APPENDIX H: NOISE STUDY

Noise Specialist Study for the Pilanesberg Platinum Mine Plant Expansion Project

Project done for **SLR Consulting (South Africa) (Pty) Ltd**

Report compiled by:
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Report Details

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Revision Record

Version	Date	Comments
Rev 0	November 2018	For client review
Rev 0.1	January 2019	Incorporation of grammatical changes
Rev 0.2	February 2019	Update of NEMA regulation requirements
Rev 0.3	February 2019	Incorporation of comments from the client
Rev 0.4	March 2019	Process update

NEMA Regulation (2014), Appendix 6

NEMA Regulations (2014) (as amended) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report	Section 1.3
The expertise of that person to compile a specialist report including a curriculum vitae	Section 1.3 and Appendix A
A declaration that the person is independent in a form as may be specified by the competent authority	Report details (Executive Summary) and Section 1.3
An indication of the scope of, and the purpose for which, the report was prepared	Section 1.2
An indication of the quality and age of base data used for the specialist report	Section 3.3
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change	Section 3.3 and Section 4.2
The duration date and season of the site investigation and the relevance of the season to the outcome of the assessment	Section 3.3
A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used	Section 1.6
Details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure inclusive of a site plan identifying site alternatives	Section 4
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;	Section 3.1
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 1.7
A description of the findings and potential implications of such findings on the impact of the proposed activity or activities	Section 4.2
Any mitigation measures for inclusion in the EMPr	Section 5
Any conditions for inclusion in the environmental authorisation	No comments received.
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 5
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and regarding the acceptability of the proposed activity or activities	Section 7
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Section 5
A description of any consultation process that was undertaken during the course of preparing the specialist report	Not applicable.
A summary and copies of any comments received during any consultation process and where applicable all responses thereto	Not applicable.
Any other information requested by the competent authority.	Not applicable.

Glossary and Abbreviations

Airshed	Airshed Planning Professionals (Pty) Ltd
ASG	Atmospheric Studies Group
dB	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure.
dBA	Descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure that has been A-weighted to simulate human hearing.
C_i	Correction for impulsiveness
Ct	Correction for tonality
EAP	Environmental Assessment Practitioner
EC	European Commission
EHS	Environmental, Health, and Safety (IFC)
Hz	Frequency in Hertz
HV	Heavy vehicle
IEC	International Electro Technical Commission
IFC	International Finance Corporation
ISO	International Standards Organisation
Kn	Noise propagation correction factor
K1	Noise propagation correction for geometrical divergence
K2	Noise propagation correction for atmospheric absorption
K3	Noise propagation correction for the effect of ground surface;
K4	Noise propagation correction for reflection from surfaces
K5	Noise propagation correction for screening by obstacles
kW	Power in kilowatt
L_{Aeq} (T)	The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
L_{AIeq} (T)	The impulse corrected A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured) (in dBA)
$L_{Req,d}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.
$L_{Req,n}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.
$L_{R,dn}$	The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10dB in order to account for the additional disturbance caused by noise during the night.
L_{A90}	The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels (L_{A90}) (in dBA)
L_{AFmax}	The A-weighted maximum sound pressure level recorded during the measurement period
L_{AFmin}	The A-weighted minimum sound pressure level recorded during the measurement period

L_{me}	Sound power level 25 m from a road, 4 above ground (in dBA)
L_P	Sound pressure level (in dB)
L_{PA}	A-weighted sound pressure level (in dBA)
L_{PZ}	Un-weighted sound pressure level (in dB)
Ltd	Limited
L_W	Sound Power Level (in dB)
NEMAQA	National Environment Management Air Quality Act
masl	Meters above sea level
m^2	Area in square meters
m/s	Speed in meters per second
NLG	Noise level guideline
NSR	Noise sensitive receptor
p	Pressure in Pa
Pa	Pressure in Pascal
µPa	Pressure in micro-pascal
p_{ref}	Reference pressure, 20 µPa
Pty	Proprietary
rpm	Rotational speed in revolutions per minute
SABS	South African Bureau of Standards
SANS	South African National Standards
SLM	Sound Level Meter
SoW	Scope of Work
STRM	Shuttle Radar Topography Mission
USGS	United States Geological Survey
WG-AEN	Working Group – Assessment of Environmental Noise (EC)
WHO	World Health Organisation
%	Percentage

Executive Summary

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by SLR Consulting (South Africa) (Pty) Ltd. to conduct a Noise Impact Assessment (NIA) for the proposed plant expansion at the Pilanesberg Platinum Mines (PPM) (hereafter referred to as the project). Current operations at the PPM include open pit mining on the farm Tuschenkomst 135JP. Ore from the open pit operations is transported to the existing mineral processing facility located on the farms Witkleifontein 136JP and Tuschenkomst 136JP for processing. Waste rock is stockpiled on waste rock dumps. Tailings from the mineral processing facility are disposed of on the PPM tailings storage facility on the farm Witkleifontein 136JP. Services and infrastructure exist to support the mining and mineral processing activities.

The main objective of the noise specialist study was to determine the potential impact on the acoustic environment and noise sensitive receptors (NSRs) as a result of the development of the project and recommend suitable management and mitigation measures. To meet the above objective, the following tasks were included in the Scope of Work (SoW):

1. A review of available technical project information.
2. A review of the legal requirements and applicable environmental noise guidelines.
3. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of NSRs from available maps and field observations;
    b. A study of environmental noise attenuation potential by referring to available weather records, land use and topography data sources; and
    c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from surveys conducted in 13th and 14th October 2015.
4. An impact assessment, including:
    a. The establishment of a source inventory for proposed activities.
    b. Noise propagation simulations to determine environmental noise levels as a result of the project.
    c. The screening of simulated noise levels against environmental noise criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. The preparation of a comprehensive specialist noise impact assessment report.

In the assessment of simulated noise levels, reference was made to the South African National Standard (SANS) 10103 guidelines and the International Finance Corporation (IFC) guidelines.

The baseline acoustic environment was described in terms of the location of NSRs, the ability of the environment to attenuate noise over long distances, as well as existing background and baseline noise levels. The following was found:

- The closest NSRs include the Black Rhino Game Reserve to the south and residential areas of Mothabe to the north, Ngweding to the north east and Legkraal to the south east.
- Atmospheric conditions are more conducive to noise attenuation during the day.
- There are no natural terrain features that would provide acoustic shielding to the closest receptors.

- Livestock, community activity, birds, insects and surrounding mining activities are the main contributors to the acoustic environment of the area.

Noise from the project were calculated using default noise “emission factors” for heavy industrial, light industrial and commercial areas, developed by the European Commission’s (EC) Working Group for the Assessment of Exposure to Noise (WG-AEN) for their *Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure* (EC WG-AEN, 2006). The EC recommends using these factors when information for a detailed source inventory is not available.

The source inventory, local meteorological conditions and information on local land use were used to populate the noise propagation model (CadnaA, ISO 9613). The propagation of noise was calculated over an area of 11.3 km east-west by 11.1 km north-south. The area was divided into a grid matrix with a 20-m resolution and NSRs were included as discrete receptors.

The main findings of the impact assessment are:

- The noise levels from the project operations do not exceed the selected noise criteria at any of the NSRs.
- Construction and closure phase impacts are expected to me similar or slightly lower than simulated noise impacts of the operational phase.

Based on the findings of the assessment, it is the specialist opinion that the project may be authorised.

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1 Introduction

Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by SLR Consulting (South Africa) (Pty) Ltd. to conduct a Noise Impact Assessment (NIA) for the proposed plant expansion at the Pilanesberg Platinum Mines (PPM) (hereafter referred to as the project). Current operations at the PPM include open pit mining on the farm Tuschenkomst 135JP. Ore from the open pit operations is transported to the existing mineral processing facility located on the farms Witkleifontein 136JP and Tuschenkomst 136JP for processing. Waste rock is stockpiled on waste rock dumps. Tailings from the mineral processing facility are disposed of on the PPM tailings storage facility on the farm Witkleifontein 136JP. Services and infrastructure exist to support the mining and mineral processing activities.

PPM proposes to expand the existing mineral processing facilities to incorporate:

- a hydrometallurgical plant for the extraction of PGMs and base metals;
- a UG2 milling and flotation circuit to process ore from the Sedibelo Platinum Mine (SPM) operation.

In addition, the following is planned:

- upgrading of the existing sewage treatment plant; and
- relocation of the waste storage and handling facility from inside the plant to an area outside the plant.

Furthermore, a number of community-based initiatives have been established at the mine. These have been included in this report at the request of the DMR. They include:

- an aggregate crusher and brick making project;
- nursery;
- vegetable garden and composting area;
- car wash.

1.1 Study Objective

The main objective of the noise specialist study was to determine the potential impact on the acoustic environment and noise sensitive receptors (NSRs) as a result of the project and recommend suitable management and mitigation measures.

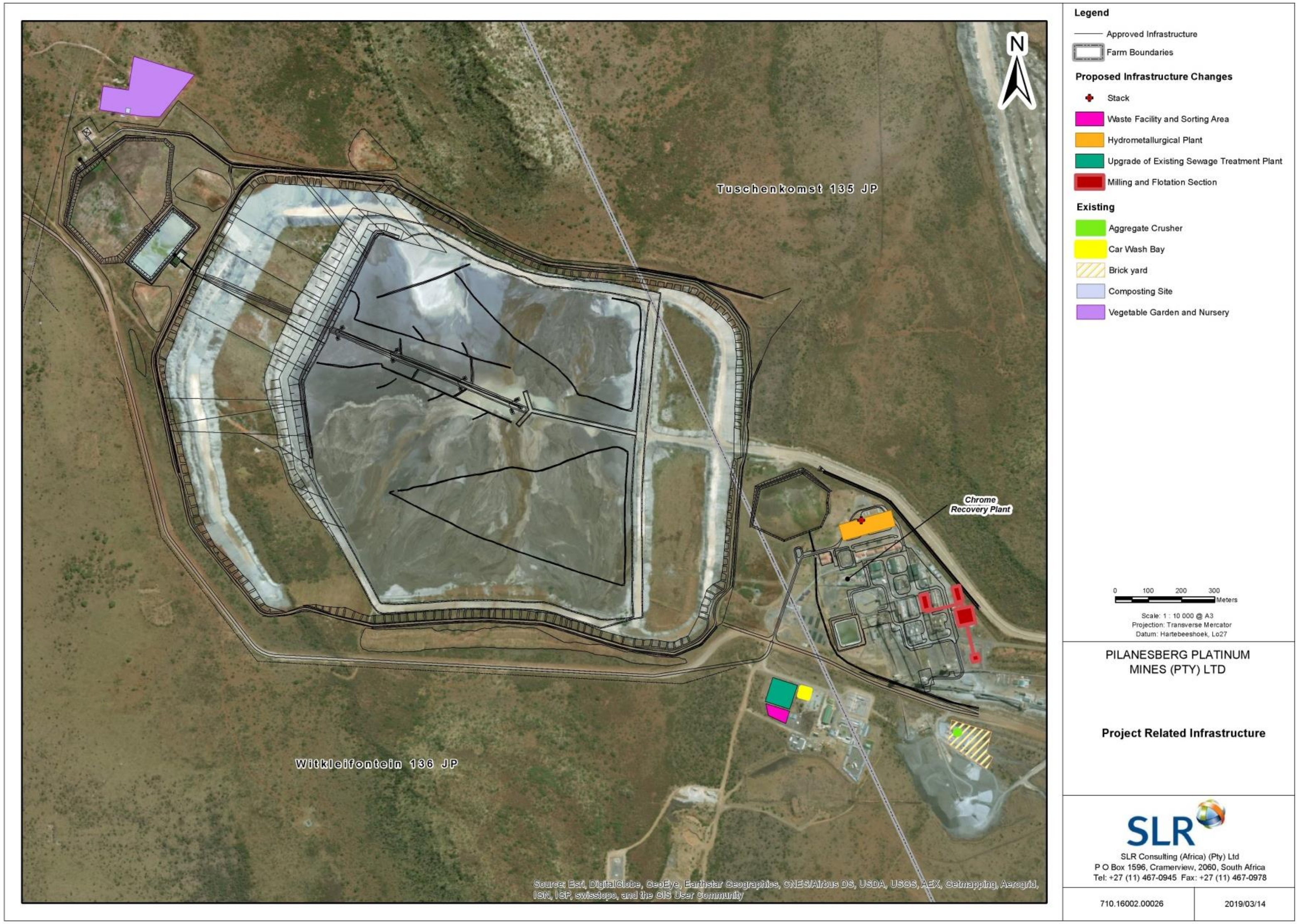

Figure 1: Location of Plant Expansion Infrastructure

1.2 Scope of Work

To meet the above objective, the following tasks were included in the Scope of Work (SoW):

1. A review of available technical project information.
2. A review of the legal requirements and applicable environmental noise guidelines.
3. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of NSRs from available maps and field observations;
    b. A study of environmental noise attenuation potential by referring to available weather records, land use and topography data sources; and
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6. The preparation of a comprehensive specialist noise impact assessment report.

1.3 Specialist Details

1.3.1 Specialist Details

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

1.3.2 Competency Profile of Specialist

Reneé von Gruenewaldt is a Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP) and a member of the National Association for Clean Air (NACA).

Following the completion of her bachelor's degree in atmospheric sciences in 2000 and honours degree (with distinction) with specialisation in Environmental Analysis and Management in 2001 at the University of Pretoria, her experience in air pollution started when she joined Environmental Management Services (now Airshed Planning Professionals) in 2002. Reneé von Gruenewaldt later completed her Master's Degree (with distinction) in Meteorology at the University of Pretoria in 2009.

Reneé von Gruenewaldt became partner of Airshed Planning Professionals in September 2006. Airshed Planning Professionals is a technical and scientific consultancy providing scientific, engineering and strategic air pollution impact assessment and management services and policy support to assist clients in addressing a wide variety of air pollution related risks and air quality management challenges.

She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Reneé has been the principal air quality specialist and manager on several Air Quality Impact Assessment between 2006 to present and Noise Assessment projects between 2015 and present and 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.

A comprehensive curriculum vitae of Reneé von Gruenewaldt is provided in Appendix A.

1.4 Description of Activities from a Noise Perspective

PPM proposes to expand the existing mineral processing facilities to incorporate:

- a hydrometallurgical plant for the extraction of PGMs and base metals;
- a UG2 milling and flotation circuit to process ore from the Sedibelo Platinum Mine (SPM) operation.

In addition, the following is planned:

- upgrading of the existing sewage treatment plant; and
- relocation of the waste storage and handling facility from inside the plant to an area outside the plant.

Furthermore, a number of community-based initiatives have been established at the mine. They include:

- an aggregate crusher and brick making project;
- nursery;
- vegetable garden and composting area;
- car wash.

The project consists of components that are added to the existing plant. The project components are similar to those that already exist on site.

Construction phase activities will include bulk earthworks (for the establishment of the processing plant and infrastructure), as well as metal and concrete works for the erection of the processing plant and other infrastructure. Access to site will be via the main access road.

Sound fields in an industrial setting such as an operational ore processing plant, are usually complex due to the participation of many sources: propagation through air (air-borne noise), propagation through solids (structure-borne noise), diffraction at the machinery boundaries, reflection from the floor, wall, ceiling and machinery surface, absorption on the surfaces, etc. High noise levels can therefore be present near operating machinery. The project components will include conveyors; electric motors; fans; pumps, piping etc. For a given machine, the sound pressure levels depend on the part of the total mechanical or electrical energy that is transformed into acoustical energy. Piping and pumping noise associated with tailings disposal are usually very localised and not considered significant.

Decommissioning for this project would fall within the overall decommissioning of the plant and involve the same activities of dismantling and removal of equipment, demolishing building structures, removal of related waste from the site, etc. Very little information regarding the decommissioning phase was available for consideration, from a noise perspective it is however likely to be similar in character and impact to the construction phase.

1.5 Background to Environmental Noise and the Assessment Thereof

Before more details regarding the approach and methodology adopted in the assessment is given, the reader is provided with some background, definitions and conventions used in the measurement, calculation and assessment of environmental noise.

Noise is generally defined as unwanted sound transmitted through a compressible medium such as air. Sound in turn, is defined as any pressure variation that the ear can detect. Human response to noise is complex and highly variable as it is subjective rather than objective.

A direct application of linear scales (in pascal (Pa)) to the measurement and calculation of sound pressure leads to large and unwieldy numbers. And, as the ear responds logarithmically rather than linearly to stimuli, it is more practical to express acoustic parameters as a logarithmic ratio of the measured value to a reference value. This logarithmic ratio is called a decibel or dB. The advantage of using dB can be clearly seen in Figure 2. Here, the linear scale with its large numbers is converted into a manageable scale from 0 dB at the threshold of hearing (20 micro-pascals (μPa)) to 130 dB at the threshold of pain (~100 Pa) (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

As explained, noise is reported in dB. “dB” is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities that have the same units, in this case sound pressure. The relationship between sound pressure and sound pressure level is illustrated in this equation.

$$L_p = 20 \cdot \log_{10}\left(\frac{p}{p_{ref}}\right)$$

Where:

***L_p** is the sound pressure level in dB;*

***p** is the actual sound pressure in Pa; and*

***p_{ref}** is the reference sound pressure (p_{ref} in air is 20 μPa).*

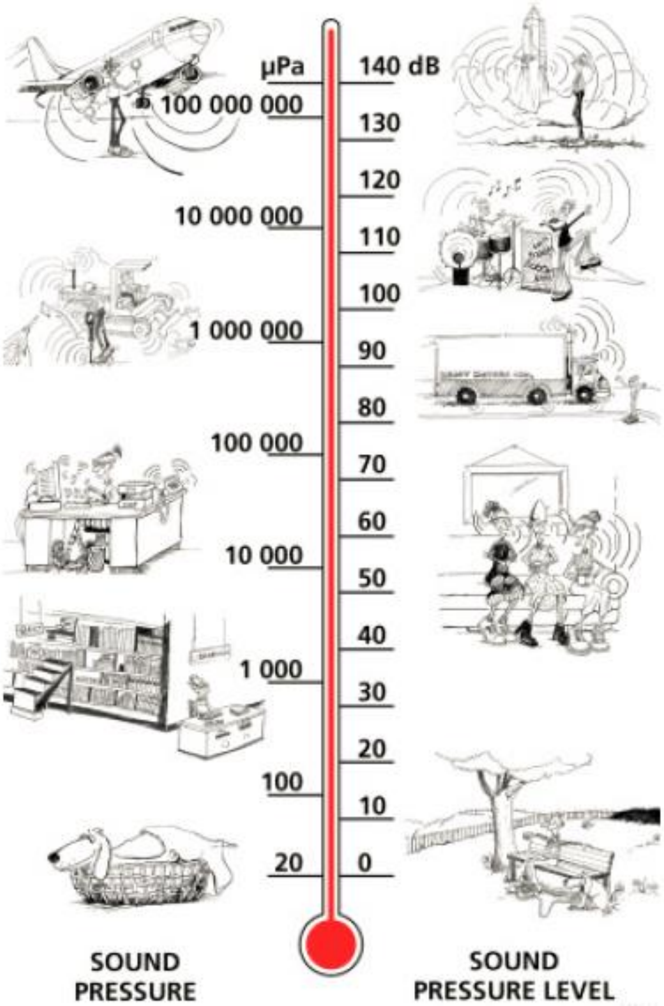


Figure 2: The decibel scale and typical noise levels (Brüel & Kjær Sound & Vibration Measurement A/S, 2000)

1.5.1 Perception of Sound

Sound has already been defined as any pressure variation that can be detected by the human ear. The number of pressure variations per second is referred to as the frequency of sound and is measured in hertz (Hz). The hearing frequency of a young, healthy person ranges between 20 Hz and 20 000 Hz.

In terms of L_P, audible sound ranges from the threshold of hearing at 0 dB to the pain threshold of 130 dB and above. Even though an increase in sound pressure level of 6 dB represents a doubling in sound pressure, an increase of 8 to 10 dB is required before the sound subjectively appears to be significantly louder. Similarly, the smallest perceptible change is about 1 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.5.2 Frequency Weighting

Since human hearing is not equally sensitive to all frequencies, a 'filter' has been developed to simulate human hearing. The 'A-weighting' filter simulates the human hearing characteristic, which is less sensitive to sounds at low frequencies than at high frequencies (Figure 3). "dBA" is the descriptor that is used to indicate 10 times a logarithmic ratio of quantities, that have the same units (in this case sound pressure) that has been A-weighted.

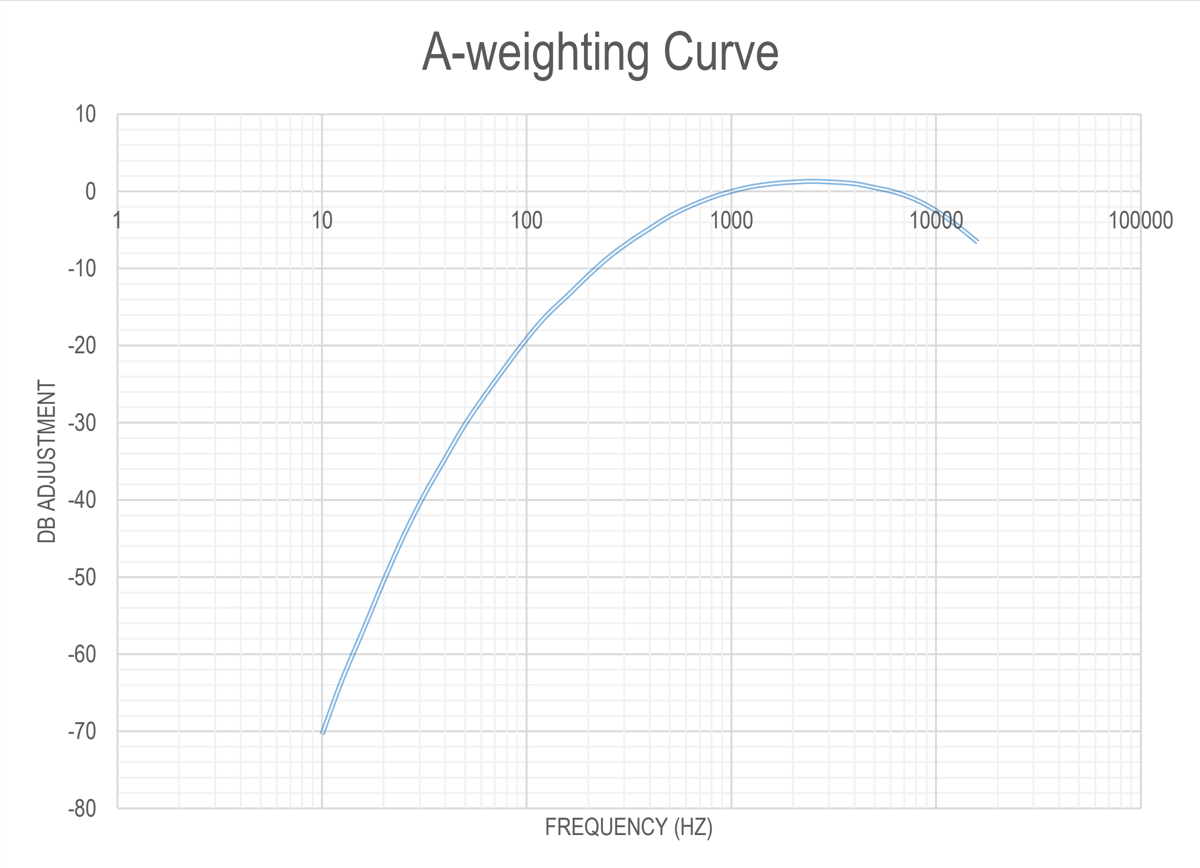


Figure 3: A-weighting curve

1.5.3 Adding Sound Pressure Levels

Since sound pressure levels are logarithmic values, the sound pressure levels as a result of two or more sources cannot just simply be added together. To obtain the combined sound pressure level of a combination of sources such as those at an industrial plant, individual sound pressure levels must be converted to their linear values and added using:

$$L_{p\_combined} = 10 \cdot \log\left(10^{\frac{L_{p1}}{10}} + 10^{\frac{L_{p2}}{10}} + 10^{\frac{L_{p3}}{10}} + \cdots 10^{\frac{L_{pi}}{10}}\right)$$

This implies that if the difference between the sound pressure levels of two sources is nil the combined sound pressure level is 3 dB more than the sound pressure level of one source alone. Similarly, if the difference between the sound pressure levels of two sources is more than 10 dB, the contribution of the quietest source can be disregarded (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.5.4 Environmental Noise Propagation

Many factors affect the propagation of noise from source to receiver. The most important of these are:

- The type of source and its sound power (L_W);
- The distance between the source and the receiver;
- Atmospheric conditions (wind speed and direction, temperature and temperature gradient, humidity etc.);
- Obstacles such as barriers or buildings between the source and receiver;
- Ground absorption; and
- Reflections.

To arrive at a representative result from either measurement or calculation, all these factors must be taken into account (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

1.5.5 Environmental Noise Indices

In assessing environmental noise either by measurement or calculation, reference is generally made to the following indices:

- **L_{Aeq} (T)** – The A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured). The International Finance Corporation (IFC) provides guidance with respect to L_{Aeq} (1 hour), the A-weighted equivalent sound pressure level, averaged over 1 hour.
- **L_{AIeq} (T)** – The impulse corrected A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured). In the South African Bureau of Standards' (SABS) South African National Standard (SANS) 10103 of 2008 for 'The measurement and rating of environmental noise with respect to annoyance and to speech communication' prescribes the sampling of L_{AIeq} (T).
- **$L_{Req,d}$** – The L_{Aeq} rated for impulsive sound (**L_{AIeq}**) and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.
- **$L_{Req,n}$** – The L_{Aeq} rated for impulsive sound (**L_{AIeq}**) and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.
- **$L_{R,dn}$** – The L_{Aeq} rated for impulsive sound (L_{AIeq}) and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10 dB in order to account for the additional disturbance caused by noise during the night.
- **L_{A90}** – The A-weighted 90% statistical noise level, i.e. the noise level that is exceeded during 90% of the measurement period. It is a very useful descriptor which provides an indication of what the L_{Aeq} could have been in the absence of noisy single events and is considered representative of background noise levels.
- **L_{AFmax}** – The maximum A-weighted noise level measured with the fast time weighting. It's the highest level of noise that occurred during a sampling period.

1.6 Approach and Methodology

The assessment included a study of the legal requirements pertaining to environmental noise impacts, a study of the physical environment of the area surrounding the project and the analyses of existing noise levels in the area. The impact assessment focused on the estimation of sound power levels (L_W's) (noise 'emissions') and sound pressure levels (L_P's) (noise impacts) associated with the operational phase. The findings of the assessment components informed recommendations of management measures, including mitigation and monitoring. Individual aspects of the noise impact assessment methodology are discussed in more detail below.

1.6.1 Information Review

An information requirements list was submitted to SLR Consulting at the onset of the project. In response to the request, the following information was supplied:

- Project and site layout maps; and
- A basic process description.

1.6.2 Review of Assessment Criteria

In South Africa, provision is made for the regulation of noise under the National Environmental Management Air Quality Act (NEMAQA) (Act. 39 of 2004) but environmental noise limits have yet to be set. It is believed that when published, national criteria will make extensive reference to SANS 10103 of 2008 '*The measurement and rating of environmental noise with respect to annoyance and to speech communication*'. This standard has been widely applied in South Africa and is frequently used by local authorities when investigating noise complaints. These guidelines, which are in line with those published by the IFC in their *General EHS Guidelines* and World Health Organisation (WHO) *Guidelines for Community Noise*, were considered in the assessment.

1.6.3 Study of the Receiving Environment

NSRs generally include private residences, community buildings such as schools, hospitals and any publicly accessible areas outside an industrial facility's property. Homesteads and residential areas which were included in the assessment as NSRs were identified from available maps and satellite imagery and confirmed during the site visit conducted.

The ability of the environment to attenuate noise as it travels through the air was studied by considering local meteorology, land use and terrain. Atmospheric attenuation potential was described based on MM5 meteorological data for the period 2013 to 2015. Data from this time period is still considered relevant to the study as the meteorological conditions within the study area have not shown any significant historical changes.

Readily available terrain data was obtained from the United States Geological Survey (USGS) web site (https://earthexplorer.usgs.gov/). A study was made of Shuttle Radar Topography Mission (STRM) 1 arc-sec data.

1.6.4 Noise Survey

The extent of noise impacts as a result of an intruding noise depends largely on existing noise levels in an area. Higher ambient noise levels will result in less noticeable noise impacts and a smaller impact area. The opposite also holds true. Increases in noise will be more noticeable in areas with low ambient noise levels. The data from a baseline noise surveys conducted on 13 and 14 October 2015 was studied to determine current noise levels within the area. The mine and plant as well as the community-based aggregate and brick-making projects were active at the mine at the time of the sampling.

The survey methodology, which closely followed guidance provided by the IFC (2007) and SANS 10103 (2008), is summarised below:

- The survey was designed and conducted by a trained specialist.
- Sampling was carried out using a Type 1 sound level meter (SLM) that meet all appropriate International Electrotechnical Commission (IEC) standards and is subject to calibration by an accredited laboratory. Equipment details are included in Table 1.
- The acoustic sensitivity of the SLM was tested with a portable acoustic calibrator before and after each sampling session.
- Samples, 20 minutes in duration, representative and sufficient for statistical analysis were taken with the use of the portable SLM capable of logging data continuously over the sampling time period. Samples representative of the day- and night-time acoustic environment were taken. SANS 10103 defines day-time as between 06:00 and 22:00 and night-time between 22:00 and 06:00 (SANS 10103, 2008).
- L_{Aleq} (T), L_{Aeq} (T); L_{AFmax}; L_{AFmin}; L_{90} and 3rd octave frequency spectra were recorded.
- The SLM was located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface.
- SANS 10103 states that one must ensure (as far as possible) that the measurements are not affected by the residual noise and extraneous influences, e.g. wind, electrical interference and any other non-acoustic interference, and that the instrument is operated under the conditions specified by the manufacturer.
- A detailed log and record were kept. Records included site details, weather conditions during sampling and observations made regarding the acoustic environment of each site.

Table 1: Sound level meter details

Equipment	Serial Number	Purpose
Brüel & Kjær Type 2250 Lite SLM	S/N 2731851	Attended 20-minute sampling.
Brüel & Kjær Type 4950 ½" Pre-polarized microphone	S/N 2709293	Attended 20-minute sampling.
SVANTEK SV33 Class 1 Acoustic Calibrator	S/N 57649	Testing of the acoustic sensitivity before and after each daily sampling session.
Kestrel 4000 Pocket Weather Tracker	S/N 559432	Determining wind speed, temperature and humidity during sampling.

SANS 10103 (2008) prescribes the method for the calculation of the equivalent continuous rating level ($L_{Req,T}$) from measurement data. $L_{Req,T}$ is the equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$) during a specified time interval, plus specified adjustments for tonal character, impulsiveness of the sound and the time of day; and derived from the applicable equation:

$$L_{Req,T} = L_{Aeq,T} + C_i + C_t + K_n$$

Where

- $L_{Req,T}$ is the equivalent continuous rating level;
- $L_{Aeq,T}$ is the equivalent continuous A-weighted sound pressure level, in decibels;
- C_i is the impulse correction;
- C_t is the correction for tonal character; and
- K_n is the adjustment for the time of day (or night), 0 dB for daytime and +10 dB for night-time.

Instrumentation used in this survey are capable of integrating while using the I-time (impulse) weighting and $L_{AIeq,T}$ directly measured. When using $L_{AIeq,T}$, only the tonal character correction and time of day adjustment need to be applied to derive $L_{Req,T}$. For this assessment, the $L_{Req,T}$ was conservatively assumed from the $L_{Aeq,T}$.

If audible tones such as whines, whistles, hums, and music, are present as determined by the procedure given hereafter (e.g. if the noise contains discernible pitch), then C_t = +5 dBA may be used. If audible tones are not present, then C_t = 0 should be used.

The presence of tones can be determined as follows (SANS 10103, 2008): Using a one-third octave band filter, which complies with the requirements of IEC 61260, the time average sound pressure level in the one-third octave band that contains the tone to be investigated as well as the time average one-third octave band sound pressure level in the adjacent bands to the one that contains the tone frequency should be measured. The difference between the time average sound pressure levels in the two adjacent one-third octave bands should be determined with the time average sound pressure level of the one-third octave band that contains the tone frequency. A level difference between the one-third octave band that contains the tone frequency and the two adjacent one-third octave bands should exceed the limits given in Table 2 to indicate the presence of a tonal component.

NOTE: the adjustment for tonality was not applied for this assessment.

Table 2: Level differences for the presence of a tonal component

Centre frequencies of 3rd octave bands (Hz)	Minimum 3rd octave band L_P difference (dB)
25 to 125	15
160 to 400	8
500 to 10 000	5

The equivalent continuous day/night rating level can be calculated using the following equation:

$$L_{R,dn} = \left[\left(\frac{d}{24}\right)10^{L_{Req,d}/10} + \left(\frac{24-d}{24}\right)10^{(L_{Req,n}+k_n)/10}\right]$$

Where

- $L_{R,dn}$ is the equivalent continuous day/night rating level;
- D is the duration of the day-time reference time period (06:00 to 22:00);
- $L_{Req,d}$ is the equivalent continuous rating level determined for the day-time reference time period (06:00 to 22:00);
- $L_{Req,n}$ is the equivalent continuous rating level determined for the night-time reference time period (22:00 to 06:00); and
- K_n is the adjustment 10 dB that should be added to the night-time equivalent continuous rating level.

1.6.5 Source Inventory

As detailed information on the equipment for the expansion was not available, source noise levels were calculated using default noise "emission factors" for heavy industrial, light industrial and commercial areas, developed by the European Commission's (EC) Working Group for the Assessment of Exposure to Noise (WG-AEN) for their *Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure* (EC WG-AEN, 2006). The EC recommends using these factors when information for a detailed source inventory is not available.

1.6.6 Noise Propagation Simulations

The propagation of noise from proposed activities was simulated with the DataKustic CadnaA software. Use was made of the International Organisation for Standardization's (ISO) 9613 module for outdoor noise propagation from industrial noise sources.

1.6.6.1 ISO 9613

ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favourable to propagation from sources of known sound emission. These conditions are for downwind propagation or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.

The method also predicts an average A-weighted sound pressure level. The average A-weighted sound pressure level encompasses levels for a wide variety of meteorological conditions. The method specified in ISO 9613 consists specifically of octave-band algorithms (with nominal midband frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound which originates from a point sound source, or an assembly of point sources. The source (or sources) may be moving or stationary. Specific terms are provided in the algorithms for the following physical effects; geometrical divergence, atmospheric absorption, ground surface effects, reflection and obstacles. A basic representation of the model is given in the equation below:

$$L_P = L_W - \sum [K_1, K_2, K_3, K_4, K_5, K_6]$$

Where;

L_P is the sound pressure level at the receiver;
L_W is the sound power level of the source;
K_1 is the correction for geometrical divergence;
K_2 is the correction for atmospheric absorption;
K_3 is the correction for the effect of ground surface;
K_4 is the correction for reflection from surfaces; and
K_5 is the correction for screening by obstacles.

This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, industrial noise sources, construction activities, and many other ground-based noise sources.

To apply the method of ISO 9613, several parameters need to be known with respect to the geometry of the source and of the environment, the ground surface characteristics, and the source strength in terms of octave-band sound power levels for directions relevant to the propagation.

1.6.6.2 Simulation Domain

If the dimensions of a noise source are small compared with the distance to the listener, it is called a point source. All sources were quantified as point sources or areas/lines represented by point sources. The sound energy from a point source spreads out spherically, so that the sound pressure level is the same for all points at the same distance from the source and decreases by 6 dB per doubling of distance. This holds true until ground and air attenuation noticeably affect the level. The impact of an intruding industrial noise on the environment will therefore rarely extend over more than 5 km from the source and is therefore always considered “local” in extent.

The propagation of noise was calculated over an area of 11.3 km east-west by 11.1 km north-south. The area was divided into a grid matrix with a 20 m resolution. NSRs and survey locations were included as discrete receptors. The model was set to calculate L_P’s at each grid and discrete receptor point at a height of 1.5 m above ground level.

1.6.7 Presentation of Results

Noise impacts were calculated in terms of:

- The day-time noise level (L_{Aeq});
- The night-time noise level (L_{Aeq}); and
- The equivalent day/night noise level (L_{Aeq}).

Results are presented in table form at the NSRs within the modelling domain. Simulated noise levels were assessed according to guidelines published in SANS 10103 and by the IFC. To assess annoyance at nearby places of residence, the increase in noise levels above the baseline at NSRs were calculated and compared to guidelines published in SANS 10103.

1.6.8 Recommendations of Management and Mitigation

The findings of the noise specialist study informed the recommendation of suitable noise management and mitigation measures.

1.6.9 Impact Significance Assessment

The significance of environmental noise impacts was assessed according to the methodology adopted by SLR Consulting and considered both an unmitigated and mitigated scenario.

1.7 Limitations and Assumptions

The following limitations and assumptions should be noted:

- Estimates of sound power levels were limited to default noise "emission factors" for heavy industrial, light industrial and commercial areas, developed by the European Commission's (EC) Working Group for the Assessment of Exposure to Noise (WG-AEN) for their *Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure* (EC WG-AEN, 2006). These default noise levels were used in the absence of detailed source inventory.
- All activities were assumed to be 24 hours per day, 7 days per week.
- Although other existing sources of noise within the area were identified (such as existing mining activities, community noise form residential areas, etc.), such sources were not quantified but were taken into account during the survey.

2 Legal Requirements and Noise Level Guidelines

2.1 South African National Standards

SANS 10103 (2008) successfully addresses the manner in which environmental noise measurements are to be taken and assessed in South Africa, and is fully aligned with the WHO guidelines for Community Noise (WHO, 1999). It should be noted that the values given in Table 3 are typical rating levels that it is recommended should not be exceeded outdoors in the different districts specified. Outdoor ambient noise exceeding these levels will be annoying to the community.

Table 3: Typical rating levels for outdoor noise

Type of district	Equivalent Continuous Rating Level ($L_{Req,T}$) for Outdoor Noise		
	Day/night $L_{R,dn}$[(c)] (dBA)	Day-time $L_{Req,d}$[(a)] (dBA)	Night-time $L_{Req,n}$[(b)] (dBA)
Rural districts	45	45	35
Suburban districts with little road traffic	50	50	40
Urban districts	55	55	45
Urban districts with one or more of the following; business premises; and main roads.	60	60	50
Central business districts	65	65	55
Industrial districts	70	70	60

Notes

(a) $L_{Req,d}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the day-time period, i.e. from 06:00 to 22:00.

(b) $L_{Req,n}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the night-time period, i.e. from 22:00 to 06:00.

(c) $L_{R,dn}$ =The L_{Aeq} rated for impulsive sound and tonality in accordance with SANS 10103 for the period of a day and night, i.e. 24 hours, and wherein the $L_{Req,n}$ has been weighted with 10dB in order to account for the additional disturbance caused by noise during the night.

SANS 10103 also provides a useful guideline for estimating community response to an increase in the general ambient noise level caused by intruding noise. If Δ is the increase in noise level, the following criteria are of relevance:

- "$\Delta \leq 0$ dB: There will be no community reaction;
- 0 dB < $\Delta \leq 10$ dB: There will be 'little' reaction with 'sporadic complaints';
- 5 dB < $\Delta \leq 15$ dB: There will be a 'medium' reaction with 'widespread complaints'. $\Delta = 10$ dB is subjectively perceived as a doubling in the loudness of the noise;
- 10 dB < $\Delta \leq 20$ dB: There will be a 'strong' reaction with 'threats of community action'; and
- 15 dB < Δ: There will be a 'very strong' reaction with 'vigorous community action'.

The categories of community response overlap because the response of a community does not occur as a stepwise function, but rather as a gradual change.

2.2 International Finance Corporation Guidelines on Environmental Noise

The IFC General Environmental Health and Safety Guidelines on noise address impacts of noise beyond the property boundary of the facility under consideration and provides noise level guidelines.

The IFC states that noise impacts **should not exceed the levels presented in Table 4**, or result in a maximum **increase above background levels of 3 dBA** at the nearest receptor location off-site (IFC, 2007). For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. Δ = 3 dBA is, therefore, a useful significance indicator for a noise impact.

It is further important to note that the IFC noise level guidelines for residential, institutional and educational receptors correspond with the SANS 10103 guidelines for urban districts.

Table 4: IFC noise level guidelines

Area	One Hour L_{Aeq} (dBA) 07:00 to 22:00	One Hour L_{Aeq} (dBA) 22:00 to 07:00
Industrial receptors	70	70
Residential, institutional and educational receptors	55	45

2.3 Criteria Applied in This Assessment

Reference is made to the IFC noise level guidelines for residential receptors (which is in line with the SANS 10103 rating for urban districts) and the increase in noise levels of 3 dBA above background levels.

3 Description of the Receiving Environment

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

- Local NSRs;
- The local environmental noise propagation and attenuation potential; and
- Current noise levels and the existing acoustic climate.

3.1 Noise Sensitive Receptors

NSRs generally include places of residence and areas where members of the public may be affected by noise generated by the project activities. There are several potentially sensitive receptors within the project area, the closest of which lie adjacent to the project boundary. All identified potential NSRs within the study area are shown in Figure 4.

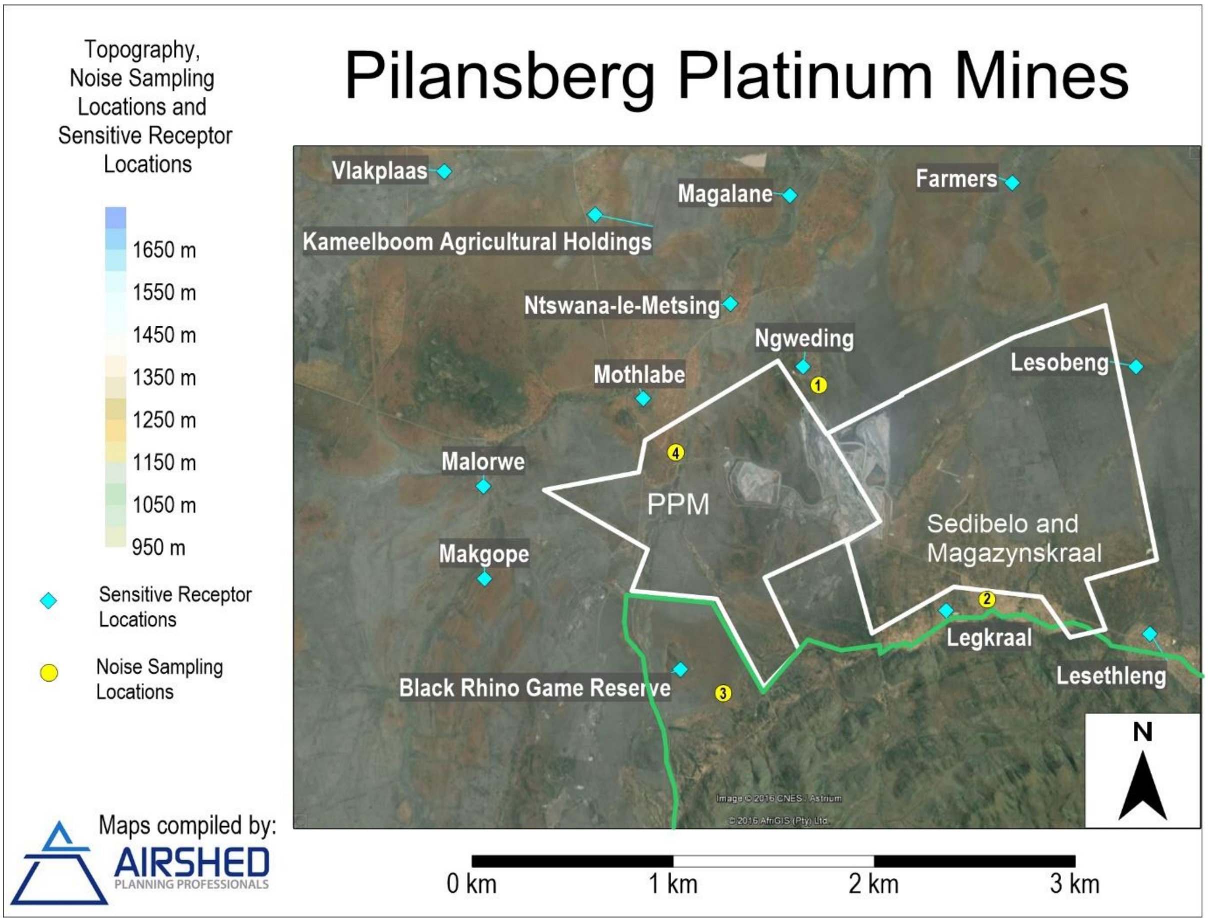


Figure 4: Study area, project location, and the location of NSRs

3.2 Environmental Noise Propagation and Attenuation potential

3.2.1 Atmospheric Absorption and Meteorology

Atmospheric absorption and meteorological conditions have already been mentioned with regards to their role in the propagation on noise from a source to receiver (Section 1.5.4). The main meteorological parameters affecting the propagation of noise include wind speed, wind direction and temperature. These along with other parameters such as relative humidity, air pressure, solar radiation and cloud cover affect the stability of the atmosphere and the ability of the atmosphere to absorb sound energy. Use is made of MM5 data recorded for the period 2013 to 2015.

Wind speed increases with altitude. This results in the 'bending' of the path of sound to 'focus' it on the downwind side and creating a 'shadow' on the upwind side of the source. Depending on the wind speed, the downwind level may increase by a few dB but the upwind level can drop by more than 20 dB (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). It should be noted that at wind speeds of more than 5 m/s, ambient noise levels are mostly dominated by wind generated noise.

The MM5 diurnal wind field is presented in Figure 5. Wind roses represent wind frequencies for 12 cardinal wind directions. Frequencies are indicated by the length of the shaft when compared to the circles drawn to represent a frequency of occurrence. Wind speed classes are assigned to illustrate the frequencies with high and low winds occurring for each wind vector. The frequencies of calms, defined as periods for which wind speeds are below 1 m/s, are also indicated.

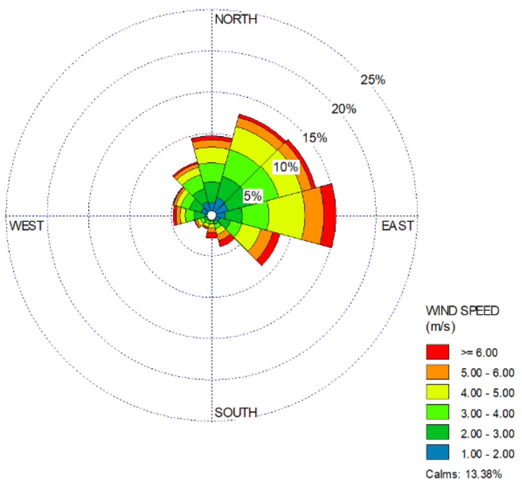
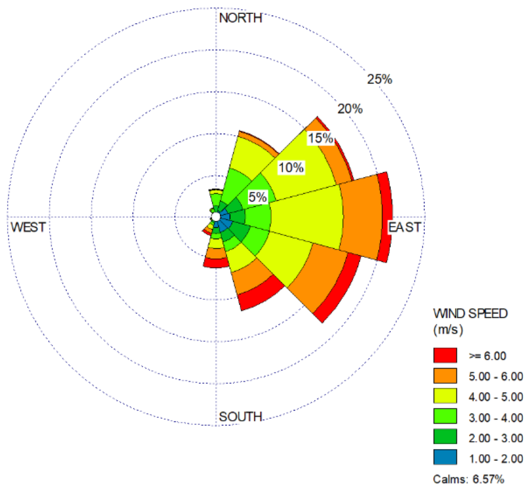
Day-time wind field (06:00 to 22:00)	**Night-time wind field (22:00 to 06:00)**
	

Figure 5: Day- and night-time wind field (2013 to 2015)

On average, noise impacts are expected to be more notable to the south-south-east and south during the day and night respectively.

Temperature gradients in the atmosphere create effects that are uniform in all directions from a source. On a sunny day with no wind, temperature decreases with altitude and creates a 'shadowing' effect for sounds. On a clear night, temperatures may increase with altitude thereby 'focusing' sound on the ground surface. Noise impacts are therefore generally more notable during the night. CadnaA allows the input of the average temperature and relative humidity. Use was made of 19°C and 60% in simulations, as obtained from the MM5 data set.

3.2.2 Terrain, Ground Absorption and Reflection

Noise reduction caused by a barrier (i.e. natural terrain, installed acoustic barrier, building) feature depends on two factors namely the path difference of a sound wave as it travels over the barrier compared with direct transmission to the receiver and the frequency content of the noise (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Terrain data was included in the simulations.

Sound reflected by the ground interferes with the directly propagated sound. The effect of the ground is different for acoustically hard (e.g., concrete or water), soft (e.g., grass, trees or vegetation) and mixed surfaces. Ground attenuation is often calculated in frequency bands to take into account the frequency content of the noise source and the type of ground between the source and the receiver (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Based on observations made during the visit to site, ground cover was found to be acoustically mixed, that is, somewhat conducive to noise attenuation.

3.3 Baseline Noise Survey and Results

Day- and night-time noise measurements were conducted on 13 and 14 October 2015 at four locations shown in Figure 4. No change to existing operations, to the specialist's knowledge, has taken place from the time of the survey to present. The baseline survey results should thus be representative of current levels. The Survey sites were selected taking into consideration proposed activities, NSRs, accessibility and safety. Fieldwork log sheets of the sampling sites and microphone placement are included in Appendix B.

It should be noted that the noise survey would capture all current noise sources in the area including the mining activities of RMDC and community activities.

Recorded L_{A90}, L_{Aeq} and L_{AIeq} during the day and night are presented in Figure 6 and Figure 7 respectively.

During the day, the acoustic environment at all sites were influenced by birds and insects, some livestock (viz. goats), and local community. During the night mining activities (specifically heavy mining vehicles) were audible at Site 1 and Site 3.

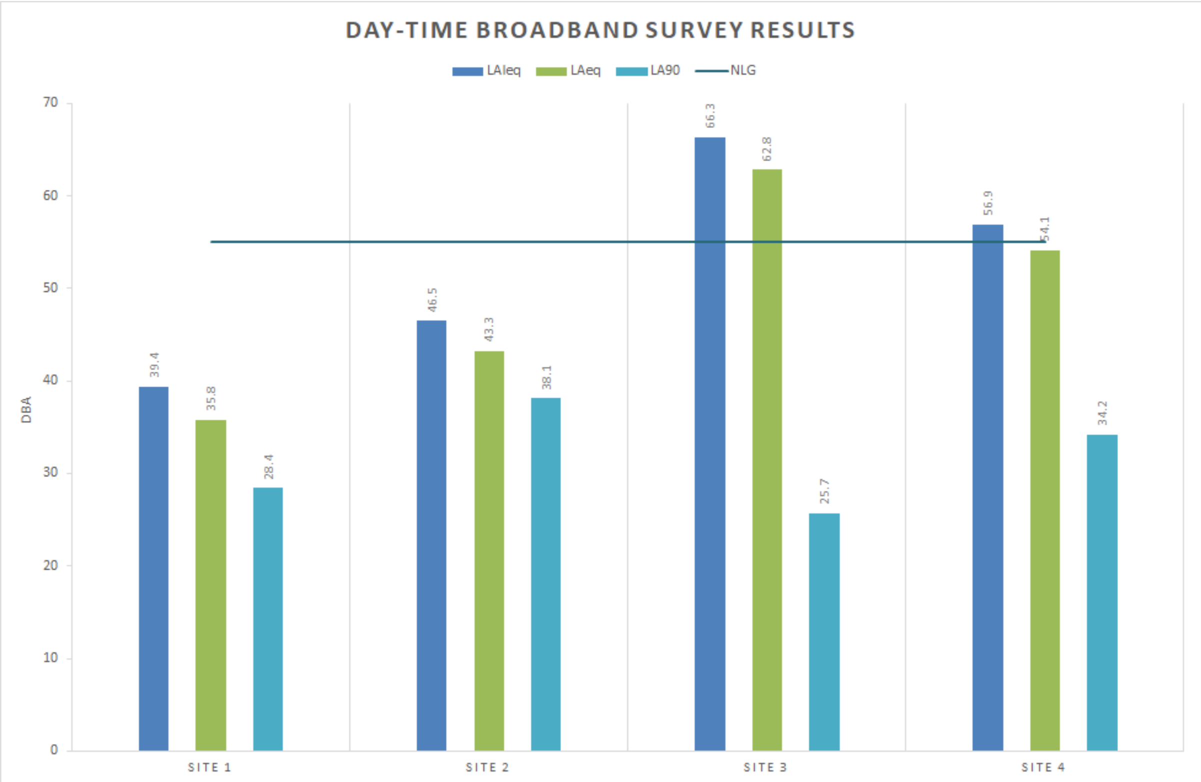


Figure 6: Day-time survey broadband results

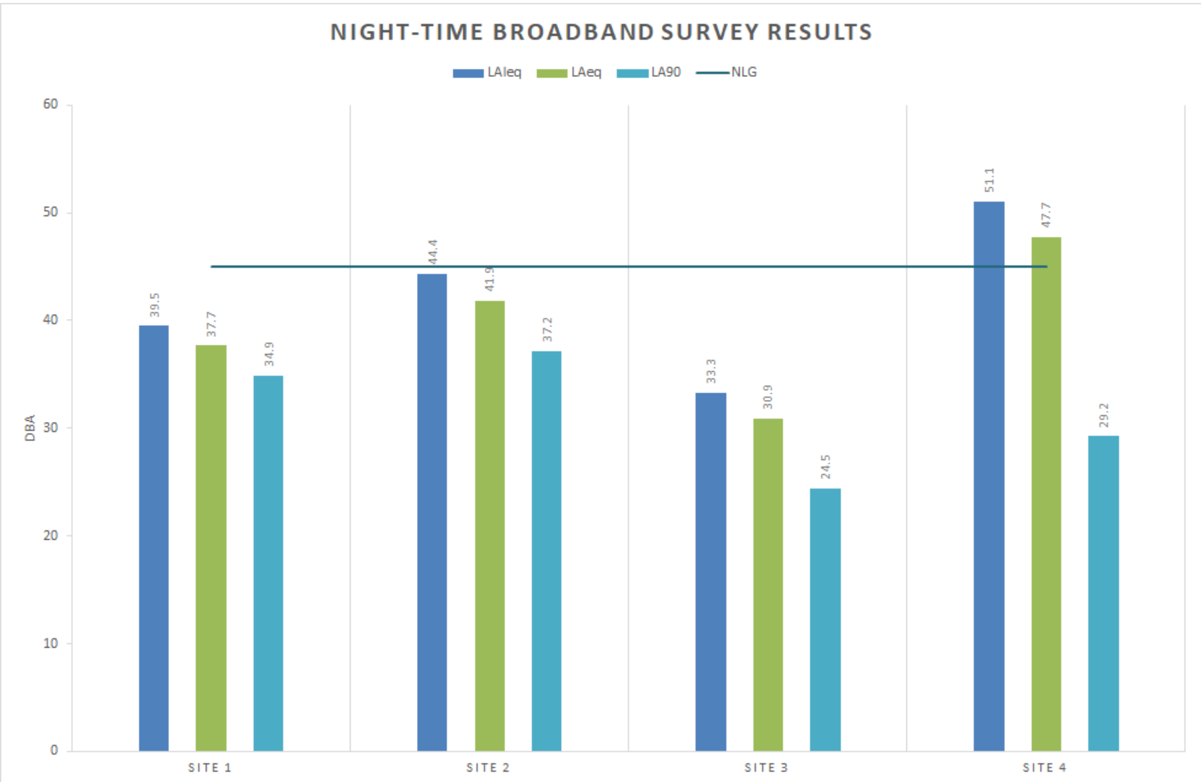


Figure 7: Night-time survey broadband results

4 Impact Assessment

The noise source inventory, noise propagation modelling and results are discussed in Section 4.1 and Section 4.2 respectively.

4.1 Noise Sources and Sound Power Levels

The complete source inventory for the project is included in Table 5. Octave band frequency spectra L_W's are included in Table 6.

The reader is reminded of the non-linearity in the addition of L_W's. If the difference between the sound power levels of two sources is nil the combined sound power level is 3 dB more than the sound pressure level of one source alone. Similarly, if the difference between the sound power levels of two sources is more than 10 dB, the contribution of the quietest source can be disregarded (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

Table 5: Noise source inventory for the project

Source Name	Source type	Equipment ID	Operating time, day and night-time hours		L_W (dB)
UG2 milling and flotation circuit	Area	HEAVYINDUSTRY	16	8	65
Hydrometallurgical plant	Area	HEAVYINDUSTRY	16	8	65
Support and services infrastructure	Area	LIGHTINDUSTRY	16	8	60
Aggregate crusher and brick making project	Area	HEAVYINDUSTRY	16	8	65
Composting area, nursery, vegetable garden and car wash	Area	LIGHTINDUSTRY	16	8	60

Table 6: Octave band frequency spectra L_W's

Equipment ID	Equipment details	Type	L_W octave band frequency spectra (dB)								L_W (dB)	L_{WA} (dBA)	Source
			63	125	250	500	1000	2000	4000	8000			
LIGHTINDUSTRY	Default for Light Industry	L_W	26.8	36.9	44.4	49.8	53	54.2	54	51.9	60	62.5	EC WG-AEN (2006)
HEAVYINDUSTRY	Default for Heavy Industry	L_W	31.8	41.9	49.4	54.8	58	59.2	59	56.9	65	67.5	EC WG-AEN (2006)

4.2 Noise Propagation and Simulated Noise Levels

The propagation of noise generated during the operational phase was calculated with CadnaA in accordance with ISO 9613. Meteorological and site specific acoustic parameters as discussed in Section 3.2 along with source data discussed in 4.1, were applied in the model.

Table 7 provides a summary of simulated noise levels at NSRs. The simulated equivalent continuous day-time rating level ($L_{Req,d}$) due to project operations of 55 dBA (guideline level) and equivalent continuous night-time rating level ($L_{Req,n}$) of 45 dBA (guideline level) is at the source. For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. According to SANS 10103 (2008); no reaction expected from the community for increased noise levels up to 1 dBA. With the approach adopted for the assessment (detailed in Section 1.6), the predicted increase in noise levels are expected to result in no reaction from the surrounding NSRs.

Table 7: Summary of simulated noise levels (provided as dBA) due to the project and baseline noise measurements at NSR within the study area

Noise Sensitive Receptor	Baseline Noise Measurements		Increase in Noise Levels Above Baseline (due to Project Activities) (g)	
	Day	Night	Day	Night
Ngweding (a)	35.8	37.7	0	0
Legkraal (a)	43.3	41.9	0	0
Black Rhino Game Reserve (b)	62.8 (e)	30.9	0	0
Mothlabe (a)	54.1	47.7 (d)	0	0

Notes:

(a) Residential/ educational NSR

(b) Ecological NSR

(c) Exceeds day-time IFC guideline of 55 dBA for residences

(d) Exceeds night-time IFC guideline of 45 dBA for residences

(e) Exceeds day-time SANS 10103 levels of 45 dBA for rural districts

(f) Exceeds night-time SANS 10103 levels of 35 dBA for rural districts

(g) Likely community response:

0 to 1 dBA – No reaction, increase not detectable

1 to 3 dBA – Increase just detectable to persons with average hearing acuity, annoyance unlikely.

3 to 5 dBA – There will be 'little' reaction with 'sporadic complaints'.

5 to 10 dBA – There will be 'little' to 'medium' reaction with 'sporadic' to 'widespread' complaints.

10 to 15 dBA – There will be a 'strong' reaction with 'threats of community action'.

> 15 dBA – There will be a 'very strong' reaction with 'vigorous community action'.

5 Management Measures

In the quantification of noise emissions and simulation of noise levels as a result of the proposed project, it was calculated that ambient noise evaluation criteria for human receptors will not be exceeded at NSRs. No reaction can be expected from members of the community within this impact area. However, even with the best mitigation, it is possible that people may hear the mining operation at night. Reverse alarms and other impulsive sounds do have a nuisance effect and people may complain.

From a noise perspective, the project may proceed. It is recommended, however, that mitigation measures be implemented to ensure minimal impacts on the surrounding environment.

For general activities, the following good engineering practice **should** be applied to **all project phases**:

- All diesel-powered equipment and plant vehicles should be kept at a high level of maintenance. This should particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment should serve as trigger for withdrawing it for maintenance.
- Equipment with lower sound power levels must be selected. Vendors should be required to guarantee optimised equipment design noise levels.
- In managing noise specifically related to truck and vehicle traffic, efforts **should** be directed at:
  - Minimising individual vehicle engine, transmission, and body noise/vibration. This is achieved through the implementation of an equipment maintenance program.
  - Maintain road surface regularly to avoid corrugations, potholes etc.
  - Avoid unnecessary idling times.
  - Minimising the need for trucks/equipment to reverse. This will reduce the frequency at which disturbing but necessary reverse warnings will occur. Alternatives to the traditional reverse ‘beeper’ alarm such as a ‘self-adjusting’ or ‘smart’ alarm could be considered. These alarms include a mechanism to detect the local noise level and automatically adjust the output of the alarm is so that it is 5 to 10 dB above the noise level near the moving equipment. The promotional material for some smart alarms does state that the ability to adjust the level of the alarm is of advantage to those sites ‘with low ambient noise level’ (Burgess & McCarty, 2009).
  - Limiting traffic to hours to between 06:00 and 18:00.
- Where possible, other non-routine noisy activities such as construction, decommissioning, start-up and maintenance, should be limited to day-time hours.
- A **noise complaints register must be kept**.

6 Impact Significance Rating

The significance of environmental noise impacts was assessed according to the methodology adopted by SLR Consulting. The noise impact significance for all phases on nearby NSRs is considered ***low*** (Table 8). No noise impacts are expected post-closure. It must be noted that reverse alarms is exempt from an acoustical assessment due to Government Notice R154 of 1992 (Noise Control Regulations) – Clause 7.(1) – "the emission of sound is for the purposes of warning people of a dangerous situation".

Table 8: Significance rating for all phases due to unmitigated operations

Activity	Impact	Nature (Negative or Positive Impact)	Probability	Duration	Scale	Magnitude/ Severity	Significance
Construction and Closure Phases - UG2 Milling and Flotation Circuit, and Kell Plant							
Movement of vehicles on site, earthworks, demolition of buildings	Noise Impact	Negative	Possible	Short term	Localised	Low	Low
Operational Phase – UG2 Milling and Flotation Circuit and Kell plant							
Stationary and mobile equipment	Noise Impact	Negative	Seldom/ Unlikely	Medium term	Localised	Low	Low

7 Conclusion

Based on the findings of the assessment, it is the specialist opinion that the project may be authorised.

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Appendix A – Specialist Curriculum Vitae

CURRICULUM VITAE	RENÉ VON GRUENEWALDT

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	René von Gruenewaldt (*nee* Thomas)
Profession	Air Quality Scientist
Date of Birth	13 May 1978
Years with Firm	More than 15 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Registered Professional Natural Scientist (Registration Number 400304/07) with the South African Council for Natural Scientific Professions (SACNASP)
- Member of the National Association for Clean Air (NACA)

KEY QUALIFICATIONS

René von Gruenewaldt (Air Quality Scientist): René joined Airshed Planning Professionals (Pty) Ltd (previously known as Environmental Management Services cc) in 2002. She has, as a Specialist, attained over fifteen (15) years of experience in the Earth and Natural Sciences sector in the field of Air Quality and three (3) years of experience in the field of noise assessments. As an environmental practitioner, she has provided solutions to both large-scale and smaller projects within the mining, minerals, and process industries.

She has developed technical and specialist skills in various modelling packages including the AMS/EPA Regulatory Models (AERMOD and AERMET), UK Gaussian plume model (ADMS), EPA Regulatory puff based model (CALPUFF and CALMET), puff based HAWK model and line based models. Her experience with emission models includes Tanks 4.0 (for the quantification of tank emissions), WATER9 (for the quantification of waste water treatment works) and GasSim (for the quantification of landfill emissions). Noise propagation modelling proficiency includes CONCAWE, South African National Standards (SANS 10210) for calculating and predicting road traffic noise.

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

RELEVANT EXPERIENCE

Mining and Ore Handling

René has undertaken numerous air quality impact assessments and management plans for coal, platinum, uranium, copper, cobalt, chromium, fluorspar, bauxite, manganese and mineral sands mines. These include: compilation of emissions databases for Landau and New Vaal coal collieries (SA), impact assessments and management plans for numerous mines over Mpumalanga (viz. Schoonoord, Belfast, Goedgevonden, Mbila, Evander South, Driefontein, Hartogshoop, Belfast, New Largo, Geluk, etc.), Mmamabula Coal Colliery (Botswana), Moatize Coal Colliery (Mozambique), Revuboe Coal Colliery (Mozambique), Toliera Sands Heavy Minerals Mine and Processing (Madagascar), Corridor Sands Heavy Minerals Mine monitoring assessment, El Burullus Heavy Minerals Mine and processing (Egypt), Namakwa Sands Heavy Minerals Mine (SA), Tenke Copper Mine and Processing Plant (DRC), Rössing Uranium (Namibia), Lonmin platinum mines including operations at Marikana, Baobab, Dwaalkop and Doornvlei (SA), Impala Platinum (SA), Pilannesburg Platinum (SA), Aquarius Platinum, Hoogland Platinum Mine (SA), Tamboti PGM Mine (SA), Sari Gunay Gold Mine (Iran), chrome mines in the Steelpoort Valley (SA), Mecklenburg Chrome Mine (SA), Naboom Chrome Mine (SA), Kinsenda Copper Mine (DRC), Kassinga Mine (Angola) and Nokeng Flourspar Mine (SA), etc.

Mining monitoring reviews have also been undertaken for Optimum Colliery's operations near Hendrina Power Station and Impunzi Coal Colliery with a detailed management plan undertaken for Morupule (Botswana) and Glencor (previously known as Xstrata Coal South Africa).

Air quality assessments have also been undertaken for mechanical appliances including the Durban Coal Terminal and Nacala Port (Mozambique) as well as rail transport assessments including BHP-Billiton Bauxite transport (Suriname), Nacala Rail Corridor (Mozambique and Malawi), Kusile Rail (SA) and WCL Rail (Liberia).

Metal Recovery

Air quality impact assessments have been carried out for Highveld Steel, Scaw Metals, Lonmin's Marikana Smelter operations, Saldanha Steel, Tata Steel, Afro Asia Steel and Exxaro's Manganese Pilot Plant Smelter (Pretoria).

Chemical Industry

Comprehensive air quality impact assessments have been completed for NCP (including Chloorkop Expansion Project, Contaminated soils recovery, C3 Project and the 200T Receiver Project), Revertex Chemicals (Durban), Stoppani Chromium Chemicals, Foskor (Richards Bay), Straits Chemicals (Coega), Tenke Acid Plant (DRC), and Omnia (Sasolburg).

Petrochemical Industry

Numerous air quality impact assessments have been completed for Sasol (including the postponement/exemption application for Synfuels, Infrachem, Natref, MIBK2 Project, Wax Project, GTL Project, re-commissioning of boilers at Sasol Sasolburg and Ekandustria), Engen Emission Inventory Functional Specification (Durban), Sapref refinery (Durban), Sasol (at Elrode) and Island View (in Durban) tanks quantification, Petro SA and Chevron (including the postponement/exemption application).

Pulp and Paper Industry

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

Power Generation

Air quality impact assessments have been completed for numerous Eskom coal fired power station studies including the ash expansion projects at Kusile, Kendal, Hendrina, Kriel and Arnot; Fabric Filter Plants at Komati, Grootvlei, Tutuka, Lethabo and Kriel Power Stations; the proposed Kusile, Medupi (including the impact assessment for the Flue Gas Desulphurization) and Vaal South Power Stations. René was also involved and the cumulative assessment of the existing and return to service Eskom power stations assessment and the optimization of Eskom's ambient air quality monitoring network over the Highveld.

In addition to Eskom's coal fired power stations, various Eskom nuclear power supply projects have been completed including the air quality assessment of Pebble Bed Modular Reactor and nuclear plants at Duynefontein, Bantamsklip and Thyspunt.

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

Waste Disposal

Air quality impact assessments, including odour and carcinogenic and non-carcinogenic pollutants were undertaken for the Waste Water Treatment Works in Magaliesburg, proposed Waterval Landfill (near Rustenburg), Tutuka Landfill, Mogale General Waste Landfill (adjacent to the Leipardsvlei Landfill), Cape Winelands District Municipality Landfill and the Tsoeneng Landfill (Lesotho). Air quality impact assessments have also been completed for the BCL incinerator (Cape Town), the Ergo Rubber Incinerator and the Ecorevert Pyrolysis Plant.

Cement Manufacturing

Impact assessments for ambient air quality have been completed for the Holcim Alternative Fuels Project (which included the assessment of the cement manufacturing plants at Ulco and Dudfield as well as a proposed blending platform in Roodepoort).

Management Plans

René undertook the quantification of the baseline air quality for the first declared Vaal Triangle Airshed Priority Area. This included the establishment of a comprehensive air pollution emissions inventory, atmospheric dispersion modelling, focusing on impact area "hotspots" and quantifying emission reduction strategies. The management plan was published in 2009 (Government Gazette 32263).

René has also been involved in the Provincial Air Quality Management Plan for the Limpopo Province.

Other Experience (2001)

Research for B.Sc Honours degree was part of the "Highveld Boundary Layer Wind" research group and was based on the identification of faulty data from the Majuba Sodar. The project was THRIP funded and was a joint venture with the University of Pretoria, Eskom and Sasol (2001).

EDUCATION

M.Sc Earth Sciences	University of Pretoria, RSA, Cum Laude (2009) Title: *An Air Quality Baseline Assessment for the Vaal Airshed in South Africa*
B.Sc Hons. Earth Sciences	University of Pretoria, RSA, Cum Laude (2001) Environmental Management and Impact Assessments
B.Sc Earth Sciences	University of Pretoria, RSA, (2000) Atmospheric Sciences: Meteorology

ADDITIONAL COURSES

CALMET/CALPUFF	Presented by the University of Johannesburg, RSA (March 2008)
Air Quality Management	Presented by the University of Johannesburg, RSA (March 2006)
ARCINFO	GIMS, Course: Introduction to ARCINFO 7 (2001)

COUNTRIES OF WORK EXPERIENCE

South Africa, Mozambique, Malawi, Liberia, Kenya, Angola, Democratic Republic of Congo, Lesotho, Namibia, Madagascar, Egypt, Suriname and Iran.

EMPLOYMENT RECORD

January 2002 - Present

Airshed Planning Professionals (Pty) Ltd, (previously known as Environmental Management Services cc until March 2003), Principal Air Quality Scientist, Midrand, South Africa.

2001

University of Pretoria, Demi for the Geography and Geoinformatics department and a research assistant for the Atmospheric Science department, Pretoria, South Africa.

Department of Environmental Affairs and Tourism, assisted in the editing of the Agenda 21 document for the world summit (July 2001), Pretoria, South Africa.

1999 - 2000

The South African Weather Services, vacation work in the research department, Pretoria, South Africa.

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Understanding the Synoptic Systems that lead to Strong Easterly Wind Conditions and High Particulate Matter Concentrations on The West Coast of Namibia, H Liebenberg-Enslin, R von Gruenewaldt, H Rauntenbach and L Burger. National Association for Clean Air (NACA) conference, October 2017.
- Topographical Effects on Predicted Ground Level Concentrations using AERMOD, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2011.
- Emission Factor Performance Assessment for Blasting Operations, R.G. von Gruenewaldt. National Association for Clean Air (NACA) conference, October 2009.
- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007.
- A High-Resolution Diagnostic Wind Field Model for Mesoscale Air Pollution Forecasting, R.G. Thomas, L.W. Burger, and H Rautenbach. National Association for Clean Air (NACA) conference, September 2005.
- Emissions Based Management Tool for Mining Operations, R.G. Thomas and L.W. Burger. National Association for Clean Air (NACA) conference, October 2004.
- An Investigation into the Accuracy of the Majuba Sodar Mixing Layer Heights, R.G. Thomas. Highveld Boundary Layer Wind Conference, November 2002.

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Fair	Good	Good

CERTIFICATION

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

____________________	22/11/2017
Signature of staff member	Date (Day / Month / Year)

Full name of staff member: René Georgeinna von Gruenewaldt

Appendix B – Fieldwork Log Sheets

Noise Survey Sheet					
Project Number		**Project Name**	PPM 1		
Day	M T W T F S S			**Date**	**Site Number:** 1 (day)
Site Describtion	Dusty area				
	Birds and insects				
	Music from Residential area is audible				
GPS	**S**		**E0**		
Altitude	**m**				
Start Time	**h**	**End Time**	**h**	**Duration**	**Min**
Temperature	31.9 °C	**Cloud Cover**	None	**Humidity**	28.10%
Wind Speed	3.5 m/s	**Wind Direction**	North West	**Bar Pressure**	893. 6Kpa
Vehicles Passing	**Cars**	**Total**	**Heavy**	**Total**	**Total Vehicles**
			2	2	2
Notes:			**Saved as:** 151013 007		
Birds 11:07:07; 11:23:56-11:24:09					
People Talking -11:13:03; 11:16:54; 11:17:54					
Gust of wind-11:13:29; 11:14:24; 11:18:44; 11:18:8-11:19:42; 11:20:45; 11:22:06; 11:23:24; 11:25:06					
Dog barking-11:15:56					
Music-11:21:40					
Chickens-11:16:37					
Trucks-11:17:40; 11:18:48					
Start Time	**h**	**End Time**	**h**	**Duration**	**Min**
Temperature	28.4°C	**Cloud Cover**	None	**Humidity**	27.90%
Wind Speed	3.5 m/s	**Wind Direction**	West	**Bar Pressure**	893.3Kpa
Vehicles Passing	**Cars**	**Total**	**Heavy**	**Total**	**Total Vehicles**
Notes:			**Saved as:** 151013008		
Goat-22:38:34					
Noise from mine-22:39:09					
Winds: 22:43:10-22:43:27; 22:44:36; 22:51:18-22:52:33; 22:53:36-22:53:58					
Mine vehicle loading-22:45:55-22:46:20; 22:56:40-22:56:56;					

Figure 8: Log sheet for Site 1

Noise Survey Sheet					
Project Number		**Project Name**	PPM 2		
Day	M T W	T F S	S	**Date**	**Site Number:** 2 (Day)
Site Description	Crickets, birds and goats				
	Windy conditions				
GPS	**S**		**E0**		
Altitude	**m**				
Start Time	**h**	**End Time**	**h**	**Duration**	**20 Min**
Temperature	34.1 °C	**Cloud Cover**	None	**Humidity**	19.30%
Wind Speed	1.2 m/s	**Wind Direction**	North East	**Bar Pressure**	889.8 Kpa
Vehicles Passing	**Cars**	**Total**	**Heavy**	**Total**	**Total Vehicles**
	8	8	2	2	10
Notes:			**Saved as:** 151013 007		
Cars passing-12:06:51; 12:07:09; 12:08:10					
Birds-12:09:35-12:09:51; 12:10:22-12:11:41; 12:15:43;					
Chicken-12:10:50; 12:14:48; 12:22:40					
Goats-12:13:57; 12:22:20; 12:22:40					
Heavy vehicle-12:17:39-12:17:56; 12:19:53-12:20:10					
Gust -12:08:18-12:09:17; 12:12:17-12:26:25					
Crickets-12:18:14-12:18:54					
Day	M T W	T F S	S	**Date**	**Site Number:** 2(Night)
Start Time	h	**End Time**	**h**	**Duration**	**Min**
Temperature	26.7°C	**Cloud Cover**	60%	**Humidity**	26.80%
Wind Speed	2.2m/s	**Wind Direction**	South west	**Bar Pressure**	889.9Kpa
Vehicles Passing	**Cars**	**Total**	**Heavy**	**Total**	**Total Vehicles**
	2	2	0		2
Notes:					
Gust-23:46:05					
Car passing-23:50:26; 00:55					

Figure 9: Log sheet for Site 2

Project Number			**Project Name**	PPM 3	
Day	M	**T** **W**	**T** **F** **S**	**S**	**Date:** **2015/10/13**	**Site Number:** 3 (day)
Site Discribtion	100m away from the given coordinates				
	Next to the road with lots of traffic				
GPS	**S**		**E0**		
Altitude	**m**				
Start Time	h	**End Time**	**h**	**Duration**	20 Min
Temperature	35.4 °C	**Cloud Cover**	None	**Humidity**	12.20%
Wind Speed	1.8m/s	**Wind Direction**	North east	**Bar Pressure**	890 Kpa
Vehicles Passing	**Cars**	**Total**	**Heavy**	**Total**	**Total Vehicles**
	12	12	2	2	14
Notes:			**Saved as**: 151013004		
Car passing-15:34:03; 15:34:37; 15:36:39; 15:36:39; 15:37:16; 15:36:38; 15:37:15; 15:42:23; 12:42:56; 15:43:16; 15:44:43; 15:46:08; 15:47:36; 15:49:49; 15:51:57					
Heavy vehicle-15:40:57-15:41:22					
Tractor-15:37:40					
Birds-15:38:59; 15:49:00; 15:49:16-15:49:36; 15:50:51; 15:51:55					
Gust-15:39:26; 15:40:21; 15:47:15-15:47:31					
Start Time	**h**	**End Time**	**h**	**Duration**	20 Min
Temperature	27.2°C	**Cloud Cover**	60%	**Humidity**	31.70%
Wind Speed	1.5m/s	**Wind Direction**	South west	**Bar Pressure**	893.4 Kpa
Vehicles Passing	**Cars**	**Total**	**Heavy**	**Total**	**Total Vehicles**
Notes:			**Saved as:** 151014002		
Mine Noise is audible					
Gust-01:17:37-01:17:48; 01:18:01; 01:20:30; 01:23:10; 01:24:30					
Crickets-01:20:16					
Jeffery's keys falling-01:22:28					
Insects-01:29:37; 01:29:45					

Figure 10: Log sheet for Site 3

Noise Survey Sheet					
Project Number		**Project Name**	PPM 4		
Day	M **T W T F S S**			**Date**	**Site Number:** 4 (Day)
Site Discribtion	Windy				
	Has lots of birds and insects noise				
GPS	**S**		**E0**		
Altitude	**m**				
Start Time	**h**	**End Time**	**h**	**Duration**	20 Min
Temperature	36.5 °C	**Cloud Cover**	10%	**Humidity**	12.20%
Wind Speed	2.2 m/s	**Wind Direction**	North West	**Bar Pressure**	892.4 Kpa
Vehicles Passing	**Cars**	**Total**	**Heavy**	**Total**	**Total Vehicles**
		6			
Notes:			**Saved as:** 151013006		
Car Passing-16:18:25; 16:21:20; 16:21:25; 16:23:34; 16:25:24; 16:25:44; 16:27:09; 16:32:21-16:33:13; 16:35:27; 16:37:02; 16:37:29					
Birds and insects-16:22:08-16:23:16					
Cow-16:34:58					

Project Number		**Project Name**			
Day	M **T W T F S S**			**Date**	**Site Number:** 4 (Night)
Start Time	**h**	**End Time**	**h**	**Duration**	**Min**
Temperature	27.7°C	**Cloud Cover**	60%	**Humidity**	29.40%
Wind Speed	0.9 m/s	**Wind Direction**	South west	**Bar Pressure**	895.4 Kpa
Vehicles Passing	**Cars**	**Total**	**Heavy**	**Total**	**Total Vehicles**
	2	2	0	0	2
Notes:					
Insects-Throughout					
Car passing-00:39:34-00:40:18; 00:50:38-00:51:30					

Figure 11: Log sheet for Site 4