_{2.5}$ concentrations are associated with potential health impacts due to the size of the particulates being small enough to be inhaled. Nuisance effects are caused by the TSP fraction (20 µm to 75 µm in diameter) resulting in soiling of materials and visibility reductions. This could in effect also have financial implications due to the requirement for more cleaning materials.

Activities resulting in the release of these pollutants include topsoil removal, material loading and hauling, stockpiling, grading, bulldozing, as well as metal and concrete works for the establishment of infrastructure. Each of these operations has its own duration and potential for dust generation. It is anticipated that the extent of dust emissions would vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions. This contrasts with most other fugitive dust sources where emissions are either relatively steady or follow a discernible annual cycle. It is often necessary to estimate area wide construction emissions, without regard to the actual plans of any individual construction process.

Quantified construction emissions are usually lower than operational phase emissions and since the construction schedule was not available (and due to its temporary nature); and the likelihood that these activities will not occur concurrently at all portions of the site; emissions were not quantified and dispersion simulation not undertaken for the construction phase.

4.2.2 Operational Phase

The emissions inventory was compiled using the throughput of material as supplied by the client, and any gaps in information was supplemented with information obtained from the literature (Section 1.3.1). The potential air impacts from activities at MMT were identified in Section 1.3.4. The material throughputs for opencast mining, processing plant and sinter plant activities are provided in Section 4.2.2.1.

4.2.2.1 Material Throughput

4.2.2.1.1 Opencast Mining

The current mining activities are focused on the Central Pit. The mining direction is towards the north. The life of operation plan for MMT including overburden and bench-design is shown in Figure 13 (from South32 Mamatwan Mine, Investor Tour, 2016). The opencast areas included in the dispersion model for the baseline year 2020 and project year 2023 (relative to the in-pit crusher, conveyor and proposed top-cut stockpile and crusher) are shown in Figure 14.

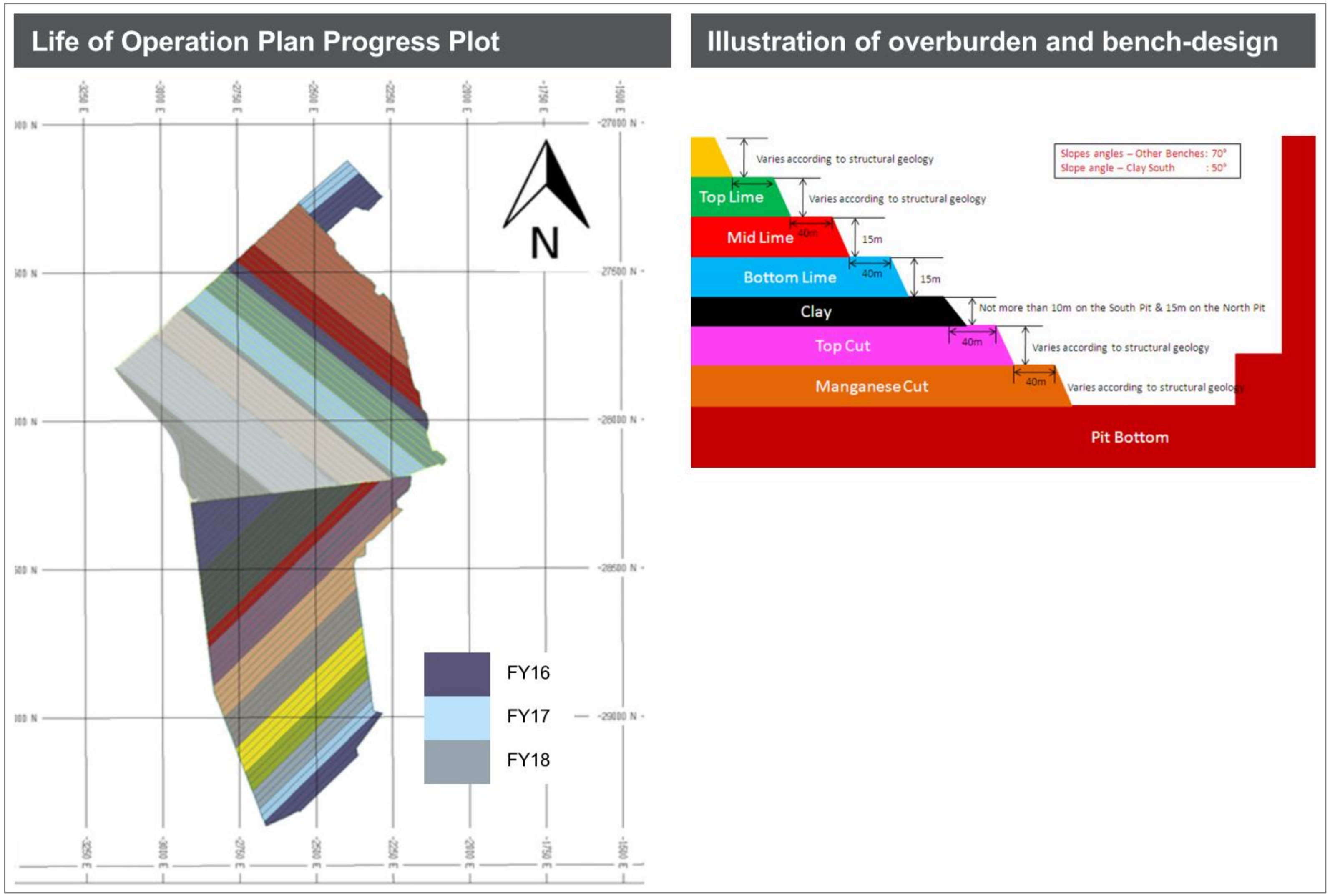

Figure 13: Life of operation progress plot (as of 30 June 2016)

Figure 14: Opencast areas for the baseline and project scenarios (years 2020 and 2023 respectively)

The overburden and bench design in Figure 13 shows the position of the top-cut and manganese layers in the structural geography of the mine. The top-cut consists of three separate manganese layers (the X, Y and Z zones) and when compared to the deeper layers (the M, C and N zones) the top-cut is lower grade. As of 30 June 2016, the inferred manganese ore and top-cut resources were estimated at 61 Mt and 27 Mt respectively. Mining is expected to continue until the year 2033 (i.e. life of operation at the time of the 2016 estimation is approximately 17 to 18 years).

Material throughput was calculated by taking into account the operation flow (starting with opencast activities and ending with tipping of ROM and top-cut material at the processing plant) as shown in Figure 15.

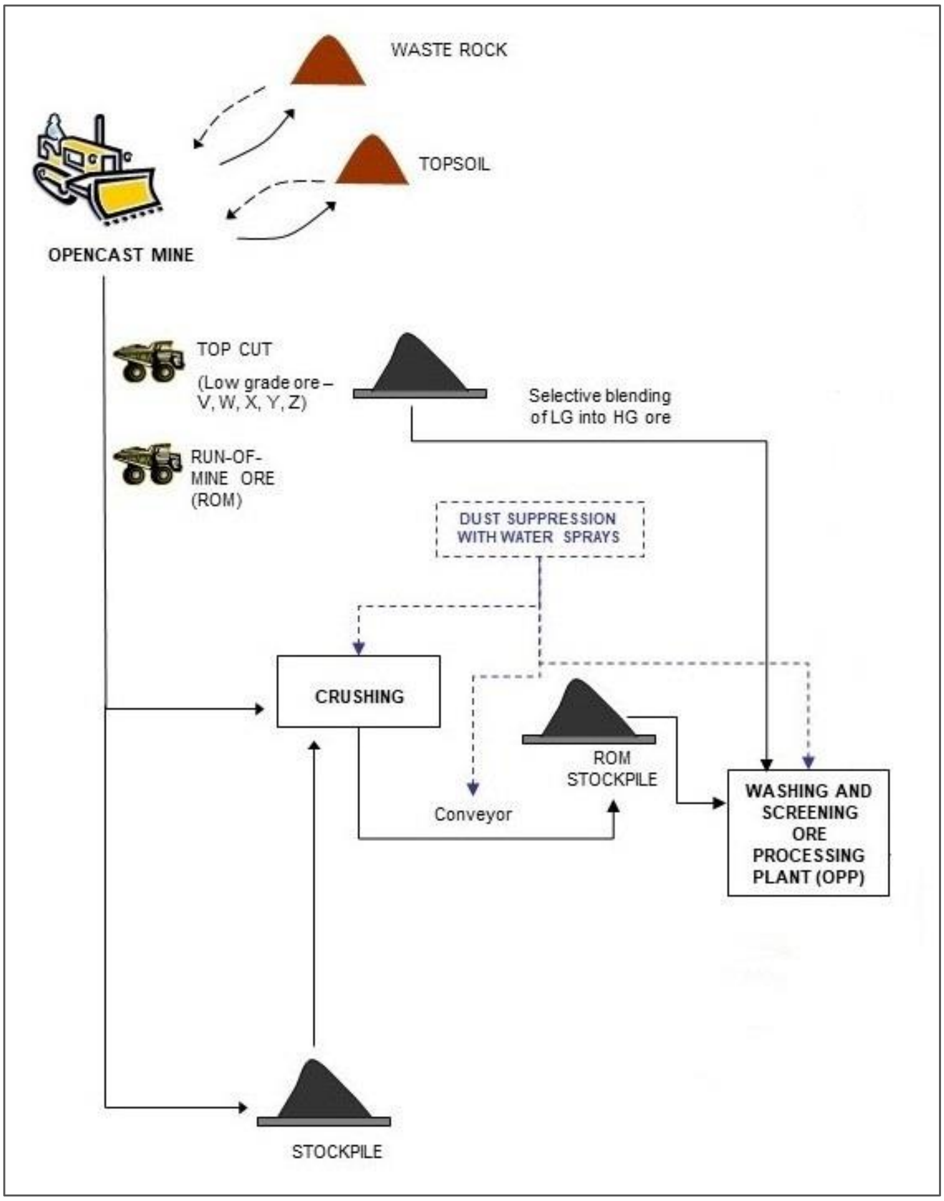

Figure 15: Process flow (opencast mining)

Baseline scenario (2020): The annual throughput of manganese ROM and top-cut material was calculated from the estimated reserves (61 Mt and 27 Mt over a 17 to 18-year period) as ~3.15 Mtpa and ~1.5 Mtpa respectively. The throughput of waste rock and topsoil was given as 1.3 Mt per month and 540 000 tpa respectively. From Figure 15 the waste rock and topsoil are either backfilled or hauled to a dedicated stockpile.

From Figure 15 a portion of ROM gets stockpiled, and a portion hauled to the in-pit crusher where it gets crushed and then tipped to a conveyor, destined for the ROM stockpile at the washing and screening ore processing plant (OPP). The amount of HG ROM crushed at the in-pit crusher was given as 2.8 Mtpa.

No information was given as to the amount of top-cut that goes to the OPP for selective blending with the HG ROM ore. However, it is understood that the current infrastructure output is 3.5 Mtpa (South32 Mamatwan Mine, Gemco Visit, 2015). It was assumed that the top-cut makes up the difference, viz. 700 000 tpa. No information was available as to how the top-cut gets transported to the OPP. It was assumed that it also gets crushed and conveyed from the in-pit crusher to the ROM stockpile at the OPP. The material throughput (in tonnes per annum) for the baseline scenario is given in Table 13. Operational hours for the mine and processing plant were assumed to be 12 hours a day, 7 days a week.

Table 13: Material throughput at mine (baseline scenario)

Material	Annual throughput (tpa)	Comments
Excavation (opencast area)		
ROM (HG)	3 150 000	Total reserve (in Mt) divided by operational LOM (in years)
Top-cut (LG)	1 500 000	Total reserve (in Mt) divided by operational LOM (in years)
Overburden (waste rock)	14 000 000	Given
Overburden (topsoil)	540 000	Given
In-pit crusher/conveyor		
ROM (HG)	2 800 000	Given
Top-cut (LG)	700 000	Total output (3.5 Mtpa) minus ROM (2.8 Mtpa)
Conveyor to ROM SP at processing plant	3 500 000	Sum of HG and LG ore
Tipping (stockpiles)		
ROM SP (in-pit)	350 000	3.15 Mtpa excavated minus 2.8 Mtpa crushed
Top-cut SP (in-pit)	800 000	1.5 Mtpa excavated minus 0.7 Mtpa conveyed to OPP
Waste rock dump (Central)	14 000 000	Waste rock hauled to Central WRD and off-loaded
Topsoil stockpile (Central)	540 000	Topsoil hauled to stockpile (assumed near Central WRD)
Tipping (Adams Pit)		
Sinter product + sinter fines (in bags)	770 000	Stored product (not loaded to train)
Tailings (from DMS plant)	70 000	~2% of OPP feed

Project scenario (2023): No information was supplied for the project scenario throughputs. It was assumed that everything stays the same, apart from (a) the location of the topsoil stockpile (assumed to the north of the opencast area), (b) location of the opencast area and in-pit ROM stockpile (see life of operation plot in Figure 14 – year 2023), (c) backfilling of waste rock instead of stockpiling, (d) hauling of 800 000 tpa top-cut to new stockpile instead of stockpiling it in-pit, and (e) crushing of 800 000 tpa top-cut at new mobile crusher.

4.2.2.1.2 Processing Plant

The operations flow at the OPP and DMS plant is illustrated in Figure 16. The layout of the processing plant is shown in Figure 17. The annual throughput of material is provided in Table 14.

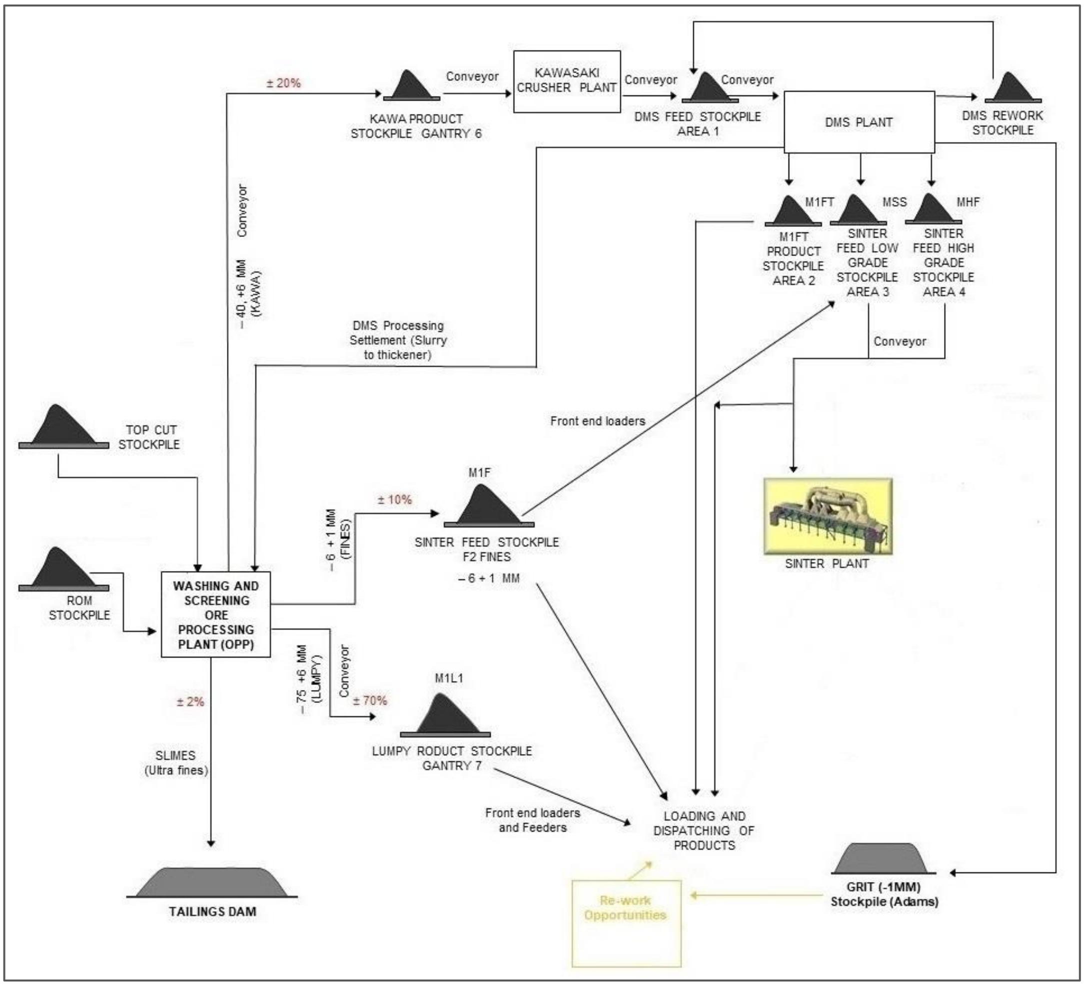

Figure 16: Process flow (OPP and DMS plant)

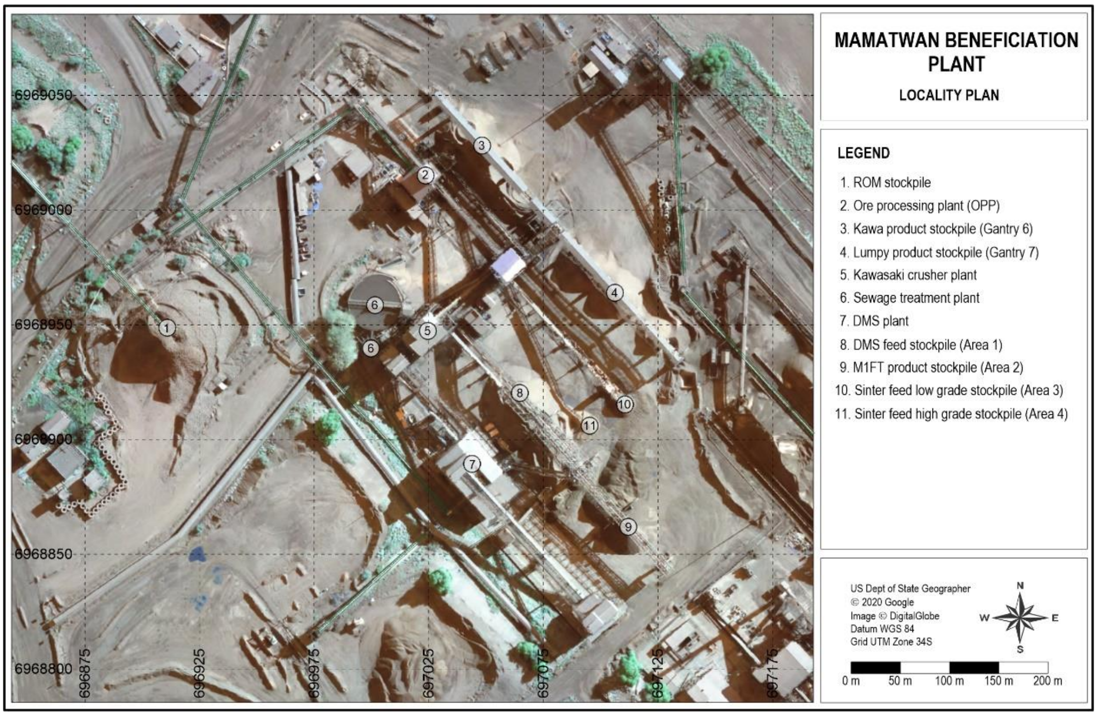

Figure 17: Layout of MMT OPP and DMS plant

Table 14: Material throughput at the OPP and DMS plant

Material	Annual throughput (tpa)	Comments
Raw Stockpiles		
ROM stockpile	2 800 000	ROM stockpile
Top-cut stockpile	700 000	Assumed stockpiled near ROM stockpile
OPP		
ROM + Top-cut	3 500 000	Selectively blended ROM + Top-cut
Product Stockpiles		
Lumpy product stockpile	2 080 000	~60% of total
Kawa feed stockpile	1 420 000	Total minus lumpy product
DMS feed stockpile	1 420 000	Feed from Kawa crusher plant
M1FT product stockpile	170 000	DMS feed minus MSS minus MHF minus M1F
Sinter feed LG SP (MSS)	600 000	M1F (from OPP) + 18% DMS recovery
Sinter feed HG SP (MHF)	650 000	45% DMS recovery

4.2.2.1.3 Sinter Plant

The operations flow at the sinter plant is illustrated in Figure 18. The sinter plant layout is shown in Figure 19. The annual throughput of material is provided in Table 15. Operational hours for the sinter plant were assumed to be 7920 hours per annum (sinter plant process diagram, design capacity).

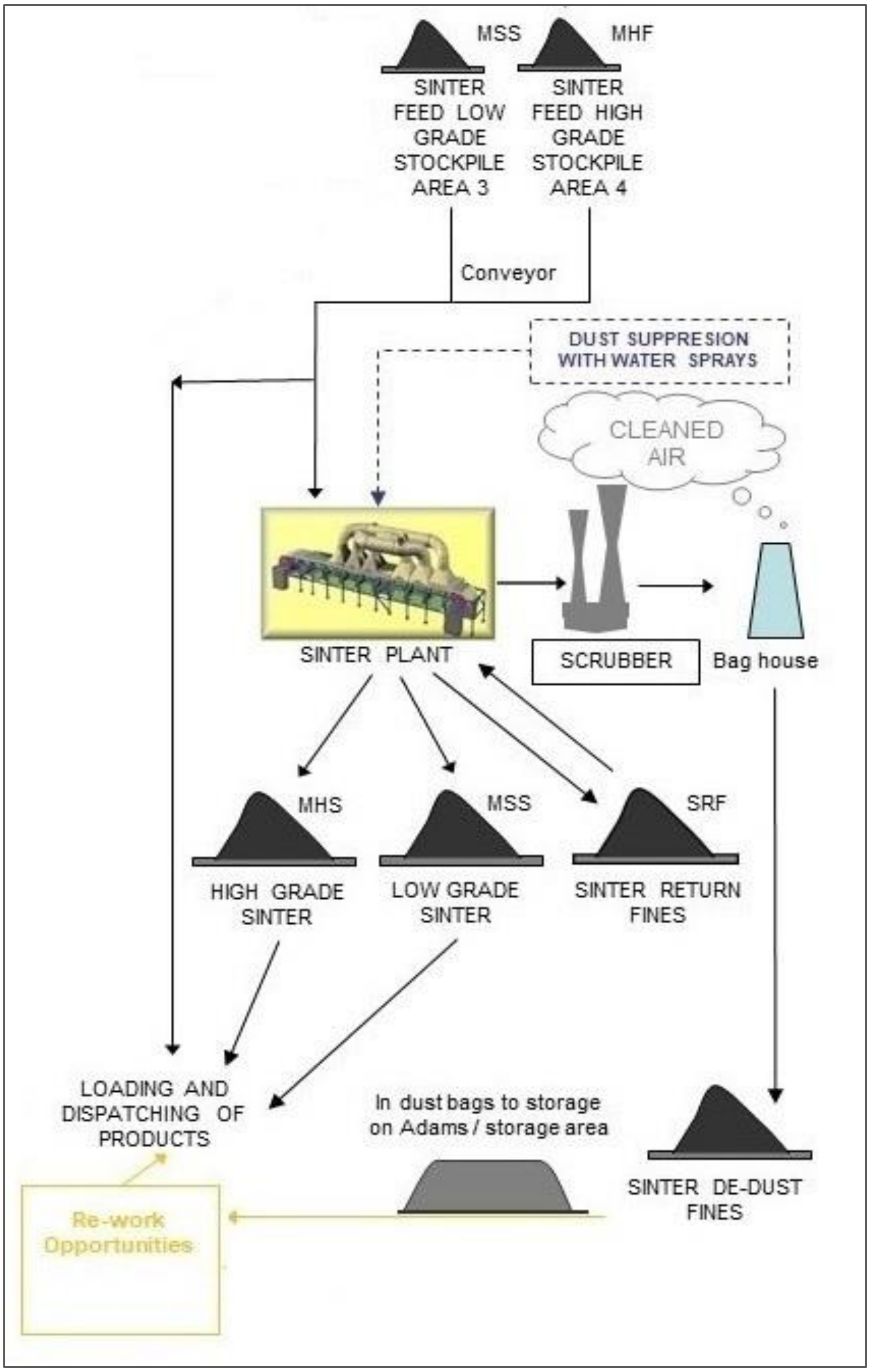

Figure 18: Process flow (sinter plant)

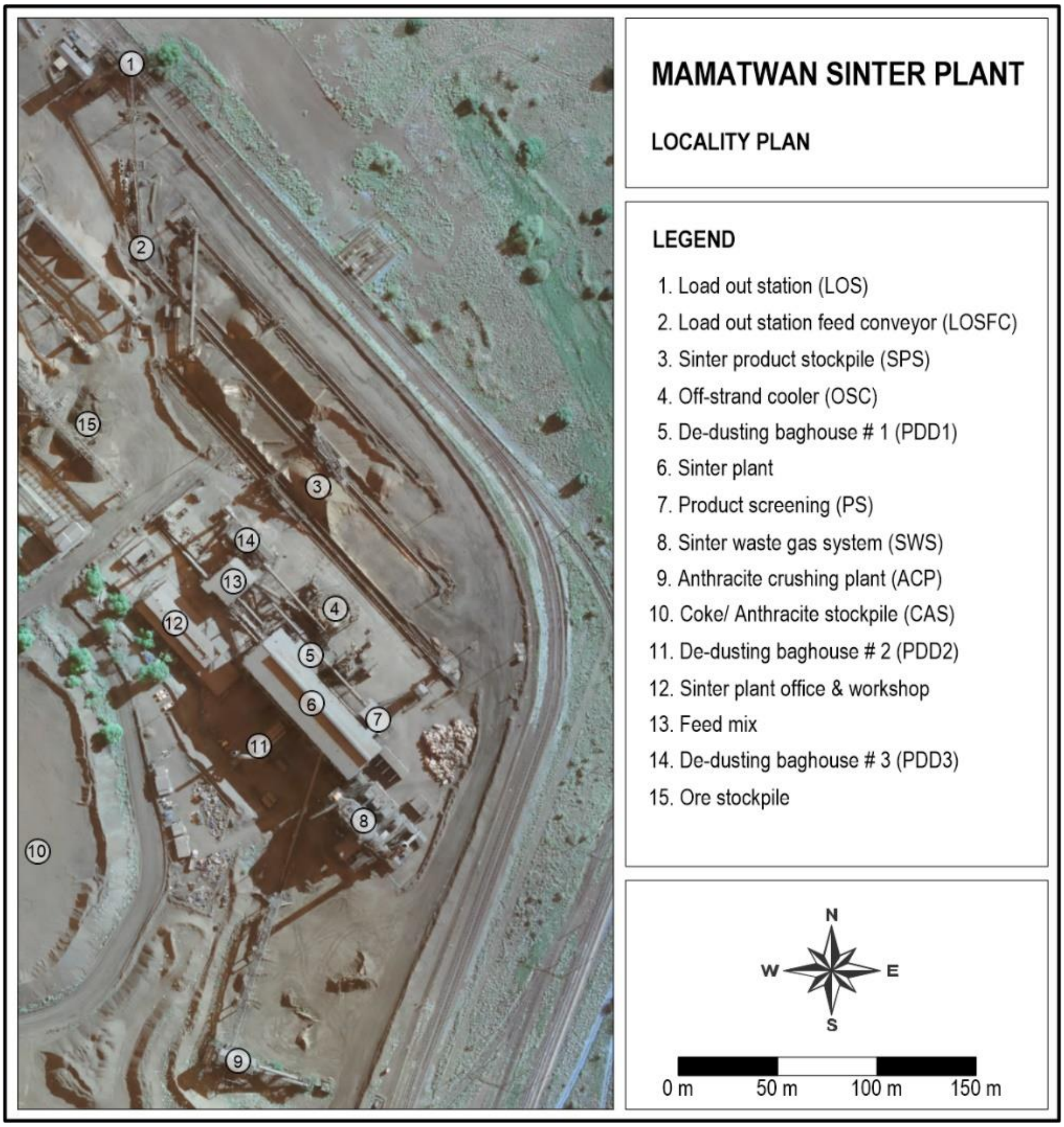

Figure 19: Sinter plant layout

Table 15: Material throughput at the sinter plant (sinter plant process diagram – design capacity)

Material	Annual throughput (tpa)	Comments
	Raw materials	
Manganese ore (feed mix)	1 250 000	Processed material (from OPP)
Coke/Anthracite (feed mix)	95 000	Crushed material (from ACP) used as fuel in sinter process
Recycled dust (feed mix)	3 960	From baghouse (SWS, PDD1 and PDD2)
Recycled fines (feed mix)	216 040	From PS (product screen)
Heavy fuel oil	3 000	For moving sinter grate

Material	Annual throughput (tpa)	Comments
Reductant (anthracite)	95	From anthracite stockpile, for use in sinter process
Product		
Sinter product (total)	1 000 000	From sinter plant (sinter plant process diagram)
Sinter product (for loadout)	260 000	Loadout capacity (2.34 Mtpa) minus lumpy product
Sinter product (transport offsite)	740 000	Assumed that the remainder of product gets transported offsite
Sinter fines	27 920	From PDD3 to Adams Pit (sinter plant process diagram)
Loadout Station		
Lumpy product to siding	2 080 000	From OPP
Sinter product to siding	260 000	Loadout capacity (2.34 Mtpa) minus lumpy product

4.2.2.2 Emissions Inventory

4.2.2.2.1 Fugitive Emissions

The emission equations used to quantify fugitive emissions from the current and proposed activities are shown in Table 17. For each scenario, both unmitigated and mitigated activities were assessed. The control efficiencies for the various mining operations are shown in Table 16 below. The particle size distribution used to calculate emissions for wind erosion from the various stockpile materials are shown in Table 18. The estimated emissions due to unmitigated and mitigated MMT activities are provided in Table 19 (mining activities), Table 20 (processing plant) and Table 21 (sinter plant).

Table 16: Estimated control factors for various mining operations

Operation/Activity	Control method and emission reduction
Windblown dust from stockpiles	No control
Bulldozing	No control
Blasting	No control
Drilling	No control (assumed)
Haul roads	75% CE for water sprays (assumed)
Materials handling	50% CE for water sprays (assumed)
Primary crushing at in-pit and ACP crushers	50% CE for water sprays (assumed)
Crushing at OPP, Kawa and DMS crushers	83% CE for enclosure
Windblown dust from conveyor	50% for roofing and one side covering of the conveyor

Note: CE is Control Efficiency

4.2.2.2.2 Process Emissions

The main pollutants associated with the sintering process included SO_2; NOx; PM. These were quantified based on the MES and stack parameters (Table 22).

Table 17: Emission equations used to quantify fugitive dust emissions from the project

Activity	Emission Equation	Source	Information assumed/provided
Materials handling (excavation, stockpiling, tipping including conveyor transfer)	$$E = 0.0016\frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$$ Where, E = Emission factor (kg dust / t transferred) U = Mean wind speed (m/s) M = Material moisture content (%) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively. An average wind speed of 2.04 m/s was used based on Kuruman SAWS data for the period 2016 – 2018.	US-EPA AP42 Section 13.2.4	The moisture content of material was assumed as follows: ROM and top-cut: 3% (assumed) Waste rock: 7.9% (US EPA default mean moisture content, Table 11.9-3) Topsoil: 3.4% (US EPA default mean moisture content, Table 11.9-3) Product: 4% (assumed) Other: 2% (assumed) (including anthracite/coke and other feed mix materials) The throughput of materials was assumed as per Table 13 (mining), Table 14 (processing plant) and Table 15 (sinter plant). Hours of operation were assumed as follows: • 12 hrs per day, 7 days per week (mining and processing plant) • 7920 hours per annum (sinter plant activities)
Materials handling (loading to trains)	$$E_{TSP} = 0.0004\ kg/t\ material\ processed$$ $$E_{PM10} = 0.00017\ kg/t\ material\ processed$$ $$E_{PM2.5} = 0.000085\ kg/t\ material\ processed$$ Where, E = Default emission factor in kg/t sinter product	NPI Section: Mining	Loading to trains at loadout station Moisture content of product assumed as 4% Throughput of material: Total product loaded was assumed as 260 000 tpa sinter product and 2 080 500 tpa lumpy product. Hours of operation were assumed as follows: • 18 hours per day, 7 days a week (baseline scenario) • 12 hours per day, 7 days a week (project scenario option 1) • 8 hours per day, 7 days a week (project scenario option 2) • 4 hours per day, 7 days a week (project scenario option 3)

Activity	Emission Equation	Source	Information assumed/provided
Materials Handling (pile formation stacker)	$E_{TSP} = 0.00015\ kg/t\ material\ processed$ $E_{PM10} = 0.000075\ kg/t\ material\ processed$ $E_{PM2.5} = 0.000022\ kg/t\ material\ processed$ Where, E = Default emission factor in kg/t sinter product	US-EPA AP42 Section 12	Pile formation stacking operations at sinter product stockpiles Moisture content of product assumed as 4% Throughput as per Table 15. Hours of operation assumed as 7920 hours per annum.
Bulldozing	$E = k \cdot (s)^{a}/(M)^{b}$ Where, E = Emission factor (kg dust / hr / vehicle) s = Material silt content (%) M = Material moisture content (%) The particle size multiplier k is given as 2.6 (TSP), 0.34 (PM_{10}) The empirical constant (a) is given as 1.2 (TSP), and 1.5 (PM_{10}) The empirical constant (b) is given as 1.3 (TSP), and 1.4 (PM_{10}) Fraction of $PM_{2.5}$ assumed to be 10% of PM_{10}	NPI Section: Mining	Activities were assumed to include: in-pit cleaning (12 hours per day, 7 days per week), and levelling of stockpiled/backfilled waste rock (3 hours per day, 7 days per week) for 2 vehicles Silt content and moisture content of waste rock was assumed as 6.9% and 7.9% respectively (US EPA default values)
Drilling	$E_{TSP} = 0.59\ kg/hole\ drilled$ $E_{PM_{10}} = 0.31\ kg/hole\ drilled$ $E_{PM_{2.5}} = 0.31\ kg/hole\ drilled$	NPI Section: Mining	Number of drill holes per day was assumed as 53 (under the assumption of drilling areas of 10 000 m² on a 5m × 5m blasting pattern. Hours of operation were assumed as 12 hours per day, 7 days a week.
Blasting	$E = 0.00022 \cdot (A)^{1.5}$ Where, E = Emission factor (kg dust / t transferred) A = Blast area (m²) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively.	NPI Section: Mining	The blast area was given as 10 000 m² (for both waste rock and ore). The number of blasts for waste rock and ore were assumed as 1 blast per week each, on alternate days.

Activity	Emission Equation	Source	Information assumed/provided
Vehicle entrainment on unpaved surfaces	$$E = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b} \cdot 281.9$$ Where, E = particulate emission factor in grams per vehicle km travelled (g/VKT) k = basic emission factor for particle size range and units of interest s = road surface silt content (%) W = average weight (tonnes) of the vehicles travelling the road The particle size multiplier (k) is given as 0.15 for $PM_{2.5}$ and 1.5 for PM_{10}, and as 4.9 for TSP The empirical constant (a) is given as 0.9 for $PM_{2.5}$ and PM_{10}, and 4.9 for TSP The empirical constant (b) is given as 0.45 for $PM_{2.5}$, PM_{10} and TSP	US-EPA AP42 Section 13.2.2	Operational transport activities include the transport of: ROM and top-cut from the opencast area to the in-pit crusher, Waste rock and topsoil from the opencast area to dedicated stockpiles (or back to the opencast area), Top-cut to the new top-cut stockpile and top-cut crusher (project scenario), and Anthracite/coke and heavy duty oil to the sinter plant. Sinter product (not loaded to train) transported offsite Hours of operation were assumed as 12 hrs per day, 7 days per week. In the absence of site-specific silt data, use was made of the US EPA default upper limit silt content for haul roads of 25.2%. The capacity of the haul trucks to be used were assumed as: 95.87 t (overburden), 96.1 t (ore), and 3.13 t (anthracite/coke and heavy duty oil). The layout of the roads was provided. The throughputs of material were provided in Table 13 (mining), Table 14 (processing plant) and Table 15 (sinter plant).
Crushing and screening	Primary: $E_{TSP} = 0.2\ kg/t\ material\ processed$ $E_{PM10} = 0.02\ kg/t\ material\ processed$ $E_{PM2.5} = 0.01\ kg/t\ material\ processed$ Secondary: $E_{TSP} = 0.6\ kg/t\ material\ processed$ $E_{PM10} = 0.04\ kg/t\ material\ processed$ $E_{PM2.5} = 0.02\ kg/t\ material\ processed$ Where,	NPI Section: Mining	Material to be crushed includes ROM ore and top-cut at: Primary crusher (in-pit) – 800 tph (given) Secondary crusher (OPP) – 800 tph (assumed) Tertiary crusher (Kawa) – 325 tph, low moisture ore (assumed) Tertiary crusher (DMS) – 325 tph, high moisture ore (assumed) Primary crushing (ACP) – 12 tph (calculated, design capacity), low moisture ore (assumed)

Activity	Emission Equation	Source	Information assumed/provided
	E = Default emission factor for low moisture content ore Tertiary (low moisture content ore): $E_{TSP} = 1.4\ kg/t\ material\ processed$ $E_{PM10} = 0.08\ kg/t\ material\ processed$ $E_{PM2.5} = 0.04\ kg/t\ material\ processed$ Tertiary (high moisture content ore): $E_{TSP} = 0.03\ kg/t\ material\ processed$ $E_{PM10} = 0.01\ kg/t\ material\ processed$ $E_{PM2.5} = 0.005\ kg/t\ material\ processed$ Fraction of $PM_{2.5}$ taken from US-EPA crushed stone emission factor ratio for tertiary crushing		Hours of operation were assumed as follows: In-pit crusher – 12 hours per day, 7 days a week OPP, Kawa and DMS crushers – 12 hours per day, 7 days a week ACP crusher – 7920 hours a year
Screening (processing plant)	$E_{TSP} = 0.08\ kg/t\ material\ processed$ $E_{PM10} = 0.06\ kg/t\ material\ processed$ $E_{PM2.5} = 0.03\ kg/t\ material\ processed$ Where E = Default emission factor for low moisture content ore	NPI Section: Mining	Tertiary screening, 800 tph, 12 hours per day, 7 days a week
Screening (sinter plant)	$E_{TSP} = 0.0011\ kg/t\ material\ processed$ $E_{PM10} = 0.00037\ kg/t\ material\ processed$ $E_{PM2.5} = 0.000025\ kg/t\ material\ processed$ Where, E = Default emission factor in kg/t sinter product	US.EPA AP42 emission factors for fines screening (controlled) - Ch 11	Throughput assumed as 1000 000 tpa (design specifications)
Off-strand cooler (OSC)	Emission factor for particulate matter due to cooling, with bag filter, given as 0.06 kg/t sinter	Emission Inventory Guidebook, 2006, citing IPPC BAT Reference Document, EU.	Throughput assumed as 1000 000 tpa (design specifications)
Wind Erosion	$E(i) = G(i)10^{(0.134(\%clay)-6)}$	Marticorena & Bergametti, 1995	ROM ore, product ore, waste rock and topsoil particle size distributions were obtained from similar projects (see Table 18).

Activity	Emission Equation	Source	Information assumed/provided
	For $$G(i) = 0.261 \left[\frac{P_a}{g}\right] u^{*3}(1+R)(1-R^2)$$ And $$R = \frac{u_*^{\,t}}{u^*}$$ where, $E_{(i)}$ = emission rate (g/m²/s) for particle size class i P_a = air density (g/cm³) G = gravitational acceleration (cm/s³) u_*^t = threshold friction velocity (m/s) for particle size i u^* = friction velocity (m/s)		The moisture contents of materials were assumed as 0.1%. Typical values for particle density and particle size were assumed: ROM ore – 4500 kg/m³ Product – 3500 kg/m³ Waste rock – 3200 kg/m³ Topsoil – 2650 kg/m³ Anthracite coal – 1600 kg/m³ Layout of stockpiles was provided. Hourly emission rate file was calculated and simulated.
Wind-blown dust from conveyor	$E_{TSP} = c\,(u^* - u^t)$ (in g/metre of conveyor) where the dust emission rate E is equivalent to a constant c multiplied by the difference between the friction velocity (u*) and the threshold friction velocity of the coal (u^*_t). An estimate for the constant (*c*) has been made based on data reported by GHD/Oceanics (1975) for measured conveyor emissions at a wind speed of 10 m/s. The PM_{10} fraction has been estimated as 45% of the TSP. The $PM_{2.5}$ fraction has been assumed as 50% of the PM_{10}. The approach is conservative since it assumes emissions from a conventional conveyor and based on emission factors provided for coal dust. A control efficiency of 50% for roofing and one side covering of the conveyor was factored into the emissions calculation under the *mitigated* scenario.	GHD/Oceanics (1975)	Emissions were calculated for the following conveyor belt sections In-pit crusher to ROM stockpile: 1.84 km OPP and DMS plant conveyor system: 630 m Stack conveyor (baseline): 474 m Loadout station feed conveyor (baseline): 325 m Feed conveyor to SC (project): 865 m Stack conveyor (project): 1.125 km Loadout station feed conveyor (project): 225 m The width of the conveyor belts was assumed as 2 m. Typical values for particle density and particle size were assumed. The wind speed profile was created from the Kuruman SAWS data for the period 2016-2018.

Table 18: Particle size distributions of materials (given as a fraction)

Product		ROM & Top-cut		Coal		Topsoil		Waste rock	
Size µm	Mass Fraction	Size µm	Mass Fraction	Size µm	Mass Fraction	Size µm	Mass Fraction	Size µm	Mass Fraction
30	0.15	252	0.107	2000	0.158	2000	0.056	300.5	0.02
10	0.23	178	0.152	1000	0.211	1000	0.067	200.2	0.034
6	0.04	126	0.123	425	0.447	425	0.389	152.5	0.105
5	0.10	89	0.057	75	0.079	75	0.189	101.5	0.054
4	0.12	37	0.561	40	0.026	40	0.033	88.6	0.058
3	0.06	10	0	30	0.053	30	0.067	77.3	0.057
2.5	0.09	2.5	0	10	0.026	10	0.067	67.5	0.052
2	0.15	10.10	0.07	4	0	4	0.044	58.9	0.047
1	0.06	5.12	0.01	2	0	2	0.089	51.5	0.078
		2.27	0.00					39.2	0.066
								29.9	0.083
								19.9	0.059
								15.2	0.098
								10.1	0.078
								6.7	0.02
								5.9	0.029
								4.5	0.024
								3.4	0.017
								2.6	0.015
								2.0	0.008

Table 19: Calculated emission rates due to unmitigated and mitigated mining activities

Description	Baseline (unmitigated)			Baseline (mitigated)			Project (unmitigated)			Project (mitigated)		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
In-pit operations [(a)]	139.96	988.97	1 735.81	58.35	308.93	604.05	139.87	988.36	1 735.14	58.31	308.63	603.71
Blasting	0.65	11.30	11.44	0.65	11.30	11.44	50.97	164.72	306.22	0.65	11.30	11.44
Backfilling [(b)]	-	-	-	-	-	-	0.60	10.45	20.10	0.60	10.45	20.10
Crushing [(c)]	-	-	-	-	-	-	11.50	23.00	230.00	5.75	11.50	115.00
Materials handling	0.25	1.65	3.48	0.12	0.82	1.74	0.45	2.97	6.28	0.22	1.49	3.14
Bulldozing	2.48	5.93	23.62	2.48	5.93	23.62	2.48	5.93	23.62	2.48	5.93	23.62
Vehicle entrainment	112.17	1 121.70	3 158.92	28.04	280.43	789.73	225.30	2 253.01	6 344.90	56.33	563.25	1 586.23
Wind erosion (conveyor)	1.69	3.37	7.49	0.84	1.69	3.75	1.69	3.37	7.49	0.84	1.69	3.75
Wind erosion (open areas)	36.83	131.12	237.93	36.83	131.12	237.93	35.19	124.27	235.92	35.19	124.27	235.92
Total	**294**	**2 264**	**5 179**	**127**	**740**	**1 672**	**468**	**3 576**	**8 910**	**160**	**1 039**	**2 603**

Notes:

(a) Including materials handling, drilling, in-pit hauling, in-pit crushing and in-pit cleaning (bulldozing)

(b) Backfilling of waste rock modelled for project scenario, stockpiling of waste rock modelled for baseline scenario

(c) Primary crushing of top-cut at the new mobile crusher plant (project scenario)

Table 20: Calculated emission rates due to unmitigated and mitigated processing plant activities

Description	Baseline (unmitigated)			Baseline (mitigated)			Project (unmitigated)			Project (mitigated)		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Materials handling	1.17	7.71	16.30	0.58	3.85	8.15	1.17	7.71	16.30	0.58	3.85	8.15
Crushing and screening	40.67	81.35	751.12	40.67	81.35	751.12	40.67	81.35	751.12	40.67	81.35	751.12
Wind erosion (conveyors)	0.45	0.91	2.01	0.23	0.45	1.01	0.45	0.91	2.01	0.23	0.45	1.01
Wind erosion (open areas)	0.79	2.23	2.62	0.79	2.23	2.62	0.79	2.23	2.62	0.79	2.23	2.62
Total	**43**	**92**	**772**	**42**	**88**	**763**	**43**	**92**	**772**	**42**	**88**	**763**

Notes:

(a) It was assumed that all processing plant activities remained the same for baseline and project scenarios

(b) It was assumed that crushers are enclosed (83% CE), and therefore the unmitigated and mitigated emissions are the same

Table 21: Calculated emission rates due to unmitigated and mitigated sinter plant activities

Description	Baseline (unmitigated)			Baseline (mitigated)			Project (unmitigated)			Project (mitigated)		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Materials handling	0.36	1.42	3.09	0.18	0.71	1.54	0.36	1.42	3.09	0.18	0.71	1.54
Crushing	0.16	0.32	3.23	0.16	0.32	3.23	0.16	0.32	3.23	0.16	0.32	3.23
Product screen	0.03	0.37	1.10	0.03	0.37	1.10	0.03	0.37	1.10	0.03	0.37	1.10
Cooler (OSC)	21.00	37.50	60.00	21.00	37.50	60.00	21.00	37.50	60.00	21.00	37.50	60.00
Access road (raw materials)	2.99	29.86	84.09	0.75	7.47	21.02	2.99	29.86	84.09	0.75	7.47	21.02
Access road (sinter product)	42.50	425.03	1 196.97	10.63	106.26	299.24	42.50	425.03	1 196.97	10.63	106.26	299.24
Wind erosion (conveyors)	0.53	1.07	2.42	0.27	0.53	1.21	1.24	2.48	5.51	0.62	1.24	2.76
Wind erosion (open areas)	2.89	9.07	15.04	2.89	9.07	15.04	8.90	26.10	35.09	8.90	26.10	35.09
Total	**70**	**505**	**1 366**	**36**	**162**	**402**	**77**	**523**	**1 389**	**42**	**180**	**424**

Notes:

(a) It was assumed that all sinter plant throughputs remained the same for baseline and project scenarios

Table 22: Emission estimation techniques and parameters (process emissions)

Common Name	Chemical Symbol	New Plant emission limits (MES): mg/Nm³ under normal conditions of 273 Kelvin and 101.3 kPa	Volumetric Flow (m³/hr)[(a)]	Volumetric Flow normal conditions (Nm³/hr)[(b)]	Emissions (g/s)[(c)]
Particulate Matter	PM	50	321 (SWS)	209	0.003
			9.56 (PDD1)	8.08	0.0001
			14.57(PDD2)	11.53	0.0002
			54.63(PDD3)	44.65	0.001
Sulphur Dioxide	SO_2	500	321 (SWS)	209	0.029
			9.56 (PDD1)	8.08	0.0011
			14.57(PDD2)	11.53	0.0016
			54.63(PDD3)	44.65	0.006
Oxides of nitrogen	NO_x expressed as NO_2	700	321 (SWS)	209	0.041
			9.56 (PDD1)	8.08	0.0016
			14.57(PDD2)	11.53	0.0022
			54.63(PDD3)	44.65	0.009

(a) Provided by the client

(b) Normalised volumetric flow = Volumetric flow * (273/(200+273)), where Stack Exit Temperature = 200°C, and Normal Temperature = 273K.

(c) Emissions (g/s) = MES (mg/Nm³) x Volumetric Flow (Nm³/hr) x 1000 / 3600

4.2.3 Closure Phase

All operational activities will have ceased by the closure (decommissioning and post-closure) phase of the project. This will result in a positive impact on the surrounding environment and human health. The potential for impacts during the closure phase will therefore depend on the extent of rehabilitation efforts to be undertaken at the infrastructure area and existing waste rock stockpile areas. Aspects and activities associated with the closure phase of the proposed project are listed in Table 23.

Table 23: Activities and aspects identified for the closure phase

Aspects	Activities
Fugitive dust	Demolition and stripping away of structures and facilities
Fugitive dust	Wind-blown dust from stockpile and exposed areas
Fugitive dust	Degradation of roads resulting in exposed surface areas

4.3 Atmospheric Dispersion Modelling

The impact assessment of the project's operations on the environment is discussed in this section. To assess impact on human health and the environment the following important aspects need to be considered:

- The criteria against which impacts are assessed (Section 2.2);
- The potential of the atmosphere to disperse and dilute pollutants emitted by the project (Section 3.2);
- The AQSRs in the vicinity of the mine (Section 3.1); and
- The methodology followed in determining ambient pollutant concentrations and dustfall rates (Section 3.4).

The impact of proposed operations on the atmospheric environment was determined through the simulation of ambient pollutant concentrations. Dispersion models simulate ambient pollutant concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions of various sources. Increasing reliance has been placed on concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and emission control requirements. It is therefore important to carefully select a dispersion model for the purpose.

4.3.1 Dispersion Model Selection

Gaussian-plume models are best used for near-field applications where the steady-state meteorology assumption is most likely to apply. One of the most widely used Gaussian plume model is the US EPA AERMOD model that was used in this study. AERMOD is a model developed with the support of AERMIC, whose objective has been to include state-of the-art science in regulatory models (Hanna, Egan, Purdum, & Wagler, 1999). AERMOD is a dispersion modelling system with three components, namely: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD terrain pre-processor), and AERMET (AERMOD meteorological pre-processor).

AERMOD is an advanced new-generation model. It is designed to predict pollution concentrations from continuous point, flare, area, line, and volume sources. AERMOD offers new and potentially improved algorithms for plume rise and buoyancy, and the computation of vertical profiles of wind, turbulence and temperature however retains the single straight-line trajectory limitation. AERMET is a meteorological pre-processor for AERMOD. Input data can come from hourly cloud cover observations, surface meteorological observations and twice-a-day upper air soundings. Output includes surface meteorological observations and parameters and vertical profiles of several atmospheric parameters. AERMAP is a terrain pre-processor designed to simplify and standardise the input of terrain data for AERMOD. Input data includes receptor terrain elevation data. The terrain data may be in the form of digital terrain data. The output includes, for each receptor, location, and height scale, which are elevations used for the computation of air flow around hills.

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model include: Source data, meteorological data (supplied in the required format with the WRF data), terrain data, information on the nature of the receptor grid and pre-development or background pollutant concentrations or dustfall rates.

4.3.2 Meteorological Requirements

For the current study, use was made of data from the South African Weather Services (SAWS) Kuruman Weather Station for the period 2016-2018 (Section 3.2).

4.3.3 Source Data Requirements

The AERMOD model can model point, jet, area, line and volume sources. Sources were modelled as follows:

- Opencast areas – modelled as inpit sources
- Materials handling – modelled as volume sources;
- Crushing and screening – modelled as volume sources;
- Stacks – modelled as point sources
- Unpaved roads – modelled as area sources;
- Windblown dust from conveyors – modelled as area sources; and
- Windblown dust from stockpiles – modelled as area sources.

4.3.4 Modelling Domain

The dispersion of pollutants expected to arise from proposed activities was modelled for an area covering 10 km (east-west) by 8.5 km (north-south). The area was divided into a grid matrix with a resolution of 100 m by 100 m, with the project located centrally. AERMOD calculates ground-level (1.5 m above ground level) concentrations and dustfall rates at each grid and discrete receptor points (AQSRs).

4.4 Impact Assessment

Dispersion modelling was undertaken to determine highest daily and annual average ground level concentrations (GLCs). Averaging periods were selected to facilitate the comparison of predicted pollutant concentrations to relevant ambient air quality and inhalation health criteria as well as dustfall regulations.

Pollutants with the potential to result in human health impacts which are assessed in this study[7] include $PM_{2.5}$ and PM_{10}. Dustfall is assessed for its nuisance potential. Results are primarily provided in form of isopleths to present areas of exceedance of assessment criteria. Ground level concentration or dustfall isopleths presented in this section depict interpolated values from the concentrations simulated by AERMOD for each of the receptor grid points specified.

Isopleth plots reflect the incremental GLCs for $PM_{2.5}$ and PM_{10} where exceedances of the relevant NAAQSs were simulated.

It should also be noted that ambient air quality criteria apply to areas where the Occupational Health and Safety regulations do not apply, normally outside the property or lease area. Ambient air quality criteria are therefore not occupational health indicators but applicable to areas where the general public has access.

4.4.1 PM_{10}

The simulated highest daily and annual average PM_{10} concentrations for the baseline and project scenarios are provided in Figure 20 to Figure 23 respectively, with the GLCs at each of the AQSRs provided in Table 24 (unmitigated activities) and Table 25 (mitigated activities).

Baseline: Simulated PM_{10} daily ground level concentrations (GLCs), with no mitigation in place, are in non-compliance with the NAAQS for distances up to 4 km from the mining rights boundary (Figure 20). The simulated number of exceedances of the daily PM_{10} NAAQS at AQSR 5 and 6 are in non-compliance with the standard for unmitigated activities. Over an annual average the GLCs are within the NAAQS at all AQSRs (Table 24. With mitigation in place, the simulated daily (Figure 20) and annual (Figure 22) PM_{10} concentrations are within NAAQS at all AQSRs (see Table 25).

Project: PM_{10} daily GLCs, for unmitigated activities, are likely to exceed the NAAQS for a distance of up to 6 km from the mining rights boundary (Figure 21). The simulated number of exceedances of the daily PM_{10} NAAQS at five (5) AQSRs are not in compliance with the standard (Table 24). The footprint of exceedance of the annual NAAQS is much larger than that of the baseline scenario, but the annual GLCs are in compliance with the standard (Figure 23 and Table 24). With mitigation in place, the area of exceedances of the PM_{10} daily NAAQS is reduced (Figure 21) and no exceedances of the daily PM_{10} NAAQS were simulated at any of the AQSRs (Table 25). Over an annual average the GLCs are low and well within the standard (Figure 23 and Table 25).

[7] Impact assessment for PM, SO_2 and NO_x (due to sintering process emissions) are presented in the AIR accompanying this report.

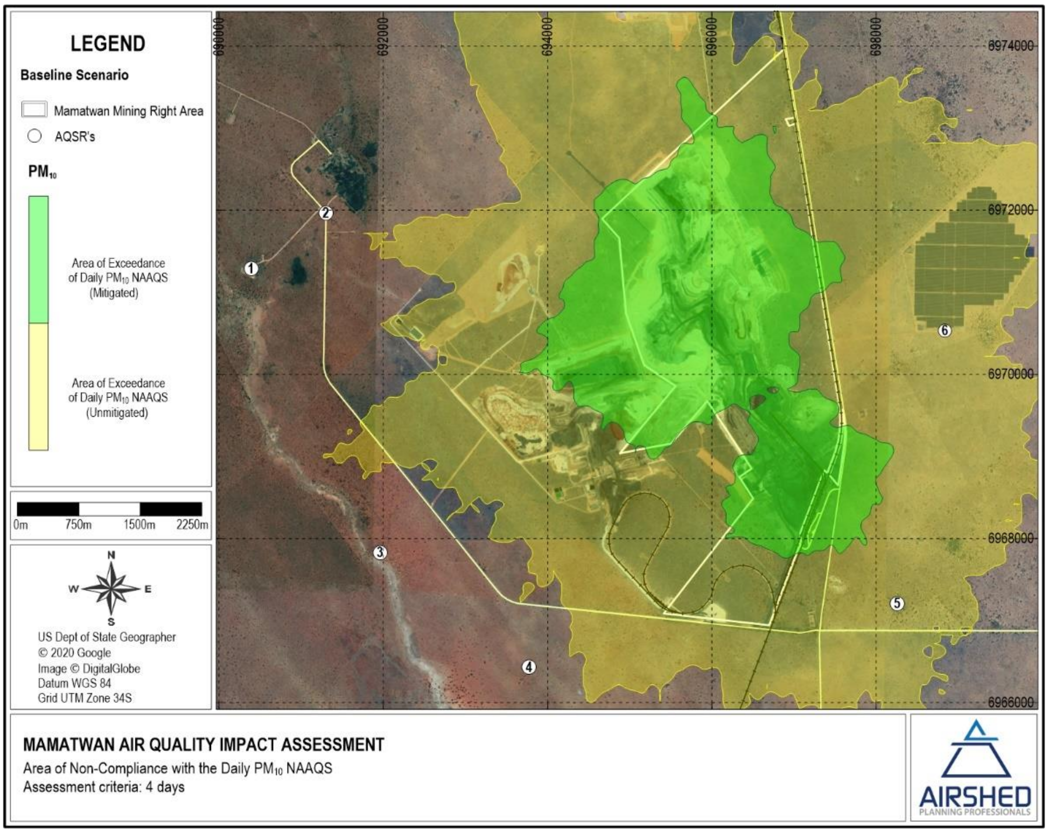

Figure 20: Baseline scenario – Area of non-compliance of daily PM_{10} NAAQS (all sources)

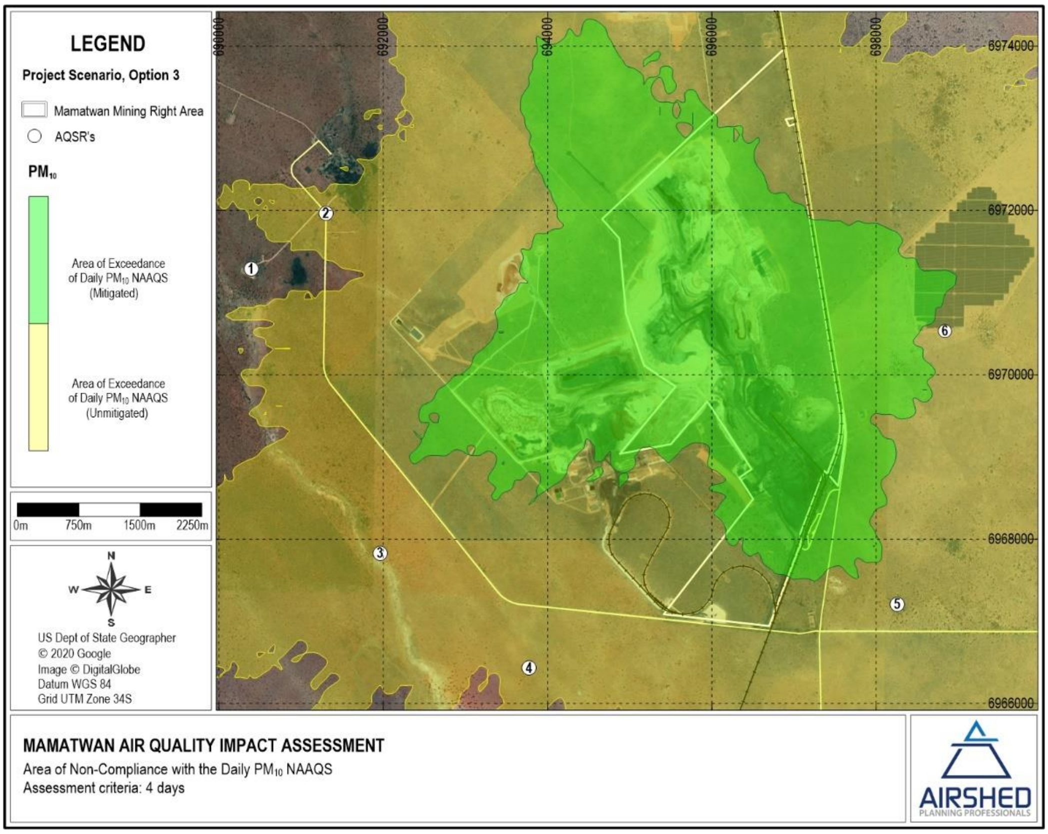

Figure 21: Project scenario, option 3 – Area of non-compliance of daily PM_{10} NAAQS (all sources)

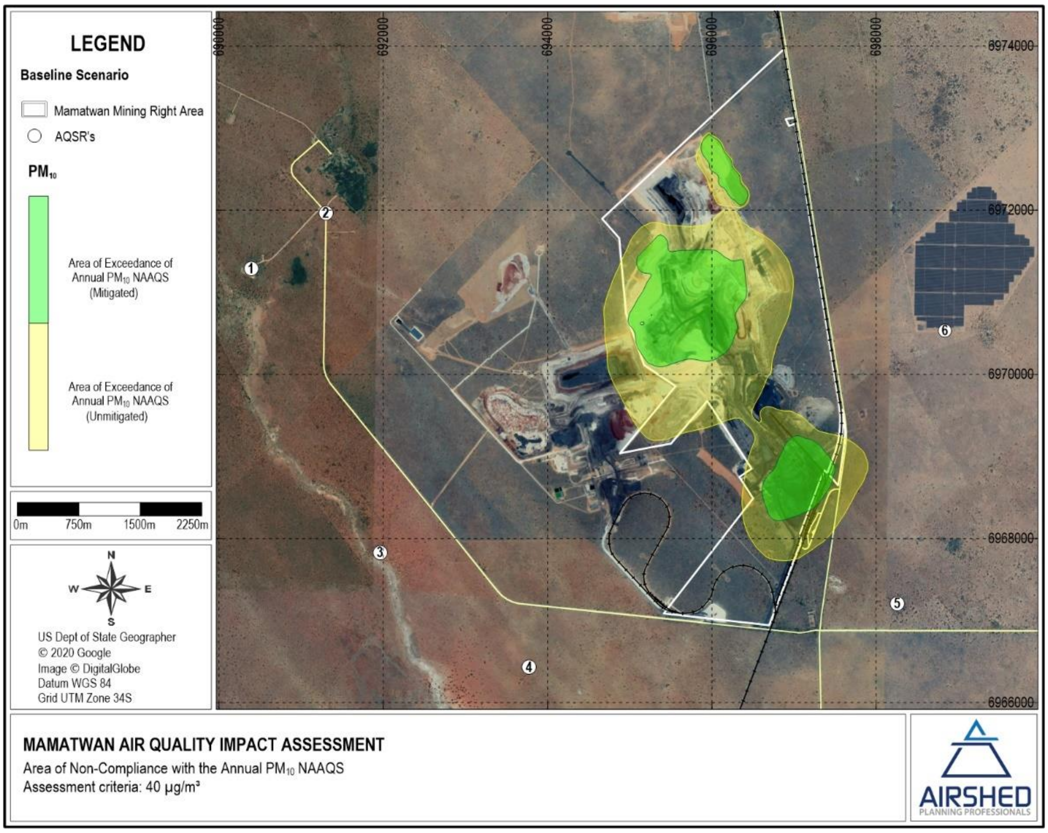

Figure 22: Baseline scenario – Area of non-compliance of annual PM_{10} NAAQS (all sources)

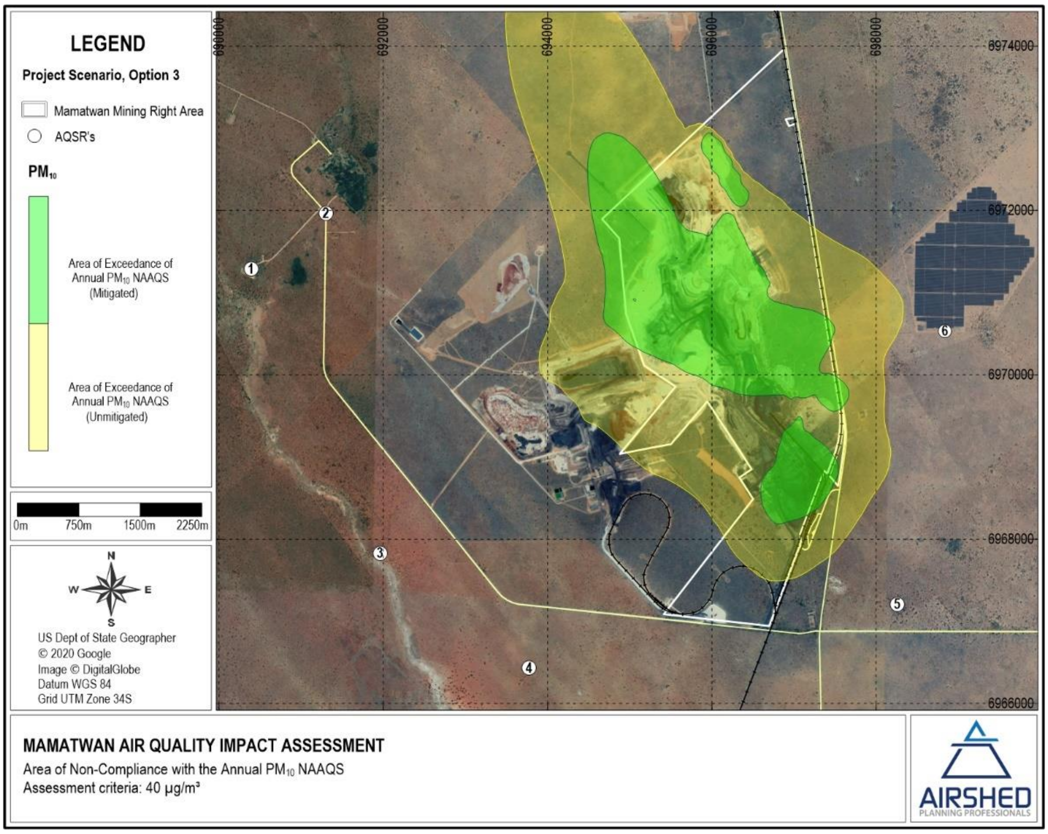

Figure 23: Project scenario, option 3 – Area of non-compliance of annual PM_{10} NAAQS (all sources)

Table 24: Simulated AQSR PM_{10} concentrations (in µg/m³) due to unmitigated operations (all sources)

AQSR	Baseline (µg/m³)				Project Option 1 (µg/m³)				Project Option 2 (µg/m³)				Project Option 3 (µg/m³)			
	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)
1	67.1	1.6	1	Yes	99.1	3.9	1	Yes	99.1	3.9	1	Yes	99.1	3.9	1	Yes
2	71.6	2.1	1	Yes	117.1	5.2	6	No	117.1	5.2	6	No	117.1	5.2	6	No
3	117.8	3.2	2	Yes	140.5	9.2	19	No	140.5	9.2	19	No	140.5	9.2	19	No
4	89.3	5.7	1	Yes	121.0	10.8	9	No	121.0	10.8	9	No	121.1	10.8	9	No
5	174.0	10.1	10	No	222.7	16.1	25	No	222.7	16.1	25	No	223.2	16.3	25	No
6	106.2	10.8	14	No	263.8	26.2	60	No	263.8	26.2	60	No	263.9	26.6	60	No

Table 25: Simulated AQSR PM_{10} concentrations (in µg/m³) due to mitigated operations (all sources)

AQSR	Baseline (µg/m³)				Project Option 1 (µg/m³)				Project Option 2 (µg/m³)				Project Option 3 (µg/m³)			
	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)
1	23.9	0.6	0	Yes	31.5	1.2	0	Yes	31.5	1.2	0	Yes	31.6	1.2	0	Yes
2	27.3	0.7	0	Yes	31.9	1.6	0	Yes	31.9	1.6	0	Yes	31.9	1.6	0	Yes
3	32.8	1.1	0	Yes	46.4	2.8	0	Yes	46.4	2.8	0	Yes	46.4	2.8	0	Yes
4	38.0	1.9	0	Yes	77.0	3.3	1	Yes	77.0	3.3	1	Yes	77.0	3.3	1	Yes
5	52.8	3.4	0	Yes	75.7	5.0	1	Yes	75.7	5.0	1	Yes	76.0	5.1	1	Yes
6	30.3	3.6	0	Yes	69.7	7.6	0	Yes	69.7	7.6	0	Yes	69.8	7.8	0	Yes

4.4.2 $PM_{2.5}$

The simulated highest daily and annual average $PM_{2.5}$ concentrations for the baseline and project scenarios are provided in Figure 24 to Figure 27 respectively, with the GLCs at each of the AQSRs provided in Table 26 (unmitigated activities) and Table 27 (mitigated activities).

Baseline: Simulated daily $PM_{2.5}$ GLCs, with no mitigation in place, are likely to be in non-compliance with the 2030 NAAQS for distances of up to 2 km from the mining rights boundary (Figure 24). From Table 26 no exceedances of the daily $PM_{2.5}$ NAAQS were simulated at any of the AQSRs. With mitigation in place, the footprint of exceedances of the $PM_{2.5}$ daily NAAQS is reduced to within the site (Figure 24). Over an annual average the GLCs are within the standard at all receptors (Figure 26 and Table 27).

Project: Simulated daily $PM_{2.5}$ GLCs, for unmitigated activities, are likely to exceed the 2030 NAAQS for distances up to 3.5 km from the mining rights boundary (Figure 25). The daily $PM_{2.5}$ NAAQS was exceeded at AQSR 6 (Table 26). The maximum distance of exceedance of the annual NAAQS is approximately 800 m from the northern mining rights boundary (Figure 27). Annual average simulated GLCs are within the standard at all receptors.

With mitigation in place, the area of exceedance of the $PM_{2.5}$ daily NAAQS is reduced and no exceedances of the daily $PM_{2.5}$ NAAQS were simulated at any of the AQSRs (Figure 25 and Table 27). Over an annual average, simulated exceedances of the 2030 NAAQS are largely confined to site (Figure 27). Annual average simulated GLCs are within the standard at all receptors.

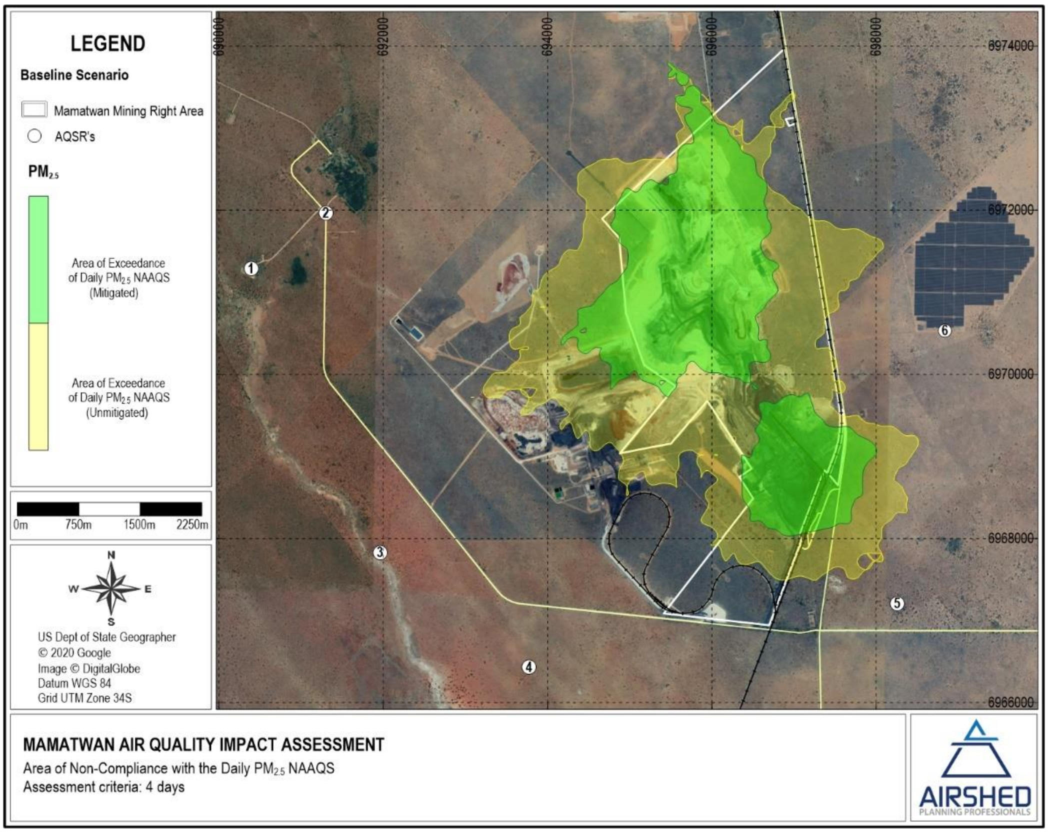

Figure 24: Baseline scenario – Area of non-compliance of daily $PM_{2.5}$ NAAQS (all sources)

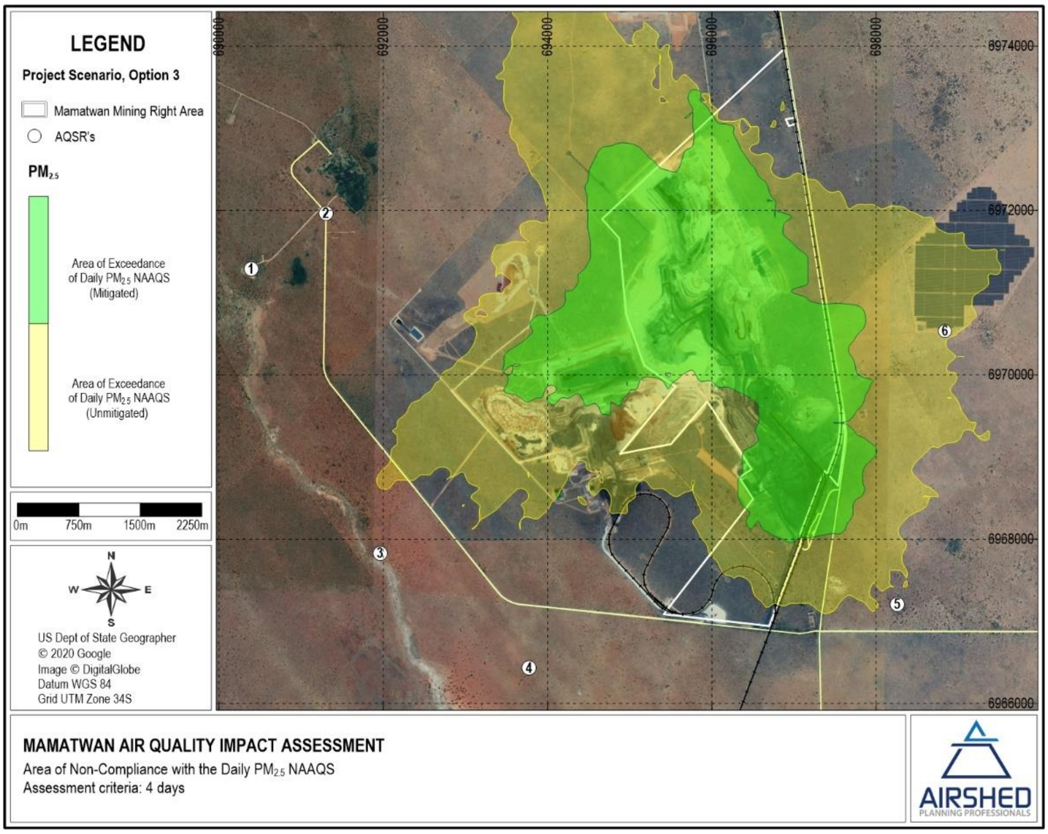

Figure 25: Project scenario, option 3 – Area of non-compliance of daily $PM_{2.5}$ NAAQS (all sources)

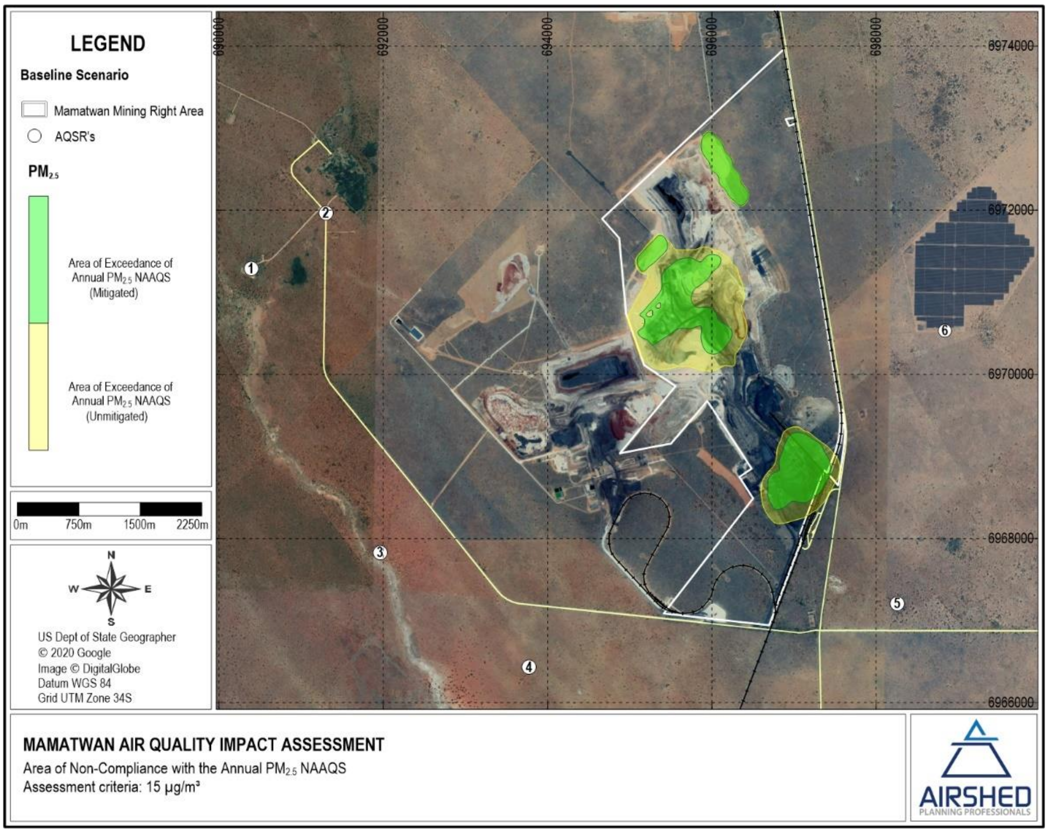

Figure 26: Baseline scenario – Area of non-compliance of annual $PM_{2.5}$ NAAQS (all sources)

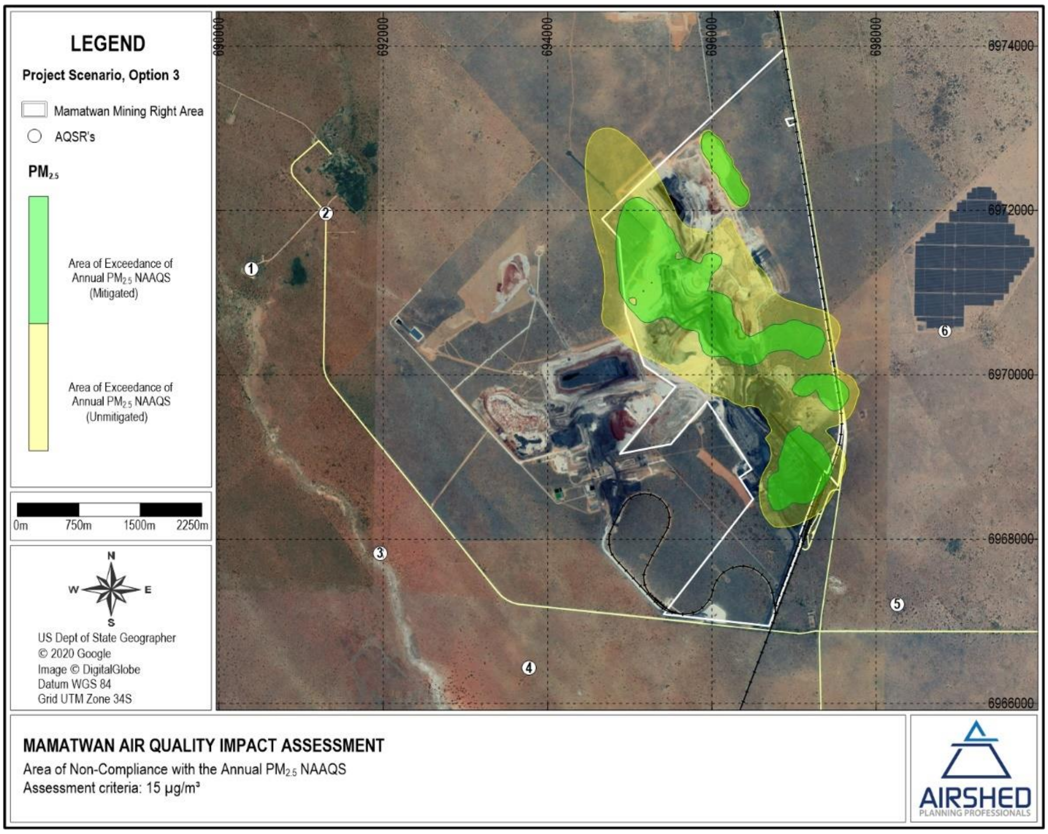

Figure 27: Project scenario, option 3 – Area of non-compliance of annual $PM_{2.5}$ NAAQS (all sources)

Table 26: Simulated AQSR $PM_{2.5}$ concentrations (in µg/m³) due to unmitigated operations (all sources)

AQSR	Baseline (µg/m³)				Project Option 1 (µg/m³)				Project Option 2 (µg/m³)				Project Option 3 (µg/m³)			
	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)
1	7.8	0.2	0	Yes	11.0	0.5	0	Yes	11.0	0.5	0	Yes	11.0	0.5	0	Yes
2	8.3	0.3	0	Yes	21.0	0.7	0	Yes	21.0	0.7	0	Yes	21.1	0.7	0	Yes
3	14.2	0.5	0	Yes	27.2	1.2	1	Yes	27.2	1.2	1	Yes	27.2	1.2	1	Yes
4	33.2	0.8	1	Yes	36.0	1.4	1	Yes	36.0	1.4	1	Yes	36.0	1.4	1	Yes
5	27.8	1.5	1	Yes	32.8	2.2	2	Yes	32.8	2.2	2	Yes	33.1	2.3	2	Yes
6	12.9	1.6	0	Yes	30.0	3.3	8	No	30.0	3.3	8	No	30.0	3.5	9	No

Notes:

(a) Compliance evaluation against 1 January 2030 NAAQS

Table 27: Simulated AQSR $PM_{2.5}$ concentrations (in µg/m³) due to mitigated operations (all sources)

AQSR	Baseline (µg/m³)				Project Option 1 (µg/m³)				Project Option 2 (µg/m³)				Project Option 3 (µg/m³)			
	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)	Highest Daily	Annual	No of Exceedances	Within Compliance (Yes/No)
1	6.0	0.1	0	Yes	6.1	0.2	0	Yes	6.1	0.2	0	Yes	6.1	0.2	0	Yes
2	4.8	0.2	0	Yes	6.9	0.3	0	Yes	6.9	0.3	0	Yes	6.9	0.3	0	Yes
3	9.4	0.2	0	Yes	10.4	0.5	0	Yes	10.4	0.5	0	Yes	10.4	0.5	0	Yes
4	32.1	0.4	0	Yes	14.9	0.6	1	Yes	14.9	0.6	1	Yes	14.9	0.6	1	Yes
5	10.1	0.8	0	Yes	11.8	1.0	1	Yes	11.8	1.0	1	Yes	11.9	1.1	1	Yes
6	6.3	0.8	0	Yes	9.6	1.4	0	Yes	9.6	1.4	0	Yes	10.1	1.4	0	Yes

Notes:

(b) Compliance evaluation against 1 January 2030 NAAQS

4.4.3 Dust Fallout

The simulated maximum daily dustfall rates for the baseline and project scenarios are provided in Figure 28 to Figure 29 respectively, with the values at each of the AQSRs provided in Table 28.

Simulated maximum daily dustfall rates for baseline and project operations (unmitigated and design mitigated operations) are in compliance with the NDCR residential limit (600 mg/m²/day).

Table 28: Simulated AQSR dustfall levels (in mg/m²/day) due to unmitigated and mitigated operations (all sources)

AQSR	Baseline		Project, option 1		Project, option 2		Project, option 3	
	Unmitigated	Mitigated	Unmitigated	Mitigated	Unmitigated	Mitigated	Unmitigated	Mitigated
1	6.6	2.6	11.2	3.8	11.2	3.8	11.2	3.8
2	10.4	3.6	16.2	4.9	16.2	4.9	16.4	4.9
3	21.4	8.5	37.9	12.9	37.9	12.9	38.2	13.0
4	28.1	9.9	40.9	12.8	40.9	12.8	41.2	13.0
5	49.6	21.3	71.9	27.0	71.9	27.0	74.7	27.4
6	75.5	26.8	242.9	69.2	242.9	69.2	244.9	70.2

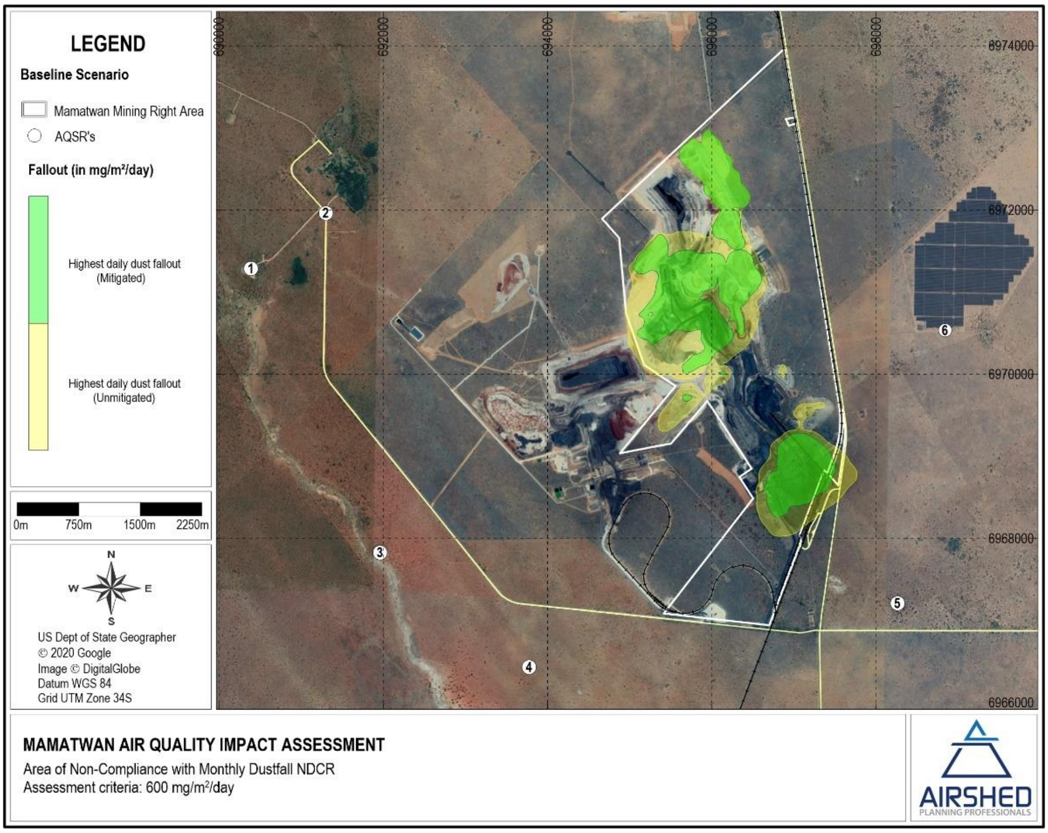

Figure 28: Baseline scenario – Area of non-compliance with monthly dustfall NDCR (all sources)

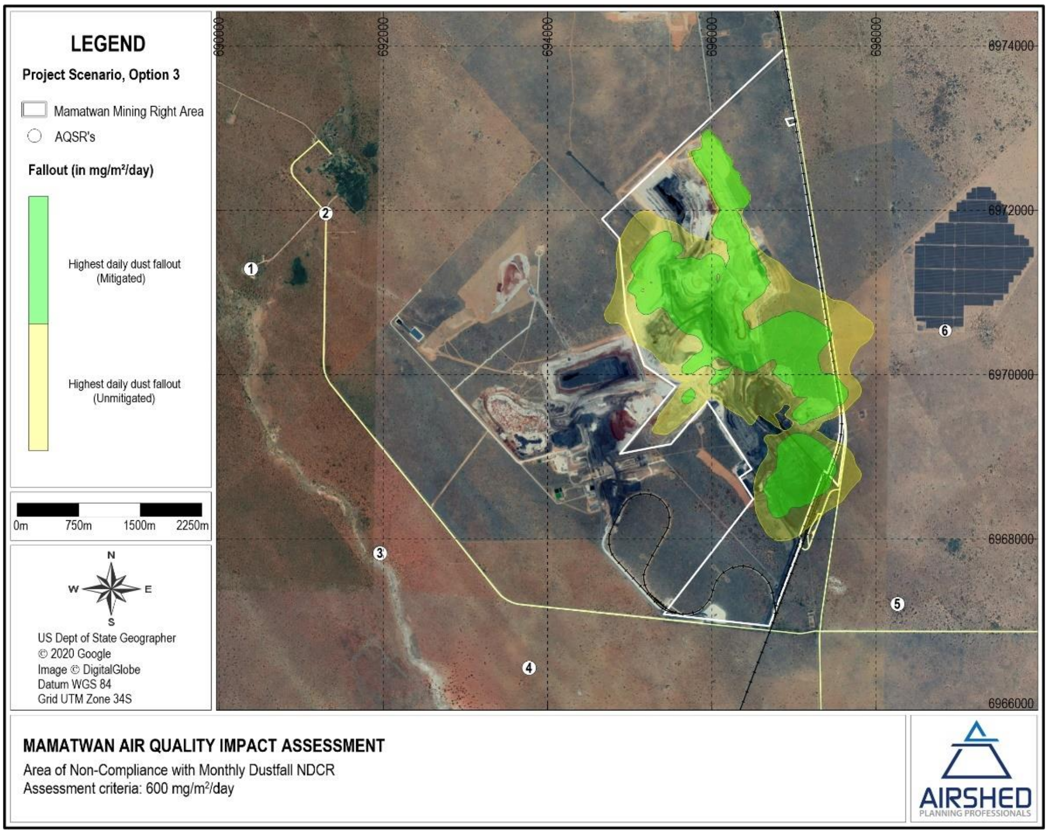

Figure 29: Project scenario, option 3 – Area of non-compliance with monthly dustfall NDCR (all sources)

5 Impact Significance Rating

The significance of air quality impacts was assessed according to an impact significance rating methodology provided by SLR. Refer to Appendix B of this report for the methodology.

5.1 Air Quality Impacts

Likely activities to result in dust impacts during construction are listed in 6.1.1. The significance of air quality impacts due to construction are expected to be:

- Medium (Table 29) for unmitigated activities and Low for design mitigated activities. This applies to $PM_{2.5}$ and PM_{10} concentrations. For dustfall rates the impacts are Low for both unmitigated and mitigated activities.

Table 29: Significance rating for air quality impacts due to Mamatwan Mine activities (construction)

Project Activity	Air Quality Impact		Consequence			Probability	Significance
Phase of project	**Controlled/ uncontrolled**	**Impact**	**Duration**	**Intensity**	**Extent**	**Probability of exposure**	**Significance**
Construction	Uncontrolled	PM_{10}	Low	Medium	Low	Probable	**Medium**
Construction	Controlled	PM_{10}	Low	Low	Low	Probable	**Low**

The significance of air quality impacts due to operational activities were found to be:

- **Baseline** operations: Medium to High (Table 30) for unmitigated activities and Low for design mitigated activities. This applies to $PM_{2.5}$ and PM_{10} concentrations. For dustfall rates the impacts are Low for both unmitigated and mitigated activities.
- **Project** operations: High (Table 31) for unmitigated activities and Low for design mitigated activities. This applies to $PM_{2.5}$ and PM_{10} concentrations. For dustfall rates the impacts are Low for both unmitigated and mitigated activities.

Table 30: Significance rating for air quality impacts due to Mamatwan Mine activities (baseline scenario)

Project Activity	Air Quality Impact		Consequence			Probability	Significance
Phase of project	**Controlled/ uncontrolled**	**Impact**	**Duration**	**Intensity**	**Extent**	**Probability of exposure**	**Significance**
Operational – Baseline	Uncontrolled	PM_{10}	Medium	Medium	High	Probable	**High**
Operational – Baseline	Controlled	PM_{10}	Medium	Very Low	Medium	Probable	**Low**
Operational – Baseline	Uncontrolled	$PM_{2.5}$	Medium	Medium	Medium	Probable	**Medium**

Project Activity	Air Quality Impact		Consequence			Probability	Significance
Operational – Baseline	Controlled	$PM_{2.5}$	Medium	Very Low	Medium	Probable	**Low**
Operational – Baseline	Uncontrolled	Dustfall	Medium	Low	Low	Probable	**Low**
Operational – Baseline	Controlled	Dustfall	Medium	Low	Low	Probable	**Low**

Table 31: Significance rating for air quality impacts due to Mamatwan Mine activities (project scenario)

Project Activity	Air Quality Impact		Consequence			Probability	Significance
Phase of project	**Controlled/ uncontrolled**	**Impact**	**Duration**	**Intensity**	**Extent**	**Probability of exposure**	**Significance**
Operational – Project	Uncontrolled	PM_{10}	Medium	Medium	High	Probable	**High**
Operational – Project	Controlled	PM_{10}	Medium	Very Low	Medium	Probable	**Low**
Operational – Project	Uncontrolled	$PM_{2.5}$	Medium	Medium	High	Probable	**High**
Operational – Project	Controlled	$PM_{2.5}$	Medium	Very Low	Medium	Probable	**Low**
Operational – Project	Uncontrolled	Dustfall	Medium	Low	Low	Probable	**Low**
Operational – Project	Controlled	Dustfall	Medium	Low	Low	Probable	**Low**

The likely activities to result in dust impacts during closure are listed in 6.1.1. Similar to construction, the significance of air quality impacts due to the closure phase is expected to be:

- Medium (Table 32) for unmitigated activities and Low for design mitigated activities. This applies to $PM_{2.5}$ and PM_{10} concentrations. For dustfall rates the impacts are Low for both unmitigated and mitigated activities.

Table 32: Significance rating for air quality impacts due to Mamatwan Mine activities (closure)

Project Activity	Air Quality Impact		Consequence			Probability	Significance
Phase of project	**Controlled/ uncontrolled**	**Impact**	**Duration**	**Intensity**	**Extent**	**Probability of exposure**	**Significance**
Closure	Uncontrolled	PM_{10}	Low	Medium	Low	Probable	**Medium**
Closure	Controlled	PM_{10}	Low	Low	Low	Probable	**Low**

6 Air Quality Management Measures

In the light of the potential exceedances of the air quality limits around the mining operations, it is recommended that the project proponent commit to adequate air quality management planning throughout the life of the project. The air quality management plan provides options on the control of dust particles at the main sources, while the monitoring network is designed to track the effectiveness of the mitigation measures.

Based on the findings of the impact assessment, the following mitigation, management and monitoring recommendations are proposed.

6.1 Air Quality Management Objectives

The main objective of the proposed air quality management measures for the project is to ensure that operations result in ambient air concentrations (specifically $PM_{2.5}$ and PM_{10}) and dustfall rates that are within the relevant ambient air quality standards and regulations outside the mining area and at the relevant AQSRs. In order to define site specific management objectives, the main sources of pollution need to be identified. Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

6.1.1 Ranking of Sources

The ranking of sources serves to confirm the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Sources ranking can be established on:

- Emissions ranking; based on the comprehensive emissions inventory established for the operations (Section 4.2); and
- Impacts ranking; based on the simulated pollutant GLCs.

Sources were ranked based on PM_{10} emissions and impacts, since PM_{10} impacts were considered most significant among the three pollutants assessed, as illustrated in Figure 30 (baseline) and Figure 31 (project).

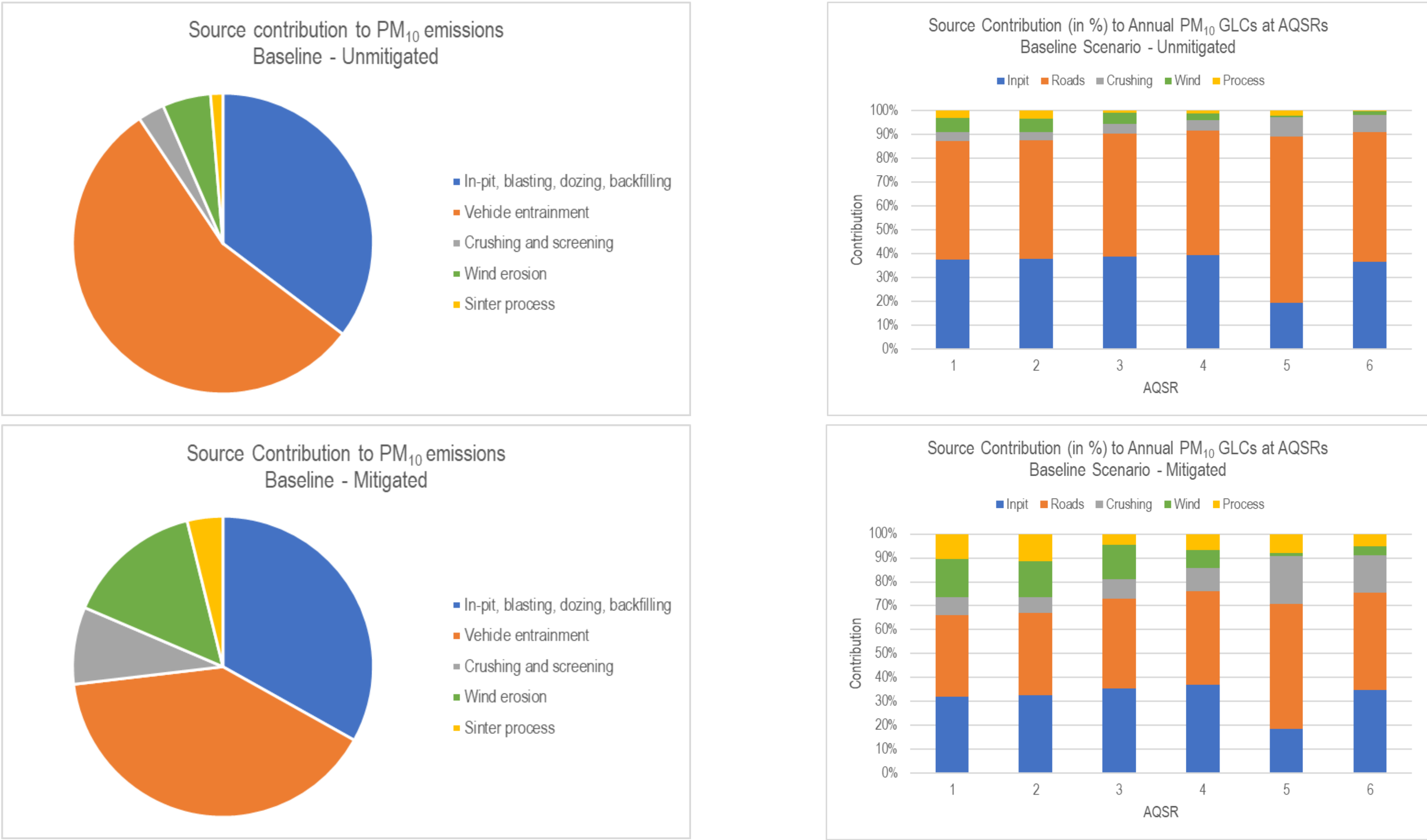

Figure 30: Source ranking for PM_{10}, based on emissions and ground level impacts at AQSRs (baseline scenario)

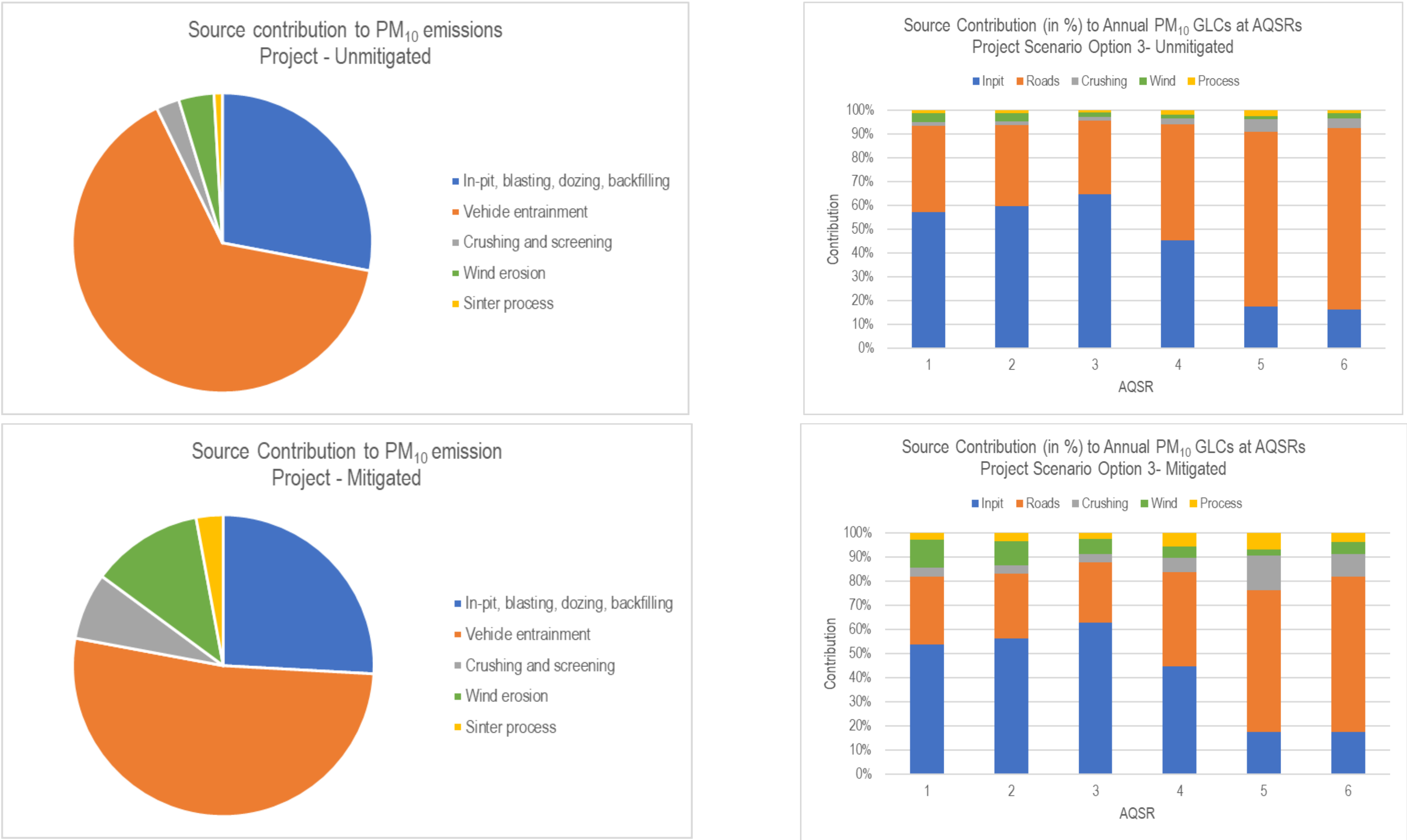

Figure 31: Source ranking for PM_{10}, based on emissions and ground level impacts at AQSRs (project scenario)

Ranking of sources based on qualified impacts for the construction, closure and post-closure phases, and quantified emissions and impacts for the operational phase are as follows:

- **Construction**: Likely activities to result in dust impacts during construction are:
    - metal and concrete works for the establishment of new plant and mine infrastructure;
    - scraping of topsoil and land clearing;
    - material loading and stockpiling; and
    - vehicle entrainment on unpaved road surfaces during construction.
- **Baseline**: The primary and secondary sources of emissions and impact at AQSRs during the baseline scenario, for both unmitigated and mitigated activities are: roads and in-pit operations. For unmitigated activities roads are the dominant source of emissions and impacts at all AQSRs. For mitigated activities, the AQSRs to the west and south of the mine boundary are impacted more by in-pit activities and those to the east of the mine boundary more by vehicle entrainment.
- **Project**: For the project scenario, emissions due to both unmitigated and mitigated activities are dominated by the roads source. Impacts due to unmitigated activities are dominated by in-pit activities at AQSRs 1 to 3, and by roads at AQSRs 4 to 6. For mitigated activities the contribution of impacts due to in-pit activities remains largely unchanged, but the contribution due to roads are reduced at all AQSRs.
- **Closure and Post-closure**: Likely activities to result in dust impacts during closure are:
    - infrastructure removal/demolition;
    - topsoil recovered from stockpiles for rehabilitation and re-vegetation of surroundings; and
    - vehicle entrainment on unpaved road surfaces during rehabilitation – once that is done, vehicle activity associated with the operations should cease.

6.2 Proposed Mitigation and Management Measures

6.2.1 Proposed Mitigation Measures and/or Target Control Efficiencies

From the above discussion it is recommended that the project include the following measures:

- Construction and closure phases:
    - Air quality impacts during construction would be reduced through basic control measures such as limiting the speed of haul trucks; limit unnecessary travelling of vehicles on unpaved roads; and to apply water sprays on regularly travelled, unpaved sections.
    - When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and the material transported must be covered to minimise windblown dust.
    - The access road to the sinter plant also needs to be kept clean to minimise carry-through of mud on to public roads.
- Operational phase – the recommended mitigation measures for the proposed operations are shown in Table 33.

Table 33: Air Quality Management Plan – Operation Phase

Aspect	Impact	Management Actions/Objectives	Responsible Person(s)	Target Date
Vehicle activity on unpaved roads	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Regular water sprays on unpaved roads to ensure at least 75% control efficiency. Literature indicates an application rate >2 litre/m²/hour should achieve this. • Monthly physical inspection of road surface, daily visual observation of entrained dust emissions from unpaved road surfaces.	Environmental Manager	On-going during operational phase
Drilling & Blasting	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Controlled blasting techniques to be used to ensure minimal dust generation. • Blasting only to be conducted on cloudless days, if possible. • Addition of chemical surfactants to water sprays to lower water surface tension and increase binding properties. • Drill rigs to be fitted with dust suppression to achieve 97% control efficiency.	Mine Production Engineer Drill Rig Operator Environmental Officer	On-going during operational phase
Materials Handling	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Increase in-pit material moisture content. • Drop height from excavator into haul trucks to be kept at a minimum for ore and waste rock. • Tipping onto ROM storage piles to be controlled through water sprays, should visible amounts of dust be generated. This should result in a 50% control efficiency. • Keep material handled by dozers and wheeled loaders moist to achieve a control efficiency of 50%, especially during dry periods. • Regular clean-up at loading areas.	Mine Production Engineer Environmental Officer	On-going during operational phase
Wind Erosion	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Water sprays at ROM stockpile can achieve 50% control efficiency. Increase in moisture content provides higher threshold friction velocity and ensures that particulates are not as easily entrained due to high surface winds. • Reshape all disturbed areas to their natural contours. • Cover disturbed areas with previously collected topsoil and replant native species. • Rock cladding with larger pieces of waste rock is recommended to reduce wind erosion emissions from the overburden storage piles. • Revegetation of overburden stockpile is recommended.	Mining Engineer Environmental Officer	On-going during operational phase
Crushing	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Water sprays at mobile crushers to achieve at least 50% control efficiency.	Mining Engineer Environmental Officer	On-going during operational phase

6.3 Performance Indicators

Key performance indicators against which progress of implemented mitigation and management measures may be assessed, form the basis for all effective environmental management practices. In the definition of key performance indicators careful attention is usually paid to ensure that progress towards their achievement is measurable, and that the targets set are achievable given available technology and experience.

Performance indicators are usually selected to reflect both the source of the emission directly (source monitoring) and the impact on the receiving environment (ambient air quality monitoring). Ensuring that no visible evidence of windblown dust exists represents an example of a source-based indicator, whereas maintaining off-site dustfall levels, at the identified AQSRs, to below 600 mg/m^2-day represents an impact- or receptor-based performance indicator.

Except for vehicle/equipment emission testing, source monitoring at operational activities can be challenging due to the fugitive and wind-dependent nature of particulate emissions. The focus is therefore rather on receptor-based performance indicators i.e. compliance with ambient air quality standards and dustfall regulations.

6.3.1 Ambient Air Quality Monitoring

Ambient air quality monitoring can serve to meet various objectives, such as:

- Compliance monitoring;
- Validate dispersion model results;
- Use as input for health risk assessment;
- Assist in source apportionment;
- Temporal and spatial trend analysis;
- Source quantification; and,
- Tracking progress made by control measures.

To ensure that mitigation is effective, it is recommended that the dustfall monitoring network at the mine be expanded to include single dust buckets at AQSR 4 and AQSR 5 (Figure 32). It is also recommended that PM_{10} sampling be conducted at AQSR 5 (or AQSR 6 if it is more secure). This can be done as an annual campaign before the project commences (as part of the baseline) and again once mitigated project operations are in place.

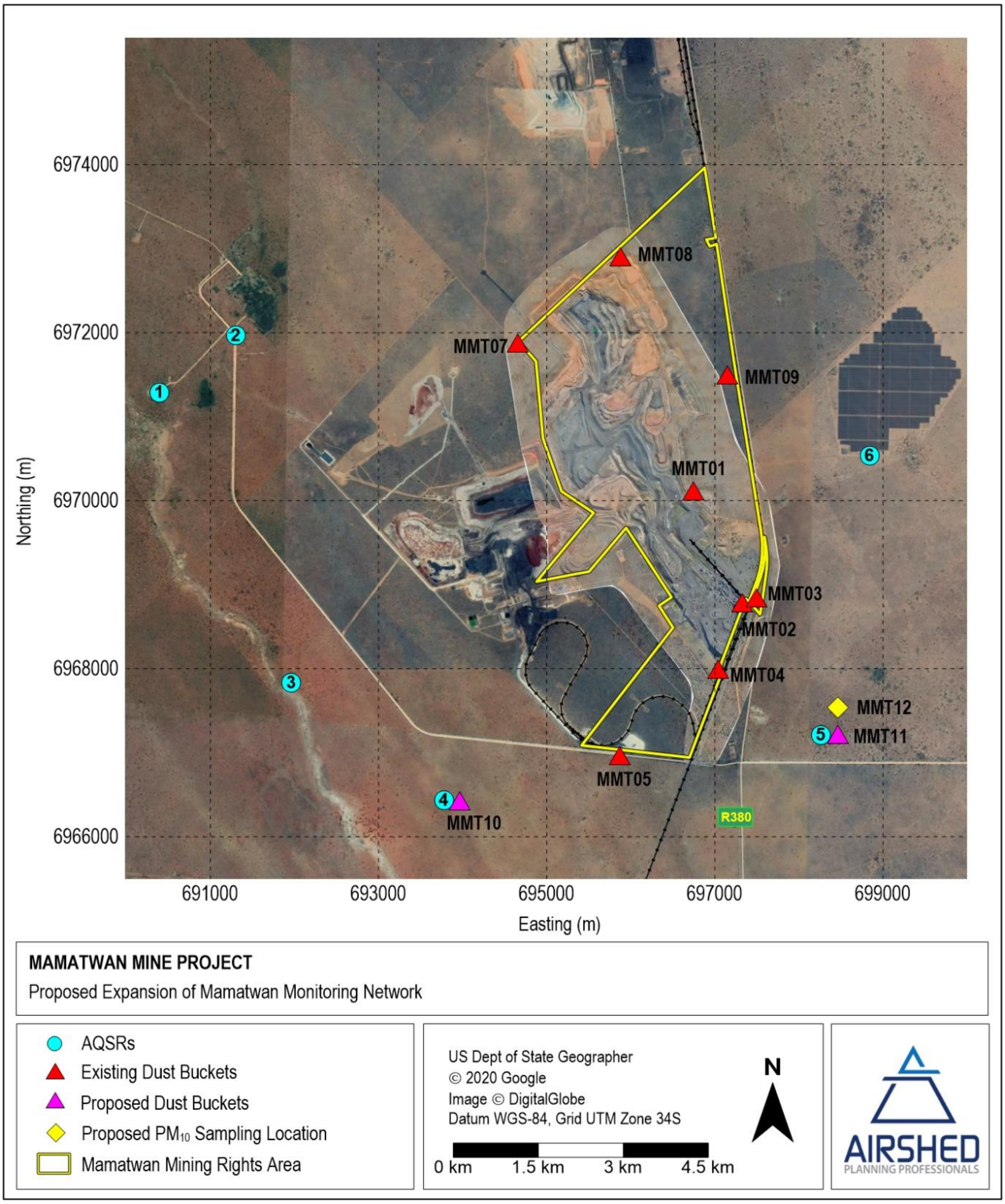

Figure 32: Recommended additions to the current air quality monitoring network at Mamatwan Mine

6.4 Periodic Inspections and Audits

Periodic inspections and external audits are essential for progress measurement, evaluation and reporting purposes. It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly), with annual environmental audits being conducted. Annual environmental audits should be continued at least until closure. Results from site inspections and monitoring efforts should be combined to determine progress against source- and receptor-based performance indicators. Progress should be reported to all interested and affected parties, including authorities and persons affected by pollution.

The criteria to be taken into account in the inspections and audits must be made transparent by way of minimum requirement checklists included in the management plan. Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event that progress towards targets is indicated by the quarterly/annual reviews to be unsatisfactory.

6.5 Liaison Strategy for Communication with Interested and Affected Parties (I&APs)

Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. Management plans should stipulate specific intervals at which forums will be held and provide information on how people will be notified of such meetings. Given the proximity of the study site to the nearby farmsteads, it is recommended that such meetings be scheduled and held at least on an annual basis. A complaints register must be kept at all times.

6.6 Financial Provision

The budget should provide a clear indication of the capital and annual maintenance costs associated with dust control measures and dust monitoring plans. It may be necessary to make assumptions about the duration of aftercare prior to obtaining closure. This assumption must be made explicit so that the financial plan can be assessed within this framework. Costs related to inspections, audits, environmental reporting and I&APs liaison should also be indicated where applicable. Provision should also be made for capital and running costs associated with dust control contingency measures and for security measures. The financial plan should be audited by an independent consultant, with reviews conducted on an annual basis.

7 Greenhouse Gas Statement

7.1 Introduction

7.1.1 The Greenhouse Effect

Greenhouse gases are "those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are several anthropogenic (human made) GHG in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol deals with the GHG sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) (IPCC, 2007). Human activities since the beginning of the Industrial Revolution (taken as the year 1750) have produced a 40% increase in the atmospheric concentration of carbon dioxide, from 280 ppm in 1750 to 406 ppm in early 2017 (NOAA, 2017).. This increase has occurred despite the uptake of a large portion of the emissions by various natural "sinks" involved in the carbon cycle (NOAA, 2017). Anthropogenic carbon dioxide (CO_2) emissions (i.e., emissions produced by human activities) come from combustion of fossil fuels, principally coal, oil, and natural gas, along with deforestation, soil erosion and animal agriculture (IPCC, 2007).

7.1.2 International Agreements

In 1992, countries joined an international treaty, the United Nations Framework Convention on Climate Change, (UNFCCC) as a framework for international cooperation to combat climate change by limiting average global temperature increases and the resulting climate change, and coping with impacts that were, by then, inevitable.

By 1995, countries launched negotiations to strengthen the global response to climate change, and, two years later, adopted the Kyoto Protocol. The Kyoto Protocol legally binds developed country parties to emission reduction targets. The Protocol's first commitment period started in 2008 and ended in 2012. As agreed in Doha in 2012, the second commitment period began on 1 January 2013 and will end in 2020 (UNFCCC, 2017) but due to lack of ratification has not come into force.

The Paris Agreement (2016) builds upon the Convention and – for the first time – brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

The central aim of the Paris Agreement is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2.0°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives.

The Paris Agreement requires all Parties to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts.

In 2018, Parties will take stock of the collective efforts in relation to progress towards the goal set in the Paris Agreement and to inform the preparation of NDCs. There will also be a global stocktake every five years to assess the collective progress towards achieving the purpose of the Agreement and to inform further individual actions by Parties.

As of October 2020, 189 Parties of the 197 Parties to the UNFCCC Convention, including South Africa, had ratified the Paris agreement. South Africa submitted its Nationally Determined Contribution (NDC) to the UNFCCC on 25 September 2016.

7.2 South Africa's Status in terms of Climate Change and Quantification of Greenhouse Gases

7.2.1 South African National Climate Change Response Policy 2011

South Africa ratified the UNFCCC in August 1997 and acceded to the Kyoto protocol in 2002, with effect from 2005. However, since South Africa is an Annex 1 country it implies no binding commitment to cap or reduce GHG emissions.

The National Climate Change Response White Paper stated that in responding to climate change, South Africa has two objectives: to manage the inevitable climate change impacts and to contribute to the global effort in stabilising GHG emissions at a level that avoids dangerous anthropogenic interference with the climate system. The White Paper proposes mitigation actions, especially a departure from coal-intensive electricity generation, be implemented in the short- and medium-term to match the GHG trajectory range. Peak GHG emissions are expected between 2020 and 2025 before a decade long plateau period and subsequent reductions in GHG emissions.

The White Paper also highlighted the co-benefit of reducing GHG emissions by improving air quality and reducing respiratory diseases by reducing ambient particulate matter, ozone and SO_2 concentrations to levels in compliance with NAAQS by 2020. In order to achieve these objectives, the DFFE established a national GHG emissions inventory that reports through SAAQIS.

7.2.2 Nationally Determined Contribution

The first South African Nationally Determined Contribution (NDC) submission was completed in 2016. This was undertaken to comply with decision 1/CP.19 and 1/CP.20 of the Conference of the Parties to the UNFCCC. A draft update of the first NDC was published for public comment[10] on the 30th March 2021 in preparation for the 26th Conference of the Parties (to be held in Glasgow, Scotland in November 2021). This document describes South Africa's NDC on adaptation, mitigation and finance and investment necessities to undertake the resolutions with updated revisions to the adaptation goals and mitigation targets.

As part of the updated adaption portion the following goals have been assembled:

1. Goal 1: Enhance climate change adaptation governance and legal framework.
2. Goal 2: Develop an understanding of the impacts on South Africa of 1.5 and 2°C global warming and the underlying global emission pathways through geo-spatial mapping of the physical climate hazards, and adaptation needs in the context of strengthening the key sectors of the economy. This will provide the scientific basis for strengthening the national and provincial governments' readiness to respond to climate risk.
3. Goal 3: Implementation of National Climate Change Adaptation Strategy adaptation interventions for the period 2021 to 2030, where priority sectors have been identified as biodiversity and ecosystems; water; health; energy; settlements (coastal, urban, rural); disaster risk reduction, transport infrastructure, mining, fisheries, forestry and agriculture.
4. Goal 4: Mobilise funding for adaptation implementation through multilateral funding mechanisms.
5. Goal 5: Quantification and acknowledgement of the national adaptation and resilience efforts.

As part of the mitigation portion the following have been, or can be, implemented at National level:

- The approval of 79 (5 243 MW) renewable energy Independent Power Producer projects as part of a Renewable Energy Independent Power Producer Procurement Programme. An additional 6 300 MW is being deliberated.
- A "Green Climate Fund" has been created to back green economy initiatives. This fund will be increased in the future to sustain and improve successful initiatives.
- It is intended that by 2050 electricity will be decarbonised.
- Carbon Capture and Sequestration (or Carbon Capture and Storage) (CCS).
- To support the use of electric and hybrid electric vehicles.
- Reduction of emissions can be achieved through the use of energy efficient lighting; variable speed drives and efficient motors; energy efficient appliances; solar water heaters; electric and hybrid electric vehicles; solar photovoltaic (PV); wind power; CCS; and advanced bioenergy.
- Updated targets based on revised 100-year global warming potential (GWP) factors (published in the Annex to decision 18/CMA.1 of the Intergovernmental Panel on Climate Change's (IPCC) 5th assessment report) and based on exclusion of land sector emissions arising from natural disturbance. The updated NDC mitigation targets, consistent with South Africa's fair share, are presented in Table 34.

[10] https://www.environment.gov.za/mediarelease/creecy_indc2021draftlaunch_climatechangecop26

Table 34: South Africa's NDC mitigation targets

Year	Target	Corresponding period
2025	South Africa's annual GHG emissions will be in a range between 398 - 510 Mt CO_2-e.	2021-2025
2030	South Africa's annual GHG emissions will be in a range between 398 - 440 Mt CO_2-e.	2026-2030

7.2.3 South African Energy Supply

Coal provides in the order of 70% of the primary energy supply to the SA economy, with more than 90% of the electricity being generated from coal combustion. South Africa is thus regarded as having a carbon-intensive energy economy.

The 1998 White Paper on the Energy Policy of the Republic of South Africa covered both supply and demand of energy for the next decade and made specific provision for independent suppliers of energy to enter the market. No additional capacity ensued during the decade 1998 to 2008, leading to the 'load shedding' of 2008 and the subsequent short-term interventions to ensure stability of supply. The 2011 Integrated Resource Plan (IRP) (DOE, 2011) provided a planning basis for the period up to 2030 and made provision for the supply of energy – including renewable energy – by independent producers, as well as 9 600 MW of nuclear energy over that period. An update of the IRP was gazetted on the 18th October 2019 (Government Gazette No 42784) where the update accounts for electricity capacity development changes since the 2011 IRP. The drafts IRP updates attracted considerable criticism regarding the cost and greenhouse gas implications as part of the public participation process, including a report by the Council for Scientific and Industrial Research (CSIR) arguing for a much larger use of renewable sources (Wright, et al., 2017). Although the planning period is unchanged (2010 to 2030), the updated IRP includes increased capacity allocations to solar PV and wind, alongside a decrease in gas and diesel and the inclusion of nuclear and storage capacity (DMR, 2019).

As of March 2020, 112 renewable energy Independent Power Producer (IPP) projects have been approved and several others are being deliberated as part of a Renewable Energy Independent Power Producer Procurement Programme (REI4P) where 4 201 MW of renewable electricity generating capacity has been connected to the grid (DFFE, 2021).

7.2.4 GHG Inventories

7.2.4.1 National GHG Emissions Inventory

South Africa is perceived as a global climate change contributor and is undertaking steps to mitigate and adapt to the changing climate. DFFE is categorised as the lead climate change institution and is required to coordinate and manage climate related information such as development of mitigation, monitoring, adaption, and evaluation strategies (DEA, nd). This includes the establishment and updating of the National GHG Inventory. The National Greenhouse Gas Improvement Programme (GHGIP) has been initiated; it includes sector specific targets to improve methodology and emission factors used for the different sectors as well as the availability of data.

The 2000 to 2017 National GHG Inventory was prepared using the 2006 IPCC Guidelines (IPCC, 2006). According to the draft 4th Biennial Update Report to the UNFCCC (DFFE, 2020), the total GHG emissions in 2017 were estimated at approximately 574.696 million metric tonnes CO_2-e (excluding Forestry and Other Land Use (FOLU)). This was a 27.9% increase from the 2000 total GHG emissions (excluding FOLU). FOLU is estimated to be a net carbon sink which reduces the 2017 GHG emissions to 532.173 million metric tonnes CO_2-e. The assessment (excluding FOLU) showed the main sectors contributing to GHG emissions in 2017 to be the energy industry, contributing 79.8% to the total GHG emissions (excluding FOLU), this increased by 2.9% from 2000.

7.2.4.2 GHG Emission Inventory for the Sector

MMT operations, including the proposed project, will be categorised in the "IPPU" (Industrial Process and Product Use) category for both the global GHG inventory and for the national GHG inventory. According to the World Resources Institute – CAIT Climate Data Explorer the 2017 global GHG emissions from the IPPU category were approximately 2 825.88 Mt CO_2-e; 6% of the total anthropogenic GHG emissions (excluding FOLU). The South African IPPU sector contributed represented 0.8% of the global emissions from the sector; contributed approximately 21.55 Mt CO_2-e to global emissions in 2017.

7.2.5 Physical Risks of Climate Change on the Region

In 2017 the South African Weather Services (SAWS) published an updated Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections (SAWS, 2017). It must be noted that as with all atmospheric models there is the possibility of inaccuracies in the results because of the model's physics and accuracy of input data; for this reason, an ensemble of models' projections is used to determine the potential change in near-surface temperatures and rainfall depicted in the CCRA. The projections are for to 30-year periods described as the near future (2036 to 2065) and the far future (2066 to 2095). Projected changes are defined relative to a historical 30-year period (1976 to 2005). The Rossby Centre regional model (RCA4) was used in the predictions for the CCRA which included the input of nine GCMs results. The RCA4 model was used to improve the spatial resolution to 0.44° x 0.44°- the finest resolution GCMs in the ensemble were run at resolutions of 1.4° x 1.4° and 1.8° x 1.2°.

Two trajectories are included based on the four Representative Concentration Pathways (RCPs) discussed in the IPCC's fifth assessment report (AR5) (IPCC, 2013). RCPs are defined by their influence on atmospheric radiative forcing in the year 2100. RCP4.5 represents an addition to the radiation budget of 4.5 W/m^2 as a result of an increase in GHGs. The two RCPs selected were RCP4.5 representing the medium-to-low pathway and RCP8.5 representing the high pathway. RCP4.5 is based on a CO_2 concentration of 560 ppm and RCP8.5 on 950 ppm by 2100. RCP4.5 is based on if current interventions to reduce GHG emissions being sustained (after 2100 the concentration is expected to stabilise or even decrease). RCP8.5 is based on if no interventions to reduce GHG emissions being implemented (after 2100 the concentration is expected to continue to increase).

7.2.5.1 RCP4.5 Trajectory

Based on the median, for the region in which MMT and the proposed project are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 1.0°C and 1.5°C for the near future and between 2.5°C and 3.0°C for the far future. The seasonal average temperatures are expected to increase for all seasons, in the same order as the annual average increases, with slightly larger temperature increases in autumn (March to May) and spring (September to November). The total annual rainfall is expected to increase by between 0 mm and 5 mm for the near future and decrease by up to 5 mm in the far future. Seasonal rainfall is expected to increase in summer (December to February) in the near- and far future, while other seasons are likely to show decreases between 5 and 10 mm.

7.2.5.2 RCP8.5 Trajectory

Based on the median, for the region in which MMT and the proposed project are situated, the annual average near surface temperatures (2 m above ground) are expected to increase by between 2.5°C and 3.0°C for the near future and between 4.5°C and 5.0°C for the far future. The seasonal average temperatures are expected to increase for all seasons in similar ranges to the annual average temperature, with slightly higher increases in spring, summer, and autumn. The total annual rainfall change is likely to decrease by between 0 and 5 mm, while it is more uncertain for the far future with potential decrease up to 30 mm. Seasonal rainfall changes could see an increase of 20 mm in summer in the near future with decreased up to 5 mm in spring and winter, and a decrease of up to 10 mm in autumn. In the far future, the seasonal the rainfall changes are similar to the near future, but with lower increased rainfall in summer of up to 5 mm and a higher decreased rainfall in winter of up to 10 mm.

7.2.5.3 Water Stress and Extreme Events

South Africa is known to be a water stressed country (Kusangaya, Shekede, & Mbengo, 2017), and MMT falls within one of the extremely high water risk zones (Hofste, et al., 2019). It also falls in the extremely high interannual variability but with a low to medium seasonal variability, leading to a low to medium drought risk[11]. Climate change, through elevated temperatures, is likely to increase evaporation rates and decrease water volumes available for dryland and irrigated agriculture (Davis-Reddy & Vincent, 2017). Commercial agriculture (stock farming) is the predominant agricultural land-use in the vicinity of Hotazel, where the vegetation is of the Kathu Bushveld (South African National Biodiversity Institute, 2021).

Extreme weather events affecting southern Africa, including heat waves, flooding due to intensified rainfall due to large storms and drought, have been shown to increase in number since 1980 (Davis-Reddy & Vincent, 2017). Projections indicate (Davis-Reddy & Vincent, 2017):

- with high confidence, that heat wave and warm spell duration are likely to increase while cold extremes are likely to decrease, where up to 80 days above 35°C are projected by the end of the century under the RCP4.5 scenario;
- with medium confidence, that droughts are likely to intensify due to reduced rainfall and/or an increase in evapotranspiration; and
- with low confidence, that heavy rainfall events (more than 20 mm per 24 hours) will increase.

[11] https://www.wri.org/applications/aqueduct/water-risk-atlas/#/?advanced=false&basemap=hydro&indicator=drr_cat&lat=-27.143478757638256&lng=22.164916992187504&mapMode=view&month=1&opacity=0.5&ponderation=DEF&predefined=false&projection=absolute&scenario=optimistic&scope=baseline&timeScale=annual&year=baseline&zoom=9

7.3 GHG Assessment

7.3.1 GHG Emissions Estimation Approach

As the emission of GHG has a global impact, it is not feasible to follow the normal impact assessment methodology where the state of the physical environment after implementation of the project is compared to the condition of the physical environment prior to its implementation. Instead, this report will assess the following:

(i) the GHG emissions associated with disturbance of the carbon stocks during land clearing; the GHG emissions associated with electricity and liquid fuel-use for normal operation of the mine (including the proposed Project activities); and compared to the global and South African emission inventory;

(ii) the impact of climate change over the lifetime of the project taking the robustness of the project into account; and,

(iii) the vulnerability of communities in the immediate vicinity of the project to climate change.

The Carbon Footprint is an indication of the GHG estimated to be emitted directly and/or indirectly by an organisation, facility or product. It can be estimated from:

$$Carbon\ emissions = Activity\ information * emission\ factor * GWP$$

where

- *Activity information* relates to the activity that causes the emissions.
- *Emission factor* refers to the amount of GHG emitted per unit of activity.
- GWP or global warming potential is the potential of an emitted gas to cause global warming relative to CO_2. This converts the emissions of all GHGs to the equivalent amount of CO_2 or CO_2-e. National GHG reporting guidelines state GWP for CH_4 emissions should have a multiplier of 23; and N_2O emissions should have a multiplier of 296.

7.3.2 Construction Phase

7.3.2.1 Carbon Sequestration and Carbon Sink

Accounting for the uptake of carbon by plants, soils and water is referred to as *carbon sequestration* and these sources are commonly referred to as *carbon sinks*. Quantifying the rate of carbon sequestration is however not a trivial task requiring detailed information on the geographical location, climate (specifically temperature and humidity) and species dominance (Ravin & Raine, 2007).

Photosynthesis is the main sequestration process in forests and in soils. Carbon is absorbed as fixed carbon into the roots, trunk, branches and leaves, and during the shedding of leaves and limbs, but is emitted – although at a reduced percentage – from foliage and when biomass decays. Several factors also determine the amount of carbon absorbed by trees such as species, size and age. Mature trees, for example, will absorb more carbon than saplings (Ravin & Raine, 2007).

There will be a carbon sink loss due to the vegetation removal during the Construction Phase of the project, mainly associated with the supporting infrastructure (upgrading of the railway and railway loadout station, and the establishment of stormwater management infrastructure as well as a top-cut stockpile and mobile crusher plant).

These are considered **Scope 1** carbon emissions. However, since these are all located within the MMT mining rights area, and within already disturbed areas, CO_2 released as a result of vegetation clearing at the site is regarded insignificant.

7.3.2.2 Fuel Combustion

GHG emissions from fuel during construction of the MMT Project are also considered **Scope 1** emissions. The IPCC default emission factors for diesel combustion in both stationary (for example: backup generators) and mobile combustion (for example from heavy earth moving vehicles) were used together with country-specific density and calorific (DEA, 2017). Emissions from these activities were not included in this assessment as the detail is not available, however due to the assumed short construction period, they are not likely to make a significant contribution to the project's life-time total emissions

7.3.2.3 Electricity use

These emissions are related to purchased energy, heat or steam and can be calculated from the average South African emission factor published annually by Eskom in its integrated report. Electricity use on-site during the construction phase was not estimated but likely to be less than that used annually during the operational lifetime of the facility.

7.3.3 Operational Phase

This report considers **Scope** 1 emissions, which are the emissions directly attributable to the Project, and **Scope 2** emissions, which are the emissions associated with bought-in electricity over the lifetime of the project. Scope 3 emissions, which consider the "embedded" carbon in bought-in materials, are not considered here, in line with the guidelines provided by the International Finance Corporation (IFC, 2012).

7.3.3.1 Scope 1 Emissions

The Carbon Tax Bill and its supporting technical documents provides default emission factors for various operations (i.e. production, mobile and stationary combustion for different fuel types) (DEA, 2017). Processing operations at MMT falls under Ferroalloy production, which uses coking coal as fuel source. The mining operations use diesel as fuel for al mobile sources, but stationary sources using different fuels – diesel, Liquified Petroleum Gas (LPG) and Heavy fuel oil (HFO). A summary of the GHG emissions, based on calculated fuel consumption for the period Jul'2020 to Jun'2021, is provided in Table 35. The total processing CO_2 (equivalent) emissions are approximately 104 232.08 tpa. The GHG emissions are assumed to remain the same for the duration of the proposed project. The annual South African emission rate of GHG is approximately 512.38 million metric tonnes CO_2-e (2015 national emission inventory[12]).

[12] Most recent published inventory reported in the GHG National Inventory Report: South Africa 2000 – 2015 from https://www.environment.gov.za/sites/default/files/reports/GHG-National-Inventory-Report-SouthAfrica-2000-2015.pdf

Table 35: Summary of Scope 1 estimated greenhouse gas emissions for the MMT operations (actual consumption for period Jul'2020 to Jun'2021)

Source Type	Fuel Type	Amount		Energy content	Density	Emission Factor			Emissions Equivalent (ton)			Total Emissions
		per annum	Unit	GJ/t	t/kL	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	tCO_2e
Ferroalloy Production	Coking Coal	29 352.00	t	28.2	1	94.6	0.025	0.447	78 302.92	20.69	369.99	78 693.60
Fuel use – transport	Diesel	8 310.46	kL	38.1	0.845	74.1	0.104	8.523	19 825.54	27.76	2 280.28	22 133.58
Fuel use – stationary combustion	Diesel	279.16	kL	38.1	0.845	74.1	0.075	0.179	665.97	0.67	1.61	668.25
Fuel use – liquid	LPG	0.29	kL	47.3	0.555	63.1	0.025	0.030	0.47	0.00	0.00	0.47
Fuel use – stationary combustion	HFO	910.40	kL	40.4	0.958	77.4	0.075	0.179	2 727.23	2.64	6.30	2 736.17
											TOTAL	**104 232.08**

7.3.3.2 Scope 2 Emissions

These emissions are related to purchased energy, heat or steam and can be calculated from the average South African emission factor published annually by Eskom in its integrated report. The emission factors for the last four years are given in Table 36. This allows the Scope 2 emissions to be calculated directly from electricity consumption from the Eskom or local authority account. The electricity usage for the 12-month period (Jul'2020 to Jun'2021) is estimated to result in approximately 37 487.92 tonnes of indirect CO_2 emissions based on the 2018/2019 emission factor of 1.04 (Table 37).

Table 36: Eskom electricity emission factors

Year	Emission Factor (tonnes CO_2/MWh)	Source
2015/2016	1.00	Eskom 2016 Integrated Report
2016/2017	0.98	Eskom 2017 Integrated Report
2017/2018	0.97	Eskom 2018 Integrated Report
2018/2019	1.04	Eskom 2019 Integrated Report
Median	0.99	

Table 37: Scope 2 estimated greenhouse gas emissions for the MMT operations (actual consumption for period Jul'2020 to Jun'2021)

Phase	Annual electricity use (MWh)	Emission Factor (tonnes CO_2/MWh)	Annual Scope 2 CO_2 emissions (tonnes)
Operational phase	36 045.93	1.04	37 487.92

8 Conclusions and Recommendations

South32 Mamatwan Mine is situated south of Hotazel and north of Kuruman and is an opencast manganese mine which is proposing to undertake an integrated regulatory process to cater for layout/activity changes that have already taken place at the mine, as well as proposed layout/activity changes.

The proposed mining and processing activities will result in air quality impacts in the study area. The main objective of the air quality specialist study was to determine the potential impact on ambient air quality and air quality sensitive receptors (AQSRs) as a result of the project and to recommend suitable mitigation and management measures.

The air quality impact assessment includes two parts, namely (a) the estimation of air pollution impacts from all mining activities, and (b) the air quality impact from the sinter plant in support of the Atmospheric Emission Licence (AEL) amendment. This report covered the air quality impacts from all activities and a greenhouse gas emissions statement.

Typical of specialist investigations the air quality study comprises both a baseline and an impact assessment. The baseline study included the review of the site-specific atmospheric dispersion potential, relevant air quality standards and guidelines and baseline dustfall levels and annual emissions monitoring data.

In assessing the impacts associated with the operations at the site, an emissions inventory was compiled, atmospheric dispersion modelling undertaken, and modelled concentrations evaluated. Dispersion modelling was conducted using the US EPA AERMOD model over an area of 10 km east-west by 8.5 km north-south. The evaluation of simulated concentrations and dustfall levels was compared against National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR) respectively.

Main Findings

The findings from the baseline assessment can be summarised as follows:

- The prevailing wind field in the area come from the south-southeast and south with most of strong winds from the west. Frequent winds also occur from the north. During the day, winds are more frequent from the westerly and the northerly sectors, with the strongest winds directly from the west. The wind shifts during the night-time to dominantly south-southeasterly and southerly winds. Day-time calms occurred for 8% of the time, with night-time calms for 28% of the time.
- Mining activities, farming and residential land-uses occur in the region. These land-uses contribute to baseline pollutant concentrations via vehicle tailpipe emissions, household fuel combustion, biomass burning and various fugitive dust sources.
- Six AQSRs around the project site were identified, four of which are farmsteads, the other two being a farmworkers residence and the nearby Solar Plant Management Office.

- A dustfall monitoring network is in place at Mamatwan Mine, comprising of eight (8) single dustfall units (one has been decommissioned) that can be compared to the NDCR limits. Dustfall results for the single units were made available for the period January to December 2018, and January to December 2019. The dustfall over the year 2018 was low and well below the NDCR for residential and non-residential areas. The highest dustfall rates were recorded at MMT07 for most of the months. The annual average ranged between 48 mg/m²/day (MMT05) to 151 mg/m²/day (MMT07).
- MMT does not undertake ambient air quality monitoring of PM_{10} concentration levels and thus the baseline concentration levels are yet to be established for the site.

The findings from the impact assessment can be summarised as follows:

PM_{10}

Baseline: Simulated PM_{10} daily GLCs, with no mitigation in place, are in non-compliance with the NAAQS for distances up to 4 km from the mining rights boundary. The simulated number of exceedances of the daily PM_{10} NAAQS at AQSR 5 and 6 are in non-compliance with the standard for unmitigated activities. Over an annual average the GLCs are within the NAAQS at all AQSRs. The significance of impacts is considered High.

With mitigation in place, simulated daily and annual PM_{10} concentrations are within NAAQS at all AQSRs. The significance of impacts is considered Low.

Project: PM_{10} daily GLCs, for unmitigated activities, are likely to exceed the NAAQS for a distance of up to 6 km from the mining rights boundary. The simulated number of exceedances of the daily PM_{10} NAAQS at five AQSRs are not in compliance with the standard. The footprint of exceedance of the annual NAAQS is much larger than that of the baseline scenario, but the annual GLCs are in compliance with the standard. The significance of impacts is considered High.

With mitigation in place, the area of exceedances of the PM_{10} daily NAAQS is reduced and no exceedances of the daily PM_{10} NAAQS were simulated at any of the AQSRs. Over an annual average the GLCs are within the NAAQS at all AQSRs. The significance of impacts is considered Low.

$PM_{2.5}$

Baseline: Simulated daily $PM_{2.5}$ GLCs, with no mitigation in place, are likely to be in non-compliance with the NAAQS applicable from 1 January 2030 for distances of up to 2 km from the mining rights boundary. No exceedances of the daily $PM_{2.5}$ NAAQS were simulated at any of the AQSRs. With mitigation in place, the footprint of exceedances of the $PM_{2.5}$ daily NAAQS is reduced to within the site. Over an annual average the GLCs are within the NAAQS at all AQSRs.

Project: Simulated daily $PM_{2.5}$ GLCs, for unmitigated activities, are likely to exceed the NAAQS applicable from 1 January 2030 for distances up to 3.5 km from the mining rights boundary. The daily $PM_{2.5}$ NAAQS was exceeded at AQSR 6. The maximum distance of exceedance of the annual NAAQS is approximately 800 m from the northern mining rights boundary. Annual average simulated GLCs are within the standard at all receptors. The significance of impacts is considered High.

With mitigation in place, the area of exceedance of the $PM_{2.5}$ daily NAAQS is reduced and no exceedances of the daily $PM_{2.5}$ NAAQS were simulated at any of the AQSRs. Over an annual average, simulated exceedances of the 2030 NAAQS are largely confined to site. Annual average simulated GLCs are within the standard at all receptors. The significance of impacts is considered Low.

Dustfall

Simulated maximum daily dustfall rates for baseline and project operations (unmitigated and design mitigated operations) are in compliance with the NDCR residential limit (600 mg/m²/day). The significance of impacts is considered Low for both unmitigated and mitigated baseline operations, and Low for unmitigated and mitigated project operations.

GHG Emissions

The total GHG emission for the project is assumed to be the same as for the actual operations during the period Jul'2021 to Jun'2020 of 104 232 tCO_2-e. Based on the published 2015 National GHG Inventory, the total CO_2-e emissions from the project, would contribute approximately 0.02% to the total South African GHG inventory emissions of 512.38 million metric tonnes CO_2-e. The annual MMT GHG emissions exceeds the 0.1 Mt threshold which requires a pollution prevention plan to be submitted to the Minister for approval.

Conclusions

The impacts due to the proposed project were assessed with respect to the establishment of a new top-cut stockpile and crusher and changes to the railway infrastructure at the sinter plant. It was assumed that approximately half of the top-cut material would be hauled to the new stockpile per annum via unpaved road and that all of it would be crushed.

No significant differences in air quality impacts were found with respect to the options for railway loadout for the project scenario. However, simulated ground level concentrations due to the project scenario were much higher than for the baseline. The contribution of source groups to overall impact was analysed and showed unpaved roads and in-pit sources to be the largest contributors.

Exceedances of the NAAQS were predicted at five AQSRs for PM_{10} and at one AQSR for $PM_{2.5}$ under unmitigated conditions, project scenario. With design mitigation measures in place, no exceedances of the NAAQS at AQSRs were simulated. For baseline operations no exceedances of the NAAQS for either PM_{10} or $PM_{2.5}$ were simulated. Simulated dustfall levels were within the NDCR at all AQSRs for baseline and project operations.

The proposed project operations should not result in significant ground level concentrations or dustfall levels at the nearby receptors provided the design mitigation measures are applied effectively, and that the assumptions as to what current mitigation measures are in place are correct. From an air quality perspective, the proposed project can be authorised permitted the recommended mitigation and monitoring measures are applied.

Recommendations

A summary of the recommendations and management measures is given below:

- Construction and closure phases:
  - Air quality impacts during construction would be reduced through basic control measures such as limiting the speed of haul trucks and to apply water sprays on regularly travelled unpaved road sections.
  - When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and the material transported must be covered to minimise windblown dust.
- Operational phases:
  - In controlling dust due to drilling operations, dust suppression must be fitted on drill rigs to achieve an emission reduction efficiency of 97%.
  - For the control of vehicle entrained dust it is recommended that water sprays be applied to ensure a control efficiency of 75%. Literature indicates an application rate >2 litre/m²/hour should achieve this.
  - In controlling dust from mobile crushing operations, it is recommended that water sprays be applied to keep the ore wet, to achieve a control efficiency of up to 50%.
  - Mitigation of materials transfer points should be done using water sprays at the tip points. This should result in a 50% control efficiency. Also, regular clean-up at loading points is recommended. In-pit transfer points can be controlled through reducing excavator drop heights into haul trucks.
  - In minimizing windblown dust from stockpile areas, water sprays should be used to keep surface material moist. A mitigation efficiency of 50 % is anticipated.
  - In minimizing windblown dust from the conveyors, roofing and covering of one side of the conveyor should be installed to achieve a mitigation efficiency of 50 %. In addition, reshaping disturbed areas to natural contours, vegetation cover and rock cladding would limit wind erosion potential.
  - To ensure that mitigation is effective, it is recommended that the dustfall monitoring network at the mine be expanded to include single dust buckets at AQSR 4 and AQSR 5 and also that PM_{10} sampling be conducted at AQSR 5 (or AQSR 6 if it is more secure). This can be done as an annual campaign before the project commences (as part of the baseline) and again once mitigated project operations are in place.
- Greenhouse Gas Emissions:
  - MMT quantify GHG emissions monthly and quarterly, and it is assumed that it is reported annually on the SAAELIP system.
  - GHG emissions from the MMT operations, including the proposed project, are in excess of the 0.1 Mt threshold, *a pollution prevention plan* must be submitted to the Minister for approval, if this has not been done to date.

9 References

Andreae, M. et al. (1996). Trace gas and aerosol emissions from savanna fires. In: *Biomass Burning and Global Change.* Cambridge: MIT Press.

ASTM International, 1998. *Standard Test Method for Collection and Measurement of Dustfall (Settleable Particulate Matter),* Philadelphia, PA: ASTM Data Series.

CERC. 2004. *ADMS Urban Training. Version 2. Unit A.*

Davis-Reddy, C. & Vincent, K., 2017. *Climate Risk and Vulnerability: A Handbook for Southern Africa (2nd Ed),* Pretoria, South Africa: CSIR.

DEA, 2005. *National Environmental Management: Air Quality Act (39/2004)*. Pretoria, SA: Government Gazette, No. 27318.

DEA, 2009. *National Ambient Air Quality Standards.* Department of Environmental Affairs, Government Gazette, No. 32816.

DEA, 2012. *National Ambient Air Quality Standards for Particulate Matter with Aerodynamic Diameter Less than 2.5 Micron Metres (PM2.5).* Department of Environmental Affairs, Government Gazette, No. 35463.

DEA, 2013. *National Dust Control Regulations.* Department of Environmental Affairs, Government Gazette, No. 36974 .

DEA, 2014. *National Environmental Management: Air Quality Act (39/2004): Regulations regarding Air Dispersion Modelling,* Pretoria, SA: Government Gazette.

DEA, 2014. *Regulations regarding Air Dispersion Modelling,* s.l.: Department of Environmental Affairs, Government Gazette No. 37804, 11 July 2014.

DEA, 2014a. *GHG Inventory for South Africa 2000 -2010,* s.l.: Department of Environmental Affairs.

DEA , 2015. *NEMAQA - National Atmospheric Emission Inventory System,* Pretoria: Department of Environmental Affairs (Government Gazette).

DEA, 2014. *Regulations regarding Air Dispersion Modelling,* s.l.: Department of Environmental Affairs, Government Gazette No. 37804, 11 July 2014.

DEA, 2017. *Technical guidelines for monitoring, reporting, and verification of greenhouse gas emissions by industry: A companion to the South African national GHG emission reporting regulations,* Pretoria: Department of Environmental Affairs (TG-2016.1).

DEA, nd. *GHG Inventory for South Africa 2000 -2015,* Pretoria: Department of Environmental Affairs.

DFFE, 2020. *Draft South Africa's 4th Biennial Update Report to the United Nations Framework Convention On Climate Change,* Pretoria, South Africa: Department of Forestry, Fisheries and Environment.

DFFE, 2021. *South Africa's First Nationally Determined Contribution under the Paris Agreement: Proposed updated Nationally Determined Contribution,* Pretoria, South Africa: Department of Forestry, Fisheries and Environment.

DMR, 2019. *Integrated Resource Plan (IRP2019).* Pretoria: Department of Mineral Resources.

Department of Labour (1993). Occupational Health and Safety Act (OHS) 1985 of 1993. Republic of South Africa. Pretoria: Government Printer.

Department of National Treasury, 2013. *Carbon Tax Policy Paper,* s.l.: s.n.

DOE, 2011. *Integrated Resource Plan for Electricity 2010-2030 Revision 2.* [Online] Available at: http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf

Emission Inventory Guidebook, 2006. Processes with Contact. Sinter and Pelletising Plants, Activities 030301 & 040209. Available online at: https://www.eea.europa.eu/ds_resolveuid/C0H79ZSVTY.

Farmer, A. M., 1993. The Effects of Dust on Vegetation – A Review. *Environmental Pollution,* Volume 79, pp. 63-75.

Garstang, M., Tyson, P., Swap, R. & Edwards, M. (1996). Horizontal and vertical transport of air over southern Africa.

Godish, R., 1990. *Air Quality.* Michigan: Lewis Publishers.

Golder Associates Africa, 2019. Atmospheric Emissions Impact Report for Mamatwan Sinter Plant Application for Postponement of Compliance timeframes. South32: Hotazel Manganese Mines (Pty) Limited.

Goldreich, Y. & Tyson, P., 1988. Diurnal and Inter-Diurnal Variations in Large-Scale Atmospheric Turbulence over Southern Africa. *South African Geographical Journal,* pp. 48-56.

Gutteridge Haskins & Davey (GHD)/Oceanics 1975. Hay Point Environmental Planning Study.

Hanna, S. R., Egan, B. A., Purdum, J. & Wagler, J., 1999. *Evaluation of ISC3, AERMOD, and ADMS Dispersion Models with Observations from Five Field Sites,* s.l.: s.n.

Hofste, R., Kuzma, S., Walker, S. & Sutanudjaja, E. H., 2019. *Aqueduct 3.0: Updated Decision- Relevant Global Water Risk Indicators. Technical Note.,* Washington, DC: World Resources Institute. Available online at: https://www.wri.org/publication/aqueduct-30..

IFC, 2007. *General Environmental, Health and Safety Guidelines,* s.l.: s.n.

IFC, 2012. *Performance Standard 3 Resource Efficiency and Pollution Prevention.* [Online] Available at: https://www.ifc.org/wps/wcm/connect/25356f8049a78eeeb804faa8c6a8312a/PS3_English_2012.pdf?MOD=AJPERE

IPCC, 2006. *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* [Online] Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/

IPCC, 2007. *Intergovernmental Panel on Climate Change 4th Assessment Report.* [Online] Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_appendix.pdf

IPCC, 2013. *Intergovernmental Panel on Climate Change 5th Assessment Report.* [Online] Available at: https://www.ipcc.ch/report/ar5/

IPCC, 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the IPCC,* United States of America: Cambridge University Press.

Krause, N. & Liebenberg-Enslin, H., 2009. *Air Quality Impact Assessment for the Proposed Ntsimbintle Manganese Mining,* s.l.: Metago Engineering Services (Pty) Ltd.

Kornelius, G., Loans, C., Lotter, J. L. & Ramsuchit, D., 2015. *Comparison of different dust fallout measurement techniques with specific reference to the standard ASTM D1739:1970 technique for the measurement of dust deposition in South Africa.* Bloemfontein, s.n.

Marticorena, B. & Bergametti, G., 1995. Modelling the Atmospheric Dust Cycle. 1. Design of a Soil-Derived Dust Emission Scheme. *Journal of Geophysical Research,* pp. 100, 16 415 - 16430.

Minister of Finance, 2017. *Draft Carbon Tax Bill.* s.l.:s.n.

MMT AEL, 2015. Hotazel Manganese Mines (MMT): Mamatwan Sinter Plant Atmospheric Emission Licence (AEL), number NC/AEL/NDM/ZRH01/2014 (Valid until 31 March 2020), issued by the Department of Environment and Nature Conservation.

MMT AEL, 2020. Hotazel Manganese Mines (MMT): Mamatwan Sinter Plant Atmospheric Emission Licence (AEL), number NC/AEL/JTG/MAM01/2012 (Valid until 31 January 2025), issued by the Department of Environment and Nature Conservation.

NOAA, 2017. *Earth System Research Laboratory Global Monitoring Division.* [Online] Available at: https://www.esrl.noaa.gov/gmd/ccgg/trends/global.html

NPI, 2012. *Emission Estimation Technique Manual for Mining. Version 3.1.* s.l.:Australian Government Department of Sustainability, Environment, Water, Population and Communities.

Parrett, FW, 1992. "Dust emission – a review". Applied Environmetrics (Balwyn).

Piketh, S., Annegarn, H. & Kneen, M. (1996). Regional scale impacts of biomass burning emissions over southern Africa. In: *Biomass Burning and Global Change.* Cambridge: MIT Press.

Preston-Whyte, R.A., and Tyson, P.D., 1988. The Atmosphere and Weather of Southern Africa. Oxford University Press, Cape Town.

Ravin, A. & Raine, T., 2007. *Best Practices for Including Carbon Sinks in Greenhouse Gas Inventories. 16th Annual International Emissions Inventory Conference,* Raleigh: United States Environmental Protection Agency.

SAWS, 2017. *A Climate Change Reference Atlas 2017 - based on CMIP5 – CORDEX downscaling,* Pretoria, South Africa: South African Weather Service and the Water Research Commission.

South African National Biodiversity Institute, 2021. *2012 Vegetation Map App [Vector] 2012,* Pretoria: s.n.
UNFCCC, 2017. *United Nations Framework Convention on Climate Change e-Handbook.* [Online] Available at: http://bigpicture.unfccc.int/

South32 Limited, 2015. Mamatwan Mine Gemco Visit. 12 October 2015.

South32 Limited, 2016. South Africa Manganese - Mamatwan Investor Tour. JSE Sponsor: UBS South Africa (Pty) Ltd, 26 September 2016. Available at: https://www.south32.net/docs/default-source/all-financial-results/reports-and-presentations/mamatwan-site-tour-2016.pdf?sfvrsn=2ba37bd2_8.

South32 Limited, Wessels & Mamatwan Mines, 2019. Project Raptor Pre-Feasibility Study, 3 October 2019.

UNFCCC, 2017. *United Nations Framework Convention on Climate Change e-Handbook.* [Online] Available at: http://bigpicture.unfccc.int/

US EPA, 1992. Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures, EPA-450/2-92-004,. Retrieved from S Environmental Protection Agency: http://www.epa.gov

US EPA, 1995. AP-42, 5th Edition, Volume I, Chapter 12.5: Iron and Steel Production, 12.5.1.1 Sinter Production. Retrieved from United States Environmental Protection Agency: http://www.epa.gov/ttn/chief/ap42/

US EPA, 1995. AP-42, 5th Edition, Volume I, Chapter 13: Miscellaneous Sources, 13.2.2 Unpaved Roads. Retrieved from United States Environmental Protection Agency: http://www.epa.gov/ttn/chief/ap42/

US EPA, 2006. Emission Factor Documentation for AP-42 Section 11.19.2. Crushed Stone Processing. Retrieved from Unites States Environmental Protection Agency AP42: http://www.epa.gov/ttnchief/ap42/

US EPA, 2006. *AP 42, 5th Edition, Volume 1, Chapter13: Miscellaneous Sources, 13.2.4 Introduction to Fugitive Dust Sources, Aggregate Handling and Storage Piles.* [Online] Available at: http://www.epa.gov/ttn/chief/ap42/

Wright, J. et al., 2017. *Formal comments on the Integrated Resource Plan (IRP) Update Assumptions, Base Case and Observations 2016 (Report 20170331-CSIR-EC-ESPO-REP-DOE-1.1A Rev 1.1),* Pretoria: Council for Scientific and Industrial Research.

Appendix A – Specialist Curriculum Vitae

CURRICULUM VITAE

Name	Rochelle Bornman
Date of Birth	24 August 1974
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Air Quality Specialist
Profession	Scientist
Years with Firm	12

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Member of National Association for Clean Air (NACA)

EXPERIENCE

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), TANKS
- Other: Golden Software Surfer, Lakes Environmental WRPlot, MS Word, MS Excel, MS PowerPoint, ArcMap, ArcView

EDUCATION

- B. Land Surveying: 1997, *University of Pretoria*
- MPhil: (Geographical Information Systems and Remote Sensing) 1998, *University of Cambridge*

COURSES COMPLETED AND CONFERENCES ATTENDED

- NACA Conference 2010, 2011
- Laboratory Systems Course (ISO 17025: 2017) March 2018

COURSES PRESENTED

- Geodesy and Land Surveying at the University of Pretoria (1999)

COUNTRIES OF WORK EXPERIENCE

- South Africa, Namibia, Mozambique, Saudi Arabia, Mali

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Full professional proficiency

REFERENCES

Name	Position	Contact Number
Dr. Gerrit Kornelius	Associate of Airshed Planning Professionals	+27 (82) 925 9569 gerrit@airshed.co.za
Dr Lucian Burger	Director at Airshed Planning Professionals	+27 (82) 491 0385 lucian@airshed.co.za
Dr. Hanlie Liebenberg Enslin	Managing Director at Airshed Planning Professionals	+27 (83) 416 1955 hanlie@airshed.co.za

CERTIFICATION

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications and my experience.

Appendix B – Significance Rating Methodology

PART A: DEFINITIONS AND CRITERIA*		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of intensity, spatial extent and duration**
Criteria for ranking of the INTENSITY of environmental impacts	**VH**	Severe change, disturbance or degradation. Associated with severe consequences. May result in severe illness, injury or death. Targets, limits and thresholds of concern continually exceeded. Substantial intervention will be required. Vigorous/widespread community mobilization against project can be expected. May result in legal action if impact occurs.
	H	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.
	M	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.
	L	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.
	VL	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.
	VL+	Negligible change or improvement. Almost no benefits. Change not measurable/will remain in the current range.
	L+	Minor change or improvement. Minor benefits. Change not measurable/will remain in the current range. Few people will experience benefits.
	M+	Moderate change or improvement. Real but not substantial benefits. Will be within or marginally better than the current conditions. Small number of people will experience benefits.
	H+	Prominent change or improvement. Real and substantial benefits. Will be better than current conditions. Many people will experience benefits. General community support.
	VH+	Substantial, large-scale change or improvement. Considerable and widespread benefit. Will be much better than the current conditions. Favourable publicity and/or widespread support expected.
Criteria for ranking the DURATION of impacts	**VL**	Very short, always less than a year. Quickly reversible
	L	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.
	M	Medium-term, 5 to 10 years.
	H	Long term, between 10 and 20 years. (Likely to cease at the end of the operational life of the activity)
	VH	Very long, permanent, +20 years (Irreversible. Beyond closure)
Criteria for ranking the EXTENT of impacts	**VL**	A part of the site/property.
	L	Whole site.
	M	Beyond the site boundary, affecting immediate neighbours
	H	Local area, extending far beyond site boundary.
	VH	Regional/National

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
Very High	Potential fatal flaw unless mitigated to lower significance.
High	It must have an influence on the decision. Substantial mitigation will be required.
Medium	It should have an influence on the decision. Mitigation will be required.
Low	Unlikely that it will have a real influence on the decision. Limited mitigation is likely required.
Very Low	It will not have an influence on the decision. Does not require any mitigation
Insignificant	Inconsequential, not requiring any consideration.

***VH = very high, H = high, M= medium, L= low and VL= very low and + denotes a positive impact.**

PART B: DETERMINING CONSEQUENCE							
INTENSITY = VL							
DURATION	Very long	VH	Low	Low	Medium	Medium	High
	Long term	H	Low	Low	Low	Medium	Medium
	Medium term	M	Very Low	Low	Low	Low	Medium
	Short term	L	Very low	Very Low	Low	Low	Low
	Very short	VL	Very low	Very Low	Very Low	Low	Low
INTENSITY = L							
DURATION	Very long	VH	Medium	Medium	Medium	High	High
	Long term	H	Low	Medium	Medium	Medium	High
	Medium term	M	Low	Low	Medium	Medium	Medium
	Short term	L	Low	Low	Low	Medium	Medium
	Very short	VL	Very low	Low	Low	Low	Medium
INTENSITY = M							
DURATION	Very long	VH	Medium	High	High	High	Very High
	Long term	H	Medium	Medium	Medium	High	High
	Medium term	M	Medium	Medium	Medium	High	High
	Short term	L	Low	Medium	Medium	Medium	High
	Very short	VL	Low	Low	Low	Medium	Medium
INTENSITY = H							
DURATION	Very long	VH	High	High	High	Very High	Very High
	Long term	H	Medium	High	High	High	Very High
	Medium term	M	Medium	Medium	High	High	High
	Short term	L	Medium	Medium	Medium	High	High
	Very short	VL	Low	Medium	Medium	Medium	High
INTENSITY = VH							
DURATION	Very long	VH	High	High	Very High	Very High	Very High
	Long term	H	High	High	High	Very High	Very High
	Medium term	M	Medium	High	High	High	Very High
	Short term	L	Medium	Medium	High	High	High
	Very short	VL	Low	Medium	Medium	High	High
			VL	L	M	H	VH
			A part of the site/ property	Whole site	Beyond the site, affecting neighbours	Extending far beyond site but localised	Regional/ National
			EXTENT				

PART C: DETERMINING SIGNIFICANCE							
PROBABILITY (of exposure to impacts)	Definite/ Continuous	VH	Very Low	Low	Medium	High	Very High
	Probable	H	Very Low	Low	Medium	High	Very High
	Possible/ frequent	M	Very Low	Very Low	Low	Medium	High
	Conceivable	L	Insignificant	Very Low	Low	Medium	High
	Unlikely/ improbable	VL	Insignificant	Insignificant	Very Low	Low	Medium
			VL	L	M	H	VVH
			CONSEQUENCE				

Appendix C – Effects of Climate Change on the Region

Climate Change Reference Atlas

In 2017 the SAWS published an updated Climate Change Reference Atlas (CCRA) based on Global Climate Change Models (GCMs) projections. It must be noted that as with all atmospheric models there is the possibility of inaccuracies in the results as a result of the model's physics and accuracy of input data; for this reason, an ensemble of models' projections is used to determine the potential change in near-surface temperatures and rainfall depicted in the CCRA. The projections are for two 30-year periods described as the near future (2036 to 2065) and the far future (2066 to 2095). Projected changes are defined relative to a historical 30-year period (1976 to 2005). The Rossby Centre regional model (RCA4) was used in the predictions for the CCRA which included the input of nine GCMs results. The RCA4 model was used to improve the spatial resolution to 0.44° x 0.44°- the finest resolution GCMs in the ensemble were run at resolutions of 1.4° x 1.4° and 1.8° x 1.2°.

Two trajectories are included based on the four Representative Concentration Pathways (RCPs) discussed in the IPCC's fifth assessment report (AR5) (IPCC, 2013). RCPs are defined by their influence on atmospheric radiative forcing in the year 2100. RCP4.5 represents an addition to the radiation budget of 4.5 W/m^2 as a result of an increase in GHGs. The two RCPs selected were RCP4.5 representing the medium-to-low pathway and RCP8.5 representing the high pathway. RCP4.5 is based on a CO_2 concentration of 560 ppm and RCP8.5 on 950 ppm by 2100. RCP4.5 is based on if current interventions to reduce GHG emissions are sustained (after 2100 the concentration is expected to stabilise or even decrease). RCP8.5 is based on if no interventions to reduce GHG emissions are implemented (after 2100 the concentration is expected to continue to increase).

RCP4.5 trajectory

Based on the median and the region in which the Elandsfontein Project and AQSRs discussed are situated, the annual average near-surface temperatures (2 m above ground) are expected to increase by between 1°C and 2.5°C for the near future and between 2.5°C and 3°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to decrease by between 0 mm and 10 mm for the near future and between 0 mm and 10 mm for the far future. For the near future the total seasonal rainfall is expected to increase in summer, remain the same or slightly increase for autumn. Winter total rainfall is expected to decrease and spring to stay the same or decrease slightly for near future. The total seasonal rainfall is expected to remain the same or slightly decrease for summer, winter and spring for the far future. Autumn total rainfall is expected to increase for the far future.

RCP8.5 trajectory

For the RCP8.5 trajectory the annual average near-surface temperatures are expected to increase by between 2.5°C and 3°C for the near future and between 4.5°C and 5°C for the far future. The seasonal average temperatures are expected to increase for all seasons. The total annual rainfall is expected to decrease by between 0 mm and 10 mm for the near future and far future. For the near future the total seasonal rainfall is expected to increase for summer and remain the same or slightly increase for autumn and spring. Winter total rainfall is expected to decrease for the near future. The total seasonal rainfall is expected to decrease for autumn and winter for the far future. Spring and summer total rainfall is expected to increase for the far future.