Air Quality Impact Assessment for the Elandsfontein Colliery in Mpumalanga

Project done for **Environmental Impact Management Services (EIMS)** on behalf of **Geo Soil & Water**

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Revision Record

Version	Date	Comments
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Rev 1	November 2020	Updated to include information from the latest Mine Works Programme as well as updated layout information.

Abbreviations

AEL	Atmospheric Emissions License
Airshed	Airshed Planning Professionals (Pty) Ltd
APPA	Air Pollution Prevention Act
AQIA	Air quality Impact Assessment
AQSR	Air Quality Sensitive Receptors
ASTM	American Standard Testing Method
CE	Control efficiency
CHPP	Coal Handling and Preparation Plant
DEA	Department of Environmental Affairs (now DEFF)
DEFF	Department of Environment, Forestry and Fisheries (previously DEA)
EHS	Environmental, Health, and Safety (IFC)
EIA	Environmental Impact Assessment
GG	Government Gazette
GHG	Greenhouse gas
GLC	Ground Level Concentration
HFO	Heavy Fuel Oil
I&APs	Interested and Affected Parties
IFC	International Finance Corporation
LOM	Life of Mine
Ltd	Limited
NAAQSs	National Ambient Air Quality Standards
NDCR	National Dust Control Regulations
NEMAQA	National Environment Management Air Quality Act
NPI	National Pollutant Inventory (Australia)
ROM	Run-of-mine
SAAQIS	South Africa Air Quality Information System
SABS	South African Bureau of Standards
SANS	South African National Standards
SoW	Scope of Work
US EPA	United States Environmental Protection Agency
WHO	World Health Organisation

Symbols and Units

°C	Degrees Celsius
µg	Microgram(s)
µg/m³	Micrograms per cubic meter
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
HFCs	Hydrofluorocarbons
L_{MO}	Monin-Obukhov Length
m/s	Metres per second
m^2	Metres squared
masl	Metres above sea level
mg	Milligram(s)
$mg/m^2/day$	Milligram per metre squared per day
mm	Millimetres
mtpa	million tons per annum
N_2O	Nitrous oxide
NOx	Oxides of nitrogen
NO_2	Nitrogen dioxide
PFCs	Perfluorocarbons
PM	Particulate Matter
PM_{10}	Thoracic particulate matter
$PM_{2.5}$	Respirable particulate matter
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide
TSP	Total Suspended Particulate
%	Percentage

Glossary

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

Executive Summary

Elandsfontein Colliery is an existing underground and opencast coal mine currently producing 500 000 tons of coal per annum (tpa) at their Coal Handling and Preparation Plant (CHPP). The mine plans to add an additional opencast and underground mining area to increase production to 100 000 tons of Run of Mine (ROM) per month (tpm) with a Life of Mine (LOM) of 6 years. The mining method will be a combination of opencast mining with a truck and shovel operation, and underground mining using conventional drill and blast, board and pillar mining.

Airshed Planning Professionals (Pty) Ltd was appointed by Environmental Impact Management Services (EIMS), on behalf of Geo Soil & Water, to assess the potential for air quality related impacts from the planned mining activities on the surrounding environment and human health as part of the Environmental Management Programme (EMPR) amendment. The current study constitutes the baseline and impact assessment of the proposed study[1].

Baseline Assessment

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

- Meteorological data was obtained for the period Jan 2016 – Dec 2018 from the DEFF station in Emalahleni, located about 10 km to the east-northeast of the mine.
- The prevailing wind field in the area consists of northerly, easterly and east-southeasterly winds, with infrequent winds from the south and west. During the day, winds at higher wind speeds occurred more frequently from the north whereas at night-time the airflow shifts to more frequent winds from the east and east-southeast but at somewhat lower wind speeds. Day-time calms occurred for 3.6% of the time, with night-time calms for 7.6% of the time.
- Wind speeds exceeding 5.4 m/s occurred for 7.9% over the three years.
- The area experiences mild summers and cold winters with monthly average temperatures of between -2.1°C and 20.7°C.
- Average annual rainfall amounts to 730 mm per annum (November to April) with an average annual evaporation rate of 1500 mm (CPR, 2019).
- Air quality sensitive receptors (AQSRs) around the mine include the residential areas of Clewer immediately to the east, Kwa-Guqa 4 km to the north-northeast, Ackerville 7 km to the northeast, Phola 9 km to the southwest and Emalahleni 10 km to the east.
- Elandsfontein Mine is located within the Highveld Priority Area.
- Ambient air pollutant levels in the project area are currently affected by the following sources of emission:

[1] An updated layout map with the locations of the proposed new topsoil and overburden stockpiles was received in November 2020, viz. two months after the impact assessment had been completed. The changes to the layout are considered minor, however, and will not require re-modelling or affect the conclusions from the original impact assessment.

- Ambient air pollutant levels in the project area are currently affected by the following sources of emission: Coal Fired Power Plants – Kusile some 13 km to the west with Duvha Power Station approximately 21 km to the east.
- Industrial (metallurgical) operations – Transalloys is located northeast of Elandsfontein Colliery; Highveld Steel is located to the north; and Ferro Metals is located in the western part of Emalahleni some 6 km away.
- Opencast and underground mines – Greenside Colliery is located 4 km to the east with other coal mines within a 10 km radius including Landau Colliery to the north and Tweefontein- and Klipspruit mines to the south.
- Other sources – including domestic fuel burning; vehicle entrained dust on paved and unpaved roads; vehicle tailpipe emissions; and agriculture.

- Monitoring data from the DEFF Emalahleni station (approximately 9 km east-northeast of the mine) for the period January to December 2018 was analysed. SO_2 and NO_2 ambient concentrations are within acceptable levels within the Emalahleni area, but ambient PM concentrations are elevated exceeding both the daily and annual NAAQS for PM_{10} and $PM_{2.5}$.
- Time series plots of ambient SO_2, NO_2 and PM_{10} concentrations show residential fuel burning contributions to SO_2 and NO_2 concentrations especially during the winter months, traffic contributions to NO_2 concentrations and more general industrial, mining and fuel burning contributions to PM.
- 2017 AQIA Report Review: The AQIA Report compiled for Elandsfontein Colliery by DWE in August 2017 was assessed as part of the baseline to determine whether the methodology followed is defendable; and whether the modelled results are regarded representative of the operations. As far as could be ascertained, the study followed the correct methodology for an air quality impact assessment. An underestimation in the emissions from the crushers was noted but not enough information was provided to verify all the calculations. The meteorological data used in the model is acceptable, and the dispersion model used is in line with the regulations. The modelled results, even though very high, could be possible; however, the area of exceedance from the modelled results seemed extensive given the emission rates reported. Only unmitigated results were provided for PM_{10} and $PM_{2.5}$, where a mitigated modelling scenario would have assisted in the understanding of the potential impacts from the mine with controls in place. The reduction in the dustfall rates between unmitigated and mitigated indicated a significant improvement due to mitigation measures.

Impact Assessment

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. To determine the significance of air pollution impacts due to the operational phase of the Project, emissions were quantified for three modelling scenarios:

- Scenario 1 – representative of opencast mining activities (Blocks F and G) and underground mining (Blocks B and C) for Year 2;

- Scenario 2 – representative of opencast mining activities (Block H) and underground mining (Block D) for Year 3; and
- Scenario 3 – representative of underground mining activities (Block A) for Year 5.

Scenario 1 was chosen to represent maximum ROM and product throughput from simultaneous mining of opencast resource blocks (located to the northwest of the CHPP) and underground resource blocks (located to the southwest of the CHPP) respectively.

Scenario 2 was chosen to represent maximum waste production (overburden and topsoil) where opencast mining activities are located to the southeast of the CHPP (in near proximity to the closest AQSR) and underground mining activities are located to the northwest of the CHPP, respectively.

Scenario 3 represents impacts due to underground mining activities only, where the underground mining block is located to the southeast of the CHPP (in near proximity to the closest AQSR).

The main findings from the impact assessment are as follows:

- The main contributors to uncontrolled emissions during the operational phase were found to be crushing and wind erosion for $PM_{2.5}$, unpaved roads and wind erosion for PM_{10}, and unpaved roads and crushing for TSP. With mitigation, although the unpaved roads contribution is much reduced; the main contributing sources to $PM_{2.5}$, PM_{10} and TSP emissions remain the same.
- Dispersion modelling results are as follows:
    - ***PM_{10}*** daily GLCs, with or without mitigation in place, are not likely to exceed the NAAQS at any of the AQSRs. Over an annual average the GLCs are within the standard at all receptors.
    - ***$PM_{2.5}$*** daily GLCs, for both unmitigated and mitigated activities, are not likely to exceed the NAAQS at any of the AQSRs. Over an annual average the GLCs are within the standard at all receptors.
    - Maximum daily **dustfall** rates due to both unmitigated and mitigated scenarios were within the NDCR for residential areas at all AQSRs.
- The simulated footprint areas of exceedance for PM_{10} and $PM_{2.5}$ impacts were found to be much larger for Scenario 2 than for Scenarios 1 or 3. This increase in magnitude may be explained the higher waste production (overburden and topsoil), and the relative location of opencast mining activities (southeast of the CHPP, in near proximity to the closest AQSR to the east of the mine boundary) and underground mining activities (located to the northwest of the CHPP, in close proximity to the closest AQSR to the north of the mine boundary).
- The main sources of impacts due to uncontrolled emissions during the operational phase were found to be unpaved roads, followed by in-pit sources. For controlled operations unpaved roads remains the largest contributor although the crushing source becomes a larger contributor at AQSRs to the north and northeast of the mine boundary.
- The significance rating for the operational phase was **Medium negative** for uncontrolled operations and **Low negative** for mitigated operations.

- The impact significance associated with the construction and closure phases was determined as **Low negative**.
- The proposed Project operations should not result in significant ground level concentrations or dustfall levels at the nearby receptors provided the design mitigation measures are applied effectively. From an air quality perspective, the proposed project can be authorised permitted the recommended mitigation measures are applied.

The main findings from the GHG impact assessment are as follows:

- The total CO_2-e emissions for Elandsfontein operations are not likely to be more than 214 417 tpa. The calculated CO_2-e emissions from the proposed project operations contribute less than 0.04% to the total of the national inventory's GHG emissions (excluding land-use change and forestry) and 0.05% to the national inventory's "energy" sector GHG emissions.
- GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The scope 1 GHG contribution due to the proposed mining operations is below 100 000 tons. Based on this, a Pollution Prevention Plan is not required for the proposed project operations.
- The GHG emissions from the proposed operational phase are not likely to result in a noteworthy contribution to climate change on its own.
- The project and the community are likely to be negatively impacted by climate change, the project less than the community due to the short time that operations are likely to occur.

Conclusions and Recommendations

The conclusion from the impact assessment is that cumulative impacts due to the planned mining operations would have a "Medium negative" significance on the surrounding environment and human health during the operational phase, before and even after mitigation is applied, due to the increased mining and production rates and the close proximity of AQSR (Clewer) to the planned mining operations.

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

- Construction and closure phases:
  - Air quality impacts during construction would be reduced through basic control measures such as limiting the speed of haul trucks; limit unnecessary travelling of vehicles on untreated roads; and to apply water sprays on regularly travelled, unpaved sections.
  - When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and the material transported must be covered to minimise windblown dust.
  - The access road to the Project also needs to be kept clean to minimise carry-through of mud on to public roads.
- Operational phases:
  - For the control of vehicle entrained dust it is recommended that water (at an application rate >2 litre/m^2/hour), be applied. Literature reports an emissions reduction efficiency of 75%.

- In controlling dust from crushing and screening operations, it is recommended that water sprays be applied to keep the ore wet, to achieve a control efficiency of up to 50%.
- Mitigation of materials transfer points should be done using water sprays at the tip points. This should result in a 50% control efficiency. Regular clean-up at loading points is recommended.
- In minimizing windblown dust from stockpile areas, water sprays should be used to keep surface material moist. A mitigation efficiency of 50 % is anticipated.
- Continuous monitoring of dustfall must be conducted as part of the Project's air quality management plan.

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1 Introduction

Elandsfontein Colliery is an existing underground and opencast coal mine that started operations in the 1980s. Opencast operations commenced in October 2016 with pre-stripping of waste material to waste dumps to expose the No 2 seam. The No.1 Seam has been mined through underground board and pillar operation while No.4 Seam and No.2 Seam have been mined though opencast methods. The No.4 Seam is mined out with the No.2 Seam currently being mined. Elandsfontein Colliery has an operational Coal Handling and Preparation Plant (CHPP) producing 500 000 tons of coal per annum (tpa).

Elandsfontein Colliery plans to add an additional 249 hectares (ha) of opencast and 485 ha of underground mining areas into their existing approved Mine Works Programme and Environmental Management Plan (EMP). As part of the EMP certain environmental indicators have to be monitored to ensure that the operation stays within legal requirements for water, dust and noise. This includes compliance monitoring obligations to ensure dust and PM_{10} are kept below acceptable levels.

Airshed Planning Professionals (Pty) Ltd was appointed by Environmental Impact Management Services (EIMS), on behalf of Geo Soil & Water, to assess the potential for air quality related impacts from the proposed opencast and underground mining operations on the surrounding environment and human health as part of the Environmental Management Programme (EMPR) amendment. As part of the air quality impact assessment (AQIA), greenhouse gas (GHG) emissions will be quantified per legal requirements.

1.1 Study Objective

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

Two tasks need to be assessed:

1. The review of the existing specialist reports and a professional opinion on the additional impacts and associated management and mitigation measures (if any) associated with the proposed new underground mining area; and
2. A new assessment report for the proposed new mining areas- in the instance where the existing specialist study does not adequately address the new mining area and a new assessment is required.

Task 1 was addressed in the baseline characterisation of the AQIA and GHG study and is included in Appendix C. Task 2 will be addressed in the current study. The terms of reference are provided in Section 4 and a detailed description of the project is given in Section 5. The impact assessment criteria and methodology are given in Sections 6 and 7, respectively. A detailed description of the environment associated with the project is provided in Section 8. Air quality impacts due to the proposed expansion are assessed in Section 9, and a statement on the project's GHG footprint provided in Section 10.

2 Document Structure

NEMA Regulations (2014) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report.	Section 3: Specialist Details
The expertise of that person to compile a specialist report including curriculum vitae.	Section 3: Specialist Details Appendix B: Curriculum Vitae
A declaration that the person is independent in a form as may be specified by the competent authority.	Appendix A: Specialist Declaration
An indication of the scope of, and the purpose for which, the report was prepared.	Introduction and background (Executive Summary) Section 1: Introduction Section 4: Terms of Reference
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Meteorological and ambient data were analysed as part of a desktop review of all available project data and associated data. No site visit was conducted as sufficient data was available.
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Introduction and background (Executive Summary) Section 1.1: Study Objective Section 3.1: Scope of Work
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 8.3: Existing Sources of Emissions in the Region Section 11: Spatial Sensitivity Mapping
An identification of any areas to be avoided, including buffers.	Not applicable
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Section 8.2.2: Sensitive Receptors Section 11: Sensitivity Mapping
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 15: Assumptions, Uncertainties and Gaps in Knowledge
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 12. Impact Assessment Section 14. Findings and Recommendations
Any mitigation measures for inclusion in the environmental management programme report	Section 13. Air Quality Management Plan Section 14.2. Conclusions and Recommendations
Any conditions for inclusion in the environmental authorisation	Section 14.2. Conclusions and Recommendations
Any monitoring requirements for inclusion in the environmental management programme report or environmental authorisation.	Section 13. Air Quality Management Plan Section 14.2. Conclusions and Recommendations
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 14.2. Conclusions and Recommendations
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the environmental management programme report, and where applicable, the closure plan.	Section 13.2. Proposed Mitigation and Management Measures. Section 14.2: Conclusions and Recommendations
A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable
A summary and copies if any comments that were received during any consultation process.	Not applicable.
Any other information requested by the competent authority.	Not applicable.

3 Specialist Details

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

Rochelle Bornman started her professional career in Air Quality in 2008 when she joined Airshed Planning Professionals (Pty) Ltd after having worked in malaria research at the Medical Research Council in Durban. Rochelle has worked on several air quality specialist studies between 2008 and 2018. She has experience on the various components including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality. Whilst most of her working experience has been in South Africa, a number of investigations were made in countries elsewhere, including Mozambique, Namibia, Saudi Arabia and Mali.

The CV of Rochelle Bornman is provided in Appendix A.

4 Terms of Reference

Based on the required scope, the baseline assessment comprised the following:

- A study of the receiving environment by referring to:
  - Desktop review of all available project and associated data, including meteorological data, previous air quality assessments, environmental impact assessments and technical air quality data and modelling.
  - A study of atmospheric dispersion potential by referring to available weather records or simulated hourly sequential meteorological data for a period of at least 3 years (required for dispersion modelling), land use and topography data.
  - Details on the physical environment i.e. meteorology (atmospheric dispersion potential), land use and topography.
  - Identification of existing air pollution sources (other mines; power stations; industries; etc.)
  - Identification of air quality-sensitive receptors, including any nearby residential dwellings and proposed receptors (temporary or permanent workers accommodation site(s)) in the vicinity of the mine;
  - Any and all freely available ambient air quality data for PM (PM_{10}, $PM_{2.5}$ and TSP).
- Review the existing specialist report to:
  - Determine whether the methodology followed is defendable; and
  - Determine whether the modelled results are regarded representative of the operations.
- Qualitatively assess the potential impacts for the planned underground and opencast mining operations.
- Provide recommendations for mitigation measures.

The following tasks were included in the analysis and impact assessment:

- Development of comprehensive atmospheric source and emissions inventory, including:
  - Source descriptions;
  - Source locations;
  - Emission rates and the methodology/emission factors used (pollutants to include PM_{10}, $PM_{2.5}$, and TSP as a minimum and if required, NO_2, CO, and SO_2).
- Atmospheric dispersion simulations using the United States Environmental Protection Agency's regulatory AERMOD modelling suite.
- Human health, nuisance and environmental impact screening.
- A qualitative cumulative air quality assessment.
- Development of an air quality management, mitigation, and monitoring plan.
- A Tier 1 (if required Tier 2) greenhouse gas inventory and qualitative discussion on climate change impacts.
- A specialist air quality impact report detailing:
  - All results and findings of the baseline and impact assessments
  - All limitations
  - All assumptions.

5 Project Description

5.1 Mining Method

The mining method will be a combination of opencast (OC) mining with a truck and shovel operation, and underground (UG) mining using conventional drill and blast, and bord and pillar mining (CPR, 2019). Production is planned at a rate of approximately 100 000 tons of Run of Mine (ROM) per month (tpm) with a Life of Mine (LOM) of 6 years. The product is transported by rail to the port of Richards Bay from the Oosbank siding.

The layout of the planned project is provided in Figure 1.

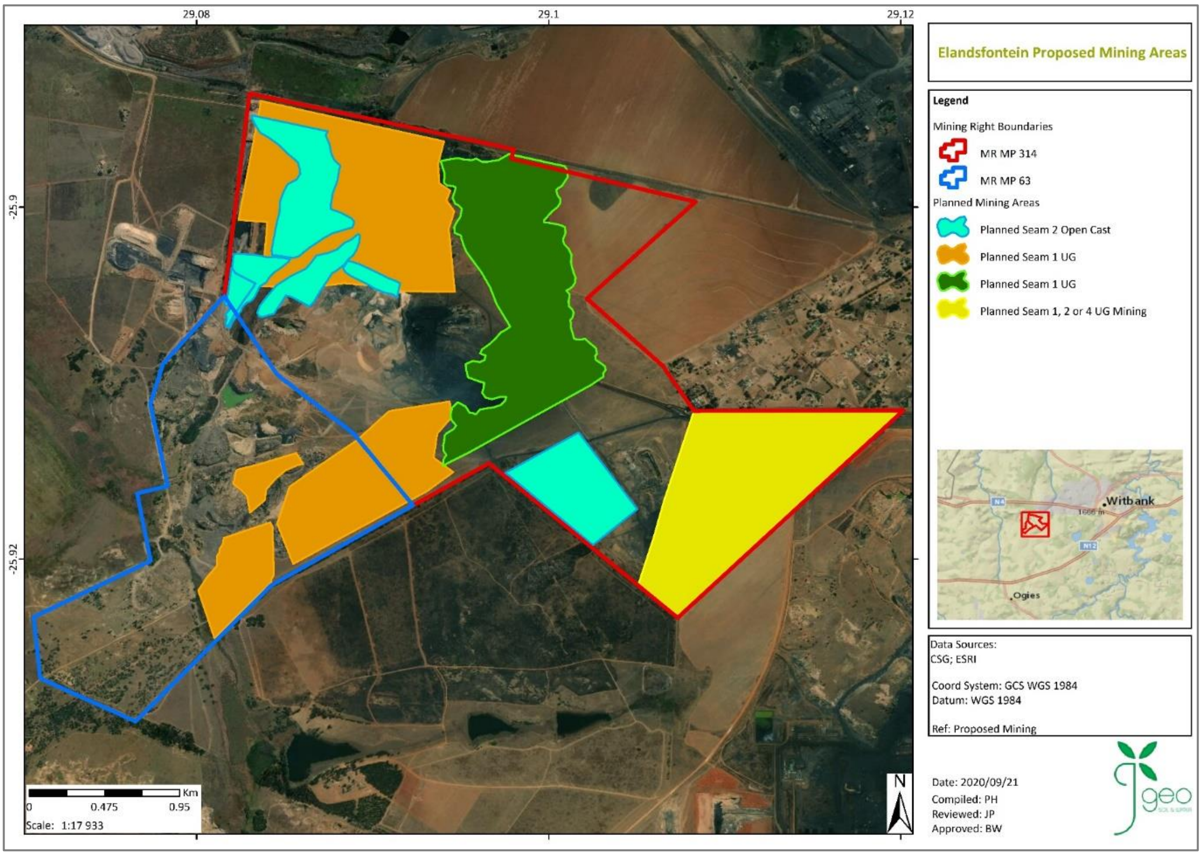


Figure 1: Elandsfontein planned mining area

The locations of the proposed topsoil and overburden stockpiles were finalised in November 2020 and are shown in Figure 2.

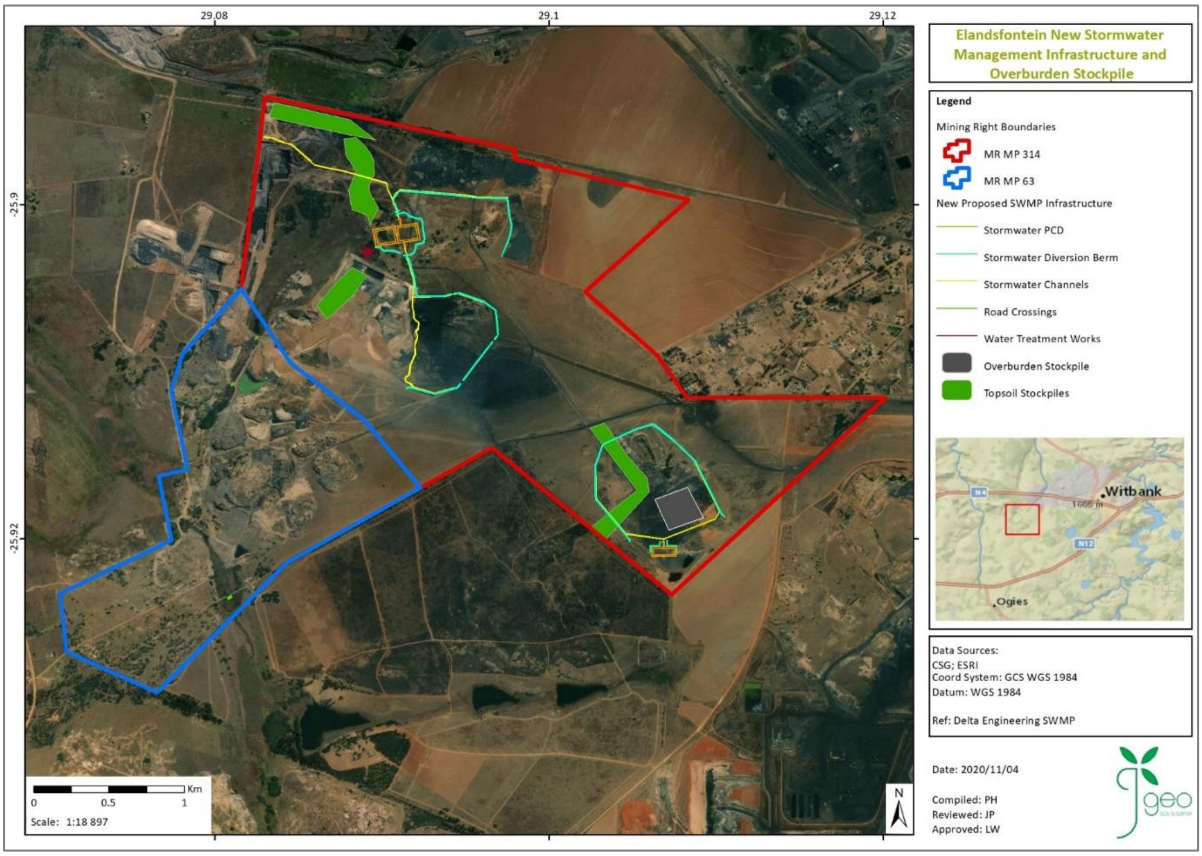


Figure 2: Updated layout map including the location of new overburden and topsoil stockpiles

5.2 Coal Handling and Preparation Plant

Only a portion of the anticipated ROM tonnage for the Elandsfontein operation, namely the coal from the No. 1 Seam underground reserves, will be beneficiated in the Dense Medium Separation (DMS) plant. The reject from the DMS plant will be mixed with the ROM coal from the opencast No. 2 Seam coal. Discard will be conveyed to a bin with overflow facility located at the plant and transported via haul truck to the discard dump.

5.2.1.1 Process Design

ROM coal from opencast areas gets transported by dump trucks to a ROM stockpile, where it is crushed and screened into different products. Coal from underground blocks is conveyed from the working faces to surface via conveyor system to a ROM stockpile. From the ROM stockpile it is transported by truck to the ROM stockpile at the DMS wash plant. The plant is based on the premise that the coal can be separated from the waste rock by means of their respective densities.

5.2.1.2 Product Handling

ROM product from opencast will be placed on the ROM product stockpile. Washed coal from the No 1 seam from underground mining will be placed on the Export product stockpile (60%), reclaimed by FEL, loaded onto trucks and hauled to the siding. Secondary product will be placed/mixed with the ROM product from the opencast operations (40%), reclaimed by FEL and trucked to a suitable Eskom power station.

5.3 UG and OC Resource Blocks

The coal resources estimation (as provided by the client) is based on geological interpretation and modelling done on a 20 m × 20 m grid. The extent of the resource blocks was determined by the mineral right boundary, environmental factors and data point (borehole) spatial distribution (MWP, 2020). The resource blocks for Seam 1 (underground mining) and Seam 2 (opencast mining) are shown in Figure 3 and Figure 4 respectively.

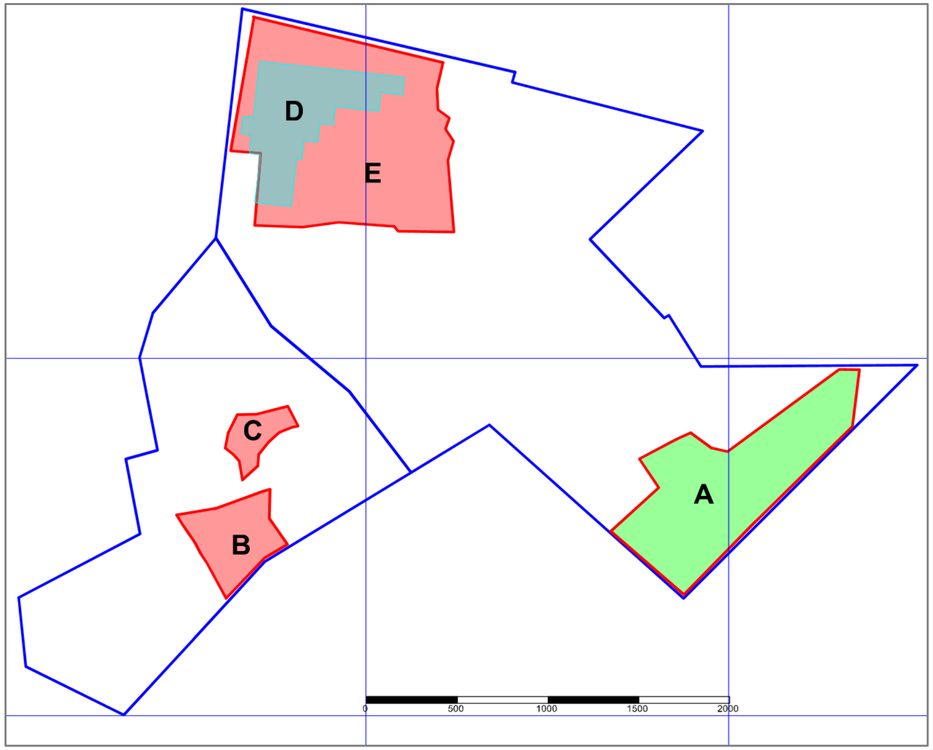


Figure 3: No 1 Seam mining blocks – underground mining

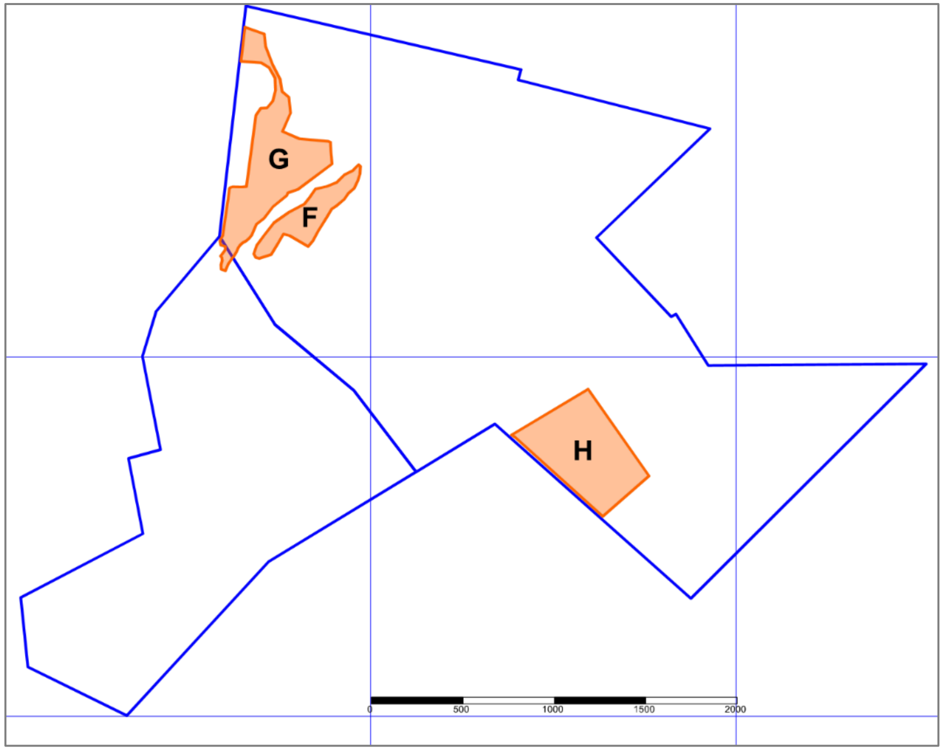


Figure 4: No 2 Seam mining blocks – opencast mining

5.4 Mining Schedule

Construction of the new mine areas is planned to take place between 2021 and 2022 with steady state production being achieved in 2022. A depletion schedule for the Elandsfontein Colliery (Pty) Ltd. was developed based on the target mine production and resulted in a 6-year production life. The overall life of mine (LOM) including construction and rehabilitation is 12 years.

5.4.1 Construction

The construction phase will involve a box-cut in the north of the opencast reserve of Block H and developing cuts in a southerly direction. A new decline will be developed to access the No.1 Seam at Resource Block D and E, with existing infrastructure used to access the other underground Resource Blocks. The construction will take up to a year.

5.4.2 Operational – Opencast Mining

The anticipated monthly production of opencast ROM coal is 50 000 tonnes per month. Topsoil and subsoil will be stockpiled separately. Overburden and waste will be stockpiled separately until steady state mining is reached. Once steady state mining is reached the material will be placed back as part of the rollover operation, when backfilling commences.

The production schedules of No 2 Seam ROM coal/coal product (tonnes per month) (MWP, 2020) and waste volumes (m^3 per month) (CPR, 2019) are shown in Figure 5 and Figure 6 respectively.

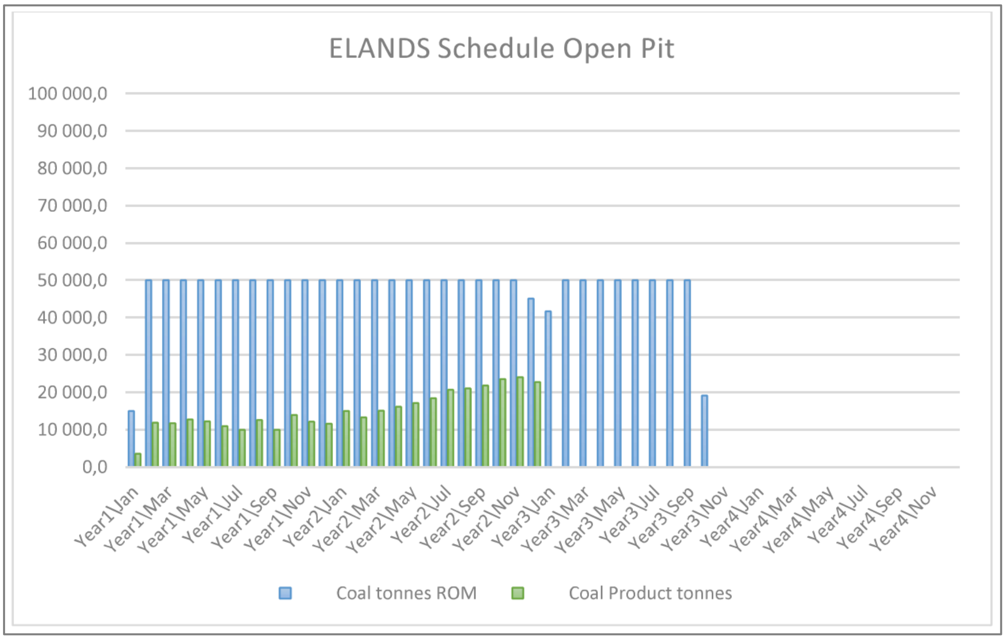


Figure 5: No 2 Seam ROM production schedule

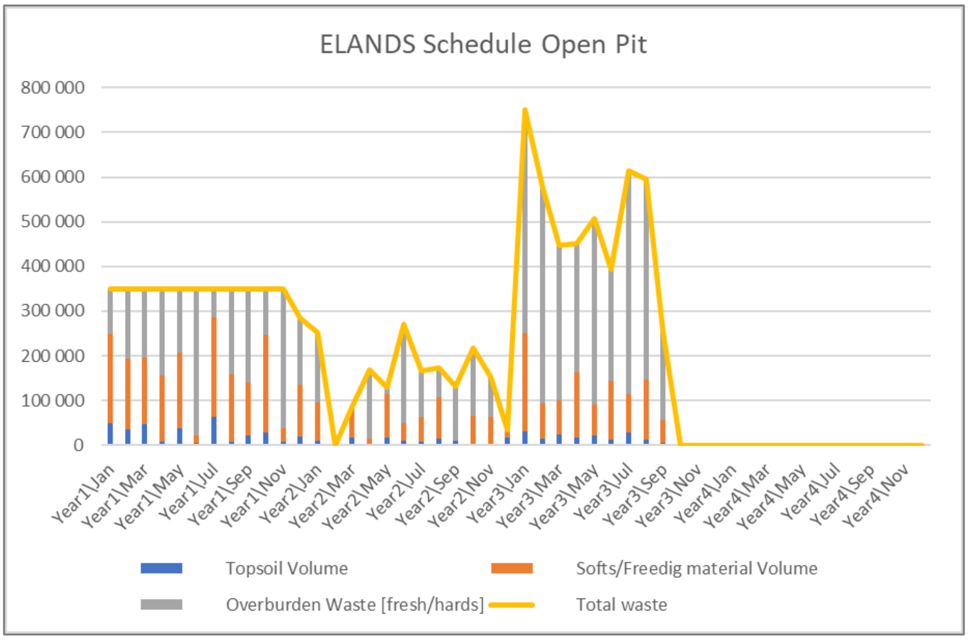


Figure 6: No 2 Seam waste production schedule

5.4.3 Operational – Underground Mining

The anticipated monthly production of underground ROM coal is 50 000 tonnes per month. The production schedule of No 1 Seam ROM coal (MWP, 2020) is shown in Figure 7.

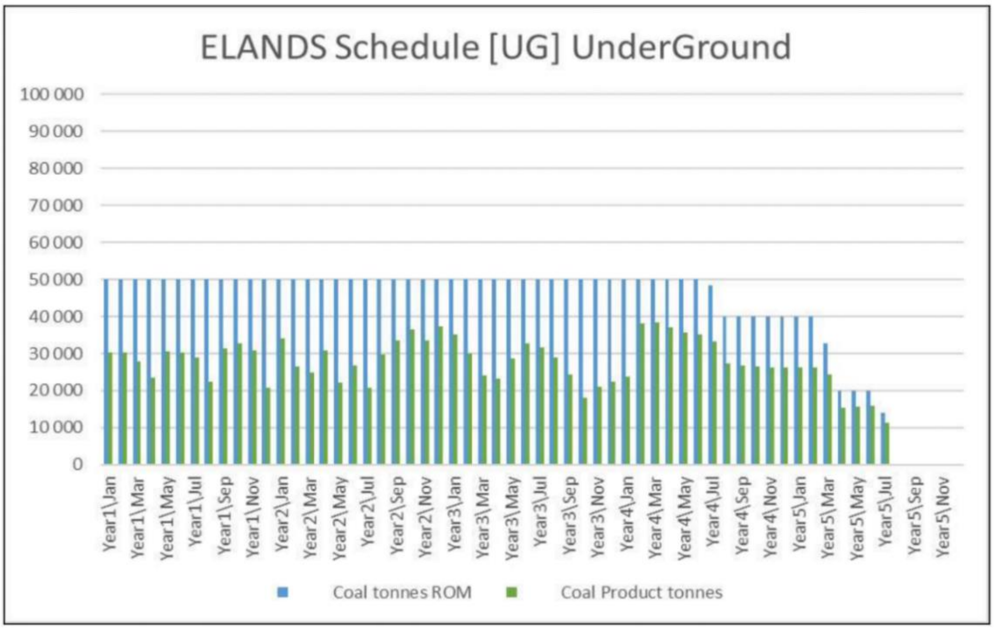


Figure 7: No 1 Seam ROM production schedule

5.4.4 Combined mining schedule

A combined mining schedule (opencast and underground) was created using the above monthly figures and the annual mining costs and beneficiation costs estimated in Table 14 in the MWP (MWP, 2020). The combined throughput of material for the LOM period is shown in Table 1 below.

Table 1: Underground and opencast annual throughputs (in tonnes per annum) for the LOM period

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
UG ROM	–	600 000	600 000	600 000	538 000	192 000
OC ROM	565 000	592 000	470 000	–	–	–
Total ROM	**565 000**	**1 192 000**	**1 070 000**	**600 000**	**538 000**	**192 000**
UG Product	–	337 000	356 000	329 000	372 000	137 000
OC Product	137 000	228 000	–	–	–	–
Total Product	**137 000**	**565 000**	**356 000**	**329 000**	**372 000**	**137 000**
Topsoil†	532 500	165 000	277 500	–	–	–
OB (hard) †	4 047 000	1 520 000	6 365 000	–	–	–
OB (soft) †	2 796 500	1 003 000	1 674 500	–	–	–
Total waste	**7 376 000**	**2 688 000**	**8 317 000**	**–**	**–**	**–**
Resource Blocks	**OC (F, G)**	**OC (F, G)** **UG (B, C)**	**OC (H)** **UG (D)**	**UG (E)**	**UG (A)**	**UG (A)**

† Volumes of waste (in m^3) were converted to tonnes per annum using generic bulk densities for the various materials

5.4.5 Mine Sequencing

The LOM mining schedules for the opencast and underground mining blocks indicated in Section 5.3 are shown in Figure 8 and Figure 9 respectively (MWP, 2020). From these schedules the sequence of the resource blocks to be mined throughout the LOM period could be inferred (confirmed by the client). The sequence is indicated in Table 1.

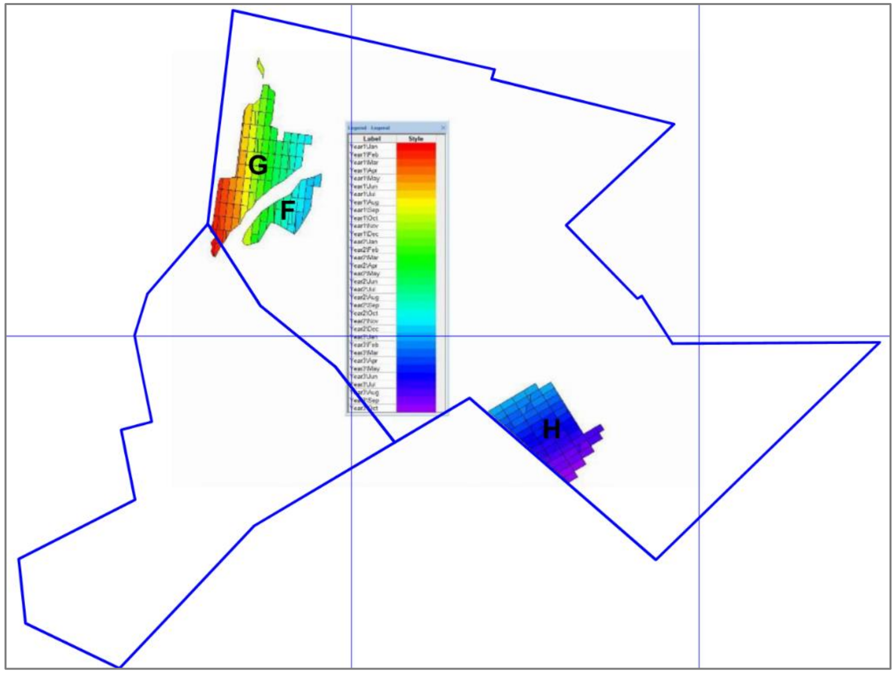


Figure 8: Mine sequencing: No 2 Seam opencast LOM schedule

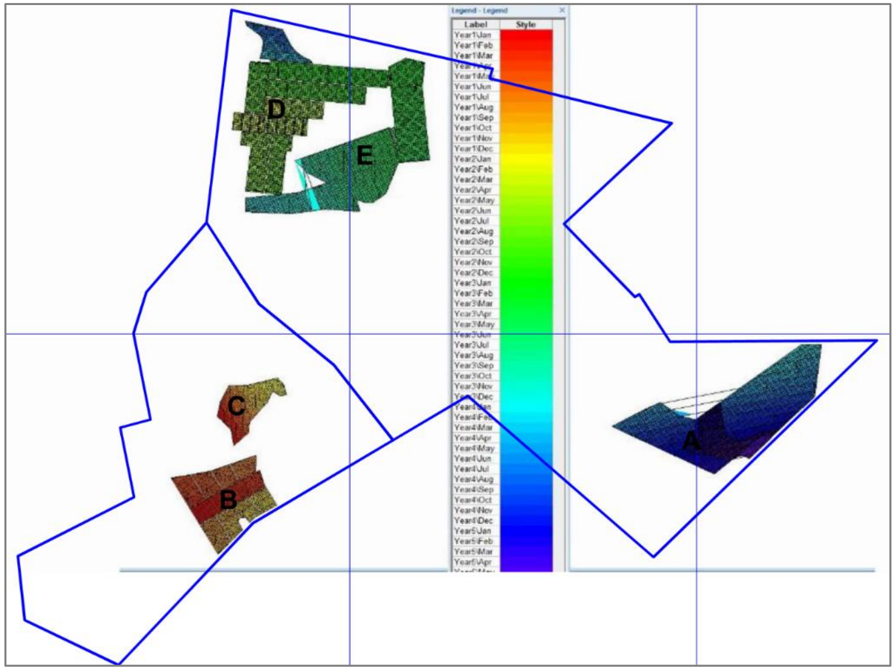


Figure 9: Mine sequencing: No 1 Seam underground LOM schedule

5.5 Rehabilitation Plan

The closure objectives set as part of the mine-closure planning process aims to ensure that the final Land Use Plan is achieved and that the area is sustainable in the long-term from an environmental and social point of view (CPR, 2019). The rehabilitation plan comprises the following activities:

- Backfilling of voids;
- Reshaping of landforms;
- Replacement of soils or soft overburden;
- Revegetation of the landscape;
- Rehabilitation of disturbed wetland; and
- Monitoring and maintenance.

Backfilling will be initiated as an integral part of the mining operation as soon as possible, thus reducing the volume of overburden and spoils that will be placed on surface.

5.6 Air Pollutants Associated with Proposed Mining Activities

Air quality impacts will be associated with four distinct phases namely: the construction phase, the operational phase with underground and opencast mining operations, the decommissioning phase and the rehabilitation and closure phase. Typical sources of fugitive emissions associated with **construction** activities are shown in Table 2.

Table 2: Typical sources of fugitive emissions associated with construction

Impact	Source	Activity
Gases	Vehicle tailpipe	Transport and general construction activities
Dustfall, PM_{10} and $PM_{2.5}$	Box-cut development	Clearing of groundcover
		Excavation
		Wind erosion from open areas
		Materials handling
	New decline shaft	Clearing of groundcover
		Excavation
		Wind erosion from open areas
		Materials handling
	Transport infrastructure	Clearing of vegetation and topsoil
		Levelling of transportation route areas

The proposed **opencast and underground mining activities**, with associated air pollutants, are listed in Table 3.

Table 3: Proposed mining and processing activities with associated pollutants

Activity	Associated pollutants
Mining Operations	
Opencast mining: excavation of ROM coal and waste	Mostly Particulate matter (PM)[(a)], gaseous emissions from mining equipment (PM, sulfur dioxide (SO_2) oxides of nitrogen (NOx); carbon monoxide (CO); and carbon dioxide (CO_2)[(b)])
Opencast mining: removal and stockpiling of topsoil	Mostly PM, gaseous emissions from excavation equipment (PM, SO_2; NOx; CO; CO_2)
Opencast mining: haulage of ROM coal, waste and topsoil	PM from road surfaces, windblown dust from trucks, gaseous emissions from truck exhaust (PM, SO_2; NOx; CO; CO_2)
Underground mining: drilling and blasting	PM, SO_2; NOx; CO; and CO_2
Underground mining: conveying of ROM coal to surface ROM stockpile	Mostly PM, gaseous emissions from machinery (PM, SO_2; NOx; CO; CO_2)
Underground mining: haulage of ROM surface stockpile to DMS ROM stockpile	PM from road surfaces, windblown dust from trucks, gaseous emissions from truck exhaust (PM, SO_2; NOx; CO; CO_2)
Discard dump(s)	PM from tipping, windblown dust, gaseous emissions from truck exhaust (PM, SO_2; NOx; CO; CO_2)
Processing Operations	
ROM transfer point and reclaim system	Mostly PM, gaseous emissions from reclaim system (PM, SO_2; NOx; CO; CO_2)
Primary, secondary and tertiary ROM crushing and screening	Mostly PM, gaseous emissions from diesel powered machinery (PM, SO_2; NOx; CO; CO_2)
Transfer conveyor to overland conveyor to plant ROM stockpile	Mostly PM, gaseous emissions from diesel powered machinery (PM, SO_2; NOx; CO; CO_2)
ROM feed conveyor	Mostly PM, gaseous emissions from machinery (PM, SO_2; NOx; CO; CO_2)
Dense medium cyclone plant	PM, SO_2; NOx; CO; and CO_2
Fines treatment plant	PM, SO_2; NOx; CO; and CO_2
Stockpiling of final product, and fines spiral plant	Mostly PM, gaseous emissions from machinery (PM, SO_2; NOx; CO; CO_2)
Conveying of discard to a bin with overflow facility located at the plant	Mostly PM, gaseous emissions from machinery (PM, SO_2; NOx; CO; CO_2)

Notes: [(a)] Particulate matter (PM) comprises a mixture of organic and inorganic substances, ranging in size and shape and can be divided into coarse and fine particulate matter. Total Suspended Particulates (TSP) represents the coarse fraction >10µm, with particulate matter with an aerodynamic diameter of less than 10µm (PM_{10}) and particulate matter with an aerodynamic diameter of less than 2.5µm ($PM_{2.5}$) falling into the finer inhalable fraction. TSP is associated with dust fallout (nuisance dust) whereas PM_{10} and $PM_{2.5}$ are considered a health concern.

[(b)] CO_2 and methane are greenhouse gases (GHG).

During **decommissioning and closure**, bulk earthworks and demolishing activities are expected. Very little information regarding the decommissioning phase was available for consideration, from an air quality perspective it is, however, likely to be similar in character and impact to the construction phase (Table 4).

Table 4: Activities and aspects identified for the decommissioning and closure phases

Impact	Source	Activity
Generation of $PM_{2.5}$ and PM_{10}	Stockpiles and mine pit	Dust generated during rehabilitation activities
Generation of $PM_{2.5}$ and PM_{10}	Plant and infrastructure	Demolition of the process plant and infrastructure
Gas emissions	Vehicles	Tailpipe emissions from vehicles utilised during the closure phase

Due to the lack of detailed information and the relatively short duration of most of the activities associated with the construction, decommissioning and closure phases, the assessment of impacts for these phases will be done qualitatively.

5.7 Project Scenarios for Determining Air Pollution Impacts

To determine the significance of air pollution impacts from the proposed Project, three scenarios were assessed:

- **Scenario 1** – representative of opencast mining activities (Blocks F and G) and underground mining (Blocks B and C) for Year 2;
- **Scenario 2** – representative of opencast mining activities (Block H) and underground mining (Block D) for Year 3; and
- **Scenario 3** – representative of underground mining activities (Block A) for Year 5.

Scenario 1 was chosen to represent maximum ROM and product throughput from simultaneous mining of opencast resource blocks (located to the northwest of the CHPP) and underground resource blocks (located to the southwest of the CHPP) respectively.

Scenario 2 was chosen to represent maximum waste production (overburden and topsoil) where opencast mining activities are located to the southeast of the CHPP (in near proximity to the closest AQSR) and underground mining activities are located to the northwest of the CHPP, respectively.

Scenario 3 represents impacts due to underground mining activities only, where the underground mining block is located to the southeast of the CHPP (in near proximity to the closest AQSR).

A quantitative assessment of air quality impacts due to the above project scenarios is provided in Section 9.

6 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. air emission standards, ambient air quality standards, and dust control regulations.

Air quality legislation that is relevant to the project is provided in Table 5.

Table 5: Legislation applicable to the project

Air Quality Legislation	Implementation/ revision dates	Reference	Affected Project Activity
National Framework	Second Generation 2013 Third Generation 2018	Government Gazette (GG) 37078, 29 Nov 2013 GG 41996 of 26 Oct 2018	Industry legal responsibilities
Section 21 – Listed Activities	Implemented: 1 April 2010 Revised: 2013 Amendments: 2015 and 2018	GG 37054, 22 Nov 2013 GG 38863, 12 Jun 2015	N.A. – no Listed Activity planned
National Ambient Air Quality Standards (NAAQS)	24 December 2009 29 July 2012	GG 32816, 24 Dec 2009 GG 35463, 29 Jun 2012	SO_2, NO_2, CO, PM_{10} and $PM_{2.5}$ ground level concentrations as a result from the mining activities
National Dust Control Regulations (NDCR)	1 November 2013	GG 37054, 22 Nov 2013	Dust fallout rates as a result from the mining activities
National Atmospheric Emission Reporting Regulations (NAERR)	2 April 2015	GG 3863, 2 Apr 2015	Emissions reporting on mining operations
Regulation on Administrative Fines and Air quality offsets guideline	18 March 2016	GG 39833, 18 Mar 2016	N.A. – no Listed Activity planned
Declaration of Greenhouse Gases (GHG) as Priority Air Pollutants	Draft in 2016	GG 40996, 21 Jul 2017	N.A.[(a)]
National Pollution Prevention Plans (PPP) Regulations	Draft in 2016 Final 2017	GG 40996, 21 Jul 2017	N.A.[(a)]
National Greenhouse Gas (GHG) Emission Reporting Regulations	3 April 2017	GG 40762, 3 Apr 2017	Mining and quarrying to report on all stationary combustion emissions above 10 MW(th)

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

6.1 National Framework

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

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

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

6.2 National Standards

6.2.1 Emission Standards

The NEMAQA (Act No. 39 of 2004 as amended) (DEA, 2005) mandates the Minister of Environment to publish a list of activities which result in atmospheric emissions and consequently cause significant detrimental effects on the environment, human health and social welfare. All scheduled processes as previously stipulated under the Air Pollution Prevention Act (APPA) (Dept of Labour, 1993) are included as listed activities with additional activities added to the list. The updated Listed Activities and Minimum National Emission Standards (MES) were published on the 22nd November 2013 (Government Gazette No. 37054). An amendment to this Act was published in June 2015, and further amendments in October 2018.

According to the Project description, none of the Project activities trigger the MES's nor the need for an Atmospheric Emissions Licence (AEL) application.

6.2.2 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. These include CO, NO_2, SO_2, $PM_{2.5}$ and PM_{10}. The pollutant of concern in this study is particulate matter.

The South African Bureau of Standards (SABS) assisted the DEA (now DEFF) in the development of ambient air quality standards. NAAQS were determined based on international best practice for PM_{10}, $PM_{2.5}$, dustfall, SO_2, NO_2, O_3, CO, lead and benzene.

The final revised NAAQSs were published in the Government Gazette on 24 of December 2009 (DEA, 2009) and in some instances included a margin of tolerance and linked implementation timelines. NAAQSs for $PM_{2.5}$ were published on 29 June 2012 (DEA, 2012). NAAQSs for the criteria pollutants assessed in this study are listed in Table 6. Currently, only $PM_{2.5}$ has a margin of tolerance, which is applicable until 31 December 2029. Short-term standards (daily) are represented by a limit value based on the 99th percentile of the observation (or simulated concentration) for that averaging period.

With the main pollutants of concern being particulates, the NAAQSs applicable to PM_{10} and $PM_{2.5}$ are provided in Table 6.

Table 6: Air quality standards for specific criteria pollutants (NAAQS)

Pollutant	Averaging Period	Limit Value (µg/m³)	Frequency of Exceedance	Compliance Date
PM_{10}	24-hour	75	4	Currently enforceable
	1 year	40	0	Currently enforceable
$PM_{2.5}$	24-hour	40	4	Currently enforceable
		25	4	1 Jan 2030
	1 year	20	0	Currently enforceable
		15	0	1 Jan 2030

6.2.3 National Dust Control Regulations

The NDCR were published on the 1st of November 2013 (DEA, 2013). The purpose of the regulations is to prescribe general measures for the control of dust from areas operations identified by a local Air Quality Officer as potentially causing a nuisance. Acceptable dustfall rates for residential and non-residential areas according to the regulation is summarised in Table 7.

The regulation also specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be American Standard Testing Method (ASTM, 1970)[2], 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.

Table 7: Acceptable dustfall rates

Restriction areas	Dustfall rate (D) in mg/m²-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.

6.2.4 Impact on the Environment (Vegetation and Animals)

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

6.3 National Atmospheric Emission Reporting Regulations (NAERR)

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

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

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

[2] ASTM 1739:70 is a previous version of ASTM 1739 which did not prescribe a wind shield around the opening of the bucket; the addition of a wind shield is intended to deflect wind away from the lip of the container, allowing for a more laminar flow across the top of the collecting container (Kornelius *et al*., 2015). SANS 1929-2004 does, however, refer to ASTM 1739-98 (ASTM, 1998), which has a wind shield. The latest draft of the NDCR stipulates the latest version of D1738. It has not been propagated but is expected early 2020.

With regards to registration, the regulation stipulates that:

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

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

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

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

6.4 Regulations Regarding Air Dispersion Modelling

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

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

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

- The distribution of pollutant concentrations and deposition are required in time and space.

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

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

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

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

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

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

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

6.5 Greenhouse Gas Emissions

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

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

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

The NAEIS web-based monitoring and reporting system will also be used to collect GHG information in a standard format for comparison and analyses. The system forms part of the National Atmospheric Emission Inventory component of South African Atmospheric Emission Licensing & Inventory Portal (SAAELIP) and South African Air Quality Information System (SAAQIS).

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

The Carbon Tax Act was introduced for a further round of public consultation. The Carbon Tax Policy Paper (CTPP) (Department of National Treasury, 2013) stated consideration will be given to sectors where the potential for emissions reduction is limited. The Carbon Tax Act was published in 2019 (GG 42483 of 23 May 2019).

6.6 Highveld Priority Area

The Highveld Airshed was declared the second priority area by the minister at the end of 2007. This required that an Air Quality Management Plan for the area be developed. The plan includes the establishment of an emissions reduction strategies and intervention programmes based on the findings of a baseline characterisation of the area. The implication of this is that all contributing sources in the area will be assessed to determine the emission reduction targets to be achieved over the following few years.

The project area is located within the footprint demarcated as the Highveld Priority Area. Emission reduction strategies will be included for the numerous coal mines in the area with specific targets. The DEA published the management plan for the Highveld Priority Area in September 2011. Included in this management plan are seven goals, each of which has a further list of objectives that must be met. The goals for the Highveld Priority area are as follows:

- Goal 1: By 2015, organisational capacity in government is optimised to efficiently and effectively maintain, monitor and enforce compliance with ambient air quality standards.
- Goal 2: By 2020, industrial emissions are equitably reduced to achieve compliance with NAAQSs and NDCR limit values.
- Goal 3: By 2020, air quality in all low-income settlements is in full compliance with ambient air quality standards.
- Goal 4: By 2020, all vehicles comply with the requirements of the National Vehicle Emission Strategy.
- Goal 5: By 2020, a measurable increase in awareness and knowledge of air quality exists.
- Goal 6: By 2020, biomass burning and agricultural emissions will be 30% less than current.
- Goal 7: By 2020, emissions from waste management are 40% less than current.

Goal 2 applies directly to the Project. The objectives associated with this goal include:

- Emissions are quantified from all sources;
- Gaseous and particulate emissions are reduced;
- Fugitive emissions are minimised;
- Emissions from dust generating activities are reduced;
- Incidences of spontaneous combustion are reduced;
- Abatement technology is appropriate and operational;
- Industrial Air Quality Management (AQM) decision making is robust and well-informed, with necessary information available;
- Clean technologies and processes are implemented;
- Adequate resources are available for AQM in industry;
- Ambient air quality standard and dustfall limit value exceedances as a result of industrial emissions are assessed; and,
- A line of communication exists between industry and communities.

Each of these objectives is further divided into activities, each of which have a timeframe, responsibility and indicator. Refer to the DEA (2011) Highveld Priority Management Plan for further details[3].

[3] This document can be downloaded from the SAAQIS website: www.saaqis.org.za

7 Methodology

The air quality study includes both baseline and predicted impact assessment. The approach to, and methodology followed in the completion of tasks (or scope of work, see Section 4) are discussed below.

7.1 Project Information and Activity Review

All project/process related information referred to in this study was obtained from the Independent Competent Person's (CPR) Report, dated 30 October 2019 (CPR, 2019); the Mining Works Programme (MWP), dated January 2020 (MWP, 2020); and the Air Quality Impact Assessment report by Digby Wells Environmental, dated August 2017 (DWE, 2017).

7.2 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);
- National Dust Control Regulations (SA NDCR) as set out in the National Environmental Management Air Quality Act (Act No. 39 of 2004) (NEMAQA); and
- Site location within Highveld Priority Area

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

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

7.3 Study of the Receiving Environment

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

Meteorological data from the weather and ambient air quality monitoring station in Emalahleni, approximately 9 km away from the mine offices, were used to (a) describe the dispersion potential of the site and (b) as input into the AERMOD modelling suite.

Monitoring data from the DEFF Emalahleni station for the period January to December 2018 was analysed to gain an understanding of the baseline ambient air quality in the region, and dustfall results from the Elandsfontein monitoring network was analysed for October to November 2019.

Readily available terrain data was obtained from the United States Geological Survey (USGS) via the Earth Explorer website (U.S. Department of the Interior, U.S. Geological Survey, 2018) to characterise the topography of the region. Use was made of Shuttle Radar Topography Mission (SRTM) (30 m, 1 arc-sec) data. Land cover data as provided by EIMS was used to create the AERMET file.

7.4 Review of the 2017 AQIA Report

The AQIA Report compiled for Elandsfontein Colliery by DWE in August 2017 was assessed as part of the baseline to determine whether the methodology followed is defendable; and whether the modelled results are regarded representative of the operations. As far as could be ascertained, the study followed the correct methodology for an air quality impact assessment. An underestimation in the emissions from the crushers was noted but not enough information was provided to verify all the calculations. The meteorological data used in the model is acceptable, and the dispersion model used is in line with the regulations. The modelled results, even though very high, could be possible; however the area of exceedance from the modelled results seemed extensive given the emission rates reported. Only unmitigated results were provided for PM_{10} and $PM_{2.5}$, where a mitigated modelling scenario would have assisted in the understanding of the potential impacts from the mine with controls in place. The reduction in the dustfall rates between unmitigated and mitigated indicated a significant improvement due to mitigation measures. The review is included in Appendix E.

7.5 Determining the Impact of the Project on the Receiving Environment

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

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

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

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

7.6 Compliance Assessment

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

7.7 Sensitivity Mapping

Sensitivity mapping was conducted in accordance with the EIMS methodology, which focuses on scoring the proposed project impact on landscape features. The sensitivity map was created based on the expected impact extent on air quality from the mining operations.

7.8 Impact Significance

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

7.9 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.

8 Description of the Receiving Environment

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

- A study of the atmospheric dispersion potential of the area;
- The identification of Air Quality Sensitive Receptors (AQSRs) from available maps;
- The identification of existing sources of emissions in the study area; and
- The analysis of all available ambient air quality information/data.

8.1 Atmospheric Dispersion Potential

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

The South African Weather Services (SAWS) operates, on behalf of DEFF, a weather and ambient air quality monitoring station in Emalahleni, approximately 9 km away from the mine offices (see Figure 19). Data from this station was obtained for the period January 2016 to December 2018 to quantify the atmospheric dispersion potential (http://saaqis.environment.gov.za/). A period of three years is required by the regulations on Air Dispersion Modelling (DEA, 2014). The dataset is regarded as representative of the weather conditions at the project site.

8.1.1 Surface Wind Field

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

The period wind field and diurnal variability in the wind field are shown in Figure 10. Seasonal variations in the wind field are provided in Figure 11. The wind field was predominantly from the north, east and east-southeast, also the directions associated with the strongest winds. The night-time wind rose shows a decrease in the northerly and the north-westerly winds with an increase in the easterly and east-southeasterly winds. The night-time is also characterised by a higher frequency of calm conditions. Summer and autumn show similar wind direction profiles to the period average, while winter shows more frequent winds from the west and spring more from the north.

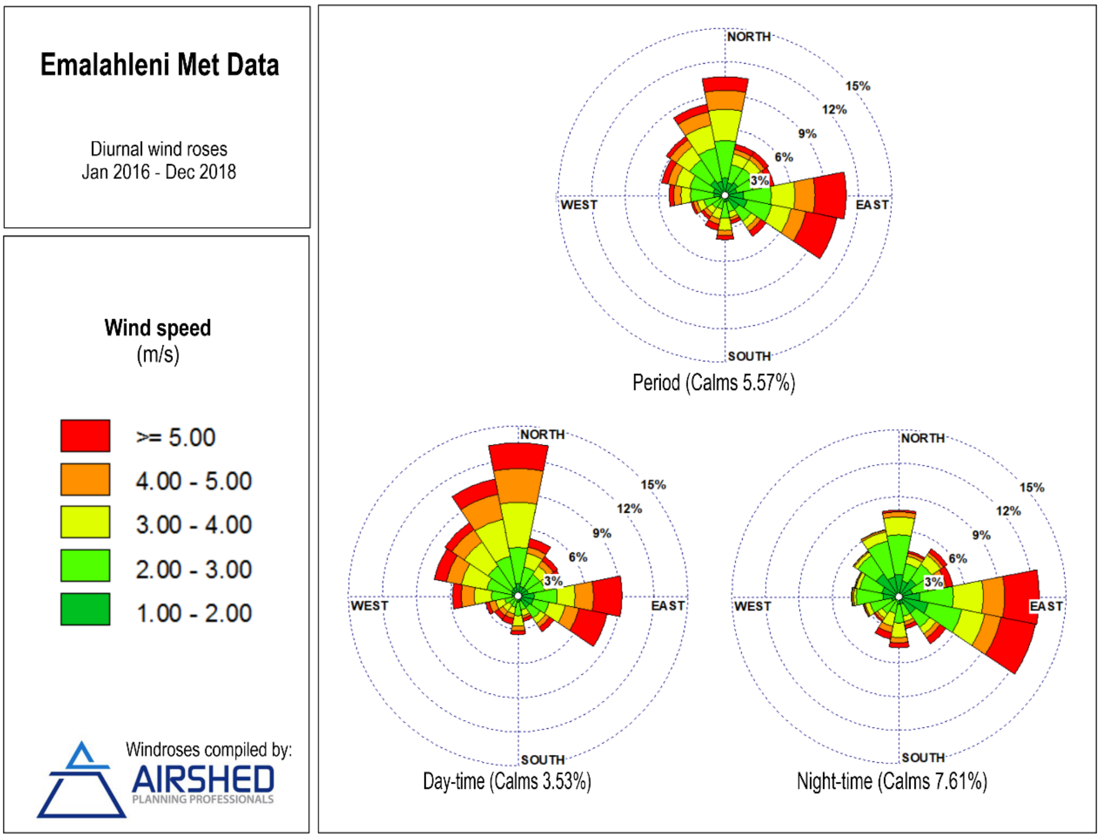


Figure 10: Period, day- and night-time wind roses (DEFF data; 2016 to 2018)

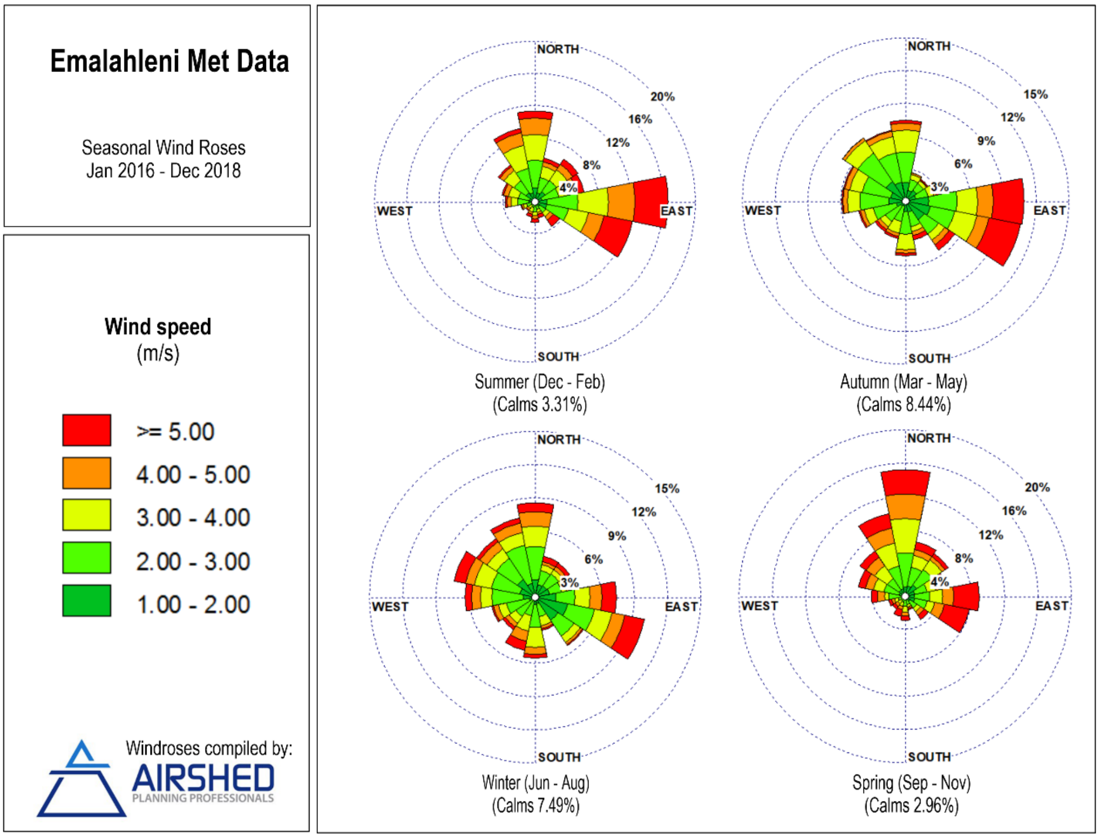


Figure 11: Seasonal wind roses (DEFF data; 2016 to 2018)

According to the Beaufort wind force scale (https://www.metoffice.gov.uk/guide/weather/marine/beaufort-scale), wind speeds between 6-8 m/s equates to a moderate breeze, with wind speeds between 14-17 m/s near gale force winds. Based on the three years of DEFF data, wind speeds exceeding 5 m/s occurred for only 12.6% of the time, with a maximum wind speed of 11.8 m/s. The average wind speed over the three years was 2.95 m/s. Calm conditions (wind speeds < 1 m/s) occurred for 5.6% of the time (Figure 12). The US EPA indicates a friction velocity of 5.4 m/s to initiate erosion from a coal storage piles (US EPA, 2006) and (Mian & Yanful, 2003). Thus, the likelihood exists for wind erosion to occur from open and exposed surfaces, with loose fine material, when the wind speed exceeds at least 5.4 m/s. Wind speeds exceeding 5.4 m/s occurred for 7.9% over the three years (2016 - 2018).

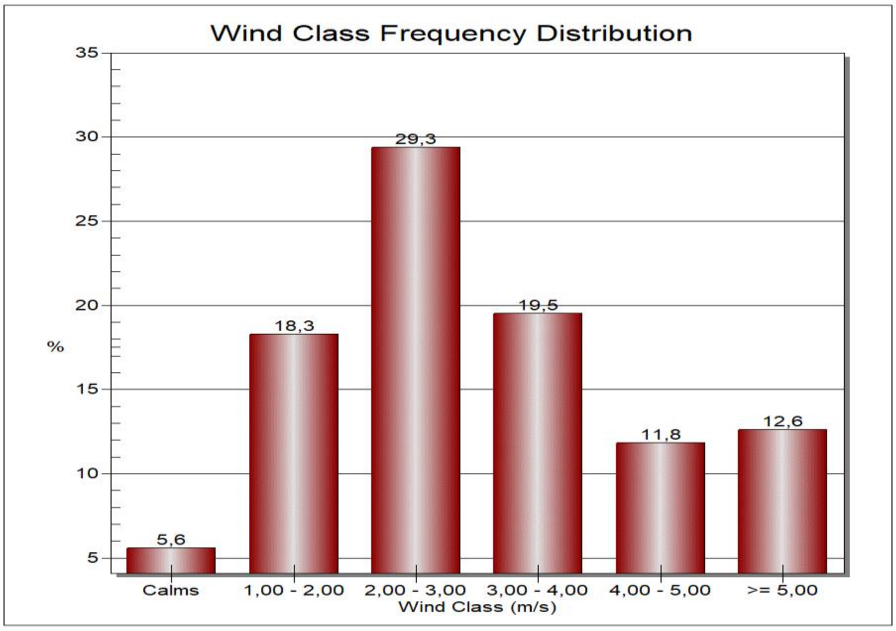


Figure 12: Wind speed categories (DEFF data; 2016 to 2018)

8.1.2 Temperature

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

The diurnal temperature profile for the site is given in Figure 13 and the monthly mean and hourly maximum and minimum temperatures are given in Table 8. Monthly average temperatures ranged between 11.3°C and 20.7°C. The highest temperatures (35.8°C) occurred in January and the lowest (-2.1°C) in June/July. During the day, temperatures increase to reach maximum at around 15:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 07:00 i.e. just before sunrise.

Table 8: Monthly temperature summary (2016 - 2018)

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	9.1	11.5	7.8	5.3	2.4	0.2	-2.1	0.2	0.4	4.1	5	11.1
Maximum	35.8	33.5	31.2	30.1	24.5	23.9	23.3	28	33.1	33.6	3.4	34
Average	20.5	20.4	19.3	17.2	13.6	11.8	11.3	14.2	18.2	18.4	19.2	20.7

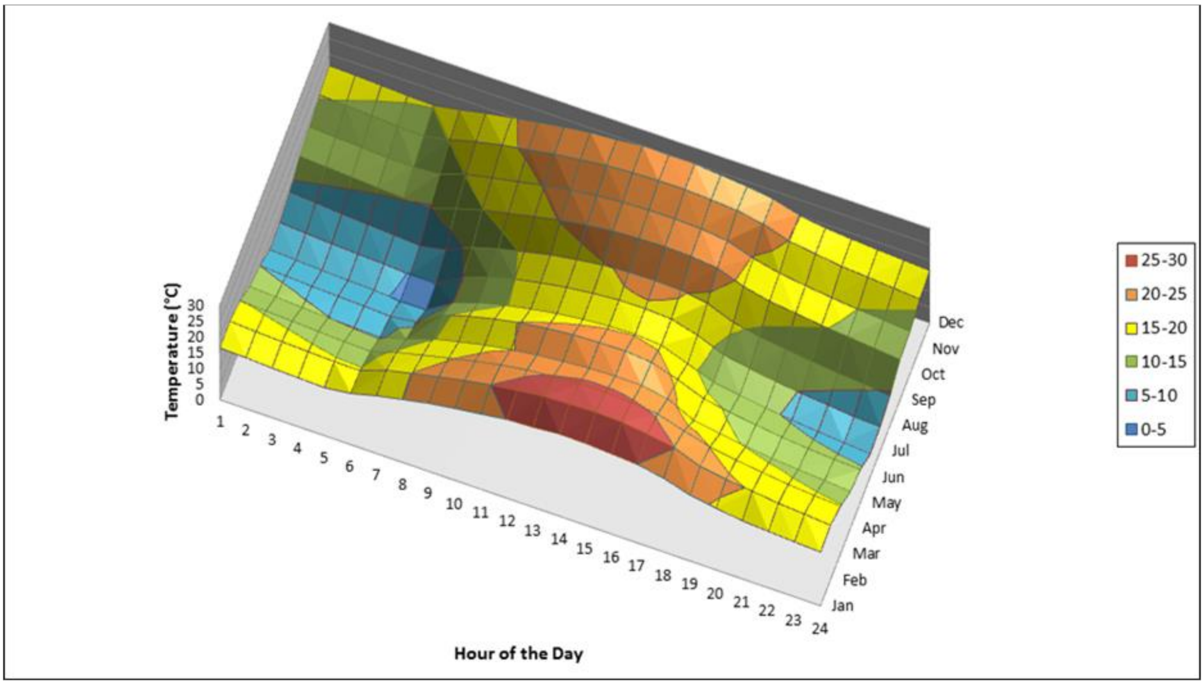


Figure 13: Diurnal temperature profile (DEFF data; 2016 to 2018)

8.1.3 Precipitation

Precipitation is important to air pollution studies since it represents an effective removal mechanism for atmospheric pollutants and inhibits dust generation potentials. Average annual rainfall amounts to 730 mm per annum (November to April) with an average annual evaporation rate of 1500 mm (CPR, 2019).

8.2 Site Location

8.2.1 Topography

The topography within and surrounding the Elandsfontein Mine is shown in Figure 14 and Figure 15 below. Elevations in the immediate vicinity of the Mine range from approximately 1460 to 1595 metres above mean sea level (mamsl) (Figure 14), and from approximately 1410 to 1640 mamsl in the greater study region (Figure 15). The topography of Elandsfontein comprises of flat ground with the highest point 1564 mamsl.

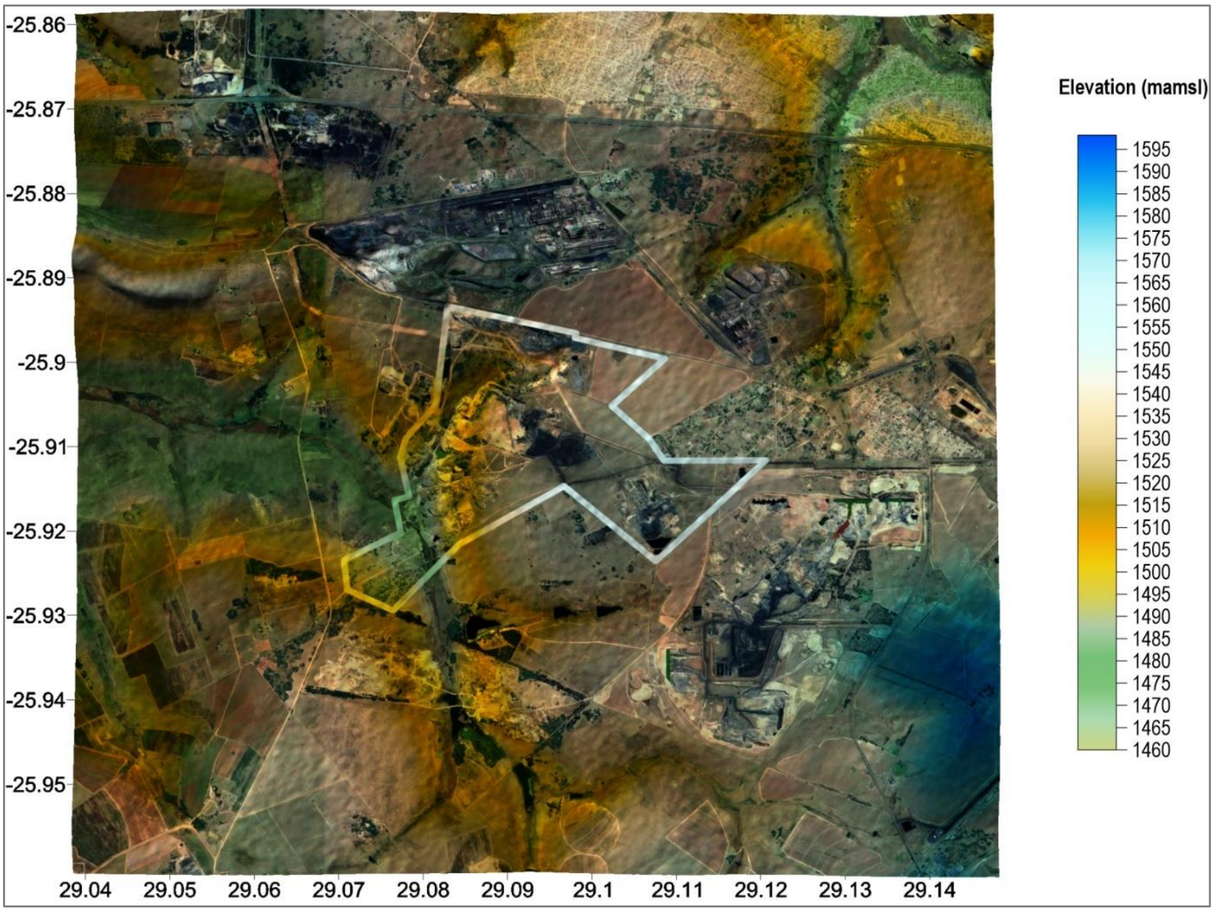


Figure 14: Topography in the near vicinity of Elandsfontein Mine

8.2.2 Sensitive Receptors

AQSRs primarily refer to places where people reside; however, it may also refer to other sensitive environments that may adversely be affected by air pollutants. Ambient air quality guidelines and standards, as discussed under Section 6.2.2, have been developed to protect human health. Ambient air quality, in contrast to occupation exposure, pertains to areas outside of an industrial site/mine boundary where the public has access to and according to the NEMAQA, excludes areas regulated under the Occupational Health and Safety Act (Act No 85 of 1993) (Dept of Labour, 1993).

The main receptors near the mine are Clewer immediately to the east, Kwa-Guqa 4 km to the north-northeast, Ackerville 7 km to the northeast, Phola 9 km to the southwest and Emalahleni 10 km to the east (Table 9 and Figure 15). Sensitive receptors, as shown in Figure 16, include schools, residential areas, clinics and farmsteads.

Table 9: Air quality sensitive receptors

ID	Name	Type	Longitude	Latitude	Distance (km)	Bearing
1	Moruti Makuse Primary School	School	29.1073	-25.8833	1.73	N
2	Kwa-Guqa	Residential	29.1187	-25.8624	4.26	NNE
3	Unjani Clinic	Clinic	29.1419	-25.8683	4.84	NE

ID	Name	Type	Longitude	Latitude	Distance (km)	Bearing
4	Clewer AH	Residential	29.1166	-25.9079	0.40	E
5	Clewer	Residential	29.1346	-25.9063	1.56	E
6	Phola	Residential	29.0373	-26.0040	9.18	SSW
7	Ackerville	Residential	29.1769	-25.8712	7.23	NE
8	eMalahleni	Residential	29.2553	-25.8728	10.36	ENE
9	Wilge	Residential	28.9863	-25.9734	9.94	SW
10	Itireleng Primary School	School	29.1865	-25.8743	7.83	NE
11	St Thomas Aquinas school	School	29.2212	-25.8732	10.98	ENE
12	Laerskool Taalfees	School	29.2264	-25.8821	11.14	ENE
13	Leonard Ntshuntshe Secondary School	School	29.1180	-25.8593	4.58	N
14	Robert Carruthers School	School	29.2272	-25.8796	11.30	ENE
15	Thuthukani Primary School	School	29.0392	-26.0094	9.64	SSW
16	Hlangu Phala Primary School	School	29.0324	-26.0067	9.65	SSW
17	Mabande C.h School	School	29.0373	-26.0040	9.18	SSW
18	Sizanani Early Childhood School	School	29.0333	-26.0058	9.52	SSW
19	Siyathokoza Primary School	School	29.0396	-26.0018	8.86	SSW
20	Sukumani Primary School	School	29.0361	-26.0056	9.38	SSW
21	Mehlwana Secondary School	School	29.0388	-25.9946	8.17	SSW
22	Makause Combined School	School	29.0438	-25.9966	8.15	SSW
23	Gekombineerde Skool Ogies	School	29.0687	-26.0484	13.23	S
24	Bonisana Primary School	School	29.1456	-25.9751	6.90	SE
25	Dunbar Primary School	School	29.1001	-25.8543	4.62	N
26	Phillip Ndimande Secondary School	School	29.1290	-25.8557	5.29	N
27	Zacheus Malaza Secondary School	School	29.1187	-25.8624	4.26	N
28	Besilindile Primary School	School	29.1167	-25.8389	6.68	N
29	Life Cosmos Hospital	Hospital	29.2321	-25.8843	11.62	ENE
30	Witbank Hospital	Hospital	29.2266	-25.8756	11.39	ENE
31	Emalahleni Private Hospital	Hospital	29.2162	-25.8748	10.45	ENE
32	Anglo Coal Highveld Hospital	Hospital	29.1998	-25.9169	8.00	E
33	Impungwe Hospital	Hospital	29.2774	-25.9833	17.65	SE
34	Emalahleni Day Hospital	Hospital	29.2159	-25.8749	10.42	ENE
35	Louis Street Clinic	Clinic	29.2324	-25.8866	11.59	ENE
36	Poly Clinic	Clinic	29.1892	-25.8819	7.66	ENE
37	Hlalanikahle Clinic	Clinic	29.1255	-25.8631	4.40	N
38	Beatty Clinic	Clinic	29.2139	-25.8785	10.08	ENE
39	Empumelelweni CHC Clinic	Clinic	29.1058	-25.8540	4.78	N
40	Green Cross Clinic	Clinic	29.2161	-25.8762	10.38	ENE
41	Life Occupational Health Clinic	Clinic	29.2186	-25.8766	10.60	ENE
42	Top Med Women's Clinic	Clinic	29.2114	-25.8731	10.08	ENE
43	Phola Community Centre Clinic	Clinic	29.0368	-26.0085	9.65	SSW
44	Lynnville Clinic	Clinic	29.1926	-25.8783	8.14	ENE
45	Tomas Mahlangu Ville Clinic	Clinic	29.1784	-25.8705	7.40	NE

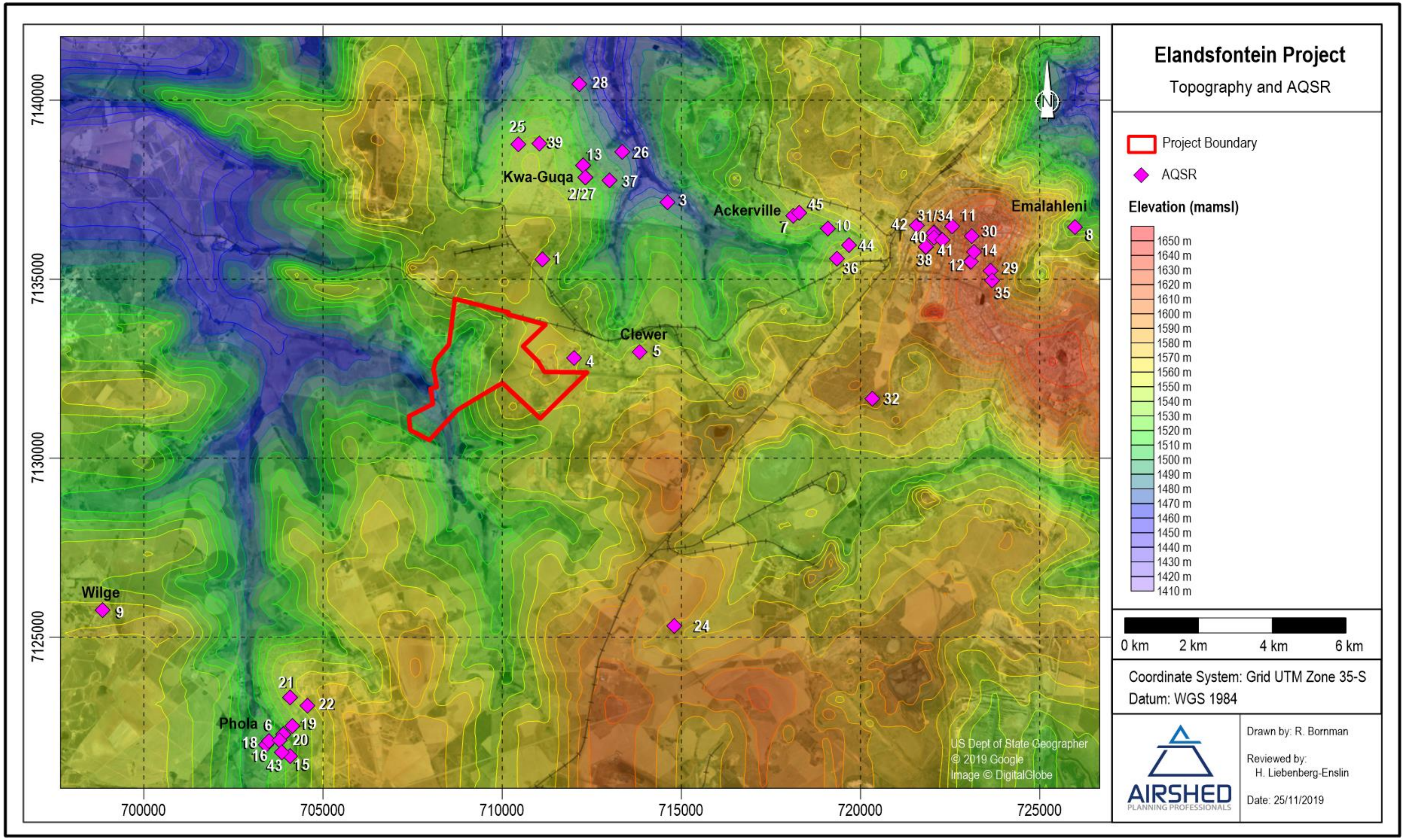


Figure 15: Topography and AQSR within the study region

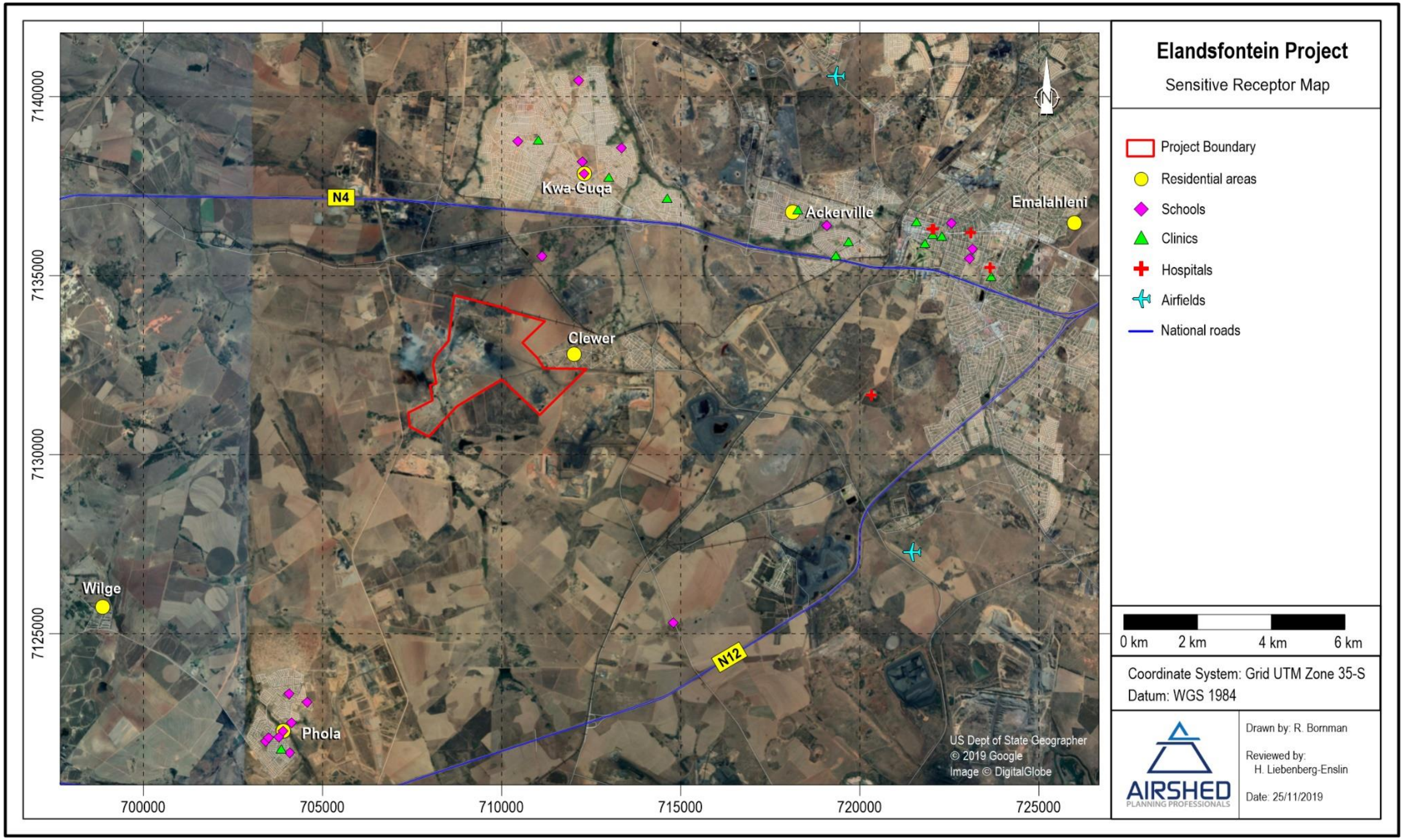


Figure 16: Location of residential areas, schools, clinics and hospitals in the study region

8.3 Existing Sources of Emissions in the Region

The sources of SO_2 and NO_x that occur in the region include industrial emissions, blasting operations at mines, veld burning, vehicle exhaust emissions and household fuel burning.

Various local and far-a-field sources are expected to contribute to the suspended fine particulate concentrations (which would include PM_{10} and $PM_{2.5}$) in the region. Local sources include metallurgical plants, coal fires power stations, wind erosion from exposed areas, fugitive dust from agricultural and mining operations, vehicle entrainment from roadways and veld burning. Long-range transport of particulates, emitted from remote tall stacks and from large-scale biomass burning in countries to the north of South Africa, has been found to contribute significantly to background fine particulate concentrations over the interior (Andreae et al., 1996; Piketh, 1996).

8.3.1 Materials handling

Materials handling operations associated with mining activities in the area include the transfer of material by means of tipping, loading and off-loading of trucks. The quantity of dust that will be generated from such loading and off-loading operations will depend on various climatic parameters, such as wind speed and precipitation, in addition to non-climatic parameters such as the nature (i.e. moisture content) and volume of the material handled.

8.3.2 Industrial Emissions

Industrial sources within the Mpumalanga region include the following:

- Emissions from coal combustion by power generation, metallurgical and petrochemical industries represent the greatest contribution to total emissions from the industrial / institutional / commercial fuel use sector within the Mpumalanga region.
    - The closest power station is Kusile some 13 km to the west with Duvha Power Station approximately 21 km to the east.
- The metallurgical group is estimated to be responsible for at least ~50% of the particulate emissions from this sector. This group includes iron and steel, ferro-chrome, ferro-alloy and stainless-steel manufacturers (includes Highveld Steel & Vanadium, Ferrometals, Columbus Stainless, Transalloys, Middelburg Ferrochrome).
    - Transalloys is located northeast of Elandsfontein Colliery;
    - Highveld Steel is located to the north; and
    - Ferro Metals is located in the western part of Emalahleni some 6 km away.
- Petrochemical and chemical industries are primarily situated in Secunda (viz. Sasol Chemical Industries). The use of coal for power generation and the coal gasification process represent significant sources of sulfur dioxide emissions. (Particulate emissions are controlled through the implementation of stack gas cleaning equipment.)
- Other industrial sources include: brick manufacturers which use coal (e.g. Witbank Brickworks, Quality Bricks, Corobrik, Hoëveld Stene, Middelwit Stene) and woodburning and wood drying by various sawmills (Bruply, Busby, M&N Sawmills) and other heavy industries (use coal and to a lesser extent Heavy Fuel

Oil (HFO) for steam generation). The contribution of fuel combustion (primarily coal) by institutions such as schools and hospitals to total emissions is relatively due to the extent of emissions from other groups.

8.3.3 Household Fuel Burning

Despite the intensive national electrification program, a large number of households continue to burn fuel to meet all or a portion of their energy requirements. The main fuels with air pollution potentials used by households within the study region are coal, wood and paraffin.

Coal burning emits a large amount of gaseous and particulate pollutants including sulfur dioxide, heavy metals, total and respirable particulates including heavy metals and inorganic ash, carbon monoxide, polycyclic aromatic hydrocarbons, and benzo(a)pyrene. Polyaromatic hydrocarbons are recognised as carcinogens. Pollutants arising due to the combustion of wood include respirable particulates, nitrogen dioxide, carbon monoxide, polycyclic aromatic hydrocarbons, particulate benzo(a)pyrene and formaldehyde. The main pollutants emitted from the combustion of paraffin are NO_2, particulates carbon monoxide and polycyclic aromatic hydrocarbons.

8.3.4 Biomass Burning

The biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the project vicinity, crop-residue burning and wildfires (locally known as veld fires) may represent significant sources of combustion-related emissions.

The biomass burning is an incomplete combustion process (Cachier, 1992), with carbon monoxide, methane and nitrogen dioxide gases being emitted. Approximately 40% of the nitrogen in biomass is emitted as nitrogen, 10% is left is the ashes, and it may be assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds (Held et al, 1996). The visibility of the smoke plumes is attributed to the aerosol (particulate matter) content. In addition to the impact of biomass burning within the vicinity of the proposed mining activity, long-range transported emissions from this source can be expected to impact on the air quality between the months August to October. It is impossible to control this source of atmospheric pollution loading; however, it should be noted as part of the background or baseline condition before considering the impacts of other local sources.

8.3.5 Vehicle Exhaust Emissions

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere as a result of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The significant primary pollutants emitted by motor vehicles include carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbon compounds (HC), sulfur dioxide (SO_2), nitrogen oxides (NO_x) and particulate matter (PM). Secondary pollutants include nitrogen dioxide (NO_2), photochemical oxidants (e.g. ozone), hydrocarbon compounds (HC), sulfur acid, sulfates, nitric acid and nitrate aerosols.

8.3.6 Opencast Mining

Opencast mines are associated with significant dust emissions, sources of which include land clearing, blasting and drilling operations, materials handling, vehicle entrainment, crushing, screening (etc.).

There is a number of underground and opencast mines in the vicinity of Elandsfontein Colliery, of which most are coal mines. Greenside Colliery is located 4 km to the east with other coal mines within a 10 km radius including Landau Colliery to the north and Tweefontein- and Klipspruit mines to the south.

8.3.7 Other Fugitive Dust Sources

Fugitive dust emissions may occur as a result of vehicle entrained dust from local paved and unpaved roads, wind erosion from open areas and dust generated by agricultural activities (e.g. tilling) and mining. The extent of particulate emissions from the main roads will depend on the number of vehicles using the roads, and on the silt loading on the roadways.

8.4 Baseline Air Quality

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

8.4.1 Monitored Ambient Concentrations

A summary of ambient data measured at the DEFF Emalahleni station for the period 2018 is provided in Table 10. Time series of the measured ambient air quality data is provided in Appendix C.

Table 10: Summary of the ambient measurements at Emalahleni for the period 2018 (units: µg/m³)

Period	Availability	Hourly Max	Annual Average	No of recorded hourly exceedances
		NO_2		
2018	67%	139	30	-
		SO_2		
2018	84%	562	39	3
Period	**Availability**	**Daily Max**	**Annual Average**	**No of recorded daily exceedances**
		SO_2		
2018	84%	165	39	1
		PM_{10}		
2018	16%	235	83	67
		$PM_{2.5}$		
2018	31%	123	40	57

Note: Exceedances of the NAAQS are provided in red.

The measured ambient concentrations for 2018 indicate:

- The hourly and daily 99th percentiles for SO_2 were below the limit value of 350 µg/m³ and 125 µg/m³ respectively.
- The hourly 99th percentiles for NO_2 were below the limit value (200 µg/m³).
- The daily 99th percentiles for PM_{10} exceeded the limit value (75 µg/m³) and the daily 99th percentiles for $PM_{2.5}$ exceeded the limit value (40 µg/m³).
- The SO_2 and NO_2 annual averages were below the NAAQS, but the PM_{10} and $PM_{2.5}$ annual averages exceeded the limit value of 40 µg/m³ and 20 µg/m³ respectively for 2018 at the Emalahleni (DEFF) station.

This is similar to the trend seen from 2015 to 2017 data (State of Air Reports). It can be concluded that while SO_2 and NO_2 ambient concentrations are within acceptable levels within the Emalahleni area, ambient particulate concentrations are elevated.

Time series plots (mean with 95% confidence interval) of ambient SO_2, NO_2 and PM_{10} concentrations measured at Emalahleni (Figure 17 and Figure 18) show the variation of these pollutants over daily, weekly and annual cycles.

Increased NO_2 concentrations during peak traffic times illustrate the contribution of vehicle emissions to the ambient NO_2 concentrations. The winter (June, July and August) elevation of SO_2 and NO_2 shows the contribution of residential fuel burning to the ambient SO_2 and NO_2 concentrations.

Monthly variation of PM_{10} shows a typical Highveld signature of elevated concentrations during winter months due to the greater contribution from domestic fuel burning, windblown dust from exposed surfaces and the lack of the settling influence of rainfall.

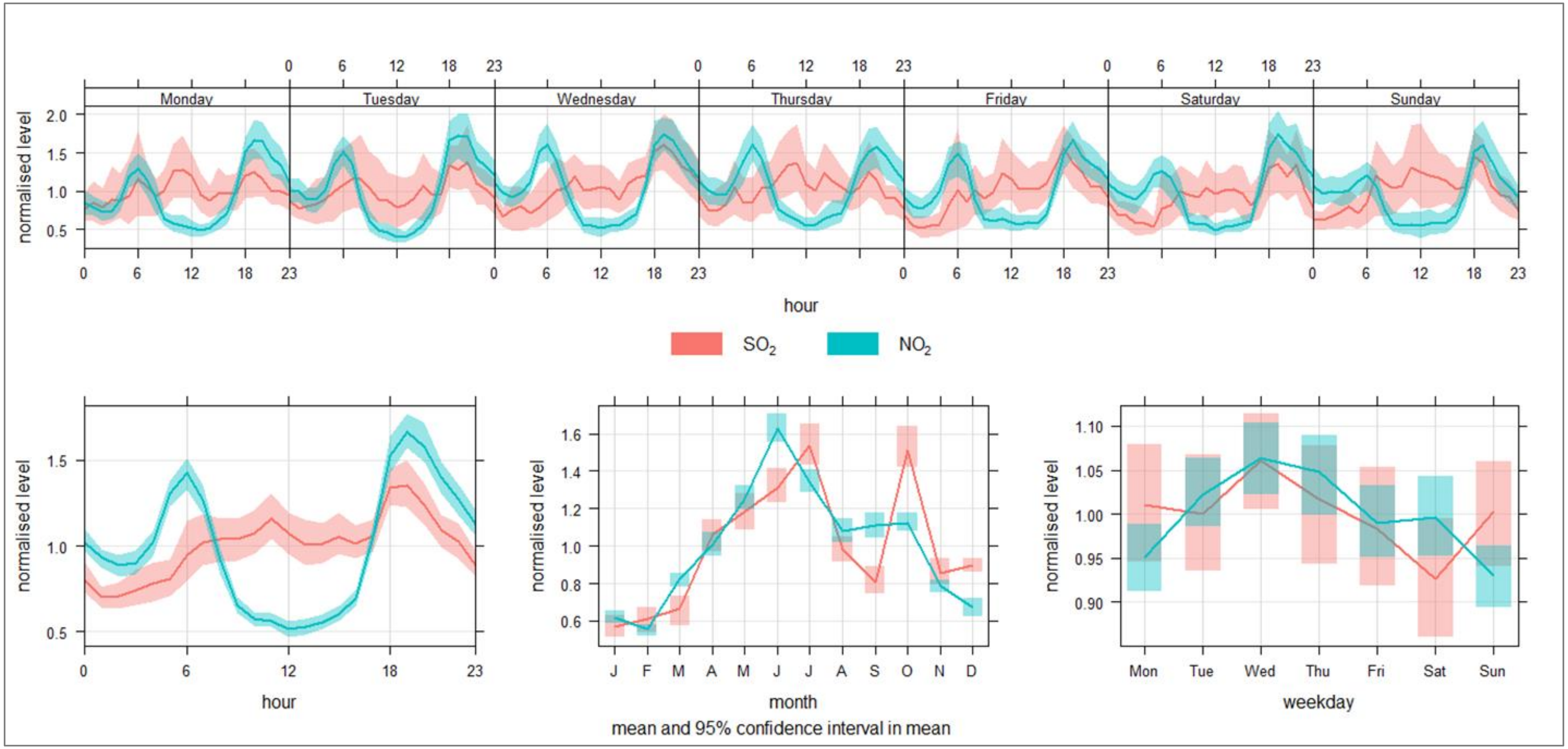


Figure 17: Time series plot of normalised observed SO_2 and NO_2 concentrations at Emalahleni (shaded area indicates 95th percentile confidence interval)

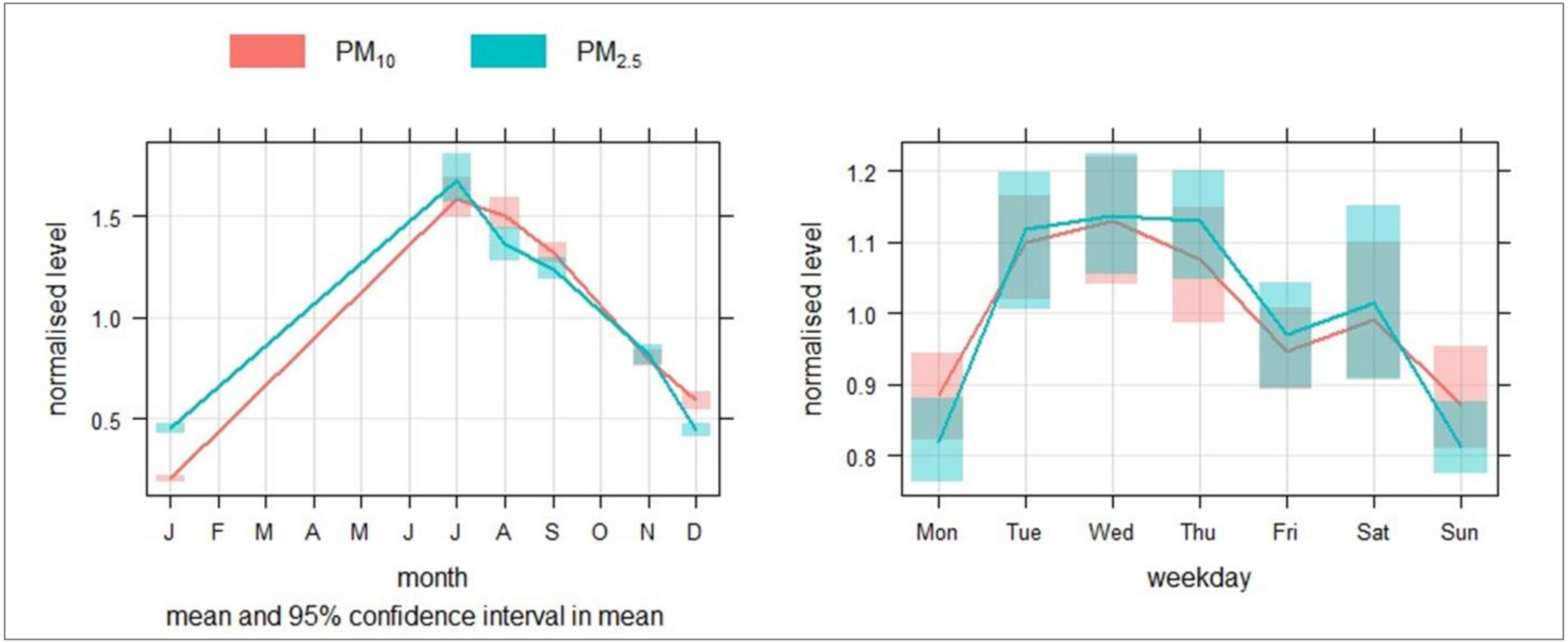


Figure 18: Time series plot of normalised observed PM_{10} and $PM_{2.5}$ concentrations at Emalahleni (shaded area indicates 95th percentile confidence interval)

8.4.2 Monitored Dustfall data

Dust fallout is governed by the NDCR (Section 6.2.3). Elandsfontein Colliery dustfall monitoring network comprises seven (7) single dust fallout units placed strategically around the mine boundary to collect dust fallout from the unpaved haul roads and mining activities (Figure 19). The dustfall sampling campaign is managed by Geo Soil & Water, with the analysis conducted by Yanka Laboratories. The dustfall units were implemented in September 2019, with two months of data available for the periods: October 2019 (2 Sept- 2 Oct'19) and November 2019 (2 Oct- 4 Nov'19).

The dustfall results for the two months are provided in Table 11, also indicating the NDCR limit applicable to each site and a graphical representation is provided in Figure 20. Only EFD East and EFD Clewer are evaluated against the residential limit (600 mg/m³-day), with the other five sites evaluated against the non-residential limit (1,200 mg/m³-day). During October 2019 the exposure period was for 30 days with dustfall rates below the non-residential- and residential limits at all the sites. Dust fallout rates ranged between 159 and 377 mg/m²-day, with the highest rate at EFD North and the lowest at EFD South East. Dust fallout rates were generally higher for November 2019, but all the non-residential sites remained below the limit. For the two residential sites dust fallout at EFD Clewer was 706 mg/m³-day, exceeding the residential limit – the reason for this is not clear since the October field log reported coal dust in the bucket, but the November field log only indicates "clear – water". The field logs are provided in Appendix C.

Table 11: Dustfall rates at Elandsfontein Colliery

Site Name	NDCR	Dustfall rate (mg/m²-day)	
		September 2019	**October 2019**
EFD North	Non-residential	377	1 160
EFD East	Residential	Installed 2 Oct'19	303
EFD Clewer	Residential	291	706
EFD South	Non-residential	194	262
EFD South West	Non-residential	272	302
EFD West	Non-residential	159	308
EFD South East	Non-residential	Installed 4 Nov'19	Installed 4 Nov'19

Exceeds NDC limit for residential areas

Exceeds NDC limit for non-residential areas

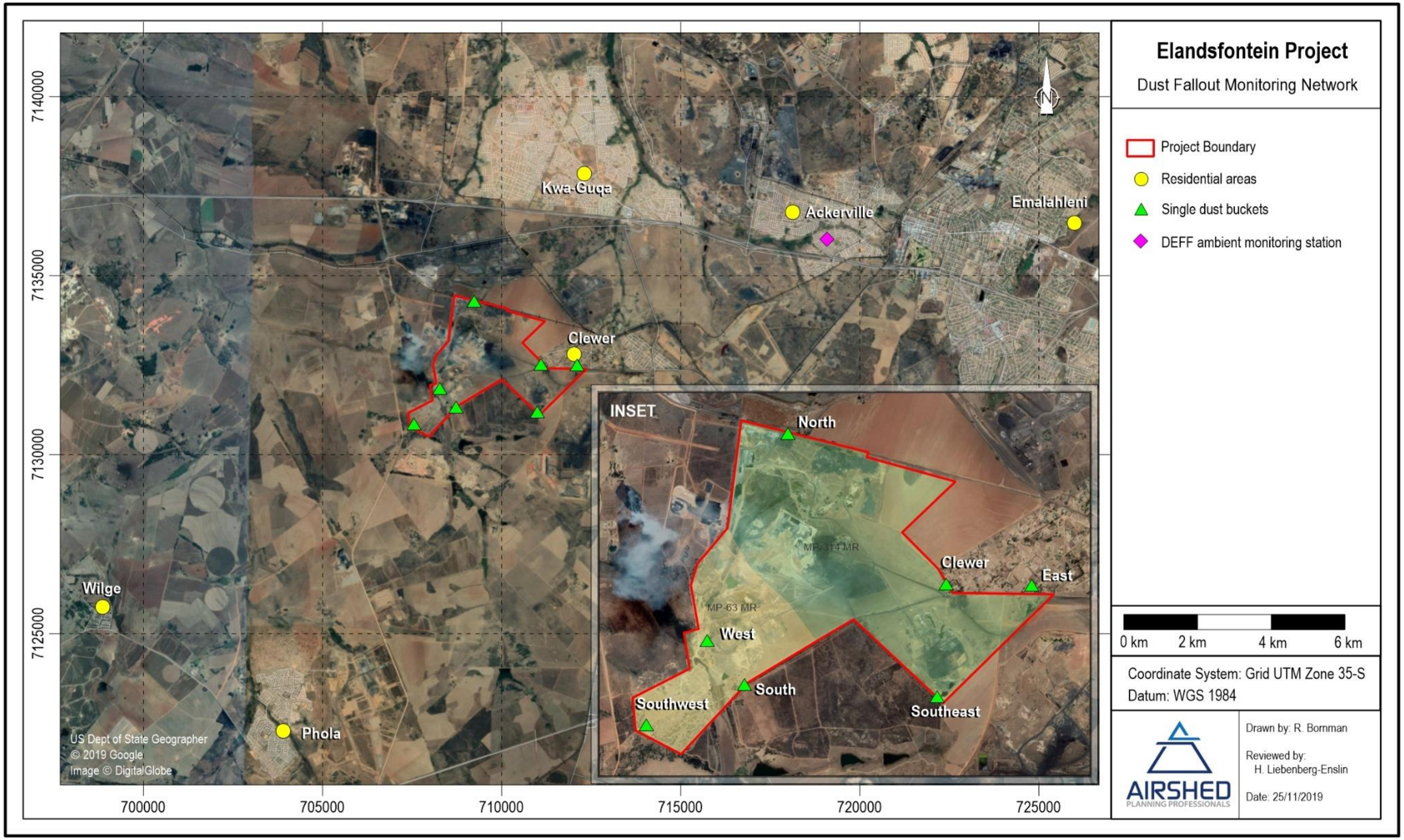


Figure 19: Locality map dust fallout monitoring at Elandsfontein Colliery

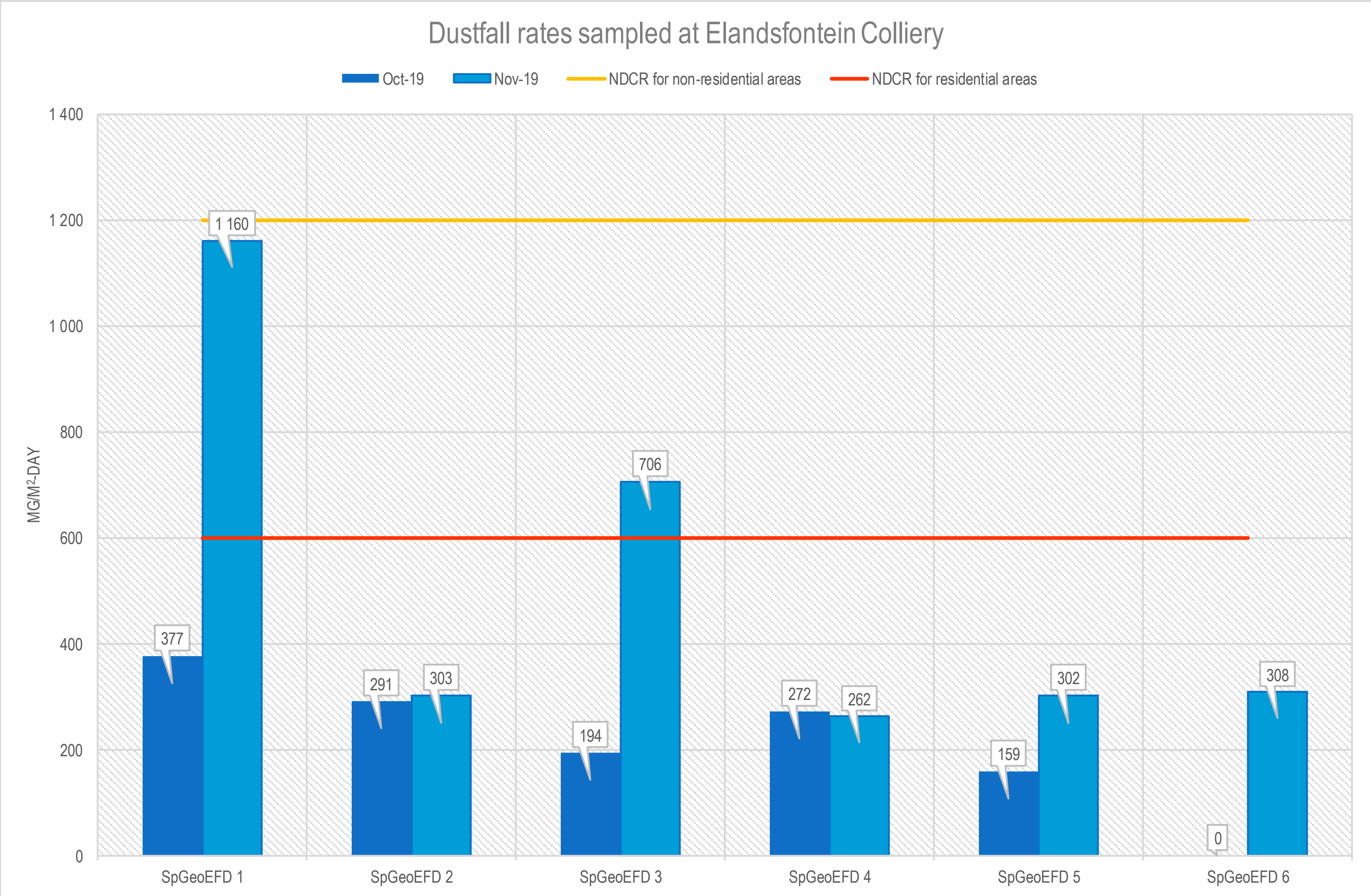


Figure 20: Dustfall results for October and November 2019

8.4.3 Modelled Ambient Air Pollutant Concentrations

The Elandsfontein Colliery is located within the Highveld Priority Area, and also falls within the modelled ambient Witbank "hotspot" area, where exceedances of the 24-hour ambient PM_{10} and SO_2 NAAQS due to industrial sources were indicated (Figure 21 and Figure 22 respectively).

From Figure 21 it appears that the mine is situated in an area where more than 12 exceedances of the 24-hour ambient PM_{10} NAAQS were predicted over a 3-year period (i.e. > 4 days per year). This is in agreement with the measured values reported for Emalahleni in Section 8.4.1.

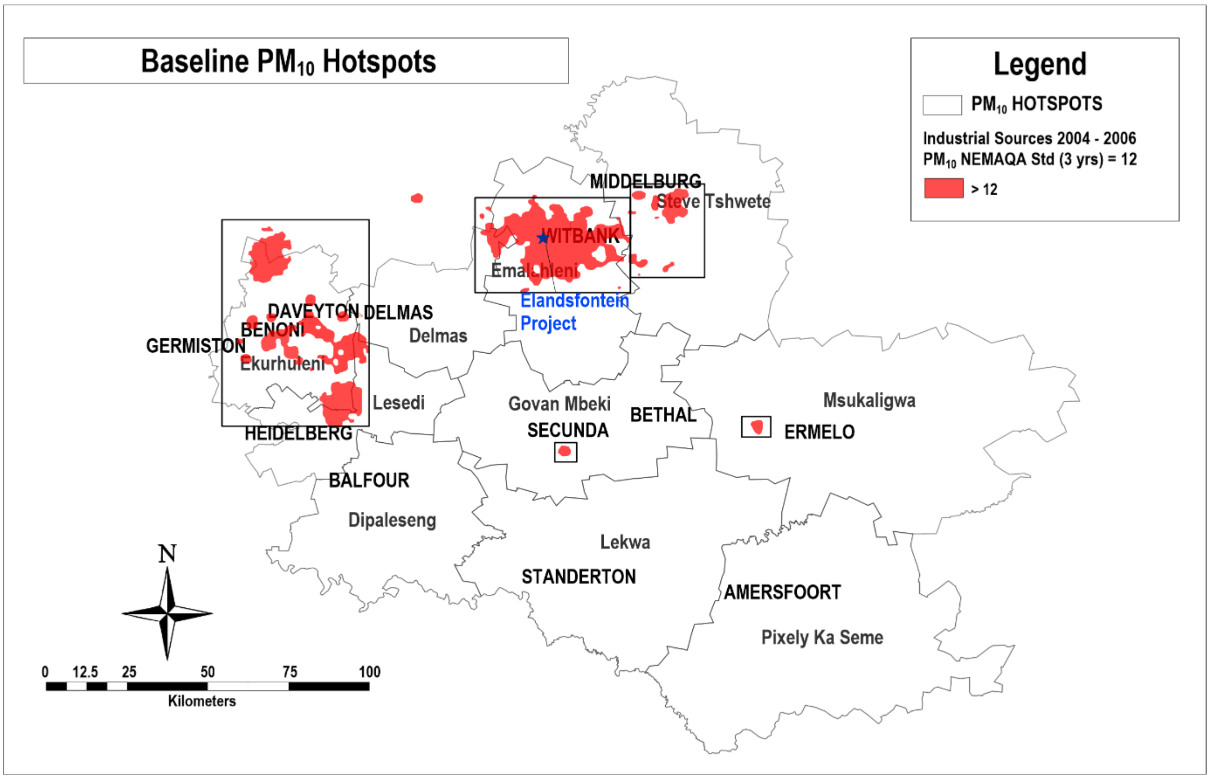


Figure 21: Modelled frequency of exceedance of 24-hour ambient PM_{10} standards in the Highveld Priority Area, indicating the modelled Air Quality Hot Spot areas

From Figure 22 the Project (indicated with a star) falls within the (red) area of non-compliance with the 24-hour ambient SO_2 NAAQS. It should be noted however that the ambient concentrations measured at the Emalahleni site may not be representative of the baseline ambient levels at the sensitive receptor sites included in the current assessment, as local sources of emissions (i.e. domestic fuel burning, local vehicles, etc.) will contribute to the background levels in both areas.

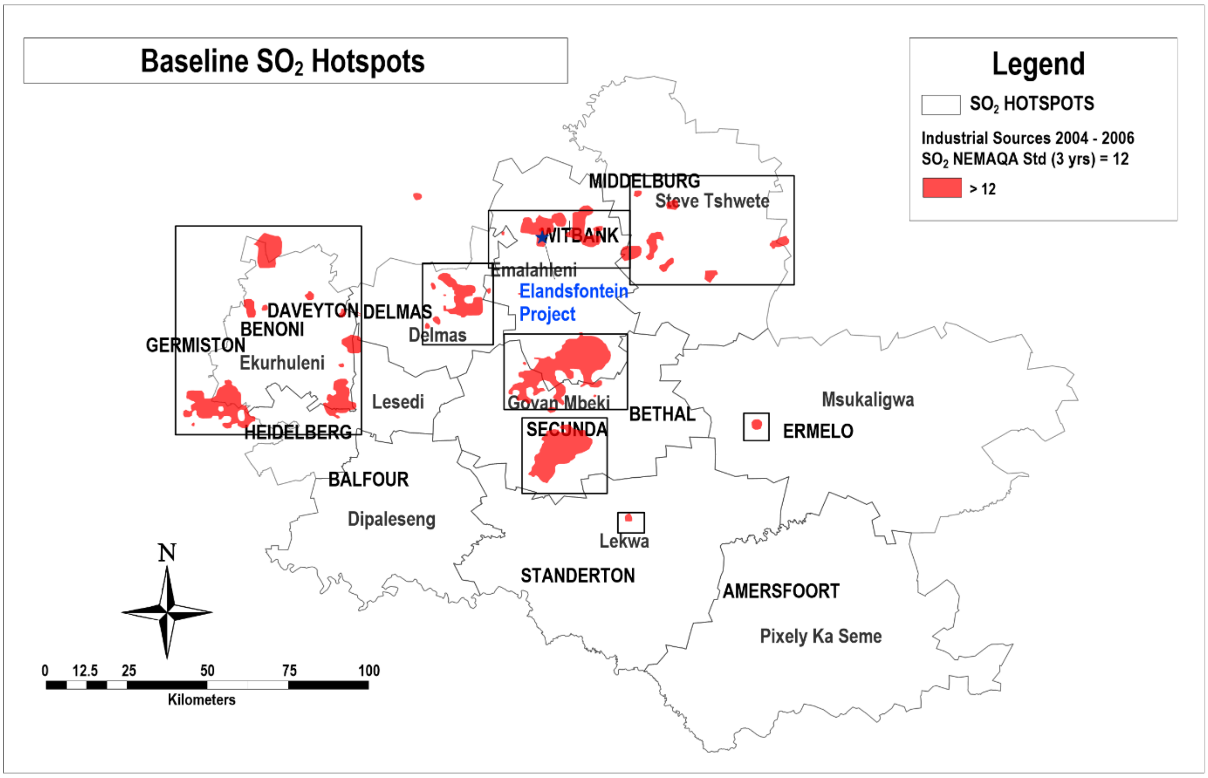


Figure 22: Modelled frequency of exceedance of 24-hour ambient SO_2 standards in the Highveld Priority Area, indicating the modelled Air Quality Hot Spot areas

9 Air Quality Impact Assessment

9.1 Emissions Inventory

Based on the project description (see Section 5.6) the following impacts are to be considered.

9.1.1 Construction phase

Construction normally comprises a series of different operations including land clearing, topsoil removal, road grading, material loading and hauling, stockpiling, grading, bulldozing, compaction, etc. (see Table 2).

Each of these operations has their own duration and potential for dust generation. It is therefore often necessary to estimate area wide construction emissions, without regard to the actual plans of any individual construction process. Emissions were calculated for general infrastructure construction activities during the construction period.

The US-EPA documents emissions factors which aim to provide a general rule-of-thumb as to the magnitude of emissions which may be anticipated from construction operations. The quantity of dust emissions is assumed to be proportional to the area of land being worked and the level of construction activity. The approximate emission factors for general construction activity operations are given as:

E = 2.69 Mg/hectare/month of activity (269 g/m^2/month)

The PM_{10} fraction is given as ~39% of the US-EPA total suspended particulate factor. These emission factors are most applicable to construction operations with (i) medium activity levels, (ii) moderate silt contents, and (iii) semiarid climates. The emission factor for TSP considers 42 hours of work per week of construction activity. Test data were not sufficient to derive the specific dependence of dust emissions on correction parameters. Because the above emission factor is referenced to TSP, use of this factor to estimate particulate matter (PM) no greater than 10 µm in aerodynamic diameter (PM_{10}) emissions will result in conservatively high estimates. Also, because derivation of the factor assumes that construction activity occurs 30 days per month, the above estimate is somewhat conservatively high for TSP as well.

The construction period was given as 12 months. The proposed infrastructure includes the decline shaft and boxcut; areas requiring ground cover clearing are the new opencast blocks F, G and H, as well as the topsoil stockpile and overburden stockpiles for Blocks F, G and H. The total land area extends over 64.88 hectares, and the resultant emissions were estimated as 175 tpa for TSP, 68 tpa for PM_{10} and 34 tpa for $PM_{2.5}$.

9.1.2 Operational phase

Opencast mining activities would have significantly higher air quality impacts than underground operations. This is primarily due to excavation, material handling and vehicle entrainment on roads (haulage of ROM coal, waste and topsoil). The main pollutant of concern is particulate matter, specifically PM_{10} and $PM_{2.5}$ due to the potential for health impacts. Dustfall is likely to be high close to the active mining areas. The AQSR most likely to be affected by the opencast operations are the residents of Clewer to the east of the mine and to the northeast of the planned open pit. Various controls could be applied to opencast mining, with control efficiencies (CE) ranging from 50% due to water suppression to 99% control by using fabric filters on drills (NPI, 2012).

Underground mining activities would mainly result in gaseous and particulate emissions from the ventilation shaft and the tipping of ROM from the conveyor onto the ROM stockpile. Vehicle entrained dust from road surfaces, windblown dust from trucks and gaseous emissions from truck exhaust (PM, SO_2; NOx; CO; CO_2) are most likely to impact the AQSR near the haul roads. Controls on the haul roads could range between watering (50% CE) to 100% for sealed or salt-crusted roads (NPI, 2012).

The CHPP is an existing plant but the production would increase from the current 500 000 tpa to 1,365,000 tpa (based on 300 tph, 6500 hrs/yr and 70% efficiency). This would result in increased emissions especially from the crushing and screening circuit.

To determine the significance of air pollution impacts from the Project, emissions were quantified for three modelling scenarios, with throughputs for each scenario specified in Table 1:

- **Scenario 1** – representative of opencast mining activities (Blocks F and G) and underground mining (Blocks B and C) for Year 2;
- **Scenario 2** – representative of opencast mining activities (Block H) and underground mining (Block D) for Year 3; and
- **Scenario 3** – representative of underground mining activities (Block A) for Year 5.

Scenario 1 was chosen to represent maximum ROM and product throughput from simultaneous mining of opencast resource blocks (located to the northwest of the CHPP) and underground resource blocks (located to the southwest of the CHPP) respectively.

Scenario 2 was chosen to represent maximum waste production (overburden and topsoil) where opencast mining activities are located to the southeast of the CHPP (in near proximity to the closest AQSR) and underground mining activities are located to the northwest of the CHPP, respectively.

Scenario 3 represents impacts due to underground mining activities only, where the underground mining block is located to the southeast of the CHPP (in near proximity to the closest AQSR).

The emission equations used to quantify emissions from the proposed activities are shown in Table 12. For each scenario, both unmitigated and mitigated[4] activities were assessed. The estimated emissions due to unmitigated and mitigated Project operations are provided in Table 15 and Table 16 respectively.

[4] Design mitigated activities include: 75% CE on unpaved haul roads; 50% CE on materials handling; 50% CE on crushing and screening

Table 12: Emission equations used to quantify fugitive dust emissions from the Project

Activity	Emission Equation		Source	Information assumed/provided
Materials handling	$$E = 0.0016\frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$$ Where, E = Emission factor (kg dust / t transferred) U = Mean wind speed (m/s) M = Material moisture content (%) The $PM_{2.5}$, PM_{10} and TSP fraction of the emission factor is 5.3%, 35% and 74% respectively. An average wind speed of 2.95 m/s was used based on data for the period 2016 – 2018.		US-EPA AP42 Section 13.2.4	The moisture content of materials are as follows: *Overburden*: 7.9% (US EPA default mean moisture content, Table 11.9-3) *ROM coal*: 2% (Assumed – low moisture ore) *Topsoil*: 3.4% (US EPA default mean moisture content, Table 11.9-3) Hours of operation were given as 24 hrs per day, 7 days per week
Vehicle entrainment on unpaved surfaces	$$E = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b} \cdot 281.9$$ Where, E = particulate emission factor in grams per vehicle km travelled (g/VKT) k = basic emission factor for particle size range and units of interest s = road surface silt content (%) W = average weight (tonnes) of the vehicles travelling the road = 80 t The particle size multiplier (k) is given as 0.15 for $PM_{2.5}$ and 1.5 for PM_{10}, and as 4.9 for TSP The empirical constant (a) is given as 0.9 for $PM_{2.5}$ and PM_{10}, and 4.9 for TSP The empirical constant (b) is given as 0.45 for $PM_{2.5}$, PM_{10} and TSP		US-EPA AP42 Section 13.2.2	In the absence of site-specific silt data, use was made of US EPA default mean silt content of 8.4%. Operational transport activities onsite include in-pit haul roads, hauling of ROM coal to the ROM stockpile, product to the product stockpiles and discard to the discard stockpile. Hours of operation were given as 24 hrs per day, 7 days per week The capacity of the haul trucks to be used was assumed to be 64 t (from the previous air quality study). The layout of the roads was provided. The width of the roads was given as 6 m.
Bulldozing	$$E = k \cdot (s)^{a}/(M)^{b}$$ Where,		NPI Section: Mining	The particle size multiplier (k) is given as 2.6 for TSP, and 0.34 for PM_{10}

Activity	Emission Equation		Source	Information assumed/provided
	E = Emission factor (kg dust / hr / vehicle) s = Material silt content (%) M = Material moisture content (%)			The empirical constant (a) is given as 1.2 for TSP, and 1.5 for PM_{10} The empirical constant (b) is given as 1.3 for TSP, and 1.4 for PM_{10} Fraction of $PM_{2.5}$ assumed to be 10% of PM_{10}
Wind Erosion	$$E(i) = G(i)10^{(0.134(\%clay)-6)}$$ For $$G(i) = 0.261\left[\frac{P_a}{g}\right]u^{*3}(1+R)(1-R^2)$$ And $$R = \frac{u_*^{\ t}}{u^*}$$ where, $E_{(i)}$ = emission rate (g/m²/s) for particle size class i P_a = air density (g/cm³) G = gravitational acceleration (cm/s³) u_*^t = threshold friction velocity (m/s) for particle size i u^* = friction velocity (m/s)		Marticorena & Bergametti, 1995	Wind erosion was modelled for the ROM, overburden, topsoil and discard stockpiles. The particle size distribution for the various materials was obtained from similar processes (see Table 13). The moisture contents of ROM ore, overburden and topsoil were assumed as 0.1%, 0.1% (hard overburden), 1% (soft overburden), and 1% respectively. The particle densities of ROM ore, soft overburden, hard overburden and topsoil were assumed as 1.6 t/m³, 2.2 t/m³, 3.8 t/m³ and 1.8 t/m³. Layout of ROM, overburden and topsoil stockpiles was provided (updated layout provided in November 2020 and emissions adjusted to reflect increase in stockpile areas). Hourly emission rate file was calculated and simulated.

Table 13: Particle size distribution of ROM, product, discard, overburden and topsoil material (given as a fraction) (from similar processes)

Product/ Discard		ROM/ Overburden		Topsoil	
Size µm	Mass Fraction	Size µm	Mass Fraction	Size µm	Mass Fraction
1000	0	2000	0.158	2000	0.056
425	0.914	1000	0.211	1000	0.067
75	0.055	425	0.447	425	0.389
40	0	75	0.079	75	0.189
30	0	40	0.026	40	0.033
10	0	30	0.053	30	0.067
4	0.031	10	0.026	10	0.067
2	0	4	0	4	0.044
		2	0	2	0.089

The estimated control factors for the various mining operations are given in Table 14 below.

Table 14: Estimated control factors for various mining operations (NPi, 2012)

Operation/Activity	Control method and emission reduction
Windblown dust from stockpiles	No control
Unpaved haul roads	75% CE for water sprays
Materials handling (loading and unloading)	50% CE for water sprays
Crushing and screening	50% CE for water sprays

Note: CE is Control Efficiency

Table 15: Calculated emission rates due to unmitigated operations at Elandsfontein Colliery (in tpa)

	Scenario 1			Scenario 2			Scenario 3		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Opencast	24.15	89.63	264.51	11.21	109.66	198.98	–	–	–
Materials handling	1.28	8.48	17.92	1.34	8.85	18.71	0.73	4.85	10.25
Crushing and screening	49.24	98.48	1 425.40	46.34	92.68	1 354.40	31.02	62.04	951.20
Vehicle entrainment	12.45	124.52	436.84	32.52	325.23	1 140.98	6.36	63.62	223.19
Wind erosion	71.07	125.82	157.43	74.20	131.18	165.91	74.20	131.18	165.91
Total	**158**	**447**	**2 302**	**166**	**668**	**2 879**	**112**	**262**	**1 351**

Table 16: Calculated emission rates due to mitigated operations at Elandsfontein Colliery (in tpa)

	Scenario 1			Scenario 2			Scenario 3		
	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP	$PM_{2.5}$	PM_{10}	TSP
Opencast	21.02	58.77	208.66	2.98	28.60	51.07	–	–	–
Materials handling	0.64	4.24	8.96	0.67	4.43	9.36	0.37	2.43	5.13
Crushing and screening	24.62	49.24	712.70	23.17	46.34	677.20	15.51	31.02	475.60
Vehicle entrainment	3.11	31.13	109.21	8.13	81.31	285.25	1.59	15.91	55.80
Wind erosion	71.07	125.82	157.43	74.20	131.18	165.91	74.20	131.18	165.91
Total	**120**	**269**	**1 197**	**109**	**292**	**1 189**	**92**	**181**	**702**

9.1.3 Closure and Decommissioning Phase

It is assumed that all the operations will have ceased by the closure phase of the project. The potential for impacts during this phase will depend on the extent of rehabilitation efforts during closure. Aspects and activities associated with the closure phase of the proposed operations are listed in Table 4. Simulations of the closure phase were not included in the current study due to its temporary impacting nature.

9.2 Atmospheric Dispersion Modelling

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

- The criteria against which impacts are assessed (Section 6);
- The potential of the atmosphere to disperse and dilute pollutants emitted by the project (Section 8.1);
- The AQSRs in the vicinity of the proposed mine (Section 8.2.2); and
- The methodology followed in determining ambient pollutant concentrations and dustfall rates (Section 7.4).

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

9.2.1 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, terrain data, information on the nature of the receptor grid and pre-development or background pollutant concentrations or dustfall rates. The EPA_09292 executable was used in Version 7.2.5 of AERMOD for this study.

9.2.2 Meteorological Requirements

For the current study, use was made of meteorological data from the DEFF Emalahleni station for the period 2016-2018 (Section 8.1).

9.2.3 Source Data Requirements

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

- Opencast areas – modelled as inpit sources
- Materials handling – modelled as volume sources;
- Crushing and screening – modelled as volume sources;
- Unpaved roads – modelled as area sources; and
- Windblown dust from overburden, topsoil, discard and coal stockpiles – modelled as area sources.

9.2.4 Modelling Domain

The dispersion of pollutants expected to arise from proposed activities was modelled for an area covering 10 km (east-west) by 10 km (north-south). The area was divided into a grid matrix with a resolution of 100 m by 100 m, with the project located centrally. AERMOD calculates ground-level (1.5 m above ground level) concentrations and dustfall rates at each grid and discrete receptor points (AQSRs). All AQSRs shown in Figure 15 were included in the model.

9.3 Dispersion Modelling Results

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

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

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

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

9.3.1 PM_{10}

Scenario 1

The simulated exceedances of highest daily and annual average PM_{10} NAAQS for unmitigated and mitigated operations are provided in Figure 23 to Figure 24 respectively, with the GLCs at the nearest AQSRs provided in Table 17. The GLCs at all AQSRs indicated in Figure 15 are shown in Table 40 (Appendix F)

The main findings are:

- ***PM_{10}*** daily GLCs, for both unmitigated and mitigated activities, are not likely to exceed the NAAQS at any of the AQSRs (Figure 23). Over an annual average the GLCs are within the standard at all receptors (Figure 24). From Table 17 exceedance of the daily (but not the annual) PM_{10} NAAQS is only expected at the mining boundary.

Table 17: Simulated PM_{10} ground level concentrations (in µg/m³) at selected AQSRs – Scenario 1

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	18.55	1.15	No	0	7.92	0.46	No	0
2	Kwa-Guqa	9.14	0.43	No	0	3.93	0.18	No	0
3	Unjani Clinic	7.56	0.38	No	0	3.01	0.15	No	0
4	Clewer AH	24.44	2.12	No	0	9.50	0.79	No	0
5	Clewer	16.91	0.96	No	0	6.05	1.67	No	0
	Mine Boundary (max)	288.2	29.0	Yes	18	286.4	12.13	Yes	8

Scenario 2

The simulated exceedances of highest daily and annual average PM_{10} NAAQS for unmitigated and mitigated operations are provided in Figure 25 to Figure 26 respectively, with the GLCs at the nearest AQSRs provided in Table 18. The GLCs at all AQSRs indicated in Figure 15 are shown in Table 41 (Appendix F)

The main findings are:

- ***PM_{10}*** daily GLCs, with no mitigation in place, are likely to exceed the PM_{10} NAAQS limit value at one (1) AQSR (Figure 25). For mitigated activities PM_{10} daily GLCs are within the PM_{10} NAAQS at all AQSRs (Figure 25 and Table 18). Over an annual average the GLCs are within the standard at all receptors

(Figure 26). From Table 18 exceedance of the daily and annual PM_{10} NAAQS is only expected at the mining boundary. The number of exceedances is greatly reduced for mitigated activities.

Table 18: Simulated PM_{10} ground level concentrations (in µg/m³) at selected AQSRs – Scenario 2

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	31.47	2.34	No	0	8.27	0.71	No	0
2	Kwa-Guqa	14.90	0.87	No	0	4.37	0.27	No	0
3	Unjani Clinic	12.95	0.59	No	0	3.55	0.18	No	0
4	Clewer AH	78.28	5.58	No	2	21.45	1.59	No	0
5	Clewer	33.00	2.31	No	0	8.59	0.67	No	0
	Mine Boundary (max)	1485.3	179.5	Yes	204	373.3	46.56	Yes	60

Scenario 3

The simulated exceedances of highest daily and annual average PM_{10} NAAQS for unmitigated and mitigated operations are provided in Figure 27 to Figure 28 respectively, with the GLCs at the nearest AQSRs provided in Table 19. The GLCs at all AQSRs indicated in Figure 15 are shown in Table 42 (Appendix F)

The main findings are:

- ***PM_{10}*** daily GLCs, for both unmitigated and mitigated activities, are not likely to exceed the NAAQS at any of the AQSRs (Figure 27). Over an annual average the GLCs are within the standard at all receptors (Figure 28). From Table 19 exceedance of the daily and annual PM_{10} NAAQS is only expected at the mining boundary. With mitigation in place, only the daily PM_{10} NAAQS is exceeded at the mining boundary (Table 19).

Table 19: Simulated PM_{10} ground level concentrations (in µg/m³) at all identified AQSRs – Scenario 3

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	8.70	0.57	No	0	4.89	0.23	No	0
2	Kwa-Guqa	4.16	0.21	No	0	3.43	0.09	No	0
3	Unjani Clinic	3.20	0.16	No	0	1.33	0.06	No	0
4	Clewer AH	14.43	1.34	No	0	5.02	0.47	No	0
5	Clewer	9.00	0.55	No	0	3.69	0.20	No	0
	Mine Boundary (max)	286.4	42.9	Yes	55	286.4	11.6	Yes	8

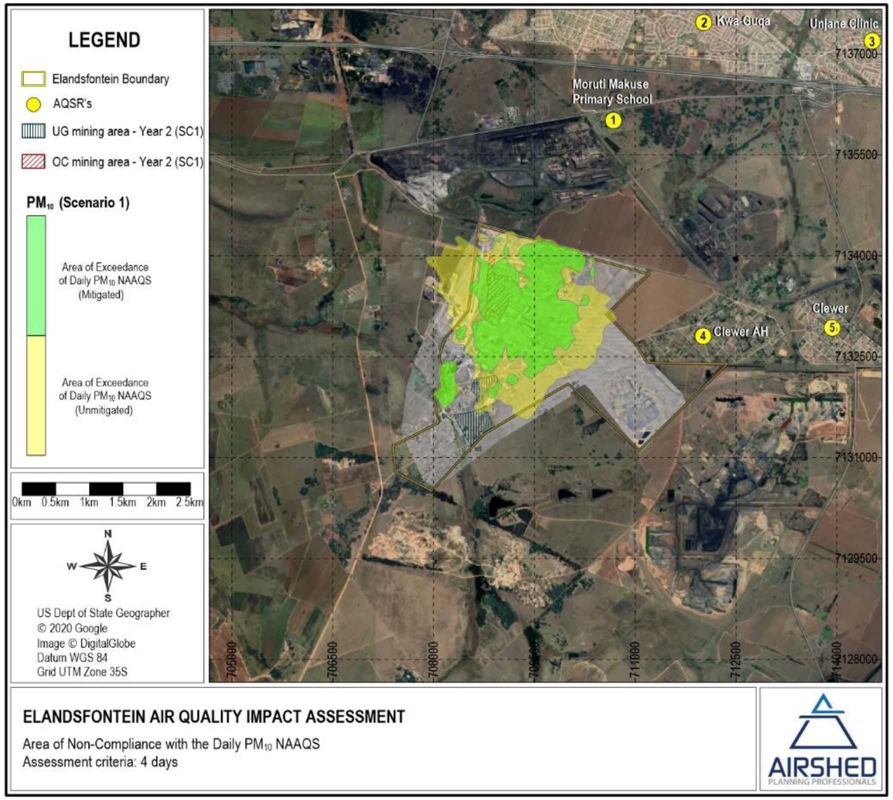


Figure 23: Scenario 1 – Area of non-compliance of daily PM_{10} NAAQS for unmitigated and mitigated YEAR 2 operations

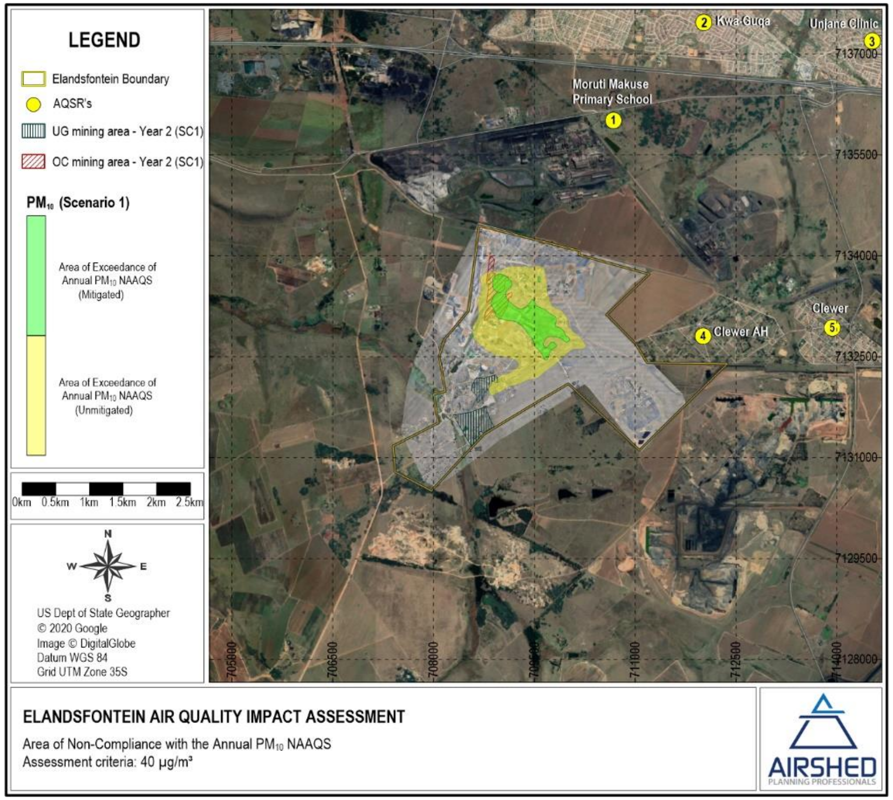


Figure 24: Scenario 1 – Area of non-compliance of annual PM_{10} NAAQS for unmitigated and mitigated YEAR 2 operations

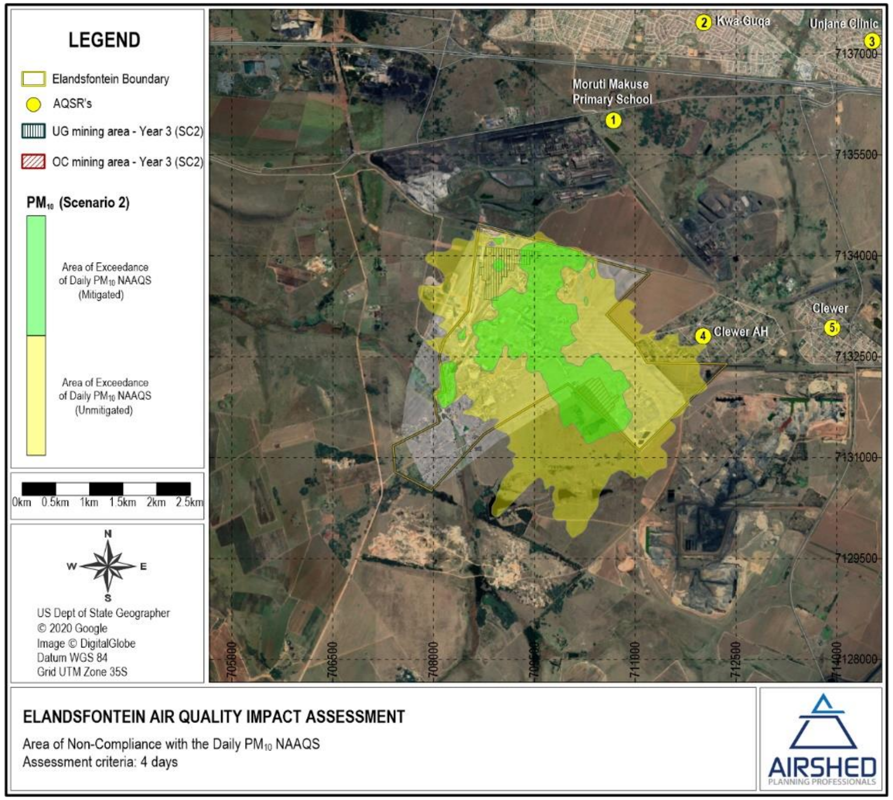


Figure 25: Scenario 2 – Area of non-compliance of daily PM_{10} NAAQS for unmitigated and mitigated YEAR 3 operations

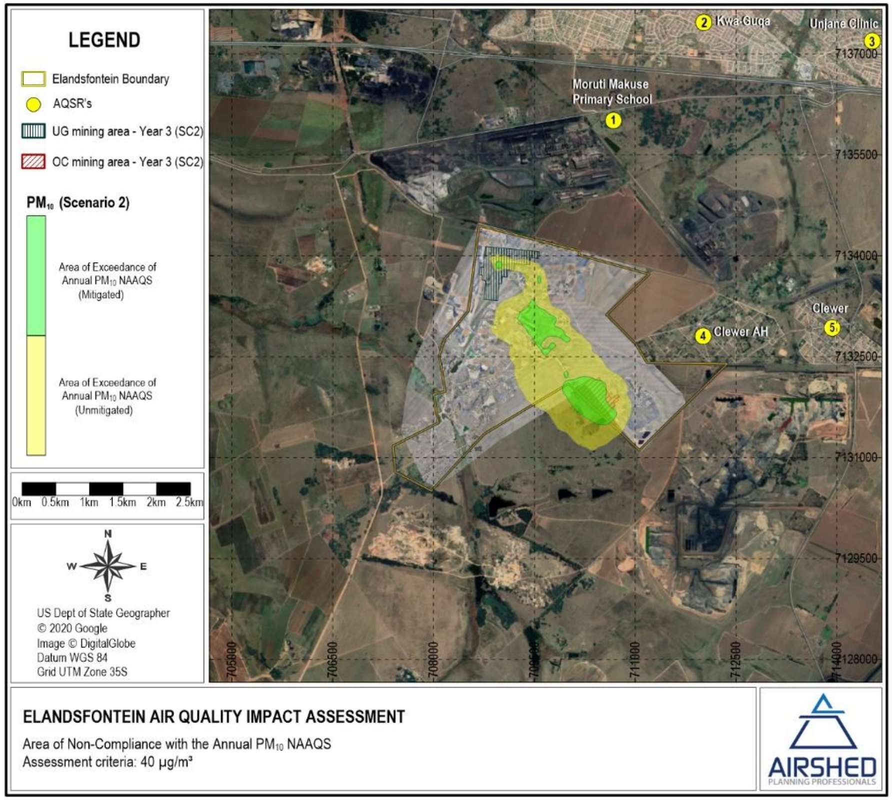


Figure 26: Scenario 2 – Area of non-compliance of annual PM_{10} NAAQS for unmitigated and mitigated YEAR 3 operations

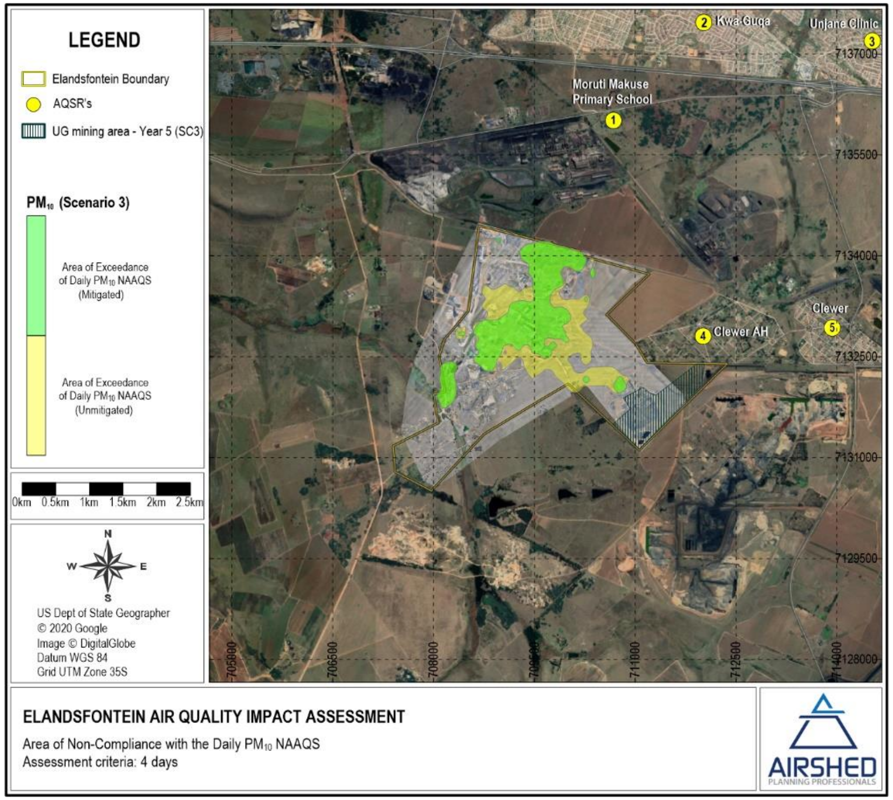


Figure 27: Scenario 3 – Area of non-compliance of daily PM_{10} NAAQS for unmitigated and mitigated YEAR 5 operations

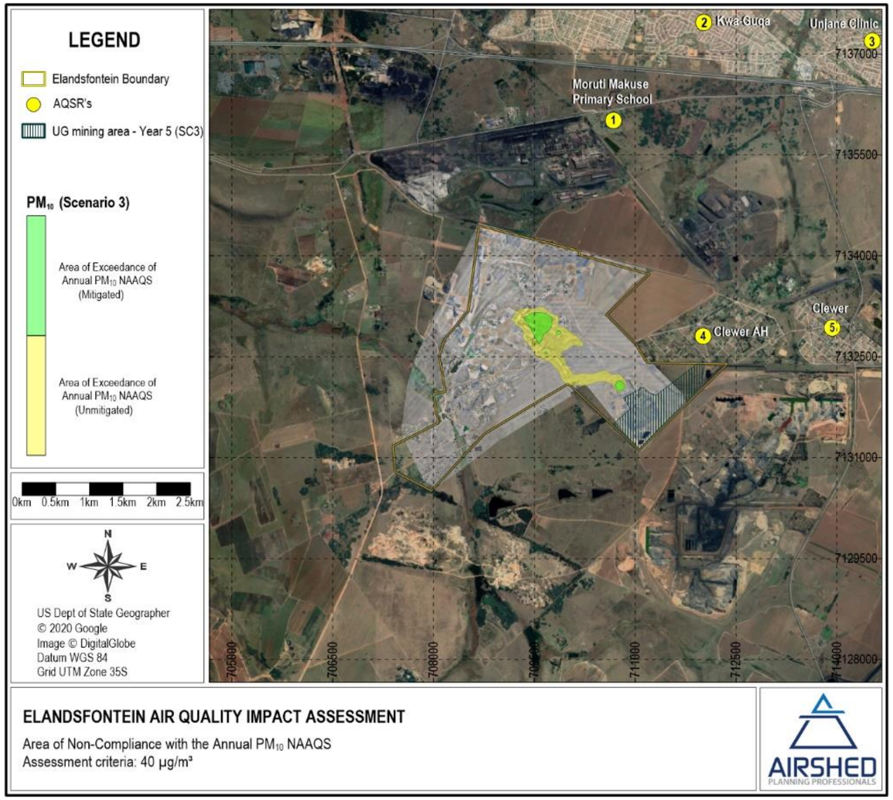


Figure 28: Scenario 3 – Area of non-compliance of annual PM_{10} NAAQS for unmitigated and mitigated YEAR 5 operations

9.3.2 $PM_{2.5}$

Scenario 1

The simulated exceedances of highest daily and annual average $PM_{2.5}$ NAAQS (applicable 1 January 2030) for unmitigated and mitigated operations are provided in Figure 29 to Figure 30 respectively, with the GLCs at the nearest AQSRs provided in Table 20. The GLCs at all AQSRs indicated in Figure 15 are shown in Table 43 (Appendix F).

The main findings are:

- ***$PM_{2.5}$*** daily GLCs, for both unmitigated and mitigated activities, are not likely to exceed the NAAQS at any of the AQSRs (Figure 29). Over an annual average the GLCs are within the standard at all receptors (Figure 30). From Table 20 exceedance of the daily (but not the annual) $PM_{2.5}$ NAAQS is only expected at the mining boundary.

Table 20: Simulated $PM_{2.5}$ ground level concentrations (in µg/m³) at all identified AQSRs – Scenario 1

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	5.91	0.30	No	0	3.00	0.15	No	0
2	Kwa-Guqa	2.78	0.11	No	0	1.62	0.06	No	0
3	Unjani Clinic	2.10	0.10	No	0	1.08	0.05	No	0
4	Clewer AH	7.26	0.51	No	0	3.41	0.24	No	0
5	Clewer	5.17	0.24	No	0	2.47	0.11	No	0
	Mine Boundary (max)	176.0	7.9	Yes	18	172.6	4.31	Yes	13

Scenario 2

The simulated exceedances of highest daily and annual average $PM_{2.5}$ NAAQS (applicable 1 January 2030) for unmitigated and mitigated operations are provided in Figure 31 to Figure 32 respectively, with the GLCs at the nearest AQSRs provided in Table 21. The GLCs at all AQSRs indicated in Figure 15 are shown in Table 44 (Appendix F).

The main findings are:

- ***$PM_{2.5}$*** daily GLCs, for both unmitigated and mitigated activities, are not likely to exceed the NAAQS at any of the AQSRs (Figure 31). Over an annual average the GLCs are within the standard at all receptors (Figure 32). From Table 21 exceedance of the daily and annual $PM_{2.5}$ NAAQS is only expected at the mining boundary, when no mitigation is in place.

Table 21: Simulated $PM_{2.5}$ ground level concentrations (in µg/m³) at all identified AQSRs – Scenario 2

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	5.45	0.39	No	0	2.81	0.15	No	0
2	Kwa-Guqa	2.59	0.15	No	0	1.27	0.06	No	0
3	Unjani Clinic	2.32	0.11	No	0	1.04	0.04	No	0
4	Clewer AH	9.42	0.82	No	0	3.24	0.29	No	0
5	Clewer	4.73	0.35	No	0	2.15	0.13	No	0
	Mine Boundary (max)	174.6	19.7	Yes	81	171.7	5.52	Yes	14

Scenario 3

The simulated exceedances of highest daily and annual average $PM_{2.5}$ NAAQS (applicable 1 January 2030) for unmitigated and mitigated operations are provided in Figure 33 to Figure 34 respectively, with the GLCs at the nearest AQSRs provided in Table 22. The GLCs at all AQSRs indicated in Figure 15 are shown in Table 45 (Appendix F).

The main findings are:

- ***$PM_{2.5}$*** daily GLCs, for both unmitigated and mitigated activities, are not likely to exceed the NAAQS at any of the AQSRs (Figure 33). Over an annual average the GLCs are within the standard at all receptors (Figure 34). From Table 22 exceedance of the daily (but not the annual) $PM_{2.5}$ NAAQS is only expected at the mining boundary.

Table 22: Simulated $PM_{2.5}$ ground level concentrations (in µg/m³) at all identified AQSRs – Scenario 3

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	3.16	0.16	No	0	1.82	0.08	No	0
2	Kwa-Guqa	1.62	0.06	No	0	1.16	0.03	No	0
3	Unjani Clinic	1.11	0.05	No	0	0.53	0.02	No	0
4	Clewer AH	3.98	0.31	No	0	1.92	0.14	No	0
5	Clewer	3.01	0.14	No	0	1.43	0.06	No	0
	Mine Boundary (max)	172.6	5.4	Yes	13	170.7	3.7	Yes	13

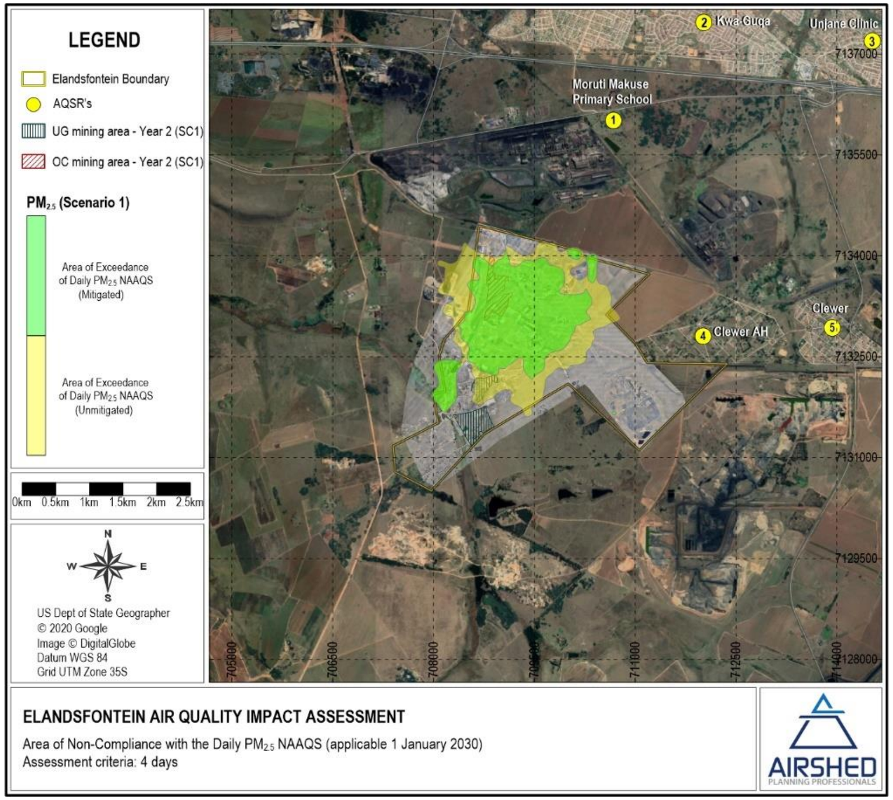


Figure 29: Scenario 1 – Area of non-compliance of daily $PM_{2.5}$ NAAQS for unmitigated and mitigated YEAR 2 operations

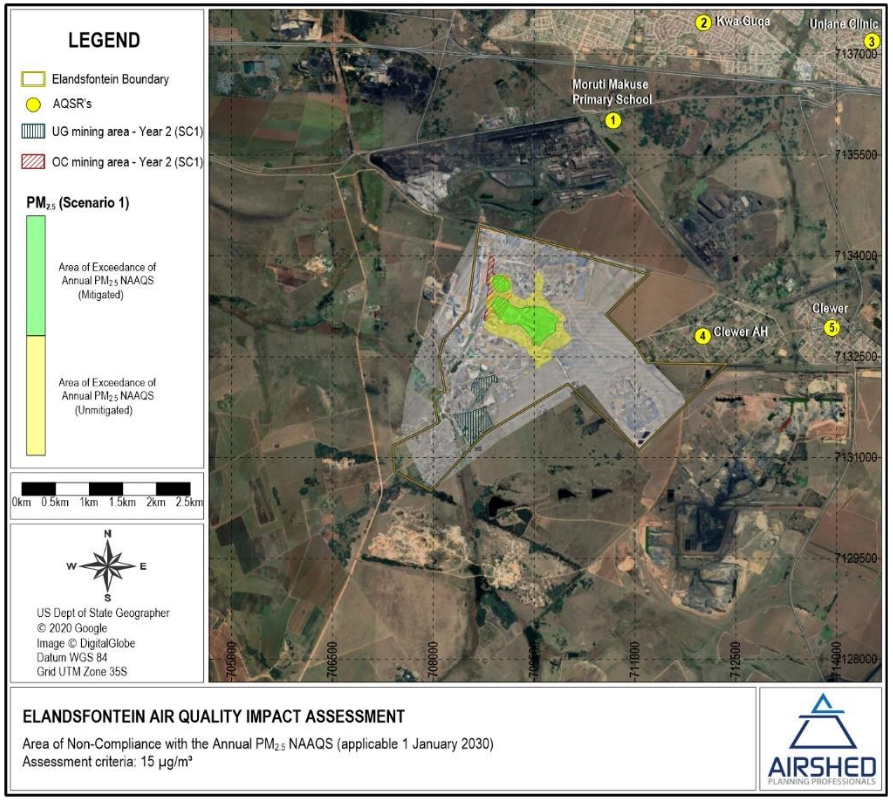


Figure 30: Scenario 1 – Area of non-compliance of annual $PM_{2.5}$ NAAQS for unmitigated and mitigated YEAR 2 operations

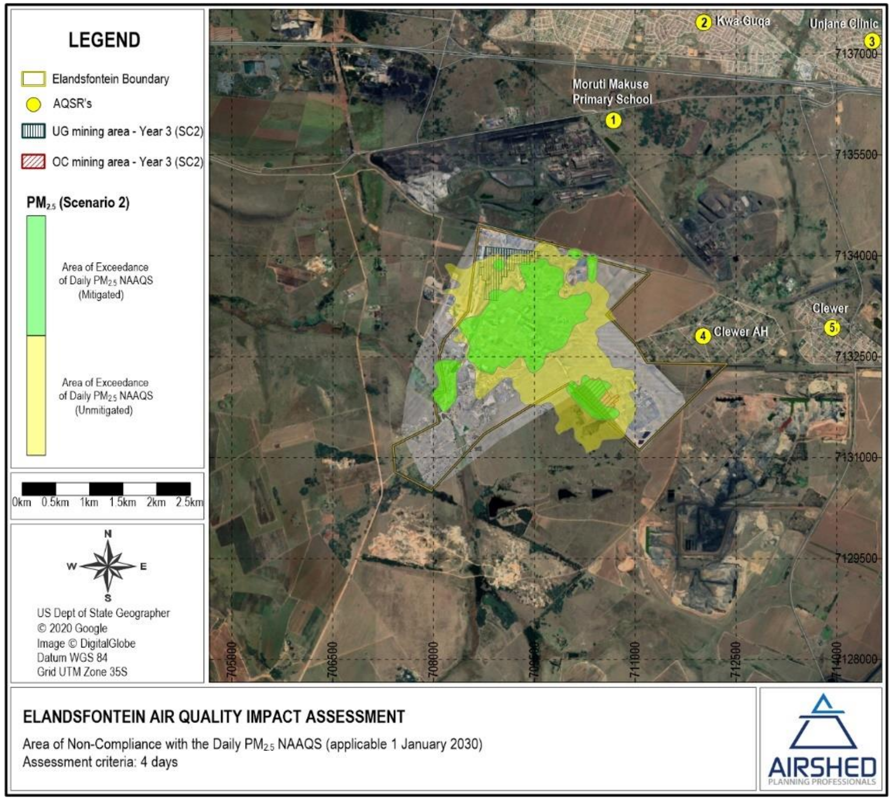


Figure 31: Scenario 2 – Area of non-compliance of daily $PM_{2.5}$ NAAQS for unmitigated and mitigated YEAR 3 operations

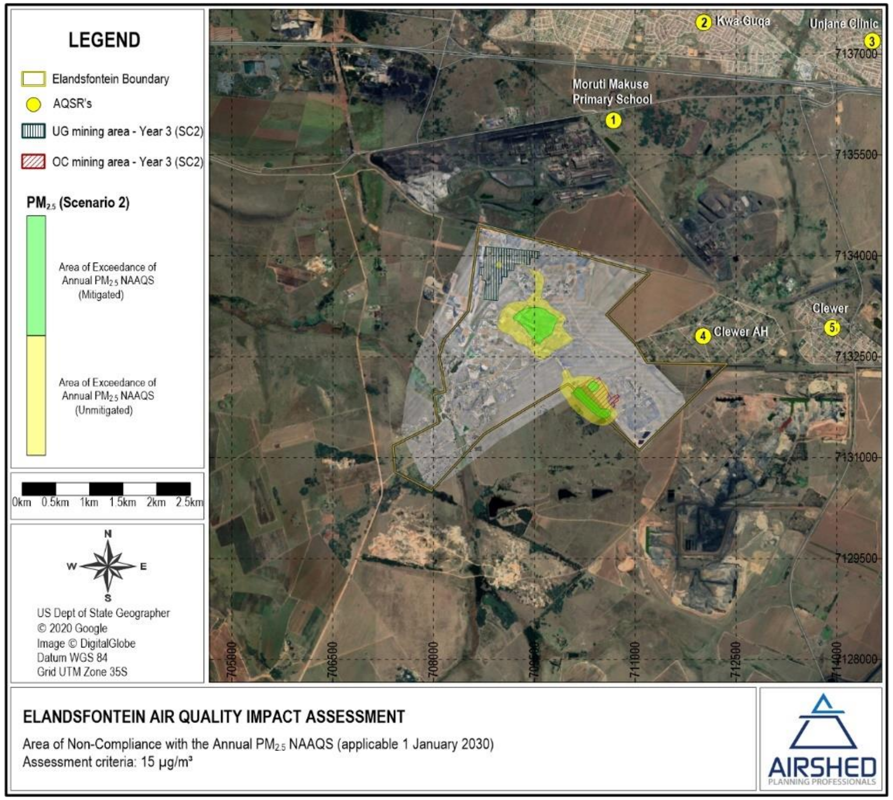


Figure 32: Scenario 2 – Area of non-compliance of annual $PM_{2.5}$ NAAQS for unmitigated and mitigated YEAR 3 operations

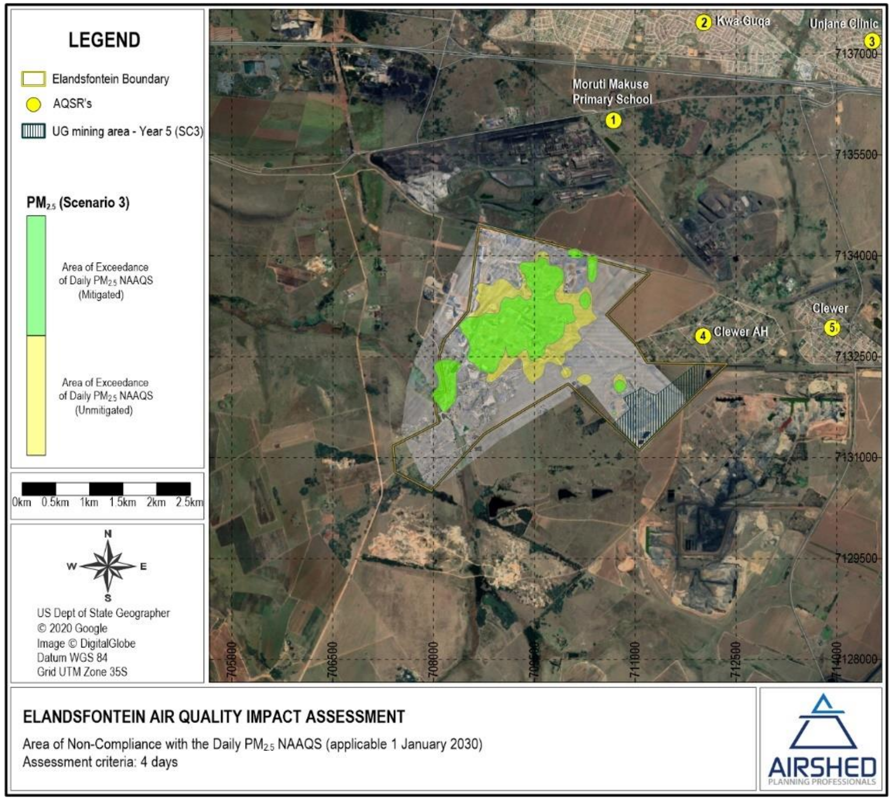


Figure 33: Scenario 3 – Area of non-compliance of daily $PM_{2.5}$ NAAQS for unmitigated and mitigated YEAR 5 operations

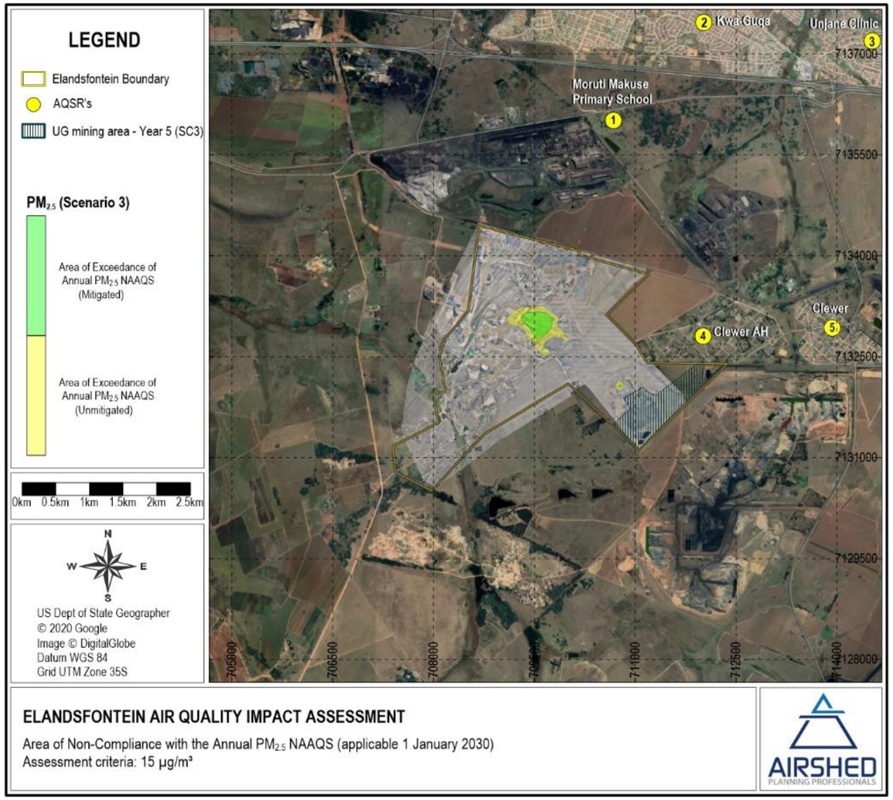


Figure 34: Scenario 3 – Area of non-compliance of annual $PM_{2.5}$ NAAQS for unmitigated and mitigated YEAR 5 operations

9.3.3 Dust Fallout

The simulated maximum daily dustfall rates for the three scenarios (both mitigated and unmitigated activities) are provided in Figure 35 to Figure 37, with the values at each of the AQSRs provided in Table 23. The dustfall rates at all AQSRs indicated in Figure 15 are shown in Table 46 (Appendix F)

The main findings are:

- Maximum daily ***dustfall rates***, for both unmitigated and mitigated activities (all scenarios), are not likely to exceed the NDCR residential limit (600 mg/m²/day) at any of the AQSRs (Figure 35 to Figure 37). From Table 23 no exceedances are expected at any of the AQSRs.

Table 23: Simulated dustfall rates (in mg/m²/day) at selected AQSRs – all scenarios

ID	AQ Sensitive Receptor	Scenario 1		Scenario 2		Scenario 3	
		Highest 30-day avg (unmitigated)	Highest 30-day avg (mitigated)	Highest 30-day avg (unmitigated)	Highest 30-day avg (mitigated)	Highest 30-day avg (unmitigated)	Highest 30-day avg (mitigated)
1	Moruti Makuse Primary School	9.51	4.50	14.72	5.32	5.98	3.03
2	Kwa-Guqa	2.91	1.44	4.10	1.68	1.88	0.98
3	Unjani Clinic	2.77	1.29	2.97	1.19	1.47	0.68
4	Clewer AH	21.16	9.86	28.71	10.97	13.09	5.93
5	Clewer	6.21	3.06	7.84	3.01	3.61	1.75
	Mine Boundary (max)	330.8	164.5	1245.2	325.1	617.4	179.1

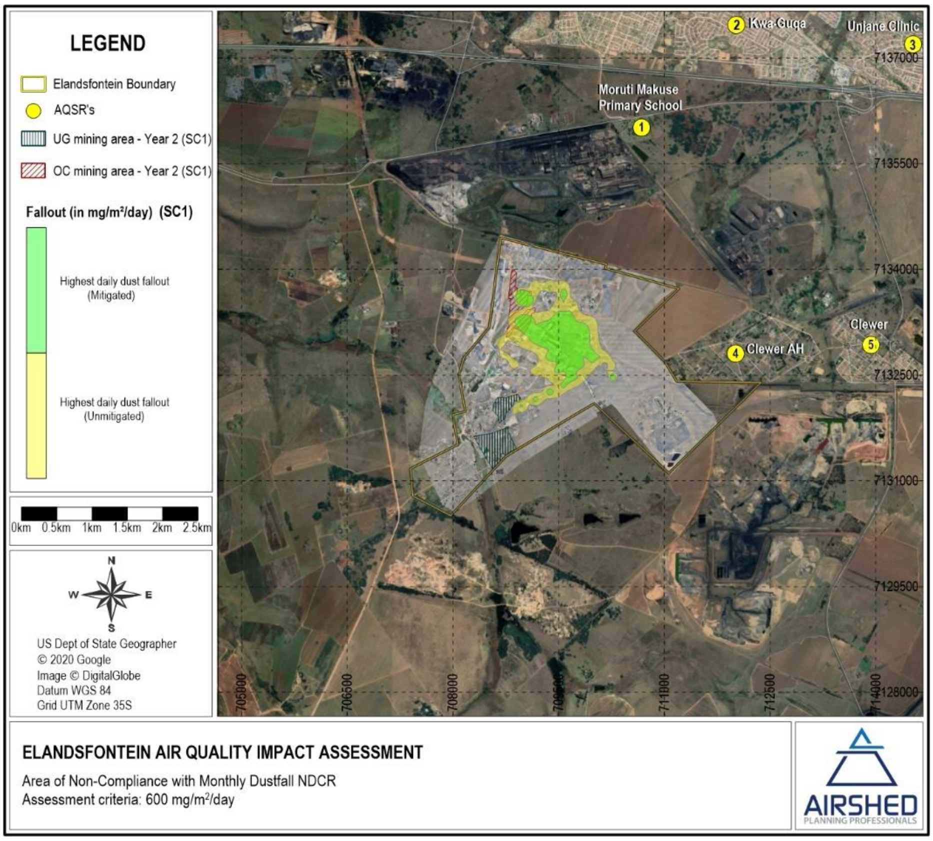


Figure 35: Scenario 1 – Simulated dustfall deposition rates due to unmitigated and mitigated YEAR 2 operations

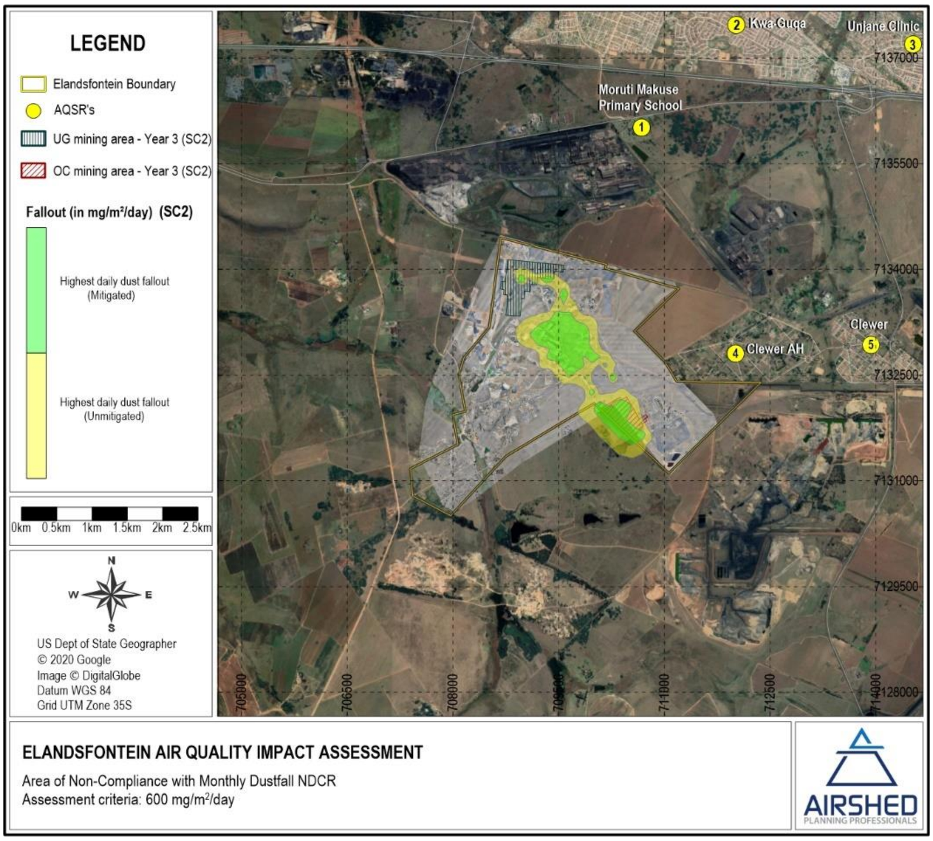


Figure 36: Scenario 2 – Simulated dustfall deposition rates due to unmitigated and mitigated YEAR 3 operations

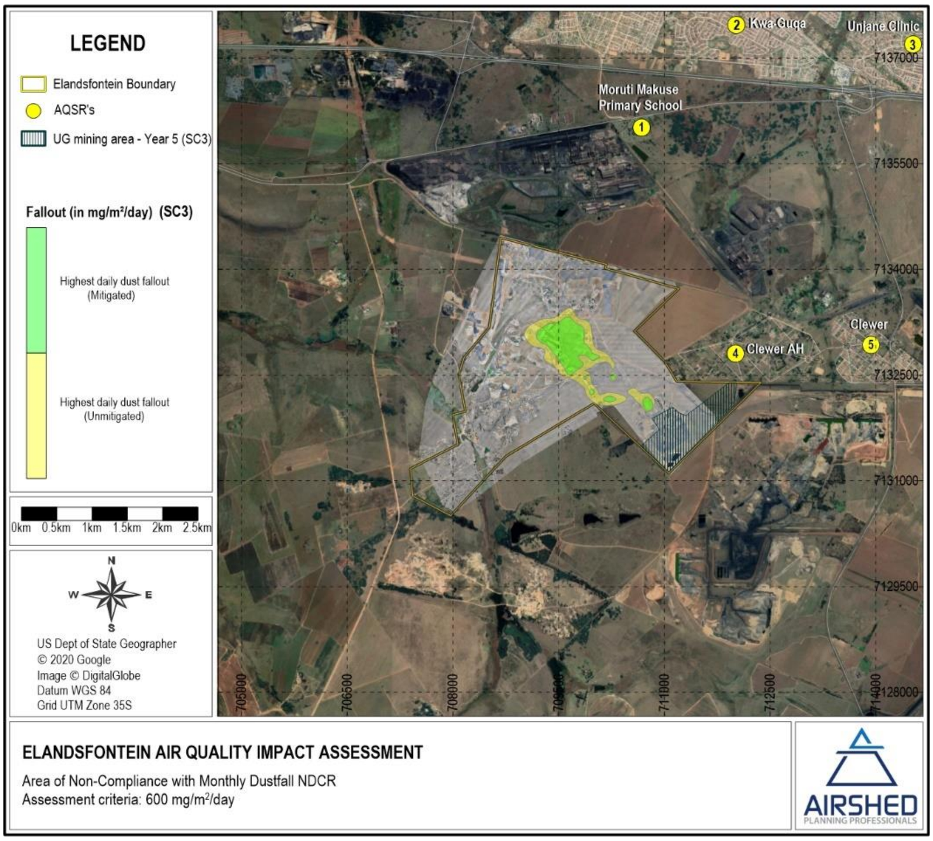


Figure 37: Scenario 3 – Simulated dustfall deposition rates due to unmitigated and mitigated YEAR 5 operations

10 Greenhouse Gas Statement

10.1 Introduction

10.1.1 The greenhouse effect

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

10.2 The Project's Operational Phase Carbon Footprint

10.2.1 GHG Emissions Estimation

The impact assessment follows IPCC methodology with the following scopes:

- Scope 1: Emissions from the mine itself, as well as the liberation of CO_2, CH_4 and N_2O during fossil fuel combustion (diesel).
- Scope 2: Emissions from the electricity bought from non-project sources.
- Scope 3: This covers the mining and transport of coal, as well as the recovery of discard for usage as a fuel source.

Scope 1 Emissions

The geological processes of coal formation produce CH_4 and CO_2. CH_4 is the major GHG emitted from coal mining and handling (DEA, 2013). In underground mines, ventilation of the mines causes significant amounts of CH_4 to be pumped into the atmosphere. Such ventilation is the main source of CH_4 emissions in hard coal mining activities. In addition, CH_4 can continue to be emitted from abandoned coal mines after mining has ceased. CH_4 releases from surface coal mining operations are low.

A summary of direct GHG emissions due to underground mining at the Elandsfontein Project (assuming the tier 1 and 2 approach) is given in Table 24 (CH_4, expressed as tonne CO_2 equivalent or tCO_2-e). CO_2-e is a term for describing different GHG in a common unit. For any quantity and type of GHG, CO_2-e signifies the amount of CO_2 which would have the equivalent global warming impact. A quantity of GHG can be expressed as CO_2-e by multiplying the amount of the GHG by its global warming potential (GWP). E.g. if 1kg of CH_4 is emitted, this can be expressed as 23kg of CO_2-e (1kg CH_4 * 23 = 23kg CO_2-e). GWP for CH_4 and N_2O were obtained from the technical guidelines document (DEA, 2017).

Table 24: Calculation of underground mining GHG emissions (tonnes CO_2-e pa)

No	Variable	Value	Unit	Comments
1	Underground ROM coal throughput	600 000	tpa	(Note 1, 2)
2	CH_4 emission factor for underground mining (coal mining)	0.77	m^3/t	(Note 3)
3	CH_4 emission factor for underground mining (post-mining: handling and transport)	0.18	m^3/t	(Note 3)
4	CO_2 emission factor for underground mining (coal mining)	0.077	m^3/t	(Note 3)
5	CO_2 emission factor for underground mining (post-mining: handling and transport)	0.018	m^3/t	(Note 3)
6	Density CH_4	6. 68e-04	t/m^3	(at NTP) (Note 4)
7	Density CO_2	1.842e-04	t/m^3	(at NTP) (Note 4)
8	Annual CH_4 emissions	381	tpa	1*(2+3)*6
9	Annual CO_2 emissions	105	tpa	1*(4+5)*7
	Total GHG emissions	**8 862**	**tCO_2-e pa**	8*$GWP_{(CH4)}$ + 9 (Note 5)

Notes:

1. See Table 1
2. GHG emissions only calculated for underground mining activities; the national emission factors for surface coal mining and post-mining activities are given as 0 (DEA 2017, Annexure B).
3. DEA (2017) – Annexure B, Table B.1
4. Density of gases at normal temperature and pressure (standard engineering databases)
5. DEA (2017) – Annexure H, CH_4 Global Warming Potential value =23

The Intergovernmental Panel on Climate Change (IPCC) provides default emission factors for diesoline in kg CO_2/unit energy content (Annexure A, DEA 2017), while country-specific density and calorific values are available for South Africa (Annexure B, DEA 2017). Using the values in Table 25, the CO_2 and CH_4 emission factors can be calculated per litre of fuel used, which allows calculation of the total emissions directly from fuel records. The amount of fuel (diesel) used by Elandsfontein Colliery for the year 2019 is 2 650 390 litres (vehicles) and 16 254 litres (generators). The fuel usage for 2019 was provided by the client. There wasn't any information available on the future fuel usage, and Scope 2 emissions were calculated using the numbers for 2019.

Table 25: Calculation of GHG emissions due to diesel fuel combustion (tonnes CO_2-e pa)

No	Variable	Value	Unit	Comments
	Liquid fuel-related GHG emissions due to diesel fuel combustion (vehicles)			
1	Maximum fuel use projected for 2019 (vehicles)	2 650 390	litres/annum	(Note 1)
2	Density Diesel	0.845	kg/l	(Note 2)

No	Variable	Value	Unit	Comments
3	Calorific value Diesel (mobile combustion)	0.0381	TJ/t	(Note 3)
4	CH_4 emission factor for diesel (vehicles)	4.15	kg/TJ	(Note 3)
5	N_2O emission factor for diesel (vehicles)	28.6	kg/TJ	(Note 3)
6	CO_2 emission factor for diesel (vehicles)	74 100	kg/TJ	(Note 3)
7	Annual CH_4 emissions (vehicles)	0.35	tpa	1*2*3*4*1e-06
8	Annual N_2O emissions (vehicles)	2.44	tpa	1*2*3*5*1e-06
9	Annual CO_2 emissions (vehicles)	6 323	tpa	1*2*3*6*1e-06
Liquid fuel-related GHG emissions due to diesel fuel combustion (generators)				
10	Maximum fuel use projected for 2019 (generators)	16 254	litres/annum	(Note 1)
11	Density Diesel	0.845	kg/l	(Note 2)
12	Calorific value Diesel (stationary combustion)	0.043	TJ/t	(Note 4)
13	CH_4 emission factor for diesel (generators)	3	kg/TJ	(Note 4)
14	N_2O emission factor for diesel (generators)	0.6	kg/TJ	(Note 4)
15	CO_2 emission factor for diesel (generators)	74 100	kg/TJ	(Note 4)
16	Annual CH_4 emissions (generators)	1.77e-06	tpa	10*11*12*13*1e-06
17	Annual N_2O emissions (generators)	3.54e-07	tpa	10*11*12*14*1e-06
18	Annual CO_2 emissions (generators)	0.044	tpa	10*11*12*15*1e-06
	Total GHG emissions	**7 053**	**tCO_2-e pa**	16*$GWP_{(CH4)}$ + 17*$GWP_{(N2O)}$ + 18 (Notes 5, 6)

Notes:

1. Provided by client
2. DEA (2017) – Annexure D, Table D1
3. DEA (2017) – Annexure A, Table A.2
4. DEA (2017) – Annexure A, Table A.1
5. DEA (2017) – Annexure H, CH_4 Global Warming Potential value =23
6. DEA (2017) – Annexure H, N_2O Global Warming Potential value =296

Scope 2 Emissions

These emissions are related to purchased energy, heat or steam, and can be calculated from the average South African emission factor published annually by Eskom in its annual report (more recently its integrated sustainability report). The numbers for the six-year period (2007-2012, 2014) are given in Table 26. This allows the scope 2 emissions to be calculated directly from electricity consumption from the Eskom or local authority account. The mine's current electricity usage per annum is ~22 MVA, or 192 720 MWh (assuming 8760 hours of operation) (electricity usage obtained from the Mine Working Plan). There wasn't any information available on the future electricity usage, and Scope 2 emissions were calculated for the electricity usage in 2019 using the most recent emission factor of 1.03 tCO_2-e/MWh (which is based on energy generated) (Table 26).

Table 26: Eskom electricity emission factors (tonne CO_2-e/MWh)

Year	Emission Factor 1 (based on energy sold)	Emission Factor 2 (based on energy generated)	Source
2007/2008	1.00	–	Eskom 2009 Annual Report
2008/2009	1.03	–	Eskom 2009 Annual Report
2009/2010	1.03	0.98	Eskom 2010 Integrated Report
2010/2011	–	0.99	Eskom 2011 Integrated Report
2011/2012	1.03	0.99	Eskom 2012 Integrated Report
2013/2014	1.07	1.03	Eskom 2014 Integrated Report

Summary

A summary of the greenhouse gas emissions for the operational phase is provided in Table 27.

Table 27: Summary of estimated greenhouse gas emissions for the operational phase

Source group	CO_2	CH_4 as CO_2-e	N_2O as CO_2-e	Total CO_2-e
	t/a	t/a	t/a	t/a
Underground coal mining (scope 1)	105	8 757	–	8 862
Vehicle exhaust (scope 1)	6 323	8	722	7 053
TOTAL (scope 1)	**6 428**	**8 765**	**722**	**15 915**
Electricity (scope 2)	–	–	–	**198 502**
			TOTAL	**214 417**

The total CO_2 (equivalent) emissions of approximately 214 417 tpa (Table 27) for the operational phase, should be seen in the perspective of the annual South African emission rate of GHG, which is approximately 544.75 million metric tonnes CO_2-e (excluding FOLU[5]) (DEA, 2018).

The calculated CO_2-e emissions due to the Project operations contribute 0.04% to the total of South Africa's GHG emissions. As indicated in Section 6.5, GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The scope 1 GHG contribution of the operational period is below 100 000 tons (Table 27). Based on this, a Pollution Prevention Plan is not required for the Project operations.

[5] Forestry and Other Land Use

10.2.2 The Project's GHG Impact

Magnitude

The GHG emissions due to the project's operations are low and will not likely result in a noteworthy contribution to climate change on its own.

Impact on the sector

The GHG emissions from the project's operations form 0.05% of the "energy" sector's total annual CO_2-e emissions and will therefore not make a significant contribution towards the sector's GHG impact.

Impact on the National Inventory

The GHG emissions from the project's operations form 0.04% of the national inventory's total annual CO_2-e emissions, which is very low.

Alignment with national policy

As from the next NAEIS reporting period, after construction has commenced, Elandsfontein Colliery will have to start reporting on Scope 1 GHG emissions.

10.3 Potential Effect of Climate Change on the Project

The most significant of the discussed climate change impacts on the project would be as a result of:

- Temperature increase[6],
- Possible reduction in rainfall[7].

With the increase in temperature there is the likelihood of an increase in discomfort and possibility of heat related illness (such as heat exhaustion, heat cramps, and heat stroke). Both of these have the potential to negatively affect staff performance and productivity. There is also the increased risk of overheating of equipment/machinery with effects on production, and a possible increase in demand for energy to satisfy an increased cooling need (in buildings). The potential exists for higher evaporation rates and thus the need for increased watering of the roads. Higher temperatures also increase the risk of veld fires and spontaneous combustion of coal stockpiles.

A decrease in rainfall may result in severe water shortages, which may interrupt mining activities and increase working costs, thereby potentially making the project unprofitable. Lower rainfall will also have a negative impact on food security, possibly resulting in food shortages which may negatively affect staff performance.

[6] Under a no intervention scenario, temperatures are projected to rise over the Project region, by 2.5°C to 3°C over the South African interior in the near-future and even higher in the far-future.

[7] The region is projected to become systematically drier, with considerably more dry years than wet years. The drastically higher temperatures may have a negative impact on water availability from local dams due to enhanced evaporation.

10.4 Potential Effect of Climate Change on the Community

Of the discussed climate change impacts, significant effect on the surrounding communities will be as a cumulative result of land uses contributing to GHG emissions and not the Elandsfontein project only. As stated in Section 10.2.2 the project's contribution to climate change is not noteworthy.

10.5 Adaptation and Management Measures

Climate change management includes both mitigation and adaptation. The main aim of mitigation is to stabilise or reduce GHG concentrations as a result of anthropogenic activities. This is achievable by lessening sources (emissions) and/or enhancing sinks through human intervention.

10.5.1 Project adaptation and mitigation measures

General

Additional support infrastructure can reduce the climate change impact on the staff and project, for example ensuring adequate water supply for staff and reducing on-site water usage as much as possible.

Scope 1 (technology/sector-specific)

One way to keep GHG emissions to a minimum would be to ensure there is minimal fuel use, this can be achieved by ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program. A measure of reducing the project's impact is to limit the removal of vegetation and to ensure that as much as possible revegetation occurs, e.g. that concurrent rehabilitation is implemented, and possibly even the addition of vegetation surrounding the project area.

10.6 Conclusions and recommendations

- Calculation of the Scope 1 GHG emissions from the proposed operations is at this stage an uncomplicated procedure involving the use of liquid fuel consumption figures from estimated amounts based on fleet and power supply requirements; and multiplying by simple emission factors as given in tables above. The total CO_2-e emissions (scope 1 and 2 emissions) for Elandsfontein operations is not likely to be more than 214 417 tpa. The calculated CO_2-e emissions from the proposed project operations contribute less than 0.04% to the total of the national inventory's GHG emissions (excluding land-use change and forestry) and 0.05% to the national inventory's "energy" sector GHG emissions.
- GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The scope 1 GHG contribution due to the proposed mining operations is below 100 000 tons. Based on this, a Pollution Prevention Plan is not required for the proposed project operations.

- The GHG emissions from the proposed operational phase are not likely to result in a noteworthy contribution to climate change on its own.
- The project and the community are likely to be negatively impacted by climate change, the project less than the community due to the short time period that operations are planned for.
- The following is recommended to reduce the impacts of climate change on the project and the community:
    - Additional support infrastructure can reduce the climate change impact on the staff and project, for example ensuring adequate water supply for staff and reducing on-site water usage as much as possible.
- The following is recommended to reduce the GHG emissions from the project:
    - Ensuring the vehicles and equipment is maintained through an effective inspection and maintenance program.
    - Limiting the removal or vegetation and ensuring adequate re-vegetation or addition of vegetation surrounding the project. Vegetation acts as a carbon sink.

11 Spatial Sensitivity Mapping

Sensitivity mapping was conducted in accordance with the EIMS methodology, which focuses on scoring the proposed project impact on landscape features. The main pollutant of concern from the planned opencast and underground mining activities is PM, with PM_{10} and $PM_{2.5}$ the fractions associated with health impacts. The sensitivity map therefore focused primarily on the expected impact areas from PM_{10} and $PM_{2.5}$ concentrations. Nuisance impacts from dust fallout would be more localised. Gaseous emissions from mining equipment and vehicles are also expected to have a less significant impact with a much smaller footprint than PM_{10} and $PM_{2.5}$.

Considerations for the projected impact areas were:

- The planned mining areas in relation to the AQSR;
- The project site's location within the Highveld Priority Area;
- The prevailing wind field – the wind field determines both the distance of downward transport and the rate of dilution of pollutants;
- The modelled isopleth plots in Section 9.3, and
- The sensitivity map created as part of the baseline assessment (based on the 2017 AQIA predicted impacts).

The impact area depicted in the sensitivity map (reflecting predicted impacts from the 2017 AQIA Specialist Report) (Figure 44) was regarded as a possible footprint of the Project operations based on credible meteorological data used in the dispersion model, the planned Elandsfontein operations in relation to the AQSRs and the location of the Project in a hot spot area of the Highveld Priority Area. The area of exceedance from the modelled results was deemed extensive given the emission rates reported. The significance rating given to the modelled impacts also seemed too low based on the extent of the modelled impact area.

The modelled isopleth plots in Section 9.3 show much lower impacts than those predicted in the 2017 AQIA. These are only the incremental impacts however, and the cumulative impacts are expected to be much larger. The sensitivity map for the current study was drawn to reflect the lower impacts, by adjusting the sensitivity rating map to fit the "High" sensitivity area to the maximum PM_{10} impact footprint reported in Section 9.3. The new sensitivity map is shown in Figure 38.

The sensitivity areas are classified as follows:

- "High" is the area where the concentrations are expected to be in non-compliance with the NAAQS.
- "Medium" is the area is where there will be likely single exceedances of the NAAQS limit values but not resulting in non-compliance.
- "Low" area is where there is likely a low significant effect on human health and well-being.

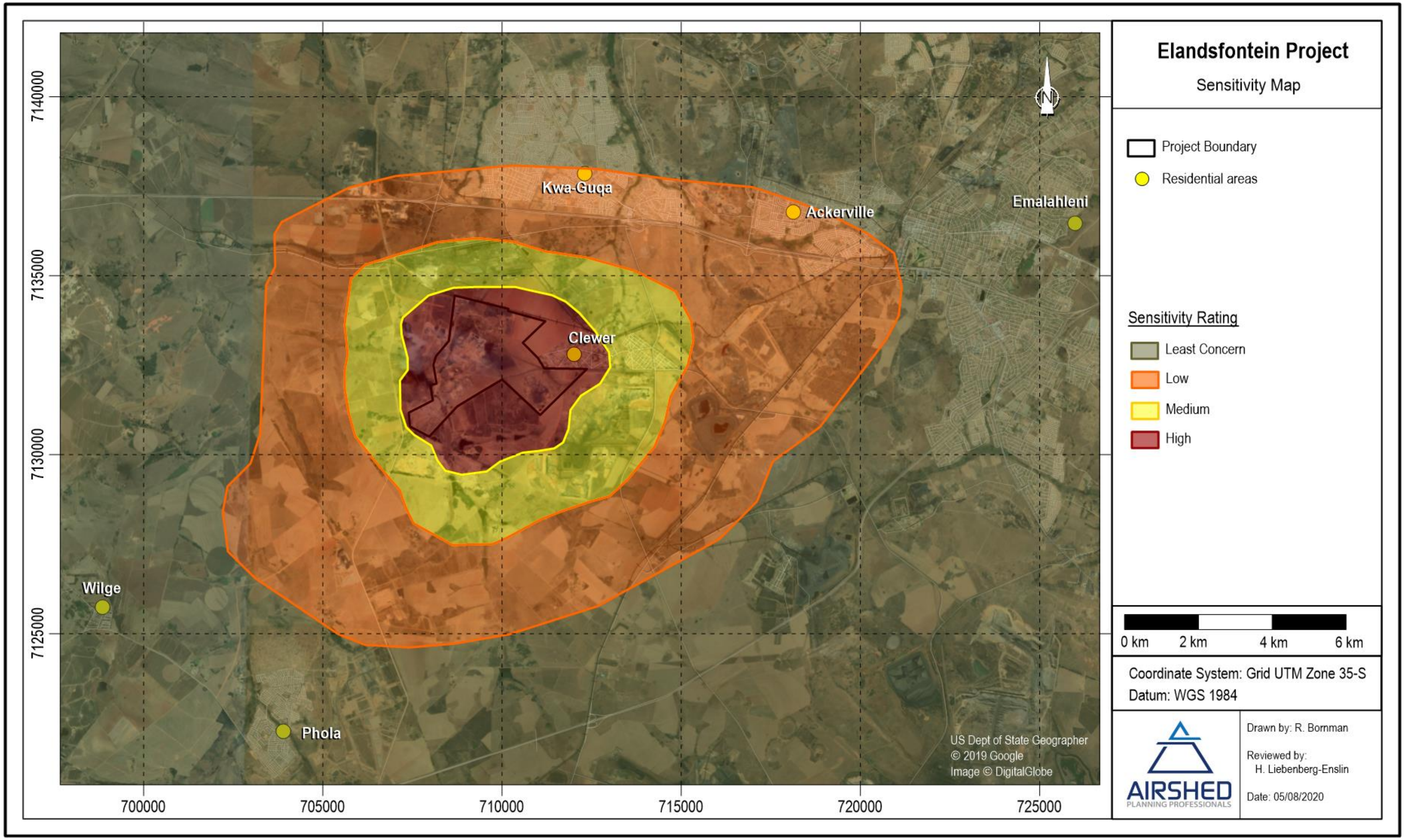


Figure 38: Air quality sensitivity map (based on the maximum PM_{10} impact footprint for the operational phase)

12 Impact Assessment

12.1 Impact Assessment Methodology

The impact assessment methodology is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/likelihood (P) of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S).

Determination of Environmental Risk:

The significance (S) of an impact is determined by applying a prioritisation factor (PF) to the environmental risk (ER). The environmental risk is dependent on the consequence (C) of the particular impact and the probability (P) of the impact occurring. Consequence is determined through the consideration of the Nature (N), Extent (E), Duration (D), Magnitude (M), and reversibility (R) applicable to the specific impact.

For the purpose of this methodology the consequence of the impact is represented by:

$$C = \frac{(E+D+M+R)}{4} \times N$$

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 28.

Table 28: Criteria for determining impact consequence

Aspect	Score	Definition
Nature	- 1	Likely to result in a negative/ detrimental impact
	+1	Likely to result in a positive/ beneficial impact
Extent	1	Activity (i.e. limited to the area applicable to the specific activity)
	2	Site (i.e. within the development property boundary),
	3	Local (i.e. the area within 5 km of the site),
	4	Regional (i.e. extends between 5 and 50 km from the site
	5	Provincial / National (i.e. extends beyond 50 km from the site)
Duration	1	Immediate (<1 year)
	2	Short term (1-5 years),
	3	Medium term (6-15 years),
	4	Long term (the impact will cease after the operational life span of the project),
	5	Permanent (no mitigation measure of natural process will reduce the impact after construction).
Magnitude/ Intensity	1	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected),

Aspect	Score	Definition
	2	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected),
	3	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way),
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

Once the C has been determined the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P. Probability is rated/scored as per Table 29.

Table 29: Probability scoring

Probability	1	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%),
	2	Low probability (there is a possibility that the impact will occur; >25% and <50%),
	3	Medium probability (the impact may occur; >50% and <75%),
	4	High probability (it is most likely that the impact will occur- > 75% probability), or
	5	Definite (the impact will occur),

The result is a qualitative representation of relative ER associated with the impact. ER is therefore calculated as follows:

ER= C x P

Table 30: Determination of environmental risk

Consequence	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Probability					

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 31.

Table 31: Significance classes

Environmental Risk Score	
Value	**Description**
< 9	Low (i.e. where this impact is unlikely to be a significant environmental risk),
≥9; <17	Medium (i.e. where the impact could have a significant environmental risk),
≥ 17	High (i.e. where the impact will have a significant environmental risk).

The impact ER will be determined for each impact without relevant management and mitigation measures (pre-mitigation), as well as post implementation of relevant management and mitigation measures (post-mitigation). This allows for a prediction in the degree to which the impact can be managed/mitigated.

Impact Prioritisation:

In accordance with the requirements of Regulation 31 (2)(l) of the EIA Regulations (GNR 543), and further to the assessment criteria presented in the Section above it is necessary to assess each potentially significant impact in terms of:

- Cumulative impacts; and
- The degree to which the impact may cause irreplaceable loss of resources.

In addition, it is important that the public opinion and sentiment regarding a prospective development and consequent potential impacts is considered in the decision-making process.

In an effort to ensure that these factors are considered, an impact prioritisation factor (PF) will be applied to each impact ER (post-mitigation). This prioritisation factor does not aim to detract from the risk ratings but rather to focus the attention of the decision-making authority on the higher priority/significance issues and impacts. The PF will be applied to the ER score based on the assumption that relevant suggested management/mitigation impacts are implemented.

Table 32: Criteria for determining prioritisation

Public response (PR)	Low (1)	Issue not raised in public response.
	Medium (2)	Issue has received a meaningful and justifiable public response.
	High (3)	Issue has received an intense meaningful and justifiable public response.
Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.
	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.

Irreplaceable loss of resources (LR)	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 32. The impact priority is therefore determined as follows:

Priority = PR + CI + LR

The result is a priority score which ranges from 2 to 6 and a consequent PF ranging from 1 to 1.5 (refer to Table 33).

Table 33: Determination of prioritisation factor

Priority	Ranking	Prioritisation Factor
2	Low	1
3	Medium	1.125
4	Medium	1.25
5	Medium	1.375
6	High	1.5

In order to determine the final impact significance the PF is multiplied by the ER of the post mitigation scoring. The ultimate aim of the PF is to be able to increase the post mitigation environmental risk rating by a full ranking class, if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential, significant public response, and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

Table 34: Final environmental significance rating

Environmental Significance Rating	
Value	**Description**
≤ -20	High negative (i.e. where the impact must have an influence on the decision process to develop in the area).
> -10 ≤ -20	Medium negative (i.e. where the impact could influence the decision to develop in the area),
≤ -10	Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area),
0	No impact
< 10	Low positive (i.e. where the impact would not have a direct influence on the decision to develop in the area).
≥ 10 < 20	Medium positive (i.e. where the impact could influence the decision to develop in the area),
≥ 20	High positive (i.e. where the impact must have an influence on the decision to develop in the area).

12.2 Incremental Impacts

The environmental risk of the air quality impacts due to project activities were found to be:

- **Construction phase** (Table 35): ***Low*** for unmitigated activities and ***Low*** with mitigation applied. This applies to $PM_{2.5}$ and PM_{10} concentrations and dustfall rates.
- **Operational phase** (Table 36): ***Medium*** for unmitigated activities and ***Medium*** with mitigation applied (based on PM_{10} impacts). The highest impacts are mainly due to unpaved roads and crushing activities.
- **Rehabilitation and Closure Phase** (Table 37): the impacts are expected to be ***Low*** for unmitigated activities and ***Low*** with mitigation applied**.** This applies to $PM_{2.5}$ and PM_{10} concentrations and dustfall rates.

12.3 Cumulative impacts

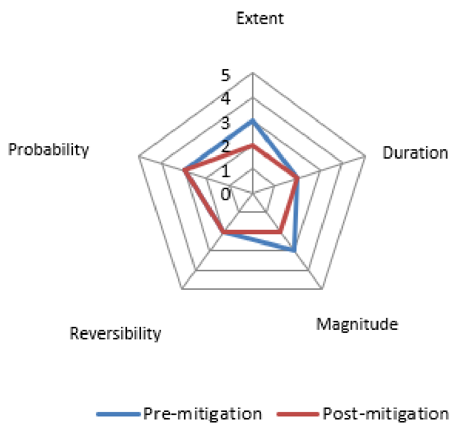
In order to prioritise the simulated impacts, it is necessary to assess the potentially significant impacts in terms of cumulative impacts and the degree to which the impact may cause irreplaceable loss of resources, as well as taking the public opinion and sentiment regarding the prospective development into account (see Section 12.1 for the methodology used to prioritise impacts).

The public response (PR) towards the proposed development was not known at the time of writing the report; it was assumed that PR is **Medium** (2). The assessment of whether the loss of resources due to the proposed development is irreversible (LR), is considered **Low** (1) for construction and closure, and **Medium** (2) for the operational phase. The cumulative impact (CI) with respect to the construction phase is assessed as **Low** (1), and the CI with respect to the operational and closure phases is assessed as **High** (3) and **Medium** (2) respectively. The priority score is determined by adding the scores for PR, CI and LR, giving a prioritisation factor (PF) of 1.17 for the construction phase, 1.67 for the operational phase and 1.33 for the closure phase.

The final impact significance associated with the proposed development is determined by multiplying the PF with the ER of the post-mitigation scoring, viz. **Low negative** for the construction phase and closure phase (Table 35 and Table 37 respectively), and **Medium negative** for the operational phase (Table 36).

Table 35: Significance rating for the Elandsfontein Project (Construction)

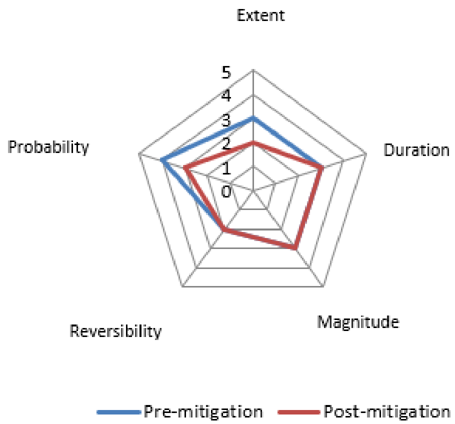
Impact Table



Impact Name	**Decline in Air Quality: Elandsfontein Project**				
Phase	**Construction**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	2
Extent of Impact	3	2	Reversibility of Impact	2	2
Duration of Impact	2	2	Probability	3	3
Environmental Risk (Pre-mitigation)					-7.5
Mitigation Measures					
Environmental Risk (Post-mitigation)					-6.00
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response (assumption)					
Cumulative Impacts					1
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
The impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.17
Final Significance					-7.00

Table 36: Significance rating for the Elandsfontein Project (Operational Phase)

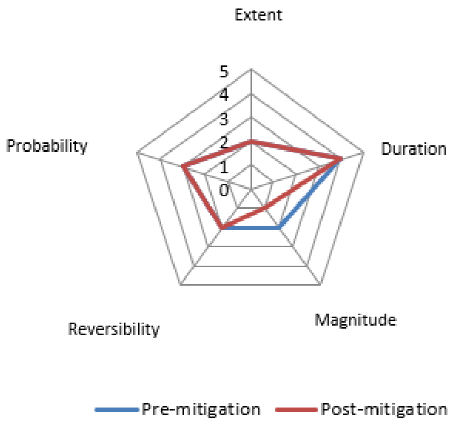
Impact Table



Impact Name	**Decline in Air Quality: Elandsfontein Project**				
Phase	**Operational**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	3
Extent of Impact	3	2	Reversibility of Impact	2	2
Duration of Impact	3	3	Probability	4	3
Environmental Risk (Pre-mitigation)					-11.00
Mitigation Measures					
Environmental Risk (Post-mitigation)					-7.50
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response (assumption)					
Cumulative Impacts					3
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					2
The impact may result in the irreplaceable loss of resources but the value of these resources is limited.					
Prioritisation Factor					1.67
Final Significance					-12.50

Table 37: Significance rating for the Elandsfontein Project (Rehabilitation and Closure Phase)

Impact Table



Impact Name	**Decline in Air Quality: Elandsfontein Project**				
Phase	**Rehabilitation and Closure**				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	2	1
Extent of Impact	2	2	Reversibility of Impact	2	2
Duration of Impact	4	4	Probability	3	3
Environmental Risk (Pre-mitigation)					-7.50
Mitigation Measures					
Environmental Risk (Post-mitigation)					-6.75
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response (assumption)					
Cumulative Impacts					2
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
The impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.33
Final Significance					-9.00

13 Air Quality Management Plan

In the light of the Project being in the Highveld Priority Area, and close to various mining and power generation activities, it is recommended that air quality management planning forms part of the operational phase and decommissioning of the Project. The air quality management plan provides options on the control of dust at the main sources with the monitoring network designed as such to track the effectiveness of the mitigation measures. The sources need to be ranked according to sources strengths (emissions) and impacts. Once the main sources have been identified, target control efficiencies for each source can be defined to ensure acceptable cumulative ground level concentrations.

13.1 Source Ranking

The ranking of sources serves to confirm or, where necessary revise, the current understanding of the significance of specific sources, and to evaluate the emission reduction potentials required for each. Sources of emissions during the operational phase of the Project may be ranked based on emissions and impacts. Ranking was performed for Year 3 operations (Scenario 2) since both emissions and impacts were estimated to be highest for this scenario.

13.1.1 Emissions

The main contributing sources to PM emissions are shown in Figure 39 (uncontrolled) and Figure 40 (controlled). The main contributors to uncontrolled emissions are crushing and wind erosion for $PM_{2.5}$, unpaved roads and wind erosion for PM_{10}, and unpaved roads and crushing for TSP. With mitigation, although the unpaved roads contribution is much reduced; the main contributing sources to $PM_{2.5}$, PM_{10} and TSP emission remain the same.

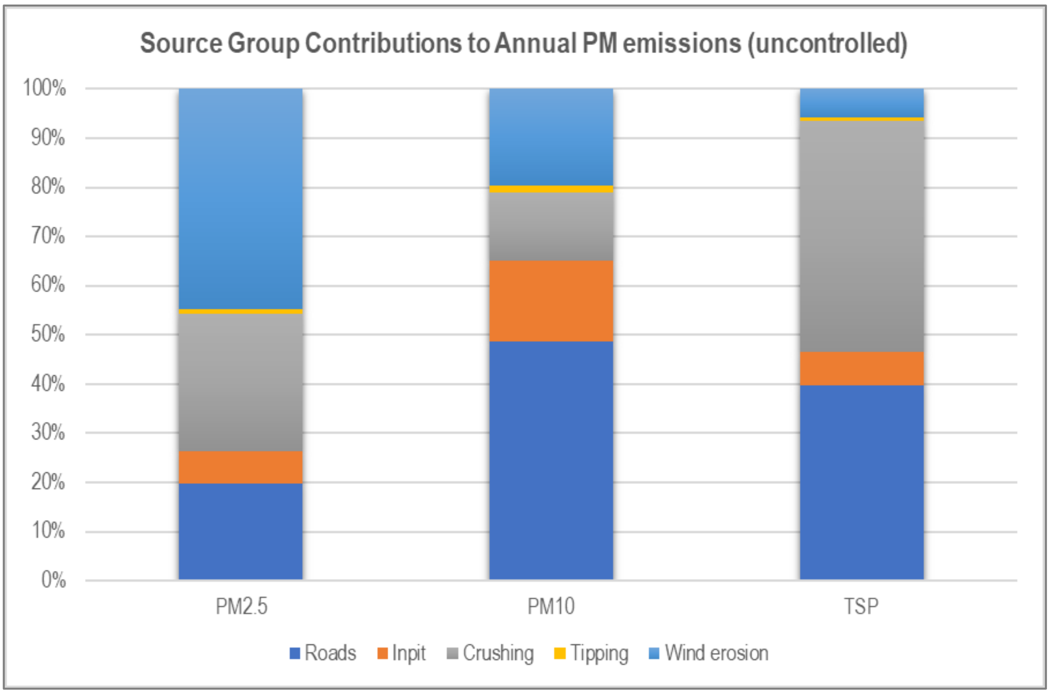


Figure 39: Source group contributions to estimated annual PM emissions (Operational phase – uncontrolled)

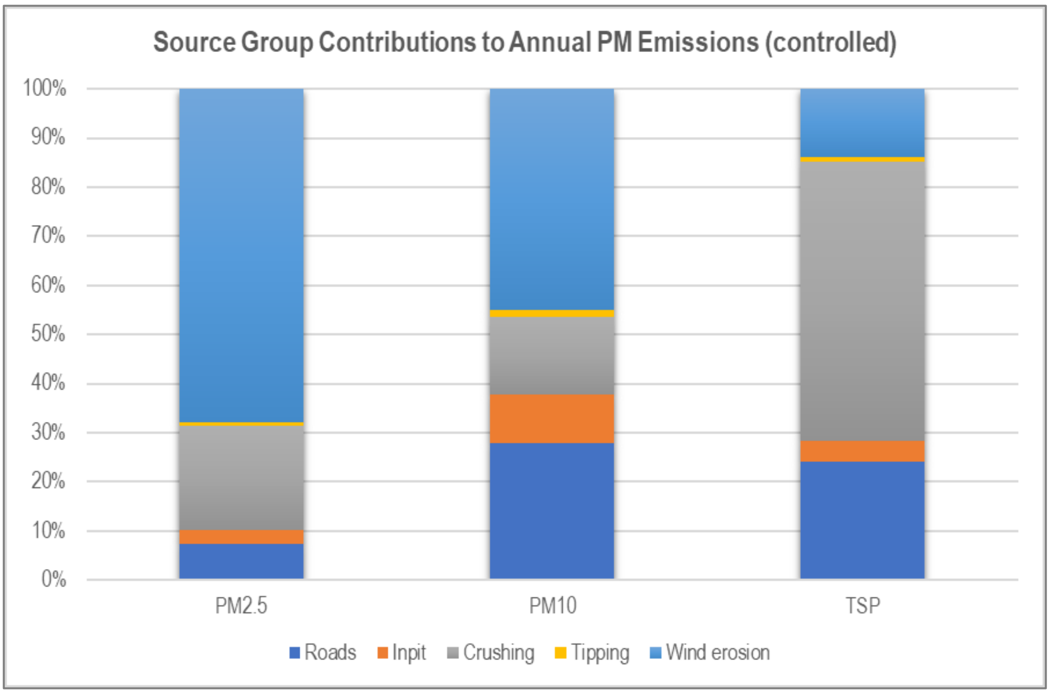


Figure 40: Source group contributions to estimated annual PM emissions (Operational phase – controlled)

13.1.2 Impacts

Simulated impacts due to Scenario 2 were ranked for PM_{10} only, since isopleth plots for PM_{10} showed the highest impacts of all the pollutants (see Figure 26, Figure 32, Figure 36 for comparison purposes). Uncontrolled PM_{10} impacts depicted in Figure 41 show the main source to be unpaved roads, followed by the in-pit source. For controlled Scenario 2 operations unpaved roads remain the largest contributor although the crushing source becomes a larger contributor to simulated PM_{10} impacts at AQSRs to the north and northeast (Figure 42).

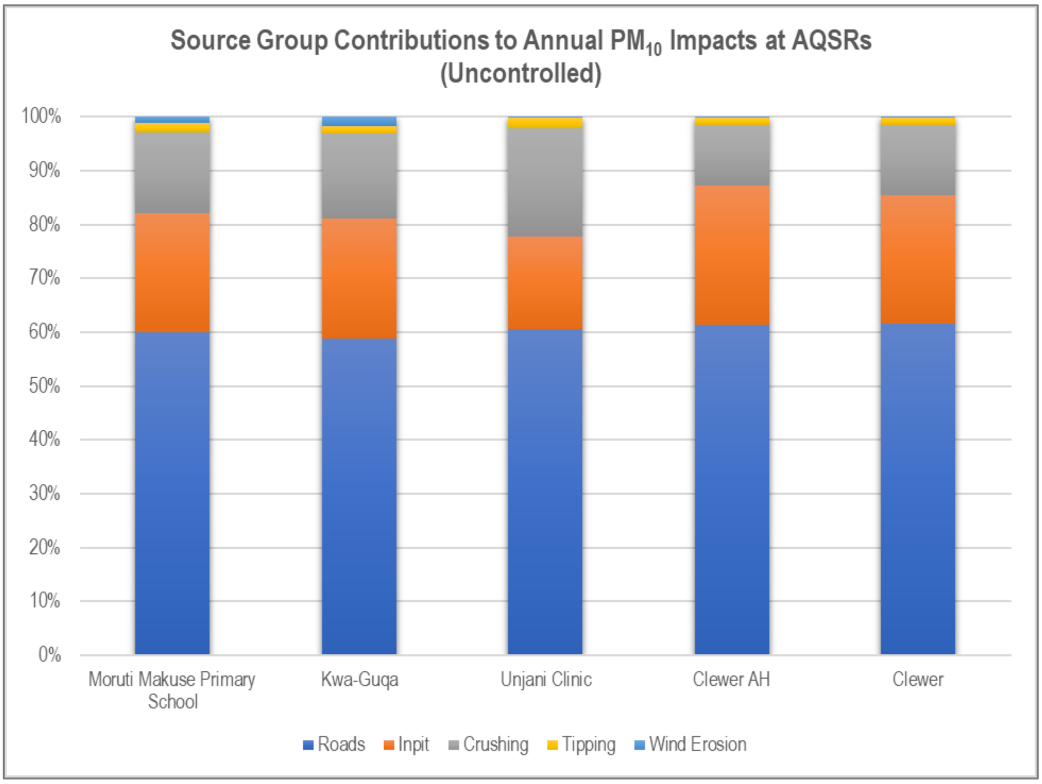


Figure 41: Source group contribution to annual average PM_{10} concentrations (Operational phase – uncontrolled)

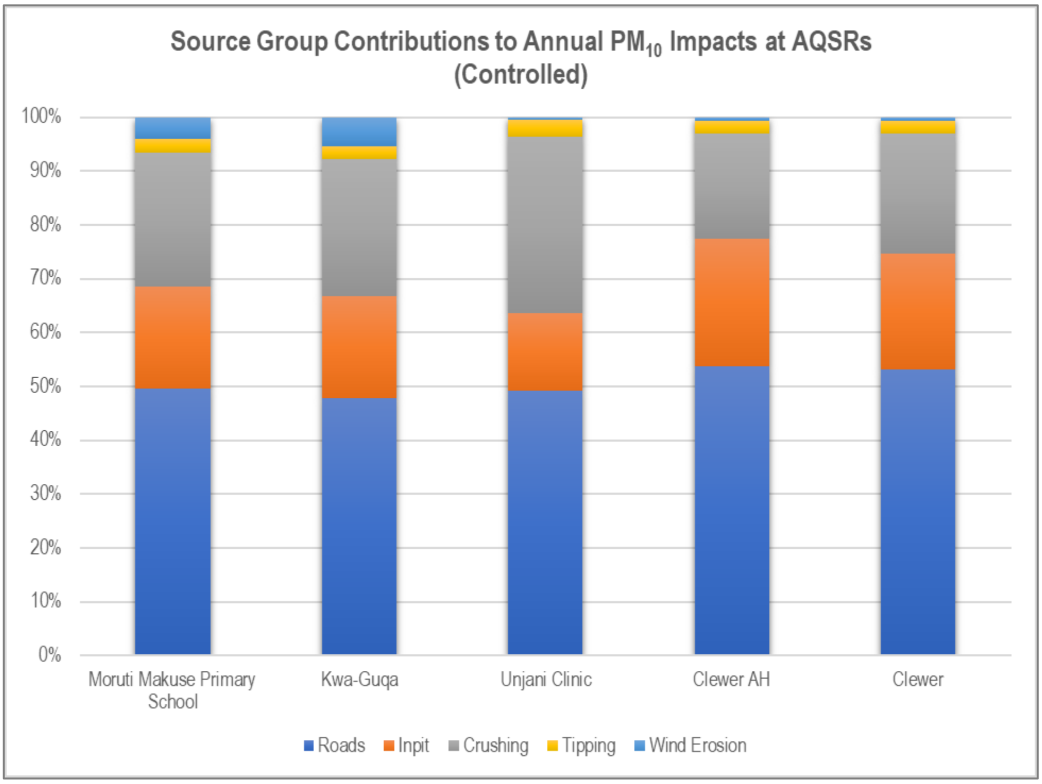


Figure 42: Source group contribution to annual average PM_{10} concentrations (Operational phase – controlled)

13.2 Proposed Mitigation and Management Measures

13.2.1 Proposed Mitigation Measures and/or Target Control Efficiencies

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

- Construction and closure phases:
  - Air quality impacts during construction and closure would be reduced through basic control measures such as limiting the speed of haul trucks; limit unnecessary travelling of vehicles on untreated roads; and to apply water sprays on regularly travelled, unpaved sections.
  - When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and the material transported must be covered to minimise windblown dust.
  - The access road to the Project also needs to be kept clean to minimise carry-through of mud on to public roads.
- Operational phase – the recommended mitigation measures for the proposed operations are shown in Table 38.
- Decommission phase – the recommended mitigation measures for the decommissioning operations are shown in Table 39.

Table 38: Air Quality Management Plan – Operation Phase

Aspect	Impact	Management Actions/Objectives	Responsible Person(s)	Target Date
Vehicle activity on unpaved roads	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Regular water sprays on unpaved roads to ensure at least 75% control efficiency. • Monthly physical inspection of road surface, daily visual observation of entrained dust emissions from unpaved road surfaces.	Environmental Manager	On-going during operational phase
Materials Handling	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Increase in-pit material moisture content. • Drop height from excavator into haul trucks to be kept at a minimum for ore and waste rock. • Tipping onto ROM storage piles to be controlled through water sprays, should significant amounts of dust be generated. • Keep material handled by dozers and wheeled loaders moist to achieve a control efficiency of 50%, especially during dry periods. • Regular clean-up at loading areas.	Mine Production Engineer Environmental Officer	On-going during operational phase
Wind Erosion	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	• Water sprays at ROM stockpile can achieve 50% control efficiency. Increase in moisture content provides higher threshold friction velocity and ensures that particulates are not as easily entrained due to high surface winds. • Reshape all disturbed areas to their natural contours. • Cover disturbed areas with previously collected topsoil and replant native species. • Rock cladding with larger pieces of waste rock is recommended to reduce wind erosion emissions from the overburden storage piles. • Revegetation of overburden stockpile is recommended.	Mining Engineer Environmental Officer	On-going during operational phase

Table 39: Air Quality Management Plan - Decommission Phase

Aspect	Impact	Management Actions/Objectives	Responsible Person(s)	Target Date
Wind erosion from exposed areas	PM_{10} and $PM_{2.5}$ concentrations and dust fallout	Demolition of infrastructure to have water sprays where vehicle activity is high. Rehabilitation and vegetation of mined area.	Contractor(s) Environmental Manager	Post-operational, can cease once rehabilitation is in place

14 Findings and Recommendations

The baseline study assessed the potential for air quality impacts from the planned underground and opencast operations at Elandsfontein Colliery. All available project and associated data, including meteorological data, previous air quality assessments, EIAs and technical air quality data were evaluated together with the planned mine design and schedule[8]. The air quality impact assessment findings are based on the quantitative assessment of the potential impacts due to the planned operations at the Elandsfontein Project. The main findings from the baseline and impact assessments are presented in Section 14.1. The conclusions and recommendations are included in Section 14.2.

14.1 Main Findings

14.1.1 Baseline Assessment

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

- Meteorological data was obtained for the period Jan 2016 – Dec 2018 from the DEFF station in Emalahleni, located about 10 km to the east-northeast of the mine.
- The prevailing wind field in the area consists of northerly, easterly and east-southeasterly winds, with infrequent winds from the south and west. During the day, winds at higher wind speeds occurred more frequently from the north whereas at night-time the airflow shifts to more frequent winds from the east and east-southeast but at somewhat lower wind speeds. Day-time calms occurred for 3.6% of the time, with night-time calms for 7.6% of the time.
- Wind speeds exceeding 5.4 m/s occurred for 7.9% over the three years.
- The area experiences mild summers and cold winters with monthly average temperatures of between -2.1°C and 20.7°C.
- Average annual rainfall amounts to 730 mm per annum (November to April) with an average annual evaporation rate of 1500 mm (CPR, 2019).
- Air quality sensitive receptors (AQSRs) around the mine include the residential areas of Clewer immediately to the east, Kwa-Guqa 4 km to the north-northeast, Ackerville 7 km to the northeast, Phola 9 km to the southwest and Emalahleni 10 km to the east.
- Elandsfontein Mine is located within the Highveld Priority Area.
- Ambient air pollutant levels in the project area are currently affected by the following sources of emission:

[8] An updated mine layout was made available in November 2020, after the impact assessment had been completed. The main difference (as seen from an air quality perspective) is the increased size of the topsoil stockpiles. Additional air quality impact due to this layout change will be due to wind erosion. Since wind erosion is not a significant contributor to total particulate impact at the nearest AQSRs, the conclusions from the original study are still valid and remain unchanged.

- Ambient air pollutant levels in the project area are currently affected by the following sources of emission: Coal Fired Power Plants – Kusile some 13 km to the west with Duvha Power Station approximately 21 km to the east.
- Industrial (metallurgical) operations – Transalloys is located northeast of Elandsfontein Colliery; Highveld Steel is located to the north; and Ferro Metals is located in the western part of Emalahleni some 6 km away.
- Opencast and underground mines – Greenside Colliery is located 4 km to the east with other coal mines within a 10 km radius including Landau Colliery to the north and Tweefontein- and Klipspruit mines to the south.
- Other sources – including domestic fuel burning; vehicle entrained dust on paved and unpaved roads; vehicle tailpipe emissions; and, agriculture.

- Monitoring data from the DEFF Emalahleni station (approximately 9 km east-northeast of the mine) for the period January to December 2018 was analysed. SO_2 and NO_2 ambient concentrations are within acceptable levels within the Emalahleni area, but ambient PM concentrations are elevated exceeding both the daily and annual NAAQS for PM_{10} and $PM_{2.5}$.
- Time series plots of ambient SO_2, NO_2 and PM_{10} concentrations show residential fuel burning contributions to SO_2 and NO_2 concentrations especially during the winter months, traffic contributions to NO_2 concentrations and more general industrial, mining and fuel burning contributions to PM.
- 2017 AQIA Report Review: The AQIA Report compiled for Elandsfontein Colliery by DWE in August 2017 was assessed as part of the baseline to determine whether the methodology followed is defendable; and whether the modelled results are regarded representative of the operations. As far as could be ascertained, the study followed the correct methodology for an air quality impact assessment. An underestimation in the emissions from the crushers was noted but not enough information was provided to verify all the calculations. The meteorological data used in the model is acceptable, and the dispersion model used is in line with the regulations. The modelled results, even though very high, could be possible; however, the area of exceedance from the modelled results seemed extensive given the emission rates reported. Only unmitigated results were provided for PM_{10} and $PM_{2.5}$, where a mitigated modelling scenario would have assisted in the understanding of the potential impacts from the mine with controls in place. The reduction in the dustfall rates between unmitigated and mitigated indicated a significant improvement due to mitigation measures.

14.1.2 Impact Assessment

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. To determine the significance of air pollution impacts due to the operational phase of the Project, emissions were quantified for three modelling scenarios:

- Scenario 1 – representative of opencast mining activities (Blocks F and G) and underground mining (Blocks B and C) for Year 2;

- Scenario 2 – representative of opencast mining activities (Block H) and underground mining (Block D) for Year 3; and
- Scenario 3 – representative of underground mining activities (Block A) for Year 5.

The main findings from the impact assessment due to the Project operations are as follows:

- The main contributors to uncontrolled emissions during the operational phase were found to be crushing and wind erosion for $PM_{2.5}$, unpaved roads and wind erosion for PM_{10}, and unpaved roads and crushing for TSP. With mitigation, although the unpaved roads contribution is much reduced; the main contributing sources to $PM_{2.5}$, PM_{10} and TSP emissions remain the same.
- Dispersion modelling results are as follows:
  - ***PM_{10}*** daily GLCs, with or without mitigation in place, are not likely to exceed the NAAQS at any of the AQSRs. Over an annual average the GLCs are within the standard at all receptors.
  - ***$PM_{2.5}$*** daily GLCs, for both unmitigated and mitigated activities, are not likely to exceed the NAAQS at any of the AQSRs. Over an annual average the GLCs are within the standard at all receptors.
  - Maximum daily **dustfall** rates due to both unmitigated and mitigated scenarios were within the NDCR for residential areas at all AQSRs.
- The simulated footprint areas of exceedance for PM_{10} and $PM_{2.5}$ impacts were found to be much larger for Scenario 2 than for Scenarios 1 or 3. This increase in magnitude may be explained the higher waste production (overburden and topsoil), and the relative location of opencast mining activities (southeast of the CHPP, in near proximity to the closest AQSR to the east of the mine boundary) and underground mining activities (located to the northwest of the CHPP, in close proximity to the closest AQSR to the north of the mine boundary).
- The main sources of impacts due to uncontrolled emissions during the operational phase were found to be unpaved roads, followed by in-pit sources. For controlled operations unpaved roads remains the largest contributor although the crushing source becomes a larger contributor at AQSRs to the north and northeast of the mine boundary.
- The significance rating for the operational phase was **Medium negative** for uncontrolled operations and **Low negative** for mitigated operations.
- The impact significance associated with the construction and closure phases was determined as **Low negative**.

The main findings from the GHG impact assessment are as follows:

- The total CO_2-e emissions for Elandsfontein operations is not likely to be more than 203 544 tpa. The calculated CO_2-e emissions from the proposed project operations contribute less than 0.04% to the total of the national inventory's GHG emissions (excluding land-use change and forestry) and 0.5% to the national inventory's "manufacturing industry and construction" sector GHG emissions.
- GHGs were declared priority pollutants in March 2014 and pollution prevention plans must be developed if the operation contributes more than 100 000 tons CO_{2eq} emissions. The scope 1 GHG contribution due

to the proposed mining operations is below 100 000 tons. Based on this, a Pollution Prevention Plan is not required for the proposed project operations.

- The GHG emissions from the proposed operational phase are not likely to result in a noteworthy contribution to climate change on its own.
- The project and the community are likely to be negatively impacted by climate change, the project less than the community due to the short time that operations are likely to occur.

14.2 Conclusions and Recommendations

The conclusion from the impact assessment is that cumulative impacts due to the planned mining operations would have a “Medium negative” significance on the surrounding environment and human health during the operational phase, even after mitigation is applied, due to the increased mining and production rates and the close proximity of AQSR (Clewer) to the planned mining operations.

The proposed Project operations should not result in significant ground level concentrations or dustfall levels at the nearby receptors provided the design mitigation measures are applied effectively. From an air quality perspective, the proposed project can be authorised permitted the recommended mitigation measures are applied.

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

- Construction and closure phases:
  - Air quality impacts during construction would be reduced through basic control measures such as limiting the speed of haul trucks; limit unnecessary travelling of vehicles on untreated roads; and to apply water sprays on regularly travelled, unpaved sections.
  - When haul trucks need to use public roads, the vehicles need to be cleaned of all mud and the material transported must be covered to minimise windblown dust.
  - The access road to the Project also needs to be kept clean to minimise carry-through of mud on to public roads.
- Operational phases:
  - For the control of vehicle entrained dust it is recommended that water (at an application rate >2 litre/m^2/hour), be applied. Literature reports an emissions reduction efficiency of 75%.
  - In controlling dust from crushing and screening operations, it is recommended that water sprays be applied to keep the ore wet, to achieve a control efficiency of up to 50%.
  - Mitigation of materials transfer points should be done using water sprays at the tip points. This should result in a 50% control efficiency. Regular clean-up at loading points is recommended.
  - In minimizing windblown dust from stockpile areas, water sprays should be used to keep surface material moist. A mitigation efficiency of 50 % is anticipated.
- Continuous monitoring of dustfall must be conducted as part of the Project’s air quality management plan.

15 Assumptions, Uncertainties and Gaps in Knowledge

The main assumptions, exclusions and limitations are summarized below:

- Meteorological data: no onsite meteorological data was available and measured data from the Department of Environment, Forestry and Fisheries (DEFF) station in Emalahleni was obtained for the period January 2016 – December 2018. The data is regarded representative with the station located approximately 9 km to the east-northeast of the mining offices.
- Information: All project/process related information referred to in this study was obtained from the Independent Competent Person's (CPR) Report, dated 30 October 2019 (CPR, 2019); the Mining Works Programme (MWP), dated January 2020 (MWP, 2020); and the Air Quality Impact Assessment report by Digby Wells Environmental, dated August 2017 (DWE, 2017). It was assumed that this information is correct.
- Impacts: The impact of the operational phase was determined quantitatively through emissions calculation and dispersion simulation. Due to their temporary nature, the assessment of impacts from the construction and closure phases is mainly of a qualitative nature. A general estimation of emissions due to the construction phase was provided. No impacts are expected post-closure provided the rehabilitation of final landforms is successful.
- Emissions:
    - The impact assessment was limited to airborne particulates (including TSP, PM_{10} and $PM_{2.5}$). These pollutants are either regulated under NAAQS or considered a key pollutant released by this operation.
    - The quantification of sources of emission was restricted to the proposed Project. Although other existing sources of emission within the area were identified, such sources were not quantified as part of the emissions inventory and simulations. Their impact would be considered by ambient air quality monitoring in the region.
    - In the absence of detailed construction and decommissioning plans, fugitive dust emissions for these phases were discussed qualitatively.
- Uncertainty of modelled results:
    - There will always be some error in any geophysical model; however, modelling is recognised as a credible method for evaluating impacts, but it is desirable to structure the model in such a way to minimise 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.
    - The stochastic uncertainty includes all errors or uncertainties in data such as source variability, observed concentrations, and meteorological data. Even if the field instrument accuracy is excellent, there can still be large uncertainties due to unrepresentative placement of the instrument (or taking of a sample for analysis). Model evaluation studies suggest that the data input error term is often a major contributor to total uncertainty. Even in the best tracer studies, the source emissions are known only with an accuracy of ±5%, which translates directly into a

minimum error of that magnitude in the model predictions. It is also well known that wind direction errors are the major cause of poor agreement, especially for relatively short-term predictions (minutes to hourly) and long downwind distances. All of the above factors contribute to the inaccuracies not even associated with the mathematical models themselves.

- A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Although the model has been shown to be an improvement on the ISC model, especially short-term predictions, the range of uncertainty of the model predictions is -50% to 200%. The accuracy improves with fairly strong wind speeds and during neutral atmospheric conditions.

16 References

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Appendix A – Specialist Declaration

I, Rochelle Bornman, as the appointed independent air quality specialist for the Elandsfontein Colliery Project, hereby declare that I:

- acted as the independent specialist in this impact assessment;
- performed the work relating to the study in an objective manner;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct,
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment;
- declare that there are no circumstances that may compromise my objectivity in performing such work;
- have expertise in conducting the specialist report relevant to this application;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- have no vested interest in the proposed activity proceeding;
- undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing the decision of the competent authority; and
- all the particulars furnished by us in this specialist input/study are true and correct.

Signature of the specialist: 

Name of Specialist: Rochelle Bornman

Date: August 2020

Appendix B – Specialist Curriculum Vitae

CURRICULUM VITAE

Name	Rochelle Bornman
Date of Birth	24 August 1974
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Air Quality Specialist
Profession	Scientist
Years with Firm	10

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Member of National Association for Clean Air (NACA)

EXPERIENCE

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

EDUCATION

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

COURSES COMPLETED AND CONFERENCES ATTENDED

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

COURSES PRESENTED

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

COUNTRIES OF WORK EXPERIENCE

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

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Full professional proficiency

REFERENCES

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

CERTIFICATION

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

Appendix C – Time Series Plots for the Measured Ambient Air Quality in the Study Area

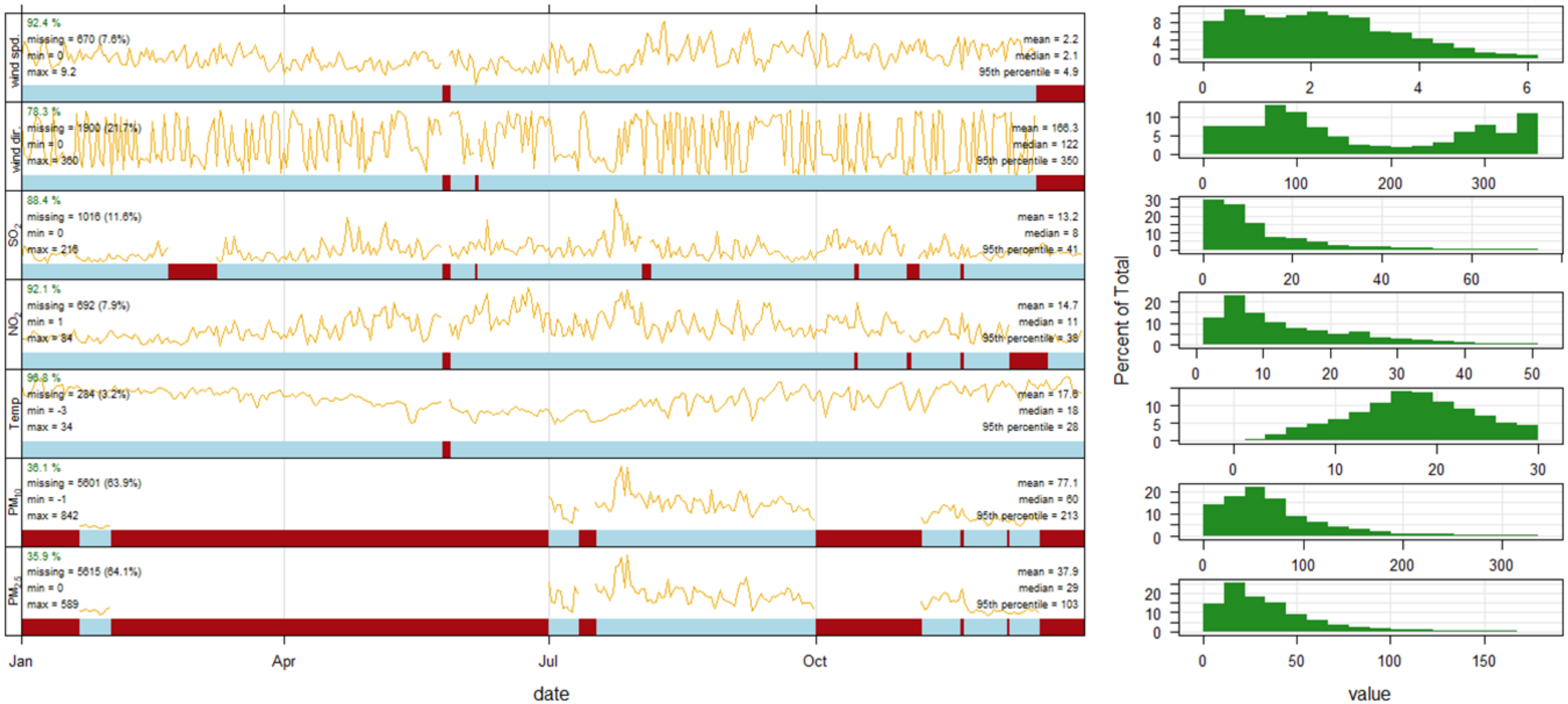

Figure 43: Data available from the DEFF Emalahleni ambient air quality monitoring station (2018)

Appendix D – Field Log Sheets

YANKALABS

sanas South African National Accreditation System

T0647

Geo Soil and Water CC
Tel: 082 648 4765
Fax: 086 654 3631
E-mail: louis@geosoilwater.co.za
Web: www.geosoilwater.co.za
VAT No 4420244586
Postnet Suite C319 Private Bag X18 Lynnwood Ridge 0040
15A Midas Ave, Olympys, Pretoria

Project	Elandsfontein Colliery
Monitoring Month	Oct-19
Monitoring Occasion	Monthly Dust Fallout Monitoring
Date of Sampling	02/10/2019 to 03/10/2019

Analyses Required: Dust Fallout

	Locality ID	Time / Date	Sampled	Date on	Date off	Days	Comment/Observations
✓	EFD North	15:25	Yes	02-Sep-19	02-Oct-19	30	Dust – Dry
✗	EFD East	09:30	No	02-Sep-19	02-Oct-19	~~30~~	~~Monitored by WSP~~ On 2/10/19
✓	EFD Clewer	10:00	Yes	02-Sep-19	02-Oct-19	30	Coal dust – Wet.
✓	EFD South	12:40	Yes	02-Sep-19	02-Oct-19	30	Dust – Wet
✓	EFD South West	13:10	Yes	02-Sep-19	02-Oct-19	30	Dust – Dry
✓	EFD West	13:50	Yes	02-Sep-19	02-Oct-19	30	Dust – Dry
✗	EFD MD North	12:06	No	02-Sep-19	02-Oct-19	30	Stand + buckets stolen.
✗	EFD MD East	12:06	No	02-Sep-19	02-Oct-19	30	Stand + buckets stolen.
✗	EFD MD South	12:06	No	02-Sep-19	02-Oct-19	30	Stand + buckets stolen.
✗	EFD MD West	12:06	No	02-Sep-19	02-Oct-19	30	Stand + buckets stolen.

Sent by: L Marais

Received by: Yanica Labs

Date: 2019/10/08

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T0647

Project	Elandsfontein Colliery
Monitoring Month	Nov-19
Monitoring Occasion	Monthly Dust Fallout Monitoring
Date of Sampling	04/11/2019 to 04/11/2019

Analyses Required		Locality ID	Time / Date	Sampled	Date on	Date off	Days	Comment/Observations
Dust Fallout	✓	EFD North	13:55	Yes	02-Oct-19	04-Nov-19	33	Clear - Water
	✓	EFD East	14:25	Yes	02-Oct-19	04-Nov-19	33	Clear - Water
	✓	EFD Clewer	14:05	Yes	02-Oct-19	04-Nov-19	33	Clear - Water.
	✓	EFD South	12:05	Yes	02-Oct-19	04-Nov-19	33	Clear - Water
	✓	EFD South West	12:30	Yes	02-Oct-19	04-Nov-19	33	Clear - Water
	✓	EFD West	13:05	Yes	02-Oct-19	04-Nov-19	33	Clear - West.
Sent by: L Marais	✓	EFD South East	11:00	No	04-Nov-19	-	-	On 4/11/19
Received by: Elize Smit								
Date: 8/11/19								

Appendix E – 2017 Air Quality Specialist Report Review

An Air Quality Impact Assessment (AQIA) Report was compiled by Digby Wells Environmental (DWE) for Elandsfontein Colliery in August 2017 (DWE, 2017). The AQIA was one of the specialist studies required to amend the approved Environmental Management Plan (EMP) and renewal of Mining Right (MR) MP 314 MR for the Elandsfontein Colliery. The study focused only on MP 314 MR and the activities associated with this part of the Colliery.

Emissions Inventory

Air emissions were limited to activities associated with the operational phase and only included particulates ($PM_{2.5}$, PM_{10}, and dust fallout) with gaseous emissions such as SO_2, NOx, CO and hydrocarbons (HC) from vehicle exhaust emissions assumed to be negligible. The following mining activities associated with the MP314 MR were assessed:

- Drilling and blasting;
- Materials handling operations;
- Vehicle entrainment on unpaved roads during hauling of material; and
- Wind erosion from exposed area and volume sources.

Emissions were quantified using the US EPA and Australian NPI emission factors. The amount of coal processed was taken to be 720,000 tpa with operational hours of 8760 per annum (DWE, 2017).

<u>Review Comment</u>

The methodology followed in the quantification of the emissions are correct. The omission of gaseous emissions is not regarded a significant gap in the assessment, however tailpipe combustion from haul trucks could contribute notably to NO_2 concentrations. It is agreed that particulates matter is the main pollutant of concern from opencast mining activities. The amount of emissions (tpa) from each of the activities as provided in Table 8-6 of the DWE report seem in line with emissions from opencast coal mining operations of a similar size, except for the crusher emissions which appear to be underestimated. The throughput at the crusher is given as 720,000 tpa, operating for 8760 hours a year and a coal moisture of 3.4%. A control efficiency of 75% was assumed from the dust suppression system. When the low moisture emission factor as provided in Table 8-3 of the DWE report is applied (high moisture material is >4%), then the mitigated emissions from the primary and secondary crushers are 50 times higher for PM_{10} and 100 times higher for TSP. Not all the emission calculations could be verified due to insufficient detailed information.

Meteorological data

MM5 modelled meteorological data (2013-2015) from Lakes Environmental Software was analysed and used to generate wind rose plots and determine the local prevailing weather conditions.

Review Comment

The use of MM5 data for a location at the mine is an accepted approach. The DEFF ambient monitoring station in Emapahleni provides actual measured data and is regarded representative of the mining area. By comparing the wind roses from the MM5 data to the DEFF ambient monitoring station wind roses, the prevailing wind field is similar with the MM5 wind speeds slightly stronger than the measured DEFF data.

Dispersion Modelling

The USA Environmental Protection Agency's Preferred/Recommended Models: AERMOD modelling system (as of December 9, 2006, AERMOD is fully promulgated as a replacement to ISC3 model) was used for the simulation of potential impacts form the project.

The modelling results indicated elevated PM_{10} and $PM_{2.5}$ concentrations exceeding the NAAQSs at the mine boundary and selected receptors without mitigation measures in place. Similarly, the modelled dustfall rates exceeded the non-residential limit for a large area when no mitigation was applied. It was found that emissions from haul roads, drilling and blasting activities were the main contributors.

Review Comment

The dispersion model used is in line with the Air Dispersion Modelling Regulations (see Section 6.4). The area of exceedance from the modelled results seem extensive given the emission rates reported. It is however very difficult to determine whether this is an overestimation of the impacts. Only unmitigated impacts are shown for PM_{10} and $PM_{2.5}$ concentrations with no indication as how the impact area would reduce with mitigation in place. This is only provided for dust fallout where there is a significant reduction in the impact area after mitigation is applied. The significance rating given to the modelled impacts seem too low based on the extent of the modelled impact area.

To put the review comments in context a sensitivity map for the expansion Project was created based on the 2017 Specialist Report and informed by the annual dispersion modelling plots for PM_{10} and $PM_{2.5}$.

The sensitivity was classified as follows (Figure 44):

- “High” is the area where the concentrations are expected to be in non-compliance with the NAAQS.
- “Medium” is the area is where there will be likely single exceedances of the NAAQS limit values but not resulting in non-compliance.
- “Low” area is where there is likely a low significant effect on human health and well-being.

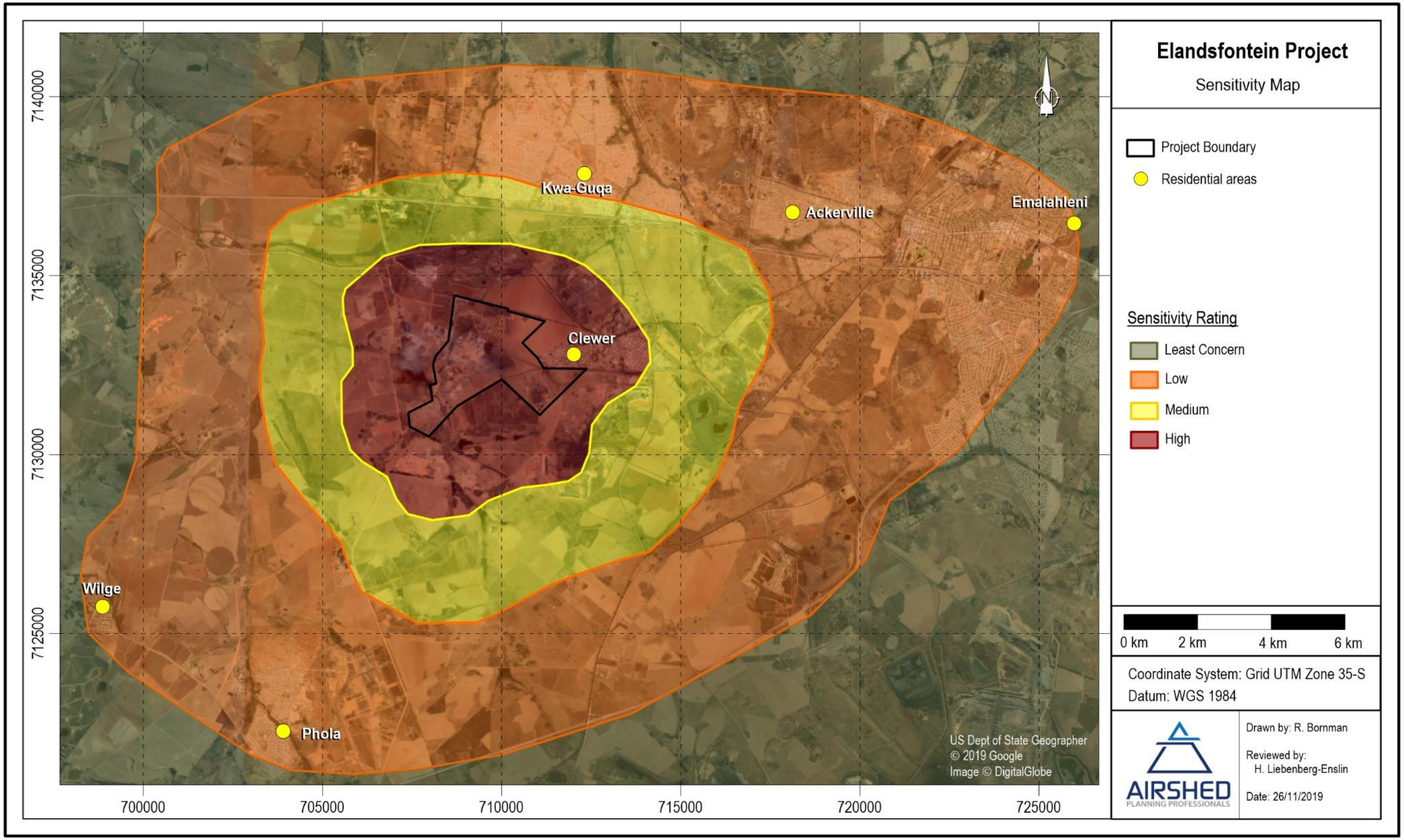

Figure 44: Air quality sensitivity map for the Elandsfontein project (based on the 2017 AQIA Specialist Report)

Appendix F – Dispersion Modelling Results

Table 40: Simulated PM_{10} ground level concentrations (in µg/m³) at all identified AQSRs – Scenario 1

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	18.55	1.15	No	0	7.92	0.46	No	0
2	Kwa-Guqa	9.14	0.43	No	0	3.93	0.18	No	0
3	Unjani Clinic	7.56	0.38	No	0	3.01	0.15	No	0
4	Clewer AH	24.44	2.12	No	0	9.50	0.79	No	0
5	Clewer	16.91	0.96	No	0	6.05	1.67	No	0
6	Phola	4.72	0.26	No	0	1.93	0.10	No	0
7	Ackerville	5.21	0.26	No	0	1.90	0.10	No	0
8	eMalahleni	2.36	0.13	No	0	0.83	0.05	No	0
9	Wilge	4.51	0.23	No	0	1.98	0.09	No	0
10	Itireleng Primary School	5.65	0.25	No	0	2.46	0.10	No	0
11	St Thomas Aquinas school	3.14	0.16	No	0	1.29	0.06	No	0
12	Laerskool Taalfees	3.22	0.18	No	0	1.19	0.07	No	0
13	Leonard Ntshuntshe Secondary School	8.87	0.39	No	0	3.97	0.16	No	0
14	Robert Carruthers School	3.06	0.18	No	0	1.11	0.07	No	0
15	Thuthukani Primary School	4.59	0.24	No	0	2.13	0.09	No	0
16	Hlangu Phala Primary School	4.77	0.24	No	0	2.43	0.10	No	0
17	Mabande C.h School	4.72	0.26	No	0	1.93	0.10	No	0
18	Sizanani Early Childhood School	4.81	0.24	No	0	2.40	0.10	No	0
19	Siyathokoza Primary School	4.89	0.27	No	0	1.84	0.10	No	0
20	Sukumani Primary School	4.64	0.25	No	0	1.97	0.10	No	0
21	Mehlwana Secondary School	5.07	0.28	No	0	2.58	0.11	No	0
22	Makause Combined School	5.14	0.30	No	0	2.24	0.12	No	0
23	Gekombineerde Skool Ogies	4.01	0.24	No	0	2.06	0.10	No	0
24	Bonisana Primary School	3.95	0.28	No	0	1.33	0.11	No	0
25	Dunbar Primary School	10.23	0.66	No	0	4.16	0.26	No	0
26	Phillip Ndimande Secondary School	5.82	0.28	No	0	2.59	0.12	No	0
27	Zacheus Malaza Secondary School	9.14	0.43	No	0	3.93	0.18	No	0
28	Besilindile Primary School	6.07	0.30	No	0	2.45	0.12	No	0
29	Life Cosmos Hospital	2.75	0.18	No	0	1.17	0.07	No	0
30	Witbank Hospital	3.35	0.16	No	0	1.19	0.06	No	0
31	Emalahleni Private Hospital	3.33	0.17	No	0	1.30	0.07	No	0
32	Anglo Coal Highveld Hospital	3.90	0.17	No	0	1.39	0.07	No	0
33	Impungwe Hospital	1.31	0.07	No	0	0.51	0.03	No	0
34	Emalahleni Day Hospital	3.34	0.17	No	0	1.30	0.07	No	0
35	Louis Street Clinic	2.90	0.18	No	0	1.27	0.07	No	0
36	Poly Clinic	4.36	0.26	No	0	1.70	0.10	No	0
37	Hlalanikahle Clinic	6.84	0.35	No	0	2.95	0.14	No	0
38	Beatty Clinic	3.72	0.19	No	0	1.33	0.07	No	0
39	Empumelelweni CHC Clinic	9.44	0.56	No	0	4.65	0.22	No	0
40	Green Cross Clinic	3.58	0.18	No	0	1.36	0.07	No	0
41	Life Occupational Health Clinic	3.65	0.18	No	0	1.33	0.07	No	0

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
42	Top Med Women's Clinic	3.74	0.18	No	0	1.70	0.07	No	0
43	Phola Community Centre Clinic	4.58	0.24	No	0	1.75	0.09	No	0
44	Lynnville Clinic	4.27	0.23	No	0	1.84	0.09	No	0
45	Tomas Mahlangu Ville Clinic	5.08	0.25	No	0	1.85	0.10	No	0
46	Mine Boundary (max)	288.2	29.0	Yes	18	286.4	12.13	Yes	8

Table 41: Simulated PM_{10} ground level concentrations (in µg/m³) at all identified AQSRs – Scenario 2

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	31.47	2.34	No	0	8.27	0.71	No	0
2	Kwa-Guqa	14.90	0.87	No	0	4.37	0.27	No	0
3	Unjani Clinic	12.95	0.59	No	0	3.55	0.18	No	0
4	Clewer AH	78.28	5.58	No	2	21.45	1.59	No	0
5	Clewer	33.00	2.31	No	0	8.59	0.67	No	0
6	Phola	7.16	0.40	No	0	1.83	0.12	No	0
7	Ackerville	10.78	0.52	No	0	2.93	0.16	No	0
8	eMalahleni	5.24	0.22	No	0	1.41	0.07	No	0
9	Wilge	5.20	0.33	No	0	1.68	0.10	No	0
10	Itireleng Primary School	8.20	0.43	No	0	2.35	0.13	No	0
11	St Thomas Aquinas school	7.94	0.32	No	0	2.17	0.10	No	0
12	Laerskool Taalfees	6.39	0.32	No	0	1.74	0.10	No	0
13	Leonard Ntshuntshe Secondary School	13.39	0.85	No	0	3.90	0.26	No	0
14	Robert Carruthers School	7.03	0.30	No	0	1.99	0.09	No	0
15	Thuthukani Primary School	7.00	0.39	No	0	1.81	0.12	No	0
16	Hlangu Phala Primary School	8.49	0.41	No	0	2.19	0.13	No	0
17	Mabande C.h School	7.17	0.40	No	0	1.83	0.12	No	0
18	Sizanani Early Childhood School	8.62	0.42	No	0	2.22	0.13	No	0
19	Siyathokoza Primary School	6.49	0.42	No	0	1.76	0.13	No	0
20	Sukumani Primary School	7.11	0.39	No	0	1.82	0.12	No	0
21	Mehlwana Secondary School	11.17	0.59	No	0	2.83	0.18	No	0
22	Makause Combined School	7.35	0.46	No	0	1.94	0.14	No	0
23	Gekombineerde Skool Ogies	6.49	0.41	No	0	1.86	0.12	No	0
24	Bonisana Primary School	10.56	0.65	No	0	3.18	0.19	No	0
25	Dunbar Primary School	16.24	1.00	No	0	6.40	0.32	No	0
26	Phillip Ndimande Secondary School	11.40	0.54	No	0	2.90	0.16	No	0
27	Zacheus Malaza Secondary School	14.90	0.87	No	0	4.37	0.27	No	0
28	Besilindile Primary School	9.96	0.57	No	0	2.86	0.17	No	0
29	Life Cosmos Hospital	5.94	0.31	No	0	1.64	0.09	No	0
30	Witbank Hospital	6.82	0.30	No	0	1.84	0.09	No	0
31	Emalahleni Private Hospital	8.22	0.35	No	0	2.24	0.10	No	0
32	Anglo Coal Highveld Hospital	6.86	0.34	No	0	1.86	0.10	No	0
33	Impungwe Hospital	2.39	0.12	No	0	0.68	0.04	No	0

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
34	Emalahleni Day Hospital	8.25	0.35	No	0	2.24	0.10	No	0
35	Louis Street Clinic	5.97	0.31	No	0	1.56	0.10	No	0
36	Poly Clinic	8.94	0.51	No	0	2.61	0.15	No	0
37	Hlalanikahle Clinic	12.91	0.68	No	0	3.29	0.21	No	0
38	Beatty Clinic	8.07	0.36	No	0	2.04	0.11	No	0
39	Empumelelweni CHC Clinic	15.65	1.00	No	0	4.66	0.31	No	0
40	Green Cross Clinic	9.17	0.35	No	0	2.51	0.11	No	0
41	Life Occupational Health Clinic	8.20	0.34	No	0	2.08	0.10	No	0
42	Top Med Women's Clinic	6.98	0.35	No	0	1.98	0.10	No	0
43	Phola Community Centre Clinic	6.74	0.37	No	0	1.78	0.12	No	0
44	Lynnville Clinic	9.01	0.43	No	0	2.29	0.13	No	0
45	Tomas Mahlangu Ville Clinic	10.54	0.51	No	0	2.88	0.15	No	0
46	Mine Boundary (max)	1485.3	179.5	Yes	204	373.3	46.56	Yes	60

Table 42: Simulated PM_{10} ground level concentrations (in µg/m³) at all identified AQSRs – Scenario 3

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	8.70	0.57	No	0	4.89	0.23	No	0
2	Kwa-Guqa	4.16	0.21	No	0	3.43	0.09	No	0
3	Unjani Clinic	3.20	0.16	No	0	1.33	0.06	No	0
4	Clewer AH	14.43	1.34	No	0	5.02	0.47	No	0
5	Clewer	9.00	0.55	No	0	3.69	0.20	No	0
6	Phola	1.81	0.11	No	0	0.73	0.04	No	0
7	Ackerville	2.30	0.12	No	0	0.90	0.05	No	0
8	eMalahleni	1.31	0.06	No	0	0.59	0.02	No	0
9	Wilge	2.44	0.10	No	0	1.08	0.04	No	0
10	Itireleng Primary School	2.48	0.12	No	0	1.02	0.04	No	0
11	St Thomas Aquinas school	1.47	0.08	No	0	0.71	0.03	No	0
12	Laerskool Taalfees	1.53	0.08	No	0	0.60	0.03	No	0
13	Leonard Ntshuntshe Secondary School	4.18	0.21	No	0	2.43	0.09	No	0
14	Robert Carruthers School	1.67	0.08	No	0	0.69	0.03	No	0
15	Thuthukani Primary School	2.13	0.11	No	0	0.81	0.04	No	0
16	Hlangu Phala Primary School	1.74	0.10	No	0	0.87	0.04	No	0
17	Mabande C.h School	1.81	0.11	No	0	0.73	0.04	No	0
18	Sizanani Early Childhood School	1.78	0.10	No	0	0.84	0.04	No	0
19	Siyathokoza Primary School	1.95	0.12	No	0	0.81	0.05	No	0
20	Sukumani Primary School	1.78	0.11	No	0	0.69	0.04	No	0
21	Mehlwana Secondary School	1.92	0.12	No	0	1.09	0.05	No	0
22	Makause Combined School	2.29	0.13	No	0	0.99	0.05	No	0
23	Gekombineerde Skool Ogies	1.62	0.10	No	0	0.64	0.04	No	0
24	Bonisana Primary School	2.03	0.14	No	0	0.72	0.05	No	0
25	Dunbar Primary School	4.94	0.30	No	0	3.11	0.13	No	0

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
26	Phillip Ndimande Secondary School	2.84	0.13	No	0	1.50	0.05	No	0
27	Zacheus Malaza Secondary School	4.16	0.21	No	0	3.43	0.09	No	0
28	Besilindile Primary School	2.34	0.15	No	0	0.93	0.06	No	0
29	Life Cosmos Hospital	1.50	0.08	No	0	0.60	0.03	No	0
30	Witbank Hospital	1.59	0.07	No	0	0.69	0.03	No	0
31	Emalahleni Private Hospital	1.54	0.08	No	0	0.75	0.03	No	0
32	Anglo Coal Highveld Hospital	1.45	0.08	No	0	0.59	0.03	No	0
33	Impungwe Hospital	0.60	0.03	No	0	0.20	0.01	No	0
34	Emalahleni Day Hospital	1.55	0.08	No	0	0.75	0.03	No	0
35	Louis Street Clinic	1.51	0.08	No	0	0.54	0.03	No	0
36	Poly Clinic	2.45	0.12	No	0	0.97	0.05	No	0
37	Hlalanikahle Clinic	3.10	0.17	No	0	1.48	0.07	No	0
38	Beatty Clinic	1.79	0.09	No	0	0.79	0.03	No	0
39	Empumelelweni CHC Clinic	4.32	0.26	No	0	2.03	0.11	No	0
40	Green Cross Clinic	1.66	0.08	No	0	0.71	0.03	No	0
41	Life Occupational Health Clinic	1.69	0.08	No	0	0.67	0.03	No	0
42	Top Med Women's Clinic	1.76	0.08	No	0	0.73	0.03	No	0
43	Phola Community Centre Clinic	1.92	0.11	No	0	0.76	0.04	No	0
44	Lynnville Clinic	2.10	0.11	No	0	0.94	0.04	No	0
45	Tomas Mahlangu Ville Clinic	2.25	0.12	No	0	0.88	0.04	No	0
46	Mine Boundary (max)	286.4	42.9	Yes	55	286.4	11.6	Yes	8

Table 43: Simulated $PM_{2.5}$ ground level concentrations (in µg/m³) at all identified AQSRs – Scenario 1

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	5.91	0.30	No	0	3.00	0.15	No	0
2	Kwa-Guqa	2.78	0.11	No	0	1.62	0.06	No	0
3	Unjani Clinic	2.10	0.10	No	0	1.08	0.05	No	0
4	Clewer AH	7.26	0.51	No	0	3.41	0.24	No	0
5	Clewer	5.17	0.24	No	0	2.47	0.11	No	0
6	Phola	1.22	0.07	No	0	0.64	0.03	No	0
7	Ackerville	1.35	0.07	No	0	0.63	0.03	No	0
8	eMalahleni	0.59	0.03	No	0	0.33	0.02	No	0
9	Wilge	1.24	0.06	No	0	0.62	0.03	No	0
10	Itireleng Primary School	1.53	0.06	No	0	0.93	0.03	No	0
11	St Thomas Aquinas school	0.92	0.04	No	0	0.43	0.02	No	0
12	Laerskool Taalfees	0.84	0.05	No	0	0.42	0.02	No	0
13	Leonard Ntshuntshe Secondary School	2.50	0.11	No	0	1.45	0.05	No	0
14	Robert Carruthers School	0.83	0.05	No	0	0.39	0.02	No	0
15	Thuthukani Primary School	1.21	0.06	No	0	0.71	0.03	No	0
16	Hlangu Phala Primary School	1.25	0.06	No	0	0.84	0.03	No	0
17	Mabande C.h School	1.22	0.07	No	0	0.64	0.03	No	0

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
18	Sizanani Early Childhood School	1.26	0.06	No	0	0.82	0.03	No	0
19	Siyathokoza Primary School	1.27	0.07	No	0	0.61	0.03	No	0
20	Sukumani Primary School	1.21	0.06	No	0	0.66	0.03	No	0
21	Mehlwana Secondary School	1.34	0.07	No	0	0.88	0.04	No	0
22	Makause Combined School	1.36	0.08	No	0	0.77	0.04	No	0
23	Gekombineerde Skool Ogies	1.14	0.06	No	0	0.69	0.03	No	0
24	Bonisana Primary School	0.90	0.07	No	0	0.43	0.04	No	0
25	Dunbar Primary School	2.58	0.17	No	0	1.53	0.09	No	0
26	Phillip Ndimande Secondary School	1.81	0.07	No	0	1.02	0.04	No	0
27	Zacheus Malaza Secondary School	2.78	0.11	No	0	1.62	0.06	No	0
28	Besilindile Primary School	1.67	0.08	No	0	0.84	0.04	No	0
29	Life Cosmos Hospital	0.77	0.05	No	0	0.42	0.02	No	0
30	Witbank Hospital	0.85	0.04	No	0	0.44	0.02	No	0
31	Emalahleni Private Hospital	0.95	0.04	No	0	0.44	0.02	No	0
32	Anglo Coal Highveld Hospital	0.96	0.04	No	0	0.43	0.02	No	0
33	Impungwe Hospital	0.29	0.02	No	0	0.17	0.01	No	0
34	Emalahleni Day Hospital	0.95	0.04	No	0	0.44	0.02	No	0
35	Louis Street Clinic	0.76	0.05	No	0	0.47	0.02	No	0
36	Poly Clinic	1.22	0.07	No	0	0.58	0.03	No	0
37	Hlalanikahle Clinic	2.27	0.10	No	0	1.09	0.05	No	0
38	Beatty Clinic	0.96	0.05	No	0	0.49	0.02	No	0
39	Empumelelweni CHC Clinic	2.51	0.15	No	0	1.75	0.07	No	0
40	Green Cross Clinic	0.96	0.05	No	0	0.45	0.02	No	0
41	Life Occupational Health Clinic	0.93	0.05	No	0	0.46	0.02	No	0
42	Top Med Women's Clinic	1.03	0.05	No	0	0.59	0.02	No	0
43	Phola Community Centre Clinic	1.21	0.06	No	0	0.58	0.03	No	0
44	Lynnville Clinic	1.15	0.06	No	0	0.63	0.03	No	0
45	Tomas Mahlangu Ville Clinic	1.31	0.06	No	0	0.61	0.03	No	0
46	Mine Boundary (max)	176.0	7.9	Yes	18	172.6	4.31	Yes	13

Table 44: Simulated $PM_{2.5}$ ground level concentrations (in µg/m³) at all identified AQSRs – Scenario 2

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	5.45	0.39	No	0	2.81	0.15	No	0
2	Kwa-Guqa	2.59	0.15	No	0	1.27	0.06	No	0
3	Unjani Clinic	2.32	0.11	No	0	1.04	0.04	No	0
4	Clewer AH	9.42	0.82	No	0	3.24	0.29	No	0
5	Clewer	4.73	0.35	No	0	2.15	0.13	No	0
6	Phola	1.18	0.07	No	0	0.51	0.03	No	0
7	Ackerville	1.58	0.09	No	0	0.62	0.03	No	0
8	eMalahleni	0.76	0.04	No	0	0.36	0.02	No	0
9	Wilge	1.05	0.06	No	0	0.57	0.03	No	0

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
10	Itireleng Primary School	1.42	0.08	No	0	0.64	0.03	No	0
11	St Thomas Aquinas school	1.25	0.05	No	0	0.43	0.02	No	0
12	Laerskool Taalfees	0.93	0.06	No	0	0.38	0.02	No	0
13	Leonard Ntshuntshe Secondary School	2.26	0.14	No	0	1.09	0.06	No	0
14	Robert Carruthers School	0.99	0.05	No	0	0.40	0.02	No	0
15	Thuthukani Primary School	1.20	0.07	No	0	0.47	0.03	No	0
16	Hlangu Phala Primary School	1.19	0.07	No	0	0.45	0.03	No	0
17	Mabande C.h School	1.18	0.07	No	0	0.51	0.03	No	0
18	Sizanani Early Childhood School	1.20	0.07	No	0	0.46	0.03	No	0
19	Siyathokoza Primary School	1.17	0.08	No	0	0.52	0.03	No	0
20	Sukumani Primary School	1.15	0.07	No	0	0.50	0.03	No	0
21	Mehlwana Secondary School	1.41	0.10	No	0	0.58	0.04	No	0
22	Makause Combined School	1.50	0.08	No	0	0.55	0.03	No	0
23	Gekombineerde Skool Ogies	0.98	0.07	No	0	0.39	0.03	No	0
24	Bonisana Primary School	1.61	0.10	No	0	0.56	0.04	No	0
25	Dunbar Primary School	3.03	0.19	No	0	1.42	0.08	No	0
26	Phillip Ndimande Secondary School	1.59	0.09	No	0	0.76	0.04	No	0
27	Zacheus Malaza Secondary School	2.59	0.15	No	0	1.27	0.06	No	0
28	Besilindile Primary School	1.60	0.10	No	0	0.59	0.04	No	0
29	Life Cosmos Hospital	0.77	0.05	No	0	0.32	0.02	No	0
30	Witbank Hospital	0.96	0.05	No	0	0.43	0.02	No	0
31	Emalahleni Private Hospital	1.28	0.06	No	0	0.45	0.02	No	0
32	Anglo Coal Highveld Hospital	0.88	0.06	No	0	0.39	0.02	No	0
33	Impungwe Hospital	0.35	0.02	No	0	0.12	0.01	No	0
34	Emalahleni Day Hospital	1.29	0.06	No	0	0.46	0.02	No	0
35	Louis Street Clinic	0.87	0.06	No	0	0.33	0.02	No	0
36	Poly Clinic	1.40	0.09	No	0	0.56	0.03	No	0
37	Hlalanikahle Clinic	2.02	0.12	No	0	0.96	0.05	No	0
38	Beatty Clinic	1.11	0.06	No	0	0.48	0.02	No	0
39	Empumelelweni CHC Clinic	2.46	0.18	No	0	1.15	0.07	No	0
40	Green Cross Clinic	1.23	0.06	No	0	0.44	0.02	No	0
41	Life Occupational Health Clinic	1.00	0.06	No	0	0.45	0.02	No	0
42	Top Med Women's Clinic	1.02	0.06	No	0	0.39	0.02	No	0
43	Phola Community Centre Clinic	1.18	0.07	No	0	0.45	0.03	No	0
44	Lynnville Clinic	1.07	0.07	No	0	0.45	0.03	No	0
45	Tomas Mahlangu Ville Clinic	1.52	0.08	No	0	0.60	0.03	No	0
46	Mine Boundary (max)	174.6	19.7	Yes	81	171.7	5.52	Yes	14

Table 45: Simulated $PM_{2.5}$ ground level concentrations (in µg/m³) at all identified AQSRs – Scenario 3

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
1	Moruti Makuse Primary School	3.16	0.16	No	0	1.82	0.08	No	0

ID	AQ Sensitive Receptor	Unmitigated		Exceedances		Design Mitigated		Exceedances	
		Highest Daily	Annual	Yes/No	No of Exceedances	Highest Daily	Annual	Yes/No	No of Exceedances
2	Kwa-Guqa	1.62	0.06	No	0	1.16	0.03	No	0
3	Unjani Clinic	1.11	0.05	No	0	0.53	0.02	No	0
4	Clewer AH	3.98	0.31	No	0	1.92	0.14	No	0
5	Clewer	3.01	0.14	No	0	1.43	0.06	No	0
6	Phola	0.63	0.03	No	0	0.31	0.02	No	0
7	Ackerville	0.80	0.03	No	0	0.39	0.02	No	0
8	eMalahleni	0.36	0.02	No	0	0.20	0.01	No	0
9	Wilge	0.82	0.03	No	0	0.37	0.01	No	0
10	Itireleng Primary School	0.84	0.03	No	0	0.40	0.02	No	0
11	St Thomas Aquinas school	0.45	0.02	No	0	0.25	0.01	No	0
12	Laerskool Taalfees	0.46	0.03	No	0	0.22	0.01	No	0
13	Leonard Ntshuntshe Secondary School	1.43	0.06	No	0	1.05	0.03	No	0
14	Robert Carruthers School	0.46	0.02	No	0	0.23	0.01	No	0
15	Thuthukani Primary School	0.65	0.03	No	0	0.31	0.01	No	0
16	Hlangu Phala Primary School	0.57	0.03	No	0	0.31	0.01	No	0
17	Mabande C.h School	0.63	0.03	No	0	0.31	0.02	No	0
18	Sizanani Early Childhood School	0.57	0.03	No	0	0.31	0.01	No	0
19	Siyathokoza Primary School	0.68	0.04	No	0	0.33	0.02	No	0
20	Sukumani Primary School	0.61	0.03	No	0	0.29	0.02	No	0
21	Mehlwana Secondary School	0.68	0.04	No	0	0.43	0.02	No	0
22	Makause Combined School	0.73	0.04	No	0	0.34	0.02	No	0
23	Gekombineerde Skool Ogies	0.50	0.03	No	0	0.22	0.01	No	0
24	Bonisana Primary School	0.52	0.04	No	0	0.23	0.02	No	0
25	Dunbar Primary School	1.89	0.09	No	0	1.07	0.05	No	0
26	Phillip Ndimande Secondary School	1.03	0.04	No	0	0.63	0.02	No	0
27	Zacheus Malaza Secondary School	1.62	0.06	No	0	1.16	0.03	No	0
28	Besilindile Primary School	0.75	0.04	No	0	0.37	0.02	No	0
29	Life Cosmos Hospital	0.42	0.02	No	0	0.24	0.01	No	0
30	Witbank Hospital	0.48	0.02	No	0	0.30	0.01	No	0
31	Emalahleni Private Hospital	0.48	0.02	No	0	0.26	0.01	No	0
32	Anglo Coal Highveld Hospital	0.49	0.02	No	0	0.23	0.01	No	0
33	Impungwe Hospital	0.13	0.01	No	0	0.06	0.00	No	0
34	Emalahleni Day Hospital	0.48	0.02	No	0	0.26	0.01	No	0
35	Louis Street Clinic	0.44	0.02	No	0	0.21	0.01	No	0
36	Poly Clinic	0.65	0.04	No	0	0.34	0.02	No	0
37	Hlalanikahle Clinic	1.24	0.05	No	0	0.64	0.02	No	0
38	Beatty Clinic	0.54	0.03	No	0	0.34	0.01	No	0
39	Empumelelweni CHC Clinic	1.29	0.08	No	0	0.66	0.04	No	0
40	Green Cross Clinic	0.51	0.02	No	0	0.27	0.01	No	0
41	Life Occupational Health Clinic	0.51	0.02	No	0	0.30	0.01	No	0
42	Top Med Women’s Clinic	0.47	0.02	No	0	0.27	0.01	No	0
43	Phola Community Centre Clinic	0.62	0.03	No	0	0.29	0.02	No	0
44	Lynnville Clinic	0.60	0.03	No	0	0.34	0.01	No	0
45	Tomas Mahlangu Ville Clinic	0.78	0.03	No	0	0.37	0.02	No	0
46	Mine Boundary (max)	172.6	5.4	Yes	13	170.7	3.7	Yes	13

Table 46: Simulated dustfall rates (in mg/m²/day) at all identified AQSRs – all scenarios

ID	AQ Sensitive Receptor	Scenario 1		Scenario 2		Scenario 3	
		Highest 30-day avg (unmitigated)	Highest 30-day avg (mitigated)	Highest 30-day avg (unmitigated)	Highest 30-day avg (mitigated)	Highest 30-day avg (unmitigated)	Highest 30-day avg (mitigated)
1	Moruti Makuse Primary School	9.51	4.50	14.72	5.32	5.98	3.03
2	Kwa-Guqa	2.91	1.44	4.10	1.68	1.88	0.98
3	Unjani Clinic	2.77	1.29	2.97	1.19	1.47	0.68
4	Clewer AH	21.16	9.86	28.71	10.97	13.09	5.93
5	Clewer	6.21	3.06	7.84	3.01	3.61	1.75
6	Phola	1.40	0.68	1.86	0.69	0.79	0.37
7	Ackerville	1.20	0.56	1.90	0.67	0.68	0.31
8	eMalahleni	0.29	0.17	0.49	0.18	0.18	0.13
9	Wilge	1.13	0.66	1.13	0.61	0.70	0.46
10	Itireleng Primary School	1.03	0.47	1.38	0.51	0.57	0.33
11	St Thomas Aquinas school	0.54	0.25	0.84	0.30	0.32	0.19
12	Laerskool Taalfees	0.47	0.27	0.65	0.26	0.28	0.19
13	Leonard Ntshuntshe Secondary School	2.82	1.41	3.95	1.59	1.79	0.96
14	Robert Carruthers School	0.44	0.24	0.68	0.26	0.26	0.18
15	Thuthukani Primary School	1.44	0.70	1.70	0.66	0.77	0.36
16	Hlangu Phala Primary School	1.35	0.63	1.86	0.67	0.76	0.35
17	Mabande C.h School	1.40	0.68	1.86	0.69	0.79	0.37
18	Sizanani Early Childhood School	1.37	0.64	1.89	0.68	0.77	0.36
19	Siyathokoza Primary School	1.52	0.74	1.94	0.73	0.81	0.38
20	Sukumani Primary School	1.34	0.65	1.80	0.67	0.77	0.36
21	Mehlwana Secondary School	1.68	0.79	2.54	0.88	0.95	0.45
22	Makause Combined School	1.77	0.86	2.20	0.83	0.94	0.44
23	Gekombineerde Skool Ogies	1.16	0.56	1.53	0.57	0.63	0.29
24	Bonisana Primary School	2.60	1.22	3.89	1.40	1.51	0.67
25	Dunbar Primary School	6.24	2.89	6.69	2.75	3.55	1.66
26	Phillip Ndimande Secondary School	1.92	0.91	2.66	1.03	1.17	0.66
27	Zacheus Malaza Secondary School	2.91	1.44	4.10	1.68	1.88	0.98
28	Besilindile Primary School	2.14	1.02	3.18	1.18	1.28	0.60
29	Life Cosmos Hospital	0.49	0.26	0.64	0.24	0.28	0.17
30	Witbank Hospital	0.45	0.22	0.76	0.26	0.27	0.18
31	Emalahleni Private Hospital	0.57	0.26	0.90	0.32	0.34	0.21
32	Anglo Coal Highveld Hospital	1.21	0.59	1.60	0.62	0.66	0.33
33	Impungwe Hospital	0.45	0.22	0.61	0.22	0.24	0.11
34	Emalahleni Day Hospital	0.57	0.26	0.91	0.32	0.34	0.21
35	Louis Street Clinic	0.52	0.26	0.64	0.24	0.29	0.17
36	Poly Clinic	0.88	0.40	1.38	0.49	0.53	0.31
37	Hlalanikahle Clinic	2.10	1.01	3.07	1.15	1.27	0.69
38	Beatty Clinic	0.54	0.27	0.91	0.31	0.33	0.21
39	Empumelelweni CHC Clinic	4.98	2.38	7.00	2.65	2.95	1.38
40	Green Cross Clinic	0.55	0.26	0.90	0.31	0.33	0.20
41	Life Occupational Health Clinic	0.52	0.25	0.86	0.30	0.31	0.20
42	Top Med Women's Clinic	0.65	0.30	0.97	0.34	0.37	0.22
43	Phola Community Centre Clinic	1.36	0.66	1.67	0.64	0.73	0.34

ID	AQ Sensitive Receptor	Scenario 1		Scenario 2		Scenario 3	
		Highest 30-day avg (unmitigated)	Highest 30-day avg (mitigated)	Highest 30-day avg (unmitigated)	Highest 30-day avg (mitigated)	Highest 30-day avg (unmitigated)	Highest 30-day avg (mitigated)
44	Lynnville Clinic	0.87	0.40	1.27	0.46	0.51	0.31
45	Tomas Mahlangu Ville Clinic	1.16	0.54	1.83	0.64	0.65	0.30
46	Mine Boundary (max)	330.8	164.5	1245.2	325.1	617.4	179.1

Appendix G – Effects of Climate Change on the Region

Climate Change Reference Atlas

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

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

RCP4.5 trajectory

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

RCP8.5 trajectory

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