Rayten
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Environmental and Engineering Consultants

TONKMETER RESOURCE FACILITY – PROPOSED EXTENSION OF THE FINAL LANDFILL-CELL HEIGHT FOR AREA E, CITY OF EKURHULENI

AIR QUALITY IMPACT ASSESSMENT REPORT

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EXECUTIVE SUMMARY

Rayten Engineering Solutions (Pty) Ltd was appointed by EcoPartners to compile an Air Quality Impact Assessment report (AQIAr) for the Tonkmeter Resource Facility (TRF) (hereafter referred to as the "landfill"), owned by Tonkmeter (Pty) Ltd. The facility operates as both a landfill and resource recovery facility, and is located on the remaining extent of Portion 81 of the Farm Rietfontein 128IR in the City of Ekurhuleni Metropolitan Municipality, Gauteng Province.

Tonkmeter is the holder of an Integrated Environmental Authorisation (IEA) for the TRF, which is licensed as a GLB+ or Class B landfill in terms of the National Environmental Management: Waste Act 2008 (Act 59 of 2008). Tonkmeter is in the process of applying for an amendment of their IEA. The amendment is required for the following:

a) To amend the types of waste that may be accepted and disposed on the Class B liner i.e., Type 2 and 3.
b) To amend the landfill final height.
c) To amend conditions of the IEA that are either not applicable or should be amended to clarify intension of conditions.
d) To amend the Environmental Management Programme (EMPr) to remove / amend commitments made that are not applicable and to be in line with the amendments proposed in bullets a) to c) above.

This AQIAr is required as a supporting document for the IEA amendment application. The main objective of the AQIA is to determine the potential impact of emissions associated with the operational activities at the landfill site on ambient air quality in terms of dustfall, hazardous air pollutants (HAPs) and odorous gases, considering the proposed amendments.

As part of the AQIA, a baseline air quality assessment was undertaken to determine the following:

- the prevailing meteorological conditions at the site;
- baseline concentrations of key air pollutants of concern;
- identify existing sources of emissions; and
- identify key sensitive receptors surrounding the project site.

The AQIA consisted of an emissions inventory and subsequent dispersion modelling simulations to determine ambient air quality concentrations for various air pollutants, as well as odour impacts associated with the operational phase of the landfill site. Comparison of the modelled concentrations for PM_{10}, $PM_{2.5}$ and benzene (annual average) are made with the South African National Ambient Air Quality Standards (NAAQS) to determine compliance. Comparison of the dustfall rates is made with the South African National Dust Control Regulations. Comparison of the predicted concentrations for the various other HAPs and Odour Units (OU) assessed in this study was made with international guidelines and published odour thresholds, as there are no NAAQS available for these pollutants.

The main conclusions based on the information obtained during the Baseline Assessment are as follows:

The landfill site is located in Springs on the remaining extent of Portion 81 of the Farm Rietfontein 128IR, in the City of Ekurhuleni Metropolitan Municipality, Gauteng Province. The land use

immediately surrounding the landfill site, within a 20km radius, is characterised largely by cultivated land, grasslands, fallow land, waterbodies, small holdings as well as built-up industrial and formal residential areas. In addition, built-up urban recreational and commercial areas, informal residential areas, wetlands, subsistence crops, mining activities, historic tailings storage facilities, and landfills are found interspersed within the main land use types. The project area falls within the nationally declared Highveld Air Quality Priority Area (HPA). Existing key sources of airborne emissions surrounding the project site have been identified as follows:

- Commercial agricultural activities (cultivated land) and potential biomass burning;
- Mining areas;
- Informal settlements and townships;
- Industrial activities; and
- Vehicle activity and exhaust emissions.

Landfills, such as the Rietfontein municipal and TRF landfills, which are located adjacent to each other, and wind erosion from exposed bare lands, contribute minimally to air pollution near the project site. These sources are scattered intermittently among the primary pollution sources.

MM5 meteorological data for the project area for the period 01 January 2023 – 31 December 2025 was used as for input into the dispersion model and to determine prevailing meteorological conditions for the project site. Based on the prevailing wind fields for the period 01 January 2023 – 31 December 2025, emissions from the landfill will likely be transported towards the south, south-southwest and south-southeast, depending on the season and time of day. Wind conditions observed during all time periods were generally classified as light air to fresh breezes, which may help in effective dispersion of pollutants from the landfill operations. However, higher wind speeds can also facilitate fugitive dust emissions from open exposed areas such as the active landfill cells.

The existing air quality situation was evaluated using available monitoring data for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 from a permanent ambient air quality monitoring station (AQMS) operated near the project site, i.e., at the Springs AQMS (26.270361°S; 28.416005°E). The Springs AQMS is accessible via the South African Air Quality Information System (SAAQIS) portal and is located approximately 2 km north of the landfill site. The monitoring station is located within the same broader airshed and is influenced by similar regional land uses, pollution sources, and meteorological conditions as the landfill site. Furthermore, given the relatively short separation distance and absence of significant topographical or meteorological differences between the monitoring station and the landfill site, the available monitoring data was regarded as appropriate for characterising background concentrations of key pollutants of concern for the purposes of this assessment.

The ambient air quality monitoring data covers the period 01 January 2022 – 31 December 2023, for which data was available. However, there was low data capture for NO_2 in 2022, therefore, only data from 2023 was considered for the assessment of background NO_2 concentrations. The data capture rate at the Springs AQMS was above average for all pollutants, i.e., PM_{10} (92.76%), $PM_{2.5}$ (92.77%), SO_2 (88.55%) and NO_2 (92.80%, for year 2023). Several exceedances of the daily PM_{10} and $PM_{2.5}$ standards of 75 µg/m^3 and 40 µg/m^3, respectively, were recorded over the monitoring period (i.e., 160 and 155 exceedances, respectively). In addition, annual PM_{10} and $PM_{2.5}$ concentrations exceeded the respective standards of 40 µg/m^3 and 20 µg/m^3 in 2022 and 2023. SO_2

hourly, daily and annual concentrations for 2022 – 2023, as well as NO_2 hourly and annual concentrations for 2023, were below the applicable South African NAAQS.

In terms of the South African NAAQS, 4 exceedances of the PM_{10} 24-hour standard are permitted within a calendar year, while no exceedances of the PM_{10} annual standard are permitted. Additionally, no exceedances of the $PM_{2.5}$ 24-hour and annual standards are permitted within a calendar year. For the gaseous pollutants, a total of 88 exceedances of the NO_2 and SO_2 hourly standards are permitted within a calendar year, while only 4 exceedances of the SO_2 24-hour standard are permitted. No exceedances of the SO_2 and NO_2 annual standards are permitted within a calendar year. Background PM_{10} and $PM_{2.5}$ data from the Springs AQMS indicates non-compliance with the South African NAAQS for the monitoring period, while background SO_2 and NO_2 data shows no exceedances.

The main conclusions for the AQIA for the project can be summarised as follows:

Landfill gas (including HAPs), dust and odour are identified as the key pollutants of concern associated with operational activities at the landfill and are emitted from the following key sources:

- Landfill gas emissions (consisting of a mixture of pollutants) due to:
    - anaerobic decomposition of solid matter mainly generated from the biodegradation of the organic matter contained within the waste,
    - general landfill activities such as active tipping of fresh waste and exposed areas of waste.
- Emissions of Hydrogen Sulphide (H_2S) from the nearby Rietfontein leachate dams.
- Odour emissions associated with overall landfilling activities.
- Flare emissions – mainly secondary pollutants exiting the landfill flare based on the volume of methane flared.
- Dust emissions from:
    - Vehicle dust entrainment from the movement of trucks on unpaved roads onsite (in and around active Cells),
    - wind erosion of exposed surfaces (exposed waste at active Cell's workface and material stockpiling at the rubble crushing area),
    - compacting of waste at the active Cell's workface,
    - material handling (loading and offloading material from trucks).

The dispersion modelling considered a standalone scenario for active operations at Tonkmeter Area E, as well as a cumulative scenario incorporating relevant emissions from the neighbouring Rietfontein landfill.

Construction activities associated with the development of each landfill Cell at Area E are additional sources of fugitive dust emissions at the landfill site. However, these fugitive emission sources are not significant, with associated emissions being intermittent and short-term (for construction), in comparison to long-term emissions associated with landfilling operations. Therefore, the fugitive emission sources associated with the construction/development of each landfill Cell were not modelled in this study but can be easily mitigated through the implementation of dust mitigation measures. The dust mitigation measures are explained in more detail in Section 7 of this AQIAr.

Dispersion modelling indicates that particulate impacts are generally localised to the landfill and its immediate surroundings. For both the standalone Area E and cumulative scenarios, predicted incremental PM_{10} and $PM_{2.5}$ concentrations at the Tonkmeter boundary remain below the applicable daily and annual South African NAAQS. The maximum cumulative dustfall rate at the boundary is approximately 660 mg/m^2/day, which is below the non-residential standard of 1200 mg/m^2/day, although the residential guideline of 600 mg/m^2/day is marginally exceeded along limited portions of the boundary.

Predicted incremental hydrogen sulphide (H_2S) concentrations are highest within and immediately surrounding the Tonkmeter and Rietfontein landfill areas. Localised exceedances of the Alberta 1-hour and 24-hour screening guidelines are predicted along portions of the Tonkmeter boundary, indicating that H_2S represents an important near-field air-quality and odour consideration. The modelling indicates, however, that most of the predicted H_2S impact is associated with emissions from the neighbouring Rietfontein landfill, particularly its relatively large and poorly managed leachate dam, rather than from Tonkmeter operations. At Tonkmeter, H_2S emissions are primarily associated with landfill gas released from the active workface and are comparatively limited. Tonkmeter also does not operate an open leachate dam; leachate generated onsite is collected in a storage tank for temporary containment prior to treatment and disposal, thereby reducing the potential for additional H_2S emissions.

For the other hazardous air pollutants, predicted incremental benzene, toluene, ethylene and xylene (BTEX) concentrations remain well below the applicable ambient guidelines and odour-recognition thresholds. Reduced sulphur compounds also remain below their applicable ambient air-quality guidelines at the boundary; however, dimethyl sulphide may occasionally be detectable, while ethyl and methyl mercaptan concentrations reach or exceed their respective odour-recognition thresholds and may therefore contribute to recognisable landfill-related odours under unfavourable dispersion conditions. Predicted incremental chlorinated compound and ammonia concentrations are low and remain below the relevant assessment criteria.

Predicted flare-related SO_2, NO_2 and CO concentrations are low and remain well below the applicable South African NAAQS, with no exceedances expected at surrounding receptor areas.

Overall odour impacts are predicted to be most relevant close to the landfill. Odour concentrations above the 5 OU/m^3 annoyance threshold are largely confined to the immediate vicinity of the active landfill areas. At the Tonkmeter boundary, maximum predicted incremental concentrations are approximately 7.45 OU/m^3 for the 1-hour average and 10.66 OU/m^3 for the 10-minute average, indicating that noticeable and potentially objectionable odours may occur locally under worst-case meteorological conditions. Odour impacts decrease substantially with increasing distance from the landfill.

Overall, the modelling indicates that most predicted air-quality impacts remain within the applicable assessment criteria, with the principal residual concern being localised odour impacts associated with H_2S and reduced sulphur compounds near the landfill boundary. Recommendations provided in Section 7 of this report should be considered as far as possible (depending on feasibility and affordability) to continuously reduce negative air quality impacts associated with the proposed height extension at Area E.

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LIST OF ABBREVIATIONS

AEL	Atmospheric Emissions License
AQIA	Air Quality Impact Assessment
AQIAr	Air Quality Impact Assessment Report
AQMP	Air Quality Management Plan
AQMS	Air Quality Monitoring Station
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
$CO_{2\text{-eq}}$	Carbon dioxide equivalent
DEA	Department of Environmental Affairs (now known as the Department of Forestry, Fisheries and the Environment: DFFE)
DMP	Dust Management Plan
DR	Discrete Receptor
ERMP	Emission Reduction and Management Plan
EMPr	Environmental Management Programme
GDARD	Gauteng Department of Agriculture and Rural Development
GHG	Greenhouse gas
GMT	Greenwich Meridian Time
HAPs	Hazardous Air Pollutants
HCL	Hydrogen Chloride
HFC	Hydrofluorocarbons
HPA	Highveld Priority Area
H_2S	Hydrogen Sulphide
IEA	Integrated Environmental Authorisation
NAEIS	National Atmospheric Emissions Inventory System
SNAAQS	South African National Ambient Air Quality Standards
NEMA	National Environmental Management Act
NEM: AQA	National Environmental Management Air Quality Act
NMOCs	Non-Methane Organic Compounds
NPI	National Pollutant Inventory
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
N_2O	Nitrous Oxide
Mtpa	Million tonnes per annum
O_3	Ozone
PBL	Planetary Boundary Layer
PFC	Perfluorocarbons
PM_{10}	Particulate Matter, aerodynamic diameter equal to or size less than 10µm
$PM_{2.5}$	Particulate Matter, aerodynamic diameter size equal to or less than 2.5µm
PRIME	Plume Rise Model Enhancements

RSC	Reduced Sulphur Compounds
SAIGE	System for Administration of Integrated Greenhouse Gas Emissions (SAIGE)
SANAS	South African National Accreditation System
SANS	South African National Standard
S21	Section 21
SF_6	Sulphur hexafluoride
SO_2	Sulphur Dioxide
TRF	Tonkmeter Resource Facility
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds

1. INTRODUCTION

Rayten Engineering Solutions (Pty) Ltd was appointed by EcoPartners to compile an Air Quality Impact Assessment report (AQIAr) for the Tonkmeter Resource Facility (TRF) (hereafter referred to as the "landfill"), owned by Tonkmeter (Pty) Ltd. The facility operates as both a landfill and resource recovery facility, and is located on the remaining extent of Portion 81 of the Farm Rietfontein 128IR in the City of Ekurhuleni Metropolitan Municipality, Gauteng Province.

Tonkmeter is the holder of an Integrated Environmental Authorisation (IEA) for the TRF, which is licensed as a GLB+ or Class B landfill in terms of the National Environmental Management: Waste Act 2008 (Act 59 of 2008). Tonkmeter is in the process of applying for an amendment of their EIA. The amendment is required for the following:

a) To amend the types of waste that may be accepted and disposed on the Class B liner i.e., Type 2 and 3.
b) To amend the approved final landfill height for Area E from 1m to 25m.
c) To amend conditions of the IEA that are either not applicable or should be amended to clarify intension of conditions.
d) To amend the Environmental Management Programme (EMPr) to remove / amend commitments made that are not applicable and to be in line with the amendments proposed in bullets a) to c) above.

This AQIAr is required as a supporting document for the EIA amendment application. The main objective of the AQIA is to determine the potential impact of emissions associated with the operational activities at the landfill site on ambient air quality in terms of dustfall, hazardous air pollutants (HAPs) and odorous gases, considering the proposed amendments.

As part of the AQIA for the landfill, a baseline air quality assessment was undertaken through a review of meteorological monitoring data, available air quality monitoring data, air quality legislation and the identification of nearby sensitive receptors and existing emissions sources surrounding the facility. The potential impact of emissions from the operational activities associated with the landfill on air quality is evaluated through the compilation of an emissions inventory and subsequent dispersion modelling simulations using AERMOD. Comparison of predicted concentrations for benzene and dust is made with the South African National Ambient Air Quality Standards (NAAQS) (DEA, 2009 and 2012) and the South African National Dust Control Regulations (DFFE, 2026), respectively. There are no South African NAAQS for many of the pollutants assessed in this study. Therefore, comparisons were also made with various international air quality guidelines to determine compliance.

1.1. Project Details

Client	Tonkmeter (Pty) Ltd
Co-ordinates (centre of landfill)	26.289871°S, 28.421564°E
Municipality and Province	City of Ekurhuleni Metropoliant Municipality, Gauteng Province.
AEL number	N/A – the facility does not trigger any of the Section 21

	listed activities and does not require an Atmospheric Emission Licence (AEL).
Designated Air Quality Priority Area	Highveld Priority Area
Modelling contractor	Rayten Engineering Solutions (Pty) Ltd *Gertrude Mafusire (MPhil; Pr. Sci. Nat.)* *Snr Associate* *9 years working experience.* *0117920880* *info@rayten.co.za*

1.2. Brief Project Description

The TRF is an existing facility, which operates as both a landfill and resource recovery facility. Existing activities at the site include the following:

- landfilling of general waste (i.e., municipal waste, organic waste, construction and demolition waste, as well as commercial and industrial waste) and recovery,
- sorting,
- cleaning and baling of recyclable material,
- crushing of building rubble (approval received, not commenced), and
- chipping and composting garden greens (approval received, not commenced).

The landfilling and recycling operations follow the sequence described below.

1. ***Entry & Identification***

- Access Control: All vehicles must pass through the main gate for security clearance and initial identification.
- Sign-In: Waste transport truck drivers proceed to the Weighbridge Office to sign in and present necessary documentation.

2. ***Initial Weighing***

- Laden Weighing: The truck is driven onto the weighbridge. The gross weight (truck + waste) is recorded to determine the incoming tonnage.

3. ***Disposal at Landfill Cell***

- Transit to Cell: Trucks proceed from the weighbridge to the active landfill disposal cell.
- Discharge: Trucks discharge general waste at the designated working face under the direction of site marshals.

4. ***Recovery & Recycling***

- Resource Recovery: Authorized waste pickers manually recover recyclable components (plastics, metals, paper, etc.) directly from the working face.
- Sorting & Baling: Recovered materials are transferred to the on-site Recycling Centre. Here, materials are sorted by grade and compressed into bales for sale to external vendors.

5. Site Exit

- Tare Weighing: Empty trucks proceed to the exit weighbridge to be weighed out.
- Documentation: The system calculates the net waste weight, and the driver is issued a weighbridge slip as proof of disposal.

6. Daily Maintenance & Compaction

- Waste Treatment: The remaining non-recyclable waste at the working face is spread and compacted using heavy machinery to maximize landfill density.
- Daily Cover: At the end of each operational day, the compacted waste is covered with soil or an alternative daily cover (ADC) to control odours, pests, and litter.

Existing infrastructure includes, but is not limited to, the following:

- Administration building;
- Access control facilities;
- Access roads to the landfill and link roads between the disposal cells and onsite infrastructure;
- Weighbridge with a weighbridge control room;
- A security and pump house;
- A recycling centre;
- Waste disposal cells (developed in phases);
- A contaminated water pond to prevent stormwater runoff and prevent surface and groundwater contamination;
- Leachate collection system and leachate pond/tank to prevent surface and groundwater contamination; and
- Electricity, water and sewage infrastructure and connections.

Tonkmeter are currently undergoing an application process to amend their IEA. The amendment is required for the following:

a) To amend the types of waste that may be accepted and disposed on the Class B liner i.e., Type 2 and 3.
b) To amend the approved final landfill height for Area E from 1m to 25m.
c) To amend conditions of the IEA that are either not applicable or should be amended to clarify intension of conditions.
d) To amend the Environmental Management Programme (EMPr) to remove / amend commitments made that are not applicable and to be in line with the amendments proposed in bullets a) to c) above.

The airspace as recorded in the IEA for the landfill is 13.7 million cubic metres. The initial design of the cells in the 3 areas (Figure 1-1) indicates that 9.77 million cubic metres is available, filling to a final cell height of 1m above natural ground level. This provides sufficient airspace for 32 years if filling occurs at an average rate of 25,000 tonnes per month. Once the final cell height for Area E is extended to 25m above natural ground level, the available airspace and operational life of the landfill will increase. The expected monthly airspace usages and landfill operational life are as shown in Table 1-1, and were estimated based on an average monthly volume of up to 15,000 tonnes per month of waste.

Table 1-1: Landfill life associated with the proposed Area E height extension.

Scenario (tonnes/month)	7 500	15 000
Monthly Airspace Usage (m^3)	8 876	17 751
Annual Airspace Usage (m^3)	106 509	213 018
Total Life without Area E Height 25m extension (years)	87	44
Total Life with Area E Height 25m extension (years)	126	63
Area E Life without Height Extension (years)	39	19
Area E life with Height Extension (years)	77	39

The application for Area E's height extension will be submitted now, when the neighbouring Rietfontein Municipal Landfill is still in operation.

The key sources of emissions at the landfill site, which have been taken into consideration in this study, include:

- Landfill gas emissions (consisting of a mixture of pollutants) due to:
    - anaerobic decomposition of solid matter mainly generated from the biodegradation of the organic matter contained within the waste,
    - general landfill activities such as active tipping of fresh waste and exposed areas of waste.
- Emissions of Hydrogen Sulphide (H_2S) from the nearby Rietfontein leachate dams.
- Odour emissions associated with overall landfilling activities.
- Flare emissions – mainly secondary pollutants exiting the landfill flare based on the volume of methane flared.
- Dust emissions from:
    - vehicle dust entrainment from the movement of trucks on unpaved road onsite (in and around active Cells),
    - wind erosion of exposed surfaces (exposed waste at active Cell's workface and material stockpiling at the rubble crushing area),
    - compacting of waste at the active Cell's workface,
    - material handling (loading and offloading material from trucks).

The Rietfontein landfill operations are additionally assessed as part of the cumulative assessment.

Construction activities associated with the development of each landfill Cell at Area E are additional sources of fugitive dust emissions at the landfill site. However, these fugitive emission sources are not significant, with associated emissions being intermittent and short-term (for construction), in comparison to long-term emissions associated with landfilling operations. Therefore, fugitive emission sources associated with the construction/development of each landfill Cell were not considered in this assessment and can be easily mitigated through the implementation of dust mitigation measures. The dust mitigation measures are explained in more detail in Section 7 of this AQIAr.

Site layout and process flow diagrams for current operations at the TRF are given in Figure 1-1 and Figure 1-2, respectively. The site layout diagram was used for modelling purposes.



Figure 1-1: Layout plan for the landfill site (based on original 2012 IEA application).

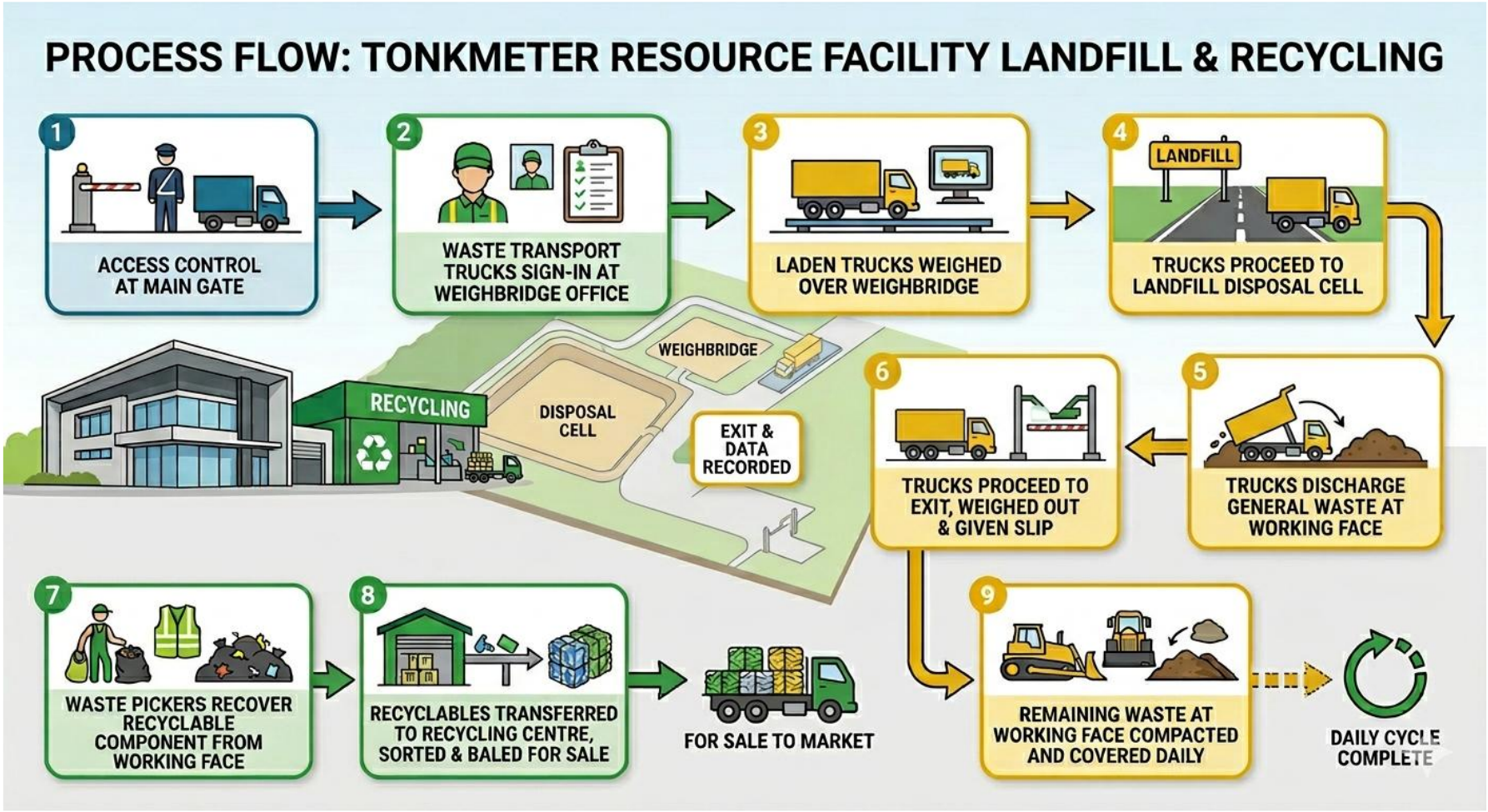


Figure 1-2: Process flow diagram for the landfill site.

1.3. Terms of Reference

The scope of work for the AIQA is as follows:

- A review of the study site and activities;
- An overview of the prevailing meteorological conditions in the area which influence the dilution and dispersion of pollutants in the atmosphere;
- The identification of existing sources of emissions;
- The identification of key air pollutants of concern that may be emitted from landfill activities;
- Characterisation of the ambient air quality within the area using available air quality monitoring data;
- A review of the current South African legislative and regulatory requirements for air quality; and
- The identification of sensitive receptors, such as local communities, surrounding the study area.
- The compilation of an emission inventory for key sources of emissions;
- Dispersion modelling simulations of ground level particulate and gaseous emissions for incremental impacts; and
- Provision of general recommendations for the mitigation and management of identified potential impacts.

1.4. Outline of Report

An overview of the site location including surrounding receptors is given in **Section 2**. National Ambient Air Quality Standards, Dust Control Regulations and associated health impacts for the relevant criteria pollutants are discussed in **Section 3**. An overview of landfill gas emissions, including associated health and odour impacts are provided in **Section 4**. The local meteorological conditions and baseline air pollutants concentrations are provided in **Section 5**. Potential emissions and their impact on air quality associated with existing operations are outlined in **Section 6.** Mitigation measures, recommendations and conclusions are summarised in **Section 7**.

2. SITE CHARACTERISTICS

2.1. Site Location

The landfill site is located in Springs on the remaining extent of Portion 81 of the Farm Rietfontein 128IR, in the City of Ekurhuleni Metropolitan Municipality, Gauteng Province (26.289871°S, 28.421564°E) (Figure 2-3). The project area falls within the Highveld Air Quality Priority Area.

2.1.1. Highveld Priority Area: First Generation Air Quality Management Plan

The HPA was declared a priority area by the Minister of Environmental Affairs and Tourism on 23 November 2007 under the National Environmental Management Air Quality Act (Act No. 39 of 2004) (NEM: AQA) (Government Gazette, No. 30518 of 23 November 2007). A Priority Area is usually associated with elevated ambient concentrations of criteria air pollutants such as PM_{10}, $PM_{2.5}$, SO_2 and NO_x. Generally, a high number of emitters (industrial and non-industrial) are also concentrated in these areas. To meet the requirements of the NEM: AQA, a first-generation Air Quality

Management Plan (AQMP) was compiled for the HPA in 2011 (Government Gazette 35072 of 02 March 20212) and provides a management tool that can be used and implemented by departments and industry to ensure effective air quality management within the area. The primary aim of the AQMP is to provide a framework including short to long term strategies and programs that can be used to work towards achieving and maintaining compliance with the National Ambient Air Quality Standards within the HPA. In the HPA (Figure 2-1 and Figure 2-2), industrial emitters were identified as the most significant contributors of emissions accounting for 89% of PM_{10}, 90% of NO_x and 99% of SO_2. Industrial emitters within the HPA include (DEA, 2011):

- Power generation;
- Coal mining;
- Primary & secondary metallurgical operations;
- Brick manufacturers;
- Petrochemical industry;
- Ekurhuleni industrial sources (excluding the above); and
- Mpumalanga industrial sources (excluding the above).

An assessment of ambient air quality monitoring data within the HPA, allowed for the following areas to be identified as areas of concern. These areas are associated with high frequency exceedances of the PM_{10} and SO_2 ambient standards. The air quality monitoring data for the HPA also shows seasonal trends. Higher frequencies of exceedances of the standards are observed during the winter season where the dispersion potential of ground level pollutants (e.g., vehicle exhaust emissions) is largely reduced due to the strengthening of surface inversions (DEA, 2011).

- Witbank;
- Middelburg;
- Secunda;
- Ermelo;
- Standerton;
- Balfour; and
- Komati.

A comprehensive emissions inventory was compiled for the HPA. A combination of ambient air quality monitoring and dispersion modelling results identified nine (9) areas within the HPA as hotspot areas, where ambient concentrations of PM_{10}, SO_2 and NO_2 frequently exceed and/or were predicted to exceed the ambient standards (Table 2-1). Residential areas associated with a high level of domestic fuel burning (wood and coal) were identified to experience high concentrations of particulates and CO.

Table 2-1: HPA Air Quality Hot Spot Areas (DEA, 2011;20).

Hot Spot	PM_{10}	SO_2	NO_2
Emalahleni	✓	✓	
Kriel		✓	
Steve Tshwete	✓	✓	✓
Ermelo	✓	✓	
Secunda	✓	✓	✓
Ekurhuleni	✓	✓	
Lekwa	✓	✓	
Balfour	✓		
Delmas		✓	

In order to achieve compliance with the NAAQS for criteria pollutants within the HPA, the AQMP for the HPA developed seven goals which are given below (DEA, 2011):

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

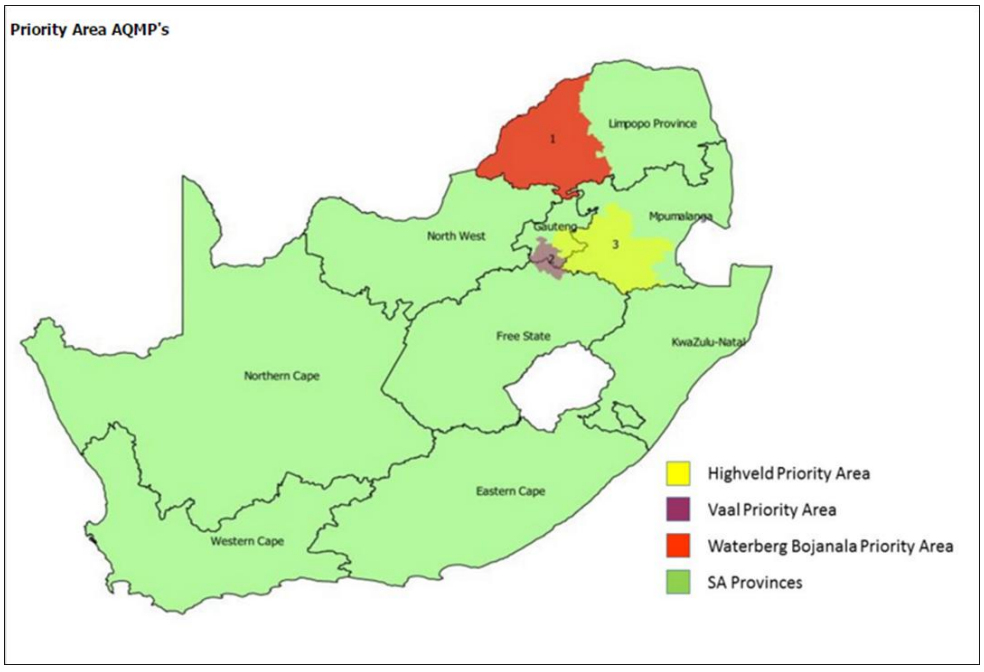


Figure 2-1: Air Quality Priority Areas.

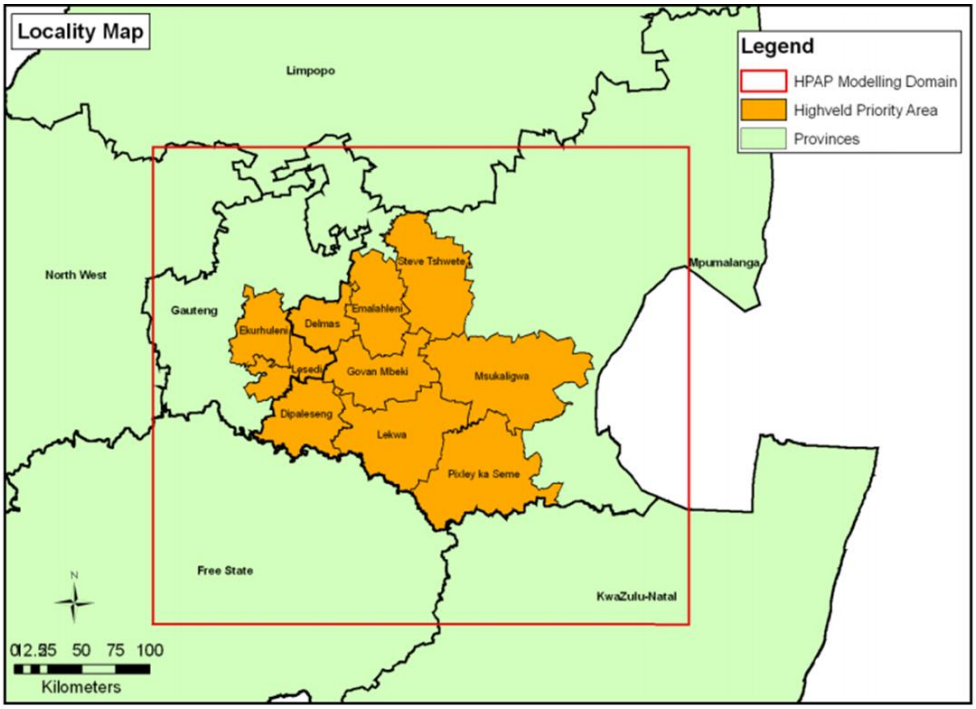


Figure 2-2: Highveld Priority Area (DEA, 2011).

2.1.2. Highveld Priority Area: Second Generation Air Quality Management Plan

An updated AQMP for the HPA, i.e., the second-generation AQMP, was published in 2025 (in Government Gazette, No. 52387 of 26 March 2025). The updated AQMP is aimed at establishing emission reduction targets, based on a better understanding of the impact on ambient air quality in the HPA due to various emission reductions (brought about by interventions), that will ensure further improvement and eventual compliance within the priority area.

Furthermore, sector-specific emission reduction plans, which are based on the following conditions: (1) Objectives; (2) Key results; and (3) Levels of responsibility, are provided in the updated AQMP. These sector-specific emission reduction plans apply to various stakeholders identified in Section 3(2) of the Regulations for Implementing and Enforcing Priority Area Air Quality Management Plans (Government Gazette No. 51120 of 26 August 2024) (see Section 3.7). The stakeholders include any person conducting a listed activity, any person operating a controlled emitter, any holder of a right or permit related to a prospecting operation, exploration operation, mining operation or production operation as defined in section 1 of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2022), and any person conducting reclamation. The TRF does not fall within any of the identified categories for current operations.

Emission reduction targets that are outlined in the updated AQMP for various emission source categories are summarised in Table 2-2. However, these targets are not applicable to the TRF, as landfills are not identified as stakeholders under the priority area regulations.

Table 2-2: Summary of emission reductions applied to the baseline towards compliance by 2030.

Sector	2030 Emission Reduction Target from 2019 Baseline
Industry	40%
Mining and Reclamation Operations	40%
On-road Vehicle Sources	30%
Residential Fuel Burning	30%
Residential Waste Burning	100%
Biomass Burning	30%
Agriculture	20%

2.2. Surrounding Land Use

The land use immediately surrounding the landfill site, within a 20km radius, is characterised largely by cultivated land, grasslands, fallow land, waterbodies, small holdings as well as built-up industrial and formal residential areas. In addition, built-up urban recreational and commercial areas, informal residential areas, wetlands, subsistence crops, mining activities, historic tailings storage facilities, and landfills are found interspersed within the main land use types (Figure 2-4). The larger area surrounding the project site is classified as rural in nature.

2.3. Topography

The topography surrounding the landfill site is shown in Figure 2-5. Surrounding elevations range from 1560 – 1680 m above sea level. The project site is situated approximately 1608 – 1624 m above sea level; with increasing elevation mainly towards the south-southwest and north-west. (Figure 2-5).

2.4. Sensitive Receptors

A sensitive receptor is defined as a person or place where involuntary exposure to air pollutants released by the site's activities could occur. Identified sensitive receptors, which are located within a 10km radius of the landfill are given in Figure 2-4 and Figure 2-6.

The discrete receptors given in Table 2-3 below, were used for modelling purposes. Maximum predicted incremental concentrations are provided for the identified discrete receptors. These points are located at the centre of residentials areas, or near schools, hospitals, old age homes, dwellings or buildings in order to determine the maximum concentrations that could be expected near sensitive receptors. Discrete points are not plotted for each individual sensitive receptor but are used to represent a group of sensitive receptors located near to each other (e.g. several schools, dwellings or buildings.

Table 2-3: Discrete receptors within a 10km radius of the landfill site. Receptors were identified through a desktop study.

SURROUNDING RECEPTORS (<10KM)				
Discrete Receptor ID	Name Edu = educational/school/training facilities HC = healthcare/clinic/hospital facilities Old = old age home Residential = Dwellings/ farm houses	UTM Co-ordinates (35S)		Elevation (m)
		X (m)	Y (m)	
DR1	Res (unknown)	638840.01	7094108.55	1636.71
DR2	Res (unknown)	637845.91	7093256.29	1641.61
DR3	Res (Tornado, Phomolo)	638995.83	7092221.81	1631.91
DR4	Res (Kwa-Thema)/ Edu (KwaThema Skills School)	639841.19	7091500.99	1635.15
DR5	Edu (Ekurhuleni East College)	640743.32	7091590.75	1624.71
DR6	Res/Edu (Nkumbulo Secondary School)	640617.39	7091001.96	1629.62
DR7	Res (Wright Park)	640287.94	7094225.96	1635.25
DR8	Res (Dal Fouche)	639306.90	7095032.74	1636.18
DR9	Edu (Hoerskool Die Anker)	638185.19	7094970.65	1641.49
DR10	Edu (Muriel Brand School)	637771.77	7096227.67	1643.65
DR11	Res (Brenthurst)	637421.14	7095647.40	1648.32
DR12	Edu (Brenthurst Primary School & Brakpan High School)	636604.81	7096171.83	1644.16
DR13	Edu (Dalpark Primary School)	635557.62	7094902.23	1651.09
DR14	Res (Minnerbron & Sonneveld)/Edu (Thandimfundo Academy)	634059.18	7093751.50	1630.98
DR15	HC (Life Dalview Hospital)/Edu (Laerskool Die Arend)	635349.54	7096473.69	1637.62
DR16	Res (Dalview)	634752.94	7096114.23	1644.07
DR17	Res (Brakpan)	637012.29	7097562.11	1631.21
DR18	Edu (Brakpan Primary School)	637097.86	7096780.67	1639.59
DR19	Edu (Laerskool Brakpan-Oos)	637978.82	7097857.63	1633.82
DR20	Res (Brakpan North & New State Areas)	639449.90	7097221.90	1609.06
DR21	Res (Geduld)/Old (Esda Tehuis Retirement Home)	642736.19	7096415.65	1627.74
DR22	Res (Springs Central)/HC (Life Springs Parkland Hospital)/Old (Springs 13	643479.61	7094428.34	1629.03

SURROUNDING RECEPTORS (<10KM)				
Discrete Receptor ID	Name Edu = educational/school/training facilities HC = healthcare/clinic/hospital facilities Old = old age home Residential = Dwellings/ farm houses	UTM Co-ordinates (35S)		Elevation (m)
		X (m)	Y (m)	
	Assisted Living Facility)			
DR23	Res (Whtite City)/Edu (Ntokozweni Prumary School)	638489.67	7089895.40	1623.44
DR24	Res (Masimini)/Edu (Job Maseko, Sechaba & Sakhelwe Primary Schools)	639331.33	7089959.54	1635.75
DR25	Edu (Umsobomvu & Tsimong Primary Schools)	639518.26	7090881.52	1640.97
DR26	Edu (Zamani Community School)	638946.37	7089916.08	1636.56
DR27	Res (Vergenoeg)/Edu (Zithembeni & Qedusizi Primary Schools)	639107.02	7089365.19	1624.53
DR28	Edu (Langaville Secondary School)/HC (Unjani Clinic Langaville)	638772.52	7088767.54	1612.62
DR29	Res (486 Scheme)/Edu (Phelang School & Phelang Training Centre, Phulong Secondary School)/HC (White City Clinic)	640898.44	7089963.25	1627.14
DR30	Res (Thembilisha)/HC (Thembelisha Clinic)/Edu (Muzomsha Primary School)	640211.26	7089493.93	1623.43
DR31	Res (Langaville Extension 8)	638068.85	7089011.55	1613.09
DR32	Old (San Michele Home)	636952.07	7089578.16	1615.33
DR33	Old (Gold Reef Retirement Villlage)	634760.61	7093196.37	1630.36
DR34	Old (Witpoort Care Centre)	637908.99	7093886.26	1645.77
DR35	Old (Pebble Bridge Care Centre NPO)	635511.13	7095519.68	1642.9
DR36	Old (Eventide Home/Ebenhaeser Tehuis Vir Bejaardes)	637493.04	7097305.04	1639.41
DR37	Old (Frank Mynhardt Care Centre)	637892.97	7098191.81	1628.18
DR38	HC (Impilo Medical Centre)	639393.64	7090287.62	1640.39
DR39	HC (Medicross KwaThema & Bophelong Medical Centre)	638938.09	7090772.92	1645.57
DR40	HC (KwaThema Community Health Centre)	638897.22	7091005.24	1644.19
DR41	Res (Langaville/Langaville Ext 6)	638862.24	7087337.93	1607.69
DR42	Res (Kwa-Thema Phase 2/Phase 3)	641084.98	7088208.97	1620.64
DR43	Res & Edu (Kwa-Thema Phase 1/Phase 3)	641334.76	7088937.74	1628.84

SURROUNDING RECEPTORS (<10KM)				
Discrete Receptor ID	Name Edu = educational/school/training facilities HC = healthcare/clinic/hospital facilities Old = old age home Residential = Dwellings/ farm houses	UTM Co-ordinates (35S)		Elevation (m)
		X (m)	Y (m)	
DR44	Res (Selection Park)	644392.26	7091497.55	1608.76
DR45	Res (Petersfield, East Geduld)/Edu (Hoerskool Hugenote)	643785.00	7097703.87	1607.92
DR46	Res (Dersley)	641655.01	7101143.45	1607.35
DR47	Res (Sherwood Gardens)	637963.99	7098991.12	1615.53
DR48	Res (unknown)	635873.50	7099274.71	1628.32
DR49	Old (Rus n Bietjie)	642729.44	7097121.05	1620.18
DR50	Old (Esda Frail Care Community Centre)	640515.92	7096462.02	1628.19
DR51	Old (KwaThema Old Age Home Helath Post)	640376.50	7090231.63	1632.51
DR52	Res (Selcourt)	643952.49	7089663.26	1635.74
DR53	Edu (Springs Boys High School)	644085.20	7090458.57	1623.63
DR54	Res (Nokuphila Community Centre)	642852.89	7090444.15	1617.21
DR55	Res (Pollark Park)/HC (Netcare N17 Hospital)	642607.16	7093467.04	1625.25
DR56	Res (Selection Park & Restaurants)	643788.16	7092644.90	1606.32
DR57	Edu (Laerskool Selection Park)	644521.30	7092420.90	1592.31
DR58	Old (MHA Springs Retirement Village)	644502.50	7095203.61	1606.10
DR59	Res (farmhouses)	632880.32	7089666.71	1587.03
DR60	HC (Pholosong Hospital)	637344.78	7086108.68	1629.66
DR61	Res (Sharon Park)	642861.54	7088168.93	1618.29
DR62	Res (Dunnottar)	642547.16	7084973.56	1619.45
DR63	Res (Tsakane)	637571.59	7084138.11	1641.81
DR64	Res (Duduza)	640381.99	7082388.00	1649.48
DR65	Res (unknown)	646756.41	7088743.14	1601.53
DR66	Res (Edelweiss)	646505.25	7092137.36	1599.38
DR67	Res (Casseldale, Strubenvale)	646654.24	7094402.34	1594.53

SURROUNDING RECEPTORS (<10KM)				
Discrete Receptor ID	Name Edu = educational/school/training facilities HC = healthcare/clinic/hospital facilities Old = old age home Residential = Dwellings/ farm houses	UTM Co-ordinates (35S)		Elevation (m)
		X (m)	Y (m)	
DR68	Res (unknown)	645417.05	7096356.38	1591.93
DR69	Res (Petersfield)/Edu (Dr WK Du Plessis School)	644309.52	7097404.85	1608.65
DR70	Res (several)	645742.49	7097815.69	1597.51
DR71	Res (Geluksdal)	635619.16	7084799.25	1623.92

Notes:
*DR = discrete receptor
*>10 hospitals/healthcare/clinic facilities within 10km of project site (located in surrounding areas).
*>10 school/training/educational facilities within 10km of project site (located in surrounding areas).
*>5 old age home facilities identified within 10km of the project site.
*Numerous dwellings in surrounding areas.

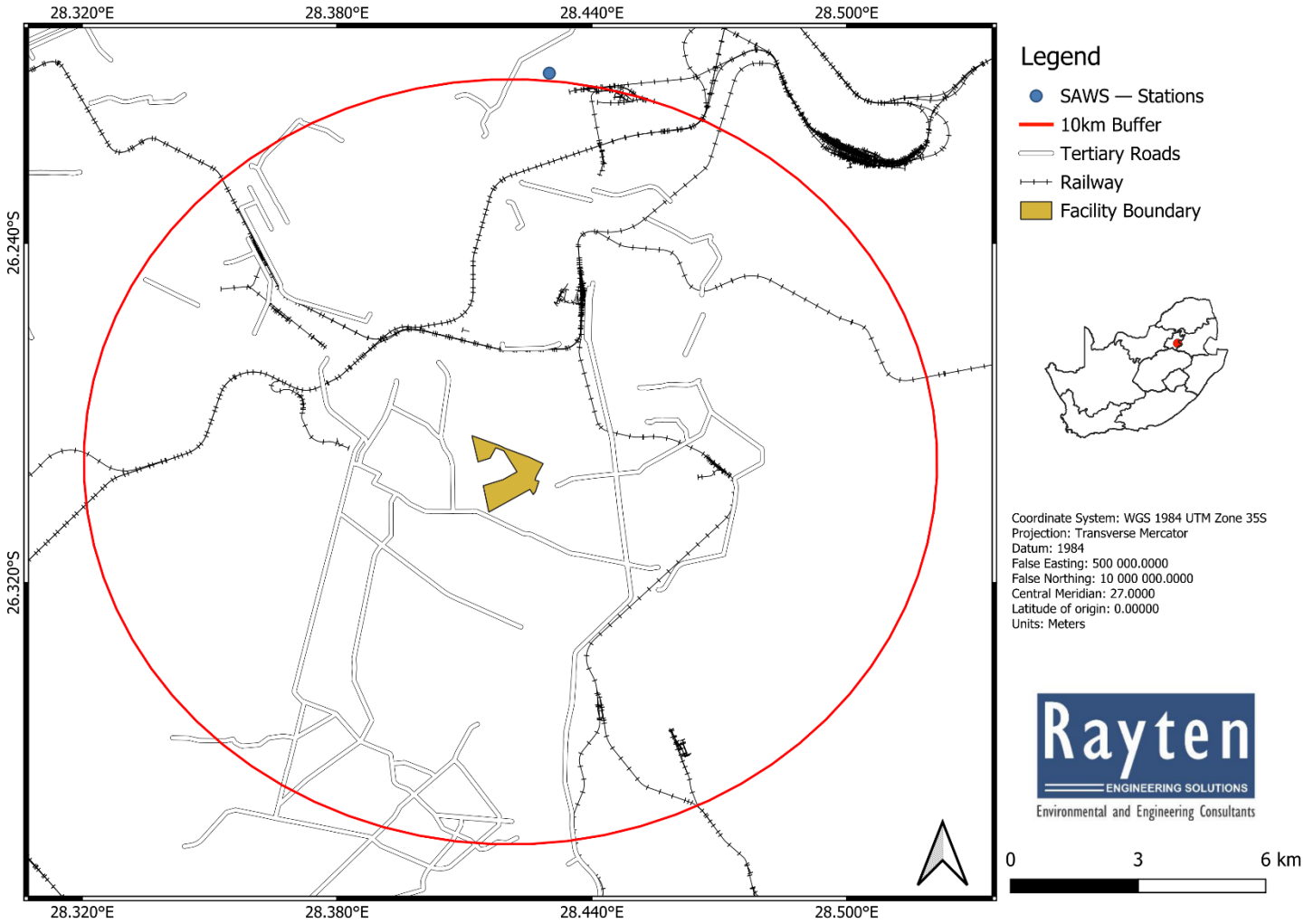


Figure 2-3: Site locality for the landfill site.

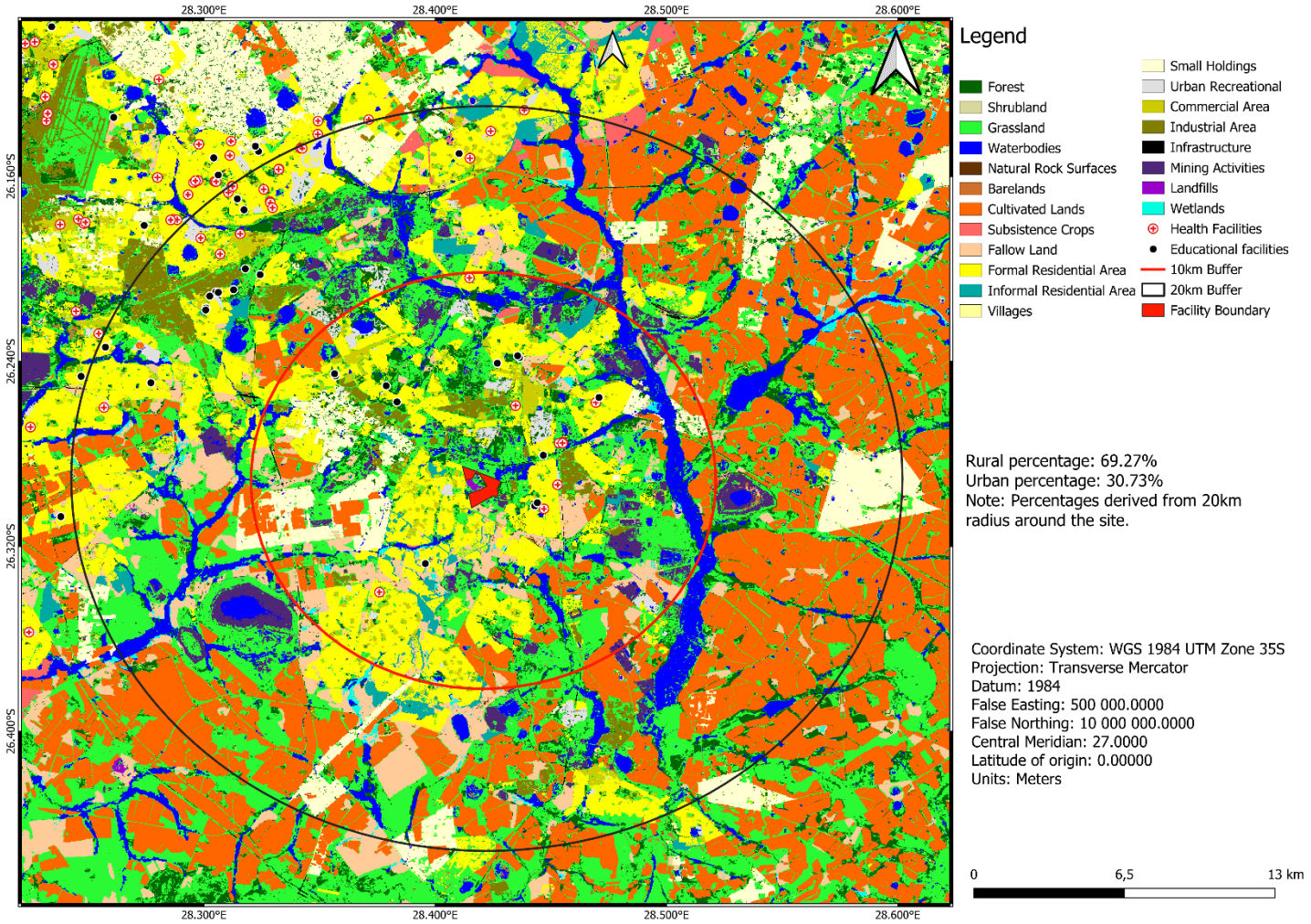


Figure 2-4: Land use surrounding the landfill site.

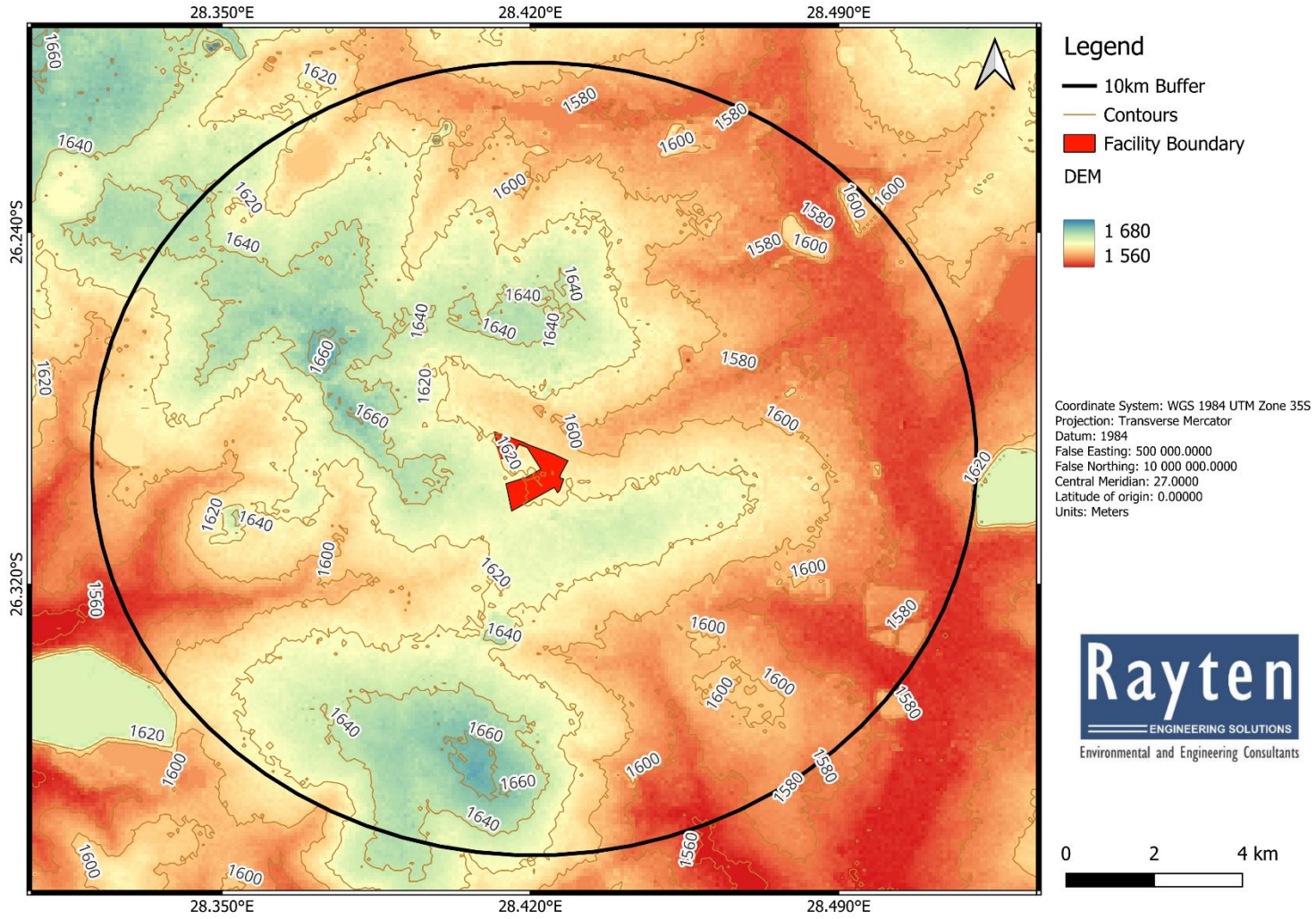


Figure 2-5: Digital elevation surrounding the landfill site.

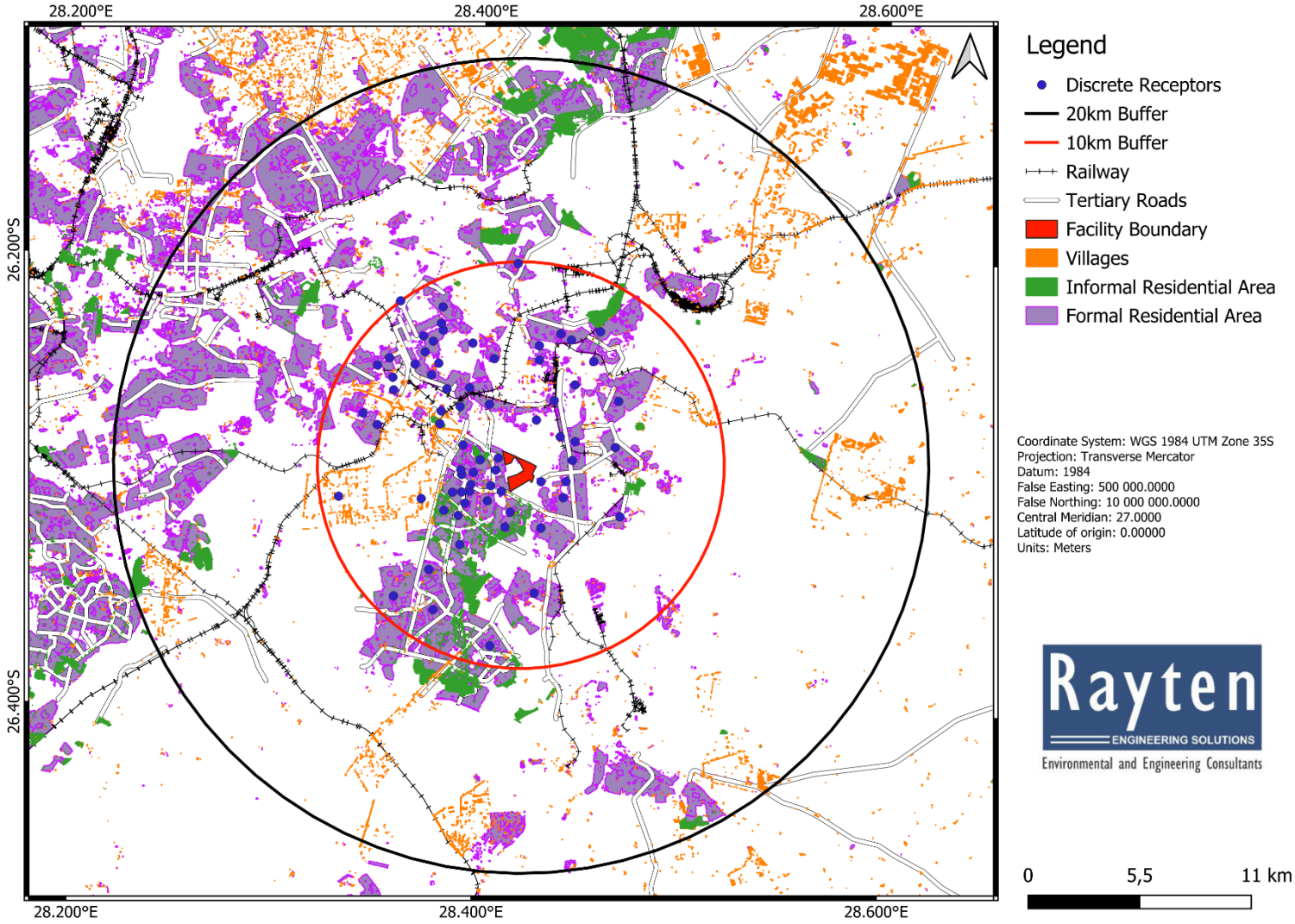


Figure 2-6: Modelled sensitive receptors surrounding the landfill site.

3. LEGISLATION

3.1. National Environmental Management: Air Quality Act No.39 of 2004 (NEM: AQA)

The NEM: AQA, has shifted the approach of air quality management from source-based control to receptor-based control. The main objectives of the Act are to;

- protect the environment by providing reasonable measures for—
  i. the protection and enhancement of the quality of air in the Republic;
  ii. the prevention of air pollution and ecological degradation; and
  iii. securing ecologically sustainable development while promoting justifiable economic and social development; and
- generally, to give effect to section 24(b) of the Constitution in order to enhance the quality of ambient air for the sake of securing an environment that is not harmful to the health and wellbeing of people.

The Act makes provisions for the setting and formulation of National Ambient Air Quality Standards for “substances or mixtures of substances which present a threat to health, well-being or the environment”. More stringent standards can be established at the provincial and local levels.

The control and management of emissions in the NEM: AQA relates to the listing of activities that are sources of emissions and the issuing of Atmospheric Emission Licences (AEL). Listed activities are defined as activities which “result in atmospheric emissions and are regarded as having a significant detrimental effect on the environment, including human health”. Listed activities have been identified by the Minister of the Department of Environmental Affairs (DEA) (now known as the Department of Environment, Forestry and Fisheries (DEFF)) and atmospheric emission standards have been established for each of these activities. These listed activities now require an AEL to operate. The issuing of AELs for listed activities is the responsibility of the Metropolitan and District Municipalities, with the exception of those associated within mining operations.

In addition, the Minister may declare any substance contributing to air pollution as a priority pollutant. Any industries or industrial sectors that emit these priority pollutants will be required to implement a Pollution Prevention Plan. Municipalities are required to “designate an air quality officer to be responsible for co-ordinating matters pertaining to air quality management in the Municipality”. The appointed Air Quality Officer is responsible for the issuing of AELs.

3.2. Listed Activities and Minimum Emission Standards

The NEM: AQA requires all persons undertaking listed activities in terms of Section 21 (S21) of the Act to obtain an AEL. The original listed activities and associated minimum emission standards were issued by the DEA on 31 March 2010 (Government Gazette No. 33064 of 31 March 2010), but were repealed and replaced by the 2013 Regulations (Government Gazette No. 37054 of 22 November 2013). Following promulgation of the 2013 Regulations, several amendments were made in:

- 2015 (Government Gazette No. 38863 of 12 June 2015);

- 2018 (Government Gazette No.41650 of 25 May 2018; Government Gazette No.42013 of 31 October 2018);
- 2019 (Government Gazette No.42472 of 22 May 2019);
- 2020 (Government Gazette No. 43174 of 27 March 2020); and
- 2025 – Draft Amendments (Government Gazette No. 53241 of 29 August 2025).

There is currently no incineration of the waste received at the landfill site. Furthermore, there are no combustion sources or material processing activities (needing heat or chemical reactions). Only landfilling and resource recovery are undertaken at the site. In addition, the landfill currently does not accept any hazardous waste materials, nor does it store large quantities of chemicals or fuel products. Based on the current information and landfill design, the TRF does not trigger any of the listed activities in terms S21 of the NEM: AQA and is therefore not required to obtain an AEL.

South Africa launched an online National reporting system, referred to as the National Atmospheric Emissions Inventory System (NAEIS). The NEM: AQA requires all emission source groups identified in terms of the National Atmospheric Emission Reporting Regulations (Government Gazette No. 38633 of 02 April 2015), to register and report emissions on the NAEIS. The landfill site does not fall within any of the groups (Group A - D) listed under Annexure 1 of the regulations. Group D under Annexure 1 states that emitting facilities identified in terms of municipal air quality by-laws are required to report on the NAEIS but at present, landfills are not listed as a controlled activity in the City of Ekurhuleni's draft air quality by-laws.

However, landfills may be required to report their Greenhouse Gas (GHG) emissions on the South African Greenhouse Gas Reporting System (SAGERS) in terms of the National GHG Reporting Regulations (refer to Section 3.3 for more details).

3.3. Greenhous Gas (GHG) Emissions

On 14 March 2014, the DEA (now known as the DFFE) (Government Gazette No. 37421 of 14 March 2014), declared the following six GHGs as priority air pollutants in South Africa:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF_6)

National GHG Emission Reporting Regulations (Government Gazette No. 40762 of 3 April 2017), as amended (General Notice 994 in Government Notice 43712 of 11 September 2020), were published by the DEA (now known as the DFFE). A person identified as a Category A data provider in terms Annexure 1 of these regulations, must register their facilities using the online System for Administration of Integrated Greenhouse Gas Emissions (SAIGE) and must submit a GHG emissions inventory, activity data and report in the required format given under Annexure 3 of these regulations on an annual basis. All data must be provided annually, by the 31 March of the following year. However, given the recent implementation of the SAIGE system, report submissions in 2026 may be done manually (i.e., by email to GHGreporting@dffe.gov.za) or through SAIGE. The NEM:

AQA and the National GHG Emission Reporting Regulations, establish the legislative framework for the national GHG reporting system in South Africa.

Waste disposal sites are a significant source of methane and carbon dioxide GHG emissions, as such landfilling activities are included in Annexure 1 of the regulations, as shown below:

- Sector: Waste
  - **4A1** - Managed Waste Disposal Sites (receiving ≥5 tonnes per day, or a total storage capacity ≥ 25 000 tonnes waste).

As such, Tonkmeter will be required to report on their total GHG emissions from the landfill operations annually before 31 March of each year, if they trigger the thresholds for Category 4A1.

National Pollution Prevention Plans

National Pollution Prevention Plan Regulations (Government Gazette No. 40996) were published on 21 July 2017 by the DEA. A pollution prevention plan will be required should the development do the following:

a) Undertake any of the following activities identified in Annexure A of the National GHG Emission Reporting Regulations (Government Gazette No. 40762 of 3 April 2017), as amended (General Notice 994 in Government Notice 43712 of 11 September 2020)), which involves the direct emission of GHG in excess of **0.1 Megatonnes (Mt)** annually measured as carbon dioxide equivalents ($CO_{2\text{-}eq}$); or
b) Undertake any of the following activities identified in Annexure A of the National Pollution Prevention Plan Regulations (Government Gazette No. 40996 of 21 July 2017) as a primary activity, which involves the direct emission of GHG in excess of **0.1 Megatonnes (Mt)** annually measured as carbon dioxide equivalents ($CO_{2\text{-}eq}$);

Annexure A activities in terms of the National Pollution Prevention Plan Regulations include:

- Coal mining
- Production and /or refining of crude oil
- Production and/or processing of natural gas
- Production of liquid fuels from coal or gas
- Cement production
- Glass production
- Ammonia production
- Carbon black production
- Iron & steel production
- Ferro-alloys production
- Aluminium production
- Polymers production
- Pulp and paper production
- Electricity production
- Nitric acid production

Total GHG emissions (in $CO_{2\text{-}eq}$) for the landfill were quantified separately as part of the Climate Change Impact Assessment. Should the total GHG emissions exceed the 0.1 Mt threshold, Tonkmeter may need to compile a Pollution Prevention Plan for the landfill.

3.4. Carbon Tax Act

The Carbon Tax Act No. 15 of 2019 was promulgated on 23 May 2019 and is implemented using a phased approach, allowing emitters time to transition to cleaner and more efficient technologies resulting in lower GHG emissions. Phase One is effective from 1 June 2019 to 31 December 2022 (extended to 31 December 2025) and focuses on Scope 1 (direct) emissions, while phase 2, running from 31 December 2022 (extended to 2025) to 31 December 2030, will include Scope 2 (indirect) emissions.

Any person, company or entity who undertakes an activity (above a certain threshold) and is responsible for the release of GHG emissions is required to report on their emissions to the DFFE by the 31 March each year and pay tax on those emissions by July each year.

The base tax rate when the Act was published was R120 per tonne of $CO_{2\text{-eq}}$ (carbon dioxide equivalent) emitted by the generation facility or entity for the relevant reporting period, but it is now at R159 per tonne of $CO_{2\text{-eq}}$. The carbon tax rate will increase at a rate determined by the Minister. However, there are tax-free allowances that apply that can make the overall effective tax rate much lower between R6 and R48 per tonne of $CO_{2\text{-eq}}$ emitted. Tax free allowances are capped at 95% and include:

- A basic tax-free allowance of 60% during Phase One (until December 2022).
- An additional tax-free allowance of 10% for process emissions.
- An additional tax-free allowance of 10% for fugitive emissions.
- An additional tax-free allowance of up to a maximum of 10% for trade exposed sectors.
- An additional tax-free performance allowance of 5% based on performance against intensity benchmarks.
- An additional tax-free allowance of 5% for companies who participate in the carbon budget system.
- An additional tax-free carbon offset allowance of 5% or 10%.

3.5. Ambient Air Quality Standards

South African National Ambient Air Quality Standards (SNAAQS), including permitted frequencies of exceedance and compliance timeframes, were issued by the Minister of Water and Environmental Affairs on 24 December 2009 (Table 3-1). National standards for $PM_{2.5}$ were established by the Minister of Water and Environmental Affairs on 29 June 2012.

Criteria air pollutants are air pollutants that are commonly found in the atmosphere and are known to have a negative impact on human health and environmental quality. Ambient air quality standards have been developed for these common pollutants based on a form of criterion (like a standard), thus they are commonly referred to as criteria air pollutants. In South Africa we have ambient air quality standards for eight (8) criteria air pollutants as shown in Table 3-1.

Table 3-1: National Ambient Air Quality Standards for Criteria Pollutants.

POLLUTANT	AVERAGING PERIOD	CONCENTRATION ($\mu g/m^3$)	FREQUENCY OF EXCEEDANCE(3)
Sulphur dioxide (SO_2)	10 minutes	500 (191)	526
	1 hour	350 (134)	88
	24 hours	125 (48)	4
	1 year	50 (19)	0
Nitrogen dioxide (NO_2)	1 hour	200 (106)	88
	1 year	40 (21)	0
Particulate Matter (PM_{10})	24 hours	75	4
	1 year	40	0
Particulate Matter ($PM_{2.5}$)	24 hours	40(1) 25(2)	0
	1 year	20(1) 15(2)	0
Ozone (O_3)	8 hours (running)	120 (61)	11
Benzene (C_6H_6)	1 year	5 (1.6)	0
Lead (Pb)	1 year	0.5	0
Carbon monoxide (CO)	1 hour	30 000 (26 000)	88
	8 hours (calculated on 1 hourly averages)	10 000 (8 700)	11

Notes:

*Values indicated in blue are expressed in part per billion (ppb)

(1) Compliance required by 1 January 2016 – 31 December 2029.

(2) Compliance required by 1 January 2030.

(3) Frequency of exceedance refers to the number of times an exceedance is allowed within a calendar year.

The only South African criteria air pollutants of concern associated with current operations at the landfill site include benzene, PM_{10}, $PM_{2.5}$, NO_2, SO_2 and CO (gaseous pollutants are primarily linked to vehicle tailpipe emissions associated with waste transportation and on-site machinery). However, there are several other air pollutants which are not classified as criteria air pollutants in South Africa that will likely be emitted as part of the landfill gas emissions. These pollutants are considered hazardous air pollutants, commonly referred to as ‘’HAPs’’, and are also known for their malodorous impacts. International guidelines and odour thresholds are available for these pollutants. More detailed information about these pollutants and their guidelines are given in Section 4.4.

3.6. Dust Deposition Standards

The DEA (now known as the DFFE) issued National Dust Control Regulations (NDCR) promulgated in Government Notice 827 of 2013, which came into effect on 1 November 2013, and subsequently the updated NDCR in Government Gazette No. 54440 of 31 March 2026 (Table 3-2), which officially repealed and replaced the 2013 Regulations. The purpose of the regulations is to prescribe general measures for the control of dust in all areas nationally and to prescribe steps that must be taken to

prevent nuisance dust. The regulations prohibit activities which give rise to dust in such quantities and concentrations that the dustfall at the boundary or beyond the boundary of the premises where it originates exceeds:

a) 600 mg/m^2/day averaged over 30 days in residential areas measured using reference method South African National Standard (SANS) 1137, or any equivalent method.
b) 1 200 mg/m^2/day averaged over 30 days in non-residential areas measured using reference method SANS 1137, or any equivalent method.

Table 3-2: South African National Dust Control Regulations (2026).

RESTRICTION AREAS	DUSTFALL RATE (D) (1)	REQUENCY OF EXCEEDANCE
Residential Areas	D < 600 mg/m^2/day	Two within a year, no two sequential months (2)
Non-residential areas	600 < D < 1200 mg/m^2/day	Two within a year, no two sequential months (2)

Notes:
(1) Averaged over 1 month (30±2-day average) (mg/m^2/day)
(2) Per dustfall monitoring site.

A person identified as a stakeholder in terms of the NDCR (2026), must submit a dust management plan (DMP) to the air quality officer or licensing authority for approval, within 60 days of commencement of the 2026 NDCR (i.e., by 31 May 2026). Identified stakeholders include:

a) any holder of a right or permit related to prospecting, exploration, mining or production as contemplated in the Mineral and Petroleum Resources Development Act (Act 28 of 2002);
b) any person conducting reclamation (defined as obtaining materials of value from a historical mine dump);
c) any person conducting a listed activity and who is required in terms of an AEL, to develop a DMP;
d) any person conducting a controlled emitter that has the potential to generate dust; and
e) any person conducting an activity that an air quality officer reasonably suspects is causing or has the potential to cause nuisance by dust.

The DMP must include:

a) the person responsible for the implementation of the DMP;
b) a description of the surrounding land use (within a 5km radius);
c) a description of the premises and all possible sources of dust and activities with the potential to generate dust within the premises;

d) detailed and time-bound best practicable control measures that must be taken to prevent, minimise, and manage dust, including fugitive dust;
e) measures to manage dust complaints and complaints register;
f) measures that must be taken to prevent nuisance by dust;
g) a dustfall monitoring programme if required by the air quality officer or licensing authority with the following:
    i. procedures for the collection and measurement of dustfall in terms of the standard test method; and
    ii. dust monitoring sampling sites sufficient in number to monitor identified or likely sensitive receptor locations in the vicinity of the premises; and
h) any other relevant information as an air quality or licensing authority may deem necessary.

Monthly DMP-implementation progress reports must be submitted to the air quality officer or licensing authority. The contents of the implementation reports are as prescribed in the 2026 NDCR and include the submission of monthly dustfall monitoring reports, where dustfall monitoring is required.

Persons who have approved DMPs in terms of the 2013 NDCR, must submit reviewed DMPs that align with the 2026 NDCR within 60 days. The reviewed plan must include a transitioning period from using ASTM D1739:1970 to SANS 1137 (which period may not exceed 6 months). Furthermore, the failure to submit DMPs and implementation reports as required in terms of the 2026 NDCR, constitutes an offence, and a fine not exceeding R5 million may be imposed (first conviction).

Dustfall monitoring reports should include relevant information about the dustfall monitoring method used, potential identified sensitive receptor locations, locations of sampling sites, a classification of the study area, meteorological data for the sampling area, proof of South African National Accreditation System (SANAS) accreditation by the laboratory undertaking the gravimetric sample analysis (soluble and insoluble fractions), proof of SANAS accreditation by testing providers on the use of SANS 1137, or any equivalent method, and any other relevant information.

3.7. Emission Reduction and Management for Air Quality Priority Areas

Regulations for implementing and enforcing priority area AQMPs were issued by the Minister of the DFFE (Government Gazette No. 51120 of 26 August 2024), to provide for the implementation and enforcement of a priority area AQMP approved and published in terms of Section 19(1)(b) and 19(5) of the NEM: AQA. These regulations apply to a priority area AQMP published by the Minister in terms of Section 19(5)(a) of the of the NEM: AQA, and to a stakeholder assigned responsibility in terms of a priority area AQMP, which include:

- any person conducting a listed activity;
- any person operating a controlled emitter;
- any holder of a right or permit related to a prospecting operation, exploration operation, mining operation or production operation as defined in section 1 of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2022);
- any person conducting reclamation; and

- any department of state or administration in the national, provincial or local sphere of government.

In addition, the regulations make provision for the inclusion of emission reduction targets within all priority area AQMPs, as well as compilation and submission of emission reduction and management plans (by stakeholders identified in the regulations) for approval to the relevant licensing authority or air quality officer, within a specified period.

3.7.1. Emission Reduction Targets

A priority area AQMP must, in addition to the requirements in Section 19(6) of the NEM: AQA, include measurable emission reduction targets. Any priority area AQMP published prior to the commencement of these regulations must, within two years of the commencement of these regulations, be reviewed to include emission reduction targets. The second-generation AQMP for the HPA, which includes emission reduction targets, was published in 2025 (in Government Gazette, No. 52387 of 26 March 2025). The emission reduction targets are summarised in Section 2.1.2.

3.7.2. Emission Reduction and Management Plans (ERMPs)

A stakeholder identified in these regulations (as listed above), must within six months of publication of a priority area AQMP or reviewed AQMP, submit an ERMP for approval to the relevant licensing authority or air quality officer, where applicable. The ERMP must include the following:

a) Measures to achieve emission reduction and management;
b) Emissions reduction targets aligned to the priority area AQMP;
c) Implementation timeframes to achieve emissions reduction targets; and
d) Any other requirements determined by the licensing authority or air quality officer.

Once approved or noted, an ERMP must be implemented by the identified stakeholder within timeframes specified in that plan, which must align with those in the priority area AQMP. In addition, progress reports must be submitted on an annual basis to verify progress made, identify any challenges being experienced in implementing the emission reduction measures, come up with remedial actions and adjust timeframes so that the challenges are dealt with in the regulated reporting timelines.

The TRF is not identified as a stakeholder in terms of the priority area regulations (for current operations). Therefore, an ERMP is not required at present.

3.8. Gauteng Pollution Buffer Zones

The Gauteng Department of Rural Development (GDARD) developed a guideline for pollution buffer zones. The purpose of the guideline is to ensure that pollution buffer areas are created between the pollution sources and the nearest human settlements to protect the residents. A buffer zone is defined as an area of land required to filter out the deleterious effects of the pollution source that is buffered (based on current understanding of the pollution type and mode of dispersal).

Pollution sources are classified into three categories as shown below:

Category 1 represents a group of industries with pollution risks that can have potentially serious health effects on a large scale.

Category 2 represents a group of industries with pollution risks that may cause minor health effects or with activities that result in nuisance rather than actual health impacts.

Category 3 represents a group of industries that pose little or no health impacts and that may result in a nuisance on a localised scale.

The guideline provides two generic buffer zones including a) best-case scenario buffer zone (larger buffer around pollution source), which ideally is the preferred option and b) the worst-case scenario buffer zone (smaller buffer around the pollution source). The smaller buffer zone is the absolute minimum distance that is allowed around a pollution source and is a legal requirement in terms of national, provincial and local legislation and policies where applicable.

Maximum buffer zones included in the guideline are shown below for the different landfill class types. The landfill site associated with the TRF only accepts general waste and is thus classified as a Class B landfill. As such, the maximum buffer that is required around the landfill site is 1000m. In other words, a buffer of at least 1000m distance would be required around the landfill site boundary.

LANDFILL SITES

Class	*Maximum Buffer*
Class A	*2000m*
Class B	*1000m*
Class C	*400m*
Class D	*200m*

Where a site is accepting hazardous and general waste (Class B) buffer is 2000m. The licensing conditions include requirements for buffer zones around the landfill sites.

Buffer zones around hazardous landfill sites are based on expert opinion and the potential toxicity of waste accepted at the site. An additional safety factor was built into the buffers for these sites, thus the buffers prescribed by this project are generally larger than the buffers prescribed by the landfill licensing conditions.

4. OVERVIEW OF LANDFILL GAS EMISSIONS AND ASSOCIATED HEALTH AND ODOUR IMPACTS

4.1. General Solid Waste Landfill Sites

In South Africa, wastes may broadly be described as general or hazardous depending on their characteristics and potential risks to human health and the environment. General waste typically

includes domestic and commercial wastes such as paper, glass, plastics and food waste, as well as certain industrial wastes and construction and demolition wastes. Historically, the management and disposal of waste to landfill was regulated with reference to the Minimum Requirements for Waste Disposal by Landfill (DWAF, 1998).

There are three common landfill design configurations, namely area, trench and ramp landfills. Irrespective of the landfill configuration, typical landfilling practices include the placement, spreading and compaction of waste, followed by the application of cover material (USEPA, 1998). Modern engineered landfills also incorporate containment barriers and associated pollution-control infrastructure to limit the migration of leachate and landfill gas and to protect surface water and groundwater resources.

The former DWAF (1998) Minimum Requirements for Waste Disposal by Landfill classified landfill sites according to factors including waste type, landfill size and climatic water balance. Under this system, a climatic water balance classification of B− or B+ was used to indicate the potential for significant leachate generation. A B− classification generally represented climatic conditions under which significant leachate generation was unlikely, while a B+ classification indicated climatic conditions with a greater potential for significant leachate generation. This classification is retained in this report as historical and site-design context, as the TRF was originally classified under the DWAF Minimum Requirements framework.

The current regulatory framework for the classification and disposal of waste to landfill is established under the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEM:WA), through the Waste Classification and Management Regulations, 2013 (GN R.634), as amended. These Regulations are supported by the National Norms and Standards for the Assessment of Waste for Landfill Disposal (GN R.635), as amended, and the National Norms and Standards for Disposal of Waste to Landfill (GN R.636), as amended. The current framework provides for the assessment and classification of waste prior to landfill disposal, waste acceptance criteria and the engineering requirements for landfill containment barriers. Landfill containment barriers are classified as Classes A to D according to the waste types that they are designed to receive.

Under the former DWAF classification system, the TRF was classified as B+, indicating a relatively high potential for leachate generation associated with the climatic conditions of the area. Most rainfall occurs between September and March during the spring, summer and early-autumn months (see Section 5.1.3). The B+ designation is therefore referenced in this report only to describe the historical climatic and leachate-generation classification of the landfill and should not be confused with the current Class B landfill classification prescribed under GN R.636.

To manage the potential for leachate generation, the landfill incorporates a comprehensive leachate-management system comprising a leachate collection network and a leachate tank. The leachate tank provides temporary storage of collected leachate prior to treatment and subsequent disposal in accordance with the landfill's operational requirements. The system is designed to manage leachate and contaminated stormwater runoff and minimise the potential for contamination of surface water and groundwater resources. The landfill also incorporates a Class B containment-barrier system. The applicable engineering requirements for a Class B containment barrier are prescribed in the National Norms and Standards for Disposal of Waste to Landfill (GN R.636), as amended.

4.2. Landfill Gas Emissions

Landfill gas consists of a mixture of pollutants, but methane and carbon dioxide collectively make up most of the volume of landfill gas emitted (~90% of total landfill gas). Typically, landfill gas will contain approximately 45 – 60% of methane and 40 – 60% of carbon dioxide, which are both GHG pollutants, thus making landfills a significant source of GHG emissions globally (ATSDR, 2001). The balance of landfill gas contains a variety of other gases such as nitrogen (2 – 5% of total landfill gas), oxygen (0.1 – 1% of total landfill gas), hydrogen (0 – 0.2% of total landfill gas), ammonia (0.1 – 1% of total landfill gas), sulphides (0 – 1% of total landfill gas) and Non-Methane Organic Compounds (NMOCs) (0.01-0.6% of total landfill gas) (ATSDR, 2001) (Figure 4-1). NMOCs are also known as Volatile Organic Compounds (VOCs), but without the methane component. Many of the NMOCs are quite volatile and can easily evaporate at ambient room temperature (20 – 25°C) and enter the atmosphere.

Landfill gas is mostly produced by anaerobic biodegradation of the organic matter contained in the disposed waste. This occurs when the organic matter in the waste is broken down by bacteria that is present in the actual waste, as well as the material used to cover the waste (e.g. soil, sand) and the surrounding landfill environment (ATSDR, 2001). Typical types of general waste that contain high organic matter include food, paper, garden and landscape waste, textiles and wood products.

Biodegradation of waste at a landfill occurs over four phases which are summarised in Table 4-1. It is important to note that all four phases of the decomposition process can occur at a single landfill site at the same time. Old waste will be in a later phase of decomposition compared to new fresh waste that has recently been deposited. Different gases are released during the different phases of decomposition (Figure 4-1).

Table 4-1: The four phases of biodegradation of waste in landfills (ATSDR, 2001; USEPA, 1998).

Phase	Description	Key Gases Produced
Phase 1	• Aerobic decomposition occurs, where bacteria that lives in the presence of oxygen, breaks down the organic matter contained in the waste. • Oxygen is consumed by the bacteria during this process and carbon dioxide is released as a by-product. • Phase 1 of the aerobic decomposition can last for several days to a few months, depending on the presence of oxygen. As the oxygen becomes depleted and there is little to no oxygen available for the aerobic bacteria anymore, the decomposition will progress to phase 2. Factors such as how well compacted the waste is during landfilling and how much cover material was used, including the frequency of compacting and covering, can influence the availability of oxygen. • Nitrogen content of the waste is high during phase 1 but rapidly declines as decomposition progresses over the next four phases. High amounts of nitrogen gas are released during phase 1.	Carbon dioxide (CO_2) Nitrogen (N_2)
Phase 2	• Phase 2 is characteristic of an anaerobic environment (lack of available oxygen) that is highly acidic. • The anaerobic bacteria convert compounds into acids (i.e. acetic, lactic and formic acids) and alcohols (methanol and ethanol). Nutrients begin to dissolve as the acids and alcohols mix with moisture, generating nitrogen and phosphorous compounds. • The nitrogen and phosphorous feed the acid producing anaerobic bacteria, allowing for further decomposition of waste.	Carbon dioxide (CO_2) Hydrogen (H_2)

Phase 3	• Phase 3 of the anaerobic decomposition begins as some of the bacteria start consuming organic acids produced during phase 2. This results in a more neutral environment in which methanogenic bacteria (capable of producing methane) can establish themselves. • Methanogenic bacteria consume carbon dioxide, resulting in a reduction of carbon dioxide emissions and an increase in methane gas production.	Methane (CH_4)
Phase 4	• In phase 4 of the anaerobic decomposition, the production of carbon dioxide, methane and nitrogen in the landfill gas becomes more stable and constant. • The composition of landfill gas (the mixture of pollutants, gases and their respective volumes) also becomes more stable. • The landfill gas emission rates will be relatively stable for several years throughout the operational life of the landfill and even years after the closure of the landfill.	Landfill gas (CH_4, CO_2, N_2 and other gases/pollutants)

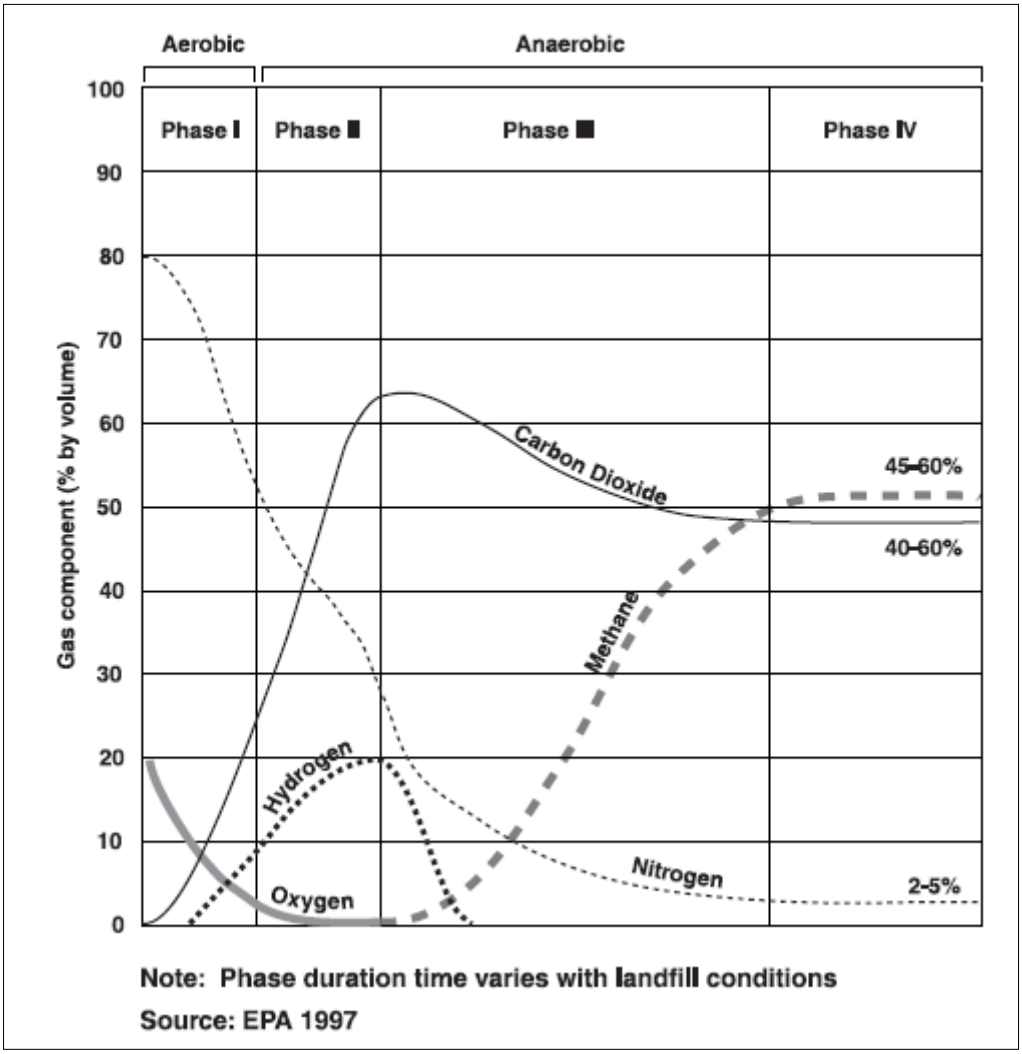


Figure 4-1: Production of landfill gases over the four decomposition phases (taken from ATSDR, 2001, pg. 6).

Landfill gases are also produced through volatilisation processes, where some waste types (such as those containing organic compounds e.g. chemicals) change from a liquid or solid state into a vapour. Emissions of NMOCs can often occur due to volatilisation processes in landfill sites

(ATSDR, 2001). Chemical reactions also happen when certain waste products come into contact with each other, such as chlorine and ammonia (often found in house cleaning products). Emissions of NMOCs and other pollutants can occur due to chemical reactions within landfills (ATSDR, 2001).

Factors affecting landfill gas production include waste composition and age, availability of oxygen in the landfill, moisture content (high moisture environment will promote biological and chemical processes) and temperature (higher temperature environment accelerates biological, chemical and volatilisation processes) (ATSDR, 2001).

The mixture of gases that are produced within the landfill will move or migrate through available spaces such as pores or cracks inside the landfill or in the cover material (ATSDR, 2001). The gases, depending on their properties, will generally move in the direction that offers least resistance, resulting in vertical or horizontal movement of gases. The gases diffuse out of the landfill (point of high concentration of landfill gases) into the atmosphere (point of low concentration of landfill gases). It is extremely difficult to monitor emission fluxes over these passive area sources (i.e. landfill surface) due to the large area size. Thus, often it is assumed that the landfill gas emissions are homogenous over certain areas of a landfill that share similar characteristics and are likely to be within the same phase of decomposition. However, landfill gas composition and emission rates will differ over the surface area of a landfill.

4.3. Health and Odour Impacts

Some of the air pollutants, such as NMOCs, emitted from landfill sites can have a negative impact on human health and environmental quality. Even though these pollutants only make up a very small percentage (~≤1%) of the total volume of landfill gas emitted, they are of importance because of the hazardous and malodorous effects associated with the pollutants, even at very low ambient concentrations.

Air pollutants that are commonly found in landfill gas are listed in Table 4-2 (ATSDR, 2001; Brattoli *et al.*, 2011). Table 4-2 also provides a summary of the potential health impacts linked to inhalation exposure to these pollutants. Acute exposure (i.e. short term) to very high concentrations of these pollutants or long-term exposure to low-medium concentrations of these pollutants can have a negative impact on human health.

The pollutants listed in Table 4-2 also have odour impacts. Odours are often the main concern for people living near landfill sites. Odour impacts are not only caused by exposure to one specific pollutant but can occur due to exposure to a mixture or cocktail of various odorous gases (which is common in the case of landfill sites). The human nose is extremely sensitive to odours and can detect malodorous compounds at incredibly low concentrations. Odour perception also varies from person to person and is thus subjective. Some people may identify an odour that is quite irritating, while others don’t. Odours are not known to be toxic to human health, however, continuous exposure to objectionable odours may cause physiological symptoms, such as respiratory problems, headaches, nausea, as well as psychological stress (Brattoli *et al.*, 2011).

Table 4-2: Health impacts associated with exposure to HAPs commonly found in landfill gas.

Air Pollutant		Health Impacts	Reference Link
Name	**Chemical formula**		
BTEX Group (form part of NMOCs)			
Benzene	C_6H_6	Acute exposure can result in headaches, dizziness, confusion and fatigue. Benzene can also be classified as a moderate eye and skin irritant. Chronic exposure to Benzene may result in cancer due to its carcinogenic properties.	https://www.who.int/ipcs/features/benzene.pdf
Toluene	C_7H_8	Acute exposure to Toluene may cause harmful effects to the central nervous system, irritation to the skin and respiratory track in the human body. Most common side effects are nausea, vomiting, headaches and dizziness. Chronic exposure to Toluene may cause memory loss, loss of coordination, fatigue and headaches.	https://www.atsdr.cdc.gov/mmg/mmg.asp?id=157&tid=29
Ethylbenzene	$C_6H_5C_2H_5$	Exposure of high concentrations in air can cause irritation to the throat and eyes. Increased levels of Ethylbenzene can cause vertigo as well as dizziness. Long term exposure to Ethylbenzene can cause hearing impairments, kidney damage and cancer.	https://www.atsdr.cdc.gov/phs/phs.asp?id=381&tid=66
Xylene	C_8H_{10}	Acute exposure to Xylene may cause harmful effects to the central nervous system, irritation to the skin and respiratory track in the human body. Most common side effects are nausea, vomiting, headaches, dizziness and difficulties in breathing. Chronic exposure to Xylene may cause damage to the brain.	https://www.atsdr.cdc.gov/mmg/mmg.asp?id=291&tid=53
Reduced Sulphur Compounds (RSC) (form part of NMOCs)			

Air Pollutant		Health Impacts	Reference Link
Name	Chemical formula		
Carbon Disulphide*	CS_2	Carbon Disulphide may cause severe irritation to the eyes, throat and mucus membranes. Acute exposure to very high levels may result in respiratory failure and death. Chronic exposure can cause neurological effects and is harmful to the central nervous system and the peripheral nervous system which may result in permanent damage.	https://www.atsdr.cdc.gov/mmg/mmg.asp?id=470&tid=84#:~:text=Carbon%20disulfide%20is%20severely%20irritating,in%20respiratory%20failure%20and%20death.
Dimethyl Sulphide*	C_2H_6S	Dimethyl Sulphide can cause irritation to the eyes and skin. It can also irritate the respiratory system, causing inflammation and a chronic cough.	http://www.gcesystems.com/dimethyl-sulfide/
Hydrogen Sulphide*	H_2S	Hydrogen Sulphide can cause harmful effects to the central nervous system, the eyes and the respiratory system. Hydrogen Sulphide is not considered carcinogenic to humans.	https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=67
Ethyl Mercaptan (Ethanethiol)*	CH_3CH_2SH	Ethyl Mercaptan can cause harmful effects to the central nervous system, the eyes and the respiratory system. Ethyl Mercaptan is not considered carcinogenic to humans.	https://www.ncbi.nlm.nih.gov/books/NBK201325/#:~:text=Ethyl%20mercaptan%20depresses%20the%20central,gait%2C%20nausea%2C%20and%20vomiting.
Methyl Mercaptan (Methanethiol)*	CH_3SH	Methyl Mercaptan can cause harmful effects to the haematological system impacting on blood formation as well as the neurological system. Methyl Mercaptan is not considered carcinogenic to humans.	https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=40
Chlorinated Compounds			
Vinyl Chloride	C_2H_3CL	Vinyl Chloride can cause harmful effects to the cardiovascular system and the liver. Vinyl Chloride can also have harmful effects in child development as well as harmful effects to the reproductive and immune system. Vinyl Chloride is considered carcinogenic to humans.	https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=51

Air Pollutant		Health Impacts	Reference Link
Name	**Chemical formula**		
Dichloromethane (Methylene Chloride)	CH_2CL_2	Dichloromethane can cause harmful effects to the central nervous system and the liver. Dichloromethane is considered carcinogenic to humans.	https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=42
Dichloroethylene (1,2 Dichloroethene)	$C_2H_2CL_2$	Dichloroethylene can cause harmful effects to the haematological system impacting on blood formation as well as the liver. Dichloroethylene is not considered carcinogenic to humans.	https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=82
Trichloroethylene	C_2HCL_3	Exposure of high concentrations in air can cause damaging effects on the central nervous system relating to hearing, seeing and balance. Exposure can also impact the liver, respiratory system, kidneys, blood, immune system, heart, and body weight.	https://www.atsdr.cdc.gov/phs/phs.asp?id=171&tid=30
Tetrachloroethylene (perchloroethylene)	C_2CL_4	Tetrachloroethylene can cause harmful effects to the central nervous system, liver, urinary tracts and kidneys as well as harmful effects to the reproductive system. Tetrachloroethylene is considered carcinogenic to humans.	https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=48
Other Gases			
Ammonia	NH_3	Ammonia can cause irritation to the respiratory system from the nose to the lungs. Not considered as carcinogenic to humans.	https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=2

Notes:
* RSC = Reduced sulphur compounds, which are a group of organic and inorganic chemicals that contain sulphur atoms in their low oxidation state. There are many species of RSC, however, only a few are found in the atmosphere. Common RSC pollutants that are emitted into the air include hydrogen sulphide, methyl mercaptan, ethyl mercaptan, dimethyl sulphide, carbon disulphide and dimethyl disulphide.

4.4. Air Quality Guidelines and Odour Thresholds

The pollutants listed in Table 4-2 were assessed in this AQIAr. Comparison of the modelled concentrations of these pollutants was made with the various international air quality guidelines (mainly Canadian guidelines) given in Table 4-3.

Dynamic olfactometry is a commonly used method for determining odour concentrations. The method involves collecting odour samples in specific containers (e.g. Tedlar bags) and taking them to a laboratory where a sensory measurement using a panel of judges takes place. The odour sample is diluted with odour-free air in specific ratios to a point where just barely 50% of the panel of judges can detect the odour (via their nose). The point where 50% of the panel can detect the odour is referred to as the 'threshold of detection' (Nicolas *et al.,* 2006; Brattoli *et al.*, 2011). Typically, the amount of dilution required to achieve the 'threshold of detection' is equal to 1D/T. Odour Units (OU) refer to the quantity of odorous material that must be present in one cubic metre (m^3) of air for the odour concentration to reach the 'threshold of detection'. Therefore, 1 D/T = 1 OU per m^3. The concentration of odours can be expressed as OU/m^3 (Nicolas *et al.,* 2006; Brattoli *et al.*, 2011).

Odour thresholds are defined in different ways such as odour detection threshold and odour recognition threshold. The *odour detection threshold* is defined based on the laboratory field tests described above and represents the point at which 50% of the population will just barely detect the odour. However, this does not necessarily mean that the average person will notice the odour in their natural environment. Nor does it mean that the odour will be a nuisance or have a negative impact. As such, an *odour recognition threshold* exists (normally higher than the detection threshold), which represents a level of odour that most people (the average person) will likely recognise or notice in their natural environment. This level of odour may be annoying if someone is repeatedly exposed to it. Odour thresholds for the pollutants that will be assessed in this AQIAr are given in Table 4-3 and were obtained from the AQIAr compiled by Airshed for the proposed Enviroserv Chloorkop landfill expansion in the City of Ekurhuleni (Airshed, 2018). It should be noted that there are many different odour thresholds for a single pollutant, and these can vary significantly. Differences in a person's perception of odour and odour sampling techniques can account for the high variability in published odour thresholds.

Table 4-3: Air quality guidelines and odour thresholds for air pollutants commonly found in landfill gas.

Air Pollutant		Air Quality Guideline			Odour Thresholds***		Odour Characteristics
Name	Chemical formula	Air Quality Guideline ($\mu g/m^3$)	Averaging period	Guideline Source	Detection Threshold ($\mu g/m^3$)	Recognition Threshold ($\mu g/m^3$)	
BTEX Group (form part of NMOCs)							
Benzene	C_6H_6	30	1-hour	Alberta Ambient Air Quality Guideline	1500	16000	sweet-like odour
		5	Annual	SA Ambient Air Quality Standard			
Toluene	C_7H_8	1880	1-hour	Alberta Ambient Air Quality Guideline	1300	20000	sweet-like odour
Ethylbenzene	$C_6H_5C_2H_5$	2000	1-hour	Alberta Ambient Air Quality Guideline	730	1900	sweet-like odour
Xylene	C_8H_{10}	2300	1-hour	Alberta Ambient Air Quality Guideline	180	2000	sweet-like odour
Reduced Sulphur Compounds (RSC) (form part of NMOCs)							
Carbon Disulphide**	CS_2	30	1-hour	Alberta Ambient Air Quality Guideline	100	1000	strong sweet rotting odour
Dimethyl Sulphide**	C_2H_6S	30	1-hour	Ontario Ambient Air Quality Criteria	1	49	strong rotten cabbage-like odour
Hydrogen Sulphide**	H_2S	14	1-hour	Alberta Ambient Air Quality Guideline	0.57	7	foul rotten egg odour
		4	24-hour				
Ethyl Mercaptan (Ethanethiol)**	CH_3CH_2SH	28	1-hour	British Columbia Ambient Air Standard for RSC mercaptan	1	2.5	strong rotting odour

Air Pollutant		Air Quality Guideline			Odour Thresholds***		Odour Characteristics
Name	**Chemical formula**	**Air Quality Guideline (µg/m^3)**	**Averaging period**	**Guideline Source**	**Detection Threshold (µg/m^3)**	**Recognition Threshold (µg/m^3)**	
Methyl Mercaptan (Methanethiol)**	CH_3SH			compounds (not defined)**	0.14	2	strong rotting odour
Chlorinated Compounds							
Vinyl Chloride	C_2H_3CL	130	1-hour	Alberta Ambient Air Quality Guideline	520000	910000	sweet-like odour
Dichloromethane (Methylene Chloride)	CH_2CL_2	694000	1-hour*	AIHA ERPG1*	560000	730000	chloroform-like sweet odour
Dichloroethylene (1,2 Dichloroethene)	$C_2H_2CL_2$	unknown	1-hour	could not find an hourly guideline	23000	unknown	sharp harsh odour
		105	24-hour	Ontario Ambient Air Quality Criteria			
Trichloroethylene	C_2HCL_3	unknown	1-hour	could not find an hourly guideline	1500	20000	sweet-like odour
		12	24-hour	Ontario Ambient Air Quality Criteria			
Tetrachloroethylene (perchloroethylene)	C_2CL_4	unknown	1-hour	could not find an hourly guideline	unknown	8000	sharp sweet-like odour
		360	24-hour	Ontario Ambient Air Quality Criteria			
Other Gases							
Ammonia	NH_3	1400	1-hour	Alberta Ambient Air Quality	1100	35000	strong pungent odour

Air Pollutant		Air Quality Guideline			Odour Thresholds***		Odour Characteristics
Name	Chemical formula	Air Quality Guideline ($\mu g/m^3$)	Averaging period	Guideline Source	Detection Threshold ($\mu g/m^3$)	Recognition Threshold ($\mu g/m^3$)	
				Guideline			

Notes:
* AIHA ERPG = American industrial Hygiene Association Emergency Response Planning Guidelines.
* ERPG 1 = defined by AIHA as the maximum hourly concentration that individuals can be exposed to without experiencing serious health effects other than mild transient adverse health effects (short term, non-repetitive) or perceiving a clearly defined objectionable odour.
** RSC = Reduced sulphur compounds, which are a group of organic and inorganic chemicals that contain sulphur atoms in their low oxidation state. There are many species of RSC, however, only a few are found in the atmosphere. Common RSC pollutants that are emitted into the air include hydrogen sulphide, methyl mercaptan, ethyl mercaptan, dimethyl sulphide, carbon disulphide and dimethyl disulphide.
*** Odour Thresholds taken from Table 2-6 of the Airshed AQIA Report for proposed expansion of Chloorkop Landfill (2018).

4.5. Dust Emissions

4.5.1. Dustfall

Dustfall are particles with an aerodynamic diameter greater than 20 µm that have been entrained into the air by a physical process such as wind, movement of vehicles, stack emissions or from fugitive dust. These particles are generally too heavy to remain in suspension in the air for any period and fall out of the air over a relatively short distance depending on a combination of various factors such as particle size, density, temperature (of the air and particle), emission velocity or method, ambient wind speed and humidity. These particles are therefore commonly known as "dustfall". Particulates in this range are generally classified as a nuisance dust and can cause physical damage to property and physical irritation to plants, animals and humans.

4.5.2. Particulates (PM_{10} & $PM_{2.5}$)

Particles can be classified by their aerodynamic properties into coarse particles, PM_{10} (particulate matter with an aerodynamic diameter equal to or less than 10 µm) and fine particles, $PM_{2.5}$ (particulate matter with an aerodynamic diameter equal to or less than 2.5 µm). The fine particles mostly contain secondary formed aerosols such as sulphates and nitrates, combustion particles and re-condensed organic and metal vapours. The coarse particles mostly contain earth crust materials and fugitive dust from roads and industries (Harrison and van Grieken, 1998) (Fenger, 2002).

In terms of health impacts, particulate air pollution is associated with effects on the respiratory system (WHO, 2000 and 2021). When looking at human health particle size is an important factor to consider because it controls where in the respiratory system a given particle will be deposited. Fine particles are thought to be more damaging to human health than coarse particles as larger particles do not penetrate deep into the lungs compared to smaller particles. Larger particles are deposited into the extra thoracic part of the respiratory tract while smaller particles are deposited into smaller airways that lead to the respiratory bronchioles (WHO, 2000 and 2021).

Recent studies suggest that short-term exposure to particulate matter leads to adverse health effects, even at low concentrations of exposure (below 100 µg/m^3). Morbidity effects associated with short-term exposure to particulates include increases in lower respiratory symptoms, medication use and small reductions in lung function. Long-term exposure to low concentrations (~10 µg/m^3) of particulates is associated with mortality and other chronic effects such as increased rates of bronchitis and reduced lung function (WHO, 2000 and 2021). Those most at risk include the elderly, individuals with pre-existing heart or lung disease, asthmatics and children.

5. BASELINE ASSESSMENT

5.1. Meteorological Overview

Meteorological processes will determine the dispersion and dilution potential of pollutants emitted into the atmosphere. The vertical dispersion of pollution is governed by the stability of the atmosphere as well as the depth of the surface mixing layer. Horizontal dispersion of pollution is defined by dominant wind fields. Therefore, meteorological parameters including temperature, precipitation, wind speed and wind direction are of significance as they will influence the degree to which pollution will accumulate or disperse in the atmosphere.

As per the Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014), representativeness of the meteorological data is influenced by the following four factors:

- Proximity of the meteorological site to the area being modelled;
- Complexity of the terrain;
- Exposure of the meteorological measurement site; and
- Period of data collection.

MM5 modelled meteorological data was used for the project area. MM5 meteorological data was obtained from Lakes Environmental for the period January 2023 to December 2025. MM5 is a PSU/NCAR meso-scale model used to predict meso-scale and regional-scale atmospheric circulation. The model provides integrated model meteorological data, which can be used in a wide range of applications. This model is often used to create weather forecasts and climate projections. Details of the meteorological data obtained are summarised in Table 5-1 below.

The South African dispersion modelling regulations require a minimum of 3-years of meteorological data for input into the dispersion model. The meteorological overview given below is with reference to the data used for input into the model. The meteorological data is representative of recent prevailing weather conditions that will likely be experienced at the project site.

Table 5-1: Meteorological Data Details.

Meteorological Data Details	
Met Data Information	**Description**
Met data type	MM5 AERMET-Ready (Surface & Upper Air Data)
Datum	WGS 84
Closest Town	Springs - South Africa
Co-ordinates of centre of met grid:	
Latitude	26.292657°S
Longitude	28.423939°E
Time zone	UTC +2 hours
Period of record	January 2023 - December 2025
Met Station Parameters	**Description**
Anemometer height	14 m
Station base elevation	1592 m
Upper air adjustment	-2 hours
Grid Cell Information	
Cell centre	26.292657°S, 28.423939°E
Cell dimension	12km * 12km
Surface Met Data	**Description**
File format	SAMSON file
Output interval	Hourly
Upper Air Data	**Description**
Format	TD-6201- Fixed Length

Reported in	GMT
Output interval	00Z and 12Z
Models used to process met data	
Model used to process data for wind roses	WR Plot
Model used to process data for AERMOD	AERMET

5.1.1. Local Wind Field

Figure 5-1 provides the period wind rose plot for the project site for the period January 2023 to December 2025. The predominant wind directions for the period are observed from the north (~13.1% of the time), north-northeast (~12% of the time) and north-northwest (~10.0% of the time). Wind conditions during the three-year period ranged from light air to fresh breezes, with wind speeds ranging from 0.5 m/s to 8.80 m/s. Calm conditions, with a wind speed equal to 0 m/s, were observed with a frequency of ~6.7%. Light air to fresh breezes occurred for 92.7% of the time.

The morning (AM) and evening (PM) period wind rose plots for the period January 2023 to December 2025 are given in Figure 5-2 and show some variation in the wind field data, with high frequency winds originating from the north-northeast and north during the morning (AM) period. During the evening (PM) period, winds from the north-western quadrant predominate (i.e., north-northwesterly, north-westerly and northerly winds). Furthermore, the frequency of north-northeasterly winds decreases significantly by evening time (Figure 5-2). The wind intensity remained consistent across both time periods, with comparable wind speeds of 3.55 m/s during the morning period and 3.23 m/s during the evening period.

There is significant seasonal variation in winds at the project site as shown in Figure 5-3. During the summer and spring seasons, northerly and north-northeasterly winds prevail, with weaker and less frequent north-easterly (summer) and north-northwesterly (spring) winds also occurring. During the winter season, high frequency winds originate from the north, north-northwest and north-west. The autumn season is characterised by a combination of high-frequency winds from the north-eastern and north-western quadrants.

Based on the prevailing wind fields for the period January 2023 to December 2021, emissions from activities at the landfill will likely be transported towards the south, south-southwest and south-southeast, depending on the season and time of day. Wind conditions observed during all time periods were generally classified as light air to fresh breezes, which may help in effective dispersion of pollutants from the landfill operations. However, higher wind speeds can also facilitate fugitive dust emissions from open exposed areas such as the active landfill cells.

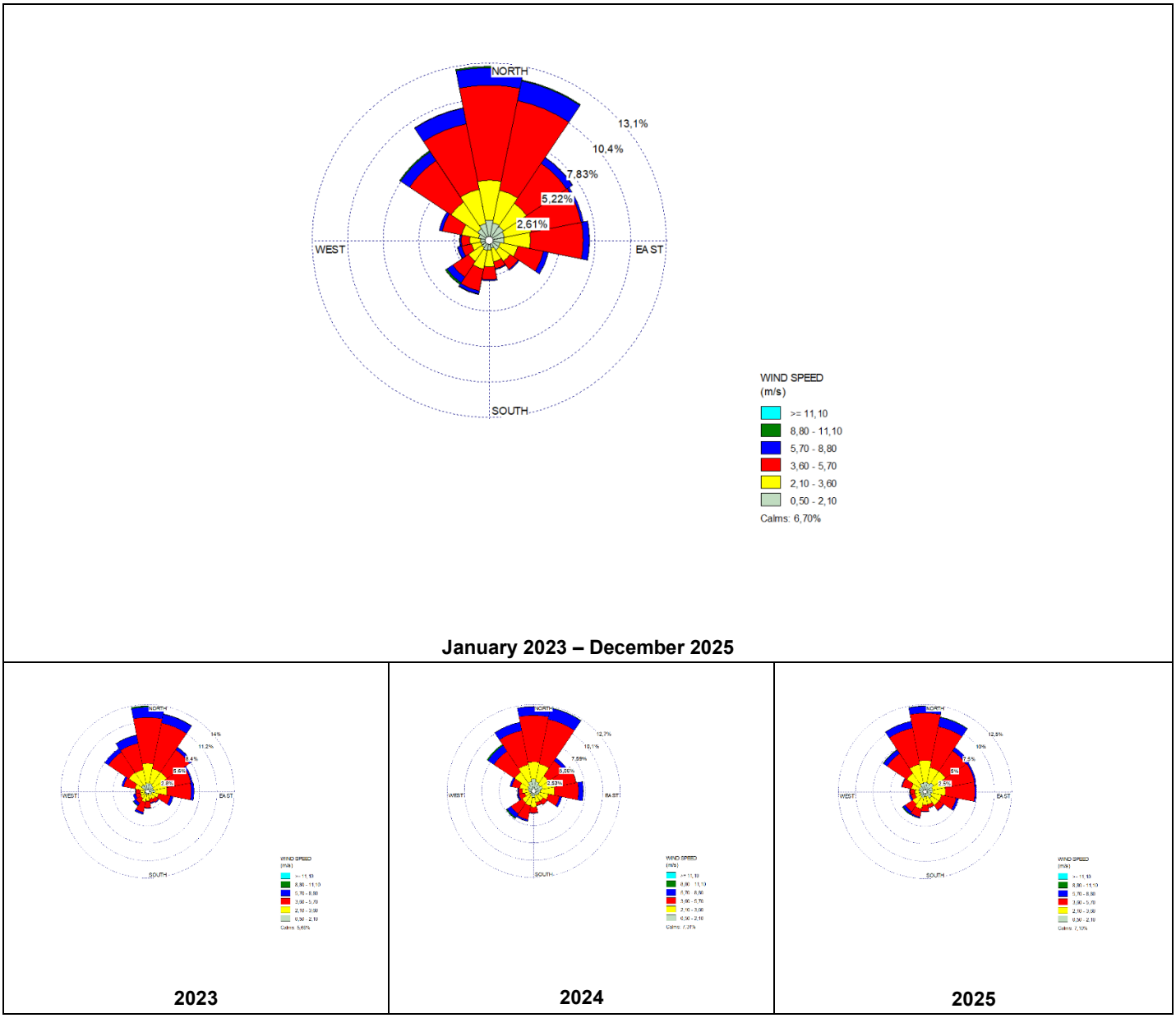


Figure 5-1: Period Wind Rose Plots for the project site for the period January 2023 - December 2025.

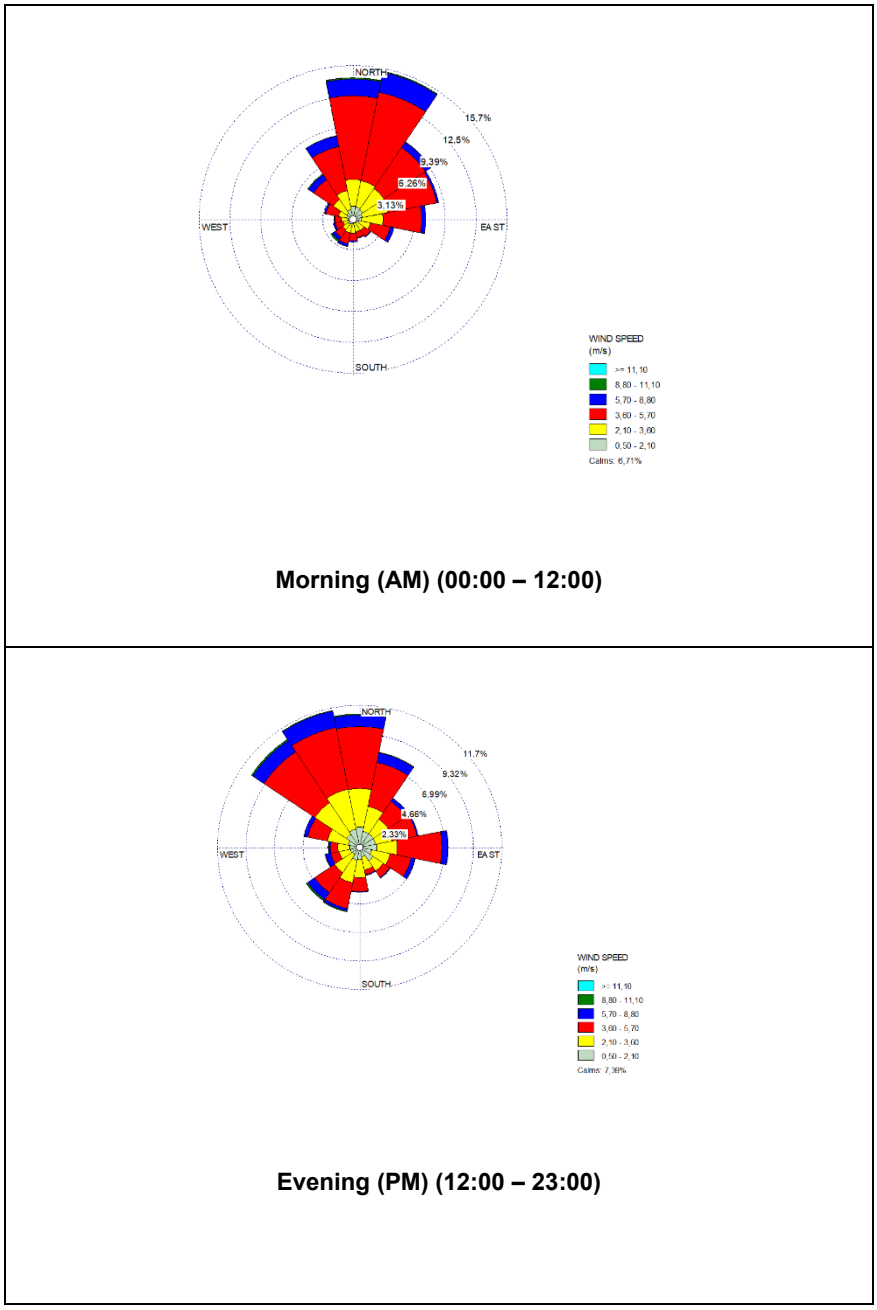


Figure 5-2: Morning (AM) (00:00 - 12:00) and Evening (PM) (12:00 - 23:00) Period Wind Rose Plots for project site for the Period January 2023 - December 2025.

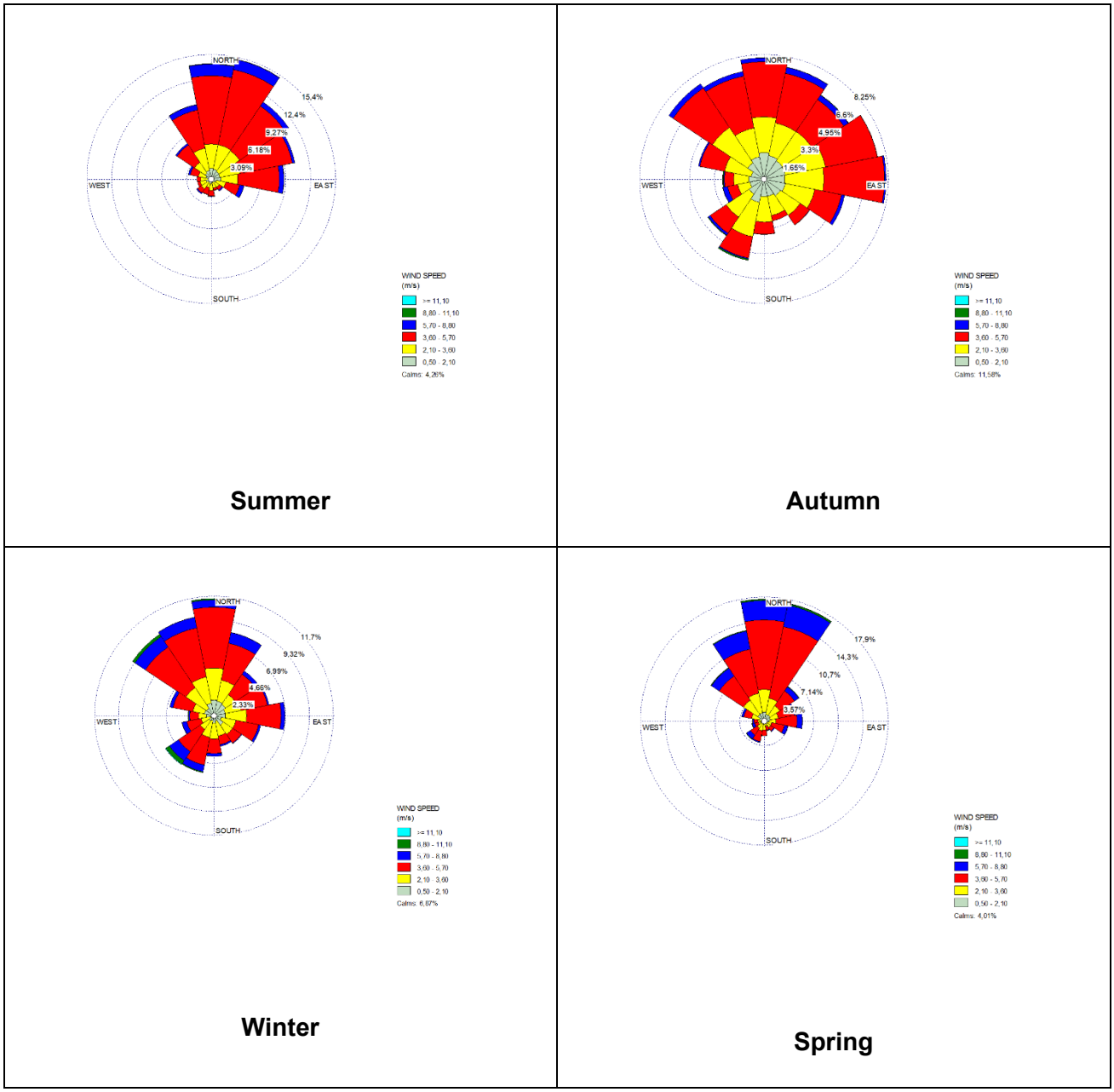


Figure 5-3: Seasonal Variation of Winds for the project site for the period January 2023 - December 2025.

5.1.2. Temperature and Relative Humidity

Temperature affects the formation, action and interactions of pollutants in various ways. Temperature provides an indication of the rate of development and dissipation of the mixing layer, which is largely controlled by surface inversions. Surface temperature inversions play a major role in air quality, especially during the winter months when these inversions are the strongest. Higher ambient temperatures will facilitate the dispersion of air pollutants which can result in lower ambient concentrations.

Chemical reaction rates also tend to increase with temperature and the warmer the air, the more water it can hold and therefore the higher the humidity. When relative humidity exceeds 70%, light scattering by suspended particles begins to increase, as a function of increased water uptake by the particles. This results in decreased visibility due to the resultant haze. Many pollutants may also dissolve in water to form acids.

The Gauteng province generally experiences a varied climate with warm, rainy summers and cold winters. Monthly average temperatures and relative humidity profiles at the project site for the period January 2023 to December 2025 are presented in Figure 5-4. Average monthly temperatures range from 9.0 – 21.2 ºC (Table 5-2). Highest temperatures are observed from mid-spring, throughout summer to early-autumn (October – March), while lower average temperatures are observed from mid-autumn, throughout winter to early spring (April – September)). Relative humidity levels are slightly elevated in February and between May and July, while the remainder of the year is characterised by lower and more variable humidity conditions.

Table 5-2: Hourly Minimum, Maximum and Monthly Average Temperatures for January 2023 - December 2025.

MINIMUM, MAXIMUM AND MONTHLY AVERAGE TEMPERATURES (°C)												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Minimum	8.1	11.2	9.6	5.1	0.5	-1.4	-3.1	-1.0	3.6	1.9	4.5	10.6
Maximum	30.6	30.5	28.9	25.1	22.5	19.1	20.4	24.0	25.2	28.2	30.9	30.1
Average	21.2	21.2	19.6	16.1	12.8	9.1	9.0	12.4	15.5	17.6	20.1	21.0

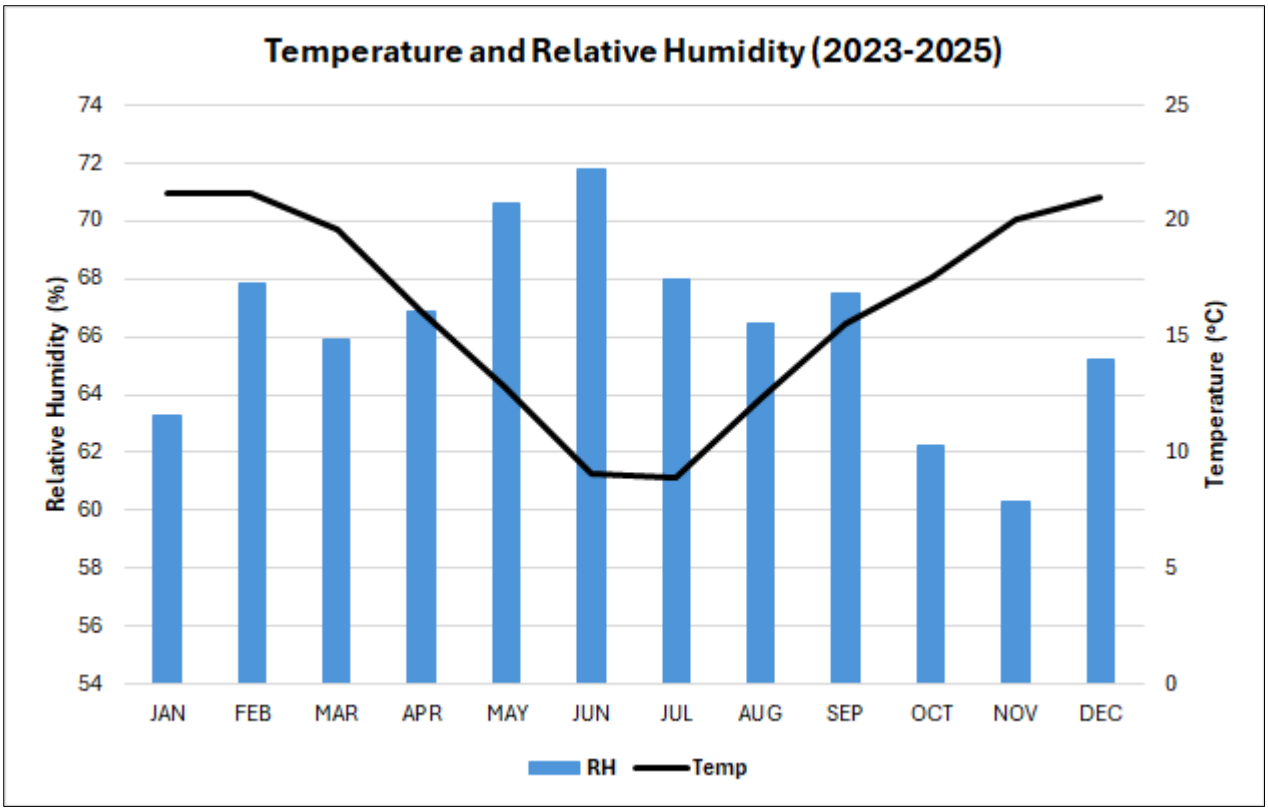


Figure 5-4: Monthly Average Temperature and Relative Humidity profiles for the project site for January 2023 - December 2025.

5.1.3. Precipitation

Precipitation has an overall dilution effect and cleanses the air by washing out particles suspended in the atmosphere. Monthly total rainfall at the project site for the period January 2023 to December 2025 is presented in Figure 5-5. The area receives most of its rainfall during the spring, summer and early-autumn seasons, from September to March. Minimal rainfall is received during the remainder of the autumn season and in winter (April to August) (Table 5-3).

Table 5-3: Total Monthly Rainfall for January 2023 - December 2025.

TOTAL MONTHLY RAINFALL (mm)													
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
2023	67.8	139.4	48.5	17.0	73.9	7.6	3.8	5.1	41.1	125.0	129.0	237.5	895.9
2024	215.9	91.2	46.2	16.0	0.0	23.1	0.0	1.8	58.4	65.8	101.3	158.0	777.7
2025	187.2	281.7	107.2	62.7	16.0	2.3	12.4	7.1	85.9	106.9	261.4	165.4	1296.2

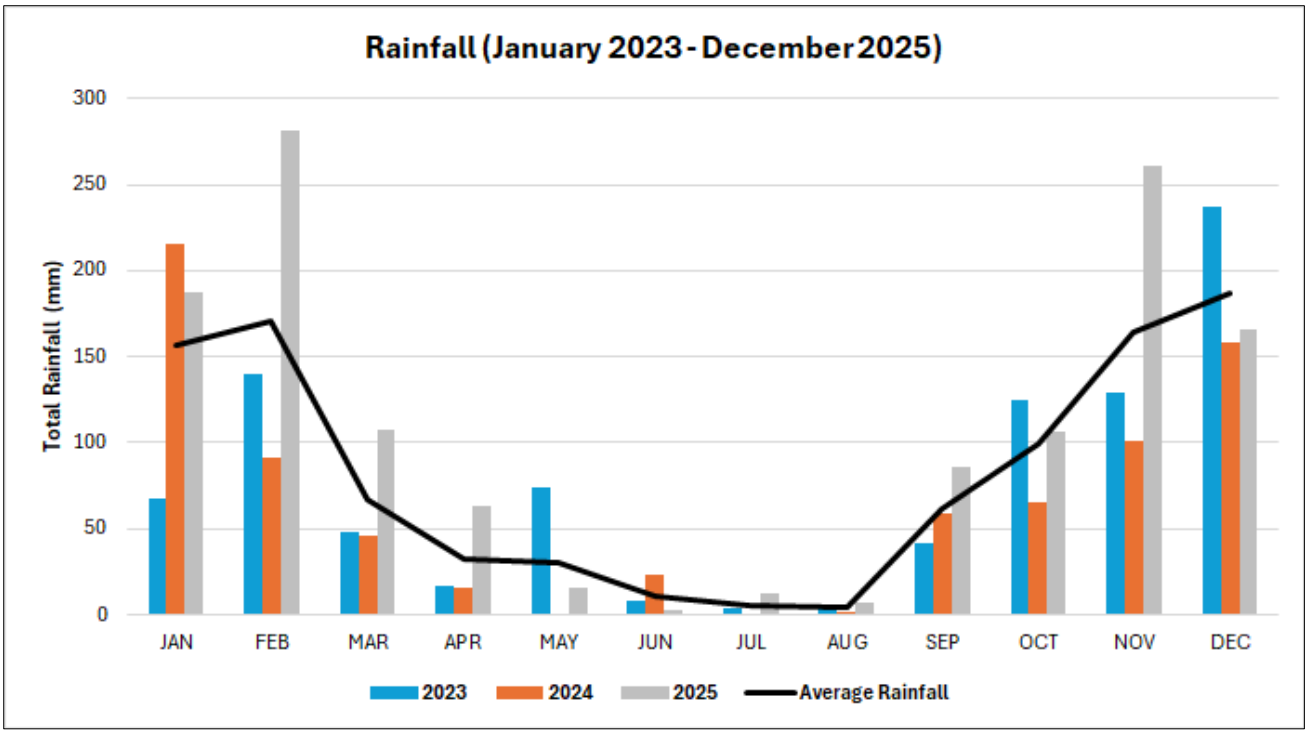


Figure 5-5: Total Monthly and Average Rainfall (mm) for the project site for the period January 2023 - December 2025.

5.2. Background Air Quality Concentrations

The existing air quality situation was evaluated using available monitoring data for PM_{10}, $PM_{2.5}$, SO_2, and NO_2 from a permanent ambient air quality monitoring station (AQMS), i.e., at the Springs AMQS Station (26.270361°S, 28.416005°E). The Springs AQMS is accessible via the South African Air Quality Information System (SAAQIS) portal and is located approximately 2 km north of the landfill site (Figure 5-6). The monitoring station is located within the same broader airshed and is influenced by similar regional land uses, pollution sources, and meteorological conditions as the landfill site. Furthermore, given the relatively short separation distance and absence of significant topographical or meteorological differences between the monitoring station and the landfill site, the available monitoring data was regarded as appropriate for characterising background concentrations of key pollutants of concern for the purposes of this assessment.

The ambient air quality monitoring data covers the period 01 January 2022 – 31 December 2023, for which data was available. However, there was low data capture for NO_2 in 2022 (i.e., 29.7%), therefore, only data from 2023 was considered for the assessment of background NO_2 concentrations. Table 5-4 below provides the data capture rate for the monitoring period under review for PM_{10}, $PM_{2.5}$, SO_2 and NO_2.

Table 5-4: Data Capture Rate (Springs Air Quality Monitoring Station).

Pollutant	Data Capture Rate (%) (January 2022 – December 2023)	Data Capture Rate (%) (January 2023 – December 2023)
PM_{10}	92.76	

Pollutant	Data Capture Rate (%) (January 2022 – December 2023)	Data Capture Rate (%) (January 2023 – December 2023)
$PM_{2.5}$	92.77	
SO_2	88.55	
NO_2		92.80

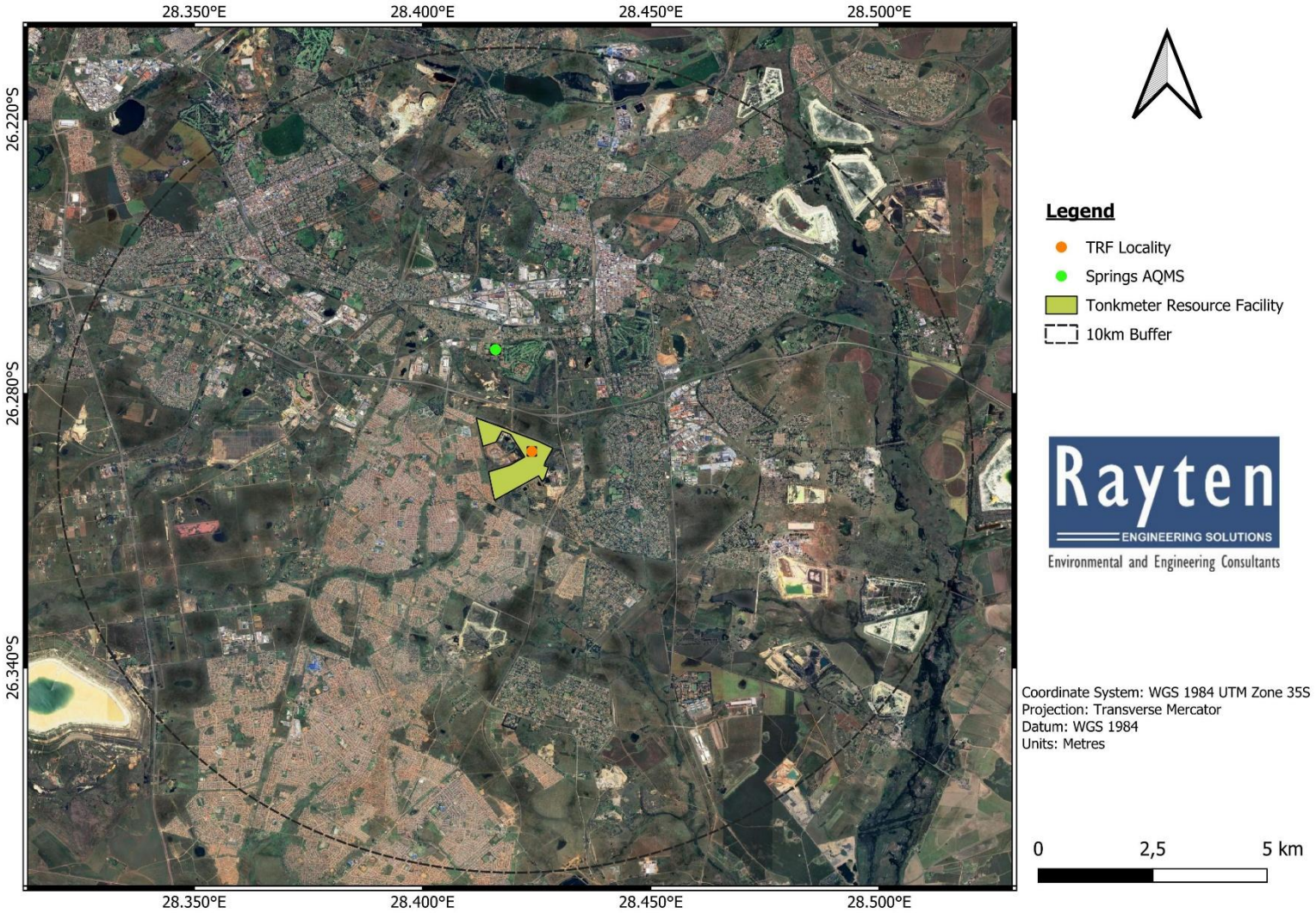


Figure 5-6: Locality of Ambient Air Quality Monitoring Station (green pin) in relation to the landfill site (orange pin).

5.2.1. PM_{10} Concentrations

PM_{10} concentrations at the Springs AQMS for the period 01 January 2022 to – 31 December 2023 are provided in in Figure 5-7 to Figure 5-10. There was 92.76% data capture in terms of PM_{10} concentrations at the Springs station. Daily average PM_{10} concentrations range between 4.24 µg/m^3 – 287.70 µg/m^3, with an average of 53.81 µg/m^3 (Figure 5-8). A total of 160 exceedances of the PM_{10} daily standard of 75 µg/m^3 were observed over the monitoring period.

Existing sources of PM_{10} within a 20 km radius of the plant include mining activities, vehicle exhaust emissions, agricultural activities, solid fuel combustion in the townships/informal settlements and industrial activities.

Annual average PM_{10} concentrations were 53.20 µg/m^3 and 53.90 µg/m^3 for 2022 and 2023, respectively (Table 5-5), thus exceeding the annual standard of 40 µg/m^3 in both years. Higher PM_{10} concentrations were mostly recorded between May and October (late-autumn to mid-spring seasons), and the highest daily concentration was recorded in winter – on 03 July 2022 (287.70 µg/m^3).

In terms of the South African NAAQS, 4 exceedances of the PM_{10} 24-hour standard are permitted within a calendar year, while no exceedances of the PM_{10} annual standard are permitted. Background PM_{10} data from the Springs AQMS indicates non-compliance with the South African NAAQS for the 2022 – 2023 monitoring period.

Table 5-5: Annual average concentrations for PM_{10}.

Year	Annual Average (µg/m^3)	Annual NAAQS (µg/m^3)
2022	53.20	40
2023	53.90	40

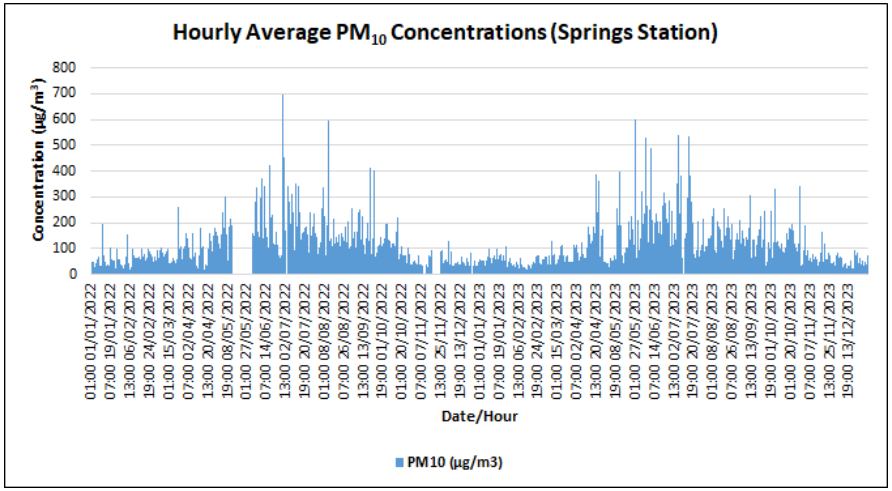


Figure 5-7: Hourly PM_{10} concentrations at Springs AQMS for the period January 2022 – December 2023.

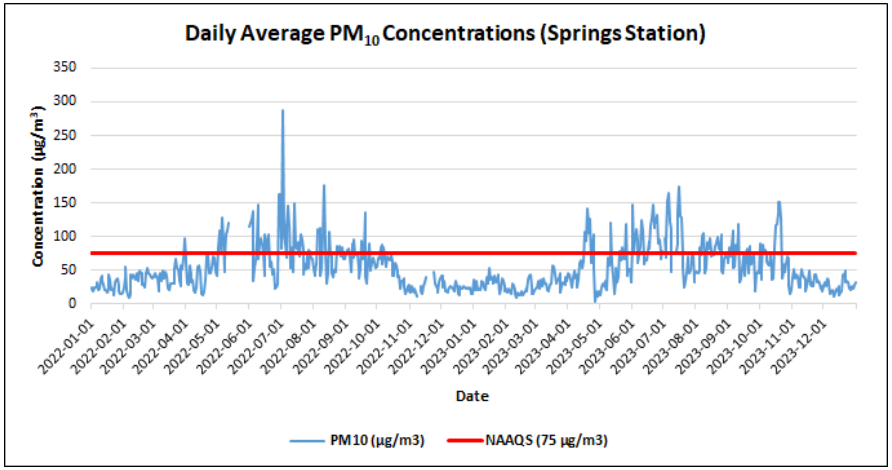


Figure 5-8: Daily PM_{10} concentrations at Springs AQMS for the period January 2022– December 2023.

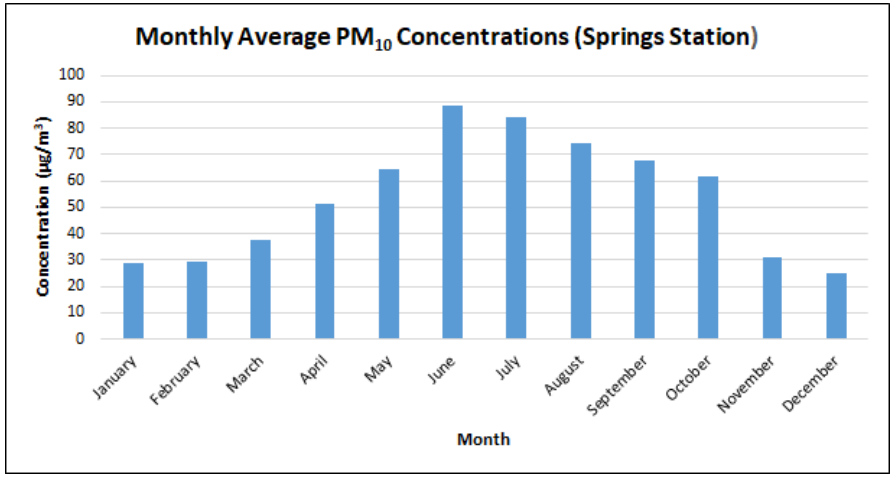


Figure 5-9: Monthly PM_{10} concentrations at Springs AQMS for the period January 2022 – December 2023.

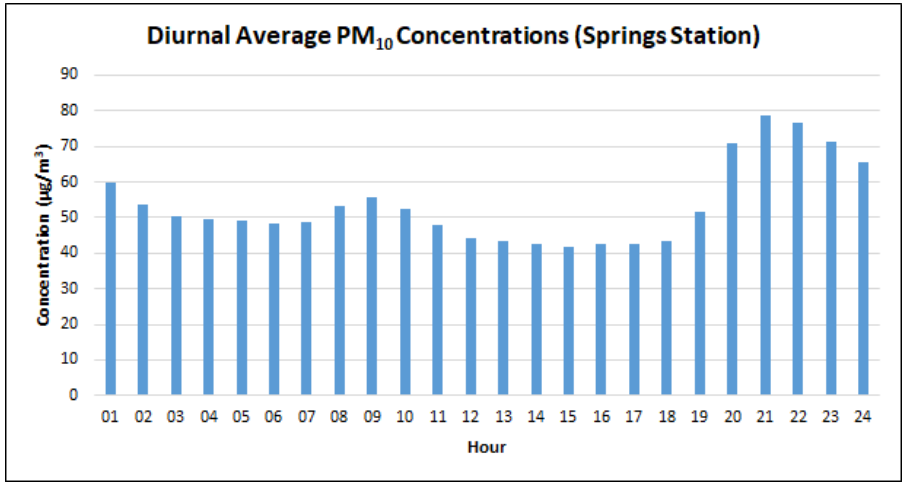


Figure 5-10: Diurnal PM_{10} concentrations at Springs AQMS for the period January 2022 – December2023.

5.2.2. $PM_{2.5}$ Concentrations

$PM_{2.5}$ concentrations at the Springs AQMS for the period 01 January 2022 to 31 December 2023 are provided in Figure 5-11 to Figure 5-14. There was 92.77% data capture in terms of $PM_{2.5}$ concentrations at the Springs station. Daily average $PM_{2.5}$ concentrations range between 1.71 µg/m^3 – 192.95 µg/m^3, with an average of 28.90 µg/m^3 (Figure 5-12). 155 exceedances of the $PM_{2.5}$ daily standard of 40 µg/m^3 were observed over the monitoring period.

Existing sources of $PM_{2.5}$ within a 20 km radius of the plant include mining activities, vehicle exhaust emissions, agricultural activities, solid fuel combustion in the townships/informal settlements and industrial activities.

Annual average $PM_{2.5}$ concentrations were 29.09 µg/m^3 and 28.33 µg/m^3 for 2022 and 2023, respectively (Table 5-6), thus exceeding the annual standard of 20 µg/m^3 in both years. Highest $PM_{2.5}$ concentrations were observed between May and September (late-autumn to early-spring seasons) with the highest daily concentration being recorded in winter – on 03 July 2022 (192.95 µg/m^3).

In terms of the South African NAAQS, no exceedances of the $PM_{2.5}$ 24-hour and annual standards are permitted within a calendar year. Background $PM_{2.5}$ data from the Springs AQMS indicates non-compliance with the South African NAAQS for the 2022 – 2023 monitoring period.

Table 5-6: Annual average concentrations for $PM_{2.5}$.

Year	Annual Average (µg/m^3)	Annual NAAQS (µg/m^3)
2023	29.09	20
2024	28.33	20

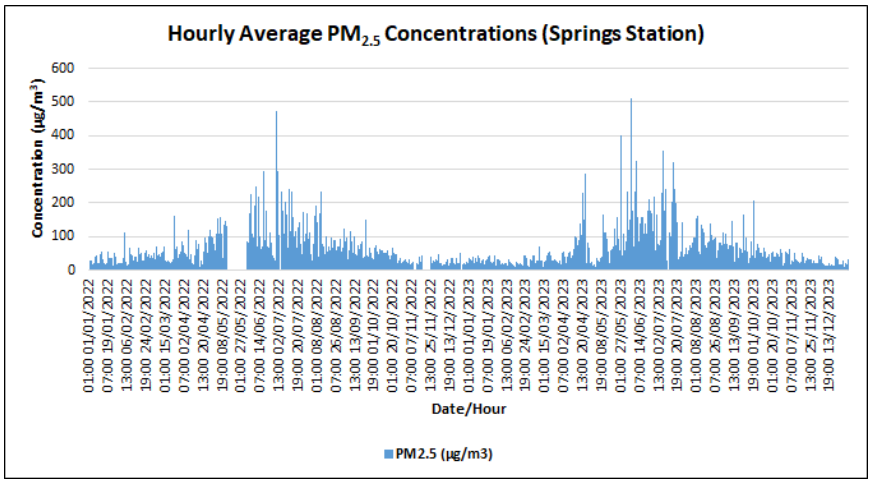


Figure 5-11: Hourly $PM_{2.5}$ concentrations at Springs AQMS for the period January 2022 – December 2023.

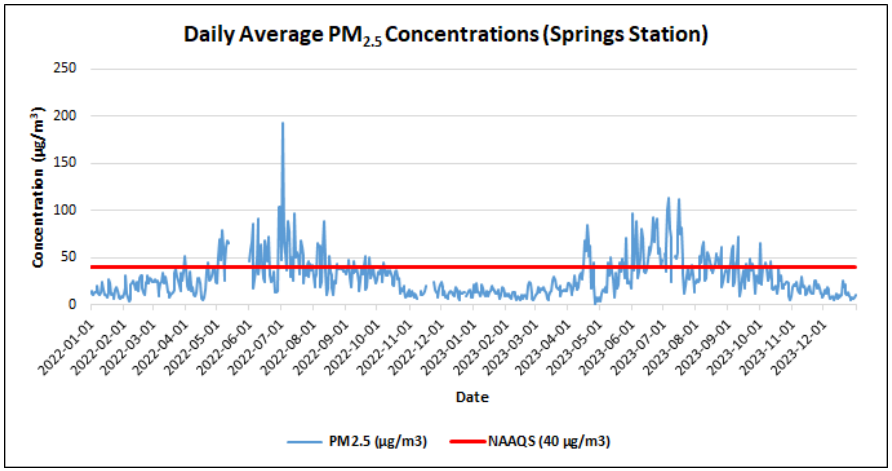


Figure 5-12: Daily $PM_{2.5}$ concentrations at Springs AQMS for the period January 2022 – December 2023.

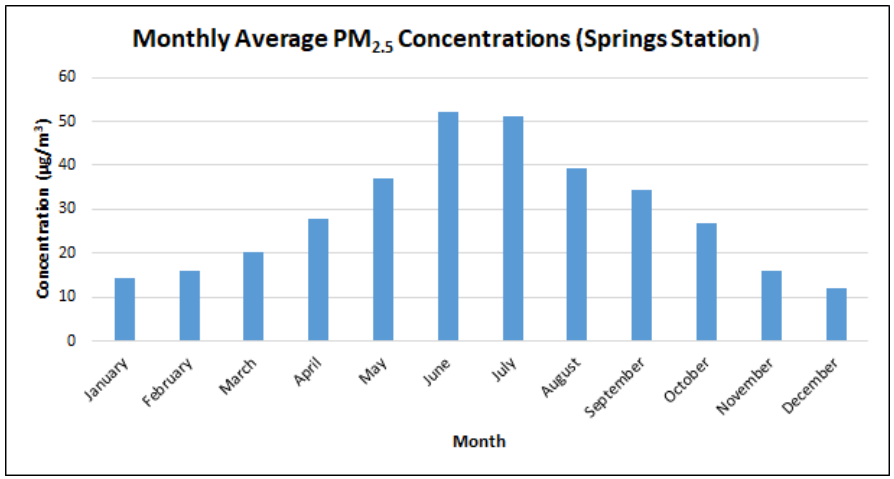


Figure 5-13: Monthly $PM_{2.5}$ concentrations at Springs AQMS for the period January 2022 – December 2023.

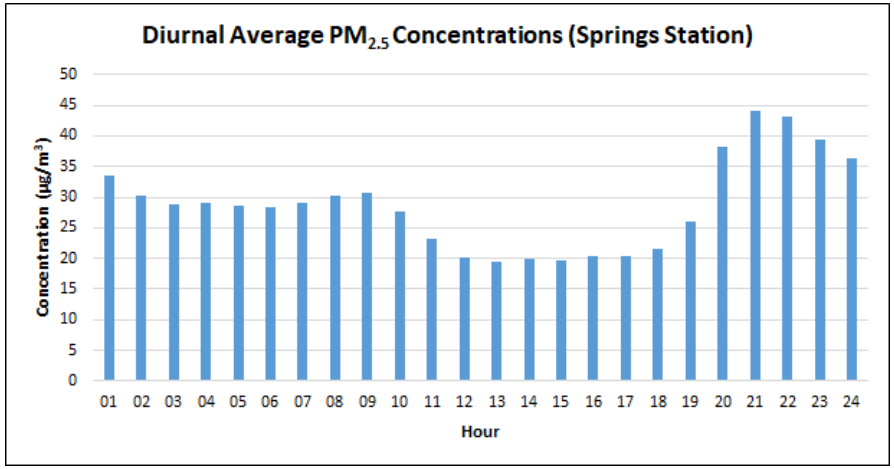


Figure 5-14: Diurnal $PM_{2.5}$ concentrations at Springs AQMS for the period January 2022 – December 2023

5.2.3. SO_2 Concentrations

SO_2 concentrations at the Springs AQMS for the period 01 January 2022 to 31 December 2023 are provided in Figure 5-15 to Figure 5-18. There was 88.55% data capture in terms of SO_2 concentrations at the Springs station. Hourly and daily average SO_2 concentrations for the period range between 0.00 ppb – 91.04 ppb and 0.29 ppb – 23.00 ppb, respectively (Figure 5-15 and Figure 5-16), with average hourly and daily concentrations of 6.08 ppb and 6.05 ppb, respectively. No exceedances of the respective hourly (134 ppb) and daily (48 ppb) standards were observed over the monitoring period.

Existing sources of SO_2 within a 20 km radius of the plant include solid fuel combustion in the townships/informal settlements, vehicle exhaust emissions from surrounding local and provincial roads, and industrial activities.

Annual average SO_2 concentrations were 6.26 ppb and 5.90 ppb for 2022 and 2023, respectively, which is well below the annual standard of 19 ppb (Table 5-7). Monthly SO_2 concentrations fluctuate throughout the year but were highest in the late-winter month of August (Figure 5-17).

In terms of the South African NAAQS, a total of 88 exceedances of the SO_2 hourly standard are permitted within a calendar year, while only 4 exceedances of the SO_2 24-hour standard are permitted. No exceedances of the SO_2 annual standard are permitted within a calendar year. Background SO_2 data from the Springs AQMS indicates compliance with the South African NAAQS for the 2022 – 2023 monitoring period.

Table 5-7: Annual Average Concentrations for SO_2.

Year	Annual Average (ppb)	Annual NAAQS (ppb)
2022	6.26	19
2023	5.90	19

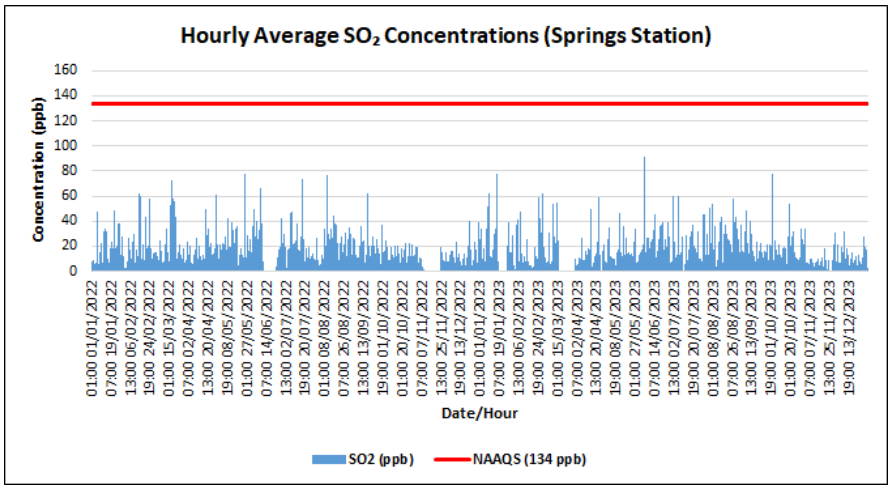


Figure 5-15: Hourly SO_2 concentrations at Springs AQMS for the period January 2022 – December 2023.

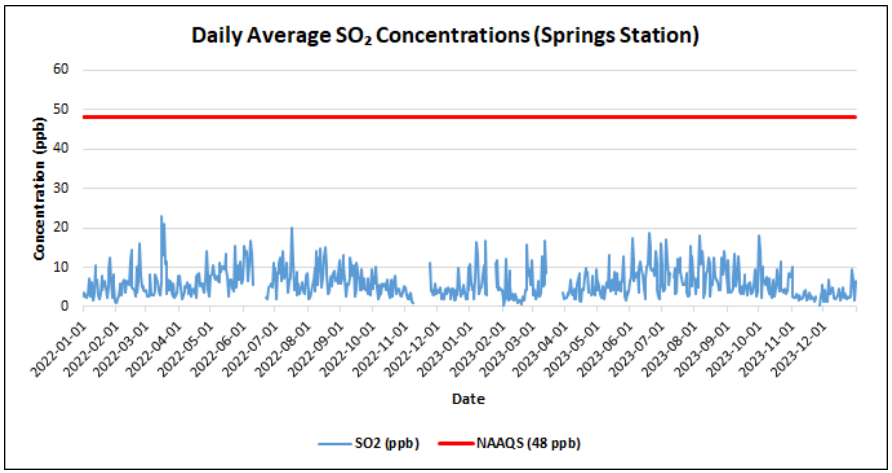


Figure 5-16: Daily SO_2 concentrations at Springs AQMS for the period January 2022 – December 2023.

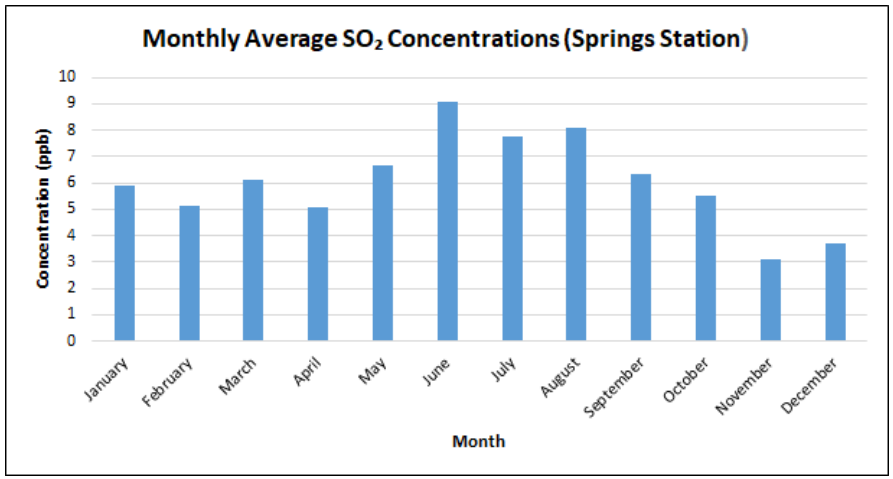


Figure 5-17: Monthly SO_2 concentrations at Springs AQMS for the period January 2022 – December 2023.

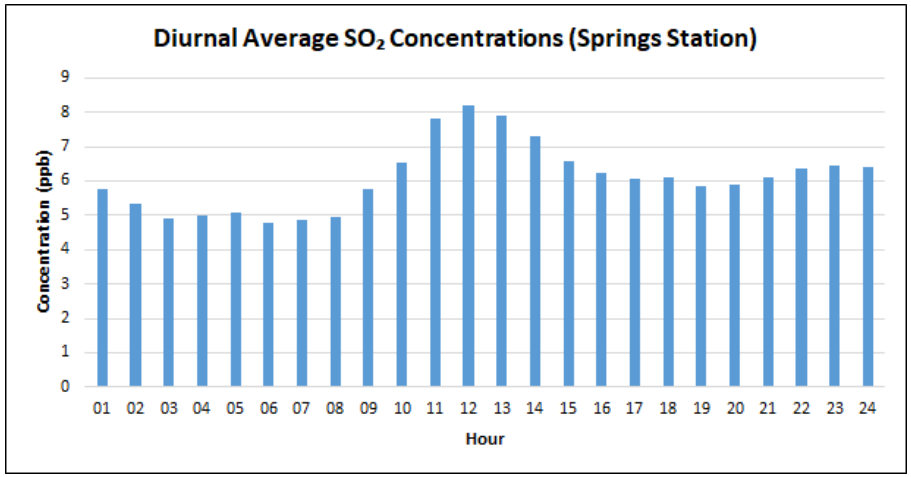


Figure 5-18: Diurnal SO_2 concentrations at Springs AQMS for the period January 2022 – December 2023.

5.2.4. NO_2 Concentrations

NO_2 concentrations at the Springs AQMS for the period 01 January 2023 to 31 December 2023 are provided in Figure 5-19 to Figure 5-22. There was 92.80% data capture in terms of NO_2 concentrations at the Springs station. Hourly average NO_2 concentrations for the period range between 0.00 ppb – 96.15 ppb (Figure 5-19), while an annual average concentration of 15.05 ppb was recorded (Table 5-8). No exceedances of the hourly (106 ppb) and annual (21 ppb) standards were recorded. Existing sources of NO_2 within a 20 km radius of the plant include vehicle exhaust emissions from surrounding roads and industrial activities.

Monthly average NO_2 concentrations were higher in the mid-autumn to early-spring months of April – September (Figure 5-21).

In terms of the South African NAAQS, a total of 88 exceedances of the NO_2 hourly standard are permitted within a calendar year, while no exceedances of the NO_2 annual standard are permitted. Background NO_2 data from the Springs AQMS indicates compliance with the South African NAAQS for the 2023 monitoring period.

Table 5-8: Annual Average Concentrations for NO_2.

Year	Annual Average (ppb)	Annual NAAQS (ppb)
2023	15.05	21

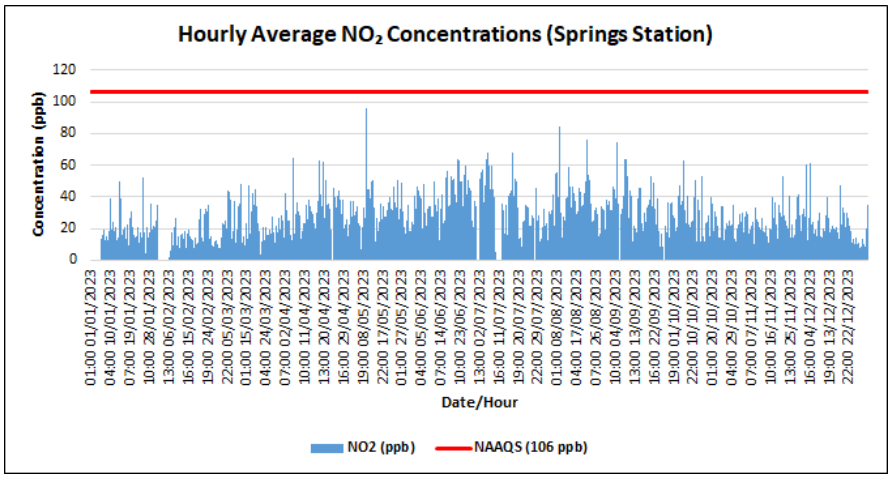


Figure 5-19: Hourly NO_2 concentrations at Springs AQMS for the period January 2023 – December 2023.

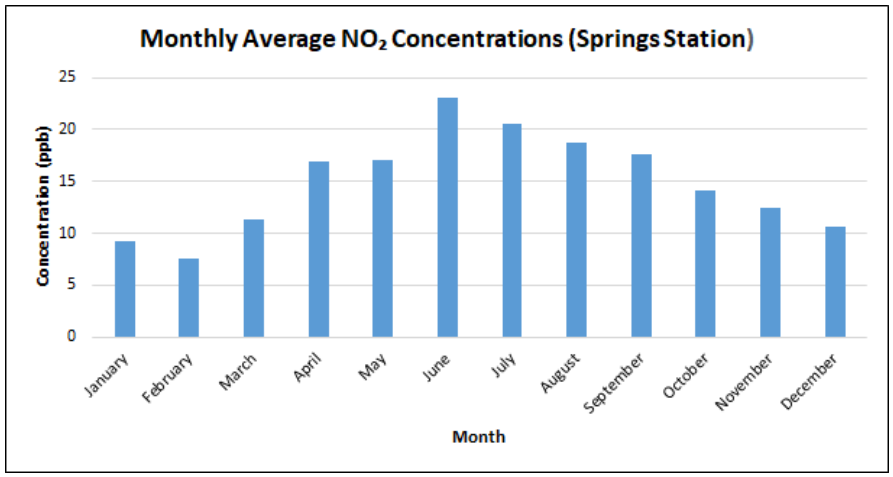


Figure 5-21: Monthly NO_2 concentrations at Springs AQMS for the period January 2023 – December 2023.

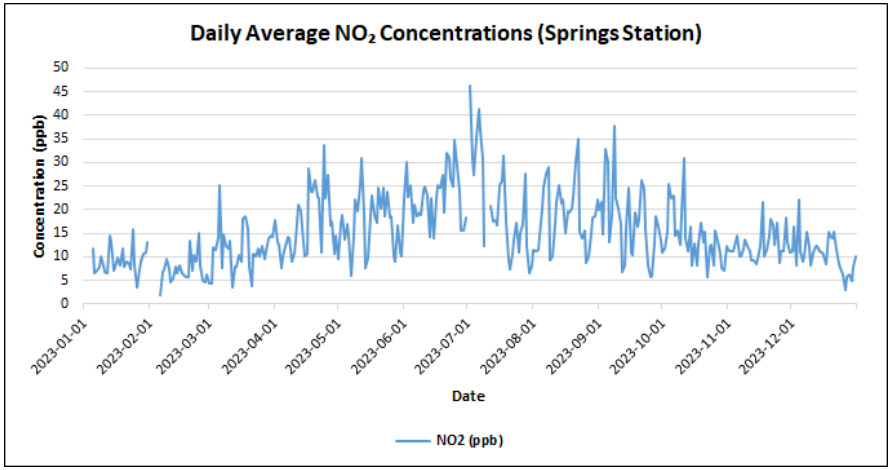


Figure 5-20: Daily NO_2 concentrations at Springs AQMS for the period January 2023 – December 2023.

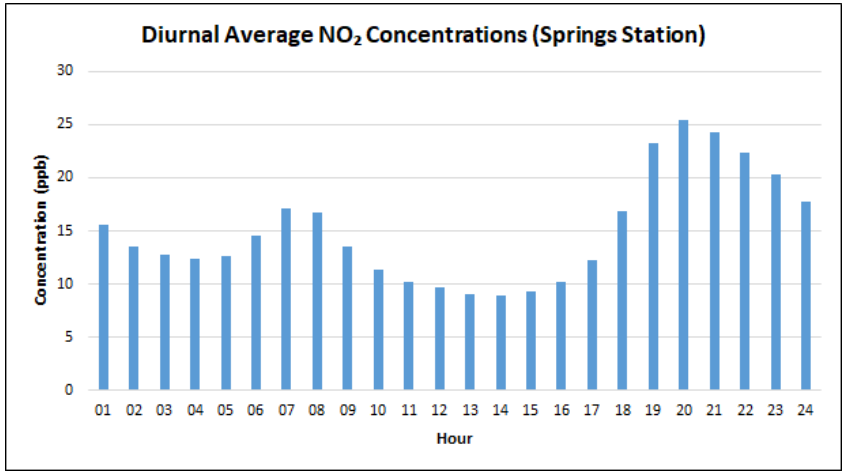


Figure 5-22: Diurnal NO_2 concentrations at Springs AQMS for the period January 2023 – December 2023.

5.3. Surrounding Sources of Air Pollution

Existing key sources of air pollution surrounding the project site within a 20km radius were identified during a desktop exercise and include (Figure 5-23):

- Commercial agricultural activities (cultivated land) and potential biomass burning;
- Mining areas;
- Informal settlements and townships;
- Industrial activities; and
- Vehicle activity and exhaust emissions.

Landfills, such as the Rietfontein municipal and TRF landfills, which are located adjacent to each other, and wind erosion from exposed bare lands, contribute minimally to air pollution near the project site. These sources are scattered intermittently among the primary pollution sources.

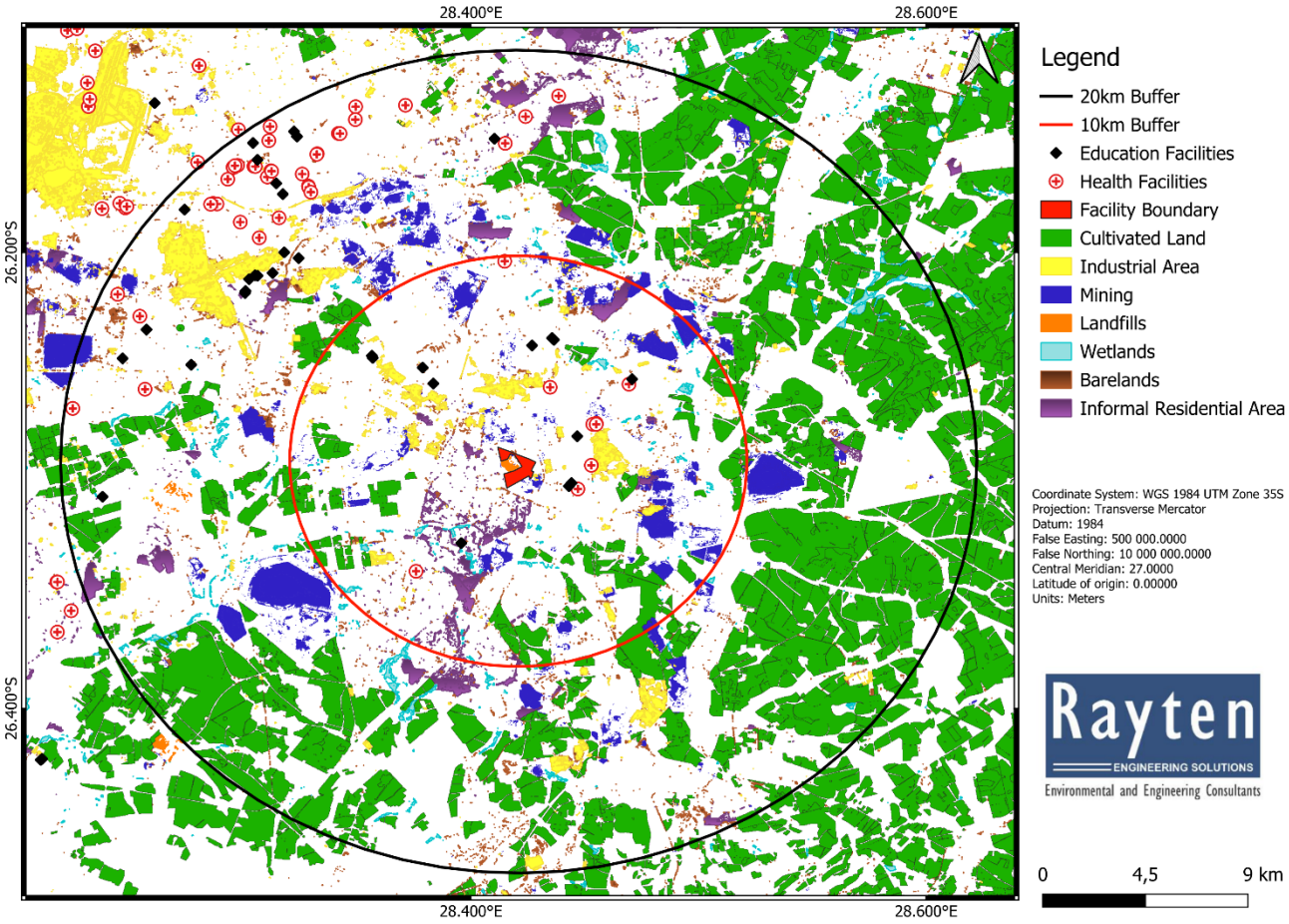


Figure 5-23: Identified surrounding emission sources within 20km of the project site.

5.3.1. Agricultural Activity (cultivated lands) and Potential Biomass Burning

There are several commercial agricultural areas surrounding the project site, particularly towards the north-east, south-east and south-west. Emissions from agricultural activities are difficult to control due to the seasonality of emissions and the large surface area producing emissions. Expected emissions resulting from agricultural activities include particulates associated with wind erosion and burning of crop residue, chemicals associated with crop spraying and odiferous emissions resulting from manure, fertilizer and crop residue. Dust associated with agricultural

practices may contain seeds, pollen and plant tissue, as well as agrochemicals, such as pesticides. The application of pesticides during temperature inversions increases the drift of the spray and the area of impact.

Dust entrainment from farming vehicles travelling on gravel roads may also cause high particulate concentrations in an area. Dust from traffic on gravel roads increases with higher vehicle speeds, more vehicles and lower moisture conditions. The seasonal burning of the veld for field clearing in preparation for planting may also be a source of smoke. Agricultural activity therefore has a potential impact on air quality in the area.

5.3.2. Mining Areas

Active mining areas are known to produce significant amounts of fugitive dust emissions, which result from activities such as blasting and drilling, material handling, vehicle entrainment by haul vehicles, as well as windblown dust from stockpiles and other exposed areas (DEA, 2009). However, mining areas identified through the desktop study are mostly historic and inactive mines, including historic tailing storage facilities associated with these mines. Some mining areas and tailings dumps are found in surrounding areas, within a 20km radius of the project site.

5.3.3. Informal Settlements and Townships

South Africa is characterised as a developing country, where many middle- to low-income settlements are located. Due to increased levels of poverty and the rising cost of electricity in South Africa, many residents from middle- to low-income settlements make use of solid fuel (coal) combustion as a primary energy source for cooking and heating in winter (Language *et al*., 2017). The household burning of coal emits large quantities of pollutants such as SO_2, CO, polycyclic aromatic hydrocarbons (PAHs) and respirable particulates (DEA, 2009). Some informal settlements are located in surrounding areas within a 20km radius of the project site.

5.3.4. Industrial Activities

Industrial areas are additional sources of air pollution surrounding the project site. The closest ones include the Nuffield industrial area (~2.6km to the east-northeast), the New Era industrial area (~2.7km to the north), and the Springs Central industrial area (~3.5km north-northeast). Some industrial areas are often associated with heat processes (e.g., smelting and melting in furnaces), chemical treatment and processes, material incineration, stationary fuel combustion activities, stack emissions, etc. These activities are all sources of air pollution at industrial sites.

5.3.5. Vehicle Activity and Exhaust Emissions

There are several existing national, provincial and municipal roads in areas surrounding the project site, within a 20km radius. These roads include the N17 national route and R51 provincial routes, which run north and east of the project site, respectively. Vehicle activity on these roads contributes significantly to exhaust emissions in the area.

Vehicle emissions emanating from the movement of heavy traffic on national roads are a significant contributor to ambient air pollution in urban areas. Pollutants emitted from motor vehicle engines

include NOx, VOCs, CO, SO_2, CO_2, particulates, and lead (Pb). The quantity and type of emissions largely depend on the fuel type and the combustion temperature within the engine. Efficient engines with complete combustion primarily emit carbon dioxide and water vapor. In contrast, inefficient petrol engines can produce higher levels of CO and VOCs due to incomplete combustion. Diesel engines, when operating inefficiently, are typically associated with the emission of VOCs and smoke. Additionally, nitrogen dioxide (NO_2) is formed through the oxidation of nitrogen impurities present in the fuel during combustion (http://www.air-quality.org.uk/08.php).

Although most VOCs are emitted in the exhaust emissions, evaporative losses and breathing losses also account for the release of VOCs from the fuelling chain into the atmosphere. Evaporative losses can occur when the cars are being driven or when engines are cooling down. Breathing losses are mostly a result of fluctuations in tank fuel temperature during the day, with higher temperatures causing vapours to evaporate from the fuel (http://www.air-quality.org.uk/08.php).

6. AIR QUALITY IMPACT ASSESSMENT

Landfill gas (including HAPs), dust and odour are identified as the key pollutants of concern associated with operational activities at the landfill and are emitted from the following key sources:

- Landfill gas emissions (consisting of a mixture of pollutants) due to:
    - anaerobic decomposition of solid matter mainly generated from the biodegradation of the organic matter contained within the waste,
    - general landfill activities such as active tipping of fresh waste and exposed areas of waste.
- Emissions of Hydrogen Sulphide (H_2S) from the Rietfontein leachate dams.
- Odour emissions associated with overall landfilling activities.
- Flare emissions – mainly secondary pollutants exiting the landfill flare based on the volume of methane flared.
- Dust emissions from:
    - Vehicle dust entrainment from the movement of trucks on unpaved roads onsite (in and around active Cells),
    - wind erosion of exposed surfaces (exposed waste at active Cell's workface and material stockpiling at the rubble crushing area),
    - compacting of waste at the active Cell's workface,
    - material handling (loading and offloading material from trucks).

The Rietfontein landfill operations are additionally assessed as part of the cumulative assessment.

Construction activities associated with the development of each landfill Cell at Area E are additional sources of fugitive dust emissions at the landfill site. However, these fugitive emission sources are not significant, with associated emissions being intermittent and short-term (for construction), in comparison to long-term emissions associated with the landfilling operations. Therefore, the fugitive emission sources associated with the construction/development of each landfill Cell were not modelled in this study but can be easily mitigated through the implementation of dust mitigation measures. The dust mitigation measures are explained in more detail in Section 7 of this AQIAr.

The above-mentioned sources were identified for the landfill based on the information provided by the client. A detailed questionnaire was given to the client prior to modelling to obtain specific details needed for input into the model and for calculation of emission rates. The conservative scenario was assumed where information was not known for input into the model. To investigate the potential impact of operations associated with the landfill site on local ambient air quality, the following air pollutants were chosen in the quantification of emissions for the operational phase of the landfill:

Dust:

- Dustfall;
- Particulate matter (PM_{10} and $PM_{2.5}$);

BTEX:

- Benzene (C_6H_6);
- Toluene (C_7H_8)
- Ethylbenzene ($C_6H_5C_2H_5$)
- Xylene (C_8H_{10})

Reduced Sulphur Compounds:

- Carbon Disulphide (CS_2)
- Dimethyl Sulphide (C_2H_6S)
- Hydrogen Sulphide (H_2S)
- Ethyl Mercaptan (Ethanethiol) (CH_3CH_2SH)
- Methyl Mercaptan (Methanethiol) (CH_3SH)

Chlorinated Compounds:

- Vinyl Chloride (C_2H_3CL)
- Dichloromethane (Methylene Chloride) (CH_2CL_2)
- Dichloroethylene (1,2 Dichloroethene) ($C_2H_2CL_2$)
- Trichloroethylene (C_2HCL_3)
- Tetrachloroethylene (perchloroethylene) (C_2CL_4)

Other:

- Ammonia (NH_3)
- Odour (OU)

In the quantification of emissions for the above pollutants, use was made of the United States Environmental Protection Agency's (USEPA) Landfill Gas Emissions Model (LandGEM), published odour and H_2S emission flux rates, and published emission factors for dust given in the Australian National Pollutant Inventory (NPI) Emission Estimate Technique (EET) Manual for Mining. Emissions of dust due to the movement of trucks onsite were estimated using the Missouri Department of Natural Resources, Haul Road Fugitive Emissions Worksheet Instructions. The South African Regulations regarding Air Dispersion Modelling recommends the use of published emission factors for national consistency, such as the USEPA AP-42 and Australian NPI emissions factors.

An emission factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. Emission factors are always expressed as a function of the weight, volume, distance or duration of the activity emitting the pollutant. The general equation used for the estimation of emissions is:

$$E = A \times EF \times \left(1 - \frac{ER}{100}\right)$$

Where:

E = emission rate
A = activity rate
EF = emission factor
ER = overall emission reduction efficiency (%)

The emission factors and equations used in the assessment for the landfill site are described in Sections 6.1 to 6.4 below. Material throughputs are based on the information provided by the client and include:

- A monthly throughput of 15 000 tonnes of waste per month, to represent the worst-case scenario.
- A daily throughput of ~500 tonnes of waste per day for 39 years operational life at Area E (incoming fresh waste per day). Daily throughputs assumed to remain consistent throughout operational life for modelling purposes.
- Operational hours: 11 hour working day (07:00 - 18:00) for 7 days a week, as confirmed by the client. Thus, assumed to operate 365 days per year (conservative scenario).
- The cover material required at the active workface was estimated to be 100 tonnes/day. This was calculated based on a cover to waste ratio of 1:5, assuming a compacted waste density of 1 tonne/m^3.

6.1. Landfill Gas Emissions

To quantify emissions from the landfill, the USEPA Landfill Gas Emissions Model (LandGEM Version 3.02), was used. The LandGEM model is a simple Microsoft Excel based estimation tool that can be used to quantify emission rates for total landfill gas, methane, carbon dioxide, NMOCs, and several individual air pollutants (HAPs or malodorous gases) from municipal solid waste disposal sites.

The LandGEM model quantifies the annual emission rates through a first-order decomposition rate equation (USEPA, 1998, USEPA, 2005). Model default parameters are based on empirical data from landfills in the United States. Site specific data collected from actual field tests, normally applicable to existing landfills, can be used instead of model defaults. However, this data is often not available and difficult to obtain. As such model default parameters are often used for input into the LandGEM model. The first-order decomposition rate equation used by the model is shown below:

$$Q_{CH_4} = \sum_{i=1}^{n} \sum_{j=0.1}^{1} kL_o \left(\frac{M_i}{10}\right) e^{-kt_{ij}}$$

where

Q_{CH4} = annual methane generation in the year of the calculation (m^3/year)
i = 1 year time increment
n = (year of the calculation) - (initial year of waste acceptance)
j = 0.1 year time increment
k = methane generation rate ($year^{-1}$)
L_o = potential methane generation capacity (m^3/Mg)
M_i = mass of waste accepted in the i^{th} year (Mg)
t_{ij} = age of the j^{th} section of waste mass M_i accepted in the i^{th} year (decimal years, e.g., 3.2 years)

Inventory conventional default parameters were used in this AQIA study, which are based on the emission factors provided in the USEPA Compilation of Air Pollutant Emission Factors (AP-42) document for municipal solid waste landfills (USEPA, 1998). These default parameters can be used to generate average landfill gas emission estimates suitable for use in emission inventories and air emission licence applications in the absence of site-specific test data (USEPA, 2005).

Parameters used for input into the LandGEM model are given in Table 6-1. Calculated annual average emissions of total landfill gas, methane, carbon dioxide and NMOCs for Area E are shown in Figure 6-1 and Table 6-2. Estimated annual emissions are shown for the period 2025 – 2164 (i.e., Area E life with height extension). The LandGEM model is designed to estimate gas emissions generated by the landfill. It is generally accepted that the bulk of the landfill gases generated by the landfill will be emitted into the atmosphere through cracks and openings in the landfill surface (USEPA, 1998).

Table 6-1: LandGEM model input parameters for Area E at the TRF landfill.

Model Parameters	Data used for input into model
Landfill Characteristics	
Landfill open year	2025
Scenario (tons/month)	15 000 (worst-case scenario)
Area E Life with Height Extension (years)	39
Monthly airspace usage (m^3)	17 751
Annual airspace usage (m^3)	213 018
Model Parameters (inventory conventional default parameters)	
Methane generation rate, k ($year^{-1}$)	0.04
Potential methane generation capacity, L_0 (m^3/tonne)	100
NMOC concentration (ppmv as hexane)	600 (no or unknown co-disposal of general & hazardous waste)
Methane content (% by volume)	50%
Pollutants modelled	
Pollutants selected to be calculated in LandGEM.	• Total landfill gas • Methane (CH_4) • Carbon dioxide (CO_2) • Total NMOCs • Benzene (C_6H_6) • Toluene (C_7H_8)

	• Ethylbenzene ($C_6H_5C_2H_5$) • Xylene (C_8H_{10}) • Carbon Disulphide (CS_2) • Dimethyl Sulphide (C_2H_6S) • Hydrogen Sulphide (H_2S) • Ethyl Mercaptan (Ethanethiol) (CH_3CH_2SH) • Methyl Mercaptan (Methanethiol) (CH_3SH) • Vinyl Chloride (C_2H_3CL) • Dichloromethane (Methylene Chloride) (CH_2CL_2) • Dichloroethylene (1,2 Dichloroethene) ($C2H_2CL_2$) • Trichloroethylene (C_2HCL_3) • Tetrachloroethylene (perchloroethylene) (C_2CL_4)

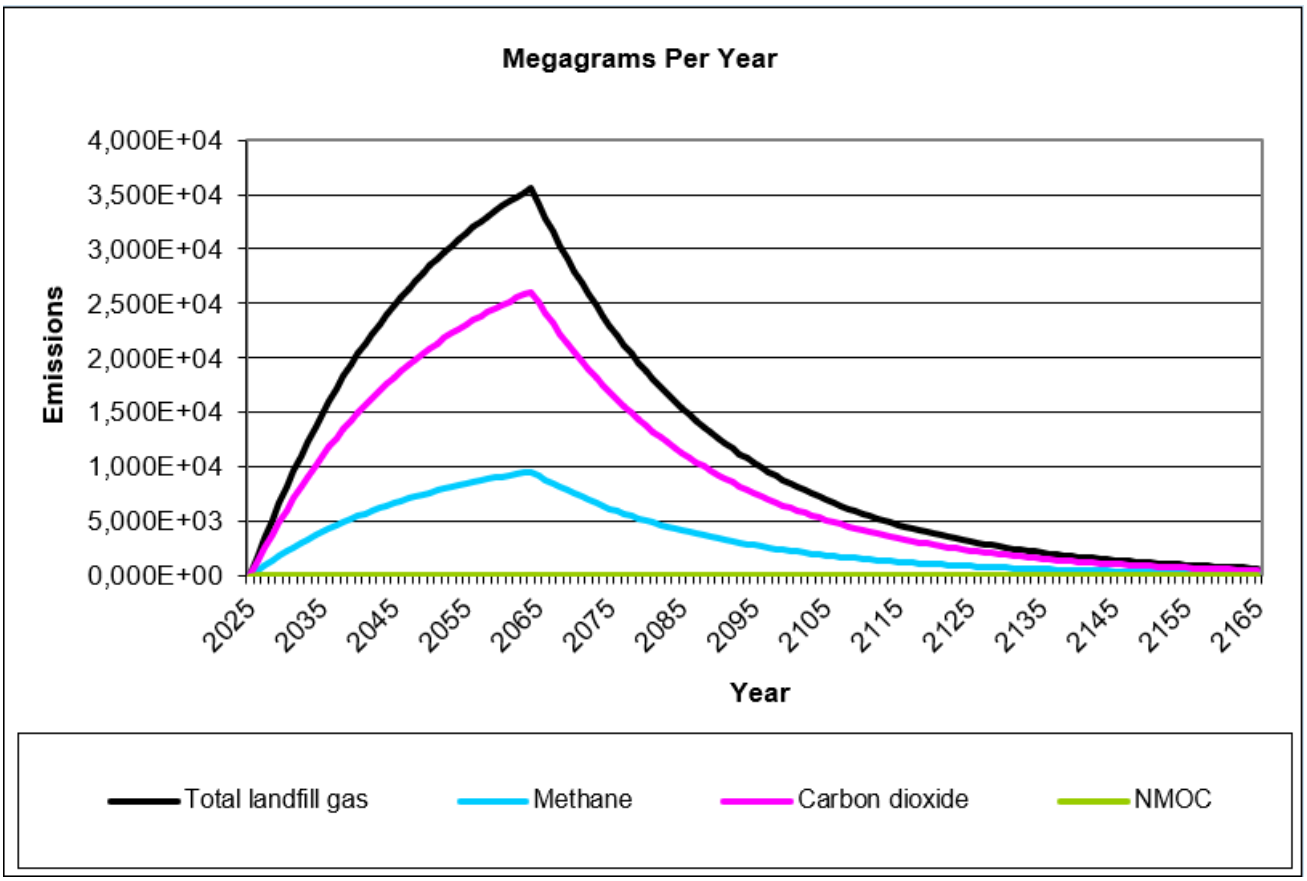


Figure 6-1: Emissions profile for Total landfill gas, methane, carbon dioxide and NMOCs for Area E using LandGEM (1 megagram = 1 tonne).

Table 6-2: Estimated annual emissions for Total landfill gas, methane, carbon dioxide and NMOCs (tonnes/year and grams/second) for Area E using LandGEM.

Pollutant	Total LFG	GHGs GROUP				VOCs (no methane)	
		Methane (CH_4)		Carbon dioxide (CO_2)		NMOCs	
Year	Ton/year	Ton/year	Gram/Sec	Ton/year	Gram/Sec	Ton/year	Gram/Sec
2025	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2026	1766.3	471.8	15.0	1294.5	41.0	3.0	0.1
2027	3463.4	925.1	29.3	2538.3	80.5	6.0	0.2

2028	5094.0	1360.7	43.1	3733.3	118.4	8.8	0.3
2029	6660.6	1779.1	56.4	4881.5	154.8	11.5	0.4
2030	8165.7	2181.2	69.2	5984.6	189.8	14.1	0.4
2031	9611.9	2567.4	81.4	7044.5	223.4	16.6	0.5
2032	11001.4	2938.6	93.2	8062.8	255.7	18.9	0.6
2033	12336.3	3295.2	104.5	9041.2	286.7	21.2	0.7
2034	13619.0	3637.8	115.4	9981.2	316.5	23.5	0.7
2035	14851.3	3966.9	125.8	10884.4	345.1	25.6	0.8
2036	16035.3	4283.2	135.8	11752.1	372.7	27.6	0.9
2037	17172.9	4587.1	145.5	12585.8	399.1	29.6	0.9
2038	18265.9	4879.0	154.7	13386.9	424.5	31.5	1.0
2039	19316.0	5159.5	163.6	14156.5	448.9	33.3	1.1
2040	20325.0	5429.0	172.2	14895.9	472.3	35.0	1.1
2041	21294.4	5688.0	180.4	15606.4	494.9	36.7	1.2
2042	22225.7	5936.7	188.3	16289.0	516.5	38.3	1.2
2043	23120.6	6175.8	195.8	16944.8	537.3	39.8	1.3
2044	23980.4	6405.4	203.1	17575.0	557.3	41.3	1.3
2045	24806.4	6626.1	210.1	18180.4	576.5	42.7	1.4
2046	25600.1	6838.1	216.8	18762.0	594.9	44.1	1.4
2047	26362.6	7041.7	223.3	19320.9	612.7	45.4	1.4
2048	27095.3	7237.4	229.5	19857.8	629.7	46.7	1.5
2049	27799.2	7425.5	235.5	20373.7	646.0	47.9	1.5
2050	28475.5	7606.1	241.2	20869.4	661.8	49.0	1.6
2051	29125.3	7779.7	246.7	21345.6	676.9	50.2	1.6
2052	29749.7	7946.5	252.0	21803.2	691.4	51.2	1.6
2053	30349.5	8106.7	257.1	22242.8	705.3	52.3	1.7
2054	30925.8	8260.6	261.9	22665.2	718.7	53.3	1.7
2055	31479.5	8408.5	266.6	23071.0	731.6	54.2	1.7
2056	32011.6	8550.6	271.1	23460.9	743.9	55.1	1.7
2057	32522.7	8687.2	275.5	23835.5	755.8	56.0	1.8
2058	33013.8	8818.3	279.6	24195.5	767.2	56.9	1.8
2059	33485.7	8944.4	283.6	24541.3	778.2	57.7	1.8
2060	33939.0	9065.5	287.5	24873.5	788.7	58.4	1.9
2061	34374.6	9181.8	291.2	25192.8	798.9	59.2	1.9
2062	34793.1	9293.6	294.7	25499.5	808.6	59.9	1.9
2063	35195.2	9401.0	298.1	25794.2	817.9	60.6	1.9
2064	35581.5	9504.2	301.4	26077.3	826.9	61.3	1.9
MAX	301.4	26077.3	**826.9**	61.3	**1.943**	301.4	**26077.3**
MEAN	104.6	9052.039	**287.0**	21.271	**0.674**	104.6	**9052.039**

6.1.1. Ammonia (NH_3) Emissions

LandGEM does not have ammonia (NH_3) listed in its pollutant database as there is little information available on ammonia emissions from landfill sites. However, ammonia is a known pollutant emitted from municipal landfills. Much of the information known about ammonia emissions from municipal landfills is based on the studies done by Munday (1990), who found that about 7.3% of methane gas generated by landfill sites is made up of nitrogenous emissions, of which 10% consists of ammonia emissions (Roe *et al.*, 2004). As such, the below emission factor was used to estimate ammonia emissions for the landfill site. The emission factor is recommended by the USEPA Emission Factors and Inventory Group (Roe *et al.*, 2004).

Annual average methane emissions generated by the LandGEM model for the landfill were used for the calculations (Table 6-2). A maximum emission rate of 69.4 tonnes/year (2.20 g/s) was calculated for ammonia for the year 2064 (Year 39 of Area E operations).

SCC	Description	EF (lb/unit)	EF Unit	EF Rating; Notes
2620030000	Waste Disposal Treatment and Recovery; Landfills; Municipal; Total	7.30E-03	lb methane	E; source - Munday (1990).

6.1.2. Hydrogen Sulphide (H_2S) Emissions

Hydrogen sulphide emissions generated from Area E's active workface were estimated using the LandGEM model. A maximum emission rate of 1.454 tonnes/year (0.046 g/s) was calculated for the year 2064 (Year 39 of Area E operations).

Leachate dams also have a high potential to emit hydrogen sulphide gas which has a strong odour associated with it. The Airshed AQIA estimates an H_2S emission flux of 1.08 mg/m^2/min (99th percentile) for a leachate dam, using a model developed by Blunden, Anja and Overton (2008) (Airshed, 2018). This emission flux was used in this study to represent H_2S emissions from the leachate dams at the nearby Rietfontein landfill. The converted emission flux is 0.000018 g/m^2/s for input into the AERMOD dispersion model.

The Tonkmeter landfill has a leachate tank that provides temporary storage of collected leachate prior to treatment and subsequent disposal in accordance with the landfill's operational requirements. Therefore, there is no long-term storage of leachate associated with the TRF landfill operations.

Sources of hydrogen sulphide emissions that were modelled in this assessment therefore included the active workface at Area E and leachate dams at the Riefontein landfill site.

6.1.3. Emission Rates for HAPs and Odorous Gases

Total annual, maximum and mean emission rates in tonnes/year and grams/second for all the different HAPs and odorous gases modelled in this AQIAr for Area E are given in Table 6-3. The maximum emission rate (in g/s) for the different pollutants was used as input into the model. This can be considered a conservative estimate as the emission rate corresponds with the total emissions generated for Area E's final year of operations (i.e., year 39 or 2064). The gases generated by Area E reach their peak at the point of closure and then decline steadily thereafter. The decline in landfill gas emissions after the final year of operations for Area E results from the cessation of waste disposal and a subsequent decrease in organic matter available for decomposition within this area.

The maximum emission rate was converted into an emission flux represented in units of $g/m^2/s$ for input into the AERMOD dispersion model. The emission flux was applied to the surface area of the active Cell at Area E (assumed to be Cell 1), which is approximately 18,700m^2 (determined using the site layout diagram provided by client). As landfilling is conducted using a phased approach over several years, not all eight landfill cells will be active and worked on at the same time. Modelling all eight landfill Cells simultaneously for Area E would result in an unrealistic overestimation of predicted concentrations for the various pollutants.

Table 6-3: Estimated annual, maximum and mean emissions for HAPs and odorous gases for Area E using LandGEM.

Pollutant	BTEX GROUP (form part of NMOCs)							
	Benzene		Toluene		Ethylbenzene		Xylene	
Year	Ton/year	Gram/Sec	Ton/year	Gram/Sec	Ton/year	Gram/Sec	Ton/year	Gram/Sec
2025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2026	0.009	0.000	0.211	0.007	0.029	0.001	0.075	0.002
2027	0.017	0.001	0.414	0.013	0.056	0.002	0.147	0.005
2028	0.025	0.001	0.610	0.019	0.083	0.003	0.216	0.007
2029	0.033	0.001	0.797	0.025	0.108	0.003	0.283	0.009
2030	0.040	0.001	0.977	0.031	0.133	0.004	0.346	0.011
2031	0.048	0.002	1.150	0.036	0.156	0.005	0.408	0.013
2032	0.054	0.002	1.317	0.042	0.179	0.006	0.467	0.015
2033	0.061	0.002	1.476	0.047	0.201	0.006	0.523	0.017
2034	0.067	0.002	1.630	0.052	0.222	0.007	0.578	0.018
2035	0.073	0.002	1.777	0.056	0.242	0.008	0.630	0.020
2036	0.079	0.003	1.919	0.061	0.261	0.008	0.680	0.022
2037	0.085	0.003	2.055	0.065	0.279	0.009	0.729	0.023
2038	0.090	0.003	2.186	0.069	0.297	0.009	0.775	0.025
2039	0.095	0.003	2.312	0.073	0.314	0.010	0.820	0.026
2040	0.100	0.003	2.432	0.077	0.331	0.010	0.862	0.027
2041	0.105	0.003	2.548	0.081	0.346	0.011	0.903	0.029
2042	0.110	0.003	2.660	0.084	0.361	0.011	0.943	0.030
2043	0.114	0.004	2.767	0.088	0.376	0.012	0.981	0.031
2044	0.119	0.004	2.870	0.091	0.390	0.012	1.017	0.032
2045	0.123	0.004	2.969	0.094	0.403	0.013	1.053	0.033
2046	0.127	0.004	3.064	0.097	0.416	0.013	1.086	0.034
2047	0.130	0.004	3.155	0.100	0.429	0.014	1.119	0.035
2048	0.134	0.004	3.242	0.103	0.441	0.014	1.150	0.036
2049	0.137	0.004	3.327	0.105	0.452	0.014	1.179	0.037
2050	0.141	0.004	3.408	0.108	0.463	0.015	1.208	0.038
2051	0.144	0.005	3.485	0.111	0.474	0.015	1.236	0.039

2052	0.147	0.005	3.560	0.113	0.484	0.015	1.262	0.040
2053	0.150	0.005	3.632	0.115	0.494	0.016	1.288	0.041
2054	0.153	0.005	3.701	0.117	0.503	0.016	1.312	0.042
2055	0.156	0.005	3.767	0.119	0.512	0.016	1.336	0.042
2056	0.158	0.005	3.831	0.121	0.521	0.017	1.358	0.043
2057	0.161	0.005	3.892	0.123	0.529	0.017	1.380	0.044
2058	0.163	0.005	3.951	0.125	0.537	0.017	1.401	0.044
2059	0.166	0.005	4.007	0.127	0.545	0.017	1.421	0.045
2060	0.168	0.005	4.061	0.129	0.552	0.018	1.440	0.046
2061	0.170	0.005	4.114	0.130	0.559	0.018	1.458	0.046
2062	0.172	0.005	4.164	0.132	0.566	0.018	1.476	0.047
2063	0.174	0.006	4.212	0.134	0.572	0.018	1.493	0.047
2064	0.176	0.006	4.258	0.135	0.579	0.018	1.510	0.048
MAX	0.176	**0.006**	4.258	**0.135**	0.579	**0.018**	1.510	**0.048**
MEAN	0.061	**0.002**	1.478	**0.047**	0.201	**0.006**	0.524	**0.017**
g/m²/s		**2.98E-07**		**7.22E-06**		**9.81E-07**		**2.56E-06**

Pollutant	**REDUCED SULPHUR COMPOUNDS (RSC) (form part of NMOCs)**									
	Carbon disulphide		**Dimethyl sulphide**		**Hydrogen sulphide**		**Ethyl mercaptan**		**Methyl mercaptan**	
Year	Ton/year	Gram/Sec	Ton/year	Gram/Sec	Ton/year	Gram/Sec	Ton/year	Gram/Sec	Ton/year	Gram/Sec
2025	0.000	0.0000	0.000	0.0000	0.000	0.0000	0.000	0.0000	0.000	0.0000
2026	0.003	0.0001	0.029	0.0009	0.072	0.0023	0.008	0.0003	0.007	0.0002
2027	0.005	0.0002	0.056	0.0018	0.142	0.0045	0.016	0.0005	0.014	0.0004
2028	0.007	0.0002	0.082	0.0026	0.208	0.0066	0.024	0.0008	0.020	0.0006
2029	0.010	0.0003	0.108	0.0034	0.272	0.0086	0.032	0.0010	0.027	0.0008
2030	0.012	0.0004	0.132	0.0042	0.334	0.0106	0.039	0.0012	0.033	0.0010
2031	0.014	0.0004	0.155	0.0049	0.393	0.0125	0.046	0.0015	0.039	0.0012
2032	0.016	0.0005	0.178	0.0056	0.450	0.0143	0.052	0.0017	0.044	0.0014
2033	0.018	0.0006	0.199	0.0063	0.504	0.0160	0.059	0.0019	0.049	0.0016

2034	0.020	0.0006	0.220	0.0070	0.556	0.0176	0.065	0.0021	0.055	0.0017
2035	0.022	0.0007	0.240	0.0076	0.607	0.0192	0.071	0.0022	0.059	0.0019
2036	0.024	0.0007	0.259	0.0082	0.655	0.0208	0.076	0.0024	0.064	0.0020
2037	0.025	0.0008	0.277	0.0088	0.702	0.0223	0.082	0.0026	0.069	0.0022
2038	0.027	0.0009	0.295	0.0093	0.746	0.0237	0.087	0.0028	0.073	0.0023
2039	0.028	0.0009	0.312	0.0099	0.789	0.0250	0.092	0.0029	0.077	0.0025
2040	0.030	0.0009	0.328	0.0104	0.831	0.0263	0.097	0.0031	0.081	0.0026
2041	0.031	0.0010	0.344	0.0109	0.870	0.0276	0.101	0.0032	0.085	0.0027
2042	0.033	0.0010	0.359	0.0114	0.908	0.0288	0.106	0.0034	0.089	0.0028
2043	0.034	0.0011	0.373	0.0118	0.945	0.0300	0.110	0.0035	0.093	0.0029
2044	0.035	0.0011	0.387	0.0123	0.980	0.0311	0.114	0.0036	0.096	0.0030
2045	0.036	0.0012	0.400	0.0127	1.014	0.0321	0.118	0.0037	0.099	0.0032
2046	0.038	0.0012	0.413	0.0131	1.046	0.0332	0.122	0.0039	0.103	0.0033
2047	0.039	0.0012	0.426	0.0135	1.077	0.0342	0.125	0.0040	0.106	0.0033
2048	0.040	0.0013	0.437	0.0139	1.107	0.0351	0.129	0.0041	0.109	0.0034
2049	0.041	0.0013	0.449	0.0142	1.136	0.0360	0.132	0.0042	0.111	0.0035
2050	0.042	0.0013	0.460	0.0146	1.164	0.0369	0.136	0.0043	0.114	0.0036
2051	0.043	0.0014	0.470	0.0149	1.190	0.0377	0.139	0.0044	0.117	0.0037
2052	0.044	0.0014	0.480	0.0152	1.216	0.0385	0.142	0.0045	0.119	0.0038
2053	0.045	0.0014	0.490	0.0155	1.240	0.0393	0.144	0.0046	0.122	0.0039
2054	0.045	0.0014	0.499	0.0158	1.264	0.0401	0.147	0.0047	0.124	0.0039
2055	0.046	0.0015	0.508	0.0161	1.286	0.0408	0.150	0.0048	0.126	0.0040
2056	0.047	0.0015	0.517	0.0164	1.308	0.0415	0.152	0.0048	0.128	0.0041
2057	0.048	0.0015	0.525	0.0166	1.329	0.0421	0.155	0.0049	0.130	0.0041
2058	0.049	0.0015	0.533	0.0169	1.349	0.0428	0.157	0.0050	0.132	0.0042
2059	0.049	0.0016	0.540	0.0171	1.368	0.0434	0.159	0.0051	0.134	0.0043
2060	0.050	0.0016	0.548	0.0174	1.387	0.0440	0.162	0.0051	0.136	0.0043
2061	0.051	0.0016	0.555	0.0176	1.405	0.0445	0.164	0.0052	0.138	0.0044
2062	0.051	0.0016	0.562	0.0178	1.422	0.0451	0.166	0.0053	0.139	0.0044
2063	0.052	0.0016	0.568	0.0180	1.438	0.0456	0.168	0.0053	0.141	0.0045
2064	0.052	0.0017	0.574	0.0182	1.454	0.0461	0.169	0.0054	0.143	0.0045

MAX	0.052	**0.002**	0.574	**0.018**	1.454	**0.046**	0.169	**0.005**	0.143	**0.005**
MEAN	0.018	**0.001**	0.199	**0.006**	0.505	**0.016**	0.059	**0.002**	0.049	**0.002**
g/m²/s		**8.87E-08**		**9.73E-07**		**2.46E-06**		**2.87E-07**		**2.42E-07**

Pollutant	**CHLORINATED COMPOUNDS**										**AMMONIA**
	Vinyl chloride		**Dichloromethane**		**Dichloroethylene**		**Trichloroethylene**		**Tetrachloroethylene**		**NH_3**
Year	Ton/year	Gram/Sec	Ton/year	Gram/Sec	Ton/year	Gram/Sec	Ton/year	Gram/Sec	Ton/year	Gram/Sec	Gram/Sec
2025	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
2026	0.03	0.001	0.07	0.002	0.02	0.001	0.02	0.001	0.04	0.001	0.11
2027	0.05	0.002	0.14	0.004	0.03	0.001	0.04	0.001	0.07	0.002	0.21
2028	0.08	0.002	0.20	0.006	0.05	0.001	0.06	0.002	0.10	0.003	0.31
2029	0.10	0.003	0.26	0.008	0.06	0.002	0.08	0.003	0.14	0.004	0.41
2030	0.12	0.004	0.32	0.010	0.07	0.002	0.10	0.003	0.17	0.005	0.50
2031	0.15	0.005	0.38	0.012	0.09	0.003	0.12	0.004	0.20	0.006	0.59
2032	0.17	0.005	0.44	0.014	0.10	0.003	0.13	0.004	0.22	0.007	0.68
2033	0.19	0.006	0.49	0.015	0.11	0.004	0.15	0.005	0.25	0.008	0.76
2034	0.21	0.007	0.54	0.017	0.12	0.004	0.17	0.005	0.28	0.009	0.84
2035	0.23	0.007	0.59	0.019	0.13	0.004	0.18	0.006	0.30	0.010	0.92
2036	0.24	0.008	0.64	0.020	0.14	0.005	0.20	0.006	0.33	0.010	0.99
2037	0.26	0.008	0.68	0.022	0.16	0.005	0.21	0.007	0.35	0.011	1.06
2038	0.28	0.009	0.72	0.023	0.17	0.005	0.22	0.007	0.37	0.012	1.13
2039	0.29	0.009	0.77	0.024	0.17	0.006	0.24	0.008	0.39	0.013	1.19
2040	0.31	0.010	0.80	0.026	0.18	0.006	0.25	0.008	0.42	0.013	1.26
2041	0.32	0.010	0.84	0.027	0.19	0.006	0.26	0.008	0.44	0.014	1.32
2042	0.34	0.011	0.88	0.028	0.20	0.006	0.27	0.009	0.45	0.014	1.37
2043	0.35	0.011	0.92	0.029	0.21	0.007	0.28	0.009	0.47	0.015	1.43
2044	0.36	0.012	0.95	0.030	0.22	0.007	0.29	0.009	0.49	0.016	1.48
2045	0.38	0.012	0.98	0.031	0.22	0.007	0.30	0.010	0.51	0.016	1.53

2046	0.39	0.012	1.01	0.032	0.23	0.007	0.31	0.010	0.52	0.017	1.58
2047	0.40	0.013	1.04	0.033	0.24	0.008	0.32	0.010	0.54	0.017	1.63
2048	0.41	0.013	1.07	0.034	0.24	0.008	0.33	0.011	0.55	0.018	1.68
2049	0.42	0.013	1.10	0.035	0.25	0.008	0.34	0.011	0.57	0.018	1.72
2050	0.43	0.014	1.13	0.036	0.26	0.008	0.35	0.011	0.58	0.018	1.76
2051	0.44	0.014	1.15	0.037	0.26	0.008	0.36	0.011	0.60	0.019	1.80
2052	0.45	0.014	1.18	0.037	0.27	0.009	0.36	0.012	0.61	0.019	1.84
2053	0.46	0.015	1.20	0.038	0.27	0.009	0.37	0.012	0.62	0.020	1.88
2054	0.47	0.015	1.22	0.039	0.28	0.009	0.38	0.012	0.63	0.020	1.91
2055	0.48	0.015	1.25	0.040	0.28	0.009	0.39	0.012	0.64	0.020	1.95
2056	0.49	0.015	1.27	0.040	0.29	0.009	0.39	0.012	0.65	0.021	1.98
2057	0.49	0.016	1.29	0.041	0.29	0.009	0.40	0.013	0.66	0.021	2.01
2058	0.50	0.016	1.31	0.041	0.30	0.009	0.40	0.013	0.67	0.021	2.04
2059	0.51	0.016	1.33	0.042	0.30	0.010	0.41	0.013	0.68	0.022	2.07
2060	0.52	0.016	1.34	0.043	0.31	0.010	0.42	0.013	0.69	0.022	2.10
2061	0.52	0.017	1.36	0.043	0.31	0.010	0.42	0.013	0.70	0.022	2.13
2062	0.53	0.017	1.38	0.044	0.31	0.010	0.43	0.014	0.71	0.023	2.15
2063	0.53	0.017	1.39	0.044	0.32	0.010	0.43	0.014	0.72	0.023	2.18
2064	0.54	0.017	1.41	0.045	0.32	0.010	0.44	0.014	0.73	0.023	2.20
MAX	0.541	**0.017**	1.409	**0.045**	0.322	**0.010**	0.436	**0.014**	0.727	**0.023**	**2.200**
MEAN	0.188	**0.006**	0.489	**0.016**	0.112	**0.004**	0.151	**0.005**	0.252	**0.008**	**0.764**
g/m²/s		**9.16E-07**		**2.39E-06**		**5.45E-07**		**7.39E-07**		**1.23E-06**	

6.2. Odour Emissions

Odour emissions from the active cell at Area E (assumed to be Cell 1) were estimated using emission rates and fluxes from published literature.

The baseline emission rate was sourced from a study by Nicolas, *et.al.,* (2006), which reports a rate of 34 000 OU/s for a general landfill receiving 100 000 m^3 of waste per year. The proposed height extension for Area E expects a monthly throughput of up to 15 000 tonnes (worst-case scenario). Assuming a compacted waste density of 1 T/m^3, this equates to an annual throughput of approximately 180 000 m^3, which is 1.8 times greater than the baseline literature site. Scaling the 34 000 OU/s baseline rate by this factor of 1.8 yielded a total applied emission rate of 61,200 OU/s for the entire active cell area.

Based on the above approach, an odour emission rate flux of approximately 3.3 $OU/m^2/s$ was calculated for the active Cell (assumed as Cell 1), which is comparable to reported odour emission fluxes quantified in other similar studies (referenced in Nicolas *et al*., 2006). Thus, I modelled an emission rate flux of 3.3 $OU/m^2/s$ for Area E.

The odour emission fluxes reported in other published literature (referenced in Nicolas *et al*., 2006) are summarised below:

Other reported emission fluxes in literature:		
freshly deposited waste	60	OU/m2/s
uncovered waste no active disposal	1	OU/m2/s
uncovered waste no active disposal	25	OU/m2/s
old disposed waste	2.6	OU/m2/s
mixed disposed waste	5.4	OU/m2/s
truck waiting area	3.5	OU/m2/s
freshly tipped waste	5	OU/m2/s
freshly tipped waste	4.5	OU/m2/s
calculated average	13.5	OU/m2/s

Sophia:
all references for the studies are reported in the Nicolas, et al (2006) paper

6.3. Dust Emissions

Dust emissions for the landfill were quantified using the available emission factors and equations given in the Australian NPI EET Manual for Mining. The margins of uncertainty/accuracy associated with the emission factors used are given in the below section. NPI Emission factor symbols and ratings can be summarised as follows (NPI, 2015):

- A – Excellent;
- B – Above average;
- C – Average;
- D – Below Average;
- E – Poor; and
- U – Unrated.

An A or B rating indicates a higher degree of certainty, whereas a D or E rating indicates a lower degree of certainty. A rating of U indicates that the emission factor uncertainty has not been rated (e.g. for emission factors generated by modelling rather than actual test results) (NPI, 2015).

6.3.1. Wind Erosion from Exposed Surfaces

Wind erosion from exposed surfaces is a source of dust emissions. Physical properties namely the shape, size, height, the surface area coverage, moisture content and the surface compaction of the exposed area together with prevailing meteorological conditions will influence the rate at which dust is emitted. Significant amounts of dust will be eroded from the exposed surfaces under wind speeds greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s). Fugitive dust generation resulting from wind erosion under high winds (i.e. > 5.4 m/s) is directly proportional to the wind speed.

Emissions due to wind erosion of exposed surfaces at the landfill site were calculated using the emission factors for wind erosion given in the NPI, EET manual for mining (NPI, 2012). The emission factors for TSP, PM_{10} and $PM_{2.5}$ used are given below.

Wind erosion (NPI Mining, Table 2):

$$E_{TSP} = 0.4 \text{ kg/Ha/hr}$$

$$\mathrm{E_{PM10}} = 0.2 \text{ kg/Ha/hr}$$

$$E_{PM2.5} = 5\% \; of \; TSP$$

Where:
E = Emission rate (Kg/Hectare/hour)
Emission factor rating symbol = U

The emission rates for TSP, PM_{10} and $PM_{2.5}$ and the input parameters for the exposed areas are given in Table 6-4.

Table 6-4: Input parameters for exposed areas.

SOURCE	EMISSION RATE (g/s)			MAX HEIGHT (m)[1]	MAX LENGTH (m)	MAX WIDTH (m)
	TSP	PM_{10}	$PM_{2.5}$			
Tonkmeter Landfill Site						
Exposed area at active workface at Area E - Cell 1 (uncovered waste area) (1)	0.01	0.005	0.0005	0.5	30	30
Area E (proposed final height) (1)	2.40	1.20	0.12	25	multiple	multiple
Reitfontein Landfill Site						
Area A (2)	0.82	0.41	0.041	10	multiple	multiple
Area C (2)	1.04	0.52	0.052	10	multiple	multiple
Notes:						

1. The source dimensions were confirmed by the client. Approximately 500 tonnes of waste is tipped, spread and compacted at the Tonkmeter active workface each day. This daily throughput was derived from a worst-case monthly waste throughput of 15 000 tonnes, assuming 30 operating days per month. The 15 000 tonnes/month throughput represents the anticipated worst-case operating scenario associated with the proposed increase in landfill height at Area E.
2. Source dimensions at the Rietfontein landfill were estimated from google earth and from information sourced from the City of Ekurhuleni's Integrated Waste Management Plan (May 2025).
3. A 30% control efficiency was applied to the exposed areas due to the compacting of waste and cover material.

6.3.2. Material Handling

Waste is transported by truck to the active disposal cell at Tonkmeter, assumed to be Cell 1, where it is offloaded at the active workface. Cover material is excavated on-site using an excavator/TLB and transported to the active workface, where it is offloaded and subsequently spread evenly over the deposited waste. Material handling activities are a source of dust emissions. Emissions due to material handling operations at the landfill site were calculated using emission factors given in the NPI, EET manual for mining (NPI, 2012). The emission factors for TSP, PM_{10} and $PM_{2.5}$ used are given below.

Excavators/shovels & front-end-loaders (*excavating/offloading cover material*) (NPI Mining, Table 2):

$$E_{TSP} = 0.025 \text{ kg/ton}$$

$$E_{PM10} = 0.012 \text{ kg/ton}$$

$$E_{PM2.5} = 5\% \text{ of TSP}$$

Where:
E = Emission rate (kg/tonne)
Emission factor rating symbol = U

Miscellaneous transfer points (*tipping of fresh waste*) (NPI Mining, Table 2):

$$E_{TSP} = 0.00032 \text{ kg/ton}$$

$$E_{PM10} = 0.00015 \text{ kg/ton}$$

$$E_{PM2.5} = 5\% \text{ of TSP}$$

Where:
E = Emission rate (kg/tonne)
Emission factor rating symbol = U

The emission rates for TSP, PM_{10} and $PM_{2.5}$ and the input parameters for the material handling activities are given in Table 6-5.

Table 6-5: Input parameters for material handling activities.

SOURCE	EMISSION RATE (g/s)			MATERIAL THROUGHPUT
	TSP	PM_{10}	$PM_{2.5}$	
x1 excavator excavating/offloading cover material on site	0.063	0.0303	0.0032	9.10 tonnes/hour (1)
x1 truck tipping fresh waste at active Cell (assumed as Cell 1)	0.004	0.002	0.0002	45.45 tonnes/hour (2)

Notes:
1. Hourly cover material throughput calculated based on cover to waste ratio of 1:5. The cover material required at the active workface was estimated to be 100 tonnes/day, assuming a compacted waste density of 1 tonne/m^3 and an 11-hour working day.
2. A daily waste throughput of 500 tonnes/day was assumed. This daily throughput was derived from a worst-case monthly waste throughput of 15 000 tonnes, assuming 30 operating days per month. The daily throughput translates to 45.45 tonnes/hour based on an 11-hour working day.

6.3.3. Compacting

A landfill compactor is used to compact the waste material disposed of at the active Cell at Tonkmeter (assumed as Cell 1). Compacting activities are a source of dust emissions. There is no specific emission factor for compacting at landfills, as such an emission factor for bulldozing given in the NPI, EET manual for mining (NPI, 2012) was used as an alternative. The emission factors for TSP, PM_{10} and $PM_{2.5}$ used are given below. The emission rates for TSP, PM_{10} and $PM_{2.5}$ and the input parameters for the compacting activities are given in Table 6-6.

Bulldozing material other than coal (NPI Mining, Table 2):

$$E_{TSP} = 17 \text{ kg/hour/vehicle}$$

$$E_{PM10} = 4.1 \text{ kg/hour/vehicle}$$

$$E_{PM2.5} = \text{assumed to be } 5\% \text{ of TSP}$$

Where:
E = Emission rate (kg/hour/vehicle)
Emission factor rating symbol = B

Table 6-6: Input parameters for compacting activities.

SOURCE	EMISSION RATE (g/s)			DIMENSIONS OF AREA COMPACTED
	TSP	PM_{10}	$PM_{2.5}$	
x1 landfill waste compactor at active Cell (assumed as Cell 1)	4.7	1.1	0.2	30m x 30m (1)

Notes:
1. The dimensions of the source were assumed. Compacting was assumed to occur at the end of each operational day, based on information provided by the client. About 500 tonnes of waste was assumed to be tipped, spread and compacted per day at the active workface.

6.3.4. Vehicle Dust Entrainment on Unpaved Roads

Trucks are used to transport waste material onsite. The disposal route onsite is unpaved. A water bowser truck is used onsite and operates all day to reduce dust emissions from the haul road. Therefore, the unpaved disposal route is treated for dust suppression daily (except when the roads are already wet due to rain). As such a 50% control efficiency was applied in this study to account for this dust mitigation measure.

The quantity of dust emissions from a given segment of unpaved road varies linearly with the volume of traffic. In addition to the volume of traffic, emissions also depend on source parameters which characterise the condition of a road and the associated vehicle traffic. These parameters include vehicle speeds, mean vehicle weight, average number of wheels per vehicle and road surface moisture (EPA, 1995). Although vehicle entrainment on unpaved roads is found to result in high fugitive dust emissions, these impacts are often limited close to the source.

Fugitive dust emissions from the movement of trucks at the landfill, are quantified using the following equations provided in the Missouri Department of Natural Resources, Haul Road Fugitive Emissions Worksheet Instructions (Missouri Department of Natural Resources, 2009):

$$E = K\,(\frac{s}{12})^{a}\,x\,(\frac{W1+W2}{6})^{b}$$

$$Annual\,VMT = \frac{2\,x\,(length\,of\,haul\,road)\,x\,(annual\,amount\,hauled)}{(average\,weight\,of\,material\,per\,load)}$$

Where:
E = emission factor (lb/VMT) (lb/VMT x 281.9 = g/VKT)
VMT = Vehicle miles travelled
VKT = Vehicle kilometres travelled
s = surface material silt content (%)
K = empirical constant (K_{TSP}, K_{PM10} & $K_{PM2.5}$)
a = empirical constant (a_{TSP}, a_{PM10} & $a_{PM2.5}$)
b = empirical constant (b_{TSP}, b_{PM10}, $b_{PM2.5}$)
W1 = Weight of unloaded truck
W2 = Weight of loaded truck

A surface material silt content of 6.4 % was assumed for the unpaved haul/disposal road onsite. This value was assumed based on the typical silt content value provided by the USEPA for municipal solid waste landfills (disposal routes) and can be found in Table 13.2.2-1 of the USEPA AP-42 document. The weights of the trucks were estimated based on a Caterpillar 69D Rock Truck ($18m^3$), which is a similar sized truck to the ones that are used at the landfill site. The empirical constants K, a and b were chosen for industrial roads based on the values provided in the USEPA, AP-42 document, Section 13.2 unpaved haul roads (Table 6-7).

A summary of input parameters for the trucks at the landfill is given in Table 6-8. Emission rates for TSP, PM_{10} and $PM_{2.5}$ due to vehicle dust entrainment from the movement of trucks are given in Table 6-9 below.

Table 6-7: Empirical constants used in the calculation for dust emissions from hauling trucks (USEPA, 1995: Section 13.2, Table 13.2.2).

Constant	Industrial Roads (Equation 1a)			Public Roads (Equation 1b)		
	PM-2.5	PM-10	PM-30*	PM-2.5	PM-10	PM-30*
k (lb/VMT)	0.15	1.5	4.9	0.18	1.8	6.0
a	0.9	0.9	0.7	1	1	1
b	0.45	0.45	0.45	-	-	-
c	-	-	-	0.2	0.2	0.3
d	-	-	-	0.5	0.5	0.3
Quality Rating	B	B	B	B	B	B

*Assumed equivalent to total suspended particulate matter (TSP)
"-" = not used in the emission factor equation

Table 6-8: Source parameters for trucks.

SOURCE (1)	TRUCK PARAMETERS				
	UNLOADED WEIGHT (Tonnes)	LOADED WEIGHT (Tonnes)	LENGTH (m)	WHEEL WIDTH (m)	HEIGHT (m)
Truck activity on unpaved road	30	38	8.1	3.7	3.4
Notes: 1. Parameters were based on the specifications provided for a Caterpillar 69D rock truck.					

Table 6-9: Input parameters for vehicle dust entrainment due to the movement of trucks on unpaved road surfaces.

SOURCE (1,2,4)	VKT (3)	EMISSION RATE (g/s)		
		TSP	PM_{10}	$PM_{2.5}$
Unpaved road 1 from entrance to active Cell 1	43 526	3.99	1.08	0.108
Notes: 1. Truck hauling hours: 11 hours for 7 days a week. 2. 50% control efficiency applied due to water spraying for dust suppression. The percentage control efficiency was based on the Australian NPI document (NPI, 2012). 3. VKT = vehicle kilometres travelled and was based on annual throughput of approx.,180 000 tonnes/year of waste material (worst-case scenario). 4. The disposal route was determined using the site layout diagram provided by the client.				

6.4. Flare Emissions

A flare is proposed for future landfill operations to control emissions of landfill gas collected by the gas collection system. The control efficiency of the flare was confirmed to be 98%, thus, emissions of HAPs exiting the proposed flare are expected to be minimal. However, there will be secondary pollutants emitted from the landfill flare, whose emission rates are based on the volume of methane flared.

The USEPA has published emission factors for secondary compounds exiting landfill gas flares based on the volume of methane flared (Table 6-10). These emission factors were used to estimate emissions of SO_2, NO_2, CO and PM_{10} from the flare based on the maximum annual volume of methane estimated to be generated from Area E, the gas collection system efficiency and the control efficiency of the landfill gas flare (in accordance with equation 5 in the screen shot below, which was taken from the USEPA AP-42, Chapter 2.4 - Emission factors for Municipal Solid Waste landfills).

The maximum annual volume of methane was estimated to be ~14 250 000 m^3 using the LandGEM model, while the maximum controlled emission rate of methane generated was estimated to be ~3 775 191 m^3/year.

Estimated SO_2, NO_2, CO and PM_{10} emissions from the proposed flare are given in Table 6-11.

Controlled CH_4, NMOC, and speciated emissions can be calculated with equation 5. It is assumed that the landfill gas collection and control system operates 100 percent of the time. Minor durations of system downtime associated with routine maintenance and repair (i.e., 5 to 7 percent) will not appreciably effect emission estimates. The first term in equation 5 accounts for emissions from uncollected landfill gas, while the second term accounts for emissions of the pollutant that were collected but not combusted in the control or utilization device:

$$CM_P = \left[UM_P * \left(1 - \frac{\eta_{col}}{100}\right)\right] + \left[UM_P * \frac{\eta_{col}}{100} * \left(1 - \frac{\eta_{cnt}}{100}\right)\right] \quad (5)$$

where:

CM_P = Controlled mass emissions of pollutant P, kg/yr;
UM_P = Uncontrolled mass emissions of P, kg/yr (from equation 4 or the Landfill Air Emissions Estimation Model);
η_{col} = Collection efficiency of the landfill gas collection system, percent; and
η_{cnt} = Control efficiency of the landfill gas control or utilization device, percent.

Table 6-10: USEPA emission factors for secondary pollutants exiting landfill gas flares, based on the volume of methane flared (USEPA, AP-42: Section 2.4, Table 2.4.4).

Table 2.4-4. (Metric Units) EMISSION FACTORS FOR SECONDARY COMPOUNDS EXITING CONTROL DEVICES[a]

Control Device	Pollutant[b]	kg/10^6 dscm Methane	Emission Factor Rating
Flare[c] (50100410) (50300601)	Nitrogen dioxide	650	C
	Carbon monoxide	12,000	C
	Particulate matter	270	D
IC Engine (50100421)	Nitrogen dioxide	4,000	D
	Carbon monoxide	7,500	C
	Particulate matter	770	E
Boiler/Steam Turbine[d] (50100423)	Nitrogen dioxide	530	D
	Carbon monoxide	90	E
	Particulate matter	130	D
Gas Turbine (50100420)	Nitrogen dioxide	1,400	D
	Carbon monoxide	3,600	E
	Particulate matter	350	E

[a] Source Classification Codes in parentheses. Divide kg/10^6 dscm by 16,700 to obtain kg/hr/dscmm.
[b] No data on PM size distributions were available, however for other gas-fired combustion sources, most of the particulate matter is less than 2.5 microns in diameter. Hence, this emission factor can be used to provide estimates of PM-10 or PM-2.5 emissions. See section 2.4.4.2 for methods to estimate CO_2, SO_2, and HCl.
[c] Where information on equipment was given in the reference, test data were taken from enclosed flares. Control efficiencies are assumed to be equally representative of open flares.
[d] All source tests were conducted on boilers, however emission factors should also be representative of steam turbines. Emission factors are representative of boilers equipped with low-NO_x burners and flue gas recirculation. No data were available for uncontrolled NO_x emissions.

Table 6-11: Input parameters for secondary compounds from landfill gas flaring.

SOURCE (1)	Maximum controlled CH_4 emissions (2)	EMISSION RATE (g/s)			
		PM_{10}	NO_2	CO	SO_2 (3)
Landfill Gas Flare	3 775 191	0.032	0.078	1.44	0.025

Notes:
1. Operation hours assumed to be 24 hours for 7 days a week.
2. Controlled emissions were calculated based on a published USEPA landfill gas collection efficiency, and a flare combustion efficiency of 98%.
3. Emissions of SO_2 were estimated based on emission rates given in the AECOM – 2015 AQIA report for a similar landfill site.

The proposed flare was modelled as a point source, using parameters given in Table 6-12 below.

Table 6-12: Point source parameters used as input into the model for the landfill gas flare.

Parameter [1]	Modelled Value
Stack ID	001
UTM Coordinates, 35S (X, Y)	642546.78, 7091170.53
Stack Height (m)	9
Stack Diameter (m)	2.0
Gas Exit Velocity (m/s)	10
Gas Exit Temperature (ºC)	1 100
Gas Exit Flow Rate (m^3/hr)	113 040

Notes:
1. Stack parameters, except the gas exit velocity and gas exit flow rate, were confirmed by the client. Gas exit velocity was estimated based on parameters for a similar plant. The gas exit flow rate was automatically calculated by the model.

6.5. Model Overview

6.5.1. AERMOD View

AERMOD, a state-of-the-art Planetary Boundary Layer (PBL) air dispersion model, was developed by the American Meteorological Society and USEPA Regulatory Model Improvement Committee (AERMIC). AERMOD utilizes a similar input and output structure to ISCST3 and shares many of the same features, as well as offering additional features. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain effects, and advanced meteorological turbulence calculations.

The AERMOD atmospheric dispersion modelling system is an integrated system that includes three modules:

- A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources.
- A meteorological data pre-processor (AERMET) for surface meteorological data, upper air soundings, and optionally, data from on-site instrument towers. It then calculates atmospheric parameters needed by the dispersion model, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux.
- A terrain pre-processor (AERMAP) which provides a physical relationship between terrain features and the behaviour of air pollution plumes. It generates location and height data for each receptor location. It also provides information that allows the dispersion model to simulate the effects of air flowing over hills or splitting to flow around hills.

AERMOD includes Plume Rise Model Enhancements (PRIME) building downwash algorithms which provide a more realistic handling of building downwash effects. PRIME algorithms were designed to address two fundamental features associated with building downwash; enhanced plume dispersion coefficients due to the turbulent wake and to reduce plume rise caused by a combination of the descending streamlines in the lee of the building and the increased entrainment in the wake. AERMOD is suitable for a wide range of near field applications in both simple and complex terrain.

The evaluation results for AERMOD, particularly for complex terrain applications, indicate that the model represents significant improvements compared to previously recommended models.

AERMOD has been used in various dispersion modelling studies in the United States and around the world (Perry *et al*., 2004).

6.5.2. Model Requirements

The approach to this dispersion modelling study is based on the Code *of Practice for Air Dispersion Modelling in Air Quality Management in South Africa* (DEA, 2014). As per the *Code of Practice*, this assessment is a Level 2 assessment. Level 2 assessments should be used for air quality impact assessments in standard/generic licence or amendment processes where:

- The distribution of pollutant concentrations and depositions are required in time and space;
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. Although more complicated processes may be occurring, a more complicated model that explicitly treats these processes may not be necessary depending on the purposes of the modelling and the zone of interest.
- Emissions are from sources where the greatest impacts are in the order of a few kilometres (less than 50 km) downwind.

A summary of the key variables input into the AERMOD model is given in Table 6-13 below. Data input into the model includes MM5 modelled meteorological data (surface and upper air) for 01 January 2023 – 31 December 2025. Terrain data at a resolution of 90 m (SRTM90) was used for input into the model, as generated by the terrain pre-processor, AERMAP. A modelling domain of 15km x 15km from the centre of the landfill operations was used. A multi-tier grid with a grid receptor spacing of 250m (5km from facility), 500m (10km from facility) and 1000 m (15km from facility) (3 tiers) was used.

Table 6-13: Key Variables to be used in the modelling study.

Parameter	Model Input
Model	**Input**
Assessment level	Level 2
Dispersion model	AERMOD Version 12.0.0
Supporting models	AERMET Version 12.0.0 AERMAP Version 12.0.0
Emissions	**Input**
Pollutants to be modelled	Various, see Section 6
Scenarios	Operational
Chemical transformations	N/A
Exponential decay	Rural
Settings	**Input**
Terrain setting	Elevated
Terrain data	SRTM90
Terrain data resolution (m)	90
Land use characteristics	Grassland, cultivated land & urban

Grid receptors	Input
Farm boundary (m)	50
Modelling domain (km)	15 x 15
Fine grid resolution (m)	250 (5km from facility)
Medium grid resolution (m)	500 (10km from facility)
Large grid resolution (m)	1000 (15km from facility)

6.5.3. Modelling Scenarios

Two modelling scenarios were assessed for particulate emissions, namely dustfall, PM_{10} and $PM_{2.5}$, while a single cumulative scenario was assessed for HAPs, odour and flare-related emissions.

For particulate emissions, the first scenario considered the standalone impact of active landfilling activities at Tonkmeter Area E. The second scenario represented cumulative impacts and included active operations at Tonkmeter Area E together with windblown dust emissions from Rietfontein Areas A and C.

Tonkmeter Areas D and F were assumed to remain vacant and were therefore excluded from the modelling, on the basis that Area E would be filled to its maximum capacity before landfilling progresses to Areas D and F. At the neighbouring Rietfontein landfill, Areas A and C were treated as completed landforms awaiting final rehabilitation, as the site is approaching the end of its operational life. Therefore, peak operational activities such as waste hauling, tipping, spreading and compaction were modelled only for Tonkmeter Area E. Rietfontein Areas A and C were represented as passive legacy sources, with emissions limited to fugitive landfill gas, leachate dams, and windblown dust.

6.5.4. Sensitivity Analysis and Treatment of Uncertainty

The proposed Area E height extension has a multi-decade operational period and, consequently, future operating conditions cannot be defined with complete certainty. The AQIA therefore relies on a combination of client-confirmed information, published emission factors, model defaults and conservative engineering assumptions. Where detailed source information was unavailable, reasonable conservative assumptions were adopted to avoid underestimating potential air-quality impacts.

A sensitivity screening was undertaken to identify which assumptions have the greatest potential to materially influence the emissions inventory, dispersion modelling results and overall impact conclusions (Table 6-14). The purpose of the screening was to distinguish between assumptions that require explicit representation in the emissions inventory and dispersion model, and assumptions that are unlikely to materially alter the assessment outcome and can therefore be addressed through disclosure of uncertainty, operational controls, monitoring and/or future mitigation measures.

The sensitivity screening considered: (i) the extent to which an assumption affects the calculated emission rate; (ii) whether a plausible change in the assumption could alter compliance with an ambient air-quality standard, screening guideline or odour threshold; (iii) the duration and spatial

extent of the associated emissions; (iv) the proximity of sensitive receptors; and (v) whether the alternative condition represents a reasonably foreseeable operating scenario. Assumptions capable of materially changing the predicted impact or compliance outcome were assigned a higher sensitivity and were retained explicitly in the modelling or addressed through conservative input values.

The sensitivity analysis was not intended to model every conceivable future operating configuration. Rather, it provides a proportionate means of focusing the assessment on those variables most likely to affect the conclusions of the AQIA, while transparently recording lower-sensitivity uncertainties as limitations or future management considerations.

Table 6-14: Sensitivity screening of key AQIA assumptions.

Assumption / uncertain variable	Relative sensitivity	Basis for rating	Treatment in the AQIA
Waste throughput (15 000 t/month; approximately 500 t/day)	High	Directly affects waste tipping, handling, haul-road activity, cover requirements and long-term landfill-gas generation. The AQIA already applies a worst-case throughput assumption.	Retain explicit worst-case modelling assumption.
Waste composition / proposed Type 2 and Type 3 waste streams	High	Waste composition can materially influence landfill-gas generation, HAP speciation and odour potential. The specific future waste streams have not yet been finalised.	Retain as a key uncertainty. Apply strict waste-acceptance controls and reassess if future waste streams differ materially from those assumed.
Landfill-gas generation parameters / LandGEM default inputs	High	These parameters directly control predicted landfill-gas, HAP and odorous-compound emissions. Site-specific gas-generation data are currently unavailable.	Retain conservative/default modelling inputs and validate against operational landfill-gas monitoring data when available.
Landfill-gas capture and flaring	High	Gas collection and flaring can materially reduce uncontrolled landfill-gas and odour emissions, while producing comparatively small combustion emissions.	Reflect the applicant-confirmed flaring decision in the assessment and mitigation framework. Retain flare-related emissions in the model and link future performance to landfill-gas monitoring.
Active workface location and dimensions	Moderate-High	The workface controls the location and extent of short-range dust, HAP and odour emissions and therefore affects source-to-receptor distance.	Use the current/client-confirmed workface dimensions and location. Record that the active workface will migrate during the operational life.
Watering of unpaved disposal roads (50% dust-control efficiency)	Moderate-High	Haul-road dust is sensitive to the assumed control efficiency. If watering is not maintained, particulate emissions could be materially higher.	Retain the 50% control efficiency only as an operational commitment, supported by routine watering, inspection and corrective action.

Assumption / uncertain variable	Relative sensitivity	Basis for rating	Treatment in the AQIA
Application of daily cover at the active workface (30% dust-control assumption, where applied)	Moderate	Daily cover reduces exposed waste, windblown dust and odour. Effectiveness depends on consistent operational implementation.	Retain as an operational mitigation assumption and ensure it is incorporated into the EMPr / operating procedures.
Cover material throughput / cover-to-waste ratio	Moderate	Influences emissions from excavation, handling and placement of cover material, but is less influential than waste throughput and landfill-gas assumptions.	Retain the current modelling assumption and document the uncertainty.
Truck characteristics, road silt content and vehicle activity assumptions	Moderate	These variables influence calculated haul-road dust emissions. The inventory uses representative truck specifications and published/default road parameters where site-specific data are unavailable.	Retain representative/conservative inputs. Verify site-specific fleet and road conditions during operation where practicable.
Construction of future cells within Area E	Low-Moderate	Construction dust may be locally elevated but will be intermittent and short-term relative to long-term landfill operations and is readily controlled through standard dust mitigation.	Retain as a modelling exclusion/limitation. Manage through construction dust-control measures rather than additional long-term dispersion scenarios.
Vehicle fuel type / exhaust emissions	Low for the AQIA conclusions	The principal AQIA risks are dominated by fugitive dust, landfill gas and odour. Reasonable changes in vehicle fuel type are unlikely to alter the overall air-quality conclusions at the assumed activity level.	Record as a limitation unless fleet composition or traffic intensity changes substantially.
On-site recycling and separation of garden/organic waste	Low-Moderate	These activities can reduce the mass and organic fraction of waste ultimately disposed, thereby reducing landfill-gas generation. Assuming less diversion is conservative from an air-quality perspective.	Treat as an operational benefit / future mitigation measure rather than requiring a separate dispersion scenario unless the assumed disposal tonnage changes materially.

6.6. Dispersion Modelling Results

Dispersion simulations were undertaken to determine:

- Predicted ground-level impacts for dustfall, PM_{10} and $PM_{2.5}$ associated with operations at the landfill site.
- Predicted ground-level impacts for various HAPs (including odorous compounds) associated with landfill gas emissions generated by the Tonkmeter and Rietfontein landfill sites.
- Predicted ground-level impacts of odour associated with the Tonkmeter and Rietfontein landfill sites.
- Proposed ground-level impacts for gaseous air pollutants (CO, SO_2, NO_2) associated with proposed flaring activities at the landfill site.

The Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014), recommends the use of the 99th percentile concentrations for short-term assessment with the SNAAQS since the highest predicted ground-level concentrations can be considered outliers due to complex variability of meteorological processes. This might cause exceptionally high concentrations that the facility may never actually exceed in its lifetime. For short-term averaging periods, the predicted 99th percentile concentrations or the 4th ranked highest concentrations are provided. For odour units, the 98th percentile concentrations were considered to align with odour unit concentration thresholds given in published literature (Nicolas *et al.,* 2006). Isopleth plots of predicted concentrations for the various pollutants assessed in this study are given in the below sections in Figure 6-2 to Figure 6-36.

Comparison of the predicted CO, SO_2, NO_2, PM_{10}, $PM_{2.5}$ and benzene (annual average) ambient concentrations are made with the SNAAQS to determine compliance. Comparison of the dustfall rates is made with the South African dust control regulations. Comparison of the predicted concentrations for the remainder of the pollutants assessed in this study was made with international screening guidelines and published odour thresholds, as there are no SNAAQS available for these pollutants (Table 4-3). The relevant ambient air quality standards, guidelines and odour thresholds are repeated under Sections 6.6.1 to 6.6.5 for ease of reference.

In determining compliance, predicted incremental concentrations (as determined beyond the site boundary) are compared against the applicable standards. Inside the site boundary, air pollutant concentrations are required to comply with occupational health and safety standards. In this case the Tonkmeter site boundary is considered.

6.6.1. Dispersion Model Output Plots for Dustfall, PM_{10} and $PM_{2.5}$.

6.6.1.1. Standalone Scenario.

The dispersion model output plots for dust emissions associated with isolated operations at Area E are given in Figure 6-2 to Figure 6-6. The South African dustfall standards and SNAAQS for PM_{10} and $PM_{2.5}$ are as follows:

- Dustfall rates:
  - Non-residential area standard (1200 mg/m^2/day)
  - Residential area standard (600 mg/m^2/day)
- PM_{10} ambient air quality concentrations:
  - Daily average (75 µg/m^3)

    - Annual average (40 µg/m^3)
- $PM_{2.5}$ ambient air quality concentrations:
    - Daily average (40 µg/m^3)
    - Annual average (20 µg/m^3)

Predicted incremental dustfall rates and PM_{10} and $PM_{2.5}$ concentrations decrease rapidly with increasing distance from Area E, with the highest impacts concentrated within and immediately adjacent to the Tonkmeter site. Maximum dustfall rates along a small section of the site boundary fall just above 600 mg/m^2/day. Dustfall may therefore locally exceed the residential dustfall guideline of 600 mg/m^2/day at or immediately adjacent to the operational boundary but does not exceed the applicable non-residential standard of 1200 mg/m^2/day. Dustfall rates reduce substantially away from the landfill, with the surrounding receptor areas generally complying with both the residential and non-residential standards. At the site boundary, maximum predicted incremental 24-hour PM_{10} and $PM_{2.5}$ concentrations are approximately 64.4 µg/m^3 and less than 8 µg/m^3, respectively, and remain below the applicable daily SNAAQS. Maximum annual PM_{10} and $PM_{2.5}$ concentrations at the boundary are approximately 17.7 µg/m³ and 1.78 µg/m³, respectively, which are also well below the corresponding annual standards (Figure 6-2 to Figure 6-6).

6.6.1.2. Cumulative Scenario.

The dispersion model output plots for dust emissions associated with the cumulative scenario are given in Figure 6-7 to Figure 6-11. Under this scenario, predicted incremental dustfall rates and PM_{10} and $PM_{2.5}$ concentrations are highest within and immediately surrounding the landfill source areas, with concentrations decreasing progressively with increasing distance. At the Tonkmeter site boundary, the maximum predicted 24-hour and annual PM_{10}/$PM_{2.5}$ concentrations remain below the applicable SA NAAQS. The maximum predicted dustfall at the site boundary is approximately 660 mg/m^2/day. This is below the non-residential dustfall standard, although it marginally exceeds the residential standard at portions of the site boundary. Overall, cumulative particulate impacts are therefore largely confined to the landfill and its immediate surroundings, with concentrations reducing substantially further away from the source areas.

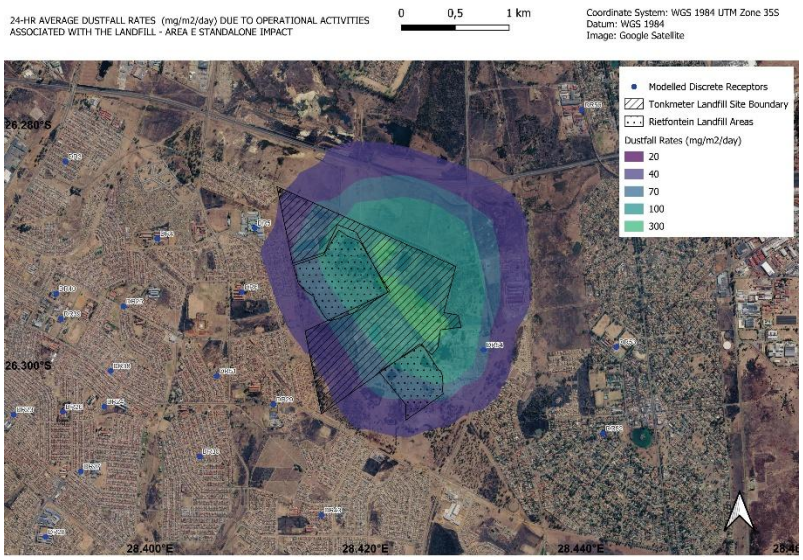


Figure 6-2: Predicted Dust-fall daily average incremental rates for Area E – Standalone Impact.

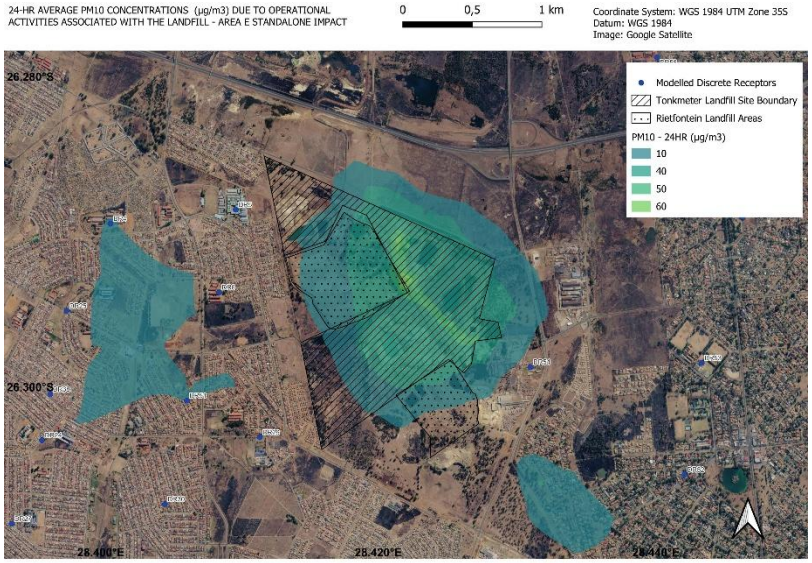


Figure 6-3: Predicted PM_{10} daily average incremental concentrations for Area E – Standalone Impact.

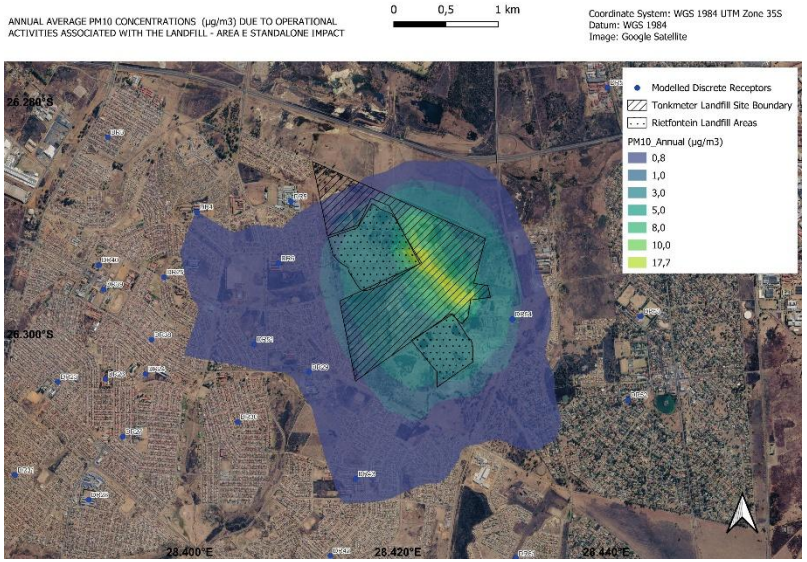


Figure 6-4: Predicted PM_{10} annual average incremental concentrations for Area E – Standalone Impact.

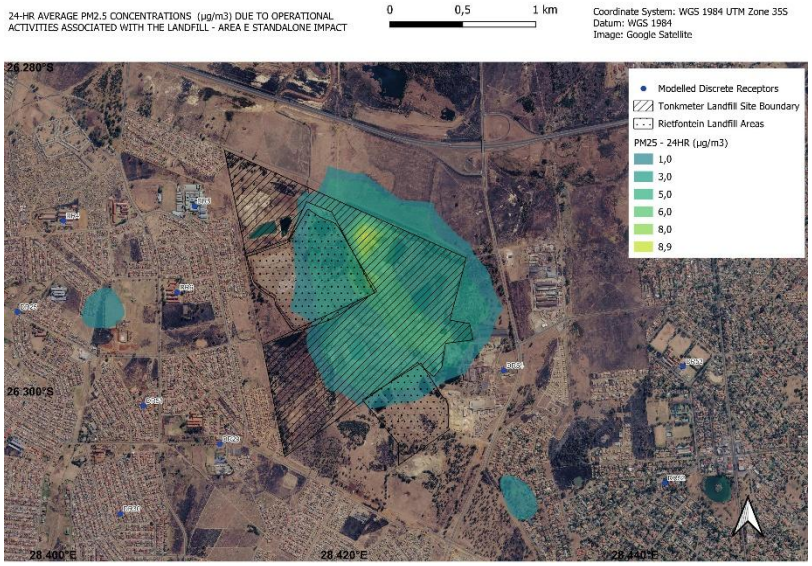


Figure 6-5: Predicted $PM_{2.5}$ daily average incremental concentrations for Area E – Standalone Impact.

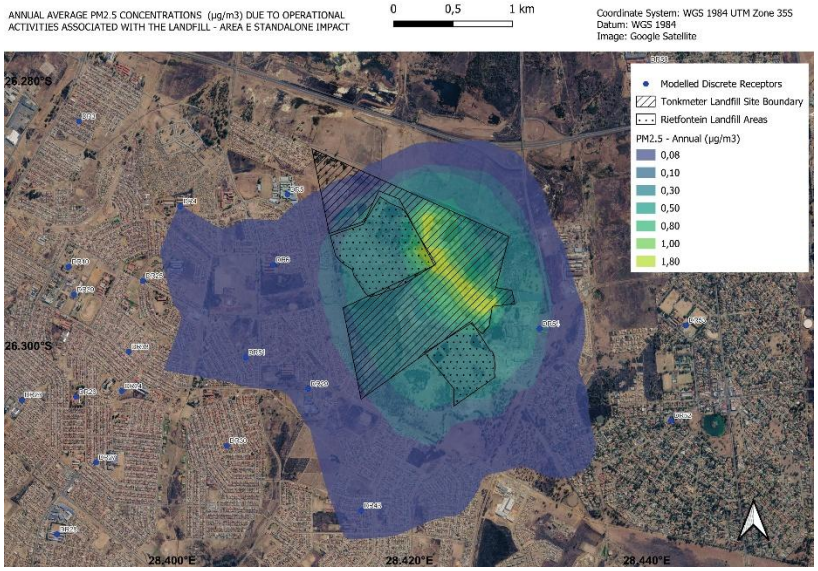


Figure 6-6: Predicted $PM_{2.5}$ annual average incremental concentrations for Area E – Standalone Impact.

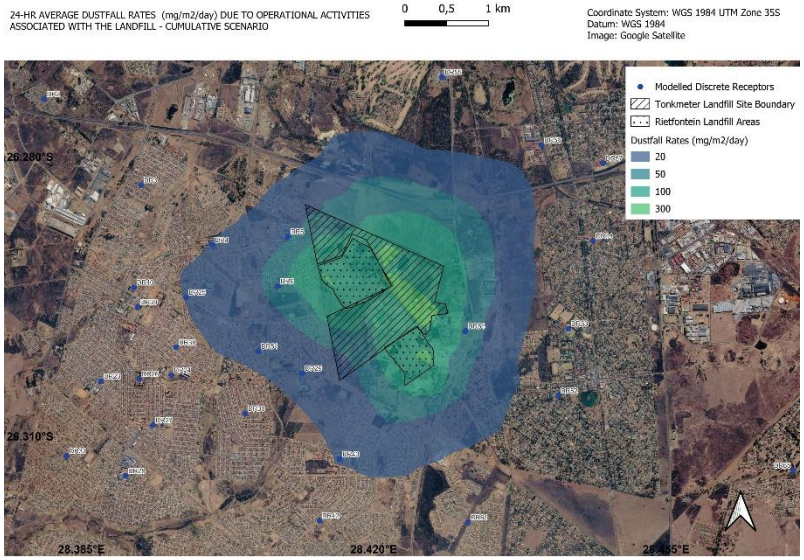


Figure 6-7: Predicted Dust-fall daily average incremental rates for the project site – Cumulative Scenario.

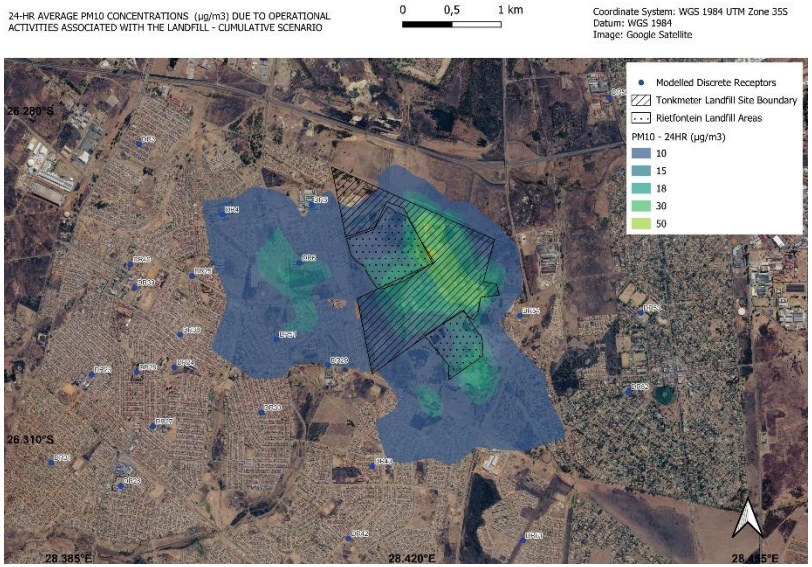


Figure 6-8: Predicted PM_{10} daily average incremental concentrations for the project site – Cumulative Scenario.

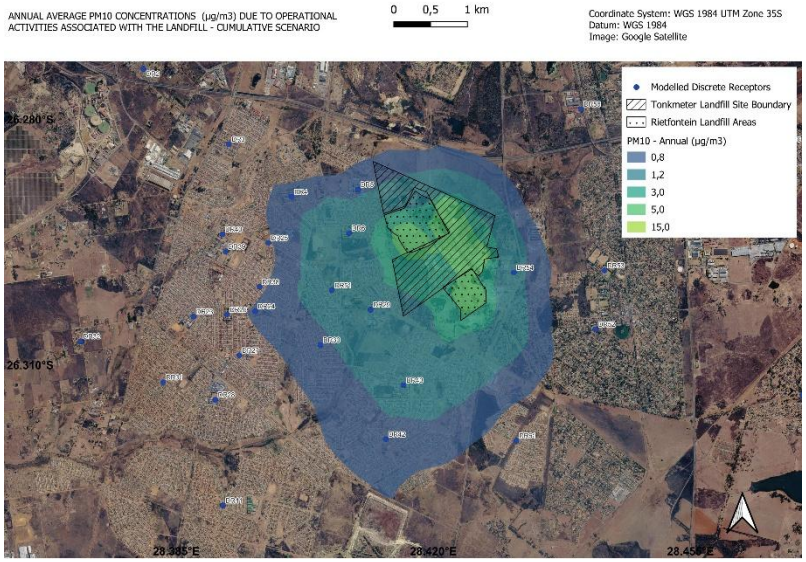


Figure 6-9: Predicted PM_{10} annual average incremental concentrations for the project site – Cumulative Scenario.

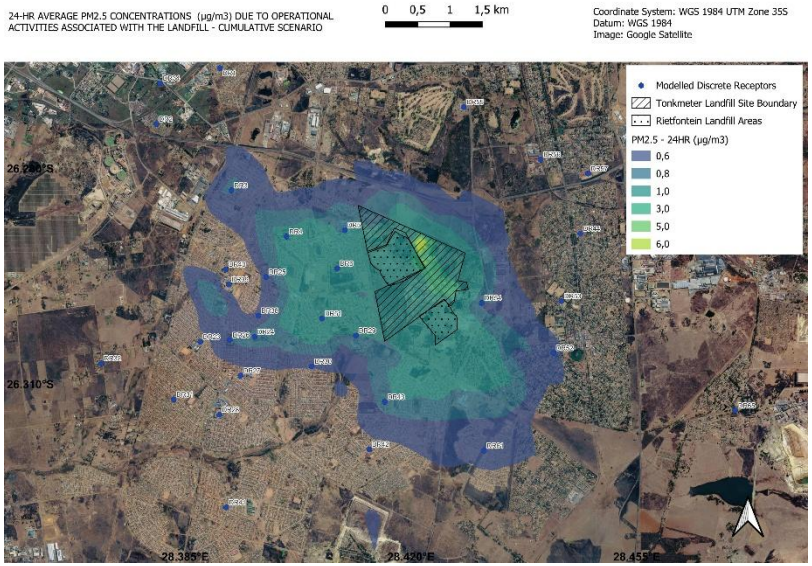


Figure 6-10: Predicted $PM_{2.5}$ daily average incremental concentrations for the project site – Cumulative Scenario.

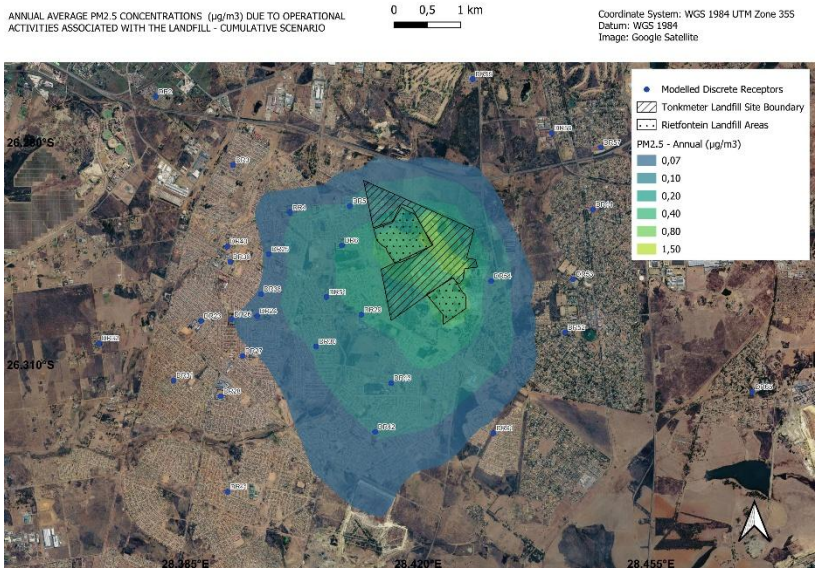


Figure 6-11: Predicted $PM_{2.5}$ annual average incremental concentrations for the project site – Cumulative Scenario.

6.6.2. Dispersion Model Output Plots for Hydrogen Sulphide (H_2S) (Cumulative Scenario).

The dispersion model output plots for hydrogen sulphide emissions associated with the Tonkmeter and Rietfontein landfills (including the Reitfonetin leachate dams) are given in Figure 6-12 and Figure 6-13. The area shown in red in the dispersion output plots indicates areas of exceedances with the Alberta air quality guidelines (i.e., screening thresholds), which are as follows:

- Hydrogen sulphide ambient air quality guidelines:
    - Hourly average (14 µg/m^3)
    - Daily average (4 µg/m^3)

Odour thresholds which are given in the Airshed AQIAr (2018) are shown below. The odour recognition threshold is the concentration at which most people will recognise the odour in their environment and may find it annoying if there is prolonged exposure (see Section 4.4).

- Hydrogen sulphide ambient air quality concentrations:
    - Odour detection threshold (0.57 µg/m^3)
    - Odour recognition threshold (7 µg/m^3)

Predicted incremental hydrogen sulphide concentrations are highest within and immediately surrounding the Tonkmeter and Rietfontein landfill areas and decrease with increasing distance from the source areas. The highest hourly and 24-hour concentrations along the Tonkmeter site boundary fall above 14 µg/m^3 and 4 µg/m^3, indicating localised exceedance of the Alberta 1-hour and daily air quality guidelines, respectively (Figure 6-12 and Figure 6-13).

The predicted 0.57 µg/m^3 odour-detection threshold extends considerably beyond the landfill boundary, indicating that hydrogen sulphide odours may occasionally be detectable across portions of the surrounding area under unfavourable dispersion conditions. In contrast, concentrations exceeding the 7 µg/m³ odour-recognition threshold are substantially more localised and occur mainly within and immediately adjacent to the landfill source areas. Consequently, the potential for recognisable and potentially annoying hydrogen sulphide odours is expected to be greatest close to the landfills, with the likelihood of odour impacts decreasing with distance from the site (Figure 6-12 and Figure 6-13).

Although the ambient guideline exceedances are concentrated within the near-field area surrounding the landfills, the results indicate that hydrogen sulphide emissions warrant appropriate landfill-gas management and monitoring, particularly at the site boundary and at nearby sensitive receptors.

The modelling indicates, however, that most of the predicted H_2S impact is associated with emissions from the neighbouring Rietfontein landfill, particularly its relatively large and poorly managed leachate dam, rather than from Tonkmeter operations. At Tonkmeter, H_2S emissions are primarily associated with landfill gas released from the active workface and are comparatively limited. Tonkmeter also does not operate an open leachate dam; leachate generated onsite is collected in a storage tank for temporary containment prior to treatment and disposal, thereby reducing the potential for additional H_2S emissions.

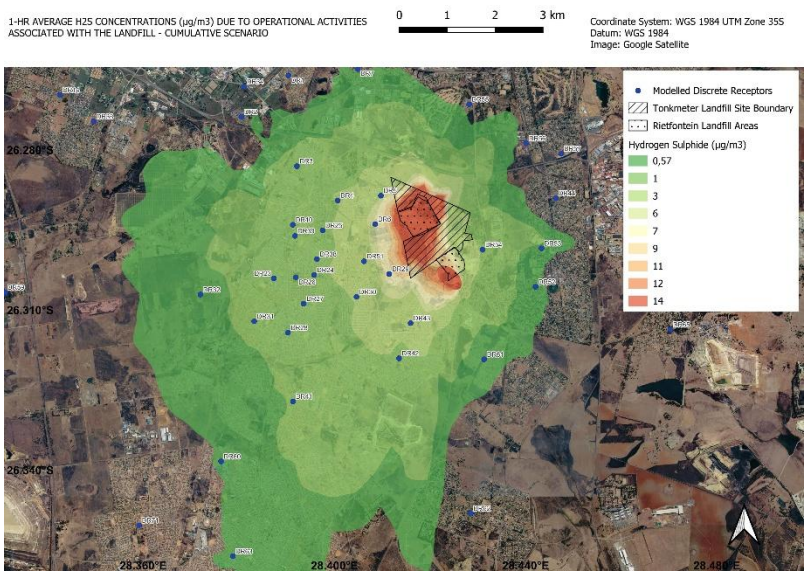


Figure 6-12: Predicted H_2S hourly average incremental concentrations for the project site – Cumulative Scenario.

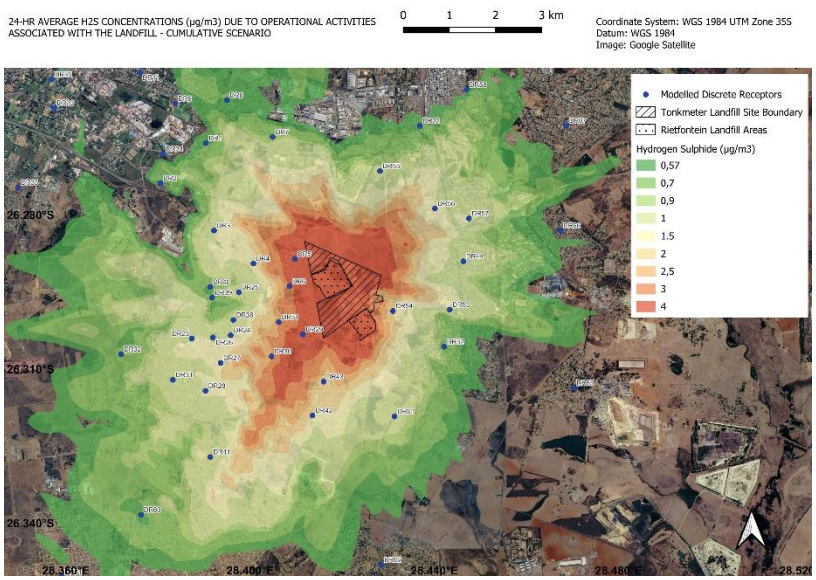


Figure 6-13: Predicted H_2S daily average incremental concentrations for the project site – Cumulative Scenario.

6.6.3. Dispersion Model Output Plots for Various HAPs due to Landfill Gas (Cumulative Scenario).

The dispersion model output plots for BTEX, reduced sulphur compounds, chlorinated compounds and ammonia emissions associated with the Tonkmeter and Rietfontein landfill sites are given in Figure 6-14 to Figure 6-28. The air quality guidelines for the various pollutant groups are summarised below. While most serve as screening thresholds, the benzene annual SA NAAQS is applied as a strict statutory metric.

BTEX ambient air quality guidelines and odour thresholds:

- Benzene:
  - Hourly average (30 µg/m^3) (Alberta air quality guideline)
  - Annual average (5 µg/m^3) (SNAAQS)
  - Odour detection threshold (1500 µg/m^3) (Airshed AQIAr, 2018)
  - Odour recognition threshold (16000 µg/m^3) (Airshed AQIAr, 2018)
- Toluene:
  - Hourly average (1880 µg/m^3) (Alberta air quality guideline)
  - Odour detection threshold (1300 µg/m^3) (Airshed AQIAr, 2018)
  - Odour recognition threshold (20000 µg/m^3) (Airshed AQIAr, 2018)
- Ethylbenzene:
  - Hourly average (2000 µg/m^3) (Alberta air quality guideline)
  - Odour detection threshold (730 µg/m^3) (Airshed AQIAr, 2018)
  - Odour recognition threshold (1900 µg/m^3) (Airshed AQIAr, 2018)
- Xylene:
  - Hourly average (2300 µg/m^3) (Alberta air quality guideline)
  - Odour detection threshold (180 µg/m^3) (Airshed AQIAr, 2018)
  - Odour recognition threshold (2000 µg/m^3) (Airshed AQIAr, 2018)

Predicted incremental hourly and annual benzene concentrations fall well below the respective Alberta air quality guideline and SA NAAQS (Figure 6-14 and Figure 6-15). Similarly, predicted incremental hourly average concentrations of toluene, ethylbenzene and xylene fall well below the Alberta air quality guidelines, with no exceedances predicted (Figure 6-16 to Figure 6-18). Predicted concentrations for BTEX fall well below the recommended odour recognition thresholds.

Reduced Sulphur Compounds ambient air quality guidelines and odour thresholds:

- Carbon Disulphide:
  - Hourly average (30 µg/m^3) (Alberta air quality guideline)
  - Odour detection threshold (100 µg/m^3) (Airshed AQIAr, 2018)
  - Odour recognition threshold (1000 µg/m^3) (Airshed AQIAr, 2018)
- Dimethyl Sulphide:
  - Hourly average (30 µg/m^3) (Ontario air quality guideline)
  - Odour detection threshold (1 µg/m^3) (Airshed AQIAr, 2018)
  - Odour recognition threshold (49 µg/m^3) (Airshed AQIAr, 2018)
- Ethyl Mercaptan:
  - Hourly average (28 µg/m^3) (British Columbia air quality standard)
  - Odour detection threshold (1 µg/m^3) (Airshed AQIAr, 2018)
  - Odour recognition threshold (2.5 µg/m^3) (Airshed AQIAr, 2018)

- Methyl Mercaptan:
    - Hourly average (28 µg/m^3) (British Columbia air quality standard)
    - Odour detection threshold (0.14 µg/m^3) (Airshed AQIAr, 2018)
    - Odour recognition threshold (2 µg/m^3) (Airshed AQIAr, 2018)

Predicted incremental 1-hour concentrations of the reduced sulphur compounds are highest within and immediately adjacent to the landfill source areas and decrease with increasing distance from the site. At the Tonkmeter boundary, predicted concentrations of all four compounds remain well below the applicable hourly ambient air quality guidelines, indicating that adverse ambient air quality impacts associated with these compounds are not anticipated at or beyond the site boundary.

The potential for odour impacts is more relevant for the mercaptans and dimethyl sulphide. The maximum boundary concentration of dimethyl sulphide is 7.10 µg/m^3, which exceeds its odour detection threshold of 1 µg/m^3 but remains well below its odour recognition threshold of 49 µg/m^3 (Figure 6-20). Dimethyl sulphide odours may therefore occasionally be detectable near the landfill, although recognisable or potentially annoying odours are not expected based on the predicted boundary concentrations.

Maximum predicted incremental ethyl mercaptan and methyl mercaptan concentrations at the Tonkmeter boundary are 2.66 µg/m^3 and ~2.00 µg/m^3, respectively. These concentrations exceed both the applicable odour detection thresholds and the odour recognition thresholds of 2.5 µg/m^3 for ethyl mercaptan and 2 µg/m^3 for methyl mercaptan (Figure 6-21 and Figure 6-22). Consequently, these compounds have the greatest potential to contribute to recognisable landfill-related odours at or immediately adjacent to the site boundary under unfavourable dispersion conditions. Mercaptan compounds are typically known to have a strong odour, even at very low ambient concentrations.

Carbon disulphide concentrations are comparatively low, with a maximum boundary concentration of 0.9 µg/m^3, which is well below the applicable ambient guideline and its odour detection threshold (Figure 6-19). Carbon disulphide is therefore not expected to be a significant contributor to either ambient air quality or odour impacts.

Chlorinated Compounds ambient air quality guidelines and odour thresholds:

- Vinyl Chloride:
    - Hourly average (130 µg/m^3) (Alberta air quality guideline)
    - Odour detection threshold (520000 µg/m^3) (Airshed AQIAr, 2018)
    - Odour recognition threshold (910000 µg/m^3) (Airshed AQIAr, 2018)
- Dichloromethane:
    - Hourly average (694000 µg/m^3) (American industrial hygiene association emergency response planning guideline)
    - Odour detection threshold (560000 µg/m^3) (Airshed AQIAr, 2018)
    - Odour recognition threshold (730000 µg/m^3) (Airshed AQIAr, 2018)
- Dichloroethylene:
    - Daily average (105 µg/m^3) (Ontario air quality guideline)
    - Odour detection threshold (23000 µg/m^3) (Airshed AQIAr, 2018)
    - Odour recognition threshold (unknown) (Airshed AQIAr, 2018)

- Trichloroethylene:
    - Daily average (12 µg/m^3) (Ontario air quality guideline)
    - Odour detection threshold (1500 µg/m^3) (Airshed AQIAr, 2018)
    - Odour recognition threshold (20000 µg/m^3) (Airshed AQIAr, 2018)
- Tetrachloroethylene:
    - Daily average (360 µg/m^3) (Ontario air quality guideline)
    - Odour detection threshold (unknown) (Airshed AQIAr, 2018)
    - Odour recognition threshold (8000 µg/m^3) (Airshed AQIAr, 2018)

Predicted incremental hourly average concentrations of vinyl chloride and dichloromethane, as well as daily average concentrations of dichloroethylene and tetrachloroethylene are particularly low and fall well within the relevant air quality guidelines. Furthermore, no exceedances of the recommended odour recognition thresholds are predicted for the chlorinated compounds (Figure 6-23 to Figure 6-27).

Ammonia ambient air quality guideline and odour thresholds:

- Hourly average (1400 µg/m^3) (Alberta air quality guideline)
- Odour detection threshold (1100 µg/m^3) (Airshed AQIAr, 2018)
- Odour recognition threshold (35000 µg/m^3) (Airshed AQIAr, 2018)

Predicted incremental hourly average ammonia concentrations are low over all areas surrounding the landfill site, with no exceedances of the Alberta air quality guideline expected. Additionally, the predicted concentrations fall well below the odour detection and odour recognition thresholds (Figure 6-28).

6.6.4. *Dispersion Model Output Plots for Flare-Related Gaseous Emissions.*

The dispersion model output plots for flare-related gaseous emissions are given in Figure 6-29 to Figure 6-34 for SO_2, NO_2 and CO. The South African SNAAQS for these pollutants are as follows:

- SO_2 ambient air quality concentrations:
    - Hourly average (350 µg/m^3)
    - Daily average (125 µg/m^3)
    - Annual average (50 µg/m^3)
- NO_2 ambient air quality concentrations:
    - Hourly average (200 µg/m^3)
    - Annual average (40 µg/m^3)
- CO ambient air quality concentrations:
    - Hourly average (30 000 µg/m^3)
    - 8-Hourly average (10 000 µg/m^3)

Predicted incremental concentrations for all these gaseous emissions fall well below the applicable SA NAAQS, with no exceedances expected. Low to minimal incremental concentrations are expected to disperse from the landfill site to nearby surrounding receptor areas.

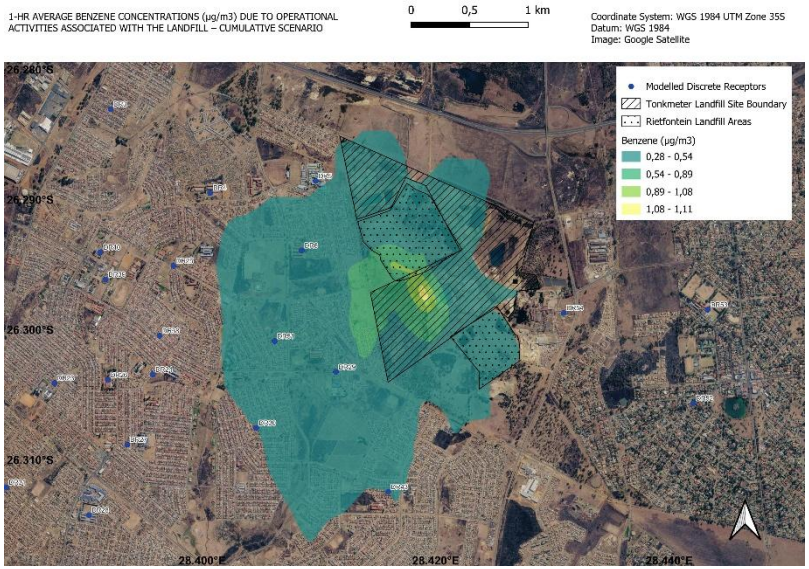


Figure 6-14: Predicted Benzene hourly average incremental concentrations for the project site.

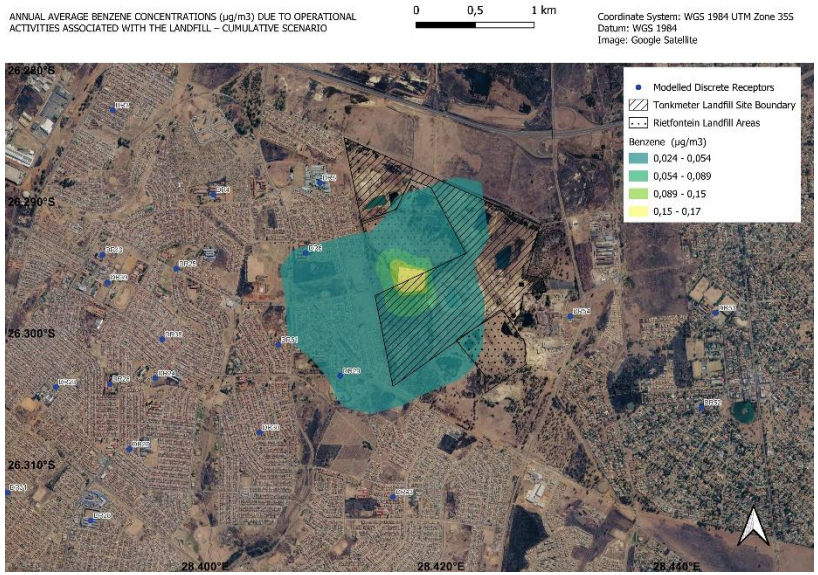


Figure 6-15: Predicted Benzene annual average incremental concentrations for the project site.

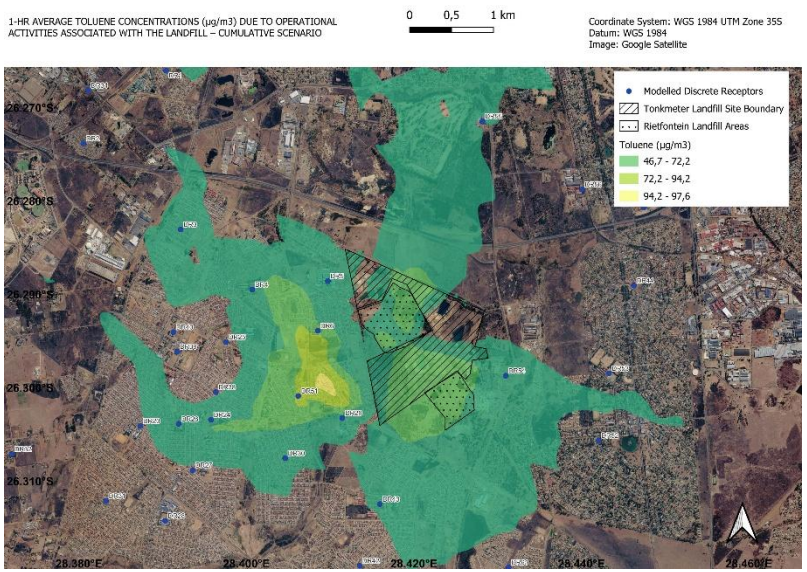


Figure 6-16: Predicted Toluene hourly average incremental concentrations for the project site

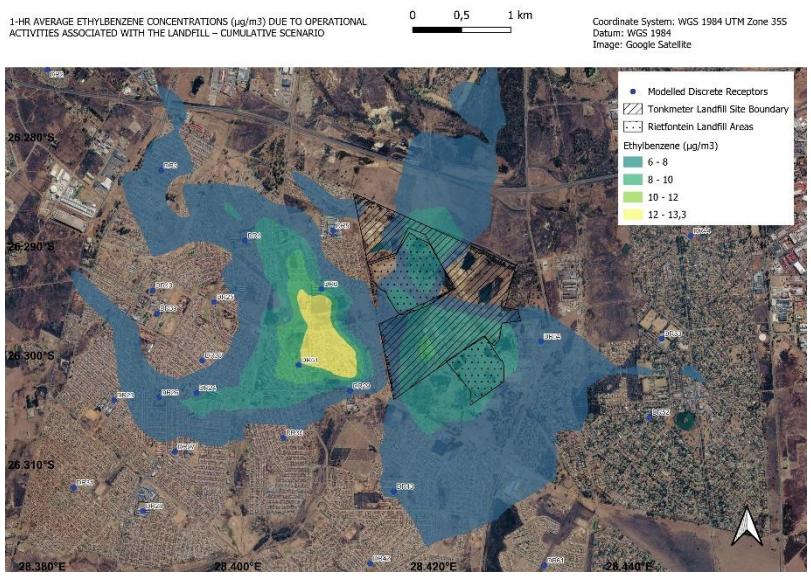


Figure 6-17: Predicted Ethylbenzene hourly average Incremental concentrations for the project site.

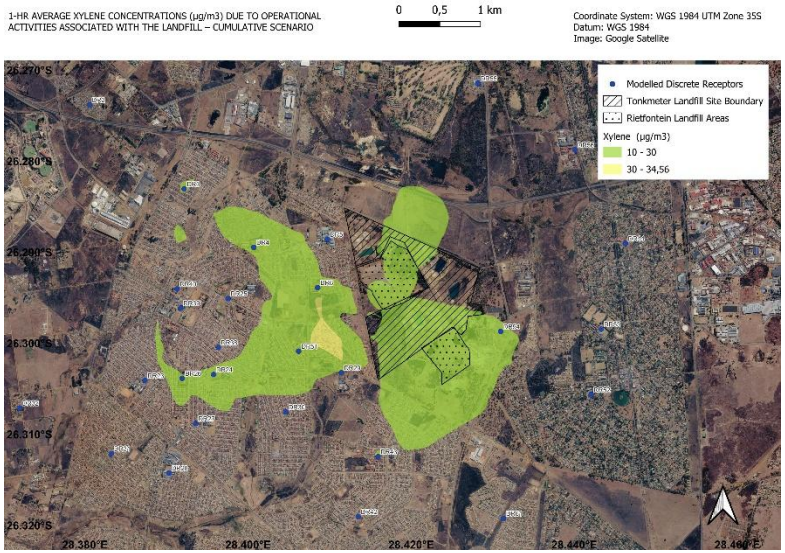


Figure 6-18: Predicted Xylene hourly average incremental concentrations for the project site.

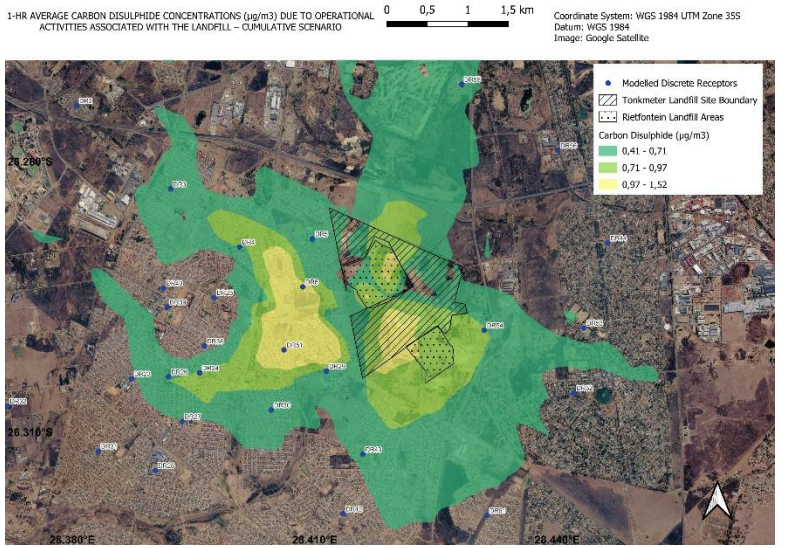


Figure 6-19: Predicted Carbon Disulphide hourly average incremental concentrations for the project site.

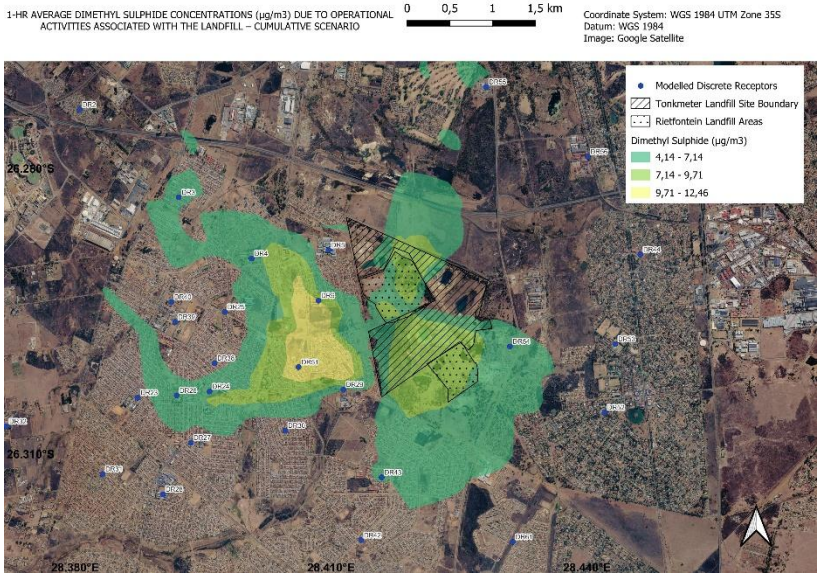


Figure 6-20: Predicted Dimethyl Sulphide hourly average incremental concentrations for the project site.

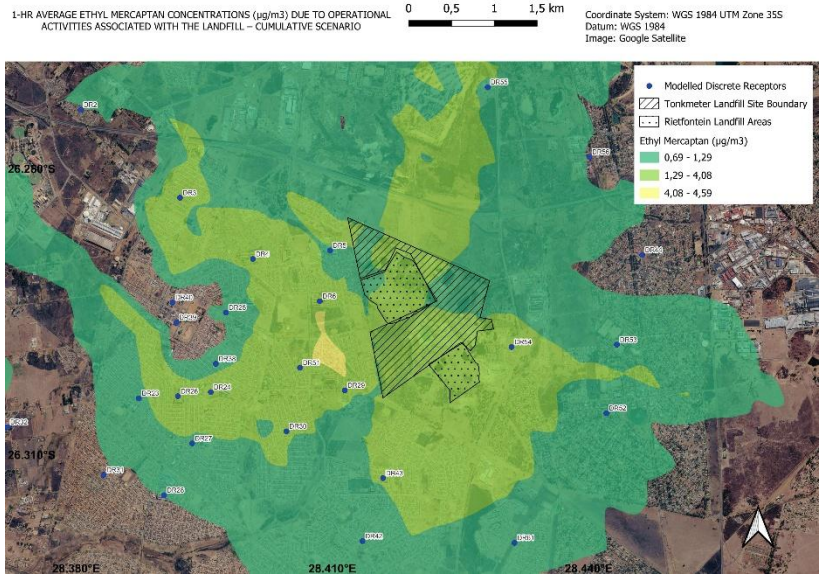


Figure 6-21: Predicted Ethyl Mercaptan hourly average Incremental concentrations for the project site.

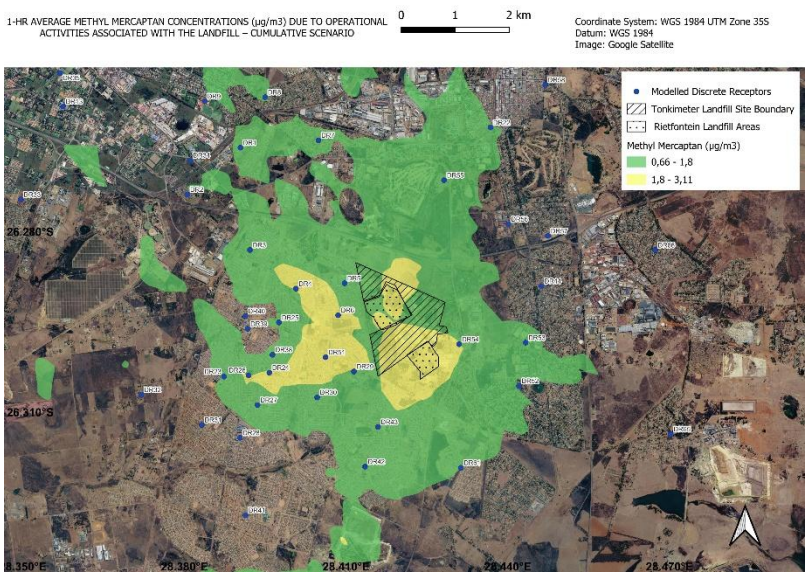


Figure 6-22: Predicted Methyl Mercaptan hourly average incremental concentrations for the project site.

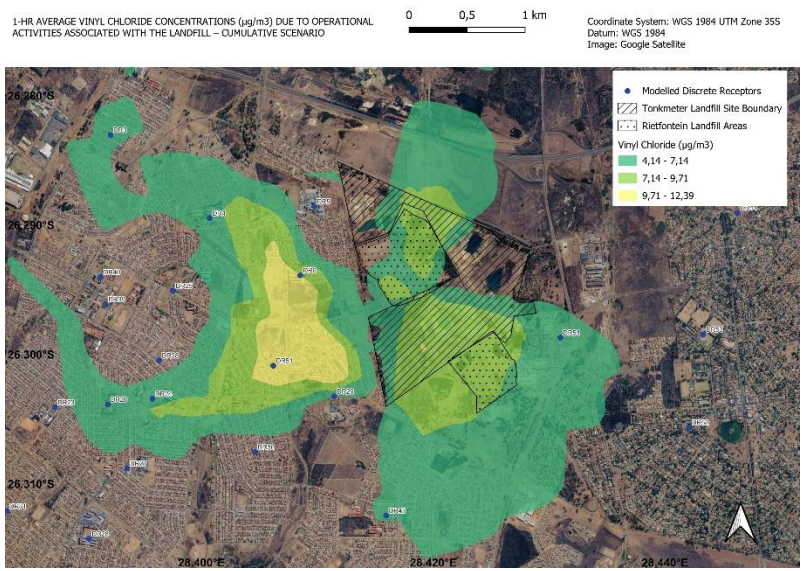


Figure 6-23: Predicted Vinyl Chloride hourly average incremental concentrations for the project site.

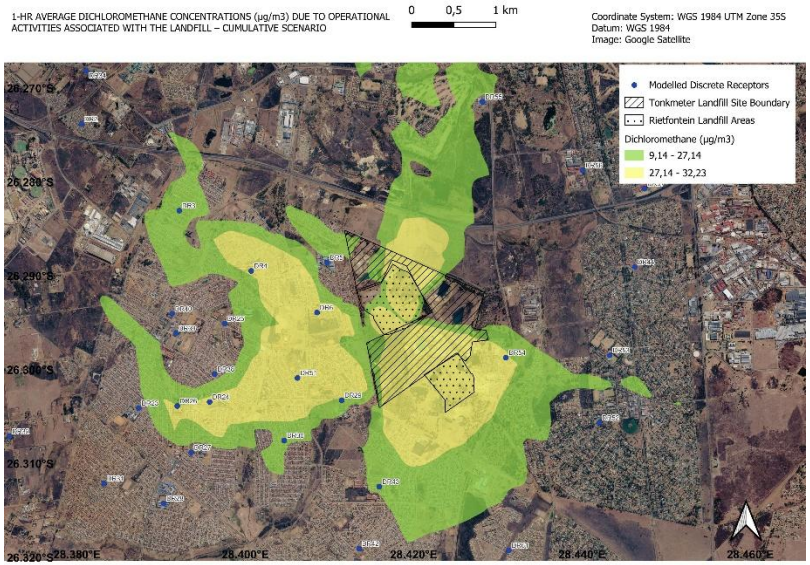


Figure 6-24: Predicted Dichloromethane hourly average incremental concentrations for the project site.

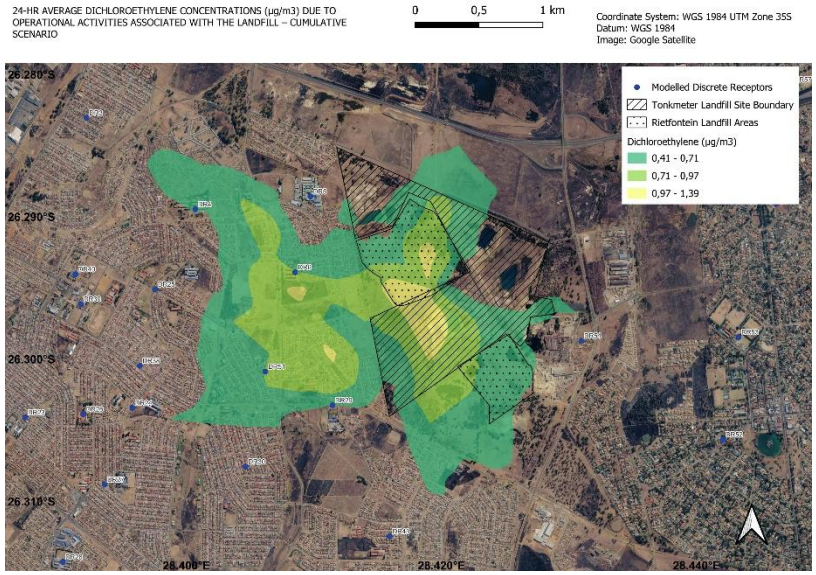


Figure 6-25: Predicted Dichloroethylene daily average incremental concentrations for the project site.

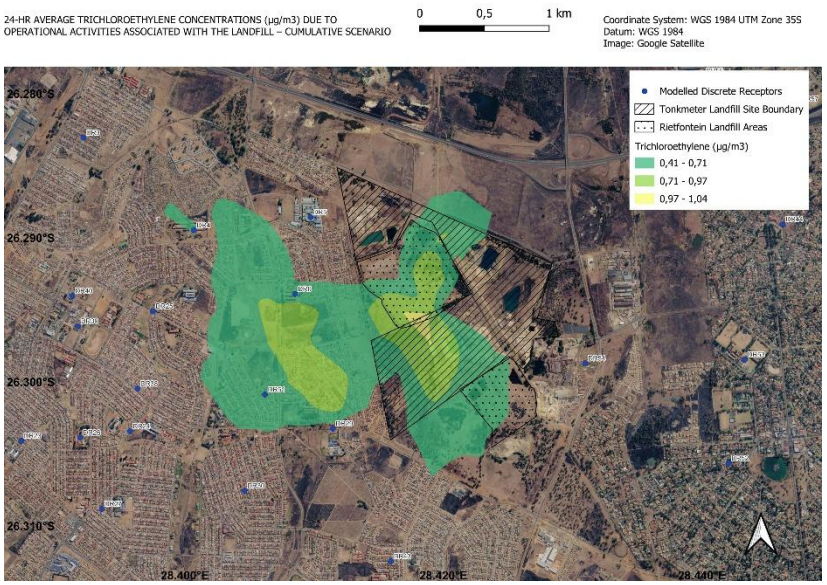


Figure 6-26: Predicted Trichloroethylene daily average incremental concentrations for the project site.

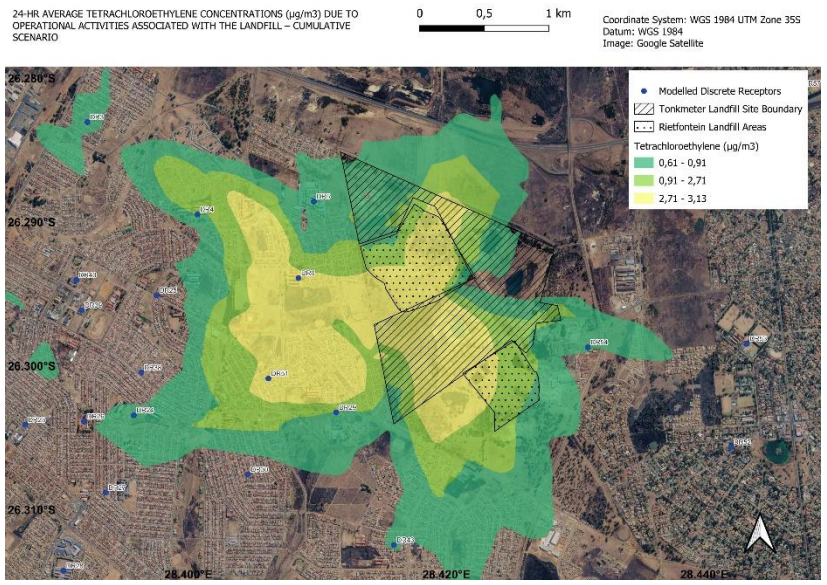


Figure 6-27: Predicted Tetrachloroethylene daily average incremental concentrations for the project site.

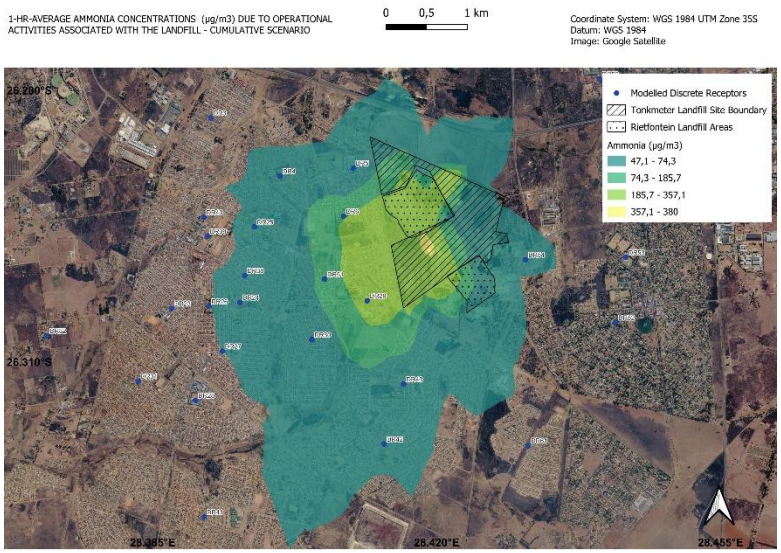


Figure 6-28: Predicted Ammonia hourly average incremental concentrations for the project site.

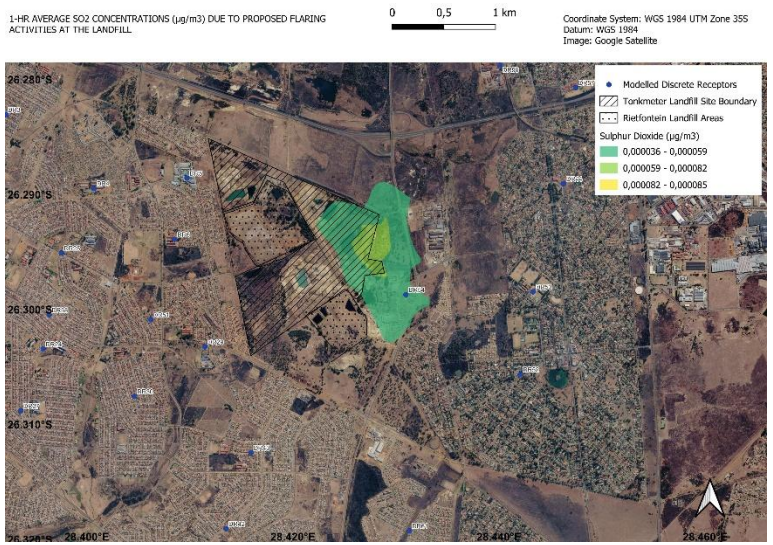


Figure 6-29: Predicted SO_2 hourly average incremental concentrations associated with proposed flaring activities.

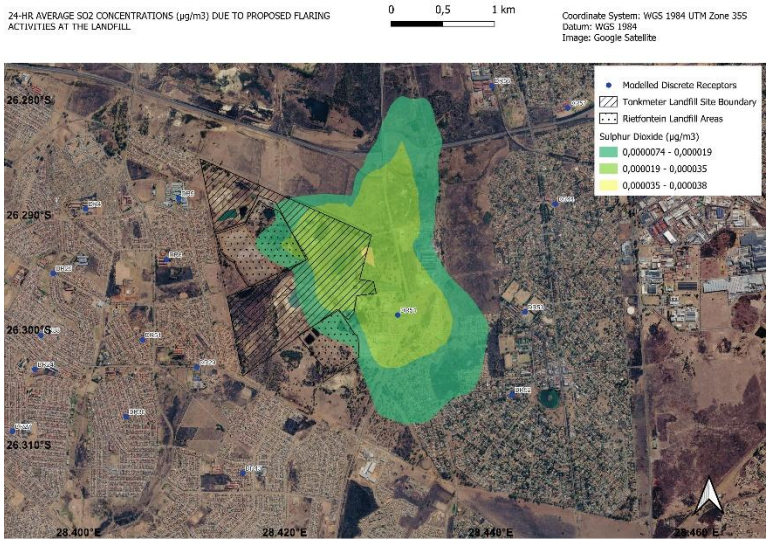


Figure 6-30: Predicted SO_2 daily average incremental concentrations associated with proposed flaring activities.

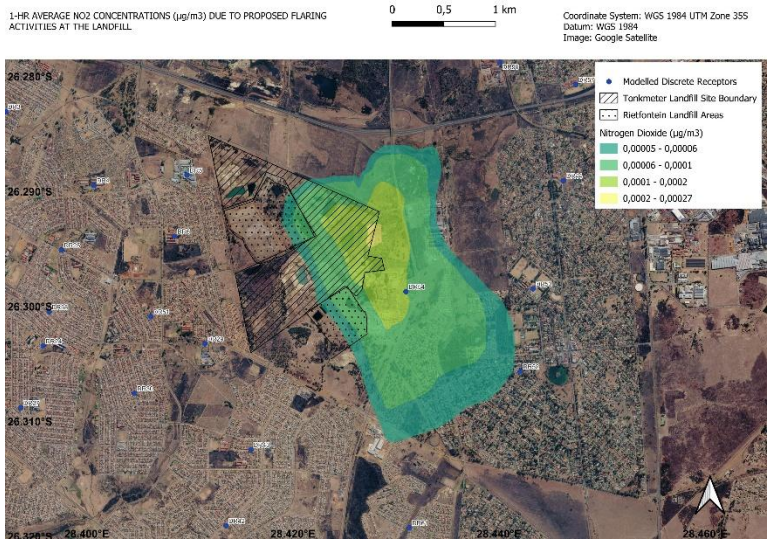


Figure 6-31: Predicted NO_2 hourly average incremental concentrations associated with proposed flaring activities.

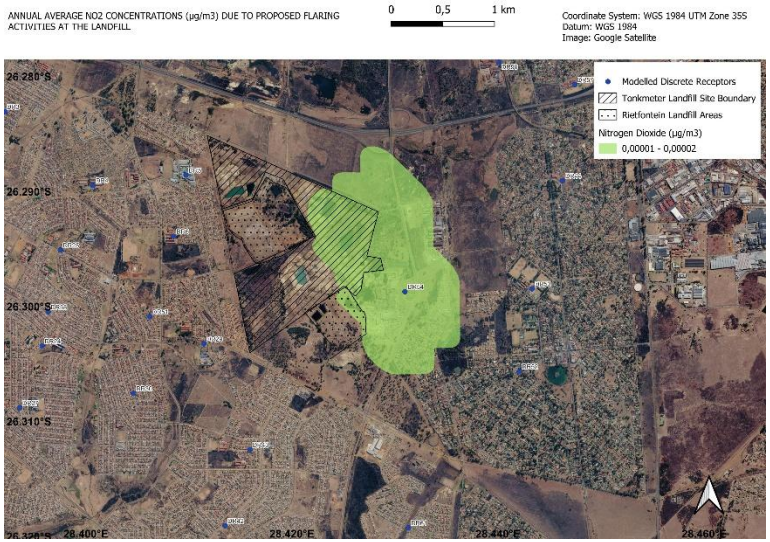


Figure 6-32: Predicted NO_2 annual average incremental concentrations associated with proposed flaring activities.

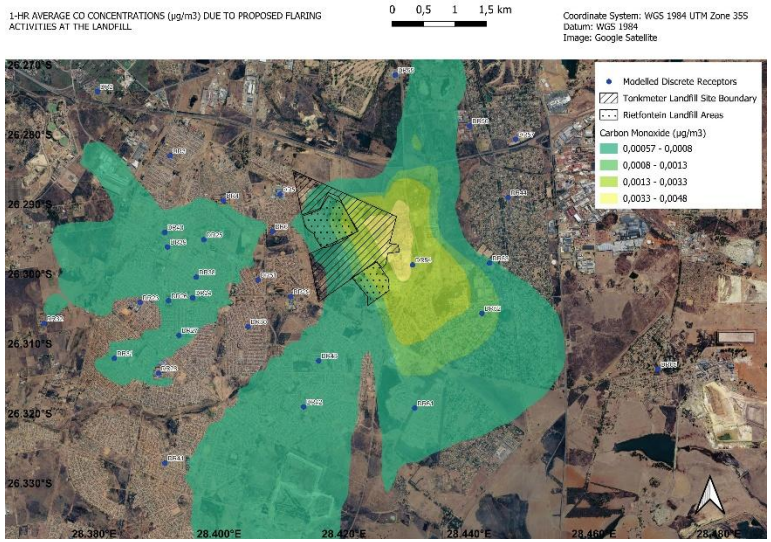


Figure 6-33: Predicted CO hourly average incremental concentrations associated with proposed flaring activities.

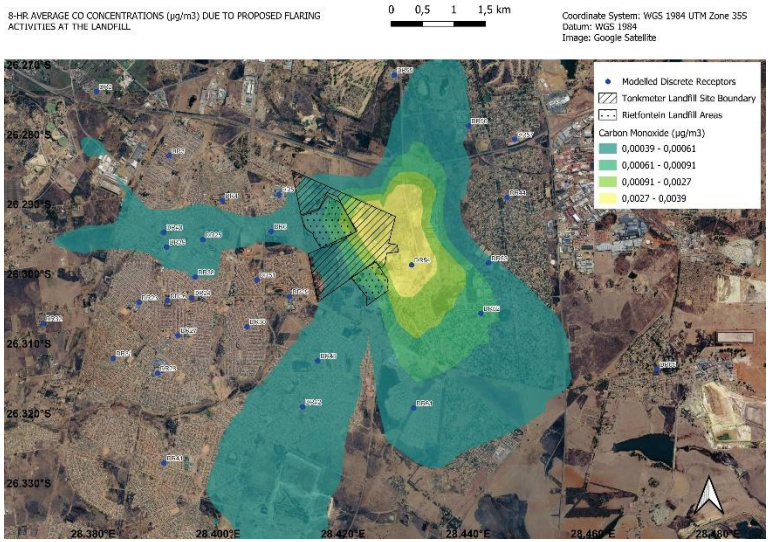


Figure 6-34: Predicted CO 8-hourly average incremental concentrations associated with proposed flaring activities.

6.6.5. Dispersion Model Output Plots for Odour Impacts (Cumulative Scenario).

The dispersion model output plots for odour emissions associated with the cumulative scenario are given in Figure 6-35 to Figure 6-36. The dispersion model output plots are shown for both hourly and 10-minute averaging periods. Odour impacts can change quickly within a few minutes; thus a shorter timeframe of 10-minutes was also considered in this study to identify any potential short-term odour effects.

Three odour unit concentration thresholds were used in this assessment to determine the level of impact. These thresholds are based on the study completed by Nicolas *et al.,* 2006, as well as other thresholds references in the literature (ATSDR, 2007; Brattoli *et al.,* 2011; Sonibare *et al.,* 2019).

The three odour unit concentration thresholds used in this AQIA:

- **1 OU/m^3 limit = Odour detection threshold**. The odour is just barely detected in a laboratory test environment following a standard procedure, such as the European standard sampling method EN13725(2003), where 50% of a panel of trained judges detect an odour but the odour may not necessarily be recognised nor result in an annoyance if the average person were exposed to it in their environment.
- **3 OU/m^3 limit = Odour recognition threshold.** It is assumed that the average person would recognise that there is an odour and would notice if the odour is unpleasant.
- **5 OU/m^3 limit = Odour annoyance threshold.** It is assumed that most people would notice the unpleasant odour in their environment. If the person is exposed to the odour for a prolonged period or repeatedly, they may find it objectionable (i.e. annoying) resulting in a significant negative impact.

The areas shown in orange in the dispersion output plots indicate areas of exceedances with the odour unit concentration annoyance threshold limits. Based on the model output plots, it is evident that areas positioned south, south-west, and west of the project site, would be most affected by potential odour impacts from the landfill site.

Predicted odour concentrations exceed the 1 OU/m^3 detection threshold across a relatively broad area surrounding the landfill, indicating that landfill-related odours may occasionally be detectable beyond the site boundary. Areas exceeding the 3 OU/m^3 recognition threshold are more localised around the landfill, while concentrations above the 5 OU/m^3 annoyance threshold are largely confined to the immediate vicinity of the active landfill areas. The 10-minute averaging period produces higher peak odour concentrations than the 1-hour averaging period, as expected for short-term odour events (Figure 6-35 and Figure 6-36).

At the Tonkmeter site boundary, the highest predicted 1-hour odour concentration is approximately 7.45 OU/m³, while the highest predicted 10-minute concentration is approximately 10.66 OU/m³. These values exceed the 5 OU/m³ annoyance threshold, indicating that noticeable and potentially objectionable odours may occur locally at portions of the site boundary under worst-case dispersion conditions. Odour impacts are expected to decrease substantially with increasing distance from the landfill. Mitigation measures such as compacting and daily covering of waste are essential to ensure that odour emission fluxes are kept at low as possible at the landfill and to avoid potential significant odour impacts south, south-west, and west of the site.

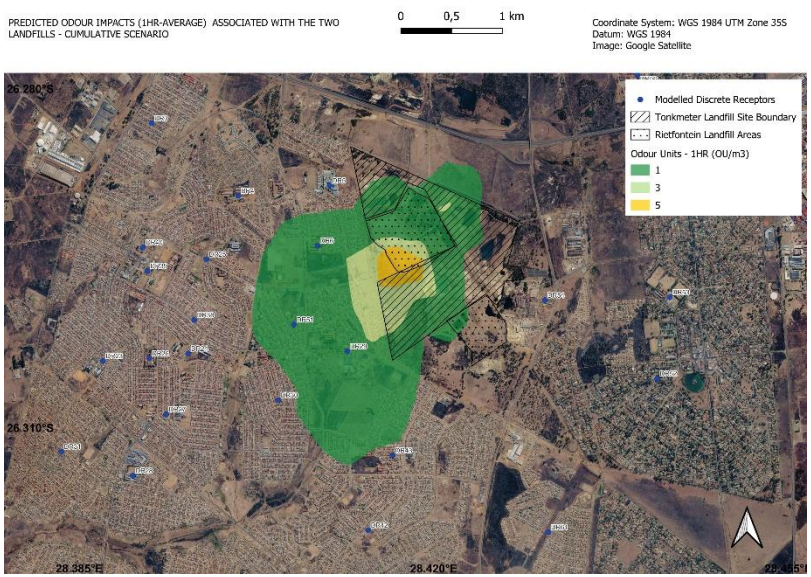


Figure 6-35: Predicted hourly average odour impacts (OU/m^3) at the project site due to odour emission fluxes from Rietfontein and Tonkmeter.

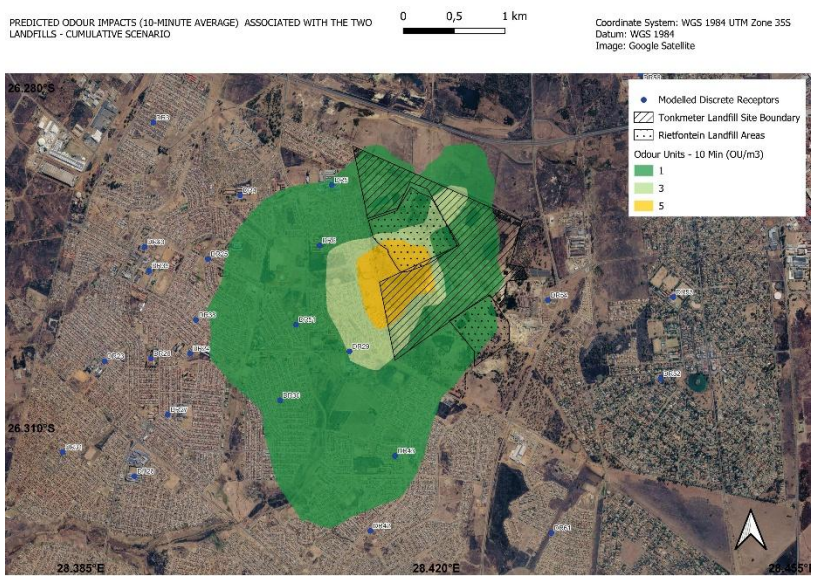


Figure 6-36: Predicted 10-minute average odour impacts (OU/m^3) at the project site due to odour emission fluxes from Rietfontein and Tonkmeter.

The maximum predicted concentrations at the Tonkmeter landfill site boundary are given in Table 6-15 below.

Table 6-15: Summary of maximum modelled incremental concentrations at the Tonkmeter landfill site boundary.

Air Pollutant	Max modelled concentration at site boundary ($\mu g/m^3$) (2)	Air Quality Guideline			Odour Threshold	
Name		Air Quality Guideline ($\mu g/m^3$)	Averaging period	Guideline Source	Detection Threshold ($\mu g/m^3$)	Recognition Threshold ($\mu g/m^3$)
Dust Group (Area E Isolated Impacts)						
Dustfall rates	650	600 mg/m^2/day	residential	SA Dust Control Regulations	N/A	
		1200 mg/m^2/day	non-residential			
Particulate matter (PM_{10})	64.40	75	24-hour	SA Ambient Air Quality Standard		
	17.70	40	Annual			
Particulate matter ($PM_{2.5}$)	6.47	40	24-hour	SA Ambient Air Quality Standard		
	1.78	20	Annual			
Dust Group (Cumulative Scenario)						
Dustfall rates	660	600 mg/m^2/day	residential	SA Dust Control Regulations	N/A	
Particulate matter (PM_{10})	64.50	1200 mg/m^2/day	non-residential	SA Ambient Air Quality Standard		
	18.90	75	24-hour			
Particulate matter ($PM_{2.5}$)	6.50	40	Annual	SA Ambient Air Quality Standard		
	1.90	40	24-hour			
BTEX Group (form part of NMOCs) (Cumulative Scenario)						
Benzene	0.83	30	1-hour	Alberta Ambient Air Quality Guideline	1500	16000
	0.17	5	Annual	SA Ambient Air Quality Standard		
Toluene	55.90	1880	1-hour	Alberta Ambient Air Quality Guideline	1300	20000
Ethylbenzene	7.60	2000	1-hour	Alberta Ambient Air Quality Guideline	730	1900
Xylene	19.79	2300	1-hour	Alberta Ambient Air Quality Guideline	180	2000
Reduced Sulphur Compounds (RSC – form part of NMOC) (Cumulative Scenario)						
Carbon Disulphide	0.9	30	1-hour	Alberta Ambient Air Quality Guideline	100	1000
Dimethyl Sulphide	7.10	30	1-hour	Ontario Ambient Air Quality Criteria	1	49
Hydrogen Sulphide (1)	>14	14	1-hour	Alberta Ambient Air Quality Guideline	0.57	7

	>4	4	24-hour	Alberta Ambient Air Quality Guideline		
Ethyl Mercaptan (Ethanethiol)	2.66	28	1-hour	British Columbia Ambient Air Standard for RSC mercaptan compounds (not defined)	1	2.5
Methyl Mercaptan (Methanethiol)	1.77				0.14	2
Chlorinated Compounds (Cumulative Scenario)						
Vinyl Chloride	7.10	130	1-hour	Alberta Ambient Air Quality Guideline	520000	910000
Dichloromethane (Methylene Chloride)	18.46	694000	1-hour	AIHA ERPG1	560000	730000
Dichloroethylene (1,2 Dichloroethene)	1.39	105	24-hour	Ontario Ambient Air Quality Criteria	23000	unknown
Trichloroethylene	1.04	12	24-hour	Ontario Ambient Air Quality Criteria	1500	20000
Tetrachloroethylene (perchloroethylene)	3.13	360	24-hour	Ontario Ambient Air Quality Criteria	unknown	8000
Other Gases						
Ammonia	285.55	1400	1-hour	Alberta Ambient Air Quality Guideline	1100	35000
SO_2	8.5E-05	350	1-hour	SA Ambient Air Quality Standard	670 – 4750	unknown
	3.8E-05	125	24-hour			
	0.00	50	Annual			
NO_2	0.00026	200	1-hour	SA Ambient Air Quality Standard	200 – 800	unknown
	2.0E-05	40	Annual			
CO	0.0048	30000	1-hour	SA Ambient Air Quality Standard	N/A	N/A
	0.0038	10000	8-hour			
Odour Units Concentrations (OU/m^3) (Cumulative Scenario)						

Scenario	Maximum OU concentration (3)	Averaging time	OU concentration threshold	Comment	N/A
OU emission flux - Tonkmeter (3.3 OU/m^2/s)	7.45	1-hour	3	odour recognition threshold	
OU emission flux – Rietfontein (3.1 OU/m^2/s)	10.66	10-minute	5	odour annoyance threshold	

Notes:
1) Relatively high values modelled along southern landfill boundary.
2) Maximum concentrations are mostly recorded along the southern and south-western landfill boundaries.
3) Maximum odour unit concentrations are moderately high along south-western landfill boundary.
4) https://www.ncbi.nlm.nih.gov/books/NBK219999.
5) European Commission, *Employment, Social Affairs & Inclusion*, Scientific Committee on Occupational Exposure Limits: Recommendation on Nitrogen Dioxide, 2014.
6) https://nj.gov/health/eoh/rtkweb/documents/fs/1012.pdf.

6.6.6. Cumulative Impacts

Emissions from sources need to be assessed in terms of the cumulative impacts in an area. The *Code of Practice for Air Dispersion Modelling in Air Quality Management in South Africa (DEA, 2014),* outlines the following for sources influenced by background concentrations in urban areas and priority areas:

- For annual averages, the sum of the highest predicted concentration (C_P) and background concentration (C_B) must be less than the SNAAQS, no exceedances allowed;
- For short-term averages (24 hours or less), the sum of 99th percentile concentrations and background concentration (C_B) must be less than the SNAAQS. Wherever one year is modelled, the highest concentrations shall be considered.

Cumulative impacts associated with operation of the Tonkmeter and Rietfontein landfills were discussed in Section 6.6. Cumulative concentrations, calculated by adding the predicted incremental Tonkmeter/Rietfontein contributions to the measured background pollutant concentrations are presented in Table 6-16. There was background air quality monitoring data (for PM_{10}, $PM_{2.5}$, SO_2 and NO_2 from the Springs AQMS for the project site (see Section 5.2).

The cumulative concentrations represent a conservative screening assessment based on the arithmetic addition of the maximum measured background concentration and the maximum predicted incremental concentration at the landfill boundary. These maxima may not occur at the same location or at the same time and therefore do not necessarily represent an actual coincident ambient concentration.

Table 6-16: Summary of cumulative impacts at the Tonkmeter landfill boundary.

Pollutant	Averaging Period	Highest Concentration (µg/m^3)		Sum of C_B and C_P	Standard (µg/m^3)
		Background [1] (C_B)	Predicted [2] (C_P)		
All modelled scenarios					
PM_{10}	Daily	287.70	64.50	352.20	75[4]
	Annual	53.90	18.90	72.80	40[5]
$PM_{2.5}$	Daily	192.95	6.50	199.45	40[4]
	Annual	29.09	1.90	30.99	20[5]
SO_2	Hourly	238.52 (91.04 ppb)	0.000085	238.52	350[3]
	Daily	60.26 (23.00 ppb)	0.000038	60.26	125[4]
	Annual	16.40 (6.26 ppb)	0.00	16.40	50[5]
NO_2	Hourly	180.76 (96.15 ppb)	0.00026	180.76	200[3]
	Annual	28.29 (15.05 ppb)	0.00002	28.29	40[5]

Notes:

(1) Considered the maximum background PM_{10}, $PM_{2.5}$, SO_2 and NO_2 concentrations recorded at the Springs AQMS. Please refer to Section 5.2 for more details on the background air quality data.
(2) Considered the maximum predicted incremental PM_{10}, $PM_{2.5}$, SO_2 and NO_2 concentrations at the Tonkmeter landfill boundary.
(3) Hourly South African NAAQS.
(4) Daily South African NAAQS.
(5) Annual South African NAAQS.

6.6.7. Impact Analysis

The level of impact of operational activities associated with the proposed activities, is assessed based on consequence/inherent risk and likelihood, using the methodology in Table 6-17 and Table 6-18 and summarised in Table 6-19, which provides the residual risk/overall impact significance ratings (O'Beirne, 2024). The impact rating methodology is explained in more detail in Appendix E.

Overall, low to moderate negative impact significance ratings (i.e., low-moderate residual risk) for air quality are predicted at the sensitive receptor locations and at the site boundary (Table 6-19).

Table 6-17: The hierarchy of potential consequences of changes in the receiving environment (impacts). These consequences are expressed as inherent risks or benefits (what could happen) because of the impacts.

	Environmental Cost	Rating
Inherent Risk	Human health – morbidity / mortality, loss of threatened species population(s), loss of strategic water source potential or sequestered carbon stocks.	High
	Material reductions in threatened or endemic species populations or habitat, loss of livelihoods, individual economic loss.	Moderate-high
	Material reductions or degradation of environmental quality – air. Loss of habitat, loss of heritage, amenity.	Moderate
	Nuisance	Moderate-low
	Negative change - with no other consequences.	Low

Table 6-18: Likelihood categories and definitions in ascribing impact significance.

Likelihood	Definitions
Highly unlikely	The possibility of the consequence occurring is negligible
Unlikely but possible	The possibility of the consequence occurring is low but cannot be discounted entirely
Likely	The consequence may not occur, but a balance of probability suggests it will.
Highly likely	The consequence may still not occur, but it is most likely that it will.
Definite	The consequence will definitely occur.

Table 6-19: Integrated rating of air quality and odour impacts associated with the proposed Area E height extension.

Impact Pathway	Spatial Context	Consequence	Likelihood	Residual Risk	Rating Rationale
PM_{10}, $PM_{2.5}$ and dustfall	Site boundary	Moderate-low (local nuisance) / Low for health-related consequence under the assessed concentrations	Likely that some local dust effect will occur, but material deterioration is unlikely with controls	**LOW**	The predicted effect is localised and mainly nuisance related. The project increment remains within the applicable particulate standards at the boundary.
PM_{10}, $PM_{2.5}$ and dustfall	Sensitive receptor areas	Low	Unlikely but possible	**LOW**	A measurable project-related change may occur, but material deterioration in receptor-area air quality is not expected from the project increment.
HAPs / BTEX	Site boundary	Low to Moderate consequence potential, but no material degradation is predicted under the assessed waste assumptions	Highly unlikely to Unlikely but possible	**LOW**	The existence of hazardous compounds gives an inherent concern, but predicted ambient concentrations are low and health-based consequences are not expected under the assessed conditions.
HAPs / BTEX	Sensitive receptor areas	Low	Highly unlikely	**LOW**	No material HAP-related deterioration of receptor-area air quality is predicted.

Impact Pathway	Spatial Context	Consequence	Likelihood	Residual Risk	Rating Rationale
H_2S and reduced sulphur compounds	Site boundary / near-field	Moderate – localised material degradation of air quality	Likely under unfavourable dispersion conditions in the affected near-field portions	**MODERATE**	The H_2S screening-guideline exceedance moves the impact beyond nuisance alone and supports a Moderate consequence. The effect is localised rather than widespread, so a High residual risk is not supported.
H_2S and reduced sulphur compounds	Nearest potentially affected receptors	Moderate where a material air-quality deterioration could occur; otherwise Moderate-low for nuisance	Unlikely but possible	**MODERATE (conservative near-field rating)**	Intentionally conservative for the closest receptor areas.
H_2S / odour	Wider receptor area	Moderate-low (nuisance)	Unlikely but possible	**LOW**	Nuisance impacts
Overall odour (OU)	Site boundary	Moderate-low (nuisance)	Highly likely during adverse/worst-case conditions, but not Definite continuously	**LOW for odour nuisance alone**	Nuisance impacts.
Landfill-gas flare emissions (SO_2, NO_2 and CO)	Boundary and receptor areas	Low	Likely that a small incremental change will occur, but without material consequence	**LOW**	The predicted change is small and no material deterioration in ambient air quality is expected.

6.6.7.1. Reasoned Opinion Regarding the Acceptability of the Project.

The overall residual risk rating for the proposed operations is classified as Moderate (Table 6-20). Therefore, the proposed Area E height extension is considered acceptable for authorisation from an air quality perspective, subject to enforceable mitigation, monitoring and corrective-action requirements recommended in Section 7 of this report. No fatal flaw has been identified. The project is not predicted to cause widespread non-compliance with the applicable SA NAAQS; the residual concern is instead a localised near-field risk associated with H_2S and landfill odour.

The acceptability conclusion is dependent on the measures relied upon by the AQIA being implemented as binding commitments. These include routine dust suppression on unpaved roads, effective spreading/compaction and daily cover, strict waste-acceptance control, effective leachate and stormwater management, landfill-gas and odour monitoring, a complaints and corrective-action system, and implementation of landfill-gas capture/flaring when monitoring indicates that active gas management is required.

Table 6-20: Decision-making implications of the different significance categories.

Rating	Implication for decision-making
Fatally Flawed	The project cannot be authorised.
High	The project can be authorised but with strict conditions and high level of compliance and enforcement.
Moderate	The project can be authorised but with conditions and routine inspections.
Low	The project can be authorised with a low risk of environmental degradation.

6.7. Assumptions, Limitations and Exclusions

The following key assumptions, limitations and exclusions of the study are given below.

The assumptions adopted in this assessment were reviewed as part of the sensitivity analysis described in Section 6.5.4. The sensitivity analysis considered whether reasonable changes to individual assumptions could materially affect calculated emissions, predicted concentrations, compliance with applicable assessment criteria, the spatial extent of impacts, or the overall air-quality impact significance.

Assumptions identified as having a high or moderate influence on the assessment outcome were incorporated explicitly into the emissions inventory and dispersion modelling, generally using conservative or reasonably foreseeable operating conditions. Assumptions considered less likely to materially alter the overall conclusions were retained as disclosed limitations and, where appropriate, addressed through operational mitigation, monitoring or future verification.

Assumptions:

- Landfill operating hours were assumed to be 11 hours per day (07:00 – 18:00), seven days per week, except for waste compaction, which was assumed to occur for approximately 5 – 6 hours per day. Operating duration influences annual and short-term emission rates and was therefore incorporated directly into the assessment.
- Flaring was assumed to occur for 24 hours a day and seven days a week.
- The dimensions and locations of the modelled emission sources, including the landfill cells, active workface, disposal route and Rietfontein leachate dams, were based on information supplied by the client and available site information. Source dimensions and locations were identified as potentially material to near-field impacts, as changes in source extent or proximity to the site boundary may influence predicted concentrations. The available information was therefore used to represent the reasonably foreseeable operating configuration.
- Material throughputs were based on information supplied by the client and included the following:
    - A maximum waste throughput of 500 tonnes/day was adopted. The sensitivity assessment identified waste throughput as a material input, as it directly affects waste handling, vehicle movements, cover-material requirements and long-term landfill-gas generation. The maximum throughput was therefore conservatively assumed to remain constant throughout the 39-year operational period associated with the proposed Area E height extension.
    - Cover material requirements were calculated using a cover-to-waste ratio of 1:5, assuming a compacted waste density of 1 tonne/m³. The cover-material assumption has a lesser influence on the overall assessment than total waste throughput but affects emissions from excavation, transport, handling and placement of cover material.
- The landfill currently accepts predominantly low-risk general waste, with no hazardous waste accepted. The proposed amendment would allow for the disposal of Type 2 and Type 3 waste on the Class B liner; however, the specific waste streams within these categories have not yet been finalised. Waste composition was identified as a material uncertainty, particularly for landfill-gas, HAPs and odour emissions. Published/default landfill-gas

parameters and conservative assumptions were therefore retained for the assessment. Should the final waste streams differ materially from those assumed in this AQIA, the potential air-quality implications should be reviewed prior to acceptance.

- Published/default landfill-gas generation parameters were applied where site-specific gas-generation measurements were unavailable. Landfill-gas generation was identified as a high-sensitivity variable because it directly influences predicted HAP and odorous-gas emissions. Operational landfill-gas monitoring is therefore recommended to verify the assumptions once sufficient waste has been deposited and gas generation becomes established.
- Landfill-gas capture and flaring were considered in the assessment following confirmation of the proposed gas-management approach. Flaring was identified as a material air-quality management variable, as effective collection and destruction of landfill gas can reduce uncontrolled landfill-gas and odour emissions. Combustion emissions associated with the flare were therefore modelled separately to confirm that implementation of this mitigation would not introduce significant secondary air-quality impacts.
- Dust-control measures incorporated into the assessment included:
    - watering of the unpaved disposal route, assumed to achieve a 50% reduction in dust emissions; and
    - compaction and application of daily cover at the active workface, assumed to provide a 30% reduction in dust emissions.
- The sensitivity screening identified haul-road dust control and management of the active workface as material operational controls. The modelled reductions therefore rely on these measures being implemented consistently throughout operations. Reduced or ineffective application of these controls could result in higher particulate emissions than those predicted in the assessment.

Limitations

- Dispersion modelling requires source-specific information such as emission-source dimensions, activity rates, material characteristics, control efficiencies and source locations. Not all future operational details can be known with certainty over the multi-decade life of the landfill. Where information was unavailable, published parameters, engineering estimates and conservative assumptions were applied.
- The sensitivity assessment was undertaken to identify those uncertainties most likely to influence the conclusions of the AQIA. It does not represent modelling of every conceivable future operating configuration. Additional dispersion scenarios were considered necessary only where a reasonably foreseeable alternative assumption could materially change predicted compliance, receptor exposure, the spatial extent of impacts or the overall impact-significance rating.
- The assessment considers operational activities associated with Area E at the Tonkmeter landfill, together with relevant cumulative emissions from exposed areas, leachate dams and landfill gas associated with the neighbouring Rietfontein landfill.
- Construction activities associated with the phased development of future cells within Area E were not explicitly modelled. The sensitivity screening identified construction emissions as being of lower long-term materiality than operational emissions because these activities will be temporary, intermittent and spatially variable. Construction-related dust can also be readily managed through standard dust-control measures. Provided that appropriate controls

are implemented during each development phase, these emissions are not expected to materially alter the overall AQIA conclusions.

- The exact location and dimensions of the active workface will change as landfilling progresses. The model therefore represents a reasonable operating configuration rather than every possible future workface position. Operational controls, including minimisation of the active workface, compaction and daily cover, should be maintained irrespective of workface location.
- The long operational period introduces unavoidable uncertainty regarding future equipment, vehicle technology and fuel type. Vehicle exhaust emissions were considered less material to the overall AQIA conclusions than fugitive particulate, landfill-gas and odour sources and were therefore not subjected to additional detailed scenario modelling. This assumption should be reviewed if future vehicle numbers or operating characteristics differ substantially from those assessed.

Exclusions

- Emission sources outside the Tonkmeter and Rietfontein landfill areas were not individually quantified or explicitly represented as sources within the dispersion model, as detailed source-specific information for all surrounding activities is not available. Regional background air quality was instead characterised using available ambient monitoring data and, where appropriate, was combined with predicted incremental concentrations to provide a conservative indication of cumulative ambient concentrations.
- Activities or future operational changes outside the project scope, and which cannot presently be reasonably defined, were not modelled. Should future operations differ materially from the assumptions identified by the sensitivity analysis as being of high significance, particularly waste throughput, waste composition, landfill-gas generation or gas-management practices, the AQIA assumptions should be reviewed and additional assessment undertaken where warranted.

7. MITIGATION MEASURES

7.1. Recommended Mitigation Measures for the Construction Phase

Dust emissions due to construction activities at Area E will occur over different stages of the operational life of Area E as the Cells will be developed using a phased approach. These emissions will be short-term but can be easily mitigated with the implementation of dust control measures summarised in Table 7-1.

Table 7-1: Dust control measures for construction (Department of Environment and Conservation, 2011).

DUST CONTROL MEASURE	DESCRIPTION
Limit Cleared Areas	Before the commencement of any site works and during the operation, as much vegetation as possible should be retained, including patches and strips to minimise dust. Dust emissions can be controlled using the following procedures: • Before any site works commence, plan and locate the vegetation cover that needs to be retained; • Protect this vegetation by fencing or blocking off from the rest of the site operations; • In other areas, maintain the original vegetation cover for as long as possible; • Avoid clearing the entire site at once, instead clear areas as required in stages of the operation. Retaining the original trees, shrubs and grasses is one of the most efficient and effective ways of minimising dust emissions. Even low or sparse vegetation can be very effective at dissipating wind velocity at the ground surface, where dust lift off occurs.
Vegetative Stabilisation	Vegetation is a very effective form of reducing dust emissions. The following procedures should be considered in minimising dust emissions: • Retain as much existing vegetation as possible; • If an area needs to be cleared, transplant established plants that must be disturbed to areas that need vegetation; • If existing vegetation must be removed and cannot be immediately transplanted elsewhere, remove and maintain them for replanting at project completion. If trees and plants must be removed and it is not possible for them to be replanted, consider chipping and using the material as mulch – the advantage is that reseeding of original vegetation can occur. Where possible, restore vegetation that is native to the area to maximise plant success and improve environmental conditions.
Timing of Development	Activities with high dust-causing potential, such as topsoil stripping, should not be carried out in sensitive areas during adverse wind conditions. When necessary, topsoil should be stripped in discrete sections, allowing buffer strips (windbreaks) between clearings.
Wind Barriers	Having appropriate wind barriers can be an effective measure for the control of dust over short distances. Wind barriers provide protection against the movement and impact of dust on nearby land uses. Wind barriers should be placed on site before commencement of works and when it is apparent that one is required during the phase of the operation. Consider the following options when placing barriers to prevent dust emissions: • Wind barriers are most effective when placed perpendicular to the direction of the prevailing wind, but will have little or no effect when the wind direction is parallel to the fence; • When choosing wind barriers, it has been observed that solid barriers provide significant reductions in wind velocity for relatively short leeward distances, whereas porous barriers provide smaller reductions in velocity for more extended distances;

	• Wind barriers should be at least 2 meters high; • The screening material should have a porosity of 50% or less.
Earth Moving Management	Earth-moving works have the potential to generate large amounts of dust. Planning earth-moving works particularly at the start of an operation can reduce dust emissions by limiting the time the site is exposed. Options for dust control can include the following: • Plan earth-moving works so that they are completed just prior to the time they are needed; • Observe weather conditions and do not commence or continue earth moving works if conditions are unsuitable e.g., under conditions of strong winds; • Reduce off-site hauling via balanced cut and fill operations; • Pre-water areas to be disturbed.

7.2. Recommended Mitigation Measures for the Operational Phase

The mitigation and management measures recommended below for the operational phase have been classified according to their importance to the AQIA findings. Measures that were incorporated into the emissions inventory or dispersion modelling, or are necessary to maintain the predicted impact significance, are regarded as mandatory operational commitments. Measures triggered by monitoring results or future operational conditions are regarded as conditional mandatory measures. Additional measures that would further reduce emissions but were not relied upon in determining the modelled impacts, are regarded as best-practice measures.

7.2.1. Mandatory Operational Mitigation Measures

These controls that must be implemented throughout operations because the emissions inventory, dispersion modelling and residual impact conclusions depend on their effective implementation.

- Dust suppression on unpaved roads: The unpaved disposal route must be routinely watered to maintain effective dust suppression. A 50% control efficiency was incorporated into the emissions inventory and dispersion modelling; therefore, this measure should be treated as a binding operational commitment.
- Spreading, compaction and daily covering of waste: Freshly disposed waste must be spread, compacted and covered on a routine basis. These measures reduce dust, windblown litter, odour and landfill-gas emissions. Where a 30% emission reduction has been credited in the AQIA, consistent implementation is required for the predicted impacts to remain representative.
- Waste acceptance and access control: Strict access and waste-acceptance controls must be maintained to prevent illegal or unauthorised dumping and the disposal of unauthorised waste streams. This limits uncontrolled dust, HAPs, landfill-gas and odour emissions.
- Prohibition of open burning: Open burning or incineration of waste must remain prohibited, as uncontrolled burning can result in significant emissions of particulate matter, toxic pollutants and odorous compounds.
- Leachate and stormwater management: The leachate collection, storage and stormwater management systems must be properly operated and maintained to avoid excessive moisture accumulation and minimise conditions that may promote landfill-gas and odour generation.
- Complaints register: An internal complaints register must be maintained to record air-quality and odour complaints, investigations, corrective actions and outcomes.

- Landfill-gas and odour monitoring: Landfill-gas and odour monitoring should be implemented once gas generation becomes established, with monitoring used to verify the AQIA assumptions and identify the need for further corrective action.

7.2.2. Conditional/Trigger Mitigation Measures

These measures are not necessarily required from the onset of operations associated with the Area E height extension but should become mandatory once defined operational or monitoring triggers are reached.

- Landfill-gas capture and flaring: The landfill-gas collection and flaring system should be implemented when landfill-gas generation reaches levels requiring active management, as informed by landfill-gas monitoring and the approved gas-management design.
- Formal landfill-gas management plan: A formal landfill-gas management plan should be implemented if monitoring shows that gas extraction or flaring is ineffective, or where elevated methane, persistent odour complaints or off-site gas migration are identified.
- Additional controls for Type 2 and Type 3 waste streams: Once the specific additional waste streams are confirmed, the potential air-quality and odour implications should be reviewed before acceptance. Additional controls should be made mandatory where the final waste composition could materially alter landfill-gas, HAPs or odour emissions.

7.2.3. Best Practice Measures

These measures provide additional environmental benefit but were not relied upon directly to derive the modelled impact conclusions. They should be implemented where feasible and where consistent with the final landfill design and operational requirements.

- Continue recovery and recycling of recyclable materials to reduce the volume of waste placed in the landfill.
- Separate garden and green waste from the incoming waste stream and manage it separately for chipping or composting where feasible.
- Limit highly putrescible or high-organic-content wastes where operationally and legally feasible.
- Use suitable permeable daily cover material where this is compatible with geotechnical, landfill-gas and operational requirements.
- Undertake dry recycling activities within an enclosed building where practicable.
- Retain and stabilise vegetation where this assists with exposed-surface dust control.
- Use wind barriers where local conditions or sensitive receptors indicate that additional windblown-dust control is required.

7.3. Summary and Conclusions

The sensitivity review indicates that the conclusions of the AQIA are most influenced by assumptions relating to waste throughput and composition, landfill-gas generation, landfill-gas capture and flaring, active-workface characteristics, and the effective implementation of dust-control measures. These variables were therefore treated conservatively in the assessment and should

remain subject to operational control and verification. Other variables, including short-term cell-construction activities and vehicle fuel type, are not expected to materially alter the overall assessment conclusions under the assumed operating conditions. Residual uncertainty should therefore be managed through appropriate waste-acceptance controls, dust-management measures, landfill-gas and odour monitoring, and adaptive management where monitoring identifies the need for further intervention.

The residual air-quality impacts associated with the proposed Area E height extension are predicted to range from Low to Moderate. Residual impacts associated with particulate matter, dustfall, most HAPs and flare-related criteria pollutants are considered Low, as predicted incremental concentrations remain within the applicable assessment criteria and generally decrease with increasing distance from the landfill. The principal residual concern relates to localised hydrogen sulphide (H_2S) and landfill odour impacts. The H_2S impact is rated Moderate at the site boundary and immediate near-field because localised exceedances of the applicable screening guidelines indicate the potential for material deterioration in air quality under unfavourable dispersion conditions. A Moderate residual rating is also applied conservatively to the nearest potentially affected receptors, while impacts across the wider receptor area are considered Low.

Overall, no High or Fatally flawed air-quality impacts have been identified. The proposed Area E height extension is therefore considered acceptable from an air-quality perspective, provided that the mitigation measures relied upon in the AQIA are incorporated into the EMPr as binding commitments and effectively implemented throughout the operational life of the facility. Emphasis should be placed on dust suppression, compaction and daily cover, strict waste-acceptance controls, effective leachate management, landfill-gas and odour monitoring, landfill-gas capture and flaring where required, and prompt corrective action in response to monitoring results or complaints.

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9. DECLARATIONS

Name of Enterprise: Tonkmeter (Pty) Ltd - Air Quality Impact Assessment Report for the TRF - Proposed Extension of the Final Landfill Cell Height for Area E

Project Consultant:	EcoPartners		
Contact person:	San Oosthuizen		
Postal address:	177 Weltevreden Road, Berario		
Postal code:	2195	Cell:	072 391 4679
Telephone:	TBC	Fax:	
E-mail:	san@ecopartners.co.za		

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act:

I San Oosthuizen declare that – General declaration

The information provided in this atmospheric impact report is, to the best of my knowledge, in all respects factually true and correct.

I am aware that the supply of false or misleading information to an air quality officer is a criminal offence in terms of section 51(1)(g) of this Act.

Signed at _____on this_____ day of_____

_____

SIGNATURE

_____

CAPACITY OF SIGNATORY

DECLARATION OF INDEPENDENCE - PRACTITIONER

Specialist:	Rayten Engineering Solutions (Pty) Ltd		
Contact person:	Gertrude Mafusire		
Postal address:	PO Box 1369, Bromhof, 2154		
Postal code:	2154	Cell:	
Telephone:	0117920880	Fax:	086 592 0298
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Professional affiliation(s) (if any)	SACNASP (400171/15)		

Name of Practitioner: Rayten Engineering (Pty) Ltd

Name of Registration Body: South African Council for Natural Scientific Professions

Professional Registration No: 400171/15

Declaration of accuracy of information provided:

Atmospheric Impact Report in terms of Section 30 of the Act:

I Gertrude Mafusire, declare that – General declaration

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

Signed at **Roodepoort** on the **13TH** day of **October 2026**



SIGNATURE

Senior Associate

CAPACITY OF SIGNATORY

APPENDIX A

AIR DISPERSION MODELLING CHECKLIST

Table A 1: Information Required in Air Dispersion Modelling Report.

Information Required in Plan of Study Report				
Description	**Included (Y/N)**	**Section**	**Page no.**	**Comments**
1. Facility and Modellers Information				
Project Identification Information				
Applicant details	Y	1.1	1-2	
Facility Identification	Y	1.1	1-2	
Physical address of facility	Y	1.1	1-2	Co-ordinates provided
AEL number	N	1.1	1-2	No AEL Required
EIA reference	N			
Modelling contractors	Y	1.1	1-2	
Project Background				
Objectives of Baseline Assessment	Y	1	1	
Process description	Y	1.2	2-4	
Project Location				
Site layout plan	Y	1.2	5	
Regional map	Y	2	16-19	
Adjacent area map	Y	2	16-19	
Surrounding land use map	Y	2	16-19	
Elevation data (DEM)	Y	2	16-19	
2. Emission Characterisation				
Proposed emissions & source parameters				
All identifiable emissions listed	Y	6	61-62	
Parameters for each operating scenario	Y	6.1-6.4	63-82	
Proposed emissions calculations	Y	6.1-6.4	63-82	
3. Meteorological Data				
Surface Data				
Source of data	Y	5.1	41-42	
Seasonal wind roses	Y	5.1.1	45	
3-year representative data	Y	5.1.1	43	
Program used to process data	Y	5.1	41-42	
Description of station	Y	5.1	41-42	
Period of record	Y	5.1	41-42	
Spatial representativeness	Y	5.1	41-42	
Data complies with Code of Practice	Y	5.1	41-42	

Upper Air Data				
Source of data	Y	5.1	41-42	
4. Ambient Impact Analysis and Ambient Levels				
Standard Levels				
National Ambient Air Quality Standards	Y	3.5	24-25	
Background Concentrations				
Background values specified	N	5.2	48-58	For criteria air pollutants
5. Modelling Procedures				
Proposed Model				
Assessment level proposed	Y	6.5.2	83-84	
Dispersion model to be used	Y	6.5.1	82-83	
Supporting models to be used	Y	6.5.2	83-84	
Version of models to be used	Y	6.5.2	83-84	
Proposed Emissions to be Modelled				
Pollutants specified	Y	6.5.2	83-84	
Scenarios to be modelled	Y	6.5.3	84	
Conversion factor utilized	N			Not used
Proposed Settings				
Settings to be utilized	Y	6.5.2	83-84	Table 6-13
Terrain settings	Y	6.5.2	83-84	Table 6-13
Land characteristics	Y	6.5.2	83-84	Table 6-13
Grid Receptors				
Property line resolution	Y	6.5.2	83-84	Table 6-13
Fine grid resolution	Y	6.5.2	83-84	Table 6-13
Medium grid resolution	Y	6.5.2	83-84	Table 6-13
Large grid resolution	Y	6.5.2	83-84	Table 6-13
6. Ambient Impact Results Documentation				
Tables of Modelling Results				
Pollutant	Y	6.6.5	112-114	Table 6-15
Averaging time	Y	6.6.5	112-114	Table 6-15
Operating scenario	Y	6.6.5	112-114	Table 6-15
Maximum modelled concentration	Y	6.6.5	112-114	Table 6-15
Receptor location	Y	2.4	12-15	
Receptor elevation	Y	2.4	12-15	
Date of maximum impact	N			
Name of output e-files	Y	Appendix B	135	
Source Impact Area Figures				
UTM co-ordinates	Y	6.6.1 – 6.6.5	87-114	
Modelled facility	Y	6.6.1 –	87-114	

		6.6.5		
Topography features	Y	2.3	9&13	
Isopleths	Y	6.6.1 – 6.6.5	87-114	
Value of maximum impact	Y	6.6.5	112-114	At boundary (Table 6-15)
Value of maximum cumulative impact	N			
7. Ambient Impact Supporting Documentation				
Electronic Files				
Electronic files can be provided upon request				
Input & output files for models	Y	Appendix B	135	name of files specified
Input & output files for pre-processors	Y	Appendix B	135	name of files specified
Input & output files for post-processors	Y	Appendix B	135	name of files specified
Digital terrain files	N			
Plot files	Y	Appendix B	135	name of files specified
Final report	Y			

APPENDIX B

OUTPUT E-FILES

Table B1: List of output e-files

Tonkmeter_Benzene_Cumulative	10/5/2026 6:32 AM	File folder
Tonkmeter_BTEX_Cumulative	10/5/2026 6:35 PM	File folder
Tonkmeter_CHLOROS_Cumulative	10/6/2026 5:28 PM	File folder
Tonkmeter_CO_Flaring	10/6/2026 6:04 PM	File folder
Tonkmeter_H2S_Cumulative	10/6/2026 9:34 PM	File folder
Tonkmeter_Met	8/22/2026 10:01 AM	File folder
Tonkmeter_NH3_Cumulative	10/6/2026 8:39 PM	File folder
Tonkmeter_NO2_Flaring	10/6/2026 9:54 PM	File folder
Tonkmeter_Odour_Cumulative	10/8/2026 3:56 PM	File folder
Tonkmeter_PM10_AreaE	10/11/2026 6:57 PM	File folder
Tonkmeter_PM10_Cumulative1	10/12/2026 8:40 AM	File folder
Tonkmeter_PM25_AreaE	10/11/2026 7:12 PM	File folder
Tonkmeter_PM25_Cumulative1	10/12/2026 6:14 AM	File folder
Tonkmeter_SO2_Flaring	10/6/2026 10:18 PM	File folder
Tonkmeter_SULPHIDES_Cumulative	10/6/2026 10:26 PM	File folder
Tonkmeter_TSP_AreaE	10/11/2026 7:12 PM	File folder
Tonkmeter_TSP_Cumulative 1	10/12/2026 2:09 AM	File folder

Note: a copy of the modelling files can be provided upon request.

APPENDIX D

WIND SPEEDS ACCORDING TO THE BEAUFORT SCALE

Table D1: Beaufort Scale - Wind Speeds (Artemova, n.d.).

Beaufort number	Wind type	Wind speed	Land conditions
0	**Calm**	**0 m/s**	Calm, Smoke rises vertically
1	**Light air**	**0-2 m/s**	Wind motion visible in smoke
2	**Light breeze**	**2-3 m/s**	Wind felt on exposed skin, Leaves rustle
3	**Gentle breeze**	**3-5 m/s**	Leaves and smaller twigs in constant motion
4	**Moderate breeze**	**5-8 m/s**	Dust and loose paper are raised. Small branches move
5	**Fresh breeze**	**8-11 m/s**	Smaller trees sway
6	**Strong breeze**	**11-14 m/s**	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult
7	**Near gale**	**14-17 m/s**	Whole tree in motion. Some difficulty when walking into wind
8	**Gale, fresh gale**	**17-21 m/s**	Twigs broken from trees. Cars veer on road
9	**Severe gale**	**21-24 m/s**	Light structure damage
10	**Storm whole gale**	**24-28 m/s**	Trees uprooted. Considerable structural damage
11	**Violent storm**	**28-33 m/s**	Widespread structural damage
12	**Hurricane storm**	**>33 m/s**	Considerable and widespread structural damage

APPENDIX E

IMPACT ASSESSMENT METHODOLOGY

The significance of each identified impact was determined using the approach outlined below, which was adopted from SE Solutions' proposed impact rating methodology report (O'Beirne, 2024). However, it is noted that O'Beirne's 2024 report is in draft phase and under public review. This approach incorporates two aspects for assessing the potential significance of impacts, namely consequence/inherent risk and likelihood. Consequence and likelihood are then combined to estimate the anticipated residual risk//overall impact significance rating.

A. Inherent Risk

What ***could*** happen is expressed as ***inherent risk***, given any activity in question. For example, if there will be emissions of SO_2 from a proposed activity, then adverse human health effects are an inherent risk. Expressing inherent risk is important in significance ratings to respect the concerns of stakeholders in public participation, who are fully entitled to raise concerns about what *could* happen if an activity is authorised (O'Beirne, 2024). A preliminary list of potential consequences associated with any proposed activity is given in Table E1. This table is qualitative but can be refined over time to include additional characteristics added to each of the categories (O'Beirne, 2024).

Table E1: The hierarchy of potential consequences of changes in the receiving environment (impacts). These consequences are expressed as inherent risks or benefits (viz. what could happen) because of the impacts.

	Environmental Cost	Rating
Inherent Risk/Benefit	Human health – morbidity / mortality, loss of threatened species population(s), loss of strategic water source potential or sequestered carbon stocks.	High
	Material reductions in threatened or endemic species populations or habitat, loss of livelihoods, individual economic loss.	Moderate-high
	Material reductions or degradation of environmental quality – air. Loss of habitat, loss of heritage, amenity.	Moderate
	Nuisance	Moderate-low
	Negative change - with no other consequences.	Low
	Environmental Benefits	
	Net improvement in human welfare or threatened species habitat.	Moderate – high
	Improved environmental quality – air, soil, water. Improved individual livelihoods.	Moderate
	Economic Development but no tangible environmental benefit or impact.	Moderate-low
	Positive change – with no other consequences.	Low

There is no 'high' rating for benefits. This is to reflect that there are certain environmental costs that are intolerable regardless of the benefit they bring, and these costs cannot be 'traded off'. There is also no scientific way to 'match' the categories (viz. a moderate cost being equivalent to a moderate benefit) (O'Beirne, 2024). However, O'Beirne's 2024 report still details the importance of cost-

benefit analysis to decision-making. But the author notes that cost-benefit analysis cannot be done with qualitative findings, which are presented in Table E1.

B. Likelihood

The regulations call for 'probability' to be used in defining significance. However, Johan Nel, previously of the CEM at NWU, argues that 'likelihood' is a preferable term compared to the term 'probability', since 'probability' implies a solid statistical foundation. In most if not all instances, the probability of a given consequence is going to be expressed qualitatively rather than quantitatively in an Environmental Impact Assessment (EIA), and likelihood better articulates the qualitative nature of the assessment. One way or another, expressing the residual risk of an inherent risk requires an articulation of probability (which for significance ratings in EIA is then expressed as 'likelihood') (O'Beirne, 2024).

The likelihood of the consequences is given as a function of the scale of the impact and the sensitivity of the affected environment. Likelihood defines the difference between an inherent risk (what *could* happen) and a residual risk (what is *likely* to happen). Significance categories in the regulations can (and must) be used to argue the likelihood of the consequence viz extent, duration, intensity, etc Proposed likelihood categories are provided in Table E2 (O'Beirne, 2024).

Table E2: Likelihood categories and definitions in ascribing impact significance.

Likelihood	Definitions
Highly unlikely	The possibility of the consequence occurring is negligible
Unlikely but possible	The possibility of the consequence occurring is low but cannot be discounted entirely
Likely	The consequence may not occur, but a balance of probability suggests it will.
Highly likely	The consequence may still not occur, but it is most likely that it will.
Definite	The consequence will definitely occur.

C. Residual Risk/Impact Significance

The specialist (or Environmental Assessment Practitioner) must then ascertain what is likely to happen given the specific circumstances of the activity and the characteristics of the receiving environment. What is likely to happen (in the specialist's opinion) is expressed as residual risk. Residual risk is what must be accepted if the application is to be approved. Stated differently, what will have to be 'lived with' if the activity goes ahead? The competent authority must decide on the application based on the residual risks and how these reflect who wins and who loses (O'Beirne, 2024).

Significance is expressed as the residual risk of the consequence. The matrix given in Tabel E3 is used to combine likelihood and consequence, which provides an estimate of the residual risk/impact significance (O'Beirne, 2024).

Table E3: Residual risk matrix combining likelihood and consequence.

		Residual Risk				
Consequence	High	Moderate	High	High	Fatally Flawed	
	Moderate-high	Low	Moderate	High	High	High
	Moderate	Low	Moderate	Moderate	Moderate	Moderate
	Moderate-low	Low	Low	Low	Low	Moderate
	Low	Low	Low	Low	Low	Low
		Highly unlikely	Unlikely but possible	Likely	Highly likely	Definite
		Likelihood				

D. *Reasoned opinion regarding whether activity should be authorised.*

After determining the impact significance associated with any proposed activity, O'Beirne (2024) recommends the inclusion of a reasoned opinion regarding whether the proposed activity should be authorised in all specialist reports, in line with requirements of the EIA regulations. Ratings provided in Table E4 are proposed by O'Beirne (2024), to help assess the acceptability of any project.

Table E4: Decision-making implications of the different significance categories.

Rating	Implication for decision-making
Fatally Flawed	The project cannot be authorised.
High	The project can be authorised but with strict conditions and high level of compliance and enforcement.
Moderate	The project can be authorised but with conditions and routine inspections.
Low	The project can be authorised with a low risk of environmental degradation.