Ambient Air Quality Impact Study Commissioned By

NSOVO ENVIRONMENTAL CONSULTING

ON BEHALF OF KHANYAZWE FLEXPOWER

Project Reference 0124-P041-NSO KFP AQIS

Date 24 June 2024

This report documents the results and findings of an air quality impact study in support of the proposed 1 000MW natural gas-fired power plant in Malelane within the Nkomazi Local Municipality and Ehlanzeni District Municipality of the Mpumalanga Province.

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EXECUTIVE SUMMARY

EHRCON (Pty) Ltd (EHRCON) was commissioned by Nsovo Environmental Consulting (Nsovo Environmental) to assess the air quality impact associated with the proposed 1 000MW natural gas-fired power plant of Khanyazwe Flexpower (Pty) Ltd (KFP). The proposed project will be located on Portions 1, 4, and 116 of Farm Malelane 389 FP, in Malelane within the Nkomazi Local Municipality and the Ehlanzeni District Municipality of the Mpumalanga Province.

The project involves developing, constructing, and operating a 1 000MW natural gas-fired power plant using reciprocating engine technology. The proposed project will comprise of a phased development approach, with Phase 1: 440MW to be built by 2028 and Phase 2: 560MW to be completed by 2030.

KFP will source gas from the Republic of Mozambique Pipeline Investments Company (ROMPCO), which has an existing gas pipeline that connects Mozambique's Pande Temane gas fields to Sasol's operations in South Africa, as well as several industrial and retail customers. Alternative gas sources may include imported Liquid Natural Gas (LNG) projects developed in Matola, which will provide additional gas into the ROMPCO pipeline. KFP is also proposing the development of approximately two 500 metre 275 KV and/or 132 kV overhead powerlines from the proposed power plant to the existing Eskom Khanyazwe substation. The power plant will provide a mid-merit power profile to the national grid.

The objectives of the air quality impact study were to describe the ambient emissions from the KFP Power Plant and to assess the impact on the health of the receiving community. The findings of the study are aimed at providing KFP, the Ehlanzeni District Municipality and other stakeholders with scientific data required in terms of present and future air quality management systems.

The assessment considered a review of the relevant health legislation, ambient air quality guidelines and standards. A process description was provided, and an overview given of the prevailing meteorological conditions in the area. An overview was given of the available data on criteria air pollutant concentrations. A process emission inventory was compiled, founded on current emission factors. An evaluation of the potential for human health and environmental impacts, centred on comparisons of modelled pollutant concentrations with relevant guidelines and standards was performed. An assessment of the contribution and outcome of the process on the current air quality, completed the study.

The air quality impact study concludes the following:

- The project falls within the Nkomazi Local Municipality and the Ehlanzeni District Municipality of the Mpumalanga Province. Air Quality Management is defined within the Ehlanzeni District Municipality Integrated Development Plan, as well as the Municipal Health Services By-Laws.
- Emission rates will remain stable throughout the life of the project, influenced only by fluctuations in power requirements.
- A total emission rate of 9.99E+4 gram per second was calculated for power generation using reciprocating technology.
- Primary combustion emissions will be the dominant source of ambient pollution, discharging more than 99.9% of the total emission load. Less than 0.1% of the atmospheric pollution load will be attributed to fugitive emissions from support processes, fuel handling and vehicle movement.
- NO_2 is the criteria pollutant of concern and contributes about 0.29% of the pollution load.
- Dispersion of particulate emissions from the process was modelled using the ISC-AERMOD View model based on the standard Gaussian solution.
- The results present the spectrum from maximum ground level concentration to maximum impact area, and accounts for daily and annual reference periods.

  Ground level concentrations were predicted for atmospheric conditions based on local meteorological data for the period 1 May 2019 to 30 April 2024. Winds from the southeastern sector (33.7%) were mostly reported for the study area. Calm periods were the exception and wind speeds were most often brisk, between 3.6 and 5.7 m/s (29.3%). Moderate winds between 2.1 and 3.6 m/s were recorded

28%, light winds between 0.5 and 2.1 m/s were recorded 24.5%, and strong winds above 5.7m/s, about 16.6% of the time.

- Dust deposition rates during construction are expected to remain at current levels at all the closest receivers identified. Incremental $PM_{10/2.5}$ concentrations will probably remain below 5% of the relevant standards.
- During operation at full capacity, PM_{10} is expected to peak about 1.6 kilometres east of the plant at daily concentrations between 10 and 25% of the standard. Isolated areas where concentrations above 10% of the standard may occur can be expected up to 6 kilometres east through to south of the plant during maximum pollution events.
- SO_2 concentrations are expected to peak above 5% of the standard, east through to south of the plant at an average distance of 2.5 kilometres.
- PM_{10} and SO_2 concentrations will most likely be insignificant for all other reference periods.
- A significant number of hourly NO_2 exceedances can be expected due east and southeast of the plant. Incremental annual NO_2 concentrations are projected to be in the region of 25% of the standard.
- It is unlikely that the process independently, would result in average NO_2 concentrations above current background concentrations at the nearest residential receivers.
- The incremental impact of all pollutants during construction is expected to be negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of PM_{10}, SO_2 and VOC during normal operation is expected to be negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of NO_2 during normal operation is expected to be negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.

- Controlled emissions can be further mitigated through application of best available industrial control measures and sound environmental management principles. A reduction in emissions of up to 98% can be achieved.
- Continuous monitoring of ambient PM_{10}, SO_2, NO_2 and VOC concentrations for a minimum period of one (1) year before commissioning of the plant and in accordance with the Atmospheric Emission Licence (AEL) requirements, thereafter, should be performed. For the background monitoring, one monitoring station, placed in the main impact area of the future plant, should suffice. Background monitoring data will be critical to determine the proportional impact of the plant in the cumulative setting.
- Ambient monitoring should be used in combination with modelling and emission inventory to assess the effectiveness of control measures at source and receivers, throughout the life of the project. It will also contribute to open communication to all stakeholders.

DECLARATION AND REPORT APPROVAL

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- it acts as an independent specialist.
- all results and related data have been obtained through careful and precise execution of recognised methods of evaluation and are related to the scope of work covered in this report and of prevailing conditions at the time of the assessment.
- the opinions and interpretations are embraced through judgment, discernment and comprehension to the best of available knowledge and are outside the scope of any accreditation.
- it performed the work relating to this project in an objective manner, notwithstanding the results, views and findings.
- it has expertise in conducting the specialist report relevant to this project, including knowledge of the Act, regulations and any guidelines that may have relevance.
- it complies with the Act, regulations and all other applicable legislation.
- it has no, and will not engage in, conflicting interests in the undertaking of the activity.
- it undertakes to disclose to the client and authorities all material information it possesses that reasonably has or may have the potential of objectively influencing any decision based on the results and finings of this project.
- all the particulars furnished by EHRCON in this report are true and correct; and any false declaration is a punishable offence.

Report compile by EHRCON (Pty) Ltd

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1.1 PROJECT OUTLINE

EHRCON (Pty) Ltd (EHRCON) was commissioned by Nsovo Environmental Consulting (Nsovo Environmental) to assess the air quality impact associated with the proposed 1 000MW natural gas-fired power plant of Khanyazwe Flexpower (Pty) Ltd (KFP). The proposed project will be located on Portions 1, 4, and 116 of Farm Malelane 389 FP, in Malelane within the Nkomazi Local Municipality and the Ehlanzeni District Municipality of the Mpumalanga Province.

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The assessment considered a review of the relevant health legislation, ambient air quality guidelines and standards. A process description was provided, and an overview given of the prevailing meteorological conditions in the area. An overview was given of the available data on criteria air pollutant concentrations. A process emission inventory was compiled, founded on current emission factors. An evaluation of the potential for human health and environmental impacts, centred on comparisons of modelled pollutant concentrations with relevant guidelines and standards was performed. An assessment of the contribution and outcome of the process on the current air quality, completed the study.

The report was compiled with due consideration of all process information and specific conditions outlined by Nsovo Environmental Consulting and Khanyazwe Flexpower.

1.2 PROJECT DESCRIPTION

The study area is located in the Nkomazi Local Municipality, within the Ehlanzeni District Municipality of the Mpumalanga Province. Current land use includes agricultural, residential and commercial (See Error! Reference source not found.).

The assessment of the potential air quality impact associated with the KFP Power Plant comprised the following terms of reference:

- A review of relevant health legislation, ambient air quality guidelines and standards.
- A process description and emission inventory.
- An overview of the topography, geography and prevailing meteorological conditions in the area.
- An overview of available data on criteria air pollutant concentrations in the area.
- Evaluation of the potential for human health and environmental impacts centred on comparisons of modelled pollutant concentrations with relevant guidelines and standards.
- Assessment of the contribution and outcome of the process on the current air quality parameters in the study area.

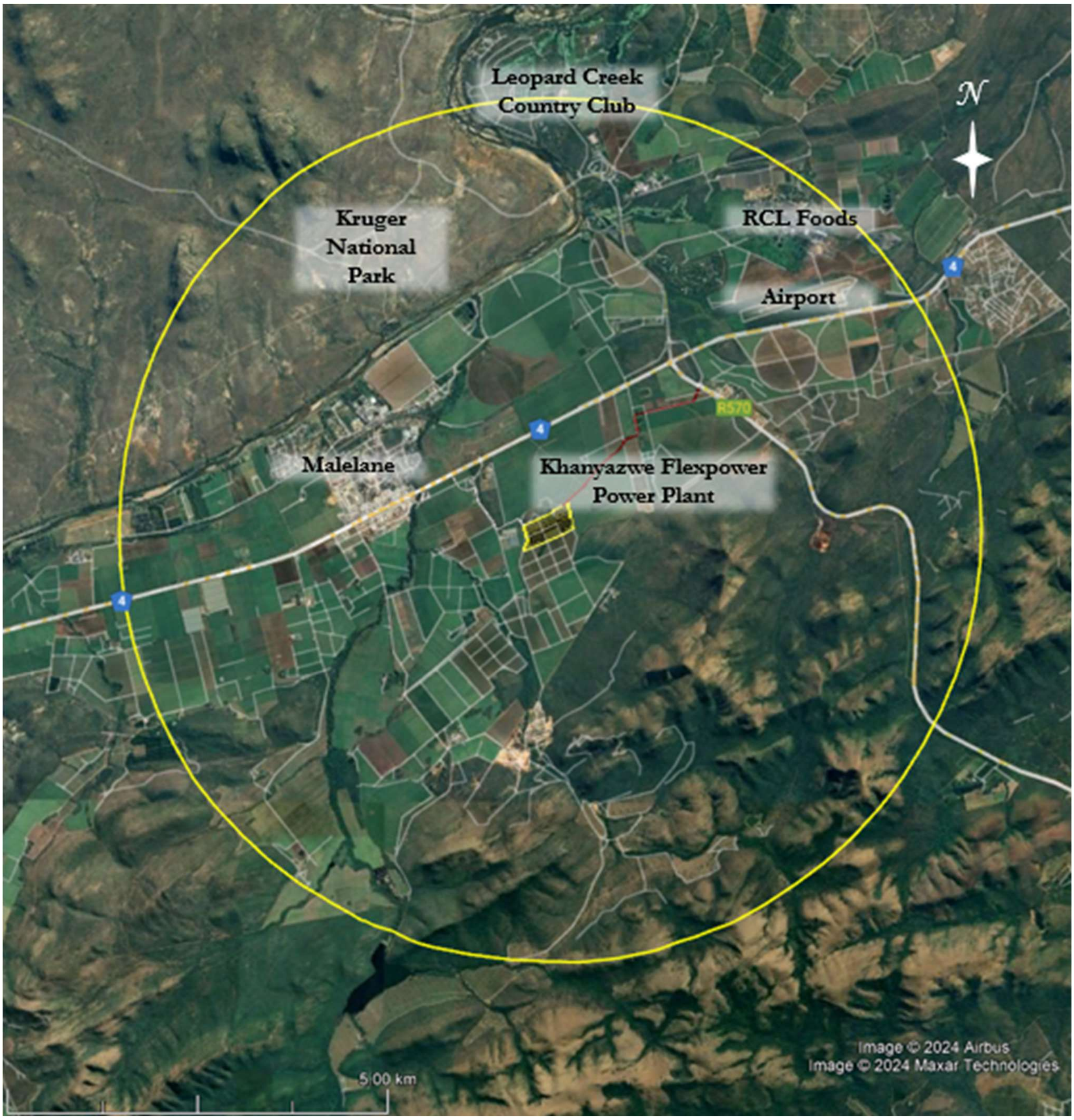

Figure 1: Khanyazwe Flexpower Power Plant Location

1.3 METHODOLOGICAL OVERVIEW

The establishment of an emissions inventory formed the basis for assessing the impact from the KFP Power Plant. This comprised the identification of sources of emission and the quantification of each source's contribution to ambient air concentrations. In the emissions inventory, dispersion simulation and impact assessment, reference was made to routine emissions from the process.

Process emission rates were obtained from emission factors which associate the quantity of a pollutant to the activity associated with its release. Due to the absence of locally generated emission factors, use was made of the comprehensive set of emission factors published by the United States Environmental Protection Agency (US-EPA) in its AP-42 document *Compilation of Pollution Emission Factors.*

The simulation of emissions was performed through the application of the ISC-AERMOD View Model. AERMOD is a steady-state plume model, applicable to rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including, point, area and volume sources).

In the stable boundary layer (SBL), the concentration distribution is assumed to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL), the horizontal distribution is assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function. Additionally, in the CBL, AERMOD treats "plume lofting", whereby a portion of plume mass, released from a buoyant source, rises to and remains near the top of the boundary layer before becoming mixed into the CBL. AERMOD also tracks any plume mass that penetrates elevated stable layer, and then allows it to re-enter the boundary layer when and if appropriate.

The dispersion simulations of emissions facilitated a preliminary or screening study of the potential for human health impacts. To assess the health implications, the simulated concentrations were compared to ambient air quality guidelines and standards.

1.4. ASSUMPTIONS, EXCLUSIONS AND LIMITATIONS

Data limitations and assumptions associated with the air quality impact study in support of the proposed KFP Power Plant are listed below:

- No reference to cumulative impact was included in the study, as no ambient air quality monitoring data is available for the District or Local municipality.
- Unified model meteorological data for the site, supplied by Meteoblue, was used for dispersion modelling.
- The report was compiled with due consideration of all process information and specific conditions outlined by Nsovo Environmental and Khanyazwe Flexpower.
- All sources were digitised from site layout diagram provided by Nsovo Environmental and Khanyazwe Flexpower.

2. LEGISLATION, GUIDELINES AND STANDARDS

2.1 AIR QUALITY ACT

The Department Forestry, Fisheries and the Environment (DFFE) has brought into effect the National Environmental Management: Air Quality Act (Act No. 39 of 2004, NEMAQA) on 11 September 2005 as part of a broad programme of air quality management reform.

The purpose of the Act is to set norms and standards that relate to institutional frameworks, roles and responsibilities; air quality management planning; air quality monitoring and information management; air quality management measures and general compliance and enforcement. Amongst other things, it is intended that the setting of norms and standards will achieve the following:

- The protection, restoration and enhancement of air quality in South Africa.
- Increased public participation in the protection of air quality and improved public access to relevant and meaningful information about air quality.
- The reduction of risks to human health and the prevention of the degradation of air quality.

A key aspect is the establishment of national ambient air quality standards. These standards provide the goals for air quality management plans and provide the yardstick by which the effectiveness of these management plans is measured. The Act provides for the identification of priority pollutants and the setting of ambient standards with respect to these pollutants.

The Act describes various regulatory tools that should be developed to ensure the implementation and enforcement of air quality management plans. These include:

- Priority Areas, which are air pollution "hot spots".
- Listed Activities, which are "problem" processes that require an Atmospheric Emission Licence.
- Controlled Emitters, which includes the setting of emission standards for "classes" of emitters, such as motor vehicles, incinerators, etc.
- Control of Noise.
- Control of Odours.

2.2 AMBIENT AIR QUALITY STANDARDS

The exclusive use of source-based controls (e.g. emission limits) as an air quality management tool has been found to have important short-comings. Emission limits do not take the unique characteristics of the receiving environment into account, such as the dispersion potential, existence of other sources, existing ambient pollutant concentrations, and the sensitivity of the receiving environment. Such limits therefore provide no insurance that ambient air quality objectives will be achieved and that there will be no adverse effects on human health and welfare.

There has been a strong shift from air pollution control based exclusively on source-based methods (e.g. emission limits) to air quality management based on an effects-based approach (e.g. air quality objectives).

An effects-based approach requires the setting of ambient air quality guidelines and standards. Ambient air quality guidelines and standards are laid down by various countries, including South Africa, for the regulation of air concentrations of various criteria pollutants (e.g. sulphur dioxide, particulate matter, nitrogen oxides and lead). Such ambient guideline and standards define satisfactory air quality to ensure human health and welfare, thus providing objectives for air quality management.

Air quality guidelines and standards are fundamental to effective air quality management, providing the link between the source of atmospheric emissions and the receptor. These guideline values indicate safe daily exposure levels for most of the population, including the very young and the elderly, throughout the individual's entire lifetime. Air quality guidelines and standards are normally given for specific averaging periods, i.e. the duration over which the standard or guideline is applicable. Generally, five averaging periods are applicable, namely an instantaneous peak, 1-hour average, 24-hour average, 1-month average and annual average.

The NEMAQA is part of a broad programme of air quality management reform. The publication in May 2000 of government's Integrated Pollution and Waste Management Policy (IP & WM Policy) marked a turning point for pollution and waste governance in South Africa. The National Air Quality Management Plan (NAQMP), borne from the IP & WM Policy, has as its definition the NEMAQA.

Government's vision with respect to the NAQMP is that the programme will develop, implement and maintain an air quality management regime that contributes to sustainable development and a measurable improvement in the quality of life of all, by harnessing the energy and commitment of all South Africans for the effective prevention, minimisation and control of atmospheric pollution.

The DFFE is responsible for establishing a national framework for achieving the objectives of NEMAQA, which includes:

- Mechanisms, systems and procedures to attain compliance with ambient air quality standards.
- Mechanisms, systems and procedures to give effect to South Africa's obligations in terms of international agreements.
- National norms and standards for the control of emissions from point and non-point sources.
- National norms and standards for air quality monitoring.
- National norms and standards for air quality management planning.
- National norms and standards for air quality information management.
- Any other matter which the Minister considers necessary for achieving the objectives of the Act.

The establishment of national ambient air quality standards is achieved through NEMAQA and the South African Bureau of Standards (SABS) standard setting initiative. The National Ambient Air Quality Standards (NAAQS) have subsequently been published in the Government Gazette of 24 December 2009 and 29 June 2012.

The standards are summarised in **Table 1**.

Table 1: Ambient Air Quality Standards

Substance	Time weighted average ($\mu g/m^3$)				
	10-minutes	1-hour	8-hour	24-hour	Annual
Ozone (O_3)	n.a.	n.a.	120[1]	n.a.	n.a.
Nitrogen dioxide (NO_2)	n.a.	200[2]	n.a.	n.a.	40
Sulphur dioxide (SO_2)	500[3]	350[2]	n.a.	125[4]	50
Lead (Pb)	n.a.	n.a.	n.a.	n.a.	0.5
Particulate matter (PM_{10})	n.a.	n.a.	n.a.	75[4]	40
Particulate matter ($PM_{2.5}$)	n.a.	n.a.	n.a.	40[4] 25[4]*	20 15*
Carbon monoxide (CO)	n.a.	30 000[2]	10 000[1]	n.a.	n.a.
Benzene (C_6H_6)	n.a.	n.a.	n.a.	n.a.	5

Notes:

$\mu g/m^3$: microgram per cubic meter air @ 25°C and 101.3kPa
DEA : Department of Environmental Affairs, Forestry and Fisheries
1 : Not to be exceeded more than 11 times per annum.
2 : Not to be exceeded more than 88 times per annum.
3 : Not to be exceeded more than 526 times per annum.
4 : Not to be exceeded more than 4 times per annum.
5 : Not to be exceeded more than 4 times per annum.
* : All standards are to be complied with immediately.
Standards with an asterisk are to be complied with as from 1 January 2030.

2.3 DUST CONTROL REGULATIONS

National Dust Control Regulations was published on 1 November 2013 (Notice 827 of 2013). The purpose of the regulations is to prescribe general measures for the control of dust in all areas.

Standards for the acceptable dustfall rate for residential and non-residential areas is set out in **Table 2** below.

Table 2: Acceptable Dustfall Rate

Restriction Areas	Dustfall rate (D) (mg/m²/day, 30 days average)	Permitted frequency of exceeding dust fall rate
Residential Area	D < 600	Two within a year, not sequential months
Non-residential Area	600 < D > 1200	Two within a year, not sequential months

According to the regulations, any entity conducting any activity in such a way as to give rise to dust in quantities and concentrations that exceeded the dustfall standard set out in the regulation is impelled to, upon receipt of a notice from an air quality officer, implement a dustfall monitoring programme.

The method to be used for measuring the dustfall rate and the guideline for locating sampling points is the American Standards for Testing and Materials method, or an equivalent method approved by any internationally recognised body.

The regulation further states that an air quality officer could require any entity, through a written notice, to undertake a dustfall monitoring programme, if the officer reasonably suspected that the entity was contravening the regulations or that the activity being conducted required a fugitive dust emission management plan. An entity required to implement the programme must then, within a specified period, submit a dustfall monitoring report to the air quality officer.

A dustfall monitoring report must provide information on the location of sampling sites, classification of the area where samplers were located, as well as reference to the standard methods used for site selection, sampling and analysis. The report must also provide meteorological data for the sampling area, the dustfall monitoring results, including a comparison of current year and historical results for each site, as well as a tabular summary of compliance with the dustfall standard.

Any entity that exceeds the dustfall standard must, within three months after submission of the dustfall monitoring report, develop and submit a dustfall management plan to the air quality officer for approval. This management plan must identify all possible sources of dust within the affected site, detail the best practicable measures to be undertaken to mitigate dust emissions, identify the line management responsible for implementation and incorporate the dust fallout monitoring plan. Such a plan would need to be implemented within a month of the date of approval and an implementation progress report must be submitted to the air quality officer at agreed time intervals.

2.4 ATMOSPHERIC EMISSION REPORTING REGULATIONS

The National Atmospheric Emission Reporting Regulations came into effect on the 2 April 2015 (Notice 283 of 2015). The purpose of the regulations is to regulate the reporting of data and information from an identified point, non-point and mobile source of atmospheric emissions to the internet based National Atmospheric Emissions Inventory System (NAEIS) as to compile atmospheric emission inventories.

The following entities will be required to report in terms of the regulations:

- **Listed Activities:** Any entity that undertakes a NEMAQA air quality-related listed activity.
- **Controlled Emitters:** Any entity that undertakes a NEMAQA listed activity and uses an appliance or conducts an activity that has been declared a controlled emitter. To date small boilers, asphalt and temporary asphalt plants have been declared as controlled emitters.
- **Air quality officer:** Any air quality officer receiving emission reports in terms of Section 23 of NEMAQA.
- **Mines:** Any entity that holds a mining right or permit in terms of the Mineral and Petroleum Resources Development Act (Act No. 28 of 2002).
- **Facilities with Criteria Pollutants:** Any entity that operates facilities which generate criteria pollutants and who has been identified in accordance with the applicable municipal by-law. Criteria pollutants are those for which national ambient standards are prescribed in Schedule A to the NEMAQA.

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

2.5 ATMOSPHERIC IMPACT REPORT REGULATIONS

The Regulations Prescribing the Format of the Atmospheric Impact Report were published on 11 October 2013 (Notice 747 of 2013). The regulations prescribe the format of the impact reports and requires the submission of the following information:

- Full enterprise details.
- Location and extent of the plant.
- Atmospheric emission licences and other authorisations.
- The nature of the plant's processes and activities.
- Description of the surrounding areas.
- Raw materials used.
- Appliances and abatement equipment control technology used.
- Point sources parameters and maximum source emission rates.
- Fugitive emissions.
- Impact of the enterprise on human health and the environment.

2.6 AIR DISPERSION MODELLING REGULATIONS

Regulations Regarding Air Dispersion Modelling were promulgated in terms of NEMAQA on 11 July 2014 (Notice 533 of 2014).

Air dispersion modelling is defined as a series of mathematical simulations of how air pollutants disperse in the ambient atmosphere and is performed with computer programs that solve the mathematical equations and algorithms which simulate the dispersion of pollutants.

The Code of Practice for Air Dispersion Modelling applies in the development of:

- An air quality management plan.
- A priority area air quality management plan.
- An atmospheric impact report.
- A specialist air quality impact assessment study.

The air dispersion regulations standardise model applications for regulatory purposes. The Code of Practice recommends a suite of dispersion models to be applied for regulatory practices. It also provides guidance on modelling input requirements, protocols and procedures.

2.7 AIR QUALITY MANAGEMENT

2.7.1 Gert Sibande District Municipality Draft Air Quality Management Plan

NEMAQA requires Municipalities to introduce an AQMP that sets out what will be done to achieve the prescribed air quality standards. Five of the seven Local Municipalities of the Gert Sibande District Municipality (GSDM) is within the Highveld Priority Area (HPA) declared in terms of NEMAQA. Mkhondo Local Municipality and Chief Albert Luthili Local Municipality do not fall within the HPA.

The Gert Sibande District Municipality AQMP provides a management framework to maintain and improve air quality in the District. This is achieved through setting goals and objectives driven by national, provincial and local policies and priorities.

2.7.2 Ehlanzeni District Municipality Municipal Health Services By-law

The Council of Ehlanzeni District Municipality enacted the Municipal Health Services By-Law on 5 December 2018.

The objective of this By-Law is to enable the Municipality to promote and protect the health and well-being of all people within the municipal area by providing an effective legal and administrative framework, in conjunction with any other applicable laws, within which the Municipality can develop and manage its municipal health service obligations.

Chapter 9 of the By-Law includes Air Pollution and specifies aspects such as Duty of Care, Smoke Emission from Premises other than Dwellings, Smoke Emissions from Dwellings, Emissions from Compressed Ignition Powered Vehicles, Emission Caused by Open Burning, Pesticides and Crop Spraying, Spray Painting Emissions, Offensive Odours, Fume Nuisance, Sand Blastind Operations, Dust Nuisance, and Emissions that Cause a Nuisance.

2.8 INTERNATIONAL AIR QUALITY GUIDELINES

2.8.1 World Health Organisation Air Quality Guidelines

The WHO air quality guidelines were last published in 2006: *Air quality guidelines - global update 2005. Particulate matter, ozone, nitrogen dioxide and sulphur dioxide*. Since they were issued, air pollution has become recognised as the single biggest environmental threat to human health based on its notable contribution to disease burden. This is particularly true for PM (both $PM_{2.5}$ and PM_{10}). However, other commonly measured air pollutants such as ozone (O_3), nitrogen dioxide (NO_2),sulphur dioxide (SO_2) and carbon monoxide (CO) are also of concern, as are other components of air pollution.

The latest edition of World Health Organisation Global Air Quality Guidelines (WHO GAQGs) for ambient air pollutants was published in 2021 and included recommendations for the classical air pollutants particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

The overall objective of these guidelines is to offer quantitative health-based recommendations for air quality, expressed as long- or short-term concentrations of several key air pollutants. The goal of these guidelines is to provide guidance to help reduce levels of air pollutants to decrease the enormous worldwide health burden resulting from exposure to air pollution.

Particulate Matter

The WHO recommends an annual average for $PM_{2.5}$ of 5 $\mu g/m^3$ and a short-term, 24-hour average of 15 $\mu g/m^3$. When evaluating the WHO AQGs and interim targets, it is generally recommended that the annual average take precedence over the 24-hour average.

The annual average for PM_{10} is 15 $\mu g/m^3$ and the 24-hour mean is 45 $\mu g/m^3$. Besides the guideline values, four annual and 24-hour interim targets (IT) are defined for $PM_{2.5}$ and PM_{10} (see **Figure 2**, **Figure 3**, **Figure 4** and **Figure 5**).

Interim targets are proposed as incremental steps in a progressive reduction of air pollution and are intended for use in areas where pollution is high.

Recommendation	$PM_{2.5}$ (µg/m³)
Interim target 1	35
Interim target 2	25
Interim target 3	15
Interim target 4	10
AQG level	**5**

Figure 2: WHO AQGs for Annual $PM_{2.5}$

Recommendation	$PM_{2.5}$ (µg/m³)
Interim target 1	75
Interim target 2	50
Interim target 3	37.5
Interim target 4	25
AQG level	**15**

Figure 3: WHO AQGs for Short Term (24-hour) $PM_{2.5}$

Recommendation	PM_{10} (μg/m³)
Interim target 1	70
Interim target 2	50
Interim target 3	30
Interim target 4	20
AQG level	**15**

Figure 4: WHO AQGs for Annual PM_{10}

Recommendation	PM_{10} (μg/m³)
Interim target 1	150
Interim target 2	100
Interim target 3	75
Interim target 4	50
AQG level	**45**

Figure 5: WHO AQGs for Short Term (24-hour) PM_{10}

Sulphur dioxide

The WHO AQGs stipulates 40 μg/m^3 as a 24-hour mean for Sulphur Dioxide (SO_2), while the 10-minute AQG of 500 μg/m^3 remains valid. Besides the guideline values, two 24-hour interim targets (IT) are defined for SO_2 (see **Figure 6**).

Recommendation	SO_2 (μg/m³)
Interim target 1	125
Interim target 2	50
AQG level	**40**

Figure 6: WHO AQGs for Annual SO_2

Nitrogen dioxide

The current annual WHO AQG for NO_2 is 10 μg/m³ and a short-term, 24-hour average of 25 μg/m³. The 1-hour AQG of 200 μg/m³ remains valid. Besides the guideline values, three annual and two 24-hour interim targets (IT) are defined.

Recommendation	NO_2 (μg/m³)
Interim target 1	40
Interim target 2	30
Interim target 3	20
AQG level	**10**

Figure 7: WHO AQGs for Annual NO_2

Recommendation	NO_2 (µg/m³)
Interim target 1	120
Interim target 2	50
AQG level	**25**

Figure 8: WHO AQGs for Short Term (24-hour) NO_2

Carbon monoxide

The current short-term, 24-hour average for CO is 4 mg/m^3, while the 15-minute AQG of 100 mg/m^3, 1-hour AQG of 35 mg/m^3 and the 8-hour AQG of 10 mg/m^3 remain valid. Besides the guideline value, one 24-hour interim target (IT) is defined.

Recommendation	CO (mg/m³)
Interim target 1	7
AQG level	**4**

Figure 9: WHO AQGs for Annual CO

Ozone

The WHO AQG sets the value for ozone levels at 60 µg/m^3 for an 8-hour daily average. Besides the guideline value, an 8-hour interim target (IT) has been set for ozone (see **Figure 10**).

Recommendation	O_3 (μg/m³)
Interim target 1	100
Interim target 2	70
AQG level	**60**

Figure 10: WHO AQGs for Ozone

Lead

Levels of lead found in air, food, water and soil/dust vary widely throughout the world and depend on the degree of industrial development, urbanisation and other lifestyle factors. In cities of developing countries traffic-related lead levels range between 0.3 and 1 μg/m^3 with extreme annual mean values between 1.5 and 2 μg/m^3.

3. BACKGROUND ASSESSMENT

3.1 PROCESS DESCRIPTION

The project involves developing, constructing, and operating a 1 000MW natural gas-fired power plant using reciprocating engine technology. The proposed project will comprise of a phased development approach, with Phase 1: 440MW to be built by 2028 and Phase 2: 560MW to be completed by 2030.

KFP will source gas from the Republic of Mozambique Pipeline Investments Company (ROMPCO), which has an existing gas pipeline that connects Mozambique's Pande Temane gas fields to Sasol's operations in South Africa, as well as several industrial and retail customers. Alternative gas sources may include imported Liquid Natural Gas (LNG) projects developed in Matola, which will provide additional gas into the ROMPCO pipeline.

An approximately 500 metre gas pipeline extension will be required to connect the power plant to the ROMPCO pipeline.

KFP is also proposing the development of approximately two 500 metre 275 KV and/or 132 kV overhead powerlines from the proposed power plant to the existing Eskom Khanyazwe substation.

An access road (temporary and permanent) will be constructed to link the proposed power station to the nearby existing road network. The current primary road to the proposed development site is a gravel road that connects to the N4.

A new access point from the N4 has been proposed. This proposed access will tie in with the gravel road, and two access routes are proposed to access the power plant near the Eskom Khanyazwe substation.

Associated infrastructure will include:

- Water and lube oil tanks for the water and oil required for the gas turbine/engine generation process and cooling.
- Water treatment plant to produce the required quality of water for the generation process.
- Building infrastructure, which will include, but not be limited to, plant operational and maintenance building, ablution facilities and offices.
- Fencing to maximize the security of the plant.

The power plant will provide a mid-merit power profile to the national grid. It will be designed to operate for 25 years, after which, subject to prevailing circumstances, it will either be decommissioned or refurbished and extended. If decommissioned, the land where the power plant is located will undergo an extensive rehabilitation project, which will see the removal of all power plant equipment and reinstatement of the land back to its original purpose, which is sugar cane farming.

Figure 11 contains the layout diagram, while **Figure 12** contains the layout plan for the KFP Power Plant .

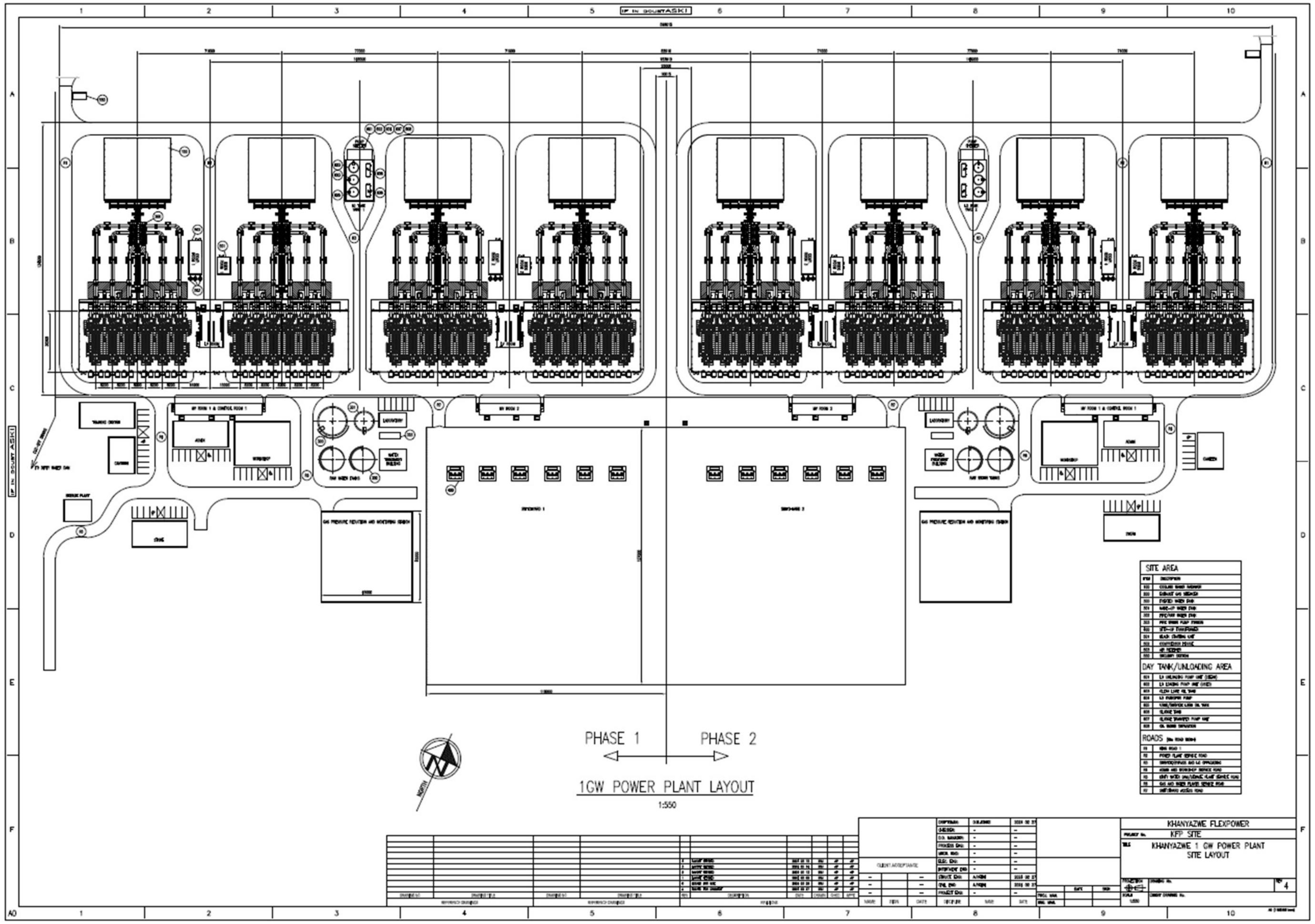

Figure 11: Khanyazwe Flexpower Layout Diagram

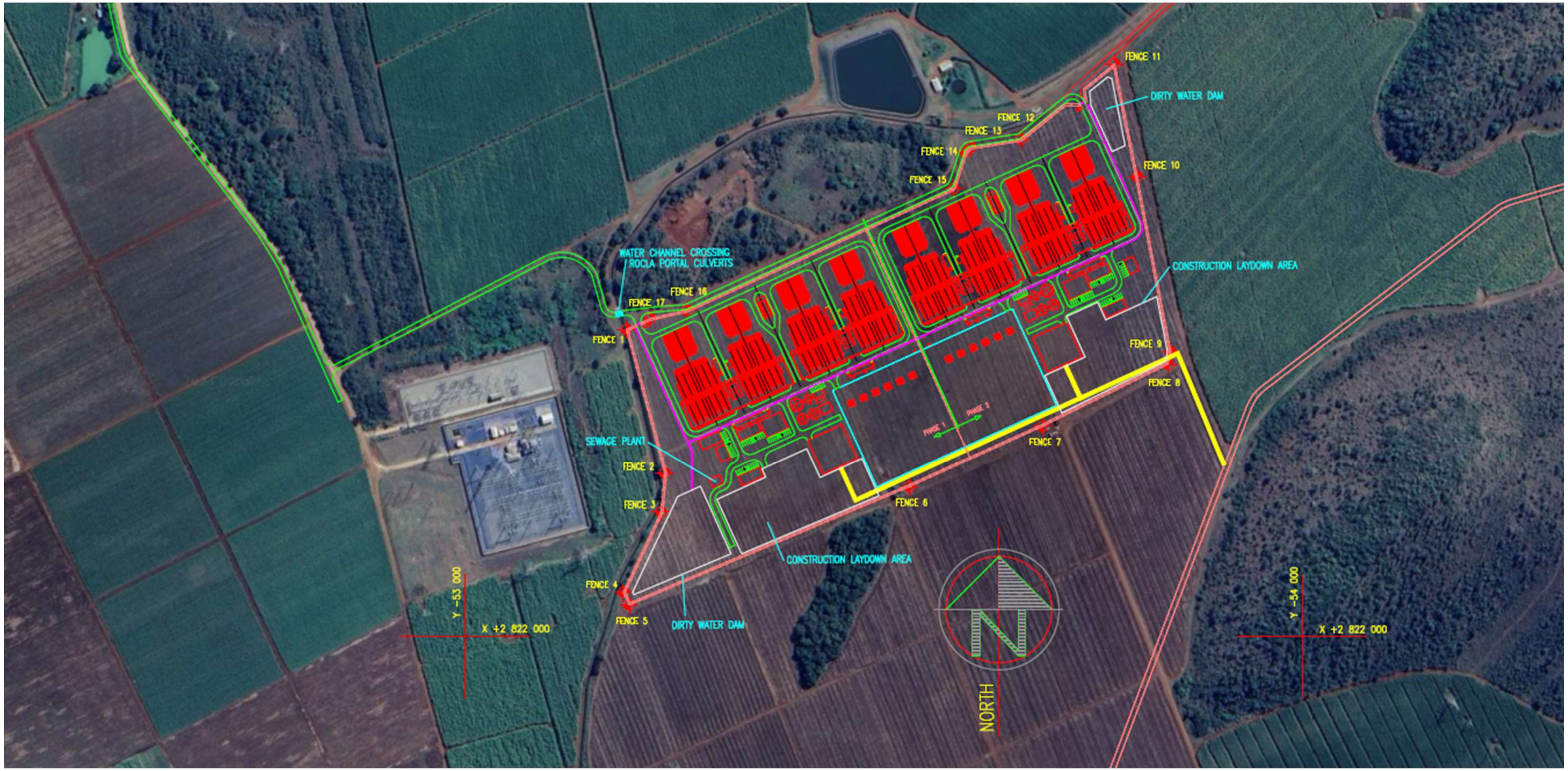

Figure 12: Khanyazwe Flexpower Layout Plan

3.2 EMISSION INVENTORY

3.2.1 Construction

Heavy construction is a source of dust emissions that may have substantial temporary impact on local air quality. Building and road construction are two examples of construction activities with high emissions potential. Emissions during the construction of a building or road can be associated with land clearing, drilling and blasting, ground excavation, cut and fill operations (i.e., earth moving), and construction of a facility itself. Dust emissions often vary substantially from day to day, depending on the level of activity, the specific operations, and the prevailing meteorological conditions. A large portion of the emissions result from equipment traffic over temporary roads at the construction site.

The temporary nature of construction differentiates it from other fugitive dust sources as to estimation and control of emissions. Construction consists of a series of different operations, each with its own duration and potential for dust generation. In other words, emissions from any single construction site can be expected (1) to have a definable beginning and an end and (2) to vary substantially over different phases of the construction process. This contrasts with most other fugitive dust sources, where emissions are either relatively steady or follow a discernable annual cycle. Furthermore, there is often a need to estimate area-wide construction emissions, without regard to the actual plans of any individual construction project.

The quantity of dust emissions from construction operations is proportional to the area of land being worked on and to the level of construction activity.

By analogy to the parameter dependence observed for other similar fugitive dust sources, one can expect emissions from heavy construction operations to be positively correlated with the silt content of the soil (that is, particles smaller than 75 micrometers [µm] in diameter), as well as with the speed and weight of the average vehicle, and to be negatively correlated with the soil moisture content.

3.2.2 Power Plant Reciprocating Engines

Natural gas-fired reciprocating engines are separated into three design classes: 2-cycle (stroke) lean-burn, 4-stroke lean-burn, and 4-stroke rich-burn. Two-stroke engines complete the power cycle in a single crankshaft revolution as compared to the two crankshaft revolutions required for 4-stroke engines.

All engines in these categories are spark-ignited. Current industry practices reflect a decline in the usage of new 2-stroke engines for stationary applications.

Four-stroke engines use a separate engine revolution for the intake/compression cycle and the power/exhaust cycle. These engines may be either naturally aspirated, using the suction from the piston to entrain the air charge, or turbocharged, using an exhaust-driven turbine to pressurize the charge.

Turbocharged units produce a higher power output for a given engine displacement, whereas naturally aspirated units have lower initial costs and require less maintenance.

Rich-burn engines operate near the stoichiometric air-to-fuel ratio (16:1) with exhaust excess oxygen levels less than 4 percent (typically closer to 1%). Additionally, it is likely that the emissions profile will be considerably different for a rich-burn engine at 4% oxygen than when operated closer to stoichiometric conditions. Considerations such as these can impact the quantitative value of the emission factor presented. It is also important to note that while rich-burn engines may operate, by definition, with exhaust oxygen levels as high as 4% most will operate within plus or minus 1 air-to-fuel ratio of stoichiometry. Even across this narrow range, emissions will vary considerably, sometimes by more than an order of magnitude. Air-to-fuel ratios were not provided in the gathered emissions data used to develop the presented factors.

Lean-burn engines may operate up to the lean flame extinction limit, with exhaust oxygen levels of 12% or greater. The air to fuel ratios of lean-burn engines range from 20:1 to 50:1 and are typically higher than 24:1. The exhaust excess oxygen levels of lean-burn engines are typically around 8%, ranging from 4 to 17%.

Some lean-burn engines are characterized as clean-burn engines. The term "clean-burn" technology is a registered trademark of Cooper Energy Systems and refers to engines designed to reduce NOx by operating at high air-to-fuel ratios. Engines operating at high air-to-fuel ratios (greater than 30:1) may require combustion modification to promote stable combustion with the high excess air. These modifications may include a turbo charger or a precombustion chamber (PCC). A turbo charger is used to force more air into the combustion chamber, and a PCC is used to ignite a fuel-rich mixture that propagates into the main cylinder and ignites the very lean combustion charge. Lean-burn engines typically have lower oxides of nitrogen (NOx) emissions than rich-burn engines.

The primary criteria pollutants from natural gas-fired reciprocating engines are oxides of nitrogen (NOx), carbon monoxide (CO), and volatile organic compounds (VOC). The formation of nitrogen oxides is exponentially related to combustion temperature in the engine cylinder. The other pollutants, CO and VOC species, are primarily the result of incomplete combustion. Particulate matter (PM) emissions include trace amounts of metals, non-combustible inorganic material, and condensable semi-volatile organics which result from volatized lubricating oil, engine wear, or from products of incomplete combustion. Sulfur oxides are very low since sulfur compounds are removed from natural gas at processing plants. However, trace amounts of sulfur containing odorant are added to natural gas at city gates prior to distribution for the purpose of leak detection.

It should be emphasized that the actual emissions may vary considerably. This variation is due to engines operating at different conditions, including air-to-fuel ratio, ignition timing, torque, speed, ambient temperature, humidity, and other factors.

3.2.3 Vehicle Transport Emissions

Particulate emissions occur whenever vehicles travel over a paved surface such as a road or parking area. Particulate emissions from paved roads are due to direct emissions from vehicles in the form of exhaust, brake wear and tire wear emissions and resuspension of loose material on the road surface.

In general terms, re-suspended particulate emissions from paved roads originate from, and result in the depletion of, the loose material present on the surface (i.e., the surface loading). In turn, that surface loading is continuously replenished by other sources. At industrial sites, surface loading is replenished by spillage of material and track-out from unpaved roads and staging areas.

In the absence of continuous addition of fresh material, paved road surface loading should reach an equilibrium value in which the amount of material re-suspended matches the amount replenished. The equilibrium surface loading value depends upon numerous factors. The most important factors are the mean speed of vehicles traveling on site; the average daily traffic volume, the fraction of heavy vehicles and the presence/absence of curbs, storm sewers and marshalling areas.

3.3 EMISSION FACTORS

Data for this investigation were obtained from several sources within the Office of Air Quality Planning and Standards (OAQPS) of the United States Environmental Protection Agency. The AP-42 background files located in the *Emission Factor and Inventory Group (EFIG)* were reviewed for information on the industry, processes, and emissions.

Table 3 summarises emission factors, **Table 4** includes the emission rates for the KFP Power Plant. The emission parameters are included in

Activity	Emission Factors (gram per second)								Totals	
	TSP	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO_2	CO	TVOCs		
A. Construction									**40,42**	**0,04%**
1. Fugitive emissions during construction	25,74	13,40	1,29	-	-	-	-	-	40,42	99,48%
2. Natural gas fugitive emissions during commissioning	-	-	-	-	-	-	-	0,21	0,21	0,52%
B. Combustion									**99 926.27**	**99,96%**
3. Reciprocating engine	5,97	5,97	5,97	2,89	289,57	99539.79	74,20	1,90	99 926.27	99,96%
D. Miscellaneous Sources									**0,22**	**2,20E-06%**
4. Forklift traffic	1,37E-02	2,62E-03	6,34E-04	-	-	-	-	-	0,02	1,69E-07%
5. Road transport traffic	-	-	-	-	-	-	-	-	-	-
6. Light vehicle traffic	1,03E-01	1,98E-02	4,79E-03	-	-	-	-	-	0,13	1,28E-06%
7. Annual natural gas fugitive emissions	-	-	-	-	-	-	-	0,08	0,08	7,54E-07%
Totals	**31,73**	**19,37**	**7,26**	**2,89**	**289,57**	**99 539.79**	**74,20**	**1,975**	**99 966.84**	**100%**
	0,03%	**0,02%**	**0,01%**	**0,003%**	**0,29%**	**99,57%**	**0,07%**	**0,002%**		

Table 5.

Table 3: Khanyazwe Flexpower Emission Factors

Activity	Unit	Emission Factors							
		TSP	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO_2	CO	TVOCs
A. Construction									
1. Fugitive emissions during construction	Mg/hectare/month	2,69E+00	1,40E+00	1,35E-01	-	-	-	-	-
2. Natural gas fugitive emissions during commissioning	Mg/year	-	-	-	-	-	-	-	6,71E+00
B. Combustion									
3. Reciprocating engine	kg/10^6 m^3	1,08E+02	1,08E+02	1,08E+02	5,22E+01	5,22E+03	1,80E+06	1,34E+03	3,43E+01
D. Miscellaneous Sources									
4. Forklift traffic	g/VKT	9,83E+01	1,89E+01	4,57E+00	-	-	-	-	-
5. Road transport traffic	g/VKT	5,42E+02	1,04E+02	2,52E+01	-	-	-	-	-
6. Light vehicle traffic	g/VKT	5,95E+01	1,14E+01	2,76E+00	-	-	-	-	-
7. Annual natural gas fugitive emissions	Mg/year	-	-	-	-	-	-	-	1,19E+00

Notes:

g/VKT : Gram per vehicle kilometre travelled.
kg/Mg : Kilogram per megagram.
g/m²/day : Gram per square metre per day.
1 : US EPA, AP42, Volume I, 5 Edition, Chapter 13.2.3 Heavy Construction Operations.
2 : Energas Emission Estimate Report T5465-eec-001, June 2024.
3 : US EPA, AP42, Volume I, 5 Edition Chapter 3.2 Natural Gas-Fir3d Reciprocating Engines. Uncontrolled Emission Factors for 4-Stroke Rich-Burn Engines.
4, 5, & 6 : US EPA, AP42, Volume I, 5 Edition Chapter 13.2.1. Paved Roads.

Table 4: Khanyazwe Flexpower Emission Rates

Activity	Emission Factors (gram per second)								Totals	
	TSP	PM_{10}	$PM_{2.5}$	SO_2	NOx	CO_2	CO	TVOCs		
A. Construction									**40,42**	**0,04%**
1. Fugitive emissions during construction	25,74	13,40	1,29	-	-	-	-	-	40,42	99,48%
2. Natural gas fugitive emissions during commissioning	-	-	-	-	-	-	-	0,21	0,21	0,52%
B. Combustion									**99 926.27**	**99,96%**
3. Reciprocating engine	5,97	5,97	5,97	2,89	289,57	99539.79	74,20	1,90	99 926.27	99,96%
D. Miscellaneous Sources									**0,22**	**2,20E-06%**
4. Forklift traffic	1,37E-02	2,62E-03	6,34E-04	-	-	-	-	-	0,02	1,69E-07%
5. Road transport traffic	-	-	-	-	-	-	-	-	-	-
6. Light vehicle traffic	1,03E-01	1,98E-02	4,79E-03	-	-	-	-	-	0,13	1,28E-06%
7. Annual natural gas fugitive emissions	-	-	-	-	-	-	-	0,08	0,08	7,54E-07%
Totals	**31,73**	**19,37**	**7,26**	**2,89**	**289,57**	**99 539.79**	**74,20**	**1,975**	**99 966.84**	**100%**
	0,03%	**0,02%**	**0,01%**	**0,003%**	**0,29%**	**99,57%**	**0,07%**	**0,002%**		

Table 5: Khanyazwe Flexpower Emission Parameters

Parameter	Unit	Value
Construction footprint	hectare	25.15
Annual production days	days	365.00
Monthly production days	days	30.00
Annual production hours	hours	8 760.00
Monthly production hours	hours	720.00
Daily production hours	hours	24.00
Natural Gas	cubic metre/annum	1.75E+09
TSP Particle Size Multiplier for Paved Road Equation	unitless	3.23
PM10 Particle Size Multiplier for Paved Road Equation	unitless	0.62
PM2.5 Particle Size Multiplier for Paved Road Equation	unitless	0.15
Paved sufaces silt loading	gram/square metres	9.70
Forklift average vehicle weight of 3.75t (Gross weight 4t & Load Capacity 3.5t)	tonnes	3.75
Light vehicle average vehicle weight of 2.29t (Gross weight 2.75t & Tare weight 1.83t)	tonnes	2.29
Road transport average vehicle weight of 20t (Gross weight 35t & Tare weight 15t)	tonnes	20.00
Paved light vehicle traffic (return)	kilometres	3.00
Paved delivery traffic (return)	kilometres	3.00
Paved forklift traffic	kilometres	3.00
Light vehicle traffic	kilometres/day	150.00
Delivery traffic	kilometres/day	0.00
Forklift traffic	kilometres/day	12.00
PM_{10} fraction factor	unitless	0.92
$PM_{2.5}$ fraction factor	unitless	0.80

3.4 METEOROLOGY

The nature of local climate will determine what will happen to pollution when it is released into the atmosphere (Tyson and Preston-Whyte, 2000). Pollution levels fluctuate daily and hourly, in response to changes in atmospheric stability and variations in mixing depth. Similarly, atmospheric circulation patterns will influence the rate of transport and dispersion of pollution.

The release of atmospheric pollutants into a large volume of air results in the dilution of those pollutants. This is best achieved during conditions of free convection and when the mixing layer is deep (unstable atmospheric conditions). These conditions occur most frequently in summer during the daytime. This dilution effect can however be inhibited under stable atmospheric conditions in the boundary layer (shallow mixing layer). Most surface pollution is thus trapped under a surface inversion (Tyson and Preston-Whyte, 2000).

Inversion occurs under conditions of stability when a layer of warm air lies directly above a layer of cool air. This layer prevents a pollutant from diffusing freely upward, resulting in an increased pollutant concentration at or close to the earth's surface. Surface inversions develop under conditions of clear, calm and dry conditions and often occur at night and during winter (Tyson and Preston-Whyte, 2000). Radiative loss during the night results in the development of a cold layer of air close to the earth's surface. These surface inversions are however, usually destroyed as soon as the sun rises and warms the earth's surface.

With the absence of surface inversions, the pollutants can diffuse freely upward. This upward motion may however still be prevented by the presence of elevated inversions. Elevated inversions occur commonly in high pressure areas. Sinking air warms adiabatically to temperatures more than those in the mixed boundary layer. The interface between the upper, gently subsiding air is marked by a stable layer or an elevated subsidence inversion. This type of elevated inversions is most common over Southern Africa (Tyson and Preston-Whyte, 2000).

The climate and atmospheric dispersion potential of South Africa is determined by atmospheric conditions associated with the continental high-pressure cell over the region. The continental high-pressure present over the region in the winter months results in fine conditions with little rainfall and light winds with a northerly flow. Elevated inversions are common in such high-pressure areas due to the subsidence of air. This reduces the mixing depth and suppresses the vertical dispersion of pollutants, causing increased pollutant concentrations (Tyson and Preston-Whyte, 2000).

Seasonal variations in the positions of the high-pressure cells influence atmospheric conditions over the region. For most of the year the tropical easterlies cause an air flow with a north-easterly to north-westerly component. In the winter months the high-pressure cells move northward, displacing the tropical easterlies northward resulting in disruptions to the westerly circulation. The disruptions result in succession of cold fronts over the area in winter with pronounced variations in wind direction, wind speeds, temperature, humidity, and surface pressure. Airflow ahead of a cold front passing over the area has a strong north-north-westerly to north-easterly component, with stable and generally cloud-free conditions. Once the front has passed, the airflow is reflected as having a dominant southerly component (Tyson and Preston-Whyte, 2000).

Easterly and westerly wave disturbances cause a southerly wind flow and tend to hinder the persistence of inversions by destroying them or increasing their altitude, thereby facilitating the dilution and dispersion of pollutants. Pre-frontal conditions tend to reduce the mixing depth. The potential for the accumulation of pollutants during pre-frontal conditions is therefore enhanced (Tyson and Preston-Whyte, 2000).

The analysis of at least one year of hourly average meteorological data is required to facilitate a reasonable understanding of the ventilation potential of the site. The most important meteorological parameters to be considered are wind speed, wind direction, ambient temperature, atmospheric stability and mixing depth.

Atmospheric stability and mixing depths are not routinely recorded and frequently need to be calculated from diagnostic approaches and prognostic equations, using as a basis routinely measured data, e.g. temperature, simulated solar radiation and wind speed.

Reference was made to Meteoblue Climate Diagrams, based on 30 years of hourly weather model simulations for Malelane. This data provides a good indication of typical climate patterns and expected conditions (temperature, precipitation, sunshine and wind).

3.4.1 Surface wind field

Dispersion comprises vertical and horizontal components of motion. The wind field largely determines the horizontal dispersion of pollution in the atmospheric boundary layer. The wind speed determines both the distance of downwind transport and the rate of dilution because of plume stretching. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction and the variability in wind direction, determine the general path pollutants will follow, and the extent of crosswind spreading.

The predominant wind direction for Malelane is from the southeastern sector. Wind speeds of between 5 and 18 km/h are generally observed. The strongest winds of around 30 km/h usually blow in October. From August to October this wind sometimes swings to blow from the north; this is usually a hot dry wind. Occasionally cyclones do occur.

Wind roses comprise of 16 spokes which represents the direction from which the winds blew during the period under review. The colours reflect the different categories of wind speeds. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The value given in the centre of the circle describe the frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s.

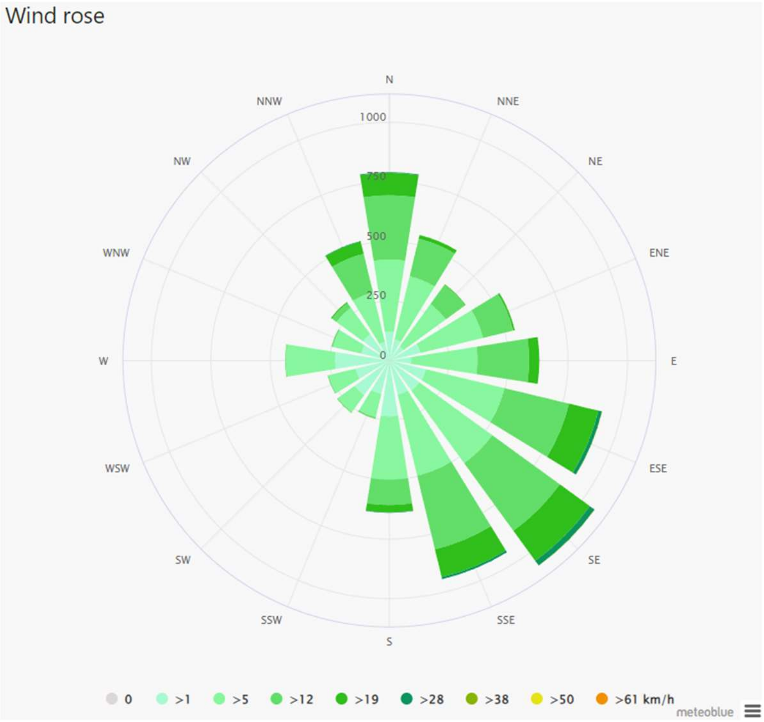

Figure 13: Malelane Wind Rose for the Period 1993 – 2023

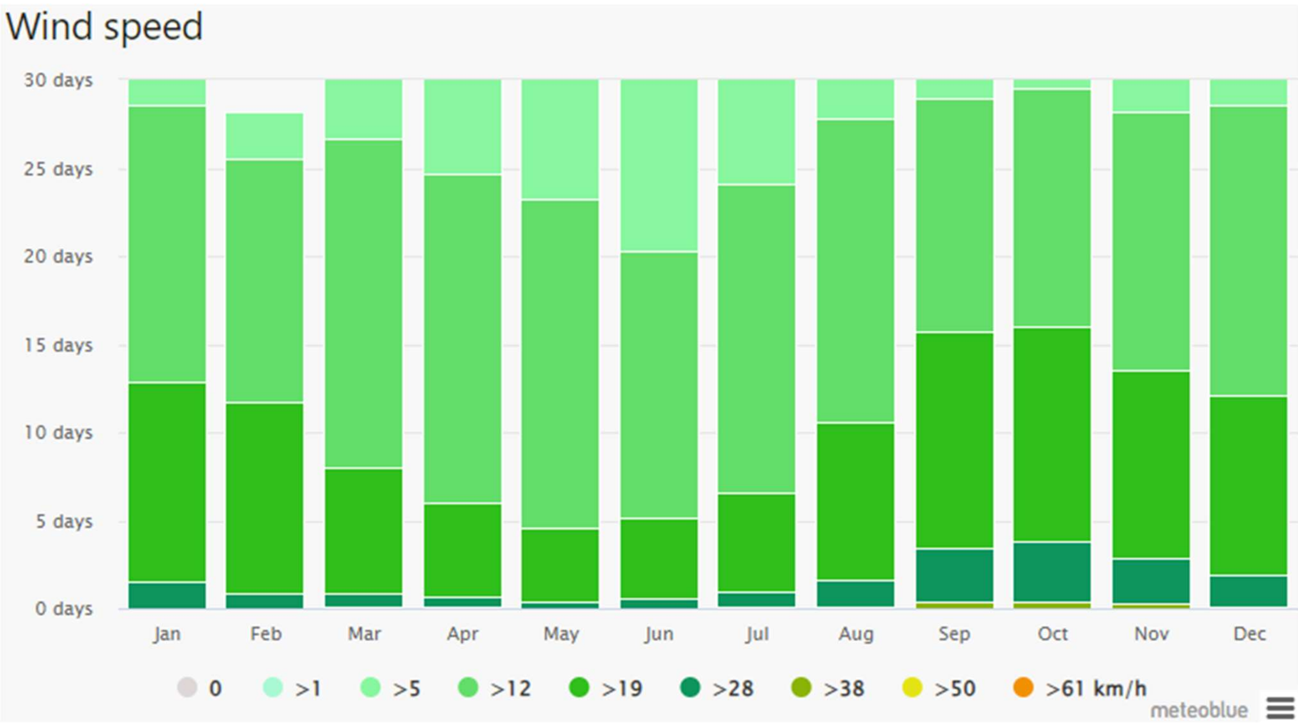

Figure 14: Malelane Average Wind Speed for the Period 1993 – 2023

Atmospheric processes at meso-scale were considered in the characterisation of the atmospheric dispersion potential of the study area. Reference was made to hourly average meteorological data modelled by Meteoblue for the KFP Power Plant. Parameters that need to be considered in the characterisation of meso-scale ventilation potentials include wind speed, wind direction, extent of atmospheric turbulence, ambient air temperature and mixing depth.

Winds from the southeastern sector (33.7%) were mostly reported for the study area. Calm periods were the exception and wind speeds were most often brisk, between 3.6 and 5.7 m/s (29.3%). Moderate winds between 2.1 and 3.6 m/s were recorded 28%, light winds between 0.5 and 2.1 m/s were recorded 24.5%, and strong winds above 5.7m/s, about 16.6% of the time.

Period, diurnal, and seasonal wind roses for the period 1 May 2019 to 30 April 2024 are presented in **Figure 15** to **Figure 22**.

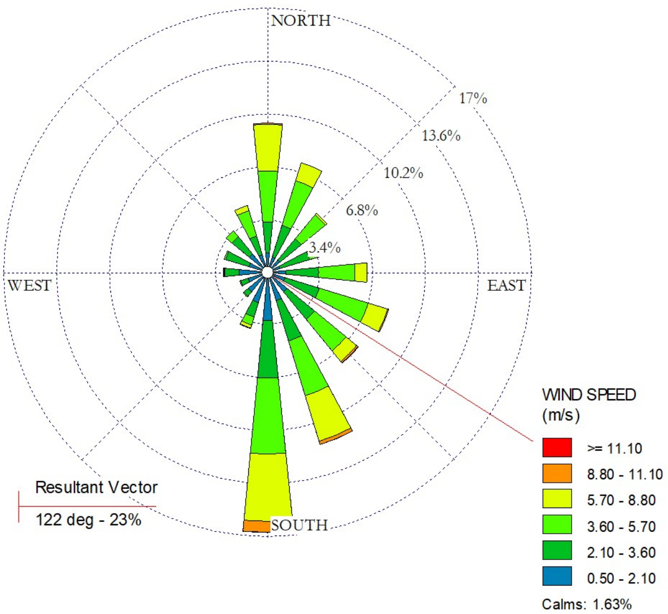

Figure 15: Period Wind Rose

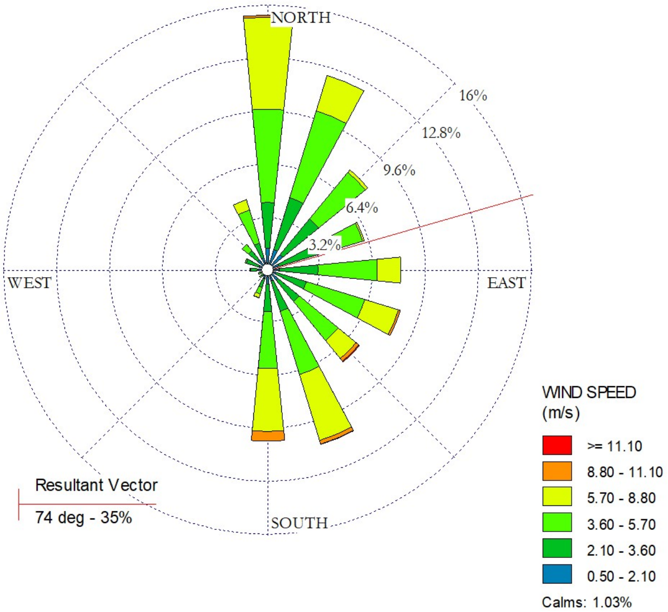

Figure 16: Day-time Wind Rose

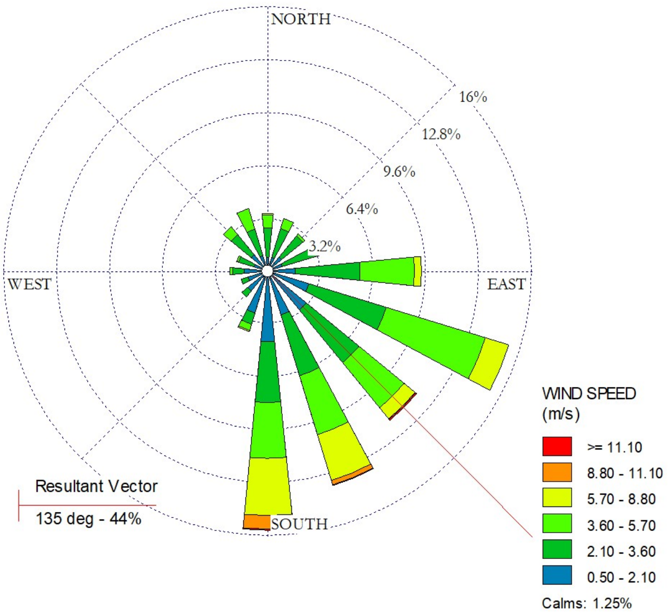

Figure 17: Evening Wind Rose

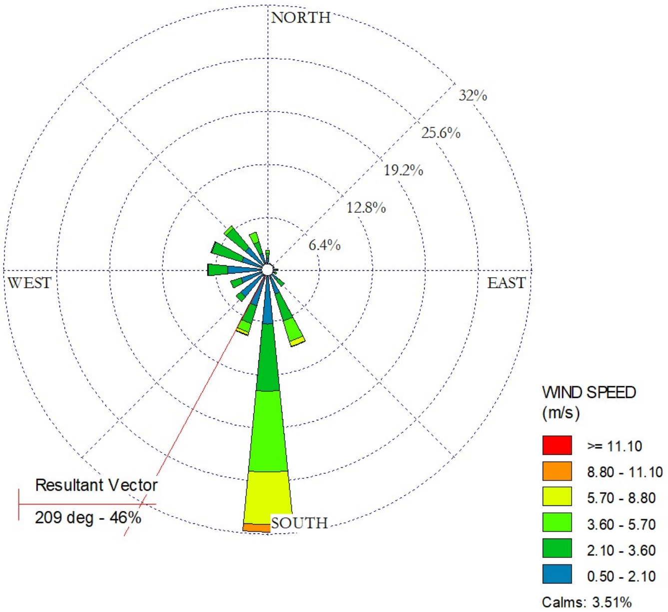

Figure 18: Night-time Wind Rose

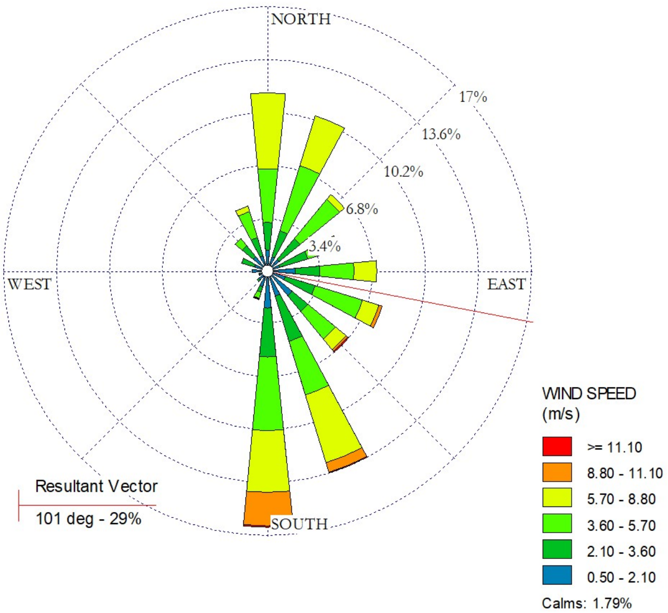

Figure 19: Spring Wind Rose

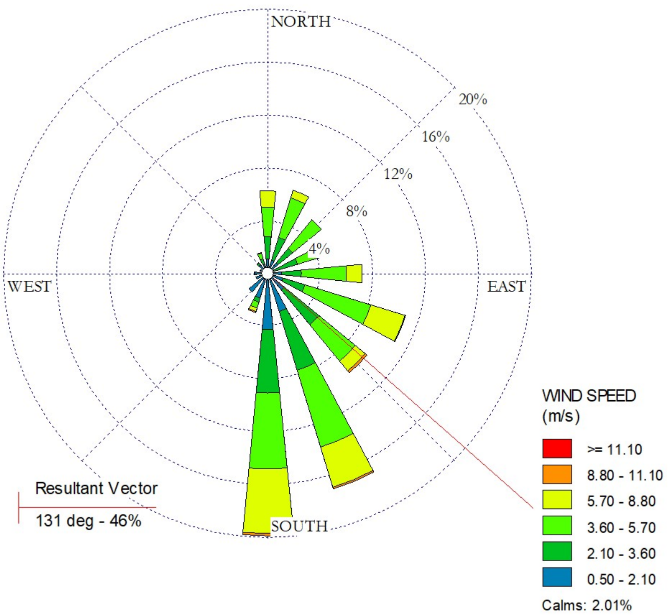

Figure 20: Summer Wind Rose

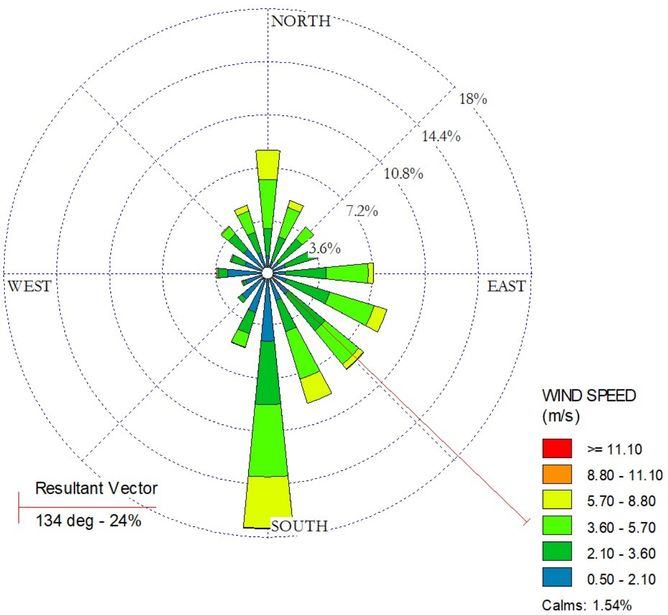

Figure 21: Autumn Wind Rose

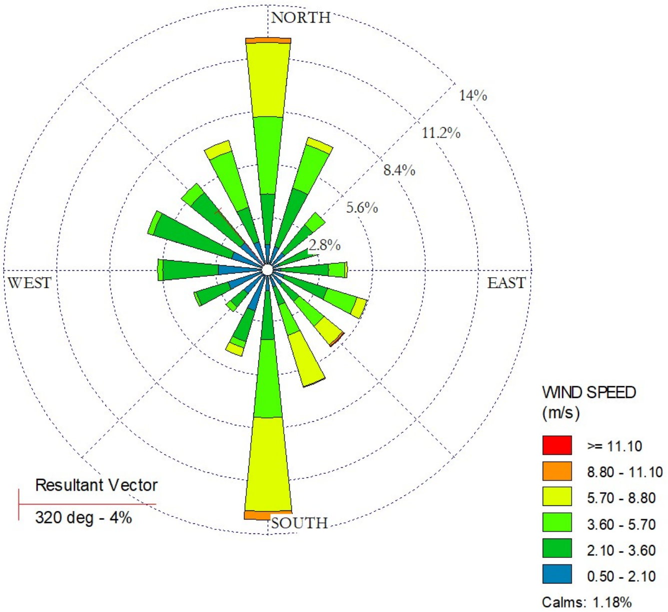

Figure 22: Winter Wind Rose

3.4.2 Temperature and humidity

Temperature affects the formation, action, and interactions of pollutants in various ways (Kupchella & Hyland, 1993). Chemical reaction rates tend to increase with temperature and the warmer the air, the more water it can hold and hence the higher the humidity. Temperature also provides an indication of the rate of development and dissipation of the mixing layer as well as determining the effect of plume buoyancy; the larger the temperature difference between the plume and ambient air, the higher the plume can rise.

Higher plume buoyancy will result in an increased lag time between the pollutant leaving the source and reaching the ground. This additional time will allow for greater dilution and ultimately a decrease in the pollutant concentrations when reaching ground level.

Humidity is the mass of water vapour per unit volume of natural air. When temperatures are at their highest the humidity is also high, the moisture is trapped inside the droplets of the water vapour. This makes the moisture content of the air high. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles (CEPA/FPAC Working Group, 1999). This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids, as well as secondary pollutants within the atmosphere.

Ehlanzeni District Municipality falls within the Lowveld Region of the Mpumalanga Province and has a subtropical climate strongly influenced by the proximity to the Indian Ocean.

In terms of temperature, there are a strong seasonality between the winter and summer months. The cooler winter months occur between May and August whilst the warmer summer months occur between December and February. Very moderate temperature variation occurs between winter and summer months.

The Nkomazi Local Municipality's climate is subtropical with an average annual temperature of 28°C. The warmest month of the year is January with an average temperature of 26.2°C, while the lowest average temperatures in the year occur in June, around 18.4°C.

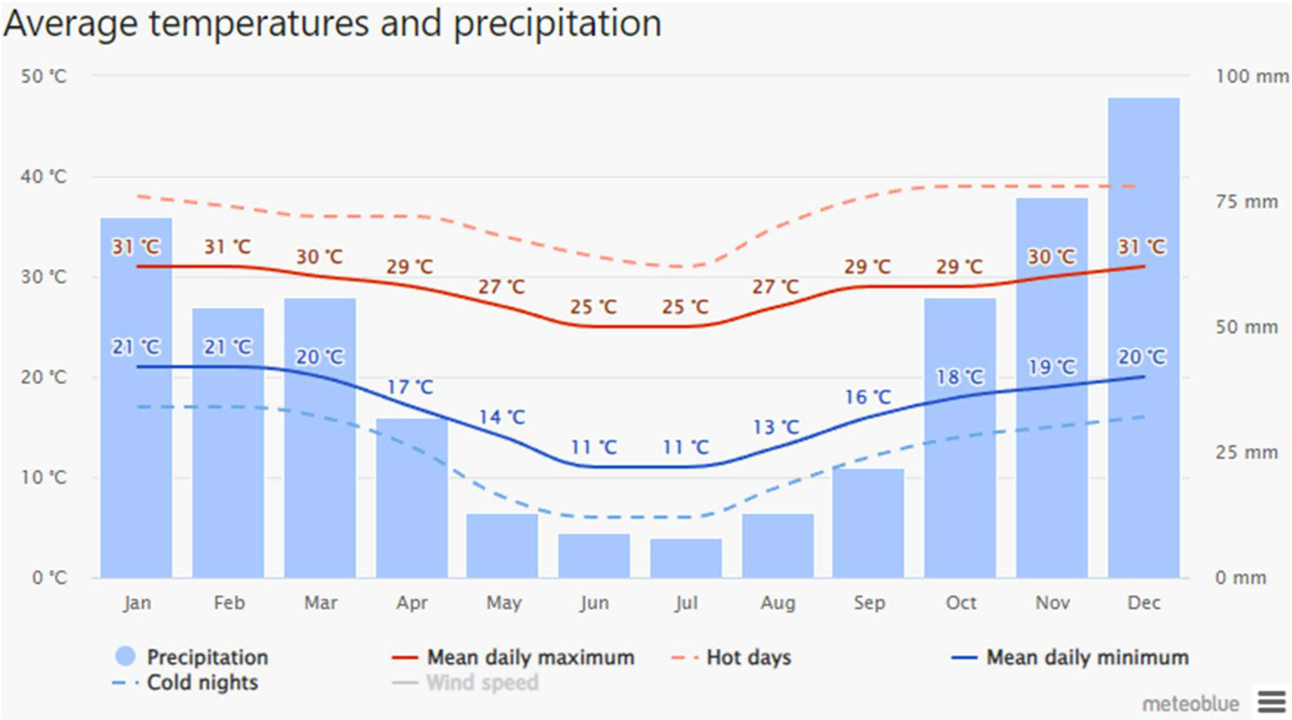

Figure 23: Malelane Average Temperature and Precipitation for the Period 1993 – 2023

3.4.3 Precipitation

Precipitation cleanses the air by washing out particles suspended in the atmosphere (Kupchella & Hyland, 1993). It is calculated that precipitation accounts for about 80-90% of the mass of particles removed from the atmosphere (CEPA/FPAC Working Group, 1999).

Ehlanzeni District Municipality is subject to subtropical summer rainfall. Rainfall is largely experienced from September to March with the highest amount of rainfall falling in the late summer months (December to February). The District also experiences summer thunderstorms as well as hailstorms, both of which are associated with periods of heavy flooding. Winter rainfall is rare.

The Nkomazi Local Municipality reports an average rainfall of 775 mm. The driest month is July, with the highest amount of rainfall received in January, with an average of 127 mm.

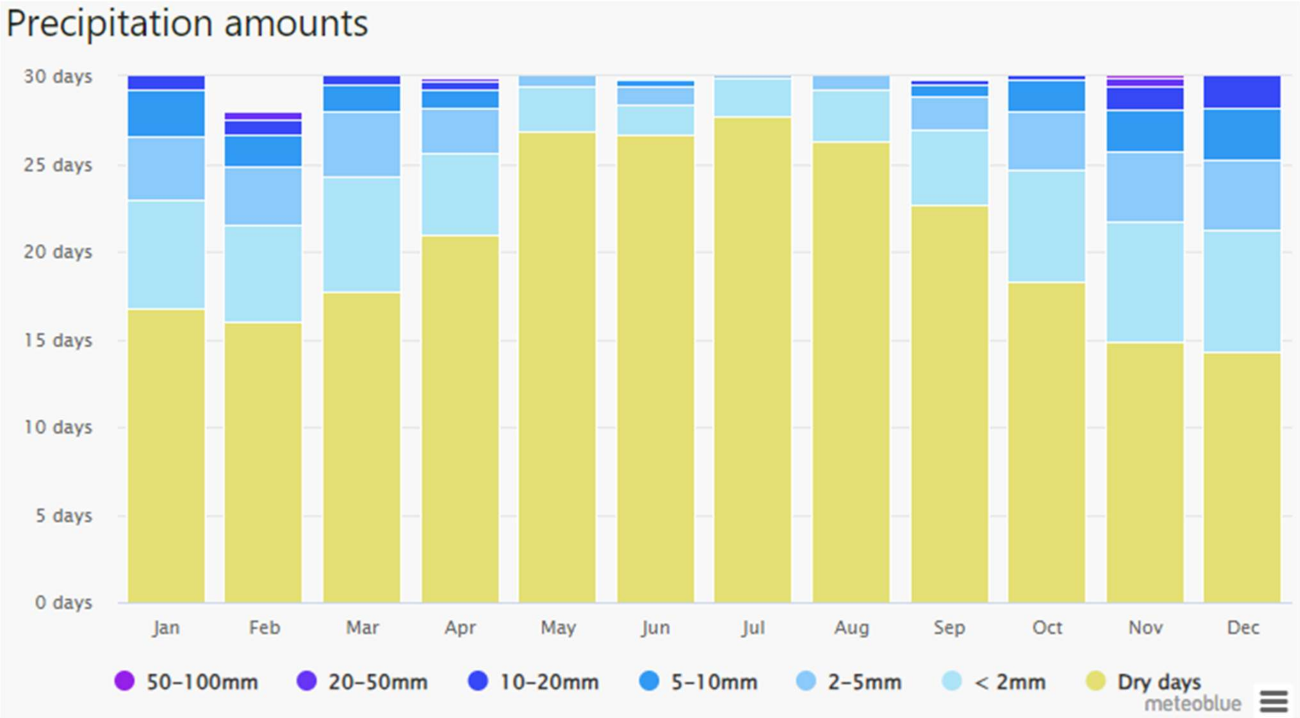

Figure 24: Malelane Average Monthly Rainfall for the Period 1993 – 2023

3.4.4 Mixing height and atmospheric stability

The vertical component of dispersion is a function of the extent of thermal turbulence and the depth of the surface mixing layer. Unfortunately, the mixing layer is not easily measured and must often be estimated using prognostic models that derive the thickness from some of the other parameters that are often measured, e.g. solar radiation and temperature.

During the daytime, the atmospheric boundary layer is characterised by thermal turbulence due to the heating of the earth's surface and the extension of the mixing layer to the lowest elevated inversion. Radiative flux divergence during the night usually results in the establishment of ground-based inversions and the erosion of the mixing layer.

Day-time mixing heights were calculated with the prognostic equations of Batchvarova and Gryning, while night-time boundary layer heights were calculated from various diagnostic approaches for stable and neutral conditions. The mixing layer in the study area ranges from 0 metres (only a stable or neutral layer exists) during night-times to the base of the lowest-level elevated inversion during unstable, day-time conditions (Batchvarova and Gryning, 1990).

Atmospheric stability is commonly categorised into one of seven stability classes. These are briefly described in **Table 6**. The atmospheric boundary layer is usually unstable during the day due to turbulence caused by the sun's heating effect on the earth's surface. The depth of this mixing layer depends mainly on the amount of solar radiation, increasing in size gradually from sunrise to reach a maximum at about 5-6 hours after sunrise. The degree of thermal turbulence is increased on clear warm days with light winds. During the night a stable layer, with limited vertical mixing, exists. During windy and/or cloudy conditions, the atmosphere is normally neutral. A neutral atmospheric potential neither enhances nor inhibits mechanical turbulences. An unstable atmospheric condition enhances turbulence, whereas a Stable atmospheric condition inhibits mechanical turbulence.

Table 6: Atmospheric Stability Classes.

Class	Stability	Description
Class A	Very unstable	Calm wind, clear skies, hot day-time conditions
Class B	Moderately unstable	Clear skies, day-time conditions
Class C	Slightly unstable	Moderate wind, slightly overcast day-time conditions
Class D	Neutral	High winds or cloudy days and nights
Class E	Slightly stable	Moderate wind, slightly overcast night-time conditions
Class F	Moderate stable	Low winds, clear skies, cold night-time conditions
Class G	Very stable	Calm winds, clear skies, cold clear night-time conditions

For elevated releases, the highest ground level concentrations would occur during unstable, day-time conditions. The wind speed resulting in the highest ground level concentration depends on the buoyancy. If the plume is considerably buoyant (high exit gas velocity and temperature) together with a low wind, the plume will reach the ground relatively far downwind. With stronger wind speed, on the other hand, the plume may reach the ground closer, but due to the increased ventilation, it will be more diluted. A wind speed between these extremes would therefore be responsible for the highest ground level concentrations.

The highest concentrations for low level releases would occur during weak wind speeds and stable atmospheric conditions. Air pollution episodes frequently occur just prior to the passage of a frontal system that is characterised by calm wind and stable conditions.

The region is characterised by a combination of sunny and partly cloudy days. Overcast conditions are experience less than 10 days per month (see **Figure 25**).

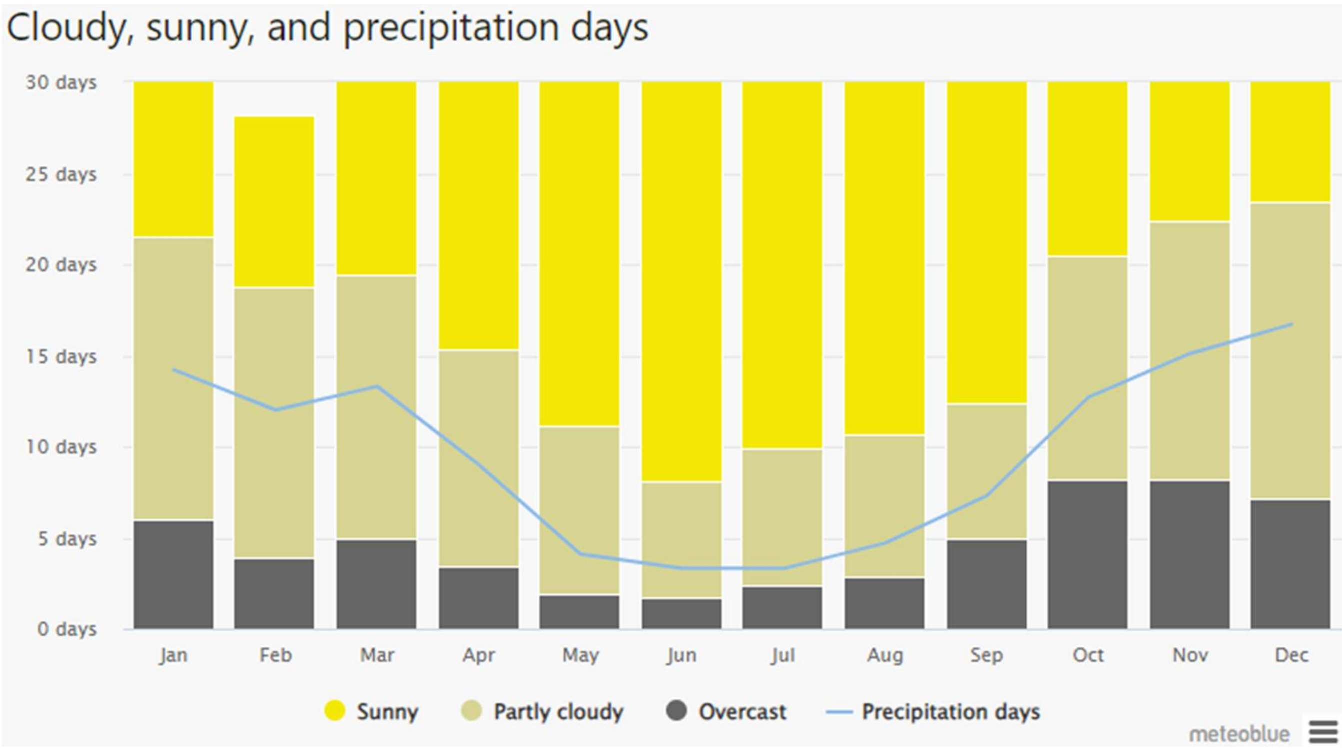

Figure 25: Malelane Cloudy, Sunny and Precipitation Days for the Period 1993 – 2023

3.5 TOPOGRAPHY AND LAND USE

The Ehlanzeni District Municipality covers 23 664km² and makes up a third of the Mpumalanga Province's land mass. The District is situated within the Lowveld escarpment with an average elevation of 1400m Above Mean Sea Level (AMSL) and altitudes varying from 600 to 2100 metres. The Ehlanzeni District Municipality comprises four local municipalities, including Bushbuckridge Local Municipality, City of Mbombela Local Municipality, Nkomazi Local Municipality and Thaba Chweu Local Municipality.

The Ehlanzeni District Municipality is the second largest contributor to the Mpumalanga Province economy at 34.1%. Community services and trade are the leading industries in terms of contribution to District's economy, followed by financial and real estate, construction, transport, agriculture and manufacturing.

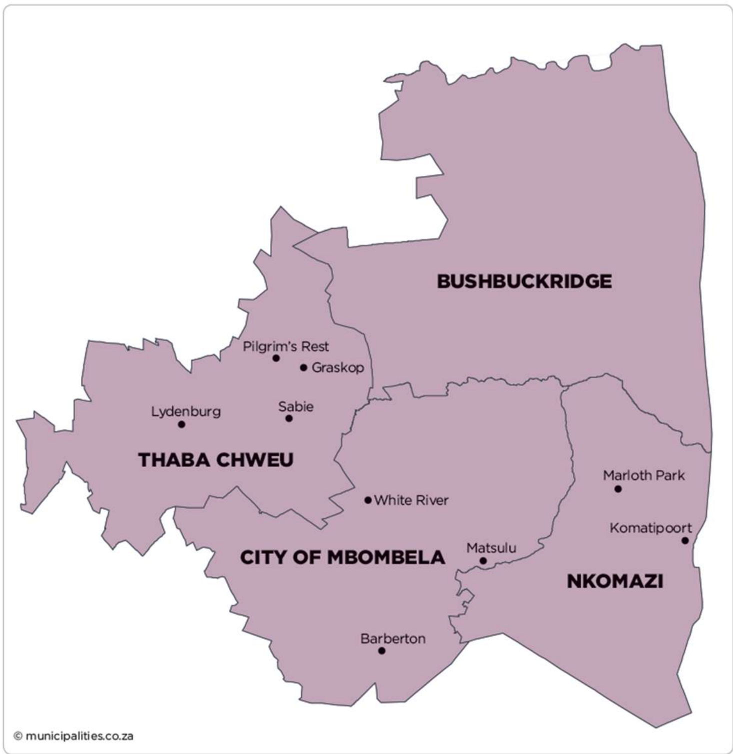

Figure 26: Local Municipalities of the Ehlanzeni District Municipality

Steep slopes and mountainous areas are found in the western part and along the eastern boundary of the Nkomazi Local Municipality. The Kaalrug Mountain range is situated to the west forming part of the Barberton Mountains and the Lebombo Mountain range is located along the eastern boundary. The Lebombo Plains, located between the Komati River and the Lebombo Mountains to the east, are characterised by flat to undulating landscapes. The central part between the Komati River and the mountainous western areas is flat, however steeper slopes occur to the south towards Swaziland border.

Economic activities that are dominant spatially in the Nkomazi Local Municipality include agriculture, trade and community services.

The topography of the study area is mountainous. The average elevation varies from 300 metres to over 1 200 metres AMSL (**Figure 27**).

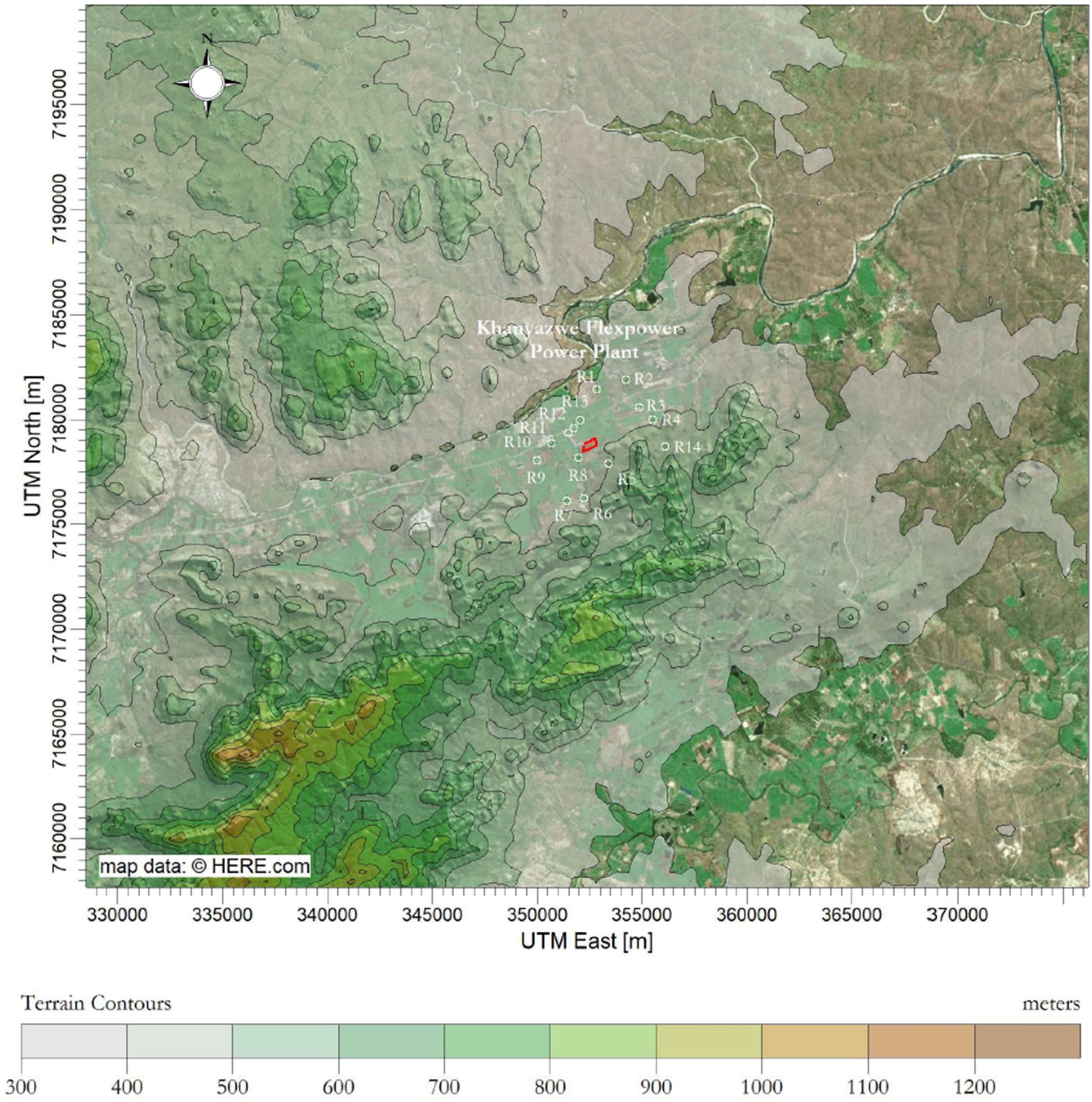

Figure 27: Khanyazwe Flexpower Terrain Elevations

3.6 POLLUTION SOURCES AND RECEPTORS

3.6.1 Pollution Sources

The outdoor sources of air pollution resulting from human activities comprise three broad categories.

Stationary sources can be subdivided into; rural area sources, e.g. agriculture, mining and quarrying and industrial point and area sources, e.g. manufacturing of chemicals, non-metallic mineral products, basic metal industries and power generation.

Community sources i.e., heating of homes and buildings, municipal waste and sewage sludge incinerators, fireplaces, cooking facilities, laundry services and cleaning plants.

Mobile sources include sources such as combustion-engine vehicles, e.g. light duty petrol-powered cars, light and heavy-duty diesel-powered vehicles, motorcycles, aircraft and line sources such as fugitive emissions from vehicle traffic.

Air pollutants are traditionally classified into suspended particulate matter (dusts, fumes, mists and smokes), gaseous pollutants (gases and vapours) and odours.

Air quality is an issue of concern in Mpumalanga, as it is in many other parts of South Africa. The driving forces of poor air quality include both human activities and natural processes. Driving forces associated with human activities include economic activity, urbanisation, industrial development and population growth. Forces from natural processes can include climate change, natural disasters and many others. These driving forces lead to pressures on the natural environment such as increased demand for resources, habitat change and increased development. The pressures in turn lead to impacts being exerted on the natural, social, political and economic environments (Mpumalanga DACE, 2003).

A wide variety of both natural and anthropogenic sources of air pollution exist in Mpumalanga, ranging from veld fires to industrial processes, agriculture, mining activities, power generation, paper and pulp processing, vehicle use and domestic use of fossil fuels. Different pollutants are associated with each activity, ranging from volatile organic compounds and heavy metals through to dust and odours (Mpumalanga DACE, 2003).

Five indicators have been selected for monitoring and reporting on air quality in Mpumalanga. These indicators include:

- Electricity generation from coal-fired power stations.
- Trends in household energy use per energy type.
- Ambient sulphur dioxide concentration.
- Ambient particulate concentration.
- Quarterly clinic admissions for respiratory infections by type of infection.

The generation of electricity through coal-fired power stations in South Africa takes place primarily in Mpumalanga. Of the 24 power generation facilities owned by Eskom in South Africa, 13 are coal-fired power stations. Eight of the coal-fired power stations are found in Mpumalanga province. The generation of electricity through coal-fired power stations produces pollutants such as particulates, sulphur dioxide and nitrogen oxides. Much of the demand for electricity in the country thus generates ambient air quality impacts that are felt largely in Mpumalanga and the surrounding areas (Mpumalanga DACE, 2003).

Most households within the Mpumalanga Province rely on electricity from the national grid, with some use of candles and to a lesser extent paraffin. Very little use is made of other energy sources such as gas. Candles are used as an energy source for lighting whereas paraffin is used for both lighting and cooking. Statistics South Africa reports that in 1999, 73% of households in urban areas used electricity for cooking, and 20% used paraffin. In the non-urban areas of the province, 50% of households used wood and/or coal for cooking, with 22% of non-urban households using paraffin and 22% using electricity (Mpumalanga DACE, 2003).

Electricity is the primary energy source used in Mpumalanga for heating purposes, with wood and paraffin being used to a lesser extent. In non-urban areas there appears to be much greater reliance on wood and/or coal, with 62% of households using this in 1999. In urban areas wood and/or coal is used by only 9% of households for heating. Urban households tend to rely more on electricity (74% of households in 1999) and paraffin (15% of households in 1999) for heating. Twenty-one percent of non-urban households relied on electricity in 1999 and 14% on paraffin (Mpumalanga DACE, 2003).

Real-time ambient air monitoring of sulphur dioxide and particulate matter in Mpumalanga is performed by various industries, associations and through ad hoc projects. These different monitoring efforts are not synchronised in any way regarding monitoring periods, equipment and methods used. The main monitoring activities in Mpumalanga are listed below:

- Apolcom (Witbank).
- Eskom (Verkykkop, Leandra, Elandsfontein, Kendal, Palmer, Majuba).
- Sasol (Secunda, Langverwacht, Amersfoort, Bosjesspruit, Grootvlei and Springs Girls High School).
- Mpumalanga Department of Agriculture and Land Administration (DALA) (Balfour, Standerton, Witbank and Middelburg)

The Eskom ambient air quality monitoring results indicate that the annual concentrations of SO_2 at all sites are within the Department of Environmental Affairs and Tourism's (DEAT) and The World Health Organisation's annual average guideline of 19 ppb. Elandsfontein and Kendal appeared to record the highest SO_2 concentrations in 2001 however, Leandra and Kendal consistently show the highest annual sulphur dioxide concentrations over the period 1996 to 2000 (Mpumalanga DACE, 2003).

At all three Sasol Synthetic Fuels monitoring stations (Club, Langverwacht and Bosjesspruit) the daily average ambient SO_2 concentration during May to October 2002 fell below 20 ppb approximately 90% of the time. No readings at the Club and Langverwacht stations were recorded above 48 ppb, the World Health Organisation 24-hour average SO_2 guideline during this period. The DEAT 24-hour guideline value for SO_2 is also 48 ppb.

Less than 2% of the readings at Bosjesspruit station exceeded the 24-hour average guideline values of 48 ppb during the period May to October 2002, falling below a 24-hour average of 80 ppb (Mpumalanga DACE, 2003).

The Southern African Fire Research Initiative conducted a monitoring project where the monthly mean concentration of sulphur dioxide was monitored at several sites in southern Africa during July 1999 to December 2001. The sulphur dioxide concentrations indicate a steep gradient from the Mpumalanga Highveld, with seasonal cycles appearing to be linked to circulation patterns with maximum values during winter (Mpumalanga DACE, 2003).

The Eskom air quality monitoring stations report on the annual mean particulate matter concentration for each station during the period 1996 to 2001. The figures show decreasing PM_{10} concentrations at most stations, with Kendal showing an increase in PM_{10}. The United States Environmental Protection Agency (US EPA) National Ambient Air Quality Standard (NAAQS) for an annual average PM_{10} concentration is 50 $\mu g/m^3$. The Leandra station showed exceedances of the US EPA standard during 1998 to 2000, with annual mean particulate matter concentrations reaching 80 $\mu g/m^3$ in 1998. Elandsfontein monitoring station showed an annual particulate concentration of more than 70 $\mu g/m^3$ in 2001. Kendal monitoring station has consistently exceeded the US EPA standard of 50 $\mu g/m^3$. The DEAT annual average guideline value is 60 $\mu g/m^3$ (Mpumalanga DACE, 2003).

The Sasol Synthetic Fuels air quality monitoring network reports on daily averages of $PM_{2.5}$ rather than annual PM_{10} concentration. The decision was made to monitor $PM_{2.5}$ rather than PM_{10} due to international consensus that $PM_{2.5}$ has a direct correlation with impact on human health . The US EPA NAAQS for a 24-hour average $PM_{2.5}$ concentration is 65 $\mu g/m^3$. Measurements of $PM_{2.5}$ were taken at the Club and Langverwacht monitoring stations. The Club station reported no exceedances of the US EPA 24-hour average standard of 65 $\mu g/m^3$. At the Langverwacht station more than 20% of the readings exceeded the 65 $\mu g/m^3$ standard (Mpumalanga DACE, 2003).

Little information could be obtained on clinic admissions for respiratory infections. Information compiled by a study performed by Beke showed a definite trend towards increased lower respiratory tract infections in children under 5 years of age in Mpumalanga in the winter months. An isolated study conducted in 1990 showed that coughs, wheezing, asthma and chest illnesses were more frequently reported in polluted areas rather than non-polluted areas (Mpumalanga DACE, 2003).

Although no clear trends in air quality and associated health effects can be reported, much of the industry in Mpumalanga contributes to the poor air quality sometimes found in the province. A provincial monitoring network is required to ascertain spatial and regional trends in air quality and any potential associated trends in health impacts.

3.6.2 Khanyazwe Flexpower Power Plant Receptors

Receptors are sites (or areas) which may potentially be impacted by the process or activity. In this study, sensitive receptors were selected based on proximity to the project and comprise of farmsteads, small holdings, residences, wildlife conservancy, recreation, commerce, utilities, light/heavy industrial – and mining processes up to 5 kilometres from the power plant.

Table 7 and **Figure 28** provides a summary of the closest receptors associated with the KFP Power Plant.

Table 7: KFP Receptor Description

Description	Direction from approximate centre of the plant	Distance from approximate centre of the plant
R1 Farmstead Lat -25.476793°, Lon 31.535908°	North (6.77°)	2.67 kilometre
R2 Residential Lat -25.472770°, Lon 31.549931°	North north-east (28.94°)	3.54 kilometre
R3 Commerce/Recreational Lat -25.484970°, Lon 31.555644°	Northeast (52.48°)	2.89 kilometre
R4 Industrial Lat -25.490424°, Lon 31.563069°	East north-east (69.37°)	3.25 kilometre
R5 Farmstead Lat -25.508951°, Lon 31.541179°	Southeast (137.40°)	1.23 kilometre
R6 Mining/Industrial Lat -25.524476°, Lon 31.528982°	South (188.06°)	2.67 kilometre
R7 Residential Lat -25.525002°, Lon 31.521204°	South south-west (203.29°)	2.93 kilometre
R8 Farmstead Lat -25.506324°, Lon 31.526735°	Southwest (224.50°)	0.87 kilometre
R9 Farmstead Lat -25.507421°, Lon 31.507540°	West south-west (253.63°)	2.65 kilometre
R10 Residential Lat -25.499741°, Lon 31.514082°	West (273.01°)	1.89 kilometre
R11 Farmstead Lat -25.495489°, Lon 31.522232°	West north-west (298.63°)	1.21 kilometre
R12 Utilities Lat -25.493646°, Lon 31.524751°	Northwest (314.18°)	1.13 kilometre
R13 Residential Lat -25.489658°, Lon 31.527695°	North north-west (337.50°)	1.32 kilometre
R14 Industrial Lat -25.502612°, Lon 31.568073°	East (93.29°)	3.56 kilometre

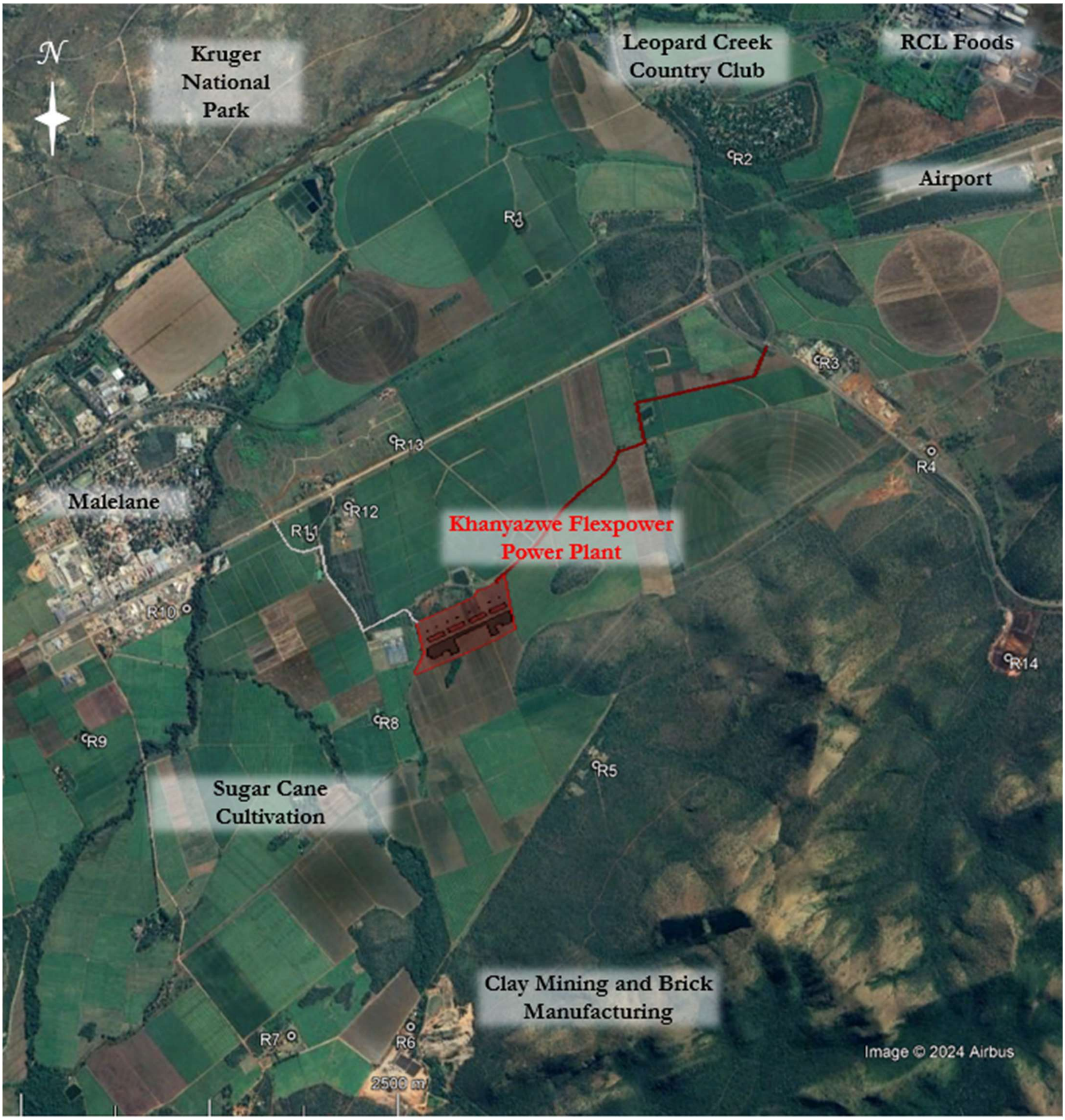

Figure 28: KFP Receptors

3.7 EHLANZENI DISTRICT MUNICIPALITY

Criteria pollutants are pollutants commonly found from various sources and for which health-based criteria (science-based guidelines) have been established as the basis for setting permissible levels. Typical pollutants include particulates (including soot, fly ash and aerosols), sulphur oxides (SO_x), oxides of nitrogen (NO_x), carbon monoxide (CO), carbon dioxide (CO_2), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), methane (CH_4), ammonia (NH_3), hydrogen chloride (HCl), hydrogen sulphide (H_2S), ozone (O_3) and other photochemical oxidants (as secondary pollutants) and various trace elements. Organic compounds released include formaldehyde, benzene, poly-aromatic hydrocarbons, PCBs and dioxins and furans.

No monitoring data was included in the study, as no ambient air quality monitoring data is available for the District or Local municipality.

3.7.1 Particulate Matter

Particulate matter (PM) is a broad term used to describe the fine particles found in the atmosphere, including soil dust, dirt, soot, smoke, pollen, ash, aerosols and liquid droplets. The most distinguishing characteristic of PM is the particle size and the chemical composition. Particle size has the greatest influence on the behaviour of PM in the atmosphere with smaller particles tending to have longer residence times than larger ones. PM is categorised, according to particle size, into TSP, PM_{10} and $PM_{2.5}$.

Total suspended particulates (TSP) consist of all sizes of particles suspended within the air smaller than 100 micrometres (µm). TSP is useful for understanding nuisance effects of PM, e.g. settling on houses, deposition on and discoloration of buildings, and reduction in visibility.

PM_{10} describes all particulate matter in the atmosphere with a diameter equal to or less than 10µm.

Sometimes referred to simply as coarse particles, they are generally emitted from motor vehicles (primarily those using diesel engines), factory and utility smokestacks, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood. Natural sources include sea spray, windblown dust and volcanoes.

Coarse particles tend to have relatively short residence times as they settle out rapidly and PM_{10} is generally found relatively close to the source except in strong winds.

$PM_{2.5}$ describes all particulate matter in the atmosphere with a diameter equal to or less than 2.5µm. They are often called fine particles, and are mostly related to combustion (motor vehicles, smelting, incinerators), rather than mechanical processes as is the case with PM_{10}. $PM_{2.5}$ may be suspended in the atmosphere for long periods and can be transported over large distances.

Fine particles can form in the atmosphere in three ways: when particles form from the gas phase, when gas molecules aggregate or cluster together without the aid of an existing surface to form a new particle, or from reactions of gases to form vapours that nucleate to form particles.

Particulate matter may contain both organic and inorganic pollutants. The extent to which particulates are considered harmful depends on their chemical composition and size, e.g. particulates emitted from diesel vehicle exhausts mainly contain unburned fuel oil and hydrocarbons that are known to be carcinogenic. Very fine particulates pose the greatest health risk as they can penetrate deep into the lung, as opposed to larger particles that may be filtered out through the airways' natural mechanisms.

In normal nasal breathing, particles larger than 10µm are typically removed from the air stream as it passes through the nose and upper respiratory airways, and particles between 3µm and 10µm are deposited on the mucociliary escalator in the upper airways. Only particles in the range of 1µm to 2µm penetrate deeper where deposition in the alveoli of the lung can occur (WHO, 2003).

Coarse particles (PM_{10} to $PM_{2.5}$) can accumulate in the respiratory system and aggravate health problems such as asthma. $PM_{2.5, which}$ can penetrate deeply into the lungs, are more likely to contribute to the health effects (e.g. premature mortality and hospital admissions) than coarse.

People with existing health conditions such as cardiovascular disease and asthmatics, as well as the elderly and children, are more at risk for the inhalation of particulates than normal healthy people. Mortality outcomes calculated for South African urban areas estimate that outdoor air pollution caused 3.7% of total mortality from cardiopulmonary disease in adults aged 30 years and older, 5.1% of mortality attributable to cancers of the trachea, bronchus, and lung in adults, and 1.1% of mortality from acute respiratory infections in children under 5 years of age.

3.7.2 Sulphur dioxide

SO_2 is a colourless pungent, irritating, water-soluble and reactive gas. The major source of SO_2 is the combustion fossil fuels such coal, oil and diesel which contain sulphur.

On inhalation, most SO_2 only penetrates as far as the nose and throat as it is readily soluble in the moist lining of the upper respiratory system, with minimal amounts reaching the lungs, unless the person is breathing heavily, breathing only through the mouth, or if the concentration of SO_2 is high.

The acute response to SO_2 is rapid, within 10 minutes in people suffering from asthma (WHO, 2005). SO_2 reacts with cell moisture in the respiratory system to form sulphuric acid. This can lead to impaired cell function and effects such as coughing, broncho-constriction, exacerbation of asthma and reduced lung function.

Effects such as a reduction in lung function, an increase in airway resistance, wheezing and shortness of breath, are enhanced by exercise that increases the volume of air inspired, as it allows SO_2 to penetrate further into the respiratory tract (WHO, 1999).

Due to its reactivity, SO_2 has a highly non-uniform dose distribution along the conductive airways of the respiratory tract. For low to moderate tidal volumes and nasal breathing, the penetration into the lungs is negligible. For larger tidal volumes and oral inhalation, doses of interest may extend into the segmental bronchi. SO_2 can only reach the gas-exchange region of the lungs after adsorption onto particulate matter.

Another special consideration for SO_2 is that there is great variation in susceptibility to bronchoconstrictive responses. Persons having asthma or atopy can be about ten times more responsive than healthy subjects.

3.7.3 Nitrogen oxides

Ambient concentrations of NO_2 in air are highly variable. Natural background concentrations can range from less than 0.4 µg/m^3 to more than 9 µg/m^3.

In cities, ambient annual mean concentrations can range from 20 to 90 µg/m^3 with hourly maximum concentrations from 75 to 1 000µg/m^3. NO_2 is formed in combustion processes and other high temperature operations such as metallurgical furnaces, blast furnaces, and internal combustion engines.

In the atmosphere, NO_2 reacts with water vapour to produce nitric acid. This acidic pollution can be transported over long distances by wind and deposited as acid rain, causing the acidification of soils, lakes, and streams, accelerated corrosion of buildings and monuments and damages paintwork. NO_2 is also a major source of secondary fine particulate pollution, which decreases visibility, and contributes to surface ozone formation through its reaction with VOCs in the presence of sunlight.

The route of exposure to NO_2 is inhalation and the seriousness of the effects depends more on the concentration, than the length of exposure. The site of deposition for NO_2 is the distal lung as NO_2 does not readily dissolve in the moist upper respiratory system where it reacts with moisture in the fluids of the lower respiratory tract to form nitrous and nitric acids (WHO, 1997).

About 80 to 90% of inhaled nitrogen dioxide is absorbed through the lungs (CCINFO, 1998). NO_2 present in the blood as the nitrite ion oxidises unsaturated membrane lipids and proteins, which result in the loss of cell permeability control. NO_2 causes decrements in lung function, particularly increased airway resistance. People with chronic respiratory problems and people who work, or exercise outside will be more at risk of NO_2 exposure.

3.7.4 Carbon monoxide

Carbon monoxide is a product of incomplete combustion of fossil fuels. It is predominantly formed in internal combustion engines of motor vehicles, but the combustion of any carbon-based material can release CO. Chemical reactions in the atmosphere may also lead to the formation of CO by the oxidation of other carbon-based gases such as methane. Decomposition of organic material within soils can also result in the release of CO.

Natural ambient concentrations of CO range between 0.06 and 0.14 mg/m^3. In urban environments, mean concentrations over eight hours are usually less than 20 mg/m^3, and one-hour peak levels are usually less than 60 mg/m^3. Highest concentrations are usually measured near major roads, as vehicles are the major source of CO.

When inhaled, CO enters the blood stream by crossing the alveolar, capillary and placental membranes. In the bloodstream approximately 80-90% of absorbed CO binds with heamoglobin to form carboxyhaemoglobin. The haemoglobin affinity for CO is approximately 200-250 times higher than that of oxygen. Carboxyhaemoglobin reduces the oxygen carrying capacity of the blood and reduces the release of oxygen from haemoglobin, which leads to tissue hypoxia. This may lead to neurological effects and sometimes delayed severe neurological effects that may include impaired coordination, vision problems, reduced vigilance and cognitive ability, reduced manual dexterity, and difficulty in performing complex tasks (WHO, 1999).

3.7.5 Ozone

Ozone is a colourless gas which carries a harsh odour. It occurs naturally in the lower stratosphere as the ozone layer. This layer protects the earth from shortwave ultraviolet radiation. Near the earth's surface, ozone is a secondary pollutant and a major constituent of photochemical smog. The formation of ozone is dependent on the availability of NOx, VOCs and sunlight. Thus, ozone may not be related directly to any source. Rather it may be associated with the sources of its precursor gases (NOx and VOCs). Ozone may also reach the lower troposphere from the stratosphere, mostly associated with deep frontal systems or with deep convective storms.

Background one-hour average concentrations of O_3 in remote and relatively unpolluted parts of the world are often in the range of 40 to 70 $\mu g/m^3$. In cities maximum mean hourly concentrations can be as high as 300 to 400 $\mu g/m^3$. High O_3 concentrations can persist for 8 to 12 hours per day for several days, when atmospheric conditions favour O_3 formation and poor dispersion conditions exists.

Ozone is a very reactive gas and a strong oxidant, associated with several health effects. Ozone toxicity occurs in a continuum in which higher concentrations, longer exposure duration and greater activity levels during exposure cause greater effects. These include respiratory system effects such as coughing, aggravation of asthma and reduced lung function.

3.7.6 Lead

Lead is a metal that occurs naturally in small amounts in the earth's crust. It is used in the production of some types of batteries, ammunition, metal products (such as solder and pipes) ceramic glazes and paint. Chemicals containing lead, such as tetraethyl lead and tetramethyl lead are used as gasoline additives. In the atmosphere, lead exists primarily in the particulate form and is removed from air by wet and dry deposition. Nearly all environmental exposure to lead is attributed to inorganic compounds.

Levels of lead found in air, food, water and soil/dust vary widely throughout the world and depend on the degree of industrial development, urbanisation and other lifestyle factors. In cities of developing countries traffic-related lead levels range between 0.3 and 1 $\mu g/m^3$ with extreme annual mean values between 1.5 and 2 $\mu g/m^3$.

Exposure to Pb may be through inhalation of contaminated air and ingestion of contaminated food, water and soil. Lead can accumulate in plants and animals. The half-life of lead in human blood (it affects haemoglobin synthesis in the blood) is 28 to 36 days, but lead accumulates in the bones and teeth where it can stay for decades and be released again. Children absorb more and excrete less of the absorbed lead than adults.

4. IMPACT ASSESSMENT

4.1 METHODOLOGY

4.1.1 Model Approach

Dilution of air contaminants in the atmosphere is an important process in preventing undesirable levels of pollutants in the ambient air. Atmospheric dispersion of air contaminants is the result of ventilation, atmospheric turbulence and molecular diffusion. However, gaseous and particulate air contaminants are primarily dispersed into the ambient air through wind action and atmospheric turbulence, much of it on the micro scale level. Depending on the relevant environmental and adiabatic lapse rates, various plume formation can be predicted. These include, looping, neutral, coning, fanning, lofting, fumigating and trapping.

Moisture content and form in the atmosphere can have a profound effect upon the air quality. The presence and amount of water vapour in the atmosphere affects the amount of solar radiation received and reflected by the earth.

Several dispersion models have been developed and are the mathematical description of the meteorological transport and dispersion of air contaminants.

To describe the position of the place where the concentration of contaminants will be estimated, relative to both the source and the ground, a standard Cartesian (x, y, z) co-ordinate system is used in which:

- the physical source is located at the origin,
- the x-axis lies along the mean wind direction,
- x is the distance from the source,
- y is the lateral distance from the mean wind direction,
- z is the height above ground level,
- h is the physical height of the source,
- Δh is the additional height by which the plume rises due to its buoyancy and/or momentum,
- $H = h + \Delta h$ is the effective (plume) height of the release, and
- u is the mean wind speed at plume height.

Most models in use today assumes Gaussian distribution of emission pollutants, horizontally and vertically downwind of the source. With the assumption that the distributions in the y and z directions is normal with a standard deviation of σ_i, the concentration of a gas or aerosol (<20µm diameter particles) can be calculated at ground level for a distance downwind of the source:

$$C_{x,y} = \frac{Q}{\pi u \sigma_z \sigma_y} \exp\left[-\frac{1}{2}\left(\frac{H}{\sigma_z}\right)^2\right] \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right]$$

Where:

$C_{x,y}$	=	pollutant concentration in g/m^3 with a maximum ground level concentration where $\sigma_z = 0.707H$,
Q	=	pollutant emission rate in g/s
π	=	constant pi = 3.14159
u	=	mean wind speed in m/s
σ_y	=	standard deviation of horizontal plume concentration at distance x in m,
σ_z	=	standard deviation of vertical plume concentration at distance x in m,
exp	=	base of natural logarithm = 2.71828183
H	=	effective stack height in m,
x	=	downwind distance along plume mean centreline from point source in m, and
y	=	crosswind distance from centreline of plume in m

The Gaussian equation contains explicit references to y and z, and implicit references to x (since σ_y and σ_z are themselves functions of x). Empirical studies resulted in graphs where values for these constants could be obtained for different Pasquill stability categories. However, these graphs were inaccurate by nature and equations for the variation of σ_y and σ_z with stability class have been developed and are shown in **Table 8**.

Table 8: Equations for Variation of σy and σz

Pasquill stability class	σ_y	σ_z
A	0.22x(1+0.0001x)-0.5	0.20x
B	0.16x(1+0.0001x)-0.5	0.12x
C	0.11x(1+0.0001x)-0.5	0.08x(1+0.0002x)-0.5
D	0.08x(1+0.0001x)-0.5	0.06x(1+0.0015x)-0.5
E	0.06x(1+0.0001x)-0.5	0.03x(1+0.0003x)-1
F	0.04x(1+0.0001x)-0.5	0.016x(1+0.0001x)-1

Process stacks have exit velocity and buoyancy due to the temperature and density difference with the surrounding air that carries them up into the air. This would result in the effective plume height being greater than the physical stack height as presented below.

$$H = h + \Delta h$$

Where:

H = effective stack height in m,
h = height of the stack in m, and
Δh = plume rise in m.

One of the popular equations for the distance the flue gas rises before levelling out is Holland's empirical equation.

$$\Delta h = \frac{v_s d}{u}\left[1.5 + \left(2.68x10^{-3} p \frac{\Delta T d}{T_s}\right)\right]$$

Where:

Δh	=	rise of plume above the stack in m,
v_s	=	stack gas velocity in m/s,
d	=	inside stack diameter in m,
u	=	mean wind speed in m/s,
p	=	atmospheric pressure in millibars
ΔT	=	stack gas temperature minus air temperature in K, and
T_s	=	stack gas temperature

The above equation is suitable for neutral conditions. For unstable conditions, Δh should be increased by a factor of 1.1 to 1.2 and decreased by a factor of 0.8 to 0.9 for stable conditions. Holland's equation frequently underestimates the effective stack height, giving a conservative figure for design purposes. Although more complex models are available to determine the upward driving force in terms of a buoyancy flux, Holland's equation will suffice when insufficient information with regards the properties of the source is known.

The simplest Gaussian solution assumes that the plume is free to expand in all directions without constraint. In the usual situation of an elevated source at some height above the ground, downwind dispersion is always limited by the presence of the ground, while upward dispersion may be limited by an elevated inversion. Assuming that no pollutant is absorbed by the ground, any pollutant that reaches the ground is available for upward dispersion and the following equation considers reflection at the ground:

$$C_{x,y} = \frac{Q}{2\pi u \sigma_z \sigma_y} \exp\frac{-y^2}{2\sigma_y^2}\left[\exp-\frac{1}{2}\left(\frac{z-H}{\sigma_z^2}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z^2}\right)^2\right]$$

4.1.2 Model Input

The dispersion of emissions from the KFP Power Plant was modelled using the following inputs:

- For the Control Pathway – Regulatory default options for gasses/PM_{10}, dry deposition options for TSP. Tier I approach for NO_2 modelling(assuming all NO_2).
- Source Pathway – Buildings were modelled as area sources. All haul roads were modelled as line area sources. Source emission factors and rates contained in **Table 3** to **Table 4**.
- The following stack parameters:
  - 8 clusters with six stacks each
  - Cluster height of 30m
  - Exhaust gas temperature of 370°C
  - Exhaust gas velocity of 27.9m/s
  - Exhaust gas volumetric flow (per cluster) of 121m^3/s
- Receptor Pathway – Elevated terrain option. Uniform Cartesian 115km^2 grid with a resolution of 250m by 250m for TSP, PM_{10}, SO_2 and TVOCs. Uniform Cartesian 2 450km^2 grid with a resolution of 500m by 500m for NO_2. Closest receivers in each direction were loaded as discrete receptors.
- Terrain Grid Pathway – SRTM1/SRTM3 digital elevation model data (~30m).
- Meteorology Pathway – Site specific Unified Model data supplied by Meteoblue for the period 1 May 2019 to 30 April 2024.

4.2 MODEL RESULTS AND DISCUSSION

This section contains the results of the predicted maximum and average ground level concentrations generated through the ISC-AERMOD VIEW model.

Prior to an analysis of the simulation results it is recommendable to briefly review areas of uncertainty which needs to be considered in the interpretation of the results. The range of uncertainty of the Gaussian plume model is given by the US-EPA as being in the range of -50% to +200% when used under the recommended conditions. Uncertainties are, however, not only associated with the mathematical model itself, but also with the generation of the meteorological and source data used as input data.

It is well known that wind data errors are the major cause of poor agreement, especially for short-term predictions and long down-wind distances. The selection of a suitable meteorological data set for use in the simulation analysis is fundamental to the accuracy of the results. Errors in source strengths translate directly into errors of similar magnitudes in the model prediction.

There will always be some error in any geophysical model, but it is desirable to structure the model in such a way to minimise the total error. A model really represents the most likely outcome of an ensemble of experimental results. The total uncertainty can be thought of as the sum of three components: the uncertainty due to errors in the model physics, the uncertainty due to data errors and the uncertainty due to stochastic processes (turbulence) in the atmosphere.

Concentration and deposition isopleths reflect interpolated values for each receptor grid point for various averaging periods. It has generally been found that the accuracy of dispersion models improves with increased averaging periods. The prediction of instantaneous peaks is the most difficult and are normally performed with more complicated dispersion models specifically fine-tuned and validated for the process and location. For this reason, concentrations resulting from routine releases are given for at least three averaging periods, viz. hourly, daily and annual averages. No significant upset (intermittent release) sources are expected for the process.

The results presented reflect the spectrum from maximum ground level concentrations, occurring during very unstable conditions with low wind speeds, to low wind speeds during very stable conditions resulting in maximum impact area.

Dispersion results for the KFP Power Plant are presented for the following scenarios:

- Total suspended particulates during construction of plant and access roads (daily averaging period).
- PM_{10}, SO_2, NO_2 and TVOCs during all 48 reciprocating engines at 100% load (hourly, daily and annual averaging periods).

Please note that only modelling outcomes showing little or more impact (>5% of the standard) are reflected in the report.

4.2.1 Construction

The dispersion plot for dust deposition during the construction phase of the project are reflected in **Figure 29**. The results for the KFP Power Plant were evaluated in terms of current South African National Standards and are presented for the project independently (i.e. incremental).

NO_2, SO_2 and CO emissions (vehicle tailpipe emissions) were not quantified for this phase of the project due to the relatively low expected risk and since an acceptable construction vehicle inventory cannot be established at this stage.

Predicted dust deposition rates during construction are expected to remain at current levels at all the closest receivers identified, as shown in **Figure 29**.

Daily and annual average $PM_{10/2.5}$ concentrations will probably remain below 5% of the relevant standards at all sensitive receivers (models not shown).

4.2.2 Operational Phase

Dispersion scenarios for PM_{10}, SO_2 and NO_2 for the operational phase of the power plant are reflected in **Figure 30** to **Figure 33**. Scenarios for vehicle tailpipe - and TVOCs emissions from power generation were not included in the report due to the low expected risk, i.e. <5% of the national standard.

PM_{10} is expected to peak about 1.6 kilometres east of the plant at daily concentrations between 10 and 25% of the standard, i.e. 7.5 to 18.75 $\mu g/m^3$. Isolated areas were concentrations above 10% of the standard may occur can be expected up to 6 kilometres east through to south of the plant during maximum pollution events (**Figure 30**).

Similarly, SO_2 concentrations are expected to peak above 5% of the standard, east through to south of the plant at an average distance of 2.5 kilometres (**Figure 31**).

PM_{10} and SO_2 concentrations will most likely be insignificant for all other reference periods.

A significant number of hourly NO_2 exceedances, i.e. >44 can be expected due east and southeast of the plant **Figure 32**. Incremental annual NO_2 concentrations are projected to be in the region of 25% of the standard **Figure 33**.

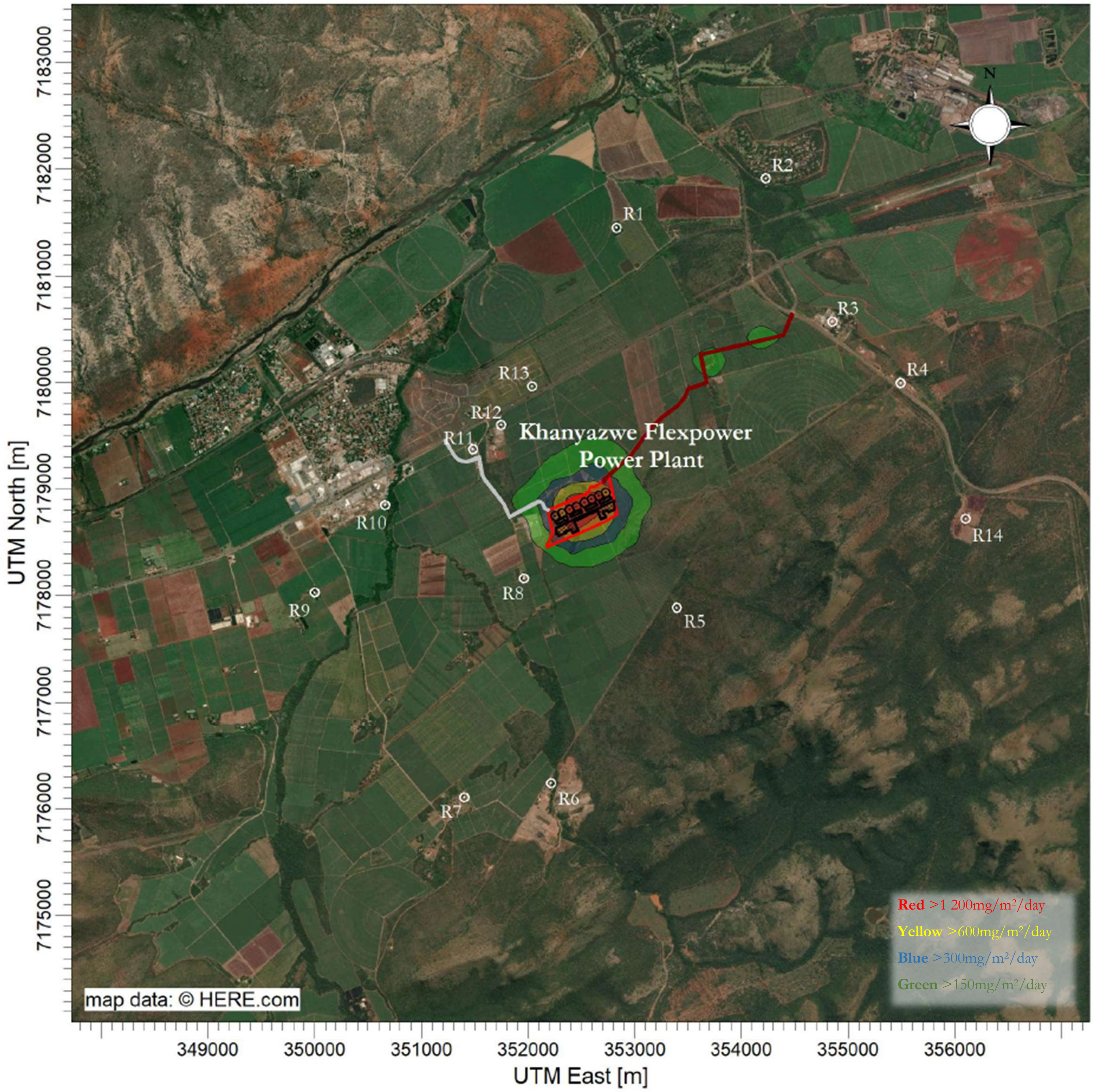

Figure 29: Daily average dust deposition rate during construction

(Non-residential Standard – 1 200mg/m^2/day, Residential Standard – 600mg/m^2/day)

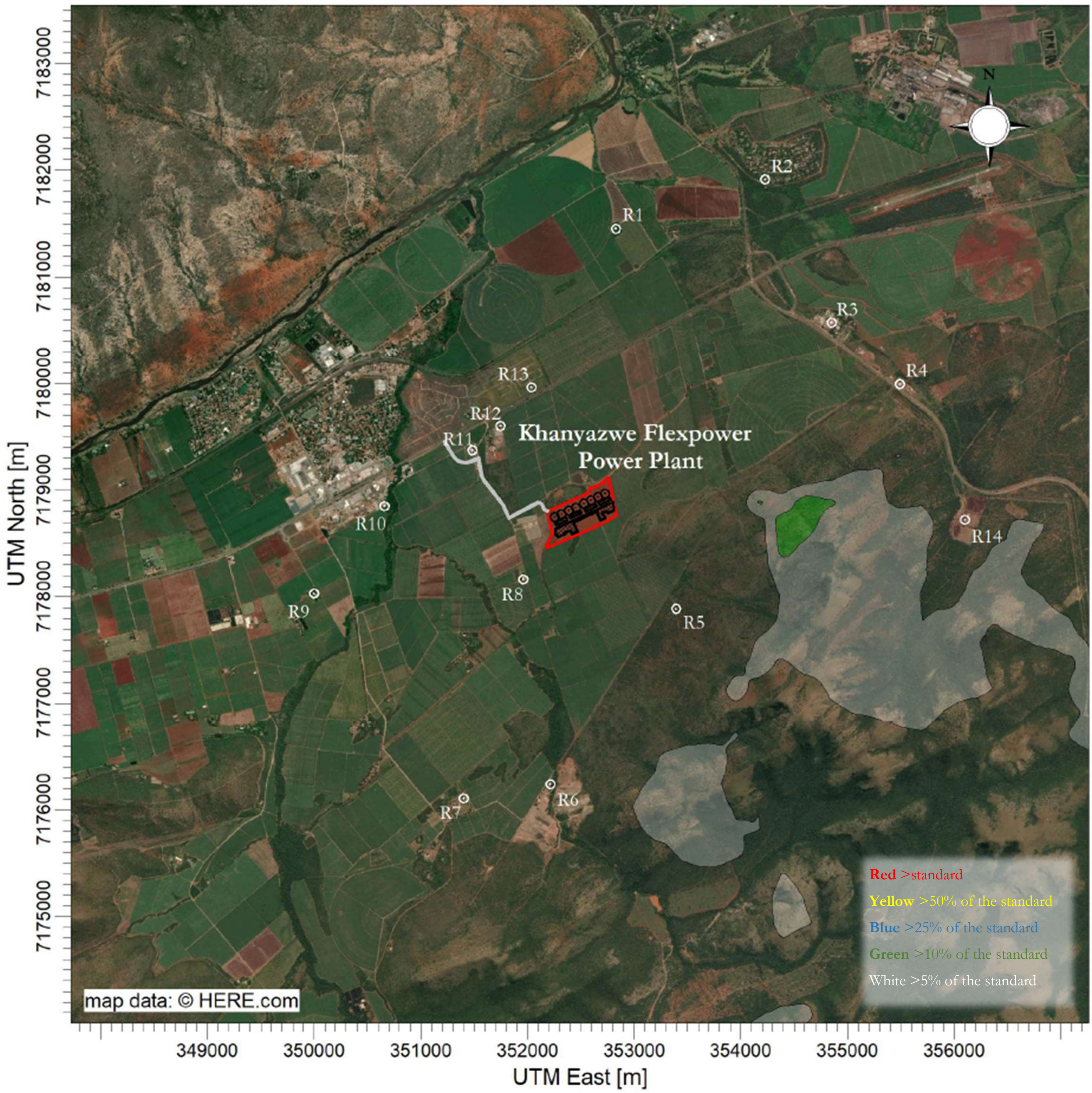

Figure 30: Daily average PM_{10} concentration

(South African National Air Quality Standard – 75 µg/m^3)

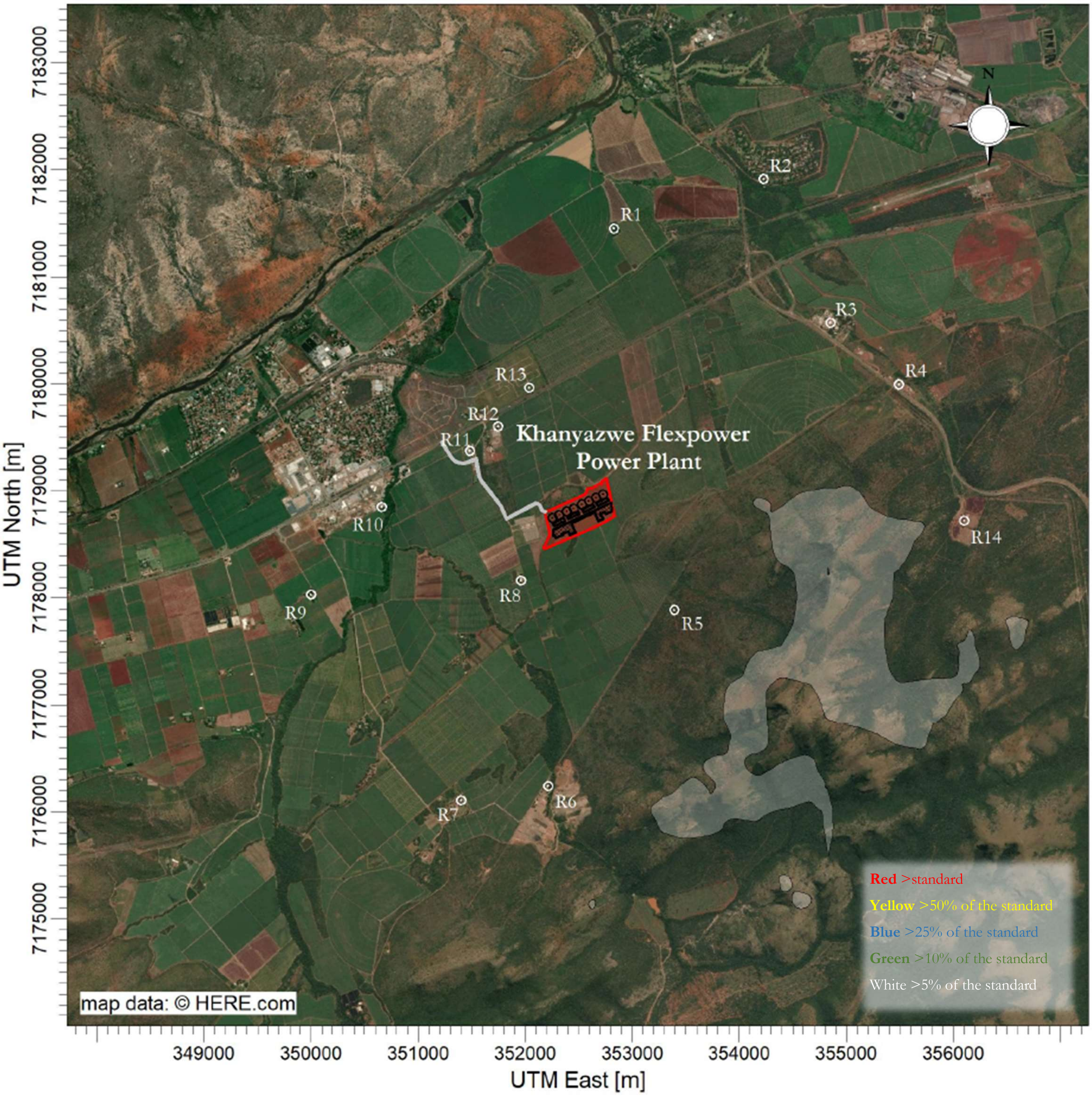

Figure 31: Hourly average SO_2 concentration

(South African National Air Quality Standard – 350 µg/m^3)

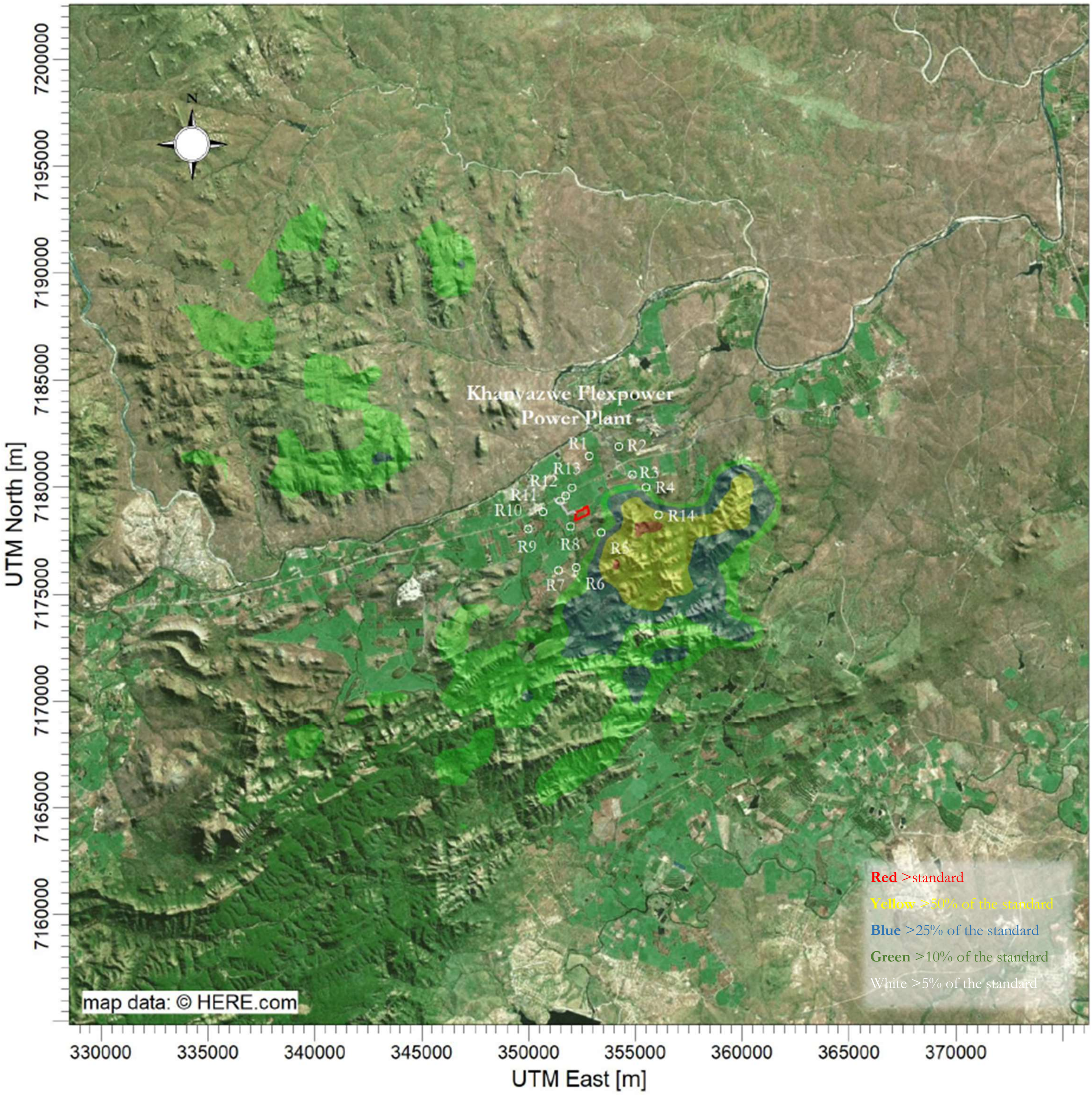

Figure 32: Hourly average NO_2 concentration

(South African National Air Quality Standard – 200 μg/m^3)

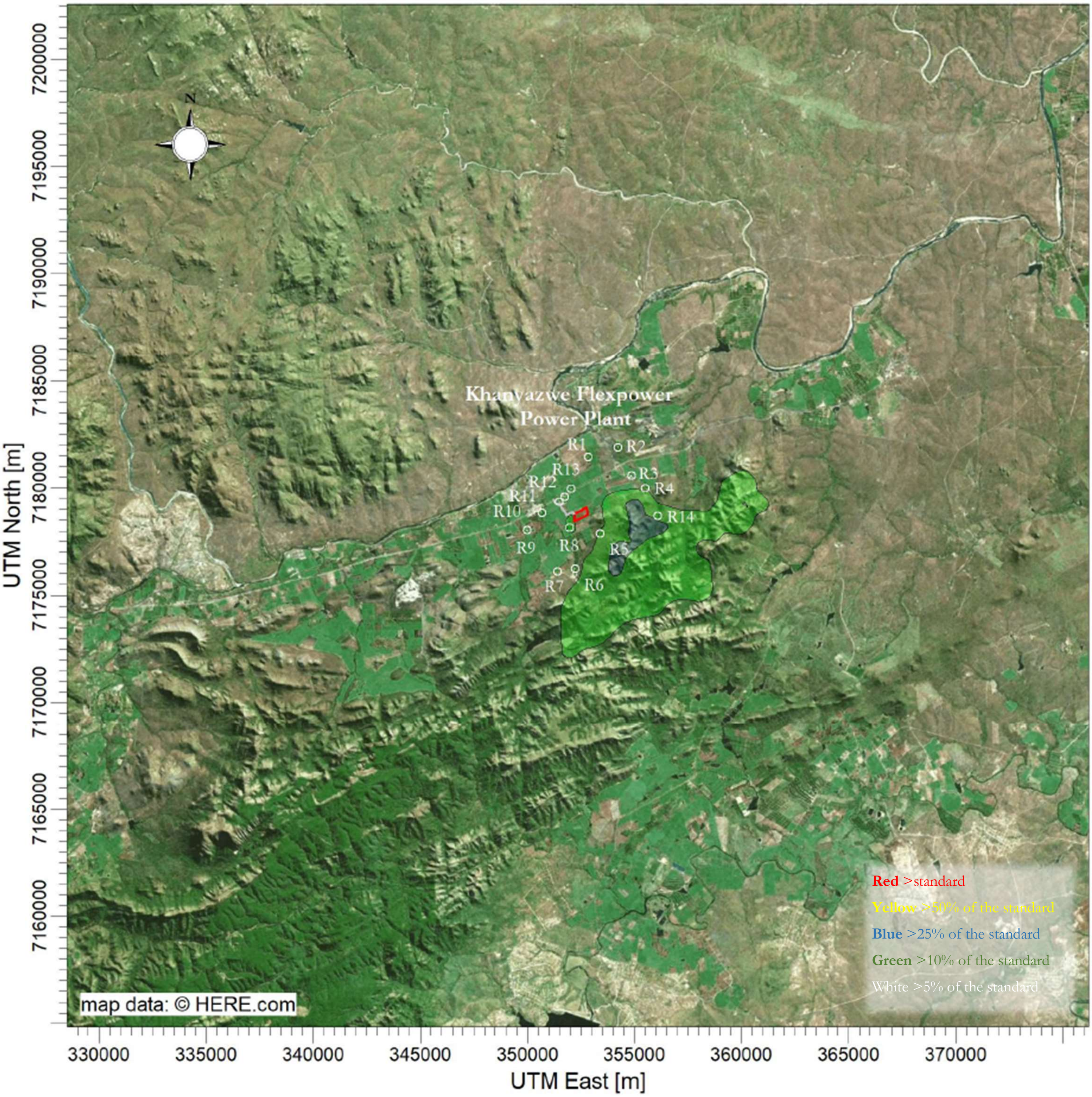

Figure 33: Incremental annual average NO_2 Concentration
(South African National Air Quality Standard – 40 µg/m^3)

4.3 SIGNIFICANSE ANALYIS

4.3.1 Significance Analysis Approach

The assessment of the significance of potential impact on ambient air quality was based on professional judgment, fieldwork and desktop analysis, as appropriate. Potential impacts were assessed using standardised and internationally recognised methodology adhering to ISO 14001, World Bank and International Finance Corporation requirements. For each predicted impact, criteria are applied to establish the significance of the impact based on likelihood and consequence.

The criteria that contribute to the consequence of the impact are intensity (the degree to which pre-development conditions are changed), duration (length of time that the impact will continue); and the extent (spatial scale) of the impact. The sensitivity of the receiving environment and/or sensitive receptors is incorporated into the consideration of consequence by appropriately adjusting the thresholds or scales of the intensity, duration and extent criteria, based on expert knowledge. For each impact, professional judgement is applied to ascribe a numerical rating for each criterion (see **Table 9**, **Table 10** and **Table 11**). The consequence is then established using the formula:

Consequence = intensity + duration + extent

Table 9: Definition of Intensity Ratings

Rating	Criteria	
	Negative impacts (Type of impact = -1)	**Positive impacts (Type of impact = + 1)**
7	Complete destruction (irreversible and irreplaceable loss) of natural or social systems, resources (e.g. species) and human health. No chance of these processes or resources ever being restored to their pre-impact condition.	Noticeable, sustainable benefits that improve the quality and extent of natural or social system or resources, including formal protection.
6	Very high degree of damage to natural or social systems or resources. These processes or resources may restore to their pre-project condition over very long periods of time (more than a typical human lifetime).	Great improvement to ecosystem or social processes and services or resources.
5	Serious damage to components of natural or social systems or resources and the contravention of legislated standards.	On-going and widespread benefits to natural or social systems or resources.
4	High degree damage to natural or social system components, species, or resources.	Average to intense positive benefits for natural or social systems or resources.
3	Moderate damage to natural or social system components, species, or resources.	Average, on-going positive benefits for natural or social systems or resources.
2	Minor damage to natural or social system components, species, or resources. Likely to recover over time. Ecosystems and valuable social processes not affected.	Low positive impacts on natural or social systems or resources.
1	Negligible damage to individual components of natural or social systems or resources, such that it is hardly noticeable.	Limited low-level benefits to natural or social systems or resources.

Table 10: Definition of Duration Ratings

Rating	Criteria
7	**Permanent:** The impact will remain indefinitely.
6	**Beyond project life**: The impact will remain for some time after the life of the project.
5	**Project life:** The impact will cease after the operational life span of the project.
4	**Long-term**: The impact will continue for 6-15 years.
3	**Medium-term:** The impact will continue for 2-5 years.
2	**Short-term:** The impact will continue for between 1 month and 2 years.
1	**Immediate**: The impact will continue for less than 1 month.

Table 11: Definition of Extent Ratings

Rating	Criteria
7	**International:** The effect will occur across international borders.
6	**National:** The impact will affect the entire country.
5	**Province/ Region:** The impact will affect the entire province or region.
4	**Municipal Area:** The impact will affect the whole municipal area.
3	**Local:** The impact will extend across the site and to nearby properties.
2	**Limited:** The impact will be limited to the site.
1	**Very limited:** The impact will be limited to the footprint of the development and will not extend to the boundaries of the site.

Depending on the numerical result, the impact's consequence would be defined as either extremely, highly, moderately, or slightly detrimental; or neutral; or slightly, moderately, highly, or extremely beneficial. These categories are provided in **Table 12**.

Table 12: Application of Consequence Ratings

Range		Consequence Rating
-21	-18	Extremely detrimental
-17	-14	Highly detrimental
-13	-10	Moderately detrimental
-9	-6	Slightly detrimental
-5	5	Negligible
6	9	Slightly beneficial
10	13	Moderately beneficial
14	17	Highly beneficial
18	21	Extremely beneficial

To determine the significance of an impact, the probability (or likelihood) of that impact occurring is also considered. In assigning probability, the likelihood of occurrence and cognisance of uncertainty and detectability of the impact is taken into consideration. The most suitable numerical rating for probability is selected from **Table 13** and applied with the consequence according to the following equation:

Significance = consequence x probability

Table 13: Definition of Probability Ratings

Rating	Criteria
7	**Certain/ Definite:** There are sound scientific reasons to expect that the impact will definitely occur.
6	**Almost certain/Highly probable:** It is most likely that the impact will occur.
5	**Likely:** This impact has occurred numerous times here or elsewhere in a similar environment and with a similar type of development and could very conceivably occur.
4	**Probable:** This impact has occurred here or elsewhere in a similar environment and with a similar type of development and could conceivably occur.
3	**Unlikely:** This impact has not happened yet but could happen.
2	**Rare/ improbable:** The impact is conceivable, but only in extreme circumstances. The possibility of the impact manifesting is very low as a result of design, experience, or implementation of adequate mitigation measures.
1	**Highly unlikely/None:** The impact is expected never to happen or has a very low chance of occurring.

When assigning probability to an impact, it is vitally important to distinguish this from the concepts of frequency and confidence:

- **Probability** refers to the likelihood that an impact will occur.
- **Frequency** refers to the regularity with which an impact occurs.
- **Confidence** (**Table 15**) refers to the degree of certainty of a prediction. Confidence may be related to any of the impact assessment criteria (extent, intensity, duration, or probability) and is not necessarily only related to probability. Confidence may be influenced by any factors that introduce uncertainty into a prediction.

Depending on the numerical result of this calculation, the impact would fall into a significance category of negligible, minor, moderate, or major, and the type would be either positive or negative. Once the significance of an impact occurring without mitigation has been established, ratings are assigned for the same impact after the proposed mitigation has been implemented.

Table 14: Application of Significance Ratings

Range		Significance Rating	Action
-147	-109	Major - negative	Impact elimination since no cost-effective mitigation options are available to reduce the impact to the level of administrative control.
-108	-73	Moderate - negative	Substitution measures required to reduce impact to the level of administrative control.
-72	-36	Minor - negative	Engineering measures required to reduce impact to the level of administrative control.
-35	-1	Negligible - negative	Mitigation through administrative control and best industry practise.
0	0	Neutral	Additional mitigation to the point where the impact becomes beneficial.
1	35	Negligible - positive	Continuous improvement.
36	72	Minor - positive	Continuous improvement.
73	108	Moderate - positive	Continuous improvement.
109	147	Major - positive	Continuous improvement.

Despite attempts at ensuring objectivity and impartiality, environmental assessment remains an act of judgement and can never escape the subjectivity inherent in attempting to define significance. The determination of the significance of an impact depends on context (spatial and duration) and intensity of that impact. Since the rationalisation of context and intensity will ultimately be prejudiced by the observer, there can be no wholly objective measure by which to judge the components of significance, let alone how they are integrated into a single comparable measure.

This notwithstanding, to facilitate informed decision-making, air quality assessment must endeavour to come to terms with the impact significance.

Recognising this, EHRCON has attempted to address potential subjectivity for the current study as follows:

- Being explicit about the difficulty of being completely objective in the determination of significance, as outlined above.
- Developing an explicit methodology for assigning significance to impacts and outlining this methodology in detail. Having an explicit methodology not only forces the specialist to come to terms with the various facets that contribute to significance (thereby avoiding arbitrary assessment), but also provides the reader with a clear summary of how the specialist derived the significance.
- Wherever possible, differentiating between the significance of potential environmental impacts as experienced by the various affected parties.
- Utilising a team approach and internal review of the assessment to facilitate a rigorous and defendable system.

Although these measures may not eliminate subjectivity, they provide an explicit context within which to review the assessment of impacts. EHRCON has empirical knowledge of ambient air quality management and can comment on the confidence its findings based on the availability of data and the certainty of their findings (see **Table 15**).

Table 15: Definition of Confidence Ratings

Rating	Criteria
Low	Judgement is based on intuition and there some major assumptions used in assessing the impact may prove to be untrue.
Medium	Determination is based on common sense and general knowledge. The assumptions made, whilst having a degree of uncertainty, are fairly robust.
High	Substantive supportive data or evidence exists to verify the assessment.

4.3.2 Significance Analysis Assessment

An impact can be defined as any change in the physical-chemical, biological, cultural and/or socio-economic environmental system that can be attributed to human activities related to alternatives under study for meeting a project need.

Table 16: TSP Emissions Significance Analysis

Item/Receptor	Description	Consequence Intensity + Duration + Extent				Significance Consequence x Probability			Motivation
		Intensity	Duration	Extent	Rating	Consequence	Probability	Rating	
All	Impact of controlled total suspended particulate, fine particulates and gaseous emissions during construction.	-1	-2	-3	Slight	-6	3	-18	Negligible damage to natural or social systems or resources. Impact could continue for up to 2 years. The impact could extend across the site and to nearby properties Mitigation through administrative control and best industry practise (see Section 5.2). Residual impact at background levels. High assessment confidence.

Table 17: PM_{10}, SO_2 and VOC Emissions Significance Analysis

Item/Receptor	Description	Consequence Intensity + Duration + Extent				Significance Consequence x Probability			Motivation
		Intensity	Duration	Extent	**Rating**	Consequence	Probability	**Rating**	
All	Impact of PM_{10}, SO_2 and VOC emissions during normal operations.	-1	-4	-3	Slight	-8	3	-32	Negligible damage to natural or social systems or resources. Impact will continue for at least 15 years. The impact could extend across the site and to nearby properties. Mitigation through administrative control and best industry practise (see Section 5.2). Residual impact at background levels. High assessment confidence.

Table 18: NO_2 Emissions Significance Analysis

Item/Receptor	Description	Consequence: Intensity + Duration + Extent				Significance: Consequence x Probability			Motivation
		Intensity	Duration	Extent	Rating	Consequence	Probability	Rating	
R1, R2, R3, R6, R7, R8, R9, R10, R11, R12, R13	Impact of NO_2 emissions during normal operations	-1	-4	-3	Slight	-8	3	-24	Negligible to minor damage to natural or social systems or resources. Impact will continue for at least 15 years. The impact could extend across the site and to nearby properties. Mitigation through administrative control and best industry practise (see Section 5.2). Residual impact at background levels. High assessment confidence.
R14, R5		-2	-4	-3	Slight	-9	3	-27	

In support of an emission reduction strategy, KFP must confirm or, where necessary revise, the current understanding of the significance of specific pollutants and sources. To fulfil this objective, emissions were ranked based on the emissions inventory and the impact significance analysis.

From the emissions inventory for the KFP Power Plant the following observations can be made:

- Emission rates will remain stable throughout the life of the project, influenced only by fluctuations in power requirements.

- A total emission rate of 9.99E+4 gram per second was calculated for power generation using reciprocating technology.
- Primary combustion emissions will be the dominant source of ambient pollution, discharging more than 99.9% of the total emission load. Less than 0.1% of the atmospheric pollution load will be attributed to fugitive emissions from support processes, fuel handling and vehicle movement.
- NO_2 is the criteria pollutant of concern and contributes about 0.29% of the pollution load.
- Primary emissions can be further mitigated through application of best available techniques combined with sound environmental management principles. A reduction in emissions of up to 98% can be achieved.

From the impact significance analysis for the KFP Power Plant the following observations can be made:

- The incremental impact of all pollutants during construction is expected to be negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of PM_{10}, SO_2 and VOC during normal operation is expected to be negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of NO_2 during normal operation is expected to be negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.

5. EPILOGUE

5.1 AIR QUALITY MANAGEMENT APPROACH

KFP's vision and policy on air quality management should essentially reflect the vision, principles and approach defined in the National Air Quality Management Plan (NAQMP). This includes a commitment to:

- Establishing goals and strategies for air quality improvement.
- The establishment and continued implementation of a comprehensive air quality monitoring and management system.
- Involving and educating people with the purpose of minimising pollution and facilitating the effective participation in air quality governance.
- Making greater use of innovative approaches to reducing pollution.
- Effectively using new information technologies.
- Responding creatively and vigorously to air quality challenges and emerging issues.

A shift from end-of-pipe air pollution control through the exclusive implementation of command-and-control measures to effects-based air quality management using proactive, flexible, varied and fair measures should be supported at all times.

The key approaches that are to be implemented to achieve policy objectives may be individually listed as follows:

- Adoption of a receiving environment approach which requires conformance to air quality standards. The standards define what constitutes satisfactory air quality to ensure human health and welfare, the protection of the natural and build environment, and finally the prevention of significant decline.
- Establishment of a sound technical basis for air quality management and planning. This would include the building of technical expertise and the development and implementation of various tools such as an emissions inventory, a meteorological and air pollution monitoring network, atmospheric dispersion model, impact assessment methodologies et cetera.
- Control and management of all significant sources of air pollution relative to their contributions to ambient air pollutant concentrations. This will ensure that improvements in air quality are secured in the most timely, even-handed and cost-effective manner.
- The integration of a wide range of emission reduction measures is required given the complexity of the process and the diversity of the receiving environment. Such approach will ensure innovative and flexible plans of action tailored to suit the specific source in the local circumstances.
- Identification and implementation of emission reduction measures that are: (i) environmentally beneficial taking all media into account, (ii) technically feasible, (iii) economically viable, and (iv) socially and politically acceptable.
- Provision will be made for the integration of air quality issues into the local community planning process to ensure that air quality issues are addressed in the long term.
- Empowerment of communities by providing easy access to ambient air quality information, including information on air pollution concentrations and environmentally harmful practices.
- Facilitation of public consultation and encouragement of public participation in the air quality management and planning process.

An air quality management plan cannot be successfully implemented and revised in the absence of an effective air quality management system. KFP must therefore have as a key focus the establishment and support of such a system. Air quality guidelines represent one important air quality management "tool".

Such guidelines need to comprise, as a minimum, guideline or limit values and permissible timeframes for bringing air quality into compliance with such values. Other essential tools in any air quality management system are emissions inventory, air quality and meteorological monitoring and atmospheric dispersion modelling (**Figure 34**).

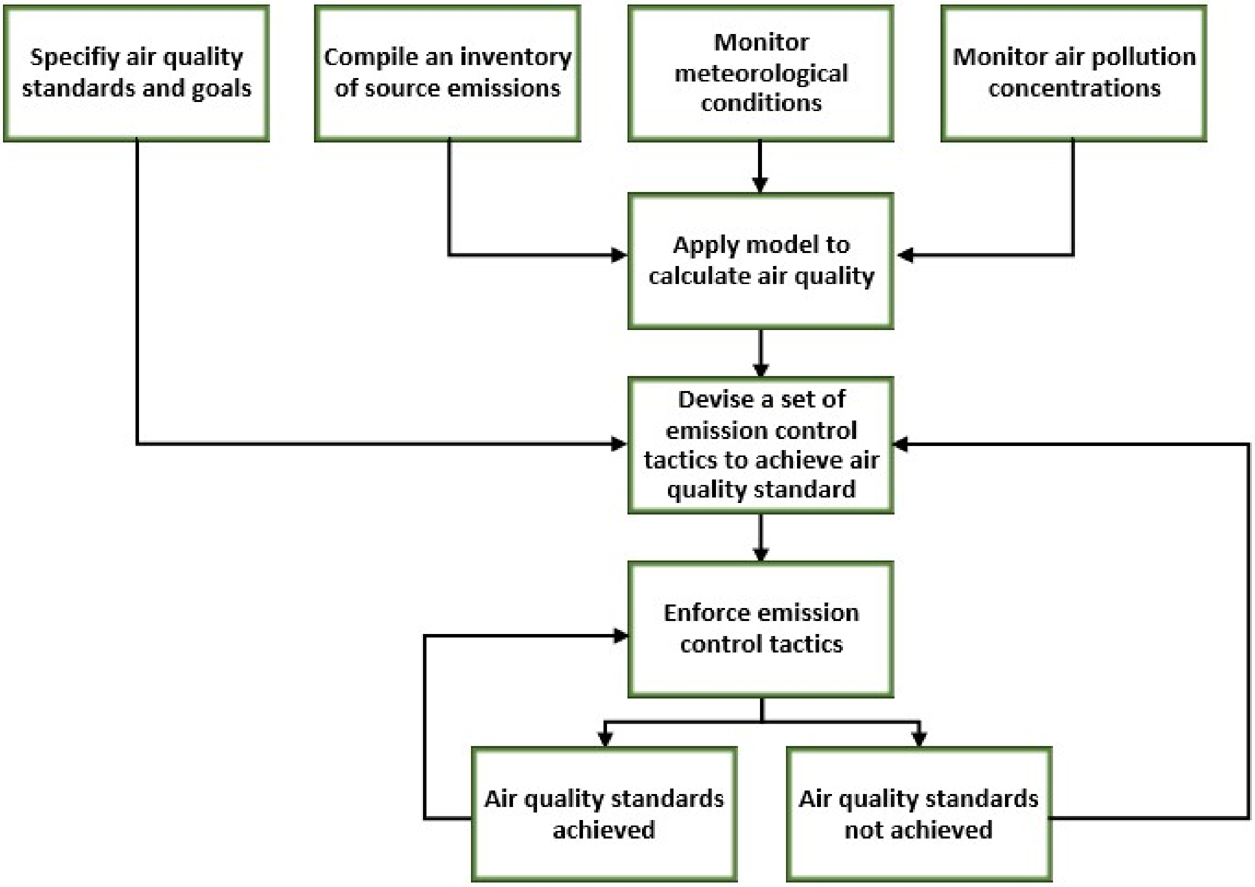

Figure 34: Air Quality Management Strategy

Based on a comprehensive emissions inventory, the application of monitoring, in combination with modelling, facilitates the effective characterisation of spatial and temporal variations in air pollutant concentrations. Such concentrations are evaluated based on local guideline values to determine the need for devising emission control strategies. Dispersion modelling is used to predict ambient air pollutant reductions possible through the implementation of specific emission control strategies.

Emission control strategies may then be selected which are able to ensure compliance with the local guideline value, the socio-economic acceptability and technological feasibility of such strategies having been assessed. The control measures selected need to be enforced, and if the standards are achieved, they need continued enforcement. If the standards are not achieved after a reasonable period of time (i.e. within the permissible timeframe stipulated), the emission control measures may need to be revised.

An integrated air quality management system, which comprises components such as an emissions inventory and air quality monitoring and modelling, therefore, forms the basis of effective air pollution control and air quality management.

Air quality management components currently implemented by KFP include the following:

- Emissions inventory.
- Atmospheric dispersion modelling.
- Public liaison and consultation mechanisms.

Based on the outputs of the air quality management system, health risk assessments and damage assessments could be undertaken, and future impacts quantified in the medium-term (3 to 5 years). Such assessment may be undertaken in the following ways: (i) in-house, through the selection and acquisition of suitable models and acquisition and preparation of locally derived input data, (ii) in-house, though the application of manual calculations based on locally derived data and international protocols, or (iii) externally, through the appointment of consultants on a project-by-project basis.

5.2 RECOMMENDATIONS

5.2.1 Administrative Measures and Monitoring

According to SANS 1929:2009 the concentrations of specific pollutants within an area shall be evaluated against the following thresholds to determine applicable assessment methods:

- Upper assessment threshold, i.e. the 99th percentile pollutant levels represent a pollutant value exceeding 70% of a limit value (considering limit values for all periods which have been used to derive averages).
- Lower assessment threshold, i.e. the 99th percentile pollutant levels represent a pollutant value below 50% of all limit values (considering limit values for all periods which have been used to derive averages).

Provision should be made for three air pollutant concentration assessment methods, based on the classification pollutant concentrations relative to the upper and lower assessment thresholds. These methods are:

- Mandatory monitoring, which may be supplemented by modelling techniques to provide an adequate level of information on ambient air quality. This method should be implemented where the upper assessment threshold for a specific pollutant is exceeded.
- A combination of measurement and modelling techniques should be implemented in areas and for pollutants for which concentrations are between the upper and lower assessment thresholds.
- The sole use of modelling or objective estimation techniques is permissible for pollutant concentrations below the lower assessment threshold.

The classification to determine applicable assessment methods should be based on air pollutant concentrations recorded during the previous five years where data is available.

Results from measurement campaigns of short duration during the period of a year and at locations likely to be typical of the highest pollution levels may be combined with information from emission inventories and modelling to provide the concentration data required. Classification should be reviewed earlier than every five years in the event of significant changes in activities relevant to ambient air pollutant concentrations.

In view of the predicted ambient pollutant concentrations resulting from emissions from the KFP Power Plant the following is recommended:

- Continuous monitoring of ambient PM_{10}, SO_2, NO_2 and VOC concentrations for a minimum period of one (1) year before commissioning of the plant and in accordance with the AEL requirements, thereafter, should be performed. For the background monitoring, one monitoring station, placed in the main impact area of the future plant, should suffice. Background monitoring data will be critical to determine the proportional impact of the plant in the cumulative setting.
- An emissions inventory and annual modelling regime must be maintained throughout the life of the project.

The ultimate purpose of monitoring is not merely to collect data, but to provide information necessary to make informed decisions on managing and improving the environment. Monitoring fulfils a central role in this process, providing the necessary sound scientific basis for policy and strategy development, objective setting, compliance measurement against targets and enforcement action.

However, the limitations of monitoring should be recognised. In many circumstances, measurements alone may be insufficient, or impractical for the purpose of fully defining population exposure. No monitoring programme, however well-funded and designed, can comprehensively quantify patterns of air pollution in both space and time.

At best monitoring provides an incomplete, but useful, picture of current environmental air quality. Monitoring often needs to be used in conjunction with other objective assessment techniques, including modelling, emission measurement and inventories, interpolation and mapping.

5.2.2 Best Available Industry Techniques for Reciprocating Engines

Generic control techniques have been developed for reciprocating engines: parametric controls (timing and operating at a leaner air-to-fuel ratio) and combustion modifications such as advanced engine design for new sources or major modification to existing sources (clean-burn cylinder head designs and pre-stratified charge combustion for rich-burn engines).

5.3 KEY FINDINGS

The air quality impact study concludes the following:

- The project falls within the Nkomazi Local Municipality and the Ehlanzeni District Municipality of the Mpumalanga Province. Air Quality Management is defined within the Ehlanzeni District Municipality Integrated Development Plan, as well as the Municipal Health Services By-Laws.
- Emission rates will remain stable throughout the life of the project, influenced only by fluctuations in power requirements.
- A total emission rate of 9.99E+4 gram per second was calculated for power generation using reciprocating technology.
- Primary combustion emissions will be the dominant source of ambient pollution, discharging more than 99.9% of the total emission load. Less than 0.1% of the atmospheric pollution load will be attributed to fugitive emissions from support processes, fuel handling and vehicle movement.
- NO_2 is the criteria pollutant of concern and contributes about 0.29% of the pollution load.
- Dispersion of particulate emissions from the process was modelled using the ISC-AERMOD View model based on the standard Gaussian solution.
- The results present the spectrum from maximum ground level concentration to maximum impact area, and accounts for daily and annual reference periods.
- Ground level concentrations were predicted for atmospheric conditions based on local meteorological data for the period 1 May 2019 to 30 April 2024. Winds from the southeastern sector (33.7%) were

mostly reported for the study area. Calm periods were the exception and wind speeds were most often brisk, between 3.6 and 5.7 m/s (29.3%). Moderate winds between 2.1 and 3.6 m/s were recorded 28%, light winds between 0.5 and 2.1 m/s were recorded 24.5%, and strong winds above 5.7m/s, about 16.6% of the time.

- Dust deposition rates during construction are expected to remain at current levels at all the closest receivers identified. Incremental $PM_{10/2.5}$ concentrations will probably remain below 5% of the relevant standards.
- During operation at full capacity, PM_{10} is expected to peak about 1.6 kilometres east of the plant at daily concentrations between 10 and 25% of the standard. Isolated areas were concentrations above 10% of the standard may occur can be expected up to 6 kilometres east through to south of the plant during maximum pollution events.
- SO_2 concentrations are expected to peak above 5% of the standard, east through to south of the plant at an average distance of 2.5 kilometres.
- PM_{10} and SO_2 concentrations will most likely be insignificant for all other reference periods.
- A significant number of hourly NO_2 exceedances can be expected due east and southeast of the plant. Incremental annual NO_2 concentrations are projected to be in the region of 25% of the standard.
- It is unlikely that the process independently, would result in average NO_2 concentrations above current background concentrations at the nearest residential receivers.
- The incremental impact of all pollutants during construction is expected to be negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of PM_{10}, SO_2 and VOC during normal operation is expected to be negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.
- The incremental impact of NO_2 during normal operation is expected to be negligible. Current industry standard techniques should be maintained and supplemented with administrative control measures to maintain the residual impact at the nearest sensitive receivers at current background levels.

- Controlled emissions can be further mitigated through application of best available industrial control measures and sound environmental management principles. A reduction in emissions of up to 98% can be achieved.
- Continuous monitoring of ambient PM_{10}, SO_2, NO_2 and VOC concentrations for a minimum period of one (1) year before commissioning of the plant and in accordance with the Atmospheric Emission Licence (AEL) requirements, thereafter, should be performed. For the background monitoring, one monitoring station, placed in the main impact area of the future plant, should suffice. Background monitoring data will be critical to determine the proportional impact of the plant in the cumulative setting.
- Ambient monitoring should be used in combination with modelling and emission inventory to assess the effectiveness of control measures at source and receivers, throughout the life of the project. It will also contribute to open communication to all stakeholders.

5.4 ABBREVIATIONS

AEL	:	Atmospheric emission licence
AQIS	:	Air quality impact study
AQMP	:	Air quality management plan
BTEX	:	Benzene, Ethylbenzene, Toluene & Xylene
ºC	:	Degree Celsius
CH_4	:	Methane
CO	:	Carbon monoxide
CO_2	:	Carbon dioxide
DEFF	:	Department of Environmental Affairs, Forestry and Fisheries
EIA	:	Environmental impact assessment
EMP	:	Environmental management plan
H_2	:	Hydrogen
HAPs	:	Hazardous air pollutants
km	:	Kilometre
km/h	:	Kilometre per hour
LPG	:	Liquid Petroleum Gas
mg	:	Milligrams
$mg/m^2/day$	:	Milligrams per square metre per day
mm	:	Millimetres
Nm^3/h	:	Normal cubic metres per hour
m/s	:	Meters per second
NAAQS	:	National Ambient Air Quality Standards

NEMAQA	:	National Environmental Management: Air Quality Act (Act no. 39 of 2004)
NO	:	Nitrogen oxide
NO_2	:	Nitrogen dioxide
NO_x	:	Oxides of nitrogen
NPI	:	National Pollutant Inventory
O_3	:	Ozone
Pb	:	Lead
$PM_{2.5}$	:	Inhalable particulate matter with a mean aerodynamic diameter less than 2.5 micrometre
PM_{10}	:	Inhalable particulate matter with a mean aerodynamic diameter less than 10 micrometre
RfC	:	Inhalation Reference Concentration
REL	:	Recommended Exposure Limit
SANS	:	South African National Standards
SAWS	:	South African Weather Service
SO_2	:	Sulphur dioxide
TLV	:	Threshold Limit Value
TSP	:	Total Suspended Particulates
t/h	:	Tonnes per hour
µg	:	Microgram
$\mu g/m^3$	:	Microgram per cubic metre
USEPA	:	United States Environmental Protection Agency
VOCs	:	Volatile organic compounds
WHO	:	World Health Organisation

5.5 GLOSSARY

Act means the National Environmental Management: Air Quality Act, 2004 (Act No.39 of 2004).

Air pollution means any change in the composition of the air caused by smoke, soot, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances.

Air quality management plan means a plan referred to in section 15 of the **Act**.

Air quality officer means an officer appointed in terms of section 14 of the **Act**.

Air-shed means a geographical area that are defined according to topographical, meteorological, political, or other criteria to address air quality issues that are common to the area.

Alternative fuels and resources mean general and hazardous wastes which are used to substitute conventional or primary fossil fuels and/or virgin raw materials in cement kilns and other industrial thermal processes.

Ambient air means environmental air excluding indoor air and air regulated by the Occupational Health and Safety Act, 1993 (Act No. 85 of 1993).

Ambient air quality standards are values that define targets for air quality management and establish the permissible amount or concentration of a particular substance in or property of discharges to air based on what a particular receiving environment can tolerate without significant deterioration.

Atmospheric emission or **emission** means any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution.

Atmospheric emission licence means an atmospheric emission licence contemplated in Chapter 5 of the **Act**.

ASTM D1739 means the American Standard for Testing and Materials method D1739, which is the standard test method for the collection and measurement of dust fall.

Averaging period means a period over which an average value is determined.

Baseline air quality assessment means a compilation of existing or current data and knowledge on air quality in a particular area. It forms an essential input into the subsequent formulation of the air quality management plan. It comprises an assessment of the current ambient air quality status; an assessment of current organisational structures for air quality management; and an assessment of current air quality initiatives to reduce air pollution.

Biomass means non fossilised and biodegradable organic material originating from plants, animals and micro-organisms excluding (a) sewage; and (b) treated or coated wood waste which may contain halogenated organic compounds or heavy metals.

Bottom loading means the transfer of compounds in a liquid state to a suitable vessel by filling from the bottom by means of bottom valve or from the top utilising a transfer pipe extended to the bottom of the vessel.

Boundary layer in terms of the earth's planetary boundary layer means the air layer near the ground affected by diurnal heat, moisture, or momentum to or from the surface.

Continuous sampling means ambient air quality sampling conducted by drawing air into sampling equipment with real time analysis of concentrations using accepted reference methods. Measurement and recording are done in a continuous manner.

Cost- Benefit analysis means the process that involves weighing the total accepted costs against the total expected benefits to choose the best option.

Controlled emitter means any appliance or activity declared as a controlled emitter in terms of Section 23 of the **Act**.

Compliance date means the date on which compliance with the standard is required.

Design capacity means capacity as installed.

Dispersion modelling means a computer-based model that simulates the dispersion or movement of pollutants in the atmosphere based on a set of equations that are determined by the meteorological conditions of the atmosphere. The output is a set of predicted values of a pollutant for a defined location and time period.

Dispersion potential means the potential a pollutant has of being transported from the source of emission by wind or upward diffusion. Dispersion potential is determined by wind velocity, wind direction, height of the mixing layer, atmospheric stability, presence of inversion layers and various other meteorological conditions.

Dust means solid materials suspended in the atmosphere in the form of small irregular particles, many of which are microscopic in size.

Dust (or settleable particulate matter) means any material composed of particles small enough to pass through a 1 mm screen and large enough to settle by virtue of their weight into the sampling container from the ambient air.

Dustfall means the deposition of dust.

Dustfall monitoring programme means monitoring of the dustfall on a continuous basis.

Emission means pollution discharged into the atmosphere from a range of stationary and mobile sources. These include smokestacks, vents and surface areas of commercial or industrial facilities; residential sources; motor vehicles and other transport related sources.

Emission control technology means technology that aims to reduce emissions into the atmosphere.

Emission inventory means a listing or register of the amount of pollution entering the atmosphere from all sources within a given time and geographic boundaries.

Emission rate means the rate at which a pollutant is emitted from a source of pollution.

Emission factor means a representative value, relating the quantity of a pollutant to a specific activity resulting in the release of the pollutant to atmosphere.

Emission reduction strategy means an intervention designed to reduce emissions into the atmosphere.

Emission standard means a specific limit to the amount of pollutant that can be released to the atmosphere by a specified source.

Environment means the surroundings within which humans exist and that are made up of (i) the land, water and atmosphere of the earth; (ii) micro-organisms, plant and animal life; (iii) any part or combination of (i) and (ii) and the interrelationships among and between them; and (iv) the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being.

Environmental management systems mean a part of the management system of an organisation in which specific competencies, behaviours, procedures and demands for the implementation of an environment policy are defined.

Exceedance means a situation in which a measured ambient air quality concentration (or emission rate) of a particular pollutant exceeds the ambient air quality guideline or standard (or emission limit) for that pollutant. Exceedances are normally expressed as a total number per time period and give an indication of the severity of the air pollution problem.

Existing plant unless where specified, shall mean any plant or process that was legally authorised to operate before 01 April 2010 or any plant where an application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), was made before 01 April 2010.

Flare means a combustion device that uses an open flame to burn combustible gases with combustion air provided by ambient air around the flame. Combustion may be steam or air assisted. Flares may be either continuous or intermittent. This term includes both ground and elevated flares.

Frequency of exceedance means a frequency (number/time) related to a limit value representing the tolerated exceedance of that limit value, i.e. if exceedances of limit value are within the tolerances, then there is still compliance with the standard. This exceedance is applicable to a calendar year.

Fugitive emissions mean emissions that are difficult to identify and quantify, such as gases that "escape" from badly managed or maintained processes, e.g. leak in pipes.

Greenhouse gas means gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation, and includes carbon dioxide, methane and nitrous oxide.

Incineration means any method, technique, or process to convert waste to flue gases and residues by means of oxidation.

Inversion means an increase of atmospheric temperature with an increase in height.

Licensing authority means an authority referred to in sections 36(1), (2), (3) or (4) responsible for implementing the licensing system set out in Chapter 5 of the **Act**.

Listed activity means any activity listed in terms of Section 21 of the **Act**.

Mitigation measures mean attempt to prevent pollution or to reduce the effects of pollution that occur.

Mixing layer means the layer of air within which pollutants are mixed by turbulence. Mixing depth is the height of this layer from the earth's surface.

Mobile source means a single identifiable source of atmospheric emission which does not emanate from a fixed location.

Monitoring means periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.

New plant unless where specified, shall mean any plant or process where the application for authorisation in terms of the National Environmental Management Act 1998, (Act No. 107 of 1998), was made on or after 01 April 2010.

Normal operating condition means any condition that constitutes operation as designed.

Non-point source means a source of atmospheric emissions which cannot be identified as having emanated from a single identifiable source or fixed location, and includes veld, forest and open fires, mining activities, agricultural activities and stockpiles.

Non- residential area means any area not classified for residential use as per local town planning scheme.

Non-thermal treatment of volatile organic compounds means the removal of volatile organic compounds through non combustion processes including but not limited to cryogenic cooling, scrubbing and vapour recovery.

Offensive odour means any smell which is malodorous or a nuisance to a reasonable person.

Ozone-depleting substance means a substance having chemical or physical properties which, by its release into the atmosphere, can cause a depletion of the stratospheric ozone layer.

Oxides of nitrogen (NO_X) means the sum of nitrogen oxide (NO) and nitrogen dioxide (NO_2) expressed as nitrogen dioxide (NO_2)

Particulate matter (PM) means total particulate matter, that is the solid matter contained in the gas stream in the solid state as well as the insoluble and soluble solid matter contained in entrained droplets in the gas stream. The collective name for fine solid or liquid particles added to the atmosphere by processes at the earth's surface and includes dust, smoke, soot, pollen and soil particles.

Passive sampling means air quality monitoring by means of exposure of the sampler to ambient air and adsorption of the pollution into the sampling medium. Sampling is over longer time periods and subsequent analysis is required to determine concentrations.

Petrochemicals means ethylene and its polymers, ethylene oxide, ethylene glycol, glycol ethers, ethoxylates, vinyl acetate, 1,2dichloroethane, trichloroethylene, tetrachloroethylene, vinyl chloride, propylene, propyl alcohols, acrylonitrile, propylene oxide, isomers of butylene, butyl ethers, butadienes, polyolefins and alphaolefins, all alcohols (except those produced during the production of beverages), acrylic acid, allyl chloride, epichlorohydrin, benzene and alkylbenzenes, toluene, o, m and p-xylene, ethylbenzene, styrene, cumene, phenols, acetone, cyclohexane, adipic acid, nitrobenzene, chlorobenzene, aniline, methylene diphenyl diisocyanate (mdi), toluene di isocyanate or other di isocynates of comparable volatility, benzoic acid.

Point source means a single identifiable source and fixed location of atmospheric emission and includes smokestacks and residential chimneys.

Point of compliance means any point within the off gas line, where a sample can be taken, from the last vessel closest to the point source of an individual listed activity to the open end of the point source or in the case of a combinations of listed activities sharing a common point source, any point from the last vessel closest to the point source up to the point within the point source prior to the combination/interference from another Listed Activity.

Precipitation means ice particles or water droplets large enough to fall at least 100 m below the cloud base before evaporating.

Priority Area means an area declared as such in terms of Section 18 of the **Act**.

Priority pollutant means pollutants which, through ambient concentrations, bioaccumulation, deposition or in any other way, present a threat to health, well-being, or the environment. Factors that may influence whether a pollutant is identified as such include: its toxicity; the volume of emissions; or the proximity of the emission relative to sensitive receptors.

Pyrolysis means the decomposition of a material by heat in the absence of oxygen.

Residential area means any area classified for residential use in terms of the local town planning scheme.

SANAS means the South African National Accreditation System established by Section 3 of the Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act, 2006 (Act No. 19 of 2006).

Sulphur recovery plant means a unit that processes sulphur containing gases obtained from the processing of crude mineral oil or the coking or gasification of coal and produces a final product of sulphur containing compounds.

Thermal treatment means incineration, co processing and other high temperature treatment of hazardous and general waste.

Total volatile organic compounds mean organic compounds listed under US EPA Compendium Method TO-14.

Upset conditions means any temporary failure of air pollution control equipment or process equipment or failure of a process to operate in a normal or usual manner that leads to an emission standard being exceeded.

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