Air Quality Specialist Report for the Deposition on Savuka 7a & 7b Tailings Storage Facilities Operations

Project done on behalf of **Environmental Impact Management Services**

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Competency Profiles

Report author: H Liebenberg-Enslin, PhD Geography (University of Johannesburg)

After earning her master's degree in science from the University of Johannesburg (formerly RAU) in Geography and Environmental Management. Hanlie Liebenberg-Enslin began her professional career in air quality management in 2000 when she joined Environmental Management Services (EMS). The same department at the University of Johannesburg awarded her a PhD in June 2014 with a focus on aeolian dust transport. She is one of the founding members of Airshed Planning Professionals and served as a director of the organization until May 2013, when she assumed the role of managing director.

She has worked across Africa and has considerable experience in the many aspects of air quality management, including impact- and health risk screening assessments, dispersion modelling simulations, and emissions quantification for a variety of source types. Hanlie has been involved in a few United Nations Environmental Programme (UNEP) projects and served as the project manager on numerous innovative air quality management plan (AQMP) developments. She also participates actively in the National Association for Clean Air (NACA) and the International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA). She served as an external examiner for various MSc and PhD dissertations and lectured at air quality management courses.

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

Rochelle Bornman started her professional career in Air Quality in 2008 when she joined Airshed after having worked in malaria research at the Medical Research Council in Durban. Rochelle has worked on several air quality specialist studies between 2008 and 2025. She has experience on the various components including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality.

Report reviewer: R von Gruenewaldt (Pr. Sci. Nat.), MSc Meteorology (University of Pretoria)

Reneé von Gruenewaldt is a Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP) and a member of the National Association for Clean Air (NACA). Following the completion of her bachelor’s degree in atmospheric sciences in 2000 and honours degree (with distinction) with specialisation in Environmental Analysis and Management in 2001 at the University of Pretoria, her experience in air pollution started when she joined Environmental Management Services (now Airshed Planning Professionals) in 2002. Reneé von Gruenewaldt later completed her master’s degree (with distinction) in Meteorology at the University of Pretoria in 2009.

Reneé von Gruenewaldt became a partner of Airshed Planning Professionals in September 2006. Airshed Planning Professionals is a technical and scientific consultancy providing scientific, engineering, strategic impact assessments, management services and policy support to assist clients in addressing a wide variety of air pollution and environmental noise related projects. Her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality and noise impacts.

Executive Summary

Golden Core Trade and Invest (Pty) Ltd (Harmony Gold Mining Company Limited) owns and operates several Gold Mines and Plants in the West Wits region in the Gauteng Province. The Savuka and Mponeng mining rights areas are located within the West Rand District Municipality (DM) and Merafong City Local Municipality (LM), approximately 6 kilometres (km) south of Carletonville.The Savuka Plant currently deposits tailings onto the Savuka 7a & 7b Tailings Storage Facilities (TSFs). However, these facilities are approaching their final height of 60 m, and the current planned Life of Mine (LOM) for the West Wits region exceed the available deposition capacity of these TSFs. Accordingly, Golden Core Trade and Invest (Pty) Ltd is undertaking feasibility assessments to increase the height of the Savuka 7a & 7b TSFs to a maximum of 70 m.

Airshed Planning Professionals (Pty) Ltd was appointed by Environmental Impact Management Services (EIMS) to undertake an Air Quality Study as part of the proposed changes at the Savuka Mine. The air quality study was conducted for the current (Savuka and Mponeng operations) and future (increased height of Savuka 7a & 7b TSFs) activities. The main objective of this study was to determine the significance the increased heights of the two TSFs will have on the air quality and resulting impacts on nearby receptors. Although the focus of the study is on the significance in impact changes of the Savuka 7a & 7b TSFs height increase, the Mponeng Mine operations are included in the baseline to provide for a semi-cumulative assessment.

Study Approach and Methodology

The investigation followed the methodology required for a specialist report as prescribed in the Environmental Impact Assessment (EIA) Regulations (Government Notice R.543 in Government Gazette 33306 of 18 June 2010).

Baseline Assessment

The baseline study encompassed the analysis of meteorological data and analysis of dustfall results.

- Simulated Weather Research and Forecasting Model (WRF) meteorological data (including wind speed, wind direction and temperature) was used for the period 2022 to 2024.
- The dustfall network comprise of 15 single Dustfall Monitoring Units (DMU) in accordance with ASTM D1739 (1970), with ten (10) units at the Savuka operations and five (5) at the Mponeng operations. Dustfall results for the period January 2023 to October 2024 were made available for inclusion into this report.

Impact Assessment Criteria

Particulates represent the main pollutants of concern in the assessment of operations from the project. Daily and annual $PM_{2.5}$ (particulate matter with diameter of less than 2.5 µm) and PM_{10} (particulate matter with diameter of less than 10 µm) ground level concentrations and dust deposition rates were assessed. The simulated impacts were assessed against published National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR).

Emissions Inventory

Emissions inventories provide the source input required for the simulation of ambient air concentrations. Fugitive source emissions as a result of wind erosion from the existing sources (surrounding TSFs and marginal ore dumps), material transfer points, crushing and screening, and vehicle entrainment on unpaved roads), and the proposed height increased Savuka 7a & 7b TSFs were quantified. Point source emissions from the ventilation shafts and Mponeng Processing Plant stacks were taken from a previous study conducted for the West Wits operations.

Impact Prediction Study

Particulate matter concentrations and deposition rates due to the current and future operations were simulated using the AERMET/AERMOD dispersion modelling suite. Ambient concentrations were simulated to ascertain daily and annual averaging levels occurring as a result of the project operations.

Assumptions, Exclusions and Limitations

The main assumptions, exclusions and limitations are summarized below:

- Use was made of simulated Weather Research and Forecasting Model data for a point at the Savuka site, and this is regarded as representative of the project area.
- The quantification of sources of emission was restricted to the project activities and operations within the study domain only. Although other background sources were identified, such sources were not quantified.
- Information required for the calculation of emissions from dust sources for the project operations was supplied by EIMS with the baseline activities taken from a previous study conducted for West Wits operations. The assumption was made that this information was accurate and correct.
- Routine emissions from the operations were estimated and modelled.

Main Findings

The main findings from the air quality assessment study are as follows:

- Air Quality Sensitive Receptors (AQSRs) near the Savuka operations include Southdene (north of Savuka 5 TSF), Elandsridge (southeast of 7b TSF and southwest of 5 TSF), Harmony Hostel (southeast of 7b TSF) and Harmony Hospital (south of the Savuka Plant).
- The main sources associated with the Savuka and Mponeng operations likely to contribute to baseline Particulate Matter (PM) emissions include mining and reclaiming operations, processing operations, vehicle entrained dust from roads, vehicle exhaust and windblown dust from exposed areas on existing TSFs.
- Other sources of PM within the area include other companies mining, transport and processing activities, farm activities, occasional biomass burning, household fuel burning in the residential areas, vehicle entrained dust from public roads and vehicle exhaust.
- The wind field is dominated by winds from the northerly sector with the strongest winds (>6 m/s) mostly from the north-northeasterly sector. The predominant northerly wind field remains similar throughout the seasons.
- Dust fallout results from the 10 DMUs at Savuka for the period January 2023 to October 2024 show compliance with the NDCR at both the residential and non-residential sites.

The main findings of the impact assessment for current and future operations are as follows:

- Simulated $PM_{2.5}$ concentrations comply with the NAAQS at all AQSRs, both for current and future operations.
- Simulated PM_{10} concentrations comply with the NAAQS at all AQSRs, both for current and future operations.
- Simulated dustfall rates are above the NDCR limits for residential areas at one AQSR (Elandsridge) both during current and future operations, with a 3.5 km area of exceedance of the agricultural limit (400 mg/m²-day). Measured dustfall rates are however below the NDCR limit for residential areas at all AQSRs, including Elandsridge for the past three years, implying a possible overprediction of simulated dustfall rates.
- The environmental risk due to unmitigated future operations is classified as **Medium.** With mitigation (80% CE through grassing of TSF side slopes and wet slurry deposition) the risk is classified as **Low.**

Recommendations:

With the potential impacts from windblown dust from the active TSFs, especially the height increased Savuka 7a & 7b TSFs, the following recommendations are proposed:

- Dustfall monitoring ensuring dustfall rate in compliance with the NDCR limits; and
- Mitigation measures aimed at reducing wind erosion from the active TSFs, i.e. the grassing of TSF side slopes.

In conclusion, it is the specialist opinion that the project may be authorised provided that the recommended air quality management measures are implemented.

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List of Abbreviations

AEL	Atmospheric Emissions Licence
Airshed	Airshed Planning Professionals (Pty) Ltd
APPA	Atmospheric Pollution Prevention Act
CO	Carbon monoxide
DM	District Municipality
EIA	Environmental Impact Assessment
EIMS	Environmental Impact Management Services
FEL	Front-end-Loader
GLC	Ground level concentration
GLCC	Global Land Cover Characterisation
I&APs	Interested and affected parties
LM	Local Municipality
LOM	Life of Mine
MES	Minimum Emission Limits
MOD	Marginal Ore Dump
NMES	National Minimum Emission Standards
NAAQS	National Ambient Air Quality Standards
NDCR	National Dust Control Regulations
NEMA	National Environmental Management Act
NEM:AQA	National Environmental Management: Air Quality Act
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
O_3	Ozone
PM	Particulate matter
PM_{10}	Particulate matter with diameter of less than 10 µm
$PM_{2.5}$	Particulate matter with diameter of less than 2.5 µm
SAAQIS	South African Air Quality Information System
SO_2	Sulphur dioxide
SRTM	Shuttle Radar Topography Mission
TSF	Tailings Storage Facility
US EPA	United States Environmental Protection Agency
WHO	World health Organisation
WRF	Weather Research and Forecasting Model

Units

°C	Degree Celsius
Gg CO_2-eq	Greenhouse gas carbon dioxide equivalent
K	Kelvin
km	kilometre
kPa	kilo pascal
m	metres
mm	millimetre
mg/m²/day	milligram per metre squared per day
t	ton
tpa	tons per annum
tpm	tons per month
µg/m³	microgram per cubic metre
%	percent

Glossary

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

Atmospheric emission: means any emission or entrainment process emanating from a point, non-point or mobile sources that result in air pollution.

Averaging period: This implies a period of time over which an average value is determined.

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

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

Particulate Matter (PM): These comprise a mixture of organic and inorganic substances, ranging in size and shape and can be divided into coarse and fine particulate matter. The former is called Total Suspended Particulates (TSP), whilst PM_{10} and $PM_{2.5}$ fall in the finer fraction referred to as Inhalable particulate matter.

TSP: Total suspended particulates refer to all airborne particles and may have particle sizes as large as 150 µm, depending on the ability of the air to carry such particles. Generally, suspended particles larger than 75 to 100 micrometre (µm) do not travel far and deposit close to the source of emission.

PM_{10}: Thoracic particulate matter is that fraction of inhalable coarse particulate matter that can penetrate the head airways and enter the airways of the lung. PM_{10} consists of particles with a mean aerodynamic diameter of 10 µm or smaller, and deposit efficiently along the airways. Particles larger than a mean size of 10 µm are generally not inhalable into the lungs. These PM_{10} particles are typically found near roadways and dusty industries.

$PM_{2.5}$: Respirable particulate fraction is that fraction of inhaled airborne particles that can penetrate beyond the terminal bronchioles into the gas-exchange region of the lungs. Also known as fine particulate matter, it consists of particles with a mean aerodynamic diameter equal to or less than 2.5 µm ($PM_{2.5}$) that can be inhaled deeply into the lungs. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.

Point sources: are discrete, stationary, identifiable sources of emissions that release pollutants to the atmosphere (International Finance Corporation (IFC), 2007).

Vehicle entrainment: This is the lifting and dropping of particles by the rolling wheels leaving the road surface exposed to strong air current in turbulent shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed.

1 INTRODUCTION

1.1 Background

Golden Core Trade and Invest (Pty) Ltd (Harmony Gold Mining Company Limited) owns and operates several Gold Mines and Plants in the West Wits region in the Gauteng Province. The Savuka and Mponeng mining rights areas are located within the West Rand District Municipality (DM) and Merafong City Local Municipality (LM), approximately 6 kilometres (km) south of Carletonville (Figure 1).

The Savuka Plant currently deposits tailings onto the Savuka 7a & 7b Tailings Storage Facilities (TSFs). However, these facilities are approaching their final height of 60 m, and the current planned Life of Mine (LOM) for the West Wits region exceed the available deposition capacity of these TSFs. Accordingly, Golden Core Trade and Invest (Pty) Ltd is undertaking feasibility assessments to increase the height of the Savuka 7a & 7b TSFs to a maximum of 70 m.

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1.2 Scope of Work

The scope of work had to include the following:

- Identifying potential areas sensitive to air pollution in the project area, as well as the site dispersion potential including meteorological conditions, topography and surface characteristics (land use);
- Estimate particulate matter (PM) emissions associated with the current Savuka operations, as well as the proposed increases in height of the Savuka 7a & 7b TSFs;
- Undertake atmospheric dispersion modelling including all the current and future sources of particulate matter (PM) emissions at Savuka operations;
- Assess the impact of the current and future Savuka operations on human health and biota by screening the modelling outputs (PM_{10} and $PM_{2.5}$ concentrations and dustfall rates) against the National Ambient Air Quality Standards (NAAQS), National Dust Control Regulations (NDCR) and limits for biota from available literature;
- Compile an air quality specialist report; and,
- Model sources of radionuclides and radon gas (modelled as a unit release) that would contribute to the radiological impact of the Savuka operations as input for the Radiological Impact Assessment to be undertaken by AquiSim Consulting (Pty) Ltd.

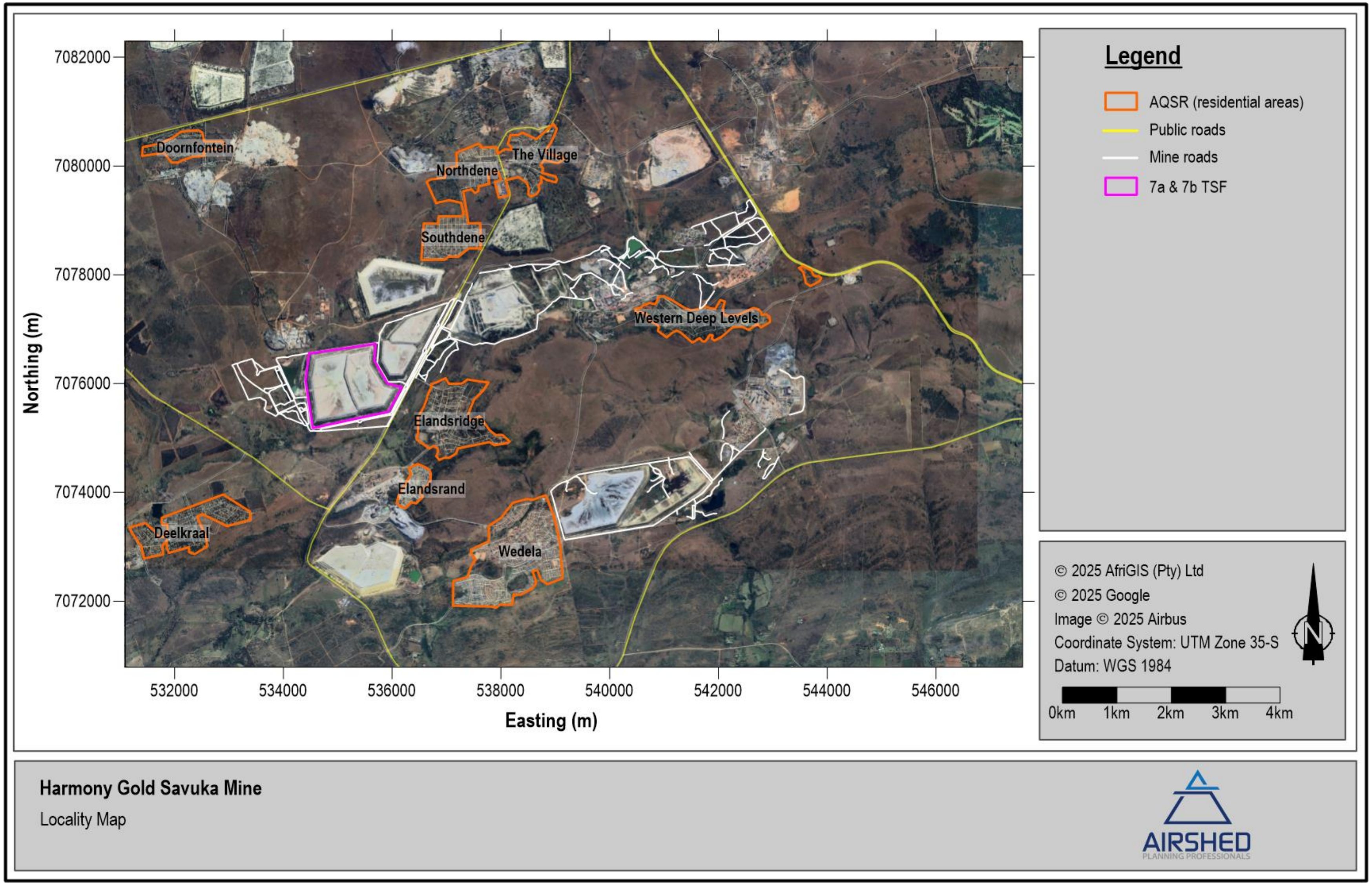

Figure 1: Location of sensitive receptor areas surrounding the current Savuka and Mponeng Mining Operations

1.3 Project Activities from an Air Quality Perspective

The current and proposed activities will result in emissions to air from a variety of activities and sources. The current operations include ventilation shaft emissions (underground operations), bulldozing, material transfer (loading and off-loading), wheel entrainment from vehicles, wind erosion from marginal ore dumps (MOD) and TSFs, and activities at the processing plant. The only source of emissions that would change due to the Project is wind erosion due to the increase in the height of the Savuka 7a & 7b TSFs. The main air pollution activities are listed in Table 1.

Table 1: Activities and associated air pollutants from the current Savuka and Mponeng Operations

Activity	Associated pollutants
Underground Mining (emissions released via vent shafts)	
Drilling and blasting	particulate matter (PM)[(a)(c)], sulfur dioxide (SO_2); oxides of nitrogen (NOx); carbon monoxide (CO); Total Organic Compounds (TOC) and carbon dioxide (CO_2)[(b)]
Loading and tipping of ore and waste	mostly PM, gaseous emissions from mining equipment (Diesel Particulate Matter [DPM], SO_2; NOx; CO; CO_2)
Primary crusher (assumed to be underground)	mostly PM, gaseous emissions from machinery (PM, SO_2; NOx; CO; CO_2)
Materials handling (loading of ore and waste)	mostly PM, gaseous emissions from Front-end-Loaders (FELs) (PM, SO_2; NOx; CO; CO_2)
Surface Operations	
Secondary & tertiary crushing and screening	mostly PM[(c)], gaseous emissions from machinery (PM, SO_2; NOx; CO; CO_2)
Materials handling (loading & off-loading)	mostly PM[(c)] and windblown dust from storage piles
Trucks transporting ore and waste	PM from vehicle entrainment on unpaved road sections and gaseous emissions from truck exhaust (PM, SO_2; NOx; CO; CO_2)
Tailings Storage Facilities (TSFs)	PM[(c)] from windblown dust and radon
Marginal Ore Dumps (MOD)	PM[(c)] from windblown dust and radon
Processing plant stacks	PM[(c)], SO_2; NOx; CO; CO_2

Notes: [(a)] Particulate matter (PM) refers to Total Suspended Particulates (TSP), PM_{10} and $PM_{2.5}$ (see Section 1.3.1).
[(b)] CO_2 and methane are greenhouse gasses (GHG).
[(c)] Radionuclides associated with PM emissions

1.3.1 Pollutants of Interest

Airborne PM is the most significant pollutant of concern from the proposed height increase of the Savuka 7a & 7b TSFs.

The impact of particles on human health is largely dependent on: (i) particle characteristics, particularly particle size and shape, and chemical composition; and (ii) the duration, frequency and magnitude of exposure. The potential of particles to be inhaled and deposited in the lung is a function of the particle size, shape and density. Airborne particulate matter may range from relatively uniform soil particles (e.g. during dust storms) to very complex mixtures of extremely small organic and inorganic particles and liquid droplets (e.g. industrial sites). These particles could be made up of a number of components, including salts and acids (such as sulfates and nitrates), organic chemicals, metals and radionuclides, and soil or dust particles. The nasal openings permit large dust particles (less than few mm's) to enter the nasal region, along with much finer airborne particulates. Larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages.

Smaller particles, typically less than 10 µm, pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. Particles are removed by impacting with the wall of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles (less than 2.5 µm) are removed by Brownian motion, which pushes them to the alveolar membrane (CEPA/FPAC Working Group, 1998; Dockery & Pope, 1994).

Ambient air pollution PM can therefore be divided into three classes based on their size:

- *Inhalable coarse particulate matter* (PM_{10}) consists of particles with a diameter between 2.5 and 10 micrometres (µm) that deposit efficiently along the airways. Particles larger than 10 µm are generally not inhaled into the lungs. These particles are typically found near roadways and dusty industries.
- *Fine particulate matter* ($PM_{2.5}$) consists of particles with a diameter less than 2.5 µm and can be inhaled deeply into the lungs. These particles can be directly emitted from sources such as vegetation fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.
- *Ultrafine particles* (PM_1) consist of particles with a diameter smaller than 0.1 µm and have widespread deposition within the respiratory tract. These particles are typically a result of secondary chemical reactions in the atmosphere.

Air quality standards and guidelines for airborne particulates are given for various particle size fractions, including total suspended particulates (TSP), and thoracic (PM_{10}) and respirable ($PM_{2.5}$) particulates.

PM comprises a mixture of organic and inorganic substances. From gold mining and processing facilities the radioactive particles in the form of radionuclides and radon releases are of concern. These are addressed in a separate radiation study conducted by AquiSim Consulting (Pty) Ltd.

1.4 Methodology

The methodology followed in the assessment to quantify the air quality impacts associated with the project is discussed below. The general tasks included:

- The establishment of the baseline air quality (based on available information);
- Quantification of air emissions from the project;
- Discussion of meteorological parameters required to establish the atmospheric dispersion potential;
- Calculation of the air concentrations from the project using a suitable atmospheric dispersion model; and,
- Assessment of the significance of the impact through the comparison of simulated air concentrations with local National Ambient Air Quality Standards (NAAQS) (for compliance) and dustfall rates with the National Dust Control Regulations (NDCR).

1.4.1 Potential Air Emissions from the Project

The pollutants of concern from the project are PM. Gaseous emissions such as sulfur dioxide (SO_2), oxides of nitrogen (NOx), carbon monoxide (CO), and Total Organic Compounds (TOC) are pollutants that would result from vehicles, ventilation shafts and plant stacks. With the focus of the study on the potential impacts from the Savuka 7a & 7b TSFs, particulates are the main concern and gaseous emissions were omitted.

Airborne PM impacts are assessed based on the varying size, with PM_{10} and $PM_{2.5}$ associated with health impacts, and TSP associated with nuisance caused by dust fallout (Colls, 2002).

1.4.2 Regulatory Requirements and Assessment Criteria

In the evaluation of air emissions and ambient air quality impacts reference is made to Minimum Emission Limits (MES) as part of the Listed Activities, NAAQS and the NDCR as set out in the National Environmental Management Air Quality Act (Act No. 39 of 2004) (NEMAQA). These standards apply only to common air pollutants, collectively known as criteria pollutants (SO_2, NO_2, CO, PM, benzene, ozone and lead).

1.4.3 Description of the Baseline Environment

An understanding of the atmospheric dispersion potential of the area is essential to an air quality impact assessment. While there is an on-site meteorological station at Mponeng, no recent data was available. Use was therefore made of modelled Weather Research and Forecasting Model (WRF) meteorological data for an on-site location for the period 1 January 2022 to 31 December 2024.

1.4.4 Existing Ambient Air Quality

No data was provided on the current ambient PM_{10} and $PM_{2.5}$ concentrations. Dustfall measurements were available for January 2022 to December 2024.

1.4.5 Emissions Inventory

The establishment of a comprehensive emission inventory formed the basis for the assessment of the air quality impacts from the project operations. Project operations result in point and fugitive gaseous and particulate emissions.

Point sources are well defined with set parameters and emission concentrations. The information on the point sources was sourced from a previous study for the West Wits operations (Shackleton & Petzer, 2020).

Fugitive emissions refer to emissions that are spatially distributed over a wide area. In the quantification of fugitive dust, use was made of emission factors which associate the quantity of a pollutant to the activity associated with the release of that pollutant.

1.4.6 Atmospheric Dispersion Modelling

1.4.6.1 Dispersion model selection

Dispersion models compute ambient pollutant concentrations as a function of source configurations, emission strengths and meteorological characteristics, thus providing a useful tool to ascertain the spatial and temporal patterns in the ground level concentrations arising from the emissions from various sources. Increasing reliance has been placed on concentration estimates from models as the primary basis for environmental and health impact assessments, risk assessments and emission control requirements.

The US Environmental Protection Agency's (US EPA) approved regulatory model – AERMOD – was selected for this study. It is one of the models recommended for Level 2 assessments, for near-source (less than 50 km from source) applications in all terrain types, in the South African Regulations Regarding Air Dispersion Modelling (Government Gazette No. 37804, 11 July 2014).

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

A disadvantage of the model is that spatial varying wind fields, due to topography or other factors cannot be included. Input data types required for the AERMOD model include: source data, meteorological data (supplied in the required format with the WRF data), terrain data, information on the nature of the receptor grid and pre-development or background pollutant concentrations or dustfall rates.

1.4.6.2 Meteorological Data Requirements

AERMOD requires two specific input files generated by the AERMET pre-processor. AERMET is designed to be run as a three-stage processor and operates on three types of data (upper air data, on-site measurements, and the national meteorological database). Use was made of simulated WRF data for the period 2022 to 2024.

1.4.6.3 Source Data Requirements

The AERMOD model can model point, area, volume and line sources. The windblown dust from the TSFs and Marginal Ore Dumps (MODs) as was modelled as area sources, with the vents and stacks modelled as point sources. Version 11.0.0.10 of AERMOD and its pre-processors were used in the study, with the US EPA 22112 AERMOD executable.

1.4.6.4 Modelling Domain

The dispersion of pollutants was modelled for an area covering 20 km (east-west) by 20 km (north-south) for the project site. The modelling domain was selected on the basis of the sources of emissions and potential impact areas. This area was divided into a grid with a resolution of 200 m (east-west) by 200 m (north-south). AERMOD simulates ground-level concentrations for each of the receptor grid points. The receptors were modelled at 1.5 m above ground.

1.4.6.5 Topographical and Land Use Data

The readily available terrain and land use data was obtained from the United States Geological Survey (USGS) via the Earth Explorer website (U.S. Department of the Interior, U.S. Geological Survey, 2025). Use was made of Shuttle Radar Topography Mission (SRTM) (30 m, 1 arc-sec) data and Global Land Cover Characterisation (GLCC) data for Africa.

1.4.6.6 Dispersion results

The dispersion model uses the specific input data to run various algorithms to estimate the dispersion of pollutants between the source and receptor. The model output is in the form of a simulated time-averaged concentration at the receptor. These simulated concentrations are compared against the relevant ambient air quality standards. The post-processing of air concentrations at discrete receptors as well as the regular grid points includes the calculation of various percentiles, specifically the 99th percentile, which corresponds to the requirements of the NAAQS.

Ground level concentration (GLC) isopleth plots presented in this report depict interpolated values from the concentrations simulated by AERMOD for each of the receptor grid points specified. Plots reflecting daily averaging periods contain only the 99th percentile of simulated ground level concentrations, for those averaging periods, over the entire period for which simulations were undertaken. It is therefore possible that even though a high daily average concentration is simulated at certain locations, this may only be true for one day during the period. Typically, NAAQS apply to areas where the Occupational Health and Safety regulations do not apply, thus outside the operational areas boundaries (fences). Ambient air quality guidelines and standards are therefore not occupational health indicators but applicable to areas where the public has access.

1.4.7 Uncertainty of Modelled Results

The main steps of uncertainty management are to:

- identify and understand uncertainties;
- understand whether uncertainties matter for decisions being made at the time;
- if they do matter, decide what to do about them; and,
- recommend a way forward.

Managing uncertainties attempts to eliminate the source of technical disagreements and failure to understand them often leads to a conclusion that all uncertainties need to be eliminated before project decisions can be made. The first decision about how to manage uncertainties relates to their significance given the decision being addressed. In the current context, the different parts of the investigation were grouped into similar uncertainty regimes, namely:

- dispersion model uncertainties;
- input data uncertainties;
- the methodology of validating model results; and,
- the methodology of expressing the modelled scenarios.

Modelled results are considered valid when they fall within the generally accepted (US EPA, 2005) "factor of two" accuracy of dispersion models. In quantifying the uncertainty of the modelled results for this assessment, measured ambient data was required which was not available for this study.

1.5 Management of Uncertainties

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

1. All project information required to calculate emissions for proposed operations was provided.
2. Simulated WRF data for a point at the Savuka site for the period January 2022 to December 2024 was used in the dispersion modelling.
3. The impact assessment is limited to PM, with reference to TSP, PM_{10} and $PM_{2.5}$, since it is the main pollutant of concern from the Savuka 7a & 7b TSFs operations.
4. Emissions:
    a. All operational data for the Savuka and Mponeng operations were taken from the 2020 Atmospheric Emissions Licence (AEL) application for the West Wits operations[1].
    b. The quantification of sources of emission was restricted to the Savuka and Mponeng operations (previously referred to as the West Wits operations). Other companies' mining operations, farming

[1] Previously owned by Anglo Gold Ashanti and referred to as the West Wits operations.

activities, domestic fires, vehicle exhaust emissions and dust entrained by vehicles on public roads were not quantified as part of the emissions inventory and simulations.

c. Site specific particle size, moisture and silt content data were retrieved from previous studies.

d. For the estimation of windblown dust emissions, use was made of the Airborne Dust Dispersion Model from Area Sources (ADDAS) (Burger, Held, & Snow, 1997; Burger L. W., 2010; Liebenberg-Enslin, 2014).

5. Airshed also modelled sources of radionuclides (specifically PM_{10} and TSP) and radon gas (modelled as a unit release) as input for the Radiological Impact Assessment to be undertaken by AquiSim Consulting (Pty) Ltd.

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

2 REGULATORY REQUIREMENTS AND ASSESSMENT CRITERIA

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

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

This section summarises legislation for PM concentrations and dustfall rates. The national Environmental management: Air Quality Act (NEM:AQA) Section 21 Listed Activities and Minimum Emissions Standards (MES), National Atmospheric Emission Reporting Regulations, Regulations regarding Air Dispersion Modelling, NAAQS and NDCR are relevant to the Savuka and Mponeng operations and are discussed below.

2.1 Emissions Standards

The NEM:AQA (Act No. 39 of 2004 as amended) mandates the Minister of Environment to publish a list of activities which result in atmospheric emissions and consequently cause significant detrimental effects on the environment, human health and social welfare, economic conditions, ecological conditions or cultural heritage. All scheduled processes as previously stipulated under the Air Pollution Prevention Act (APPA) are included as listed activities with additional activities added to the list. The updated Listed Activities and MES were published in 2013 (Government Gazette [GN] 893, No. 37054 as amended by GN 551, 12 June 2015; GN 1207, 81 October 2018; GN 687, 22 May 2019; and GN 421, 27 March 2020). Savuka and Mponeng Gold Plants have an existing Atmospheric Emissions Licence (AEL) and the activities that fall under the listed activities contained within this AEL have been included in this study.

2.2 Atmospheric Emissions Reporting Regulations

The National Atmospheric Emission Reporting Regulations (GN R283 in Government Gazette No. 38633) came into effect on 2 April 2015. The purpose of the regulations is to regulate the reporting of data and information from an identified point, non-point and mobile sources of atmospheric emissions to an internet-based National Atmospheric Emissions Inventory System (NAEIS). The NAEIS is a component of the South African Air Quality Information System (SAAQIS). Its objective is to provide all stakeholders with relevant, up to date and accurate information on South Africa's emissions profile for informed decision making.

Emission sources and data providers are classified according to groups. As the Savuka operations would be classified under Group A ("Listed activity published in terms of section 21(1) of the Act") AGA is required to report emissions. Emission reports from this group must be made in the format required for NAEIS and should be in accordance with the AEL.

As per the regulations, Golden Core Trade and Invest (Pty) Ltd and/or their data provider are registered on the NAEIS system as they are currently operating. Data providers must inform the relevant authority of changes if there are any:

- Change in registration details;
- Transfer of ownership; or
- Activities being discontinued.

A data provider must submit the required information for the preceding calendar year to the NAEIS by 31 March[2] of each year. Records of data submitted must be kept for a period of 5 years and must be made available for inspection by the relevant authority. AGA have been reporting on their emissions inventories since this legislation was instituted.

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

2.3 Atmospheric Dispersion Modelling Regulations

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to determine compliance with the relevant ambient air quality standards. Dispersion modelling provides a versatile means of assessing various emission options for the management of emissions from existing or proposed installations. Regulations regarding Air Dispersion Modelling were promulgated in GN 533, in Government Gazette No. 37804; 11 July 2014, and recommend a suite of dispersion models to be applied for regulatory practices as well as guidance on modelling input requirements, protocols and procedures to be followed. The Regulations regarding Air Dispersion Modelling are applicable –

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

Three *Levels of Assessment* are defined in the Regulations. The three levels are:

- Level 1: where worst-case air quality impacts are assessed using simpler screening models
- Level 2: for assessment of air quality impacts as part of license application or amendment processes, where impacts are the greatest within a few kilometres downwind (less than 50km)
- Level 3: require more sophisticated dispersion models (and corresponding input data, resources and model operator expertise) in situation:
    - where a detailed understanding of air quality impacts, in time and space, is required;
    - where it is important to account for causality effects, calms, non-linear plume trajectories, spatial variations in turbulent mixing, multiple source types & chemical transformations;
    - when conducting permitting and/or environmental assessment process for large industrial developments that have considerable social, economic and environmental consequences;

[2] Currently the submission date is 30 June 2025 due to manual submission requirements by the DFFE.

- when evaluating air quality management approaches involving multi-source, multi-sector contributions from permitted and non-permitted sources in an air-shed; or,
- when assessing contaminants resulting from non-linear processes (e.g. deposition, ground-level O3, particulate formation, visibility).

The first step in the dispersion modelling exercise requires a clear objective of the modelling exercise and thereby gives clear direction to the choice of the dispersion model most suited for the purpose. Accordingly, Level 2 was deemed appropriate.

2.4 National Ambient Air Quality Standards (NAAQS)

Criteria pollutants are considered those pollutants most found in the atmosphere, that have proven detrimental health effects when inhaled and are regulated by ambient air quality criteria. These generally include CO, NO_2, SO_2, PM_{10}, $PM_{2.5}$, and ground level ozone (O_3).

The initial NAAQS were published for comment in the Government Gazette on 9 June 2007. The revised NAAQS were subsequently published for comment in the Government Gazette on 13 of March 2009. The final revised NAAQS were published in the Government Gazette on 24 of December 2009 (GN 1210, Government Gazette 32816) and additional standards for particulate matter less than 2.5 µm in aerodynamic diameter ($PM_{2.5}$) were published on 29 June 2012 (GN 486, Government Gazette no. 35463). SA NAAQSs for the criteria pollutants assessed in this study are listed in Table 2

Table 2: National Ambient Air Quality Standards

Pollutant	Averaging Period	Concentration (µg/m³)	Permitted Frequency of Exceedance	Compliance Date
$PM_{2.5}$	24-hour	40	4	1 January 2016 till 31 December 2029 (currently enforceable)
	24-hour	25	4	1 January 2030
	1 year	20	-	1 January 2016 till 31 December 2029 (currently enforceable)
	1 year	15	-	1 January 2030
PM_{10}	24-hour	75	4	Currently enforceable
	1 year	40	-	Currently enforceable

2.5 National Dust Control Regulations (NDCR)

The NDCR were published on 1 November 2013 (GN R827 in Government Gazette No. 36974). The purpose of the regulations is to prescribe general measures for the control of dust in all areas including residential and non-residential areas. The standard for acceptable dustfall rates for residential and non-residential areas is set out in Table 3. According to these regulations the dustfall at the boundary or beyond the boundary of the premises where it originates cannot exceed 600 mg/m²- day in residential and light commercial areas; or 1 200 mg/m²-day in areas other than residential and light commercial areas.

In addition to the dust fall limits, the NDCR prescribe monitoring procedures and reporting requirements. This will be based on the measuring reference method ASTM 01739 averaged over 30 days.

Table 3: Acceptable dustfall rates

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

The regulation also specifies that the method to be used for measuring dustfall and the guideline for locating sampling points shall be American Standard Testing Method (ASTM, 1970)[3], or equivalent method approved by any internationally recognised body. It is important to note that dustfall is assessed for nuisance impact and not inhalation health impact.

The currently enforceable NDCR are expected to be repealed and replaced as noted in the draft NDCR published on 25 May 2018 (Gazette No. 41650, No. 517) and more recently published on 8 March 2024 (Notice 4475 GG 50272). Under the 2024 draft NDCR, the definitions of Residential area and non-residential area have changed to:

- "Residential area" means any area where the land is used for the purposes as prescribed under schedule 2 of the Spatial Planning and Land Use Management Act, 2013 (Act No. 16 of 2013), excluding the land that is scheduled for agriculture, industrial and mining purposes.
- "Non-residential area" means any area that's its land is scheduled for agriculture, industrial and mining purposes as prescribed under schedule 2 of the Spatial Planning and Land Use Management Act, 2013 (Act No. 16 of 2013).

2.6 Screening criteria for animals and vegetation

Limited information is available on the impact of dust on vegetation and grazing quality. While there is little direct evidence of the impact of dustfall on vegetation in the South African context, a review of European studies has shown the potential for reduced growth and photosynthetic activity in sunflower and cotton plants exposed to dust fall rates greater than 400 mg/m^2- day (Farmer, 1993). In addition, there is anecdotal evidence to indicate that over extended periods, high dustfall levels in grazing lands can soil vegetation and this can impact the teeth of livestock (Farmer, 1993).

[3] ASTM 1739:70 is a previous version of ASTM 1739 which did not prescribe a wind shield around the opening of the bucket; the addition of a wind shield is intended to deflect wind away from the lip of the container, allowing for a more laminar flow across the top of the collecting container (Kornelius *et al*., 2015). SANS 1929-2004 does however refer to ASTM 1739-98 (ASTM, 1998), which has a wind shield.

3 DESCRIPTION OF THE RECEIVING ENVIRONMENT

3.1 Affected Environment

Savuka and Mponeng current surface operations cover an approximate area of 62 square kilometres (km^2) and is located approximately 6 km south of Carletonville (Figure 1). Other neighbouring towns include Fochville and Potchefstroom, situated 12 km and 50 km respectively to the south and west of the Savuka operations (see Figure 1).

The land use in the area comprises primarily of mining and agriculture. The topography is characterised by undulating hills ranging from 1 500 to 1 700 metres above mean sea level (mamsl).

3.2 Atmospheric Dispersion Potential

In the assessment of the possible impacts from air pollutants on the surrounding environment and human health, a good understanding of the regional climate and local air dispersion potential of a site is essential. Meteorological characteristics of a site govern the dispersion, transformation, and eventual removal of pollutants from the atmosphere (Pasquill and Smith, 1983; Godish, 1990). The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer.

Dispersion comprises vertical and horizontal components of motion. The vertical component is defined by the stability of the atmosphere and the depth of the surface mixing layer. The horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field. The wind speed determines both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness.

The wind direction and the variability in wind direction, determine the general path pollutants will follow, and the extent of crosswind spreading (Shaw and Munn, 1971; Pasquill and Smith, 1983; Oke, 1990).

Pollution concentration levels fluctuate in response to changes in atmospheric stability, to concurrent variations in the mixing depth, and to shifts in the wind field. Spatial variations, and diurnal and seasonal changes, in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich and Tyson, 1988). Atmospheric processes at macro- and meso-scales need therefore be considered to accurately parameterise the atmospheric dispersion potential of a particular area.

Use was made of three years (2021 – 2024) of simulated WRF hourly sequential data. This data was used to construct wind roses, general climatic information such as diurnal temperature variations, atmospheric stability estimates and for dispersion modelling.

3.2.1 Local Wind Field

The wind roses comprise 16 spokes, which represent the directions from which winds blew during a specific period. The colours used in the wind roses below, reflect the different categories of wind speeds; the yellow area, for example, representing winds between 5 and 6 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. The frequency with which calms occurred, i.e. periods during which the wind speed was below 1 m/s are also indicated.

The period wind field and diurnal variability in the wind field are shown in Figure 2, while the seasonal variations are shown in Figure 2. The wind field is dominated by winds from the northerly sector. The strongest winds (>6 m/s) occurred mostly from the north-northeasterly sector. Calm conditions occurred 3.5% of the time, with the average wind speed over the period of 3.63 m/s. Both daytime and night-time show dominant northerly wind fields, with calm conditions 4.4% during the day, and 2.52% during the night.

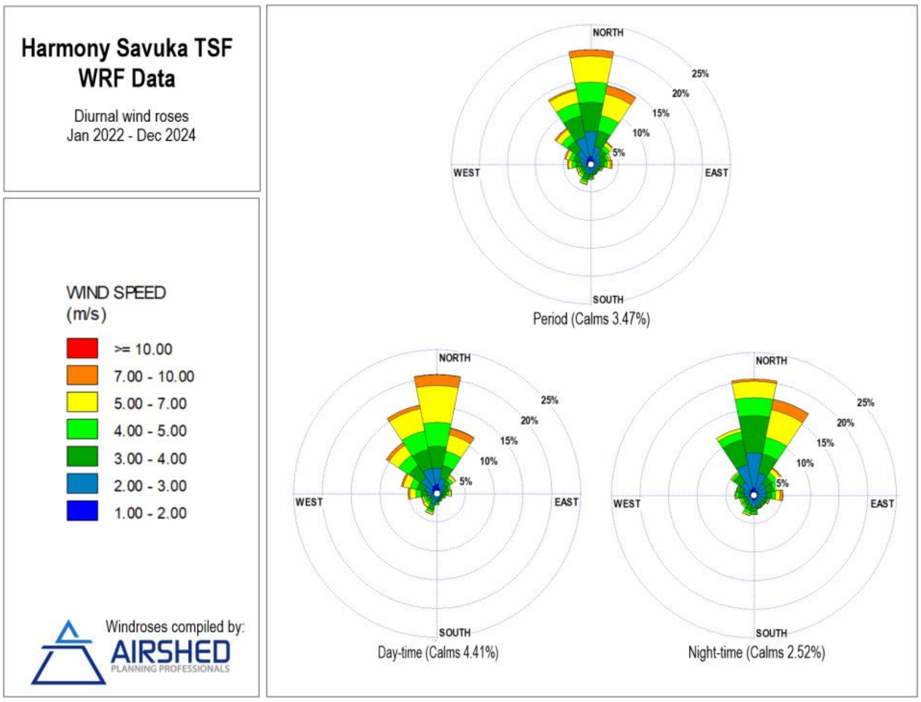

Figure 2: Period, day- and night-time wind roses (WRF data, January 2022 to December 2024)

The dominant northerly winds prevail throughout the seasons, with an increase in wind speeds during the spring months Figure 3.

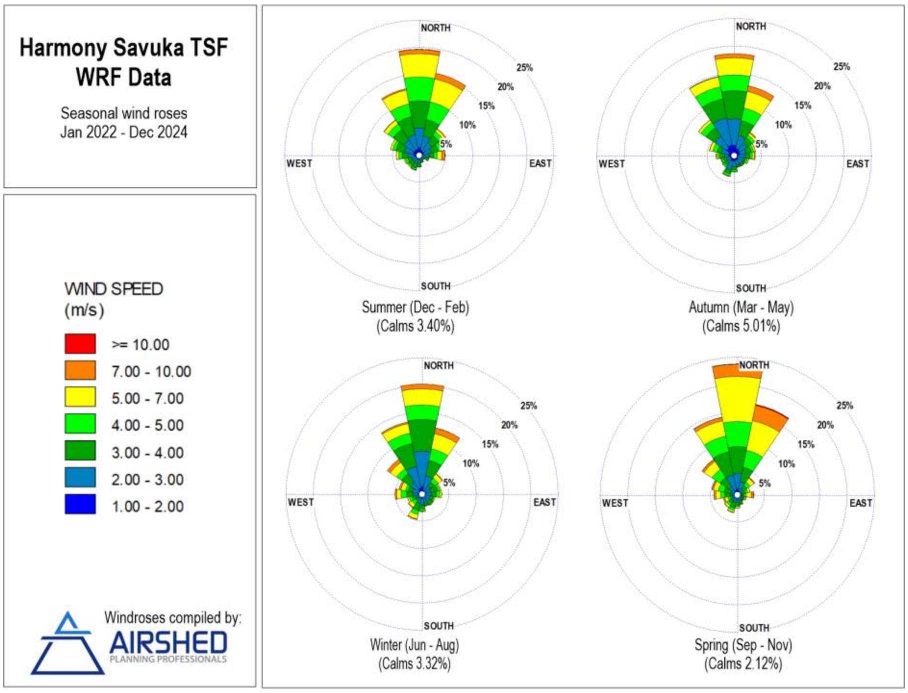

Figure 3: Seasonal wind roses (WRF data, January 2022 to December 2024)

3.2.2 Ambient Temperature

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

Monthly mean, maximum and minimum temperatures are given in Table 4 and Figure 4. Diurnal temperature variability is presented in Figure 5. Temperatures ranged between -4°C and 37°C. The highest temperature occurred in January and the lowest in July. During the day, temperatures increase to reach maximum at around 14:00 in the afternoon. Ambient air temperature decreases to reach a minimum at around 06:00 i.e. just before sunrise.

Table 4: Monthly temperature summary (WRF data, January 2022 to December 2024)

Minimum, Average and Maximum Temperatures (°C)												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Monthly Average	23	23	22	18	16	12	12	15	19	21	22	24
Hourly Maximum	33	35	33	29	27	23	23	28	30	33	34	34
Hourly Minimum	11	14	13	8	5	1	-2	1	4	3	7	13

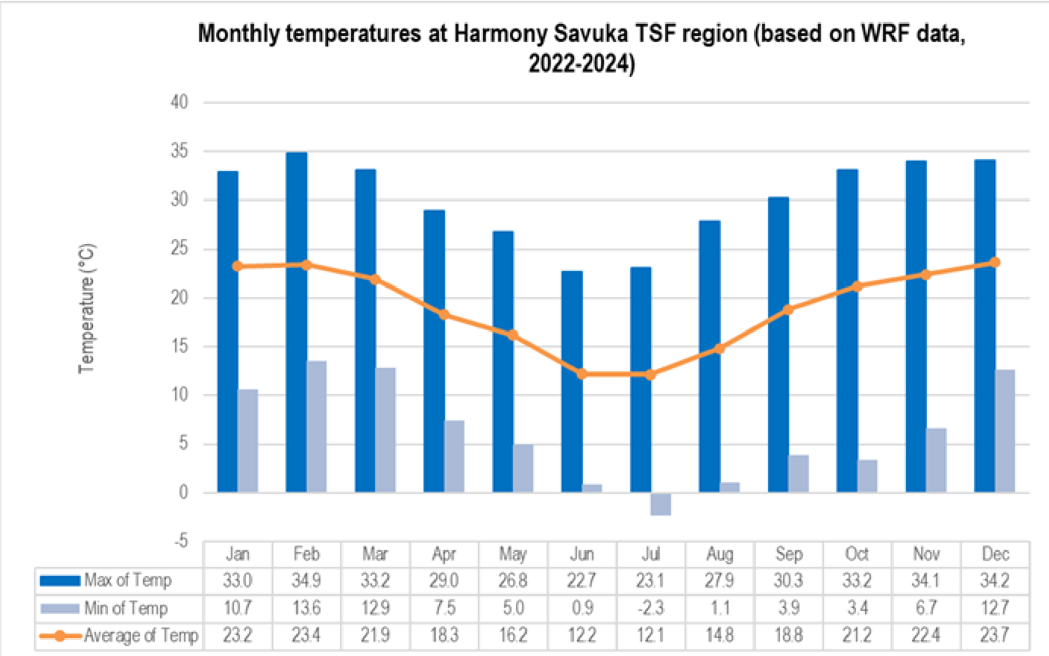

Figure 4: Monthly temperatures (WRF data, January 2022 to December 2024)

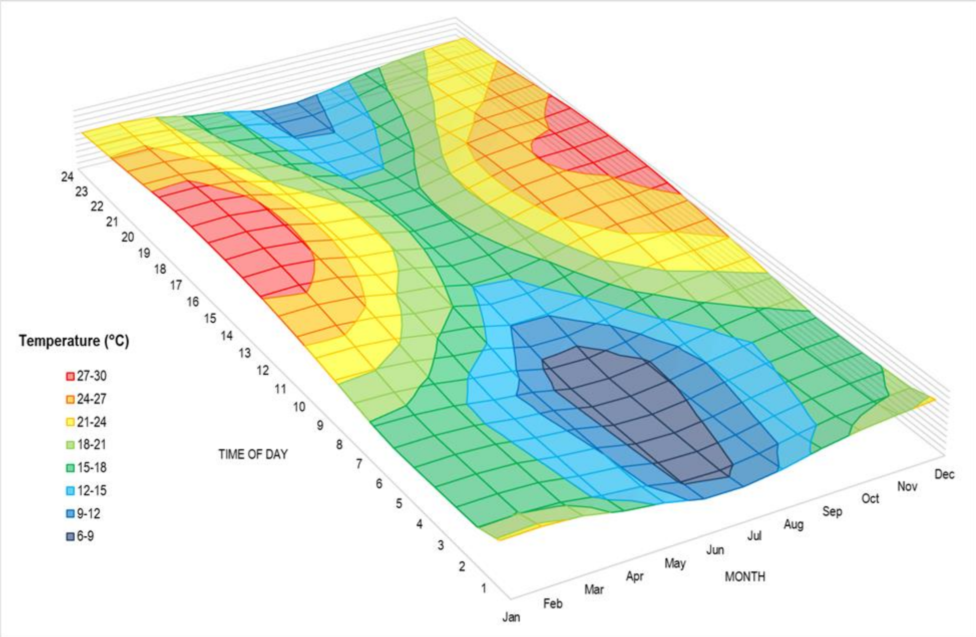

Figure 5: Diurnal temperature profile (WRF data, January 2022 to December 2024)

3.2.3 Atmospheric Stability

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

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

Diurnal variation in atmospheric stability, as calculated from measured data, and described by the inverse Obukhov length and the boundary layer depth is provided in Figure 6. The highest concentrations for ground level, or near-ground level releases from non-wind dependent sources would occur during weak wind speeds and stable (night-time) atmospheric conditions. For elevated releases, unstable conditions can result in very high concentrations of poorly diluted emissions close to the stack. This is called *looping* (Figure 6(c)) and occurs mostly during daytime hours. Neutral conditions disperse the plume fairly equally in both the vertical and horizontal planes and the plume shape is referred to as *coning* (Figure 6(b)). Stable conditions prevent the plume from mixing vertically, although it can still spread horizontally and is called *fanning* (Figure 6(a)) (Tiwary & Colls, 2010). For ground level releases such as fugitive dust the highest ground level concentrations will occur during stable night-time conditions.

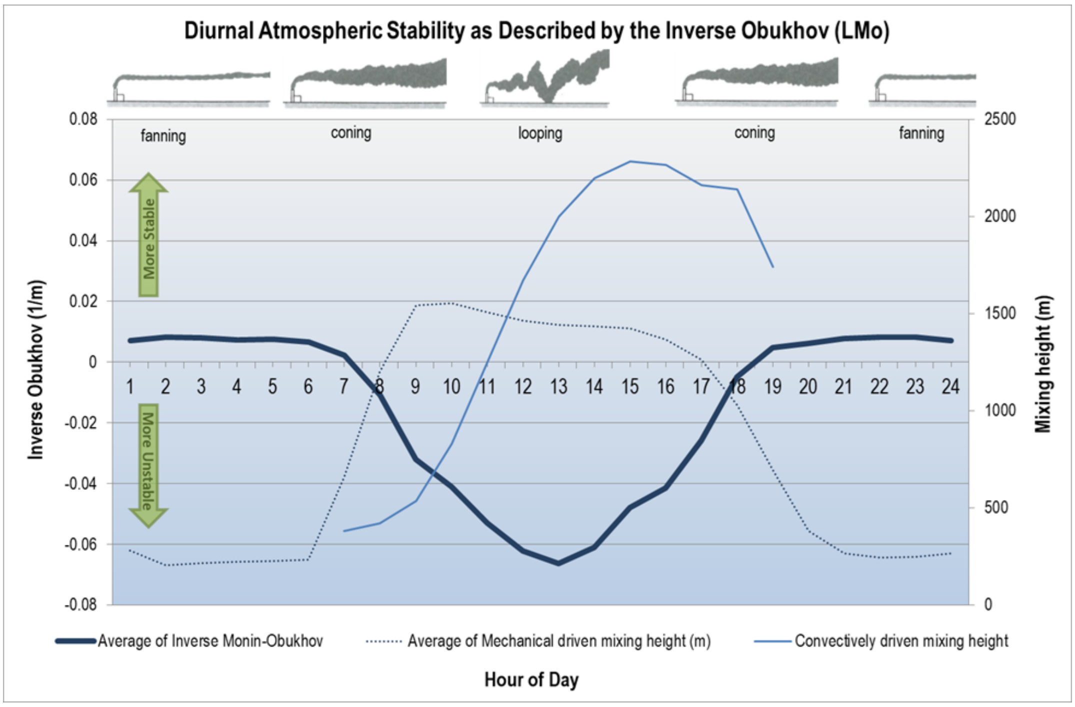

Figure 6: Diurnal atmospheric stability (WRF data, January 2022 to December 2024)

3.2.4 Precipitation and Relative Humidity

Rainfall is important to air pollution studies since it represents an effective removal mechanism of atmospheric pollutants. Monthly rainfall obtained from the on-site data did not appear to be accurate. Rainfall in this area occurs mostly during the summer months although it also rains during spring and autumn while the winter months are dry even through the relative humidity is greater during the winter period than other seasons. Colder air can hold less moisture than warmer air and thus the percentage saturation is higher at a lower moisture quantity resulting in higher relative humidity during colder periods than warmer periods.

3.3 Status Quo of Ambient Air Quality in the Area

3.3.1 Existing Sources of Air Pollution

The current air quality in the study area is mostly influenced by mining and reclamation activities at Savuka and Mponeng and other companies' mining operations, as well as farming activities, domestic fires, vehicle exhaust emissions and dust entrained by vehicles. These emission sources vary from activities that generate relatively course airborne particulates (such as farmland preparation, dust from paved and unpaved roads, and the mine sites) to fine PM such as that emitted by vehicle exhausts, diesel power generators and processing operations.

Domestic households are known to have the potential to be one the most significant sources that contribute to poor air quality within residential areas. Individual households are low volume emitters, but their cumulative impact is significant. It is likely that households within the local communities or settlements utilize coal, paraffin and/or wood for cooking and/or space heating (mainly during winter) purposes. Pollutants arising from the combustion of wood include respirable particulates, CO and SO_2 with trace amounts of polycyclic aromatic hydrocarbons (PAHs), in particular benzo(a)pyrene and formaldehyde. Particulate emissions from wood burning have been found to contain about 50% elemental carbon and about 50% condensed hydrocarbons.

Biomass burning includes the burning of evergreen and deciduous forests, woodlands, grasslands, and agricultural lands. Within the project vicinity, crop-residue burning and wildfires (locally known as veld fires) may represent significant sources of combustion-related emissions. The frequency of wildfires in the grasslands varies between annual and triennial. Biomass burning is an incomplete combustion process (Cachier, 1992), with carbon monoxide, methane and nitrogen dioxide gases being emitted. Approximately 40% of the nitrogen in biomass is emitted as nitrogen, 10% is left in the ashes, and it may be assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds (Held, et al., 1996). The visibility of the smoke plumes is attributed to the aerosol (particulate matter) content.

Emissions from unpaved roads constitute a major source of emissions to the atmosphere in the South African context. When a vehicle travels on an unpaved road the force of the wheels on the road surface causes pulverization of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong turbulent air shear with the surface. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. Dust emissions from unpaved roads vary in relation to the vehicle traffic and the silt loading on the roads. Unpaved roads in the region are mainly haul and access roads. Emissions from paved roads are significantly less than those originating from unpaved roads, however they do contribute to the particulate load of the atmosphere. Particulate emissions occur whenever vehicles travel over a paved surface. The fugitive dust emissions are due to the re-suspension of loose material on the road surface. Paved roads in the region include the N12 to the south, the R501 to the north and R500 to the east.

3.3.2 Sampled Dustfall Rates

Dust fallout sampling has been undertaken around the Savuka and Mponeng operations since April 2004[4] and includes a network comprising of 15 single Dustfall Monitoring Units (DMU) in accordance with ASTM D1739 (1970) (Figure 7). Ten (10) of these DMUs fall within the Savuka operations and five (5) within the Mponeng operations, with eight (8) DMUs located at residential areas (screened against the NDCR residential limit of 600 mg/m²/day) and nine in non-residential areas (screened against the NDCR non-residential limit of 1 200 mg/m²/day).

Dustfall rates for the Savuka DMUs for the period January 2023 to October 2024 were made available for inclusion into this report and shown in Figures 8 and 9 for 2022, Figures 10 and 11 for 2023 and Figures 12 and 13 for 2024.

During all three years (2022 -2024) and for both the residential and non-residential locations the dustfall rates were below the respective NDCRs with no exceedances recorded.

[4] Previously owned by Anglo Gold Ashanti and referred to as the West Wits operations.

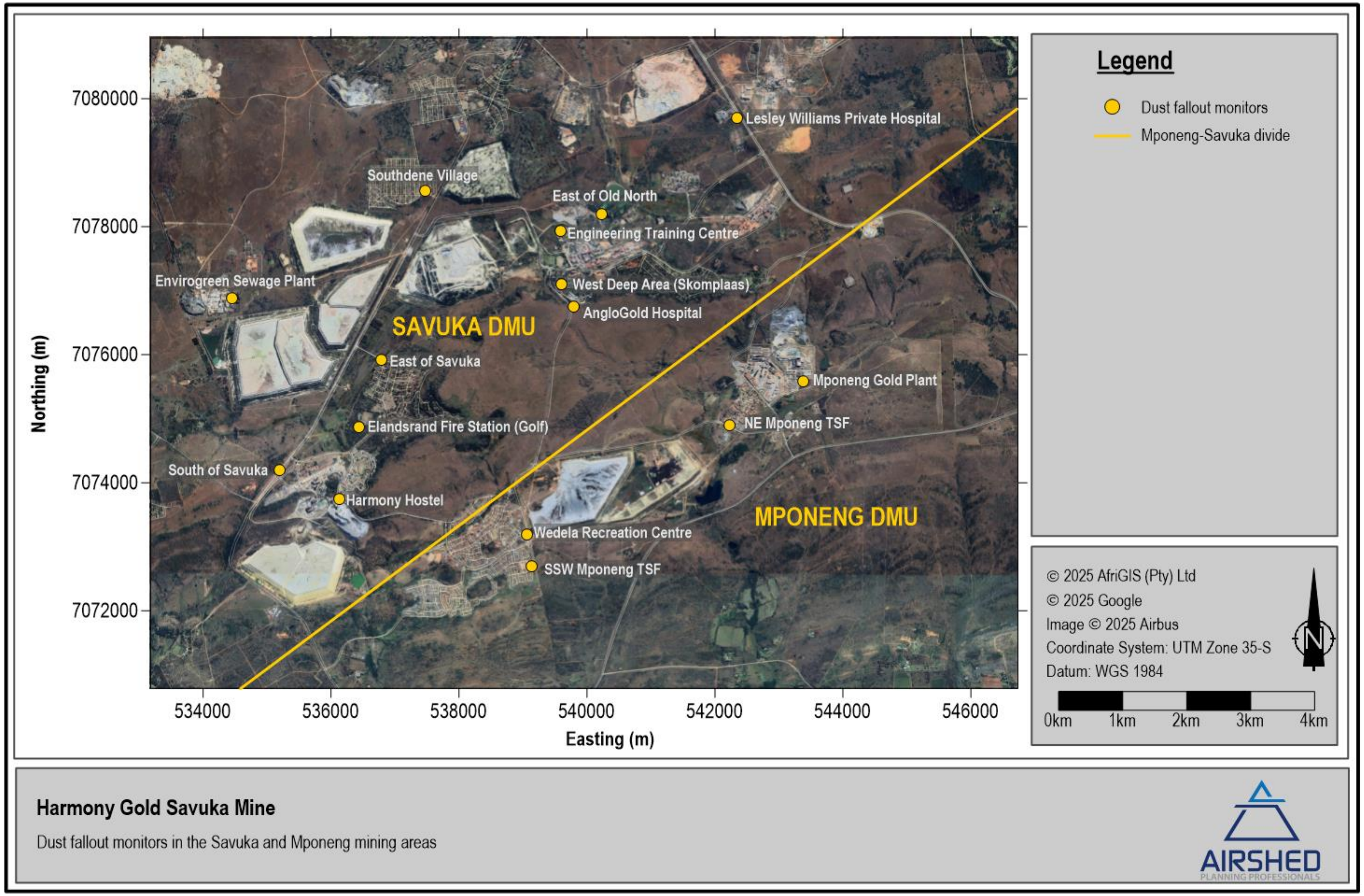

Figure 7: Savuka and Mponeng Dustfall Monitoring Units (DMU)

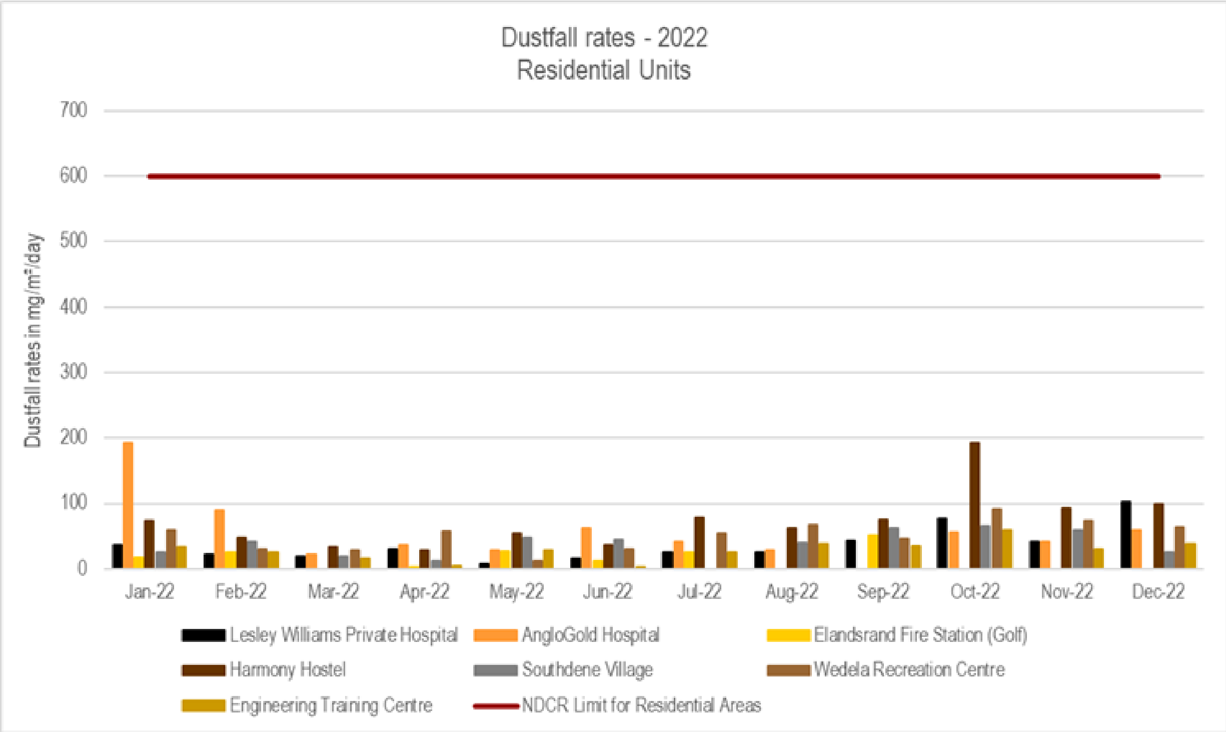

Figure 8: Savuka DMU Dustfall rates from January 2022 to December 2022 for Residential sites

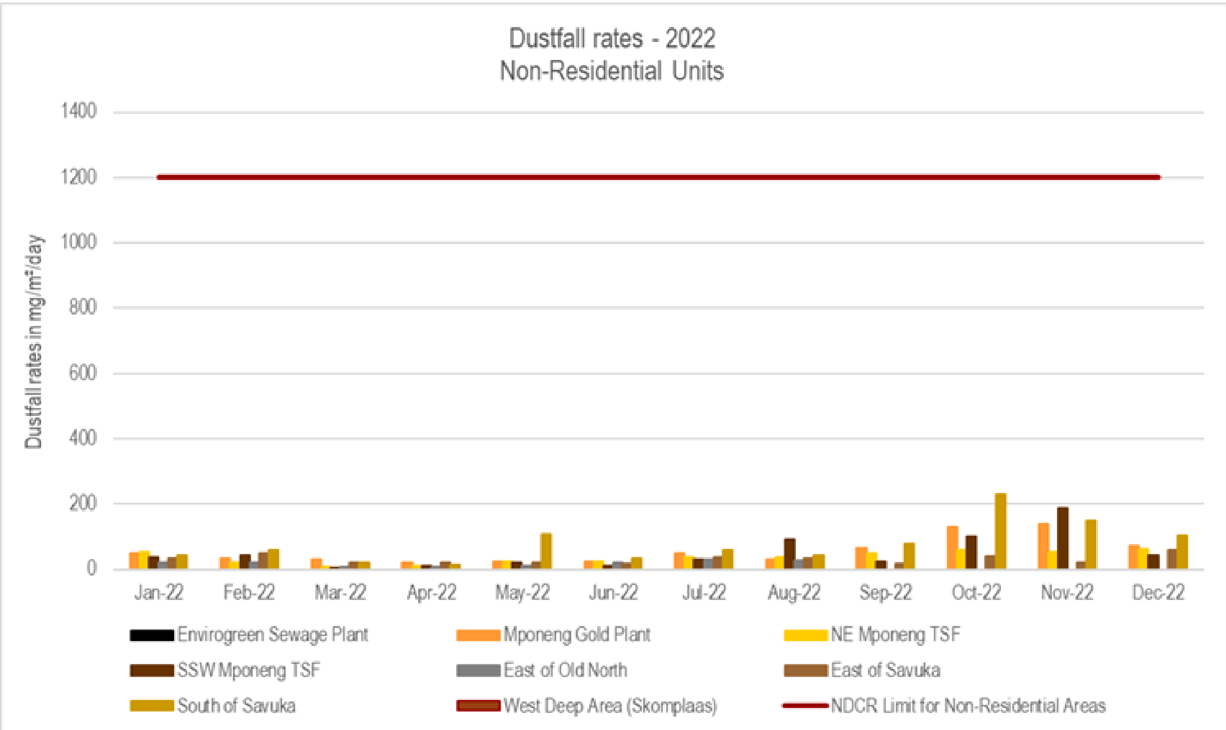

Figure 9: Dustfall rates from January 2022 to December 2022 for Non-Residential sites

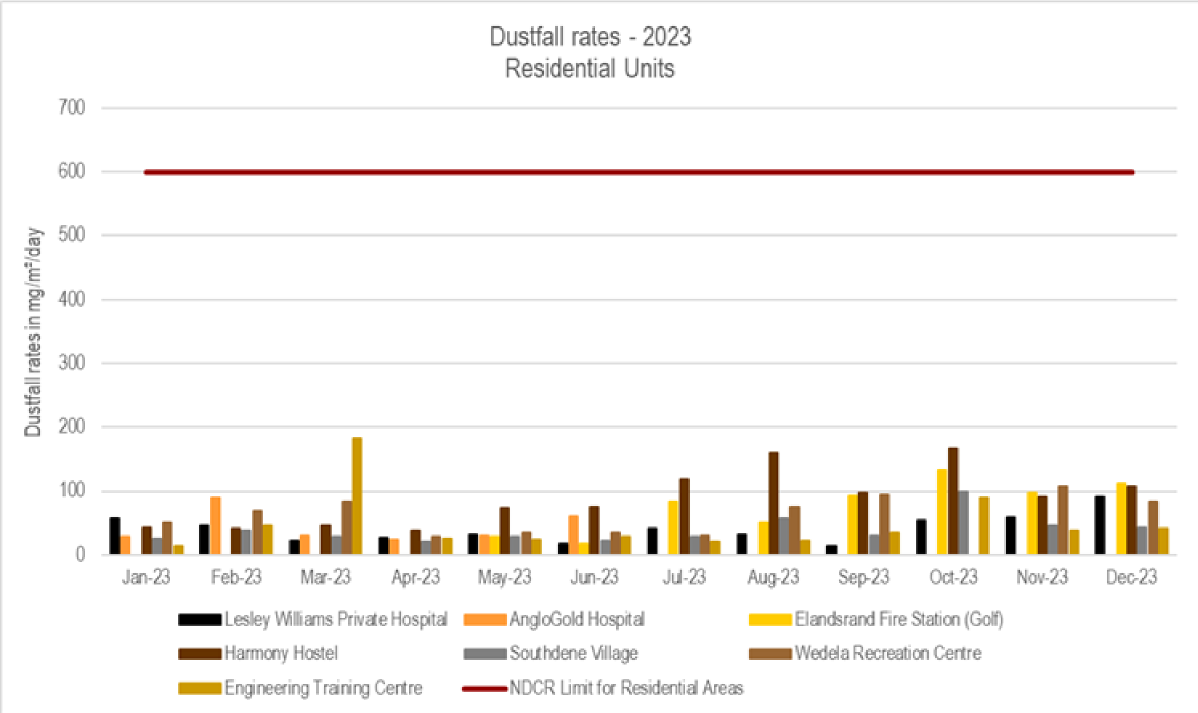

Figure 10: Dustfall rates from January 2023 to December 2023 for Residential sites

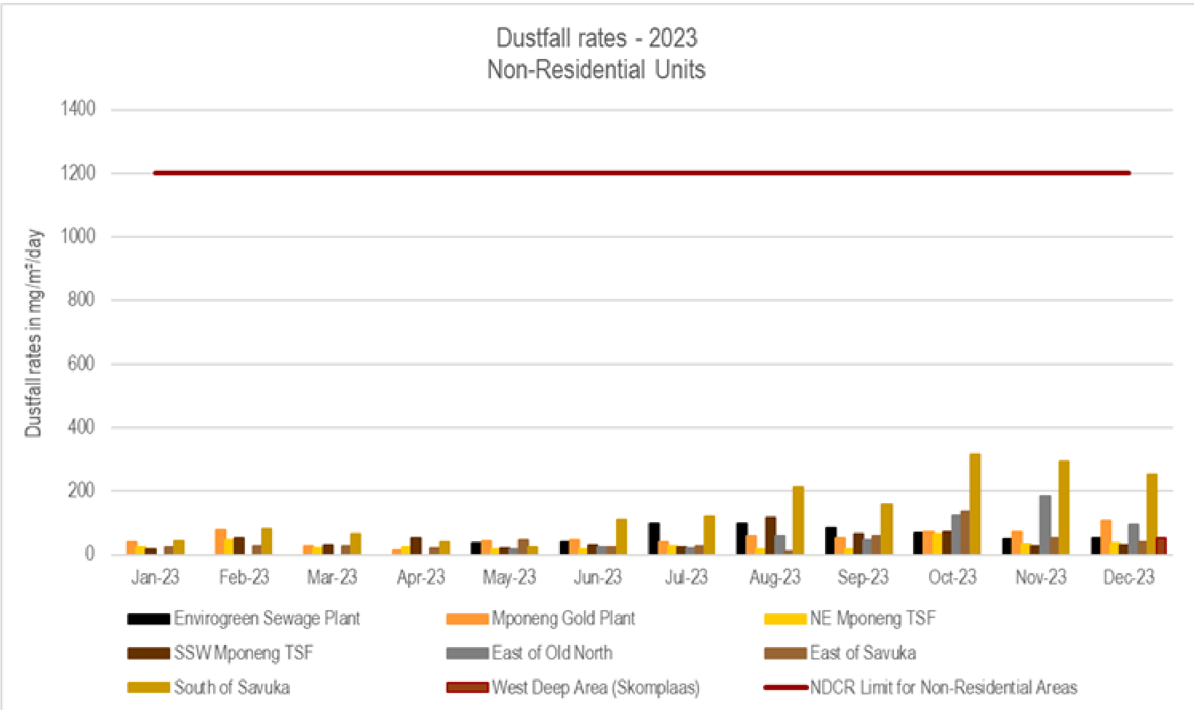

Figure 11: Dustfall rates from January 2023 to December 2023 for Non-Residential sites

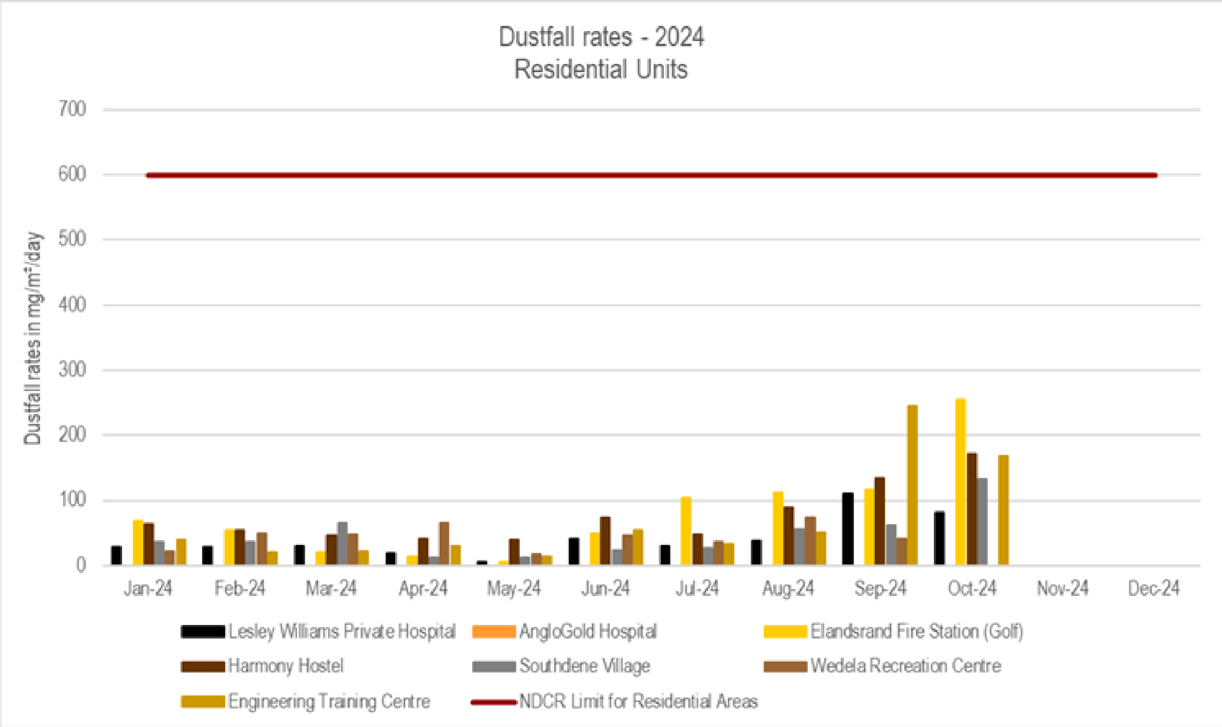

Figure 12: Dustfall rates from January 2024 to October 2024 for Residential sites

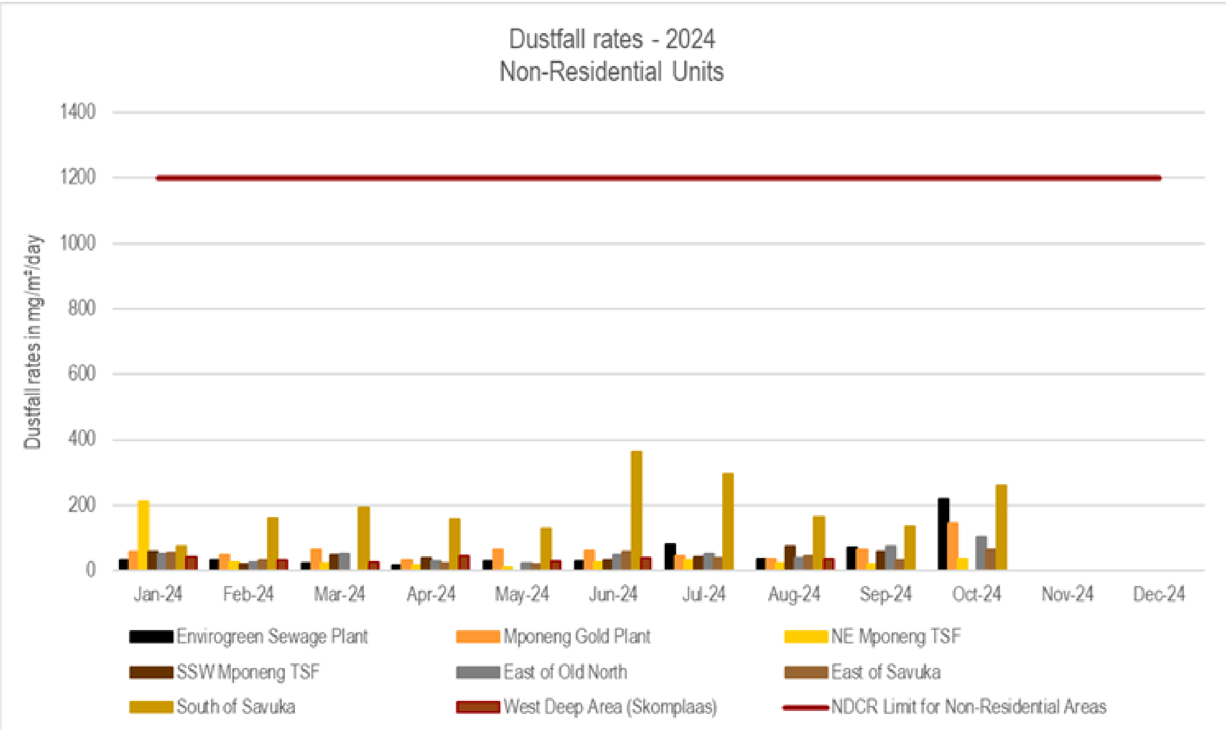

Figure 13: Dustfall rates from January 2024 to October 2024 for Non-Residential sites

4 AIR QUALITY IMPACT ASSESSMENT

4.1 Description of Operations at Savuka and Mponeng Mines

4.1.1 Ventilation shafts

Typical operations associated with underground mining include sub-surface drilling and blasting, sub-surface transferring ore and waste rock to surface with conveyors, material transfer points, stockpiling, and mobile equipment operations. There is one operational shaft at Savuka Mine and one at Mponeng Mine.

4.1.2 Savuka and Mponeng Gold Plants

The only operational plant is the Mponeng Gold Plant, with only material handling, crushing and screening at the Savuka Gold Plant. The Mponeng Gold Plant comprises of three operational carbon regeneration kilns and a smelter. While the carbon regeneration kilns do not have any associated abatement equipment/control technology; the smelter off-gas is routed through a baghouse before being vented to the atmosphere.

4.1.3 Tailings Storage Facilities

There are several active and dormant TSFs, with the focus of the study on the Savuka 7a & 7b TSFs. Tailings material is reclaimed from the dormant TSFs and loaded into trucks and transported by unpaved road to the Mponeng Gold Plant. The Savuka (5 and 7) TSFs and Mponeng TSF are in use as residue deposition sites. All these TSFs are subject to wind erosion.

Wind erosion is a complex process, including three different phases of particle entrainment, transport and deposition. It is primarily influenced by atmospheric conditions (e.g. wind, precipitation and temperature), soil properties (e.g. soil texture, composition and aggregation), land-surface characteristics (e.g. topography, moisture, aerodynamic roughness length, vegetation and non-erodible elements) and land-use practice (e.g. farming, grazing and mining) (Shao, 2008).

Windblown dust generates from natural and anthropogenic sources. For wind erosion to occur, the wind speed needs to exceed a certain threshold, called the friction velocity. This relates to gravity and the inter-particle cohesion that resists removal. Surface properties such as soil texture, soil moisture and vegetation cover influence the removal potential. Conversely, the friction velocity or wind shear at the surface is related to atmospheric flow conditions and surface aerodynamic properties. Thus, for particles to become airborne the wind shear at the surface must exceed the gravitational and cohesive forces acting upon them, called the threshold friction velocity (Shao, 2008).

The US EPA indicates a friction velocity of 5.4 m/s to initiate erosion from coal storage piles (US EPA, 2006). Liebenberg-Enslin (2014) estimated a wind erosion threshold of 8.8 m/s for gold tailings, and Mian & Yanful (2003) calculated a wind speed more than 9 m/s is required to initiate wind erosion from two tailings storage facilities in in New Brunswick and Ontario, Canada. Thus, the likelihood exists for wind erosion to occur from open and exposed surfaces, with loose fine material, when the wind speed exceeds at least 5.4 m/s.

As indicated, any binding properties would reduce the potential for wind erosion. One of the most effective measures of minimizing wind erosion emissions from tailings storage facilities is re-vegetation. The control efficiency of vegetation is given as 40% for non-sustaining vegetation and 90% for re-vegetation. Secondary rehabilitation would up the control efficiency to 60% for non-sustaining vegetation (NPI, 2012). The current active TSFs and proposed TSF would not be covered and therefore pose the largest risk for wind-blown dust

4.1.4 Marginal Ore Dumps

The Savuka and Mponeng Marginal Ore Dumps (MOD) are being reclaimed. The recovery of a MOD involves bulldozing the rock from the top of the dump in successive layers. At the bottom of the slope the rock is loaded into trucks and transported by unpaved road to the Mponeng Gold Plant. The MODs are far less susceptible to wind erosion than the TSFs due to the material properties (mostly due to the size of the particles).

4.1.5 Vehicles operations

Trucks transport the tailings and MOD material by unpaved road to the Mponeng Gold Plant. The operation of the trucks would result in both entrainment of dust along the unpaved roads and exhaust emissions. It has been found that of these two particulate matter sources associated with the truck operations the entrainment of dust as the trucks travel along the unpaved roads is far more significant than exhaust emissions and is often one of the most significant sources of elevated ground-level fine particulate matter concentrations and dustfall rates at and around mining operations.

4.2 Emissions Quantification

Sources of emissions from the baseline include active ventilation shafts, materials handling points, crushing and screening, vehicle entrainment on unpaved roads, and windblown dust from the TSFs and MODs. These sources were identified from a previous West Wits Study and Google Earth locations provided by EIMS. Sources of emissions for the project include the current operations at Savuka and Mponeng Mines and the proposed height extension of the 7a & 7b TSFs.

The total emissions from Savuka and Mponeng operations are provided in Table 5. The height increase of the Savuka 7a & 7b TSFs will have an increase in PM emissions of 5.1% ($PM_{2.5}$), 6.1% (PM_{10}) and 7.9% (TSP). Cumulatively, including the Mponeng mining and processing operations, the increase in PM emissions will be less at 0.7% ($PM_{2.5}$), 1.5% (PM_{10}) and 3.4% (TSP). The emissions quantification approach for each of these activities are provided Table 6.

Table 5: Emissions in tonnes per annum (tpa) for the various scenarios

Scenarios	$PM_{2.5}$ (tpa)	PM_{10} (tpa)	TSP (tpa)
Savuka Operations – Current	183.51	518.29	1 670.49
Savuka Operations – Future	193.35	552.01	1 814.51
Savuka & Mponeng Operations – Current	1 491.19	2 144.38	4 069.23
Savuka & Mponeng Operations – Future	1 501.02	2 178.10	4 213.25

Table 6: Emission estimation techniques and parameters

<table>
<tr><th>Source Group</th><th>Emission Estimation Technique</th><th>Input Parameters/Notes</th></tr>
<tr><td>Kiln stacks</td><td>Data provided by AngloGold Ashanti as per 2019 NAEIS reporting</td><td>Carbon Regeneration Kilns 1, 2 and 3
<table>
<tr><th>Exit velocity (m/s)</th><th>Diameter (m)</th><th>Exit temp (°C)</th><th>Release height (m)</th><th>Emission rate (mg/Nm³)</th></tr>
<tr><td>4.2</td><td>0.3</td><td>96</td><td>20</td><td>147.7*</td></tr>
</table>
Notes: *based on Stack sampling reports for 2017(Rayten, Prj No RES-AGA-171552 & RES-AGA-171598)
Hours of operation: 365 days per year, 24 hours per day.
Mitigation: None.</td></tr>
<tr><td>Smelter stack</td><td>Data provided by AngloGold Ashanti as per 2019 NAEIS reporting</td><td>
<table>
<tr><th>Exit velocity (m/s)</th><th>Diameter (m)</th><th>Exit temp (°C)</th><th>Release height (m)</th><th>Emission rate (mg/Nm³)</th></tr>
<tr><td>7.96</td><td>0.564</td><td>50</td><td>20</td><td>2.1*</td></tr>
</table>
Notes: *based on Stack sampling reports for 2017(Rayten, Prj No RES-AGA-171552)
Hours of operation: 104 days per year, 3 hours per day.
Mitigation: Baghouse (Fabric Filter).</td></tr>
<tr><td>Materials handling</td><td>US EPA miscellaneous transfer and conveying emission factor equation (US EPA, 2006)
$$\mathrm{EF} = \mathrm{k} \cdot 0.0016 \cdot \left(\frac{\mathrm{U}}{2.3}\right)^{1.3} \cdot \left(\frac{\mathrm{M}}{2}\right)^{-1.4} (1)$$
EF is the emission factor in kg/tonne material handled
k is the particle size multiplier (k_{TSP} – 0.74, k_{PM10} – 0.35, $k_{PM2.5}$ – 0.053)
U is the average wind speed in m/s
M is the material moisture content in %</td><td>Handling of materials at the Old North TSF, Savuka MOD, Mponeng MOD, Savuka Plant and Mponeng Gold Plant.
<table>
<tr><th></th><th>Old North TSF</th><th>Savuka MOD</th><th>Mponeng MOD</th></tr>
<tr><td>Material throughput (t/h)</td><td>500</td><td>198.63*</td><td>164.38*</td></tr>
</table>
Notes: *based on AEL renewal application throughput
Moisture: 4% (assumed)
Wind Speed: 3.63 m/s (WRF data 2022-2024)
Hours of operation: 365 days per year, 10 hours per day.
Mitigation: None.</td></tr>
<tr><td>Crushing and screening</td><td>Emission factors
<table>
<tr><th>Crushing</th><th>TSP</th><th>PM_{10}</th><th>$PM_{2.5}$[(a)]</th><th>Unit</th></tr>
<tr><td>Secondary</td><td>0.03</td><td>0.012</td><td>0.006</td><td>kg/tonne</td></tr>
<tr><td>Tertiary</td><td>0.03</td><td>0.010</td><td>0.005</td><td>kg/tonne</td></tr>
</table>
Notes: [(a)] Fraction of $PM_{2.5}$ taken from US-EPA crushed stone emission factor ratio for tertiary crushing.
Where,
E = Default emission factor for high moisture content ore (moisture > 4%)</td><td>
<table>
<tr><th></th><th>Old North TSF</th><th>Savuka MOD</th><th>Mponeng MOD</th></tr>
<tr><td>Material throughput (t/h)</td><td>500</td><td>198.63*</td><td>164.38*</td></tr>
</table>
Notes: *based on AEL renewal application throughput
Moisture: 4% (assumed)
Hours of operation were given as 24 hrs per day, 7 days per week.
Assumed only secondary and tertiary crushing at Processing Plants with Primary crushing underground.</td></tr>
</table>

<table>
<tr><th>Source Group</th><th>Emission Estimation Technique</th><th>Input Parameters/Notes</th></tr>
<tr><td>Underground operations (ventilation shaft)</td><td>South African Occupational Exposure Limits (OEL) for $PM_{2.5}$ and PM_{10}</td><td>
<table>
<tr><th>Flow rate (m³/s)</th><th>Exit velocity (m/s)</th><th>Diameter (m)</th><th>Exit temp (°C)</th><th>Release height (m)</th><th>Emission rate (g/s)</th></tr>
<tr><td>827</td><td>81</td><td>3.6</td><td>25</td><td>7.2</td><td>4.14</td></tr>
</table>
Hours of operation: 365 days per year, 24 hours per day.
Mitigation: None for ventilation shaft, all controls would be applied to underground operations.</td></tr>
<tr><td>Wind erosion</td><td>Use if the Airshed Planning Professionals (Pty) Ltd in-house wind erosion emissions estimation program “Airborne Dust Dispersion Model from Area Sources” (ADDAS) (Burger & Held, Revised User's Manual for the Airborne Dust Dispersion Model from Area Sources (ADDAS), 1997; Burger L. W., 2010; Liebenberg-Enslin, 2014)</td><td>Moisture content: Active TSFs = 1.3%; Dormant TSFs = 0.68%.
Particle size distribution, particle density and moisture content from previous study.
<table>
<tr><th>TSF</th><th>Description</th><th>Area (ha)</th><th>Active/ Dormant</th><th>$PM_{2.5}$ (tpa/ha)</th><th>PM_{10} (tpa/ha)</th><th>TSP (tpa/ha)</th></tr>
<tr><td>TSF1</td><td>Savuka 7a& 7b TSF</td><td>137.24</td><td>Active</td><td>0.57</td><td>1.96</td><td>8.39</td></tr>
<tr><td>TSF3</td><td>Savuka 5a TSF</td><td>29.04</td><td>Dormant</td><td>0.20</td><td>0.88</td><td>2.08</td></tr>
<tr><td>TSF4</td><td>Savuka 5b TSF</td><td>30.09</td><td>Dormant</td><td>0.20</td><td>0.88</td><td>2.08</td></tr>
<tr><td>TSF5</td><td>Old North TSF</td><td>136.03</td><td>Dormant</td><td>0.20</td><td>0.88</td><td>2.08</td></tr>
<tr><td>TSF6</td><td>Mponeng TSF</td><td>115.65</td><td>Dormant</td><td>0.20</td><td>0.88</td><td>2.08</td></tr>
<tr><td>TSF_N</td><td>Savuka 7a+7b TSF (new height)</td><td>154.4</td><td>Active</td><td>0.57</td><td>1.96</td><td>8.39</td></tr>
</table></td></tr>
<tr><td>Entrained dust from unpaved roads</td><td>US EPA emission factor equation (US EPA, 2006a)
$EF = k \cdot \left(\frac{s}{12}\right)^a \cdot \left(\frac{W}{3}\right)^b \cdot 281.9$ (2)
Where
EF is the emission factor in g/VKT
k is the particle size multiplier (k_{TSP} – 4.9, k_{PM10} – 1.5, $k_{PM2.5}$ – 0.15)
a is a constant (TSP – 0.7, PM_{10} – 0.9, $PM_{2.5}$ – 0.9)
b is a constant (TSP – 0.45, PM_{10} – 0.45, $PM_{2.5}$ – 0.45)
s is the road surface material silt content in %
W is the average weight vehicles in tonnes</td><td>Transport activities include the transport of reclaimed tailings and MOD material along the unpaved roads to the Mponeng Gold Plant.
VKT were calculated from road lengths (limited to simulation area), truck capacities and the number of trips required to transport materials.
Average vehicle weight of 20 tonnes.
Previous studies road surface silt content of 11% was applied in calculations for the roads.
Hours of operation: 365 days per year, 10 hours per day.
Design Mitigation: Level 2 watering with a control efficiency of 75%.</td></tr>
</table>

4.3 Simulation Results

Simulation results of particulate emissions for the current and future operations are discussed in this section.

4.3.1 Respirable particulate matter ($PM_{2.5}$)

The simulated $PM_{2.5}$ 24-hour concentrations are within compliance with the NAAQS (4 days of exceedance of 40 µg/m^3) at all the AQSRs, for both current and future operations (Figure 14). The annual $PM_{2.5}$ concentrations for current (Figure 15) and future (Figure 16) operations are also within compliance with the NAAQS. A summary of the results is presented in Table 7.

The increase in height of the Savuka 7a and 7b TSFs would result on average in a 2.4% increase in daily GLCs at the various AQSRs, and a 0.6% increase annually.

Table 7: Simulated $PM_{2.5}$ concentrations at the AQSRs

ID	AQ Sensitive Receptor	Current			Future		
		Highest Daily	Annual	No of Exceedances	Highest Daily	Annual	No of Exceedances
1	Doornfontein	0.8	0.1	0	0.8	0.1	0
2	Northdene	3.3	0.1	0	3.3	0.1	0
3	Southdene	5.1	0.2	0	5.1	0.2	0
4	The Village	4.6	0.2	0	4.6	0.2	0
5	Lesley Williams Private Hospital	2.4	0.2	0	2.4	0.2	0
6	AngloGold Hospital	8.1	2.1	0	8.1	2.1	0
7	Western Deep Levels	7.8	0.7	0	7.8	0.7	0
8	Elandsridge	8.7	0.3	1	9.1	0.3	1
9	Elandsrand	5.5	0.2	0	5.9	0.3	0
10	Harmony Hostel	4.3	0.2	0	4.6	0.2	0
11	Wedela	8.0	0.3	0	8.0	0.3	0
12	Deelkraal	2.8	0.1	0	3.4	0.1	0

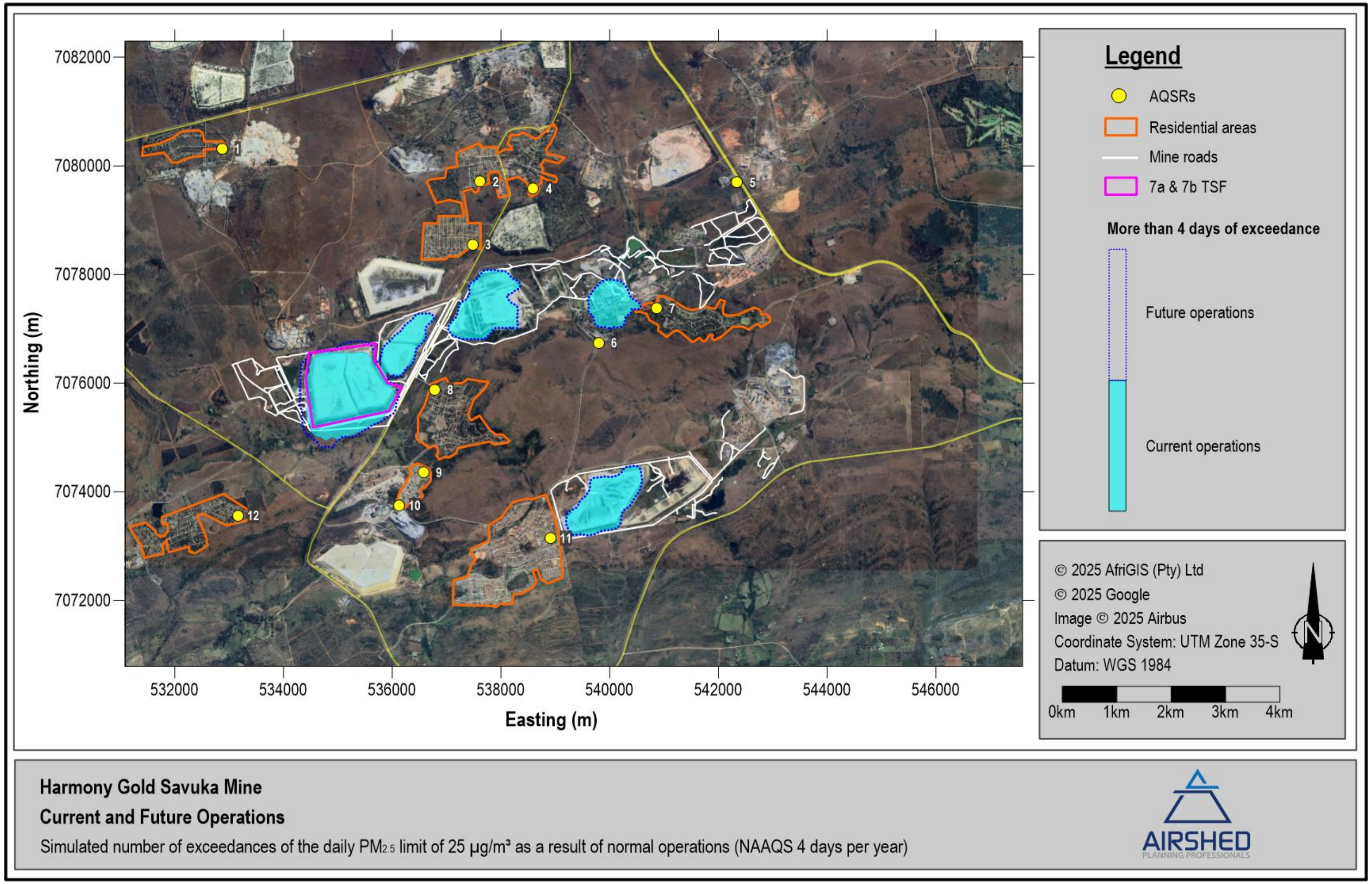

Figure 14: Simulated area of exceedance of the 24-hour $PM_{2.5}$ NAAQS as a result of current and future operations with mitigation measures applied

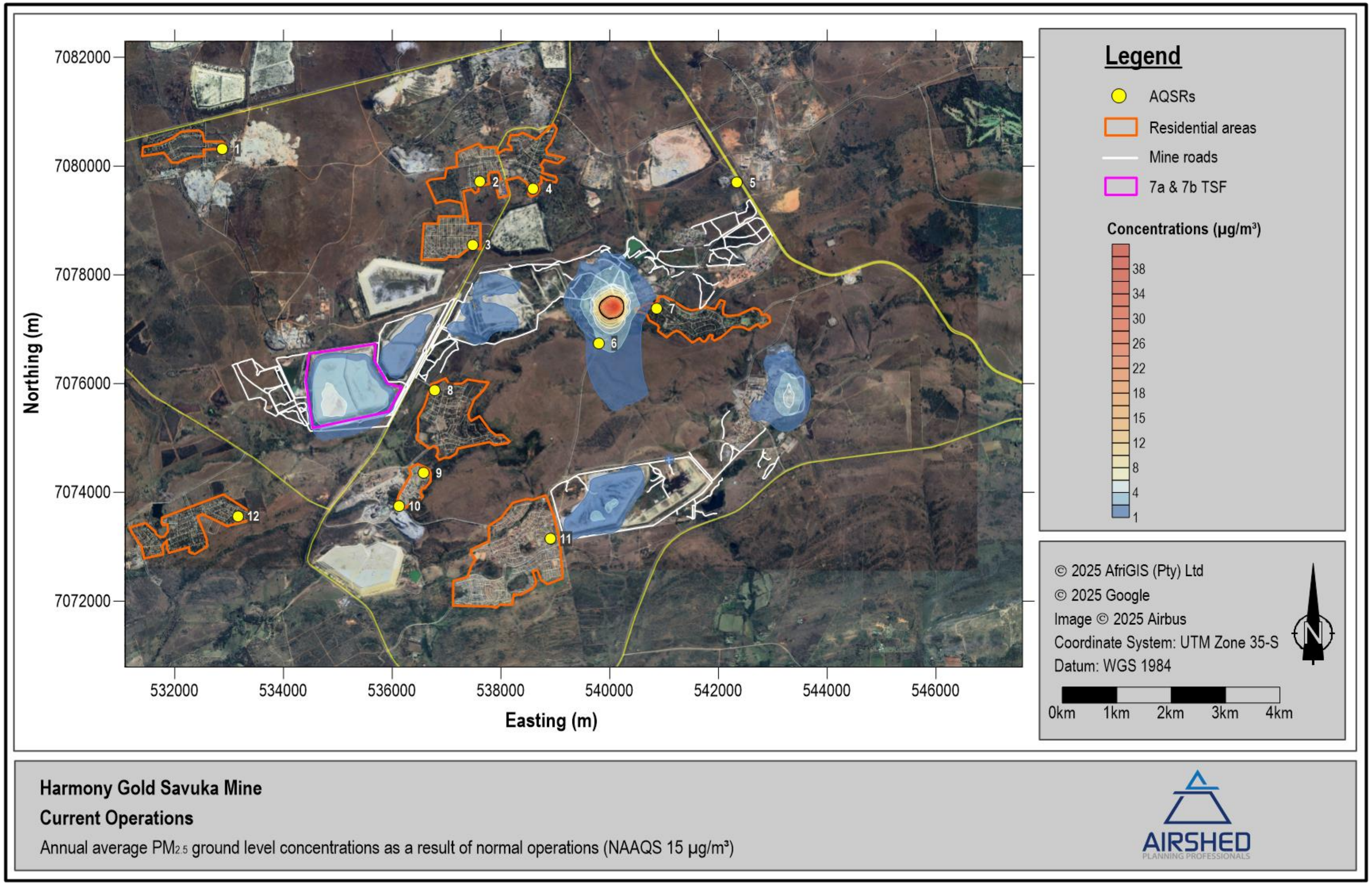

Figure 15: Simulated annual average $PM_{2.5}$ concentrations as a result of current operations with mitigation measures applied

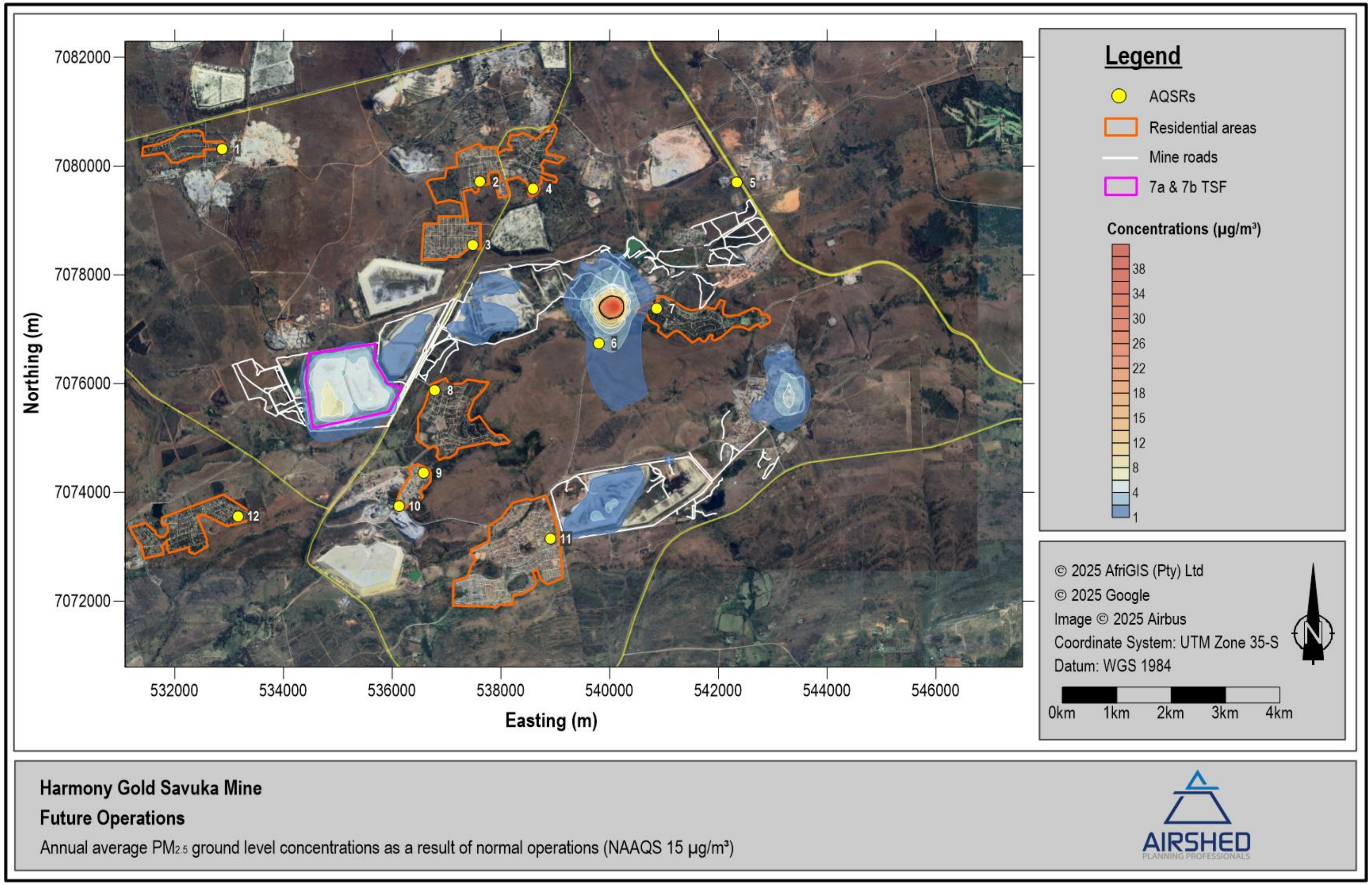

Figure 16: Simulated annual average $PM_{2.5}$ concentrations as a result of future operations with mitigation measures applied

4.3.2 *Inhalable particulate matter (PM_{10})*

The simulated PM_{10} 24-hour GLCs are within compliance with the NAAQS (4 days of exceedance of 75 µg/m^3) at all the AQSRs, for both current and future operations (Figure 17). The annual PM_{10} concentrations for current (Figure 18) and future (Figure 19) operations are also within compliance with the NAAQS. A summary of the results is presented in Table 8.

The increase in height of the Savuka 7a and 7b TSFs would result on average in a 3.9% increase in daily GLCs at the various AQSRs, and a 1.4% increase annually.

Table 8: Simulated PM_{10} concentrations at the AQSRs

ID	AQ Sensitive Receptor	Current			Future		
		Highest Daily	Annual	No of Exceedances	Highest Daily	Annual	No of Exceedances
1	Doornfontein	1.5	0.1	0	1.5	0.1	0
2	Northdene	6.3	0.2	0	6.7	0.2	0
3	Southdene	7.0	0.3	0	7.0	0.3	0
4	The Village	12.5	0.3	0	12.5	0.3	0
5	Lesley Williams Private Hospital	4.1	0.2	0	4.1	0.2	0
6	AngloGold Hospital	12.6	2.8	0	12.6	2.8	0
7	Western Deep Levels	9.2	1.0	0	9.2	1.0	0
8	Elandsridge	61.3	0.8	1	64.9	0.8	1
9	Elandsrand	32.9	0.6	1	35.5	0.6	1
10	Harmony Hostel	24.1	0.5	0	25.6	0.5	0
11	Wedela	69.8	0.8	1	69.8	0.8	1
12	Deelkraal	19.8	0.3	0	22.4	0.3	0

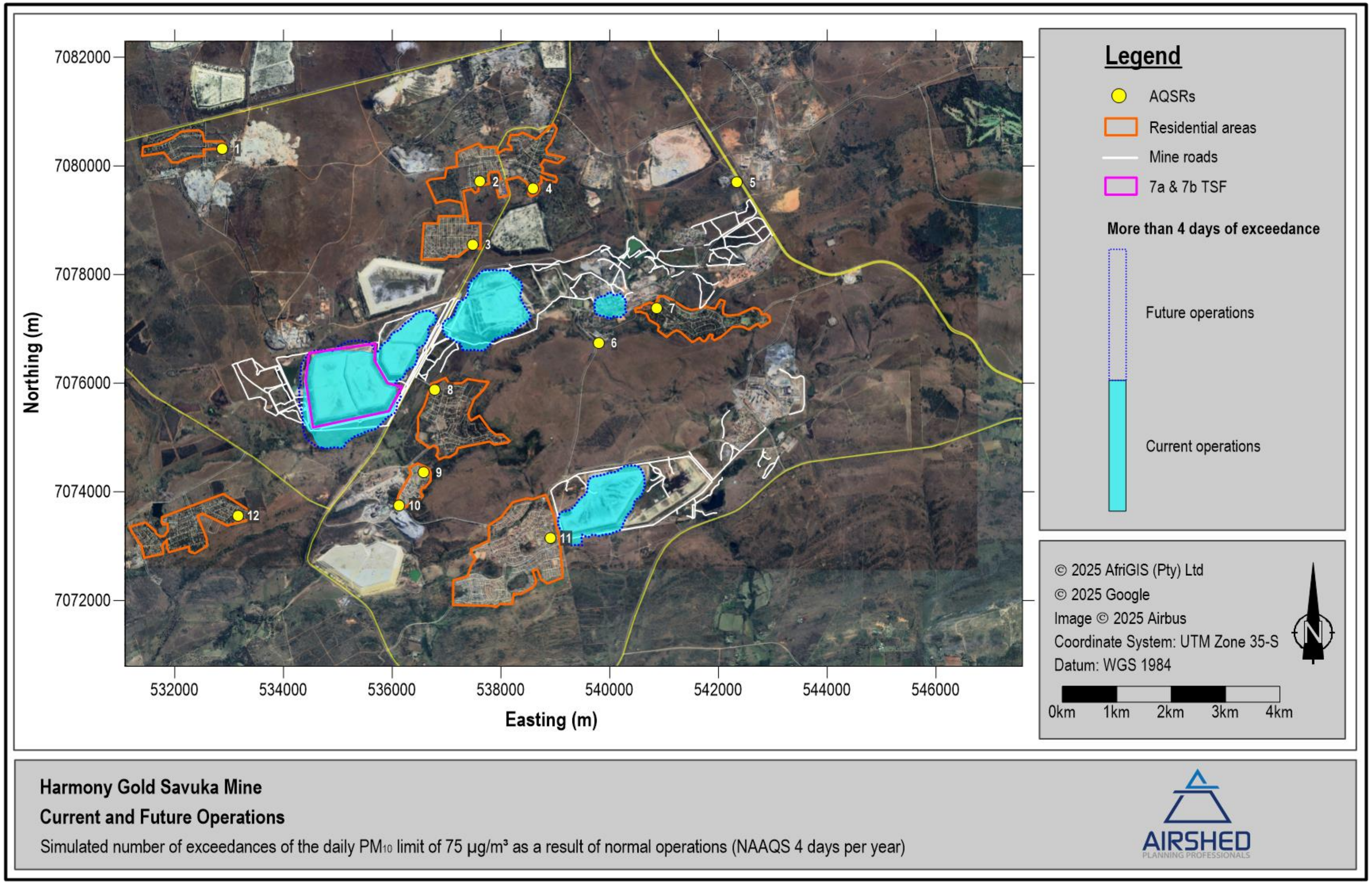

Figure 17: Simulated area of exceedance of the 24-hour PM_{10} NAAQS as a result of current and future operations with mitigation measures applied

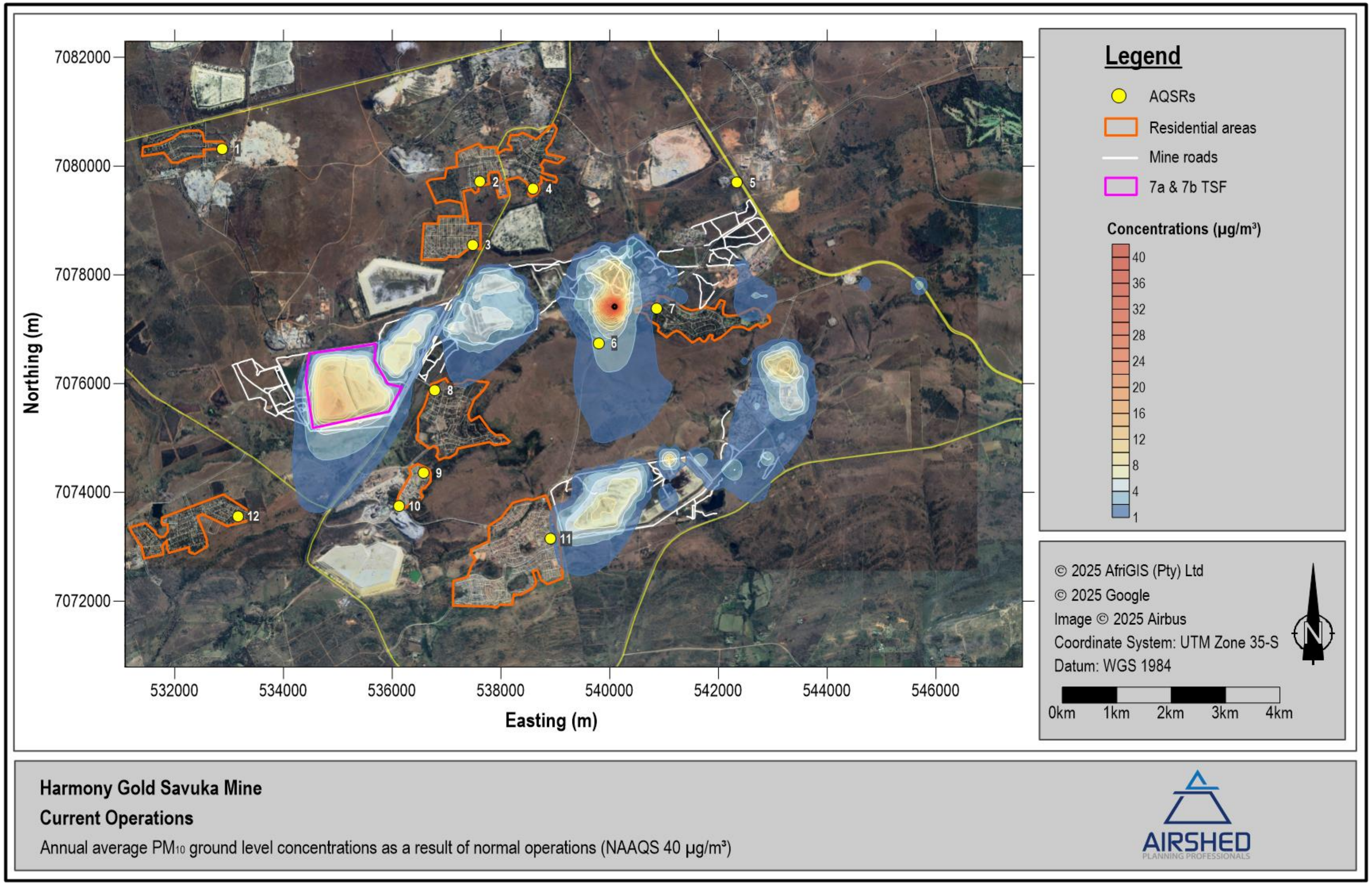

Figure 18: Simulated annual average PM_{10} concentrations as a result of current operations with mitigation measures applied

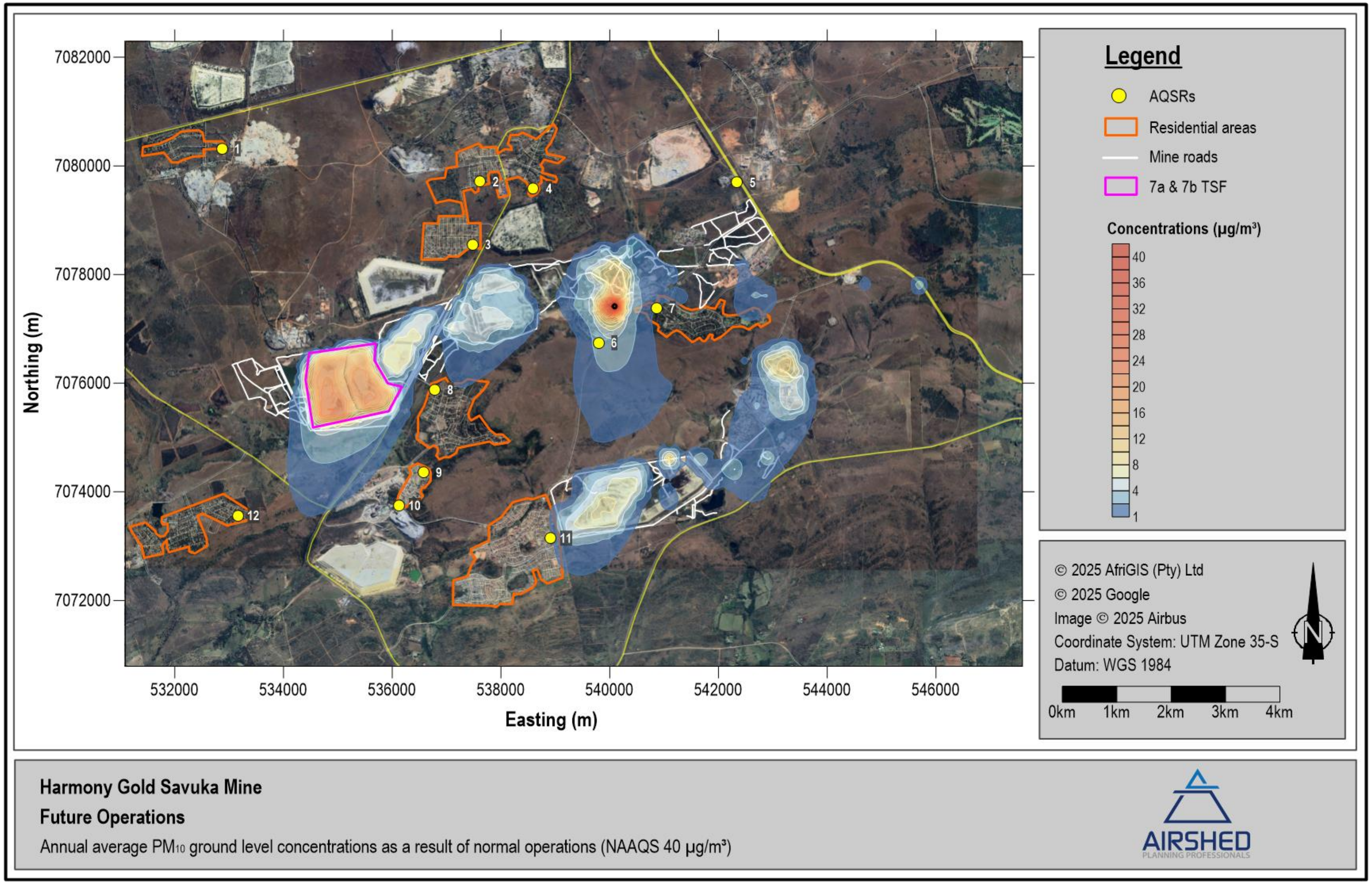

Figure 19: Simulated annual average PM_{10} concentrations as a result of future operations with mitigation measures applied

4.3.3 Fallout Dust

The simulated daily average dustfall rates with mitigation measures applied to the current operations exceed the NDCR limit for residential areas (600 mg/m²-day) at one AQSR (Elandsridge) but are below the NDCR limit for non-residential areas (1 200 mg/m²-day). The limit for agricultural areas is exceeded for up to 3.5 km to the south-southwest from the active TSFs at Savuka and Mponeng (Figure 20). The simulated daily average dustfall rates for the future operations show similar impact areas to the current operations, and average increase of 2.5% in dustfall rates (Figure 21).

Measured dustfall rates are however below the NDCR limit for residential areas (600 mg/m²-day) at all AQSRs, including Elandsridge (see Section 3.3.2) which implies a possible overprediction of simulated dustfall rates.

The dustfall rates at the AQSRs are provided in Table 9.

Table 9: Simulated dustfall rates at the AQSRs

ID	AQ Sensitive Receptor	Current	Future
		Highest 30-day average	Highest 30-day average
1	Doornfontein	5	5
2	Northdene	27	30
3	Southdene	45	45
4	The Village	52	52
5	Lesley Williams Private Hospital	12	13
6	AngloGold Hospital	140	140
7	Western Deep Levels	56	57
8	Elandsridge	**723**	**750**
9	Elandsrand	441	460
10	Harmony Hostel	304	314
11	Wedela	538	540
12	Deelkraal	227	233

Notes: Bolded text indicates exceedance of NDCRs

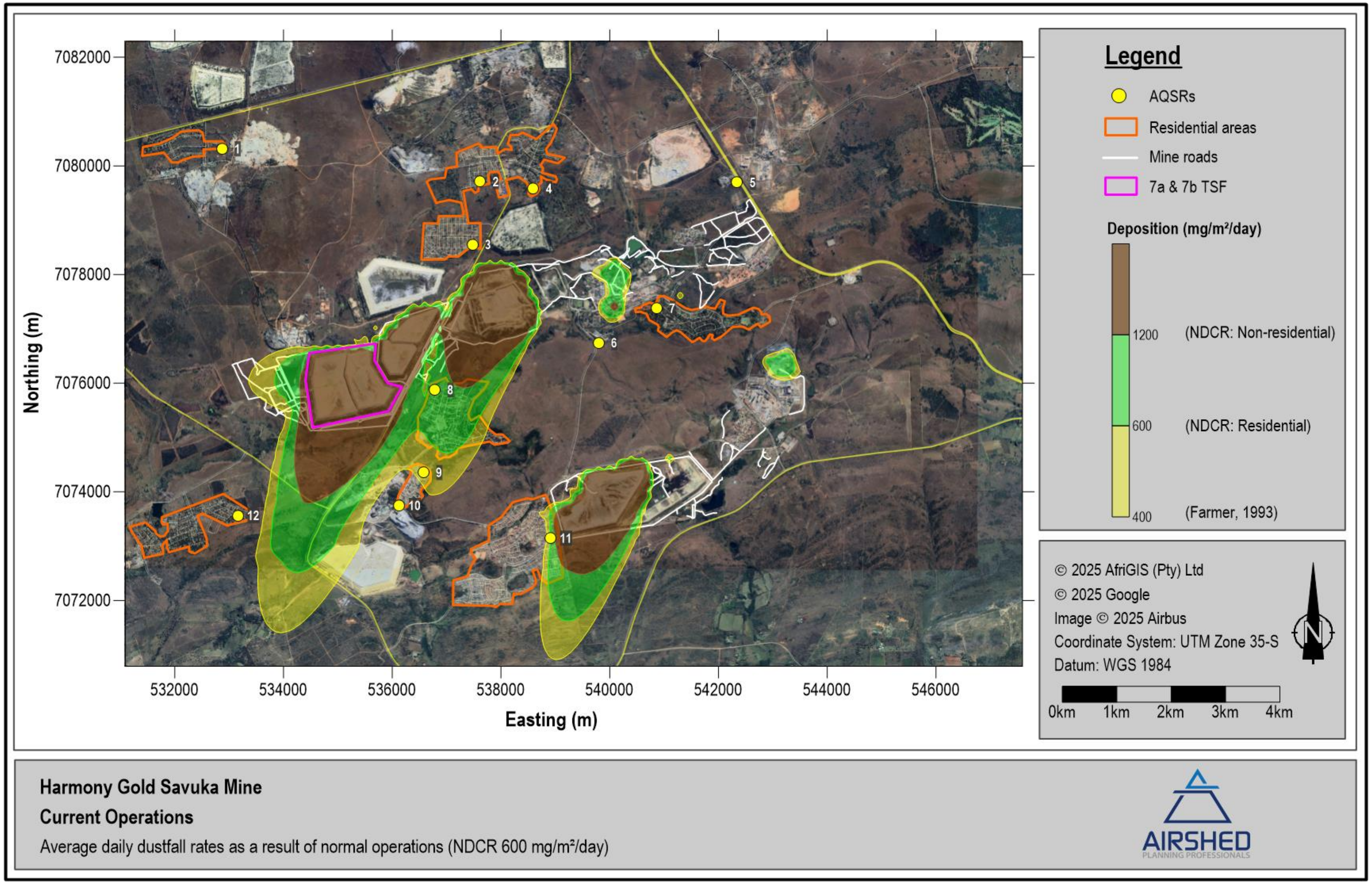

Figure 20: Simulated average daily dustfall rates as a result of current operations with mitigation measures applied

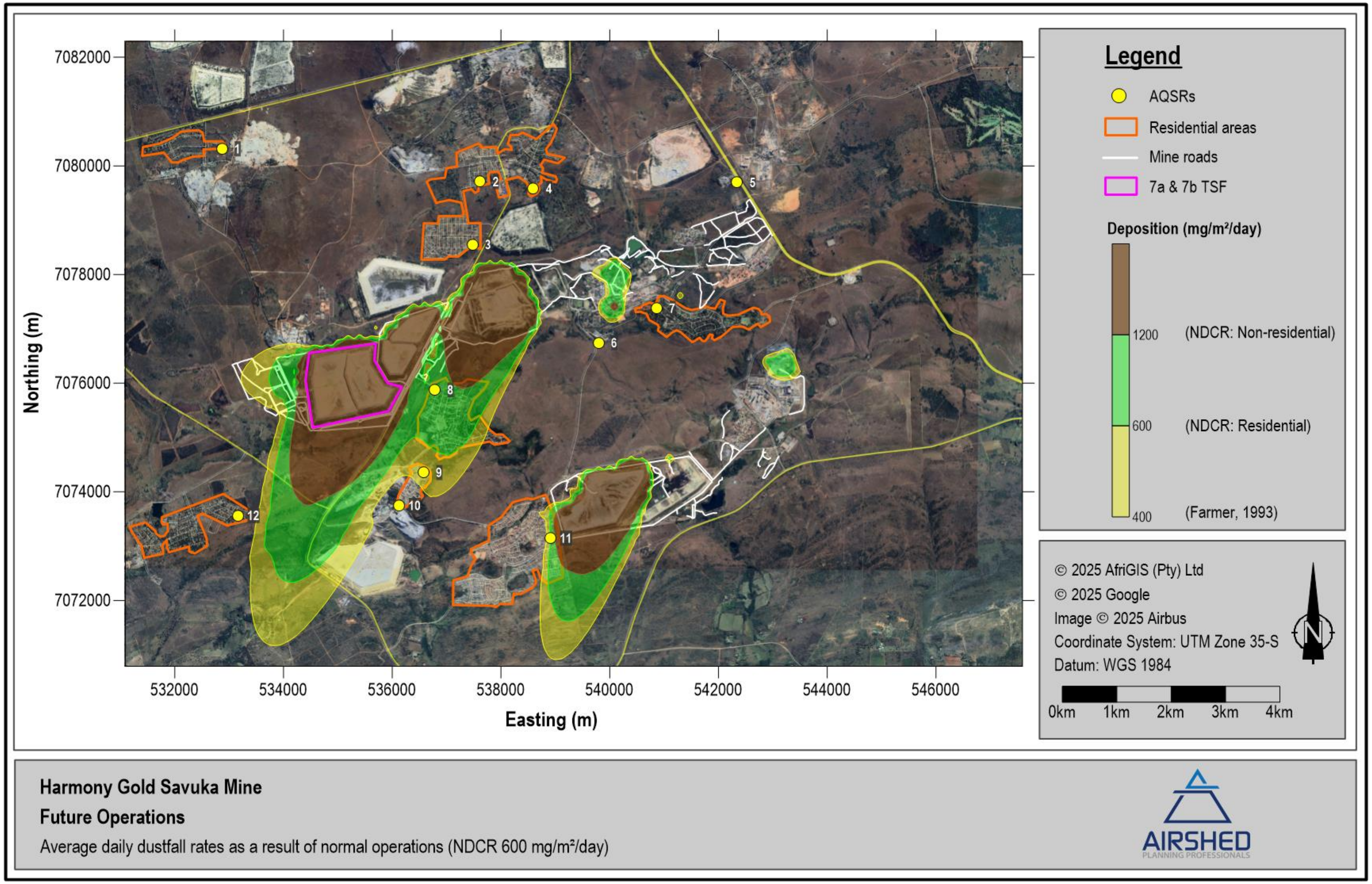

Figure 21: Simulated average daily dustfall rates as a result of future operations with mitigation measures applied

4.4 Impact Significance Rating

The significance of environmental air quality impacts due to the proposed project was assessed according to the methodology adopted by EIMS (Appendix B).

Table 10: Significance rating for potential air quality impacts due to the current operations

Impact Name	Increase in air quality impacts due to current operations at Savuka 7a & 7b				
Alternative	NA				
Phase	Operational Current				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	2
Extent of Impact	3	2	Reversibility of Impact	2	2
Duration of Impact	4	4	Probability	4	3
Environmental Risk (Pre-mitigation)					-3.00
Mitigation Measures					
• In assessing the mitigated impact, it is assumed that the slopes of the TSF are vegetated, and a control efficiency of 80% as measured by Blight (1989) is achieved. Mitigation measures are detailed in Section 5.					
Environmental Risk (Post-mitigation)					-2.5
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response					
Cumulative Impacts					1
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
The impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.17
Final Significance					-9.0

Table 11: Significance rating for potential air quality impacts due to the operational phase

Impact Name	**Increase in air quality impacts due to future operations at Savuka 7a & 7b**				
Alternative	NA				
Phase	Operational Future				
Environmental Risk					
Attribute	**Pre-mitigation**	**Post-mitigation**	**Attribute**	**Pre-mitigation**	**Post-mitigation**
Nature of Impact	-1	-1	Magnitude of Impact	3	2
Extent of Impact	3	2	Reversibility of Impact	2	2
Duration of Impact	4	4	Probability	4	3
Environmental Risk (Pre-mitigation)					-3.00
Mitigation Measures					
• In assessing the mitigated impact, it is assumed that the slopes of the TSF are vegetated, and a control efficiency of 80% as measured by Blight (1989) is achieved. Mitigation measures are detailed in Section 5. • It is assumed that the deposition process will be wet (slurry).					
Environmental Risk (Post-mitigation)					-2.50
Degree of confidence in impact prediction:					Medium
Impact Prioritisation					
Public Response					2
Issue has received a meaningful and justifiable public response					
Cumulative Impacts					1
Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in significant spatial and temporal cumulative change.					
Degree of potential irreplaceable loss of resources					1
The impact is unlikely to result in irreplaceable loss of resources.					
Prioritisation Factor					1.17
Final Significance					-9.00

5 DUST MANAGEMENT PLAN

A Dust Management Plan (DMP) for the Savuka 7a & 7b TSFs should follow an iterative process, including: implementation, monitoring, reporting, reviewing and adjustment to the necessary steps. The following sections of this DMP aim to detail the starting point with regards to fugitive dust emissions management. Included below are the definition of objectives and targets to achieve through dust suppression strategies. Monitoring, reporting, and review allow for the assessment of operations and adjustment of implemented strategies to meet objectives.

5.1 Objectives and Targets

The establishment of objectives and targets with regards to fugitive emissions are important to minimise the impacts of these emissions on the surrounding environment. The objective of the DMP generally is to reduce dust emissions within specific target ranges, by employing appropriate dust suppression strategies.

Windblown dust from the current and height increased Savuka 7a & 7b TSFs could be significant sources of dust emissions if not managed.

5.2 Dust Management Measures

Target control efficiencies are presented for the main dust emission sources identified in the emissions inventory, so that the overall objective is achieved.

5.2.1 Wind Erosion

Any approach that either binds the particles together and make it more resistant to wind erosion or reduce to the force of the wind will result in a reduction in windblown dust emissions.

Surface treatment techniques to reduce dust generation include: wet suppression, chemical stabilisation, covering of surface with less erodible aggregate material and the vegetation of open areas. Wet suppression (the use of sprinklers) can achieve results in the short-term but will require constant maintenance and management to remain effective.

Substantial research has been done on erosion from gold mine tailings. Parameters which have the potential to impact on the rate of emission of fugitive dust include the extent of surface compaction, moisture content, ground cover, the shape of the storage pile, particle size distribution, wind speed and precipitation. Any factor that binds the erodible material or otherwise reduces the availability of erodible material on the surface, decreases the erosion potential of the fugitive source. High moisture contents, whether due to precipitation or deliberate wetting, promote the aggregation and cementation of fines to the surfaces of larger particles, thus decreasing the potential for dust emissions. Surface compaction and ground cover similarly reduces the potential for dust generation (Burger *et al*., 1997).

Rock cladding or armouring of the sides of tailings dams has been shown in various international studies to be effective in various instances in reducing wind erosion of slopes. Cases in which rock cladding has been found to be effective in this regard generally involve rock covers of greater than 0.5 m in depth (Ritcey, 1989; Jewell and Newson, 1997). The application of a 300 mm layer of fine rock was found to be the most successful of the non-vegetative measures, resulting in an erosion control efficiency of 90% if the base is levelled and compacted – wind erosion is considered to reduce by 100% through the addition of such a rock cover.

In addition, screens could be installed on the crest of the tailings dam walls mainly to act as windbreaks and to reduce the potential for dust deposition on the vegetated side walls, hence curbing the growth of the grass.

Vegetal cover retards erosion by binding the residue with a root network, by sheltering the residue surface and by trapping material already eroded. Sheltering occurs by reducing the wind velocity close to the surface, thus reducing the erosion potential and volume of material removed. Vegetation is also considered the most effective control measure in terms of its ability to also control water erosion. In investigating the feasibility of vegetation types the following properties are normally taken into account: indigenous plants; ability to establish and regenerate quickly; proven effective for reclamation elsewhere; tolerant to the climatic conditions of the area; high rate of root production; easily propagated by seed or cuttings; and nitrogen-fixing ability. The long-term effectiveness of suitable vegetation selected for the site will be dependent on (a) the nature of the cover, and (b) the availability of aftercare. Multi-layer covers are frequently being used to ensure the best results (Dixon, 1997; Jewell and Newson, 1997; Ritchey, 1989). Erosion losses from grassed slopes measured by Blight (1989) were found to be in the order of 100 t/ha/year compared to uncontrolled slopes from which losses of up to 500 t/ha/year were recorded.

The removal of the TSF would be the most effective mitigation measure, providing the exposed footprint be vegetated and rehabilitated.

In assessing the mitigated impact, it was assumed that the slopes of the TSF was vegetated, and a control efficiency of 80% as measured by Blight (1989) was achieved.

5.3 Performance Indicators

Key performance indicators against which progress of implemented mitigation and management measures may be assessed, form the basis for all effective environmental management practices. In the definition of key performance indicators careful attention is usually paid to ensure that progress towards their achievement is measurable, and that the targets set are achievable given available technology and experience.

Performance indicators are usually selected to reflect both the source of the emission directly (source monitoring) and the impact on the receiving environment (ambient air quality monitoring). Ensuring that no visible evidence of windblown dust exists represents an example of a source-based indicator, whereas maintaining off-site dustfall levels, at the identified AQSRs, to below 600 mg/m²-day represents an impact- or receptor-based performance indicator.

Source monitoring at operational activities can be challenging due to the fugitive and wind-dependent nature of particulate emissions. The focus is therefore rather on receptor-based performance indicators i.e. compliance with ambient air quality standards and dustfall regulations.

5.3.1 Ambient Air Quality Monitoring

It is recommended that the current dustfall monitoring network be maintained and the monthly dustfall results used as indicators to tract the effectiveness of the applied mitigation measures. Dustfall collection should follow the ASTM method as per the NDCRs. The ASTM method covers the procedure of collection of dustfall and its measurement and employs a simple device consisting of a cylindrical container exposed for one calendar month (30 ±2 days).

5.3.2 Periodic Inspections and Audits

Periodic inspections and external audits are essential for progress measurement, evaluation, and reporting purposes. It is recommended that site inspections and progress reporting be undertaken at regular intervals (at least quarterly), with annual environmental audits being conducted. Annual environmental audits should be continued at least until closure. Results from site inspections and monitoring efforts should be combined to determine progress against source- and receptor-based performance indicators. Progress should be reported to all interested and affected parties (I&APs), including authorities and persons affected by pollution.

The criteria to be taken into account in the inspections and audits must be made transparent by way of minimum requirement checklists included in the management plan. Corrective action or the implementation of contingency measures must be proposed to the stakeholder forum in the event that progress towards targets is indicated by the quarterly/annual reviews to be unsatisfactory.

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

Stakeholder forums provide possibly the most effective mechanisms for information dissemination and consultation. Management plans should stipulate specific intervals at which forums will be held and provide information on how people will be notified of such meetings. Given the proximity of the study site to the nearby communities and farmsteads, it is recommended that such meetings be scheduled and held at least on an annual basis. A complaints register must be kept at all times.

6 MAIN FINDINGS

An air quality study was conducted for the current (Savuka and Mponeng operations) and future (increase height of Savuka 7a & 7b TSFs) activities. The main objective of this study was to determine the significance the increased heights of the two TSFs will have on the air quality and resulting impacts on nearby receptors. This section summarises the main findings of the receiving environment and impact assessment.

6.1 Main Findings

The main findings of the receiving environment assessment are:

- AQSRs near the Savuka operations include Southdene (north of Savuka 5 TSF), Elandsridge (southeast of 7b TSF and southwest of 5 TSF), Harmony Hostel (southeast of 7b TSF) and Harmony Hospital (south of the Savuka Plant).
- The main sources associated with the Savuka and Mponeng operations likely to contribute to baseline PM emissions include mining and reclaiming operations, processing operations, vehicle entrained dust from roads, vehicle exhaust and windblown dust from exposed areas on existing TSFs.
- Other sources of PM within the area include other companies mining, transport and processing activities, farm activities, occasional biomass burning, household fuel burning in the residential areas, vehicle entrained dust from public roads and vehicle exhaust.
- The wind field is dominated by winds from the northerly sector with the strongest winds (>6 m/s) mostly from the north-northeasterly sector. The predominant northerly wind field remains similar throughout the seasons.
- Dust fallout results from the 10 DMUs at Savuka for the period January 2023 to October 2024 show compliance with the NDCR at both the residential and non-residential sites.

The main findings of the impact assessment for current and future operations are as follows:

- Simulated $PM_{2.5}$ concentrations comply with the NAAQS at all AQSRs, both for current and future operations.
- Simulated PM_{10} concentrations comply with the NAAQS at all AQSRs, both for current and future operations.
- Simulated dustfall rates were above the NDCR limits for residential areas at one AQSR (Elandsridge) both during current and future operations, with a 3.5 km area of exceedance of the agricultural limit (400 mg/m²-day). Measured dustfall rates are however below the NDCR limit for residential areas at all AQSRs, including Elandsridge for the past three years, implying a possible overprediction of simulated dustfall rates.
- The environmental risk due to unmitigated future operations is classified as **Medium.** With mitigation (80% CE through grassing of TSF side slopes and wet slurry deposition) the risk is classified as **Low**.

6.2 Recommendations

With the potential impacts from windblown dust from the active TSFs, especially the height increased Savuka 7a & 7b TSFs, the following recommendations are proposed:

- Dustfall monitoring ensuring dustfall rate in compliance with the NDCR limits; and
- Mitigation measures aimed at reducing wind erosion from the active TSFs, i.e. the grassing of TSF side slopes.

In conclusion, it is the specialist opinion that the project may be authorised provided that the recommended air quality management measures are implemented.

7 REFERENCES

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8 APPENDIX A: SPECIALIST CURRICULUM VITAE

ABBREVIATED CURRICULUM VITAE	HANLIE LIEBENBERG-ENSLIN

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	Hanlie Liebenberg-Enslin
Profession	Managing Director / Air Quality Scientist
Date of Birth	09 January 1971
Years with Firm/ entity	25 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA) – President 2010–2013, Board member 2013-present
- Member of the National Association for Clean Air (NACA) - President 2008-2010, NACA Council member 2010 –2014

KEY QUALIFICATIONS

Hanlie Liebenberg-Enslin started her professional career in Air Quality Management in 2000 when she joined Environmental Management Services (EMS) after completing her Master's Degree at the University of Johannesburg (then Rand Afrikaans University) in the same field. She is one of the founding members of Airshed Planning Professionals in 2003 where she has worked as a company Director until May 2013 when she was appointed as Managing Director. She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. She has worked all over Africa and has an inclusive knowledge base of international legislation and requirements pertaining to air quality.

She has developed technical and specialist skills in various modelling packages including the industrial source complex models (ISCST3 and SCREEN3), EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS), EPA Regulatory puff based model (CALPUFF and CALMET), puff based HAWK model and line based models such as CALINE. Her experience with emission models includes Tanks 4.0 (for the quantification of tank emissions) and GasSim (for the quantification of landfill emissions).

Having worked on projects throughout Africa (i.e. South Africa, Mozambique, Botswana, Namibia, Malawi, Kenya, Mali, Democratic Republic of Congo, Tanzania, Madagascar, Guinea and Mauritania) Hanlie has developed a broad experience base. She has a good understanding of the laws and regulations associated with ambient air quality and emission limits in South Africa and various other African countries, as well as the World Bank Guidelines, European Community Limits and World Health Organisation.

Being an avid student, she received her PhD in 2014, specialising in Aeolian dust transport. Hanlie is also actively involved in the National Association for Clean Air and is their representative at the International Union of Air Pollution Prevention and Environmental Protection Associations.

RELEVANT EXPERIENCE

Air Quality Management Plans and Strategies

Vaal Triangle Airshed Priority Area Draft Second Generation Air Quality Management Plan (AQMP)(Aug 2017 – Jun 2020); Advanced Air Quality Management for the Strategic Environmental Management Plan for the Uranium and Other Industries in the Erongo Region (May 2016 – Feb 2019); City of Johannesburg AQMP (2016-2019); Air Quality Monitoring and Management for the Al Madinah Al Munawarah Development Authority (MDA) in Saudi Arabia (2016-2017). Provincial Air Quality Management Plan for the Limpopo Province (March 2013); Mauritius Road Development Agency Proposed Road Decongestion Programme (July 2013); Transport Air Quality Management Plan for the Gauteng Province (February 2012); Gauteng Green Strategy (2011); Air Quality and Radiation Assessment for the Erongo Region Namibia as part of a Strategic Environmental Assessment (June, 2010); Vaal Triangle Airshed Priority Area AQMP (March, 2009); Gauteng Provincial AQMP (January 2009); North West Province AQMP (2008); City of Tshwane AQMP (April 2006); North West Environment Outlook 2008 (December 2007); Ambient Monitoring Network for the North West Province (February 2007); Spatial Development Framework Review for the City of uMhlathuze (August 2006); Ambient Particulate Pollution Management System (Anglo Platinum Rustenburg).

Hanlie has also been the Project Director on all the listed Air Quality Management plan developments.

Mining and Ore Handling

Hanlie has undertaken numerous air quality impact assessments and management plans for coal, platinum, uranium, copper, cobalt, chromium, fluorspar, bauxite and mineral sands mines. These include air quality impact assessments for: Namibia – Husab Uranium Mine, Trekkopje Uranium Mine; Bannerman Uranium Project; Langer Heinrich Uranium Mine, Valencia Uranium Mine, Rössing Uranium Mine; and B2Gold Otjikoto Gold Mine. South Africa – Sishen Iron Ore Mine; Tshipi Borwa Manganese Mine; Mamatwan Manganese Mine; Kolomela Iron Ore Mine; Thabazimbi Iron ore Mine; UKM Manganese Mine; Everest Platinum Mine; Impala Platinum Mine; Anglo Platinum Mines; Abglo Gold Ashanti MWS, Vaal River and West Wits complexes, Harmony Gold, Glencore Coal Mines, South32 and Anglo Coal; Tselentis Coal mine (Breyeton); Lime Quarries (De Hoek, Dwaalboom, Slurry); Beesting Colliery (Ogies); Anglo Coal Opencast Coal Mine (Heidelberg); Klippan Colliery (Belfast); Beesting Colliery (Ogies); Xstrata Coal Tweefontein Mine (Witbank); Xstrata Coal Spitskop Mine (Hendrina); Middelburg Colliery (Middelburg); Klipspruit Project (Ogies); Rustenburg Platinum Mine (Rustenburg); Impala Platinum (Rustenburg); Buffelsfontein Gold Mine (Stilfontein); Kroondal Platinum Mine (Kroondal); Lonmin Platinum Mine (Mooinooi); Rhovan Vanadium (Brits); Macauvlei Colliery (Vereeniging); Voorspoed Gold Mine (Kroonstad); Pilanesberg Platinum Mine (Pilanesberg); Kao Diamond Mine (Lesotho); Modder East Gold Mine (Brakpan); Modderfontein Mines (Brakpan); Zimbiwa Crusher Plant (Brakpan); RBM Zulti South Titanium mining (Richards Bay); Premier Diamond Mine (Cullinan). Botswana – Jwaneng Diamond Mine and Debswana Mining Company. Zimbabwe – Murowa Diamond Mine. Other mining projects include Sadiola Gold Mine (Mali); North Mara Gold Mine (Tanzania); Bulyanhulu North Mara Gold Mine (Tanzania).

Metal Recovery

Air quality impact assessments have been carried out for Smelterco Operations (Kitwe, Zimbia); Waterval Smelter (Amplats, Rustenburg); Hernic Ferrochroime Smelter (Brits); Rhovan Ferrovanadium (Brits); Impala Platinum (Rustenburg); Impala Platinum (Springs); Transvaal Ferrochrome (now IFM, Mooinooi), Lonmin Platinum (Mooinooi); Xstrata Ferrochrome Project Lion (Steelpoort); ArcelorMittal South Africa (Vandebijlpark, Vereeniging, Pretoria, Newcastle, Saldanha); Hexavalent Chrome Xstrata (Rustenburg); Portland Cement Plant (DeHoek, Slurry, Dwaalboom, Hercules, Port Eelizabeth); Vantech Plant (Steelpoort); Bulyanhulu Gold Smelter (Tanzania), Sadiola Gold Recovery Plant (Mali); RBM Smelter Complex (Richards Bay);

Chibuto Heavy Minerals Smelter (Mozambique); Moma Heavy Minerals Smelter (Mozambique); Boguchansky Aluminium Plant (Russia); Xstrata Chrome CMI Plant (Lydenburg); SCAW Metals (Germiston).

Chemical Industry

Comprehensive air quality impact assessments have been completed for AECI (Pty) Ltd Operations (Modderfontein); Kynoch Fertilizer (Potchefstroom), Foskor (Richards Bay) and Omnia (Rustenburg).

Petrochemical Industry

Numerous air quality impact assessments have been completed for SASOL operations (Sasolburg); Sapref Refinery (Durban); Health risk assessment of Island View Tank Farm (Durban Harbour).

Pulp and Paper Industry

Air quality studies have been undertaken or the expansion of Mondi Richards Bay, Multi-Boiler Project for Mondi Merebank (Durban), impact assessments for Sappi Stanger, Sappi Enstra (Springs), Sappi Ngodwana (Nelspruit) and Pulp United (Richards Bay).

Power Generation

Air quality impact assessments have been completed for numerous Eskom coal fired power station studies including the Coal 3 Power Project near Lephalale, Komati Power Station and Lethabo Power Stations. In addition to Eskom's coal fired power stations, projects have been completed for the proposed Mmamabula Energy Project (Botswana); Morupule Power Plant (Botswana), NamPower Erongo Power Project (Namibia), NamPower Van Eck Power Station (Namibia) and NamPower Biomass Power Plant (Namibia).

Apart from Eskom projects, heavy fuel oil power station assessments have also been completed in Kenya (Rabai Power Station) and Namibia (Arandis Power Plant).

Green energy projects included several Solar Photovoltaic Projects (Mulilo and Enertrag South Africa (Pty) Ltd) and assessing potential particulate matter impacts from Wind Farms near the South African Large Telescope (SALT).

Waste Disposal

Air quality impact assessments, including odour and carcinogenic and non-carcinogenic pollutants were undertaken for the proposed Coega Waste Disposal Facility (Port Elizabeth); Boitshepi Waste Disposal Site (Vanderbijlpak); Umdloti Waste Water Treatment Plant (Durban).

Cement Manufacturing

Impact assessments for ambient air quality have been completed for the PPC Cement Alternative Fuels Project (which included the assessment of the cement manufacturing plants in the North West Province, Gauteng and Western).

Vehicle emissions

Transport Air quality Management Plan for the Gauteng Department of Roads and Transport (Feb 2012); Platinum Highway (N1 to Zeerust); Gauteng Development Zone (Johannesburg); Gauteng Department of Roads and Transport (Transport Air Quality Management Plan); Mauritius Road Development Agency (Proposed Road Decongestion Programme); South African Petroleum Industry Association (Impact Urban Air Quality).

Government and International Strategy Projects

Hanlie in one of the Lead Authors of Section 1.1: Africa's Development: Challenges, Drivers and key objectives, of the United Nations Environment Programme (UNEP), Climate and Clean Air Coalition (CCAC) and Stockholm Environment Institute (SEI) coordinated 'Integrated Assessment of Air Pollution and Climate Change for Africa Report. She was also the Terminal Reviewer of the UNEP/UNDA project "Air quality data for health and environment policies in Africa and the Asia-Pacific region" (May 2020). Hanlie was also the project Director on the APPA Registration Certificate Review Project for Department of Environmental Affairs (DEA); Green Strategy for Gauteng (2011).

EDUCATION

Ph.D Geography	**Ph.D Geography,** University of Johannesburg, RSA (2014) Title: *A functional dependence analysis of wind erosion modelling system parameters to determine a practical approach for wind erosion assessments*
M.Sc Geography and Environmental Management	University of Johannesburg, RSA (1999) Title: *Air Pollution Population Exposure Evaluation in the Vaal Triangle using GIS*
B.Sc Hons. Geography	University of Johannesburg, RSA (1995) GIS & Environmental Management
B.Sc Geography and Geology	University of Johannesburg, RSA (1994) Geography and Geology

ADDITIONAL COURSES AND ACADEMIC REVIEWS

External Examiner (January 2022)	MSc Candidate: P Chidhindi Using dispersion models as a regulatory tool in South Africa Department Geography and Environmental Management, North-West University
External Examiner (February 2021)	PhD Candidate: Ms NM Walton Aerosol source apportionment in southern Africa Faculty of Natural and Agricultural Sciences, North-West University
External Examiner (May 2018)	MSc Candidate: Ms A Quta Characterisation of Particulate Matter and Some Pollutant Gasses in the City of Tshwane Department of Environmental Sciences, University of South Africa
External Examiner (December 2017)	MSc Candidate: Ms B Wernecke Ambient and Indoor Particulate Matter Concentrations on the Mpumalanga Highveld Faculty of Natural and Agricultural Sciences, North-West University

External Examiner (January 2016)	MSc Candidate: Ms M Grobler Evaluating the costs and benefits associated with the reduction in SO_2 emissions from Industrial activities on the Highveld of South Africa Department of Chemical Engineering, University of Pretoria
External Examiner (August 2014)	MSc Candidate: Ms Seneca Naidoo Quantification of emissions generated from domestic fuel burning activities from townships in Johannesburg Faculty of Science, University of the Witwatersrand
Air Quality Law– Lecturer (2012 - 2016)	Environmental Law course: Centre of Environmental Management.
Air Quality law for Mining – Lecturer (2014)	Environmental Law course: Centre of Environmental Management.
Air Quality Management – Lecturer (2006 -2012)	Air Quality Management Short Course: NACA and University of Johannesburg, University of Pretoria and University of the North West
ESRI SA (1999)	ARCINFO course at GIMS: Introduction to ARCINFO 7 course
ESRI SA (1998)	ARCVIEW course at GIMS: Advanced ARCVIEW 3.1 course

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Botswana, Namibia, Malawi, Mauritius, Kenya, Mali, Zimbabwe, Democratic Republic of Congo, Tanzania, Zambia, Madagascar, Guinea, Russia, Mauritania, Morocco, and Saudi Arabia.

EMPLOYMENT RECORD

March 2003 - Present

Airshed Planning Professionals (Pty) Ltd, Managing Director and Principal Air Quality Scientist, Midrand, South Africa.

January 2000 – February 2003

Environmental Management Services CC, Senior Air Quality Scientist.

May 1998 – December 1999

Independent Broadcasting Authority (IBA), GIS Analyst and Demographer.

February 1997 – April 1998

GIS Business Solutions (PQ Africa), GIS Analyst

January 1996 – December 1996

Annegarn Environmental Research (AER), Student Researcher

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Excellent	Excellent	Excellent

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Air Quality Evolution in South Africa over the past 20 years: A Consultants' Journey. Hanlie Liebenberg-Enslin. 55th Annual Conference of the National Association for Clean Air, 4 to 6 September 2024, Johannesburg. Keynote speaker.
- Integrated Assessment of Air Pollution and Climate Change for Sustainable Development in Africa – Towards "the Africa we want". Hanlie Liebenberg-Enslin, and Kevin Hicks. Air Protection 2023 & International Conference and 13th Croatian Scientific and Professional Meeting, CAPPA, 20 - 24 September 2023, Dubrovnik, Croatia at Hotel Astarea, Mlini.
- Dust and radon levels on the west coast of Namibia – What did we learn? Hanlie Liebenberg-Enslin, Detlof von Oertzen, and Norwel Mwananawa. Atmospheric Pollution Research, 2020. https://doi.org/10.17159/caj/2020/30/1.8467
- Understanding the Atmospheric Circulations that lead to high particulate matter concentrations on the west coast of Namibia. Hanlie Liebenberg-Enslin, Hannes Rauntenbach, Reneé von Gruenewaldt, and Lucian Burger. Clean Air Journal, 27, 2, 2017, 66-74.
- Cooperation on Air Pollution in Southern Africa: Issues and Opportunities. SLCPs: Regional Actions on Climate and Air Pollution. Liebenberg-Enslin, H. 17th IUAPPA World Clean Air Congress and 9th CAA Better Air Quality Conference. Clean Air for Cities - Perspectives and Solutions. 29 August - 2 September 2016, Busan Exhibition and Convention Center, Busan, South Korea.
- A Best Practice prescription for quantifying wind-blown dust emissions from Gold Mine Tailings Storage Facilities. Liebenberg-Enslin, H., Annegarn, H.J., and Burger, L.W. VIII International Conference on Aeolian Research, Lanzhou, China. 21-25 July 2014.
- Quantifying and modelling wind-blown dust emissions from gold mine tailings storage facilities. Liebenberg-Enslin, H. and Annegarn, H.J. 9th International Conference on Mine Closure, Sandton Convention Centre, 1-3 October 2014.
- Gauteng Transport Air Quality Management Plan. Liebenberg-Enslin, H., Krause,N., Burger, L.W., Fitton, J. and Modisamongwe, D. National Association for Clean Air Annual Conference, Rustenburg. 31 October to 2 November 2012. Peer reviewed.
- Developing an Air Quality Management Plan: Lessons from Limpopo. Bird, T.; Liebenberg-Enslin, H., von Gruenewaldt, R., Modisamongwe, D. National Association for Clean Air Annual Conference, Rustenburg. 31 October to 2 November 2012. Peer reviewed.
- Modelling of wind eroded dust transport in the Erongo Region, Namibia, H. Liebenberg-Enslin, N Krause and H.J. Annegarn. National Association for Clean Air (NACA) Conference, October 2010. Polokwane.

- The lack of inter-discipline integration into the EIA process-defining environmental specialist synergies. H. Liebenberg-Enslin and LW Burger. IAIA SA Annual Conference, 21-25 August 2010. Workshop Presentation. Not Peer Reviewed.
- A Critical Evaluation of Air Quality Management in South Africa, H Liebenberg-Enslin. National Association for Clean Air (NACA) IUAPPA Conference, 1-3 October 2008. Nelspuit.
- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007, Vanderbijl Park.
- Air Quality Management plan as a tool to inform spatial development frameworks – City of uMhlathuze, Richards Bay, H Liebenberg-Enslin and T Jordan. National Association for Clean Air (NACA) conference, 29 – 30 September 2005, Cape Town.

CERTIFICATION

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

19 February 2025

Full name of staff member: Hanlie Liebenberg-Enslin

9 APPENDIX B – IMPACT SIGNIFICANCE RATING METHODOLOGY

The impact assessment methodology is guided by the requirements of the NEMA EIA Regulations (2010). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/likelihood (P) of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts, public concern, and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S).

Determination of Environmental Risk:

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

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

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

Each individual aspect in the determination of the consequence is represented by a rating scale as defined in Table 12.

Table 12: Criteria for determining impact consequence

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

Aspect	Score	Definition
	4	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease), or
	5	Very high / don't know (where natural, cultural or social functions or processes are altered to the extent that it will permanently cease).
Reversibility	1	Impact is reversible without any time and cost.
	2	Impact is reversible without incurring significant time and cost.
	3	Impact is reversible only by incurring significant time and cost.
	4	Impact is reversible only by incurring prohibitively high time and cost.
	5	Irreversible Impact

Once the C has been determined the ER is determined in accordance with the standard risk assessment relationship by multiplying the C and the P (Table 14). Probability is rated/scored as per Table 13.

Table 13: Probability scoring

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

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

ER= C x P

Table 14: Determination of environmental risk

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

The outcome of the environmental risk assessment will result in a range of scores, ranging from 1 through to 25. These ER scores are then grouped into respective classes as described in Table 15.

Table 15: Significance classes

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

≥ 17	High (i.e. where the impact will have a significant environmental risk).

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

Impact Prioritisation:

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

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

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

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

Table 16: Criteria for determining prioritisation

Public response (PR)	Low (1)	Issue not raised in public response.
	Medium (2)	Issue has received a meaningful and justifiable public response.
	High (3)	Issue has received an intense meaningful and justifiable public response.
Cumulative Impact (CI)	Low (1)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.
	Medium (2)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.
	High (3)	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is highly probable/definite that the impact will result in spatial and temporal cumulative change.
Irreplaceable loss of resources (LR)	Low (1)	Where the impact is unlikely to result in irreplaceable loss of resources.
	Medium (2)	Where the impact may result in the irreplaceable loss (cannot be replaced or substituted) of resources but the value (services and/or functions) of these resources is limited.
	High (3)	Where the impact may result in the irreplaceable loss of resources of high value (services and/or functions).

The value for the final impact priority is represented as a single consolidated priority, determined as the sum of each individual criteria represented in Table 16. The impact priority is therefore determined as follows:

Priority = PR + CI + LR

The result is a priority score which ranges from 3 to 9 and a consequent PF ranging from 1 to 2 (refer to Table 17).

Table 17: Determination of prioritisation factor

Priority	Ranking	Prioritisation Factor
3	Low	1
4	Medium	1.17
5	Medium	1.33
6	Medium	1.5
7	Medium	1.67
8	Medium	1.83
9	High	2

In order to determine the final impact significance the PF is multiplied by the ER of the post mitigation scoring (Table 18). The ultimate aim of the PF is to be able to increase the post mitigation environmental risk rating by a full ranking class, if all the priority attributes are high (i.e. if an impact comes out with a medium environmental risk after the conventional impact rating, but there is significant cumulative impact potential, significant public response, and significant potential for irreplaceable loss of resources, then the net result would be to upscale the impact to a high significance).

Table 18: Final environmental significance rating

Environmental Significance Rating	
Value	**Description**
< 10	Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
≥10 <20	Medium (i.e. where the impact could influence the decision to develop in the area),
≥ 20	High (i.e. where the impact must have an influence on the decision process to develop in the area).