

## APPENDIX E: AIR QUALITY IMPACT ASSESSMENT ASSESSMENT

# Updated Air Quality Impact Assessment for the Mokala Manganese Mine near Hotazel in the Northern Cape Province

Project done on behalf of **SLR Consulting (South Africa) (Pty) Ltd**

**Report Compiled by:**  
T.M Mukota

**Project Manager**  
Nick Grobler

**Report No:** 20SLR06. Final | **Date:** January 2022



## Report Details

---

<b>Reference</b>	20SLR06 AQIA
<b>Revision Number</b>	Final
<b>Report Title</b>	Updated Air Quality Impact Assessment for the Mokala Manganese Mine near Hotazel in the Northern Cape Province
<b>Date Submitted</b>	January 2022
<b>Client</b>	SLR Consulting (Africa) (Pty) Ltd
<b>Prepared by</b>	<b>Tinashe M. Mukota, MEng (Env. Engineering, University of Pretoria)</b>  Tinashe holds an MEng degree in Environmental Engineering from the University of Pretoria. He is currently employed at Airshed Planning Professionals as a Junior Air Quality Specialist for close to two years, focusing primarily on Air Quality scoping reports, air quality impact assessments, air quality management plans, air quality monitoring and reporting. Tinashe has worked on projects in South Africa, Namibia, Morocco, and Ghana. These Projects cut across various industries including mining and ore handling, metal recovery, power generation, roads construction, exploration, and chemical.
<b>Reviewed by</b>	<b>Nick Grobler, BEng (Chem), Beng (Hons) (Env) (University of Pretoria)</b>
<b>Notice</b>	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.
<b>Declaration</b>	I, Tinashe M. Mukota, as authorised representative of Airshed Planning Professionals (Pty) Ltd hereby confirm my independence as a specialist and declare that neither I nor Airshed Planning Professionals (Pty) Ltd have any interest, be it business, financial, personal or other, in any proposed activity, application or appeal in respect of which Airshed Planning Professionals (Pty) Ltd was appointed as air quality specialists in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), other than fair remuneration for work performed, specifically in connection with the assessment summarised in this report. I further declare that I am confident in the results of the studies undertaken and conclusions drawn as a result of it – as is described in this report.
<b>Copyright Warning</b>	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

---

Revision Number	Date	Reason for Revision
Draft	July 2021	Draft for client review
Rev1.0	August 2021	Addressed client comments
Rev1.1	August 2021	Addressed client comments
Rev1.2	October 2021	Addressed client comments
Final	January 2021	Minor changes

## Abbreviations

---

<b>AERMIC</b>	AMS/EPA Regulatory Model Improvement Committee
<b>Airshed</b>	Airshed Planning Professionals (Pty) Ltd
<b>APPA</b>	Air Pollution and Prevention Act
<b>AQG</b>	Air Quality Guideline (World Health Organisation)
<b>AQSR</b>	Air Quality Sensitive Receptor
<b>ASG</b>	Atmospheric Studies Group
<b>ASTM</b>	American Society for Testing and Materials
<b>ATSDR</b>	The Agency for Toxic Substances and Disease Registry (USA)
<b>DEA</b>	Department of Environmental Affairs (South Africa)
<b>EETM</b>	Emissions Estimation Technique Manual
<b>ESL</b>	Effects Screening Levels
<b>FEL(s)</b>	Front-end loaders
<b>GLC(s)</b>	Ground Level concentration(s)
<b>GLCC</b>	Global Land Cover Characterisation
<b>GV</b>	Guideline Value
<b>ICP</b>	Inductively Coupled Plasma
<b>IFC</b>	International Finance Corporation
<b>L<sub>mo</sub></b>	Monin-Obukhov Length
<b>MRL</b>	Minimal Risk Levels
<b>NAAQS</b>	National Ambient Air Quality Standards (South Africa)
<b>NDCR</b>	National Dust Control Regulations
<b>NEM:AQA</b>	National Environmental Management Air Quality Act (South Africa)
<b>NPI</b>	National Pollutant Inventory (Australia)
<b>RoM</b>	Run-of-Mine
<b>SA</b>	South Africa(n)
<b>SABS</b>	South African Bureau of Standards
<b>SLR</b>	SLR Consulting (Africa) (Pty) Ltd
<b>TCEQ</b>	Texas Commission for Environmental Quality
<b>TSP</b>	Total Suspended Particulates
<b>US EPA</b>	United States Environmental Protection Agency
<b>USGS</b>	United States Geological Survey
<b>VKT</b>	Vehicle kilometres travelled
<b>WHO</b>	World Health Organization
<b>WRF</b>	Weather Research and Forecasting

## Glossary

---

<b>Air pollution</b>	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
<b>Ambient Air</b>	This is defined as any area not regulated by Occupational Health and Safety regulations
<b>Atmospheric emission or emission</b>	Any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution
<b>Averaging period</b>	This implies a period of time over which an average value is determined
<b>Dispersion</b>	The spreading of atmospheric constituents, such as air pollutants
<b>Dust</b>	Solid materials suspended in the atmosphere in the form of small irregular particles, many of which are microscopic in size
<b>Frequency of Exceedance</b>	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
<b>Mechanical mixing</b>	Any mixing process that utilizes the kinetic energy of relative fluid motion
<b>Oxides of nitrogen (NO<sub>x</sub>)</b>	The sum of nitrogen oxide (NO) and nitrogen dioxide (NO <sub>2</sub> ) expressed as nitrogen dioxide (NO <sub>2</sub> )
<b>Particulate Matter (PM)</b>	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 <sub>10</sub> and PM <sub>2.5</sub> fall in the finer fraction.
<b>PM<sub>10</sub></b>	Particulate Matter with an aerodynamic diameter of less than 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
<b>PM<sub>2.5</sub></b>	Particulate Matter with an aerodynamic diameter of less than 2.5 µm. it is also referred to as inhalational 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
<b>Vehicle Entrainment</b>	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

## Symbols and Units

---

<b>°C</b>	Degree celsius
<b>µg</b>	Microgram(s)
<b>µg/m³</b>	Micrograms per cubic meter
<b>CO</b>	Carbon monoxide
<b>CO<sub>2</sub></b>	Carbon dioxide
<b>m/s</b>	Meters per second
<b>m²</b>	Metres squared
<b>mg</b>	Milligram(s)
<b>mg/m³</b>	Milligrams per cubic meter
<b>mm</b>	Millimeters
<b>Mn</b>	Manganese (elemental)
<b>NO</b>	Nitrogen oxide
<b>NO<sub>2</sub></b>	Nitrogen dioxide
<b>NO<sub>x</sub></b>	Oxides of nitrogen
<b>O<sub>3</sub></b>	Ozone
<b>Pb</b>	Lead
<b>PM</b>	Particulate Matter
<b>PM<sub>10</sub></b>	Thoracic particulate matter
<b>PM<sub>2.5</sub></b>	Inhalable particulate matter
<b>SO<sub>2</sub></b>	Sulphur dioxide
<b>VOC(s)</b>	Volatile organic compound(s)



# Executive Summary

---

## Introduction

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by SLR Consulting (South Africa) (Pty) Ltd to update the Air Quality Impact Assessment for the Mokala Manganese Mine near Hotazel in the Northern Cape Province. Airshed conducted an air quality impact assessment for the Mokala Manganese Mine in 2015, prior to commencement of activities at the Mokala Manganese Mine. This assessment however only assessed the impact of the originally planned mining activities (now termed Phase 1) and infrastructure layout for the project. It is now proposed that the extent of the open cast pit be expanded to increase the life of mine. This will be achieved in an additional five phases, termed Phase 2 to 6. In support of the above, additional infrastructure is proposed, including expansion of the current waste rock dump, establishment of a new waste rock dump, establishment of a low-grade ore stockpile and establishment of additional topsoil stockpiles. Mining rates are expected to be ~1.56 million tonnes per annum (mtpa) ROM (and product) and 17 mtpa waste rock per year. The same mining and hauling methods currently employed for Phase 1 will continue for the subsequent phases.

The project is located on the remaining extent of portion 1 of the farm Gloria 266, the farm Kipling 271 and the farm Umtu 281 in the Northern Cape Province of South Africa.

## Scope and Approach

The main purpose of this investigation was to determine the potential impacts on the ambient air quality and to the delineated sensitive receptors due to the activities proposed during the additional phases.

The following tasks, were included in the scope of work:

- A review of the updated technical project information.
- A study of regulatory requirements and health thresholds for identified key pollutants against which compliance was assessed and health risks screened.
- A study of the receiving environment in the vicinity of the project; including:
  - The identification of potential air quality sensitive receptors (AQSRs);
  - A study of the atmospheric dispersion potential of the area taking into consideration local meteorology, land-use and topography; and
  - The analysis of available ambient air quality information/data to determine pre-development ambient pollutant levels and dustfall rates.
- The compilation of a comprehensive emissions inventory which included both process and fugitive emissions guided by the mitigation scenarios stated in Table 8.
- Atmospheric dispersion modelling to simulate ambient air pollutant concentrations as a result of the project.
- A screening assessment to determine:
  - Compliance of criteria pollutants with National Ambient Air Quality Standards (NAAQSs);
  - Potential health risks as a result of exposure to non-criteria pollutants; and
  - Nuisance dustfall gauged against the National Dust Control Regulations (NDR).
- The compilation of an updated air quality specialist report detailing the study approach, limitations, assumption, results and recommendations of mitigation and management of air quality impacts.

The air quality impact assessment included a study of the receiving environment and the quantification and assessment of the impact of the project on human health and the environment. The receiving environment was described in terms of local atmospheric dispersion potential, the location of potential air quality sensitive receptors (AQSRs) in relation to proposed activities as well as ambient pollutant levels and dustfall rates.

A comprehensive atmospheric emissions inventory was compiled for the operational phase of the project. Pollutants quantified included those most commonly associated with open-cast mining i.e. particulate matter (PM) (TSP, PM<sub>10</sub>, and PM<sub>2.5</sub>), carbon monoxide (CO), oxides of nitrogen (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>) and volatile organic compounds (VOCs). In the quantification of operational phase impacts, the mine design mitigation as provided by SLR was utilized, while additional mitigation was proposed to minimise the impacts.

## Main Findings

A quantitative air quality impact assessment was conducted for operational phase activities for the Mokala Manganese Project. Construction, decommissioning and post-closure activities were assessed qualitatively. The assessment included an estimation of atmospheric emissions, the simulation of pollutant levels and determination of the significance of impacts.

This section summarises the main findings of the assessment.

- The receiving environment:
  - The area is dominated by winds from the north, northeast and east. Long-term air quality impacts are therefore expected to be the most significant to the south and south west of the project area.
  - Ambient air pollutant levels in the project area are currently affected by the following sources of emission: mining to the southwest and northwest, vehicles tail-pipe emissions and open areas exposed to the wind.
  - Air Quality Sensitive Receptors (AQSRs) around the project site include single homesteads/farmsteads, towns and a healthcare facilities. The closest AQSRs include residences of the **Gloria Mine village** situated approximately 1.3 km north of the northern project boundary and residences in the town of **Hotazel** which is approximately 3.9 km east of the eastern project boundary. All other residences, farmsteads and towns are further than 5 km from the project boundary.
- Impact due to the project components that have already taken place
  - A qualitative assessment concluded that the overall emissions could have been high if no mitigation measures were implemented, likely resulting in medium impacts to human health through inhalation, although the severity of the impacts could have been low.
  - There is no evidence that any cumulative impacts to human health due to the proposed activity/infrastructure changes can be attributed to the components that have already taken place.
- Impacts due to mining of the Kalagadi Barrier Pillar
  - The impacts due to the mining of the Kalagadi Barrier Pillar are expected to be the same in scale and magnitude as those of the Phase 2 to 6 operations. If mining takes place concurrently with other mining operations, there is a likelihood of exceedances at the closest sensitive receptors. If this is not the case, additional or adverse impacts are minimum.
- Impact of the Project:

---

Updated Air Quality Impact Assessment for the Mokala Manganese Mine near Hotazel in the Northern Cape Province

- Construction and closure phases:
  - Construction and closure phase PM emissions (PM<sub>2.5</sub>, PM<sub>10</sub> and TSP) were qualitatively assessed. Impacts due to these activities were perceived to be generally low and within the respective standards. This is especially expected for construction activities due to their temporary nature, and the likelihood that these activities will not occur concurrently at all portions of the site. The significance rating of the construction and closure phases is expected to be **'low'**.
- Operational phase:
  - Sources of emission quantified included drilling, blasting, crushing and screening, material handling, vehicles travelling on unpaved roads, windblown dust from the stockpiles, vehicle exhaust and power generation (diesel engines).
  - Operational phase PM emissions (PM<sub>2.5</sub>, PM<sub>10</sub> and TSP), including manganese (Mn), and gaseous emissions (CO, NO<sub>x</sub>, SO<sub>2</sub> and VOC) were quantified and utilized in the dispersion simulations.
  - Simulated PM<sub>10</sub> impacts during the operational phase with mine design mitigation did result in exceedances of both long-term (annual) and short-term (24-hour) ambient air quality standards off-site, but not at nearby AQSRs. A significance weighting of **'medium'** was assigned to potential inhalation health impacts associated with PM<sub>10</sub>.
  - PM<sub>10</sub> impacts reduced when recommended additional mitigation was applied resulting in exceedances to the short time criteria (24-hour) only while compliance to the long term criteria (annual) was noted. The assigned significance weighting of **'medium'** was sustained.
  - Simulated PM<sub>2.5</sub> impacts during the operational phase with mine design mitigation resulted in exceedances of the short-term (24-hour) ambient air quality criteria off-site, but not at nearby AQSRs (Hotazel and Gloria Mine village). For long-term (annual) impacts, off-site exceedances did not occur. A significance weighting of **'Low'** was assigned to potential inhalation health impacts associated with PM<sub>2.5</sub>.
  - Simulated elemental Mn impacts during the operational phase with mine design resulted in exceedances of long-term (annual) ambient air quality screening criteria off-site but not close to nearby AQSRs. A significance weighting of **'medium'** was assigned to potential inhalation health impacts associated with elemental Mn.  
 Elemental Mn impacts reduced significantly when recommended additional mitigation was applied. However, predicted exceedances of long-term (annual) ambient air quality criteria off-site remained, but not close to any AQSR. The assigned significance weighting of **'medium'** was sustained.
  - Simulated CO, NO<sub>2</sub>, SO<sub>2</sub> and VOC concentrations were low and did not result in off-site exceedances. A significance weighting of **'low'** was assigned to potential inhalation health impacts associated with these pollutants.
  - Simulated dustfall deposition rates were low and resulted in minimal off-site exceedances. A significance weighting of **'low'** was assigned to potential impacts associated with dustfall.

## Recommendations

To ensure the lowest possible impact on AQSRs and the environment, it is recommended that the air quality management plan as set out in this report be adopted.

The recommended management plan includes the following:

- The implementation of emission controls for the management of significant emission sources; and
- Air quality monitoring:
  - The extension of continuous dustfall monitoring as part of the project's air quality management plan. Monitoring should be undertaken throughout the life of the mine to provide air quality trends and indicate compliance with NAAQs.
  - The recommendation that Mokala collaborate with other mines/industries in the region to install an ambient gravimetric PM<sub>10</sub>/PM<sub>2.5</sub> monitor in Gloria Mine village or Hotazel. This will provide adequate data on cumulative PM<sub>10</sub> and PM<sub>2.5</sub> concentrations from the Mokala Manganese Project and other mines/industries in the region.
  - Finally, it is recommended that the PM<sub>10</sub>/PM<sub>2.5</sub> samples be analysed for manganese content to determine the manganese concentrations at Gloria Mine village or Hotazel. Should exceedances of the long-term assessment criteria occur (as simulated), a health risk/toxicological assessment should be conducted to ascertain the health impact due to manganese emissions at Gloria Mine village or Hotazel.

The delineation of an air quality buffer zone is not deemed necessary, considering the "low" to "medium" significance rating assigned to pollutants impacts.

Based on the findings in this report and provided the additional mitigation measures are in place, it is the specialist opinion that the project may be authorised.

# Table of Contents

---

Report Details .....	ii
Abbreviations .....	v
Glossary.....	vi
Symbols and Units .....	vii
Executive Summary .....	viii
Table of Contents.....	xii
List of Tables.....	xv
List of Figures .....	xvi
1 Introduction.....	1
1.1 Scope of Work .....	2
1.2 Description of Project Activities from an Air Quality Perspective .....	3
1.3 Approach and Methodology.....	6
1.3.1 Project Information and Activity Review .....	6
1.3.2 The Identification of Regulatory Requirements and Health Thresholds .....	6
1.3.3 Study of the Receiving Environment.....	6
1.3.4 Determining the Impact of the Project on the Receiving Environment .....	6
1.3.5 Compliance Assessment and Health Risk Screening.....	7
1.3.6 Impact Significance.....	7
1.3.7 The Development of an Air Quality Management Plan.....	7
1.4 Assumptions, Exclusions and Limitations.....	7
2 Regulatory Requirements and Impact Assessment Criteria.....	9
2.1 Emission Standards.....	9
2.2 Ambient Air Quality Standards for Criteria Pollutants .....	9
2.3 Inhalation Health Criteria for Non-criteria Pollutants .....	10
2.4 National Dust Control Regulations .....	11
2.5 Screening criteria for animals and vegetation .....	11
2.6 Regulations regarding Air Dispersion Modelling.....	11
2.7 National Atmospheric Emission Reporting Regulations (NAERR) .....	12
3 Description of the Receiving Environment .....	14
3.1 Air Quality Sensitive Receptors .....	14
3.2 Atmospheric Dispersion Potential.....	15
3.2.1 Topography.....	16

3.2.2	<i>Local Wind Field</i> .....	16
3.2.3	<i>Ambient Temperature</i> .....	18
3.2.4	<i>Atmospheric Stability</i> .....	19
3.2.5	<i>Rainfall</i> .....	20
3.3	Ambient Air Quality within the Region .....	22
3.3.1	Measured Ambient Air Quality .....	22
3.3.2	Sources of Air pollution within the region .....	22
3.4	Dustfall Sampling Results .....	24
4	Impact on the Receiving Environment .....	25
4.1	A Qualitative assessment of the project components that have already taken place .....	25
4.2	A Quantitative Assessment of the Impacts Due to the Mining of the Kalagadi Barrier Pillar .....	26
4.3	Atmospheric Emissions .....	26
4.3.1	Construction Phase .....	27
4.3.2	Operational Phase .....	27
4.3.3	Closure Phase .....	34
4.4	Atmospheric Dispersion Modelling .....	35
4.4.1	<i>Dispersion Model Selection</i> .....	36
4.4.2	<i>Meteorological Requirements</i> .....	36
4.4.3	<i>Source and Emission Data Requirements</i> .....	36
4.4.4	<i>Simulation of NO/NO<sub>2</sub> Transformation</i> .....	36
4.4.5	<i>Modelling Domain</i> .....	37
4.4.6	<i>Presentation of Results</i> .....	37
4.5	Dispersion Simulation Results, Health Risk and Nuisance Screening .....	38
4.5.1	Operational Phase .....	38
5	Impact Significance .....	48
6	Recommended Air Quality Management Measures .....	53
6.1	Air Quality Management Objectives .....	53
6.1.1	<i>Ranking of Sources</i> .....	53
6.2	Proposed Mitigation Measures and/or Target Control Efficiencies .....	55
6.3	Performance Indicators .....	55
6.3.1	Ambient Air Quality Monitoring .....	55
6.4	Periodic Inspections, Audits and Community Liaison .....	57
6.4.1	Periodic Inspections and Audits .....	58
6.4.2	Consultation with I&APs .....	58

6.5	Buffer Zone .....	59
7	Conclusions and Recommendation.....	60
7.1	Main Findings .....	60
7.2	Recommendations.....	61
8	References .....	63
9	Appendix A – Source Specific Management and Mitigation Measures.....	65
9.1	Dust Control Options for Unpaved Roads .....	65
9.2	Crushing and Screening Operations .....	66
9.3	Options for Reducing Windblown Dust Emissions .....	66
10	Appendix B – Ambient Air Quality Monitoring Methodology.....	67
10.1	Dustfall Sampling.....	67
10.2	PM <sub>10</sub> /PM <sub>2.5</sub> Sampling .....	67

## List of Tables

---

Table 1: Air quality standards for specific criteria pollutants (SA NAAQS) .....	10
Table 2: Chronic inhalation screening criteria for non-criteria pollutants .....	10
Table 3: Acceptable dustfall rates .....	11
Table 4: Provisions prescribed by the regulations regarding dispersion modelling in South Africa .....	12
Table 5: Identified individual air quality sensitive receptors .....	14
Table 6 Monthly temperature summary (AERMET processed WRF data, January 2017 to December 2019) .....	18
Table 7: Qualitative Assessment of Air Quality Impacts .....	26
Table 8: Emission estimation techniques and parameters .....	29
Table 9: Estimated annual average emission rates per source group .....	33
Table 10: Activities and aspects identified for the closure phase .....	34
Table 11: List of criteria pollutant isopleth plots .....	37
Table 12: Criteria for assessing impacts as provided by SLR .....	48
Table 13: Assessment of the significance of operational phase air quality impacts associated with PM and inhalable Mn emissions (design mitigation) .....	50
Table 14: Assessment of the significance of operational phase air quality impacts associated with PM and inhalable Mn emissions (additional mitigation) .....	50
Table 15: Assessment of the significance of operational phase air quality impacts associated with NO <sub>2</sub> , CO, SO <sub>2</sub> and VOC emissions (design mitigation) .....	51
Table 16: Assessment of the significance of construction and closure phase air quality impacts associated with PM emissions (design mitigation) .....	51
Table 17: Recommended Dustfall sampling locations and parameters .....	57
Table 18: List of comments received during the public scoping meeting on the 04 <sup>th</sup> May 2021 .....	59



## List of Figures

Figure 1: Planned phases during the expansion of the pit at Mokala Manganese Mine (Source: SLR South Africa) .....	1
Figure 2: Mine Layout with approved layout in blue and proposed changes in pink (Source: SLR South Africa) .....	5
Figure 3: AQSRs surrounding the mine area .....	15
Figure 4: Period, day- and night-time wind roses (AERMET processed WRF data, January 2017 to December 2019) .....	17
Figure 5: Seasonal wind roses (AERMET processed WRF data, January 2017 to December 2019) .....	18
Figure 6: Diurnal temperature profile (AERMET processed WRF data, January 2017 to December 2019) .....	19
Figure 7: : Diurnal atmospheric stability (AERMET processed WRF data, January 2017 to December 2019) .....	20
Figure 8: Monthly rainfall and relative humidity (AERMET processed WRF data, January 2017 to Site Visit) .....	21
Figure 9: Dustfall sampling sites at Mokala mine .....	24
Figure 10: Dustfall rates sampled at eight locations near Mokala mine from August 2020 to March 2021. ....	25
Figure 11: Source group contributions to estimated annual emissions for the design mitigated scenario in tpa .....	34
Figure 12: Source group contributions to estimated annual emissions for the additionally mitigated option in tpa. ....	34
Figure 13: Simulated daily average PM <sub>2.5</sub> concentrations for design mitigated operational activities .....	39
Figure 14: Simulated daily average PM <sub>2.5</sub> concentrations for additionally mitigated operational activities .....	39
Figure 15: Simulated annual average PM <sub>2.5</sub> concentrations for design mitigated operational activities .....	40
Figure 16: Simulated annual average PM <sub>2.5</sub> concentrations for additionally mitigated operational activities .....	40
Figure 17: Simulated daily average PM <sub>10</sub> concentrations for design mitigated operational activities .....	41
Figure 18: Simulated daily average PM <sub>10</sub> concentrations for the additionally mitigated operational activities .....	42
Figure 19: Simulated annual average PM <sub>10</sub> concentrations for design mitigated operational .....	42
Figure 20: Simulated annual average PM <sub>10</sub> concentrations for the additionally mitigated operational activities .....	43
Figure 21: Simulated dustfall rates due to unmitigated operational activities for the design mitigated scenario .....	44
Figure 22: Simulated dustfall rates due to unmitigated operational activities for the additional mitigated option .....	44
Figure 23: Area of exceedance of various international annual guidelines for Mn due to operational activities utilising design mitigation .....	45
Figure 24: Area of exceedance of various international annual guidelines for Mn due to operational activities utilising additional mitigation .....	46
Figure 25: Simulated GLCs for hourly NO <sub>2</sub> during normal operational activities .....	47
Figure 26: <b>Simulated GLCs for annual NO<sub>2</sub> during normal operational activities</b> .....	47
Figure 27: Source group contribution to simulated annual average PM <sub>10</sub> and Mn GLCs due to design mitigation .....	54
Figure 28: Source group contribution to simulated annual average PM <sub>10</sub> and Mn GLCs due to additional mitigation .....	55
Figure 29: Dustfall sampling locations at the Mokala Manganese Project .....	56
Figure 30: Location of dustfall sampling sites near the AQSRs .....	57
Figure 31: Example of a dustfall collection unit setup .....	67
Figure 32: Example of a typical PM <sub>10</sub> /PM <sub>2.5</sub> MiniVol setup .....	68

# Air Quality Impact Assessment – Mokala Manganese Mine

## 1 INTRODUCTION

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by SLR Consulting (Africa) (Pty) Ltd to update the Air Quality Impact Assessment for the Mokala Manganese Mine near Hotazel in the Northern Cape Province. Airshed conducted an air quality impact assessment, for the Mokala Manganese Mine in 2015, prior to commencement of activities at the Mokala Manganese Mine. This assessment however only assessed the impact of the originally planned mining activities (now termed Phase 1) and infrastructure layout for the mine. It is now proposed that the extent of the open cast pit be expanded to increase the life of mine. This will be achieved in an additional five phases, termed Phase 2 to 6 referred hereafter as the project (see Figure 1). Mining rates are expected to be ~1.56 mtpa ROM (and product) and 17 mtpa waste rock per year. The same mining and hauling methods currently employed for Phase 1 will continue for the subsequent phases.

The project, an open-cast manganese mine established by Mokala Manganese (Pty) Ltd (Mokala), is located on the remaining extent of portion 1 of the farm Gloria 266, the farm Kipling 271 and the farm Umtu 281 in the Northern Cape Province of South Africa. The mine is situated near the town of Hotazel and is accessed via the R380, which passes through the mine. A site layout is provided in Figure 2.

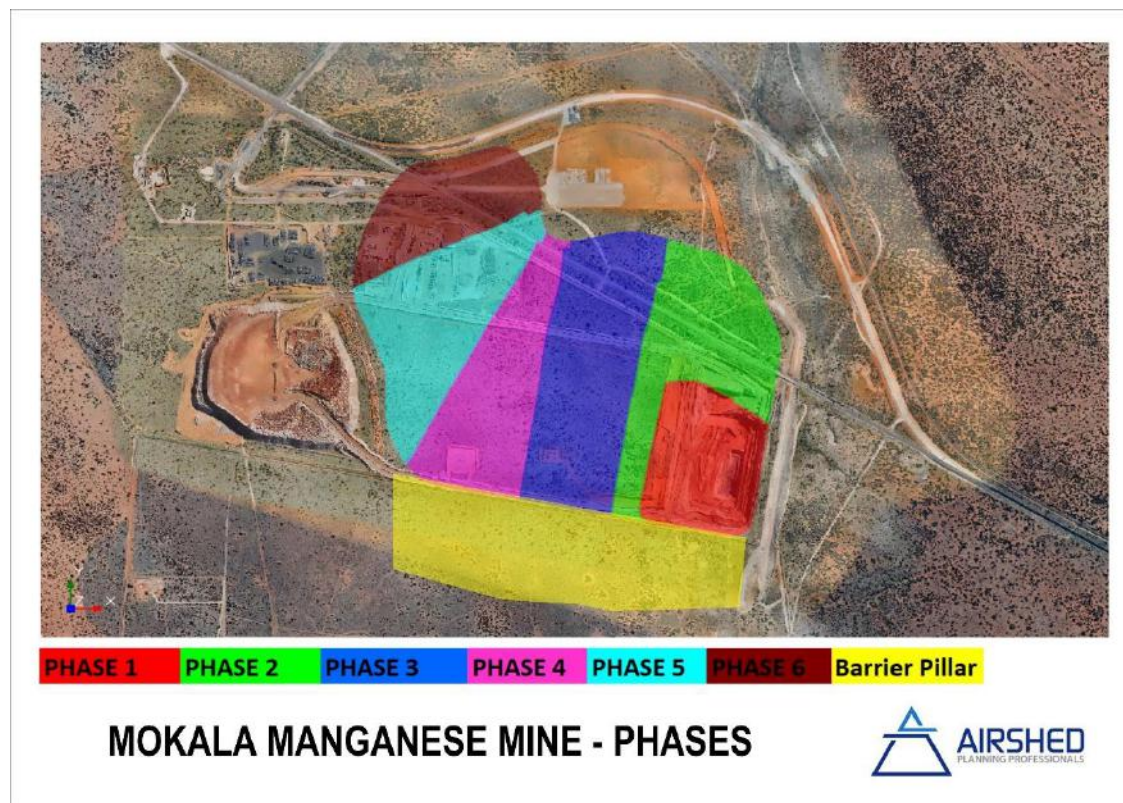


Figure 1: Planned phases during the expansion of the pit at Mokala Manganese Mine (Source: SLR South Africa)

Information gathered from SLR indicates that Mokala is now proposing to amend the approved mine layout to optimize their mining operations. Changes to the approved infrastructure layout that have already taken place include:

- the reconfiguration of the plant area, ROM, and high-grade product stockpiles to accommodate the expansion of the open pit;

- the relocation of the low-grade product stockpile;
- the relocation of support infrastructure (water storage facilities for potable and process water, workshops and wash bay, change houses, sewage treatment plant, water treatment plant, fuel storage, administrative block including offices, kitchen, canteen, training centre, mustering centre, clinic, stores and waste storage);
- relocation of transportation related facilities/infrastructure (internal haul road, weighbridges, parking areas, truck loading and staging facility);
- the relocation of the approved WRD to accommodate the expansion of the open pit; and
- the relocation of the approved topsoil stockpiles.

Proposed activity/infrastructure changes to the approved surface layout include:

- the expansion of the open pit;
- the increase in the capacity of the approved Waste Rock Dump (WRD) and the establishment of an additional WRD;
- the establishment of additional topsoil stockpiles;
- the relocation of stormwater management infrastructure;
- the increase in the capacity of product stockpiles (ROM, Low Grade and High Grade); and
- the mining of the barrier pillar between the Kalagadi Mine and Mokala Mine.

No changes are anticipated to the realignment of the R380, the realignment of the Ga-Mogara drainage channel and the intersection to the entrance of the mine. Similar to the initial phase, the updated phases will be developed using conventional open pit mining methods. Ore and waste rock will be ripped, drilled and blasted in sequential benches to facilitate loading and hauling. Ore and waste rock will be loaded into end-dump haul trucks using shovels (excavators) and front-end loaders (FELs). Ore processing will be undertaken by a mobile crushing and screening plant, (necessitated by the pit expansion throughout towards the year 2038) which will consist of a primary crusher (JAW crusher), a secondary crusher (Osborn SBS44 cone crusher) equipped with a triple deck screen (Akinshipe, 2015).

The construction, closure and post-closure phases of the mine may impact ambient air quality in the surrounding areas. However, these were assessed quantitatively due to their intermittent nature and the unavailability of the required detailed schedules of their implementation. A quantitative air quality impact assessment was conducted for operational phase activities and two scenarios assessed, namely;

- Scenario 1 (S1) – Design Mitigated option whereby mitigation is applied to all sources that have an applicable
- Scenario 2 (S2) – Additionally mitigated option whereby additional mitigation to some sources is recommended.

## 1.1 Scope of Work

The main purpose of this investigation was to determine the potential impacts on the ambient air quality and to the delineated sensitive receptors due to the activities proposed during the additional phases. The approved layout plan as well as the proposed changes is included in Figure 1 (approved layout is shown in blue and proposed changes in pink).

The following tasks, were included in the scope of work:

- A review of the updated technical project information.
- A study of regulatory requirements and health thresholds for identified key pollutants against which compliance was assessed and health risks screened.
- A study of the receiving environment in the vicinity of the project; including:
  - a) The identification of potential air quality sensitive receptors (AQSRs);

- b) A study of the atmospheric dispersion potential of the area taking into consideration local meteorology, land-use and topography; and
  - c) The analysis of available ambient air quality information/data to determine pre-development ambient pollutant levels and dustfall rates.
- The compilation of a comprehensive emissions inventory which included both process and fugitive emissions.
- Atmospheric dispersion modelling to simulate ambient air pollutant concentrations as a result of the project.
- A screening assessment to determine:
  - a) Compliance of criteria pollutants with National Ambient Air Quality Standards (NAAQSs);
  - b) Potential health risks as a result of exposure to non-criteria pollutants; and
  - c) Nuisance dustfall gauged against the National Dust Control Regulations (NDR).
- The compilation of an updated air quality specialist report detailing the study approach, limitations, assumption, results and recommendations of mitigation and management of air quality impacts.

The air quality impact assessment included a study of the receiving environment and the quantification and assessment of the impact of the project on human health and the environment. The receiving environment was described in terms of local atmospheric dispersion potential, the location of potential air quality sensitive receptors (AQSRs) in relation to proposed activities as well as ambient pollutant levels and dustfall rates.

Qualitative assessments of the air quality impacts due to the project components that have already taken place and mining of the Kalagadi barrier pillar were also conducted. A comprehensive atmospheric emissions inventory was compiled for the operational phase of the project. Pollutants quantified included those most commonly associated with open-cast mining i.e. particulate matter (PM) (TSP, PM<sub>10</sub>, and PM<sub>2.5</sub>), carbon monoxide (CO), oxides of nitrogen (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>) and volatile organic compounds (VOCs). In the quantification of operational phase impacts, the mine design mitigation as provided by SLR was utilized, while additional mitigation was proposed to minimise the impacts.

## 1.2 Description of Project Activities from an Air Quality Perspective

Air quality impacts will be associated with four distinct phases namely: the construction phase, the operational phase, the decommissioning phase and the post-closure phase. A description of each of these phases, from an air quality impact perspective is summarised below.

**Construction** will typically include land clearing of the construction footprint, general construction activities (i.e. bulk earthworks and infrastructure development for the plant, buildings, dams, onsite roads etc.), bulldozing, loading and grading activities. These operations will likely result in fugitive<sup>1</sup> PM emissions as well as particulate and gaseous vehicle exhaust emissions. Gaseous emissions, associated with the combustion of diesel, mainly include carbon monoxide (CO), oxides of nitrogen (NO<sub>x</sub>), sulphur dioxide (SO<sub>2</sub>) and volatile organic compounds (VOC). VOCs are also released from diesel storage tanks.

It is important to note that, in the discussion, regulation and estimation of PM emissions and impacts, a distinction is made between different particle size fractions, viz. TSP, PM<sub>10</sub> and PM<sub>2.5</sub>. PM<sub>10</sub> is defined as particulate matter with an aerodynamic diameter of less than 10 µm and is also referred to as thoracic particulates. Inhalable particulate matter, PM<sub>2.5</sub>, is defined as particulate matter with an aerodynamic diameter of less than 2.5 µm. Whereas PM<sub>10</sub> and PM<sub>2.5</sub> fractions are taken into account

---

<sup>1</sup> Fugitive emissions refer to emissions that are spatially distributed over a wide area and not confined to a specific discharge point as would be the case for process related emissions (IFC, 2007).

to determine the potential for human health risks, total suspended particulate matter (TSP) is included to assess nuisance effects.

During the **operational phase** fugitive PM<sub>2.5</sub>, PM<sub>10</sub> and TSP emissions will result mainly as a result of the following; drilling, blasting, crushing and screening, ore and waste handling, truck traffic on unpaved haul routes and open dusty areas exposed to the wind. Diesel generators and exhaust from diesel mobile equipment will result in additional PM<sub>2.5</sub>, PM<sub>10</sub> and TSP as well as CO, NO<sub>x</sub>, SO<sub>2</sub> and VOC emissions. As with construction, the storage of diesel to be used during the operational phase may also result in VOC emission in the form of working and standing losses.

It is proposed that all roads on the project site be treated with a dust palliative consisting of a cationic bitumen emulsion in order to stabilize the surface and prevent dust.

The **decommissioning (closure) and post closure phase** will include fugitive PM generating activities such as bulk earthworks, demolition and re-vegetation, as well as gaseous emissions from the use of diesel storage and combustion sources. With the successful implementation of a closure and rehabilitation plan, no atmospheric emissions will be expected during the **post-closure phase**.



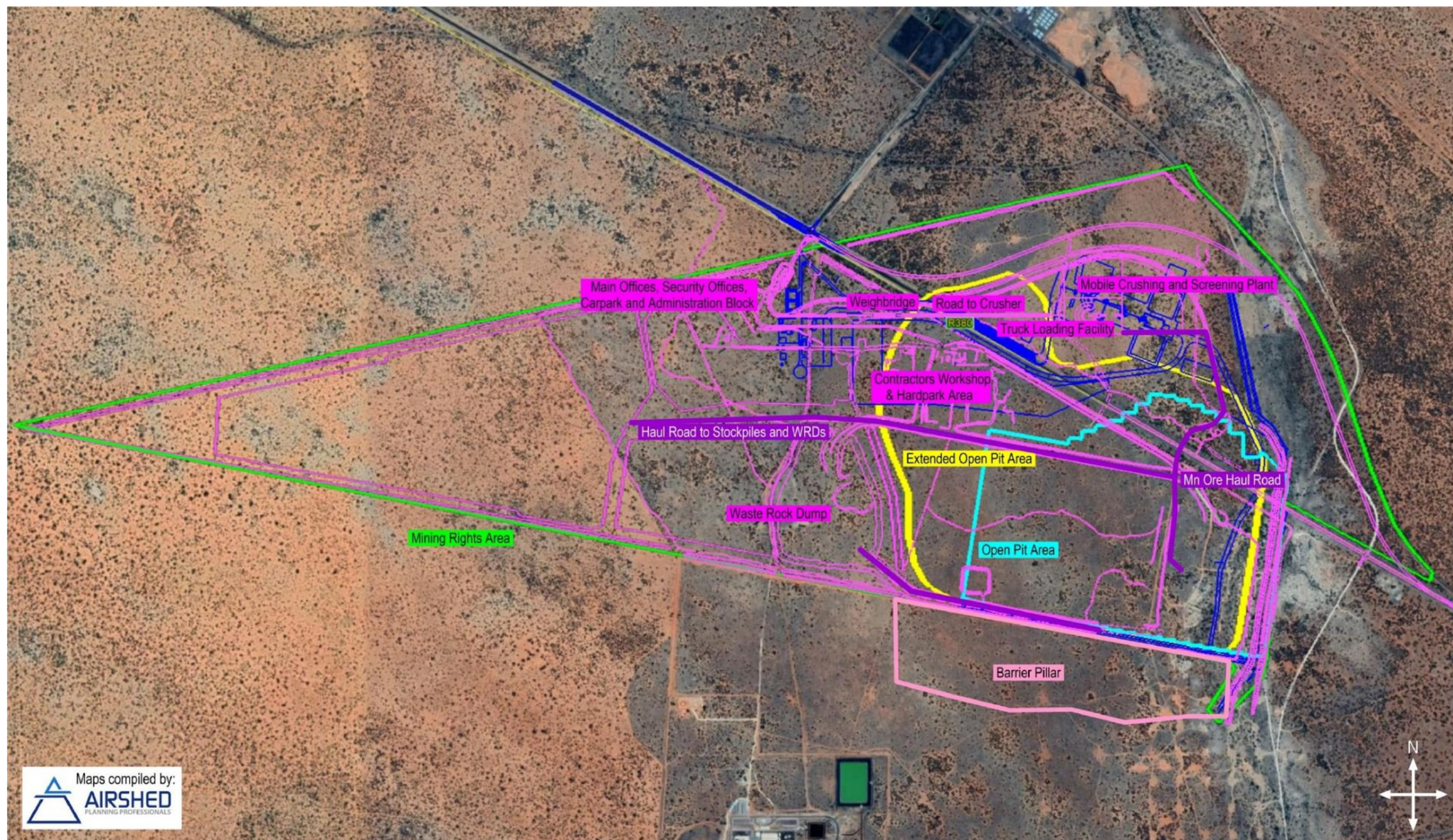


Figure 2: Mine Layout with approved layout in blue and proposed changes in pink (Source: SLR South Africa)



### 1.3 Approach and Methodology

The approach to, and methodology followed in the completion of tasks completed as part of the scope of work are discussed.

#### 1.3.1 Project Information and Activity Review

All project/process related information referred to in this study was provided by SLR.

#### 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 (SA NAAQS) and National Dust Control Regulations (SA NDCR) as set out in the National Environmental Management Air Quality Act (Act No. 39 of 2004) (NEM:AQA); and
- Screening levels for non-criteria pollutants published by various international institutions.

The following were assessed in the study:

- Criteria pollutants (i.e. inhalable particulate matter with aerodynamic diameter of  $<2.5\ \mu\text{m}$  ( $\text{PM}_{2.5}$ ), inhalable particulate matter with aerodynamic diameter of  $<10\ \mu\text{m}$  ( $\text{PM}_{10}$ ), Sulphur Dioxide ( $\text{SO}_2$ ), Nitrogen dioxide ( $\text{NO}_2$ ), and Carbon monoxide (CO).
- Non-criteria pollutants such as TSP, Mn and VOCs were assessed for their potential for;
  - Health impacts; and
  - Nuisance impacts.

#### 1.3.3 Study of the Receiving Environment

Physical environmental parameters that influence the dispersion of pollutants in the atmosphere include terrain, land cover and meteorology. Existing pre-development ambient air quality in the study area is also considered. Readily available terrain and land cover data was obtained from the Atmospheric Studies Group (ASG) via the United States Geological Survey (USGS) web site at (ASG, 2011). Use was made of Shuttle Radar Topography Mission (SRTM) (90 m, 3 arc-sec) data and Global Land Cover Characterisation (GLCC) data for Africa.

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. In the absence of on-site meteorological data (which is required for atmospheric dispersion modelling), use was made of simulated data for a period between 2017 and 2019. The Weather Research and Forecasting (WRF) Model is a next-generation mesoscale numerical weather prediction system designed for creating weather forecasts and climate projections. The effort to develop WRF began in the latter 1990's and was a collaborative partnership of the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (represented by the National Centers for Environmental Prediction (NCEP) and the Earth System Research Laboratory), the U.S. Air Force, the Naval Research Laboratory, the University of Oklahoma, and the Federal Aviation Administration (FAA).

#### 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).

Two modelling scenarios were assessed in simulating air quality impacts for the project. The first scenario utilized the mine design mitigation provided by SLR, while the second utilized the Recommended Additional Mitigation.

The **design mitigation** is the mitigation included in the project design, which includes the use of dust palliatives/cationic stabilization on roads, water sprayers and dust suppressions systems at the plant and all materials handling or conveyor transfer points. The **Recommended Additional Mitigation** is the proposed additional mitigation that will result in further emissions reduction beyond the design mitigation.

#### *1.3.5 Compliance Assessment and Health Risk Screening*

Compliance was assessed by comparing simulated ambient criteria pollutant concentrations (CO, NO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub> and SO<sub>2</sub>) and dustfall rates to selected ambient air quality and dustfall criteria. Health risk screening was done through the comparison of simulated non-criteria pollutant concentrations (VOC and elemental Mn) to selected inhalation screening levels.

#### *1.3.6 Impact Significance*

The significance of impacts was determined in accordance with the procedure adopted and prescribed by SLR.

#### *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 Assumptions, Exclusions and Limitations**

- The quantification and simulation of sources of emission was restricted to the Project. No background pollutant concentrations were available for the region and the potential for cumulative impacts were assessed qualitatively.
- Project information required to calculate emissions for proposed operations were provided by SLR. Where necessary, assumptions were made based on common industry practice and experience coupled with reference the previous studies (Akinshipe, 2015).
- Neither construction nor decommissioning phase impacts were quantified. Impacts associated with these phases are highly variable and generally less significant than operational phase impacts. Mitigation and management measures recommended for the operational phase are however also applicable to the construction and decommissioning phase.
- Emission factors were used to estimate all fugitive and processing emissions resulting from plant, mining activities and transport. These emission factors generally assume average operating conditions.
- The exact locations of all sources within the mining areas are bound to change throughout the mine lifetime. Allocation of the unknown sources into a representative volume or area sources was done during the study.
- In the absence of on-site surface meteorological data, hourly WRF surface and profile data for the period 2017 to 2019 was utilized in this study.
- The impact assessment was limited to airborne particulates (including TSP, PM<sub>10</sub> and PM<sub>2.5</sub>), elemental Mn and gaseous pollutants from diesel engines, including CO, NO<sub>x</sub>, VOCs and SO<sub>2</sub> as relevant to the various project phases.
- Nitrogen monoxide (NO) emissions are rapidly converted in the atmosphere into nitrogen dioxide (NO<sub>2</sub>). NO<sub>x</sub> impacts were calculated by AERMOD and a NO<sub>2</sub>/NO<sub>x</sub> emission ratio of 0.8 (tier 2) was applied when plotting the isopleths.



This is in line with the regulations regarding dispersion modelling for NO<sub>x</sub> concentrations above the NO<sub>2</sub> NAAQS (DEA, 2014).

- Ambient elemental manganese emissions were assumed to be 63 % (based on a mass basis) of the assigned 37.5 % of the mineral pyrolusite (MnO<sub>2</sub>) which is the major component of the ore.
- VOC emissions from diesel storage were not included. Due to diesel's low volatility, it is known to contribute minimally to total VOC emissions from mining operations.
- The silt content of unpaved roads was assumed to be the AP42 unpaved roads average silt content of 8.4%.
- Since no site-specific particle size distribution (PSD) information was available for the cover material used at the different stockpiles, reference was made to NPI guideline for exposed soils, vegetation cover < 25 % with dispersive material of a high silt content.
- Where no emission factors exist for PM<sub>2.5</sub> from fugitive dust sources, PM<sub>2.5</sub> fractions were estimated based on PM<sub>10</sub> emission rates and conservative assumption for the PM<sub>2.5</sub> based on the source type.
- 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 scientific and valuable tool in air quality management.

## 2 REGULATORY REQUIREMENTS AND IMPACT ASSESSMENT CRITERIA

Prior to assessing the impact of proposed activities on human health and the environment, reference needs to be made to the environmental regulations governing the impact of such operations i.e. emission standards, ambient air quality standards and dust control regulations.

Emission standards are generally provided for point sources and specify the amount of the pollutant acceptable in an emission stream and are often based on proven efficiencies of air pollution control equipment.

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality standards and guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging or exposure periods.

This section summarises legislation for criteria pollutants relevant to the current study and dustfall. A discussion on inhalation health risk for VOC and elemental manganese (Mn) is also provided.

### 2.1 Emission Standards

The NEM:AQA (Act No. 39 of 2004 as amended) mandates the Minister of Forestry Fisheries and the 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) are included as listed activities with additional activities being added to the list. The updated Listed Activities and Minimum National Emission Standards were published on the 22<sup>nd</sup> November 2013 (Government Gazette No. 37054).

According to the NEM:AQA, air quality management control and enforcement is in the hands of local government with District and Metropolitan Municipalities as the licensing authorities. Provincial government is primarily responsible for ambient monitoring and ensuring municipalities fulfil their legal obligations, with national government primarily as policy maker and co-ordinator. Each sphere of government must appoint an Air Quality Officer responsible for co-ordinating matters pertaining to air quality management. Given that air quality management under the Atmospheric Pollution Prevention Act (Act No. 45 of 1965) was the sole responsibility of national government, local authorities have in the past only been responsible for smoke and vehicle tailpipe emission control.

Emission limits are generally provided for point sources and specify the amount of the pollutant acceptable in an emission stream and are often based on proven efficiencies of air pollution control equipment. **The Mokala Manganese project does not include any Listed Activities and Minimum Emission Standards do not apply.**

### 2.2 Ambient Air Quality Standards for Criteria Pollutants

Criteria pollutants are considered those pollutants most commonly found in the atmosphere, that have proven detrimental health effects when inhaled and are regulated by ambient air quality criteria. In the context of this project, these include CO, NO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub> and SO<sub>2</sub> (Table 1).

The South African Bureau of Standards (SABS) assisted the Department of Forestry Fisheries and Environment (DFFE) in the development of ambient air quality standards. National Ambient Air Quality Standards (NAAQS) were determined based on international best practice for PM<sub>10</sub>, PM<sub>2.5</sub>, dustfall, SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, CO, lead and benzene.

The final revised SA NAAQSs were published in the Government Gazette on 24 of December 2009 and included a margin of tolerance (i.e. frequency of exceedance) and implementation timelines linked to it. SA NAAQSs for PM<sub>2.5</sub> were published on 29 July 2012. SA NAAQSs referred to in this study are listed in Table 1.

**Table 1: Air quality standards for specific criteria pollutants (SA NAAQS)**

Pollutant	Averaging Period	Limit Value (µg/m <sup>3</sup> )	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
CO	1 hour	30 000	26 000	88	Immediate
	8 hour	10 000	8 700	11	Immediate
NO <sub>2</sub>	1 hour	200	106	88	Immediate
	1 year	40	21	0	Immediate
PM <sub>10</sub>	24 hour	75	-	4	Immediate
	1 year	40	-	0	Immediate
PM <sub>2.5</sub>	24 hour	40	-	4	1 Jan 2016 – 31 Dec 2029
	24 hour	25	-	4	1 Jan 2030
	1 year	20	-	0	1 Jan 2016 – 31 Dec 2029
	1 year	15	-	0	1 Jan 2030
SO <sub>2</sub>	10 minutes	500	191	526	Immediate
	1 hour	350	134	88	Immediate
	24 hour	125	48	4	Immediate
	1 year	50	19	0	Immediate

### 2.3 Inhalation Health Criteria for Non-criteria Pollutants

The potential for health impacts associated with non-criteria pollutants (VOCs and elemental Mn) emitted from mobile stationery sources are assessed according to guidelines published by the following institutions:

- World Health Organization (WHO) – Guideline values (GVs) and cancer unit risk factors (URFs)
- The Texas Commission on Environmental Quality (TCEQ) - Effects Screening Levels (ESLs)
- The Agency for Toxic Substances and Disease Registry (ATSDR) - Minimal risk levels (MRLs)

Chronic inhalation criteria for non-criteria pollutants considered in the study are summarised in Table 2 (The University of Tennessee (2013); WHO (2000); and TCEQ (2013)).

**Table 2: Chronic inhalation screening criteria for non-criteria pollutants**

Pollutant	Chronic/Long term Screening Criteria (µg/m <sup>3</sup> )	Source
VOC ( <i>Diesel fuel</i> used as indicator)	100	TCEQ
Elemental Mn	0.3	ATSDR
	0.2	TCEQ
	0.15	WHO

## 2.4 National Dust Control Regulations

The National Dust Control Regulations (NDCR) was published on the 1<sup>st</sup> of November 2013. The purpose of the regulation is to prescribe general measures for the control of dust in all areas including residential and non-residential areas. Acceptable dustfall rates according to the regulation are summarised in Table 3.

**Table 3: Acceptable dustfall rates**

Restriction areas	Dustfall rate (D) in mg/m <sup>2</sup> -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 ASTM D1739 (1970), 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 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 what the impact of dust fall on vegetation is under a 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 dust fall rates greater than 400 mg/m<sup>2</sup>/day (Farmer 1991). 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.

## 2.6 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 –

- in the development of an air quality management plan, as contemplated in Chapter 3 of the NEM:AQA;
- in the development of a priority area air quality management plan, as contemplated in section 19 of the NEM:AQA;
- in the development of an atmospheric impact report, as contemplated in section 30 of the NEM:AQA; and,
- in the development of a specialist air quality impact assessment study, as contemplated in Chapter 5 of the NEM:AQA.

The above 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 proposed operation falls under a Level 2 assessment – described as follows;

- The distribution of pollutants concentrations and depositions 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. The code of practice regarding dispersion modelling is structured as outlined in Table 4 below.

**Table 4: Provisions prescribed by the regulations regarding dispersion modelling in South Africa.**

Regulations regarding Dispersion modelling		
Chapter	Purpose of regulations	Reference in document
Chapter 3	Prescribes the source data input to be used in the models. This chapter provides guidance on how emission sources are to be defined (emission rates, source types) and provide a means for establishing the preferred combination of mitigation measures that may be required.	Section 4.3.2
Chapter 4	Prescribes 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.	Section 1.3
Chapter 5	Provide guidance on geophysical data, model domain and coordinates system required in dispersion modelling.	Section 4.4
Chapter 6	Prescribes the general modelling parameterisations to be considered when carrying out regulatory modelling.	Section 4.4
Chapter 7	Outlines how the plan of study and modelling assessment reports are to be presented to authorities. This chapter also provides standard reporting checklists with the expected reporting requirements. The chapter gives guidance on information to be provided to the authorities to allow for a full understanding of the modelling results and how they were derived	Section 4.5

The modelling domain would normally be decided on the expected zone of influence; the latter extent being defined by the predicted 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) is sufficiently small to ensure that areas of maximum impact are adequately covered. No receptors however should be located within the mining right area as health and safety legislation (rather than ambient air quality standards) is applicable within the site.

## 2.7 National Atmospheric Emission Reporting Regulations (NAERR)

The National Atmospheric Emission Reporting Regulations (NAERR) were published on the 2<sup>nd</sup> of April 2015 by the Minister of Forestry, Fisheries and the Environment. The regulation's aim is to standardize the reporting of data and information from identified point, non-point and mobile sources of atmospheric emissions to an internet-based National Atmospheric Emissions Inventory System (NAEIS) with a view to 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**. Sections of the regulation that applies to data providers under **Group C** are summarized below.

---

Updated Air Quality Impact Assessment for the Mokala Manganese Mine near Hotazel in the Northern Cape Province

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 these 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.

### 3 DESCRIPTION OF THE RECEIVING ENVIRONMENT

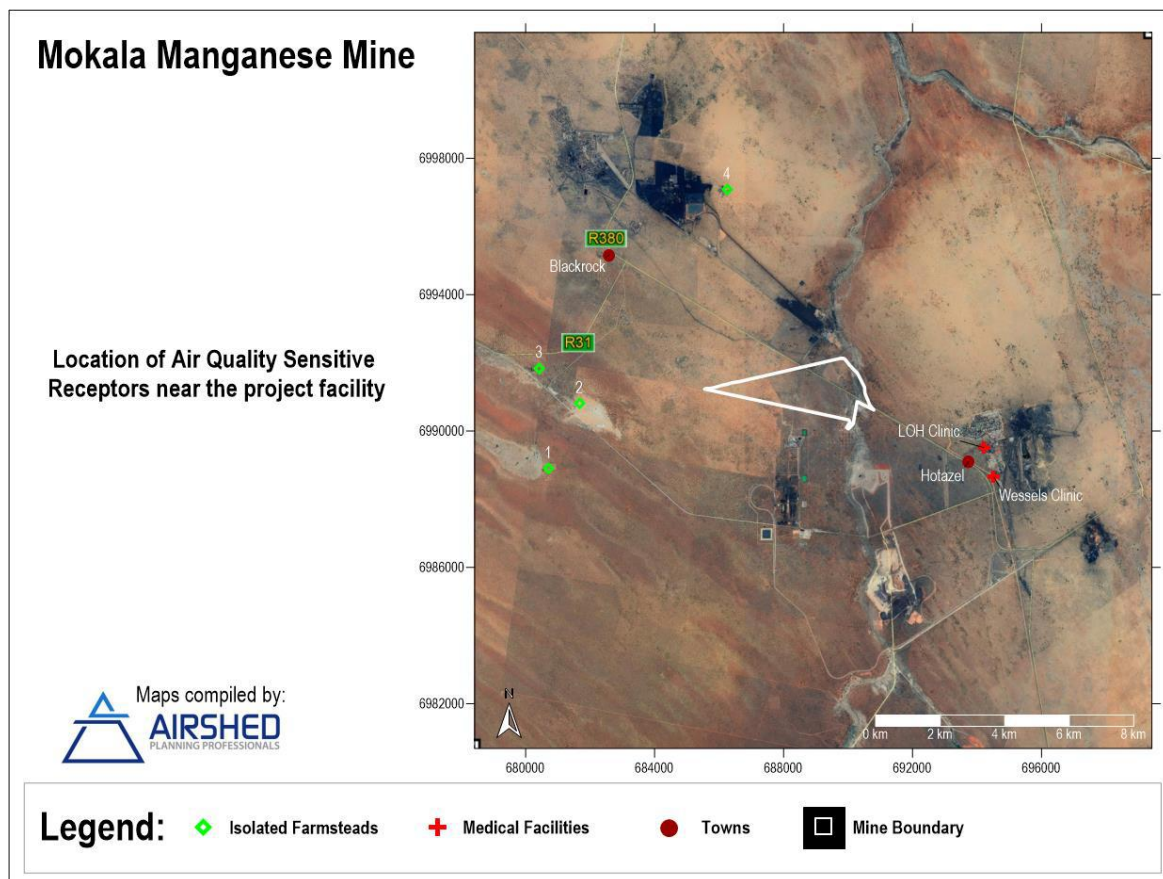
#### 3.1 Air Quality Sensitive Receptors

Air quality sensitive receptors (AQSRs) include, but are not limited to, hospitals, schools, day-care facilities, elderly housing and convalescent facilities. These are areas where the occupants are more susceptible to the adverse effects of exposure to ambient pollutants. Ambient air quality guidelines and standards, as discussed under section 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 Air Quality Act, excludes air regulated by the Occupational Health and Safety Act (Act No 85 of 1993).

A map of potential AQSRs is included in Figure 3. These include single homesteads/farmsteads, towns and a mine village. The closest AQSRs include residences of the town of **Hotazel** which is approximately 3.9 km east of the eastern project boundary. All other residences, farmsteads and towns (including Black Rock) lie further than 5 km from the project boundary. Receptors located within 20 km of the mine are listed in Table 5. These were included in the dispersion model setup, during the impact assessment phase, as discrete receptors.

**Table 5: Identified individual air quality sensitive receptors**

ID/Name	Type	Easting (UTM 34S)	Northing (UTM 34S)
1	Farmstead	680706	6988906
2	Farmstead	681668	6990811
3	Farmstead	680426	6991846
4	Farmstead	686250	6997093
<b>Blackrock</b>	Town	682583	6995156
<b>Hotazel</b>	Town	693731	6989093
<b>LOH Clinic</b>	Medical Facility	694221	6989507
<b>Wessels Clinic</b>	Medical Facility	694527	6988644



**Figure 3: AQSRS surrounding the mine area.**

### 3.2 Atmospheric Dispersion Potential

Meteorological mechanisms direct the dispersion, transformation and eventual removal of pollutants from the atmosphere. The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. This dispersion comprises vertical and horizontal components of motion. The stability of the atmosphere and the depth of the surface-mixing layer define the vertical component. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution because of plume 'stretching'. The generation of mechanical turbulence is similarly a function of wind speed, in combination with surface roughness. The wind direction, and variability in wind direction, determines the general path pollutants will follow, and the extent of crosswind spreading. The pollution concentration levels therefore fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field (Tiway & Colls, 2010).

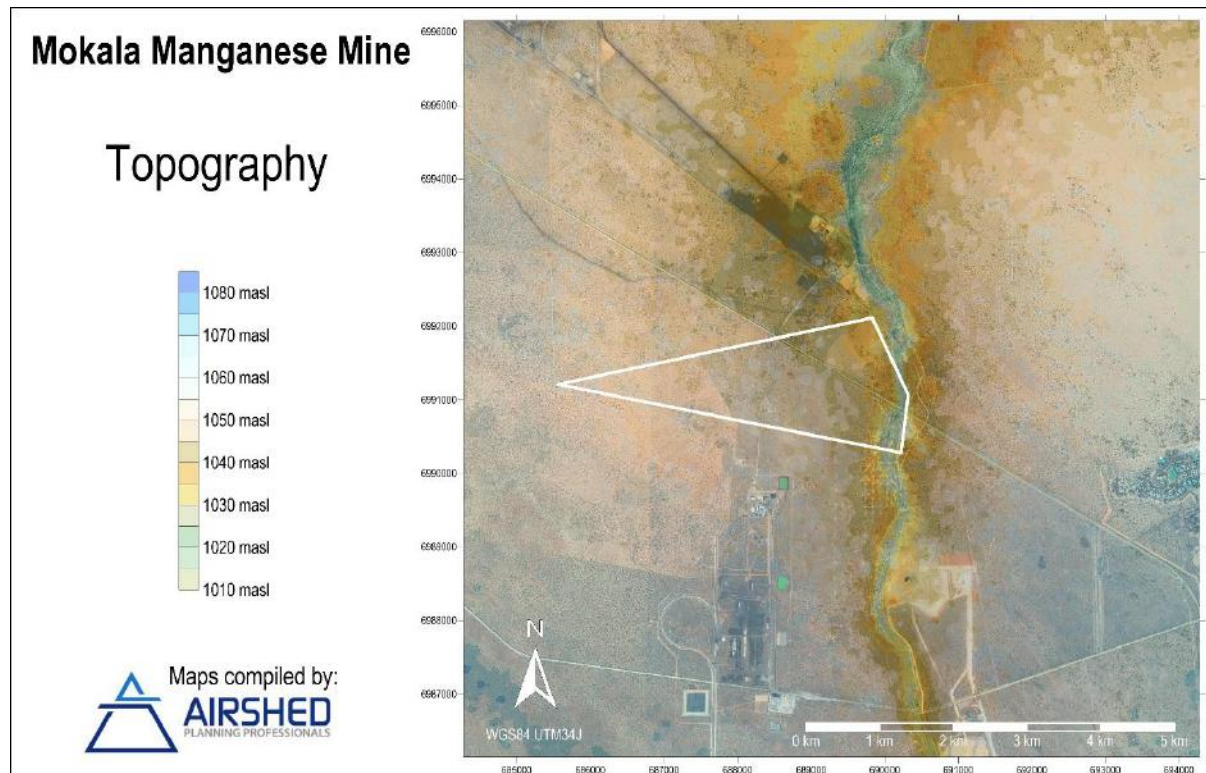
The spatial variations, and diurnal and seasonal changes, in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich & Tyson, 1988). The atmospheric processes at macro- and meso-scales need therefore be considered to accurately parameterise the atmospheric dispersion potential of a particular area. A qualitative description of the synoptic systems determining the macro-ventilation potential of the region may be provided based on the review of pertinent literature. These meso-scale systems may be investigated through the analysis of meteorological data observed for the region.



The WRF model data for a point close to site was acquired and three years of hourly sequential data was used to construct wind roses, general climatic information such as diurnal temperature variations, atmospheric stability estimates and for dispersion modelling.

### 3.2.1 Topography

The study area is characterised by flat topography with sparse vegetation. An analysis of topographical data indicated a slope of less than 1:10 from over most of the project area. Dispersion modelling guidance recommends the inclusion of topographical data in dispersion simulations only in areas where the slope exceeds 1:10 (US EPA, 2004).



### 3.2.2 Local Wind Field

The vertical dispersion of pollution is largely a function of the wind field. The wind speed determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is similarly a function of wind speed, in combination with surface roughness (Tiwary & Colls, 2010).

The 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 (Figure 4 and Figure 5), 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. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

The period wind field and diurnal variability in the wind field are shown in Figure 4, while seasonal variations are shown in Figure 5. The wind field is dominated by winds from the north-easterly sector. The strongest winds (>6 m/s) occurred mostly

from the northerly sectors. Calm conditions occurred 3.66% of the time, with the average wind speed over the period of 4.36 m/s. Wind speeds are stronger during the day but with a higher frequency of calm conditions (4.01% during the day) than during the night (3.31% during the night). Night-time shows dominant north-easterly, east-north-easterly, south-south-easterly and southerly components to the wind field and during the day these winds decrease, and the northerly winds dominate. Strong winds exceeding 6 m/s occurred most frequently during summer and spring, followed by winter. Calm conditions occurred most frequently during the autumn and winter months.

Seasonally, the wind flow pattern conforms to the period average wind flow pattern. The seasonal wind field shows considerable seasonal differences in the wind fields. During summer, autumn and winter the dominant winds are from the east, northeast and south, while in spring, the southerly winds dominate.

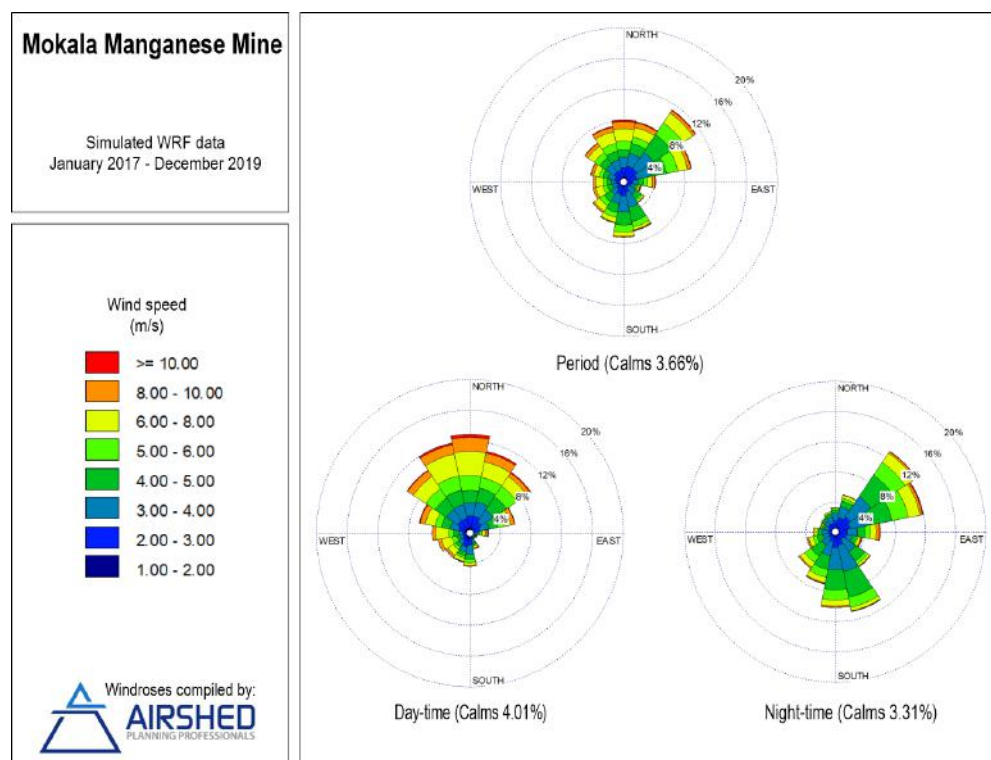


Figure 4: Period, day- and night-time wind roses (AERMET processed WRF data, January 2017 to December 2019)

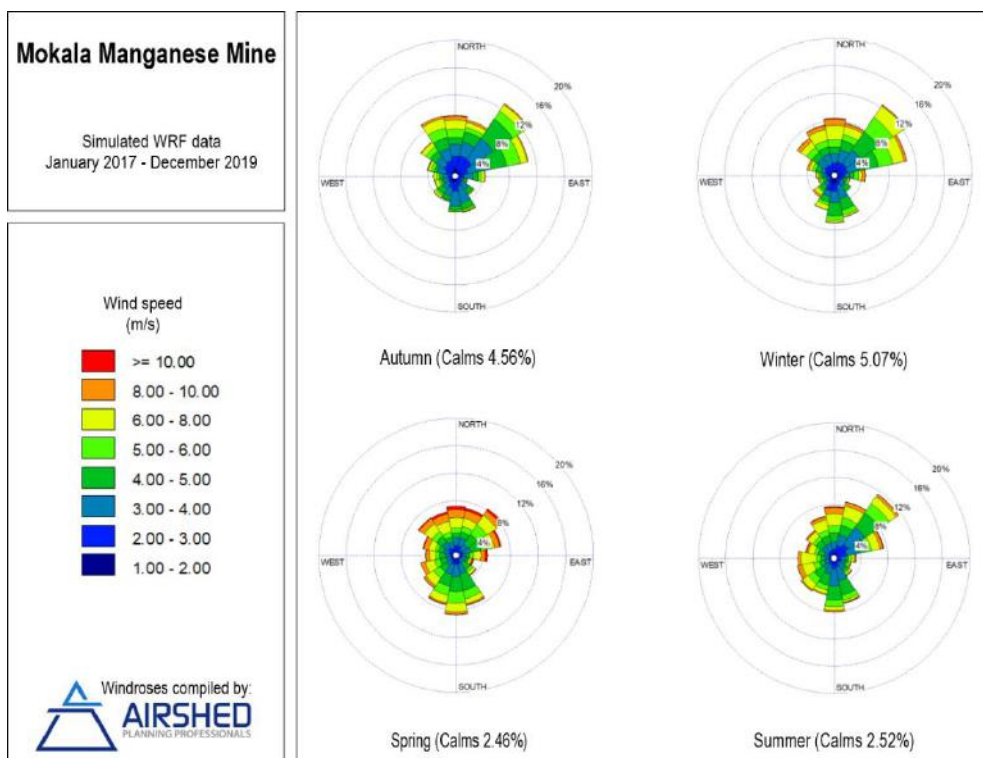


Figure 5: Seasonal wind roses (AERMET processed WRF data, January 2017 to December 2019)

### 3.2.3 Ambient Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the emission plume and the ambient air, the higher the plume is able to rise), and determining the development of the mixing and inversion layers.

Monthly mean, maximum and minimum temperatures are given in Table 6 Monthly temperature summary (AERMET processed WRF data, January 2017 to December 2019). Diurnal temperature variability is presented in Figure 6. Temperatures ranged between -5°C and 39°C. The highest temperatures occurred in December and January and the lowest in July. During the day, temperatures increase to reach maximum at around 14:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 06:00 i.e. just before sunrise.

Table 6 Monthly temperature summary (AERMET processed WRF data, January 2017 to December 2019)

Minimum, Average and Maximum Temperatures (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	12	12	9	5	0	-3	-5	-4	-4	-1	6	11
Maximum	35.0	34.1	32.5	29.9	26.9	22.3	21.7	28.3	27.8	32.3	34.7	35.0
Average	28	27	25	22	17	13	12	14	19	22	25	27

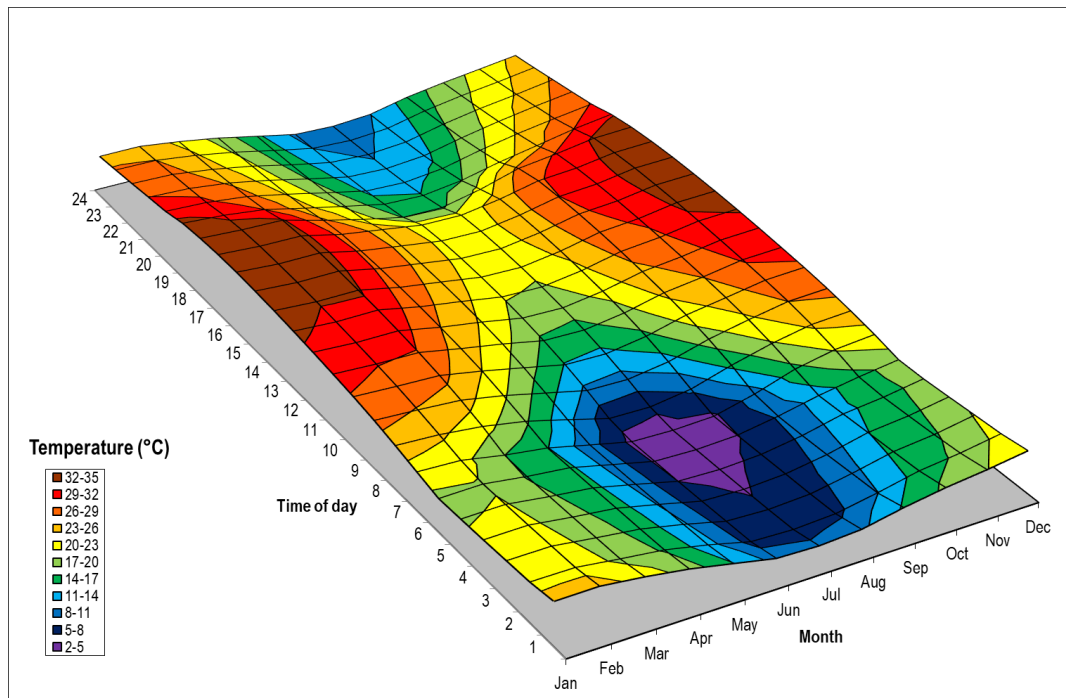


Figure 6: Diurnal temperature profile (AERMET processed WRF data, January 2017 to December 2019)

### 3.2.4 Atmospheric Stability

The new generation air dispersion models differ from the models traditionally used in several aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters; the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class.

The Monin-Obukhov length ( $L_{MO}$ ) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night-times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and lower dilution potential.

Diurnal variation in atmospheric stability, as calculated from on-site data, and described by the inverse Monin-Obukhov length and the boundary layer depth is provided in Figure 7. The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions. For elevated releases, unstable conditions can result in very high concentrations of poorly diluted emissions close to the stack. This is called *looping* and occurs mostly during daytime hours. Neutral conditions disperse the plume fairly equally in both the vertical and horizontal planes and the plume shape is referred to as *coning*. Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called *fanning* (Tiwary & Colls, 2010). For ground level releases, such as fugitive dust from mining activities, the highest ground level concentrations will occur during stable night-time conditions.

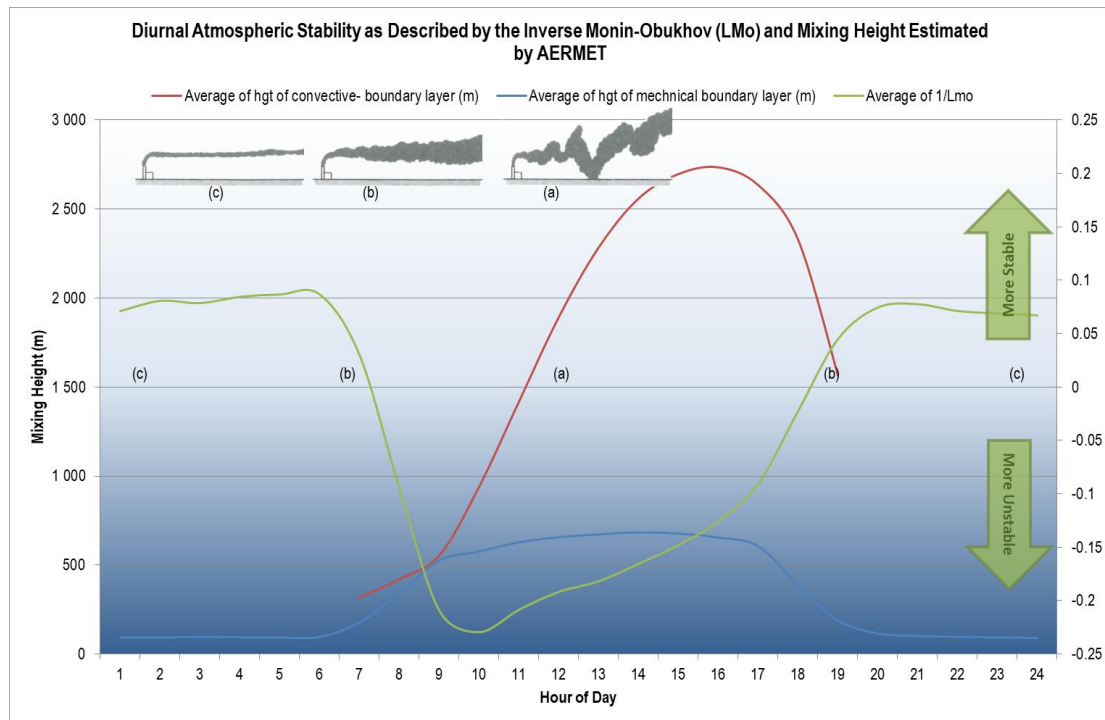
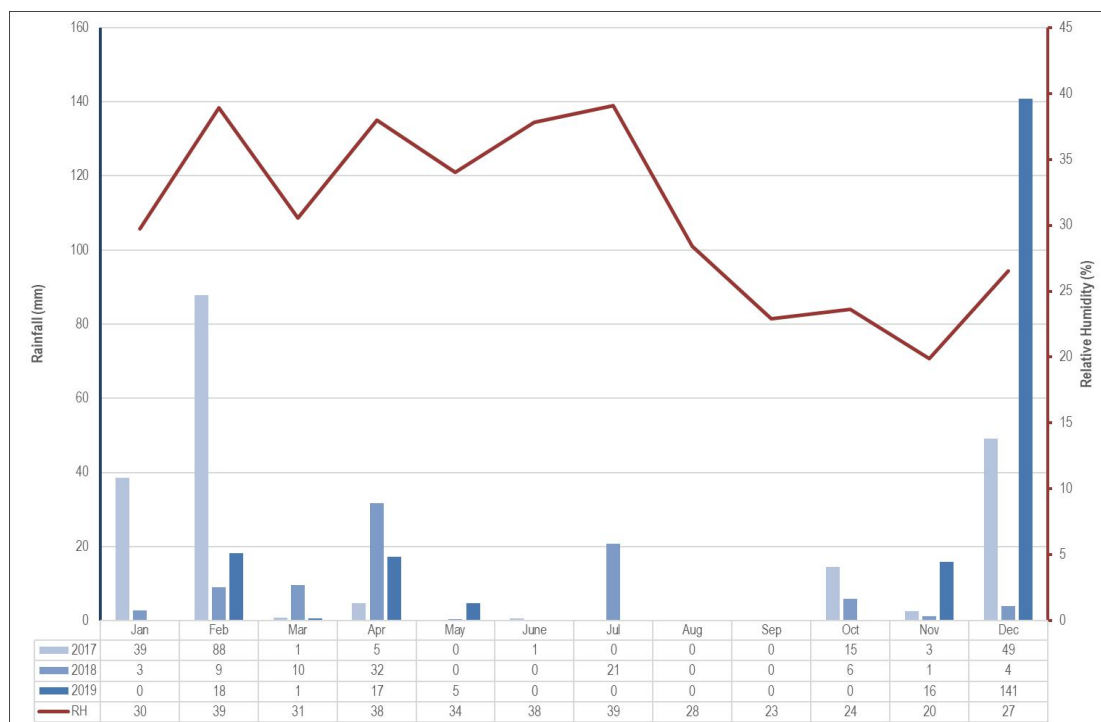


Figure 7: : Diurnal atmospheric stability (AERMET processed WRF data, January 2017 to December 2019)

### 3.2.5 Rainfall

Rainfall is important to air pollution studies since it represents an effective removal mechanism of atmospheric pollutants. Rainfall primarily as a result of storms and individual rainfall events can be intense. This creates an uneven rainfall distribution over the study area. Dust can be generated by strong winds that accompany storms. This dust generally occurs in areas with dry soils and sparse vegetation. The average annual total rainfall in the vicinity of the mining right area based on long-term data (the surface water specialist study dataset from May 1937 to November 2020) is 267 mm.

The monthly rainfall totals obtained from the hourly sequential WRF data for a location close to the mining rights area is presented in Figure 8. Average total annual rainfall from January 2017 to December 2019 is 161 mm. The rainfall for 2017, 2018 and 2019 was 199 mm, 86 mm, and 198 mm, respectively. Rainfall in this area occurs mostly during the summer months although it also rains during spring and autumn while the winter months are dry even though the relative humidity is greater during the winter period than other seasons. Colder air can hold less moisture than warmer air and thus the percentage saturation is higher at a lower moisture quantity resulting in higher relative humidity during colder periods than warmer periods.



**Figure 8: Monthly rainfall and relative humidity (AERMET processed WRF data, January 2017 to Site Visit)**

A site visit was not undertaken for the update of the air quality impact assessment. Adequate project information was obtained from SLR as well as from previous studies done in the area. Since ambient air quality monitoring was not included as part of the air quality assessment, a site visit will not have yielded any significant difference from the baseline information received.



### 3.3 Ambient Air Quality within the Region

#### 3.3.1 Measured Ambient Air Quality

The mine is in a rural area currently affected by air pollution sources such as wind-erosion from exposed areas and vehicle exhaust emissions. Pollutants released include but are not limited to, fugitive PM<sub>2.5</sub>, PM<sub>10</sub> and TSP and gaseous pollutants as products of the combustion of petrol and diesel. There are also various mining and ore processing operations in the region.

As at the time of writing this report, ambient air quality monitoring data for was not available for the Mokala Manganese Mine. However, dustfall sampling results at eight locations around and inside the mine boundary were available for a sampling period of 6 months. A literature on sources of air pollution within the region is provided in the next section.

#### 3.3.2 Sources of Air pollution within the region

Neighbouring land-use surrounding the mine comprises predominantly of agriculture and mining activities. These land-uses contribute to baseline pollutant concentrations via fugitive and process emissions, vehicle tailpipe emissions, household fuel combustion, biomass burning and windblown dust from exposed areas.

##### 3.3.2.1 Mining Sources

Particulates represent the main pollutant of concern at mining operations, whether it is underground or opencast. The amount of dust emitted by these activities depends on the physical characteristics of the material, the way in which the material is handled and the weather conditions (e.g. high wind speeds, rainfall, etc.).

The proposed, operational and decommissioned mines located within the region are:

- Kalagadi Manganese Mine;
- Mamatwan Manganese Mine;
- Black Rock Manganese Mine;
- Gloria Manganese Mine;
- Wessels Manganese Mine;
- N'Chwaning Manganese Mine;
- Khumani Iron Ore Mine;
- Tshipi Borwa Mine;
- Kudumane Mine;
- York Manganese Mine (decommissioned thus only wind erosion sources);
- Devon Mines (decommissioned thus only wind erosion sources); and
- Middelplaats Mine (decommissioned thus only wind erosion sources).
- Unitech Manganese of Kalahari
- Amari Manganese Mine

### 3.3.2.2 *Fugitive Dust Sources*

These sources are termed fugitive because they are not discharged to the atmosphere in a confined flow stream. Sources of fugitive dust identified in the study area include paved and unpaved roads and wind erosion of sparsely vegetated surfaces.

#### 3.3.2.2.1 *Unpaved and paved roads*

Emissions from unpaved roads constitute a major source of atmospheric emissions in the South African context. When a vehicle travels on an unpaved road the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong turbulent air shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. Dust emissions from unpaved roads vary in relation to the vehicle traffic and the silt loading on the roads. Unpaved roads in the region are mainly mine haul roads.

Emission from paved roads are significantly less than those originating from unpaved roads, however they do contribute to the particulate load of the atmosphere. Particulate emissions occur whenever vehicles travel over a paved surface. The fugitive dust emissions are due to the re-suspension of loose material on the road surface. Existing paved roads in the region include the R380 and R31.

#### 3.3.2.2.2 *Wind erosion of open areas*

Windblown dust generates from natural and anthropogenic sources. For wind erosion to occur, the wind speed needs to exceed a certain threshold, called the threshold velocity. This relates to gravity and the inter-particle cohesion that resists removal. Surface properties such as soil texture, soil moisture and vegetation cover influence the removal potential. Conversely, the friction velocity or wind shear at the surface is related to atmospheric flow conditions and surface aerodynamic properties. Thus, for particles to become airborne, its erosion potential has to be restored; that is, the wind shear at the surface must exceed the gravitational and cohesive forces acting upon them, called the threshold friction velocity. Every time a surface is disturbed, its erosion potential is restored (US EPA, 2004). Erodible surfaces may occur as a result of agriculture and/or grazing activities.

#### 3.3.2.3 *Vehicle Tailpipe Emissions*

Emissions resulting from motor vehicles can be grouped into primary and secondary pollutants. While primary pollutants are emitted directly into the atmosphere, secondary pollutants form in the atmosphere as a result of chemical reactions. Significant primary pollutants emitted combustion engines include carbon dioxide (CO<sub>2</sub>), carbon (C), sulphur dioxide (SO<sub>2</sub>), oxides of nitrogen (mainly NO), particulates and lead. Secondary pollutants include NO<sub>2</sub>, photochemical oxidants such as ozone, sulphur acid, sulphates, nitric acid, and nitrate aerosols (particulate matter). Vehicle type (i.e. model-year, fuel delivery system), fuel (i.e. oxygen content), operating (i.e. vehicle speed, load) and environmental parameters (i.e. altitude, humidity) influence vehicle emission rates.

Transport in the vicinity of the mine site is via trucks and private vehicles along the existing R380 (public) road, which are the main sources of vehicle tailpipe emissions.



### 3.4 Dustfall Sampling Results

Dustfall sampling and analysis was conducted by Umoya Occupational Hygiene & Laboratory Solutions (Pty) Ltd from the 18<sup>th</sup> of August 2020 to the 21<sup>st</sup> of March 2021. Dustfall units were installed at eight sites along and within the mine boundary to undertake eight months of dustfall sampling (Figure 9). Gaps in the results presented are due to misplacement of buckets during their exposure at the respective sites.

The dust fallout sampling was undertaken in accordance with ASTM D1739 (2017) as the draft NDCR recommends the most recent version of ASTM D1739. The sampling network can be classified as non-residential sites according to the NDCR; Figure 10 illustrates the dustfall rates at each of the eight locations during the sampling period. Exceedances to the NDCR non-residential limit are noted at sites MK3 (November, December and January) MK4 (October, November, December and March), and at MK7 (August). The sampled dustfall rates at MK3 and MK4 were non-compliant with the NDCR because they exceeded the applicable limit more than twice in sequential months (November, December and January at MK3; October, November and December at MK4). None of the dustfall sampling buckets was placed near any of the sensitive receptors hence no assertions or conclusions can be made about compliance to the NDCR residential limits at AQSRs.

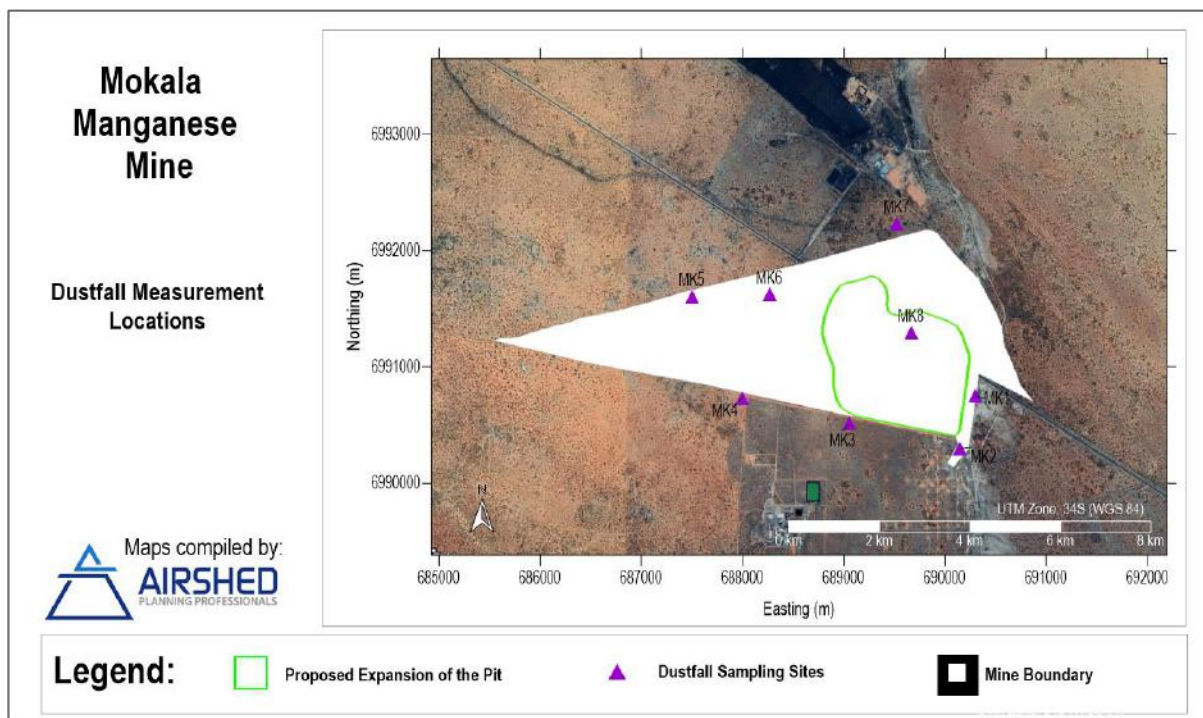


Figure 9: Dustfall sampling sites at Mokala mine

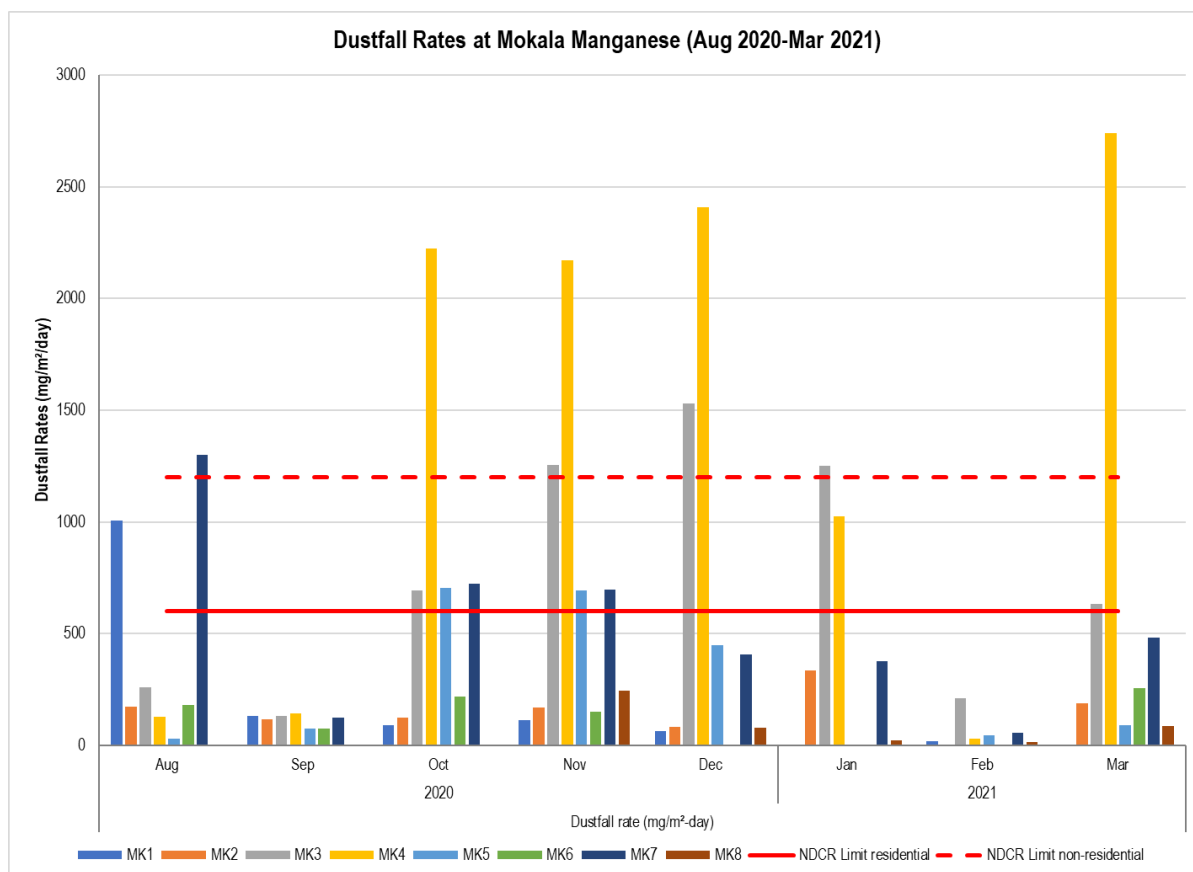


Figure 10: Dustfall rates sampled at eight locations near Mokala mine from August 2020 to March 2021.

## 4 IMPACT ON THE RECEIVING ENVIRONMENT

### 4.1 A Qualitative assessment of the project components that have already taken place

A qualitative assessment of air quality impacts due to project components that have already taken place is discussed in Table 7. Information gathered from the previous study (14SLR17a) (Akinshipe, 2015), was used to draw inferences to the qualitative assessment and from that study, the human health impacts due to PM and gaseous pollutants were low, with a medium probability of occurrence. The human health impacts due to respirable Mn (elemental) were deemed to be medium with dispersion modelling results displaying exceedances to the various international guidelines up to 4 km south of the mine boundary.

Based on the information below, the overall emissions could have been high if no mitigation measures were implemented, likely resulting in medium impacts to human health through inhalation. There is no schedule provided by SLR to indicate the time that these components could have been implemented. However, if they took place over a shorter period, the duration and severity of the impacts could have been low. Ranking of these sources is also not possible to determine the components that contribute significantly to the emissions.

Similar to construction activities, the implementation of these project components likely happened over a short period and resulted in intermittent emissions. There is no evidence that any cumulative impacts to human health due to the proposed activity/infrastructure changes can be attributed to the components that have already taken place.

**Table 7: Qualitative Assessment of Air Quality Impacts**

	Project Component	Impact on Human Health
1	The reconfiguration of the plant area, ROM, and high-grade product stockpiles to accommodate the expansion of the open pit.	It is likely that there were no dust impacts due to the reconfiguration of the plant area. However, movement of the ROM, and high-grade product stockpile to new locations could have resulted in additional dust, PM and elemental Mn emissions due to material handling. If mitigation measures such as water sprays were applied, then the impacts were significantly reduced.
2	The relocation of the low-grade product stockpile.	The movement of the low-grade product stockpile involved material handling processes such as tipping, loading and dumping, which results in the emission of dust, PM and Mn. Mitigation through water sprays can reduce the impacts by up to 50%.
3	The relocation of support infrastructure (water storage facilities for potable and process water, workshops and wash bay, change houses, sewage treatment plant, water treatment plant, fuel storage, administrative block including offices, kitchen, canteen, training centre, mustering centre, clinic, stores and waste storage).	The movement of the support infrastructure involved carrying it to their new location. Haulage trucks were likely used and this resulted in dust and PM emissions due to vehicle entrainment, and gaseous emissions through the exhaust pipes. If the relocation did not result in the construction of new infrastructure, these emissions were short lived.
4	Relocation of the approved WRD to accommodate the expansion of the open pit;	Relocation of the WRD involved material handling processes such as tipping, loading and dumping, which results in the emission of dust and PM. Mitigation through water sprays can reduce the impacts by up to 50%.
5	Relocation of the approved topsoil stockpiles	Same as above.

#### 4.2 A Quantitative Assessment of the Impacts Due to the Mining of the Kalagadi Barrier Pillar

Mining will also take place adjacent the mining right area at the Kalagadi barrier pillar. If the mining rate and fleet is the same as the current or Phase 2-6 operations, then the impact will be the same in magnitude, with the impact area likely to shift to the southwest, west-southwest, and south southwest. This attestation is guided by interpretation of the wind field. Given that there are barely any sensitive receptors in the area, the likelihood of any additional or adverse impacts are minimum. If however it is mined simultaneously with current operations, with additional equipment being brought in to achieve that, the impact will be cumulative with the other operations, hence resulting in exceedances at the closest sensitive receptors.

In conclusion, the impacts due to the mining of the Kalagadi Barrier Pillar are expected to be the same in scale and magnitude as those of the Phase 2 to 6 operations.

#### 4.3 Atmospheric Emissions

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts from the project's operations on the receiving environment. The proposed project operations will consist of a construction phase,

Updated Air Quality Impact Assessment for the Mokala Manganese Mine near Hotazel in the Northern Cape Province

an operational phase and a closure (decommissioning and post-closure) phase. A short discussion on the expected activities, typical of an open cast manganese mine is provided in the sections below with a summary on the typical sources and associated activities for construction, operational and closure phase of the project.

#### 4.3.1 Construction Phase

Construction activities are potentially significant sources of dust emissions that may have a substantial temporary impact on local air quality where emissions result from general site preparation. Construction activities that contribute to air pollution typically include land clearing, excavation, material handling activities, wheel entrainment, operation of diesel or petrol engines etc. If not properly mitigated, construction sites could generate high levels of dust (typically from concrete, cement, wood, stone, silica) and this has the potential to travel for large distances.

Construction dust, in the larger TSP fraction, will generally impact close to the construction activities and is more responsible for soiling than health issues. Health impacts are more associated with the finer PM<sub>10</sub> and PM<sub>2.5</sub> fractions, both of which are invisible to the naked eye. Combustion engines also emit emissions of CO, hydrocarbons, NO<sub>x</sub> and SO<sub>2</sub>. However, these gaseous emissions may often not be as significant when compared to particulate emissions, and the quantification of particulate matter emissions (and the atmospheric dispersion thereof) is generally considered a better key-indicator pollutant for construction phase impacts than gaseous emissions.

Dust emissions can also vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. It is therefore often necessary to estimate area wide construction emissions, without regard to the actual plans of any individual construction process. Construction phase emissions were not quantified since the construction schedule is not known and the temporary nature of these operations is not easily captured in dispersion simulations.

#### 4.3.2 Operational Phase

Sources of emission and associated pollutants considered in the emissions inventory for the operational phase include<sup>2</sup>:

- Blasting – PM<sub>2.5</sub>, PM<sub>10</sub>, TSP and elemental Mn
- Crushing and screening – PM<sub>2.5</sub>, PM<sub>10</sub>, TSP and elemental Mn
- Drilling – PM<sub>2.5</sub>, PM<sub>10</sub>, TSP and elemental Mn
- Materials handling (ore and waste rock) – PM<sub>2.5</sub>, PM<sub>10</sub>, TSP and elemental Mn
- Vehicle exhaust emissions – CO, NO<sub>x</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>, SO<sub>2</sub> and VOC
- Windblown dust from material stockpile – PM<sub>2.5</sub>, PM<sub>10</sub>, TSP and elemental Mn
- Entrained dust from unpaved roads – PM<sub>2.5</sub>, PM<sub>10</sub>, and TSP

All emissions were determined through the application of emission factors published by the US EPA and the Australian NPI. A summary of fugitive dust sources quantified, emissions estimation techniques applied, and source input parameters are summarised in Table 8. As part of the management of dust emissions, the efficiencies of some basic mitigation measures were also quantified. Estimated annual average emissions, per source group, are presented in Table 9. The contributions of each source group's emissions to the total are graphically presented in Figure 11 and Figure 12 for both the design and additionally mitigated scenarios.

---

<sup>2</sup> Refer to Section 1.4, 'Assumptions, Exclusions and Limitations', for more details about sources of emission not included in the assessment.



**Table 8: Emission estimation techniques and parameters**

Source Group	Emission Estimation Technique	Input Parameters and Activities
<b>Topsoil Scrapping</b>	<p>US EPA Mining Single valued emission factor (US EPA, 1995)</p> <p>TSP – 0.029 kg/ton</p> <p>PM<sub>10</sub> – 0.02175 kg/ton</p> <p>PM<sub>2.5</sub> – 0.003045 kg/ton</p> <p>(PM<sub>10</sub> and PM<sub>2.5</sub> calculated from PM ratio in Table 11.9-2 of US EPA (1998)).</p>	<p>Topsoil scrapping area was estimated to include the phase 2 pit area scheduled for expansion:</p> <ul style="list-style-type: none"> <li>Scrapping area = 48.72 m<sup>2</sup>/day</li> <li>Topsoil volume = 19.93 ton/hr</li> </ul> <p><b>Design Mitigation:</b> 50 % control efficiency achieved through water sprays (NPI, 2011).</p> <p><b>Recommended Additional Mitigation:</b> None</p>
<b>Drilling and Blasting</b>	<p><b>Blasting:</b> Single valued emission factors for metalliferous mines (NPI, 2011)</p> <p>TSP – 0.59 kg/hole</p> <p>PM<sub>10</sub> – 0.31 kg/hole</p> <p>PM<sub>2.5</sub> – <i>assumed</i> to be 0.16 kg/hole</p> <p><b>Drilling:</b> Emission factor equation (NPI, 2011)</p> $EF = k \cdot 0.00022 \cdot A^{1.5}$ <p>Where</p> <p>EF is the emission factor in kg/blast</p> <p>A is the area blasted at a time m<sup>2</sup></p> <p>k is the particle size multiplier (k<sub>TSP</sub> – 1, k<sub>PM10</sub> – 0.52, k<sub>PM2.5</sub> – 0.03)</p> <p><b>Elemental Mn emissions</b> taken as 39 % of PM<sub>10</sub> emissions (39 % is given as the average proportion of elemental Mn in the Ore)</p>	<p><b>Hours of operation:</b> 24 hrs per day, 5.5 days per week</p> <p><b>Design Mitigation:</b> None</p> <p><b>Activities:</b></p> <p>Drilling and blasting of waste rock</p> <p>Drilling and blasting of ore</p> <p>Area of drilling and blasting = 5000 m<sup>2</sup> of the pit area</p> <p>The number <b>holes drilled per week</b> was calculated from information provided in the previous study = 125 (Ore) and 400 (waste)</p> <p>Blasting per week = 1 (Ore) and 2 (waste)</p> <p>Average <b>depth of drill holes</b> = 15 m (waste), 7 m (Ore)</p> <p>Average <b>drill hole spacing</b> = 5.1 m (waste), 5.5 m (ore)</p> <p><b>Design Mitigation:</b> Blasting = None, Drilling = 70% control efficiency achieved through water sprays (NPI, 2011)</p> <p><b>Recommended Additional Mitigation:</b> Blasting = None; Drilling = 99 % control efficiency achieved through fabric filters (NPI, 2011)</p>
<b>Crushing and Screening</b>	<p>NPI single valued emission factors for low moisture (&gt;4%) ore (NPI, 2011) for primary crushing , secondary crushing and screening respectively</p> <p>TSP – 0.2, 0.6 and 0.08 kg/tonne</p> <p>PM<sub>10</sub> – 0.02, 0.06 and 0.06 kg/tonne</p> <p>PM<sub>2.5</sub> – <i>assumed</i> to be 0.006, 0.018 and 0.0024 kg/tonne</p> <p><b>Elemental Mn emissions</b> taken as 39 % of PM<sub>10</sub> emissions (39 % is given as the average proportion of elemental Mn in the Ore)</p>	<p>Primary and secondary crushing of ore at the following <b>rates</b>, were included:</p> <ul style="list-style-type: none"> <li>Primary crushing and screening of ore – 1 560 000 t/a</li> <li>Secondary crushing and screening of ore – 1 560 000 t/a</li> </ul> <p><b>Hours of operation:</b> 24 hrs per day, 5.5 days per week</p> <p><b>Moisture given:</b> 5 %.</p> <p><b>Design Mitigation:</b> 50% control efficiency achieved through water sprays (NPI, 2011).</p> <p><b>Recommended Additional Mitigation:</b> 75 % addition of more water.</p>

Source Group	Emission Estimation Technique	Input Parameters and Activities
<b>Materials Handling</b>	<p>US EPA emission factor equation (US EPA, 2006)</p> $EF = k \cdot 0.0016 \cdot \left(\frac{U}{2.3}\right)^{1.3} \cdot \left(\frac{M}{2}\right)^{-1.4}$ <p>Where  EF is the emission factor in kg/tonne material handled  k is the particle size multiplier (<math>k_{TSP} = 0.74</math>, <math>k_{PM10} = 0.35</math>, <math>k_{PM2.5} = 0.053</math>)  U is the average wind speed in m/s  M is the material moisture content in %</p> <p><b>Elemental Mn emissions</b> taken as 39 % of <math>PM_{10}</math> emissions (39 % is given as the average proportion of elemental Mn in the Ore)</p>	<p>All ore and waste handling steps (excavation, truck loading, truck off-loading, and conveyor transfer) were included.</p> <p>An average <b>wind speed of 4.36m/s</b> was determined from the WRF data set.</p> <p>A <b>moisture content of 5 %</b> was utilized for ore and waste.</p> <p><b>Hours of operation:</b> 24 hrs per day, 5.5 days per week.</p> <p><b>Activities:</b> The number of transfer points and rates used in the estimation of emissions are:  Loading waste onto truck by excavator and dumping at waste dump = 16,750,000. t/a  Loading ore onto trucks and tipping onto ROM storage pile = 1 570 000 t/a  Loading ore from ROM storage pile with Front-end-Loader into Static Grizzly = 1 560 000 t/a  Waste backfilling = 15,075,000 t/a (90% as in previous study)  Processed ore (Product) to product stockpile = 1 340 000 t/a  Processed ore (Fines) to Fines stockpile = 236 770 t/a</p> <p><b>Design Mitigation:</b> 50% control efficiency achieved through effective water sprays (NPI, 2011).</p> <p><b>Recommended Additional Mitigation:</b> 75% achieved through water sprays and covering (NPI, 2011).</p>
<b>Vehicle Entrained Dust from Unpaved Roads</b>	<p>US EPA emission factor equation (US EPA, 2006)</p> $E = k \cdot \left(\frac{S}{12}\right)^a \cdot \left(\frac{W}{3}\right)^{0.45} \cdot 281.9$ <p>Where  EF is the emission factor in g/vehicle kilometer travelled (VKT)  k is the particle size multiplier (<math>k_{TSP} = 4.9</math>, <math>k_{PM10} = 1.5</math>, <math>k_{PM2.5} = 0.15</math>)  a is an empirical constant (<math>a_{TSP} = 0.7</math>, <math>a_{PM10} = 0.9</math>, <math>a_{PM2.5} = 0.9</math>)  s is the road surface material silt content in %  W is the average weight vehicles in tonnes</p> <p><b>Mitigation:</b> All roads on the project site will be treated with a dust palliative consisting of a cationic bitumen emulsion to stabilize the surface and prevent dust.</p>	<p>Transport activities include the transport of ore and waste within pits, materials to stockpiles, waste to WRDs and product export. VKT were calculated from road lengths, truck capacities and the number of trips required for transporting ore, waste and product.</p> <p><b>Truck capacities</b> (Ore, waste and product): 40 to 80 tonnes</p> <p>A default road <b>surface silt content of 8.4%</b> (US EPA, 2006) was applied in calculations</p> <p><b>Hours of operation:</b> 16 hrs per day, 5.5 days per week</p> <p><b>Design Mitigation:</b> 50 % control efficiency utilized through effective water sprays (lower range of mitigation applied) plus addition of <b>RDC-20<sup>1</sup></b> (NPI, 2011).</p> <p><b>Recommended Additional Mitigation:</b> <b>75 %</b> control efficiency utilized through effective water sprays (upper range of mitigation applied) plus addition of RDC-20 (estimated based on NPI (2011)).</p> <p><b>Activities:</b></p> <ul style="list-style-type: none"> <li>Waste rock and Ore transported on unpaved haul roads in the pit = 5 520t/d</li> <li>Ore transported on unpaved haul roads to ROM pad = 2 760 t/d</li> <li>Product transported on Product export road = 5 500 t/d</li> <li>Waste to stockpile: 58 580 t/d</li> <li>Ore to Low grade stockpile: 2 200 t/d</li> <li>Plant and contractor access 445 t/d</li> </ul>

Source Group	Emission Estimation Technique	Input Parameters and Activities
Windblown Dust	<p>NPI single valued emission factors (NPI, 2011)</p> <p>TSP – 0.4 kg-ha-h</p> <p>PM<sub>10</sub> – 0.2 kg-ha-h</p> <p>PM<sub>2.5</sub> – 0.1 kg/tonne (<i>Assumed PM<sub>2.5</sub> fraction</i>)</p> <p><b>Elemental Mn emissions</b> taken as 24 % of PM<sub>10</sub> emissions (24 % is given as the average proportion of elemental Mn in the Ore)</p>	<p>Exposed dry areas of stockpiles were included in emission estimations.</p> <ul style="list-style-type: none"> <li>• ROM &amp; Low grade stockpile area = 18 670 m<sup>2</sup></li> <li>• WRD area = 191 000 m<sup>2</sup></li> <li>• Product stockpile area = 3 800 m<sup>2</sup></li> <li>• Fines stockpile area = 368 m<sup>2</sup></li> <li>• Topsoil storage area = 33 500 m<sup>2</sup></li> <li>• Supplementary Stockpile area = 220 m<sup>2</sup></li> </ul> <p>20 % of area assumed to be exposed / erodible per time.</p> <p><b>Hours of operation:</b> Continuous</p> <p><b>Design Mitigation:</b> 50 % control efficiency achieved through effective water sprays (NPI, 2011).</p> <p><b>Recommended Additional Mitigation:</b> None</p>
Vehicle/Equipment Exhaust Emissions (Diesel Engines)	<p>NPI emission factors for industrial vehicle reference Table 26 – table 38. (NPI, 2008). An example of assigned emission factors is that for a haul truck (Table 33)</p> <p>CO – 4.7E-03 kg/kWh</p> <p>PM<sub>2.5</sub> – 6.19E-03 kg/kWh</p> <p>PM<sub>10</sub> – 6.73E-03 kg/kWh</p> <p>SO<sub>2</sub> – 7.73E-06 kg/kWh (estimated based on 50 ppm sulphur)</p> <p>VOC – 5.0E-04 kg/kWh</p> <p>NOx – 1.09E-02 kg/kWh</p>	<p>A list of diesel mobile equipment was supplied. Annual diesel fuel consumption was estimated for each significant portion of the site and utilized in calculation of emissions:</p> <ul style="list-style-type: none"> <li>• Administration area= 1,100,000 litres/year (excluding diesel generators)</li> <li>• Mine pit = 1,700,000 litres/year</li> <li>• Plant area = 1,144,000 litres/year</li> </ul> <p>Since no distinction was made between equipment quantities for different years of operation, emissions were distributed over entire applicable areas.</p> <p>A load factor of 0.5 (NPI, 2008) was applied to account for variation in engine load i.e. full load and idling.</p> <p><b>Hours of operation:</b> 16 hrs per day, 5.5 days per week others)</p> <p><b>Design Mitigation:</b> None</p> <p><b>Recommended Additional Mitigation:</b> None</p>



Source Group	Emission Estimation Technique	Input Parameters and Activities
<b>Power Generation (Diesel Engines)</b>	<p>NPI single valued emission factors for miscellaneous industrial diesel engine (NPI, 2008):</p> <p>CO – 3.0E-03 kg/kWh</p> <p>NO<sub>x</sub> – 7.90E-03 kg/kWh</p> <p>PM<sub>2.5</sub> – 4.20E-04 kg/kWh</p> <p>PM<sub>10</sub> – 4.30E-04 kg/kWh</p> <p>SO<sub>2</sub> – 1.97E-02 kg/kWh (Sulphur content assumed as 50 ppm)</p> <p>VOC – 3.80E-04 kg/kWh</p>	<p>1 X CAT 3516 1600 KVA diesel generators</p> <p>Fuel use given as 1320 litres per day</p> <p>A load factor of 0.5 (NPI, 2008) was applied to account for variation in engine load.</p> <p><b>Stack parameters obtained from the CAT 3516 specification manual:</b></p> <p><b>Stack height</b> = 2.342 m</p> <p><b>Stack diameter</b> = 0.2032 m</p> <p><b>Exit flow rate</b> = 4.505 m<sup>3</sup>/s</p> <p><b>Stack exit temperature</b> = 737.65 K</p> <p><b>Hours of operation</b> = Continuous 8760 per year (Given)</p> <p><b>Design Mitigation:</b> None</p> <p><b>Recommended Additional Mitigation:</b> None</p>

**NOTE:** <sup>1</sup> RDC-20 (E-CAT) is a water-soluble anionic polyelectrolyte formulation of blended emulsified co-polymers and ionic modifiers. When sprayed onto road surfaces, it forms a durable crossed linked matrix. The matrix will bind fine soil particles into larger heavier particles, which would be less prone to becoming airborne.

**Table 9: Estimated annual average emission rates per source group**

Emissions (tpa) with Mine Design Mitigation								
Sources	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Mn	CO	NOx	SO <sub>2</sub>	VOC
Construction	18.65	13.99	1.96	-	-	-	-	-
Topsoil Scrapping	5.51	0.01	0.00	-	-	-	-	-
Blasting	340.68	336.60	19.42	0.59	-	-	-	-
Drilling	4.70	4.69	2.42	0.56	-	-	-	-
Unpaved Roads	1,865.69	537.65	53.76	-	-	-	-	-
Materials Handling	35.16	31.60	4.78	1.32	-	-	-	-
Crushing and Screening	15.11	6.04	0.92	1.43	-	-	-	-
Vehicle Exhausts	-	-	-	-	33.78	116.12	4.05	11.44
Wind erosion	76.61	38.30	5.75	4.42	-	-	-	-
<b>Total</b>	<b>2,343.47</b>	<b>954.89</b>	<b>87.05</b>	<b>8.32</b>	<b>33.78</b>	<b>116.12</b>	<b>4.05</b>	<b>11.44</b>
Emissions (tpa) with Recommended Additional Mitigation								
Sources	TSP	PM <sub>10</sub>	PM <sub>2.5</sub>	Mn	CO	NOx	SO <sub>2</sub>	VOC
Construction	18.65	13.99	1.96	-	-	-	-	-
Topsoil Scrapping	2.76	0.01	0.00	-	-	-	-	-
Blasting	340.68	673.19	38.84	0.59	-	-	-	-
Drilling	0.05	0.05	0.02	0.01	-	-	-	-
Unpaved Roads	946.74	269.22	26.92	-	-	-	-	-
Materials Handling	17.58	15.80	2.39	0.66	-	-	-	-
Crushing and Screening	1.89	0.76	0.11	0.18	-	-	-	-
Vehicle Exhausts	-	-	-	-	33.78	116.12	4.05	11.44
Wind erosion	19.15	9.58	1.44	1.10	-	-	-	-
<b>Total</b>	<b>1,328.85</b>	<b>632.00</b>	<b>50.31</b>	<b>2.54</b>	<b>33.78</b>	<b>116.12</b>	<b>4.05</b>	<b>11.44</b>

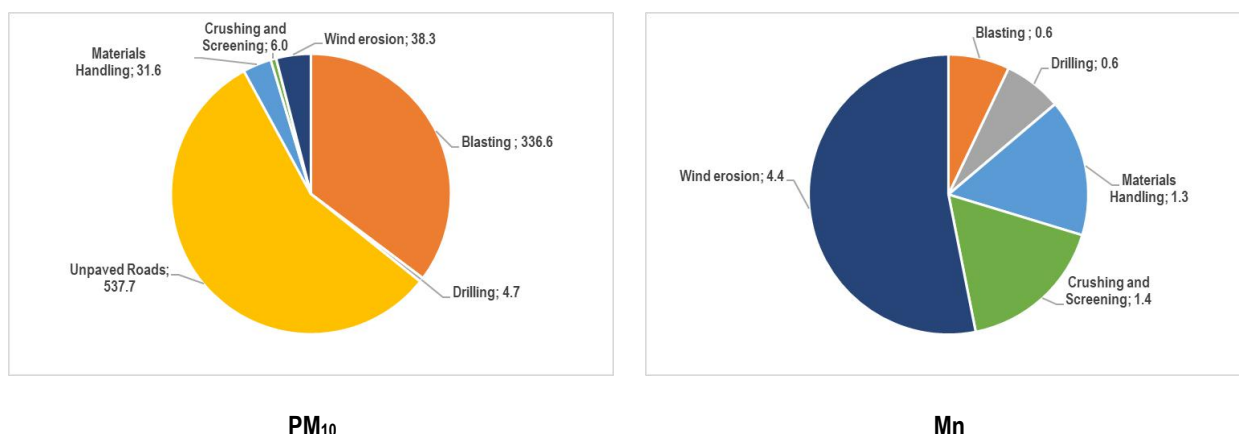


Figure 11: Source group contributions to estimated annual emissions for the design mitigated scenario in tpa.

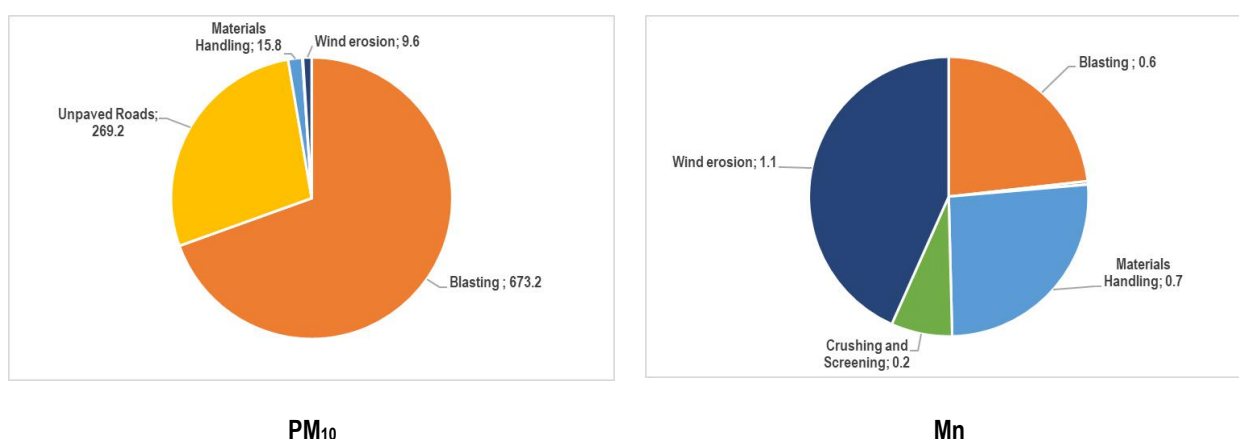


Figure 12: Source group contributions to estimated annual emissions for the additionally mitigated option in tpa.

The following should be noted with regards to the emissions inventory:

- Crushing and screening contribute most notably to estimated PM and Mn emissions during the project's operational phase. About 35% to 87% of emissions are expected to be from crushing and screening when mine design mitigation is applied. Its contribution decreases to between 17% and 63% with further mitigation measures in place. Unpaved roads, as the second highest emission source, contribute between 17 % and 42 %.
- CO, VOCs, NO<sub>x</sub> and SO<sub>2</sub> emissions are only emitted by diesel engines.

#### 4.3.3 Closure Phase

All operational activities will have ceased by the closure (decommissioning and post-closure) phase of the project. This will obviously 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 plant area and the waste dump site. Aspects and activities associated with the closure phase of the project are listed in Table 10.

Table 10: Activities and aspects identified for the closure phase

Aspects	Activities
Fugitive dust	Demolition and stripping away of buildings and facilities
Fugitive dust	Topsoil recovered from stockpiles for rehabilitation and re-vegetation of surroundings

Aspects	Activities
Fugitive dust	Wind-blown dust from stockpile and exposed areas
Fugitive dust	Degradation of paved roads resulting in unpaved road surfaces. <b>Note:</b> the R380 diversion road will remain part of the provincial road. All other roads will be rehabilitated.

#### 4.4 Atmospheric Dispersion Modelling

The assessment of the impact 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);
- The potential of the atmosphere to disperse and dilute pollutants emitted by the project (Section 3.2); and
- The methodology followed in determining ambient pollutant concentrations and dustfall rates (Section 1.3.4)

The impact of operations on the atmospheric environment was determined through the simulation of dustfall rates and ambient pollutant concentrations. Simulated air quality impacts represent those associated with the project's operations only. Cumulative pollutant concentrations and dustfall rates as a result of the project in addition to pre-development air pollution levels could not be determined at this stage.

Dispersion models simulate ambient pollutant concentrations and dustfall rates 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.

#### 4.4.1 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 (pre-processed by the AERMET model), terrain data, information on the nature of the receptor grid and pre-development or background pollutant concentrations or dustfall rates.

Version 9.0.0.17 of AERMOD and its pre-processors were used in the study. The US EPA 19191 AERMOD executable was used.

#### 4.4.2 Meteorological Requirements

For the purpose of the current study use was made of hourly WRF surface and profile data for the period 2017 to 2019 (Section 3.2).

#### 4.4.3 Source and Emission Data Requirements

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

- Crushing and materials handling – modelled as volume sources;
- Generators – modelled as point sources;
- Unpaved roads – modelled as area sources; and
- Topsoil scraping, vehicle and non-mobile equipment exhaust, drilling, blasting and windblown dust – modelled as polygon area sources.

#### 4.4.4 Simulation of NO/NO<sub>2</sub> Transformation

Nitrogen monoxide (NO) emissions are rapidly converted in the atmosphere into nitrogen dioxide (NO<sub>2</sub>). Since the maximum NO<sub>x</sub> concentrations were higher than the NAAQS for NO<sub>2</sub>, a tier 2 ambient ratio method was used to calculate NO<sub>2</sub> impacts

using NO<sub>2</sub>/NO<sub>x</sub> emission ratio of 0.8 was applied when plotting the isopleths as prescribed by the regulations regarding dispersion modelling in South Africa (DEA, 2014).

#### 4.4.5 Modelling Domain

The dispersion of pollutants expected to arise from proposed activities was modelled for an area covering 20 km (east-west) by 20 km (north-south). The area was divided into a grid matrix with a resolution of 200 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 point. The code of practice (DEA, 2014) recommends the use of the Universal Transverse Mercator (UTM) coordinate system for the air dispersion models. The UTM system uses meters as its basic unit of measurement and allows for a clearer definition of specific locations than latitude/longitude. The coordinate system used during the modelling was defined on a World Geodetic System 84, WGS-84 system.

#### 4.4.6 Presentation of Results

Dispersion modelling was undertaken to determine highest hourly, highest daily and annual average ground level concentrations as well as dustfall rates for each of the pollutants considered in the study. 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.

Impact of the Operational Phase of the mine was simulated using the parameters and emission rates given in Table 8. Short-term (hourly or daily) concentrations were extracted at the 99th percentile, to account for the number of exceedances allowed by the NAAQS, both short term and annual simulated concentration levels were compared to the immediate SA NAAQS. All sensitive receptors – as defined in Section 3.1– were included in the AERMOD model setup as discrete receptors. A visual reference of the AQSRs taken into account in this study and their proximity to the site is shown in Figure 3.

Isopleth plots reflect the incremental ground level concentrations (GLCs) for SO<sub>2</sub>, NO<sub>2</sub>, CO, VOC's, Mn, PM<sub>2.5</sub> and PM<sub>10</sub>, as well as dustfall rates for TSP. Due to the unavailability of ambient baseline concentrations, cumulative pollutant concentrations could not be determined but qualitative commentary is provided in the discussion of impact significance in section 5. Simulated ground level concentration isopleths for criteria pollutants are provided below as listed in Table 9.

**Table 11: List of criteria pollutant isopleth plots**

Pollutant	Averaging Period	Scenario	
		Design Mitigation	Additional Mitigation
PM <sub>2.5</sub>	24-Hour	Figure 13	Figure 14
	1-year	Figure 15	Figure 16
PM <sub>10</sub>	24-Hour	Figure 17	Figure 18
	1-year	Figure 19	Figure 20
Dustfall	Monthly	Figure 21	Figure 22
Mn	1-year	Figure 23	Figure 24
NO <sub>2</sub>	1-Hour	Figure 25	No mitigation available for vehicle exhausts
	1-year	Figure 26	No mitigation available for vehicle exhausts
VOC CO and SO <sub>2</sub>	All averaging periods Concentrations below 10% of the NAAQS for the entire study area therefore no isopleths are shown.		

It should also be noted that ambient air quality criteria apply to areas where the Occupational Health and Safety regulations do not apply, thus outside mining right area. Ambient air quality criteria are therefore not occupational health indicators but applicable to areas where the general public has access i.e. off-site.

#### 4.5 Dispersion Simulation Results, Health Risk and Nuisance Screening

Pollutants with the potential to result in human health impacts which are assessed in this study include CO, NO<sub>2</sub>, PM<sub>2.5</sub>, PM<sub>10</sub>, SO<sub>2</sub>, Mn and VOC. Dustfall is assessed for its nuisance potential.

##### 4.5.1 Operational Phase

In estimating emissions due to operational activities, “**design mitigation**” was utilized. Design mitigation refers to mitigation included in the Project design, which comprise the use of water sprayers and dust suppression systems on haul roads, at the crushing plants and all materials handling or conveyor transfer points. In estimating residual air quality impacts, **additional mitigation** measures were recommended. Additional mitigation measures are proposed mitigation measures that will result in further emissions reduction beyond the design mitigation. The level of mitigation assumed for this assessment is based on design mitigation as published in Table 8.

##### 4.5.1.1 PM<sub>2.5</sub> Impact

The simulated GLCs for daily PM<sub>2.5</sub> are shown in Figure 13 and Figure 14 for the design mitigated scenario and the additionally mitigated scenario respectively. Simulated GLCs for the annual PM<sub>2.5</sub> are shown in Figure 15 and Figure 16 for the design and additionally mitigated scenarios respectively. Exceedances to the simulated daily PM<sub>2.5</sub> concentrations occur outside the boundary of the mining prospects for the daily SA NAAQS during the design mitigated scenario. However, the area of the simulated exceedance is not near any of the receptors described in section 3.1. As illustrated in Figure 14, exceedances outside the mine boundary are significantly reduced by applying additional mitigation to some emission sources.

Simulated GLCs for the annual PM<sub>2.5</sub> concentrations show no exceedances to the SA NAAQS outside the boundary of the mining prospects, for any of the scenarios as shown in Figure 15 and Figure 16.



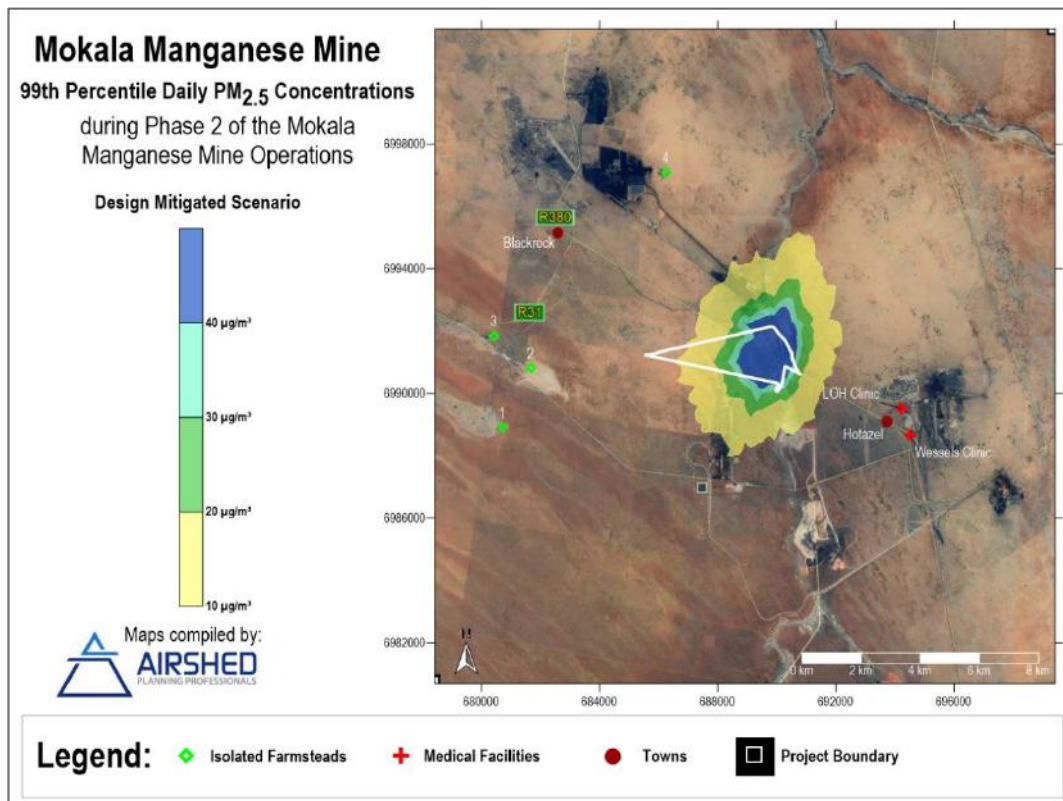


Figure 13: Simulated daily average PM<sub>2.5</sub> concentrations for design mitigated operational activities

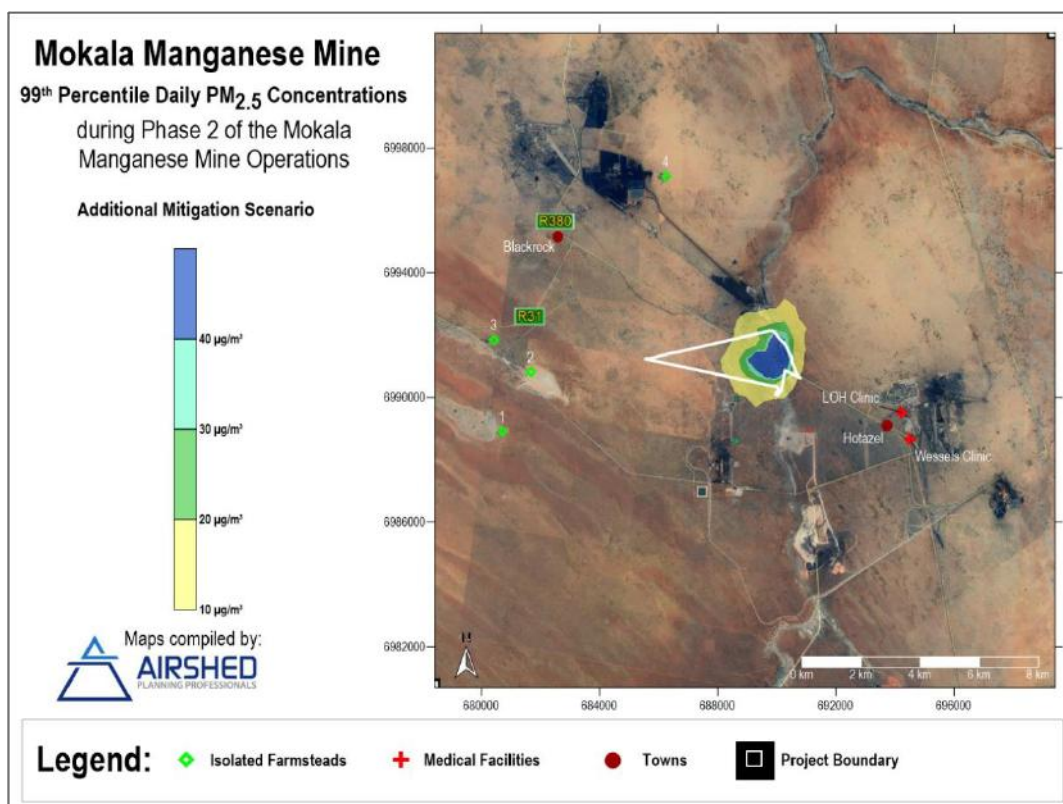


Figure 14: Simulated daily average PM<sub>2.5</sub> concentrations for additionally mitigated operational activities



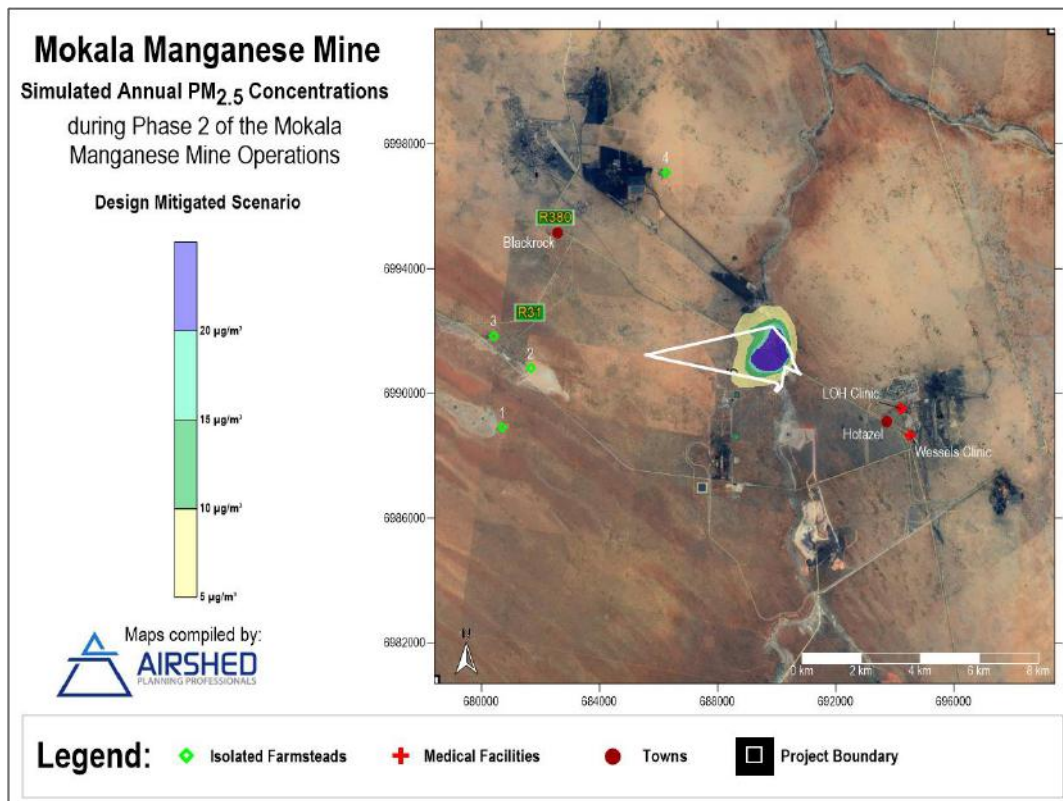


Figure 15: Simulated annual average PM<sub>2.5</sub> concentrations for design mitigated operational activities

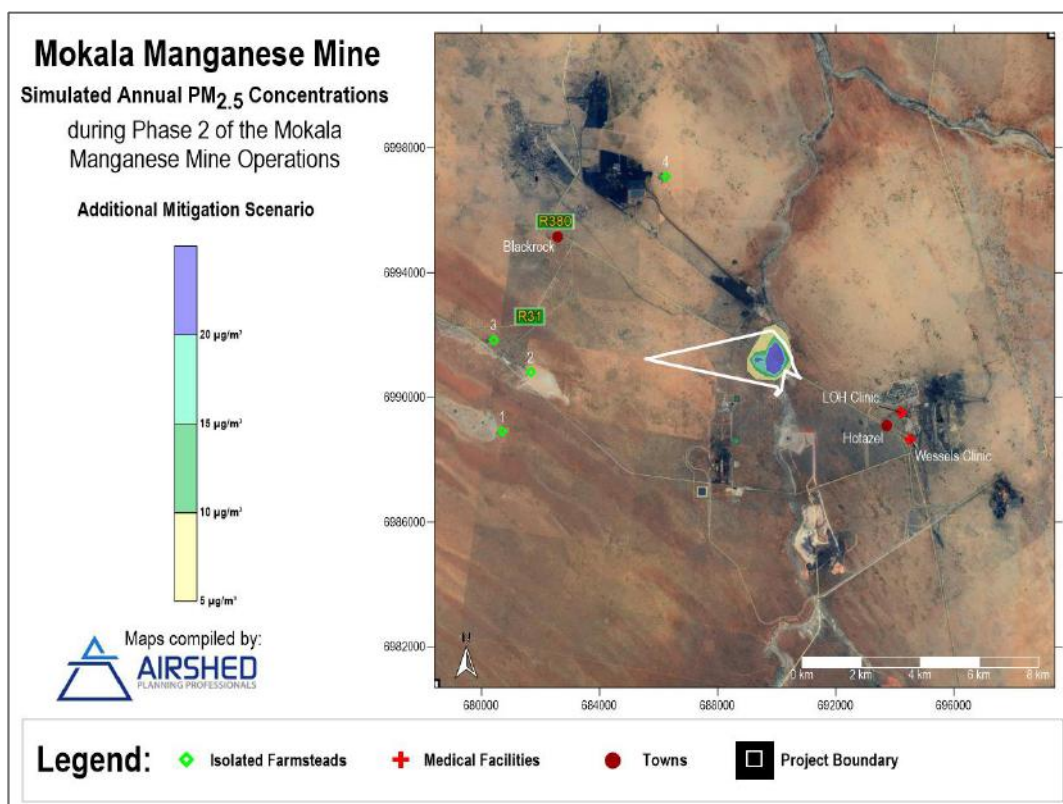


Figure 16: Simulated annual average PM<sub>2.5</sub> concentrations for additionally mitigated operational activities

#### 4.5.1.2 *PM<sub>10</sub> Impact*

The simulated GLCs for daily PM<sub>10</sub> are shown in Figure 17 and Figure 18 for the design mitigated scenario and the additionally mitigated scenario respectively; while those for the annual PM<sub>2.5</sub> are shown in Figure 19 and Figure 20 for the design and additionally mitigated scenarios respectively.

Simulated exceedances of the daily PM<sub>10</sub> NAAQS occur for ~1.5 km away from the mine boundary in the northerly and south-south-westerly directions when design mitigation is utilised. Additional mitigation reduces the impacts such that exceedance to the daily PM<sub>10</sub> NAAQS occurs for less than a kilometer outside the mine boundary. The simulated GLCs exceed the annual PM<sub>10</sub> NAAQS for less than a kilometer outside the mine boundary when design mitigation is applied. Application of additional mitigation would further reduce in impacts, thus restricting exceedances of the annual PM<sub>10</sub> NAAQS within the mine boundary.

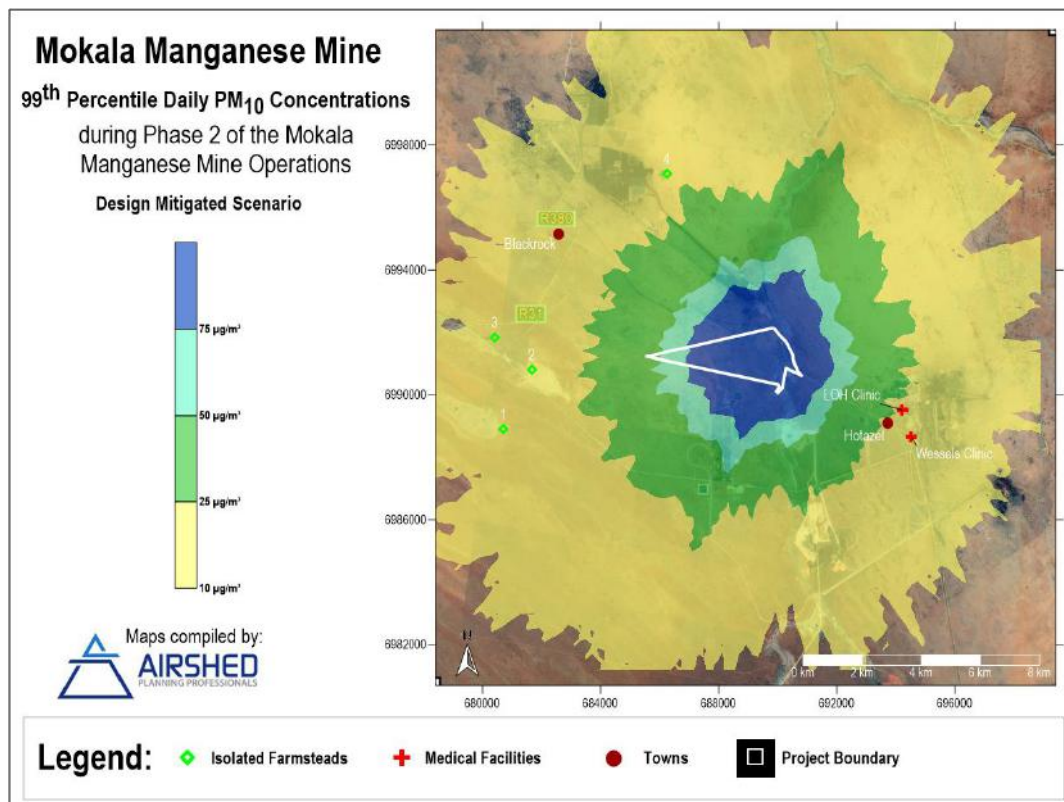


Figure 17: Simulated daily average PM<sub>10</sub> concentrations for design mitigated operational activities

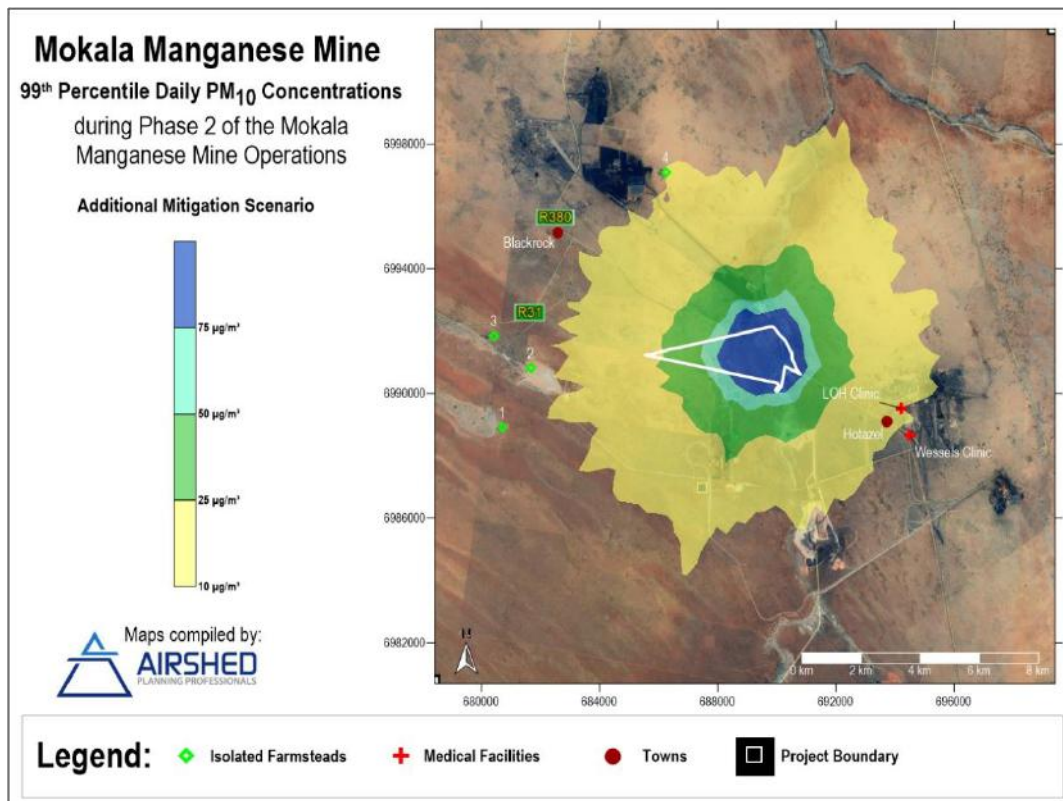


Figure 18: Simulated daily average PM<sub>10</sub> concentrations for the additionally mitigated operational activities

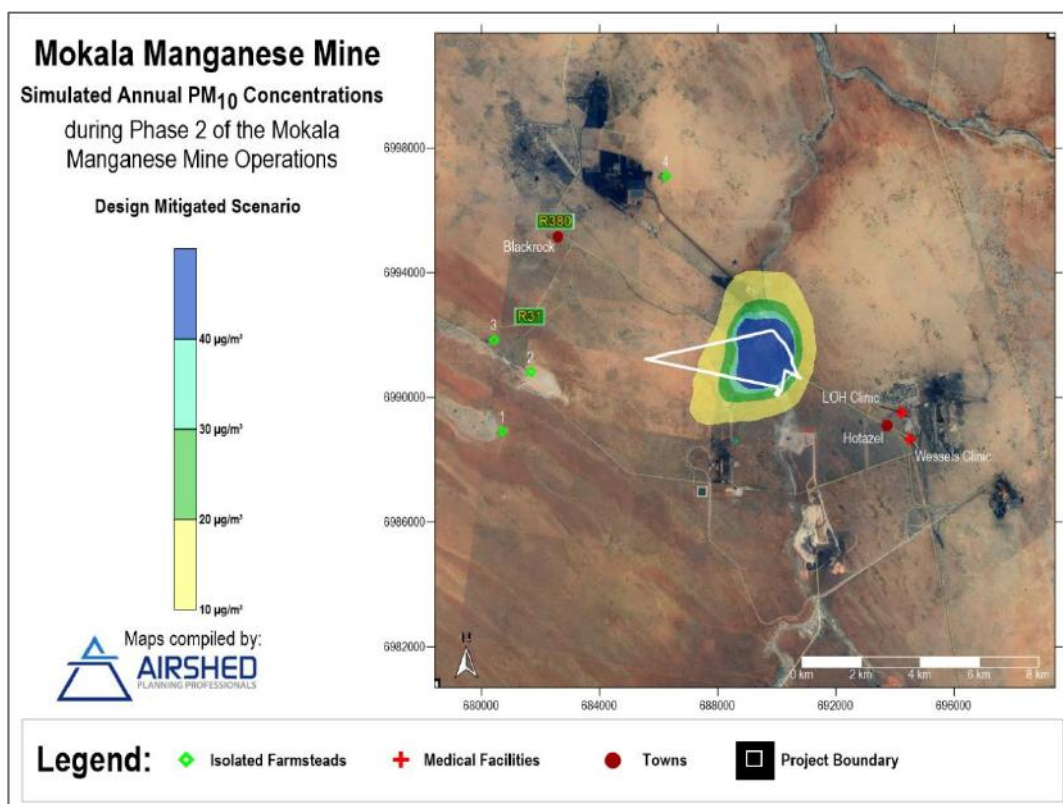
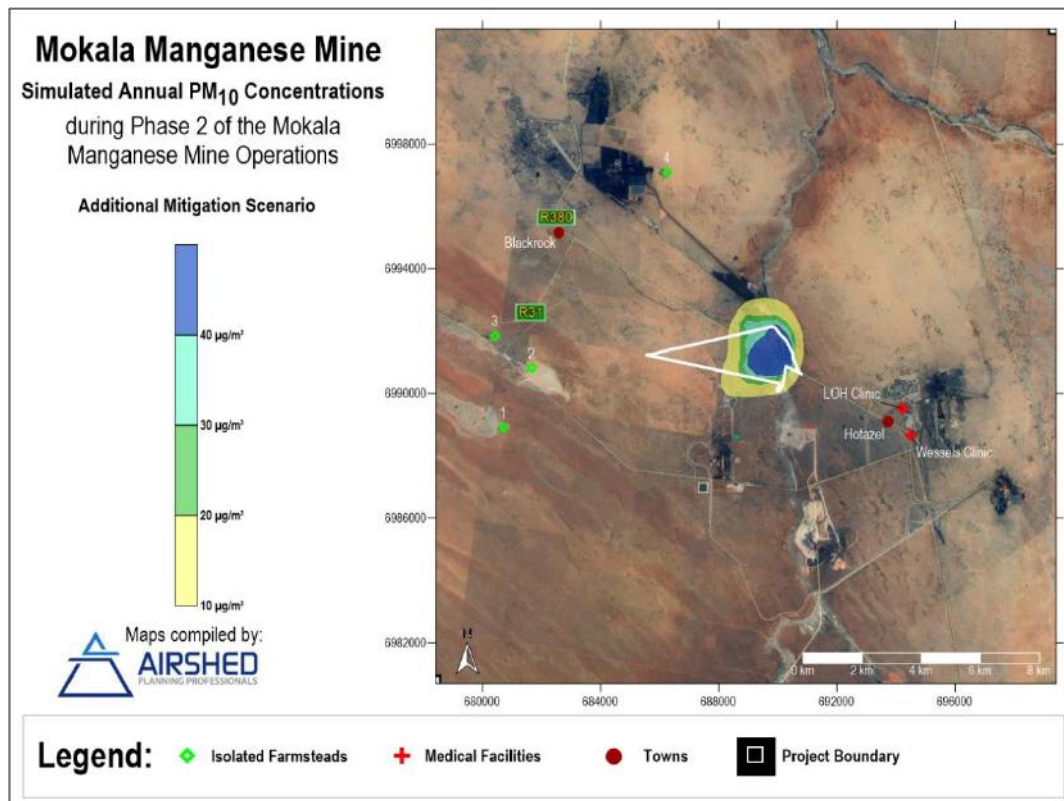


Figure 19: Simulated annual average PM<sub>10</sub> concentrations for design mitigated operational





**Figure 20: Simulated annual average PM<sub>10</sub> concentrations for the additionally mitigated operational activities**

#### 4.5.1.3 Dustfall Impact

Isopleth plots showing the ground level dustfall rates anticipated per area and screened against the NDCR residential and non-residential limits for dustfall are provided in Figure 21 and Figure 22 for the design and additionally mitigated scenarios respectively. The simulated maximum daily dustfall rates due to the design mitigated option exceeds the NDCR limit for residential areas (600 mg/m<sup>2</sup>-day) less than a kilometer beyond the southwest boundary of the mine, but not at nearby AQSRs. The NDCR non-residential standard (1200 mg/m<sup>2</sup>-day) was not exceeded beyond the mine boundary for all scenarios.

The simulated results are comparable with the measured dustfall rates presented in section 3.4 with exceedances to the NDCR non-residential limit occurring at MK3 and MK4 that lie south west of the mining boundary while the dustfall measured by the other dustfall buckets are below the non-residential limit.

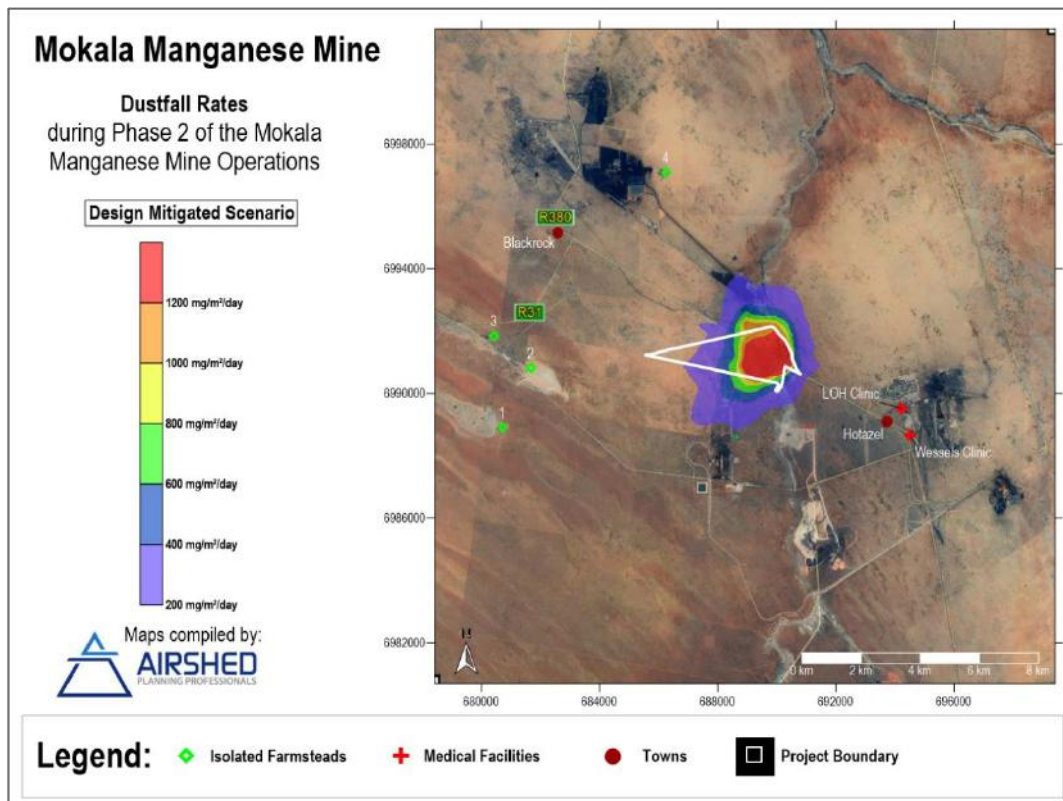


Figure 21: Simulated dustfall rates due to unmitigated operational activities for the design mitigated scenario

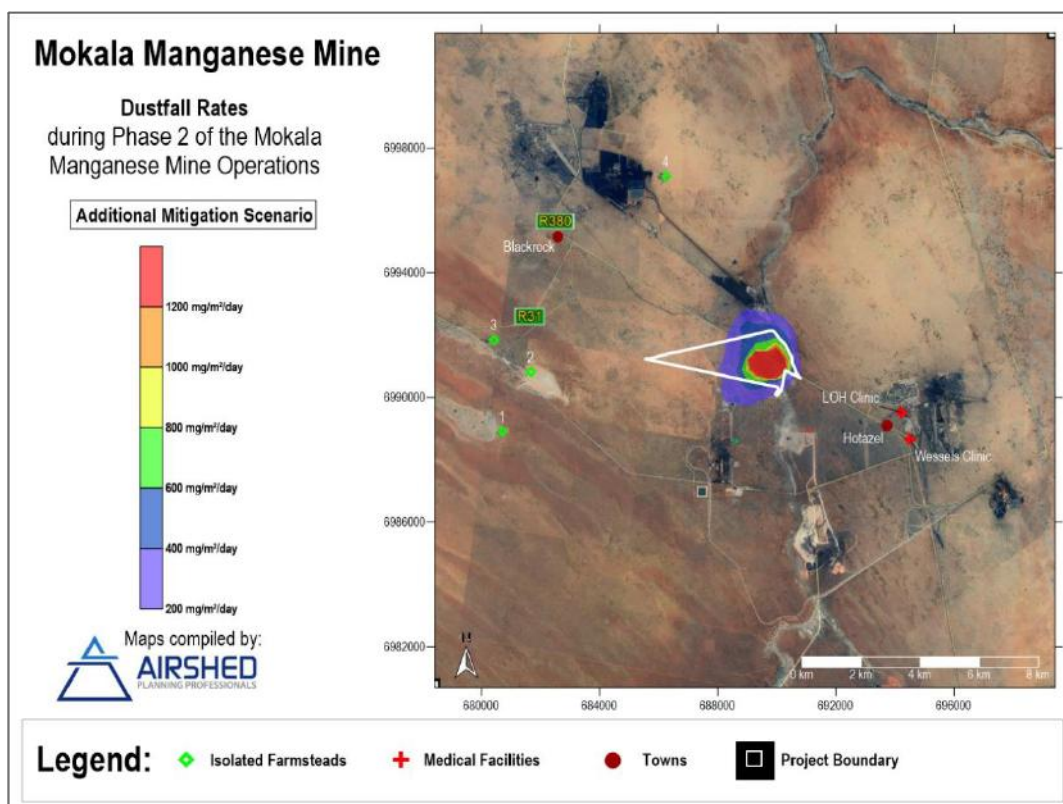
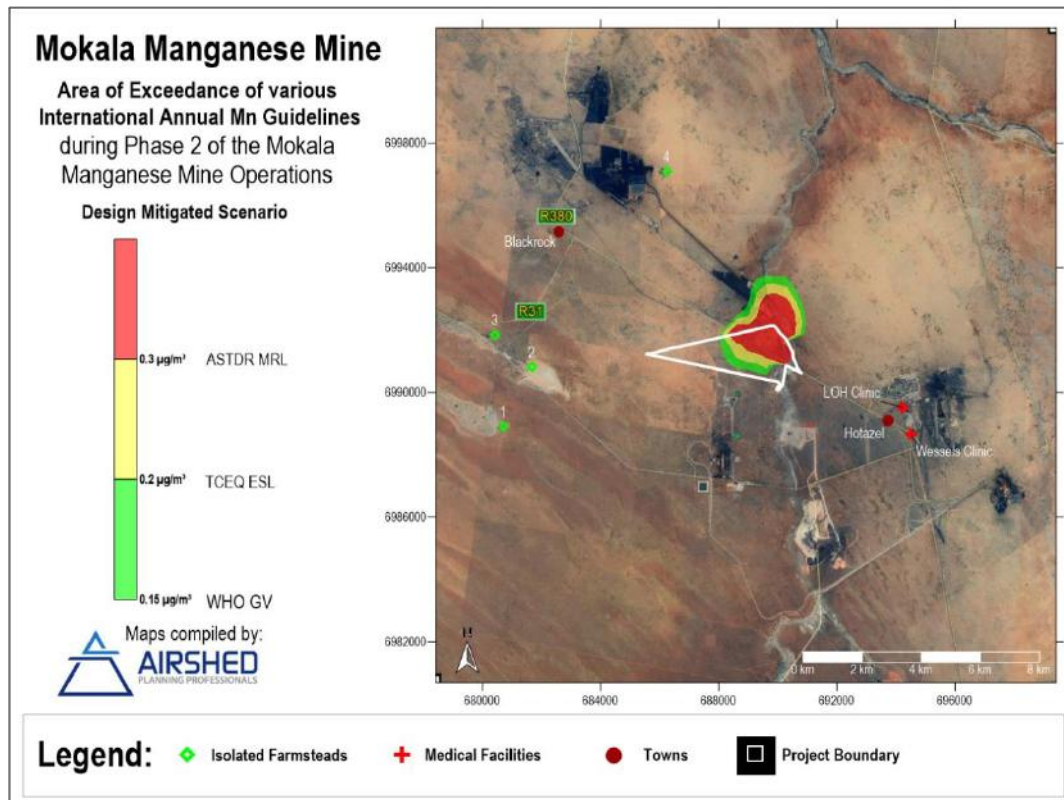


Figure 22: Simulated dustfall rates due to unmitigated operational activities for the additional mitigated option

#### 4.5.1.4 Mn Impact

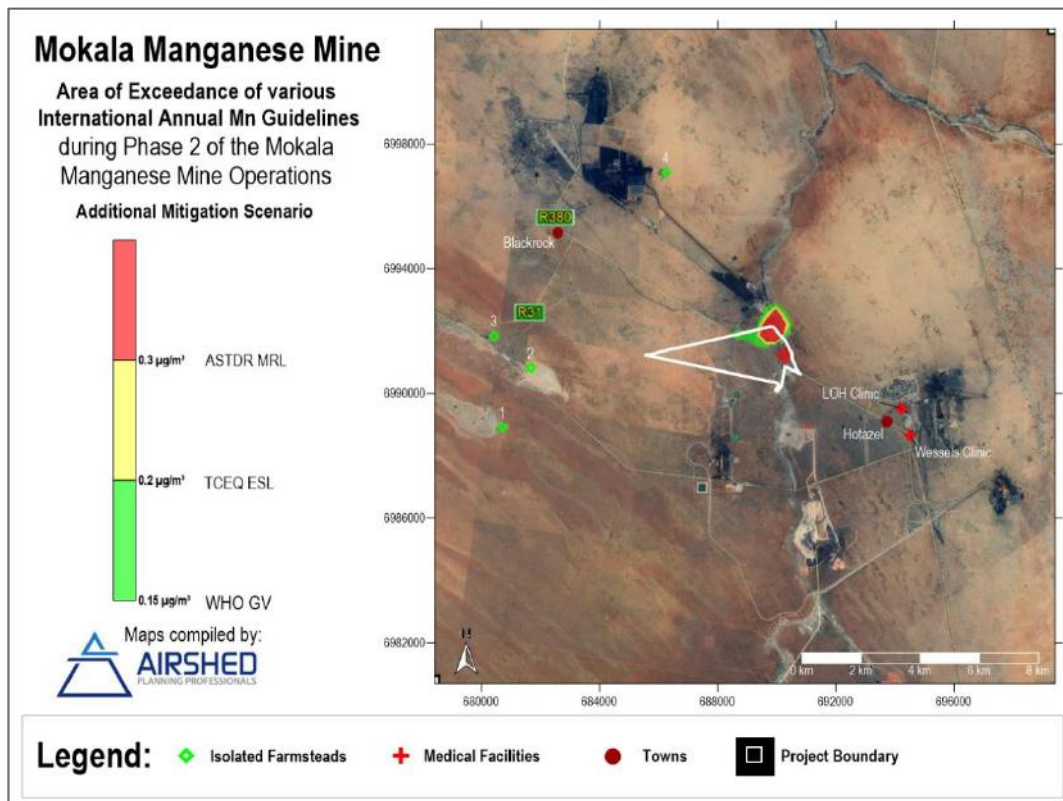
It has to be noted that in the quantification of elemental Mn emission, an estimated 24% of total PM<sub>10</sub> emissions was utilized. There is no literature on how MnO<sub>2</sub> is transformed to elemental Mn in the atmosphere. However, the most common manganese mineral is pyrolusite (MnO<sub>2</sub>), usually mined in sedimentary deposits by open-cast techniques. A factor of 0.63 (Mn is 63 % of MnO<sub>2</sub> by mass). was also applied to assign the proportion of elemental Mn contained in pyrolusite. Also, in the absence of NAAQS for Mn, reference was made to various international guidelines as presented in section 2.3. Criteria values are set as a 'guideline' and not a "limit value" or a toxicity threshold. They serve as a benchmark beyond which caution should be exerted. While Mn concentrations are shown, the Mn is unlikely to be in the elemental form (having undergone no form of heat treatment) and is mostly a constituent in MnO<sub>2</sub>.

The areas over which annual concentrations exceed the various guidelines are presented in Figure 23. Annual average Mn concentrations exceed the WHO GV, TCEQ ESL and ATSDR MRL off-site by a distance ranging from 1.5 km to 2 km. The exceedance is not expected to impact all the AQSRs within the displayed domain. Implementing additional mitigation measures slightly reduces the impacts significantly such that exceedances to these international criteria are likely to occur less than a kilometre from the boundary.



**Figure 23: Area of exceedance of various international annual guidelines for Mn due to operational activities utilising design mitigation.**





**Figure 24: Area of exceedance of various international annual guidelines for Mn due to operational activities utilising additional mitigation.**

From literature, background Mn concentrations range from very low concentrations of 0.05 – 5.4  $\text{ng}/\text{m}^3$  over the oceans to 20 – 800  $\text{ng}/\text{m}^3$  over land with 24- hour concentrations between 2-3  $\mu\text{g}/\text{m}^3$  over land having been recorded (Duce, Hoffman, & Zolle, 1975; Zoller, Gladney, & Duce, 1974; USEPA, 1994; Möller, 1974; Kretzschmarl, Delespaul, & .de Rijck, 1980; Tokyo, Environmental Agency Japan, 1975). In the proximity of foundries, manganese concentrations may rise to an annual average of 200–300  $\text{ng}/\text{m}^3$  and, in the presence of ferro- and silico-manganese industries, to over 500  $\text{ng}/\text{m}^3$  (US EPA, 1986). In such places, the average 24-hour concentrations may exceed 10  $\mu\text{g}/\text{m}^3$ . The highest concentrations of manganese in the working environment have been reported from manganese mines, ore-processing plants, dry-cell battery plants and ferro-manganese plants. In mining operations, manganese concentrations of up to 250  $\text{mg}/\text{m}^3$  or even higher have sometimes been found. In dry-cell battery and ferro-manganese plants, the concentrations of manganese in air are lower. Values of 5–8  $\text{mg}/\text{m}^3$ , and occasionally up to 20  $\text{mg}/\text{m}^3$  or more, have been reported (WHO, 1980).

#### 4.5.1.5 VOCs, $\text{NO}_2$ , CO and $\text{SO}_2$ Impact

Simulated CO, VOC and  $\text{SO}_2$  impacts were very low and did not result in offsite exceedances of assessment criteria. The GLC due to CO and  $\text{SO}_2$  emissions are expected to be insignificant, as is typical of similar processes.

Hourly and annual  $\text{NO}_2$  impacts are presented in Figure 25 and Figure 26 respectively. Typical of most mining operations, there were no exceedances to the hourly and annual SA NAAQS outside the mine boundary while the GLCs inside the mine boundary are mostly insignificant and fall below their respective standards.

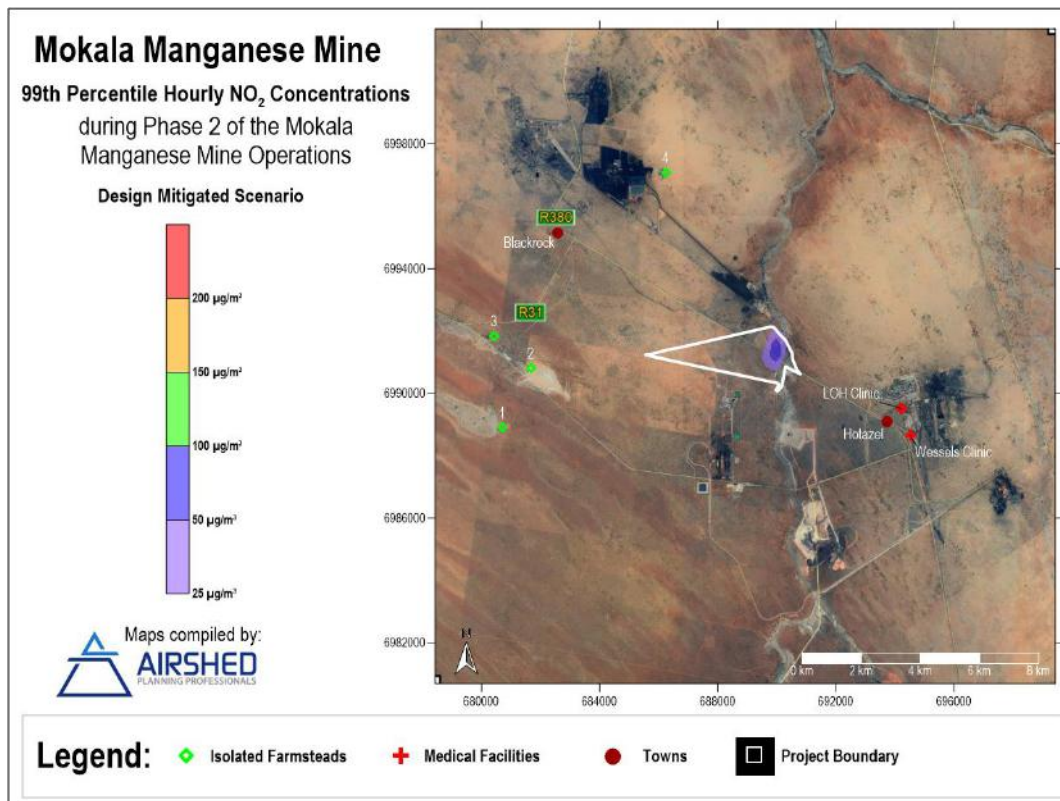


Figure 25: Simulated GLCs for hourly NO<sub>2</sub> during normal operational activities

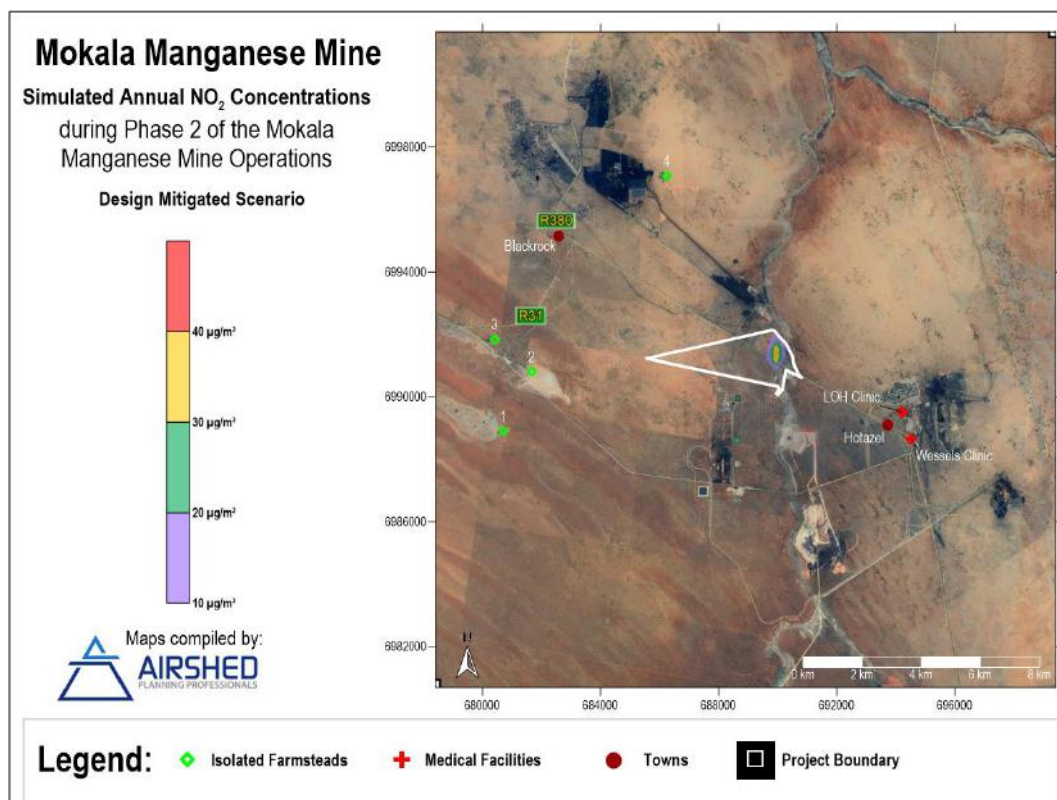


Figure 26: Simulated GLCs for annual NO<sub>2</sub> during normal operational activities

## 5 IMPACT SIGNIFICANCE

The significance of air quality related impacts were assessed in accordance with the procedure set out by SLR. The proposed method for the assessment of environmental issues is presented in Table 12.

This assessment methodology enables the assessment of environmental issues including cumulative impacts, the severity of impacts (including the nature of impacts and the degree to which impacts may cause irreplaceable loss of resources), the extent of the impacts, the duration and reversibility of impacts, the probability of the impact occurring, and the degree to which the impacts can be mitigated.

The significance rankings of the various impacts assessed in the study are presented in Table 13, Table 15, Table 16 and Table 14 respectively.

The quantitative assessment of cumulative impacts is not possible given the lack of existing ambient monitoring data for the region. It is apparent from a qualitative point of view that, with existing air emission sources in the region, the incremental impacts as assessed and summarized in this report are an underestimate of the cumulative impacts. In order to accurately evaluate the significance, ambient monitoring must be conducted in such a way that all contributing air pollution sources are understood. No schedule was provided for the activities associated with the construction or closure phases hence their significance was assessed quantitatively, bearing in mind, their related intermittent and short-term nature.

**Table 12: Criteria for assessing impacts as provided by SLR**

PART A: DEFINITION AND CRITERIA		
Definition of SIGNIFICANCE		Significance = consequence x probability
Definition of CONSEQUENCE		Consequence is a function of severity, spatial extent and duration
<b>Criteria for ranking of the SEVERITY/NATURE of environmental impacts</b>	<b>H</b>	Substantial deterioration (death, illness or injury). Recommended level will often be violated. Vigorous community action. Irreplaceable loss of resources.
	<b>M</b>	Moderate/ measurable deterioration (discomfort). Recommended level will occasionally be violated. Widespread complaints. Noticeable loss of resources.
	<b>L</b>	Minor deterioration (nuisance or minor deterioration). Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints. Limited loss of resources.
	<b>L+</b>	Minor improvement. Change not measurable/ will remain in the current range. Recommended level will never be violated. Sporadic complaints.
	<b>M+</b>	Moderate improvement. Will be within or better than the recommended level. No observed reaction.
	<b>H+</b>	Substantial improvement. Will be within or better than the recommended level. Favourable publicity.
<b>Criteria for ranking the DURATION of impacts</b>	<b>L</b>	Quickly reversible. Less than the project life. Short term
	<b>M</b>	Reversible over time. Life of the project. Medium term
	<b>H</b>	Permanent. Beyond closure. Long term.
	<b>L</b>	Localised - Within the site boundary.
	<b>M</b>	Fairly widespread – Beyond the site boundary. Local

<b>Criteria for ranking the SPATIAL SCALE of impacts</b>	<b>H</b>	Widespread – Far beyond site boundary. Regional/ national
--	----------	---

#### PART B: DETERMINING CONSEQUENCE

##### SEVERITY = L

<b>DURATION</b>	Long term	<b>H</b>	Medium	Medium	Medium
	Medium term	<b>M</b>	Low	Low	Medium
	Short term	<b>L</b>	Low	Low	Medium

##### SEVERITY = M

<b>DURATION</b>	Long term	<b>H</b>	Medium	High	High
	Medium term	<b>M</b>	Medium	Medium	High
	Short term	<b>L</b>	Low	Medium	Medium

##### SEVERITY = H

<b>DURATION</b>	Long term	<b>H</b>	High	High	High
	Medium term	<b>M</b>	Medium	Medium	High
	Short term	<b>L</b>	Medium	Medium	High
			<b>L</b>	<b>M</b>	<b>H</b>
			Localised Within site boundary Site	Fairly widespread Beyond site boundary Local	Widespread Far beyond site boundary Regional/ national
			<b>SPATIAL SCALE</b>		

#### PART C: DETERMINING SIGNIFICANCE

<b>PROBABILITY (of exposure to impacts)</b>	Definite/ Continuous	<b>H</b>	Medium	Medium	High
	Possible/ frequent	<b>M</b>	Medium	Medium	High
	Unlikely/ seldom	<b>L</b>	Low	Low	Medium
			<b>L</b>	<b>M</b>	<b>H</b>
			<b>CONSEQUENCE</b>		

#### PART D: INTERPRETATION OF SIGNIFICANCE

<b>Significance</b>	<b>Decision guideline</b>
High	It would influence the decision regardless of any possible mitigation.
Medium	It should have an influence on the decision unless it is mitigated.
Low	It will not have an influence on the decision.

**Table 13: Assessment of the significance of operational phase air quality impacts associated with PM and inhalable Mn emissions (design mitigation)**

Activity	Impact	Severity of Impact	Spatial Scale of Impacts	Duration of Impact	Consequence of Impact	Probability of Impact	Significance
							Design Mitigation
Operational phase	Human health impacts due to PM <sub>2.5</sub>	Low	Low	Medium	Low	Medium	Medium
	Human health impacts due to PM <sub>10</sub>	Medium	Medium	Medium	Medium	Medium	Medium
	Nuisance impact due to Dustfall	Low	Low	Medium	Low	Low	Low
	Human health impacts due to Respirable Mn (elemental)	Medium	Medium	Medium	Medium	Medium	Medium

**Table 14: Assessment of the significance of operational phase air quality impacts associated with PM and inhalable Mn emissions (additional mitigation)**

Activity	Impact	Severity of Impact	Spatial Scale of Impacts	Duration of Impact	Consequence of Impact	Probability of Impact	Significance
							Additional Mitigation
Operational phase	Human health impacts due to PM <sub>2.5</sub>	Low	Low	Low	Low	Low	Low
	Human health impacts due to PM <sub>10</sub>	Medium	Low	Medium	Medium	Medium	Medium
	Nuisance impact due to Dustfall	Low	Low	Medium	Low	Low	Low
	Human health impacts due to Respirable Mn (elemental)	Medium	Medium	Medium	Medium	Medium	Medium

Updated Air Quality Impact Assessment for the Mokala Manganese Mine near Hotazel in the Northern Cape Province

**Table 15: Assessment of the significance of operational phase air quality impacts associated with NO<sub>2</sub>, CO, SO<sub>2</sub> and VOC emissions (design mitigation)**

Activity	Impact	Severity of Impact	Spatial Scale of Impacts	Duration of Impact	Consequence of Impact	Probability of Impact	Significance
							Design Mitigation
Operational phase	Human health impacts due to NO <sub>2</sub>	Low	Low	Medium	Low	Low	Low
	Human health impacts due to CO	Low	Low	Medium	Low	Low	Low
	Human health impacts due to SO <sub>2</sub>	Low	Low	Medium	Low	Low	Low
	Human health impacts due to VOCs	Low	Low	Medium	Low	Low	Low

Due to the absence of any adverse impacts to human health due to inhalation of the gaseous pollutants, there may not be a need for additional mitigation to the impacts illustrated in Table 15.

**Table 16: Assessment of the significance of construction and closure phase air quality impacts associated with PM emissions (design mitigation)**

Activity	Impact	Severity of Impact	Spatial Scale of Impacts	Duration of Impact	Consequence of Impact	Probability of Impact	Significance
							Design Mitigation
Construction phase	Human health impacts due to PM <sub>2.5</sub>	Low	Low	Low	Low	Low	Low
	Human health impacts due to PM <sub>10</sub>	Low	Low	Low	Low	Low	Low
	Nuisance impact due to Dustfall	Low	Low	Low	Low	Low	Low
Closure phase	All PM emissions	Low	Low	Low	Low	Low	Low

Due to the absence of any adverse impacts to human health posed by the PM emissions, there may not be a need for additional mitigation to the impacts illustrated in Table 16.



## 6 RECOMMENDED AIR QUALITY MANAGEMENT MEASURES

In the light of the potential exceedances of the air quality limits, it is recommended that the project proponent commit itself to adequate air quality management planning throughout the life of the project. The air quality management plan provides options on the control of particulate and gaseous emissions 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<sub>2.5</sub>, PM<sub>10</sub>, Mn and NO<sub>2</sub>) and dustfall that are within the relevant ambient air quality standards at the relevant off-site receptors. 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. Source ranking can be established on:

- Emissions ranking; based on the comprehensive emissions inventory established for the operations, as published in Figure 11; and
- Impacts ranking; based on the simulated pollutant GLCs.

The source impact ranking with respect to entire study area and AQSRs are presented in Figure 27 and Figure 28 for PM<sub>10</sub> and elemental Mn respectively. As illustrated by the plots in sections 4.5.1.1 and 4.5.1.3, the simulated GLCs due to PM<sub>2.5</sub> and dustfall are minimal and do not exceed set measurement criteria, hence their respective source impact ranking are excluded in the report. The major source contributors to GLCs are blasting, unpaved roads and wind erosion. Source impact ranking is not reflected for pollutant gases due to the low simulated GLCs.

It is evident from Figure 27 and Figure 28 that, in order to reduce impacts most effectively on the receiving environment, efforts should be directed at reducing emissions from unpaved roads, blasting, and wind erosion. During normal operation of the mine, the biggest contributor to PM<sub>10</sub> emissions comes from unpaved roads while blasting also contributes significantly to the emissions. Mn emissions mainly arise due to wind erosion, materials handling, crushing and screening respectively.

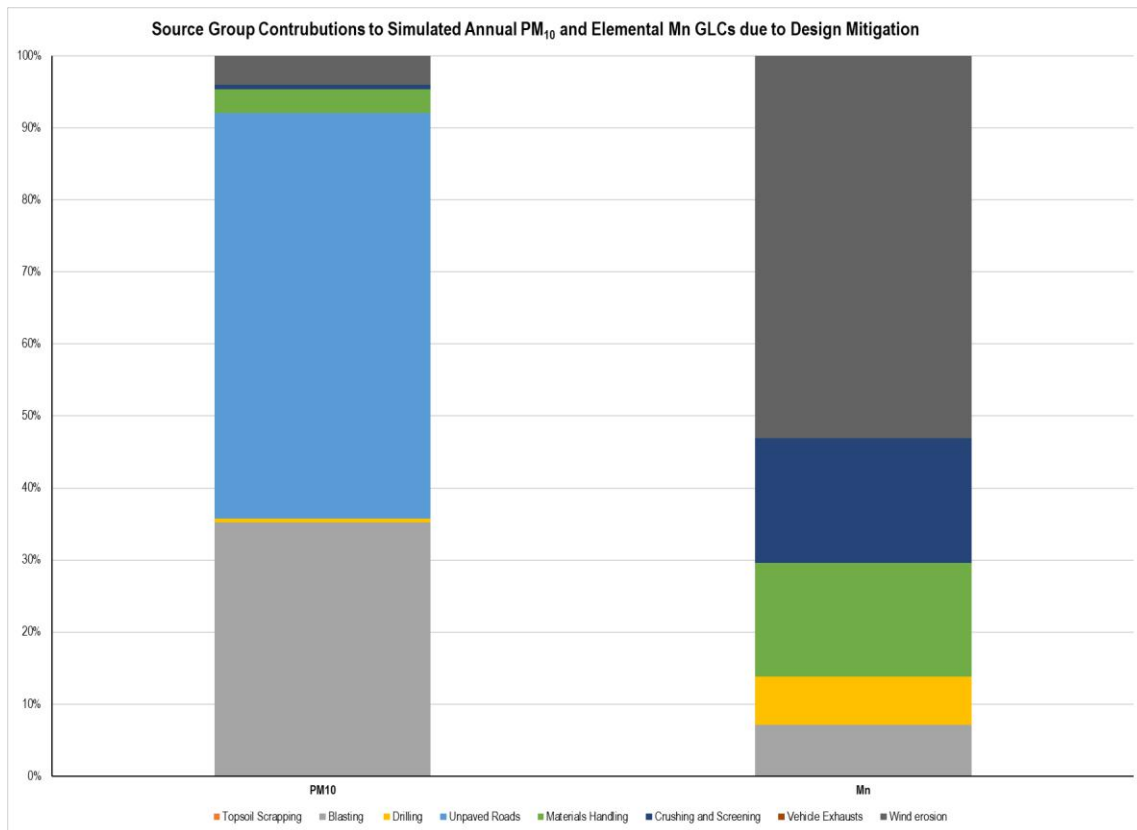
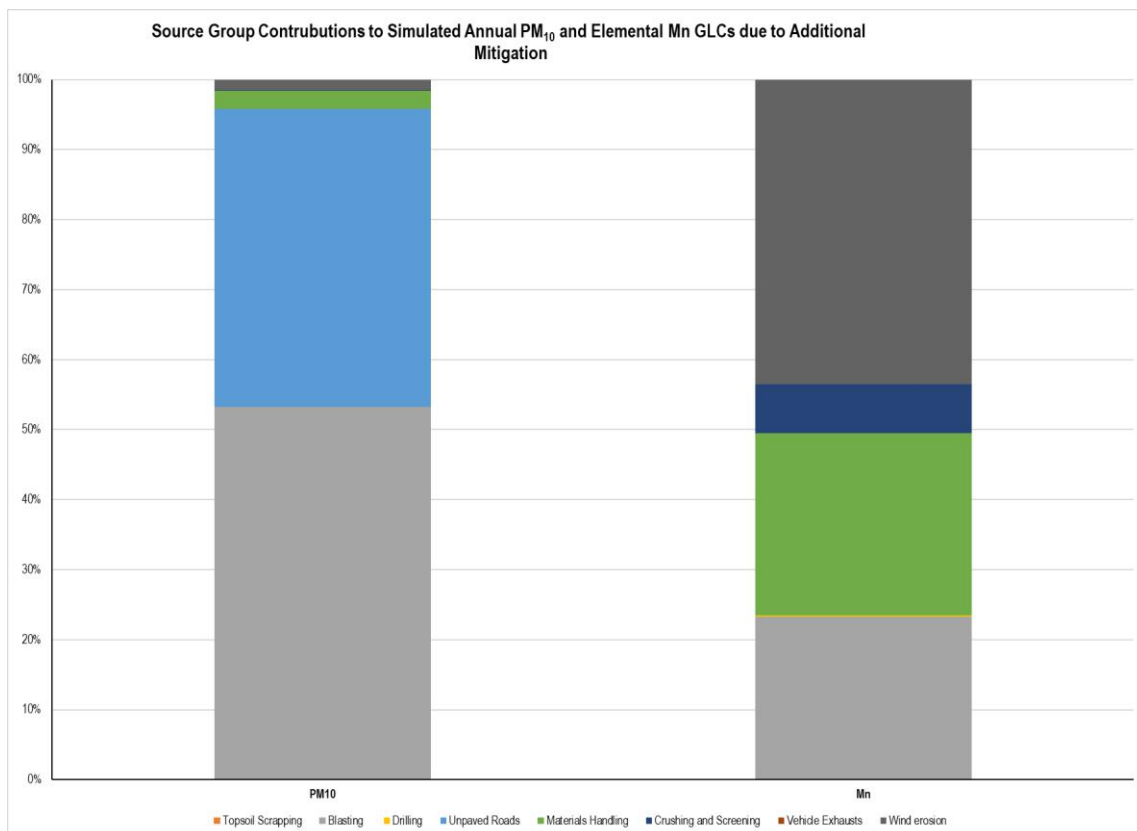


Figure 27: Source group contribution to simulated annual average PM<sub>10</sub> and Mn GLCs due to design mitigation



**Figure 28: Source group contribution to simulated annual average PM<sub>10</sub> and Mn GLCs due to additional mitigation**  
**6.2 Proposed Mitigation Measures and/or Target Control Efficiencies**

From the above discussion it is recommended that the project include the following measures as published in Table 8.

- For the control of entrained dust due to unpaved roads, it is recommended that water (at an application rate >2 litre/m<sup>2</sup>-hour), be applied in combination with dust palliative consisting of a cationic bitumen emulsion to stabilize the surface and prevent dust. Literature reports an emissions reduction efficiency of up to 90%.
- In minimizing windblown dust from stockpile areas, water sprays should be used to keep surface material moist and wind breaks installed to reduce wind speeds over the area.
- In the transportation of ore and products, trucks should be well covered to avoid spillages. This will reduce the release of PM and consequently, elemental Mn emissions (Mn emission is taken as a fraction of PM<sub>10</sub> emissions).
- While blasting apparently generates a large amount of dust, the operation occurs at infrequent intervals that it is not considered a significant contributor to particulate material of the PM<sub>10</sub> size fraction. Blasting is generally done once a day, so the level of activity is a reduction factor in the estimation of PM<sub>10</sub>. There is little to insufficient literature on the control of dust from open pit operations.
- From 2024 - 2038, as the pit expands, mitigation measures will need to be re-evaluated when relocation of the infrastructure is required.

Further literature on source specific mitigation measures is provided in Appendix A.

### 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 to below 600 mg/m<sup>2</sup>-day represents an impact- or receptor-based performance indicator.

Except for vehicle/equipment emission testing, source monitoring at mining activities can be challenging due to the fugitive and wind-dependant 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:

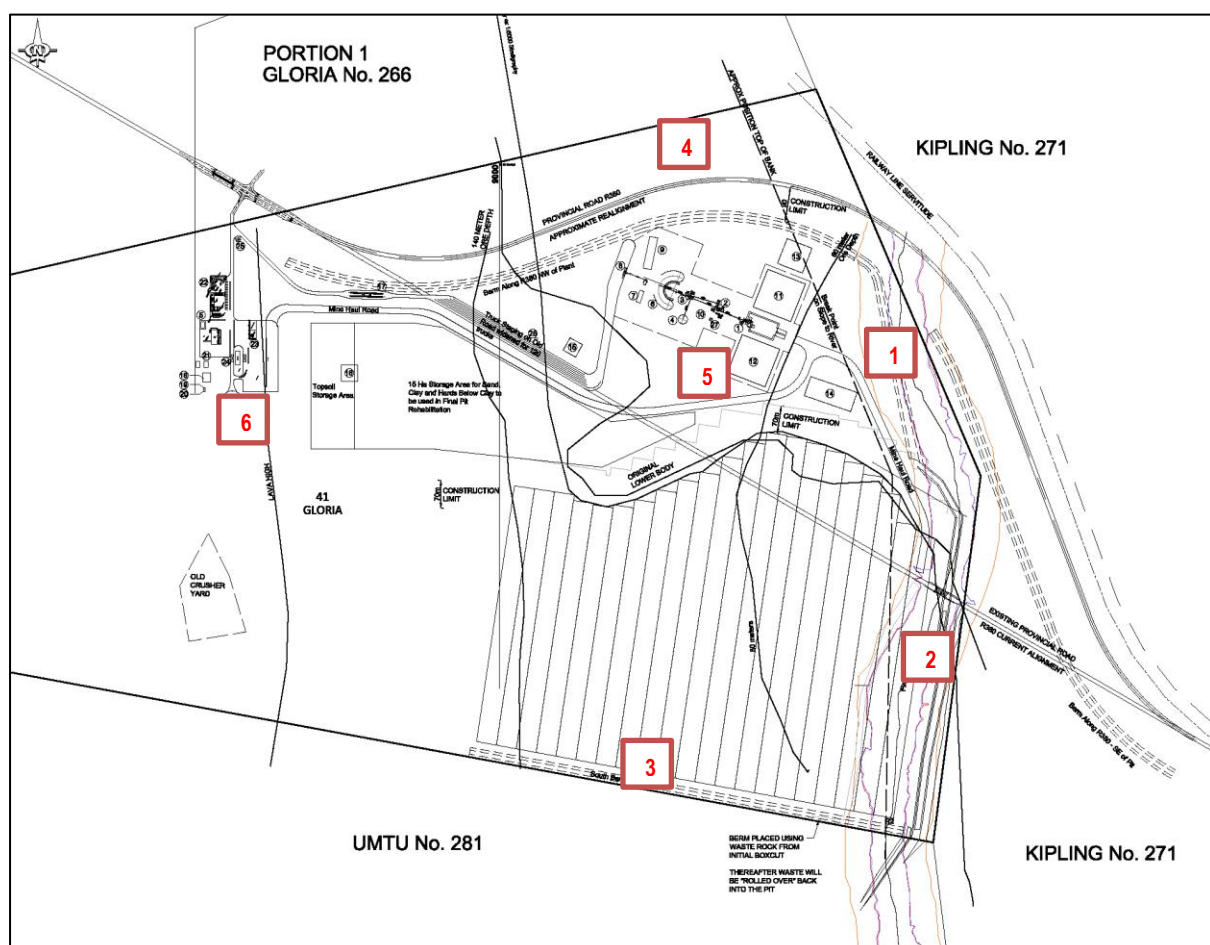
- Compliance monitoring;
- Validate dispersion model results;
- Use as input for health risk assessment;
- Assist in source apportionment;
- Temporal and spatial trend analysis;

- Source quantification; and,
- Tracking progress made by control measures.

It is recommended that continuous dustfall monitoring be conducted as part of the project's air quality management plan. This should be undertaken throughout the life of mine to provide air quality trends. Recommended dustfall collection locations are presented in Figure 29. There is also a need to setup dustfall monitoring locations close to the AQSRs (see Figure 30) to determine the footprint of the mine's activities and measure background dust fallout rates. The description of these locations is given in Table 17.

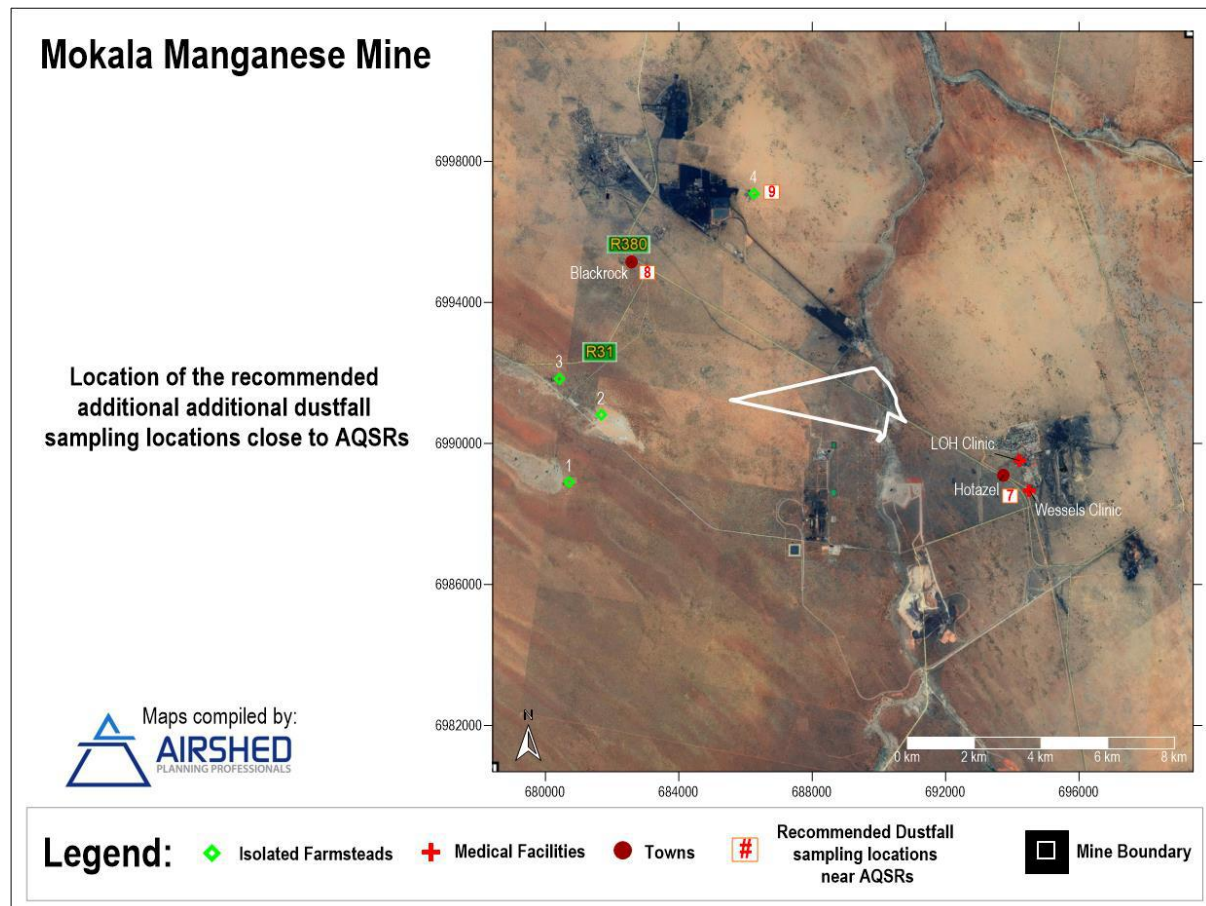
It is also recommended that Mokala collaborate with other mines/industries in the region to install a gravimetric PM<sub>10</sub>/PM<sub>2.5</sub> monitor at Gloria Mine Village or Hotazel. This will provide adequate data on cumulative PM<sub>10</sub> and PM<sub>2.5</sub> concentrations from the Mokala Manganese Project and other mines/industries in the region. Recommended dustfall and PM<sub>10</sub>/PM<sub>2.5</sub> sampling methodology is provided in Appendix B.

Finally, it is recommended that the PM<sub>10</sub>/PM<sub>2.5</sub> samples be analysed for manganese content to indicate the manganese concentrations in inhalable and respirable dust. This can be done by conducting an Inductively Coupled Plasma (ICP) analysis on the gravimetric PM<sub>10</sub>/PM<sub>2.5</sub> filter sample to determine the trace concentration of elemental manganese in the ambient air. Should exceedances of the long-term assessment criteria occur (as was simulated), a health risk/toxicological assessment should then be conducted to determine the health impact due to manganese emissions at Gloria Mine village or Hotazel.



**Figure 29: Dustfall sampling locations at the Mokala Manganese Project**

Updated Air Quality Impact Assessment for the Mokala Manganese Mine near Hotazel in the Northern Cape Province



**Figure 30: Location of dustfall sampling sites near the AQSRs**

**Table 17: Recommended Dustfall sampling locations and parameters**

No	Longitude	Latitude	Description	Pollutant(s) to be Sampled
1	22.920544°	-27.187974°	Haul road and northeast boundary	Dustfall
2	22.920825°	-27.194832°	Pit and southeast boundary	Dustfall
3	22.910793°	-27.196549°	Pit and south boundary	Dustfall
4	22.912089°	-27.182532°	North boundary	Dustfall
5	22.914059°	-27.187496°	ROM pad and plant area	Dustfall
6	22.903291°	-27.188475°	Admin area and west of operations	Dustfall
7	22.956018°	-27.207286°	Hotazel Town	Dustfall
8	22.842613°	-27.154102°	Blackrock Town	Dustfall
9	22.879313°	-27.136129°	Isolated Farmstead	Dustfall

NOTE: The coordinates merely serve to provide an indication of the recommended location and should not be seen as an exact point.

#### 6.4 Periodic Inspections, Audits and Community Liaison

#### 6.4.1 *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.

#### 6.4.2 *Consultation with I&APs*

This section provides a summary of the issues and concerns raised by the Interested and Affected Parties (I&APs) as part of the public participation process. Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. The consultation process was undertaken as part of the EIA and EMP process for the project. To date issues and concerns were raised during the Commenting Authority meeting held on the 14<sup>th</sup> of April 2021. issues and concerns were also received via e-mail correspondence during the public review period. Table 18 provides a list of comments relating to air quality received during the public scoping meeting.

**Table 18: List of comments received during the public scoping meeting on the 04<sup>th</sup> May 2021**

Comment Raised by	Issue raised	Specialist Response
Jo'lene Booysen	The scoping report highlights the fact that during the monitoring period of during October 2020 – January 2021 there has been an exceedance, the scoping report further states that the highest dust fallout rates were observed near the open pit area in December 2020 (reaching 1531.01mg/m <sup>2</sup> .day. Mokala is proposing to extend the capacity of their current waste rock dump and you propose the development of an additional waste rock dump on the south side of the project area. It is therefore recommended that as part of the air quality impact assessment a dust management plan is developed to ensure that the controls are put in place to reduce the emission from the mining activities.	An approved air quality monitoring programme is in place at the mine. The increase in waste rock dump capacity, does present additional sources of emissions. As part of the proposed project, an air quality specialist will be appointed to understand the impact that additional project components will have towards air quality. As part of the Air Quality Study, that will be prepared for the proposed project, the existing monitoring programme will be re-evaluated and adjusted, where necessary, to cater for additional emission sources.
Jo'lene Booysen	It is recommended that the discussion between Mokala and Kalagadi be initiated to allow for clarity with regards to the reequipments for mining of the boundary pillar as the boundary pillar should consider the mining practices that is required during the operational phase and the rehabilitation/decommissioning phase of the Mokala and Kalagadi Mining Right.	It is understood that initial discussions have commenced between Kalagadi and Mokala regarding the mining of the boundary pillar. However, your comment has been noted and the Mokala project team will be informed of your request.

## 6.5 Buffer Zone

The delineation of an air quality buffer zone is not deemed necessary, considering the “low” to “medium” significance rating assigned to pollutants impacts.



## 7 CONCLUSIONS AND RECOMMENDATION

### 7.1 Main Findings

A quantitative air quality impact assessment was conducted for operational phase activities for the Mokala Manganese Project. Construction, decommissioning and post-closure activities were assessed qualitatively. The assessment included an estimation of atmospheric emissions, the simulation of pollutant levels and determination of the significance of impacts.

This section summarises the main findings of the assessment.

- The receiving environment:
  - The area is dominated by winds from the north, northeast and east. Long-term air quality impacts are therefore expected to be the most significant to the south and south west of the project area.
  - Ambient air pollutant levels in the project area are currently affected by the following sources of emission: mining to the southwest and northwest, vehicles tail-pipe emissions and open areas exposed to the wind.
  - Air Quality Sensitive Receptors (AQSRs) around the project site include single homesteads/farmsteads, towns and a healthcare facilities. The closest AQSRs include residences of the **Gloria Mine village** situated approximately 1.3 km north of the northern project boundary and residences in the town of **Hotazel** which is approximately 3.9 km east of the eastern project boundary. All other residences, farmsteads and towns (including Black Rock) are further than 5 km from the project boundary.
- Impact due to the project components that have already taken place
  - A qualitative assessment concluded that the overall emissions could have been high if no mitigation measures were implemented, likely resulting in medium impacts to human health through inhalation, although the severity of the impacts could have been low.
  - There is no evidence that any cumulative impacts to human health due to the proposed activity/infrastructure changes can be attributed to the components that have already taken place.
- Impacts due to mining of the Kalagadi Barrier Pillar
  - The impacts due to the mining of the Kalagadi Barrier Pillar are expected to be the same in scale and magnitude as those of the Phase 2 to 6 operations. If mining takes place concurrently with other mining operations, there is a likelihood of exceedances at the closest sensitive receptors. If this is not the case, additional or adverse impacts are minimum.
- Impact of the proposed project activities:
  - Construction and closure phases:
    - Construction and closure phase PM emissions (PM<sub>2.5</sub>, PM<sub>10</sub> and TSP) were qualitatively assessed. Impacts due to these activities were perceived to be generally low and within the respective standards. This is especially expected for construction activities due to their temporary nature, and the likelihood that these activities will not occur concurrently at all portions of the site. The significance rating of the construction and closure phases is expected to be **'low'**.

- Operational phase:
  - Sources of emission quantified included drilling, blasting, crushing and screening, material handling, vehicles travelling on unpaved roads, windblown dust from the stockpiles, vehicle exhaust and power generation (diesel engines).
  - Operational phase PM emissions (PM<sub>2.5</sub>, PM<sub>10</sub> and TSP), including manganese (Mn), and gaseous emissions (CO, NO<sub>x</sub>, SO<sub>2</sub> and VOC) were quantified and utilized in the dispersion simulations.
  - Simulated PM<sub>10</sub> impacts during the operational phase with mine design mitigation did result in exceedances of both long-term (annual) and short-term (24-hour) ambient air quality standards off-site, but not at nearby AQSRs. A significance weighting of '**medium**' was assigned to potential inhalation health impacts associated with PM<sub>10</sub>.  
PM<sub>10</sub> impacts reduced when recommended additional mitigation was applied resulting in exceedances to the short time criteria (24-hour) only while compliance to the long-term criteria (annual) was noted. The assigned significance weighting of '**medium**' was sustained.
  - Simulated PM<sub>2.5</sub> impacts during the operational phase with mine design mitigation resulted in exceedances of the short-term (24-hour) ambient air quality criteria off-site, but not at nearby AQSRs (Hotazel and Gloria Mine village). For long-term (annual) impacts, off-site exceedances did not occur. A significance weighting of '**Low**' was assigned to potential inhalation health impacts associated with PM<sub>2.5</sub>. There is a low potential for any adverse impacts to human health hence additional mitigation is not necessary.
  - Simulated elemental Mn impacts during the operational phase with mine design resulted in exceedances of long-term (annual) ambient air quality screening criteria off-site but not close to nearby AQSRs. A significance weighting of '**medium**' was assigned to potential inhalation health impacts associated with elemental Mn.  
Elemental Mn impacts reduced significantly when recommended additional mitigation was applied. However, predicted exceedances of long-term (annual) ambient air quality criteria off-site remained, but not close to any AQSR. The assigned significance weighting of '**medium**' was sustained.
  - Simulated CO, NO<sub>2</sub>, SO<sub>2</sub> and VOC concentrations were low and did not result in off-site exceedances. A significance weighting of '**low**' was assigned to potential inhalation health impacts associated with these pollutants. There is a low potential for any adverse impacts to human health through inhalation of these gases hence additional mitigation is not necessary.
  - Simulated dustfall deposition rates were low and resulted in minimal off-site exceedances. A significance weighting of '**low**' was assigned to potential impacts associated with dustfall.

## 7.2 Recommendations

To ensure the lowest possible impact on AQSRs and the environment, it is recommended that the air quality management plan as set out in this report be adopted.

The recommended management plan includes the following:

- The implementation of emission controls for the management of significant emission sources; and
- Air quality monitoring:

- The extension of continuous dustfall monitoring as part of the project's air quality management plan. Monitoring should be undertaken throughout the life of the mine to provide air quality trends and indicate compliance with NAAQs. This was recommended in the previous assessment (Akinshipe, 2015), and at the time this report was compiled, dustfall monitoring was only conducted for eight months (August 2020 – March 2021)
- As in the previous assessment, the recommendation stands that Mokala collaborate with other mines/industries in the region to install an ambient gravimetric PM<sub>10</sub>/PM<sub>2.5</sub> monitor in Gloria Mine village or Hotazel. This will provide adequate data on cumulative PM<sub>10</sub> and PM<sub>2.5</sub> concentrations from the Mokala Manganese Project and other mines/industries in the region.
- Finally, it is recommended that the PM<sub>10</sub>/PM<sub>2.5</sub> samples be analysed for manganese content to determine the manganese concentrations at the nearest AQSRs. Should exceedances of the long-term assessment criteria occur (as simulated), a health risk/toxicological assessment should be conducted to ascertain the health impact due to manganese emissions at the AQSRs.
- The delineation of an air quality buffer zone is not deemed necessary, considering the “low” to “medium” significance rating assigned to pollutants impacts.

Based on the findings in this report and provided the additional mitigation measures are in place, it is the specialist opinion that the project may be authorised.

## 8 REFERENCES

- Akinshipe, O. (2015). *Air Quality Specialist Report for the Proposed Mokala Manganese Project in the Northern Cape Province*. Midrand, SA: Airshed Planning Professionals.
- ASG. (2011, January 20). *Air Quality Modelling Data Sets: The Atmospheric Studies Group at TRC*. Retrieved September 11, 2012, from The Atmospheric Studies Group at TRC: <http://www.src.com>
- (1965). *Atmospheric Pollution Prevention Act (Act No. 45 of 1965)*.
- CERC. (2004). *ADMS Urban Training. Version 2. Unit A*.
- Cowherd, C., Muleski, G. E., & Kinsey, J. S. (1988). *Control of Open Fugitive Dust Sources*. United States Environmental Protection Agency.
- DEA . (2015). *NEMAQA - National Atmospheric Emission Inventory System*. Pretoria: Department of Environmental Affairs (Government Gazette).
- DEA. (2010). *A Dispersion Modelling Case Study of Section 21 Emission Standards for Industrial Sources in the Highveld Priority Area*. Pretoria, SA: Department of Environmental Affairs.
- DEA. (2013). *National Environment Management: Air Quality Act- List of activities which may result in atmospheric emissions which have or may have a significant detrimental effect on the environment, including health, social conditions, economic conditions ecological*. Pretoria, SA: Government Gazette No.33064. 537.
- 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*. Department of Environmental Affairs, Government Gazette No. 37804, 11 July 2014.
- Duce, A., Hoffman, G., & Zolle, W. (1975). Atmospheric Trace Metals at Remote Northern and Southern Hemisphere Sites: Pollution or Natural? *Science*, 59-61.
- Flocchini, R. G., Cahill, T. A., Matsumura, R. T., Carvacho, O., & Lu, Z. (1994). *Study of fugitive PM10 emissions for selected agricultural practices on selected agricultural soils*. University of California.
- Goldreich, Y., & Tyson, P. (1988). Diurnal and Inter-Diurnal Variations in Large-Scale Atmospheric Turbulence over Southern Africa. *South African Geographical Journal*, 48-56.
- 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*.
- Howard, J. B. (1988). *Internal Combustion Engine Fundamentals*. Singapore: McGraw-Hill Book Co.
- IFC. (2007). *General Environmental, Health and Safety Guidelines*.
- Kretzschmar, J., Delespaul, I., & .de Rijck, T. (1980). Heavy metal levels in Belgium: a five year survey. *Science of the total environment*, 14: 85–97.
- MFE. (2001). *Good Practice Guide for Assessing and Managing the Environmental Effects of Dust Emissions*. New Zealand Ministry for the Environment.
- Mokala Manganese (Pty) Ltd. (2014a). *Mokala Manganese Project - Design Basis*.
- Mokala Manganese (Pty) Ltd. (2014b). *Mokala Manganese Project - Mine Services and Civil Design*.
- Mokala Manganese (Pty) Ltd. (2014c). *Mokala Manganese Project - Process Plant Design (Capital Project Review)*.
- Möller, G. a. (1974). Heavy metal aerosols in the air of large cities. *Boden- und Lufthygiene*, 42: 39–50.
- NPI. (2008). *Emission Estimation Technique Manual for Combustion engines*. Australian Government Department of Sustainability, Environment, Water, Population and Communities.
- NPI. (2008). *Emission Estimation Technique Manual for Combustion Engines. Version 3*.
- NPI. (2011). *Emission Estimation Technique Manual for Mining. Version 3*. Australian Government Department of Sustainability, Environment, Water, Population and Communities.
- NPI. (2012). *Emission Estimation Technique Manual for Mining*. Australian Government. Department of Environment and Heritage. National Pollutant Inventory.

- Stevenson, T. (2004). *Dust Suppression on Wyoming's Coal Min Haul Roads – Literature Review, Recommended Practices and Best Available Control Measures – A Manual*.
- TCEQ. (2013, February 01). *Texas Commission on Environmental Quality*. Retrieved September 08, 2014, from [www.tceq.state.tx.us](http://www.tceq.state.tx.us)
- The University of Tennessee. (2013). *Chemical Toxicity Values*. Retrieved October 11, 2012, from The Risk Assessment Information System: <http://rais.ornl.gov>
- Thompson, R. J., & Visser, A. T. (2000). *Integrated Asset Management Strategies for Unpaved Mine Haul Roads*. University of Pretoria.
- Tiwary, A., & Colls, J. (2010). *Air pollution: measurement, monitoring and mitigation* (3rd Edition ed.). Oxon: Routledge.
- Tokyo, Environmental Agency Japan. (1975). *Results of measurements of national air sampling stations during 1973 (fiscal year)*. Tokyo: Government of Japan.
- US EPA. (1986). *Procedures For Estimating Probability Of Nonattainment Of A PM10 NAAQS Using Total Suspended Particulate Or PM10 Data*. Triangle Park NC: National Service Center for Environmental Publications (NSCEP).
- US EPA. (1992). *Fugitive Dust Background Document and Technical Information Document for Best Available Control Measures, EPA-450/2-92-004*. North Carolina: US Environmental Protection Agency, Research Triangle Park.
- US EPA. (1995). *AP 42, 5th Edition, Volume I, Chapter 13: Miscellaneous Sources, 13.2.3 Heavy Construction Operations*. Retrieved from Technology Transfer Network .
- US EPA. (1995). *Chapter 11: Mineral Products Industry , 11.24 Metallic Minerals Processing*. USEPA. California: US EPA. Volume I.
- US EPA. (1996). *Compilation of Air Pollution Factors (AP-42)*. United States Environmental Protection Agency.
- US EPA. (1998). *AP 42, 5th Edition, Volume I, Chapter 11: Mineral Products Industry, 11.9 Western Surface Coal Mining*. USEPA.
- US EPA. (1999). *Compilation of Air Pollution Emission (AP-42)*. North Carolina: Environmental Protection Agency.
- US EPA. (2004). *AERMOD: Description of Model Formulation*. United States Environmental Protection Agency. Retrieved from United States Environmental Protection Agency: <http://www.epa.gov/scram001/>
- 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*. Retrieved from <http://www.epa.gov/ttn/chief/ap42/>
- US EPA. (2006). *AP 42, 5th Edition, Volume I, Chapter 13: Miscellaneous Sources, 13.2.2 Introduction to Fugitive Dust Sources, Unpaved Roads*. <http://www.epa.gov/ttnchief/ap42/>.
- US EPA. (2006a). *AP 42, 5th Edition, Volume I, Chapter 13: Miscellaneous Sources, 13.2.2 Unpaved Roads*.
- US EPA. (2006b). *AP 42, 5th Edition, Volume 1, Chapter13: Miscellaneous Sources, 13.2.4 Introduction to Fugitive Dust Sources, Aggregate Handling and Storage Piles*. Retrieved from <http://www.epa.gov/ttn/chief/ap42/>
- USEPA. (1994). *Reevaluation of Inhalation Health Risks Associated With Methylcyclopentadienyl Manganese Tricarbonyl (MMT) in Gasoline*. Washington, DC.; US Environmental Protection Agency.
- WHO. (1980). *WHO Study Group on Recommended Health-Based Limits in Occupational Exposure to Heavy Metals & World Health Organization*. Geneva: World Health Organization.
- WHO. (2000). *WHO Air Quality Guidelines for Europe*. Retrieved from World Health Organization Regional Office for Europe: <http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/pre2009/who-air-quality-guidelines-for-europe,-2nd-edition,-2000-cd-rom-version>
- Zoller, W. H., Gladney, E. S., & Duce, R. A. (1974). Atmospheric concentrations and sources of trace metals at the South pole. *PubMed*, 198-200.
- Zunckel, M., Venjonoka, K., Pienaar, J. J., Brunke, E. G., Pretorius, O., Koosiale, A., . . . van Tienhoven, A. M. (2004). Surface Ozone Over Southern Africa: Synthesis of Monitoring Results during the Cross Border Air Pollution Impact Assessment. *Atmospheric Environment*, 38.

## 9 APPENDIX A – SOURCE SPECIFIC MANAGEMENT AND MITIGATION MEASURES

### 9.1 Dust Control Options for Unpaved Roads

Three types of measures may be taken to reduce emissions from unpaved roads:

- Measures aimed at reducing the extent of unpaved roads, e.g. paving;
- Traffic control measures aimed at reducing the entrainment of material by restricting traffic volumes and reducing vehicle speeds; and
- Measures aimed at binding the surface material or enhancing moisture retention, such as wet suppression and chemical stabilization (Cowherd, Muleski, & Kinsey, 1988).

The main dust generating factors on unpaved road surfaces include:

- Vehicle speeds;
- Number of wheels per vehicle;
- Traffic volumes;
- Particle size distribution of the aggregate;
- Compaction of the surface material ;
- Surface moisture; and
- Climate

According to research conducted by the Desert Research Institute at the University of Nevada, an increase in vehicle speed of 16 km per hour resulted in an increase in PM<sub>10</sub> emissions of between 1.5 and 3 times. A similar study conducted by Flocchini (Flocchini, Cahill, Matsumura, Carvacho, & Lu, 1994) found a decrease in PM<sub>10</sub> emissions of 42±35% with a speed reduction from 40 km/hr to 24 km/hr (Stevenson, 2004). An evaluation of control efficiencies resulting from reductions in traffic volumes can be calculated due to the linear relationship between traffic volume, given in terms of vehicle kilometres travelled, and fugitive dust emitted. Similar affects will be achieved by reducing the truck volumes on the roads.

Water sprays on unpaved roads is the most common means of suppressing fugitive dust due to vehicle entrainment at mines, but it is not necessarily the most efficient means (Thompson & Visser, 2000). Thompson and Visser (2000) developed a model to determine the cost and management implications of dust suppression on mine haul roads using water or other chemical palliatives. The study was undertaken at 10 mine sites in Southern Africa. The model was first developed looking at the re-application frequency of water required for maintaining a specific degree of dust palliation. From this the cost effectiveness of water spray suppression could be determined and compared to other strategies. Factors accounted for in the model included climate, traffic, vehicle speed and the road aggregate material. A number of chemical palliative products, including hygroscopic salts, lignosulphonates, petroleum resins, polymer emulsions and tar and bitumen products were assessed to benchmark their performance and identify appropriate management strategies. Cost elements taken into consideration included amongst others capital equipment, operation and maintenance costs, material costs and activity related costs. The main findings were that water-based spraying is the cheapest dust suppression option over the short term. Over the longer term however, the polymer-emulsion option is marginally cheaper with added benefits such as improved road surfaces during wet weather, reduced erosion and dry skid resistance (Thompson & Visser, 2000). The empirical model, developed by the US EPA (US EPA, 1996), can also be used to estimate the average control efficiency of certain quantifies of water applied to a road. The model takes into account rainfall, evaporation rates and traffic.

Chemical suppressant has been proven to be effective due to the binding of fine particulates in the road surface, hence increasing the density of the surface material. In addition, dust control additives are beneficial in the fact that it also improves the compaction and stability of the road. The effectiveness of a dust palliative include numerous factors such as the application rate, method of application, moisture content of the surface material during application, palliative concentrations, mineralogy of aggregate and environmental conditions. Thus, for different climates and conditions you need different chemicals, one chemical might not be as effective as another under the same conditions and each product comes with various advantages and limitations of its own. In general, chemical suppressants are given to achieve a PM<sub>10</sub> control efficiency of 80% when applied regularly on the road surfaces (Stevenson, 2004).

Spillage and track-on from the surrounding unpaved areas may result in the deposition of materials onto the chemically treated or watered road resulting in the need for periodic “housekeeping” activities (Cowherd, Muleski, & Kinsey, 1988). In addition, the gradual abrasion of the chemically treated surface by traffic will result in loose material on the surface which would have to be controlled. The minimum frequency for the reapplication of watering or chemical stabilizers thus depends not only on the control efficiency of the suppressant but also on the degree of spillage and track-on from adjacent areas, and the rate at which the treated surface is abraded.

The best way to avoid dust generating problems from unpaved roads is to properly maintain the surface by grading and shaping to prevent dust generation caused by excessive road surface wear (Stevenson, 2004).

## 9.2 Crushing and Screening Operations

Enclosure of crushing operations is very effective in reducing dust. The Australian NPI (NPI, 2011) indicates that a telescopic chute with water sprays would ensure 75% control efficiency and enclosure of storage piles where tipping occur would reduce the emissions by 99%. In addition, chemical suppressants or water sprays on the primary crusher and dry dust extraction units with wet scrubbers on the secondary crushers and screens will assist in the reduction of the cumulative dust impacts. According to the Australian NPI, water sprays can have up to 50% control efficiency and hoods with scrubbers up to 75%. If in addition, the scrubbers and screens were to be enclosed; up to 100% control efficiency can be achieved. Hooding with fabric filters can result in control efficiencies of 83%. It is important that these control equipment be maintained and inspected on a regular basis to ensure that the expected control efficiencies are met (NPI, 2011).

## 9.3 Options for Reducing Windblown Dust Emissions

The main techniques adopted to reduce windblown dust potential include source extent reduction and source improvement and surface treatment methods:

- Source extent reduction:
  - Disturbed area reduction.
  - Disturbance frequency reduction.
  - Dust spillage prevention and/or removal.
- Source Improvement:
  - Disturbed area wind exposure reduction, e.g. wind fences and enclosure of source areas.



## 10 APPENDIX B – AMBIENT AIR QUALITY MONITORING METHODOLOGY

### 10.1 Dustfall Sampling

The ASTM method covers the procedure of collection of dustfall and its measurement and employs a simple device consisting of a cylindrical container (not less than 150 mm in diameter) exposed for one calendar month ( $30 \pm 2$  days). Even though the method provides for a dry bucket, de-ionised (distilled) water can be added to ensure the dust remains trapped in the bucket.

The bucket stand includes a wind shield at the level of the rim of the bucket to provide an aerodynamic shield. The bucket holder is connected to a 2 m galvanized steel pole, which is either planted and cemented or directly attached to a fence post (Figure 31). This allows for a variety of placement options for the fallout samplers. Two buckets are usually provided for each dust bucket stand. Thus, after the first month, the buckets get exchanged with the second set.

Collected samples are sent to an accredited laboratory for gravimetric analysis. At the laboratory, each sample is rinsed with clean water to remove residue from the sides, and the contents filtered through a coarse ( $>1$  mm) filter to remove insects and other coarse organic detritus. The sample is then filtered through a pre-weighed paper filter to remove the insoluble fraction. This residue and filter are dried, and gravimetrically analysed to determine total dustfall.

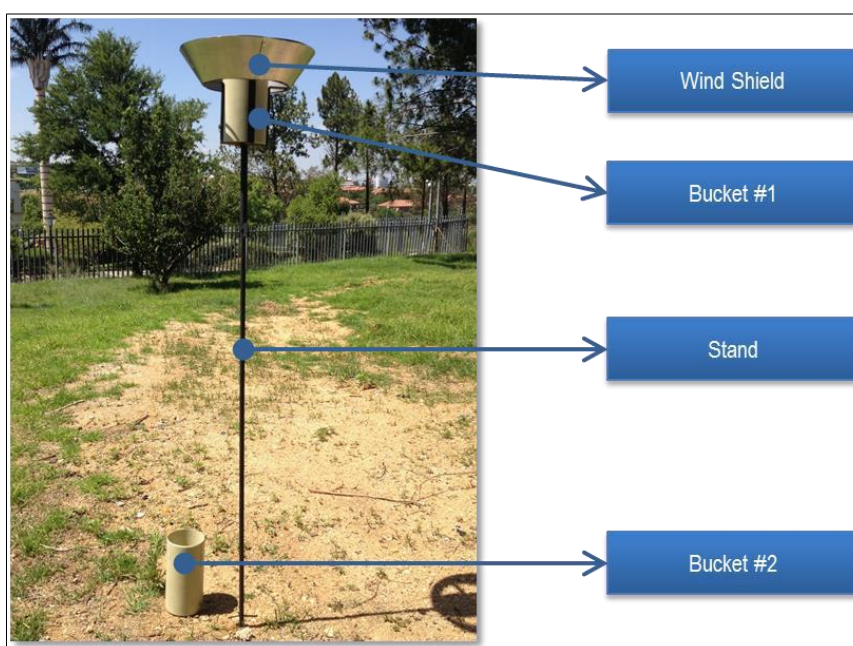


Figure 31: Example of a dustfall collection unit setup

### 10.2 PM<sub>10</sub>/PM<sub>2.5</sub> Sampling

Ambient PM<sub>10</sub>/PM<sub>2.5</sub> concentrations can be determined through the use of a MiniVol sampler (Figure 32). In summary, the monitoring methodology is as follows:

- The MiniVol sampler is programmed to draw air over a pre-weighed filter at a constant rate over a 24-hour period.
- At a specific interval (for instance, 1 in 3 days or 1 in 6 days), the used filter is removed, a new filter put in place, the battery exchanged (each MiniVol is equipped with two batteries) and the MiniVol re-programmed.
- The used filter is removed from the filter holder assembly in a clean environment and sealed in its dish.

- At each exchange, the date, location, filter number, pump run time etc. need to be noted in the data sheet that will be sent to an accredited laboratory with the sealed samples for gravimetric analysis.

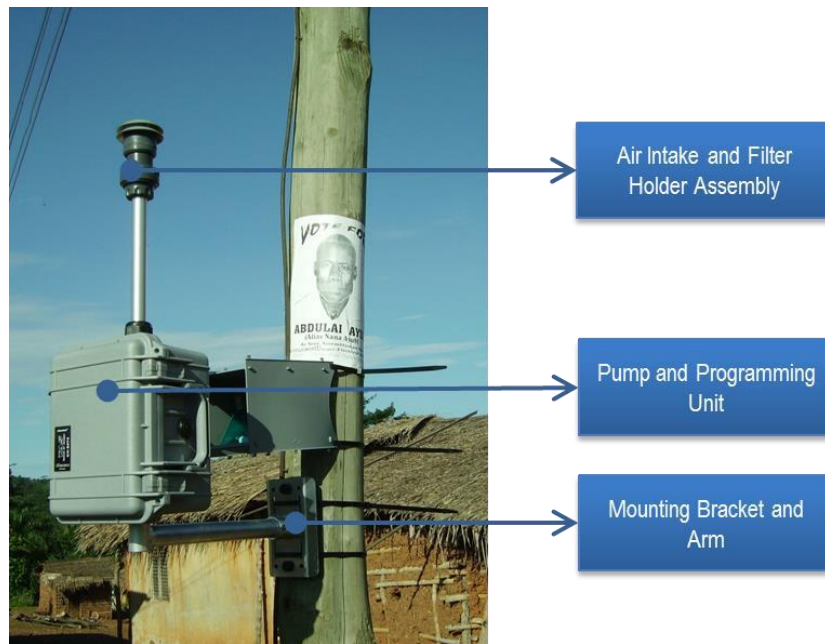


Figure 32: Example of a typical PM<sub>10</sub>/PM<sub>2.5</sub> MiniVol setup

