Air Quality Baseline Assessment for the Harmony Kalgold Expansion

Project done for **Environmental Impact Management Services (Pty) Ltd**

Report compiled by:

Natasha Shackleton

Tinashe Mukota

Project Manager:

Natasha Shackleton

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Address: 480 Smuts Drive, Halfway Gardens | Postal: P O Box 5260, Halfway House, 1685

Tel: +27 (0)11 805 1940 | Fax: +27 (0)11 805 7010

www.airshed.co.za

Report Details

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Prepared by	Tinashe Michael Mukota, MEng Environmental Engineering (University of Pretoria) Natasha Shackleton, Pr. Sci. Nat., BSc Hons Meteorology (University of Pretoria)
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Draft	28 October 2020	-	For client review (EIMS)
Draft v1	4 March 2021	Section 1 Section 3	For client review (EIMS) Revised to account for changes to the proposed process description and layout
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Competency Profiles

Report author and project manager: N A Shackleton (née Gresse), Pr. Sci. Nat., BSc Hons (Meteorology) (University of Pretoria)

Natasha Shackleton started her professional career in Air Quality in April 2011 when she joined Airshed Planning Professionals (Pty) Ltd after completing her Undergraduate Degree at the University of Pretoria in Science. In 2011 she completed her Honours Degree at the University of Pretoria in Meteorology. Natasha is also a member of the South African Society for Atmospheric Sciences (SASAS) and is a registered Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) (registration no. 116335). She is currently undertaking her MSc: Applied Science (Environmental Technology) through the University of Pretoria. Natasha has worked on several air quality specialist studies between 2011 and 2020. She has experience in the various components including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality. Whilst most of his working experience has been in South Africa, a number of investigations were made in countries elsewhere, including Burkina Faso, Guinea, Ghana, Madagascar, Mozambique, Namibia, Suriname, Tanzania, Zimbabwe and Zambia.

Report author: T M Mukota, MEng Environmental Engineering (University of Pretoria)

Tinashe Mukota holds a MEng in Environmental Engineering, from the University of Pretoria. The focus of his masters research was the calibration of locally fabricated passive aerosol samplers for particulate matter monitoring. Since November 2019 he has been employed at Airshed Planning Professionals (Pty) Ltd. In this time, he has been involved in air quality impact assessments for mining operations. Prior to joining Airshed Planning Professionals (Pty) Ltd he was involved in research of ambient measurement techniques. He is experienced in meteorological and ambient data analysis.

NEMA EIA Regulation (2014, as amended) Appendix 6 - Specialist Reports

NEMA EIA Regulations (2014, as amended) Appendix 6 – Specialist Reports	Relevant section in report
Details of the specialist who prepared the report.	Report Details (page i) Competency Profiles (page ii)
The expertise of that person to compile a specialist report including curriculum vitae.	Competency Profiles (page ii) Appendix A – Specialist Curriculum Vitae and Professional Registration Certificate (N A Shackleton) (page 65)
A declaration that the person is independent in a form as may be specified by the competent authority.	Report Details (page i)
An indication of the scope of, and the purpose for which, the report was prepared.	Section 1: Introduction (page 1)
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	No site visit has been conducted. Section 3.2: Atmospheric Dispersion Potential (page 26) Section 3.3: Existing Air Quality (page 31)
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 1.2: Study Objective (page 4) Section 1.4: Air Quality Study Methodology (page 8)
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 3.1:Affected Environment (page 23) Section 4.2: Sensitivity Map (page 37)
An identification of any areas to be avoided, including buffers.	Not applicable
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Figure 2: Locality map (page 25) Section 3.1:Affected Environment (page 23) Section 4.2: Sensitivity Map (page 37)
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.5: Managing Uncertainties (page 10)
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 4: Potential Impact from Kalgold Future Operations (page 37) Section 5: Findings (page 60)
Any mitigation measures for inclusion in the environmental management programme report	To be determined in next phase
Any conditions for inclusion in the environmental authorisation	To be determined in next phase
Any monitoring requirements for inclusion in the environmental management programme report or environmental authorisation.	To be determined in next phase
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	To be determined in next phase

NEMA EIA Regulations (2014, as amended) Appendix 6 – Specialist Reports	Relevant section in report
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the environmental management programme report, and where applicable, the closure plan.	To be determined in next phase
A description of any consultation process that was undertaken when the study was carried out.	Not applicable
A summary and copies if any comments that were received during any consultation process.	None received
Any other information requested by the competent authority.	None received

Abbreviations, Symbols and Units

AEL	Atmospheric Emissions License
AIR	Atmospheric Impact Report
Airshed	Airshed Planning Professionals (Pty) Ltd
AQIA	Air quality Impact Assessment
AQSR	Air Quality Sensitive Receptors
ASTM	American Standard Testing Method
ATSDR	US Agency for Toxic Substances and Disease Registry
CALEPA	California Environmental Protection Agency
CE	Control efficiency
CH_4	Methane
Cl_2	Chlorine
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
DEA	Department of Environmental Affairs (now DEFF)
DEFF	Department of Environment, Forestry and Fisheries
DoE	Department of Energy
EA	Environmental Authorisation
EIMS	Environmental Impact Management Services (Pty) Ltd
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
FEL	Front-end-loader
g	Gram
g/s	Gram per second
GG	Government Gazette
GHG	Greenhouse Gases
GLC(s)	Ground level concentration(s)
GLCC	Global land cover characterisation
GN	Government Notice
GV	Guideline Value
H_2O	Water vapour
ha	Hectare
Harmony	Harmony Gold Company Limited
HCl	Hydrogen chloride
HF	Hydrogen fluoride
HFCs	Hydrofluorocarbons

IRIS	Integrated Risk Information System
I&APs	Interested and Affected Parties
IFC	International Finance Corporation
kg	Kilogram
ktpm	Kilotonnes per month
LoM	Life of Mine
Ltd	Limited
m	Metre
m^2	Metre squared
m^3	Metre cubed
mamsl	Metres above mean sea level
MES	Minimum Emission Standards
mm	Millimetres
m/s	Metres per second
MPRDA	Mineral and Petroleum Resources Development Act (No. 28 of 2002)
MRL	Minimal risk levels for hazardous substances
NAAQS	National Ambient Air Quality Standards
NAEIS	National Atmospheric Emissions Inventory System
NDCR	National Dust Control Regulations
NEMA	National Environmental Management Act (No. 107 of 1998)
NEM:AQA	National Environmental Management: Air Quality Act (No. 39 of 2004)
NH_3	Ammonia
NPI	National Pollutant Inventory (Australia)
N_2O	Nitrous oxide
NO	Nitrogen oxide
NO_2	Nitrogen dioxide
NO_x	Oxides of nitrogen
O_3	Ozone
PFCs	Perfluorocarbons
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
RfCs	Inhalation reference concentrations
RoM	Run-of-mine
SAAQIS	South Africa Air Quality Information System
SABS	South African Bureau of Standards
SAGERS	South African Greenhouse Gas Emission Reporting System
SANS	South African National Standards

SAWS	South African Weather Service
SF_6	Sulfur hexafluoride
SO_2	Sulfur dioxide
SRTM	Shuttle radar topography mission
tpa	Tonnes per month
TSF	Tailings storage facility
TSP	Total suspended particulates
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WBG	World Bank Group
WHO	World Health Organisation
WRD	Waste rock dump
WRF	Weather Research and Forecasting
°C	Degrees Celsius
µg	Microgram(s)
$\mu g/m^3$	Micrograms per cubic meter
%	Percentage

Glossary

Air pollution	This 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
Ambient Air	This is defined as any area not regulated by Occupational Health and Safety regulations
Atmospheric emission or emission	Any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution
Averaging period	This implies a period of time over which an average value is determined
Dispersion	The spreading of atmospheric constituents, such as air pollutants
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
Mechanical mixing	Any mixing process that utilizes the kinetic energy of relative fluid motion
Particulate Matter (PM)	These comprise a mixture of organic and inorganic substances, ranging in size and shape. These 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.
PM_{10}	Particulate Matter with an aerodynamic diameter less than or equal to 10 µm. it is also referred to as thoracic particulates and is associated with health impacts due to its tendency to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung
$PM_{2.5}$	Particulate Matter with an aerodynamic diameter less than or equal to 2.5 µm. it is also referred to as respirable particulates. It is associated with health impacts due to its high tendency to be deposited in, and damaging to, the lower airways and gas-exchanging portions of the lung
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

Executive Summary

Harmony Gold Company Limited (hereafter referred to as Harmony), has owned and operated the Kalgold Operations since 1999. The Kalgold Operations comprises of open-pit gold mining operations and carbon-in-leach gold plant. Harmony proposes to increase the Kalgold operations production. Kalgold is located approximately 55km southwest of Mahikeng in the Ratlou Local Municipality (LM) within the Ngaka Modiri Molema District Municipality (DM) in the North West Province of South Africa.

The existing Harmony Kalgold operation wishes to increase its production from the current production rate of 130 000 tonnes per month (tpm) to 300 000 tpm. The change in production rate will require expansion of (and modification to) the current operational facilities and layout. The proposed expansion operations require Environmental Authorisation in terms of both the National Environmental Management Act (No. 107 of 1998) (NEMA) (Republic of South Africa, 1998) and Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA) (Republic of South Africa, 2004), as amended in 2008 (Republic of South Africa, 2009), as well as a Water Use Licence (WUL) issued in terms of the National Water Act (No 36 of 1998) (NWA) (Republic of South Africa, 1998). Due to the Listing Notice activities applicable a full Environmental Impact Assessment/Environmental Management Program (EIA/EMPr) process is requiring scoping and environmental impact reports (S&EIRs) and an EMPr. This process is usually conducted in two phases, the first being the scoping phase which requires the submission of a scoping report. According to NEMA EIA Regulations "a scoping report must contain the information that is necessary for a proper understanding of the process, informing all preferred alternatives, including location alternatives, the scope of the assessment, and the consultation process to be undertaken through the environmental impact assessment process".

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Environmental Impact Management Services (Pty) Ltd (EIMS) to undertake an Air Quality Impact Assessment (AQIA) as part of the Environmental Authorisation (EA) process to identify key aspects that may have significant air quality impacts during the various project phases. As such the AQIA report will conform to the amended regulated format requirements for specialist reports as per Appendix 6 of the Environmental Impact Assessment (EIA) Regulations (Republic of South Africa, 2014) (as amended by Government Notice [GN] 326 of 7 April 2017; GN 706 of 13 July 2018 and GN 320 of 20 March 2020). This report covers the baseline (existing environment) assessment for the proposed expansion project (the project) for inclusion into the scoping report.

The findings from the baseline assessment can be summarised as follows:

- Meteorological data was provided for the period August 2019 – September 2020 from the on-site Kalgold station and had 70.4% data availability after processing.
- The prevailing wind field in the area consists of east-north-easterly, north-easterly and easterly winds. Wind speeds were lower at night than during the day. Wind speeds exceeding 5.0 m/s occurred for 1.1% of the period.
- The area experiences mild summers and cold winters with monthly average temperatures ranged between 10°C and 26°C. The highest temperature of (35°C) occurred in October and the lowest (-4°C) in June.

- Simulated data (January 2011 to December 2013) from the study conducted by Digby Wells (Digby Wells Environmental, 2014) showed that the average precipitation was 66 mm. The three-year annual maximum, minimum and mean monthly precipitation rates were 81.3 mm, 38.7 mm and 60.9 mm, respectively. The highest monthly maximum precipitation (227.8 mm) was observed in December to 4.8 mm in July. The monthly minimum precipitation ranges between 202.3 mm in December to no rainfall in July.
- Nearby residential areas include Old Kraaipan (southeast), Setlagole (southwest) and Mareetsane (20 km to the east). Aside from the residential areas, individual farmsteads near the expansion operations were identified as Air Quality Sensitive Receptors (AQSRs) and agricultural areas were identified as environmentally sensitive areas.
- Ambient air pollutant levels in the project area are currently affected by the following sources of emission:
    - Current mining and Industrial operations at the Kalgold mine.
    - Agricultural operations – the surrounding land use is predominantly agricultural and hence associated activities may contribute to elevated ground level concentrations.
    - Vehicles travelling on public and private roads – fugitive dust emissions would occur because of vehicle entrained dust from local paved and unpaved roads, these are also contributors to mobile combustion emissions.
    - Household fuel burning – particulate matter and gaseous emissions may occur from the burning of fuel within households for cooking and space heating.
    - Biomass burning – burning of agricultural land, fire breaks and unplanned veld fires would result in particulate matter and gaseous emissions.
    - Other sources – windblown dust from open areas.
- Particulate matter with an aerodynamic diameter of less than 10 µm (PM_{10}) data available during the compilation of this report had low availability.
- A dustfall monitoring network (Digby Wells Environmental, 2020), at the mine premises recorded one exceedance to the non-residential limit at KG7/HAR07, with a dustfall rate of 1 573 mg/m^2-day. The dustfall rates are however still in compliance with the National Dust Control Regulations (NDCR).
- Simulated pollutant concentrations from a study conducted by Digby Wells (Digby Wells Environmental, 2014) showed no exceedance to the current daily and annual National Ambient Air Quality Standards (NAAQS) for both PM_{10} and Particulate matter with an aerodynamic diameter of less than 2.5 µm ($PM_{2.5}$). However, future expansion operations may result in exceedances to the future $PM_{2.5}$ limits effective 31 January 2030. The simulated dustfall rates for the same study indicated compliance with the NDCR.

The findings from the qualitative impact assessment can be summarised as follows:

- Construction, decommissioning/closure and post-closure phases:
    - The environmental risk rating related inhalation health, nuisance impacts and vegetation impacts are likely to be “low” without and with additional mitigation. The overall environmental risk rating is also expected to be “low negative”.
- Operational phase:

- The environmental risk rating of proposed project operations related to inhalation health impacts is likely to be “medium negative” without mitigation measures applied and becomes “low negative” with mitigation measures applied. The overall environmental risk rating is expected to be “medium negative”.
- The environmental risk rating of operations related to nuisance impacts are likely to be “low negative” without and with mitigation measures applied. The overall environmental risk rating is expected to be “low negative”.
- The environmental risk rating of proposed project operations related to the impacts on vegetation health is likely to be “medium negative” without mitigation measures applied and becomes “low negative” with mitigation measures applied. The overall environmental risk rating is expected to be “medium negative”.

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1 Introduction

Harmony Gold Company Limited (hereafter referred to as Harmony), has owned and operated the Kalgold Operations since 1999. The Kalgold operations comprises of open-pit gold mining operations and carbon-in-leach gold plant. The existing Harmony Kalgold operation wishes to increase its production from the current production rate of 130 000 tonnes per month (tpm) to 300 000 tpm. The change in production rate will require expansion of (and modification to) the current operational facilities and layout.

The proposed expansion operations require Environmental Authorisation in terms of both the National Environmental Management Act (No. 107 of 1998) (NEMA) (Republic of South Africa, 1998) and Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA) (Republic of South Africa, 2004), as amended in 2008 (Republic of South Africa, 2009), as well as a Water Use Licence (WUL) issued in terms of the National Water Act (No 36 of 1998) (NWA) (Republic of South Africa, 1998). Due to the Listing Notice activities applicable a full Environmental Impact Assessment/Environmental Management Program (EIA/EMPr) process is requiring scoping and environmental impact reports (S&EIRs) and an EMPr. This process is usually conducted in two phases, the first being the scoping phase which requires the submission of a scoping report. According to NEMA EIA Regulations "a scoping report must contain the information that is necessary for a proper understanding of the process, informing all preferred alternatives, including location alternatives, the scope of the assessment, and the consultation process to be undertaken through the environmental impact assessment process".

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1.1 Background

Kalgold is located approximately 60km southwest of Mahikeng in the Ratlou Local Municipality (LM) within the Ngaka Modiri Molema District Municipality (DM) in the North West Province of South Africa (Figure 1). The mine is owned and operated by Harmony, who acquired the mine in 1999. The mine is in the Kraaipan Greenstone Belt, which is part of the large Amalia-Kraaipan Greenstone terrain. The largest ore body is found in the D-Zone, which was mined out by a single pit operation along a strike length of 1 300m and to a depth of approximately 290m below surface. Mining at Kalgold Mine continued at the A-Zone, Windmill and Watertank Open Pits, which are all relatively new opencast operations.

Kalgold's current mining right encompasses an area of 4 595.3ha and was successfully converted, executed, and registered as a new order mining right at the Mineral and Petroleum Titles Registration Office on 9 November 2010 under the Mining Right Protocol 574/2008. The DMR reference number NW30/5/1/2/2/77MR is valid for a period of 30 years (from 28 August 2008 to 27 August 2038). During the 2019 Financial Year (FY19) the Kalgold Operations produced 1 249 kg of gold from 1.619 kilotonnes (kt) of ore milled. The ore reserves for Kalgold are estimated at 23 986 940 tons. The average mined tons as of the 2012 Business plan are 999 456 tons per year.

A pre-feasibility study has been undertaken. The findings of the pre-feasibility study have concluded that the following new activities and expansions must be provided for to increase the production rate to 300 000 tpm:

- The pit footprint will increase (bigger than what is being applied for in the EA amendment application)
- Larger dewatering pipelines (size to be determined after water balance is done)
- Extension to Spanover waste rock dump
- Road from the pit to new ROM pad
- New ROM pad
- New plant
- Recommission old TSF at low deposition rate
- Increase deposition rate at D zone pit
- Install pipeline from Central dam to the new plant
- Install a tailings pipeline from the new plant to old TSF and Dzone pit (black line in the map indicated pipelines for both deposition and also another for return water)
- Install pipeline from old plant raw water pond to the new plant (D zone return water)
- Install two power lines from Ferndale substation to the new plant
- Install evaporators at Central dam (to get rid of excess water)
- Install a water treatment plant at the new plant
- Relocate and expand the explosives magazine
- Additional new road from the plant to the N18

The proposed changes will likely result in impacts on the surrounding environment and human health during the construction, operational and decommissioning phases. The potential sources and pollutants associated with the proposed changes are presented in section 1.3.

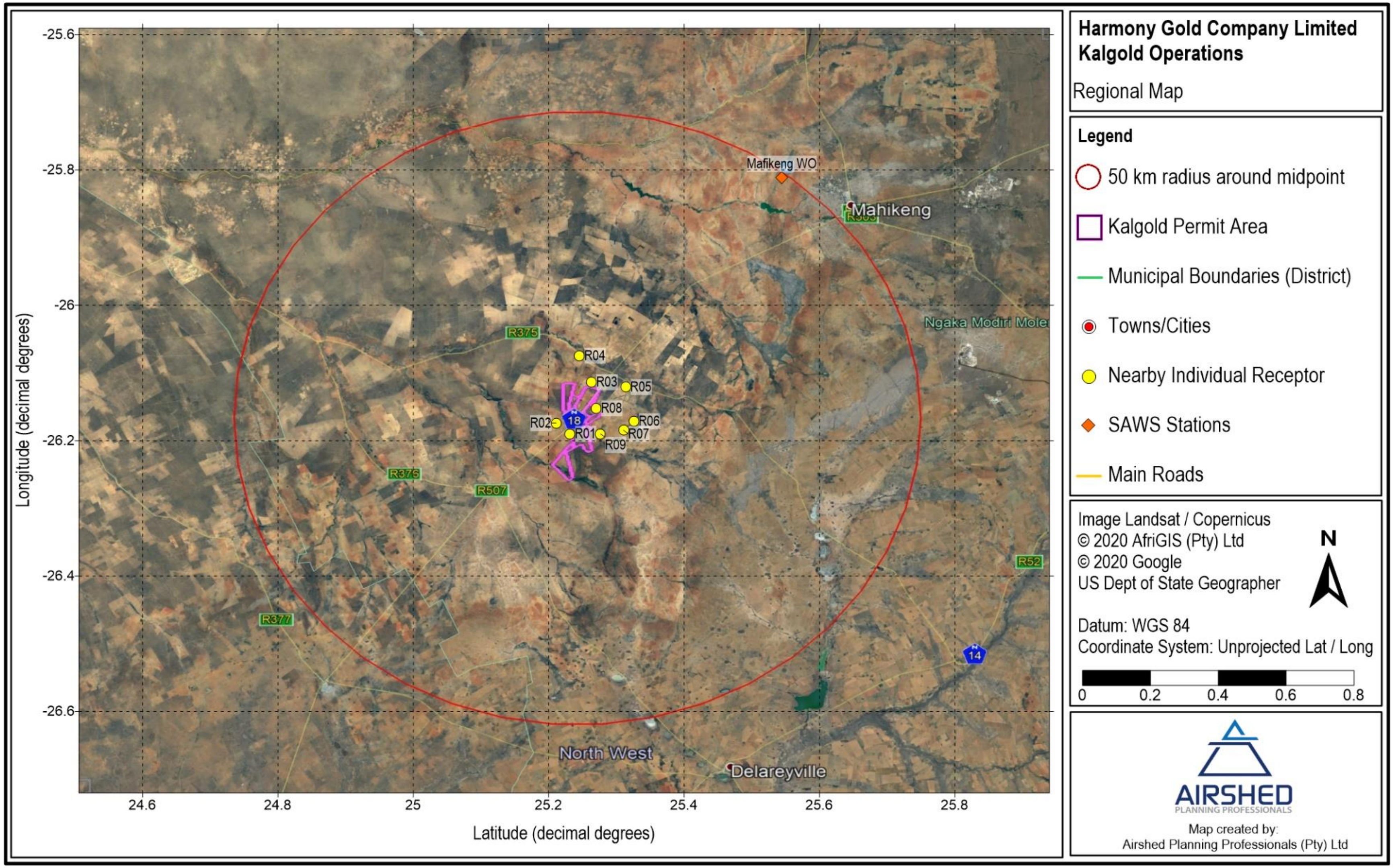

Figure 1: Regional map

1.2 Study Objective

The main objective of the air quality specialist study is to assess the impacts of the current (Kalgold operations without the changes) and future operations (Kalgold operations with the changes) on all aspects of biophysical and socio-economic receptors within the area and recommend mitigation, management, and monitoring measures based on the results of the assessment.

The specific terms of reference for the overall study are as follows:

- Identify and describe the existing air quality of the project area, as well as climatic patterns and features (i.e. the baseline);
- Assess (model) the impact on air quality on human health and biota resulting from the existing operations, specifically with reference to
  - total particulate matter (TSP),
  - particulate matter with an aerodynamic dimeter less than 10 µm (PM_{10}),
  - particulate matter with an aerodynamic dimeter less than 2.5 µm ($PM_{2.5}$),
  - sulfur dioxide (SO_2),
  - oxides of nitrogen (NO_x) expressed as nitrogen dioxide (NO_2),
  - carbon monoxide (CO),
  - chlorine (Cl_2),
  - hydrogen chloride (HCl),
  - hydrogen fluoride (HF), and
  - ammonia (NH_3)
- Assess the impact on human health and biota resulting from the future operations (including impacts associated with the construction, operations, decommissioning and post-closure phases of the project) with specific reference to the same pollutants listed above;
- Identify and describe potential cumulative air quality impacts resulting from the proposed future operations in relation to other existing developments in the surrounding area;
- Recommend mitigation measures to minimise impacts and/or optimise benefits associated with the project; and
- Recommend a monitoring network to ensure the correct implementation and adequacy of recommenced mitigation measures, if applicable.

This report covers the details relevant to the air quality study portion for the scoping phase report which includes the first point of the terms of reference.

1.3 Process Description

1.3.1 General Process Description

The current activities at Kalgold that result in emissions include but are not limited to:

- Drilling

- Blasting
- Excavation of ore and waste within the open pit
- Loading and offloading of trucks
- Vehicles travelling on unpaved roads including trucks, service vehicles and personnel/contractor vehicles
- Crushing and screening of ore
- Other processing activities
- Erosion of stockpiles, TSF and WRD by wind

1.3.2 Project Process Description

Air quality impacts will be associated with four distinct phases namely: the construction phase, the operational phase with opencast mining operations and plant/processing operations, and the closure phase and post-closure phase. During the operational phase all the same sources are expected as what is currently taking place but with a different layout/locality of some of operations. The closure and post-closure phases may only occur upon cessation of all the Kalgold operations. Due to the lack of detailed information and the relatively short duration of most of the activities associated with the construction, closure and post-closure phases the assessment of impacts for these phases will be done qualitatively.

1.3.2.1 Construction Phase

The construction phase will involve the extension of the current TSF, expansion of the ROM pad and establishment of the new production plant facility to the north or south of the Watertank pit. The potential construction activities that will take place during the construction phase and the associated pollutants are included in Table 1. It must be kept in mind that during the project construction phase the current Kalgold operations will continue to take place.

Table 1: Potential construction activities resulting in emissions and the associated pollutants

Activity	Associated pollutants
Handling and storage area for construction materials (paints, solvents, oils, grease) and waste	Particulate matter (PM)[(a)] and volatile organic compounds VOCs)
Drilling and blasting	SO_2, NO_x, CO, carbon dioxide (CO_2)[(b)], methane (CH_4)[(b)], nitrous oxide (N_2O)[(b)], and particulate matter (PM)
Clearing, grubbing and other earth moving activities	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Stockpiling topsoil and sub-soil	Mostly PM
Foundation excavations	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)

Activity	Associated pollutants
Establishment or expansion of access roads (scraping and grading)	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Digging of foundations and trenches	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Delivery of materials, storage and handling of material such as sand, rock, cement, chemical additives, etc.	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
General building/construction activities including, amongst others: mixing of concrete; operation of construction vehicles and machinery; refuelling of machinery; civil, mechanical and electrical works; painting; grinding; welding; etc	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Handling, storage and disposal of non-hazardous and hazardous waste	PM; gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O), potential for dioxin and furans from blasting cassettes incineration (burning grounds)

Notes: (a) PM comprises a mixture of organic and inorganic substances, ranging in size and shape and can be divided into coarse and fine particulate matter. TSP represents the coarse fraction >10 μm, with particulate matter with an aerodynamic diameter of less than 10 μm (PM_{10}) and particulate matter with an aerodynamic diameter of less than 2.5 μm ($PM_{2.5}$). TSP is associated with dustfall (nuisance dust) whereas PM_{10} and $PM_{2.5}$ are considered a health concern.
(b) carbon dioxide, methane and nitrous oxide are greenhouse gases (GHG).

1.3.2.2 Operational phase

According to the mine design, the mining method will be opencast mining with a truck and shovel operation with possible drilling and blasting. The Life of Mine (LoM) is estimated at 13 years. A 2019 production plan by Harmony estimate the current production at the mine to be 135 195 tpm with a 2:3 ore to waste ratio. The mine has a potential optimum performance of 136 000 tpm but the agreed three-year plan is 127 500 tpm at Harmony Kalgold operation. It is proposed to increase the Kalgold operations rate to 300 000 tpm. The proposed future operations and associated pollutants are listed in Table 2.

Table 2: Proposed future operational activities resulting in emissions and the associated pollutants

Activity	Associated pollutants
Mining Operations	
Stripping and stockpiling of topsoil	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Drilling and blasting of ore and waste	PM, SO_2, NO_x, CO, VOCs, CO_2, CH_4, and N_2O
Excavation of ore and waste	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Loading of trucks with ore and waste	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Transportation of ore, waste and topsoil	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Storage of materials at stockpiles and WRD (wind erosion)	PM
Stockpile and WRD management using front-end-loaders (FELs) and bulldozers	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Grading of roads	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
Processing Operations	
Mobile equipment operating within the plan area	PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)
ROM transfer point and reclaim system	PM
Primary ROM crushing, screening and reagents addition	PM
Transfer conveyor to overland conveyor to plant ROM stockpile	PM

Activity	Associated pollutants
ROM feed conveyor	PM
Elution, drying (using kilns) and smelting	PM, SO_2; NO_x; CO; CO_2; ammonia (NH_3) and potentially chlorine (Cl_2), hydrogen chloride (HCl) and hydrogen fluoride (HF)
TSF (wind erosion)	PM
Stockpiling of final product and transportation	Mostly PM but also gaseous emissions from equipment exhausts (including but not limited to SO_2, NOx, CO, VOCs, CO_2, CH_4, and N_2O)

1.3.2.3 Decommissioning/Closure and Post-closure Phases

During decommissioning/closure, bulk earthworks and demolition activities are expected. Very little information regarding the decommissioning phase was available for consideration, from an air quality perspective it is, however, likely to be similar in character and impact to the construction phase. Post-closure phase operations are expected to be periodic site inspections which will have insignificant impacts and no impacts are expected from final landforms provided the rehabilitation is successful.

1.4 Air Quality Study Methodology

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

- Identification of existing sources of emission and characterisation of ambient air quality and dustfall levels in the study area;
    - A partly quantitative assessment of baseline air quality was possible due to the availability of limited ambient data from the Harmony monitoring station.
    - Insufficient data was available to undertake dispersion modelling for the baseline; however, this will be conducted during the next (EIA) phase.
- It is important to have a good understanding of the meteorological parameters governing the rate and extent of dilution and transportation of air pollutants that are generated by the proposed operations. The primary meteorological parameters to obtain from measurement include wind speed, wind direction and ambient temperature. Other meteorological parameters that influence the air concentration levels include rainfall (washout) and a measure of atmospheric stability. The latter quantities are normally not measured and are derived from other parameters such as the vertical height temperature difference or the standard deviation of wind direction. The depth of the atmosphere in which the pollutants can mix is similarly derived from other meteorological parameters by means of mathematical parameterisations.

- The first step was therefore to source any on-site or near-site meteorological observations. As a minimum this data had to include hourly averaged wind speed, wind direction and ambient air temperature.
- The at least on year of on-site weather station data with the minimum parameters required was available but the data availability is insufficient for dispersion modelling and WRF (Weather Research and Forecasting) modelled data will be acquired for the next phase of the assessment. The on-site data for the period August 2019 to September 2020 was used to construct wind roses, general climatic information such as diurnal temperature variations, atmospheric stability estimates included in this report.

- Potential air pollution sensitive receptors within the study area were identified and georeferenced for detailed analysis of the impact assessment calculations in the next phase.

The next phase (impact assessment) will include the tasks below:

- The dispersion modelling executed as per *The Regulations Regarding Air Dispersion Modelling* (GN 533 in Gazette No 37804, 11 July 2014). Three *Levels of Assessment* are defined in the Regulations. A Level 2 assessment approach was deemed adequate. These are described under Section 0.
- Preparation of the model control options and input files for the AERMOD dispersion modelling suite. This includes the compilation of:
    - terrain information (topography, land use, albedo and surface roughness);
    - source layout; and
    - grid and receptor definitions.
- Preparation of hourly average meteorological data for the wind field and atmospheric dispersion model.
- Preparation of an emissions inventory for the existing and proposed operations, including fugitive sources[1] and point sources. The emission rates for the existing stacks will be based on isokinetic sampling measurements and Minimum Emission Standards (MES), and emission factors will be used for the fugitive sources.
- For the study, simulations will be conducted using the AERMOD dispersion modelling suite, which allows for the calculations of the ambient inhalable concentrations ($PM_{2.5}$, PM_{10}, SO_2, NO_x and CO) and dust fallout. The hourly, daily and annual concentrations and total daily dust deposition will be calculated. Dispersion modelling will be completed for all operations associated with the proposed operations as well as the existing Kalgold operations.
- The legislative and regulatory context, including emission limits and guidelines, ambient air quality guidelines and dustfall classifications will be used to assess the impact and recommend additional emission controls, mitigation measures and air quality management plans to maintain the impact of air

[1] Fugitive emissions refer to emissions that are spatially distributed over a wide area and not confined to a specific discharge point as would be the case for process related emissions (IFC, 2007).

pollution to acceptable limits in the study area. The model results will be analysed against the National Ambient Air Quality Standards (NAAQS) and National Dust Control Regulations (NDCR).

1.5 Managing Uncertainties

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

1. All project information was provided by EIMS; it is assumed that all this information is the most recent data and correct.
2. Meteorology:
    a. Data was available from one on-site weather station. The data for the period August 2019 to September 2020 was available but the data availability is insufficient for dispersion modelling and three years of WRF (Weather Research and Forecasting) modelled data will be acquired for the next phase of the assessment.
    b. The National Code of Practice for Air Dispersion Modelling described in the Regulations regarding air dispersion modelling prescribes the use of a minimum of one year of on-site data or at least three years of appropriate off-site data for use in Level 2 and Level 3 assessments. It also states that the meteorological data must be for a period no older than five years to the year of assessment. The WRF dataset period will be selected to be within the timeframe recommended by the National Code of Practice for Air Dispersion Modelling, that is three years of data less than five years old will be acquired for the impact assessment.
3. Emissions:
    a. The impact assessment will be limited to the pollutants of concern (those included in Section 2). Some of these pollutants are regulated under NAAQS and considered key pollutants released by the operations associated with the future operations.
    b. The quantification of sources of emission will be restricted to the Kalgold operations (current and future). Other existing sources of emission within the area including farming activities, domestic fires, biomass burning, vehicle exhaust emissions and dust entrained by vehicles on public roads will not included as part of the emissions inventory and simulations. Without detailed proposed (for when this project will be operational) operational data for other companies' mining and processing operations as well as estimated future vehicle data for public roads it is difficult to quantify these sources for the period of the proposed project operations. It is difficult to predict the contribution of the domestic and natural fires and farming sources to air quality during the period of the proposed project operations due to variability of these operations with regards to locality, spatial extent and duration.
4. Greenhouse gases (GHG):
    a. Emissions estimation and modelling is not included in the scope of work.
5. Dispersion Simulations:

a. For the current operations, all significant fugitive sources will be simulated with the current mitigation measures applied and the most recent average stack emissions will be included in the dispersion simulation task.
b. It will be assumed that all NO_x emitted is converted to NO_2.

6. Assessment of impacts:
   a. The health risk assessment is limited to the screening of ambient air concentrations against NAAQS and applicable international legal guidelines and limits and does not include a detailed human health risk assessment. Human health risk can occur due to exposures through inhalation, ingestion and dermal contact. The scope of the study will be confined to the quantification of impacts due to exposures via the inhalation pathway only.
   b. A human health risk and nuisance and environmental impact screening assessment for the operational phase (current and future) will be based on dispersion simulation results.
   c. The EA process will be completed by EIMS. For this reason, the expected impact significance of the operations was determined based on the EIMS impact significance methodology. The impact significance ratings provided in this report are based on the specialist knowledge and impacts from similar operations.

2 Regulatory Requirements and Impact 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 from NEMA and NEM:AQA. A portion of the NEMA EIA Regulations, the Listed Activities and Minimum National Emission Standards (MES) Regulations, Atmospheric Emissions Licence (AEL) Regulations, Atmospheric Impact Report (AIR) Regulations, National Atmospheric Emission Reporting Regulations, Regulations regarding Air Dispersion Modelling, NAAQS and NDCR are relevant to the Project and are discussed below.

2.1 NEMA EIA Regulations

In terms of the National Environmental Management Act, 1998 (NEMA) Environmental Impact Assessment (EIA) Regulations (Republic of South Africa, 2014) (as amended by GN 326 of 7 April 2017; GN 706 of 13 July 2018 and GN 320 of 20 March 2020) a specialist report must contain certain information (see table on page iv for full list of information required). A site environmental sensitivity screening must also be conducted for the specialist assessment using the Department screening tool to determine among other information the development incentives, restrictions, exclusions or prohibitions that apply to the proposed development site as well as the most environmental sensitive features on the site based on the site sensitivity screening results for the application classification that was selected. Based on the site sensitivity screening the only requirement is that the next phase report fulfils the Appendix 6 Specialist Report requirements.

2.2 Listed Activities

Atmospheric emissions which have or may cause a significant detrimental effect on the environment, human health and social welfare, economic conditions, ecological conditions or cultural heritage. The list of activities and associated minimum emission standards were established in March 2010 (Republic of South Africa, 2010) and the updated list of activities and associated minimum emission standards were published in 2013 (Republic of South Africa, 2013). The Department of Environmental Affairs (DEA) now the Department of Environment, Forestry and Fisheries (DEFF) published amendments to certain categories in June 2015 (Republic of South Africa, 2015), and further amendments were made in October 2018 (Republic of South Africa, 2018). In March 2020, the minister of DEFF published amendments to Category 1 (Republic of South Africa, 2020). The existing and proposed operations on-site will fall under two listed activities and require an AEL thus national MES, AELs and AIRs are discussed in this section.

2.2.1 Emission Standards

The future operations will be considered a listed activity under Section 21 of the NEM:AQA. The current Kalgold AEL (no. NWPG/ KALGOLD/AEL 4.17 /OCT 2019) states that the facility is licenced for the listed activity category 4, subcategory 4.17. It is however likely that listed activity category 4, subcategory 4.1 will need to be added to the AEL when undertaking the AEL variation or new application. The MES and special arrangements for these activities are included in Table 3 and Table 4. As of 1 April 2020, all plants (whether categorised as existing or new) were required to comply with the new plant standards unless the operator had received approval for an application submitted in terms of postponement or suspension of the compliance timeframes.

Table 3: MES for subcategory 4.1 listed activities, drying and calcining

Description:	**Drying and calcining of mineral solids including ore**		
Application:	**Facilities with capacity more than 100 tonnes/month product**		
Substance or mixture of substance:		**Plant status[(a)]**	**mg/Nm^3 under normal conditions of 273 K and 101.3 kPa**
Common name	**Chemical symbol**		
Particulate matter	n/a	New	50
Sulfur dioxide	SO_2	New	1 000
Oxides of nitrogen	NO_x expressed as NO_2	New	500

Table 4: MES for subcategory 4.17 precious and base metal production and refining

Description:	**The production or processing of precious and associated base metals through chemical treatment**		
Application:	**All installations**		
Substance or mixture of substance:		**Plant status[(a)]**	**mg/Nm^3 under normal conditions of 273 K and 101.3 kPa**
Common name	**Chemical symbol**		
Particulate matter	n/a	New	50
Chlorine	Cl_2	New	50
Sulfur dioxide	SO_2	New	400
Hydrogen chloride	HCl	New	30
Hydrogen fluoride	HF	New	30
Ammonia	NH_3	New	100
Oxides of nitrogen	NO_x expressed as NO_2	New	300
The following special arrangement shall apply – Thermal treatment standard are not applicable to precious and base metal refining processes.			

2.2.2 Atmospheric Emission Licence

In terms of the NEM:AQA, no person may conduct an activity listed on the national list anywhere in the Republic or listed on a list applicable in a province anywhere in that province without a Provisional Atmospheric Emission Licence (PAEL) or an AEL. The Kalgold operations has an existing full AEL (no. NWPG/ KALGOLD/AEL 4.17 /OCT 2019) in respect of the listed activity category 4, subcategory 4.17; of the Section 21 to NEM:AQA. The AEL was issued based on the information provided in the application dated 04 September 2019 and is valid for a period of five (5) years from 14 October 2019. AEL holders must operate according to the conditions provided within the signed AEL. The proposed changes will require application for a variation AEL. An AEL must include all sources of emission, not only those considered listed activities. In terms of the AEL application, the **applicant** should take into account the following sections of NEM:AQA:

37. Application for atmospheric emission licences:

(1) A person must apply for an AEL by lodging with the licensing authority of the area in which the listed activity is to be carried out, an application in the form required.

(2) An application for an AEL must be accompanied by –

- *(a) The prescribed processing fee; and*
- *(b) Such documentation and information as may be required by the licensing authority.*

38. Procedure for licence applications:

(1) The licensing authority –

- *(a) May, to the extent that is reasonable to do so, require the applicant, at the applicant's expense, to obtain and provide it by a given date with other information contained in or submitted in connection with the application;*
- *(b) May conduct its own investigation on the likely effect of the proposed license on air quality;*
- *(c) May invite written comments from any organ of state which has an interest in the matter; and*
- *(d) Must afford the applicant an opportunity to make representations on any adverse statements or objections to the application.*

(2) Section 24 of the NEMA and section 22 of the Environmental Conservation Act apply to all applications for atmospheric emission licenses, and both an applicant and the licensing authority must comply with those sections and any applicable notice issued or regulations made in relation to those sections.

(3) –

- *(a) An applicant must take appropriate steps to bring the application to the attention of relevant organs of state, interested persons and the public.*
- *(b) Such steps must include the publication of a notice in at least two newspapers circulating the area in which the listed activity is applied for is or is to be carried out and must-*
  - *(i) Describe the nature and purpose of the license applied for;*
  - *(ii) Give particulars of the listed activity, including the place where it is to be carried out;*
  - *(iii) State a reasonable period within which written representations on or objections to the application may be submitted and the address or place where it must be submitted; and*
  - *(iv) Contain such other particulars as the licensing authority may require.*

2.2.3 Atmospheric Impact Report

Under section 30 of NEM:AQA, an air quality officer may require any person to submit an AIR in the format prescribed if a review of provisional AEL or AEL is undertaken. The format of the AIR is stipulated in the Regulations Prescribing the Format of the Atmospheric Impact Report, published by the DEA now the DEFF in 2013 (Republic of South Africa, 2013) and with amendments published in 2015 (Republic of South Africa, 2015).

2.3 National Atmospheric Emission Reporting Regulations (NAERR)

The National Atmospheric Emission Reporting Regulations (NAERR) was published in 2015 by the Minister of Environmental Affairs (Republic of South Africa, 2015). The regulation aims to standardise 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), towards the compilation of atmospheric emission inventories. 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.

Annexure 1 of the NAERR classifies **mines** (holders of a mining right or permit in terms of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002)) as a data provider under **Group C**. **Listed Activities** as published in terms of Section 21(1) of the AQA falls under **Group A**.

As per the regulations, Harmony and/or their data provider should be 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 of each year. Records of data submitted must be kept for a period of 5 years and must be made available for inspection by the relevant authority. The relevant authority must request 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.

2.3.1 Greenhouse Gas Emissions

Regulations pertaining to GHG reporting using the NAEIS were published in 2017 (Republic of South Africa, 2017) (as amended by GN R994, 11 September 2020). The South African mandatory reporting guidelines focus on the reporting of Scope 1 emissions only. The three broad scopes for estimating GHG are:

- Scope 1: All direct GHG emissions.
- Scope 2: Indirect GHG emissions from consumption of purchased electricity, heat or steam.

- Scope 3: Other indirect emissions, such as the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity, electricity-related activities not covered in Scope 2, outsourced activities, waste disposal, etc.

The South African Greenhouse Gas Emission Reporting System (SAGERS) web-based monitoring and reporting system will be used to collect GHG information in a standard format for comparison and analyses. The system forms part of the national atmospheric emission inventory component of South African Atmospheric Emission Licensing and Inventory Portal (SAAELIP). The site operations qualify to report their GHG emissions to SAGERS.

The DEFF is working together with local sectors to develop country specific emissions factors in certain areas; however, in the interim the Intergovernmental Panel on Climate Change's (IPCC) default emission figures may be used to populate the SAAQIS GHG emission factor database. These country specific emission factors will replace some of the default IPCC emission factors. Technical guidelines for GHG emission estimation have been issued.

Also, the Carbon Tax Act (No 15 of 2019) (Republic of South Africa, 2019) includes details on the imposition of a tax on the CO_2-e of GHG emissions. Certain production processes indicated in Annexure A of the Declaration of Greenhouse Gases as Priority Pollutants (Republic of South Africa, 2017) with GHG in excess of 0.1 megatonnes (Mt), measured as CO_2-e, are required to submit a pollution prevention plan to the Minister for approval.

2.4 Regulations Regarding Air Dispersion Modelling

Air dispersion modelling provides a cost-effective means for assessing the impact of air emission sources, the major focus of which is to assess compliance with the relevant ambient air quality standards. Regulations regarding Air Dispersion Modelling were promulgated in Government Gazette No. 37804 vol. 589; 11 July 2014 (Republic of South Africa, 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 NEM:AQA;
b) in the development of a priority area air quality management plan, as contemplated in section 19 of the NEM:AQA;
c) in the development of an atmospheric impact report, as contemplated in Section 30 of the NEM:AQA; and,
d) in the development of a specialist air quality impact assessment study, as contemplated in Chapter 5 of the NEM:AQA.

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;
- 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 ozone [O_3], 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 for this study:

- The distribution of pollutant concentrations and deposition are required in time and space.
- Pollutant dispersion can be reasonably treated by a straight-line, steady-state, Gaussian plume model with first order chemical transformation. The model specifically to be used in the air quality impact assessment of the proposed operation is AERMOD.
- Emissions are from sources where the greatest impacts are in the order of a few kilometers (less than 50 km) downwind.

The Regulations will be applied in undertaking this study.

2.5 National Ambient Air Quality Standards (NAAQS)

Criteria pollutants are considered those pollutants most commonly found in the atmosphere, that have proven detrimental health effects when inhaled and are regulated by ambient air quality criteria. These generally include PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO and O_3. The state of the air document published by the Department of Environmental Affairs (DEA), now DEFF says: “Air quality limits and thresholds are fundamental to effective air quality management. Ambient air quality limits serve to indicate what levels of exposure to pollution are generally safe for most people, including the very young and the elderly, over their lifetimes.”[2]

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 the 13th of March 2009 (Republic of South Africa, 2009). The final revised NAAQS were published in the Government Gazette on the 24th of December 2009 (GN 1210, GG 32816) and additional standards for $PM_{2.5}$ were published on the 29th June 2012 (GN 486, GG 35463) (Republic of South Africa, 2012). NAAQS for the pollutants assessed in this study are listed in Table 5.

[2] https://www.environment.gov.za/sites/default/files/docs/stateofair_executive_iaiquality_standardsonjectives.pdf

Table 5: National Ambient Air Quality Standards

Pollutant	Averaging Period	Concentration (µg/m³)	Permitted Frequency of Exceedance	Compliance Date
PM_{10}	24-hour	75	4	Currently enforceable
	1 year	40	-	Currently enforceable
$PM_{2.5}$	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
SO_2	10-minutes	500	526	Currently enforceable
	1-hour	350	88	Currently enforceable
	24-hour	125	4	Currently enforceable
	1 year	50	-	Currently enforceable
NO_2	1-hour	200	88	Currently enforceable
	1 year	40	-	Currently enforceable
CO	1-hour	30 000	88	Currently enforceable
	8-hour	10 000	11	Currently enforceable

2.6 International Health Criteria and Unit Risk Factors

Air quality screening levels for non-criteria pollutants are published by various sources. These sources include:

- World Health Organization (WHO) guideline values for non-carcinogens,
- Inhalation reference concentrations (RfCs) published by the US EPA in its Integrated Risk Information System (IRIS),
- Reference exposure levels (RELs) published by the Californian Office of Environmental Health Hazard Assessment (OEHHA) department of the California Environmental Protection Agency (CALEPA),
- Minimal risk levels (MRLs) issued by the US Federal Agency for Toxic Substances and Disease Registry (ATSDR),
- Inhalation reference concentrations (RfCs) published by the US EPA Superfund Program as the Provisional Peer-Reviewed Toxicity Values (PPRTVs), and
- Effect screening levels (ESLs) published by the Texas Natural Resource Conservation Commission Toxicology and Risk Assessment Division (TARA).

The most stringent non-carcinogenic exposure thresholds for pollutants of interest in the current study will be used; however, other thresholds are also given in Table 6. It should be noted that these screening criteria are guidelines only and are not a legal requirement.

Table 6: Proposed non-carcinogenic exposure thresholds for pollutants of interest for this operation

Pollutant	Averaging Period	Selected Criteria (µg/m³)	Source
Chlorine (Cl_2)	Acute	170	ATSDR
	Sub-chronic	5.8	ATSDR
	Chronic	0.145	ATSDR
Hydrogen chloride (HCl)	Acute	2 100	CALEPA
	Sub-chronic	-	-
	Chronic	20	IRIS
Hydrogen fluoride (HF)	Acute	16.4	CALEPA
	Sub-chronic	-	-
	Chronic	14	ATSDR
Ammonia (NH_3)	Acute	180	TARA
		1 180	ATSDR
	Sub-chronic	100	PPRTV
	Chronic	70	ATSDR
		500	IRIS

Notes: 1-hour averaging period results will be compared to acute criteria; 24-hour averaging period results will be compared to sub-chronic criteria; and 1-year (annual) averaging period results will be compared to chronic criteria.

2.7 National Dust Control Regulations (NDCR)

The NDCR were published on 1 November 2013 (GN R827 in GG 36974) (Republic of South Africa, 2013). 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 7. 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 dustfall 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 7: Acceptable dustfall rates

Restriction Area	Dustfall rate (D) (mg/m²-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

Notes: The method to be used for measuring dustfall rate and the guideline for locating sampling points shall be ASTM D1739: 1970, or equivalent method approved by any internationally recognized body

2.8 Screening Criteria for Animals and Vegetation

2.8.1 Assessment Criteria for Vegetation Impacts from Dustfall Rates

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/m²-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).

2.8.2 Assessment Criteria for Vegetation Impacts from SO_2 and NO_2

The impact of emissions on surrounding vegetation was assessed by comparing the simulated annual SO_2 and NO_2 concentrations for each of the emission scenarios against the critical levels for vegetation as defined by the United Nations Economic Commission for Europe (UNECE) Convention on Long Range Trans-boundary Air Pollution Limits (CLRTAP, 2015) (Table 8).

Table 8: Critical levels for SO_2 and NO_2 by vegetation type (CLRTAP, 2015)

Pollutant	Vegetation Type	Critical Level (µg/m³)	Time Period[(a)]
SO_2	Cyanobacterial lichens	10	Annual average
	Forest ecosystems (including understorey vegetation)	20	Annual average and Half-year mean (winter)
	(Semi-)natural vegetation	20	Annual average and Half-year mean (winter)

Pollutant	Vegetation Type	Critical Level (µg/m³)	Time Period[(a)]
	Agricultural crops	30	Annual average and Half-year mean (winter)
NO_2	All	30	Annual average and Half-year mean (winter)
		75	Daily average

Notes: (a) For the purposes of mapping of critical levels and exceedances CLRTAP recommend using only the annual average, due to increased reliability of mapped and simulated data for the longer time period. It is also noted that long-term effects of NO_X are considered to be more significant than short-term effects (CLRTAP, 2015).

2.9 Nuisance Odour

2.9.1 Odour Thresholds

In the assessment of potential odour impacts use was made of the 50% recognition threshold odour concentrations (TOCs) published by Verschueren (1996) (Table 9), over a 60 minute period. The 50% recognition threshold is the concentration at which 50% of an odour panel defined the odour as being representative of the odorant being studied.

Table 9: 50% Recognition odour threshold concentrations

Pollutant	Threshold Odour Concentration (µg/m³)	Source
Ammonia (NH_3)	30	Verschueren (1996)

2.9.2 Odour Unit Calculation - Approach for Current Study

The New South Wales' (NSW) EPA draft approach (NSW EPA, 2006a), (NSW EPA, 2006b) was adopted for use in the current study largely given that it is comprehensively documented and more recently published. The approach can be summarised as follows:

- Calculation of the 1-hour average air pollutant concentrations;
- Recognition of the odour detection for a substance (Table 9);
- Calculation of odour units by calculating ratios between the 99.9th percentile 1-hour average air pollutant concentrations and the respective detection limits; and,
- The application of the odour performance criteria set out by the NSW EPA (Table 10).

A summary of the NSW EPA's odour performance criteria for various population densities is shown in Table 10.

Table 10: NSW EPA odour assessment criteria (NSW EPA, 2006a) (NSW EPA, 2006b)

Population of Affected Community	Odour Assessment Criteria (OU)
Rural single residence (≤2)	7
~ 10	6
~ 30	5
~ 125	4
~ 500	3
Urban area (≥ 2000) and/or schools and hospitals	2

3 Description of the Receiving Environment

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

- The identification of Air Quality Sensitive Receptors (AQSRs) from available maps;
- A study of the atmospheric dispersion potential of the area;
- The identification of existing sources of emissions in the study area; and
- The analysis of all available ambient air quality information/data.

3.1 Affected Environment

AQSRs primarily refer to places where people reside; however, it may also refer to other sensitive environments that may adversely be affected by air pollutants. Ambient air quality guidelines and standards, as discussed under Section 2, have been developed to protect human health. Ambient air quality, in contrast to occupation exposure, pertains to areas outside of an industrial site/mine boundary where the public has access to and according to the NEM:AQA excludes areas regulated under the Occupational Health and Safety Act (Act No 85 of 1993) (Republic of South Africa, 1993).

Nearby residential areas include Old Kraaipan (southeast), Setlagole (southwest) and Mareetsane (20 km to the east). Aside from the residential areas, individual farmsteads near the expansion operations were identified as AQSRs and agricultural areas were identified as environmentally sensitive areas. At this stage it could not be confirmed if all the farmsteads are still occupied or if the properties had been acquired by Kalgold and not occupied by public. The farmsteads occupancy will be confirmed in the next phase and the sensitive receptors list will be refined. Table 11 is a summary of the nearest farmsteads that may be influenced by air pollution emissions from the proposed Project. The surrounding land uses in the immediate vicinity of the Kalgold operations comprises of crop farming Emissions from vehicles travelling on public and private roads would also have implications on the ambient air quality of the area. Harmony conducts PM_{10} monitoring within the Kalgold permit area.

The nearest residential areas, individual farmsteads, dustfall sampling units and E-sampler locations in relation to the Kalgold permit area are shown in Figure 2.

Table 11: List of the nearest sensitive receptors

Sensitive Receptor ID	Sensitive Receptor Description	World Geodetic System (WGS 84) Unprojected Lat/Long		WGS 84 Universal Transverse Mercator (UTM) Zone 35 S		Distance from Site Boundary(km)	Direction from Site
		Longitude	Latitude	Easting (m)	Northing (m)		
R01	Farmstead	25.23152	-26.18991	323282.88	7102080.35	0.57	South
R02	Farmstead	25.21098	-26.17402	321205.97	7103812.57	1.42	South-west
R03	Farmstead	25.26321	-26.11359	326336.83	7110578.12	1.26	North-north-east
R04	Farmstead	25.24546	-26.07454	324503.95	7114879.70	5.00	North
R05	Farmstead	25.31348	-26.12076	331374.70	7109849.29	4.00	North-east
R06	Farmstead	25.32589	-26.17147	332688.42	7104248.94	4.72	East-south-east
R07	Farmstead	25.31043	-26.18452	331161.41	7102783.10	3.86	East-south-east
R08	Farmstead	25.27014	-26.15222	327086.82	7106307.92	0.51	East-north-east
R09	Farmstead	25.27640	-26.18993	327768.92	7102138.64	2.08	South-south-east

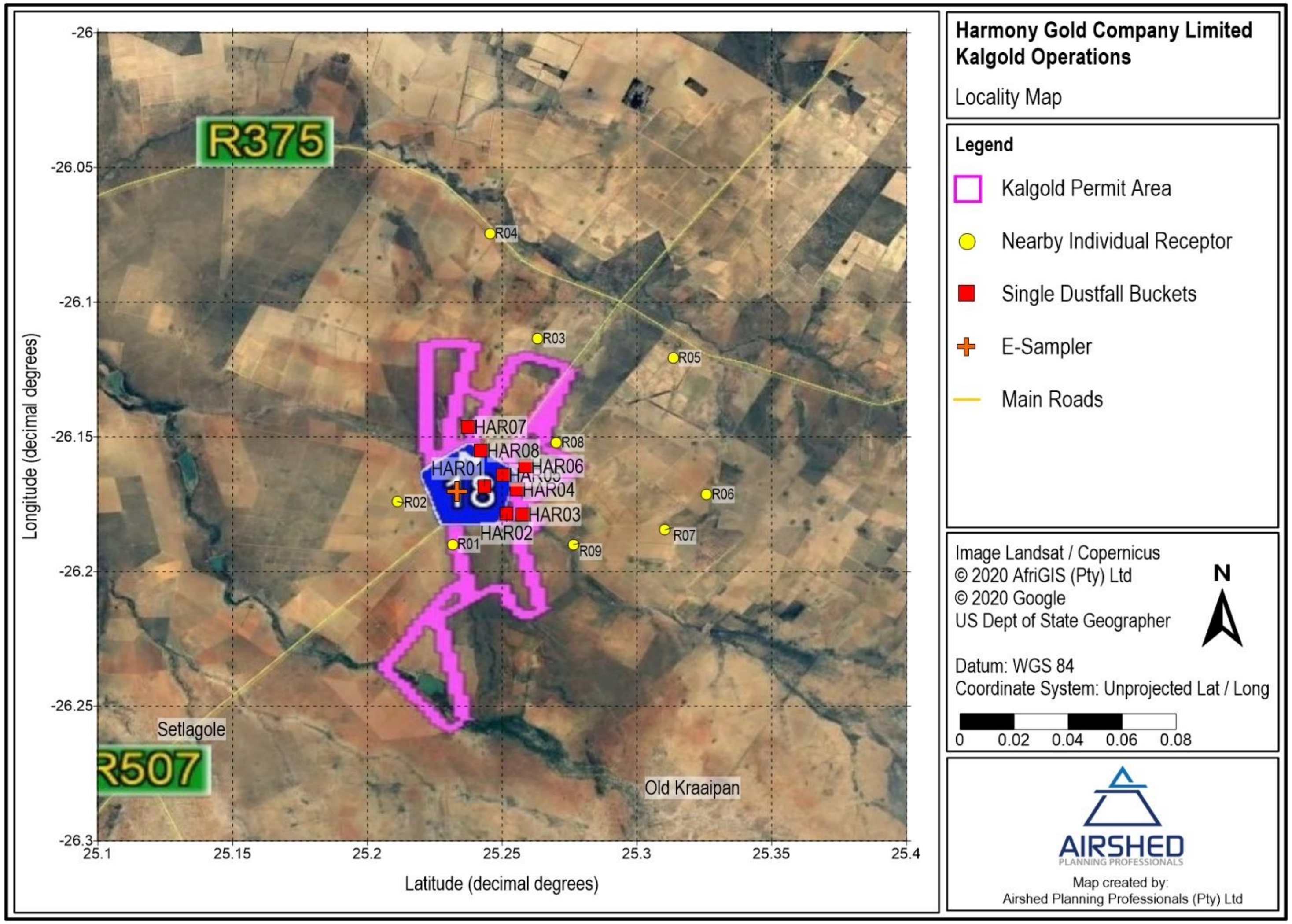

Figure 2: Locality map

3.2 Atmospheric Dispersion Potential

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

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

On-site data was provided for the period August 2019 to September 2020 to quantify the atmospheric dispersion potential. A description of the wind field, temperature, precipitation, and atmospheric stability is provided in this section.

3.2.1 Local Wind Field

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

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 orange area, for example, representing winds in between 4 and 5 m/s. The dotted circles provide information regarding the frequency of occurrence of wind speed and direction categories. Calm conditions are periods when the wind speed was below 1 m/s. Values of 0 m/s could be when there is no wind; or, when there may be wind, but it is below the anemometer starting threshold (AST).

The period wind field and diurnal variability in the wind field are shown in Figure 3, while the seasonal variations in the wind field are provided in Figure 4. The wind field is dominated by winds from the east-north-east, north-east and east. These directions were associated with the strongest winds. The period average wind speed is 1.08 m/s with calm winds occurring 29.7% of the time. The day-time wind rose shows a predominant east-north-easterly and north-easterly winds. The average wind speed during the day is 1.47 m/s with calm winds occurring 21.58%

of the time. The night-time is characterised by a higher frequency of calm conditions (39.12%) and dominant winds originating from the east with and average wind speed of 0.68 m/s. Summer, winter, autumn and spring show similar wind direction profiles to the period average with an increase in southerly winds during Winter. The winds speeds are mostly lowest during Autumn and Winter; however, there are high frequency of winds above 4 m/s during Winter.

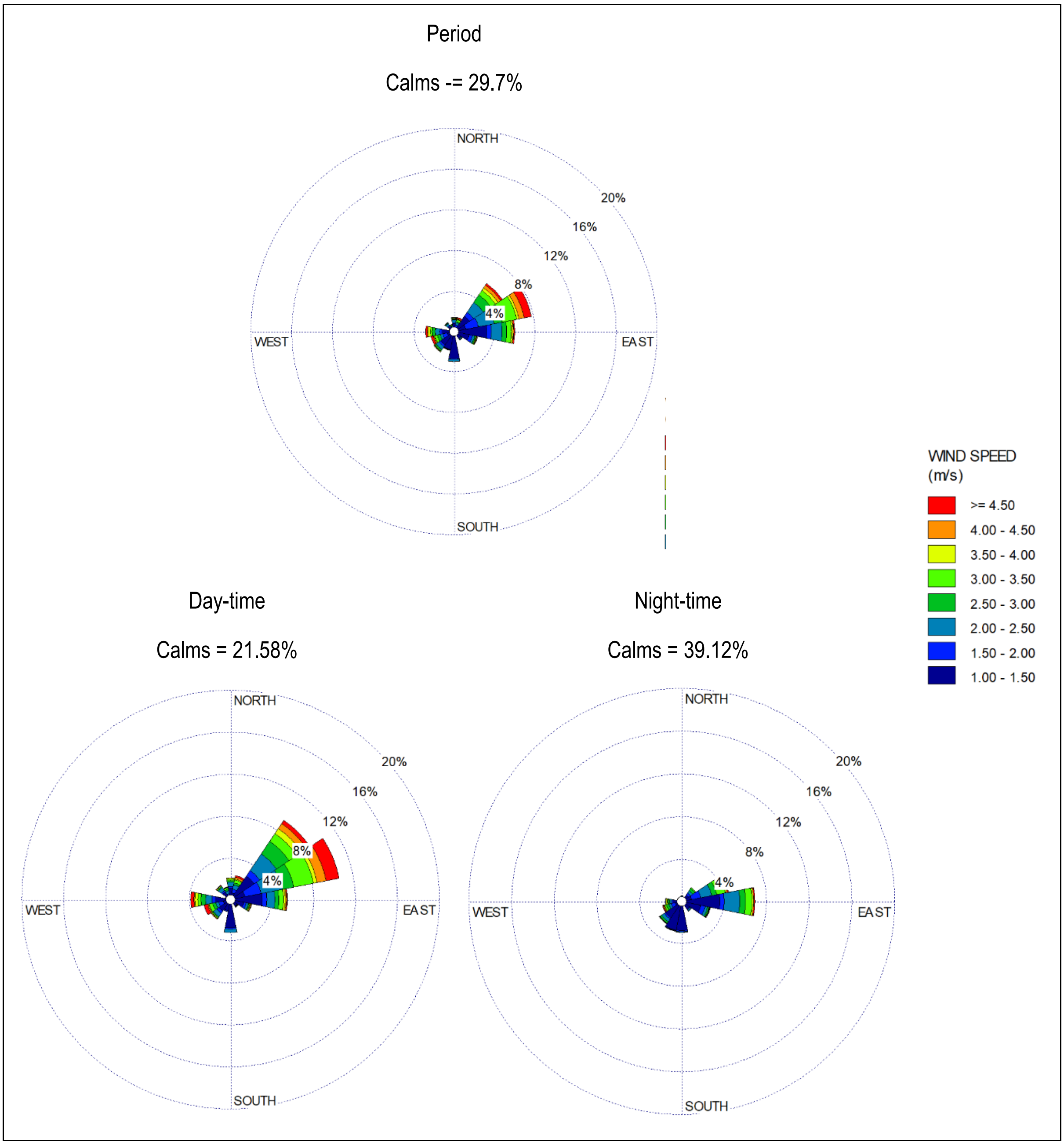

Figure 3: Period, day- and night-time wind roses (Harmony Kalgold Station August 2019 – September 2020)

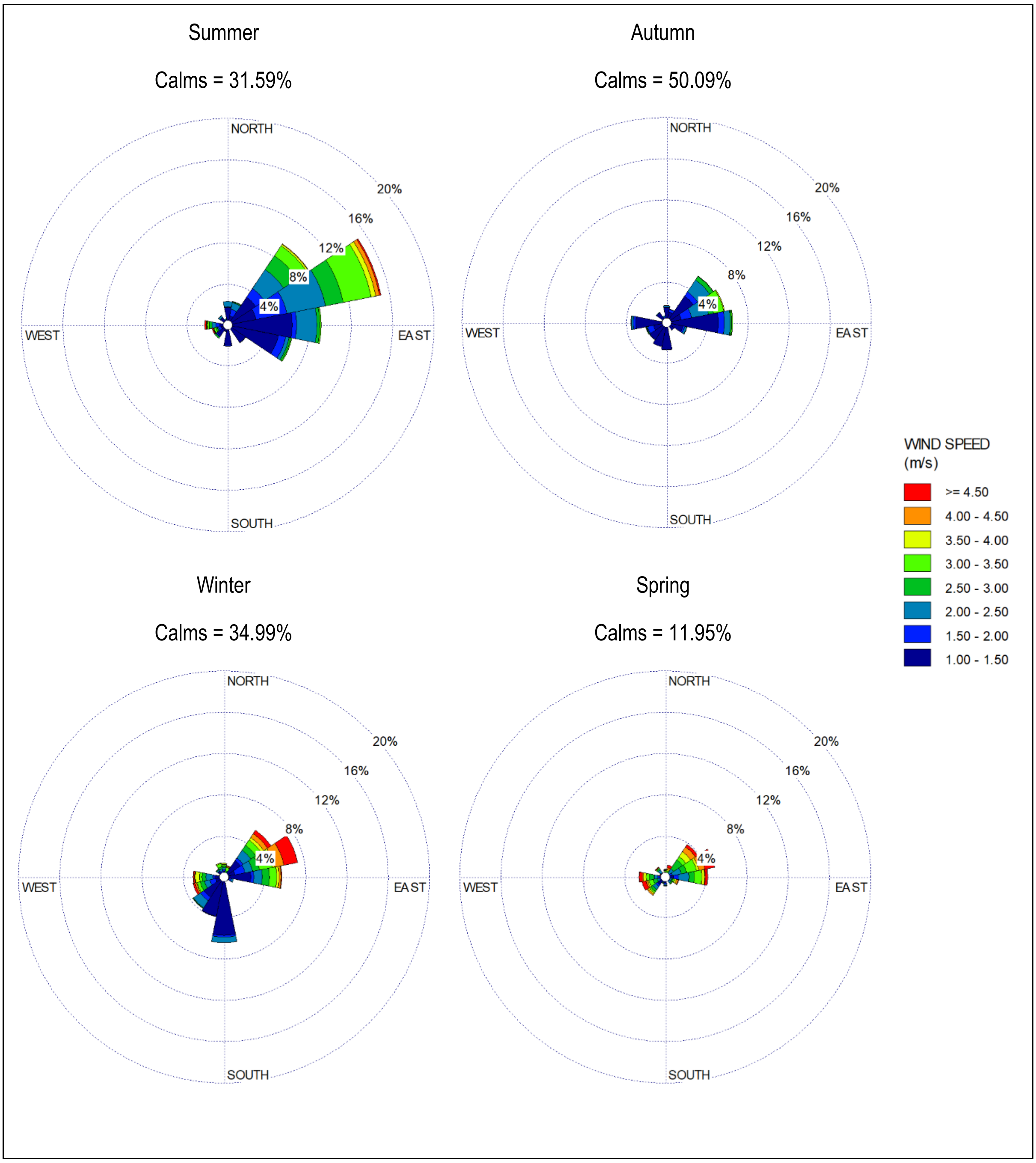

Figure 4: Seasonal wind roses (Harmony Kalgold Station August 2019 – September 2020)

3.2.2 Ambient Temperature

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

The monthly average and hourly maximum and minimum temperatures are provided in Table 12, and the diurnal temperature profile for the site is shown in Figure 5. Monthly average temperatures ranged between 10°C and

26°C. The highest temperature of (35°C) occurred in October and the lowest (-4°C) in June. In summer, daytime maximum temperatures are reached between 13:00 and 16:00. Ambient air temperature decreases to reach a minimum at around 06:00 i.e. just before sunrise.

Table 12: Monthly temperature summary (Harmony Kalgold Station August 2019 – September 2020)

Hourly Minimum, Hourly Maximum and Monthly Average Temperatures (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	13	15	11	7	-3	-4	-3	0	2	8	19	13
Maximum	32	33	30	29	26	25	23	29	33	35	33	33
Average	23	23	21	17	14	10	11	15	18	24	26	22

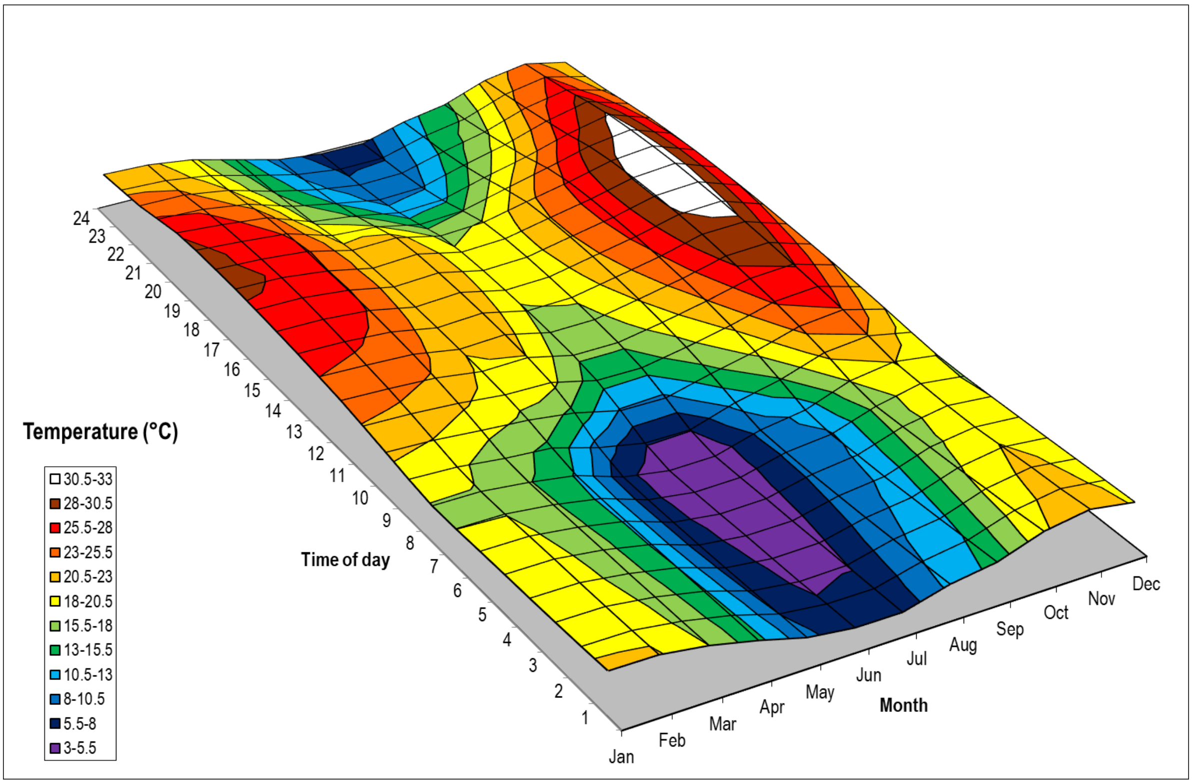

Figure 5: Diurnal temperature profile (Harmony Kalgold Station August 2019 – September 2020)

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.

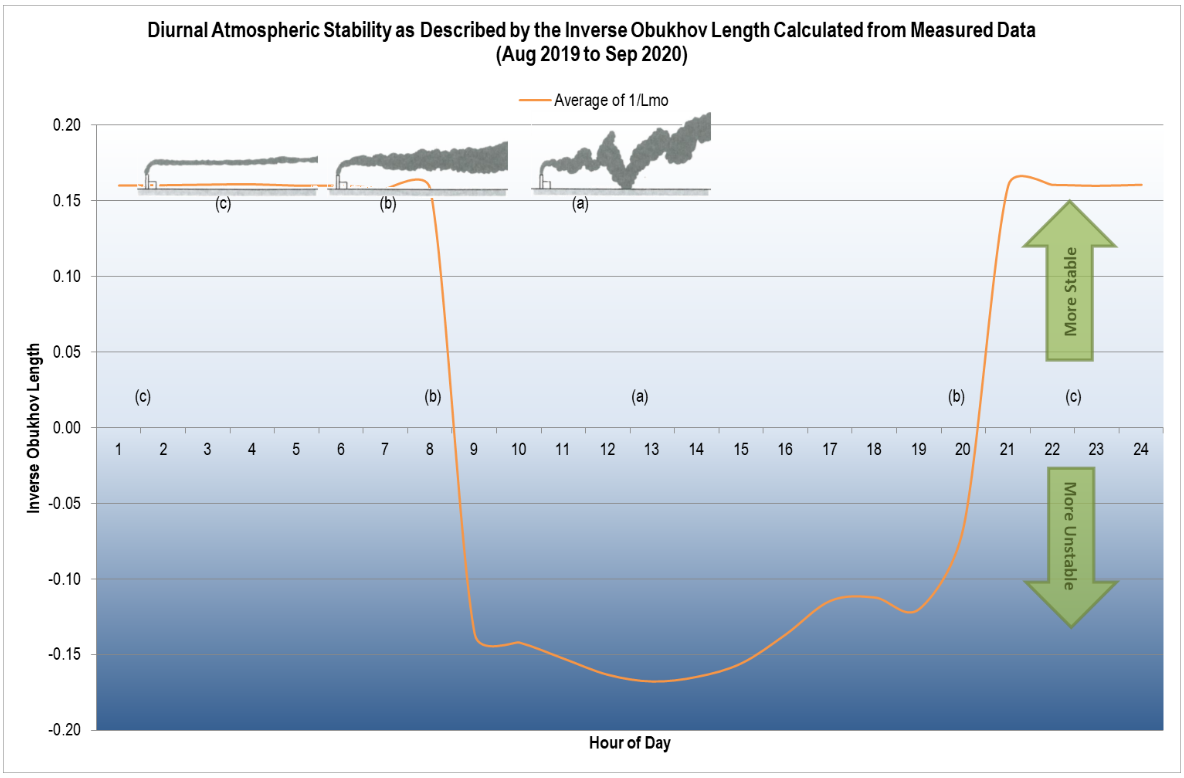

Figure 6: Atmospheric stability calculated from the Kalgold onsite data

3.2.4 Precipitation

Precipitation is important to air pollution studies since it represents an effective removal mechanism for atmospheric pollutants and inhibits dust generation potentials.

The precipitation values in the weather data provided were not precise on the units of measurement and hence measured data was obtained from a previous impact assessment (Digby Wells Environmental, 2014) were simulated data for the period Jan 2011 - Dec 2013 was processed. The main findings in the study were that the average precipitation of the Spanover 552 IO farm area was 66 mm. The three-year annual maximum, minimum and mean monthly precipitation rates for the Spanover 552 IO site were 81.3 mm, 38.7 mm and 60.9 mm, respectively. The highest monthly maximum precipitation (227.8 mm) was observed in December to 4.8 mm in July. The monthly minimum precipitation ranges between 202.3 mm in December to no rainfall in July.

3.3 Existing Air Quality

3.3.1 Regional Sources

The area surrounding the Kalgold mine is a predominant agricultural zone consisting of beef, maize, sunflower and groundnut production. Kalgold lodged a rezoning application to change the land use on Spanover 552 IO from agricultural to mining. A Record of Decision was received on the 21st of August 2013 from Ratlou Local Municipality granting the rezoning of Spanover farm from agricultural land to mining area (WSP, 2019). Currently the area surrounding Kalgold is being used for crop and livestock farming. Local sources include wind erosion from exposed areas, fugitive dust from agricultural and mining operations, vehicle entrainment from roadways and veld burning.

3.3.1.1 Agricultural Operations

Kalgold mine is predominantly surrounded by agricultural land. Activities associated with agriculture such as land tillage, land clearing by prescribed burning, animal feeding operations, mineral fertilizer application, fuel burning, movement of livestock and manure management often lead to gaseous and particulate pollutants being emitted to the air. Pollutants usually associated with agricultural activities include ammonia (NH_3), $PM_{2.5}$, PM_{10} nitrogen oxides (NO_x), volatile organic compounds (VOCs), methane (CH_4), nitrous oxides and CO_2. However, some of the activities are intermittent and only happen seasonally hence the impacts are usually less.

3.3.1.2 Domestic Fuel Burning

Many households burn fuel to meet all or a portion of their energy requirements. The main fuels with air pollution potentials used by households within the study region are gas, coal, wood and paraffin. Pollutants released from domestic fuels include CO, NO_2, SO_2, inhalable particulates and polycyclic aromatic hydrocarbons. Particulates are the dominant pollutant emitted from the burning of wood. Smoke from wood burning contains respirable particles that are small enough in diameter to enter and deposit in the lungs. These particles comprise a mixture of inorganic and organic substances including aromatic hydrocarbon compounds, trace metals, nitrates, and sulphates. Coal burning emits a large amount of gaseous and particulate pollutants including sulfur dioxide, heavy metals, total and respirable particulates including heavy metals and inorganic ash, carbon monoxide, polycyclic aromatic hydrocarbons, and benzo(a)pyrene. Polyaromatic hydrocarbons are recognised as carcinogens. Pollutants arising due to the combustion of wood include respirable particulates, nitrogen dioxide, carbon monoxide, polycyclic aromatic hydrocarbons, particulate benzo(a)pyrene and formaldehyde. The main pollutants emitted from the combustion of paraffin are NO_2, particulates carbon monoxide and polycyclic aromatic hydrocarbons.

A diurnal and seasonal pattern is usually characteristic of domestic fuel burning. Early mornings, evenings and winter are associated with higher emissions due to a demand for cooking and space heating purposes.

3.3.1.3 Biomass Burning

The 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 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 is the ashes, and it may be assumed that 20% of the nitrogen is emitted as higher molecular weight nitrogen compounds (Held et al, 1996). The visibility of the smoke plumes is attributed to the aerosol (particulate matter) content. In addition to the impact of biomass burning within the vicinity of the proposed mining activity, long-range transported emissions from this source can be expected to impact on the air quality between the months August to October. It is impossible to control this source of atmospheric pollution loading; however, it should be noted as part of the background or baseline condition before considering the impacts of other local sources.

3.3.1.4 Vehicles Travelling on Public and Private Roads

Possible contributors to mobile combustion emissions include two main roads, namely, R375 and N18, as well as other access and haul roads surrounding the site. Neighbouring communities are likely to use these routes daily to access the mine and nearby amenities and commercial areas.

Air pollution from vehicle emissions may be grouped into primary and secondary pollutants. Primary pollutants are those emitted directly into the atmosphere, and secondary, those pollutants formed in the atmosphere because of chemical reactions, such as hydrolysis, oxidation, or photochemical reactions. The significant primary pollutants emitted by motor vehicles include carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbon compounds (HC), sulfur dioxide (SO_2), nitrogen oxides (NO_x) and particulate matter (PM). Secondary pollutants include nitrogen dioxide (NO_2), photochemical oxidants (e.g. ozone), hydrocarbon compounds (HC), sulfur acid, sulfates, nitric acid and nitrate aerosols.

3.3.1.5 Other Fugitive Dust Sources

Fugitive dust emissions may occur because of vehicle entrained dust from local paved and unpaved roads, wind erosion from open areas and dust generated by agricultural activities (e.g. tilling) and mining. The extent of particulate emissions from the main roads will depend on the number of vehicles using the roads, and on the silt loading on the roadways.

3.3.2 Measured Pollutant Concentrations

An E-Sampler of the Davis Vantage Pro type is located at the Kalgold premises and was used to collect PM_{10} data. The equipment can bin ambient PM into PM_1, $PM_{2.5}$, and PM_{10} fractions, but can only sample one size fraction at a time (simultaneous sampling of all size categories is not possible). PM_{10} represents the size fraction that would be deposited in and can cause damage to the lower airways and gas-exchange chamber of the lungs. However, data for the ambient PM_{10} concentrations were not available during the same quarter in which Digby Wells conducted their dust fallout campaign. Indications point to a faulty power back-up battery and numerous power failures. Based on the available data at the time of completing this report, the daily PM_{10} concentrations measured on-site are below the 24-hour NAAQS of 75 $\mu g/m^3$; however, this is only based on data from 16 January 2020 to 5 February 2020.

3.3.3 Measured Dustfall Rates

In an assessment conducted by Digby Wells (Digby Wells Environmental, 2020), the dust monitoring was conducted following the American Standard Test Method ASTM 1739-98 (2017) in SANS1137:2019, using a single bucket container to capture dust by gravitational settling. The apparatus comprises a passive dust collector, a vertical pole supporting a 5-liter bucket, a surface area of 227 cm^2, positioned with the top 2 m above ground. The revised method specifies the use of a single bucket container, with a dry container instead of water-filled and a deeper aspect ratio (minimum H:D=2:1) (ASTM International, 2017).

Buckets were exposed for 30±2 days following the standard operating procedure specified in SANS1137:2019 from July 2019 to March 2020. For April 2020, May 2020, and June 2020 the exposure period was 33 days, 29 days, and 31 days respectively. The sampling window for April was not within the 30±2 days recommended. Data recovery was 100% since no incident of theft or damage to samples was recorded. The dust monitoring locations are shown in Figure 2. The dustfall rates for the mentioned period are presented in Table 13 and Figure 7. All of the sampling locations can be classified as non-residential areas. There was only one exceedance of the NDCR limit for non-residential areas (KG7/HAR07 during April 2020) thus the sampled dustfall rates are in compliance with the NDCR.

Table 13: Monthly dustfall rate per sampling location (July 2019 to June 2020)

ID	Dustfall (mg/m²-day)											
	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20
KG1/HAR01	94	300	51	48	180	301	458	66	137	683	84	116
KG2/HAR02	83	351	39	86	113	257	221	65	120	283	27	111
KG3/HAR03	49	677	117	136	183	452	133	21	155	324	21	30
KG4/HAR04	189	576	354	380	553	835	268	61	172	558	192	170
KG5/HAR05	210	747	207	222	412	431	434	279	191	370	222	194
KG6/HAR06	73	322	109	59	148	331	210	553	83	442	47	119
KG7/HAR07	3	284	297	893	498	271	262	178	94	217	1 573	54
KG8/HAR08	328	655	228	1164	841	525	269	231	121	323	148	459

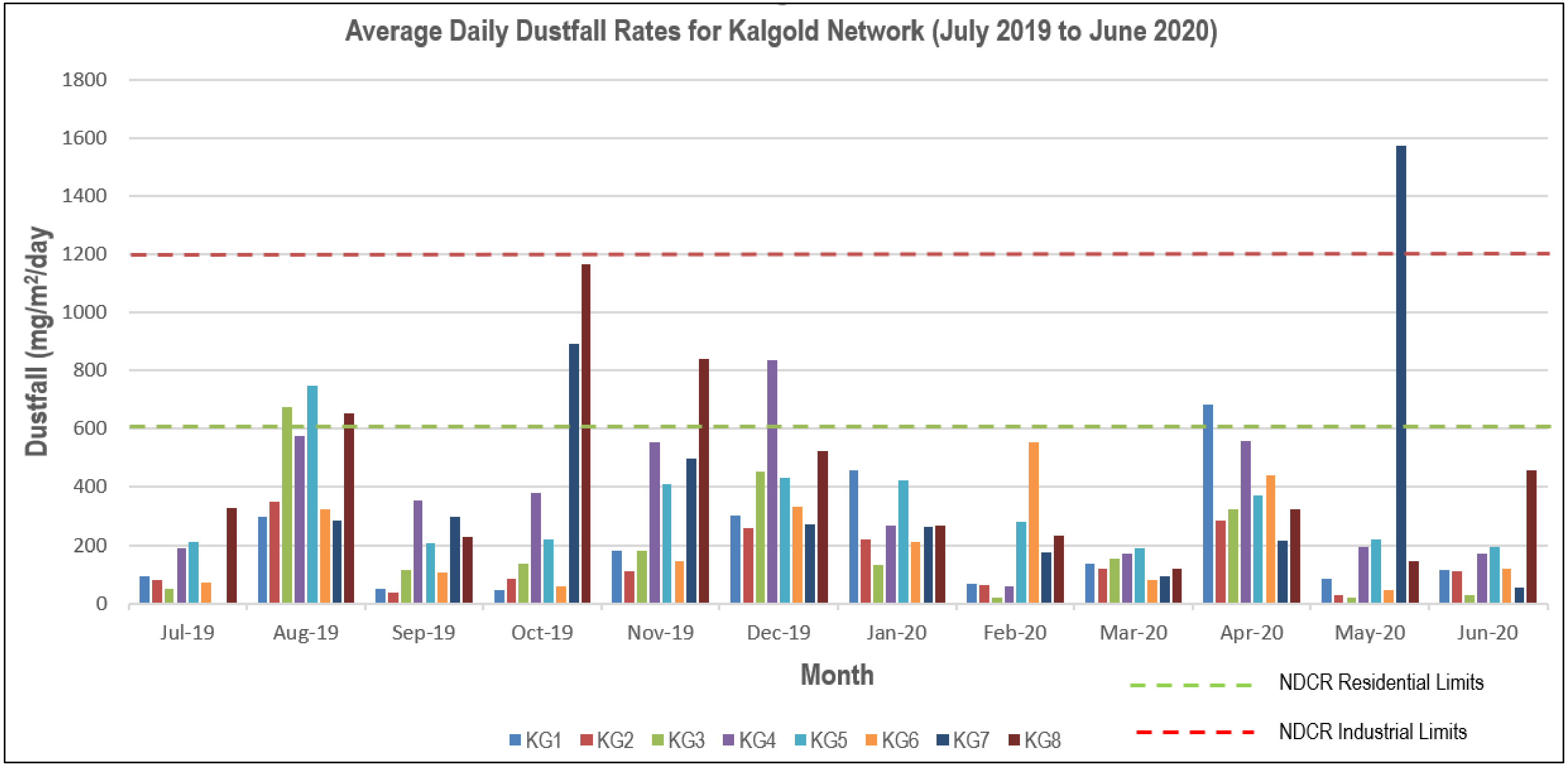

Figure 7: Average daily dustfall rates for the Kalgold network for July 2019 - June 2020

3.3.4 Simulated Pollutant Concentrations

A 2014 study conducted by Digby Wells (Digby Wells Environmental, 2014), provided simulated $PM_{2.5}$ and PM_{10} results over a 20km by 20km modelling domain using the US EPA recommended AERMOD modelling system. The model was set up to run the worst-case scenario without mitigation. The isopleth plot predicted highest daily values for PM_{10} generated by the proposed infrastructures and other activities associated with the Optimisation project on Spanover farm portion to reach a ground level concentration of 139 µg/m³ and minimum of 1.7 µg/m³. The predicted emissions exceed the current daily limit of 75 µg/m³. The main contributor to these emissions was the crusher. The levels at the discrete receptors were all within the recommended limit with no exceedances, as emissions were in exceedance only around the proposed crushing area. The least contributor to the ambient air quality was the heap leach with a predicted daily highest ground level concentration of 10 µg/m³. The predicted highest annual values for PM_{10} reached ground level concentration of 20.2 µg/m³ and minimum of 0.2 µg/m³ falling within the current annual national concentration limit of 40 µg/m³. Evidence suggests that there were no exceedances at the sensitive receptors.

Similarly, simulated $PM_{2.5}$ concentrations were represented as isopleth plots to predict the highest daily ground level concentrations. The highest calculated value was 37.6 µg/m³ with the lowest value being 0.4 µg/m³. The simulated daily ambient $PM_{2.5}$ concentrations are not in exceedance of the current NAAQS limit value of 40 µg/m³ but are higher than 25 µg/m³ applicable from 1 January 2030. The simulated maximum daily values for $PM_{2.5}$ were assessed for haul roads, crusher, heap leach, low grade stockpiles and waste rock dump without mitigation measures. The main contributor of these emissions is the crusher, and the least is the heap leach contributing only 2 µg/m³.Simulated ground level concentrations at the discrete receptors were low and below the NAAQS limit values as emissions were only concentrated around the proposed crushing area. The simulated highest and lowest annual values for $PM_{2.5}$ were 5.1 µg/m³ and 0.05 µg/m³ respectively. This is lower than the current annual NAAQS limits of 20 µg/m³ and 15 µg/m³ applicable on 1 January 2030.

The simulated current operations pollutant concentrations will be updated based on new data as part of the next phase of this study.

3.3.5 Simulated Dustfall Rates

Dust fallout levels predicted at Spanover 552 IO Optimisation Project falls within the criteria for residential areas of 600 mg/m²/day. The predicted maximum deposition modelled was 382 mg/m²/day and the minimum was 3.8 mg/m²/day. Of these emissions, the proposed heap leach contributed 72 mg/m²/day. The dust deposition rates at the selected sensitive receptors in the vicinity of the proposed operation were less than or equal to 10 mg/m²/day

The simulated current operations dustfall rates will be updated based on new data as part of the next phase of this study.

4 Potential Impact from Kalgold Future Operations

4.1 Potential Emissions as a Result of the Project

This has been discussed in Section 1.3.2.

4.2 Sensitivity Map

The EIMS sensitivity mapping categories and specialist knowledge/experience were used to determine sensitive environmental features within the locality map area. All feature/areas identified were assigned one of the following scores (if applicable), 0 (least concern), 1 (low), 2 (medium), 3 (high) or 99 (no-go) (Table 14).

Table 14: Sensitivity information

Preference for Proposed development	Preferable		Restricted		No-go
Sensitivity rating	Least concern	Low	Medium	High	Fatal flaw
Score	0	1	2	3	99
Description	The inherent feature status and sensitivity is already degraded. The proposed development will not affect the current status and/or may result in a positive impact. These features would be the preferred alternative for the project or infrastructure placement.	The proposed development will have not had a significant effect on the inherent feature status and sensitivity.	The proposed development will negatively influence the current status of the feature.	The proposed development will negatively significantly influence the current status of the feature.	The proposed development cannot legally or practically take place.

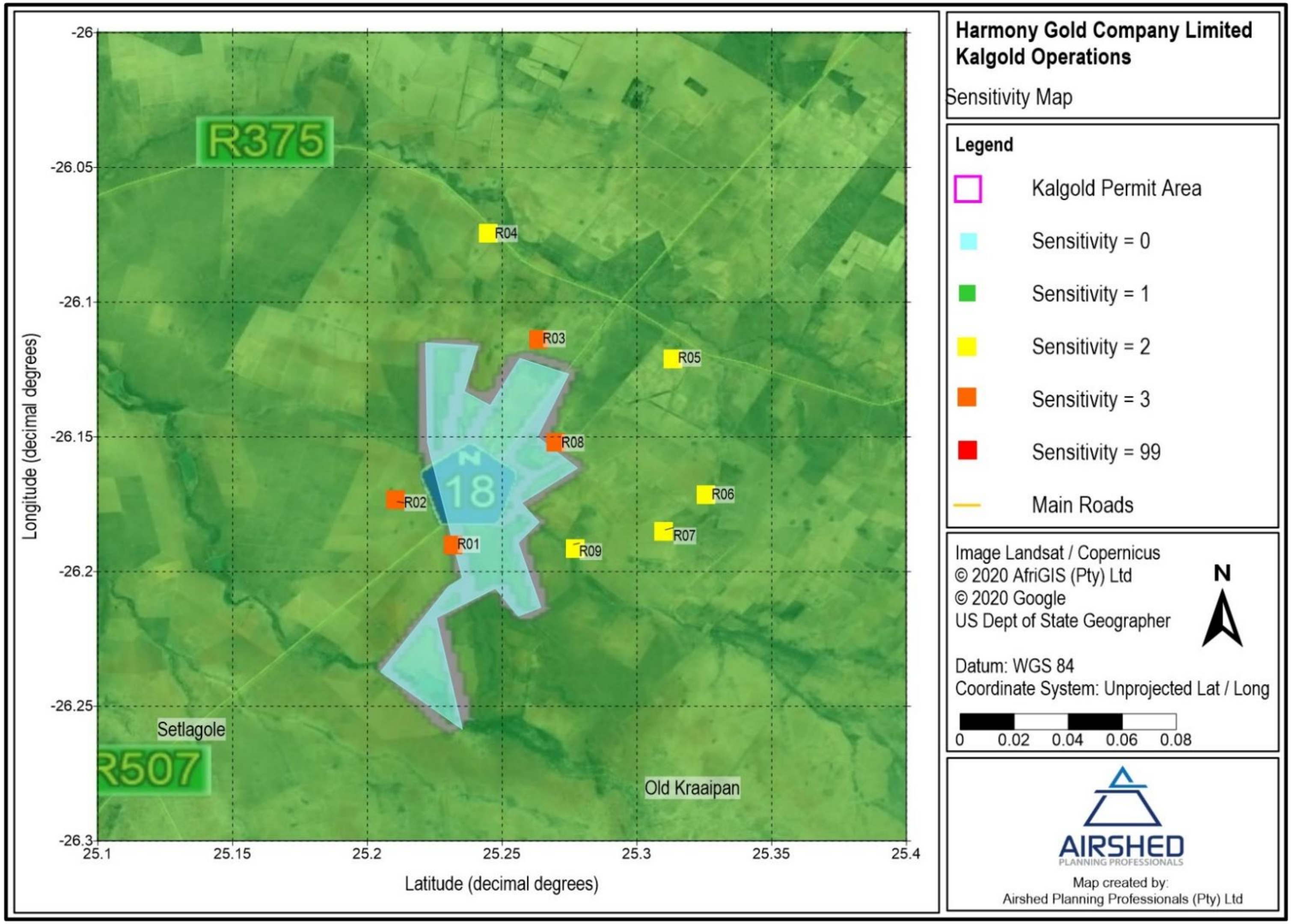

Figure 8: Sensitivity map

4.3 Impact Significance Rating

Non-compliance of $PM_{2.5}$, PM_{10}, SO_2, NO_x or CO concentrations with the relevant NAAQS could result in human health impacts. The potential significance of the impacts based the qualitative assessment of $PM_{2.5,}$ PM_{10}, SO_2, NO_x and CO and dustfall rates (TSP) during the operational phase as a result of the project are discussed below. The EIMS rating methodology was used.

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

- A1: Potential impact on human health from increased pollutant concentrations due to proposed construction operations (Table 15);
- A2: Increased nuisance dustfall rates associated with the proposed construction operations (Table 16); and
- B3: Potential impact on vegetation health from increased dustfall rates and pollutant concentrations due to proposed construction operations (Table 17).

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

- B1: Potential impact on human health from increased pollutant concentrations due to proposed operations (Table 18); and
- B2: Increased nuisance dustfall rates associated with the proposed operations (Table 19); and
- B3: Potential impact on vegetation health from increased dustfall rates and pollutant concentrations due to proposed operations (Table 20).

The environmental risk rating is expected to be the same for decommissioning/closure phase as for the construction phase and the same mitigation measures could be used, thus tables have not been included for this phase. Refer to the construction tables for the environmental risk rating. Three potential decommissioning/closure phase impacts on the air quality of the area were identified:

- C1: Potential impact on human health from increased pollutant concentrations due to proposed decommissioning/closure operations (Table 15);
- C2: Increased nuisance dustfall rates associated with the proposed decommissioning/closure operations (Table 16); and
- C3: Potential impact on vegetation health from increased dustfall rates and pollutant concentrations due to proposed decommissioning/closure operations (Table 17).

Three potential post-closure phase impacts on the air quality of the area were identified:

- D1: Potential impact on human health from increased pollutant concentrations due to proposed post-closure operations (Table 21);
- D2: Increased nuisance dustfall rates associated with the proposed post-closure operations (Table 22); and
- D3: Potential impact on vegetation health from increased dustfall rates and pollutant concentrations due to proposed post-closure operations (Table 23).

Table 15: Health risk impact significance summary table for the proposed construction operations

Air Quality	Description	Rating
Project activity or issue	Construction associated with the proposed project	
Potential impact	Increased health risk at AQSRs	
Alternative	All	
Significance Before Mitigation		
Nature	Negative due to increase in pollutant concentrations at AQSRs.	-1
Extent	Site (i.e. within the development property boundary).	2
Duration	Short term (1-5 years).	2
Magnitude	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way).	3
Reversibility	Impact is reversible without any time and cost.	1
Probability	Medium probability (the impact may occur; >50% and <75%).	3
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-6**
Significance After Additional Mitigation		
Nature	Negative due to increase in pollutant concentrations at AQSRs.	-1

Air Quality	Description	Rating
Extent	Activity (i.e. limited to the area applicable to the specific activity).	1
Duration	Short term (1-5 years).	2
Magnitude	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected).	2
Reversibility	Impact is reversible without any time and cost.	1
Probability	Low probability (there is a possibility that the impact will occur; >25% and <50%).	2
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-3**
Potential mitigation measures (construction)	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens. • Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	
Priority Factor Criteria		
Confidence	Medium	
Cumulative	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.	3
Irreplaceable loss	Where the impact is unlikely to result in irreplaceable loss of resources.	1
Priority factor		1.25
Final score	**Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).**	**-3.75**

Table 16: Nuisance impact significance summary table for the proposed construction operations

Air Quality	Description	Rating
Project activity or issue	Construction associated with the proposed project	
Potential impact	Nuisance dustfall rates at AQSRs	
Alternative	All	
Significance Before Mitigation		
Nature	Negative due to increase in dustfall rates at AQSRs	-1
Extent	Site (i.e. within the development property boundary).	2
Duration	Short term (1-5 years).	2
Magnitude	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected).	2
Reversibility	Impact is reversible without any time and cost.	1
Probability	Low probability (there is a possibility that the impact will occur; >25% and <50%).	2
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-3.5**
Significance After Additional Mitigation		
Nature	Negative due to increase in dustfall rates at AQSRs	-1

Air Quality	Description	Rating
Extent	Activity (i.e. limited to the area applicable to the specific activity).	1
Duration	Short term (1-5 years).	2
Magnitude	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected).	1
Reversibility	Impact is reversible without any time and cost.	1
Probability	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%)	1
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-1.25**
Potential mitigation measures (construction)	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens. • Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	
Priority Factor Criteria		
Confidence	Medium	
Cumulative	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.	2
Irreplaceable loss	Where the impact is unlikely to result in irreplaceable loss of resources.	1
Priority factor		1.13
Final score	**Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).**	**-1.40625**

Table 17: Vegetation health impact significance summary table for the proposed construction operations

Air Quality	Description	Rating
Project activity or issue	Construction associated with the proposed project	
Potential impact	Degradation of vegetation from increased dustfall rates and pollutant concentrations.	
Alternative	All	
Significance Before Mitigation		
Nature	Negative due to increase in dustfall rates and pollutant concentrations.	-1
Extent	Site (i.e. within the development property boundary).	2
Duration	Short term (1-5 years).	2
Magnitude	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected).	2
Reversibility	Impact is reversible without any time and cost.	1
Probability	Low probability (there is a possibility that the impact will occur; >25% and <50%).	2
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-3.5**
Significance After Additional Mitigation		
Nature	Negative due to increase in dustfall rates at AQSRs	-1

Air Quality	Description	Rating
Extent	Activity (i.e. limited to the area applicable to the specific activity).	1
Duration	Short term (1-5 years).	2
Magnitude	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected).	1
Reversibility	Impact is reversible without any time and cost.	1
Probability	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%)	1
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-1.25**
Potential mitigation measures (construction)	• Reduction of fugitive PM emissions through the watering of roads, stockpiles and inactive open areas and the use of screens. • Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	
Priority Factor Criteria		
Confidence	Medium	
Cumulative	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.	2
Irreplaceable loss	Where the impact is unlikely to result in irreplaceable loss of resources.	1
Priority factor		1.13
Final score	**Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).**	**-1.40625**

Table 18: Health risk impact significance summary table for the proposed operations

Air Quality	Description	Rating
Project activity or issue	Mining and processing operations associated with the proposed project.	
Potential impact	Increased health risk at AQSRs.	
Alternative	All.	
Significance Before Mitigation		
Nature	Negative due to increase in pollutant concentrations at AQSRs.	-1
Extent	Regional (i.e. extends between 5 and 50 km from the site).	3
Duration	Long term (the impact will cease after the operational life span of the project).	4
Magnitude	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease).	4
Reversibility	Impact is reversible without any time and cost.	1
Probability	Medium probability (the impact may occur; >50% and <75%).	3
Environmental risk	**Medium (i.e. where the impact could have a significant environmental risk).**	**-9.75**
Significance After Additional Mitigation		
Nature	Negative due to increase in pollutant concentrations at AQSRs.	-1

Air Quality	Description	Rating
Extent	Local (i.e. the area within 5 km of the site).	3
Duration	Long term (the impact will cease after the operational life span of the project).	4
Magnitude	Moderate (where the affected environment is altered but natural, cultural and social functions and processes continue albeit in a modified way).	3
Reversibility	Impact is reversible without any time and cost.	1
Probability	Medium probability (the impact may occur; >50% and <75%).	3
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-8.25**
Potential mitigation measures	Exact measures to be determined during next phase.	
Priority Factor Criteria		
Confidence	Medium	
Cumulative	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.	3
Irreplaceable loss	Where the impact is unlikely to result in irreplaceable loss of resources.	1
Priority factor		1.25
Final score	**Medium negative (i.e. where the impact could influence the decision to develop in the area).**	**-10.3125**

Table 19: Nuisance impact significance summary table for the proposed operations

Air Quality	Description	Rating
Project activity or issue	Mining and processing operations associated with the proposed project.	
Potential impact	Nuisance dustfall rates at AQSRs.	
Alternative	All.	
Significance Before Mitigation		
Nature	Negative due to increase in pollutant concentrations at AQSRs.	-1
Extent	Regional (i.e. extends between 5 and 50 km from the site).	3
Duration	Long term (the impact will cease after the operational life span of the project).	4
Magnitude	High (where natural, cultural or social functions or processes are altered to the extent that it will temporarily cease).	4
Reversibility	Impact is reversible without any time and cost.	1
Probability	Medium probability (the impact may occur; >50% and <75%).	3
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-8.25**
Significance After Additional Mitigation		
Nature	Negative due to increase in dustfall rates at AQSRs	-1

Air Quality	Description	Rating
Extent	Local (i.e. the area within 5 km of the site).	3
Duration	Long term (the impact will cease after the operational life span of the project).	4
Magnitude	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected).	2
Reversibility	Impact is reversible without any time and cost.	1
Probability	Medium probability (the impact may occur; >50% and <75%).	3
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-7.5**
Potential mitigation measures	Exact measures to be determined during next phase.	
Priority Factor Criteria		
Confidence	Medium	
Cumulative	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.	2
Irreplaceable loss	Where the impact is unlikely to result in irreplaceable loss of resources.	1
Priority factor		1.13
Final score	**Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).**	**-8.4375**

Table 20: Vegetation health impact significance summary table for the proposed operations

Air Quality	Description	Rating
Project activity or issue	Mining and processing operations associated with the proposed project.	
Potential impact	Degradation of vegetation from increased dustfall rates and pollutant concentrations.	
Alternative	All	
Significance Before Mitigation		
Nature	Negative due to increase in dustfall rates and pollutant concentrations.	-1
Extent	Site (i.e. within the development property boundary).	2
Duration	Short term (1-5 years).	2
Magnitude	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected).	2
Reversibility	Impact is reversible without incurring significant time and cost.	2
Probability	Medium probability (the impact may occur; >50% and <75%).	3
Environmental risk	**Medium (i.e. where the impact could have a significant environmental risk).**	**-9**
Significance After Additional Mitigation		
Nature	Negative due to increase in dustfall rates at AQSRs	-1

Air Quality	Description	Rating
Nature	Negative due to increase in dustfall rates and pollutant concentrations.	-1
Extent	Local (i.e. the area within 5 km of the site).	3
Duration	Long term (the impact will cease after the operational life span of the project).	4
Magnitude	Low (where the impact affects the environment in such a way that natural, cultural and social functions and processes are slightly affected).	
Reversibility	Impact is reversible without incurring significant time and cost.	2
Probability	Medium probability (the impact may occur; >50% and <75%).	3
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-8.25**
Potential mitigation measures	Exact measures to be determined during next phase.	
Priority Factor Criteria		
Confidence	Medium	
Cumulative	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is probable that the impact will result in spatial and temporal cumulative change.	2
Irreplaceable loss	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.	2
Priority factor		1.25
Final score	**Medium negative (i.e. where the impact could influence the decision to develop in the area).**	**-10.3125**

Table 21: Health risk impact significance summary table for the proposed post-closure operations

Air Quality	Description	Rating
Project activity or issue	Post closure activities.	
Potential impact	Increased health risk at AQSRs when doing site inspections.	
Alternative	All	
Significance Before Mitigation		
Nature	Negative due to increase in pollutant concentrations at AQSRs.	-1
Extent	Activity (i.e. limited to the area applicable to the specific activity).	1
Duration	Short term (1-5 years).	2
Magnitude	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected).	1
Reversibility	Impact is reversible without any time and cost.	1
Probability	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%).	1
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-1.25**
Significance After Additional Mitigation		

Air Quality	Description	Rating
Nature	Negative due to increase in pollutant concentrations at AQSRs.	-1
Extent	Activity (i.e. limited to the area applicable to the specific activity).	1
Duration	Short term (1-5 years).	2
Magnitude	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected).	1
Reversibility	Impact is reversible without any time and cost.	1
Probability	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%).	1
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-1.25**
Potential mitigation measures	Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	
Priority Factor Criteria		
Confidence	Medium	
Cumulative	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.	1
Reversibility	Where the impact is unlikely to result in irreplaceable loss of resources.	1
Priority factor		1

Air Quality	Description	Rating
Final score	**Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).**	**-1.25**

Table 22: Nuisance impact significance summary table for the proposed post-closure operations

Air Quality	Description	Rating
Project activity or issue	Post closure activities.	
Potential impact	Increased nuisance dustfall at AQSRs when doing site inspections.	
Alternative	All	
Significance Before Mitigation		
Nature	Negative due to increase in dustfall rates at AQSRs.	-1
Extent	Activity (i.e. limited to the area applicable to the specific activity).	1
Duration	Short term (1-5 years).	2
Magnitude	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected).	1
Reversibility	Impact is reversible without any time and cost.	1

Air Quality	Description	Rating
Probability	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%).	1
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-1.25**
Significance After Additional Mitigation		
Nature	Negative due to increase in dustfall rates at AQSRs.	-1
Extent	Activity (i.e. limited to the area applicable to the specific activity).	1
Duration	Short term (1-5 years).	2
Magnitude	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected).	1
Reversibility	Impact is reversible without any time and cost.	1
Probability	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%).	1
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-1.25**
Potential mitigation measures	Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	
Priority Factor Criteria		
Confidence	Medium	

Air Quality	Description	Rating
Cumulative	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.	1
Reversibility	Where the impact is unlikely to result in irreplaceable loss of resources.	1
Priority factor		1
Final score	**Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).**	**-1.25**

Table 23: Vegetation health impact significance summary table for the proposed post-closure operations

Air Quality	Description	Rating
Project activity or issue	Post closure activities.	
Potential impact	Increased health risk to vegetation when doing site inspections.	
Alternative	All	
Significance Before Mitigation		
Nature	Negative due to increase in pollutant concentrations and dustfall rates at vegetated areas.	-1
Extent	Activity (i.e. limited to the area applicable to the specific activity).	1
Duration	Short term (1-5 years).	2

Air Quality	Description	Rating
Magnitude	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected).	1
Reversibility	Impact is reversible without any time and cost.	1
Probability	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%).	1
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-1.25**
Significance After Additional Mitigation		
Nature	Negative due to increase in pollutant concentrations and dustfall rates at vegetated areas.	-1
Extent	Activity (i.e. limited to the area applicable to the specific activity).	1
Duration	Short term (1-5 years).	2
Magnitude	Minor (where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected).	1
Reversibility	Impact is reversible without any time and cost.	1
Probability	Improbable (the possibility of the impact materialising is very low as a result of design, historic experience, or implementation of adequate corrective actions; <25%).	1
Environmental risk	**Low (i.e. where this impact is unlikely to be a significant environmental risk).**	**-1.25**

Air Quality	Description	Rating
Potential mitigation measures	Reductions of vehicle exhaust emissions through the use of better-quality diesel; and inspection and maintenance programs.	
Priority Factor Criteria		
Confidence	Medium	
Cumulative	Considering the potential incremental, interactive, sequential, and synergistic cumulative impacts, it is unlikely that the impact will result in spatial and temporal cumulative change.	1
Reversibility	Where the impact is unlikely to result in irreplaceable loss of resources.	1
Priority factor		1
Final score	**Low negative (i.e. where this impact would not have a direct influence on the decision to develop in the area).**	**-1.25**

5 Findings

This report preliminary assessed the potential for air quality impacts from the planned expansion operations at Kalgold mine. All available project and associated data, including metrological data, previous air quality assessments, EIAs and technical air quality data were evaluated together with the planned mine design and schedule. The findings are based on the qualitative assessment of the potential impacts.

5.1 Baseline Assessment

The findings from the baseline assessment can be summarised as follows:

- Meteorological data was provided for the period August 2019 – September 2020 from the on-site Kalgold station and had 70.4% data availability after processing.
- The prevailing wind field in the area consists of east-north-easterly, north-easterly and easterly winds. Wind speeds were lower at night than during the day. Wind speeds exceeding 5.0 m/s occurred for 1.1% of the period.
- The area experiences mild summers and cold winters with monthly average temperatures ranged between 10°C and 26°C. The highest temperature of (35°C) occurred in October and the lowest (-4°C) in June.
- Simulated data (January 2011 to December 2013) from the study conducted by Digby Wells (Digby Wells Environmental, 2014) showed that the average precipitation was 66 mm. The three-year annual maximum, minimum and mean monthly precipitation rates were 81.3 mm, 38.7 mm and 60.9 mm, respectively. The highest monthly maximum precipitation (227.8 mm) was observed in December to 4.8 mm in July. The monthly minimum precipitation ranges between 202.3 mm in December to no rainfall in July.
- Nearby residential areas include Old Kraaipan (southeast), Setlagole (southwest) and Mareetsane (20 km to the east). Aside from the residential areas, individual farmsteads near the expansion operations were identified as AQSRs and agricultural areas were identified as environmentally sensitive areas.
- Ambient air pollutant levels in the project area are currently affected by the following sources of emission:
    - Current mining and Industrial operations at the Kalgold mine.
    - Agricultural operations – the surrounding land use is predominantly agricultural and hence associated activities may contribute to elevated ground level concentrations.
    - Vehicles travelling on public and private roads – fugitive dust emissions would occur because of vehicle entrained dust from local paved and unpaved roads, these are also contributors to mobile combustion emissions.
    - Household fuel burning – particulate matter and gaseous emissions may occur from the burning of fuel within households for cooking and space heating.

    - Biomass burning – burning of agricultural land, fire breaks and unplanned veld fires would result in particulate matter and gaseous emissions.
    - Other sources – windblown dust from open areas.
- PM_{10} data available during the compilation of this report had low availability.
- A dustfall monitoring network (Digby Wells Environmental, 2020), at the mine premises recorded one exceedance to the non-residential limit at KG7/HAR07, with a dustfall rate of 1,573 mg/m^2-day. The dustfall rates are however still in compliance with the NDCR.
- Simulated pollutant concentrations from a study conducted by Digby Wells (Digby Wells Environmental, 2014) showed no exceedance to the current daily and annual NAAQS limits for both PM_{10} and $PM_{2.5}$. However, future expansion operations may result in exceedances to the future $PM_{2.5}$ limits effective 31 January 2030. The simulated dustfall rates for the same study indicated compliance with the NDCR.

5.2 Impact Assessment

The findings from the qualitative impact assessment can be summarised as follows:

- Construction, decommissioning/closure and post-closure phases:
    - The environmental risk rating related inhalation health, nuisance impacts and vegetation impacts are likely to be "low" without and with additional mitigation. The overall environmental risk rating is also expected to be "low negative".
- Operational phase:
    - The environmental risk rating of proposed project operations related to inhalation health impacts is likely to be "medium negative" without mitigation measures applied and becomes "low negative" with mitigation measures applied. The overall environmental risk rating is expected to be "medium negative".
    - The environmental risk rating of operations related to nuisance impacts are likely to be "low negative" without and with mitigation measures applied. The overall environmental risk rating is expected to be "low negative".
    - The environmental risk rating of proposed project operations related to the impacts on vegetation health is likely to be "medium negative" without mitigation measures applied and becomes "low negative" with mitigation measures applied. The overall environmental risk rating is expected to be "medium negative".

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Appendix A – Specialist Curriculum Vitae and Professional Registration Certificate (N A Shackleton)

CURRICULUM VITAE

Name	Natasha Anne Shackleton (née Gresse)
Date of Birth	12 September 1988
Nationality	South African
Identification Number	880912 0054 081
Passport Number	A05514095
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Senior Consultant
Profession	Meteorologist employed as an Air Quality and Noise Consultant
Years with Firm	9
E-mail Address	natasha@airshed.co.za
Contact Numbers	+27 11 8051940 (Work Switchboard)
	+27 10 500 1147 (Work Direct)

MEMBERSHIP OF SOCIETIES

- Registered Professional Natural Scientist (Registration Number 116335) with South African Council for Natural Scientific Professions (SACNASP), 2018 to present.
- National Association for Clean Air (NACA), 2011 to present
- South African Society for Atmospheric Sciences (SASAS), 2016 to present.
- American Meteorological Society (AMS), 2017 and 2018.
- Golden Key International Honour Society, 2011 to present.

EXPERIENCE

Natasha has several years of experience in air quality and noise impact assessments and management. She is an employee of Airshed Planning Professionals (Pty) Ltd and is tasked with completing air, noise, greenhouse gas and climate change studies involving ambient measurements; meteorological data processing and preparation; the compilation of emission inventories; undertaking of air dispersion and noise propagation modelling; impact and compliance assessment using her substantial knowledge of South African and international legislation and requirements pertaining to air quality and noise; air quality, noise, greenhouse gas and climate change management plan preparation and report writing. Many of her projects within various countries in Africa required international financing, providing her with an inclusive knowledge base of IFC guidelines and requirements pertaining to air quality.

PROJECTS COMPETED IN VARIOUS SECTORS ARE LISTED BELOW:

Mining Sector

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

Industrial Sector

AfriSam Saldanha Project; CAH Chlorine Caustic Soda and HCl Plant, Consol Industrial Minerals, Corobrik Driefontein, Metal Concentrators SA Paarden Eiland, Namakwa Sands Dryer, Otavi Rebar Manufacturing, Phakisa Project, Pan Palladium Project, PPC Riebeeck Cement, Rare Earth Elements Saldanha Separation Plant, Saldanha Steel, Siyanda Project, Tete Iron Ore Project / Tete Steel and Vanadium Project (Mozambique), Tri-K Project (Guinea), Tormin Mineral Sands MSP, Tronox Namakwa Sands Smelter, Tronox Namakwa Sands UMM Plant, Tronox Namakwa Sands MSP, ZMY Steel Recycling Plant, Nyanza TiO_2 Pilot Plant, Musina-Makhado SEZ, West African Resources Sanbrado Project (Burkina Faso), Impala Platinum Rustenburg Mine and Smelter.

Power Generation, Oil and Gas

H2 Energy Power Station, Hwange Thermal Power Station Project (Zimbabwe), Ibhubesi Gas Project, Expansion of Staatsolie Power Company, Suriname Operations (Suriname), Tri-K Project (Guinea), Tete Iron Ore Project / Tete Steel and Vanadium Project (Mozambique).

Waste Disposal and Treatment Sector

Fishwater Flats Waste Water Treatment Works, Khutala Water Treatment Project, Moz Environmental Industrial Landfill (Mozambique), Wolverand Crematorium.

Petroleum Sector

Chevron Refinery, Exol Oil Refinery, Puma South Africa's Fuel Storage Facility, Oilkol Depot, Astron Energy Cape Town Refinery.

Transport and Logistics Sector

Saldanha Port Project.

Ambient Air Quality and Noise Sampling/Monitoring

Gravimetric particulate matter (PM) sampling, Dustfall sampling, Passive diffusive gaseous pollutant sampling, Continuous ambient air quality monitoring, Environmental noise sampling.

SOFTWARE PROFICIENCY

Software utilised in conducting air and noise studies:

- WRPLOT (wind & pollution rose generation);
- OpenAir (ambient and meteorological data processing)
- ScreenView (screening model);
- AERMOD suite (air dispersion model);
- ADMS (air dispersion model);
- CALPUFF suite (air dispersion model);
- GRAL system (air dispersion model);
- TANKS (emission estimation model);
- GasSim (emission estimation model);
- DataKustic CadnaA (noise propagation model);

- CONCAWE (noise propagation model); and
- SANS 10201 (calculating and predicting road traffic noise).

EDUCATION

- 2016 to present - MSc: Applied Science (Environmental Technology) student at the University of Pretoria (Faculty of Engineering, Built Environment and Information Technology), Pretoria. Currently undertaking studies. Supervisor: Dr G Kornelius.
- 2010 to 2011 - BSc Honours (Meteorology) student at the University of Pretoria (Faculty of Natural and Agricultural Sciences), Pretoria. Completed 30 November 2011. Degree issued/conferred 13 April 2012. Research project supervisor: Dr S Venkataraman.
- 2007 to 2010 - BSc student at the University of Pretoria (Faculty of Natural and Agricultural Sciences), Pretoria. Completed 30 June 2010. Degree issued/conferred 2 September 2010.

CONFERENCES ATTENDED, ARTICLES PUBLISHED AND COURSES COMPLETED

- Conference: Innovation Bridge and Science Forum South Africa (December 2019), attended.
- Conference: NACA (October 2018), attended and presented a paper (Correlating Dust Concentration Measurements aloft with Opencast Mining Surface Operations).
- Conference: NACA (October 2017), attended and presented a paper (Correlating Dust Concentration Measurements aloft with Opencast Mining Surface Operations).
- Published Article: Beukes, JP; Van Zyl, PG; Sofiev, M; Soares, J; Liebenberg-Enslin, H; Shackleton, N; Sundstrom, AM (2018). The use of satellite observations of fire radiative power to estimate the availabilities (activity patterns) of pyrometallurgical smelters. Journal of the Southern African Institute of Mining and Metallurgy, 118(6), 619-624., co-author.
- Undergraduate courses passed: computer literacy (word processing, spreadsheet processing, Microsoft power point, Microsoft publisher, use of Internet and Microsoft front page); MATLAB; ArcGIS 9.0.; ERDAS Image; Aan Arbor; IDRISI TAIGA; GRADS; TITAN; SUMO 3.00; and Danny Rosenfeld 2007-01.

COUNTRIES OF WORK EXPERIENCE

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

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Limited working proficiency

REFERENCES

Name	Position	Contact Number
Dr Gerrit Kornelius	Associate of Airshed Planning Professionals	+27 82 925 9569 gerrit@airshed.co.za
Dr Lucian Burger	Director at Airshed Planning Professionals	+27 11 805 1940 lucian@airshed.co.za
Dr Hanlie Liebenberg-Enslin	Managing Director at Airshed Planning Professionals	+27 11 805 1940 hanlie@airshed.co.za

CERTIFICATION

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

22/04/2020

SACNASP

South African Council for Natural Scientific Professions

herewith certifies that

Natasha Anne Shackleton

Registration Number: 116335

is a registered scientist

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

Physical Science (Professional Natural Scientist)

Effective **6 June 2018** Expires **31 March 2021**

Chairperson

Chief Executive Officer

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