Air Quality Impact Assessment Report:

Kinetic Development Group Ferrochrome Smelter in the MMSEZ, Limpopo

Project done on behalf of **Gudani Consulting**

Report Compiled by:

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Report Details

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Reviewed by	Reneé von Gruenewaldt, (Pr. Sci. Nat.), MSc (University of Pretoria)
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Revision Record

Revision Number	Date	Reason for Revision
AQIA Draft Rev0	June 2025	For client review

EXECUTIVE SUMMARY

Airshed Planning Professionals (Pty) Ltd was appointed by Gudani Consulting to undertake an air quality impact assessment (AQIA) for the Kinetic Development Group (KDG) ferrochrome smelter (the "Kinetic Project") in the Musina-Mukhado Special Economic Zone (MMSEZ), located in the Vhembe District Municipality in Limpopo Province. The Kinetic Project is located in the northern part of the MMSEZ, just south of R525 road, approximately 4 km to the west of the N1, 35 km southwest of Musina and 2km east-southeast of the railway siding and small village at Mopane.

The ferrochrome smelter at the Kinetic Project will produce approximately 125 000 tonnes per annum (t/a) of high-carbon ferrochromium by smelting together chromite ore (2 tonnes ore per tonne of ferrochromium alloy produced), reducing agents (0.5 tonne coke or semi-coke per tonne of ferrochromium alloy produced) and silica stone or dolomite (0.175 tonne per tonne of ferrochromium alloy produced). The plant will be operated 24 hours per day for 330 days per year, with expected downtime of electric furnaces of 35 days per year).

The main findings from the baseline assessment for the study area were:

The wind field for the area is dominated by easterly flow. The east-northeasterly wind flow is more dominant during the day, with increased flow from the east-southeast during night-time conditions. Calm conditions occurred for less than 1% of the time. There is some seasonal variability to the wind field, with the highest wind speeds occurring in the spring months between August and November. The lowest wind speeds occur in autumn and early winter.

Identified sensitive receptors in the study area include the small village of Mopane, approximately 2 km to the north-west of the Kinetic Project, as well as an individual homestead to the north of the R525 road, and two homesteads approximately 2 km to the southwest of the Kinetic Project. The closest sensitive receptors to the east of the Kinetic Project are homesteads and lodges close to the N1, approximately 4 km from the Kinetic Project.

The main sources of existing air pollution in the study area and surrounds include mining activities (especially coal mines), agricultural activities (both commercial and subsistence farming), transportation activities (including vehicle entrainment and exhaust from private and public roads), household fuel burning, biomass burning, wind erosion from exposed soil surfaces and landfills and wastewater treatment plants. Measured sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and carbon monoxide (CO) concentrations at the Thohoyandou monitoring station, the closest monitoring station with publicly available data (located approximately 50 km to the east-southeast of the project area) were well below the NAAQS during the period 27 July 2024 to 28 May 2025. Annual average PM_{10} (inhalable particulates with an aerodynamic diameter less than 10 µm) and $PM_{2.5}$ (respirable particulates with an aerodynamic diameter less than 2.5 µm) concentrations for the period July 2024 to May 2025 were below the NAAQS limit values, while daily PM_{10} and $PM_{2.5}$ concentrations exceeded the allowed 4 exceedances of the NAAQS limit value, likely due to local particulate sources.

The main findings from the impact assessment of the Kinetic Project were:

Atmospheric emissions at the Kinetic Project will arise from tapping and charging of the submerged arc furnaces, transporting and handling of raw materials and ferrochromium alloy products, handling and deposition of slag, crushing of ferrochromium alloy product and various process emissions, which are served by dedicated extraction points and vented to the atmosphere through elevated stacks, these include dust removal from dry material handling, dust removal from raw material batching, taphole fume extraction and charging dust removal and primary dust removal and treatment of submerged arc furnace off-gas.

A comprehensive emissions inventory was compiled for the proposed Kinetic Project operations. In the quantification of point source emissions, which include emissions from the furnaces and the dedicated dust extraction points, use was made of the design specifications for the plant and the Subcategory 4.9: Ferroalloy Production Minimum Emission Standards, as published under Section 21 of the National Environmental Management: Air Quality Act (NEM:AQA). Due to the absence of locally generated emission factors, use was made of the comprehensive set of emission factors published by the US Environmental Protection Agency (US-EPA) in its AP-42 document Compilation of Air Pollution Emission Factors as well as the Australian National Pollutant Inventory (NPI) emission estimation documents for the quantification of fugitive emission sources, such as vehicle entrainment on on-site roads and the access road, emissions generated from material handling operations, wind erosion from stockpiles and emissions from crushing.

Emissions quantified include particulate matter, including total suspended particulates (TSP), PM_{10} and $PM_{2.5}$ and gaseous pollutants i.e. oxides of nitrogen (NO_x) and sulphur dioxide (SO_2).

The US EPA AERMOD model was used to simulate the impact of emissions from the Kinetic Project on the receiving environment. Weather Research and Forecasting (WRF) model meteorological data for the period 2022 to 2024 was used in the absence of available on-site monitored meteorological data.

Simulated daily and annual PM_{10} and $PM_{2.5}$ concentrations, as well as simulated annual average SO_2 and NO_2 concentrations, are in compliance with the NAAQS for all areas outside the Kinetic Project boundary, including at all identified sensitive receptor locations. If all point sources were to be operated at the Subcategory 4.9 MES, simulated hourly NO_2 and SO_2 concentrations, as well as daily SO_2 concentrations, could exceed the NAAQS limits outside the boundary of the Kinetic Project, but are in compliance with the NAAQS at all identified sensitive receptor locations, and for all areas outside the MMSEZ. However, given the nature of the majority of point sources at the Kinetic Project, which serve as dust and fume extraction, rather than the point of release of process or combustion emissions, it is unlikely that actual NO_2 and SO_2 emissions from point sources at the Kinetic Project would be as high as the Subcategory 4.9 MES allows, and ground-level impacts of these pollutants are expected to be significantly lower than those simulated.

Based on the findings of the air dispersion modelling, the following mitigation and management measures are recommended:

- All point sources and emission abatement equipment should be designed to comply with the Subcategory 4.9 minimum emission standards.
- Best practice management and mitigation measures should be employed to minimise emissions from fugitive dust sources, including:
    - Regular cleanup of paved road surfaces;
    - Regular maintenance and servicing of dust extraction abatement equipment;
    - Installation of wind breaks around the raw material stockpiles, or enclosure of the stockpiles, to minimise fugitive dust emissions from handling of raw materials; and
    - Regular visible inspection of emission from the raw material stockpiles and slag stockpile.
- If the access road between the entrance to the MMSEZ and the Kinetic Project is unpaved, regular water sprays should be applied to the road to minimise dust emissions. It is however recommended that the road be paved and regularly cleaned and maintained.
- It is recommended that short term dust fallout monitoring be conducted at the project boundary closest to the raw material stockpiles and slag stockpile to confirm dust fallout at the site boundary is in compliance with the National Dust Control regulations once the project is operational.
- It is also recommended that a once-off sampling campaign for NO_2 and SO_2 concentrations be conducted at the project boundary to confirm compliance with the NAAQS.
- A complaints register must be kept and residents of nearby homesteads and villages, as well as Kinetic Project personnel, should be encouraged to report any air quality or dust related complaints.

It is the specialist's opinion that the project can be authorised if the design of the plant ensures compliance with the Subcategory 4.9 MES and the above recommendations are taken into consideration in the Environmental Management Plan for the project.

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LIST OF ACRONYMS AND SYMBOLS

AQIA	Air quality impact assessment
C	Carbon
CO	Carbon monoxide
CO_2	Carbon dioxide
Cr	Chromium
DFFE	Department of Forestry, Fisheries and Environment (DFFE)
EIA	Environmental Impact Assessment
EPA	United States Environmental Protection Agency
GG	Government gazette
GN	Government notice
g/m^3	Grams per cubic metre
LMo	Monin-Obukhov length
KDG	Kinetic Development Group
m	Metre
m^2	Metre squared
mg	Milligram
MMSEZ	Musina-Mukhado Special Economic Zone
NAAQS	National Ambient Air Quality Standards
NACA	National Association for Clean Air
NEM:AQA	National Environmental Management: Air Quality Act (Act 39 of 2004)
NDCR	National Dust Control Regulations
NO	Nitrous oxide
NO_x	Oxides of nitrogen
NO_2	Nitrogen dioxide
O_3	Ozone
PM	Particulate matter
PM_{10}	Particulate matter with an aerodynamic diameter of less than 10μm
$PM_{2.5}$	Particulate matter with an aerodynamic diameter of less than 2.5μm
SA	South Africa
SANS	South African National Standard
SO_2	Sulfur dioxide
t/a	Tonnes per annum
TSP	Total suspended particulates
US EPA	United States Environmental Protection Agency
WRF	Weather Research and Forecasting Model
$\mu g/m^3$	Micrograms per cubic metre

1 INTRODUCTION

Airshed Planning Professionals (Pty) Ltd was appointed by Gudani Consulting to undertake an air quality impact assessment (AQIA) for the Kinetic Development Group (KDG) ferrochrome smelter (the “Kinetic Project”) in the Musina-Mukhado Special Economic Zone (MMSEZ), located in the Vhembe District Municipality in Limpopo Province.

The Kinetic Project is located in the northern part of the MMSEZ, just south of R525 road, approximately 4 km to the west of the N1, 35 km southwest of Musina and 2km east-southeast of the railway siding and small village at Mopane (Figure 1-1).

The ferrochrome smelter at the Kinetic Project will produce approximately 125 000 tonnes per annum (t/a) of high-carbon ferrochromium by smelting together chromite ore (2 tonnes ore per tonne of ferrochromium alloy produced), reducing agents (0.5 tonne coke or semi-coke per tonne of ferrochromium alloy produced) and silica stone or dolomite (0.175 tonne per tonne of ferrochromium alloy produced). The plant will be operated 24 hours per day for 330 days per year, with expected downtime of electric furnaces of 35 days per year).

Atmospheric emissions at the Kinetic Project will arise from tapping and charging of the submerged arc furnaces, transporting and handling of raw materials and ferrochromium alloy products, handling and deposition of slag, crushing of ferrochromium alloy product and various process emissions, which are served by dedicated extraction points and vented to the atmosphere through elevated stacks, these include dust removal from dry material handling, dust removal from raw material batching, taphole fume extraction and charging dust removal and primary dust removal and treatment of submerged arc furnace off-gas.

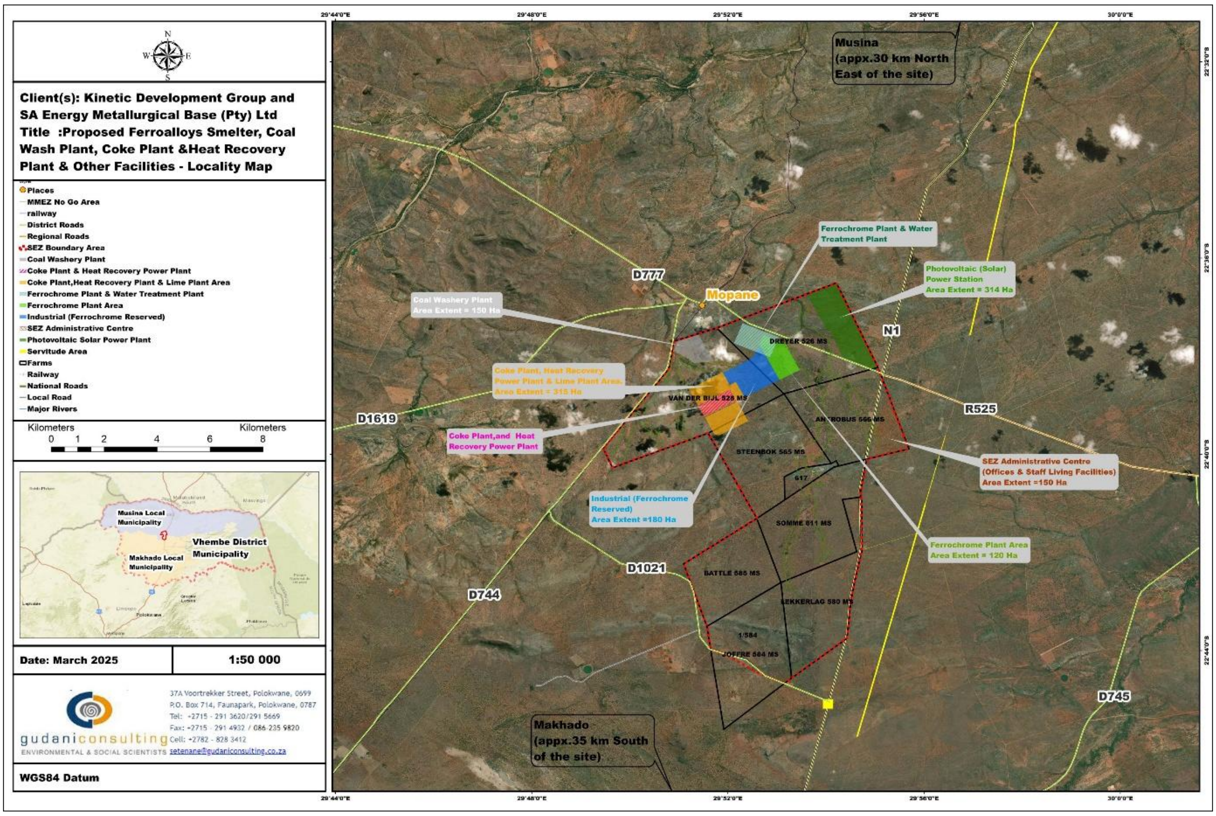


Figure 1-1: Location of Kinetic Project within the MMSEZ (provided by Gudani)

1.1 Specialist Details

1.1.1 Specialist Details

Airshed is an independent consulting firm with no interest in the project other than to fulfil the contract between the client and the consultant for delivery of specialised services as stipulated in the terms of reference.

1.1.2 Competency Profile of Specialist

Report author: NB Grobler, BEng (Chemical Engineering), BEng (Hons) (Environmental Engineering) (Pretoria)

Nick Grobler joined Airshed Planning Professionals after finishing his BEng degree in Chemical Engineering and BEng (Hons) in Environmental Engineering, both from the University of Pretoria. For the past fourteen years, Nick has been actively involved in all facets off air quality management, including ambient air quality monitoring, dispersion modelling, air quality impact assessments, and the compilation of air quality management plans. Nick also expanded into conducting environmental noise baseline and impact assessments in 2017. Nick is an associate member of the South African Institution of Chemical Engineers (SAIChE) and a member of Golden Key international.

Nick has been actively involved with projects for the opencast and underground mining of: copper, platinum, chrome, gold, iron, coal, limestone, potash, graphite, lead, mineral sands, aggregate stone, clay and zinc. Furthermore, he's also conducted air quality or noise studies for the production of: copper, platinum, PGM metals, gold, base metals, iron, steel, coal, coke, heavy mineral sands, vanadium, solder, lime, urea, chrome, gypsum, asphalt, acetylene, LNG liquefaction, vegetable oil, fertilizer, explosives, wood pulp, cement, grease, oil recycling, tyre and general waste pyrolysis, power generation, fuel storage as well as crematoriums, general waste landfills, meat processing and rendering at abattoirs and animal waste incineration. Nick has experience in working with projects in South Africa, Zimbabwe, Namibia, Mozambique, Republic of Congo, Democratic Republic of Congo, Ghana, Liberia, Guinea, Mali, Suriname and Saudi Arabia.

1.2 Terms of Reference

The terms of reference for the project include the following:

1. A **review** of available detailed project information.
2. Study of the **receiving (baseline) air quality environment**, incl.:
   a) The identification of air quality sensitive receptors.
   b) A study of atmospheric dispersion potential by referring to available weather records or simulated hourly sequential meteorological data for a period of at least 3 years (required for dispersion modelling), land use and topography data.
   c) A review of emission limits, ambient air quality criteria, inhalation reference concentrations, cancer risk factors and dust control regulations.
   d) Analysis of any available ambient air quality data.
3. The **quantification and assessment of air quality impacts**, including:
   a) The establishment of an **atmospheric emissions inventory** for the projects. Pollutants quantified will include particulate matter, including total suspended particulates(TSP), inhalable particulates with an aerodynamic diameter less than 10 µm (PM_{10}) and respirable particulates with an aerodynamic diameter less than 2.5 µm ($PM_{2.5}$), gaseous pollutants i.e. carbon monoxide (CO), oxides of nitrogen (NO_x) and sulphur dioxide (SO_2) as well as any other pollutants that might arise from the operations. Use will be made of design emission standards, emissions factors published by the United States Environmental Protection Agency (US EPA) and Australian National Pollutant Inventory (NPI).

b) **Atmospheric dispersion modelling** to determine ambient air pollutant concentrations. The US EPA AERMOD model will be used.

c) The **screening** of simulated ambient pollutant concentrations against Ambient Air Quality Standards (NAAQSs) and other applicable air quality criteria.

4. The compilation of a comprehensive **Air Quality Impact Assessment Report,** including recommendations for mitigation, monitoring and management measures.

1.3 Approach and Methodology

The methodology followed in the air quality impact assessment for the proposed project is discussed below.

1.3.1 Regulatory Requirements and Assessment Criteria

In the evaluation of air emissions and ambient air quality impacts reference is made to National Ambient Air Quality Standards (NAAQS). These standards apply only to a number of common air pollutants, collectively known as criteria pollutants. Criteria pollutants include SO_2, NO_2, CO, PM_{10}, $PM_{2.5}$, benzene, ozone and lead.

Particulates, SO_2 and NO_2 represent the main pollutants of concern in the assessment of operations from the project. For the current assessment, the impacts were assessed against published NAAQS and National Dust Control Regulations (NDCR).

1.3.2 Description of the Baseline Environment

The baseline study encompassed the analysis of air quality sensitive receptors, atmospheric dispersion potential and ambient air quality within the study area. Air quality sensitive receptors were identified from available satellite imagery.

The dispersion potential was assessed by means of modelled Weather Research and Forecasting (WRF) model meteorological data for the period 2022 to 2024.

No on-site ambient air quality and dust fallout monitoring is currently conducted. A qualitative description of existing sources of ambient air pollution is therefore provided, and reference made to publicly available ambient air quality monitoring data from the Thohoyandou monitoring station.

1.3.3 Emission Estimation

The establishment of a comprehensive emissions inventory forms the basis for the assessment of the impacts of the project's emissions on the receiving environment. The establishment of an emissions inventory comprises the identification of sources of emission, and the quantification of each source's contribution to ambient air pollution concentrations.

The main source of process emissions at the Kinetic Project will be the electric arc furnaces. Emissions from the furnaces are captured, treated and released to the atmosphere through an elevated stack. Sources of fugitive emissions, but which have dedicated extraction points include dust removal from dry material handling, dust removal from raw material batching and taphole fume extraction and charging dust removal. Other sources of fugitive emissions, mostly particulate emissions, include transporting and handling of raw materials and ferrochromium alloy products, handling and deposition of slag and crushing of ferrochromium alloy product.

In the quantification of point source emissions, which include emissions from the furnaces and the dedicated dust extraction points, use was made of the design specifications for the plant and the Subcategory 4.9: Ferroalloy Production Minimum Emission Standards, as published under Section 21 of the National Environmental Management: Air Quality Act (NEM:AQA).

Due to the absence of locally generated emission factors, use was made of the comprehensive set of emission factors published by the US Environmental Protection Agency (US-EPA) in its AP-42 document Compilation of Air Pollution Emission

Factors as well as the Australian National Pollutant Inventory (NPI) emission estimation documents for the quantification of fugitive emission sources, such as vehicle entrainment on on-site roads and the access road, emissions generated from material handling operations, wind erosion from stockpiles and emissions from crushing. The US-EPA AP-42 emission factors are of the most widely used in the field of air pollution. Experimentally derived predictive emission factor equations are available for vehicle-entrained dust from roadways, material handling operations, crushing and screening operations as well as windblown dust.

Predictive equations explain much of the observed variance in measured emission by relating emissions to parameters which characterise the source (EPA, 1996). Such parameters may be grouped into three classes:

- Measures of source activity or energy expended (e.g. the speed and weight of a vehicle on a dirt road);
- Properties of the material being disturbed (e.g. the content of suspended fines in the surface material on a dirt road); and
- Climatic parameters (e.g. number of precipitation free days per year, when a maximum of emissions occur).

In the estimation of particulate emissions and the simulation of patterns of dispersion, a distinction is made between Total Suspended Particulates (TSP) and inhalable and respirable particulates (PM_{10} & $PM_{2.5}$), which is particulate matter with an aerodynamic diameter of less than 10 µm and 2.5 µm respectively. Whereas TSP is of interest due to its implications in terms of nuisance dust impacts, the PM_{10} fraction is taken into account to determine the potential for human health risks.

1.3.4 Dispersion Model Selection

Three levels of assessment are defined in the South African Regulations for Air Dispersion Modelling:

- 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 50 km);
- Level 3: requires more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situations:
  - 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, and 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 airshed; or,
  - When assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level ozone (O_3), particulate formation, visibility).

This study was considered to meet the requirements of a Level 2 assessment, and the US EPA AERMOD model was selected on the basis that this Gaussian plume model is well suited to simulate dispersion where transport distances are likely to be less than 50 km.

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

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

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model include: source data, meteorological data (pre-processed by the AERMET model), terrain data and information on the nature of the receptor grid. Version 10.0.0.15 (executable 21112) of the AERMOD model was used in this study.

1.3.5 Modelling Domain

The dispersion of pollutants was modelled for an area covering 10 km (north-south) by 10 km (east-west). This area was divided into a grid with 101 (east-west) by 101 (north-south) grid lines, with a resolution of 100 m. The AERMOD model simulates ground-level concentrations for each of the receptor grid points.

1.3.6 Sensitive Receptors

Identified sensitive receptors in the study area include the small village of Mopane, approximately 2 km to the north-west of the Kinetic Project, as well as an individual homestead to the north of the R525 road, and two homesteads approximately 2 km to the southwest of the Kinetic Project. The closest sensitive receptors to the east of the Kinetic Project are homesteads and lodges close to the N1, approximately 4 km from the Kinetic Project (Figure 3-1). All identified sensitive receptors were modelled as discreet receptors.

1.4 Outline of Report

The regulatory requirements are discussed in Section 2. A description of the receiving environment is provided in Section 3 followed by the emissions inventory for the project in Section 4. The dispersion modelling results are discussed in Section 5 and an impact significance rating for the project is provided in Section 6. Recommended mitigation and management measures are discussed in Section 7.

2 REGULATORY REQUIREMENTS, ASSESSMENT CRITERIA AND LITERATURE REVIEW

The environmental regulations and guidelines governing the emissions and impact of the project need to be considered prior to potential impacts and sensitive receptors being identified.

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 are intended to indicate safe daily exposure levels for most 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 periods. These averaging periods refer to the timespan over which the air concentration of the pollutant was monitored at a location. Generally, five averaging periods are applicable, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average, and annual average.

2.1 National Ambient Air Quality Standards

NAAQS, as published by the Department of Forestry, Fisheries, and Environment (DFFE), are available for: (i) $PM_{2.5}$ gazetted on 29 June 2012 in Government Notice (GN) 486 of Government Gazette (GG) 35463; and (ii) PM_{10}, SO_2, NO_2, ozone (O_3), CO, lead (Pb) and benzene (gazetted on 24 December 2009 in GN 1210 of GG 32816). The NAAQS are provided in Table 2-1.

Table 2-1: South African National Ambient Air Quality Standards

Substance	Molecular formula / notation	Averaging period	Concentration limit (µg/m³)	Frequency of exceedance	Compliance date
Sulfur dioxide	SO_2	10 minutes	500	526	Currently enforceable
		1 hour	350	88	Currently enforceable
		24 hours	125	4	Currently enforceable
		1 year	50	0	Currently enforceable
Nitrogen dioxide	NO_2	1 hour	200	88	Currently enforceable
		1 year	40	0	Currently enforceable
Particulate matter	PM_{10}	24 hour	75	4	Currently enforceable
		1 year	40	0	Currently enforceable
Fine particulate matter	$PM_{2.5}$	24 hour	40	4	1 Jan 2016 – 31 Dec 2029
			25	4	1 Jan 2030
		1 year	20	0	1 Jan 2016 – 31 Dec 2029

			15	0	1 Jan 2030
Ozone	O_3	8 hours (running)	120	11	Currently enforceable
Benzene	C_6H_6	1 year	5	0	Currently enforceable
Lead	Pb	1 year	0.5	0	Currently enforceable
Carbon monoxide	CO	1 hour	30 000	88	Currently enforceable
		8 hours (calculated on 1 hour averages)	10 000	11	Currently enforceable

2.2 National Regulations for Dust Deposition

South Africa's (SA) NDCR, which include the dust fallout regulations, were published under the National Environmental Management Air Quality Act (NEMAQA) on 1 November 2013 in GN 827 of GG 36974. The purpose of these Regulations is to prescribe general measures for the control of dust in all areas including residential and light commercial areas. SA NDCRs that were published on the 1st of November 2013. Acceptable dustfall rates according to the regulation are summarised in Table 2-2.

Table 2-2: Acceptable dustfall rates

Restriction Area	Dustfall rate (D) (mg m^{-2} day^{-1}, 30-day average)	Permitted frequency of exceeding dust fall rate
Residential	D < 600	Two within a year, not sequential months.
Non-residential	600 < D < 1 200	Two within a year, not sequential months

The NDCR also specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be ASTM D1739 (1970), or an equivalent method approved by any internationally recognized body. It is important to note that dustfall is assessed for nuisance impact and not inhalation health impact. Proposed revised Draft NDCR were published by DFFE (GN 517 of GG 41650 on 25 May 2018) which references the same acceptable dustfall rates but refers to the latest version of the ASTM D1739 method to be used for sampling. These have not yet been enacted into law.

2.3 Listed Activities

Atmospheric emissions which have or may cause a significant detrimental effect on the environment, human health and social welfare, economic conditions, ecological conditions, or cultural heritage. The list of activities and associated minimum emission standards were established in March 2010 (Republic of South Africa, 2010) and the updated list of activities and associated minimum emission standards were published in 2013 (Republic of South Africa, 2013). The Department of Environmental Affairs (DEA) now the Department of Forestry, Fisheries and the Environment (DFFE) published amendments to certain categories in June 2015 (Republic of South Africa, 2015), and further amendments were made in October 2018 (Republic of South Africa, 2018). In March 2020, the minister of DFFE published amendments to Category 1 (Republic of South Africa, 2020). GNR.248 of 31 March 2011 of NEM: AQA provides the list of activities in terms of Section 21(1)(a) for which a license is required in terms of Chapter 5 of the Act.

The Listed Activities, as published in terms of Section 21 of the NEM: AQA, that will be conducted at the Kinetic Project are shown in Table 2-3.

Table 2-3: Listed activities that will be conducted at the Kinetic Project

Listed Activity Number	Category of Listed Activity	Sub-category of Listed Activity	Listed Activity Name	Description of the Listed Activity
Metallurgical Industry	4	4.9	Ferro-alloy Production	Production of alloys of iron with chromium, manganese, silicon or vanadium, the separation of titanium slag from iron-containing minerals using heat.

Under Section 21 of NEM:AQA any permanent or experimental plant with a design capacity equal to or greater than the threshold for the listed activity needs to comply with the Minimum Emission Standards for that activity (Table 2-4).

Under Section 22 of NEM:AQA no person may without a Provisional Atmospheric Emissions Licence (PAEL) or Atmospheric Emissions Licence (AEL) conduct a listed activity.

Table 2-4: Minimum emissions standards for new installations; Subcategory 4.9: Ferro-alloy Production.

Substance or mixture of substances		Mg/Nm³ under normal conditions of 273 Kelvin and 101.3 kPa
Common	**Chemical Symbol**	
Sulphur Dioxide	SO_2	500
Oxides of Nitrogen	NO_x expressed as NO_2	400
Particulate matter from primary fume capture system, open and semi-closed furnaces		30
Particulate matter from primary fume capture system, closed furnaces		50
Particulate matter from secondary fume capture system, all furnaces		50

Notes: The following special arrangements shall apply-

- Secondary fume capture installations shall be fitted to all new furnace installations.
- Emissions of hexavalent chromium [Cr(VI)], manganese (Mn) and vanadium (V) from primary fume capture systems of ferrochrome, ferromanganese and ferrovanadium furnaces respectively to be measured and reported to licencing authority annually.

With the exception of cases where express written consent is provided by the air quality officer in the AEL, all emissions provided in Table 2-4 have to be measured and reported on an annual basis.

Measurements must take place under normal operating conditions and the methods as described in Schedule A of NEM:AQA.

2.4 Atmospheric Impact Report

According to the National Environmental Management (NEM) Air Quality Act (AQA), an Air Quality Officer (AQO) may require the submission of an Atmospheric Impact Report (AIR) in terms of section 30, if:

- The AQO reasonably suspects that a person has contravened or failed to comply with the AQA or any conditions of an AEL and that detrimental effects on the environment occurred, or there was a contribution to the degradation in ambient air quality.
- A review of a provisional AEL or an AEL is undertaken in terms of section 45 of the AQA.

The format of the Atmospheric Impact Report is stipulated in the Regulations Prescribing the Format of the Atmospheric Impact Report, Government Gazette No. 36904, Notice Number 747 of 2013 (11 October 2013).

2.5 Regulations Regarding Air Dispersion Modelling

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Regulations regarding Air Dispersion Modelling were promulgated by DFFE (GN 533 in GG 37804 on 11 July 2014) (Dispersion Modelling Regulations) and recommend a suite of dispersion models to be applied for regulatory practices and give guidance on modelling input requirements, protocols, and procedures to be followed. They are applicable in the development of the following in terms of the sections of the National Environmental Management: Air Quality Act (Act 39 of 2004) (NEM:AQA) specified below:

(a) Air quality management plan (Chapter 3);
(b) Atmospheric impact report (section 30);
(c) Specialist Air Quality Impact Assessment (AQIA) (Chapter 5); and,
(d) Priority area air quality management plan (section 19).

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

- The distribution of pollutants concentrations and depositions are required in time and space.
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. The model specifically to be used in this AQIA is AERMOD.
- Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Chapter 3 of the Dispersion Modelling Regulations prescribe the source data input to be used in the models. Dispersion modelling can typically be used in the:

- Apportionment of individual sources for installations with multiple sources. In this way, the individual contribution of each source to the maximum ambient predicted concentration can be determined. This may be extended to the study of cumulative impact assessments where modelling can be used to model numerous installations and to investigate the impact of individual installations and sources on the maximum ambient pollutant concentrations.

- Analysis of ground level concentration changes due to different release conditions (e.g., by changing stack heights, diameters and operating conditions such as exit gas velocity and temperatures).
- Assessment of variable emissions due to process variations, start-up, shut-down or abnormal operations.
- Specification and planning of ambient air monitoring programs which, in addition to the location of sensitive receptors, are often based on the prediction of air quality hotspots.

The above options can be used to determine the most cost-effective strategy for compliance with the NAAQS. Dispersion models are particularly useful under circumstances where the maximum ambient concentration approaches the ambient air quality limit value and provide a means for establishing the preferred combination of mitigation measures that may be required including:

- Stack height increases;
- Reduction in pollutant emissions using air pollution control systems or process variations;
- Switching from continuous to non-continuous process operations or from full to partial load.

Chapter 4 of the Dispersion Modelling Regulations prescribe meteorological data input from onsite observations to simulated meteorological data. It also gives information on how missing data and calm conditions are to be treated in modelling applications. Meteorology is fundamental for the dispersion of pollutants because it is the primary factor determining the diluting effect of the atmosphere. Therefore, it is important that meteorology is carefully considered when modelling.

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

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

Chapter 5 provides general guidance on geophysical data, model domain and coordinates system required in dispersion modelling, whereas Chapter 6 elaborates more on these parameters and the inclusion of background air concentration data. The Chapter also provides guidance on the treatment of NO_2 formation from NO_x emissions, chemical transformation of sulfur dioxide into sulfates and deposition processes.

Chapter 7 of the Regulations outline how the plan of study and modelling assessment reports are to be presented to the competent authorities.

2.6 Regulations Regarding Report Writing

This report complies with the requirements of the National Environmental Management Act, 1998 (NEMA, No. 107 of 1998) and the Environmental Impact Assessment (EIA) regulations (GN R982 as amended by GN 326 of 7 April 2017; GN 706 of 13 July 2018; GN 320 of 20 March 2020 and GN 517 of 11 June 2021). The table below provides a summary of the requirements, with cross references to the report sections where these requirements have been addressed.

Table 2-5: Specialist report requirements in terms of Appendix 6 of the EIA Regulations (Government Notice [GN] R982 as amended by GN 326 of 7 April 2017; GN 706 of 13 July 2018; GN 320 of 20 March 2020 and GN 517 of 11 June 2021)

A specialist report prepared in terms of the Environmental Impact Regulations must contain:	Relevant section in report
Details of the specialist who prepared the report	Section 1.1
The expertise of that person to compile a specialist report including a curriculum vitae	Section 1.1
A declaration that the person is independent in a form as may be specified by the competent authority	Appendix B
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.2
An indication of the quality and age of base data used for the specialist report;	Section 3
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 5, Section 2
The duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 3
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 1.3
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternative;	Section 3.1
An identification of any areas to be avoided, including buffers	Section 3.1
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 3.1
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 4
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Section 5
Any mitigation measures for inclusion in the EMPr	Section 7
Any conditions for inclusion in the environmental authorisation	Section 7
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 7
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised	Section 6
Regarding the acceptability of the proposed activity or activities; and	Section 6
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 7
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	None received
Any other information requested by the competent authority.	None received

2.7 Effect of Dust on Vegetation, Animals and Susceptible Human Receptors

2.7.1 Effects of Particular Matter on Vegetation

Since plants are constantly exposed to air, they are the primary receptors for both gaseous and particulate pollutants of the atmosphere. In terrestrial plant species, the enormous foliar surface area acts as a natural sink for pollutants especially the particulate ones. Vegetation is an effective indicator of the overall impact of air pollution particularly in context of particulate matter (PM) (Rai, 2016).

There are two main types of direct injury that PM pollution can cause on plants: acute and chronic injury. Acute injury results from exposure to a high concentration of gas for a relatively short period and is manifested by clear visible symptoms on the foliage, often in the form of necrotic lesions. While this type of injury is very easy to detect (although not necessarily to diagnose), chronic injury is subtler: it results from prolonged exposure to lower gas concentrations and takes the form of growth and/or yield reductions, often with no clear visible symptoms. Plants that are constantly exposed to environmental pollutants absorb, accumulate and integrate these pollutants into their systems. It is reported that depending on their sensitivity level, plants show visible changes which would include alteration in the biochemical processes or accumulation of certain metabolites (Rai, 2016). Pollutants can cause leaf injury, stomatal damage (Ricks and Williams, 1974; Hirano et al., 1995; Naidoo and Chirkoot, 2004; Harmens et al., 2005), premature senescence, decrease photosynthetic activity, disturb membrane permeability (Ernst, 1981; Naidoo and Chirkoot, 2004; Harmens et al., 2005) and reduce growth and yield in sensitive plant species. The long term, low-concentration exposures of air pollution produce harmful impacts on plant leaves without visible injury. Several studies have been conducted to assess the effects of pollution on different aspects of plant life such as overall growth and development, foliar morphology, anatomy, and biochemical changes (Rai, 2016).

Plant leaves are the primary receptors for both gaseous and PM pollutants of the atmosphere. Before these pollutants enter the leaf tissue, they interact with foliar surface and modify its configuration. Dust deposition on leaf surface, consisting of ultra-fine and coarse particles, showed reduction in plant growth through its effect on leaf gas exchange, flowering and reproduction of plants, number of leaves and leaf area, one of the most common driving variables in growth analyses. Reduction in leaf area and leaf number may be due to decreased leaf production rate and enhanced senescence (Rai, 2016).

The chemical composition of the dust particles can also affect exposed plant tissue and have indirect effects on the soil pH (Spencer, 2001).

To determine the impact of dust deposition on vegetation, two factors are of importance: (i) Does dust accumulate on vegetation surfaces and if it does, what are the factors influencing the rate of deposition, and (ii) Once the dust has been deposited, what is the impact of the dust on the vegetation? Regarding the first question, there is adequate evidence that dust does accumulate on all types of vegetation. Any type of vegetation causes a change in the local wind fields, increasing turbulence and enhancing the collection efficiency. Vegetation structure alters the rate of dust deposition such that the larger the “collecting elements” (branches and leaves), the lower the impaction efficiency per element. Therefore, for the same volume of tree/shrub canopy, finer leaves will have better collection efficiencies. However, the roughness of the leaves themselves, in particularly the presence of hairs on the leaves and stems, plays a significant role, with venous surfaces increasing deposition of 1-5 µm particles by up to seven-times compared to smooth surfaces. Collection efficiency rises rapidly with particle size; wind tunnel studies show a relationship of deposition velocity on the fourth power of particle size for moderate wind speeds (Tiwary and Colls, 2010). Wind tunnel studies also show that windbreaks or “shelter belts” of three rows of trees have a decrease of between 35 and 56% of the downwind mass transport of inorganic particles.

After deposition onto vegetation, the effect of particulate matter depends on the composition of the dust. South African ambient standards are set in terms of $PM_{2.5}$ and PM_{10} but internationally it is recognised that there are major differences in the chemical composition of the fine PM (the fraction between 0 and 2.5 µm in aerodynamic diameter) and coarse PM (the fraction between 2.5 µm and 10 µm in aerodynamic diameter). The former is often the result of chemical reactions in the atmosphere and may have a high proportion of black carbon, sulfate and nitrate; whereas the latter often consists of primary particles due to abrasion, crushing, soil disturbances and wind erosion (Grantz, Garner, & Johnson, 2003). Sulfate is however often hygroscopic and may exist in significant fractions in coarse PM. This has been shown at the Elandsfontein Eskom air quality monitoring station where the PM_{10} has been shown to vary between 15% (winter) and 49% (spring) sulfate (Alade, 2009). Grantz et al. (op. cit.) however indicate that sulfate is much less phototoxic than gaseous sulfur dioxide and that “it is unusual for injurious levels of particular sulfate to be deposited upon vegetation”.

According to the Canadian Environmental Protection Agency, generally 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. 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).

Exposure to a given concentration of airborne PM may therefore lead to widely differing phytotoxic responses, depending on the mix of the deposited particles. Most documented toxic effects indicate responses to the chemical composition of the particles. Direct effects have most often been observed around heavily industrialised point sources, but even there, effects are often associated with the chemistry of the particulate rather than with the mass of particulate. Little direct evidence of the effects of dust-fall on South African vegetation, including crops, exists.

2.7.2 Effects of Particulate Matter on Animals

As presented by the CEPA (1998) studies using experimental animals have not provided convincing evidence of particle toxicity at ambient levels. Acute exposures (4-6 hours 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 ventilatory lung function;
- changes in mucociliary clearance of particles from the lower respiratory tract (front line of defence in the conducting airways);
- increased number of alveolar macrophages and polymorphonuclear leukocytes in the alveoli (primary line of defence of the alveolar region against inhaled particles);
- alterations in immunologic responses (particle composition a factor, since particles with known cytotoxic properties, such as metals, affect the immune system to a significantly greater degree);
- changes in airway defence mechanisms against microbial infections (appears to be related to particle composition and not strictly a particle effect);
- increase or decrease in the ability of macrophages to phagocytize particles (also related to particle composition);
- a range of histologic, cellular and biochemical disturbances, including the production of proinflammatory cytokines and other mediators by the lungs alveolar macrophages (may be related to particle size, with greater effects occurring with ultrafine particles);
- increased electrocardiographic abnormalities (an indication of cardiovascular disturbance); and
- increased mortality.

Bronchial hypersensitivity to non-specific stimuli, and increased morbidity and mortality from cardio-respiratory symptoms, are most likely to occur in animals with pre-existing cardio-respiratory diseases. Sub-chronic and chronic exposure tests involved repeated exposures for at least half the lifetime of the test species. Particle mass concentrations to which test animals were exposed were very high (> 1 mg/m³), greatly exceeding levels reported in the ambient environment. Exposure resulted in significant compromises in various lung functions similar to those seen in the acute studies, but including also:

- reductions in lung clearance;
- induction of histopathologic and cytologic changes (regardless of particle types, mass, concentration, duration of exposure or species examined);
- development of chronic alveolitis and fibrosis; and
- development of lung cancer (a particle and/or chemical effect).

The epidemiological finding of an association between 24-hour ambient particle levels below 100 µg/m³ and mortality has not been substantiated by animal studies as far as PM_{10} and $PM_{2.5}$ are concerned. At ambient concentrations, none of the other particle types and sizes used in animal inhalation studies result in acute effects, including high mortality, with exception of ultrafine particles (0.1 µm). The lowest concentration of $PM_{2.5}$ reported that caused acute death in rats with acute pulmonary inflammation or chronic bronchitis was 250 g/m³ (3 days, 6 hour day-1), using continuous exposure to concentrated ambient particles.

Most of the literature regarding air quality impacts on cattle refers to the impacts from feedlots on the surrounding environment, hence where the feedlot is seen as the source of pollution. This mainly pertains to odours and dust generation. The United States Environmental Protection Agency (US EPA) recently focussed on the control of air pollution from feed yards and dairies, primarily regulating coarse particulate matter. However, the link between particulates and public health is considered to be understudied (Sneeringer, 2009).

A study was conducted by the State University of Iowa on the effects of air contaminants and emissions on animal health in swine facilities. Air pollutants included gases, particulates, bioaerosols, and toxic microbial by-products. The main findings were that ammonia is associated with lowered average number of pigs weaned, arthritis, porcine stress syndrome, muscle lesions, abscesses, and liver ascarid scars. Particulates are associated with the reduction in growth and turbine pathology, and bioaerosols could lower feed efficiency, decrease growth, and increase morbidity and mortality. The authors highlighted the general lack of information on the health effects and productivity-problems of air contaminants on cattle and other livestock. Ammonia and hydrogen sulfide are regarded the two most important inorganic gases affecting the respiratory system of cattle raised in confinement facilities, affecting the mucociliary transport and alveolar macrophage functions. Holland et al., (2002) found that the fine inhalable particulate fraction is mainly derived from dried faecal dust.

Inhalation of confinement-house dust and gases produces a complex set of respiratory responses. An individual's response depends on characteristics of the inhaled components (such as composition, particle size and antigenicity) and of the individual's susceptibility, which is tempered by extant respiratory conditions (Davidson et al., 2005). Most studies concurred that the main implication of dusty environments is the stress caused to animals which is detrimental to their general health. However, no threshold levels exist to indicate at what levels these are having a negative effect. In this light it was decided to use the same screening criteria applied to human health, i.e. the South African Standards and SANS limit values.

2.7.3 Effect of Particulate Matter on Susceptible Human Receptors

The impact of particles on human health is largely depended on (i) particle characteristics, particularly particle size and chemical composition, and (ii) the duration, frequency and magnitude of exposure. The potential of particles to be inhaled and deposited in the lung is a function of the aerodynamic characteristics of particles in flow streams. The aerodynamic properties of particles are related to their size, shape and density. The deposition of particles in different regions of the respiratory system depends on their size.

The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulates. These larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages. The smaller particles (PM_{10}) pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. These particles are removed by impacting with the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which pushes them to the alveolar membrane (CEPA, 1998; Dockery and Pope, 1994).

The air quality guidelines for particulates are given for various particle size fractions, including total suspended particulates (TSP), thoracic particulates or PM_{10}, and respirable particulates or $PM_{2.5}$. Although TSP is defined as all particulates with an aerodynamic diameter of less than 100 µm, and effective upper limit of 30 µm aerodynamic diameter is frequently assigned. The PM_{10} and $PM_{2.5}$ are of concern due to their health impact potentials. As indicated previously, such fine particles are deposited in and damage the lower airways and gas-exchanging portions of the lung.

The World Health Organization states that the evidence on airborne particulates and public health consistently shows adverse health effects at exposures experienced by urban populations throughout the world. The range of effects is broad, affecting the respiratory and cardiovascular systems and extending from children to adults including large susceptible groups within the general population. Long-term exposure to particulate matter has been found to have adverse effects on human respiratory health (Abbey et al., 1995). Respiratory symptoms in children resident in an industrialised city were initially found not to be associated with long-term exposure to particulate matter; however non-asthmatic symptoms and hospitalizations did increase with increased total suspended particulate concentrations (Hruba et al., 2001). Subsequently, epidemiological evidence shows adverse effects of particles after both short-term and long-term exposures. Current scientific evidence indicates that guidelines cannot be proposed that will lead to complete protection against adverse health effects as thresholds (or no adverse effect levels (NOAEL) have not been identified.

Many scientific studies have linked inhaled particulate matter to a series of significant health problems, including:

- aggravated asthma and associated hospitalisation or emergence department admission, even for coarse particulate ($PM_{2.5}$ to PM_{10}) (Keet et al 2017);
- hospital admissions for respiratory and cardiovascular diseases associated with fine particulate ($PM_{2.5}$) exposure, even at levels consistently below limit values (Makar et al 2017)
- kidney, bladder and colorectal cancer (Turner et al 2017)
- ischaemic heart disease (Lim et al 2015)
- increases in respiratory symptoms like coughing and difficult or painful breathing;
- chronic bronchitis;
- decreased lung function; and,
- premature death.

PM_{10} is the standard measure of particulate air pollution used worldwide and studies suggest that asthma symptoms can be worsened by increases in the levels of PM_{10}, which is a complex mixture of particle types. PM_{10} has many components and there is no general agreement regarding which component(s) could exacerbate asthma. However, pro-inflammatory effects of transition metals, hydrocarbons, ultrafine particles (due to combustion processes) and endotoxins - all present to varying degrees in PM_{10} - could be important.

Exposure to motor traffic emissions can have a significant effect on respiratory function in children and adults. Studies show that children living near heavily travelled roadways have significantly higher rates of wheezing and diagnosed asthma. Epidemiologic studies suggest that children may be particularly susceptible to diesel exhaust.

3 RECEIVING ENVIRONMENT

3.1 Site Description

Identified sensitive receptors in the study area include the small village of Mopane, approximately 2 km to the north-west of the Kinetic Project, as well as an individual homestead to the north of the R525 road, and two homesteads approximately 2 km to the southwest of the Kinetic Project. The closest sensitive receptors to the east of the Kinetic Project are homesteads and lodges close to the N1, approximately 4 km from the Kinetic Project (Figure 3-1).

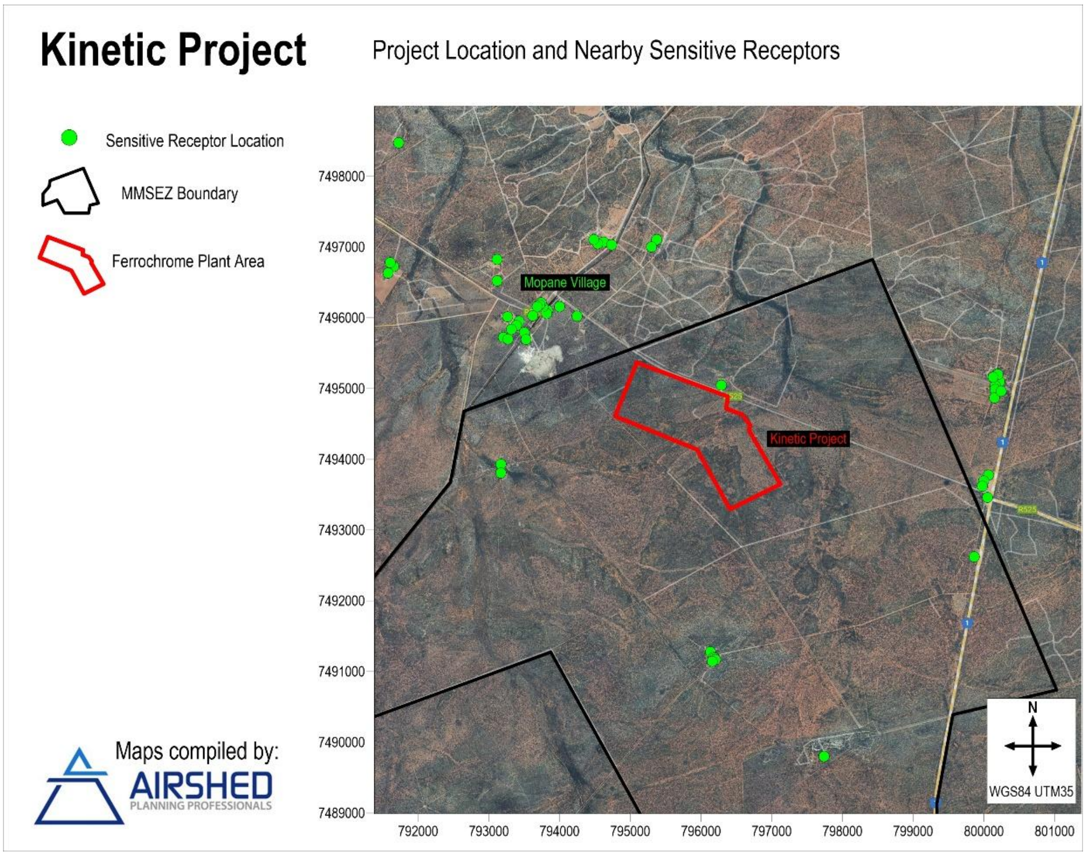


Figure 3-1: Location of potentially sensitive receptors in relation to the Kinetic Project

3.2 Terrain

Readily available terrain data was obtained from the United States Geological Survey web site (https://earthexplorer.usgs.gov/). A study was made of Shuttle Radar Topography Mission 1 arc-sec data. The terrain for the study area is provided in Figure 3-2.

The project area is approximately 35 km to the north of the Soutpansberg mountains, and while the study area is fairly flat, ranging from 720 metres above mean sea level (mamsl) in the southeast to 650 mamsl in the northwest, there is a hill approximately 50 m in height between the project area and the village of Mopane, therefore topography was included in the dispersion modelling simulations.

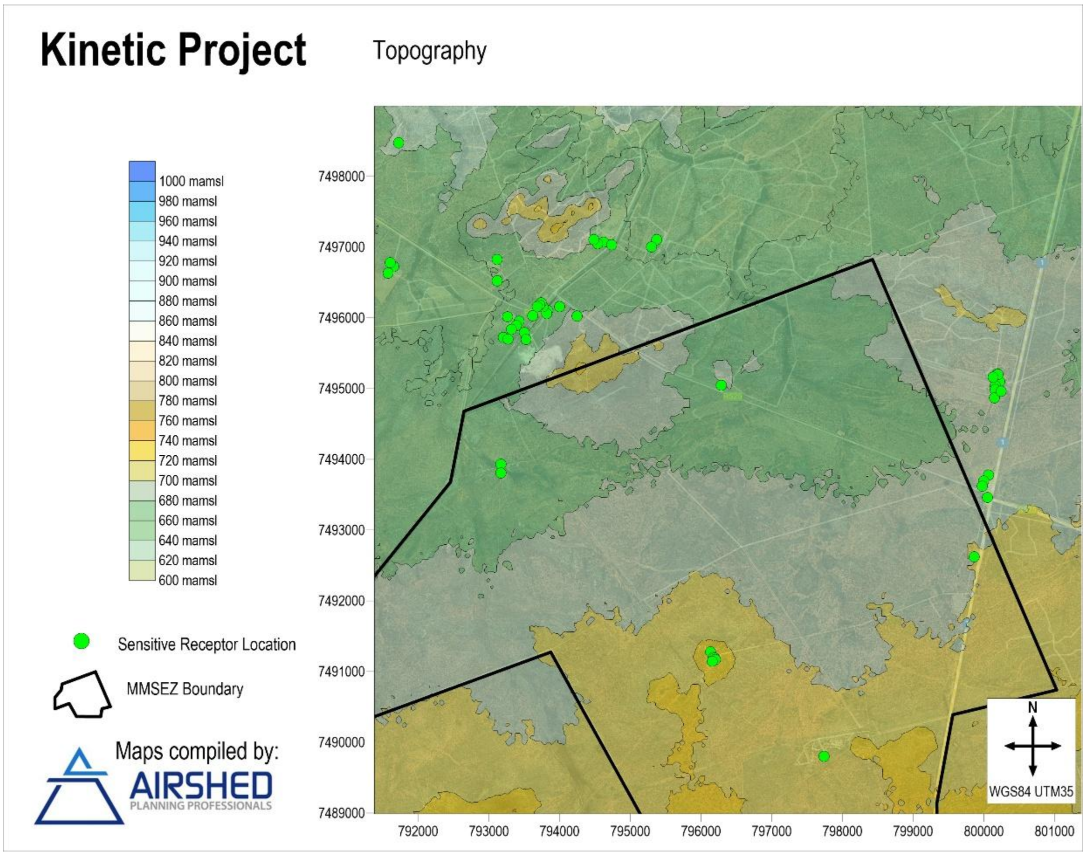


Figure 3-2: Terrain elevation for the study area

3.3 Climate and Atmospheric Dispersion Potential

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

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

Meteorological information was sourced from modelled WRF[1] data for the site for the period 2022 to 2024.

3.3.1 Local Wind Field

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

The wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, 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 0.5 m/s are also indicated.

The period wind field and diurnal variability in the wind field are shown in Figure 3-3. Monthly variation in the wind field is shown in Figure 3-4.

The wind regime for the area is dominated by easterly flow fields. The east-northeasterly wind flow is more dominant during the day, with increased flow from the east-southeast during night-time conditions. Calm conditions occurred for less than 1% of the period summarised.

There is some seasonal variability to the wind field, with the highest wind speeds occurring in the spring months between August and November. The lowest wind speeds occur in autumn and early winter.

Dust mobilisation occurs only for wind velocities higher than a threshold value, and is not linearly dependent on the wind friction and velocity. The threshold friction velocity, defined as the minimum friction velocity required initiating particle motion, is dependent on the size of the erodible particles and the effect of the wind shear stress on the surface. The friction velocity for unvegetated stockpiles usually given in the range of around 5.4 m/s (Shao, 2008), that means that at wind speeds above 5.4 m/s wind erosion could occur, whereas at windspeeds below 5.4 m/s wind erosion from open and exposed areas is unlikely. The average wind speed in the study area (4.25 m/s) is fairly high, and wind speeds above 5.4 m/s occur approximately 22% of the time (Figure 3-5). Significant fugitive dust emissions could results from raw material and slag stockpiles if these sources are not carefully managed.

[1] The Weather Research and Forecasting (WRF) Model is a next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications.

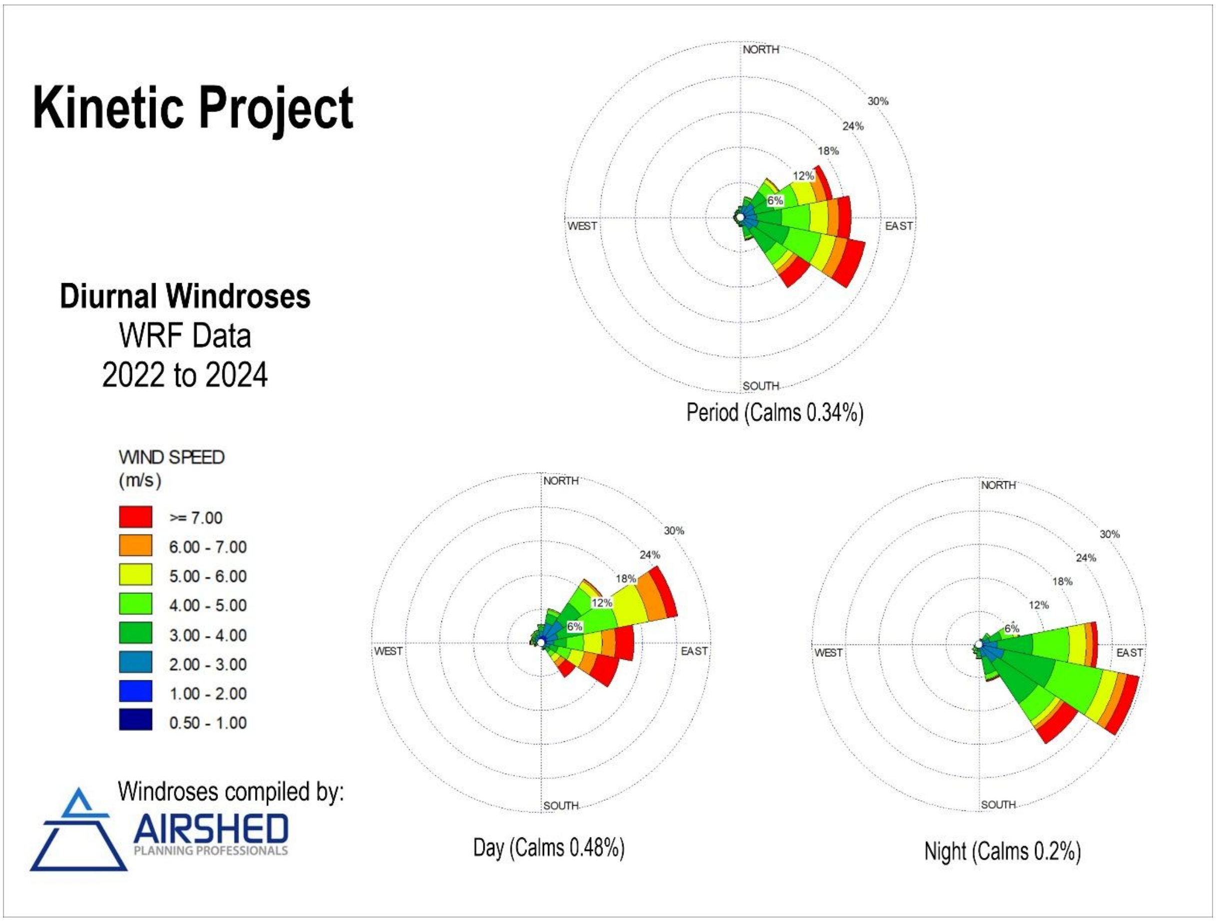


Figure 3-3: Period, day-, and night-time wind roses (WRF data, 2022 to 2024)

Figure 3-4: Monthly wind roses (WRF data, 2022 to 2024)

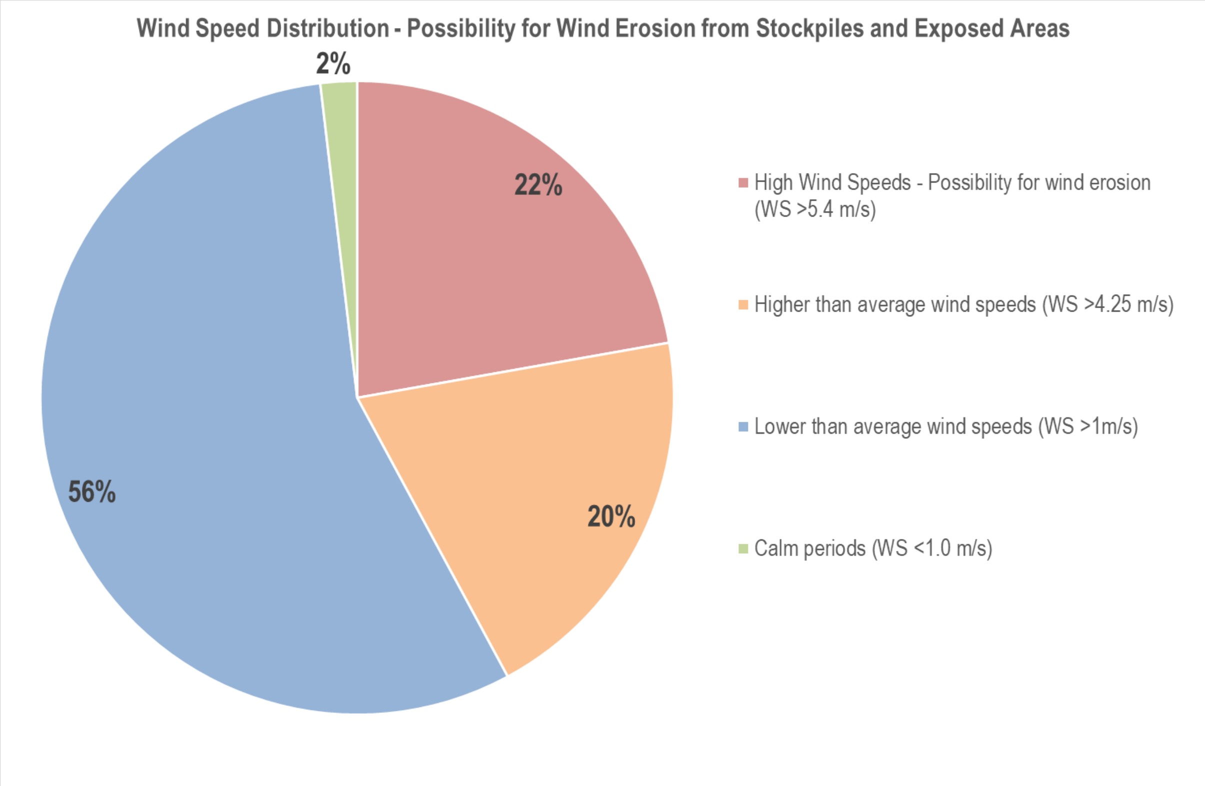


Figure 3-5: Wind speed frequency distribution - WRF data for the study area (January 2022 to December 2024)

3.3.2 Ambient Temperature

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

Monthly mean, maximum and minimum temperatures are given in Table 3-1. Diurnal temperature variability is presented in Figure 3-4. Average monthly temperatures ranged between 16.6°C in June and 27.7°C in December. During the day, temperatures increase to reach maximum at about 15:00 in the late afternoon, with the highest temperatures, exceeding 40°C, occurring in September, October, December and March. Ambient air temperature decreases to reach a minimum at between 06:00, the lowest temperatures occur in July.

Table 3-1: Monthly temperature summary (WRF data, 2022 to 2024)

Monthly Minimum, Maximum and Average Temperatures (°C)												
Parameter	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Minimum	13.6	12.9	12.4	9.9	7.5	5.6	2.7	6.7	5.7	8.5	10.8	13.2
Average	26.4	26.4	24.7	22.4	19.7	16.6	16.8	19.0	22.5	24.7	26.4	27.7
Maximum	37.3	39.7	40.2	36.8	33.9	33.0	31.6	36.3	40.5	40.7	39.6	41.5

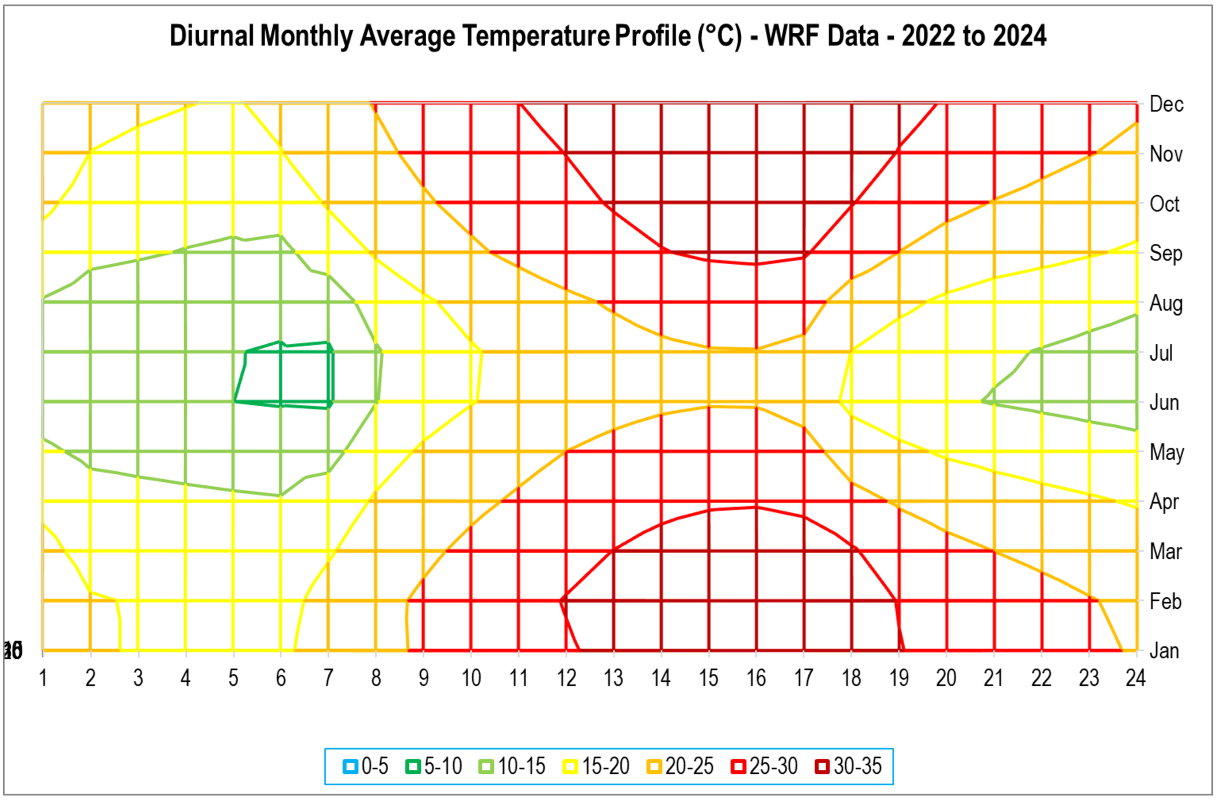
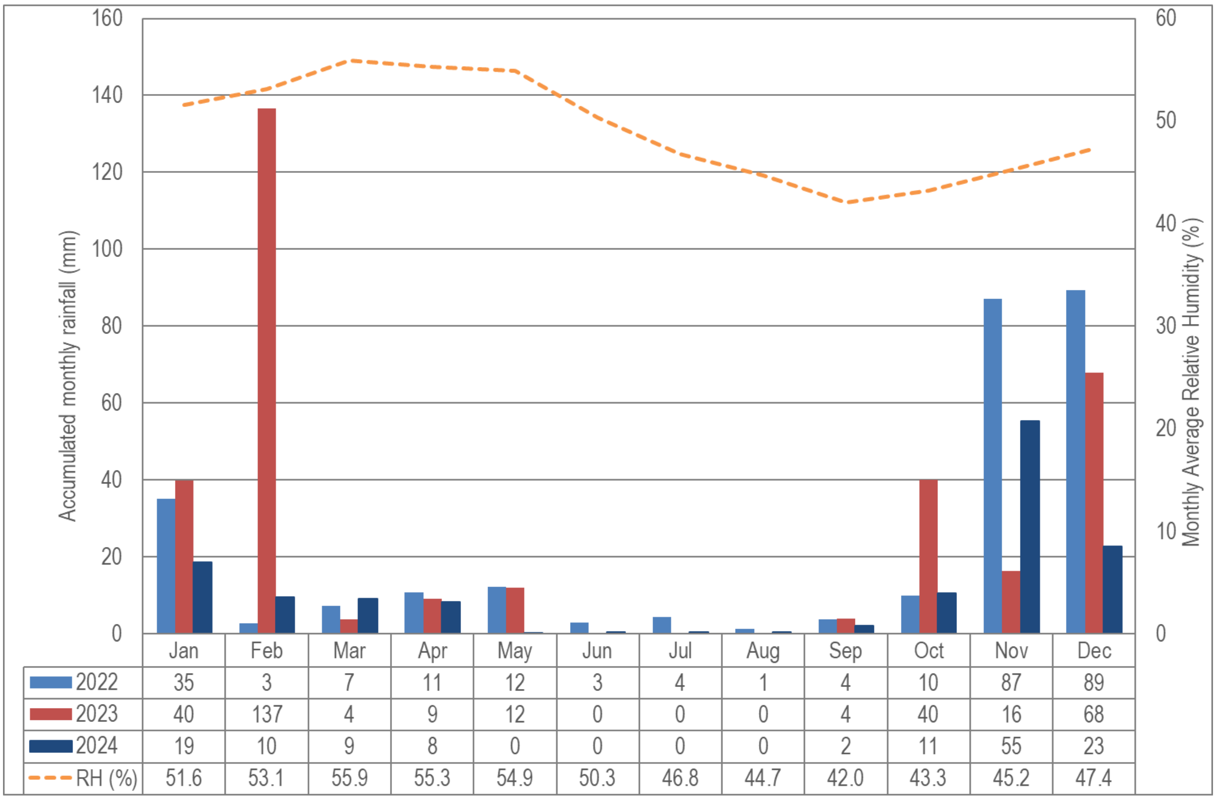


Figure 3-6: Diurnal temperature profile (WRF data, 2022 to 2024)

3.3.3 Precipitation

Precipitation is important to air pollution studies since it represents an effective removal mechanism for atmospheric pollutants and inhibits dust generation potentials. According to the rainfall data from the modelled WRF dataset, between 2022 and 2024 the total precipitation over the three years is 1 719 mm, ranging between 138 mm (2024) and 330 mm (2023). Precipitation occurs as showers and thunderstorms and falls mainly from October to April (about 88 days of measurable rain per year) with the maximum rainfall occurring in November and December, (although the maximum rainfall in 2024 occurred in February). The autumn and winter months are dry with the combined rainfall between May and September making up less than 6% of the annual total. The annual rainfall by month from 2022 to 2024 is given in Figure 3-7.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2022	35	3	7	11	12	3	4	1	4	10	87	89
2023	40	137	4	9	12	0	0	0	4	40	16	68
2024	19	10	9	8	0	0	0	0	2	11	55	23
RH (%)	51.6	53.1	55.9	55.3	54.9	50.3	46.8	44.7	42.0	43.3	45.2	47.4

Figure 3-7: Monthly precipitation at the study area (WRF data, 2022-2024)

3.3.4 Atmospheric Stability and Mixing Depth

The new generation air dispersion models differ from the models traditionally used in several aspects, the most important of which are the description of atmospheric stability as a continuum rather than discrete classes. The atmospheric boundary layer properties are therefore described by two parameters: the boundary layer depth and the Monin-Obukhov length, rather than in terms of the single parameter Pasquill Class. The Monin-Obukhov length (LMo) provides a measure of the importance of buoyancy generated by the heating of the ground and mechanical mixing generated by the frictional effect of the earth's surface. Physically, it can be thought of as representing the depth of the boundary layer within which mechanical mixing is the dominant form of turbulence generation (CERC, 2004).

The atmospheric boundary layer constitutes the first few hundred metres of the atmosphere. During the 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 less dilution potential. During windy and/or cloudy conditions, the atmosphere is normally neutral. For low level releases, the highest ground level concentrations would occur during weak wind speeds and stable (night-time) atmospheric conditions. The atmospheric stability for the site is provided in Figure 3-5.

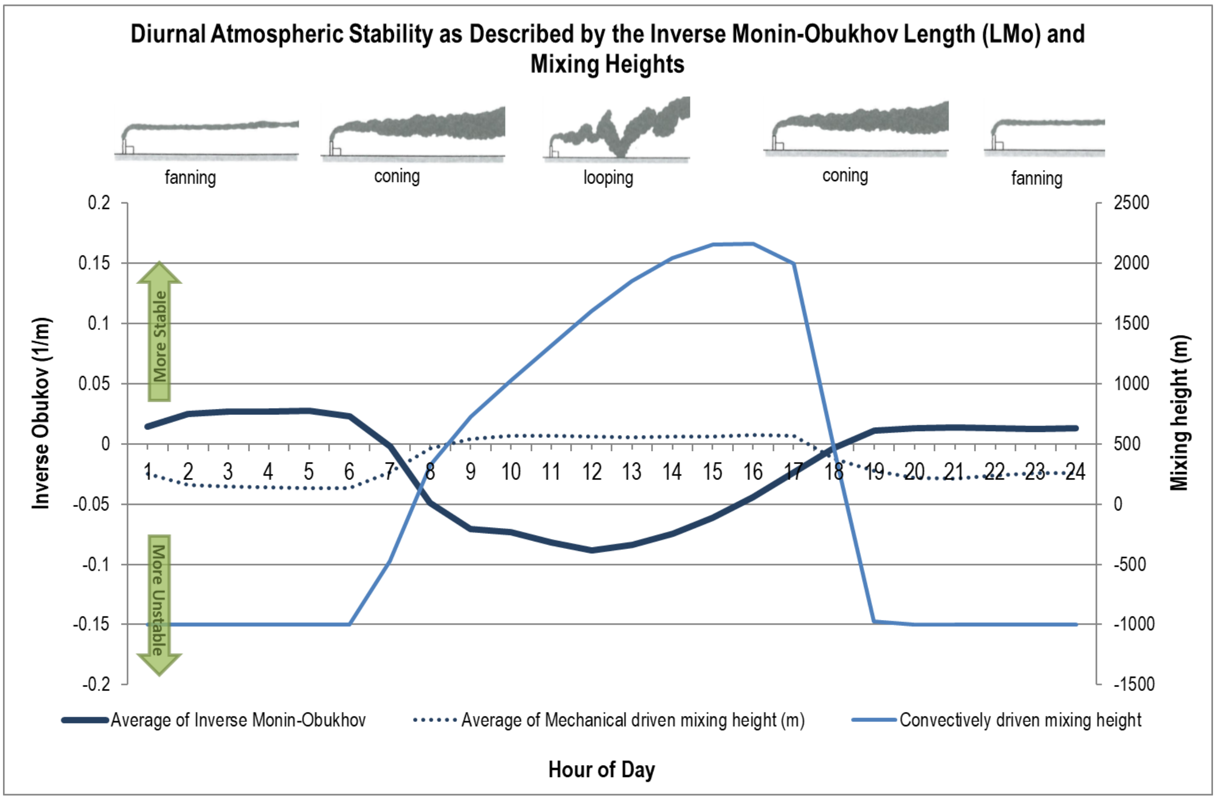


Figure 3-8: The diurnal atmospheric stability for the site as obtained from the WRF data (2022 to 2024)

3.4 Baseline Ambient Air Quality

3.4.1 Existing Sources of Air Pollution in the Area

The main sources of existing air pollution in the study area and surrounds 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.

The types of emissions associated with each of these source groups is shown in Table 3-2.

Table 3-2: Summary of air pollutants emitted from various sources in the study area

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

3.4.1.1 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.

3.4.1.2 Agricultural Activities

Agricultural activities may contribute to both particulate and gaseous air pollutants. Whereas particulate emissions are mainly from the wind erosion of soil and perhaps burning of waste and seasonal burning of biomass, gaseous emissions include 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 District Municipality, 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 Local Municipality, as sources of atmospheric pollution.

3.4.1.3 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 total 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.

3.4.1.4 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.

3.4.1.5 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 H. , 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 G. , 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).

3.4.1.6 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.

3.4.1.7 Landfill Operations

The two closest landfill facilities to the MMSEZ 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 MMSEZ location and therefore contributions to baseline air quality at the site is likely to be very small.

3.4.1.8 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 MMSEZ location and therefore contributions to baseline air quality at the site is likely to be very small.

3.4.2 Measured Pre-Development Air Pollutant Concentrations

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. The nearest air quality monitoring station to the study area with data reporting to SAAQIS is in Thohoyandou, approximately 50 km to the east-southeast of the project location. The data from this station for 2024 and 2025 were accessed as an indication of the air quality near the project site. It would appear that operation of this station only started in July 2024, with 44% data availability for the year 2024, but 99.9% availability between 23 July and 31 December 2024. Reference is therefore made for monitoring data from 27 July 2024 to 28 May 2025.

Measured SO_2, NO_2 and CO concentrations at the Thohoyandou monitoring station were well below the NAAQS during the period 27 July 2024 to 28 May 2025.

Annual average PM_{10} and $PM_{2.5}$ concentrations for the period July 2024 to May 2025 were below the NAAQS limit values, while daily PM_{10} and $PM_{2.5}$ concentrations exceeded the allowed 4 exceedances of the NAAQS limit value. All of these exceedances occurred during August and September 2024, presumably due to either veld fires or wind erosion, as this is not only the dryest period in the study area (Figure 3-7), but also the time of the year with the highest wind speeds (Figure 3-4).

Table 3-3: Pollutant concentrations recorded at the Thohoyandou AQMS - 27 July 2024 to 28 May 2025

Parameters	Recorded Pollutant Concentration during the period 27 July 2024 to 28 May 2025 (µg/m³)				
	SO_2	NO_2	CO	PM_{10}	$PM_{2.5}$
Highest Hourly Concentration	57.1	83.6	1224.0		
Exceedances of Hourly NAAQS Limit	0				
Highest Daily Concentration	29.8			131.0	85.1
Exceedances of Daily NAAQS Limit	0			**21**	**18**
Annual Average Concentration	1.5	9.2	158.2	33.3	16.3

4 EMISSIONS INVENTORY

4.1 Process Description

High-carbon ferrochromium alloy is produced through carbon reduction in a submerged arc furnace heated by electricity. Chromite ore serves as the raw material, silica stone acts as the slag-forming flux, and carbonaceous reducing agents (coke) are used. The production process features continuous smelting and intermittent tapping, adopting an electrothermal method.

Qualified coke, silica stone, and lumpy chromite ore are conveyed by belt-conveyors to the daily storage bins at the batching station. Facilities for pelletizing chromite fines are reserved. After batching, the materials are transported via belt-conveyors to the electric furnace bay and added to the storage hoppers. They are then fed into the furnace through feed pipes.

The taphole is opened by a taphole drill at intervals of 2.67 hours. Liquid ferrochromium alloy flows into the ladle, and furnace slag flows from the ladle into the slag pot. The ladle car and slag pot car are pulled out by an electric tapping car and enter the casting bay. The ladle is hoisted by a crane for slag skimming before casting. The cooled high-carbon ferrochromium alloy is processed into finished products of qualified particle size by a high-intensity crushing line in the finished product bay. Oversize materials are remelted in ingot molds. The slag pot is hoisted by a crane, and furnace slag flows into the dry slag pond through a dry slag chute. The cooled dry slag is sent to the dry slag storage area.

Two electric furnaces are installed in the electric furnace workshop. Each electric furnace is equipped with one set of flue gas purification system for electric furnaces (two sets in total). One set of dust collection system is set up at the tapping hole and top charging area of each electric furnace (two sets in total). Dust collection facilities are installed for systems such as raw material supply and batching at the ground-level raw material yard.

The flue gas from the submerged arc furnace is cooled to 230°C by an air cooler. Next, it passes through a pre-cyclone dust collector and is filtered by a large negative-pressure bag dust collector. The flue gas after filtration meets the emission standards. Every two sets of dust collection systems share one exhaust stack for emission.

The flue gas at the tapping hole and the dust-laden gas during top-charging of the furnace are captured through their respective hoods. They are then guided via air ducts to a pulse bag dust collector for filtration. After that, the gas is discharged into the venting chimney by an induced draft fan.

The dust accumulated on the filter bags is blown off by low-pressure pulse gas and falls into the ash hopper. The dust is collected by a horizontal scraper conveyor and a bucket elevator and then sent to the ash storage silo. The dust collected from the dust collector is humidified before being transported out for disposal.

To prevent the filter bags from being damaged due to excessive fluctuations in flue gas temperature, a mixing air valve is installed on the inlet pipeline of the bag dust collector. The mixing air valve is interlocked with the temperature measuring points on the inlet pipeline of the bag dust collector. When the temperature is ≥ 250°C, the mixing air valve opens automatically; when the temperature is < 230°C, it closes automatically.

The dust-laden gas at various dust source points during the production process, like those from raw material processing equipment, is captured by installed capture hoods. It then enters dust collectors through dust removal pipelines for purification. The dust removal system for bulk materials and auxiliary raw materials typically consists of dust extraction hoods at unloading points such as transfer stations of belt conveyors and unloading trolleys, pipelines, regulating valves, fans, bag dust collectors, mechanical ash conveying devices, ash storage silos, chimneys, etc. The auxiliary support systems include instrument detection and electrical automation systems, compressed air systems, etc. Natural ventilation and necessary axial-flow mechanical exhaust systems are installed in each production workshop.

4.2 Emissions Inventory

In the quantification of point source emissions, use was made of the design specifications for the plant and the Subcategory 4.9: Ferroalloy Production Minimum Emission Standards (MES), as published under Section 21 of the National Environmental Management: Air Quality Act (NEM:AQA).

Due to the absence of locally generated emission factors, use was made of the comprehensive set of emission factors published by the US Environmental Protection Agency (US-EPA) in its AP-42 document Compilation of Air Pollution Emission Factors as well as the Australian National Pollutant Inventory (NPI) emission estimation documents for the quantification of fugitive emission sources, such as vehicle entrainment on on-site roads and the access road, emissions generated from material handling operations, wind erosion from stockpiles and emissions from crushing.

4.2.1 Point Sources

The physical parameter for point sources at the Kinetic Project, together with estimated emissions (if all point sources were to operate at the Subcategory 4.9 MES), are shown in Table 4-1. Point source parameters were provided by the project proponent.

Table 4-1: Kinetic Project Point Source Parameters and Emissions

Point Source	Flow Rate (m^3/h)	Diameter (m)	Height (m)	Velocity (m/s)	Temperature (°C)	Emission Concentrations (mg/Nm^3)			Emissions Rate (g/s)		
						PM	SO_2	NO_x	PM	SO_2	NO_x
Dry material dust removal	60 000	1.32	20	13.5	25	50	500	400	0.8	7.5	6.0
Primary dust removal for submerged arc furnace	200 000	2.32	30	14.5	230	50	500	400	1.5	14.8	11.8
Raw material batching dust removal	50 000	1.22	20	13	30	50	500	400	0.6	6.1	4.9
Taphole fume extraction and charging dust removal	80 000	1.52	20	13.5	100	50	500	400	0.8	8.0	6.4
Taphole fume extraction and charging dust removal	80 000	1.52	20	13.5	100	50	500	400	0.8	8.0	6.4

4.2.2 Fugitive Sources

In addition to the point sources at the Kinetic Project, several fugitive emission sources are also expected to release pollutants to the atmosphere at or near ground level. These include transporting and handling of raw materials and ferrochromium alloy products, handling and deposition of slag, vehicle entrainment on on-site paved roads and the access road, crushing of ferrochromium alloy product and uncaptured secondary emissions from the furnaces, released during charging and tapping.

The emission factors, emission estimation techniques and parameters used in the estimation of emissions from the Kinetic Project operations are given in Table 4-2.

Table 4-2: Emission factors and parameters used in the fugitive emission estimation

Activity	Emission Equation	Source	Information assumed/provided
Materials handling	Loading stockpiles: $E_{TSP} = 0.004\ kg/t\ material$ loaded $E_{PM10} = 0.0017\ kg/t\ material$ loaded $E_{PM2.5} = 0.00017\ kg/t\ material$ loaded Unloading from stockpiles: $E_{TSP} = 0.03\ kg/t\ material$ handled $E_{PM10} = 0.013\ kg/t\ material$ handled $E_{PM2.5} = 0.0013\ kg/t\ material$ handled Conveying: $E_{TSP} = 0.005\ kg/t\ material$ handled $E_{PM10} = 0.002\ kg/t\ material$ handled $E_{PM2.5} = 0.0002\ kg/t\ material$ handled Front-End Loaders $E_{TSP} = 0.025\ kg/t\ material$ loaded $E_{PM10} = 0.012\ kg/t\ material$ loaded $E_{PM2.5} = 0.0012\ kg/t\ material$ loaded	NPI Section: Mining	The throughput of materials was given as follows: 125 329 t/a high-carbon ferrochrome 250 658 t/a chromite ore 62 664 t/a coke 21 807 t/a silica stone Hours of operation were assumed as 24 hrs per day, 7 days per week, 330 days per year.
Vehicle Entrainment on paved road surfaces	$E = 0.62\ (sL)^{0.91} \times (W)^{1.02}\ g/VKT$ Where; E = particulate emission factor in grams per vehicle km travelled (g/VKT) sL = silt loading on the road surface in g/m² W = average weight (tonnes) of the vehicles travelling the road	US-EPA AP42 Section 13.2.1	Estimated using raw material consumption and ferrochrome production rates, as given above. Distances travelled on site were estimated from site layout maps. In the absence of site-specific silt loading data, use was US EPA default mean silt loading of 9.7 g/m² for iron and steel production.
Vehicle entrainment on unpaved surfaces	$E = k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b} \cdot 281.9$ Where, E = particulate emission factor in grams per vehicle km travelled (g/VKT) k = basic emission factor for particle size range and units of interest s = road surface silt content (%) W = average weight (tonnes) of the vehicles travelling the road The particle size multiplier (k) is given as 0.15 for $PM_{2.5}$ and 1.5 for PM_{10}, and as 4.9 for TSP The empirical constant (a) is given as 0.9 for $PM_{2.5}$ and PM_{10}, and 4.9 for TSP The empirical constant (b) is given as 0.45 for $PM_{2.5}$, PM_{10} and TSP	US-EPA AP42 Section 13.2.2	In the absence of site-specific silt data, use was made of the US EPA default mean silt content for iron and steel production of 6.0%. Emissions from all raw materials and ferrochrome product, with quantities transported as listed above, were estimated from the entrance to the MMSEZ (next to the N1) to the Kinetic Project site, following existing unpaved roads. Should shorter routes be established in the future, or roads in the MMSEZ paved, the emissions from vehicle entrainment on the access road will reduce. The capacity of the trucks to be used was assumed as 30 t.
Crushing and screening	Primary: $E_{TSP} = 0.01\ kg/t\ material\ processed$ $E_{PM10} =\ 0.004\ kg/t\ material\ processed$ $E_{PM2.5} = 0.0004\ kg/t\ material\ processed$ Where,	NPI Section: Mining	It was assumed that all ferrochrome produce would be crushed, emission estimation was based on 125 329 t/a ferrochrome production. A control efficiency of 90% was applied to account for the

	E = Default emission factor for high_moisture content material Fraction of $PM_{2.5}$ taken from US-EPA crushed stone emission factor ratio for tertiary crushing		mitigating effect of the furnace building on particulate emissions inside the building.
Wind Erosion	$E_{TSP} = 0.4\ kg/ha/h$ $E_{PM10} = 0.2\ kg/ha/h$ $E_{PM2.5} = 0.02\ kg/ha/h$ Where, E = Default emission factor Fraction of $PM_{2.5}$ assumed to be 10% of PM_{10}	NPI Section: Mining	Wind erosion from raw material and slag stockpiles was only modelled for hours with wind speeds exceeding 5.4 m/s.
Furnace Fugitive Emissions	Furnace fugitive particulate emissions were estimated using the US EPA AP-42 Section 12.5 (Iron and Steel Production) emission factors for charging, tapping and slagging in electric arc furnaces (0.0215 kg/tonne ferroalloy produced) controlled by direct shell evacuation plus charging hood.	US EPA AP-42 Section 12.5 (Iron and Steel Production	Based on 125 329 t/a ferrochrome production. A control efficiency of 90% was applied to account for design fume extraction and the mitigating effect of the furnace building on particulate emissions inside the building.

4.2.3 Summary of Atmospheric Emissions

Using the point emissions summarised in Table 4-1 and the fugitive emission estimation techniques described in Table 4-2, the emissions inventory for the Kinetic Project is summarised in Table 4-3. It should be noted that SO_2 and NO_2 emissions are quantified using the Subcategory 4.9 MES (as required by the Regulations Regarding Dispersion Modelling), however, given that the majority of point sources at the Kinetic Project serve as the point of release for dust and fume extraction, rather than releasing process or combustion emissions, it is likely that actual SO_2 and NO_2 emissions would be significantly lower than estimated, since there is expected to be very little SO_2 and NO_2 in the dust extraction emissions.

Table 4-3: Criteria Pollutant Emissions Inventory – Kinetic Project

Emission Source	Estimated Average Emissions Rate in g/s				
	TSP	PM_{10}	$PM_{2.5}$	SO_2	NO_2
Point Source Emissions	4.43	4.43	4.43	44.31	35.45
Fugitive Emissions from Materials Handling at the Raw Material Stockpile	0.435	0.192	0.019		
Fugitive Emissions from Materials Handling and Unloading Slag Stockpile	0.191	0.084	0.008		
Uncaptured Fugitive Process Emission at the Furnace Workshop	0.808	0.151	0.086		
Fugitive Emissions from Conveyors and Conveyor Transfer Points	0.0301	0.0141	0.0014		
Vehicle Entrainment on On-site Paved Roads	0.1046	0.0204	0.0047		
Vehicle Entrainment on Access Road	5.42	1.04	0.25		
Total	**11.42**	**5.93**	**4.80**	**44.31**	**35.45**

5 DISPERSION MODELLING RESULTS

Dispersion modelling was undertaken to determine 99th percentile hourly, 99th percentile daily, and annual average ground level concentrations (GLCs). Averaging periods were selected to facilitate the comparison of predicted pollutant concentrations to relevant ambient air quality and inhalation health criteria.

Pollutants with the potential to result in human health impacts which are assessed in this study include PM_{10}, $PM_{2.5}$, NO_2 and SO_2. Ground level concentration or dustfall isopleths presented in this section depict interpolated values from the concentrations simulated by AERMOD for each of the receptor grid points specified.

Simulated daily (Figure 5-1) and annual (Figure 5-2) PM_{10} concentrations as well as simulated daily (Figure 5-3) and annual (Figure 5-4) $PM_{2.5}$ concentrations are in compliance with NAAQS for all areas outside the Kinetic Project boundary, including at all identified sensitive receptor locations.

If all point sources were to be operated at the Subcategory 4.9 MES, simulated hourly NO_2 (Figure 5-5) and SO_2 (Figure 5-7) concentrations, as well as daily SO_2 concentrations (Figure 5-8), may exceed the NAAQS limits outside the boundary of the Kinetic Project, but are in compliance with the NAAQS at all identified sensitive receptors, and for all areas outside the MMSEZ. However, given the nature of the majority of point sources at the Kinetic Project, which serve as dust and fume extraction, rather than the point of release of process or combustion emissions, it is unlikely that actual NO_2 and SO_2 emissions from point sources at the Kinetic Project would be as high as the Subcategory 4.9 MES allows, and ground-level impacts of these pollutants are expected to be significantly lower than those simulated.

Annual average NO_2 (Figure 5-6) and SO_2 (Figure 5-9) concentrations, even with all point sources operating at the Subcategory 4.9 MES, are below the NAAQS for these pollutants for all areas outside the Kinetic Project boundary, including at all identified sensitive receptor locations.

Simulated dust fallout rates are expected to be well below the NDCR residential and non-residential limit for all areas outside the project boundary (Figure 5-10).

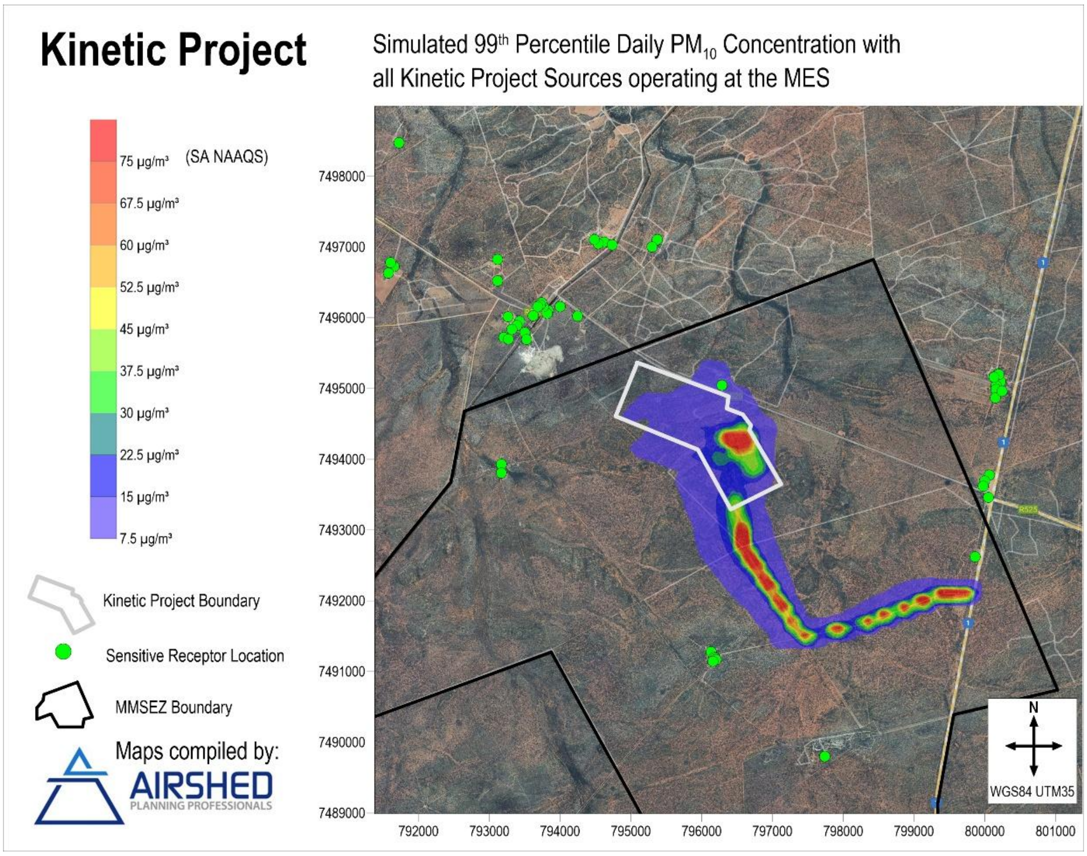


Figure 5-1: Simulated 99th Percentile Daily PM10 Concentration

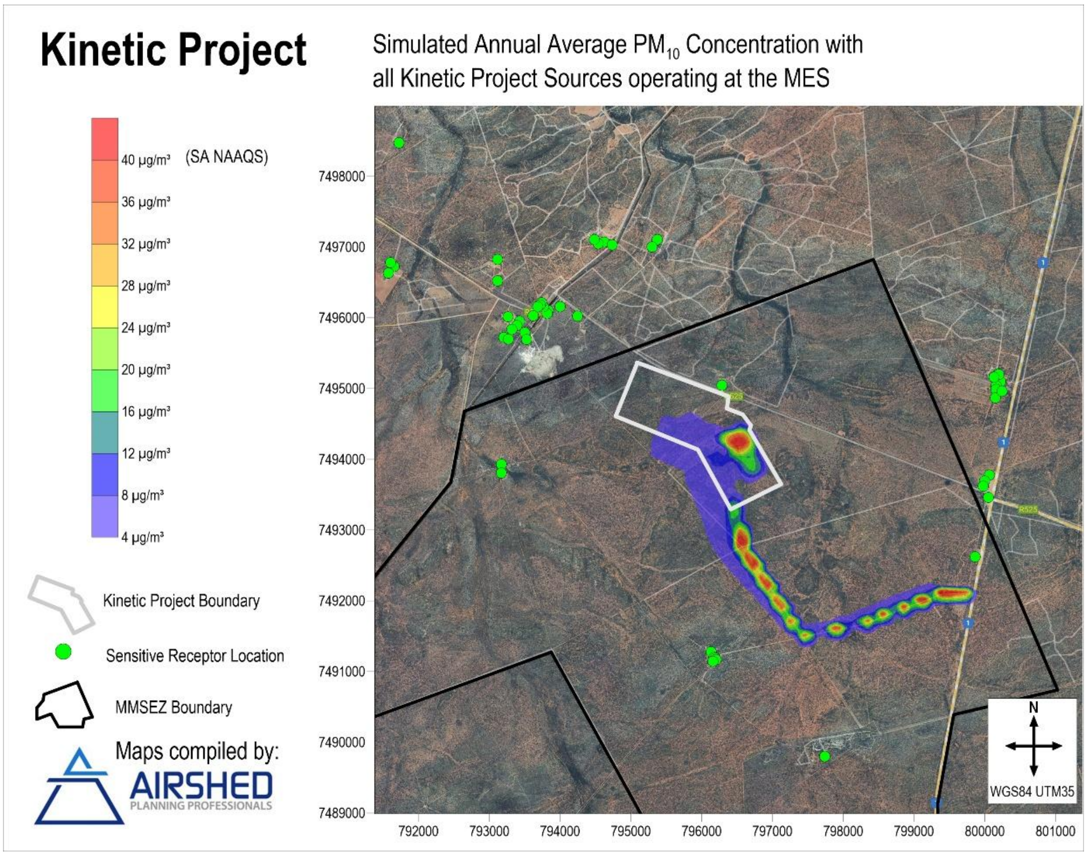


Figure 5-2: Simulated Annual Average PM10 Concentration

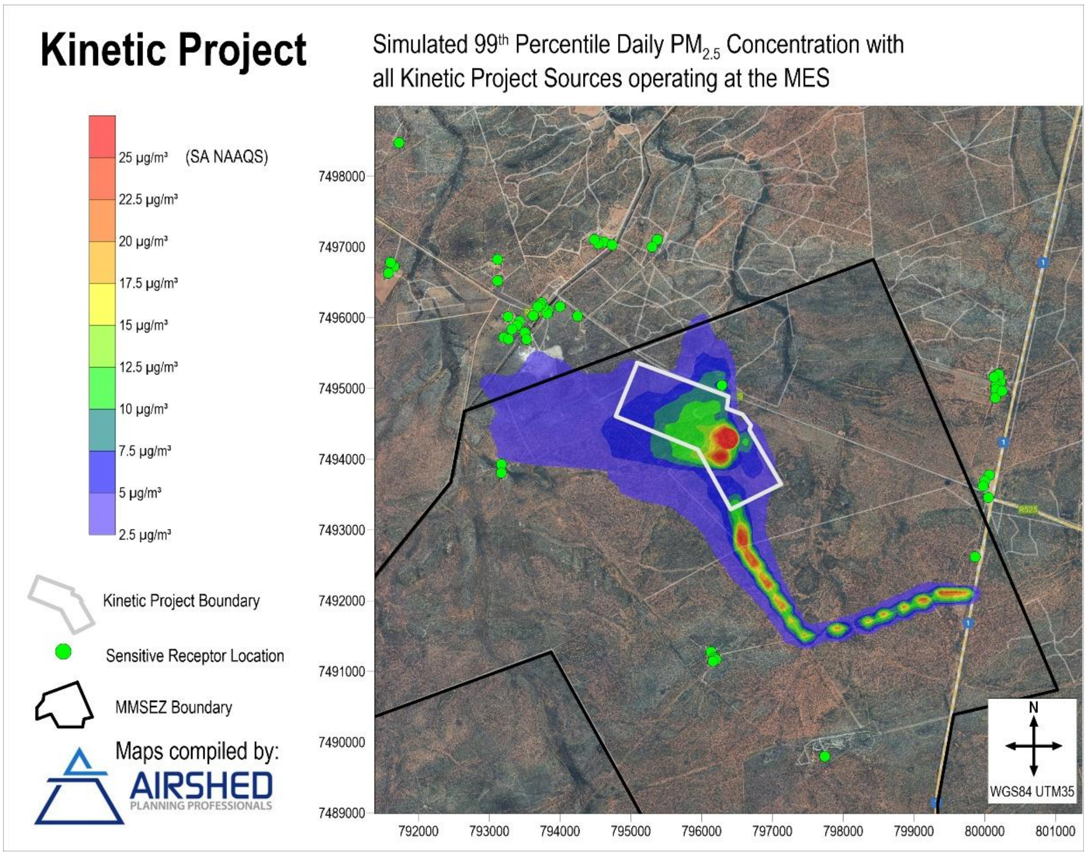


Figure 5-3: Simulated 99th Percentile Daily $PM_{2.5}$ Concentration

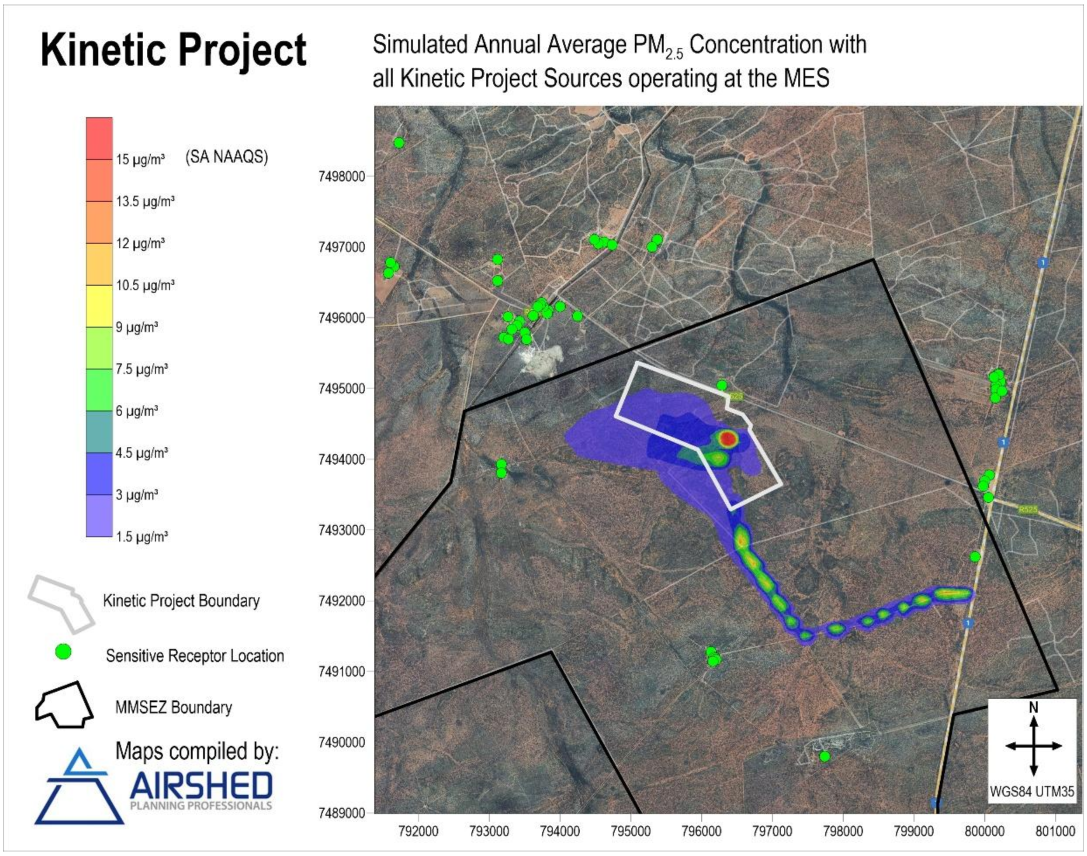


Figure 5-4: Simulated Annual Average $PM_{2.5}$ Concentration

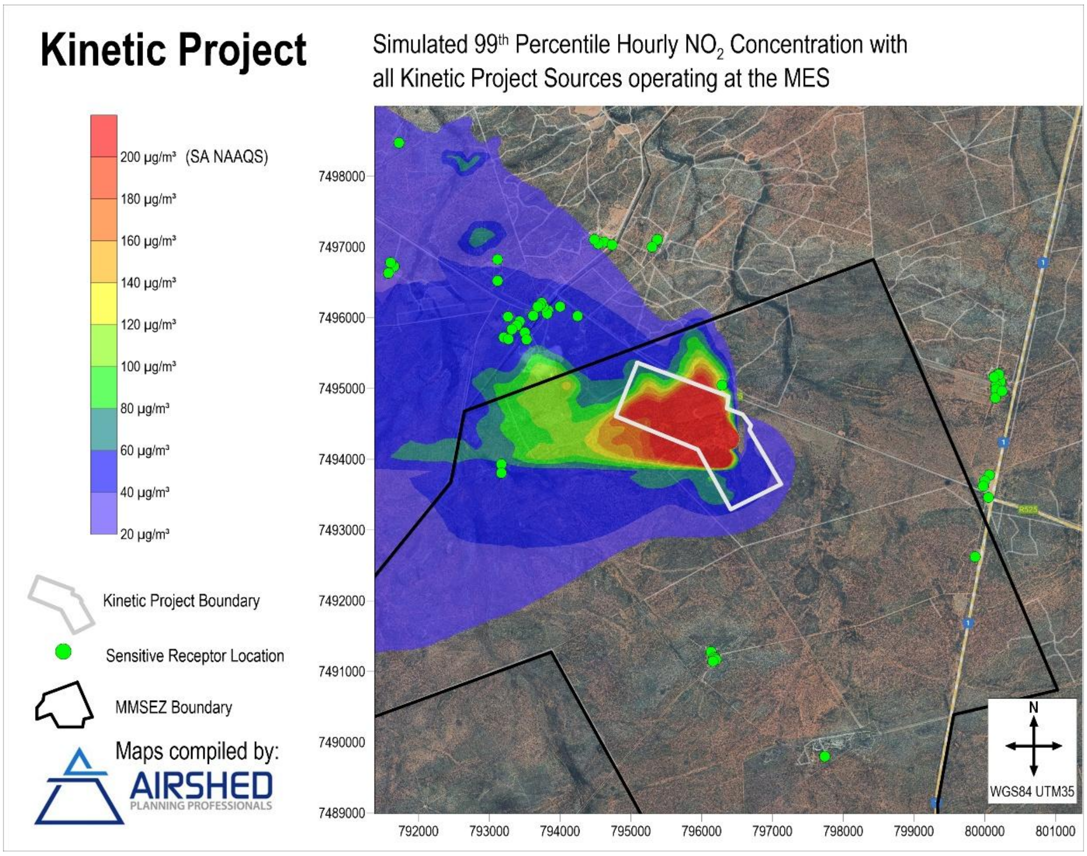


Figure 5-5: Simulated 99th Percentile Hourly NO_2 Concentration (all point sources operating at the MES)

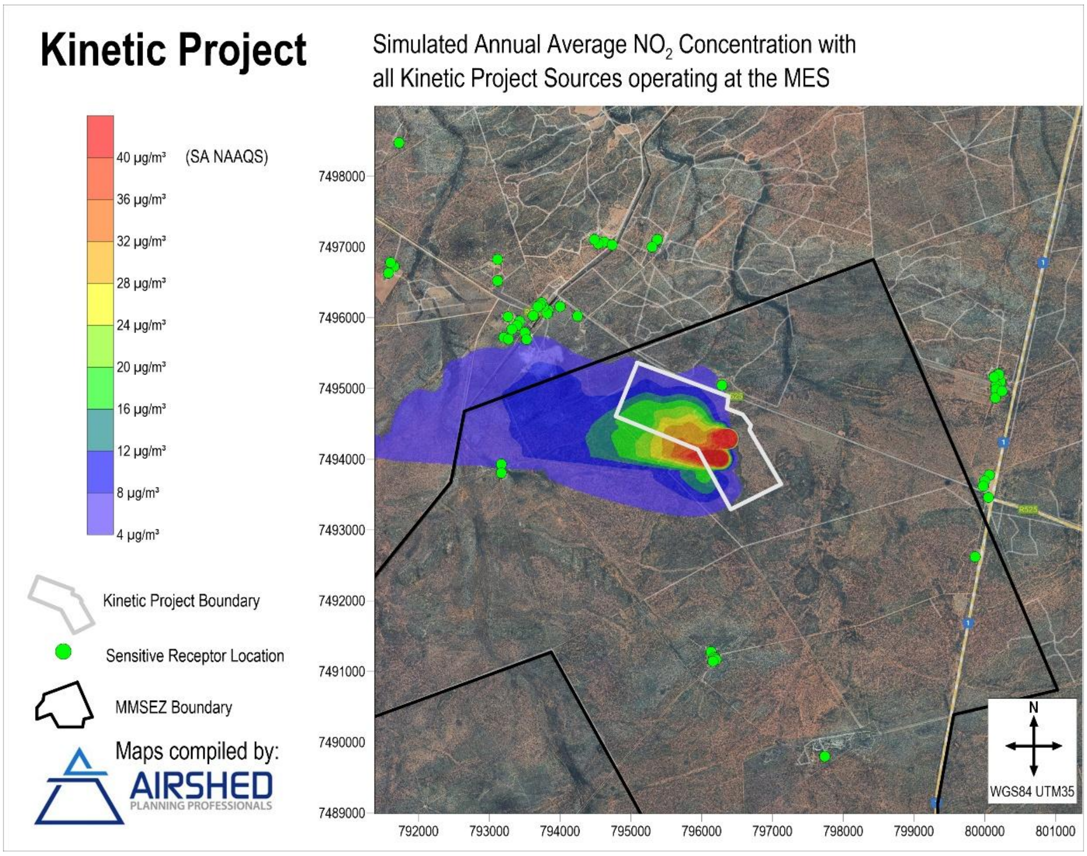


Figure 5-6: Simulated Annual Average NO_2 Concentration (all point sources operating at the MES)

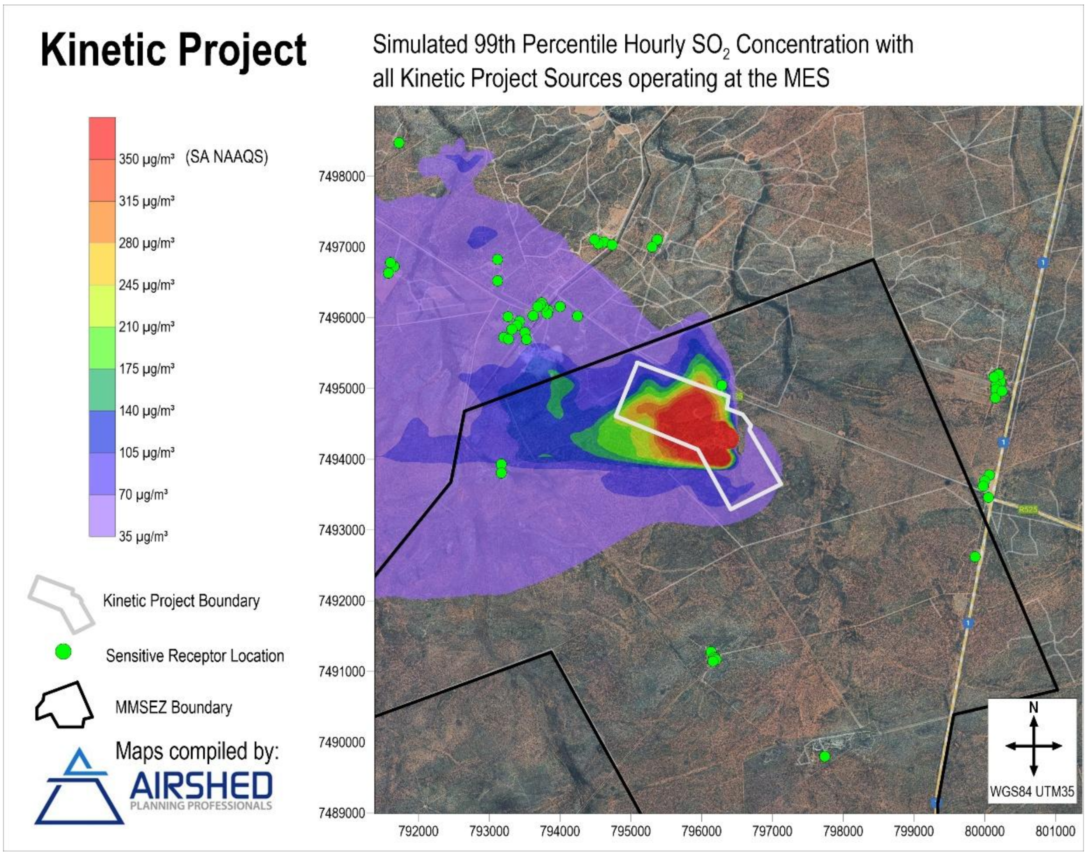


Figure 5-7: Simulated 99th Percentile Hourly SO_2 Concentration (all point sources operating at the MES)

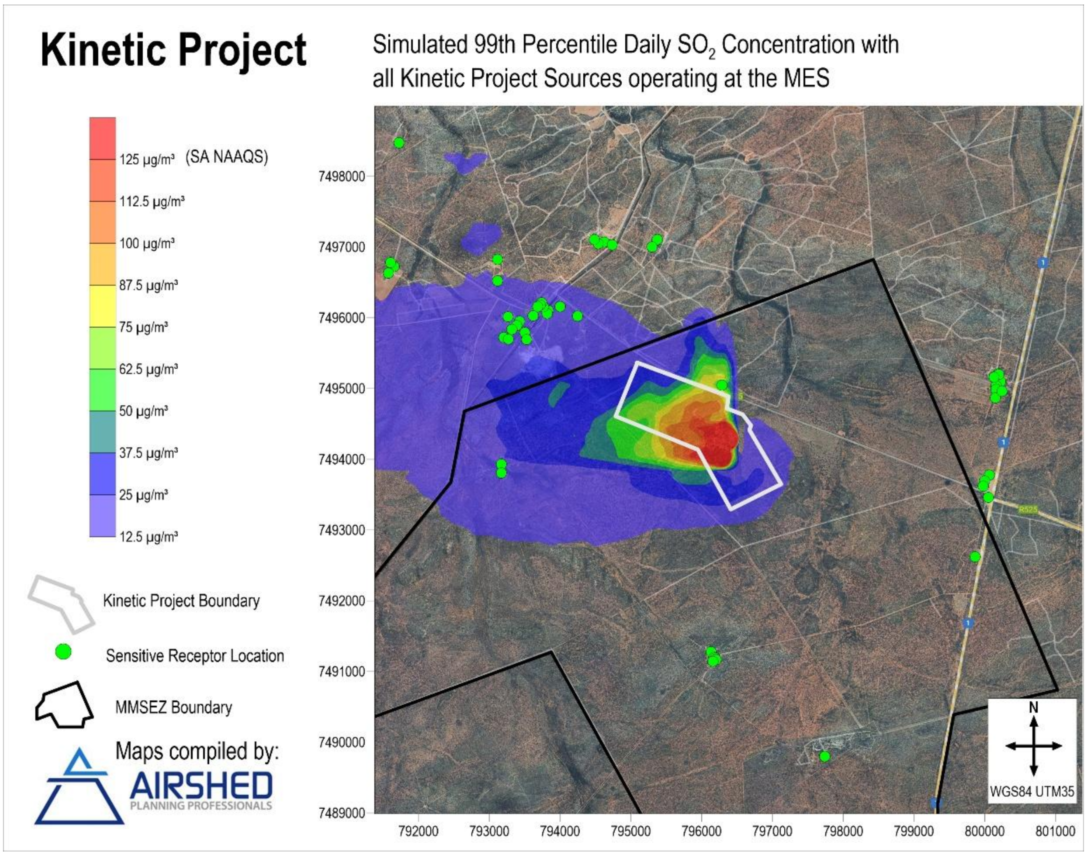


Figure 5-8: Simulated 99th Percentile Daily SO_2 Concentration (all point sources operating at the MES)

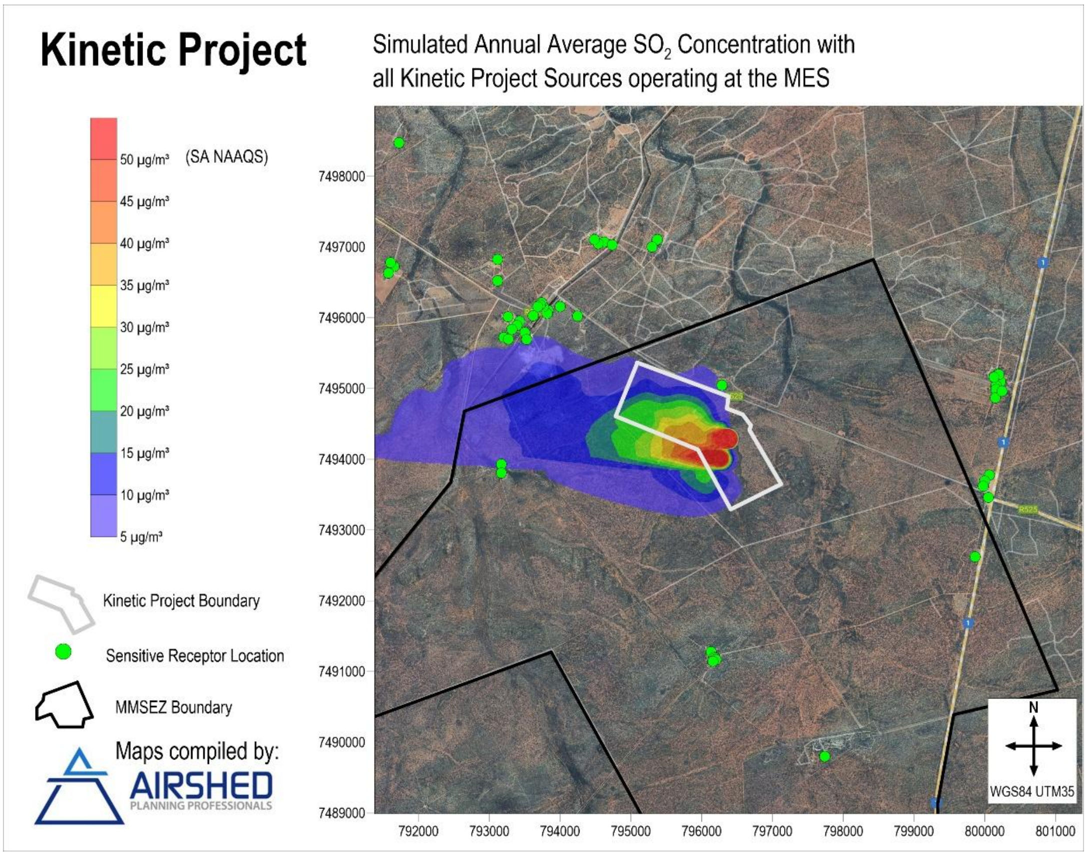


Figure 5-9: Simulated Annual Average SO_2 Concentration (all point sources operating at the MES)

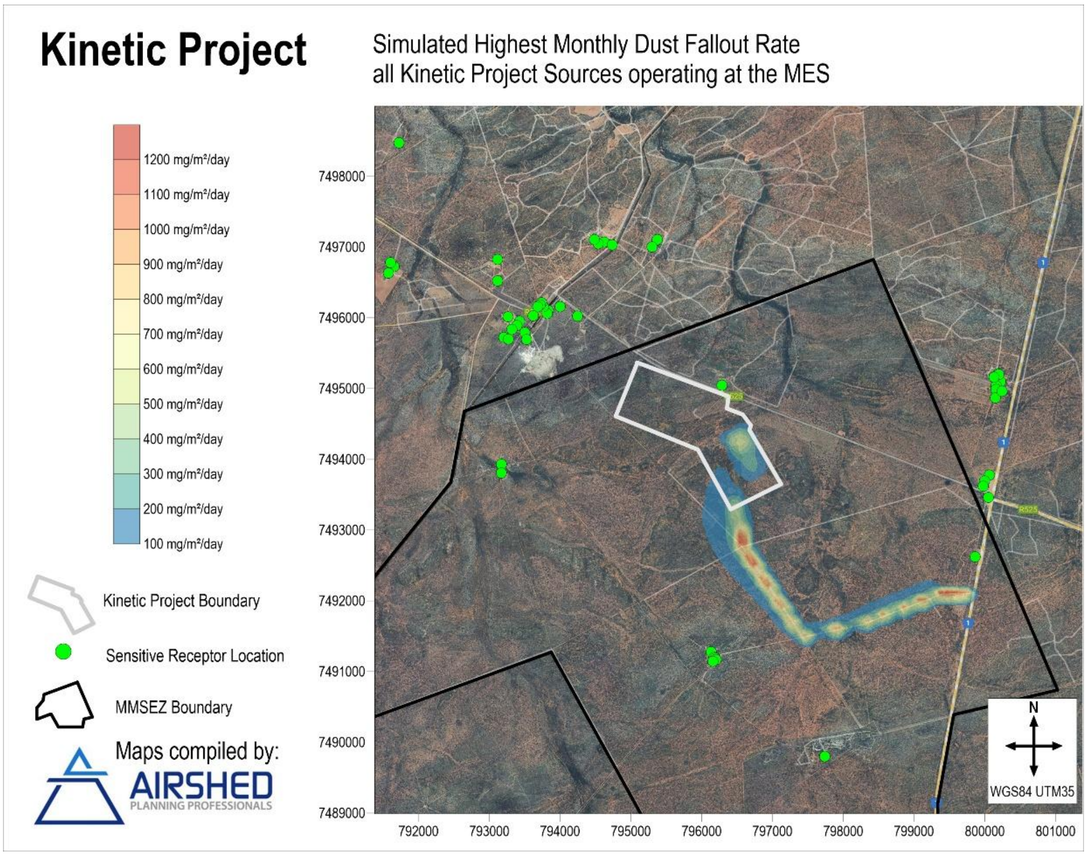


Figure 5-10: Simulated Highest Monthly Dust Fallout Rate

6 IMPACT SIGNIFICANCE RATING

Airshed was requested to provide an impact significance rating of expected air quality impacts based on the dispersion modelling results. Based on the modelling results, the significance ratings are provided in Table 6-1. The significance rating methodology (Appendix C) was provided by Gudani.

It should be noted that mitigation measures used for the assessing the "impact following mitigation" include the design mitigation measures for the Kinetic Project, including dust extraction and collection systems and the flue gas purification system for the primary furnace off-gas. The pre-mitigation significance rating is therefore given for a hypothetical scenario where abatement equipment was not included in the design of the plant.

With the design mitigation measures in place, best practice mitigation and management measures applied to fugitive emission sources, and compliance with the Subcategory 4.9 MES for all point sources, the expected impact of the Kinetic Project on ambient air quality in the receiving environment is **Low**.

Table 6-1: Significance rating for air quality impacts due to Project activities

Aspect	Extent	Duration	Intensity	Probability	Weighting Factor	Significance Rating	Mitigation Efficiency	Significance Following Mitigation
Elevated PM_{10} and $PM_{2.5}$ concentrations as a result of Kinetic Project Activities	2	4	5	5	5	80	0.2	16
Elevated NO_2 and SO_2 concentrations as a result of Kinetic Project Activities	2	4	3	1	3	30	0.4	12
Elevated Dust Fallout as a result of Kinetic Project Activities	1	4	1	2	2	16	0.4	6.4

7 CONCLUSION AND RECOMMENDATIONS

Simulated daily and annual PM_{10} and $PM_{2.5}$ concentrations, as well as simulated annual average SO_2 and NO_2 concentrations, are in compliance with the NAAQS for all areas outside the Kinetic Project boundary, including at all identified sensitive receptor locations.

If all point sources were to be operated at the Subcategory 4.9 MES, simulated hourly NO_2 and SO_2 concentrations, as well as daily SO_2 concentrations, could exceed the NAAQS limits outside the boundary of the Kinetic Project, but are in compliance with the NAAQS at all identified sensitive receptor locations, and for all areas outside the MMSEZ. However, given the nature of the majority of point sources at the Kinetic Project, which serve as dust and fume extraction, rather than the point of release of process or combustion emissions, it is unlikely that actual NO_2 and SO_2 emissions from point sources at the Kinetic Project would be as high as the Subcategory 4.9 MES allows, and ground-level impacts of these pollutants are expected to be significantly lower than those simulated.

Based on the findings of the air dispersion modelling, the following mitigation and management measures are recommended:

- All point sources and emission abatement equipment should be designed to comply with the Subcategory 4.9 minimum emission standards.
- Best practice management and mitigation measures should be employed to minimise emissions from fugitive dust sources, including:
  - Regular cleanup of paved road surfaces;
  - Regular maintenance and servicing of dust extraction abatement equipment;
  - Installation of wind breaks around the raw material stockpiles, or enclosure of the stockpiles, to minimise fugitive dust emissions from handling of raw materials; and
  - Regular visible inspection of emission from the raw material stockpiles and slag stockpile.
- If the access road between the entrance to the MMSEZ and the Kinetic Project is unpaved, regular water sprays should be applied to the road to minimise dust emissions. It is however recommended that the road be paved and regularly cleaned and maintained.
- It is recommended that short term dust fallout monitoring be conducted at the project boundary closest to the raw material stockpiles and slag stockpile to confirm dust fallout at the site boundary is in compliance with the National Dust Control regulations once the project is operational.
- It is also recommended that a once-off sampling campaign for NO_2 and SO_2 concentrations be conducted at the project boundary to confirm compliance with the NAAQS.
- A complaints register must be kept and residents of nearby homesteads and villages, as well as Kinetic Project personnel, should be encouraged to report any air quality or dust related complaints.

It is the specialist's opinion that the project can be authorised if the design of the plant ensures compliance with the Subcategory 4.9 MES and the above recommendations are taken into consideration in the Environmental Management Plan for the project.

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APPENDIX A – SPECIALIST CURRICULUM VITAE

Name	Nick Brian Grobler
Date of Birth	14 August 1986
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Senior Air Quality and Noise Specialist
Profession	Chemical Engineer employed as an Air Quality and Noise Specialist
Years with Firm	Since May 2011

Education

- BEng (Chemical Engineering) University of Pretoria – Completed in 2009
- BEng (Hons) (Environmental Engineering) University of Pretoria – Completed in 2010

Membership of Professional Societies

- Institution of Chemical Engineers (IChemE) – Associate Member – 2014 to present.
- Golden Key International Honour Society - 2011 to present.

Experience

- Project management, proposal preparation and project invoicing.
- Emissions inventory compilation. Proficient in quantifying emissions using:
    - Engineering calculations, isokinetic and continuous stack sampling results, US EPA AP42 emission factors, Australian NPI emission factors, IPCC emission factors, ADDAS model (wind erosion), US EPA TANKS, Water9, GasSim.
- Meteorological, topographical and land use data processing and preparation.
- Dispersion modelling: experienced in SCREEN, AERMOD, ADMS, CALPUFF, SLAB and HAWK dispersion models.
- Proficient with the following specialist air quality / noise software: R, OpenAir, WRPlot, Surfer, ADDAS, TANKS, GasSim, CadnaA.
- Impact and compliance assessment.
- Air quality and dust management plan preparation.
- Air quality monitoring program design and implementation.
- Air quality monitoring set-up, training, processing and interpretation of:
    - SO_2, NO_2, CO, CH_4, O_3, HCl, VOCs, BTEX, H_2S, NH_3, PAHs, PM_{10}, $PM_{2.5}$, dust fallout, salt deposition, chloride deposition and meteorological parameters.
- Environmental noise monitoring campaign design.
- Environmental noise monitoring and data processing.
- Noise source monitoring and sound power level estimation.

- Ground vibration and overblast monitoring and reporting.
- Compilation of noise source inventories.
- Noise impact and compliance assessments.
- Atmospheric Emission License application.
- Greenhouse gas emissions inventories and pollution prevention plan preparation.
- Experienced in the compilation of:
    - Monthly, quarterly and annual air quality monitoring reports,
    - Noise survey reports,
    - Baseline, scoping and air quality impact assessment reports,
    - Air quality management plans,
    - Emission reduction plans, pollution prevention plans, greenhouse gas and climate change impact assessments
    - Health impact assessments, odour assessments and radiation studies.
- Online NAEIS (National Atmospheric Emissions Inventory System) and SAGERS (South African Greenhouse Gas Emissions Reporting System) completion and submission.
- Industry sectors in which experience have been gained with specific reference to air quality include:
    - Opencast and underground mining of: copper, platinum, chrome, gold, iron, coal, limestone, potash, graphite, lead, mineral sands, aggregate stone, clay and zinc.
    - Production of: copper, platinum, PGM metals, gold, base metals, iron, steel, coal, coke, heavy mineral sands, vanadium, solder, lime, urea, chrome, gypsum, asphalt, acetylene, LNG liquefaction, vegetable oil, fertilizer, explosives, wood pulp, cement, grease, oil recycling, tyre and general waste pyrolysis, power generation, fuel storage as well as crematoriums, general waste landfills, meat processing and rendering at abattoirs and animal waste incineration.

Courses Completed

- Spreadsheets as an Engineering Tool, Presented by the University of Pretoria, RSA (September 2012)

Courses Presented

- NWU Centre for Environmental Management Essential Air Quality Management Course
- NWU Centre for Environmental Management Integrated Waste Law Course – Air Quality Aspects

Countries of Work Experience

South Africa, Zimbabwe, Namibia, Mozambique, Zambia, Democratic Republic of Congo, Republic of Congo, Ghana, Liberia, Morocco, Mali, Guinea, Suriname, Saudi Arabia

Languages

Language	Proficiency
English	Full proficiency
Afrikaans	Full proficiency

APPENDIX B – DECLARATION OF INDEPENDENCE

DECLARATION OF INDEPENDENCE - PRACTITIONER

Name of Practitioner: Nick Grobler

Name of Registration Body: South African Institution of Chemical Engineers

Professional Registration No.: 006483 - Member

Declaration of independence and accuracy of information provided:

Atmospheric Impact Report in terms of section 30 of the Act.

I, Nick Brian Grobler, declare that I am independent of the applicant. I have the necessary expertise to conduct the assessments required for the report and will perform the work relating the application in an objective manner, even if this results in views and findings that are not favourable to the applicant. I will disclose to the applicant and the air quality officer all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the air quality officer. The information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct. I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at Johannesburg on this 29th day of May 2025

SIGNATURE

Senior Air Quality and Noise Specialist

CAPACITY OF SIGNATORY

APPENDIX C - METHODOLOGY USED IN DETERMINING THE SIGNIFICANCE OF ENVIRONMENTAL IMPACTS

Assessment Criteria

The criteria for the description and assessment of environmental impacts were drawn from the EIA Guidelines (DEAT, 1998) and as amended from time to time (DEAT, 2002)

The level of detail as depicted in the EIA Guidelines (DEAT, 1998) (DEAT, 2002)) was fine-tuned by assigning specific values to each impact. In order to establish a coherent framework within which all impacts could be objectively assessed, it was necessary to establish a rating system, which was applied consistently to all the criteria. For such purposes each aspect was assigned a value, ranging from one (1) to five (5), depending on its definition. This assessment is a relative evaluation within the context of all the activities and the other impacts within the framework of the project.

An explanation of the impact assessment criteria is defined below.

Table 0-1: Impact Assessment Criteria

EXTENT	
Classification of the physical and spatial scale of the impact	
Footprint	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.
Site	The impact could affect the whole, or a significant portion of the site.
Regional	The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns.
National	The impact could have an effect that expands throughout the country (South Africa).
International	Where the impact has international ramifications that extend beyond the boundaries of South Africa.
DURATION	
The lifetime of the impact that is measured in relation to the lifetime of the proposed development.	
Short term	The impact will either disappear with mitigation or will be mitigated through a natural process in a period shorter than that of the construction phase.
Short to Medium term	The impact will be relevant through to the end of a construction phase (1.5 years).
Medium term	The impact will last up to the end of the development phases, where after it will be entirely negated.
Long term	The impact will continue or last for the entire operational lifetime i.e. exceed 30 years of the development, but will be mitigated by direct human action or by natural processes thereafter.
Permanent	This is the only class of impact, which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient.
INTENSITY	
The intensity of the impact is considered by examining whether the impact is destructive or benign, whether it destroys the impacted environment, alters its functioning, or slightly alters the environment itself. The intensity is rated as	

Low	The impact alters the affected environment in such a way that the natural processes or functions are not affected.
Medium	The affected environment is altered, but functions and processes continue, albeit in a modified way.
High	Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases.
PROBABILITY	
This describes the likelihood of the impacts actually occurring. The impact may occur for any length of time during the life cycle of the activity, and not at any given time. The classes are rated as follows:	
Improbable	The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0 %).
Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chances of this impact occurring is defined as 25 %.
Likely	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of this impact occurring is defined as 50 %.
Highly Likely	It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined as 75 %.
Definite	The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100 %.

The status of the impacts and degree of confidence with respect to the assessment of the significance must be stated as follows:

- **Status of the impact:** A description as to whether the impact would be positive (a benefit), negative (a cost), or neutral.
- **Degree of confidence in predictions:** The degree of confidence in the predictions, based on the availability of information and specialist knowledge.

Other aspects to take into consideration in the specialist studies are:

- Impacts should be described both before and after the proposed mitigation and management measures have been implemented.
- All impacts should be evaluated for the full-lifecycle of the proposed development, including construction, operation and decommissioning.
- The impact evaluation should take into consideration the cumulative effects associated with this and other facilities which are either developed or in the process of being developed in the region.
- The specialist studies must attempt to quantify the magnitude of potential impacts (direct and cumulative effects) and outline the rationale used. Where appropriate, national standards are to be used as a measure of the level of
- impact.

Mitigation

The impacts that are generated by the development can be minimised if measures are implemented in order to reduce the impacts. The mitigation measures ensure that the development considers the environment and the predicted impacts in order to minimise impacts and achieve sustainable development.

Determination of Significance-Without Mitigation

Significance is determined through a synthesis of impact characteristics as described in the above paragraphs. It provides an indication of the importance of the impact in terms of both tangible and intangible characteristics. The significance of the impact "without mitigation" is the prime determinant of the nature and degree of mitigation required. Where the impact is positive, significance is noted as "positive". Significance is rated on the following scale:

Table 0-2: Significance-Without Mitigation

NO SIGNIFICANCE	The impact is not substantial and does not require any mitigation action.
LOW	The impact is of little importance, but may require limited mitigation.
MEDIUM	The impact is of importance and is therefore considered to have a negative impact. Mitigation is required to reduce the negative impacts to acceptable levels.
HIGH	The impact is of major importance. Failure to mitigate, with the objective of reducing the impact to acceptable levels, could render the entire development option or entire project proposal unacceptable. Mitigation is therefore essential.

Determination of Significance- With Mitigation

Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the necessary mitigation measures. Significance with mitigation is rated on the following scale:

Table 0-3: Significance- With Mitigation

NO SIGNIFICANCE	The impact will be mitigated to the point where it is regarded as insubstantial.
LOW	The impact will be mitigated to the point where it is of limited importance.
LOW TO MEDIUM	The impact is of importance, however, through the implementation of the correct mitigation measures such potential impacts can be reduced to acceptable levels.
MEDIUM	Notwithstanding the successful implementation of the mitigation measures, to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw.
MEDIUM TO HIGH	The impact is of major importance but through the implementation of the correct mitigation measures, the negative impacts will be reduced to acceptable levels.
HIGH	The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and taken within the overall context of the project, is

	regarded as a fatal flaw. An impact regarded as high significance, after mitigation could render the entire development option or entire project proposal unacceptable.

Assessment Weighting

Each aspect within an impact description was assigned a series of quantitative criteria. Such criteria are likely to differ during the different stages of the project's life cycle. In order to establish a defined base upon which it becomes feasible to make an informed decision, it was necessary to weigh and rank all the criteria.

Ranking, Weighting and Scaling

For each impact under scrutiny, a scaled weighting factor is attached to each respective impact (refer Table 0-4). The purpose of assigning weights serves to highlight those aspects considered the most critical to the various stakeholders and ensure that each specialist's element of bias is taken into account. The weighting factor also provides a means whereby the impact assessor can successfully deal with the complexities that exist between the different impacts and associated aspect criteria.

Simply, such a weighting factor is indicative of the importance of the impact in terms of the potential effect that it could have on the surrounding environment. Therefore, the aspects considered to have a relatively high value will score a relatively higher weighting than that which is of lower importance.

Table 0-4: Description of assessment parameters with its respective weighting

EXTENT		**DURATION**		**INTENSITY**		**PROBABILITY**		**WEIGHTING FACTOR (WF)**		**SIGNIFICANCE RATING (SR)**	
Footprint	1	Short term	1	Low	1	Improbable	1	Low	1	Low	0-19
Site	2	Short to Medium	2			Possible	2	Low to Medium	2	Low to Medium	20-39
Regional	3	Medium term	3	Medium	3	Likely	3	Medium	3	Medium	40-59
National	4	Long term	4			Highly Likely	4	Medium to High	4	Medium to High	60-79
International	5	Permanent	5	High	5	Definite	5	High	5	High	80-100
MITIGATION EFFICIENCY (ME)						**SIGNIFICANCE FOLLOWING MITIGATION (SFM)**					
High			0.2			Low		0 - 19			
Medium to High			0.4			Low to Medium		20 - 39			
Medium			0.6			Medium		40 - 59			
Low to Medium			0.8			Medium to High		60 - 79			
Low			1.0			High		80 - 100			

Identifying the Potential Impacts Without Mitigation Measures (WOM)

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned weightings, resulting in a value for each impact (prior to the implementation of mitigation measures).

Equation 1:

Significance Rating (WOM) = (Extent + Intensity + Duration + Probability) x Weighting Factor

Identifying the Potential Impacts With Mitigation Measures (WM)

In order to gain a comprehensive understanding of the overall significance of the impact, after implementation of the mitigation measures, it was necessary to re-evaluate the impact.

Mitigation Efficiency (ME)

The most effective means of deriving a quantitative value of mitigated impacts is to assign each significance rating value (WOM) a mitigation efficiency (ME) rating (refer to *Table 0-4*). The allocation of such a rating is a measure of the efficiency and effectiveness, as identified through professional experience and empirical evidence of how effectively the proposed mitigation measures will manage the impact.

Thus, the lower the assigned value the greater the effectiveness of the proposed mitigation measures and subsequently, the lower the impacts with mitigation.

Equation 2:

Significance Rating (WM) = Significance Rating (WOM) x Mitigation Efficiency

or WM = WOM x ME

Significance Following Mitigation (SFM)

The significance of the impact after the mitigation measures are taken into consideration. The efficiency of the mitigation measure determines the significance of the impact. The level of impact is therefore seen in its entirety with all considerations taken into account.