Air Quality Specialist Study for the Musina-Makhado Special Economic Zone, Limpopo, South Africa

Project done on behalf of **Musina-Makhado Special Economic Zone (SOC) Limited**

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Report Title	Air Quality Specialist Study for the Musina-Makhado Special Economic Zone, Limpopo, South Africa
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Revision Record

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Draft	19 July 2019	Original for client comment

Competency Profiles

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Natasha Shackleton started her professional career in Air Quality in 2011 when she joined Airshed Planning Professionals (Pty) Ltd after completing her Undergraduate Degree at the University of Pretoria in Science. In 2011 she completed her Honours Degree at the University of Pretoria in Meteorology. Natasha is also a member of the South African Society for Atmospheric Sciences (SASAS) and is a registered Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) (registration no. 116335). She is currently undertaking her MSc: Applied Science (Environmental Technology) through the University of Pretoria.

Natasha has worked on a number of air quality specialist studies between 2011 and 2019. 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 his working experience has been in South Africa, a number of investigations were made in countries elsewhere, including Burkina Faso, Ghana, Madagascar, Mozambique, Namibia, Suriname, Tanzania, Zimbabwe and Zambia.

Report author - T L Bird (Pr. Sci. Nat., PhD (University of the Witwatersrand))

Dr Terri Bird holds a PhD from the School of Animal, Plant and Environmental Sciences, University of the Witwatersrand, Johannesburg. The focus of her doctoral research was on the impact of sulfur and nitrogen deposition on the soil and waters of the Mpumalanga Highveld. Since March 2012 she has been employed at Airshed Planning Professionals (Pty) Ltd. In this time, she has been involved in air quality impact assessments for various mining operations (including coal, mineral sand, diamond and platinum mines) as well as coal-fired power station ash disposal facilities. She has been a team member on the development of Air Quality Management Plans, both provincial and for specific industries. Recent projects include assessing the impact of Postponement and/or Exemption of Emission Standards for various Listed Activities.

Report Reviewer - L W Burger (Pr. Eng., FSACheE, FIChemE, PhD: Chemical Engineering (University of Natal) MScEng: Chemical Engineering (University of Natal), BScEng: Chemical Engineering (University of Natal))

Dr Burger is registered as a Professional Engineer with Engineering Council of South Africa (ECSA) (Registration No. 20170291). He is also Fellow of the South African Institute of Chemical Engineers (Fellow: No. 4533) and an Associate Fellow of the Institute of Chemical Engineers (IChemE) (Fellow: No. 99963108).

Dr Burger holds an MSc and PhD in chemical engineering from the University of Natal. Following the completion of his bachelor's degree (cum laude) in chemical engineering in 1982, his experience in air pollution started in 1983 with the development and implementation of a real-time atmospheric dispersion model for processing industries (as partial fulfilment of his MSc Eng). This model was further developed for execution on different computer platforms as an off-the-shelf software package known as "HAWK", and was marketed by the Atomic Energy Commission (later known as NECSA).

During the period 1984 to 1986, a more complex atmospheric dispersion model was developed, which contributed towards his PhD and later formed part of an international contract on the evaluation and validation of transport models as applied to the Chernobyl accident of April 1986 (International Atomic Energy Agency).

Lucian Burger currently serves on the board of directors of Airshed Planning Professionals (Pty) Ltd and of Riscom (Pty) Ltd. Airshed Planning Professionals is a technical and scientific consultancy providing scientific, engineering and strategic air pollution impact assessment and management services and policy support to assist clients in addressing a wide variety of air pollution related risks and air quality management challenges. Riscom specialises in quantitative process risk assessments, including hazan, hazop, what-if analyses, detailed risk assessments, Major Hazard Installation and incident investigations, and other risk related studies.

He has been involved in several Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) projects and has conducted specialist studies for both quantified process risk assessments and air pollution impact components of these. Over the past three decades Dr Burger has been actively involved in the development of atmospheric dispersion modelling and its applications, air pollution compliance assessments, health risk assessments, mitigation measures, development of air quality management plans, meteorological and air quality monitoring programmes, strategy and policy development, training and expert witnessing.

Whilst most of his working experience has been in South Africa, a number of investigations were made in countries elsewhere, including Angola, Botswana, Central African Republic, Congo, Democratic Republic of Congo, England, Ethiopia, Equatorial Guinea, Ghana, Iran, Ireland, Lesotho, Liberia, Madagascar, Mozambique, Namibia, Suriname, Togo, Ukraine, Zimbabwe and Zambia.

NEMA Regulation (2017), Appendix 6

NEMA Regulations (2017) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report.	Report Details (page i)
The expertise of that person to compile a specialist report including curriculum vitae.	Competency Profiles Section 11: Appendix A: Specialists Curriculum Vitae (page 83)
A declaration that the person is independent in a form as may be specified by the competent authority.	Report Details (page i)
An indication of the scope of, and the purpose for which, the report was prepared.	Section 1.1: Background (page 1) Section 1.2: Terms of Reference (page 1)
An indication of quality and age of base data used.	Section 1.3: Assumptions and Limitations (page 6) Section 5: Description of the Receiving Environment (page 30)
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change.	Section 5.5.1: Existing Sources of Air Pollution in the Area (page 39) Section 7: Impact Assessment (page 71) Section 4: Applicable Legislation (page 20)
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	A site investigation was not undertaken. Description of the current land use in the region, simulations undertaken for the current operations and meteorological data included used in the study are considered representative of all seasons. Section 5: Description of the Receiving Environment (page 30)
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 2: Methodology (page 9)
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 5: Description of the Receiving Environment (page 30)
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 3: Project Description, Figure 3-1 (page 15)
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.3: Assumptions and Limitations (page 6)
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 7: Impact Assessment (page 71) Section 9: Findings and Recommendations (page 78)
Any mitigation measures for inclusion in the EMPr.	Section 8: Air Quality Management Measures (page 74)
Any conditions for inclusion in the environmental authorisation	Section 8: Air Quality Management Measures (page 74)
Any monitoring requirements for inclusion in the EMPr or environmental authorisation.	Section 8: Air Quality Management Measures (page 74)
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 9: Findings and Recommendations (page 78)
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 EMPr, and where applicable, the closure plan.	Section 9: Findings and Recommendations (page 78)

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.	No comments received.
Any other information requested by the competent authority.	No comments/request received.

Executive Summary

The essence of the Musina-Makhado SEZ is to create a new heavy industrial hub that forms part of the Trans-Limpopo Spatial Development Initiative. The Musina-Makhado SEZ will attract foreign and domestic direct investment to promote industrial development. Other land uses envisaged to complement the energy and metallurgical complex will comprise bulk infrastructure, light industries, intermodal facilities, housing, retail centres, business uses, community facilities, and telecommunication services.

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by the Musina-Makhado SEZ to provide independent and competent services for the compilation of the air quality specialist study as part of the authorisation process, including an Environmental Impact Assessment (EIA) and an Environmental Management Programme (EMPr). As such the report conforms to the amended regulated format requirements for specialist reports as per the Appendix 6 of EIA Regulations (Government Gazette No. 40772, 7 April 2017).

The main objective of this study was to establish baseline/pre-development air quality in the study area and to quantify the extent to which ambient pollutant levels will change as a result of the project. The baseline and impact study then informed the air quality management and mitigation measures recommended as part of the Air Quality Management Plan (AQMP).

To achieve this objective, the following tasks were included in the scope of work (SoW):

1. A **review** of proposed project activities in order to identify sources of emission and associated pollutants.
2. A study of **regulatory requirements and health thresholds** for identified key pollutants against which compliance need to be assessed and health risks screened.
3. A study of the **receiving environment** in the vicinity of the project; including:
    a. The identification of potential Air Quality Receptors (AQRs);
    b. A study of the atmospheric dispersion potential of the area taking into consideration local meteorology, land-use and topography; and
    c. The analysis of all available ambient air quality information/data to determine pre-development ambient pollutant levels and dustfall rates.
4. The compilation of a comprehensive **emissions inventory** including fugitive dust, vehicle exhaust and process emissions.
5. **Atmospheric dispersion modelling** to simulate ambient air pollutant concentrations and dustfall rates.
6. A **screening** assessment to determine:
    a. Compliance of criteria pollutants with ambient air quality standards;
    b. Compliance of dustfall rates to dust control standards;
    c. Potential health risks as a result of exposure to non-carcinogenic non-criteria pollutants; and
    d. Potential increased lifetime cancer risks as a result of exposure to carcinogenic pollutants.
7. The compilation of a comprehensive air quality specialist report.

The main findings of the baseline assessment are:

- The area is dominated by winds from the east-south-east and to a lesser extent the south-east, east and east-northeast. All pollutants' long-term air quality impacts are therefore expected to be the most significant to the west-northwest, north-west, west and west-south-west of the operations.
- Residential areas have the following as AQRs: residences, schools, hospitals and clinics. Other than residential areas surrounding homesteads and tourist accommodation were included at AQRs. A total of 183 receptors were identified in the domain, including residential settlements and schools, of which 21 receptors are within 10 km of the

centre of the SEZ. The closest residential settlement (Steenbok) is located approximately 0.4 km to the south-west of the SEZ centre point. Three residential settlements are located within the SEZ study area boundary and will likely be relocated.

- The main sources contributing to current background PM concentrations likely include vehicle entrained dust from local roads, train operations, biomass burning, household fuel burning, vehicle exhaust, windblown dust from exposed areas, industrial (mining) operations and agricultural activities.

The main findings of the impact assessment are as follows:

- PM, NO_x, SO_2 and CO emissions will be released during the construction, operational decommissioning, and closure phases. Only the operational phase air quality impacts were quantified since construction and decommissioning
- SEZ operations:
  - PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, Mn, Cr^{6+} and H_2S emissions and impacts were quantified.
  - The PM_{10} and $PM_{2.5}$ emissions and simulated concentrations were likely underpredicted in this study.
  - Simulated PM_{10} concentrations were found to exceed the evaluation criteria beyond boundary but not at AQRs.
  - Simulated $PM_{2.5}$, NO_2, SO_2, Mn and Cr^{6+} concentrations were found to exceed the evaluation criteria beyond boundary and at AQRs.
  - The significance of proposed SEZ operations related inhalation health impacts is considered “very high”.

To ensure the lowest possible impact on AQRs and environment it is recommended that the air quality management plan as set out in this report should be adopted. This includes:

- The mitigation and management of all plants;
- Future facilities will be required to complete an EIA and apply for a new AEL and may be required to an air quality impact study for an AIR;
- Ambient air quality monitoring; and
- Implementation of the reporting procedures.

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List of Abbreviations

ADE	Australian Government Department of the Environment
AEL	Atmospheric Emission Licence
AIR	Atmospheric Impact Report
Airshed	Airshed Planning Professionals (Pty) Ltd
AQA	Air quality act
AQG	Air quality guideline
AQMP	Air quality management plan
AQMS	Air quality monitoring station
AQO	Air quality officer
AQR	Air quality receptor
ASG	Atmospheric Studies Group
ATSDR	US Agency for Toxic Substances and Disease Registry
BAT	Best available technology
CALEPA	California Environmental Protection Agency
C_6H_6	Benzene
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
Cr^{6+}	Hexavalent Chromium
DEA	Department of Environmental Affairs
Delta BEC	Delta Built Environment Consultants (Pty) Ltd
DM	District Municipality
DPM	Diesel particulate matter
DTI	Department of Trade and Industry
EEA	European Environmental Agency
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
FeCr	Ferrochrome
g	Gram
GHG	Greenhouse gases
GIIP	Good International Industry Practice
GLCC	Global Land Cover Characterisation
g/s	Gram per second
GV	Guideline value
HFCs	hydrofluorocarbons
H_2S	Hydrogen sulfide
I&APs	Interested and Affected Parties
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IRIS	Integrated Risk Information System
kg	Kilogram
LEDA	Limpopo Economic Development Agency

LM	Local Municipality
LMo	Obukhov length also referred to as the Monin-Obukhov length
LPG	Liquified petroleum gas
m	Metre
m^2	Metre squared
m^3	Metre cubed
mamsl	Metres above mean sea level
mm	Millimetre
MM SEZ	Musina-Makhado Special Economic Zone (SOC) Limited
Mn	Manganese
MRLs	Minimal risk levels for hazardous substances
m/s	Metres per second
NAAQ Limit	National Ambient Air Quality Limit concentration
NAAQS	National Ambient Air Quality Standards (as a combination of the NAAQ Limit and the allowable frequency of exceedance)
NAEIS	National Atmospheric Emission Inventory System
NDCR	National Dust Control Regulations
NEM	National Environmental Management Act
NMES	National Minimum Emission Standards
NMTOC	Non-methane organic compounds
N_2O	Nitrous oxide
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
NPI	National Pollutant Inventory
NYS DOH	New York State Department of Health
OEHHA	Office of Environmental Health Hazard Assessment
O_3	Ozone
PAHs	Polycyclic aromatic hydrocarbons
PFCs	perfluorocarbons
Pb	Lead
PM	Particulate matter
PM_{10}	Particulate matter with diameter of less than 10 µm
$PM_{2.5}$	Particulate matter with diameter of less than 2.5 µm
REL	Inhalation reference exposure level
RfC	Inhalation reference concentration
SAAELIP	South African Atmospheric Emission Licensing and Inventory Portal
SAAQIS	South African Air Quality Information System
SEZ	Musina-Makhado Special Economic Zone
SF6	sulfur hexafluoride
SO_2	Sulfur dioxide
SRTM	Shuttle Radar Topography Mission
t	Tonnes (megagrams)
t/h	Tonnes per hour (megagrams per hour)
TOR	Total organic compounds
TSP	Total suspended particulates

URF	Unit risk factor
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOC	Volatile organic compound
WHO	World Health Organisation
WRF	Weather Research and Forecasting
WWTW	wastewater treatment works
µ	micro
°C	Degrees Celsius

Glossary

Air-shed	An area, bounded by topographical features, within which airborne contaminants can be retained for an extended period
Algorithm	A mathematical process or set of rules used for calculation or problem-solving, which is usually undertaken by a computer
Atmospheric dispersion model	A mathematical representation of the physics governing the dispersion of pollutants in the atmosphere
Atmospheric stability	A measure of the propensity for vertical motion in the atmosphere
Baseline	Information gathered at the beginning of a study which describes the environment prior to development of a project and against which predicted changes (impacts) are measured.
Building wakes	Strong turbulence and downward mixing caused by a negative pressure zone on the lee side of a building
Calm / stagnation	A period when wind speeds of less than 0.5 m/s persist
Cartesian grid	A co-ordinate system whose axes are straight lines intersecting at right angles
Causality	The relationship between cause and effect
Complex terrain	Terrain that contains features that cause deviations in direction and turbulence from larger-scale wind flows
Cumulative Impacts	Direct and indirect impacts that act together with current or future potential impacts of other activities or proposed activities in the area/region that affect the same resources and/or receptors.
Configuring a model	Setting the parameters within a model to perform the desired task
Construction Phase	The stage of project development comprising site preparation as well as all construction activities associated with the development.
Convection	Vertical movement of air generated by surface heating
Convective boundary layer	The layer of the atmosphere containing convective air movements
Data assimilation	The use of observations to improve model results – commonly carried out in meteorological modelling
Diffusion	Clean air mixing with contaminated air through the process of molecular motion. Diffusion is a very slow process compared to turbulent mixing.
Dispersion	The lowering of the concentration of pollutants by the combined processes of advection and diffusion
Environment	The external circumstances, conditions and objects that affect the existence of an individual, organism or group. These circumstances include biophysical, social, economic, historical and cultural aspects.
Environmental Authorisation	Permission granted by the competent authority for the applicant to undertake listed activities in terms of the NEMA EIA Regulations, 2014.
Environmental Impact Assessment	A process of evaluating the environmental and socio-economic consequences of a proposed course of action or project.
Environmental Impact Assessment Report	The report produced to relay the information gathered and assessments undertaken during the Environmental Impact Assessment.
Environmental Management Programme	A description of the means (the environmental specification) to achieve environmental objectives and targets during all stages of a specific proposed activity.
Impact	A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.
Mitigation measures	Design or management measures that are intended to minimise or enhance an impact, depending on the desired effect. These measures are ideally incorporated into a design at an early stage.

Operational Phase	The stage of the works following the Construction Phase, during which the development will function or be used as anticipated in the Environmental Authorisation.
Scoping	A procedure to consult with stakeholders to determine issues and concerns and for determining the extent of and approach to an EIA and EMP (one of the phases in an EIA and EMP). This process results in the development of a scope of work for the EIA, EMP and specialist studies.
Specialist study	A study into a particular aspect of the environment, undertaken by an expert in that discipline.
Stakeholders	All parties affected by and/or able to influence a project, often those in a position of authority and/or representing others.

Air Quality Specialist Study for the Musina-Makhado Special Economic Zone, Limpopo, South Africa

1 INTRODUCTION

1.1 Background

The Limpopo Provincial Government was requested by the Department of Trade and Industry (DTI) to submit areas for evaluation considered as strategic for the development of the Limpopo economy through industrialisation. Preliminary studies were conducted, and the province submitted four areas that align with potential growth points in the province. DTI evaluated the submission and approved two of the areas for further feasibility investigation including Musina and Tubatse. The province subsequently motivated that the proposed Musina SEZ will include two components situated at two different locations (Figure 1-2). The one site in Musina targets light industrial and agro-processing clusters, the other site (southern part) targets a metallurgical/mineral beneficiation complex. The two developments will complement each other in terms of its respective product value chain and logistics.

As designated by the DTI in July 2016, the Musina-Makhado Special Economic Zone (SEZ) comprises two sites. The southern site, situated approximately 34 km from the northern site, is earmarked for the development of energy and a metallurgical cluster for the production of high-grade steel. The southern site, as the subject matter of this report, is located on eight farms overlapping the border between the Makhado and Musina local municipalities, within the Vhembe District Municipality (Figure 1-3). The essence of the Musina-Makhado SEZ is to create a new heavy industrial hub that forms part of the Trans-Limpopo Spatial Development Initiative. The Musina-Makhado SEZ will attract foreign and domestic direct investment to promote industrial development. Other land uses envisaged to complement the energy and metallurgical complex will comprise bulk infrastructure, light industries, intermodal facilities, housing, retail centres, business uses, community facilities, and telecommunication services.

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by the Musina-Makhado Special Economic Zone (SOC) Limited (MM SEZ) to provide independent and competent services for the compilation of the air quality specialist study as part of the authorisation process, including an Environmental Impact Assessment (EIA) and an Environmental Management Programme (EMPr). As such the report conforms to the amended regulated format requirements for specialist reports as per the Appendix 6 of EIA Regulations (Government Gazette No. 40772, 7 April 2017).

1.2 Terms of Reference

- Desktop study of the **receiving (baseline) air quality environment**, including:
  - A study of atmospheric dispersion potential by referring to the region's climate, local measured or simulated hourly sequential meteorological data for a period of 3 years (required for dispersion modelling), land use and topography data.
  - A review of the South African legislation minimum emission standards, ambient air quality criteria and dust control regulation; also, relevant international standards and guidelines.
  - Identification and discussion of existing sources of particulate and gaseous pollutant emissions.
  - A study of available ambient air quality data and fallout dust data.
  - The identification of air quality receptors from available maps and socio-economic studies
- The **quantification and assessment of air quality impacts**, incl.:

- The establishment of an **atmospheric emissions inventory** for the thirteen proposed operations. This will include both process (stack) and fugitive emission sources. Pollutants quantified will include particulate matter (total suspended particulates [TSP], particulate matter with and aerodynamic diameter of 10 µm or less [PM_{10}] and particulate matter with and aerodynamic diameter of 2.5 µm or less [$PM_{2.5}$]) and regulated gaseous pollutants. Use will be made of design parameters and emissions, South African and International Finance Corporation (IFC) emission limits as well as emissions factors published in the United States Environmental Protection Agency (US EPA) AP-42, Australian Government Department of the Environment (ADE) National Pollutant Inventory (NPI) and European Environmental Agency (EEA) Emission Factor Database.
- **Atmospheric dispersion modelling** to determine ambient air pollutant concentrations. The most recent version of the CALMET model will be used.
- The **screening** of simulated ambient pollutant concentrations against selected air quality criteria. Health risk can occur due to exposures through inhalation, ingestion and dermal contact. The scope of the study will be confined to the quantification of impacts due to exposures via the inhalation pathway only.
- The ranking of the **significance of air quality impacts** in accordance with the procedure adopted by Delta Built Environment Consultants (Pty) Ltd (Delta BEC).
- An **air quality impact assessment report** including a **management, mitigation and monitoring** plan.

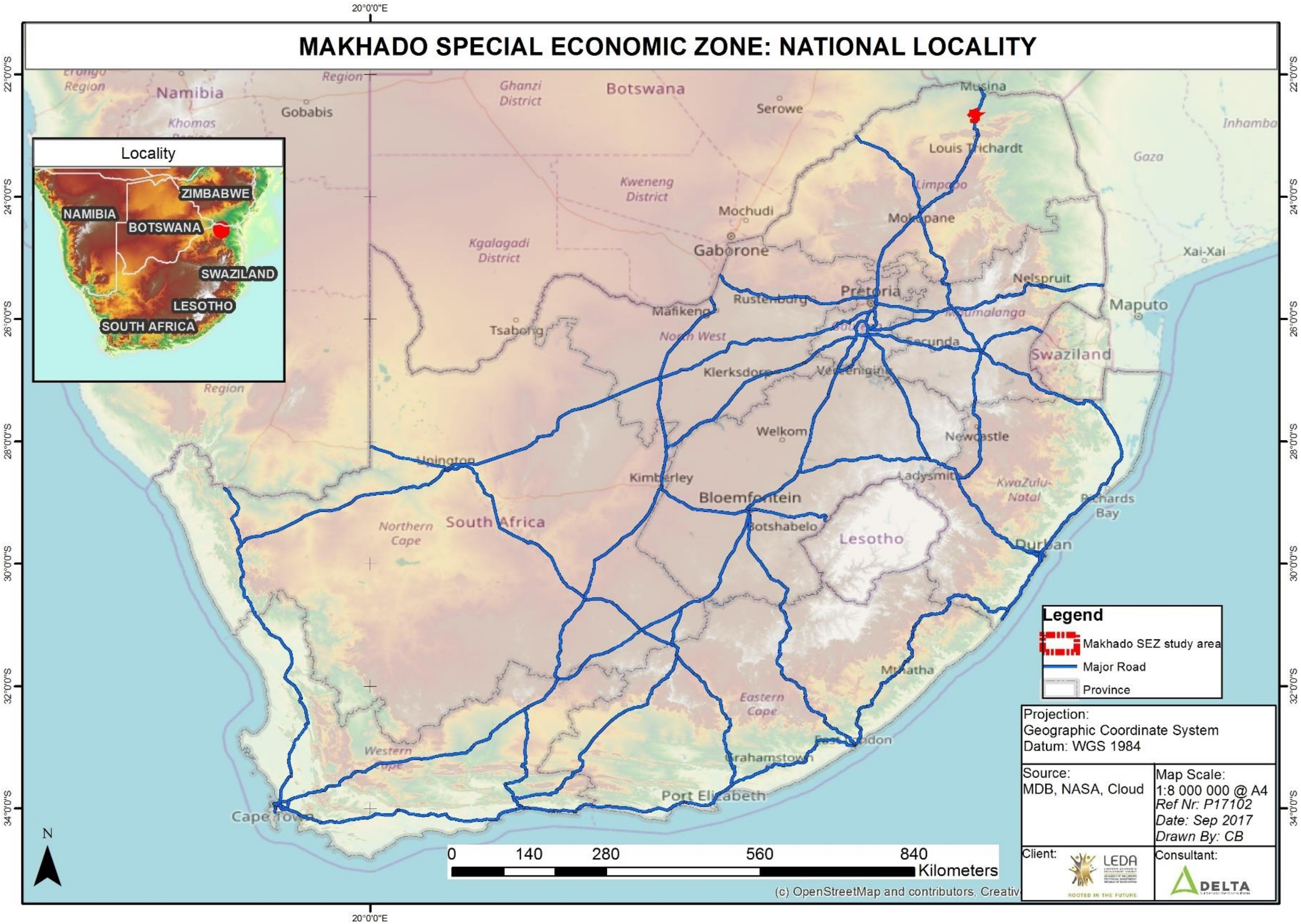

Figure 1-1: **Musina-Makhado SEZ national locality map (Delta Built Environment Consultants (Pty) Ltd, 2019)**

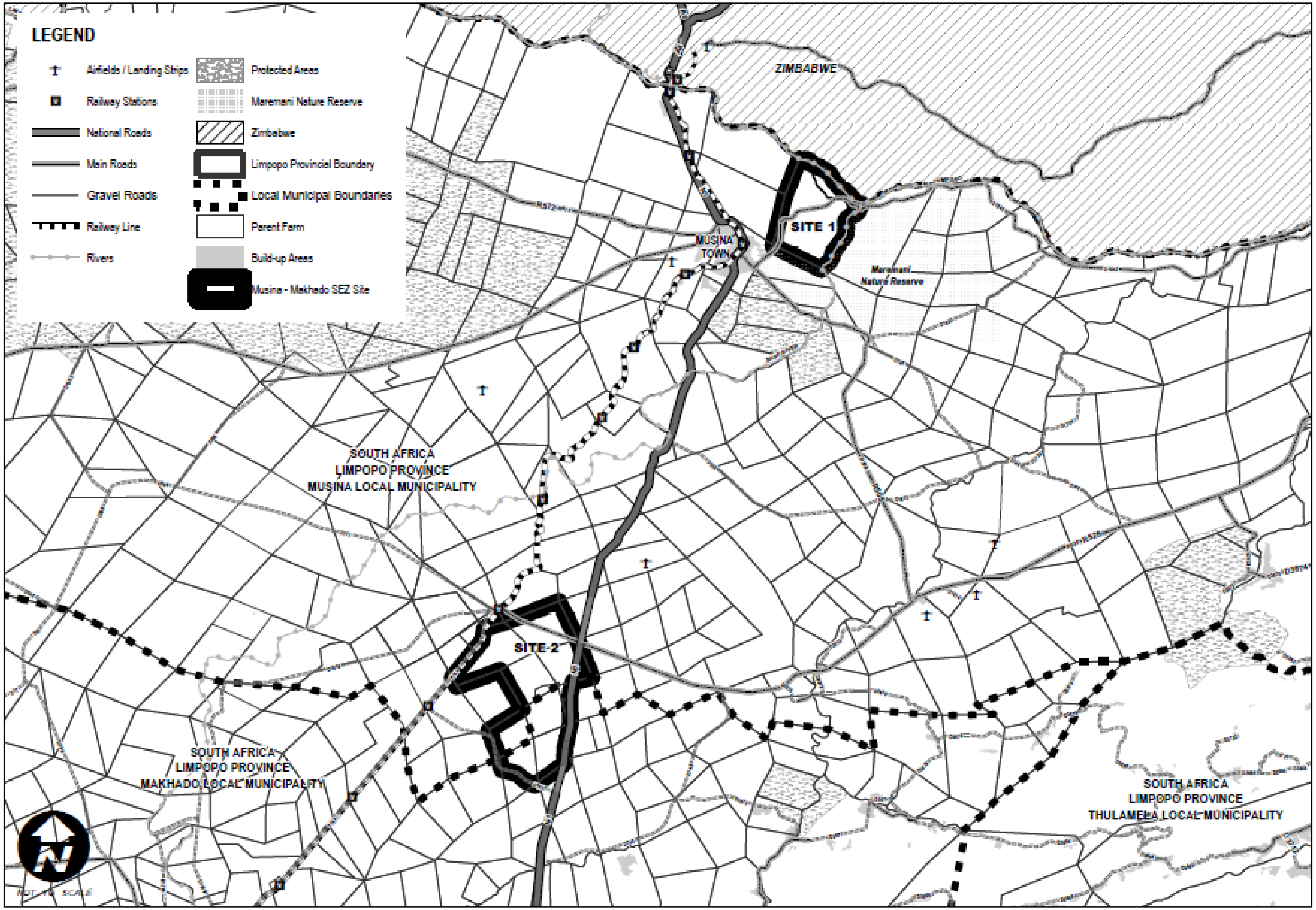

Figure 1-2: Musina-Makhado SEZ locality (Delta Built Environment Consultants (Pty) Ltd, 2019)

Figure 1-3: Musina-Makhado SEZ study area map (Delta Built Environment Consultants (Pty) Ltd, 2019)

1.3 Assumptions and Limitations

The study is based on a number of assumptions and is subject to certain limitations, which should be borne in mind when considering information presented in this report. The validity of the findings of the study is not expected to be affected by these assumptions and limitations:

1. Some project information required to calculate emissions for proposed operations were provided by Delta BEC, Limpopo Economic Development Agency (LEDA) and (MM SEZ). Some outstanding information required to calculate emissions for proposed operations were acquired from studies conducted for similar operations within South Africa and national legislation.
2. The impact of the operational phases was determined quantitatively through emissions calculation and simulation. Construction phase and decommissioning phase impacts are expected to be somewhat less significant than operational phase impacts with regards to the projects key pollutants but have more significant impacts for particulate matter. Decommissioning and closure phases impacts, and significance of the impacts were qualitatively assessed. Mitigation and management measures recommended for the construction and operational phases are also applicable to the decommissioning phase. No impacts are expected post-closure provided the rehabilitation is successful.
3. Meteorology:
    a. Considering the size of the modelling domain and the possible complexity of the meteorology in the study area, both on-site meteorology and simulated, Weather Research and Forecasting (WRF) model data for the period January 2016 to December 2018 was used in dispersion modelling.
    b. The National Code of Practice for Air Dispersion Modelling (Gazette No. 37804, vol 589; 11 July 2014) prescribes the use of a minimum of 1-year on-site data or at least three years of appropriate off-site data for use in Level 2 and 3 assessments. It also states that the meteorological data must be for a period no older than five years to the year of assessment. The dataset period is within the timeframe recommended by the National Code of Practice for Air Dispersion Modelling by being three years data and less than five years old during the assessment period (2019).
4. Emissions:
    a. The pollutants were limited to airborne particulates (including TSP, PM_{10}, $PM_{2.5}$, manganese (Mn) and hexavalent chromium (Cr^{6+})) and gaseous pollutants from stacks, including carbon monoxide (CO), oxides of nitrogen (NO_x), sulfur dioxide (SO_2), hydrogen sulphide (H_2S). These pollutants are either regulated under national ambient air quality standards (NAAQS) or considered key pollutants released by the surrounding industries.
    b. It was assumed the industry stack sources will emit at the national minimum emission standards for the relevant listed activity according to Section 21 of the National Environmental Management: Air Quality Act (NEM:AQA), Act No. 39 of 2004.
    c. It was assumed the industries operate as per similar operations in South Africa.
    d. The estimation of greenhouse gas (GHG) emissions was not included in the scope of work. Reference is made to GHG emission reporting regulations as proposed facilities are required to report emissions on the National Atmospheric Emission Inventory System (NAEIS).
    e. The fugitive PM emissions from the following plants were not estimated in detail as there was insufficient data available for emissions estimation and simulations -
        i. Coke plant (based on similar operations and ration of production rates);
        ii. High vanadium steel plant (not estimated);
        iii. Manganese steel plant (not estimated);
        iv. Ferromanganese plant (based on similar operations and ration of production rates);
        v. Manganese silicon alloy plant (not estimated);

    vi. Domestic waste handling/transfer (not estimated);
    vii. Cement plant (not estimated);
    viii. Refectories plant (not estimated);
    ix. Stainless plant (based on similar operations and ration of production rates);
    x. Ferrochromium plant (based on similar operations and ration of production rates); and
    xi. Vanadium titanium magnetite plant (not estimated).
  f. Vehicle exhaust emissions were not estimated.
  g. There are also other existing sources of emissions such as a biomass burning, residential fuel burning, agricultural activities and wind erosion within the area, such sources were not quantified as part of the emissions inventory and simulations due to the lack of information on these sources and the complexity around simulating these sources.
5. Nitrogen dioxide (NO_2) emissions and impacts:
  a. For the project operations it was conservatively assumed that all NO_x is NO_2.
6. Cr^{6+} emissions and impacts:
  a. Closed furnaces operate under reducing conditions and chromium contained in furnace off-gas would primarily be in the trivalent state (Cr^{3+}). However, the combustion or reaction of CO rich furnace off-gas may result in the formation Cr^{6+}.
  b. Data on the formation of Cr^{6+} throughout the entire ferrochrome (FeCr) production process is limited, but emissions from the furnace and tapping could be estimated based on research conducted by du Preez et al (2015) and Ma (2005).
  c. The calculation of Cr^{6+} emissions from the furnace primary fume extraction was based on the assumption that (a) the chrome content in the particles in the off-gas is the same as the chrome content in the ore (~30%); (b) all the chrome in contained in the off-gas before being emitted to the atmosphere is in the trivalent form i.e. Cr^{3+}; and (c) the amount of Cr^{3+} converted to Cr^{6+} is between 0.027% and 0.35% (du Preez, Beukes, & van Zyl, 2015).
  d. The calculation of Cr^{6+} emissions from furnace secondary fume extraction was based on the assumption that (a) the chrome content in the particles in the off-gas is the same as the chrome content in the ore (~30%); and (b) the amount of Cr^{6+} as PM_{10} is similar to what is found in open furnace baghouse dust i.e. between 0.035% and 0.122% (Ma, 2005).
  e. It was conservatively assumed that all Cr^{6+} emitted would be in the PM_{10} size fraction.
  f. It was conservatively assumed that all forms of Cr^{6+} were carcinogenic. Known carcinogenic Cr^{6+} compounds include chromium trioxide, lead chromate, strontium chromate and zinc chromate.
  g. In estimating increased lifetime cancer risk, use was made of simulated annual average Cr^{6+} concentrations. This approach is conservative since it assumes an individual will be exposed to this concentration constantly over a period of 70 years.
  h. The range in cancer unit risk factors (URF) for exposure to Cr^{6+} is evidence of uncertainty related to increased lifetime cancer risk associated with this pollutant. In the presentation of increased lifetime cancer risk use was made of both the US EPA Integrated Risk Information System (IRIS) URF of 0.012 $(\mu g/m^3)^{-1}$ (the lower limit) and the World Health Organisation (WHO) URF of 0.04 $(\mu g/m^3)^{-1}$ (the geometric mean).

Other assumptions made in the report are explicitly stated in the relevant sections.

1.4 Report Structure

Section	Description	Page
1 - Introduction	An introduction to the study including a description of the project and the scope of work.	1
2 - Methodology	A detailed description of the study methodology is given in this section along with all limitations and assumptions relevant to it.	9
3 - Project Description	The project operations are described.	15
4 - Applicable Legislation	A summary of applicable environmental legislation is presented.	20
5 - Description of the Receiving Environment	A description of the receiving environment is given. It addresses air sensitive receptors (AQRs), dispersion potential as well as baseline air quality.	5
6 - Proposed SEZ Emissions Inventory	The proposed operations emissions inventory data.	48
7 – Impact Assessment	Modelling results and assessment of air quality impacts. Discussion of the No-Go option and cumulative impacts.	54
8 - Air Quality Management Measures	Detailed discussion on recommended mitigation, management and monitoring.	74
9 - Findings and Recommendations	The main findings of the study and recommendations of mitigation, management and monitoring.	78
10 - References	A list of works cited.	80
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2 METHODOLOGY

The air quality impact study includes both baseline and predicted impact assessment. The baseline characterisation includes the following enabling tasks:

- Air Quality Receptors (AQRs) were identified from aerial photography accessed via Google Earth™ and were georeferenced for detailed analysis for the impact assessment calculations.
- Collection of the physical environmental data that influences the dispersion of pollutants in the atmosphere include terrain, land cover and meteorology. Readily available terrain and land cover data was obtained from the Atmospheric Studies Group (ASG) via the United States Geological Survey (USGS) web site at (ASG, 2011). Shuttle Radar Topography Mission (SRTM) (30 m, 1 arc-sec) data and Global Land Cover Characterisation (GLCC) data for Africa were used.
- In the absence of upper air (sounding) data (that is required for atmospheric dispersion modelling), simulated WRF model data for the period 2016 to 2018 was used.
- All available ambient concentrations at the two nearest air quality monitoring stations (AQMS) were used in the description of existing ambient air pollutant levels in the area.
- Dispersion modelling was undertaken for all the major industrial operations proposed for development within the SEZ, using.
    - National Minimum Emission Standards (NMES) for each plant;
    - US EPA AP42 and ADE NPI for other emissions (e.g. stack emissions for pollutants absent from NMES) and fugitive particulate matter (PM) sources where detailed enough operational information was available (coal plant, coke plant);
    - Fugitive PM emissions were estimated using a production rate of fugitive emissions from similar plants in South Africa;
    - The CALPUFF/CALMET model suite was used in the investigation to predict maximum short-term (1- and 24-hour) and annual average ground-level concentrations at various receptor locations within the computational domain.
    - The dispersion modelling was conducted for an area of 50 kilometres (km) (east-west) by 50 km (north-south). The area was divided into a grid matrix with a resolution of 200 m. The CALPUFF/CALMET model limits the number of grid points and it was therefore necessary to limit the simulations to a grid resolution of 200 m.
- The following standards, guidelines and screening levels pertaining to air quality were referred to:
    - National legislation (NAAQS and national dust control regulations [NDCR]); and
    - Health effect screening levels for non-criteria pollutants published by various internationally recognised organisations.

The impact assessment followed with the tasks below:

- The dispersion modelling was executed as per *The Regulations Regarding Air Dispersion Modelling* (Gazette No 37804 vol. 589; published 11 July 2014). Three *Levels of Assessment* are defined in the Regulations. Level 3 was deemed the most appropriate due to size of the SEZ, the diversity of proposed operations, and potential influence of complex topography to the south-east of the domain. The three levels considered were:
    - *Level 1*: where worst-case air quality impacts are assessed using simpler screening models.
    - *Level 2*: for assessment of air quality impacts as part of license application or amendment processes, where impacts are the greatest within a few kilometres downwind (less than 50km).
    - *Level 3*: require more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situation:

- where a detailed understanding of air quality impacts, in time and space, is required;
    - where it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types & chemical transformations;
    - when conducting permitting and/or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences;
    - when evaluating air quality management approaches involving multi-source, multi-sector contributions from permitted and non-permitted sources in an air-shed; or,
    - when assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level O_3, particulate formation, visibility).
- Preparation of the model control options and input files for the CALMET/CALPUFF dispersion modelling suite. This included the compilation of:
    - geographical information including topography, land use, albedo and surface roughness; and
    - grid and receptor definitions.
- Preparation of three years of hourly average meteorological data for determining the atmospheric dispersion potential for the region.
- Preparation of an emissions inventory (particulates and gaseous) for the proposed operations. Ideally, the emission rates should be based on design source parameters, design material flow rates and detailed layouts, but since not all this information was available for the proposed project, similar operations actual and design parameters, material flow rates and emission factors were employed for the following sources:
    - Stack (point) sources using the following source information:
        - Source locations identified using site layout maps;
        - Design and calculated emission rates;
        - Exit temperature;
        - Exit velocity; and
        - Release height;
    - Individual plant fugitive sources.
    - Material haulage via road infrastructure.
- Using the emissions inventory, simulations were conducted using the CALMET/CALPUFF dispersion modelling suite, and ambient pollutant concentrations and dustfall rates were calculated due to the proposed project. The highest hourly, daily and annual concentrations and average daily dustfall rates were calculated.
- The legislative and regulatory context, including emission limits and guidelines, ambient air quality guidelines and dustfall classifications were used to assess the impact and to 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, as well as international health risk criteria, where no NAAQS apply (the US EPA, World Health Organisation [WHO], US Agency for Toxic Substances and Disease Registry [ATSDR] and the California EPA [CALEPA] Office of Environmental Health Hazard Assessment [OEHHA] were cited) and NDCR.

2.1 CALMET/CALPUFF Atmospheric Dispersion Modelling

As per the National Code of Practice for Air Dispersion Modelling, the CALPUFF atmospheric dispersion modelling suite was used for the simulation of ambient air pollutant concentrations and dustfall rates. CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal (Scire, Strimaitis, & Yamartino, 2000). It can accommodate arbitrarily varying point source, area source, volume source, and line source emissions. The CALPUFF code includes algorithms for near-source effects such as building downwash, transitional plume rise, partial plume penetration, sub grid scale terrain interactions as well as longer range effects such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, vertical wind shear, overwater transport and coastal interaction effects.

CALPUFF is intended for use on scales from tens of metres to hundreds of kilometres from a source (US EPA, 1998a). A number of dispersion coefficients options are accommodated, including:

- stability-based empirical relationships such as the Pasquill-Gifford or McElroy-Pooler dispersion coefficients;
- turbulence-based dispersion coefficients (based on measured standard deviations of the vertical and crosswind horizontal components of the wind); and,
- similarity theory to estimate the turbulent quantities using the micrometeorological variables calculated by CALMET.

The CALPUFF modelling system consists of a number of components, as summarised in Table 2-1; however, only CALMET and CALPUFF contain the simulation engines to calculate the three-dimensional atmospheric boundary layer conditions and the dispersion and removal mechanisms of pollutants released into this boundary layer. The other codes are mainly used to assist with the preparation of input and output data. Table 2-1 also includes the development versions of each of the codes used in the investigation.

Table 2-1: Summary description of CALPUFF/CALMET model suite with versions used in the investigation

Module	Version	Description
CALPUFF	v 7.2.1(1)	Non-steady-state Gaussian puff dispersion model with chemical removal, wet and dry deposition, complex terrain algorithms, building downwash, plume fumigation and other effects.
CALPOST	v 7.1.0(1)	A post-processing program for the output fields of meteorological data, concentrations and deposition fluxes.
CALSUM	v 7.0.0(1)	Sums and scales concentrations or wet/dry fluxes from two or more source groups from different CALPUFF runs
PRTMET	v 4.495(2)	Lists selected meteorological data from CALMET and creates plot files

Notes:

(1) These modules indicate version number as listed on http://www.src.com/calpuff/download/download.htm#MOD7_VERSION

(2) These modules indicate version number as listed on http://www.src.com/calpuff/download/mod6_codes.htm.

CALPUFF was selected for the following reasons:

- It is the Department of Environmental Affairs (DEA) recommended model for application domains larger than 50 km. Since the dispersion formulation in CALPUFF is based on a Lagrangian-Gaussian Puff model, it is well well-suited for complex modelling terrain when used in conjunction with CALMET. The latter code includes a diagnostic wind field model which contains treatment of slope flows, valley flows, terrain blocking effects and kinematic effects. This Lagrangian-Gaussian Puff model is well suited to simulate low or calm wind speed conditions. Alternative regulatory models such as the US EPA AERMOD model treat all plumes as straight-line trajectories, which under calm wind conditions grossly over-estimate the plume travel distance.

- The dispersion of pollutants in CALPUFF is simulated as discrete “puffs” of pollutants emitted from the modelled sources. These puffs are tracked until they have left the modelling domain while calculating dispersion, transformation and removal along the way. An important effect of non-steady-state dispersion is that the puff can change direction with changing winds, allowing a curved trajectory. The winds can therefore vary spatially as well as with time; with the former typically as the result of topographical features.

- Although not specifically required in the current investigation, CALPUFF is able to perform chemical transformations, such as the conversion of nitrogen oxide (NO) to NO_2 and the secondary formation of particulate matter from SO_2 and NO_2 emissions.
- Stagnation conditions, i.e. when the wind is zero or near to zero.

The execution phase (i.e. dispersion modelling and analyses) involves gathering specific information regarding the emission source(s) and site(s) to be assessed, and subsequently the actual simulation of the emission sources and determination of impacts significance. The information gathering included:

- source information: emission rate, source extents and release height;
- site information: site building layout, terrain information, and land use data;
- meteorological data: wind speed, wind direction, temperature, cloud cover and mixing height; and,
- receptor information: locations using discrete receptors and/or gridded receptors.

2.1.1 Meteorological Requirements

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. In the absence of on-site surface and upper air (sounding) meteorological data required for atmospheric dispersion modelling simulated WRF data was used. The CALMET output covered a 50 km x 50 km area containing the proposed operational areas for 2016, 2017, and 2018 (Table 2-2).

2.1.2 Topographical and Land Use Data

Readily available terrain and land use 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, 2016). Use was made of Shuttle Radar Topography Mission (SRTM) (30 m, 1 arc-sec) data and Global Land Cover Characterisation (GLCC) data for Africa.

2.1.3 Receptor Grid and Discrete Receptors

The dispersion of pollutants expected to arise from the proposed operations was simulated for an area covering 20 km (east-west) by 20 km (north-south) (Table 2-2). The area was divided into a grid matrix with a resolution of 100 m. The discrete receptors data included in the dispersion model input is shown in Table 14-1. CALPUFF calculates ground-level concentrations and dustfall rates at each grid point and discrete receptor.

Table 2-2: Simulation domain

Simulation domain	CALMET	CALPUFF
South-western corner of simulation domain	771.652 km (Easting) 7 466.478 km (Northing)	786.380 km (Easting) 7 481.755 km (Northing)
Domain size	50 x 50 km	20 km x 20 km
Projection	Grid: UTM Zone 35S, Datum: WGS-84	Grid: UTM Zone 35S, Datum: WGS-84
Resolution	200 m	100 m

2.1.4 Dispersion results

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. The post-processing of air concentrations at the grid receptor intercepts and discrete receptors include the calculation of various time periods corresponding to the requirements of the NAAQS.

2.1.5 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 the above factors contribute to the inaccuracies not even associated with the mathematical models themselves.

Atmospheric dispersion models are often criticised for being inadequate since "*…it is only a model approximating reality*", and therefore include inherent uncertainty. Both reducible and inherent uncertainties mean that dispersion modelling results may over- or under-estimate measured ground-level concentrations at any specific time or place. However, the US EPA Guideline on Air Quality Models (US EPA, 2005) also states that:

> "*Models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area. For example, errors in highest estimated concentrations of +/- 10 to 40 per cent are found to be typical, i.e., certainly well within the often-quoted factor of two accuracy* [i.e. -50% to 200%] *that has long been recognized for these models. However, estimates of concentrations that occur at a specific time and site are poorly correlated with actually observed concentrations and are much less reliable."*

2.2 Impact Assessment

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 Delta BEC 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.

2.3 Mitigation and Management Recommendations

Practical mitigation and optimisation measures that can be implemented effectively to reduce or enhance the significance of impacts were identified.

3 PROJECT DESCRIPTION

3.1 Description of Activities from an Air Quality Perspective

A short description of construction, operation, decommissioning and closure phase activities are discussed below with likely sources of emission and associated pollutants identified.

3.1.1 Construction Phase

The following activities are proposed:

- Site establishment of construction phase facilities;
- Clearing of the area;
- Stripping and stockpiling of soil resources and earthworks;
- Collection, storage and removal of construction related waste; and
- Construction of all infrastructure required for the operational phase.

Fugitive PM emissions will be released to atmosphere during these activities. Fugitive emissions refer to emissions that are spatially distributed over a wide area and not confined to a specific discharge point as would be the case for process related emissions (IFC, 2007). It should be noted that in the discussion, regulation and estimation of PM emissions and impacts a distinction is made between different particle size fractions, *viz*. TSP, PM_{10} and $PM_{2.5}$. PM_{10} is defined as particulate matter with an aerodynamic diameter of less than 10 µm and is also referred to as thoracic particulates. Inhalable particulate matter, $PM_{2.5}$, is defined as particulate matter with an aerodynamic diameter of less than 2.5 µm. Whereas PM_{10} and $PM_{2.5}$ fractions are taken into account to determine the potential for human health risks, TSP is included to assess nuisance dustfall.

In addition to fugitive PM emissions, combustion related PM and gaseous emissions will also be released from construction equipment, diesel generators and construction related traffic. Key pollutants from combustion of fossil fuels include PM_{10} and $PM_{2.5}$, CO, formaldehyde, NO_x, SO_2 and volatile organic compounds (VOCs). PM emitted from diesel combustion will mostly be in the form of black carbon, commonly referred to as diesel particulate matter (DPM). Diesel fuel storage would result in additional amounts of VOCs. Currently, no information on the duration of this phase is available.

3.1.2 Operational Phase

The proposed SEZ will likely comprise of the following facilities:

1. Thermal power plant;
2. Coal washery;
3. Coke plant;
4. High vanadium steel plant;
5. Manganese steel plant;
6. Ferromanganese plant;
7. Manganese silicon alloy plant;
8. Domestic waste handling/transfer;
9. Cement plant;
10. Refectories plant;
11. Stainless plant;
12. Ferrochromium plant;

13. Lime plant;
14. Vanadium titanium magnetite plant.

Table 3-1 below summarises activities expected to result in atmospheric emissions and pollutants likely to be released. It should be noted that this assessment focusses on the pollutants applicable to the process.

3.1.3 Decommissioning and Closure Phase

The removal of infrastructure as well as sloping and revegetation of the area may be planned for the decommissioning phase. Fugitive PM emissions as well as combustion related PM and gaseous emissions will be released from mobile equipment, and traffic. Currently, no information on the duration of this phase is available. The closure phase indicates the phase when the site has been rehabilitated.

Table 3-1: Air emissions and pollutants associated with the Project

Activity/Phase	Description	Main sources of emission	Main Pollutants
Construction	Clearing, sloping and other construction operations including the operation of stationary and mobile equipment.	General construction emission sources including but not limited to: • Bulldozing • Scraping • Materials handling • Vehicle entrainment • Wind erosion of stockpiles	TSP, PM_{10} and $PM_{2.5}$
		Vehicle exhaust	TSP, PM_{10}, $PM_{2.5}$, DPM, CO, NO_x, SO_2 and VOCs
Operations	Transport, handling, storage and processing of raw materials. Handling, storage and transport of products. As well as support operations such as fuel and lubricants tanker deliveries, equipment deliveries, maintenance vehicle operations, facility inspection and administrative vehicles operations and personnel transportation.	Raw materials, molten material, products and by-products handling	TSP, PM_{10} and $PM_{2.5}$
		Raw materials, products and by-products storage	TSP, PM_{10} and $PM_{2.5}$
		Coal drying	TSP, PM_{10} and $PM_{2.5}$
		Power production (point sources)	TSP, PM_{10}, $PM_{2.5}$, CO, NO_x, SO_2, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)
		Materials processing (point sources)	TSP, PM_{10}, $PM_{2.5}$, NO_x, SO_2, CO, Mn, Cr^{6+}, H_2S CO_2, CH_4 and N_2O
		Casting and cutting	TSP, PM_{10} and $PM_{2.5}$
		Liquid material handling, e.g. filling and emptying of liquid storage facilities	Mostly VOCs but other pollutants may be emitted depending on the liquid material stored.
		Storage of liquid material	Mostly VOCs but other pollutants may be emitted depending on the liquid material stored.
		Vehicle entrainment	TSP, PM_{10} and $PM_{2.5}$
		Vehicle exhaust	TSP, PM_{10}, $PM_{2.5}$, DPM, CO, NO_x, SO_2, VOCs
Decommissioning	Decommissioning operations including the operation of mobile equipment.	General decommissioning emission sources including but not limited to: • Bulldozing • Scraping • Materials handling • Vehicle entrainment • Wind erosion of stockpiles	TSP, PM_{10} and $PM_{2.5}$

Activity/Phase	Description	Main sources of emission	Main Pollutants
		Vehicle exhaust	TSP, PM_{10}, $PM_{2.5}$, DPM, CO, NO_x, SO_2 and VOCs
Closure	Closure operations including site inspections.	Vehicle entrainment	TSP, PM_{10} and $PM_{2.5}$
		Vehicle exhaust	TSP, PM_{10}, $PM_{2.5}$, DPM, CO, NO_x, SO_2, VOCs
		Wind erosion of open areas (until fully rehabilitated)	TSP, PM_{10} and $PM_{2.5}$

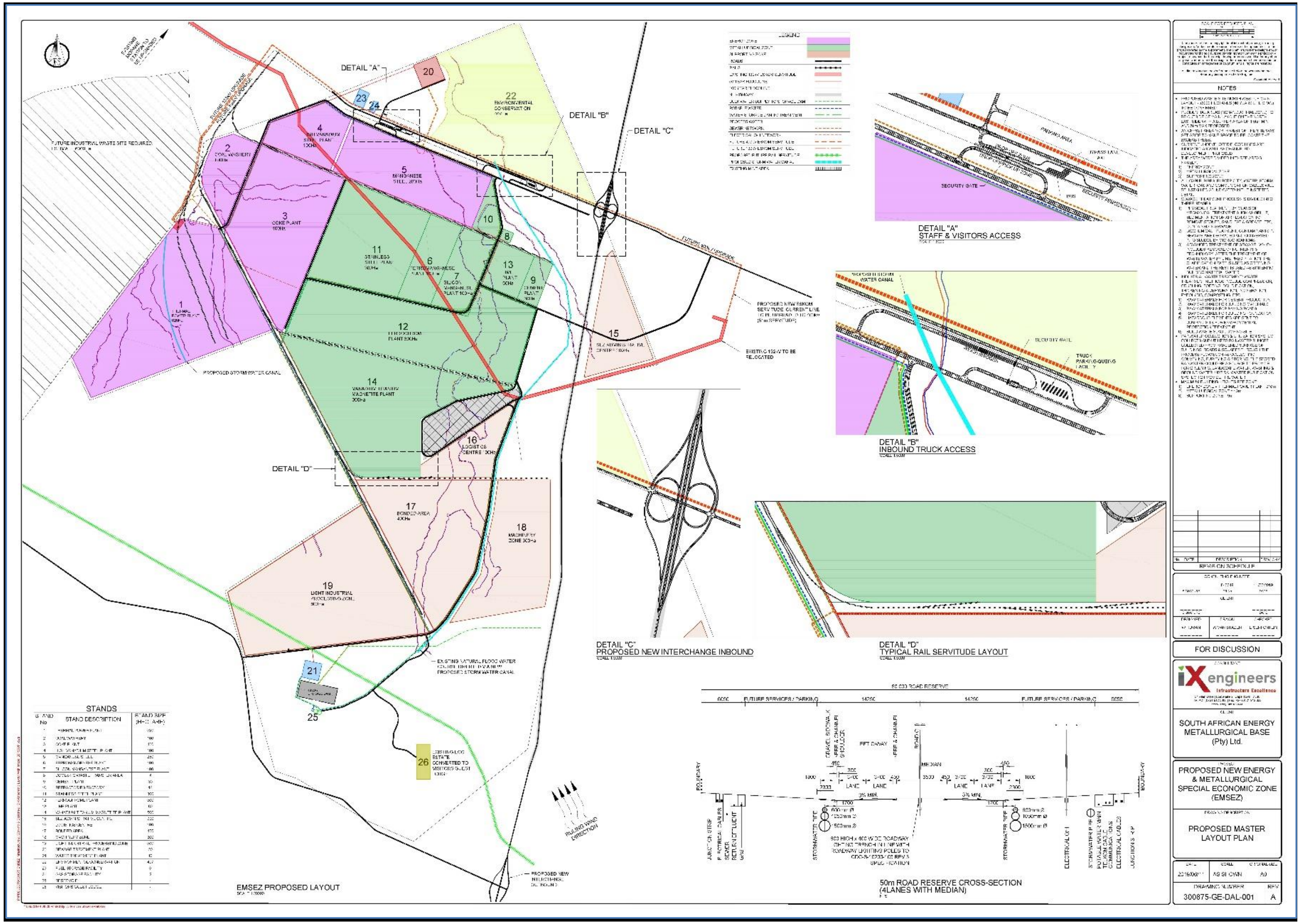


Figure 3-1: Proposed master plan

4 APPLICABLE LEGISLATION

Prior to assessing the impact of proposed activities on human health and the environment, reference needs to be made to the regulations governing the calculation and impact of such operations on air quality; including reporting requirements, emission standards, ambient air quality standards and dust control regulations.

Emission standards are generally provided for point sources and specify the amount of the pollutant acceptable in an emission stream and are often based on proven efficiencies of air pollution control equipment. Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the user of that air at the downstream receptor site. The ambient air quality standards and guideline values indicate safe daily exposure levels for the majority of the population, including the very young and the elderly, throughout an individual's lifetime. Air quality guidelines and standards are normally given for specific averaging or exposure periods.

4.1 National Ambient Air Quality Standards

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. South African NAAQS for NO_2, PM_{10}, SO_2 CO, benzene (C_6H_6) and lead (Pb) were published on 24 December 2009. On 29 June 2012 standards for $PM_{2.5}$ were also published. These standards are listed in Table 4-1.

Table 4-1: National Ambient Air Quality Standards for criteria pollutants

Pollutant	Averaging Period	Limit Value (µg/m³)	Limit Value (ppb)	Frequency of Exceedance	Compliance Date
NO_2	1-hour	200	106	88	Currently enforceable
	1-year	40	21	0	Currently enforceable
$PM_{2.5}$	24-hour	40	-	4	1 Jan 2016 – 31 Dec 2029
	24-hour	25	-	4	1 Jan 2030
	1-year	20	-	0	1 Jan 2016 – 31 Dec 2029
	1-year	15	-	0	1 Jan 2030
PM_{10}	24-hour	75	-	4	Currently enforceable
	1-year	40	-	0	Currently enforceable
SO_2	10-minute	500	191	526	Currently enforceable
	1-hour	350	134	88	Currently enforceable
	24-hour	125	48	4	Currently enforceable
	1-year	50	19	0	Currently enforceable
CO	1-hour	30 000	26 000	88	Currently enforceable
	8-hour	10 000	8 700	11	Currently enforceable
C_6H_6	1-year	5	1.6	0	Currently enforceable
Pb	1-year	0.5	-	0	Currently enforceable

4.2 Assessment Criteria for Fallout Dust - National Dust Control Regulations

The NDCR were published on the 1st of November 2013 (Government Gazette No. R. 827). Acceptable dustfall rates per the Regulation are summarised in Table 4-2.

Table 4-2: Acceptable dustfall rates

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

The regulation also specifies that the method to be used for measuring dustfall rates and the guideline for locating sampling points shall be ASTM D1739 (1970), or equivalent method approved by any internationally recognized body. Dustfall rates are assessed for nuisance impact and not inhalation health impact.

4.3 International Health Criteria and Unit Risk Factors

The potential for health impacts associated with non-criteria pollutants emitted from the operations are assessed according to guidelines published by the following institutions:

1. Inhalation reference concentrations (RfCs) and cancer URFs published by the US EPA IRIS;
2. Inhalation guideline values (GVs) and cancer URFs published by the WHO;
3. Minimal risk levels for hazardous substances (MRLs) published by the ATSDR; and
4. Inhalation reference exposure level (REL) published by the CALEPA OEHHA.

Chronic inhalation criteria and URFs for pollutants considered in the study are summarised in Table 4-3. Increased lifetime cancer risk is conservatively calculated by applying the unit risk factors to predicted long term (annual average) pollutant concentrations.

It should be noted that there are large variations in published cancer URFs. Whereas the US EPA IRIS estimated the increased lifetime cancer risk due to exposure to Cr^{6+} to be 0.012 (US EPA, 1998). The WHO summarised several epidemiological studies and found the range in URFs to be from 0.011 to 0.13 $(\mu g/m^3)^{-1}$. They further indicate that differences in the epidemiological studies cited may suggest that the different hexavalent chromium compounds have varying degrees of carcinogenic potency (WHO, 2000). They recommend the use of 0.04 $(\mu g/m^3)^{-1}$ as the URF for exposure to Cr^{6+} through inhalation. URFs are applied in the calculation of carcinogenic risks. These factors are defined as the estimated probability of a person (60-70 kg) contracting cancer as a result of constant exposure to an ambient concentration of 1 $\mu g/m^3$ over a 70-year lifetime. Increased lifetime cancer risk is conservatively calculated by applying the unit risk factors to predicted long term (annual average) pollutant concentrations.

Table 4-3: Chronic and acute inhalation screening criteria and cancer URFs for pollutants relevant to the SEZ

Pollutant	Chronic Screening Criteria ($\mu g/m^3$)	Subchronic Screening Criteria ($\mu g/m^3$)	Acute Screening Criteria ($\mu g/m^3$)	Inhalation URF $(\mu g/m^3)^{-1}$
Mn	0.05 [(a)]	-	-	-

Pollutant	Chronic Screening Criteria (µg/m³)	Subchronic Screening Criteria (µg/m³)	Acute Screening Criteria (µg/m³)	Inhalation URF $(µg/m^3)^{-1}$
	0.09 [f]			
	0.15 [c]	-	-	-
	0.3 [e]	-	-	-
Cr^{6+}	0.1 [a]	-	-	0.012 [b]
	0.2 [f]	-	-	0.04 [d]
H_2S	2 [a]	150 [c]	42 [f]	-

Notes:

(a) US EPA IRIS RfC
(b) US EPA IRIS URF
(c) WHO GV
(d) WHO URF
(e) ATSDR MRL
(f) CALEPA OEHHA REL

The identification of an acceptable cancer risk level has been debated for many years and it possibly will continue as societal norms and values change. Some people would easily accept higher risks than others, even if it were not within their own control; others prefer to take very low risks. An acceptable risk is a question of societal acceptance and will therefore vary from society to society. Despite the difficulty to provide a definitive "acceptable risk level", the estimation of a risk associated with an activity provides the means for a comparison of the activity to other everyday hazards, and therefore allowing risk-management policy decisions. Technical risk assessments seldom set the regulatory agenda because of the different ways in which the non-technical public perceives risks. Consequently, science does not directly provide an answer to the question.

Whilst it is perhaps inappropriate to make a judgment about how much risk should be acceptable, through reviewing acceptable risk levels selected by other well-known organizations, it would appear that the US EPA's application is the most suitable, i.e. *"If the risk to the maximally exposed individual (MEI) is no more than 1 x 10^{-6}, then no further action is required. If not, the MEI risk must be reduced to no more than 1 x 10^{-4}, regardless of feasibility and cost, while protecting as many individuals as possible in the general population against risks exceeding 1 x 10^{-6}"*. Some authorities tend to avoid the specification of a single acceptable risk level. Instead a "risk-ranking system" is preferred. For example, the New York State Department of Health (NYS DOH) produced a qualitative ranking of cancer risk estimates, from "very low" to "very high" (Table 4-4). Therefore, if the qualitative descriptor was "low", then the excess lifetime cancer risk from that exposure is in the range of greater than one per million to less than one per ten thousand.

Table 4-4: Excess Lifetime Cancer Risk (as applied by NYS DOH)

Risk Ratio	Qualitative Descriptor
Equal to or less than one in a million	Very low
Greater than one in a million to less than one in ten thousand	Low
One in ten thousand to less than one in a thousand	Moderate
One in a thousand to less than one in ten	High
Equal to or greater than one in ten	Very high

4.4 Screening Criteria for Animals and Vegetation

A literature review done by Farmer (1993) looked at the impact of dust on vegetation and grazing quality. While there is little direct evidence of what the impact of dust fall on vegetation is under a South African context, a review of these European studies has shown the potential for reduced growth and photosynthetic activity in various crops. The study stated that the effects of dust on plants vary significantly depending on the crop and tree species – blocked stomata, increased transpiration, inhibition of pollen germination, cell plasmolysis, no starch production, reduced photosynthesis, reduced reproductive growth, leave spotting, increased water loss, no mineral uptake, etc. Furthermore, dust deposition affects plants indirectly through changes in soil chemistry. The dust fallout limit of 400 mg/m²-day reported by Farmer (1993) may be applicable to the vegetation. More information on the effects of dust on vegetation and animals is discussed in Appendix B.

4.5 National Minimum Emission Standards

The minister has under Section 21 of the NEM:AQA (Act No. 39 of 2004) published listed activities and NMES on 22 November 2013 in Government Gazette No. 37054 (and amendments). The facilities for the development within the SEZ are likely to trigger several listed activities defined in Section 21, based on the process information already available (Table 4-5). In addition to the confirmed listed activities, there is the potential for other listed activities to be triggered by processes proposed within the SEZ (Table 4-5).

Table 4-5: Listed activities

Category of Listed Activity	Subcategory of Listed Activity	Description of the Listed Activity	Air quality management criteria
Confirmed listed activities			
1	1.1	Solid Fuel Combustion Installations	Emission limits and special arrangements
3	3.2	Coke Production	Emission limits
4	4.1	Drying and Calcining	Emission limits
4	4.6	Basic Oxygen Furnaces	Emission limits and special arrangements
4	4.7	Electric Arc Furnaces	Emission limits and special arrangements
4	4.8	Blast Furnaces	Emission limits and special arrangements
4	4.9	Ferro-alloy Production	Emission limits and special arrangements
4	4.10	Foundries	Emission limits
5	5.1	Storage and Handling of Ore and Coal	Special arrangements for dustfall monitoring
5	5.4	Cement Production (using conventional fuels raw materials)	Emission limits and special arrangements
5	5.6	Lime Production	Emission limits
5	5.9	Ceramic Production	Emission limits
Potentially triggered listed activities			
4	4.20	Slag Processes	Emission limits and special arrangements
4	4.23	Metal Spray	Emission limits
5	5.2	Drying	Emission limits

Category of Listed Activity	Subcategory of Listed Activity	Description of the Listed Activity	Air quality management criteria
5	5.5	Cement Production (using alternative fuels and/or resources)	Emission limits and special arrangements
5	5.7	Lime Production (using alternative fuels and/or resources)	Emission limits

4.6 Applying for an Atmospheric Emission Licence

The proposed facilities within the SEZ triggering listed activities will be required to apply for a new Atmospheric Emission Licence (AEL). An AEL must include all sources of emission, not only those considered listed activities. In terms of the AEL application, the applicant should take into account the following sections of NEM:AQA:

37. Application for atmospheric emission licences:

- *(1) A person must apply for an AEL by lodging with the licensing authority of the area in which the listed activity is to be carried out, an application in the form required.*
- *(2) An application for an AEL must be accompanied by –*
  - *(a) The prescribed processing fee; and*
  - *(b) Such documentation and information as may be required by the licensing authority.*

38. Procedure for licence applications:

- *(1) The licensing authority –*
  - *(a) May, to the extent that is reasonable to do so, require the applicant, at the applicant's expense, to obtain and provide it by a given date with other information contained in or submitted in connection with the application;*
  - *(b) May conduct its own investigation on the likely effect of the proposed license on air quality;*
  - *(c) May invite written comments from any organ of state which has an interest in the matter; and*
  - *(d) Must afford the applicant an opportunity to make representations on any adverse statements or objections to the application.*
- *(2) Section 24 of the NEMA and section 22 of the Environmental Conservation Act apply to all applications for atmospheric emission licenses, and both an applicant and the licensing authority must comply with those sections and any applicable notice issued or regulations made in relation to those sections.*
- *(3) –*
  - *(a) An applicant must take appropriate steps to bring the application to the attention of relevant organs of state, interested persons and the public.*
  - *(b) Such steps must include the publication of a notice in at least two newspapers circulating the area in which the listed activity is applied for is or is to be carried out and must-*
    - *(i) Describe the nature and purpose of the license applied for;*
    - *(ii) Give particulars of the listed activity, including the place where it is to be carried out;*
    - *(iii) State a reasonable period within which written representations on or objections to the application may be submitted and the address or place where it must be submitted; and*
    - *(iv) Contain such other particulars as the licensing authority may require.*

4.7 Reporting of Atmospheric Emissions

The National Atmospheric Emission Reporting Regulations (Government Gazette No. 38633) came into effect on 2 April 2015. The purpose of the regulations is to regulate the reporting of data and information from an identified point, non-point and mobile sources of atmospheric emissions to an internet-based NAEIS. The NAEIS is a component of the South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP). Its objective is to provide all stakeholders with relevant, up to date and accurate information on South Africa's emissions profile for informed decision making.

Emission sources and data providers are classified according to groups. The project would be classified under Group A ("Listed activity published in terms of section 21(1) of the Act"). Emission reports from Group A must be made in the format required for NAEIS and should be in accordance with the AEL or provisional AEL.

As per the regulation, the SEZ facilities and/or their data provider(s) should register on the NAEIS. Data providers must inform the relevant authority of changes if there are any:

- change in registration details;
- transfer of ownership; or
- activities being discontinued.

A data provider must submit the required information for the preceding calendar year to the NAEIS by 31 March of each year. Records of data submitted must be kept for a period of 5 years and must be made available for inspection by the relevant authority.

The relevant authority must request, in writing, a data provider to verify the information submitted if the information is incomplete or incorrect. The data provider then has 60 days to verify the information. If the verified information is incorrect or incomplete the relevant authority must instruct a data provider, in writing, to submit supporting documentation prepared by an independent person. The relevant authority cannot be held liable for cost of the verification of data. A person guilty of an offence in terms of Section 13 of these regulations is liable for penalties.

4.8 Atmospheric Impact Report

Under section 30 of NEM:AQA, an air quality officer (AQO) may require any person to submit an AIR in the format prescribed if a review of provisional AEL or AEL is undertaken. The format of the AIR is stipulated in the *Regulations Prescribing the Format of the Atmospheric Impact Report*, Government Gazette No. 36904 dated 11 October 2013.

4.9 Greenhouse Gas Emissions

Regulations pertaining to GHG reporting using the NAEIS was published on 3 April 2017 (Government Gazette 40762, Notice 257 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 SAAELIP.

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 GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. Technical guidelines for GHG emission estimation have been issued.

Each company's Greenhouse Gas Emissions Report will be used as the basis for their carbon tax calculations. Companies, in control of certain GHG emitting activities and which exceed a predetermined threshold, will be required to submit GHG emission data calculated in line with technical guidelines and in a format prescribed by the National Greenhouse Gas Emission Reporting Regulations (NGERs). Listed activities and associated capacity thresholds that require a GHG Emissions Report are provided in *Annexure 1: List of Activities for which GHG Emissions must be Reported to the Competent Authority* of the NGERs. The DEA separately published the *Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry* ('Technical Guideline') as a companion to the NGERs that provides details of the reporting methodology as specified in the NGERs. According to the NGERs, a data provider is defined as any person in control of or conducting an activity listed in *Table 5.2* of the Technical guideline and shall include:

- its holding company or corporation or legal entity, registered in South Africa in accordance with the Legislation of South Africa;
- all its subsidiaries and legally held operations, including joint ventures and partnerships where it has a controlling interest, or is nominated as the responsible entity for the purpose of reporting under these Regulations *(i.e. NGER)*; and
- all facilities generally over which it has operational control, which are not part of another data provider as provided for in these Regulations *(i.e. NGER)*.

An *IPCC emission source* is defined in the NGERs as "any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere which is identified by the Intergovernmental Panel on Climate Change (IPCC) code in Annexure 1 of the NGERs". These emission sources are divided into the following main groups:

1. Energy
2. Industrial Processes and Product Use
3. Agricultural, Forestry and Other Land Use
4. Waste

Each of these groups are further subdivided into subcategories, each of which is covered in Technical Guideline companion to the NGERs. The scope of activities listed for mandatory reporting as per *Table 5.2* of the Technical Guideline does not include land-based emissions covered by the United Nations Framework Convention on Climate Change (UNFCCC) categories 'Agriculture and Land Use, Land Use Change and Forestry. However, emissions from fuel combustion or any other listed emission source, and which originate from a facility operating within a land-based industry are, nonetheless, covered.

The first category *1 Energy* and second category *2 Industrial Processes and Product Use* is of relevance to the proposed Project. The method of determining GHG emissions shall be *Tier 1* or *Tier 2*, i.e. Tier 1 methodologies allow for the use of default emission factors readily available in the 2006 IPCC Guidelines. Tier 2 methodologies require more appropriate emission factors such as country-specific emission factors. (Tier 3 methodologies require facility or technology specific parameters that describe carbon inputs and process conditions.)

The greenhouse gases covered by the NGERs include:

- CO_2
- CH_4
- N_2O
- hydrofluorocarbons (HFCs)
- perfluorocarbons (PFCs)
- sulfur hexafluoride (SF_6).

The calculation of greenhouse gas emissions associated with the SEZ were not included in the scope of the Air Quality Impact Assessment.

4.10 Municipal By-Laws

A Local Municipality may, according to the Constitution of the Republic of South Africa, define and administer by-laws for the effective administration of the air quality management. This is usually undertaken by defining controlled emitters including emissions deriving from (i) vehicles; (ii) small boilers; (iii) dust generating activities; (iv) open burning; (v) open burning of industrial waste, domestic waste and garden waste in waste bins or skips on any land of premise; (vi) sugar cane burning; (vii) tyre burning and burning of rubber products and cables in open spaces; (viii) pesticide spraying; (ix) spray painting; (x) sand blasting and (xi) noise pollution.

The only criteria for these by-laws are that they should not conflict with national or provincial legislation and thus would need to be more stringent. Since air pollution is listed as a matter in which local government has authority, national or provincial government may not compromise or impede a municipality's right to exercise its powers or perform its functions. In order to assist municipalities in the development of air quality management by-laws within their jurisdictions, a generic model air quality management by-law was published in the Government Gazette, 2 July 2010. The objectives of the by-law are:

- to give effect to the right contained in Section 24 of the Constitution by regulating air pollution within the area of the municipality's jurisdiction; and,

- to provide (in conjunction with any other applicable law) an effective legal and administrative framework within which the municipality can manage and regulate listed activities, and ensure that air pollution is avoided, or in the case where it cannot be avoided, minimised or mitigated.

The by-law is intended to be read together with any applicable provisions in the Air Quality Act of 2004 and the National Framework and prevails to the extent of inconsistency with any other municipality by-laws. The by-law enables the Council to take measures against any person who is wholly or partially responsible for causing air pollution or creating the risk of causing air pollution, and/ or who does not undertake specific reasonable measures before a given date; continue with those measures and complete them before a specified reasonable date. Should the person fail to comply or inadequately comply, the Council may take reasonable measures to remedy the situation or present the case before a court. The Council can also recover costs incurred as a result of undertaking reasonable remedial measures or court appearances. The public participation process as set out in Section 13 of the Municipal Systems Act of 2000, as amended, must be followed to publish local emission standards.

The status of by-laws addressing air pollution sources not covered by Section 21 of the Air Quality Act is unknown for Vhembe District Municipality (DM).

4.11 International Finance Corporation Environmental, Health and Safety Guidelines

The technical reference documents published in the IFC Environmental, Health and Safety (EHS) Guidelines provide general and industry specific examples of Good International Industry Practice (GIIP). The General EHS Guidelines are designed to be used together with the relevant Industry Sector EHS Guidelines. EHS Guidelines' general approach to air quality (IFC, 2007) states that projects should prevent or minimize impacts by ensuring that:

- Emissions do not result in pollutant concentrations that reach or exceed the relevant national ambient air quality guidelines and standards, or in their absence, the current WHO Air Quality Guidelines (AQG) or other internationally recognised sources;
- Emissions do not contribute a significant portion to the attainment of relevant ambient AQG or standards. The Guideline suggests 25% of the applicable ambient air quality standards to allow additional, future development in the same airshed.

The General EHS Guidelines state that at project level, impacts should be estimated through qualitative or quantitative assessments using baseline air quality assessments and atmospheric dispersion models. The dispersion model should be internationally recognised and able to take into account local atmospheric, climatic and air quality data as well as the effects of downwash, wakes or eddy effects generated by structures and terrain features (IFC, 2007).
The General EHS Guidelines also provide guidance with respect to:

- projects located in degraded airsheds or ecologically sensitive areas;
- points sources and stack heights;
- emissions from small combustion facilities (3 to 50 MWth rated heat input capacity);
- fugitive sources;
- ozone depleting substances;
- land based mobile sources;
- greenhouse gases;
- monitoring; and
- air emissions prevention and control technologies

In addition to the General EHS Guidelines, the IFC also provides industry specific EHS Guidelines. The following industry specific EHS Guidelines are most relevant to the project:

- Thermal Power Plants[1]
- Base metal smelting and refining[2];
- Integrated Steel Mills[3]
- Foundries[4]
- Metal, Plastic, and Rubber Products Manufacturing[5]
- Electric Power Transmission[6]

[1] https://www.ifc.org/wps/wcm/connect/dfb6a60048855a21852cd76a6515bb18/FINAL_Thermal%2BPower.pdf?MOD=AJPERES&id=1323162579734

[2] https://www.ifc.org/wps/wcm/connect/4365de0048855b9e8984db6a6515bb18/Final%2B-%2BSmelting%2Band%2BRefining.pdf?MOD=AJPERES&id=1323152449229

[3] https://www.ifc.org/wps/wcm/connect/0b9c2500488558848064d26a6515bb18/Final%2B-%2BIntegrated%2BSteel%2BMills.pdf?MOD=AJPERES&id=1323161945237

[4] https://www.ifc.org/wps/wcm/connect/4ccab880488554c3b3f4f36a6515bb18/Final%2B-%2BFoundries.pdf?MOD=AJPERES&id=1323162141647

[5] https://www.ifc.org/wps/wcm/connect/0749ef004885566dba04fa6a6515bb18/Final%2B-%2BMetal%252C%2BPlastic%252C%2Band%2BRubber%2BProducts%2BMnfg.pdf?MOD=AJPERES&id=1323153287593

[6] https://www.ifc.org/wps/wcm/connect/66b56e00488657eeb36af36a6515bb18/Final%2B-%2BElectric%2BTransmission%2Band%2BDistribution.pdf?MOD=AJPERES&id=1323162154847

5 DESCRIPTION OF THE RECEIVING ENVIRONMENT

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

- locality data;
- AQRs;
- the atmospheric dispersion potential; and
- pre-development ambient air pollutant levels.

5.1 General Geography

The study area is characterised by terrain elevations in the range 450 to 1 470 metres above mean sea level (mamsl) (Figure 5-1). The terrain within the domain is undulating, while the Soutpansberg runs to across the south-east of the domain. The dominance of this mountain range will influence wind fields and therefore local pollutant dispersal from local sources near this topographical feature.

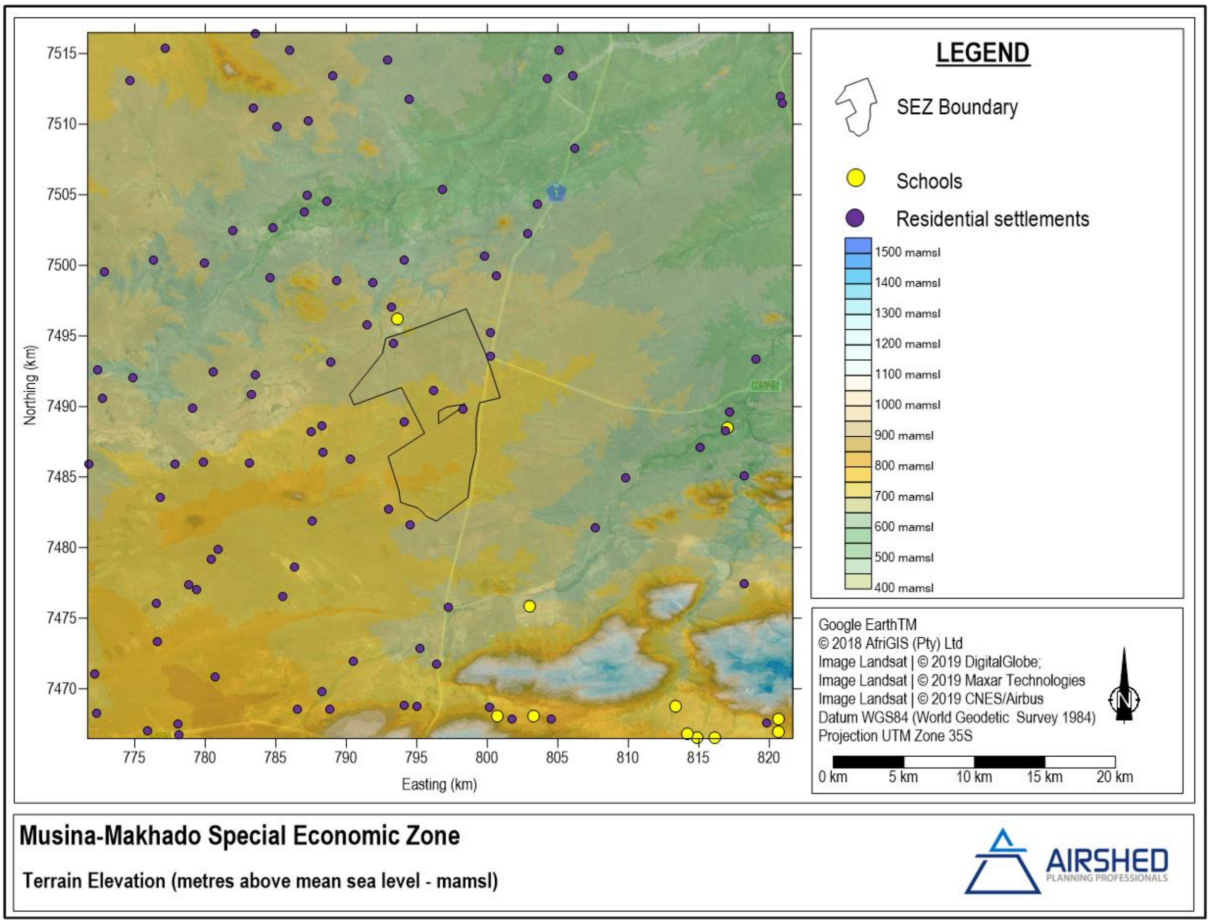


Figure 5-1: Terrain elevation

5.2 Population Density

The Vhembe DM, according to the 2016 Community Survey , has the largest population of the district municipalities in the Limpopo province and the second largest area, with an average population density of 54 persons/km^2 (Table 5-1).

Table 5-1: Spatial and population statistics of the Vhembe district municipality (based on 2016 Community Survery data)

Criteria	Vhembe
Area (km^2)	25 659
Population size	1 393 949
Administrative seat	Thohoyandou
Local Municipalities	Makhado (population: 416 728) Musina (population: 132 009) Collins Chabane[(a)] (population: 497 237) Thulamela[(a)] (population: 347 974)

Notes:
(a) SEZ development not located in this municipality

5.3 Air Quality Receptors

In accordance with the Regulations Regarding Air Dispersion Modelling (DEA, 2014), hospitals, clinics, and schools were identified as air quality receptors (AQRs) (Figure 5-2 and Table 5-2) and were included in the dispersion model setup as discrete receptors. The SEZ is proposed for development in a relatively sparely populated area to the west of the N1 national highway between Makhado and Musina. A total of 183 receptors were identified in the domain, including residential settlements and schools, of which 21 receptors are within 10 km of the centre of the SEZ. The closest residential settlement (Steenbok) is located approximately 0.4 km to the south-west of the SEZ centre point. Three residential settlements are located within the SEZ study area boundary.

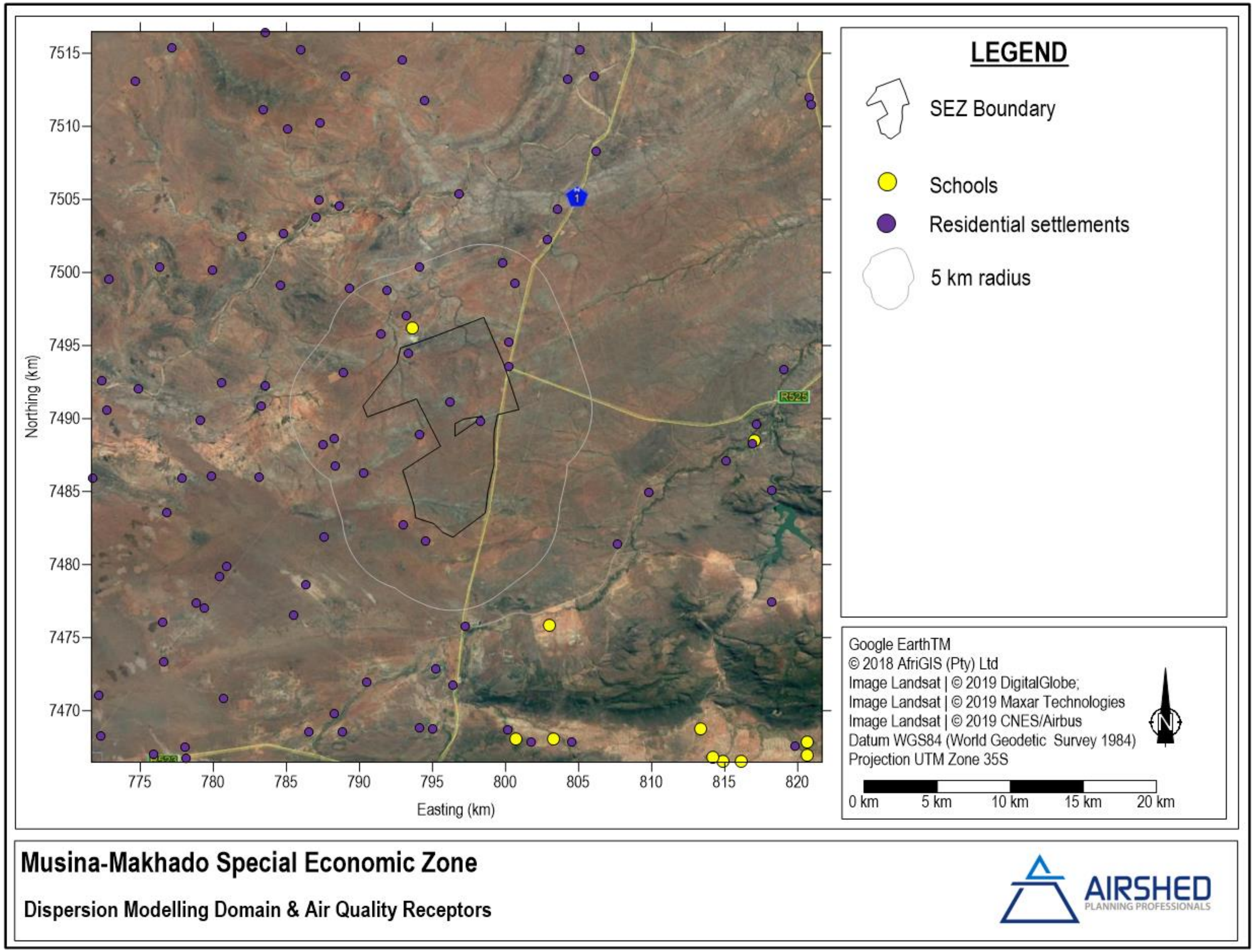


Figure 5-2: Map of the dispersion modelling domain and AQRs surrounding the SEZ

Table 5-2: List of nearest AQRs

Receptor ID	Receptor Name	Receptor type	Distance from centre of site (km)	Direction from site
155	Steenbok	Residential settlement	0.4	SW
159	Somme	Residential settlement	2	SE
149	Grootpraat	Residential settlement	3	SW
162	Bokmakierie	Residential settlement	4	ENE
147	Van der Bijl	Residential settlement	4	NW
163	Masiripan	Residential settlement	5	NE
5	Mopane Intermediate School	School	6	NNW
146	Erasmus	Residential settlement	7	NNW
142	Volharding	Residential settlement	7	NW
137	Hermanus	Residential settlement	8	WNW
140	Command	Residential settlement	8	SW
133	Du Toit	Residential settlement	9	WSW
143	Kitchener	Residential settlement	9	NNW
164	Emery	Residential settlement	9	NNE
148	Swartrand	Residential settlement	9	NNW
145	Generaal	Residential settlement	9	SSW
134	Somerville	Residential settlement	9	WSW
130	Fraure	Residential settlement	10	WSW
160	Barend	Residential settlement	10	NNE
152	Joffre	Residential settlement	10	SSW
139	Kitchener	Residential settlement	10	NW

5.4 Atmospheric Dispersion Potential

5.4.1 Surface Wind Field

The wind field determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is a function of the wind speed, in combination with the surface roughness. The wind field for the study area is described with the use of wind roses. Wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the yellow area, for example, representing winds in between 5 and 6 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated. The data described below is the WRF data as processed by the CALMET meteorological data pre-processor at the centre point of the SEZ study area.

A period, day-time and night-time wind roses for January 2016 to December 2018 are included in Figure 5-3 and Figure 5-4. The wind field was dominated by winds from the east. Calm conditions occurred for approximately 1.7% of the time. During the day, the wind field is similar to the period wind field with more frequent north-easterly winds and 2.6% calm conditions. Night-time airflow had more dominant south-easterly winds and less frequent winds from the north-eastern sector than the day-time. The percentage calm conditions increase to approximately 0.7%. Calm conditions were most frequently recorded in autumn and most infrequently in spring (Figure 5-4). Although the seasonal wind fields were similar to the period average, slight variations were observed. The autumn and winter wind fields showed more frequent winds from the south-east, while in spring and summer show a more easterly dominance. Winds in the higher wind speed categories are most common in spring, with the fewest calm conditions.

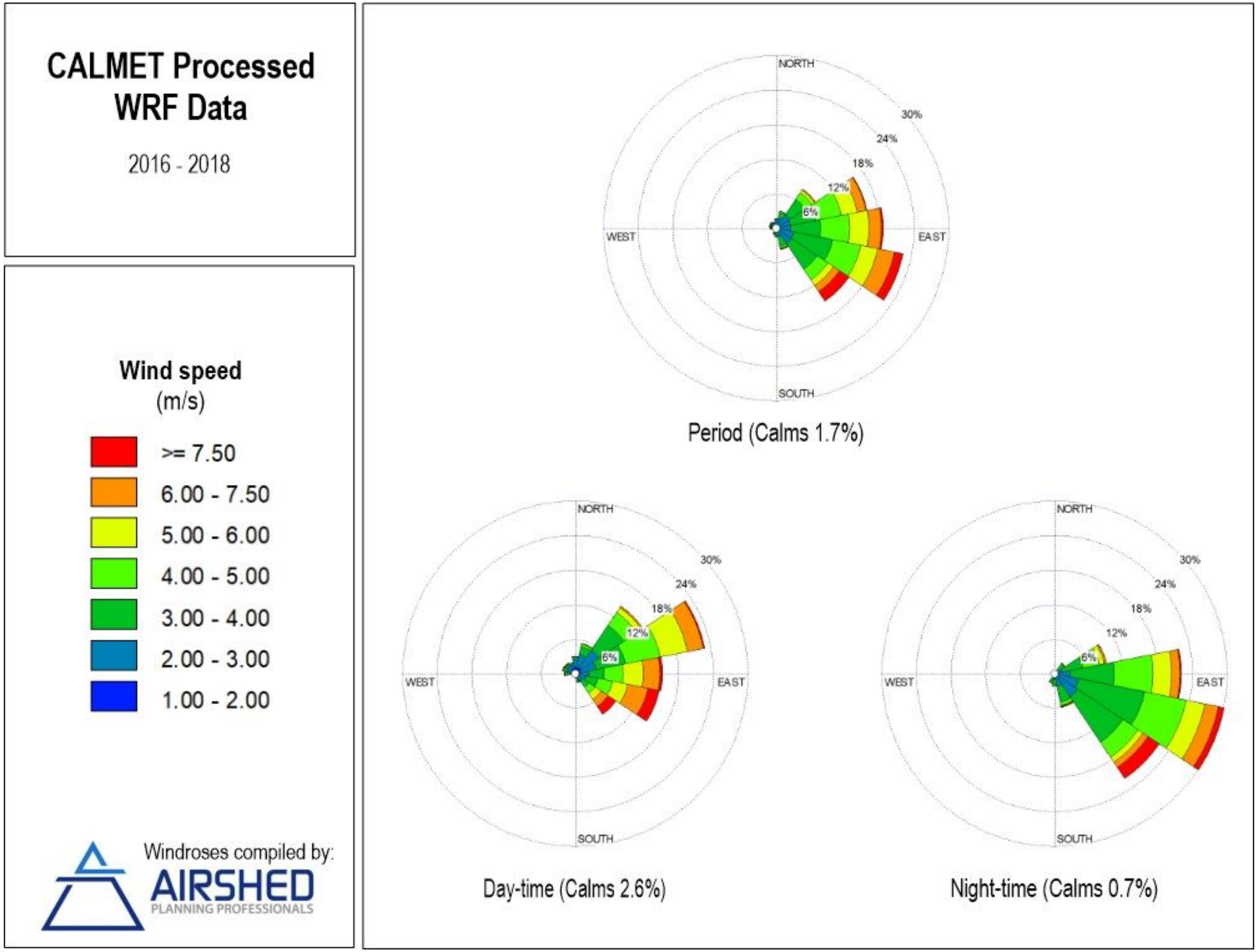


Figure 5-3: Period, day-time, and night-time wind roses (CALMET processed WRF data, 2016 to 2018)

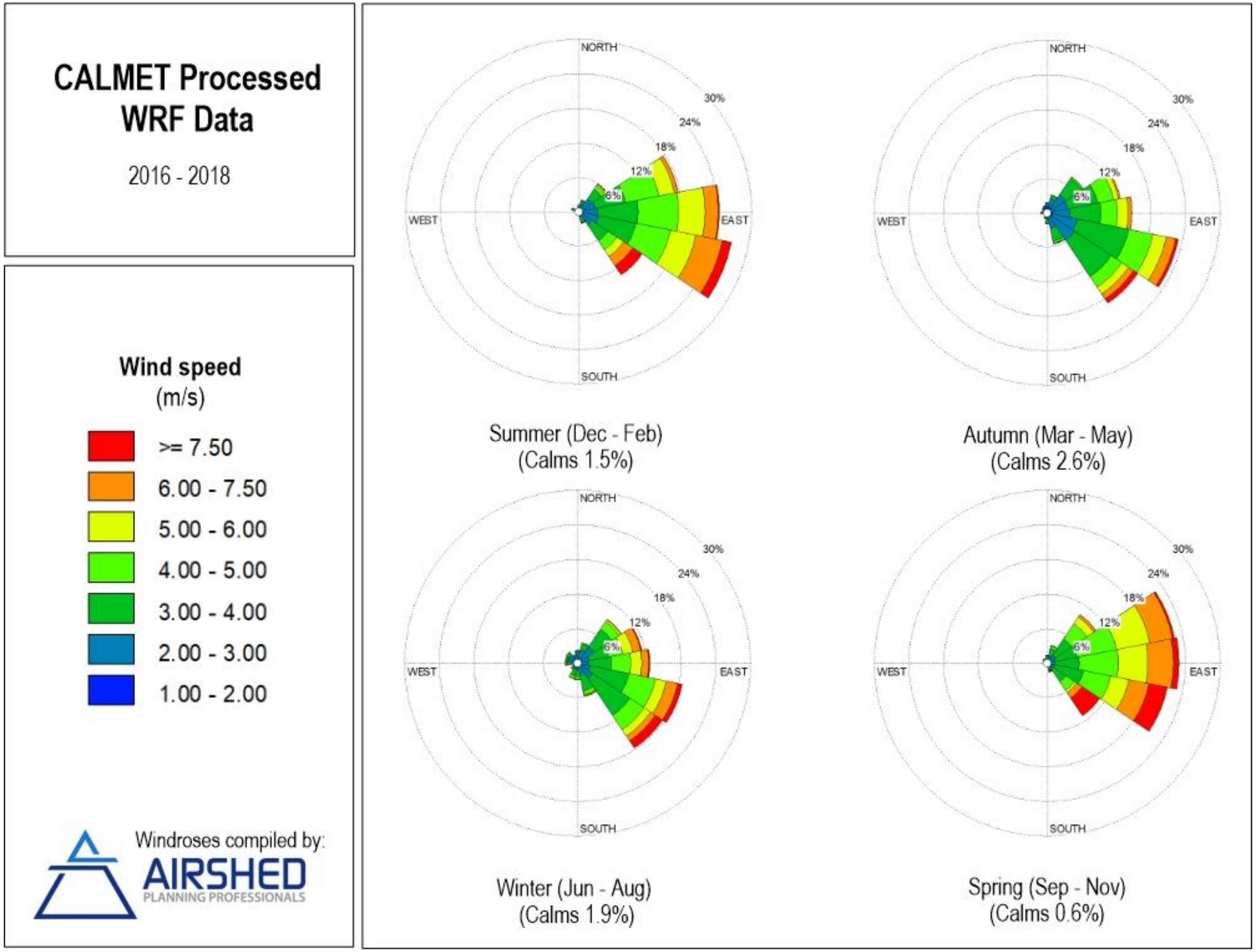


Figure 5-4: Seasonal wind roses (CALMET processed WRF data, 2016 to 2018)

5.4.2 Temperature

Air temperature is important, both for determining the effect of plume buoyancy and determining the development of the mixing and inversion layers. Minimum, maximum and mean temperatures for the project area, as obtained from CALMET processed WRF data, are shown in Table 5-3. Diurnal monthly average temperatures shown in Figure 5-5.

Minimum, average, and maximum temperatures were 7.8°C, 23.0°C and 39.6°C, respectively. The months of June to August experienced the lowest temperatures. The maximum temperature of 39.6°C occurred in October. Temperatures reach their minimum just before sunrise and there maximum between late afternoon and sunset.

Table 5-3: Minimum, average, and maximum temperatures (CALMET processed WRF, 2016 to 2018)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	14.6	16.0	13.7	13.1	10.9	9.0	7.8	8.0	10.6	9.3	13.5	15.3
Average	25.7	25.8	24.8	22.8	19.9	18.2	17.5	20.5	24.3	24.7	25.3	27.1
Maximum	38.6	38.9	36.2	33.7	29.7	29.9	29.1	34.3	38.2	39.6	38.1	39.0

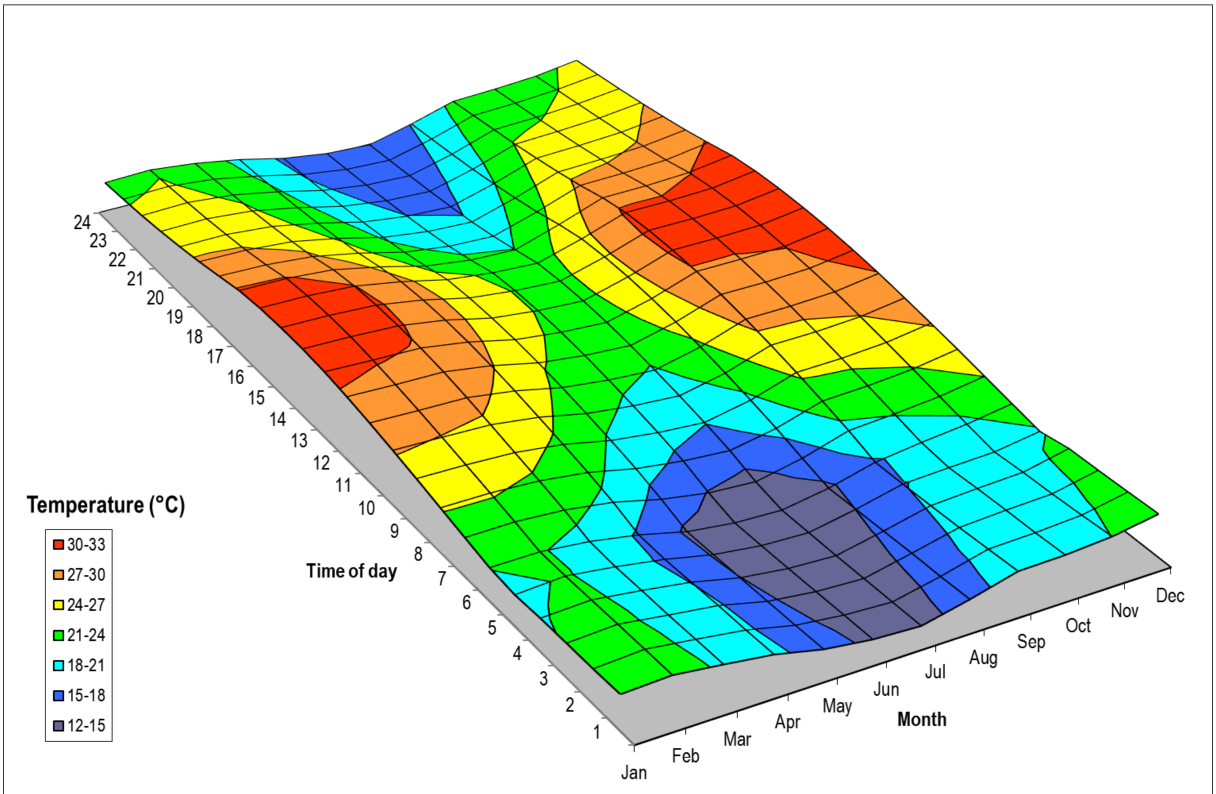
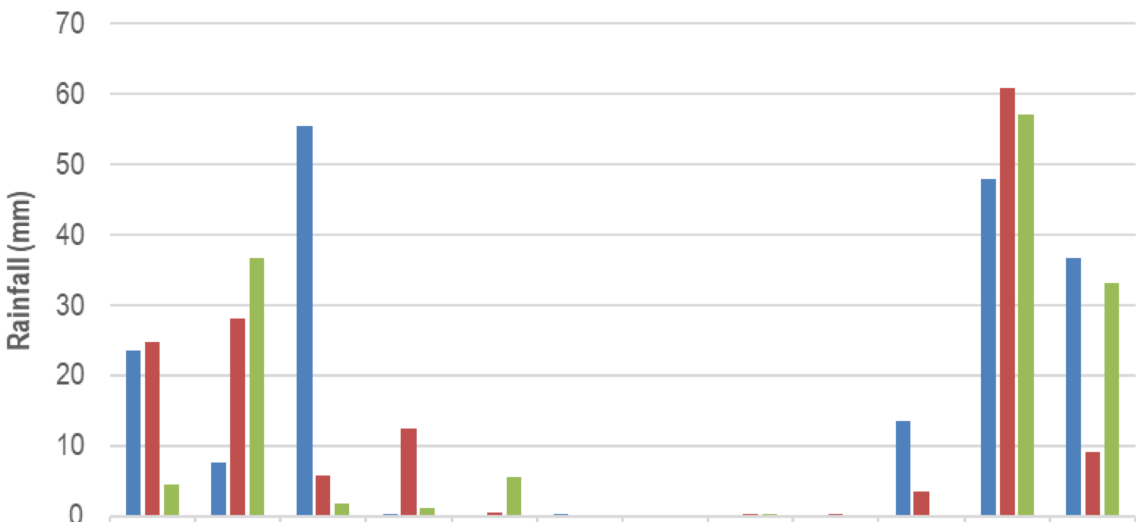


Figure 5-5: Monthly average temperature profile (CALMET processed WRF, 2016 to 2018)

5.4.3 Rainfall

Rainfall represents an effective removal mechanism of atmospheric pollutants and is therefore frequently considered during air pollution studies. According to the rainfall data from the CALMET-processed WRF data, the mean annual precipitation is 253 millimetres (mm) (for the three-year period 2016 to 2018 - Figure 5-6). Rainfall occurs mainly from October to April with high interannual variability. The winter months are dry with no rainfall between June and September in the data period.



	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec
2016	24	8	55	0	0	0	0	0	0	13	48	37
2017	25	28	6	12	1	0	0	0	0	4	61	9
2018	5	37	2	1	5	0	0	0	0	0	57	33

Figure 5-6: Monthly rainfall figures (CALMET processed WRF, 2016 to 2018)

5.4.4 Atmospheric Stability

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

The Monin-Obukhov length (L_{Mo}) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface (Figure 5-7). Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004). The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface. Night-times are characterised by weak vertical mixing and the predominance of a stable layer. These conditions are normally associated with low wind speeds and lower dilution potential.

The highest concentrations for ground level, or near-ground level, releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions (Figure 5-7). For elevated releases, unstable conditions can result in very high concentrations of poorly diluted emissions close to the stack. This is called *looping* and occurs mostly during daytime hours. Neutral conditions disperse the plume fairly equally in both the vertical and horizontal planes and the plume shape is referred to as *coning*. Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called *fanning* (Tiwary & Colls, 2010). For ground level releases such as fugitive dust the highest ground level concentrations will occur during stable night-time conditions.

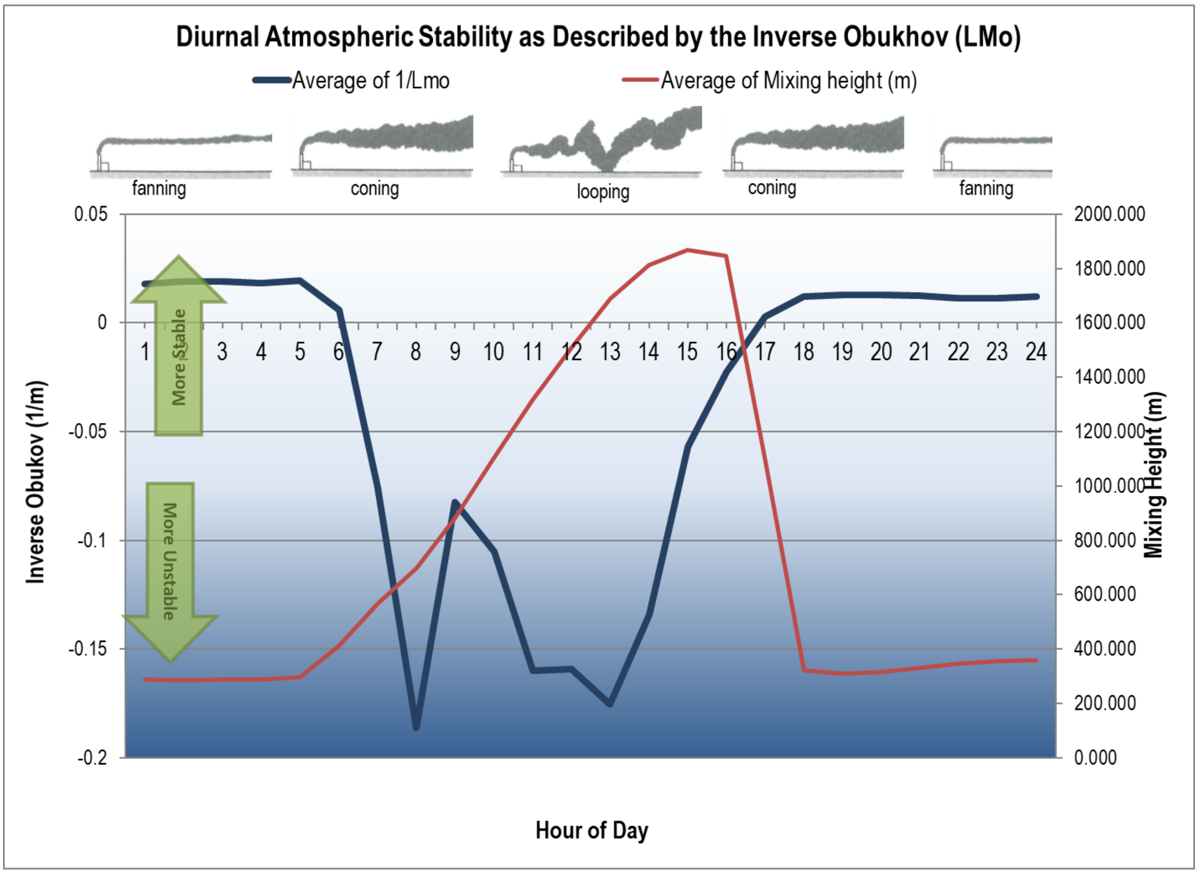


Figure 5-7: Diurnal atmospheric stability (CALMET data, 2016 to 2018)

5.5 Status Quo Ambient Air Quality

5.5.1 Existing Sources of Air Pollution in the Area

The main sources of existing air pollution include the following:

- Mining activities, especially coal mines;
- Agricultural activities, both commercial and subsistence farming;
- Transportation Activities:
  - Vehicle tailpipe emissions from public roads and during agricultural activities;
  - Entrained dust emissions from public and farm roads;
  - Commercial and recreational aircraft use.
- Household fuel burning;
- Biomass burning;

- Wind erosion from exposed soil surfaces.
- Landfills and wastewater treatment plants.

Table 5-4: Summary of air pollutants emitted from various sources in the study area

	Particulate matter	Sulfur dioxide	Oxides of nitrogen	Carbon monoxide	Organic compounds	Heavy metals	Odorous compounds (e.g. hydrogen sulfide)
Mining operations	✔	✔	✔	✔		✔	
Agricultural activities (excluding exhaust emissions)	✔				✔		✔
Transport (motor vehicles, railway, and aircraft)	✔	✔	✔	✔	✔	✔	
Household fuel burning	✔	✔	✔	✔	✔		
Biomass burning	✔	✔	✔	✔	✔		
Wind erosion	✔						
Landfills	✔				✔		✔
Wastewater treatment plants					✔		✔

5.5.1.1 Mining

Minerals and resources mined within the Vhembe district include coal, diamond, and other non-metal mines. Mining operations represent potentially significant sources of fugitive dust emissions, with particulate emissions being the main pollutant of concern. Fugitive dust sources associated with sand mining activities include materials handling activities, vehicle-entrainment by haul trucks and wind-blown dust from tailings impoundments and stockpiles.

5.5.1.2 Agricultural Activities

Agricultural activities may contribute to both particulate and gaseous air pollutants. Whereas the former emissions are mainly from the wind erosion of soil and perhaps burning of waste and seasonal burning of biomass, the latter would also include gaseous emissions from livestock. Large livestock farms, housing pigs, chickens, or cows, produce vast amounts of waste, which in turn generates gaseous emissions either through direct evaporation or by bacterial action. The most significant emissions from livestock farms include ammonia and reduced sulfur compounds (e.g. hydrogen sulfide).

Agricultural activities within the district include cattle farms, game farms, fruit trees and crop production. Particulate matter is the main pollutant of concern from agricultural activities as particulate emissions derive from windblown dust, burning crop residue, and dust entrainment as a result of vehicles travelling along dirt roads. In addition, pollen grains, mould spores and plant and insect parts from agricultural activities all contribute to the particulate load (WHO, 2000). Chemicals associated with crop spraying and malodourous emissions resulting from manure, fertilizer and crop residue have been identified as a main concern. Spray drift due to aerial crop spraying can distribute organo-chemicals in the nearby vicinity or even further afield. Crop residue burning and burning for frost prevention are additional sources of particulate emissions and other toxins.
Even though agricultural activities are acknowledged as a contributing source of specifically PM_{10} emissions within Vhembe DM, these sources have not been quantified. The Vhembe DM AQMP specifically identified livestock farming facilities, including 3 piggeries and 5 poultry farms within the Collins Chabane LM, as sources of atmospheric pollution.

5.5.1.3 Transport Sector

Atmospheric emission sources in the transportation sector include:

- Motor vehicles:
  - exhaust emissions;
  - evaporative emissions;
  - wheel entrained dust; and,
  - truck load and carry-on dust.
- Railway:
  - exhaust emissions; and,
  - wagon load emissions.

Vehicle emissions are a significant source of CO, NO_x, organic compounds (including non-methane organic compounds – NMTOC; and total organic compounds - TOC), benzene, lead, acetaldehyde, formaldehyde and 1.3-butadiene emissions in all urban areas. The significance of vehicle emissions in terms of their contribution to air pollutant concentrations and health risks is enhanced by the low level at which the emissions occur, and the proximity of such releases to high exposure areas. Vehicle emissions also tend to peak in the early morning and evenings, at which time atmospheric dispersion potentials are reduced.

5.5.1.4 Household Fuel Burning

Domestic coal combustion within informal settlements has been identified during various studies to be potentially one of the greatest sources of airborne particulates and gaseous emissions within urban areas. Traditionally use is made of wood, dung and bagasse but in the urban areas increasingly paraffin and liquified petroleum gas (LPG) are used.

Given low release level of domestic fuel burning appliances within the breathing space of people and sometimes even in enclosed areas, the impacts are significant; resulting in poor health.

The result from domestic fuel burning is the chronic exposure to pollutants emitted from coal and/or wood combustion. Coal and wood burning emits a large amount of gaseous and particulate pollutants including SO_2, heavy metals, total and respirable particulates including heavy metals and inorganic ash, carbon monoxide, polycyclic aromatic hydrocarbons (PAHs), 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, PAHs, particulate benzo(a)pyrene and formaldehyde.

5.5.1.5 Biomass Burning

Crop-residue burning and general wildfires (veld fires) represent significant sources of combustion-related emissions associated with agricultural areas. Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the Limpopo province, wildfires may represent significant sources of combustion-related emissions (Maenhaut et al., 1996; Galpin and Turner, 1999). Three vegetation biomes occur across the province although the most predominant is the savanna biome (97% of the total area). Grassland (2.9%) and forest (0.1%) patches occur in the higher lying areas. The type of savanna varies across the province from moist low-veld savanna where woody biomass is large to the more arid savanna with lower woody biomass in the west. With this diversity in plant biomass, the frequency of wildfires is likely to vary between annual and triennial (Scholes, 2004).

Biomass burning is an incomplete combustion process (Cachier, 1992), with CO, CH_4 and NO_2 gases being emitted. Approximately 40% of the nitrogen in biomass is emitted as nitrogen, 10% is left in 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 across the province, 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.

The concern with biomass burning is high potential of secondary anthropogenic $PM_{2.5}$ formation due to incomplete combustion of organic matter. It is expected that the amount of PM_{10} and $PM_{2.5}$ resulting from biomass burning are underestimated and hence the potential health risk associated with it. This also directly relate to the underestimation of the effect on atmospheric chemistry such as photochemistry.

Aerosols, black carbon and hydrocarbons are associated with biomass burning. Biomass burning is also a significant source of greenhouse gases, especially CO_2, black carbon and photochemical gases (NO_x, CO and hydrocarbons) that lead to the production of tropospheric ozone (O_3).

5.5.1.6 Wind Erosion

Significant emissions arise due to the mechanical disturbance of granular material from disturbed open areas and storage piles. A significant quantity of wind erosion can also occur from cultivated land during the dry season. Parameters which have the potential to impact on the rate of emission of fugitive dust include the extent of surface compaction, moisture content, ground cover, the shape of the storage pile, particle size distribution, wind speed and precipitation. Any factor that binds the erodible material, or otherwise reduces the availability of erodible material on the surface, decreases the erosion potential of the fugitive source. High moisture contents, whether due to precipitation or deliberate wetting, promote the aggregation and cementation of fines to the surfaces of larger particles, thus decreasing the potential for dust emissions. Surface compaction and ground cover similarly reduces the potential for dust generation. The shape of storage piles or disposal dumps influence the potential for dust emissions through the alteration of the airflow field. The particle size distribution of the material on the disposal site is important since it determines the rate of entrainment of material from the surface, the nature of dispersion of the dust plume, and the rate of deposition, which may be anticipated.

5.5.1.7 Landfill Operations

The two closest landfill facilities to the proposed SEZ are located near Louis Trichardt (within Makhado Local Municipality) and Musina (town). Landfill gas emissions and fugitive dust emissions represent the main air pollution aspects related to landfill operations. Sources of fugitive dust emissions include vehicle-entrained dust from paved and unpaved roads, materials handling operations (e.g. waste movement, compaction and tipping operations), wind erosion of open areas and soil cover, and vehicle activity on the landfill site, including general vehicle traffic (tractors, trucks, etc.) and earthmoving activities. Such particulate emissions present a health hazard since they may have adsorbed molecules of toxic substances.

Landfills are generally very complex systems where various chemical and biological processes occur simultaneously. These processes, including bacterial decomposition, volatilisation and chemical reactions, produce a number of different landfill gases. Although the gases generated within the landfill mainly constitute methane and carbon dioxide, odorous compounds such as esters, hydrogen sulfide, organo-sulfurs, alkylbenzenes, limonene and other hydrocarbons, cause the most impact.

Neither of the two landfills are within close proximity of the proposed SEZ location and therefore contributions to baseline air quality at the site is likely to be very small.

5.5.1.8 Wastewater Treatment Works

There is a wide spectrum of possible inorganic and organic molecules, which can create unpleasant odours at a wastewater treatment works (WWTW). The most common are ammonia, amines, aldehydes, ketones, sulfur compounds, hydrogen sulfide and mercaptans. Air emissions occur by volatilisation because these operations are performed in the open atmosphere. Those emitted by volatilisation mainly include volatile organic compounds (i.e., toluene and styrene), ammonia and hydrogen sulfide. These substances are water soluble and are, therefore, contained in treated wastewater as well as trapped in screenings and sludges through liquid carry-over and/or solid adsorption. The two most significant pollutants, with regards to potential toxicity and odours to the surrounding communities include hydrogen sulfide and ammonia.

There are eight (8) WWTW in the Makhado Local Municipality and two (2) WWTW in the Musina Local Municipality. None of these are within close proximity of the proposed SEZ location and therefore contributions to baseline air quality at the site is likely to be very small.

5.5.2 Measured Pre-Development Air Pollutant Concentrations

Ambient air quality monitoring is useful for management and compliance assessment. Ambient monitoring locations within the Vhembe DM as reported in the Limpopo AQMP (Albertyn, Bird, Liebenberg-Enslin, & Modisamongwe, 2013) are provided in Table 5-5 and Figure 5-8.

Table 5-5: Air quality monitoring stations across Vhembe District Municipality

Station name	Latitude (°S)	Longitude (°E)	Status	Monitoring period	Pollutants measured	Sampler type
Louis Trichardt	-23.04438	29.90474	Unknown	1994 – present?	SO_2, NO_x, NH_3, O_3	Passive
Makwarela Township	-22.94488	30.49811	Active	July 2012	SO_2, NO_2, O_3	Passive
Vhembe DM office complex	-22.96726	30.45855			SO_2, NO_2, O_3, BTEX	
Shayandima Clinic	-22.00531	30.42688			SO_2, O_3	
LEDET Mobile unit – Musina (to capture border traffic)	mobile		to be deployed		SO_2, NO_x, PM_{10}, $PM_{2.5}$, O_3 and VOCs	Continuous
Tshikondeni coal mine	18 locations		Active		Dust fall	Passive

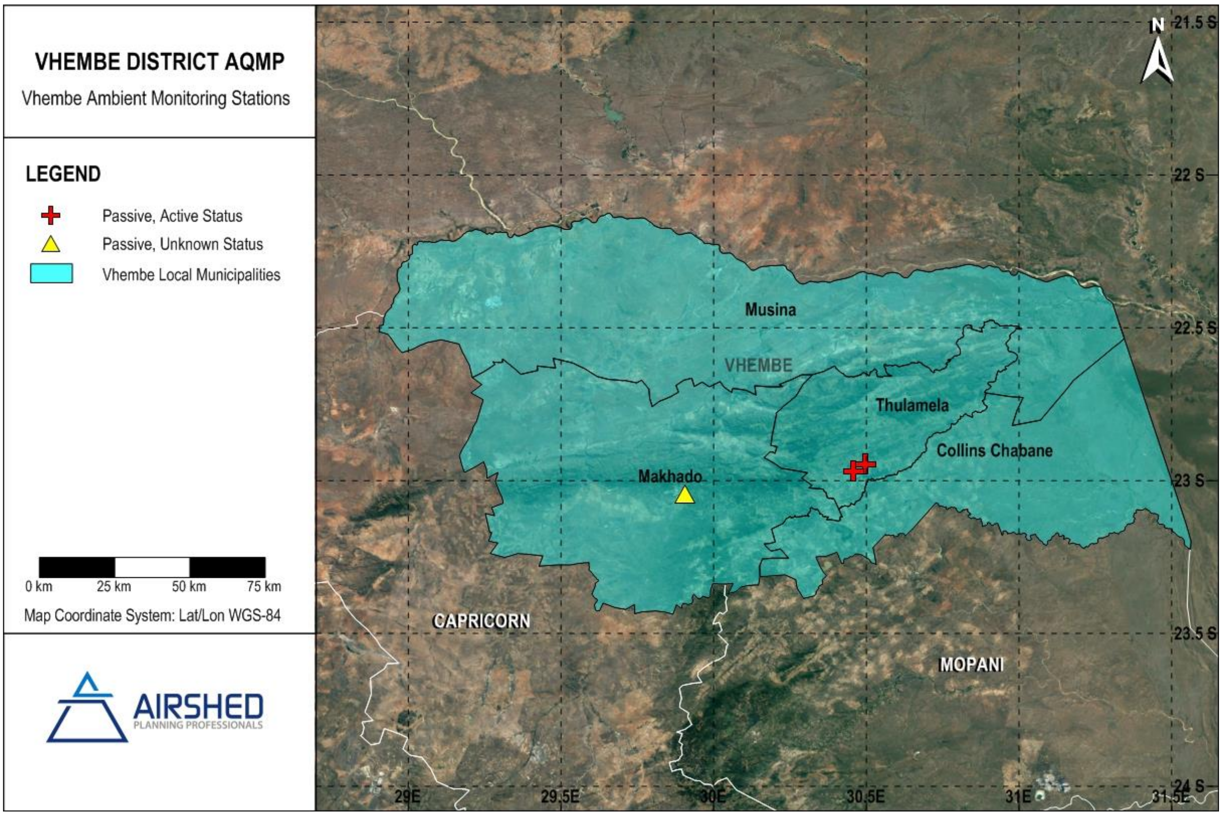


Figure 5-8: Location of ambient monitoring stations in Vhembe District Municipality, where coordinates were available

The South African Air Quality Information System (SAAQIS) aims to make information available to stakeholders, provide a common system for managing air quality in South Africa and provide uniformity in the way data; information and reporting are managed in SA. Providing near-real time ambient air quality data is one of the objectives of SAAQIS. This system was consulted for recent ambient air quality measurements in the Vhembe District; however, no permanent continuous monitoring data is available for the district via this platform. The nearest ait quality monitoring stations are in Mokopane and Phalaborwa (Table 5-6). The data from these two stations were accessed, for 2017 and 2018, as an indication of the air quality near the project site.

Table 5-6: Nearest air quality monitoring stations

Station name	Latitude (decimal degrees)	Longitude (decimal degrees)	Location
Mokopane	-24.155465	28.983222	Mahwelereng Police station, Sefakoala street, Mokopane
Phalaborwa	-23. 932049	31.139471	Frans du Toit High School. Janssen Street, Phalaborwa

Data availability at Mokopane was good (more than 80%) (Table 5-7). No exceedances of the NAAQS were recorded for NO_2, or SO_2 for all applicable averaging periods (Table 5-7). Daily $PM_{2.5}$ exceeded the allowable frequency of exceedance of the daily limit concentration in 2017, however compliance with the NAAQS is noted in 2018 (Table 5-7). PM_{10} concentrations were in non-compliance with the NAAQS over both years (Table 5-7).

Table 5-7: Summary of ambient air quality monitoring data at Mokopane AQMS (concentration units: ppb)

Period	Availability	Hourly Maximum Concentrations	Annual Average	No of recorded hourly exceedances
		NO_2		
2017	86%	51.0	6.8	-
2018	98%	55.0	7.1	-
		SO_2		
2017	86%	25.3	1.7	-
2018	90%	33.7	1.8	-
Period	**Availability**	**Daily Maximum Concentrations**	**Annual Average**	**No of recorded daily exceedances**
		SO_2		
2017	86%	11.3	1.7	-
2018	90%	9.9	1.8	-
		PM_{10}		
2017	82%	212.3	**61.6**	**93**
2018	96%	343.0	**66.1**	**116**
		$PM_{2.5}$		
2017	80%	74.2	19.3	**12**
2018	94%	46.7	16.0	4

At Phalaborwa the data availability was low (less than 60%, except for NO_2 in 2018; 64%) (Table 5-8). Despite low data availability exceedances of the hourly SO_2 and daily $PM_{2.5}$ in 2018 resulted in non-compliance with the NAAQS (Table 5-8). NO_2 and PM_{10} concentrations were compliant with NAAQS (Table 5-8).

Table 5-8: Summary of ambient air quality monitoring data at Phalaborwa AQMS (concentration units: ppb)

Period	Availability	Hourly Maximum Concentrations	Annual Average	No of recorded hourly exceedances
		NO_2		
2017	51%	390.0	1.5	3
2018	64%	258.0	1.6	3
		SO_2		
2017	51%	424.0	4.5	25
2018	50%	525.0	19.7	**103**
Period	**Availability**	**Daily Maximum Concentrations**	**Annual Average**	**No of recorded daily exceedances**
		SO_2		
2017	51%	320.0	4.5	-
2018	50%	520.9	19.7	1
		PM_{10}		
2017	0%	-	-	-
2018	28%	154.8	31.5	3
		$PM_{2.5}$		
2017	0%	-	-	-
2018	28%	89.4	16.0	**9**

6 PROPOSED SEZ EMISSIONS INVENTORY

In the quantification of emissions, use was made of NMES, similar operations stack parameters and emission factors which associate the quantity of a pollutant to the activity associated with the release of that pollutant. A summary of the sources of emission associated with the proposed storage, handling, processing and transport considered in the study are provided in Table 6-1. Detailed information on the emission factors and fundamental design information used in the study to quantify emissions is provided in Table 6-2.

Table 6-1: Sources of air pollution emissions

Source	Potential Air Pollutants									
	CO	NOx	SO_2	Mn[(a)]	Cr^{6+}	H_2S	NH_3	$PM_{2.5}$	PM_{10}	TSP
Railway transport								x	x	x
Vehicles travelling on paved roads				x				x	x	x
Road transport exhaust	x	x	x					x	x	x
Material transfer points				x				x	x	x
Storage facilities				x				x	x	x
Power production	x	x	x					x	x	x
Coal cleaning	x	x	x					x	x	x
Coke production	x	x	x			x		x	x	x
High vanadium steel production	x	x	x					x	x	x
Manganese steel production	x	x	x	x				x	x	x
Ferromanganese production	x	x	x	x				x	x	x
Silicon manganese alloy production	x	x	x	x				x	x	x
Domestic waste handling								x	x	x
Cement production	x	x	x					x	x	x
Refectories production	x	x	x		x			x	x	x
Stainless steel production	x	x	x		x			x	x	x
Ferrochrome production	x	x	x		x			x	x	x
Vanadium titanium magnetite plant	x	x	x				x	x	x	x
Sewage treatment plant						x	x			
Water treatment plant						x	x			

Notes:

(a) only associated with the manganese ore and manganese products transport, storage and processing operations

Table 6-2: Emission estimation techniques and parameters for proposed operations

Source	Emission Estimation Technique	Notes
Construction	US EPA emission factor (US EPA, 1995) $$EF = k \cdot 2.69$$ Where EF is the emission factor in t/ha-month k is the particle size multiplier (k_{TSP} – 1, k_{PM10} – 0.35, $k_{PM2.5}$ – 0.18)	A total infrastructure/disturbed area of ~8 000 ha was estimated from the master plan. It was assumed that 33.3% of this area would be under construction at any given point in time. It is assumed that roads will likely be unpaved for the majority of the construction period. **Hours of operation:** 7 days per week, 24-hours per day. **Design mitigation:** None. **Additional mitigation:** Dust management and water sprays.

Source	Emission Estimation Technique	Notes
Railway transport		Insufficient data – not quantified. **Hours of operation:** 365 days per year, 24-hours per day. **Design Mitigation:** Unknown.
Vehicles travelling on paved roads	US EPA emission factor equation (US EPA, 2011) $EF = k \cdot (sL)^{0.91} \cdot (W)^{1.02}$ Where EF is the emission factor in g/vehicle kilometer travelled (VKT) k is the particle size multiplier (k_{TSP} – 3.23, k_{PM10} – 0.62, $k_{PM2.5}$ – 0.15) sL is the road surface material silt loading in g/m^2 W is the average weight vehicles in tonnes	Insufficient data – not quantified. **Hours of operation:** 365 days per year, 24-hours per day. **Design Mitigation:** Unknown.
Road transport exhaust	NPI single valued emission factors (ADE, 2008) PM_{10} – 3.63 x 10^{-3} kg/l $PM_{2.5}$ – 3.33 x 10^{-3} kg/l NOx – 4.44 x 10^{-2} kg/l SO_2 – 2.40 x 10^{-5} kg/l CO – 1.85 x 10^{-2} kg/l	Insufficient data – not quantified. **Hours of operation:** 365 days per year, 24-hours per day. **Design Mitigation:** Unknown.
Material transfer points	US EPA emission factor equation (US EPA, 2006) $EF = k \cdot 0.0016 \cdot \left(\frac{U}{2.3}\right)^{1.3} \cdot \left(\frac{M}{2}\right)^{-1.4}$ Where EF is the emission factor in kg/tonne material handled k is the particle size multiplier (k_{TSP} – 0.74, k_{PM10} – 0.35, $k_{PM2.5}$ – 0.053) U is the average wind speed in m/s M is the material moisture content in %	The number of handlings steps (loading, off-loading and conveyor transfer points) and material handling rates used in the estimation of emissions were calculated based on the amount of materials handled per operation. An average **wind speed of 3.97 m/s** was determined from the WRF data set. A **moisture content** of 0.1% was assumed. **Hours of operation:** 365 days per year, 24-hours per day. **Design Mitigation:** None.
Storage facilities	NPI single valued emission factors **Invalid source specified.** TSP – 0.4 kg/ha-h PM_{10} – 0.2 kg/ha-h $PM_{2.5}$ – 0.1 kg/ha-h (assumed)	Insufficient data – not quantified. **Hours of operation:** 365 days per year, 24-hours per day. **Design Mitigation:** None.
Power production	<u>Boiler operations</u> Subcategory 1.1 NMES. PM – 50 mg/Nm³ NO_x expressed as NO_2 – 750 mg/Nm³ SO_2 – 500 mg/Nm³ Conservatively assumed all PM is 2.5 µm or smaller. CO - US EPA single valued emission factor for FBC, circulating bed of 9 kg/t coal (US EPA, 1998)	**4 x 600 MW boiler stacks parameters:** stack height above ground = 120 m; stack tip diameter = 8 m; exit velocity = 13.5 m/s; temperature = 418 K. **2 x 300 MW boiler stacks parameters:** stack height above ground = 120 m; stack tip diameter = 6 m; exit velocity = 13.5 m/s; temperature = 418 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.

Source	Emission Estimation Technique	Notes
Coal cleaning	Crushing and Screening NPI single valued emission factors for low moisture ore (ADE, 2012) TSP – 0.2 kg/tonne (primary), 0.0 kg/tonne (screening) PM_{10} – 0.02 kg/tonne (primary), 0.0 kg/tonne (screening) $PM_{2.5}$ – *assumed* to be 0.01 kg/tonne (primary), 0.0 kg/tonne (screening)	Crushing and screening rate ~1 231 t/h **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** None.
	Dryer operations Subcategory 4.1 NMES. PM – 50 mg/Nm³ NO_x expressed as NO_2 – 500 mg/Nm³ SO_2 – 1 000 mg/Nm³ Conservatively assumed all PM is 2.5 µm or smaller. CO – conservatively assumed US EPA single valued emission factor for multilouvered dryer CO_2 emission of 320 kg/t (US EPA, 1995)	**3 x fluidised bed dryer stacks parameters:** stack height above ground = 10 m; stack tip diameter = 2 m; exit velocity = 2.5 m/s; temperature = 313 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.
Coke production	"Furnace" operations Subcategory 3.2 NMES. H_2S – 7 mg/Nm³ US EPA single valued emission factors for Coke Production, uncontrolled (raw COG) (US EPA, 2008): PM – 0.2 kg/t NO_x - 0.82 kg/t SO_2 - 1.47 kg/t CO – 0.3 kg/t Conservatively assumed all PM is 2.5 µm or smaller.	**3 x "furnace" stacks parameters:** stack height above ground = 110 m; stack tip diameter = 3 m; exit velocity = 2.56 m/s; temperature = 403 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.
High vanadium steel production	Blast furnace operations Subcategory 4.8 NMES. PM – 530 mg/Nm³ NO_x expressed as NO_2 – 500 mg/Nm³ SO_2 – 500 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. CO - conservatively assumed US EPA single valued emission factor for basic oxygen furnace of 69 kg/t (US EPA, 1986).	**3 x furnace stacks parameters:** stack height above ground = 35 m; stack tip diameter = 2 m; exit velocity = 35.83 m/s; temperature = 343 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.
Manganese steel production	Blast furnace operations Subcategory 4.8 NMES. PM – 530 mg/Nm³ NO_x expressed as NO_2 – 500 mg/Nm³ SO_2 – 500 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. CO - conservatively assumed US EPA single valued emission factor for basic oxygen furnace of 69 kg/t (US EPA, 1986).	**3 x furnace stacks parameters:** stack height above ground = 35 m; stack tip diameter = 2 m; exit velocity = 35.83 m/s; temperature = 343 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.

Source	Emission Estimation Technique	Notes
Ferromanganese production	Furnace operations Subcategory 4.9 NMES. PM – 50 mg/Nm³ (primary fume extraction for closed furnaces) PM – 50 mg/Nm³ (secondary fume extraction for all furnaces) NO_x expressed as NO_2 – 400 mg/Nm³ SO_2 – 500 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. CO – not estimated	**3 x furnace primary stacks parameters:** stack height above ground = 55 m; stack tip diameter = 1 m; exit velocity = 7.2 m/s; temperature = 318 K. **3 x furnace secondary stacks parameters:** stack height above ground = 30 m; stack tip diameter = 1.8 m; exit velocity = 57.2 m/s; temperature = 307 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.
Silicon manganese alloy production	Furnace operations Subcategory 4.9 NMES. PM – 50 mg/Nm³ (primary fume extraction for closed furnaces) PM – 50 mg/Nm³ (secondary fume extraction for all furnaces) NO_x expressed as NO_2 – 400 mg/Nm³ SO_2 – 500 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. CO – not estimated	**3 x furnace primary stacks parameters:** stack height above ground = 55 m; stack tip diameter = 1 m; exit velocity = 7.2 m/s; temperature = 318 K. **3 x furnace secondary stacks parameters:** stack height above ground = 30 m; stack tip diameter = 1.8 m; exit velocity = 57.2 m/s; temperature = 307 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.
Domestic waste handling		Insufficient data – not quantified
Cement production	Kiln operations Subcategory 5.4 NMES. PM – 50 mg/Nm³ NO_x expressed as NO_2 – 1 200 mg/Nm³ SO_2 – 250 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. CO - US EPA single valued emission factor for preheater/precalciner kiln of 1.8 kg/t (US EPA, 1995a).	**3 x kiln stacks parameters:** stack height above ground = 35 m; stack tip diameter = 1.6 m; exit velocity = 10.5 m/s; temperature = 373 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.
Refractories production (assuming refractory bricks)	Dryer operations Subcategory 5.9 NMES. PM – 50 mg/Nm³ SO_2 – 400 mg/Nm³ HF – 50 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. NOx - US EPA single valued emission factor for rotary calciner with multiclone and wet scrubber of 0.87 kg/t (US EPA, 1995b). CO – not estimated	Insufficient data – not quantified

Source	Emission Estimation Technique	Notes
Stainless steel production	Furnace operations Subcategory 4.7 NMES. PM – 30 mg/Nm³ NO_x expressed as NO_2 – 500 mg/Nm³ SO_2 – 500 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. CO - conservatively assumed US EPA single valued emission factor for basic oxygen furnace of 69 kg/t (US EPA, 1986).	**3 x furnace stacks parameters:** stack height above ground = 35 m; stack tip diameter = 2 m; exit velocity = 35.83 m/s; temperature = 343 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.
	Casting operations Subcategory 4.10 NMES. PM – 30 mg/Nm³ NO_x expressed as NO_2 – 400 mg/Nm³ SO_2 – 400 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. CO - conservatively assumed US EPA single valued emission factor for electric arc furnace of 0.9 kg/t (US EPA, 2009).	**1 x foundry stacks parameters:** stack height above ground = 60 m; stack tip diameter = 0.9 m; exit velocity = 14 m/s; temperature = 423 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.
Ferrochrome production	Furnace operations Subcategory 4.9 NMES. PM – 50 mg/Nm³ (primary fume extraction for closed furnaces) PM – 50 mg/Nm³ (secondary fume extraction for all furnaces) NO_x expressed as NO_2 – 400 mg/Nm³ SO_2 – 500 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. Assumed furnace off-gas has 82.4% CO.	**3 x furnace primary stacks parameters:** stack height above ground = 65 m; stack tip diameter = 0.75 m; exit velocity = 6.11 m/s; temperature = 623 K. **3 x furnace secondary stacks parameters:** stack height above ground = 20 m; stack tip diameter = 1.23 m; exit velocity = 16.7 m/s; temperature = 323 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown. **Assumptions relating to Cr^{6+} emissions:** 30% Cr in PM in cleaned furnace of gas prior to emitting to the atmosphere. All Cr in cleaned furnace of gas prior to emitting to the atmosphere is in trivalent state i.e. Cr^{3+} Conversion from Cr^{3+} to Cr^{6+} during emitting to the atmosphere 0.35% (maximum) (du Preez, Beukes, & van Zyl, 2015)
Lime production	Kiln operations Subcategory 5.6 NMES. PM – 50 mg/Nm³ NO_x expressed as NO_2 – 500 mg/Nm³ SO_2 – 400 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. CO - US EPA single valued emission factor for coal-fired rotary kiln of 0.7 kg/t (US EPA, 1998)	**3 x kiln stacks parameters:** stack height above ground = 60 m; stack tip diameter = 2.4 m; exit velocity = 11.3 m/s; temperature = 373 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.

Source	Emission Estimation Technique	Notes
Vanadium titanium magnetite plant	Furnace operations Subcategory 4.6/4.7/4.8 NMES. PM – 30 mg/Nm³ NO_x expressed as NO_2 – 500 mg/Nm³ SO_2 – 500 mg/Nm³ Conservatively assumed all PM is 2.5 µm or less. CO – not estimated	**3 x furnace primary stacks parameters:** stack height above ground = 28 m; stack tip diameter = 0.32 m; exit velocity = 28.98 m/s; temperature = 373 K. **Hours of operation:** 365 days per year, 24-hours per day. **Design mitigation:** Unknown.
Sewage treatment plant		Insufficient data – not quantified
Water treatment plant		Insufficient data – not quantified

7 IMPACT ASSESSMENT

7.1 Construction Phase

The temporary nature of the construction activities, and the likelihood that these activities will be localised and on small areas at any given time, reduces the potential for significant off-site impacts. According to the Australian Environmental Protection Agency on recommended separation distances from various activities, a buffer zone of 300 m from the nearest sensitive receptor is required when quarry type operations occur without blasting and a distance of 500 m when blasting will take place (AEPA, 2000).

This may result in impacts on the Mopane Intermediate School to the north-north-east of the proposed SEZ site. The closest residential receptors are located less than 500 m from the proposed SEZ site. It is unclear exactly which activities would be carried out here during the construction phase. Windblown particulates may be a problem in this area, but only under conditions of high wind speeds which, based on the three-year weather dataset, is likely to occur for a short duration throughout the year. It is difficult to estimate the distance of impact, but other studies conducted reported that PM_{10} particles are unlikely to impact on receptors more than 1 km from the source of emissions. Larger particles of between 10 and 30 µm would settle within 500 m with coarse particles (greater than 30 µm) would deposit within 100 m from the source.

7.2 Operational Phase

Expected atmospheric emissions during the operational phase include:

- PM, NO_x, SO_2, CO, Mn, Cr^{6+} and H_2S emissions from processing operations, i.e.
  - boilers,
  - furnaces,
  - dryers,
  - kilns, and
  - casting;
- PM emissions from vehicle entrainment along the paved roads;
- PM, NO_x, SO_2 and CO emissions from vehicles' exhaust
- PM and Mn emissions from materials handling;
- PM and Mn emissions from material storage;
- PM emissions from crushing and screening;
- PM emissions from trains entrainment along the railway;

Dispersion simulations were completed for all the main processing activities associated with each plant and the fugitive sources that could be calculated (i.e. where sufficient data was available) for some plants. Simulation results of "routine" emissions are discussed in this section. Upset or emergency conditions will occur infrequently and over short time intervals making comparison with NAAQS and NDCRs, especially over periods longer than 24-hours, inaccurate.

7.2.1 Inhalable Particulate matter (PM_{10}) and Respirable Particulate matter ($PM_{2.5}$)

Due to the lack of available operating information and detailed maps on the individual plants, the fugitive PM emission sources could not be quantified adequately. The simulated results discussed in this section (for PM_{10} and $PM_{2.5}$) are an underprediction of what is expected to occur as a result of the SEZ operations; mainly to the north, north-east and east of the SEZ boundary. The simulated annual average PM_{10} concentrations exceed the NAAQS of 40 µg/m³ beyond the SEZ boundary but not at any AQRs (Figure 7-1). The simulated results show exceedance of the 24-hour NAAQS (4 days of exceedance of 75 µg/m³) beyond the SEZ boundary but not at any AQRs (Figure 7-2). The simulated annual average $PM_{2.5}$ concentrations exceed the current NAAQS of 20 µg/m³ beyond the SEZ boundary but not at any AQRs (Figure 7-1). The simulated results show exceedance of the current 24-hour NAAQS (4 days of exceedance of 40 µg/m³) beyond the SEZ boundary but not at any AQRs (Figure 7-2). The simulated annual average $PM_{2.5}$ concentrations exceed the future (from 1 January 2030) NAAQS of 15 µg/m³ beyond the SEZ boundary and at AQRs (Figure 7-1). The simulated results show exceedance of the future (from 1 January 2030) 24-hour NAAQS (4 days of exceedance of 40 µg/m³) beyond the SEZ boundary and at AQRs (Figure 7-2).

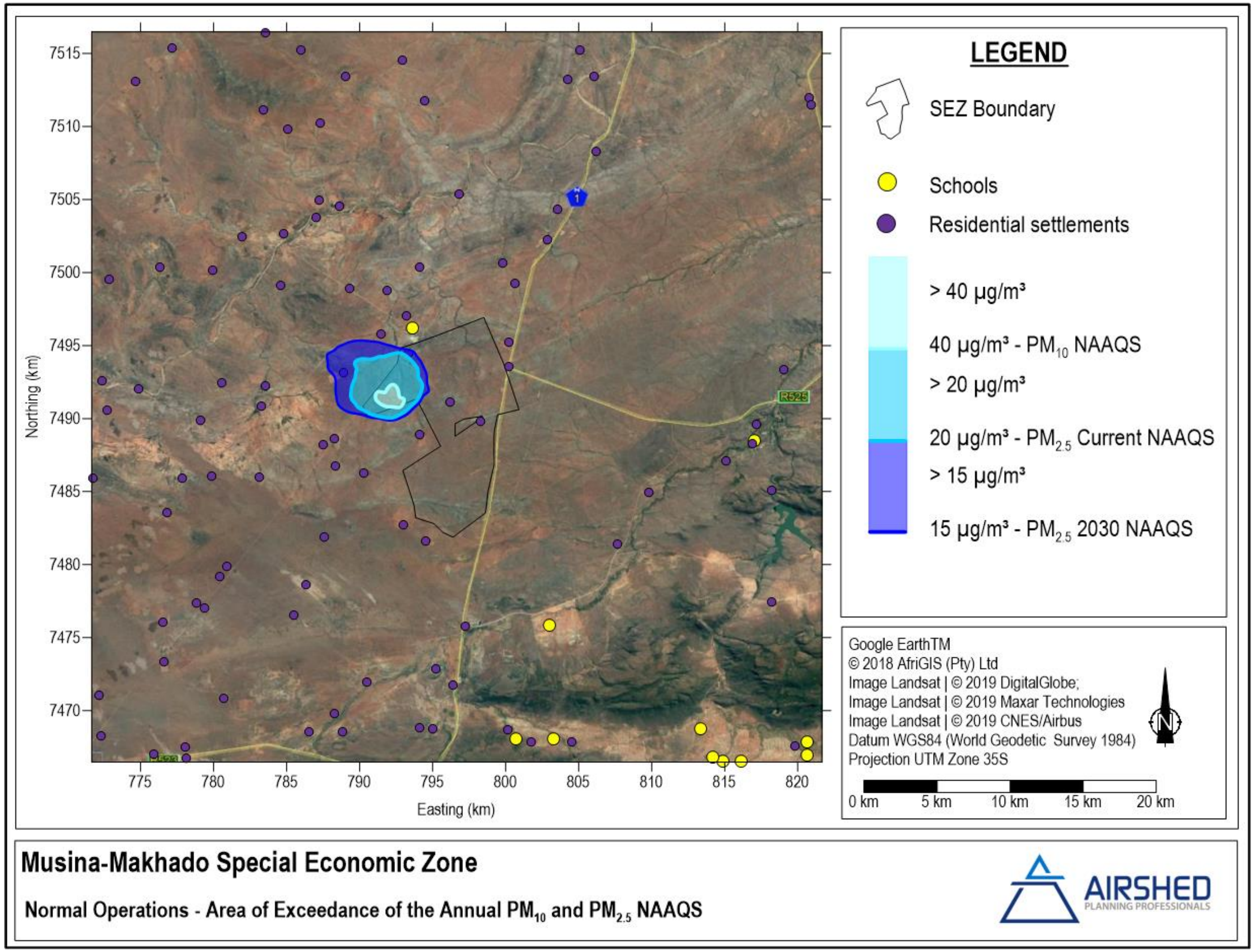


Figure 7-1: **Area of exceedance of the annual average PM_{10} and $PM_{2.5}$ NAAQS**

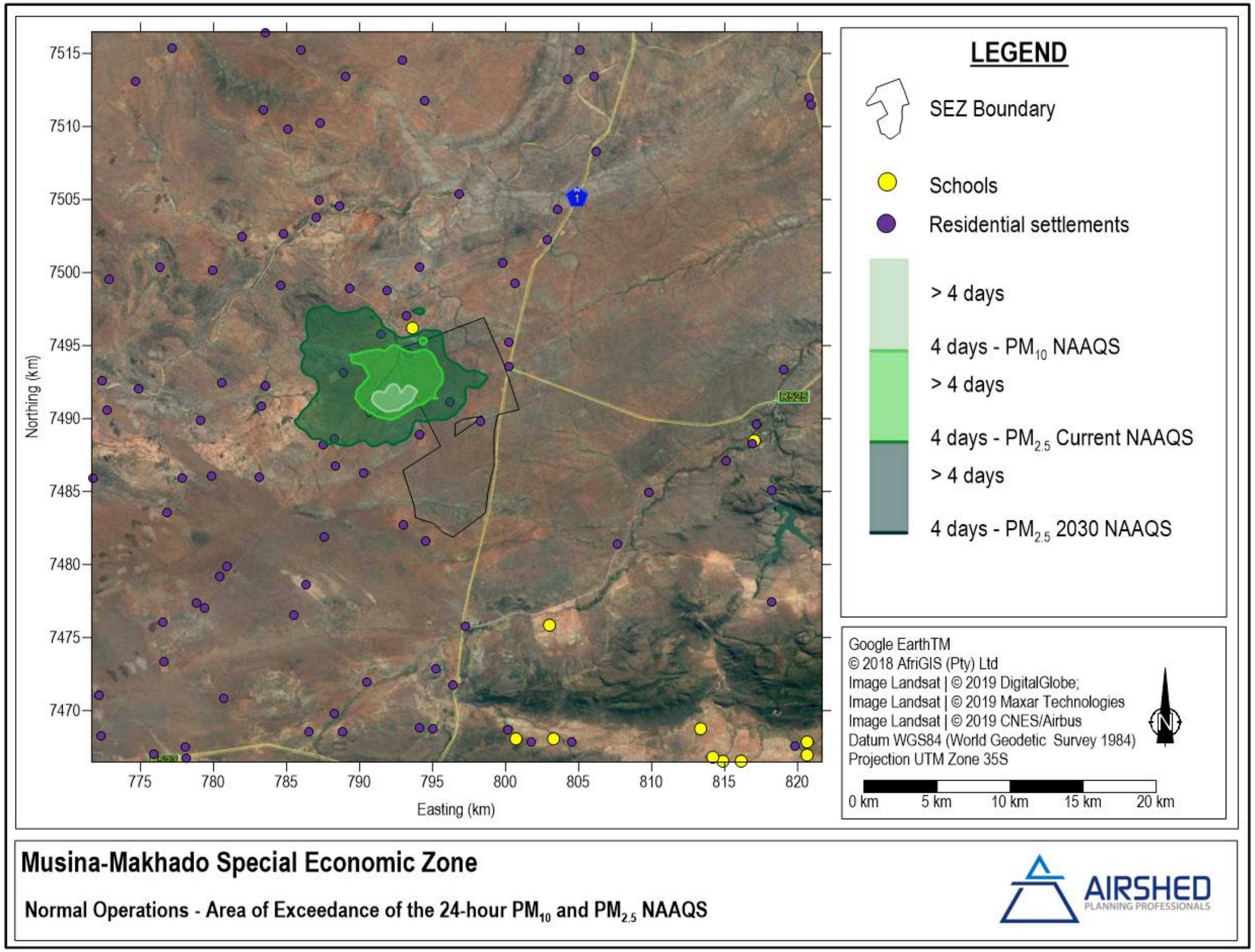


Figure 7-2: **Area of exceedance of the 24-hour average PM_{10} and $PM_{2.5}$ NAAQS**

7.2.2 Nitrogen Dioxide (NO_2)

It was conservatively assumed that all NO_x emitted is NO_2. The results are based on the plants emitting at NMES. Simulated annual average NO_x concentrations exceed the NAAQS of 40 µg/m^3 beyond the SEZ boundary and at AQRs (Figure 7-3). The 1-hour NO_2 NAAQS (88 hours of exceedance of 200 µg/m^3) is exceeded beyond the SEZ boundary and at AQRs (Figure 7-4).

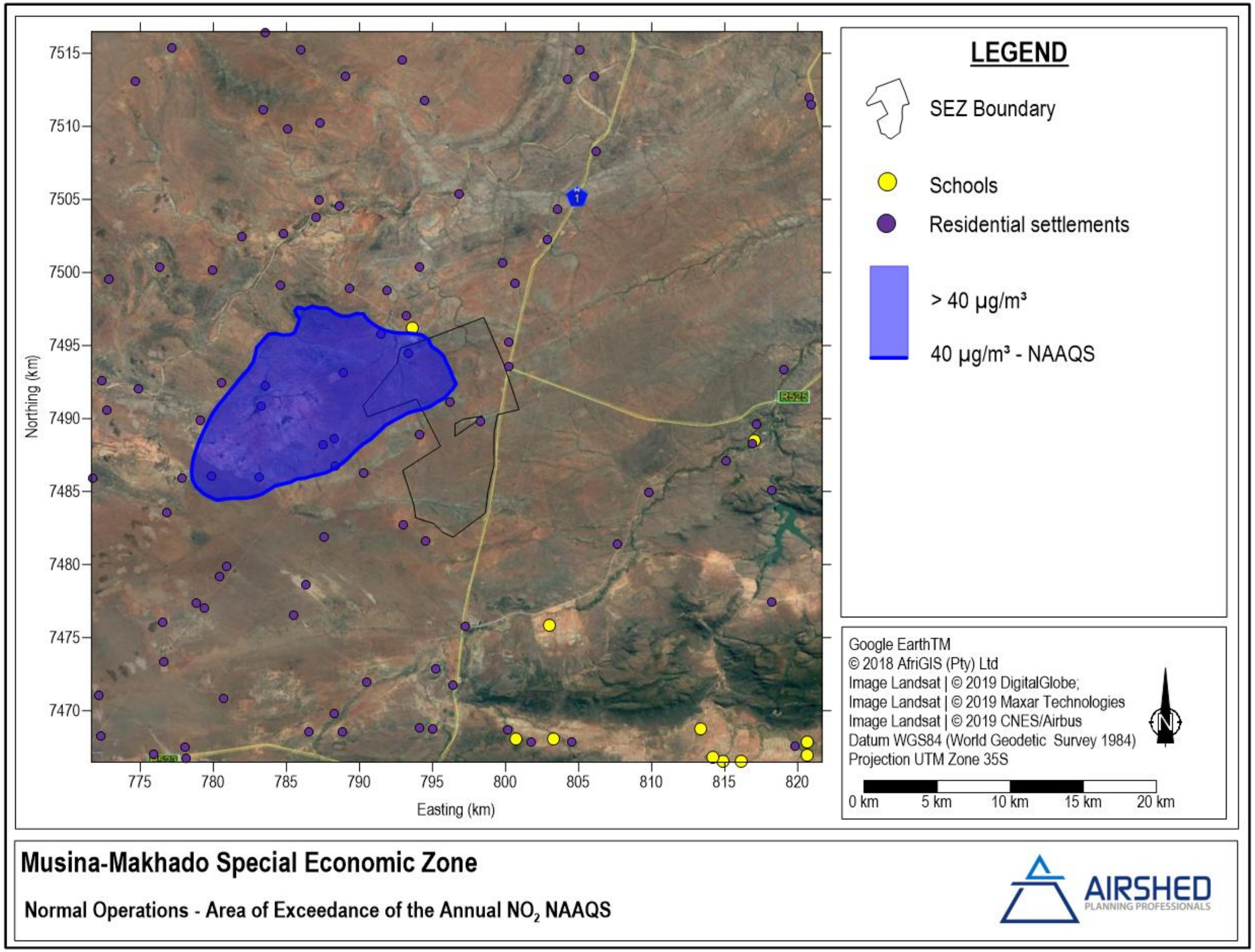


Figure 7-3: **Area of exceedance of the annual average NO_2 NAAQS**

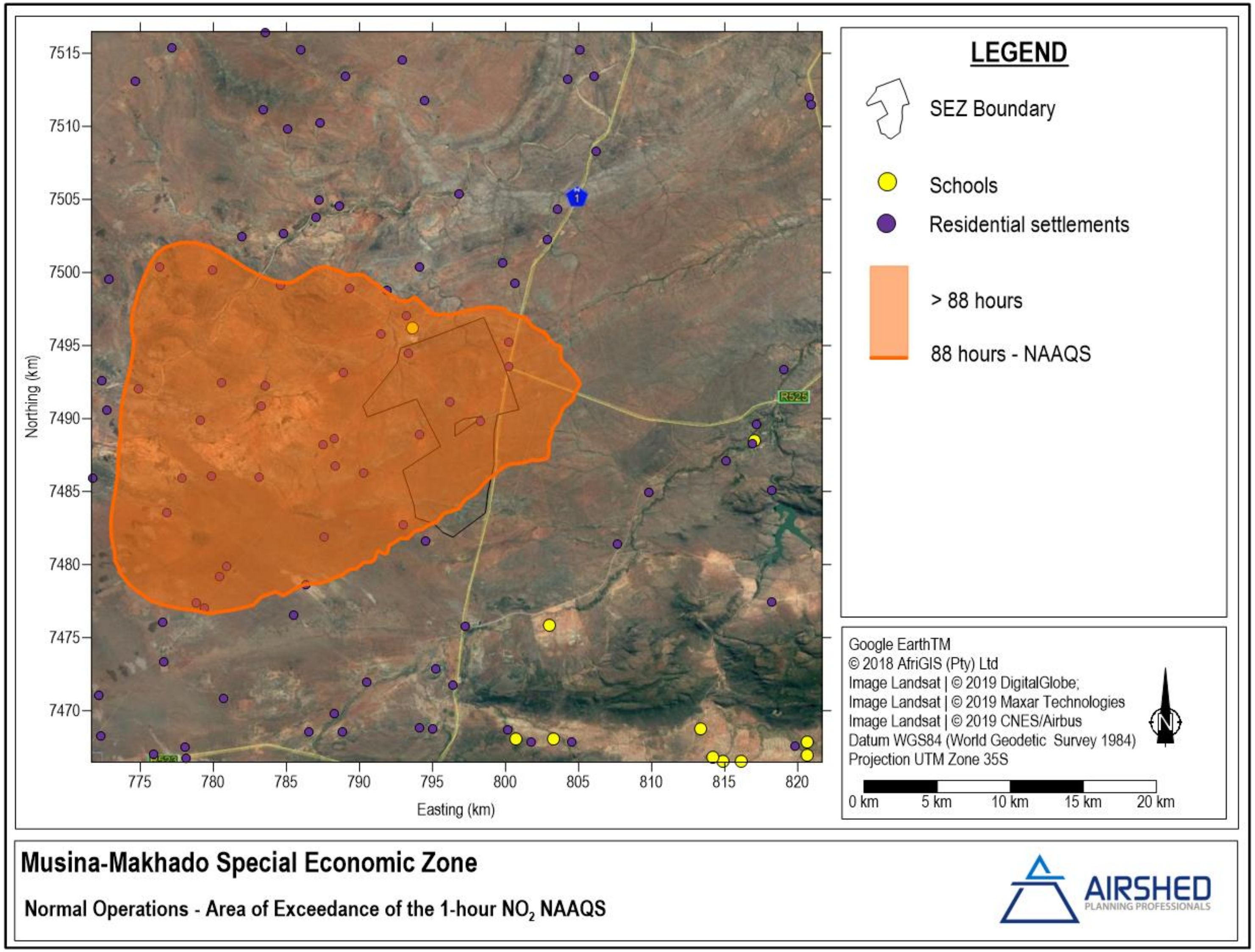


Figure 7-4: Area of exceedance of the 1-hour NO_2 NAAQS

7.2.3 Sulphur Dioxide (SO_2)

The results are based on the plants emitting at NMES. Simulated annual average SO_2 concentrations exceed the NAAQS of 50 µg/m^3 beyond the SEZ boundary and at AQRs (Figure 7-5). The 24-hour SO_2 NAAQS (4 days of exceedance of 125 µg/m^3) is exceeded beyond the SEZ boundary and at AQRs (Figure 7-6). The 1-hour SO_2 NAAQS (88 hours of exceedance of 350 µg/m^3) is exceeded beyond the SEZ boundary and at AQRs (Figure 7-7).

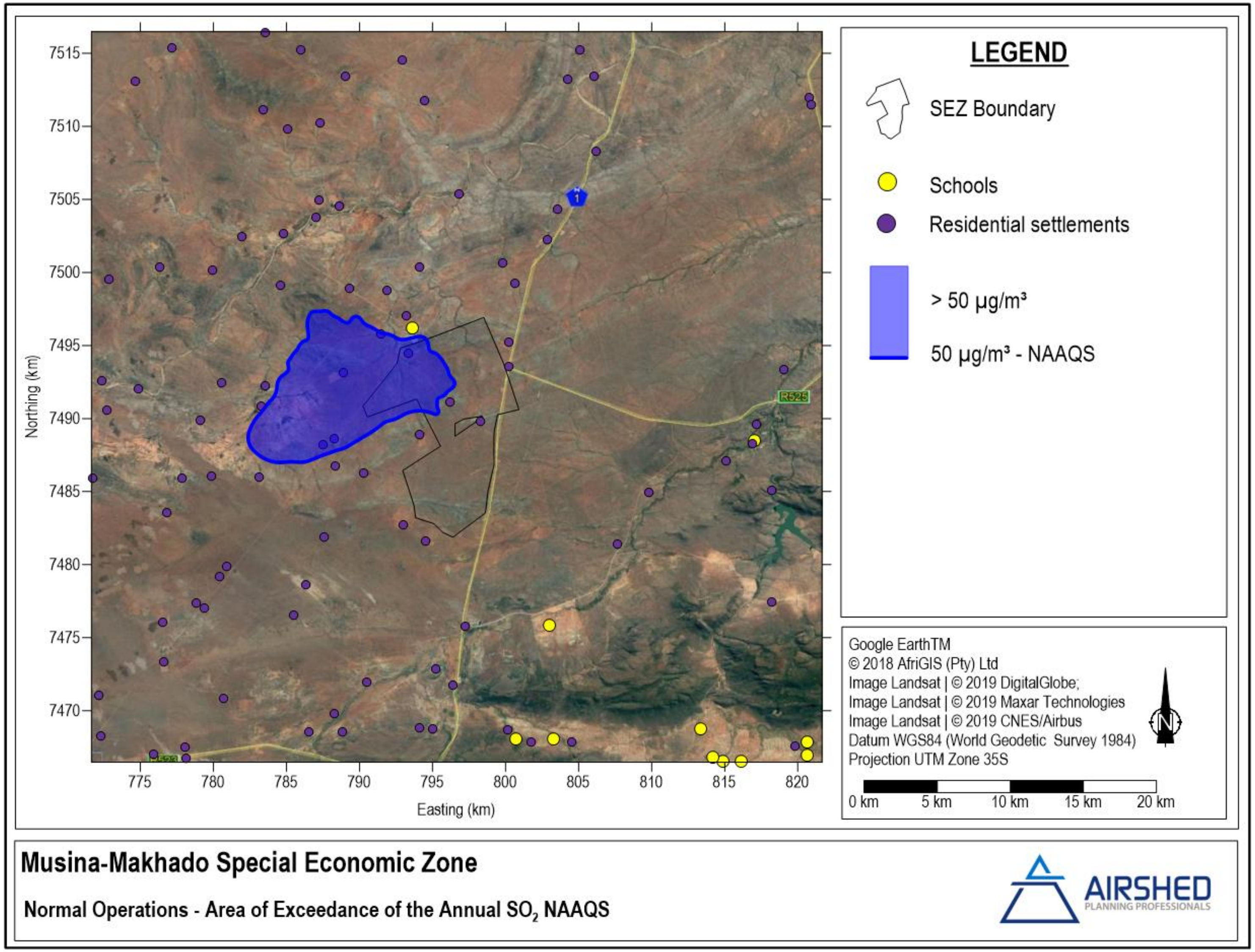


Figure 7-5: Area of exceedance of the annual average SO_2 NAAQS

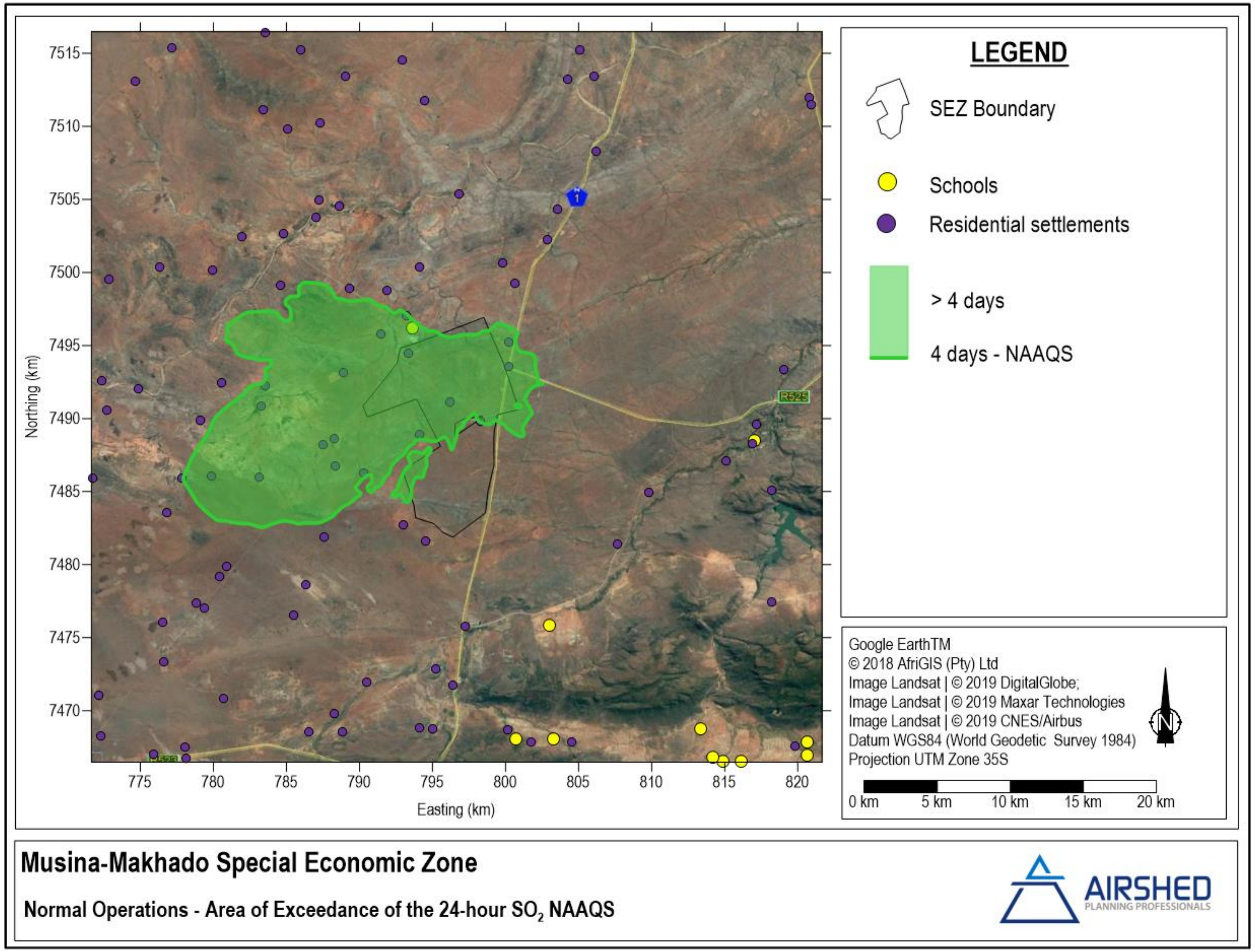


Figure 7-6: Area of exceedance of the 24-hour average SO_2 NAAQS

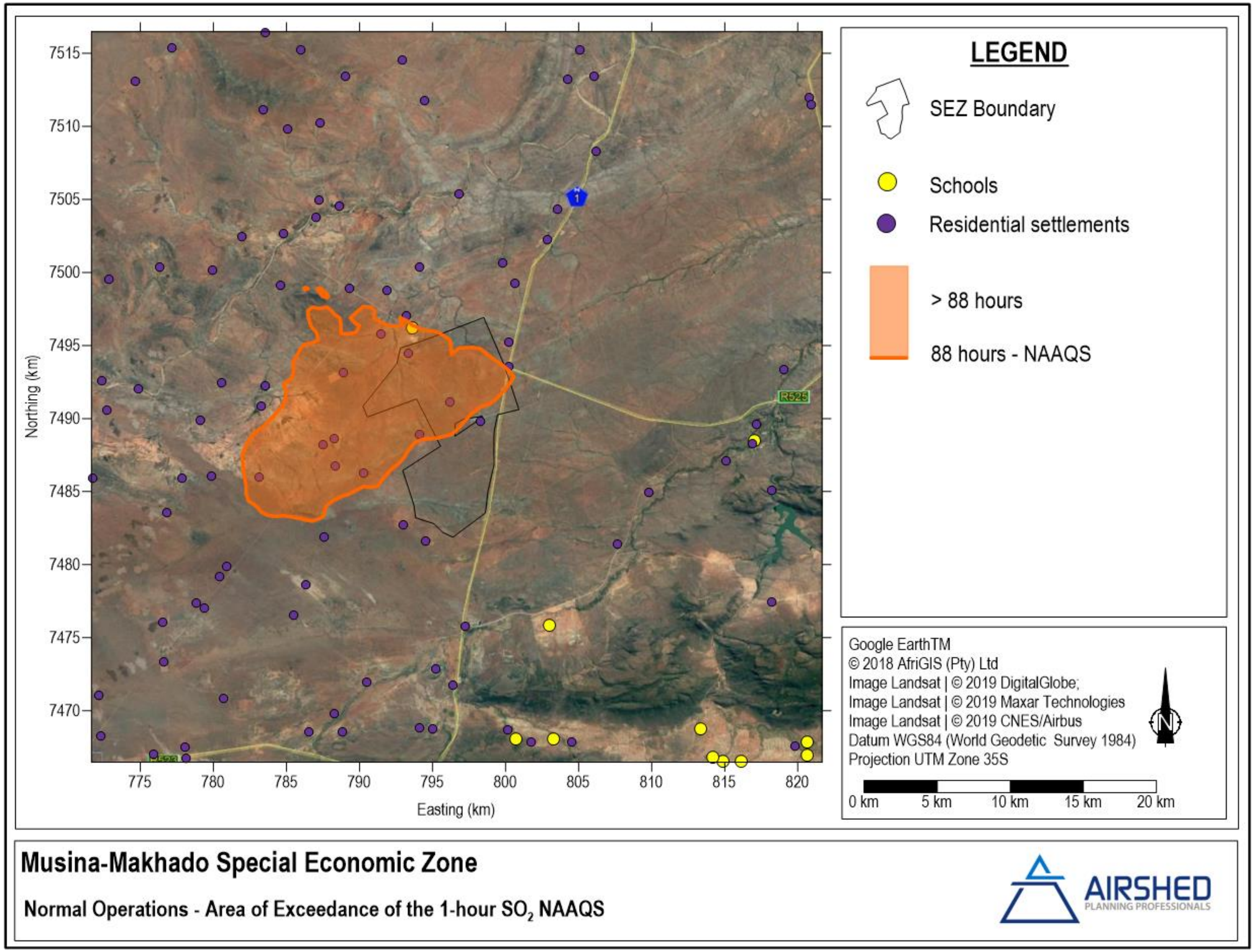


Figure 7-7: Area of exceedance of the 1-hour SO_2 NAAQS

7.2.4 Carbon Monoxide (CO)

Simulated ambient CO concentrations are within 1-hour and 8-hour NAAQS.

7.2.5 Manganese (Mn)

Simulated annual average ambient Mn concentrations exceed the selected international criteria beyond the SEZ boundary and at AQRs (Figure 7-8).

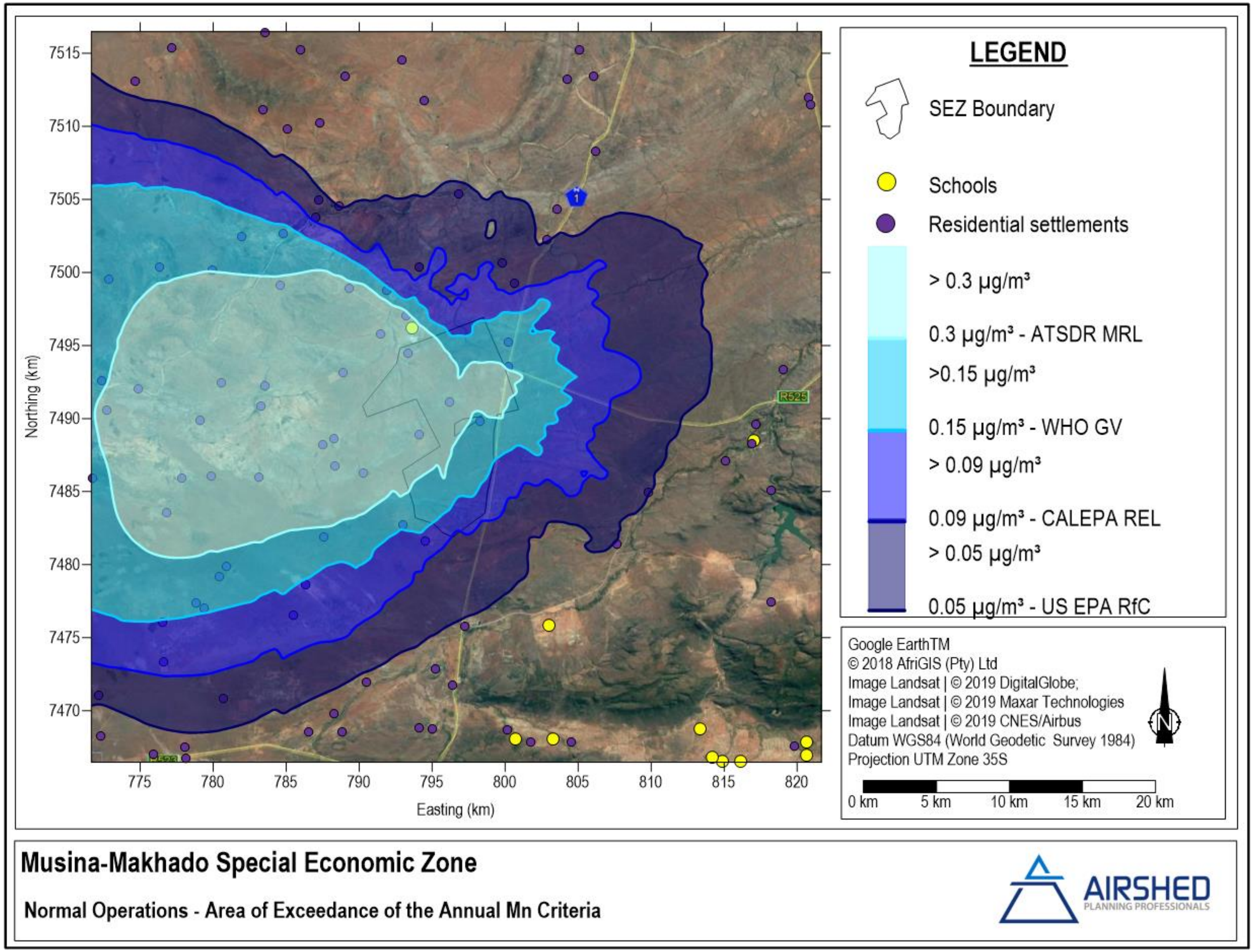


Figure 7-8: Area of exceedance of the annual average Mn criteria

7.2.6 Hexavalent Chromium (Cr^{6+})

Simulated annual average ambient Cr^{6+} concentrations exceed the US EPA IRIS RfC of 0.1 µg/m^3 beyond the boundary and at one AQR (Figure 7-9). The CALEPA OEHHA REL of 0.2 µg/m³ is also exceeded beyond the but not at any AQRs (Figure 7-9). The reader is reminded that due to uncertainty in Cr^{6+} emission estimates and conservative nature of simulation results, increased lifetime cancer risk is reported as a range where the lower range represents the most worst-case emission estimate and the least conservative URF. The upper range represents the worst-case emission estimate and most stringent URF. For the former, using US EPA IRIS cancer URF of 0.012 (µg/m^3)$^{-1}$, increased lifetime cancer risk at most AQRs was estimated to be between 1 in 1 000 000 and 1 in 10 000 which is considered “low risk” by the NYSDOH (Figure 7-10). Similarly, the WHO cancer URF of 0.04 (µg/m^3)$^{-1}$ was applied to determine worst case increased lifetime cancer risk (Figure 7-11). Increased lifetime cancer risk at most AQRs is less than 1 in 1 000 which is considered “moderate”.

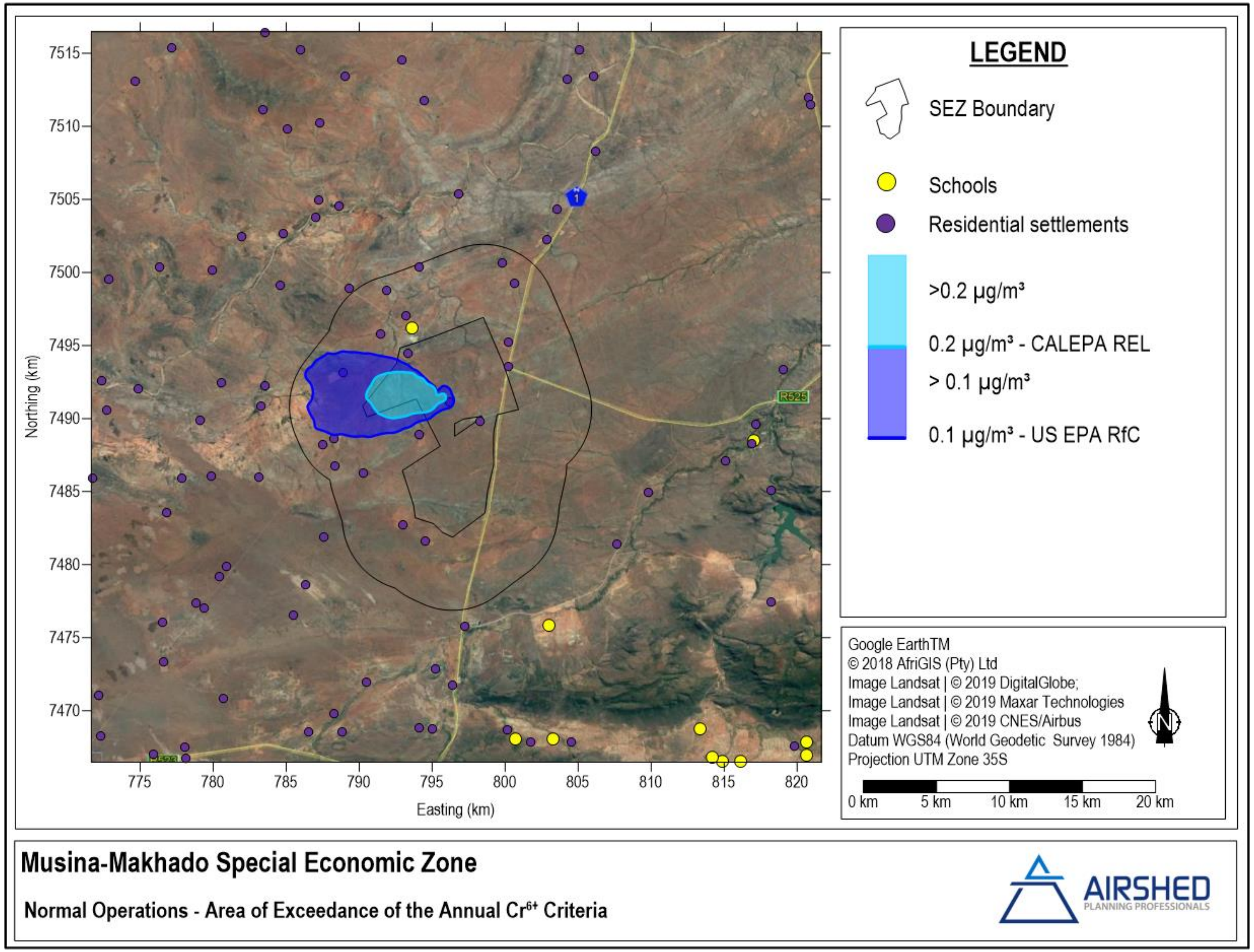


Figure 7-9: Area of exceedance of the annual average Cr^{6+} criteria

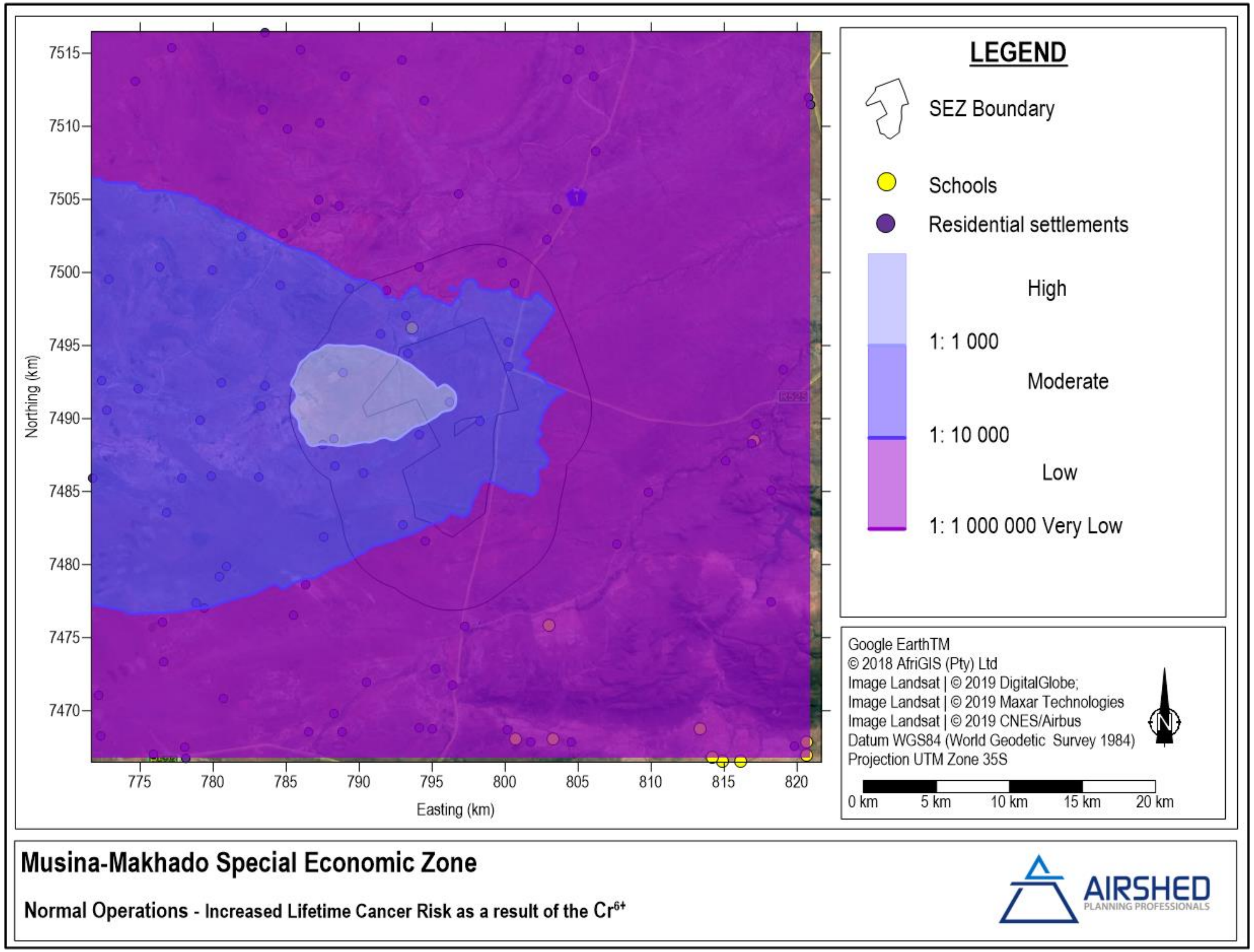


Figure 7-10: Increase lifetime cancer risk associated with Cr^{6+} (lower range)

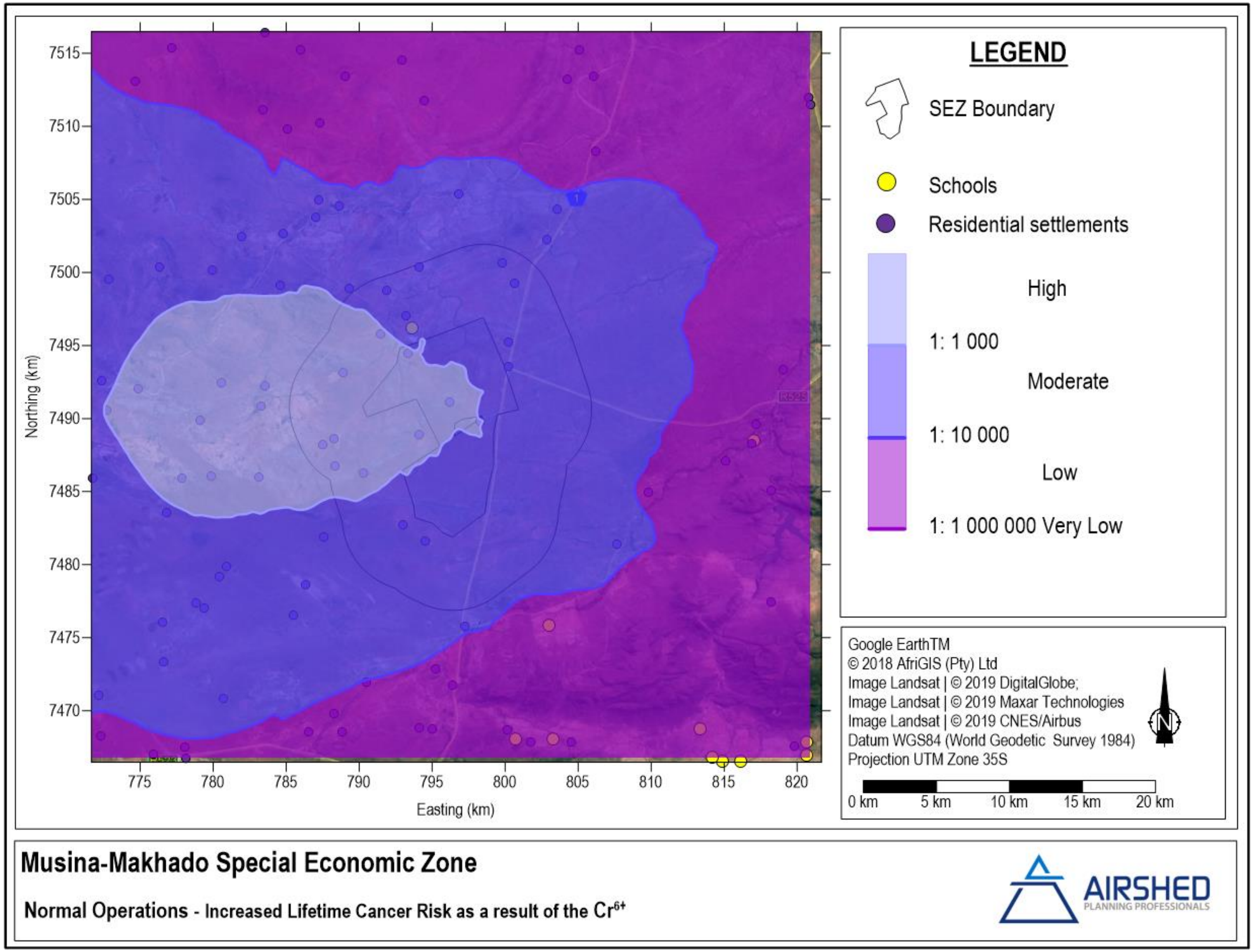


Figure 7-11: Increase lifetime cancer risk associated with Cr^{6+} (upper range)

7.2.7 *Hydrogen Sulfide (H_2S)*

Simulated ambient H_2S concentrations are low and do not exceed the selected criteria.

7.2.8 *Fallout Dust*

The 24-hr average dustfall rates are not simulated to exceed the NDCR limit of 600 mg/m²-day for residential areas.

7.3 Cumulative

Should the SEZ operations be embarked on, then both the current activities and SEZ activities will occur in the area. There will likely be an increase in ambient air pollutant concentrations and dustfall rates. There will be a definite reduction in ambient air quality should there be this additional industrial and transport operations as well as household fuel burning associated with potential residential settlements.

7.4 No Go Option

Should the no go option be embarked on, then only the current activities will occur in the area without the addition of the proposed operations. Thus, there will not likely be an increase in ambient air pollutant concentrations and dustfall rates. There is the possibility of a gradual reduction in ambient air quality should there be any additional industrial and transport operations as well as household fuel burning and biomass burning.

7.5 Significance of Impact

If PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, Mn, Cr^{6+} and H_2S impacts exceed the assessment criteria it could result in impaired human health, mostly impacting on the respiratory system's ability to function as normal. The main pollutants of concern for construction were determined to be PM_{10} and $PM_{2.5}$. The main pollutants of concern during operations were determined to be NO_2 and SO_2.

Two potential direct construction phase impacts on the air quality of the area were identified:

- A1: Impaired human health from increased pollutant concentrations from activities associated with the construction; and
- B1: Increased nuisance dustfall rates associated with the construction.

Two potential direct operational phase impacts on the air quality of the area were identified:

- A2: Impaired human health from increased pollutant concentrations from activities associated with the SEZ operations; and
- B2: Increased nuisance dustfall rates associated with the SEZ operations.

The intensity of the impact was selected based on the following:

- Insignificant / ecosystem structure and function unchanged (1) – No exceedances of assessment criteria.
- Small / ecosystem structure and function largely unchanged (2) - No exceedances of assessment criteria off-site beyond the boundary.
- Significant / ecosystem structure and function moderately altered (3) - 1-hour and/or 24-hour assessment criteria exceeded off-site beyond the boundary.

- Great / harmful/ ecosystem structure and function largely altered (4) - 1-hour and/or 24-hour and 1-year assessment criteria exceeded off-site beyond the boundary.
- Disastrous / ecosystem structure and function seriously to critically altered (5) – increased lifetime cancer risk is "moderate" to "high", 1-hour and/or 24-hour and 1-year assessment criteria exceeded at AQRs beyond the boundary.

7.5.1 Potential Impact A1: Impaired human health from increased pollutant concentrations from activities associated with the construction operations

No dispersion modelling was undertaken for the construction operations but based on literature and the baseline environment, the unmitigated construction operations will potentially exceed the short-term criteria at AQRs. The environmental significance of this impact is MEDIUM LOW.

7.5.2 Potential Impact B1: Increased nuisance dustfall rates associated with construction operations

No dispersion modelling was undertaken for the construction operations but based on literature and the baseline environment, the unmitigated construction operations will not likely exceed the NDCR limit for residential areas at AQRs. The environmental significance of this impact is LOW.

7.5.3 Potential Impact A2: Impaired human health from increased pollutant concentrations from activities associated with the construction operations

The dispersion modelling shows a definite probability that the criteria will be exceeded at AQRs. The environmental significance of this impact is VERY HIGH.

7.5.4 Potential Impact B2: Increased nuisance dustfall rates associated with SEZ operations

The dispersion modelling shows it is not likely that the NDCR limit for residential areas will be exceeded at AQRs. The environmental significance of this impact is MEDIUM LOW.

Table 7-1: Impact significance summary table for the SEZ

Aspect	Nature	Description	Probability	Sensitivity	Severity	Extent	Duration	Significance Rating	Degree to which Impact can be Reversed	Degree to which Impact may Cause Irreplaceable Loss of Resource	Degree to which Impact can be Avoided, Managed or Mitigated	Risk Taking into Account Reversibility, the Irreplaceable Loss of Resources and Impact Avoidance/ Management and Mitigation
Biological	Air Quality	Impaired human health from increased pollutant concentrations from activities associated with the construction operations	Likely - 3	Critically - 5	Significant - 3	Study areas affected < 1000m -3	One year to five years - 3	72 – Medium Low	Reversible - 1	Unlikely - 1	Possible - 1	
		Increased nuisance dustfall rates associated with construction operations	Likely - 3	Critically - 5	Insignificant - 1	Study areas affected < 100m - 2	One year to five years - 3	48 - Low	Reversible - 1	Unlikely - 1	Possible - 1	
		Impaired human health from increased pollutant concentrations from activities associated with the SEZ operations	Definite - 5	Critically - 5	Disastrous - 5	Study areas affected > 3 000m - 5	Life of operation - 4	140 – Very High	Moderate reversibility - 2	Likely - 2	Moderately possible - 2	
		Increased nuisance dustfall rates associated with SEZ operations	Highly Likely - 4	Critically - 5	Insignificant - 1	Study areas affected < 100m - 2	Life of operation - 4	63 – Medium Low	Reversible - 1	Unlikely - 1	Possible - 1	

8 AIR QUALITY MANAGEMENT MEASURES

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

8.1 Air Quality Management Objectives

The main objective of the proposed air quality management measures for the SEZ is to ensure that operations at the project result in ambient air concentrations that are within the relevant ambient air quality criteria off-site. A plan for a minimal impact on air quality is presented in this section. The source specific management plans include target control efficiency, indicators for assessing performance and implementable procedures for emissions management.

8.1.1 Mitigation and Management Measures

The operators of the SEZ should make a concerted effort to ensure the installation of the best available technologies (BAT) at the processing plants and the implementation of best engineering practices. All equipment should be maintained and replaced when necessary.

8.1.2 Source Monitoring

The authorities should inform exactly what measuring and reporting annually on stack emissions is required. It should be noted that the data provider will be expected to report annual emissions on the NAEIS system. Dustfall monitoring near sources can be an effective mechanism in determining the main emission sources. It is recommended that exhaust emissions testing be done on all mobile diesel combustion sources as part of equipment maintenance schedules.

8.1.3 Ambient Air Quality Monitoring

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

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

It is recommended that, as a minimum continuous dustfall sampling at multiple locations as well as PM_{10}, $PM_{2.5}$, NO_2 and SO_2 monitoring at one location be conducted as part of the integrated SEZ air quality management plan. It is also suggested that a short sampling campaign after commencement of operations for H_2S be conducted to determine if the operations are compliant with the international inhalation health criteria. Recommended sampling locations (Figure 8-1) and the reasons for selection are given in Table 8-1.

Table 8-1: Sampling locations and parameters

No.	Description	Parameter to be Sampled	Reasoning
1	AQR 137 - Hermanus	Fallout dust PM_{10}, $PM_{2.5}$, NO_2 and SO_2	Most affected AQR beyond the SEZ boundary. For compliance assessment
2	West of power plant beyond SEZ boundary	Fallout dust	For compliance assessment
3	AQR 149 - Grootpraat	Fallout dust	For compliance assessment
4	AQR 145 - Generaal	Fallout dust	For compliance assessment
5	South of the SEZ boundary	Fallout dust	For compliance assessment
6	South-east of logistics centre beyond SEZ boundary	Fallout dust	For compliance assessment
7	AQR 162 - Bokmakierie	Fallout dust	For compliance assessment
8	North-east of sewage treatment plant beyond SEZ boundary	Fallout dust	For compliance assessment
9	AQR 5 - Mopane Intermediate School	Fallout dust	For compliance assessment

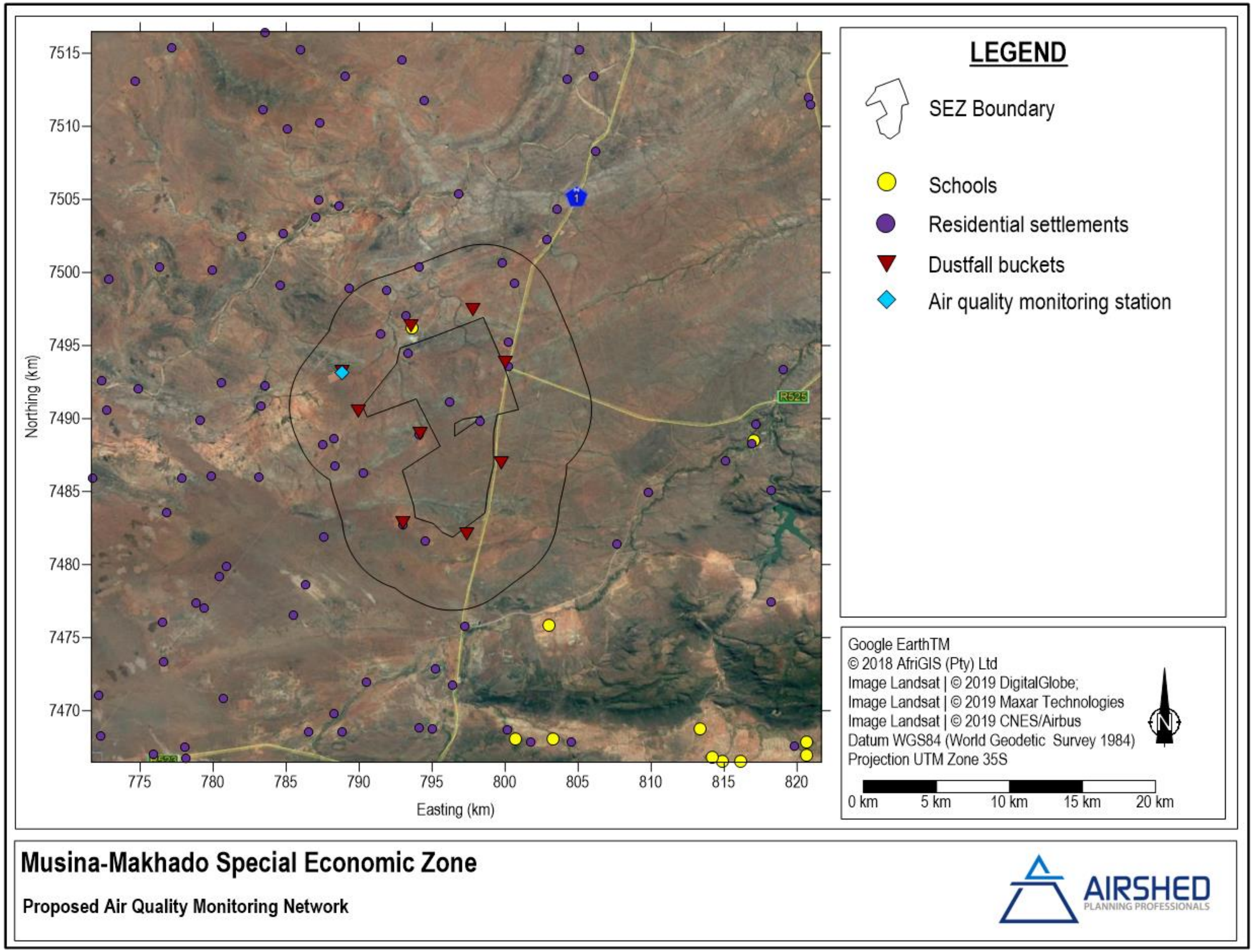


Figure 8-1: Proposed sampling locations

8.2 Record-keeping, Environmental Reporting and Community Liaison

8.2.1 Emergency Incidents

Emergency incidents on the site should be handled through standard operating procedures governing the actions that need to take place, as well as defining the responsibilities of the parties involved in managing the incident. Part of any environmental incident/emergency response, the environmental respondent will evaluate the incident and then classify it according to an internal ranking as well as against relevant legislative requirements which will then trigger the necessary reporting requirements.

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

It is recommended that a complaints register be put in place upon the start of operations and the community be encouraged to report not only odour complaints but all air quality related problems, such as nuisance dust, and fugitive emissions from roads. Staff should also be encouraged to report any air quality related problems observed on-site.

The community should be encouraged to phone or email the plant office, as well as to report any problems physically at a designated location, such as the plant office or a nearby school.

The date and time noted on the complaints register should be the date and time that the reported problem is observed, not the date and time that the complaint is logged. If used correctly, the complaints register can be compared to monitoring data as well as recorded meteorological data to identify problem areas and to iteratively adjust the air quality management plan to ensure efficient and effective mitigation of pollutant sources.

It is recommended that quarterly liaison meetings be held with the nearby communities to identify any air quality related problems. The community should be educated on the effects of the pollutants emitted on human health, especially the effects and symptoms of PM, NO_2 and SO_2 exposure, and to report any such symptoms. These complaints can then be compared with ambient monitoring data to identify periods of high concentrations and can help in the investigation of problem areas that result in especially high emissions.

9 FINDINGS AND RECOMMENDATIONS

9.1 Main Findings

An air quality impact assessment was conducted for activities proposed as part of the SEZ project. The main objective of this study was to establish baseline air quality in the study area and to quantify the extent to which ambient pollutant levels will change as a result of the proposed additional operations. The baseline and impact study then informed the air quality management and mitigation measures recommended as part of the Air Quality Management Plan (AQMP). This section summarises the main findings of the baseline and impact assessments.

The main findings of the baseline assessment are:

- The area is dominated by winds from the east-south-east and to a lesser extent the south-east, east and east-northeast. All pollutants' long-term air quality impacts are therefore expected to be the most significant to the west-northwest, north-west, west and west-south-west of the operations.
- Residential areas have the following as AQRs: residences, schools, hospitals and clinics. Other than residential areas surrounding homesteads and tourist accommodation were included at AQRs. A total of 183 receptors were identified in the domain, including residential settlements and schools, of which 21 receptors are within 10 km of the centre of the SEZ. The closest residential settlement (Steenbok) is located approximately 0.4 km to the south-west of the SEZ centre point. Three residential settlements are located within the SEZ study area boundary and will likely be relocated.
- The main sources contributing to current background PM concentrations likely include vehicle entrained dust from local roads, train operations, biomass burning, household fuel burning, vehicle exhaust, windblown dust from exposed areas, industrial (mining) operations and agricultural activities.

The main findings of the impact assessment are as follows:

- PM, NO_x, SO_2 and CO emissions will be released during the construction, operational decommissioning, and closure phases. Only the operational phase air quality impacts were quantified since construction and decommissioning
- SEZ operations:
  - PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, Mn, Cr^{6+} and H_2S emissions and impacts were quantified.
  - The PM_{10} and $PM_{2.5}$ emissions and simulated concentrations were likely underpredicted in this study.
  - Simulated PM_{10} concentrations were found to exceed the evaluation criteria beyond boundary but not at AQRs.
  - Simulated $PM_{2.5}$, NO_2, SO_2, Mn and Cr^{6+} concentrations were found to exceed the evaluation criteria beyond boundary and at AQRs.
  - The significance of proposed SEZ operations related inhalation health impacts is considered "very high" reducing.

9.2 Air Quality Recommendations

To ensure the lowest possible impact on AQRs and environment it is recommended that the air quality management plan as set out in this report should be adopted. This includes:

- The mitigation and management of all plants;
- Future facilities will be required to complete an EIA and apply for a new AEL and may be required to an air quality impact study for an AIR;
- Ambient air quality monitoring; and
- Implementation of the reporting procedures.

Based on these findings and provided the measures recommended are in place, it is the specialist opinion that the project may be authorised.

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11 APPENDIX A: SPECIALISTS CURRICULUM VITAE AND PROFESSIONAL REGISTRATION CERTIFICATE

11.1 Natasha Anne Shackleton – Report Author

CURRICULUM VITAE NATASHA ANNE SHACKLETON

CURRICULUM VITAE

Name of Staff	Natasha Anne Shackleton (née Gresse)
Name of Firm	Airshed Planning Professionals (Pty) Ltd
Position	Senior Consultant
Profession	Meteorologist employed as a Senior Consultant
Date of Birth	12 September 1988
Years with Firm	6 Years
Nationalities	South African
Race and Gender	White Female

EDUCATIONAL QUALIFICATIONS

BSc Honours (Meteorology)	University of Pretoria (Faculty of Natural and Agricultural Sciences), Pretoria.
BSc	University of Pretoria (Faculty of Natural and Agricultural Sciences), Pretoria.

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Golden Key International Honour Society, 2011 to present.
- South African Society for Atmospheric Sciences (SASAS), 2016 to present.

KEY EXPERIENCE

Natasha has 6 years of experience in air quality impact assessment and management. She is an employee of Airshed Planning Professionals (Pty) Ltd and is tasked with completing air pollution mitigation and management studies, and air and noise pollution impact work; involving ambient measurements, meteorological data processing and preparation, the compilation of emission inventories, undertaking of air dispersion and noise propagation modelling, impact and compliance assessment, air quality and dust management plan preparation and report writing.

Models applied in conducting air and noise studies:

- CONCAWE (noise propagation model);
- SANS 10201 (calculating and predicting road traffic noise);
- WRPLOT (wind & pollution rose generation);
- AERMOD Suite (air dispersion model);
- ADMS (air dispersion model);
- CALPUFF Suite (air dispersion model);
- TANKS (emission estimation model); and
- GasSim (emission estimation model).

Curriculum Vitae: Natasha Anne Shackleton **1**

RELEVANT EXPERIENCE

Natasha has completed air quality specialist studies for the projects listed below.

Mining Sector

- **Coal mining**: Argent Colliery, Commissiekraal Coal Mine, Estima Coal Project (Mozambique), Grootegeluk Coal Mine, Matla Coal Mine, Rietvlei Coal Mine, Vierfontein Coal Mine.
- **Metalliferous mines**: AngloGold Ashanti, Bakubung Platinum Mine, Bannerman Uranium Mine (Namibia), Gold Fields' South Deep Gold Mine, Kitumba Copper Project (Zambia), Lehating Manganese Mine, Lesego Platinum Mine, Lofdal Mining Project (Namibia), Marula Platinum Mine, Maseve Platinum Mine, Mkuju River Uranium Project (Tanzania), Namakwa Sands Quartz Rejects Disposal and Mine, Otjikoto Gold Project (Namibia), Otjikoto Gold Mine's Wolfshag Project (Namibia), Pan Palladium Project, Perkoa Zinc Project (Burkina Faso), Storm Mountain Diamonds (Lesotho), Tete Iron Ore Project (Mozambique), Thabazimbi Iron Ore's Infinity Project, Toliara Sands Project (Madagascar), Trekkopje Uranium Mine (Namibia), Tschudi Copper Mine (Namibia), Wayland Iron Ore Project, Zulti South Project.
- **Quarries**: AfriSam Saldanha Cement Project Limestone Quarry.

Industrial Sector

AfriSam Saldanha Project; CAH Chlorine Caustic Soda and HCl Plant, Metal Concentrators SA Paarden Eiland, Namakwa Sands Dryer, Otavi Rebar Manufacturing, Pan Palladium Project, PPC Riebeeck Cement, Rare Earth Elements Saldanha Separation Plant, Siyanda Project.

Power Generation, Oil and Gas

Hwange Thermal Power Station Project (Zimbabwe), Ibhubesi Gas Project, Expansion of Staatsolie Power Company, Suriname Operations (Suriname).

Waste Disposal and Treatment Sector

Fishwater Flats Waste Water Treatment Works, Moz Environmental Industrial Landfill (Mozambique).

Petroleum Sector

Puma South Africa's Fuel Storage Facility.

Transport and Logistics Sector

Saldanha Port Project.

EDUCATION

University

2016 - Present	MSc: Applied Science (Environmental Technology) student at the University of Pretoria (Faculty of Engineering, Built Environment and Information Technology), Pretoria. Currently undertaking studies. Supervisor: Dr G Kornelius.
2010 - 2011	BSc Honours (Meteorology) student at the University of Pretoria (Faculty of Natural and Agricultural Sciences), Pretoria. Completed 30 November 2011. Degree issued/conferred 13 April 2012. Supervisor: Dr S Venkataraman.
2007 - 2010	BSc student at the University of Pretoria (Faculty of Natural and Agricultural Sciences), Pretoria.

Completed 30 June 2010. Degree issued/conferred 2 September 2010.

Matriculated

2006 Maris Stella School, Durban.

ADDITIONAL COURSES

None

COUNTRIES OF WORK EXPERIENCE

South Africa, Botswana, Burkina Faso, Lesotho, Mozambique, Madagascar, Namibia, Suriname, Tanzania, Zambia and Zimbabwe.

EMPLOYMENT RECORD

April 2011 - Present Senior Consultant.Airshed Planning Professionals (Pty) Ltd, Midrand (previously known as Environmental Management Services 1990 to 2003).

A consulting firm providing services in the Air Quality and Noise Assessments and Management field to industry and national, provincial and local authorities. Work includes the preparation of emission inventories, dispersion modeling, impact assessment and mitigation planning in the mining, metallurgical and general industrial sectors. Legal compliance audits have been carried out.

2009 – March 2011 Demonstrator and Tutor (Cartographic Skills, Principles of Remote Sensing and Surveying) at the University of Pretoria (Faculty of Natural and Agricultural Sciences), Pretoria. Demonstrator and Tutor (Surveying) at the University of Pretoria (Faculty of Engineering, Built Environment and Information Technology), Pretoria.

A university in South Africa.

CONFRENCES AND WORKSHOP PRESENTATIONS AND PAPERS

None

LANGUAGES

	Speak	Read	Write
English	Excellent	Good	Good
Afrikaans	Good	Good	Good

CERTIFICATION

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

09/05/2017

SACNASP

South African Council for Natural Scientific Professions

herewith certifies that

Natasha Anne Shackleton

Registration number: 116335

is registered as a

Professional Natural Scientist

in terms of section 20(3) of the Natural Scientific Professions Act, 2003
(Act 27 of 2003)
in the following fields(s) of practice (Schedule 1 of the Act)

Physical Science

Effective **06 June 2018** Expires **31 March 2019**

President

Executive Director

11.2 Theresa (Terri) Leigh Bird – Report Author

CURRICULUM VITAE

Name	Theresa (Terri) Leigh Bird
Date of Birth	8 November 1976
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Senior Consultant
Profession	Air Quality Specialist Consultant
Years with Firm	5 years

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- National Association for Clean Air (NACA), 2012 to present
- South African Council for Natural Science Professions (Pr.Sci.Nat.), 2016

EXPERIENCE

Projects contributing to Environmental Impact Assessments

Project type	Experience
Mining (including coal, platinum, tin, gold, and rare earth minerals)	▪ At least five proposed open-cast coal mining projects, mostly in South Africa and Botswana ▪ Air quality assessment for the expansion of an underground platinum mine to include a concentrator facility and tailings facility. ▪ Assessment of underground mining of cassiterite (the mineral ore mined for tin) in the Democratic Republic of Congo. The project included the assessment of emissions along a long-distance haul road from the mine to Mombasa for export. ▪ Assessment of open-cast and underground mining of gold-rich ore, including gold plant activities, in order to design an air quality monitoring network. ▪ Three rare earth mineral mining projects included dispersion model runs to assist the radiation specialist assessment of impact of radioactive compounds.

Projects contributing to Environmental Impact Assessments

Project type	Experience
Power Stations	▪ A project assessing the impact of Namibian coal-fired power station on urban air quality, in the context of many small industrial sources. ▪ The assessment of retrofitting improved particulate emission controls on an existing coal-fired power station on the Mpumalanga Highveld. ▪ The assessment of impact of a floating power plant, fuelled by various potential liquid fuels, docked in a port servicing an industrial development zone. ▪ Professional opinion on the impact of solar power facilities (one concentrated solar power (CSP) and one photovoltaic (PV)) on ambient air quality. ▪ The assessment of three coal-fired power stations in Botswana, including two projects where the assessment assessed the combined impact of an open-cast coal mine and the associated coal-fired power station.
Ash disposal facilities for coal-fired power stations	▪ Conducted the assessment of impact of ash disposal facilities coal-fired power stations requiring additional disposal area. Assessment included the estimation of increased life-time cancer risk as a result of exposure to carcinogenic metals in the wind-blown dust from the disposal facilities.
Tyre pyrolysis plant	▪ Assisted on an assessment of a plant that will use waste tyres as raw material to produce machine and vehicle oils.
Domestic waste landfill	▪ Assessing the health and odour impacts of a domestic waste landfill to support residential development plans for the area.
Marine Repair Facility	▪ The project quantified the impact on air quality of a marine vessel repair facility in the context of a busy port which includes an iron-ore transfer yard.

Air Quality Management Plans (AQMP)

Project type	Experience
Provincial Level AQMP	▪ Involvement included: - baseline assessment of climatic conditions and ambient air quality across the Province; - collation of questionnaires from point-source emission; - point-source emissions inventory database management ▪ Assisted with quantification of vehicle emissions and with dispersion modelling of baseline emissions. ▪ Main contributor to management plan write-up.

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Air Quality Management Plans (AQMP)

Project type	Experience
	▪ The management intervention strategies proposed in the AQMP were a collaborative effort of the technical project team, which included the client and consultants.
Metropolitan city level AQMP	▪ Contributed to the emission inventory of industrial sources ▪ Collaborative project with the Council for Scientific Research (CSIR)
Platinum smelter complex	▪ Fugitive dust emissions from ground-level sources and materials handling were a concern for a platinum smelter complex. The project scope included the identification of all sources; the quantification and ranking of emissions; and proposed management strategies. A risk assessment model was used to assess where the variability of emission sources would constitute a risk if improperly managed.
Diamond mine	▪ The project scope for a Botswana-based diamond mine approaching end-of-life required the assessment of current and future impacts of operations on the ambient air quality; including the development of an air quality management plan and the proposal of an ambient air quality monitoring network, based on the findings of the impact assessment.

Atmospheric Impact Reports (AIR)

Project type	Experience
Coal-to-liquid fuel refineries	▪ Postponement application included four sites with multiple point-sources and modelling iterations for all sources emitting at four different levels for multiple pollutants. ▪ A collaborative project where responsibilities included: model simulations, post-processing and extractions; management of model extractions and management of file transfer for peer review process; graphic summaries results; mapping of results; and, graphic presentation of measured ambient air quality. My contributions to the written report included: report template sections (as per Government Gazette No. 36904: 747); summary of meteorological data used in the assessment; measured ambient air quality; results analysis, interpretation and write-up; and, a literature review of potential impacts of the operations on the environment. ▪ The assessment of impact of petroleum storage tanks storing products of the tar process on the ambient air quality, especially with respect to total volatile organic compounds (TVOCS).

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Atmospheric Impact Reports (AIR)

Project type	Experience
Crude oil refinery	▪ Postponement application included emissions from multiple point-sources, and fugitive emissions from storage tanks; modelling iterations for all sources emitting at two different levels for sulfur dioxide [from point sources] and total volatile organic compounds (TVOCS) [from tanks]. ▪ A collaborative project where I focused on the point-sources, including the model simulations; post-processing and extractions; graphic results summaries; and, graphic presentation of measured ambient air quality. Contributions to the written report included: report template sections; summary of meteorological data used in the assessment; measured ambient air quality; results analysis, interpretation and write-up.
Fertilizer production	▪ Assessment report (prepared as AIR) included emissions from multiple point-sources; modelling iterations for all sources emitting at two different levels for particulate matter and ammonia emissions. ▪ A collaborative project where my responsibilities included: model simulation setup, post-processing and extractions; graphic summaries results; mapping of results; and, graphic presentation of measured ambient air quality. My contributions to the written report included: report template sections (as per Government Gazette No. 36904: 747); summary of meteorological data used in the assessment; measured ambient air quality; results analysis, interpretation and write-up.
Platinum smelter	▪ Postponement application included emissions from the smelter furnace and converter; modelling iterations for the sources emitting at two different levels where the pollutant of concern was sulfur dioxide.

* all projects listed above supported the application for postponement of stricter Minimum Emissions Standards applicable to Listed Activities

Veterinary waste incinerator	▪ New Atmospheric Emissions License (AEL) application for a State Veterinary incinerator. The assessment included calculating emission rates from the incinerator; dispersion modelling; preparation of an AIR (as per Government Gazette No. 36904: 747); and completing the technical sections of the AEL application.
Galvanizing plant	▪ The project assessed the impact of a steel galvanising plant on air quality in a developing industrial development zone. Pollutants of concern included hydrochloric acid (HCl).
Secondary Aluminium Smelter	▪ A project involving the assessment of a secondary aluminium smelter in an already developed urban industrial area

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Ambient air quality monitoring projects

Project type	Comments regarding project details and involvement
Ferrochrome smelter complex	▪ Compiled reports for the dustfall monitoring campaign for a period of 12 months. Results were compared with the relevant legislation and recommendations made for source management as required.
Platinum smelter complex	▪ Project scope required monthly reports of the ambient sulfur dioxide concentrations downwind of a platinum smelter complex, for a 12 month reporting period. Report preparation included: data cleaning and filtering; data analysis, presentation; and report write-up.
Dustfall monitoring	▪ Collate, summarise and report on dustfall rates, and metal content, after laboratory analysis. Projects include: baseline monitoring prior to active coal mining; landfill dustfall monitoring; baseline dustfall monitoring for a residential development.
Ambient air quality monitoring	▪ Using radiello™ passive samplers to assess ambient pollutant concentrations. Projects include: volatile organic compounds around industrial waste water dams; pre-development levels near a medical waste incinerator; and pre-development levels near a coal-fired power station.

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, CALPUFF, ADMS (United Kingdom), CALINE, GASSIM
- Graphical Processing: Surfer, ArcGIS (basic proficiency)
- R, especially with the package "openair"
- Other: MS Word, MS Excel, MS Outlook

EDUCATION

University of the Witwatersrand

Ph.D. (School of Animal, Plant and Environmental Sciences) (2006 - 2011)	Thesis title: **Some impacts of sulfur and nitrogen deposition on the soils and surface waters of the Highveld grasslands, South Africa.**
M.Sc. (School of Animal, Plant and Environmental Sciences) (1999 – 2001).	Dissertation title: **Some effects of prescribed understory burning on tree growth and nutrient cycling, in *Pinus patula* plantations.**

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B.Sc. (Hons) (Botany) (1998)	Project title: **The rate of nitrogen mineralization in plantation soils, in the presence of *Eucalyptus grandis* wood chips.** *Courses*: Wetland ecology, Ecophysiology and Environmental studies.
B.Sc. (1995 – 1997)	Botany III, Geography III, Zoology II.

COURSES COMPLETED AND CONFERENCES ATTENDED

- Paper presented at the International Union of Air Pollution Prevention and Environmental Protection Associations World Clean Air Congress, 2013 in Cape Town, South Africa,29 September - 4th October 2013
  - *Paper entitled*: Nitrogen cycling in grasslands and commercial forestry plantations: the influence of land-use change
  - *Co-authors*: T.L. Bird, M.C. Scholes, Y. Scorgie, G. Kornelius, N.-M. Snyman, J. Blight, and S. Lorentz
- Paper prepared for the National Association for Clean Air (NACA) annual conference, 2012 in Rustenburg, South Africa, 1-2 November 2012, Rustenburg. Annual Conference Proceedings ISBN 978-0-620-53886-2, Electronic Proceedings ISBN 978-0-620-53885-5
  - *Paper entitled*: Developing an Air Quality Management Plan: Lessons from Limpopo
  - *Co-authors*: T. Bird, H. Liebenberg-Enslin*, R. von Gruenewaldt, D. Modisamongwe, P. Thivhafuni, and, T. Mphahlele

COURSES PRESENTED

Training organisation	Details of involvement
National Association for Clean Air (NACA)	▪ Presenting the module regarding the Development of Air Quality Management Plans ▪ Module forms part of a 5-day course presented annually
Centre for Environmental Management (CEM), University of the North-West (Potchefstroom)	▪ Presented two modules: 1. Development of Air Quality Management Plans 2. Air Pollution Meteorology ▪ Modules forms part of a 2-day course presented annually, or at special request

COUNTRIES OF WORK EXPERIENCE

South Africa, Botswana, Mozambique, Democratic Republic of Congo, Namibia, Tanzania

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Good understanding; fair spoken and written

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.

18 August 2017

SACNASP

South African Council for Natural Scientific Professions

herewith certifies that

Theresa Leigh Bird

Registration Number: 114332

is registered as a

Professional Natural Scientist

in terms of section 20(3) of the Natural Scientific Professions Act, 2003
(Act 27 of 2003)
in the following fields(s) of practice (Schedule 1 of the Act)

Biological Science
Botanical Science

Effective **25 May 2016** Expires **31 March 2020**

Chairperson

Chief Executive Officer

Scan this code to view online version of this certificate

11.3 Lucian Willem Burger – Report Reviewer

CURRICULUM VITAE

Name of Staff	Lucian Burger
Name of Firm	Airshed Planning Professionals (Pty) Ltd
Position	Director and Principal Consultant
Profession	Chemical Engineer/Air Quality and Process Risk Specialist
Date of Birth	24 May 1960
Years with Firm	27 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Registered with the Engineering Council of South Africa as Professional Engineer (Registration No. 20170291)
- Fellow of the South African Institute of Chemical Engineers (SAIChe)(Fellow: No. 4533)
- Associate Fellow of the Institute of Chemical Engineers (AFIChemE) (Fellow: No. 99963108)
- National Association of Clean Air (NACA)
- Accredited Inspectorate Authority (AIA) for completion of risk assessments as partial fulfilment of Major Hazard Installation Regulations (Reference MHI013)
- SANAS Risk Assessment Specialist Technical Committee (2003 - 2010)
- Member of the Technical Committee on Air Quality Standards Setting (2002-2003)
- SABS Air Quality Standards Specialist Technical Committee (Chairman of Working Group 1)

KEY QUALIFICATIONS

32 years' experience in:

- Air Pollution Dispersion Modelling (use and development)
- Loss of Containment Simulations and Consequence Modelling (Fires, Explosions, Toxic Clouds)
- Process Failure Rate Analysis
- Micrometeorology
- Quantitative Risk Assessment
- Nuclear Site Safety Report Analysis – Meteorology and Dispersion Modelling
- Ambient Air Monitoring
- Chemical Engineering
- Development of Air Emissions Inventories (Mining and Ore Handling, Metal Recovery, Chemical Industry, Petrochemical Industry, Power Generation, Waste Disposal and Recycling, Transport [motor vehicles, aircraft, ships])
- Air Quality Management Programmes
- Formulation of National Strategies
- Project Management

RELEVANT EXPERIENCE

Policy, Strategic Planning and Air Quality Management:

- Site selection for South Africa's Nuclear Installations. Specialist member (climatology, micro-meteorology and atmospheric dispersion modelling) of the Nuclear Site Safety Team appointed by Eskom for the period 2007 to 2015.
- Dispersion modelling regulations – Chairman of the Dispersion Modelling Working Group for standardizing and setting requirements for the use of dispersion models for regulatory purposes, in conjunction with the South African Department of Environmental Affairs. Published in 2014 (National Environmental Management: Air Quality Act, 2004 (Act No. 39 of 2004) Regulation No. R 533, Government Gazette 37804).
- Guidelines For Thermal Treatment Of Wastewater Sludge – Development of the position paper and subsequent guidelines on the air emissions impact from thermal treatment options of wastewater sludge. The Water Research Commission published the complete set of guidelines in 2009 [*Herselman JE; Burger LW; Moodley P (2009) Guidelines for the utilisation and disposal of wastewater sludge Volume 5 of 5: Requirements for thermal sludge management practices and for commercial products containing sludge, ISBN No: 978-1-77005-711-1*].
- Review and Implementation of the new Air Emission License (National Environmental Management Air Quality Act) role out programme (2006-2008). This included the development of the framework, technical workshops with industry and training of local authorities. The tasks were divided between principal consultants within Airshed Planning Professionals. Lucian Burger was responsible for the Power Generation and Pulp & Paper sectors.
- List of Activities, Setting of Minimum Emission Standards. Served as technical advisor to the Department of Environmental Affairs for the development of air pollution emission rates for all major stationary industrial activities. Original published in 2010 (Government Gazette 33064)
- As chairman of Working Group 1, Lucian Burger was involved in the development of the South African Air Quality Standards Framework (SANS 69) and the Air Quality Standards for Criteria Pollutants (SANS 1929), in conjunction with the South African Bureau of Standards (SABS).
- NEDLAC 'Dirty Fuels Project' - The project undertaken for NEDLAC comprised the development of emissions inventories for several major conurbations across South Africa, the prediction of resultant air pollutant concentrations and the quantification and costing of health risks due to inhalation exposures. Project was completed in 2004.
- Low Smoke Fuels Standards- Served on the Technical Committee on the Low Smoke Fuels Standards Development Committee administered by the Department of Minerals and Energy (1998-2003).
- Mercury emission limits - The South African Regulations for Mercury Waste Disposal was drafted in 2001. These regulations were completed together with Infotox (Pty) Ltd,

specialists in toxicology.

- Projects related to Air Quality Management
  - Saldanha Industrial Development Zone (IDZ) – Part of an integrated team of specialists that developed the proposed development and management strategies for the IDZ. Air quality guidelines were developed and a method of determining emissions for potential developers. The investigation included the establishment of the current air emissions and air quality impacts (baseline) with the objective to further development in the IDZ and to allow equal opportunity for development without exceeding unacceptable air pollution levels.
  - Vaal Triangle Airshed Priority Area Air Quality Management Plan– Served as technical advisor to the Department of Environmental Affairs for the development of South Africa's first air pollution priority area air quality management plan. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modelling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263)
  - Cape Town - An air quality situation assessment was undertaken on behalf of the City of Cape Town in 2002 in support of their plans for the development of an air quality management plan for the City.
  - Johannesburg - An air quality baseline assessment was undertaken and an air quality management plan compiled for Johannesburg on behalf of the City. The project was completed during September 2003.
  - Coega - An air pollution management strategy was developed in 1997 for the Coega IDZ. Air quality guidelines were developed and a method of determining emissions for potential developers. The objective was to allow equal opportunity for development without exceeding unacceptable air pollution levels. Developed an air-shed air quality management model for application at Coega in 1999. The model was developed in-house so as to assist the Coega Development Corporation in the proactive allocation of emission limits to prospective investors in the IDZ. The purpose being to maximise development opportunities whilst ensuring the maintenance of good air quality in the long-term.
  - Gauteng - An air quality baseline assessment was completed for Gauteng in 1999 to inform their proposed air quality management plan. This project was funded by DANIDA.
  - Gauteng - Part of the Environomics/Africon project team to develop industrial buffer zones for Gauteng was undertaken by members of our project team. These buffer zones have been implemented in a GIS system for DACEL and are meant as an early warning decision-support tool to indicate possible conflicts between sensitive activities (including residential development, hospitals, etc.) and pollution caused by industrial activities.
  - Ekurhuleni – An air quality baseline study and an Air Quality Management Plan has

been developed for the Ekurhuleni Metropolitan Municipality. This work was completed in 2005.

- UMhlathuze – An air quality situation analysis has being undertaken for the uMhlathuze District Municipality and guidance given in terms of the air quality implication of the municipality's spatial development framework. Work is was completed in 2005.
- Tswane – An air quality baseline study was completed for the Tswane Metropolitan Municipality (2005).

Transport Sector: Bakwena Toll Road Concession (Pretoria – Rustenburg); N1/N2 Protea Toll Road (Cape Town – Paarl – Somerset West); Protea Toll Road Tunnel Options; N14 (Germiston) On-/Offramp; N3TC Toll Road Concession De Beers Pass Alternatives; Gauteng Heavy Vehicles Freeway Re-Routing Study; SAPIA Vehicle Emissions Management Strategy; Gauteng Department of Transport Air Quality Management Plan; MMT Fuel Additive Monitoring Campaign (Afton); Sasol Vehicle Emissions Ambient Air Monitoring Campaign; Cape Town International Airport Air Quality Management Plan; OR Tambo International Airport Detailed Air Emission Inventory and Air Quality Management Plan; Sir Seretse Kama (Botswana) Air Impact Assessment; Iron Ore Train Transport (Sishen Mine to Saldanha Bay Iron Ore Port); Coal Train Transport (Moatize to Nicala Port, Mozambique); Bauxite Ore Long-haul Road Transport (Bakhuis to Nickerie, Suriname); Baseline Assessment of Iron Ore Transport (Zanaga Mine to Pointe Noir, Republic of Congo (Brazzaville)).

Provision of Expert Testimony: [e.g. Herbicide Contention Case: Victory Farm v HL&H Timber Products (Pty) Ltd, Rautenbach Aerial Spraying Ltd, Alan James McEwan; SAPREF Alkylation Unit Fire, Rhone-Poulenc Warehouse fire, Shell-Sasol Alcohol Reformulation Contention; Kudu Oils v Department of Environmental Affairs and Tourism), Global Forest Products (Pty) Ltd & Others v Lone Creak River Lodge (Pty) Ltd & Others; Pride Milling Company (Pty) Ltd v Klipspruit Colliery & Others; Triple S Diensstasie Edms Bpk / P Senekal; PetroSA v Langeberg Shopping Mall, PetroSA v Visigro Investments, Koedoeskloof Landfill in Uitenhage Nelson Mandela Municipality v Pentree.

Quantitative Risk Assessments and Consequence Modelling: Air Products Durban plant (Hydrogen); Comprehensive Risk Assessment of AECI (chlorine, ammonia, acrylonitrile, sulphur dioxide), Umbogintwini Factory Complex; Oleum Storage Tank Farm Lever Brothers. Boksburg; Ammonia Tank Farm Palabora Mining Company, Palaborwa; Ammonia Refrigeration Unit, Palabora Mining Company, Palaborwa; Chlorine Dosing facility Palabora Mining Company, Palaborwa; Accidental liquid Bromine spills and fugitive gas emissions at Delta-G Scientific, Halfway House; Accidental emissions and spills of organo-pesticides at Sanachem, Verulam. Burning of waste dumps in Botswana (Botswana Government). Chlorine Dosing Facility at mining operations (Rustenburg); Dispersion and Consequence Modelling of Toxic Liquid Spills (e.g. Acrylonitrile and Propylene Oxide), Combustion Products (e.g. Hydrogen Cyanide), Bund Fires and Vapour Cloud Explosions of a large number of storage tanks at Vopak Tank Terminals, Durban Harbour, Investigation of Fire at Sapref Refinery Alkylation Unit; Risk assessment of ammonia, hydrogen fluoride and nitric acid Columbus

Stainless (Middelburg); Natural Gas Pipeline from Mozambique to Secunda (Sasol Gas). Hydrogen gas pipeline from Vanderbijlpark to Springs (Air Products), Crude oil and white product pipelines from Chevron Refinery (Cape Town) to Cape Town Harbour, Crude oil and white product pipelines from Chevron Refinery (Cape Town) to Saldanha Bay, Liquid Fuels Transportation Infrastructure from Staatsolie Refinery To Ogane, Sol And Chevron Product Storage Depots, Suriname (Staatsolie Maatschappij Suriname N.V.) – Overland and Riverbed assessments; Liquid Fuels Transportation Infrastructure From Milnerton Refinery Area To Ankerlig Power Station (Atlantis Industrial Area), Western Cape Province (Eskom). Sunrise Liquid Petroleum Gas Ship Offloading and Pipeline Transportation Saldanha Bay – Sea and Land Spillages, Transnet Pipeline Greenvale Diesel Spill – Hillcrest, KwaZulu-Natal

Mining and Ore Handling (Blasting; quarrying; grinding; crushing; conveying; vehicles; tailings dams). BHP-Billiton Bauxite Mine (Suriname), Exxaro Heavy Minerals Mine and Processing (Madagascar), Tenke Copper Mine and Processing Plant (DRC), Sari Gunay Gold Mine (Iran), Zaldivar Copper Mine (Chile); Gold Mine at Omagh (Ireland); ZCCM Luancha Copper mine (Zambia); Skorpion Zinc mine (Namibia); Rossing Uranium (Namibia); Trekkopje Uranium (Namibia); Gokwe Coal Mine (Zimbabwe); Murowa Diamond Mine (Zimbabwe); Gamsberg Zinc Mine (Aggeneys); Prieska Copper mine (Prieska); Numerous coal collieries, including Riversdale (Tete Province Mozambique, Anglo Coal, Exxaro, Xstrata); Lime Quarries (La Farge, formerly Blue Circle, East London and Otjiwarongo, Namibia); Clinker Grinding and Cement Blending Plant (La Farge, Richards Bay); Bluff Mechanical Appliances – Durban Coal Terminal; Portnet's Saldanha Ore Port Facility; and others.

Metal Recovery (Smelting; electro-wining). Samancor Air Quality Baseline for all South African Chromium Smelter and Mines (Ferroveld, Ferrometals, MFC, Columbus, Tubatsi, Western Chrome Mines, Eastern Chrome Mines), Hexavalent Chromium Air Quality Reference Document (FAPA), Hartley Platinum Smelter (Zimbabwe); Mufulira Smelter (Zambia), Nkana Smelter (Kitwe, Zimbia); Waterval Smelter (Amplats, Rustenburg); Lonrho Smelter (Brits); Ergo (Anglo American Corporation, Springs); Coega Zinc Refinery (Billiton, Port Elizabeth); Hexavalent Chrome and Lead (Winterveld Chrome Mines); Hexavalent Chrome Xstrata (Rustenburg); Pitch releases from graphite electrode (EMSA, Union Carbide, Meyerton); Copper Smelting (Palabora Mining Company, Phalaborwa); Portland Cement Plant (La Farge, East London and Otjiwarongo, Namibia); Westplats – Mooinooi Smelter (Brits), Holcim Alternative Fuels Project (Lichtenburg, Ulco and Blending Plant – Roodepoort), PPC Riebeeck West Expansion Project, Expansion projects for ArcelorMittal South Africa Vanderbijlpark Works, Expansion projects for ArcelorMittal South Africa Saldanha Bay Works

Chemical Industry (bulk chemical; fertilizer; herbicides; pesticides). Comprehensive air pollution impact assessment of AECI (Pty) Ltd Operations, including Modderfontein, Umbogintwini, Somerset West, New Germany and Richards Bay; Kynoch Fertilizer plants in Milnerton and Potchefstroom; Fedmis Fertilizer Plant in Phalaborwa; Pesticides and Herbicides at Sanachem (Canelands); Chrome Impacts from various Bayer (Pty) Ltd operations (Newcastle and Durban); Fibre Production (Sasol Fibres, Durban); NCP Chloorkop Expansion project, NCP Chloorkop Contaminated Soils Recovery

Petrochemical Industry (Petroleum refineries, tank farms). Baseline and Expansion of Liquid Natural Gas Refinery (Equatorial Guinea); Site Selection for New South African Petroleum Refinery (DME), Proposed new Greenfields Petroleum Refinery at Coega (PetroSA), Hydrogen sulphide and sulphur dioxide emissions from SASOL operations (Sasolburg and Secunda); Sasol Coal to Gas Conversion Project (Sasolburg), Natref Refinery Expansion Project (Sasolburg); Engen Emissions Inventory Functional Specification (Durban); Air impact of air emissions from Sapref Refinery (Durban) Odour Impact assessment at ChevronTexaco Refinery (Cape Town); StaatsOlie expansion project (Suriname); Marathon LNG Expansion (Equatorial Guinea); PetroSA (Mossel Bay), Air impact of air emissions from Killarney, Milnerton and Saldanha Bay bulk storage tanks, Ambient air sampling campaign and Health Risk Analysis at Highway, Toll Plazas, Filing Stations & Taxi Ranks (Sasol), Air Products - Cryodrains at Sasol Secunda Oxygen Plants: Steam Ejector Vaporiser Vent Design

Pulp and Paper Industry. Expansion of Mondi Richards Bay, Odour Assessment and Panel Development for Mondi Richards Bay, Multi-Boiler Impact Assessment for Mondi Merebank (Durban), Impact Assessment for Sappi Ngodwana (Nelspruit), Impact Assessment for Sappi Stanger, Air Quality Monitoring Network and Air Pollution Management Plan for Sappi Saiccor (Umkomaas), Comprehensive Emissions Inventory and Screening Health Risk Assessment for Sappi Enstra (Springs), Impact Assessment for Sappi Tugela, Expansion Project for Cape Sawmills (Stellenbosch), Comprehensive Emissions Inventory and Screening Health Risk Assessment for Global Forest (Sabie), Air Impact Assessment for Pulp United (Richards Bay), MTO George Saw Mill (George)

Power Generation:

Coal Power Stations

Kelvin Power Station (Johannesburg); Athlone Power Station (Cape Town); Tatuka, Kendal, Matimba, Duvha and Majuba Power Stations, ESKOM; Open Cycle Gas Turbine Peaking Power Station (Mosselbay), Inhambane Power Station, Mozambique, Combined Cycle Gas Turbine Power Plant In Moamba, Mozambique.

Nuclear Installations

Participating member in the ATMES Phase 1 project to assess the emergency preparedness to nuclear accidents following the Chernobyl Accident, Development and Implementation of a real-time emergency dispersion model for NECSA (Pelindaba); Development of a real-time emergency dispersion model for Koeberg Nuclear Power Station; Environmental Impact Assessment for the proposed demonstration Pebble Bed Modular Reactor (PBMR); Environmental Impact Assessment for the proposed Nuclear-1 Power Station; Meteorological monitoring and development of Meteorological Chapter of Site Safety Report for potential Nuclear-1 Power Station (Thyspunt, Bantamsklip and Duynefontein).

Solar Installations

Proposed 150 MWp Photovoltaic (PV) Power Plant (Bronkhorstspruit), Baseline and Impact Assessment near Grootvlei Power Station for Solar Energy PV Power Facility, Air Quality Impact Assessment for the Abengoa KaXu Concentrated Solar Power (CSP) station (Pofadder, Northern

Cape).

Waste Disposal (Incineration; landfill; evaporation; waste water treatment) All Enviroserv disposal sites (Chloorkop, Margolis, Umlazi, Vissershok, Shongweni, Aloes, Holfontein, Rosslyn), and city/district landfill facilities, including Cape Town City Council, Durban City Council, Johannesburg City Council; East London City Council; Port Elizabeth City Council, Eden District Municipality, Beluluane landfill facility [Matola, Mozambique])

Software Development. Development of real time atmospheric dispersion model - HAWK: Atomic Energy Corporation of South Africa; CALTEX, Cape Town; NCP CHLOORKOP, Kempton Park; MOSSGAS, Mosselbay; PALABORA MINING COMPANY, Palaborwa; AECI, Umbogintwini; AECI, Modderfontein; SASOL, Secunda; SASOL, Sasolburg; SAPREF Refinery, Durban; ENGEN Refinery, Durban; ESKOM, Majuba Power Station; South Durban Air quality management system (Joint venture between major industries, authorities and community); SAPPI-SAICCOR, Umkomaas; HARTLEY PLATINUM, Zimbabwe, Richards Bay Air Quality Committee (Joint venture between major industries, authorities and community), ISCOR, Newcastle; ISCOR, Vanderbijlpark.

EDUCATION

University

1984 - 1986	:	PhD student at the University of Natal (Department of Chemical Engineering), Durban. Completed December 1986. Degree awarded March 1987 Supervisor: Prof M Mulholland
1983 - 1984	:	MSc Eng student at the University of Natal (Department of Chemical Engineering), Durban. Completed April 1984. Degree awarded March 1985 Supervisor: Prof M Mulholland
1980 - 1982	:	BSc Eng student at the University of Natal, Durban. Completed a BSc Eng (Chemical Engineering) - Cum Laude
1979	:	BSc Eng student at the University of Port Elizabeth, 1st Year Chemical Engineering

Matriculated

1978	:	Cradock High School, Cradock, South Africa. Aggregate: A

ADDITIONAL COURSES

1996 Risk Assessment for Environmental Decision Making - Presented by Harvard University School of Public Health at the CSIR, Pretoria, RSA.

1996 Risk Assessment for Environmental Decision Making - Presented by Harvard University School of Public Health at the CSIR, Pretoria, RSA.

COUNTRIES OF WORK EXPERIENCE

Central African Republic, Republic of Chile, Democratic Republic of Congo, Federal Democratic Republic of Ethiopia, Republic of Equatorial Guinea, Republic of Ghana, Kingdom of Lesotho, Republic of Liberia, Republic of Madagascar, Republic of Mozambique, Republic of Namibia, Republic of Congo, Republic of South Africa, Republic of Suriname Togolese Republic, Republic of Zambia, Republic of Zimbabwe

EMPLOYEMENT RECORD

Jan 1990 to 2018 Managing Director/Director. Airshed Planning Professionals (Pty) Ltd, Midrand (Previously known as Environmental Management Services 1990 to 2003)

A consulting firm providing services in the Air Quality and Noise Assessments and Management field to industry and national, provincial and local authorities. Work includes the preparation of emission inventories, dispersion modeling, impact assessment and mitigation planning in the mining, metallurgical and general industrial sectors. Legal compliance audits have been carried out.

Jan 1989 to Dec 1990 Process Engineer, AECI Engineering Department, Modderfontein, Johannesburg.

Part of process engineering team for the design of Coal to Liquid (CTL) processing plant, responsible for energy integration. Conceptual design of new Calcium Carbide smelter. Detailed engineering and commissioning of Gold Potassium Cyanide Plant.

Jul 1987 to Dec 1988 Research Engineer, Council for Scientific and Industrial Research (CSIR), Pretroria

Responsible for the development (design and construction) of a gas dynamic laser for industrial applications. Development of a real-time atmospheric dispersion model for emergency response applications

Jan 1984 to Dec 1986 Research Assistant, Department Chemical Engineering, University of Natal, Durban.

Development of prototype real-time atmospheric dispersion model for air pollution management applications at a petroleum refinery. Development of a new theoretical model for complex atmospheric applications.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

Burger L W and Mulholland M. Real-time prediction of point-source distributions using an anemometer-bivane and a microprocessor, Atmospheric Environment, Volume 22, Issue 7, 1988, Pages 1309–1317

Burger L W Air pollution modelling as part of an EIA study, Western Cape Annual Air Pollution Symposium, National Association for Clean Air, 11 September 1997

Burger, C.J.H. & Kornelius, G. Dust dispersion from a dust road and the attenuation thereof by tree plantations beside the road: A mathematical model. CEMSA '98 International Conference and Exhibition on Integrated Environmental Management. East London, February 1998

Burger, L.W., Coetzee, L.A., Sowden, M., Kornelius, G., Simpson, D., Swanepoel, P.A., van Niekerk, A.S., & van Niekerk, W.C.A. Development and implementation of the Integrated Energy Decision Support Model (IEDS) to improve health conditions in residential areas. Proc 11th World Clean Air and Environment Congress, Durban 1998.

Hurt Q E, Burger LW, Bell C. A Tool For Air Quality Management : The Importance Of Quality Assurance, Intelligent Assimilation Of Data And The Effective Representation Thereof To Industry, The Regulatory Authorities And The Community. Proc 11th World Clean Air and Environment Congress, Durban 1998.

Burger L W and Scorgie Y The Value Of A Quantitative Acute And Chronic Health Risk Assessment In Town Planning Around A Large Industrial Complex. Proc 11th World Clean Air and Environment Congress, Durban 1998

Burger L W, Coetzee L A, Sowden M, Kornelius G, Simpson D, Swanepoel P A , Van Niekerk A S and Van Niekerk WCA, Development And Implementation Of The Integrated Energy Decision Support Model (Ieds) To Improve Health Conditions In Residential Areas. Proc 11th World Clean Air and Environment Congress, Durban 1998

Burger L W and Hurt QE, A Tool for Air Quality Management: Real-Time Atmospheric Dispersion

Modelling In Two Large Industrial Regions - South Durban And Richards Bay. Proc 11th World Clean Air and Environment Congress, Durban 1998

Burger L W and Terblanche A P, Atmospheric Dispersion Calculations Of Toxic Gases Originating From Waste Disposal Facilities, Proc 11th World Clean Air and Environment Congress, Durban 1998

Burger L W, Grundling A, Van Heerden J, Truter T, Rautenbach H. A Case Study: Predicting the Surface and Upper Atmospheric Dispersion Of Satellite Launching Rocket Exhaust Gases, Proc 11th World Clean Air and Environment Congress, Durban 1998

Burger L W. Quantifying Flue Gas Temperature to Minimise Condensation in Scrubber Stack Plumes, National Association for Clean Air Conference 2004

Burger L W and Scorgie Y, Air Quality Management Systems: Pitfalls and Harmonization, National Association for Clean Air Conference, 2005

Burger, L W, Uncertainty in Atmospheric Dispersion Modelling, National Association for Clean Air Conference, East London 2006

Burger L W, Stead M and Moldan A. Prediction Of Motor Vehicle Air Emission Reductions Through Intervention Policies, National Association for Clean Air Conference, Vereenging 2009

Burger L W, Complexities In The Estimation Of Emissions And Impacts Of Wind Generated Fugitive Dust, National Association for Clean Air Conference, Polokwane 2010

Burger L W, A Dynamic Model for The Simulation Of Sulphur Dioxide Emissions From A Self-Propagating Sulphur Storage Fire, 16th IUAPPA World Clean Air Congress, 29 Sep to 4 Oct 2013, Cape Town

Herselman JE; Burger LW; Moodley P (2009) Guidelines for the utilisation and disposal of wastewater sludge Volume 5 of 5: Requirements for thermal sludge management practices and for commercial products containing sludge, ISBN No: 978-1-77005-711-1].

Liebenberg-Enslin, H, Annegarn, H.J and Burger, L.W (submitted Aeolian Research for publication in 2015), A Best Practice Prescription For Quantifying Wind-Blown Dust Emissions from Gold Mine Tailings Storage Facilities.

Scorgie Y, Burger L W and Sowden, M: Application of Source-Receptor Modelling to Regional Air Quality Management, National Association for Clean Air Conference, 'Into the Next Millennium', held at BMW Pavilion, Cape Town on 6-8 October 1999.

Scorgie Y, Burger L W and Annegarn, H.J: Air Quality Management within the Vaal Triangle, Air Pollution Action Committee (APAC) meeting, held at the Lethabo Power Station, Sasolburg, South Africa, 24 May 2000.

Scorgie Y, Burger L W, Annegarn, H.J and Piketh S: Background Study for the Development of an Air Quality Management Strategy for Gauteng: Characterisation of Existing Air Quality and Assessment of Future Trends and Driving Forces, National Environmental Research Institute of Denmark, 25 October 2000.

Scorgie Y, Burger L W and Annegarn, H.J: Air Quality Management System Development and Implementation in South Africa, paper to be presented at the Third International Conference on Urban Air Quality Conference entitled Measurement, Modelling and Management, 19-23 March 2001, Loutraki, Greece.

Scorgie Y, Annegarn, H.J and Burger L W: Air Quality over South Africa – Persistent Problems And Emerging Issues, 14th IUAPPA World Congress, Brisbane, 2007

LANGUAGES

	Speak	Read	Write
English	Home language	Good	Good
Afrikaans	Good	Good	Good

CERTIFICATION

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

_ 31/01/2018

Signature of staff member Date (Day / Month / Year)

Engineering Council of South Africa

This is to certify that *Lucian Willem Burger*

is registered as *Professional Engineer*

in terms of the Engineering Profession Act, 2000
(Act No. 46 of 2000)

Date *15 September 2017*

Registration Number *20170291*

President

Chief Executive Officer

12 APPENDIX B: EMISSIONS IMPACT ON THE ENVIRONMENT

12.1 Effects of Particulate Matter on Animals and Vegetation

As presented by the Canadian Environmental Protection Agency (CEPA/FPAC Working Group, 1998) experimental studies using animals have not provided convincing evidence of particle toxicity at ambient levels. Acute exposures (4-6 hour single exposures) of laboratory animals to a variety of types of particles, almost always at concentrations well above those occurring in the environment have been shown to cause decreases in lung function, changes in airway defence mechanisms and increased mortality rates.

The epidemiological finding of an association between 24-hour ambient particle levels below 100 µg/m^3 and mortality has not been substantiated by animal studies as far as PM_{10} and $PM_{2.5}$ are concerned. With the exception of ultrafine particles (0.1 µm), none of the other particle types and sizes used in animal inhalation studies cause such acute dramatic effects, including high mortality at ambient concentrations. The lowest concentration of $PM_{2.5}$ reported that caused acute death in rats with acute pulmonary inflammation or chronic bronchitis was 250 g/m^3 (3 days, 6 hr/day), using continuous exposure to concentrated ambient particles.

12.2 Dustfall Screening Criteria for Animals and Vegetation

Suspended particulate matter can produce a wide variety of effects on the physiology of vegetation that in many cases depend on the chemical composition of the particle. Heavy metals and other toxic particles have been shown to cause damage and death of some species as a result of both the phytotoxicity and the abrasive action during turbulent deposition (Harmens, Mills, Hayes, Williams, & De Temmerman, 2005). Heavy loads of particle can also result in reduced light transmission to the chloroplasts and the occlusion of stomata (Harmens, Mills, Hayes, Williams, & De Temmerman, 2005) (Naidoo & Chirkoot, 2004), decreasing the efficiency of gaseous exchange (Harmens, Mills, Hayes, Williams, & De Temmerman, 2005) (Naidoo & Chirkoot, 2004) (Ernst, 1981) and hence water loss (Harmens, Mills, Hayes, Williams, & De Temmerman, 2005). They may also disrupt other physiological processes such as bud break, pollination and light absorption/reflectance (Harmens, Mills, Hayes, Williams, & De Temmerman, 2005). The chemical composition of the dust particles can also affect the plant and have indirect effects on the soil pH (Spencer, 2001).

Naidoo and Chirkoot conducted a study during the period October 2001 to April 2002 to investigate the effects of coal dust on Mangroves in the Richards Bay harbour. The investigation was conducted at two sites where 10 trees of the Mangrove species (*Avicennia marina)* were selected and mature, fully expose, sun leaves tagged as being covered or uncovered with coal dust. From the study it was concluded that coal dust significantly reduced photosynthesis of upper and lower leaf surfaces. The reduced photosynthetic performance was expected to reduce growth and productivity. In addition, trees in close proximity to the coal stockpiles were in poorer health than those further away. Coal dust particles, which are composed predominantly of carbon, were not toxic to the leaves; neither did they occlude stomata as they were larger than fully open stomatal apertures (Naidoo & Chirkoot, 2004).

In general, according to the Canadian Environmental Protection Agency (CEPA), air pollution adversely affects plants in one of two ways; either the quantity of output or yield is reduced, or the quality of the product is lowered. The former (invisible) injury results from pollutant impacts on plant physiological or biochemical processes and can lead to significant loss of growth or yield in nutritional quality (e.g. protein content). The latter (visible) may take the form of discolouration of the leaf surface caused by internal cellular damage. Such injury can reduce the market value of agricultural crops for which visual appearance is important (e.g. lettuce and spinach). Visible injury tends to be associated with acute exposures at high pollutant concentrations whilst invisible injury is generally a consequence of chronic exposures to moderately elevated pollutant concentrations. However, given the limited information available, specifically the lack of quantitative dose-effect information, it is not possible to define a Reference Level for vegetation and particulate matter (CEPA/FPAC Working Group, 1998).

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 dust fall rates greater than 400 $mg/m^2/day$ (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).

12.3 Effects of Suphur Dioxide on Plants and Animals

Experimental studies on animals have shown the acute inhalation of SO_2 produces bronchioconstriction, increases respiratory flow resistance, increases mucus production and has been shown to reduce abilities to resist bacterial infection in mice (Costa & Amdur, 1996). Short exposures to low concentrations of SO_2 (~2.6 mg/m^3) have been shown to have immediate physiological response without resulting in significant or permanent damage. In rabbits, acute exposures (16 mg/m^3 for 4 hours) to SO_2 gas was irritating to the eyes and resulted in conjunctivitis, infection and lacrimation (Von Burg , 1995). Short exposures (<30 min) to concentrations of 26 mg/m^3 produced more significant respiratory changes in cats but were usually completely reversible once exposure had ceased (Corn, Kotsko, Stanton, Bell, & Thomas, 1972).

SO_2 can produce mild bronchial constriction, changes in metabolism and irritation of the respiratory tract and eyes in cattle (Blood & Radostits, 1989 as cited in Coppock & Nostrum (1997). An increase in airway resistance was reported in sensitized sheep after four hours of exposure to 13 mg/m^3. Studies report chronic exposure can affect mucus secretions and result in respiratory damage similar to chronic bronchitis. These effects were reported at concentrations above typical ambient concentrations (26-1053 mg/m^3) (Dalhamn, 1956 as cited in Amdur (1978).

Application of sulphur (no concentrations specified) to crops can reduce plant uptake of selenium (an essential nutrient for livestock), deposition of SO_2 might therefore also affect the selenium content of forage plants (Khan, Mostrom, & Campbell, 1997).

Exposure to air pollutants is expected to result in similar adverse effects in wildlife as in laboratory and domestic animals (Newman & Schreiber, 1984).

13 APPENDIX C: COMPETENCIES FOR PERFORMING AIR DISPERSION MODELLING

All modelling tasks were performed by competent personnel. Table 13-1 is a summary of competency requirements. Apart from the necessary technical skills required for the calculations, personnel competency also include the correct attitude, behaviour, motive and other personal characteristic that are essential to perform the assigned job on time and with the required diligence as deemed necessary for the successful completion of the project.

The project technical team included a principal engineer with relevant experience of 30 years and one senior scientist with 8 years relevant experience. The principal engineer also managed and directed the project.

Verification of modelling results was conducted by the principal engineer. The latter function requires a thorough knowledge of the

- meteorological parameters that influence the atmospheric dispersion processes and
- atmospheric chemical transformations that some pollutants may undergo during the dispersion process.

In addition, the project team included one junior staff member.

Table 13-1: Competencies for Performing Air Dispersion Modelling

Competency	Task, Knowledge and Experience
Context	Communication with field workers, technicians, laboratories, engineers and scientists and project managers during the process is important to the success of the model
	Familiar with terminology, principles and interactions
	Record keeping is important to support the accountability of the model - Understanding of data collection methods and technologies
Knowledge	Meteorology: Obtain, review and interpret meteorological data Understanding of meteorological impacts on pollutants Ability to identify and describe soil, water, drainage and terrain conditions Understanding of their interaction Familiarity with surface roughness` Ability to identify good and bad data points/sets Understanding of how to deal with incomplete/missing meteorological data
	Atmospheric Dispersion models Select appropriate dispersion model Prepare and execute dispersion model Understanding of model input parameters Interpret results of model
	Chemical and physical interactions of atmospheric pollutants Familiarity with fate and transport of pollutants in air Interaction of primary pollutants with other substances (natural or industrial) to form secondary pollutants
	Information relevant to the model Identify potential pollution (emission) sources and rates Gather physical information on sources such as location, stack height and diameter

Competency	Task, Knowledge and Experience
	Gather operating information on sources such as mass flow rates, stack top temperature, velocity or volumetric flow rate Calculate emission rates based on collected information Identify land use (urban/rural) Identify land cover/terrain characteristics Identify the receptor grid/site
	Legislation, regulations and guidelines in regards to National Environment Management: Air Quality Act (Act No 39 of 2004), including Minimum Emissions Standards (Section 21 of Act) National Ambient Air Quality Standards Regulations regarding Air Dispersion Modelling Atmospheric Impact Report (AIR)
Abilities	Ability to read and understand map information
	Ability to prepare reports and documents as necessary
	Ability to review reports to ensure accuracy, clarity and completeness
	Communication skills
	Team skills

14 APPENDIX D: FULL LIST OF AIR QUALITY RECEPTORS IDENTIFIED

Table 14-1: Air quality receptor details

ID	Name	Latitude	Longitude	Easting (km)	Northing (km)
1	Tshitandani Primary	-22.7453	30.37132	846.284	7480.732
2	Ramana Primary Farm School	-22.625	30.14859	823.672	7494.564
3	Ridgeway College	-23.0438	29.92446	799.697	7448.637
4	Louis Trichardt High School	-23.0299	29.90705	797.943	7450.211
5	Mopane Intermediate School	-22.616	29.85592	793.587	7496.170
6	Cawood Medical Clinic	-22.3514	30.0391	813.025	7525.116
7	Rambuda Clinic	-22.7847	30.43408	852.634	7476.214
8	Laerskool Messina Primary School	-22.3534	30.04504	813.632	7524.880
9	Musina Secondary School.	-22.3306	30.02701	811.825	7527.447
10	Gateway Primary School	-22.3454	30.0445	813.595	7525.768
11	Nehemiah Christian Private School	-22.3472	30.04404	813.543	7525.570
12	Hoerskool Eric Louw High School	-22.3566	30.0455	813.672	7524.528
13	Eric Louw High School	-22.3581	30.04697	813.821	7524.357
14	Rixile Primary School	-22.3351	30.03438	812.575	7526.936
15	Makushu Primary School	-22.3311	30.02984	812.116	7527.384
16	Bonwa Udi Primary School	-22.3298	30.03333	812.478	7527.523
17	Beit Bridge primary school	-22.3356	30.01909	810.998	7526.911
18	Messina Hospital.	-22.3813	30.03185	812.211	7521.826
19	Unjani Clinic Musina	-22.3385	30.01741	810.818	7526.594
20	Ridgeway Independent School	-23.0262	29.94255	801.591	7450.550
21	Laerskool Louis Trichardt	-23.0403	29.90114	797.314	7449.075
22	Eltivillas Primary School	-23.054	29.92065	799.284	7447.510
23	Emmanuel Christian School	-23.0683	29.92056	799.243	7445.934
24	Makhado Comprehensive High School	-23.0598	29.91711	798.908	7446.874
25	Gogobole Primary School	-23.0804	29.77271	784.060	7444.887
26	Masedi Combined School	-23.0472	29.87638	794.760	7448.357
27	Tshikota Secondary School	-23.0451	29.88074	795.211	7448.583
28	Louis Trichardt Memorial Hospital.	-23.0286	29.90574	797.812	7450.359
29	Zoutpansberg Private Hospital	-23.0407	29.89738	796.927	7449.036
30	Quality Care Private Hospital	-23.0448	29.91313	798.533	7448.545
31	Siloam Hospital Pharmacy	-23.0407	29.90718	797.932	7449.013
32	Madombidzha Clinic	-23.1149	29.81974	788.807	7440.970
33	Madombidza	-23.0721	29.91277	798.436	7445.521
34	Kutama Clinic	-23.0648	29.63551	770.028	7446.870
35	Louis Trichardt Clinic	-23.0377	29.90745	797.967	7449.352
36	Tshilwavhusiku Clinic	-23.0971	29.73812	780.480	7443.106

37	Vleifontein Clinic	-23.2135	29.99189	806.226	7429.692
38	Spec-Savers Louis Trichardt	-23.0315	29.91117	798.361	7450.026
39	Mens Clinic International - Makhado	-23.0401	29.91256	798.485	7449.067
43	Zoutpansberg Medical Care Clinic	-23.1149	29.81974	796.927	7449.037
44	Waterval Clinic	-23.0286	29.90574	811.837	7434.072
45	Tshikuwi Primary School	-23.0407	29.89738	801.667	7464.564
46	Tshirolwe Primary School	-23.1729	30.04576	808.863	7464.526
47	Jonathan Mushatama Secondary School	-22.8997	29.94055	809.659	7464.326
48	Nngweni Secondary School	-22.8988	30.01063	810.954	7464.684
49	Tshituni Primary School	-22.9004	30.01842	812.672	7463.217
50	Kokwane Primary School	-22.897	30.03095	814.851	7466.554
51	Luatame Secondary School	-22.9099	30.04798	813.373	7468.796
52	Maranikwe Primary School	-22.8794	30.06852	814.211	7466.829
53	Patrick Ramaano Secondary School	-22.8594	30.05368	816.161	7466.565
54	Matanda Primary School	-22.877	30.06223	818.819	7465.900
55	Mandiwana Primary School	-22.879	30.08127	820.677	7467.836
56	Gadabi Primary School	-22.8845	30.10728	820.628	7466.944
57	Mphephu High School	-22.8667	30.12497	823.613	7465.748
58	Nzhelele Senior Primary School	-22.8748	30.12468	823.183	7465.476
59	Mushaathoni Secondary School	-22.885	30.15398	826.418	7464.363
60	Tshithuthuni Primary School	-22.8875	30.14985	828.100	7467.007
61	Thononda Primary School	-22.8969	30.18158	832.221	7467.698
62	Tshikombani Primary School	-22.8727	30.1974	830.242	7463.181
63	Tshifhena Secondary School	-22.8657	30.23736	830.828	7462.454
64	Mandala Primary School	-22.9068	30.21906	831.622	7462.126
65	Tshilogoni Secondary School	-22.9133	30.22492	830.027	7460.764
66	Mutuwafhethu Primary School	-22.9161	30.23272	829.053	7461.312
67	Tondani Primary School	-22.9287	30.21748	825.836	7459.823
68	Humbelani Secondary School	-22.9239	30.20788	825.056	7459.579
69	Vhulaudzi Secondary School	-22.938	30.17687	826.610	7457.199
70	Livhuwani Junior Primary School	-22.9403	30.16932	828.557	7457.918
71	Mavhunga Primary School	-22.9615	30.18496	819.734	7461.259
72	Tshamakwatini Secondary School	-22.9546	30.20377	818.930	7461.956
73	Nanga Primary School	-22.9262	30.11715	820.831	7461.866
74	Mauluma Primary School	-22.9201	30.10917	821.650	7461.122
75	Divhani Primary School	-22.9205	30.1277	816.481	7462.446
76	Frank Ravele Secondary School	-22.9271	30.13583	815.516	7462.494
77	Gondolikhethwa Primary School	-22.9161	30.08523	819.855	7463.961
78	Raliphaswa Primary School	-22.9159	30.07582	820.505	7464.796

79	Mutititi Primary School	-22.9018	30.11777	807.331	7466.306
80	George Mbulaheni Secondary School	-22.8942	30.12392	802.753	7464.371
81	Mamvuka Secondary School	-22.883	29.99535	800.685	7468.092
82	Liphakha Primary School	-22.9013	29.95117	803.247	7468.055
83	Mudimeli Secondary School	-22.8681	29.9303	802.979	7475.880
84	Schuitdrift Intermediate School	-22.868	29.95525	816.998	7488.486
85	Hope Primary School	-22.7974	29.95112	829.394	7505.568
86	Mangwele Primary	-22.6811	30.08496	832.123	7476.737
87	Matzheketzheke	-22.5247	30.20189	821.598	7460.976
88	Sandow	-22.7842	30.23447	771.709	7485.945
89	Kliprivier	-22.9284	30.13535	772.178	7471.029
90	Kliprivier	-22.7119	29.6451	772.305	7468.305
91	Verulam	-22.8465	29.6522	772.360	7492.618
92	Bordeaux	-22.871	29.6539	772.685	7490.601
93	Baden Baden	-22.6516	29.6502	772.816	7499.517
94	Klein Eden	-22.6698	29.6537	774.639	7513.087
95	Fontainebleau	-22.5893	29.6535	774.857	7492.010
96	Coniston	-22.4665	29.6688	775.919	7467.008
97	Prachtig	-22.6567	29.6746	776.287	7500.377
98	Claudina	-22.8821	29.6894	776.539	7476.035
99	Koedoesbult	-22.581	29.687	776.578	7473.318
100	Du Plooy	-22.8006	29.6938	776.795	7483.592
101	Hartz	-22.8251	29.6946	777.131	7515.383
102	Mons	-22.7324	29.6949	777.845	7485.897
103	Woodlands	-22.4454	29.6926	778.083	7467.481
104	Blackstone Ranch	-22.7114	29.7047	778.158	7466.782
105	Toby	-22.8775	29.7103	778.857	7477.394
106	Fontainbleau	-22.8838	29.7112	779.125	7489.904
107	Excelsior	-22.7879	29.7161	779.370	7477.011
108	Bierman	-22.675	29.7165	779.864	7486.036
109	Krige	-22.7913	29.7212	779.901	7500.128
110	Afstap	-22.7098	29.7244	780.398	7479.160
111	Bellevue	-22.5826	29.7222	780.572	7492.437
112	Wildebeeshoek	-22.7717	29.7308	780.714	7470.882
113	Bruilof	-22.6519	29.7301	780.936	7479.866
114	Tevrede	-22.8464	29.7353	781.974	7502.453
115	Cohen	-22.7653	29.7359	783.095	7486.010
116	Jutland	-22.5613	29.7419	783.291	7490.829
117	Killaloe	-22.7095	29.7558	783.389	7511.098
118	Verdun	-22.666	29.7568	783.554	7492.262

119	Florence	-22.4831	29.7541	783.564	7516.444
120	Vera	-22.653	29.7591	784.584	7499.094
121	Delft	-22.4348	29.7549	784.768	7502.690
122	Gulliver	-22.5912	29.7679	785.104	7509.815
123	Driehoek	-22.5587	29.769	785.526	7476.523
124	Sagan	-22.4943	29.771	785.944	7515.201
125	Arcadia	-22.7947	29.7812	786.334	7478.607
126	Mountain View	-22.4456	29.7782	786.558	7468.576
127	Ancaster	-22.7757	29.7886	786.997	7503.764
128	Ancaster	-22.8662	29.7927	787.204	7504.985
129	Zuleika	-22.5486	29.7905	787.324	7510.263
130	Fraure	-22.5376	29.7923	787.489	7488.201
131	Runde	-22.4899	29.7925	787.558	7481.907
132	Malapchani	-22.689	29.7981	788.244	7469.834
133	Du Toit	-22.7458	29.7999	788.290	7488.624
134	Somerville	-22.8546	29.8088	788.325	7486.777
135	Banff	-22.685	29.8058	788.621	7504.541
136	Sandy Lands	-22.7017	29.8065	788.812	7468.563
137	Hermanus	-22.5413	29.8061	788.874	7493.152
138	Sheldrake	-22.8659	29.8146	789.014	7513.422
139	Kitchener	-22.6441	29.8107	789.283	7498.883
140	Command	-22.4611	29.8083	790.295	7486.279
141	Mapani Kop	-22.5923	29.8136	790.487	7471.932
142	Volharding	-22.7058	29.8258	791.433	7495.802
143	Kitchener	-22.8353	29.8303	791.887	7498.784
144	Foutainebleau	-22.6197	29.8351	792.890	7514.549
145	Generaal	-22.5927	29.8389	793.008	7482.724
146	Erasmus	-22.4503	29.8458	793.207	7497.055
147	Van der Bijl	-22.7374	29.8528	793.311	7494.479
148	Swartrand	-22.6081	29.8521	794.085	7500.390
149	Grootpraat	-22.6313	29.8536	794.113	7488.884
150	Kalkbult	-22.5779	29.86	794.137	7468.820
151	Sans Souci	-22.6817	29.8624	794.470	7511.791
152	Joffre	-22.8627	29.8664	794.551	7481.605
153	Groot Geluk	-22.4749	29.8616	795.029	7468.784
154	Sulphur Spring	-22.7473	29.868	795.235	7472.888
155	Steenbok	-22.8629	29.8751	796.191	7491.124
156	Windhoek	-22.8258	29.8763	796.421	7471.786
157	Cavan	-22.6611	29.8822	796.824	7505.356
158	Mutamba Ranch	-22.8355	29.8881	797.241	7475.801
159	Somme	-22.5326	29.8857	798.258	7489.832

160	Barend	-22.7992	29.8953	799.799	7500.643
161	Mabvuka Jazz	-22.6724	29.9025	800.157	7468.663
162	Bokmakierie	-22.5746	29.9154	800.208	7493.552
163	Masiripan	-22.863	29.9251	800.249	7495.226
164	Emery	-22.6385	29.9208	800.665	7499.289
165	Manyii	-22.6234	29.9208	801.769	7467.864
166	Blaauwkop	-22.5866	29.9241	802.873	7502.275
167	Jooste	-22.87	29.9409	803.571	7504.326
168	Lilliput	-22.5593	29.945	804.283	7513.245
169	Matsa	-22.5407	29.9514	804.534	7467.850
170	Cassel	-22.4601	29.9566	805.058	7515.241
171	Verbaard	-22.8696	29.9678	806.051	7513.398
172	Dorothy	-22.4419	29.9637	806.166	7508.299
173	Martha	-22.4584	29.9737	807.666	7481.428
174	Nakob	-22.5044	29.9758	809.776	7484.915
175	Kranspoort	-22.7465	29.9956	815.091	7487.086
176	Schuitdrif	-22.7147	30.0155	816.871	7488.305
177	Natures Valley	-22.6941	30.0667	817.160	7489.607
178	Tshitadi	-22.6828	30.0838	818.234	7477.467
179	Perseus	-22.671	30.0863	818.241	7485.116
180	Xmas	-22.7803	30.0992	819.076	7493.372
181	Ha-Mamuhoyi	-22.7113	30.0977	819.837	7467.617
182	Ebenhaezer	-22.6367	30.1042	820.771	7511.970
183	Boulogne	-22.8688	30.1168	820.899	7511.489

15 Appendix E: Comments/Issues Raised

No air quality comments or issues have been provided.

16 APPENDIX F: IMPACT SIGNIFICANCE RATING AND RISK ASSESSMENT METHODOLOGY

16.1 Methodology for Rating the Significance of Impacts

In order to allow for sufficient consideration of all environmental impacts, impacts were assessed on a preliminary basis using a common, defensible method of assessing significance that will enable comparisons to be made between risks / impacts and will enable authorities, stakeholders and the client to understand the process and rationale upon which risks / impacts have been assessed. The method to be used for assessing risks / impacts is outlined in the sections below.

The first stage of risk / impact assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. The definitions used in the impact assessment are presented below.

- An **activity** is a distinct process or task undertaken by an organisation for which a responsibility can be assigned. Activities also include facilities or infrastructure that is possessed by an organisation.
- An **environmental aspect**[7] is an 'element of an organizations activities, products and services which can interact with the environment. The interaction of an aspect with the environment may result in an impact.
- **Environmental risks/impacts** are the consequences of these aspects on environmental resources or receptors of particular value or sensitivity, for example, disturbance due to noise and health effects due to poorer air quality. In the case where the impact is on human health or wellbeing, this should be stated. Similarly, where the receptor is not anthropogenic, then it should, where possible, be stipulated what the receptor is.
- **Receptors** can comprise, but are not limited to, people or human-made systems, such as local residents, communities and social infrastructure, as well as components of the biophysical environment such as wetlands, flora and riverine systems.
- **Resources** include components of the biophysical environment.
- **Frequency of activity** refers to how often the proposed activity will take place.
- **Frequency of impact** refers to the frequency with which a stressor (aspect) will impact on the receptor.
- **Severity** refers to the degree of change to the receptor status in terms of the reversibility of the impact; sensitivity of receptor to stressor; duration of impact (increasing or decreasing with time); controversy potential and precedent setting; threat to environmental and health standards.
- **Spatial extent** refers to the geographical scale of the impact.
- **Duration** refers to the length of time over which the stressor will cause a change in the resource or receptor.

The significance of the impact is then assessed by rating each variable numerically according to the defined criteria. Refer to the Table 16-1 to Table 10-4. The purpose of the rating is to develop a clear understanding of influences and processes associated with each impact. The severity, spatial scope and duration of the impact together comprise the consequence of the impact and when summed can obtain a maximum value of 15. The frequency of the activity and the frequency of the impact together comprise the likelihood of the impact occurring and can obtain a maximum value of 10.

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[7] The definition has been aligned with that used in the ISO 14001 Standard.

The values for likelihood and consequence of the impact are then read off a significance-rating matrix and are used to determine whether mitigation is necessary[8]. The assessment of significance is undertaken twice. Initially, significance is based on only natural and existing mitigation measures (including built-in engineering designs). The subsequent assessment takes into account the recommended management measures required to mitigate the impacts. Measures such as demolishing infrastructure, and reinstatement and rehabilitation of land, are considered post-mitigation.

The model outcome of the impacts was then assessed in terms of impact certainty and consideration of available information. The Precautionary Principle is applied in line with South Africa's National Environmental Management Act (No. 108 of 1997) in instances of uncertainty or lack of information, by increasing assigned ratings or adjusting final model outcomes. In certain instances, where a variable or outcome requires rational adjustment due to model limitations, the model outcomes have been adjusted.

Table 16-1: Criteria for assessing likelihood of impacts

Probability of Impact	
Highly unlikely	1
Possible	2
Likely	3
Highly likely	4
Definite	5
Sensitivity of the Receiving Environment	
Ecology not sensitive/important	1
Ecology with limited sensitivity/importance	2
Ecology moderately sensitive/important	3
Ecology highly sensitive/important	4
Ecology critically sensitive/important	5

Table 16-2: Criteria for assessing consequence of impacts

Severity of Impact	
Insignificant/ecosystem structure and function unchanged	1
Small/ecosystem structure and function largely unchanged	2
Significant/ecosystem structure and function moderately altered	3
Great/harmful/ecosystem structure and function largely altered	4
Disastrous/ecosystem structure and function seriously to critically altered	5
Spatial Scope of Impact	
Activity specific/ < 5 ha impacted / Study areas affected < 100m	1
Development specific/ within the site boundary / < 100ha impacted / Study areas affected < 100m	2
Local area/ within 1 km of the site boundary / < 5000ha impacted / Study areas affected < 1 000 m	3
Regional within 5 km of the site boundary / < 2000ha impacted / Study areas affected < 3 000m	4
National / > 2000ha impacted / Study areas affected > 3 000m	5
Duration of Impact	
One day to one month	1
One month to one year	2
One year to five years	3

[8] Some risks/impacts that have low significance will however still require mitigation.

Life of operation or less than 20 years	4
Permanent	5

Table 16-3: Significance rating matrix

	IMPACT (Severity + Spatial Scope + Duration)														
LIKELIHOOD (Probability + Sensitivity)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
	7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
	8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
	9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

Table 16-4: Positive/negative mitigation ratings

Significance Rating	Value	Definition	Positive Impact Management Recommendation
Very High	126-150	Critically consider the viability of proposed projects Improve current management of existing projects significantly and immediately	Maintain current management
High	101-125	Comprehensively consider the viability of proposed projects Improve current management of existing projects significantly	Maintain current management
Medium High	76-100	Consider the viability of proposed projects Improve current management of existing projects	Maintain current management
Medium Low	51-75	Actively seek mechanisms to minimise impacts in line with the mitigation hierarchy	Maintain current management and/or proposed project criteria and strive for continuous improvement
Low	26-50	Where deemed necessary seek mechanisms to minimise impacts in line with the mitigation hierarchy	Maintain current management and/or proposed project criteria and strive for continuous improvement
Very Low	1-25	Maintain current management and/or proposed project criteria and strive for continuous improvement	Maintain current management and/or proposed project criteria and strive for continuous improvement

16.2 Methodology for Risk Assessment

Risk taking into account reversibility, the irreplaceable loss of resources and impact avoidance / management and mitigation

The reversibility and irreplaceable loss of resources when summed can obtain a maximum value of 6. The extent of impact avoidance/management/mitigation carries a maximum value of 3. The values are then read off a significance rating matrix and are used to determine the level of residual risk.

Table 16-5: Impact reversibility

Criteria	Definition	Rating
Reversible	Can be reversed immediately (<month)	1
Moderate Reversibility	Can be reversed over a period of time (one month – one year)	2
Irreversible	Permanent alteration, cannot be reversed	3

Table 16-6: Irreplaceable loss of resources

Criteria	Definition	Rating
Unlikely	It is unlikely that impacts will lead to an irreplaceable loss of resources	1
Likely	Impacts have potential to lead to an irreplaceable loss of resources	2
Definite	Impacts will definitely lead to an irreplaceable loss of resources	3

Table 16-7: Impact Avoidance/management/mitigation degree

Criteria	Definition	Rating
Possible	It is possible to avoid, manage and mitigate impacts	1
Moderately possible	Avoidance, management or mitigation possible but will require additional/alternative locations/technology – and financial resources	2
Impossible	It is not possible to avoid, manage and mitigate impacts	3

Table 16-8: Risk rating matrix

	(Impact Reversibility + Irreplaceable Loss of Resources)		
(Impact Avoidance/Management/Mitigation)	1	2	3
	2	4	6
	3	6	9

Risk Rating = (Impact Reversibility + Irreplaceable loss of resources) / Impact Avoidance

Table 16-9: Risk significance after mitigation

Significance Rating	Value	Definition
High	16-27	Risk higher than limit of acceptable change. Some environmental functions will permanently cease
Medium	10-15	Receiving environment is likely to absorb impacts, however altered environment will be evident, and environment will function in a modified way
Low	1-9	Risk indiscernible, natural environmental functions will not be affected