Noise Assessment for the Tshipi Borwa Manganese Mine Closure Option

Project done for **SLR Consulting**

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Report No: 18SLR17NA | **Date:** June 2019

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REPORT DETAILS

Report Title	Noise Assessment for the Tshipi Borwa Manganese Mine Closure Option
Client	SLR Consulting
Report Number	18SLR17NA
Report Version	Final Rev2
Date	June 2019
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Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
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REVISION RECORD

Version	Date	Comments
Draft Rev0	June 2019	Draft for SLR review
Final Rev1	July 2019	Addressed SLR comments
Final Rev2	18 July 2019	Addressed client comments

COMPETENCY PROFILES

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

Hanlie Liebenberg-Enslin started her professional career in Air Quality Management in 2000 when she joined Environmental Management Services (EMS) after completing her Master's Degree at the University of Johannesburg (then RAU) in the same field. She is one of the founding members of Airshed Planning Professionals in 2003 where she has worked as a company Director until she took over as Managing Director in May 2013.

She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, using different dispersion models, and conducting impact assessments and health risk screening assessments. Hanlie was the project manager on a number of ground-breaking air quality management plan (AQMP) projects and the principal air quality specialist on regional environmental assessments. Her work experience, although mostly in South Africa, range over various countries in Africa, including extensive experience in Namibia, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality.

Hanlie has lectured several Air Quality Management Courses and is actively involved in the International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA) and the South African National Association for Clean Air (NACA), where she served as President for both organisations. Being an avid student, she received her PhD from the University of Johannesburg in June 2014, specialising in Aeolian dust transport.

The CV of Hanlie Liebenberg-Enslin is provided in Appendix A.

SPECIALIST DECLARATION

I, Hanlie Liebenberg-Enslin, as the appointed independent air quality specialist for the Tshipi Borwa Manganese Mine Closure Option, hereby declare that I:

- acted as the independent specialist in this Environmental Clearance Certificate application;
- performed the work relating to the application in an objective manner;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct,
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment;
- declare that there are no circumstances that may compromise my objectivity in performing such work;
- have expertise in conducting the specialist report relevant to this application;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- have no vested interest in the proposed activity proceeding;
- undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing the decision of the competent authority; and
- all the particulars furnished by us in this specialist input/study are true and correct.

HLiebenberg-Enslin.

Signature of the specialist:
Name of Specialists: Hanlie Liebenberg-Enslin
Date: 18 July 2019

NEMA REGULATION (2014), APPENDIX 6

NEMA Regulations (2018) - Appendix 6		Relevant section in report
1.a)	Details of the specialist who prepared the report.	Report details (page ii)
	The expertise of that person to compile a specialist report including curriculum vitae.	Report details (page ii) Annex E
1.b)	A declaration that the person is independent in a form as may be specified by the competent authority.	Report details (page ii)
1.c)	An indication of the scope of, and the purpose for which, the report was prepared.	Executive Summary Section 1.2: Terms of Reference
	An indication of the quality and age of base data used for the specialist report.	Section 1.5: Approach and Methodology Section 4: Noise Assessment
	A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change.	Section 4.1: Baseline Survey Results Section 4.2: Qualitative Noise Assessment for the preferred closure option
1.d)	The duration date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Section 3: Description of the Receiving Environment
1.e)	A description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used.	Executive Summary Section 1.5: Approach and Methodology Section 1.6: Assumptions and Limitations
1.f)	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 3: Description of the Receiving Environment
1.g)	An identification of any areas to be avoided, including buffers.	Not applicable
1.h)	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: Description of the Receiving Environment
1.i)	A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.6: Assumptions and Limitations
1.j)	A description of the findings and potential implications of such findings on the impact of the proposed activity or activities.	Section 4.2: Qualitative Noise Assessment for the preferred closure option Section 5: Impact Significance
1.k)	Any mitigation measures for inclusion in the environmental management programme report	Section 6.2: Recommendations
1.l)	Any conditions for inclusion in the environmental authorisation	Section 6.2: Recommendations
1.m)	Any monitoring requirements for inclusion in the environmental management programme report or environmental authorisation.	Section 6.2: Recommendations
1.n)	A reasoned opinion as to whether the proposed activity, activities or portions thereof should be authorised.	Section 6: Conclusions
	A reasoned opinion regarding the acceptability of the proposed activity or activities.	Section 6: Conclusions
	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.	Section 6.2: Recommendations
1.o)	A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable
1.p)	A summary and copies if any comments that were received during any consultation process.	Not applicable
1.q)	Any other information requested by the competent authority.	Not applicable.

GLOSSARY AND ABBREVIATIONS

Airshed	Airshed Planning Professionals (Pty) Ltd
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.
EHS	Environmental, Health, and Safety (IFC)
EMPr	Environmental Management Programme
Hz	Frequency in Hertz
IEC	International Electro Technical Commission
IFC	International Finance Corporation
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_P	Sound pressure level (in dB)
L_{PA}	A-weighted sound pressure level (in dBA)
L_W	Sound Power Level (in dB)
NLG	Noise level guideline
NSR	Noise sensitive receptor
p	Pressure in Pa
p_{ref}	Reference pressure, 20 μPa
SABS	South African Bureau of Standards
SANS	South African National Standards
SLM	Sound Level Meter
SoW	Scope of Work
WHO	World Health Organisation

EXECUTIVE SUMMARY

Airshed Planning Professionals (Pty) Ltd was appointed by SLR Consulting (Africa) (Pty) Ltd to assess the potential for noise related impacts on the surrounding environment and human health from the proposed mine closure option. This will be used in the amendment of the approved Environmental Impact Assessment (EIA) and Environmental Management Programme Report (EMPR).

Tshipi Mine's approved closure commitment is to restore the surface to pre-mining status which includes complete backfilling of the open pit. Tshipi Mine is investigating alternative closure options. The preferred option is In-pit Dumping only (i.e. no backfill following mine closure) and this is the option that has been assessed.

The main objective of the noise assessment was to qualitatively determine the potential change in environmental noise impacts due to the preferred closure option. A noise survey was done at five baseline locations around the mine in order to determine the current ambient noise levels. The potential for impacts due to the closure option was qualitatively assessed. The findings of the noise assessment are presented below:

- Noise is currently generated by the open pit surface mining and processing activities.
- The main potential Noise Sensitive Receptors (NSRs) are farmsteads located to the northwest, west and south of Tshipi Mine.
- Based on the prevailing wind field (2015-2017), noise impacts are expected to be more notable to the east and south during the day and to the north and north-northwest during the night.
- Ambient baseline noise levels were below the IFC guideline for residential areas (55dBA) at all five sampling locations, and no audible noise from the mining operations were noted in the filed log sheets, only noise from cicadas.
- The preferred closure option is likely to result in much lower noise impacts due to fewer activities and the use of less equipment. The significance of the impacts expected during the preferred closure option, with mitigation in place, is VERY LOW.
- The potential for noise impacts from the other closure options considered would have similar noise impacts, with slight changes due to locations and operational intensity. All closure options would result in lower noise levels than the operational phase.

From a noise perspective the preferred closure option should have lower noise impacts than the current mining operations.

It is recommended that good engineering practice should be applied throughout the Life of Mine and during closure. This includes, amongst others, regular inspection; implementation of an equipment maintenance program and use equipment with lower sound power levels. Traffic should also be limited. Should aggregate crushing be implemented during post-closure, this should be located as far as possible from sensitive receptors.

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1 Introduction

Tshipi é Ntle Manganese Mining (Pty) Ltd (Tshipi) currently operates the Tshipi Borwa open pit manganese mine located on the farms Mamatwan 331 and Moab 700, approximately 18 km south of Hotazel in the Joe Morolong Local Municipality and the John Taolo Gaetsewe District Municipality in the Northern Cape Province. Tshipi currently holds the following authorisations:

- A mining right (NC/30/5/1/2/2/0206MR) issued by the Department of Mineral Resources (DMR);
- An Environmental Management Programme report (EMPr) approved by the DMR;
- An environmental authorisation (NC/30/5/1/2/2/206/000083 EM) issued by the DMR; and
- A Water Use Licence (IWUL) (10/D41K/AGJ/1735) issued by the Department of Water and Sanitation.

Key mine infrastructure includes an open pit, haul roads, run-of mine ore tip, a primary crusher, a secondary crushing and screening plant, various stockpiles for crushed and product ore, a train load-out facility, a private siding, offices, workshops, warehouses and ancillary buildings, an access control facility, various access roads, diesel generator house, electrical reticulation, clean and dirty water storage dams, water reticulation pipelines and drains, topsoil stockpiles and waste rock dumps. The mine has an anticipated life of mine of approximately 25 years and has been operational since 2012.

The approved EMPr commits Tshipi to restore the surface to pre-mining state of wilderness and grazing and requires that the open pit is backfilled. Recent operation optimisation investigations indicate that when considering environmental, socio-economic, technical, commercial and legal factors, and, completely backfilling the open pit is sub-optimal. An alternative closure and rehabilitation strategy offers:

- The opportunities for enhanced biodiversity habitats with a different backfill approach particularly in terms of topographic variety and access to surface water;
- The opportunities for enhanced land use increase with access to surface water;
- An alternative closure option will allow for earlier rehabilitation of waste rock dumps; and
- Completely backfilling the open pit is likely to sterilise an underground resource located to the north of the current approved open pit. The associated loss of employment, procurement, taxes and foreign exchange earnings is significant and will be a material net loss to the region and the country;

Tshipi is therefore proposing to change the current closure commitment to achieve a more sustainable and optimised outcome. In this regard, the proposed project focusses on:

- Concurrent backfill only i.e. in-pit dumping during mining operations only;
- Sloping and rehabilitation of waste rock dumps remaining on surface;
- Access to readily available future water supply; and
- Optimisation of the surface landforms and partially backfilled pit from a biodiversity, rehabilitation, land use and pollution prevention perspective.

Airshed Planning Professionals (Pty) Ltd was appointed by SLR Consulting (Africa) (Pty) Ltd to assess the potential for environmental noise related impacts on the surrounding environment and human receptors from the proposed mine closure option. This will be used to amend the approved EIA EMPR.

1.1 Objective

The main objective of the noise assessment is to qualitatively determine the potential change in environmental noise impacts due to the preferred closure option.

1.2 Scope of Work

To achieve the above objective, the following tasks were included:

1. A review of applicable environmental noise guidelines;
2. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of potential Noise Sensitive Receptors (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 on 3 December 2018;
3. Qualitative noise impact assessment; and
4. A specialist noise survey report.

1.3 Description of Activities from a Noise Perspective

Current mining operations include open pit mining (drilling, blasting and excavation of ore and waste rock), with haul roads linking the pit with the surrounding waste rock dumps (WRDs) and processing plant. Ore is hauled from the open pit and tipped at the run-of-mine (ROM) stockpile from where it is sent to the primary crusher, and to the secondary crushing and screening plant. Waste rock is hauled from the pit to three existing WRDs – Northern-; Western- and Eastern WRDs. Other infrastructure includes a train load-out facility, a private siding, topsoil stockpiles, product stockpiles, railway line and buildings. Amendments to the Environmental Impact Assessment (EIA) and Environmental Management Programme Report (EMPR) included the extension of the East WRD in a south-easterly direction to join with the Mamatwan WRD and essentially fill the narrow void between these two WRDs, and the extension of the West WRD in a south-westerly direction onto the remaining extent of Portion 8 of the farm Mamatwan 331. The construction of an overhead powerline and sub-station along the boundary of Portion 8 formed part of the amendment as well as the construction of an overland conveyor system from the existing crushing and screening plant to the existing manganese product stockpiles. A sinter plant is included in the mine's approved EMP but is yet to be established.

Noise is emitted by mining equipment used for activities such as the liberation, excavation, handling and transport of mined ore and waste rock. Diesel mobile mining equipment can be described or divided into distinct categories

– earthmoving equipment, materials handling equipment, stationary equipment, impact equipment, and other types of equipment. The first three categories include machines that are powered by internal combustion engines. Machines in the latter two categories are powered pneumatically, hydraulically, or electrically. Additionally, exhaust noise tends to account for most of the noise emitted by machines in the first three categories (those that use internal combustion engines) whereas engine-related noise is usually secondary to the noise produced by the impact between impact equipment and the material on which it acts (Bugliarello, Alexandre, Barnes, & Wakstein, 1976). Diesel mobile mining equipment generally produce noise in the lower end of the frequency spectrum. Reverse or moving beeper alarms emit at higher frequency ranges and are often heard over long distances.

Noise generated during surface mining and closure activities is highly variably since it is characterised by variations in the power expended by equipment. Besides having daily variations in activities, major mining projects are accomplished in several different phases where each phase has a specific equipment mix depending on the work to be accomplished during that phase.

Blasting, associated with operational open pit mining activities, can cause noise and vibration, which can have an impact upon neighbouring noise receptors. Blasting usually results in both ground and airborne vibration. The latter includes both audible noise and vibration known as airblast, which can cause objects to rattle and make noise. Annoyance and discomfort from blasting can occur when noise startles individuals or when airblast or ground vibration causes vibration of building elements such as windows. The degree of annoyance is influenced by the level of airblast and vibration as well as factors such as the time of day, the frequency of occurrence and the sensitivity of individuals. The generation and transmission of airblast and ground vibration is affected by a number of factors including blast design, meteorology (particularly wind speed and direction and temperature inversions), topography, geology and soil water content (Earth Resources | Victoria State Government, 2015). Whereas the audible part of the airblast (acoustic) is characterized by frequencies ranging from 20 to 20 000 Hz the non-audible part, consist of sound energy below 20 Hz and is referred to as an ‘over pressure’ when the air blast pressure exceeds atmospheric pressure. Airblast over pressure exerts a force on structures and may in turn cause secondary and audible rattles within structures such as windows (Aloui, Bleuzen, Essefi, & Abbes, 2016).

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 processing plant 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.

In-pit dumping is the preferred closure option to be assessed. The understanding is during the closure phase most of the in-pit dumping would be completed, leaving the WRDs and other exposed surfaces to be rehabilitated. It is further assumed that most of the WRD side slopes and some surface areas would be rehabilitated during the operational phase. Thus, during the closure phase the main sources of noise pollution remaining would be some intermitted vehicle and materials handling activities associated with rehabilitation of the exposed areas. Demolishing activities could also be expected.

1.4 Background to Environmental Noise Assessment

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 Pa) to the measurement and calculation of sound pressure leads to large and unwieldy numbers. 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 1. Here, the linear scale with its large numbers is converted into a manageable scale from 0 dB at the threshold of hearing (20 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)*

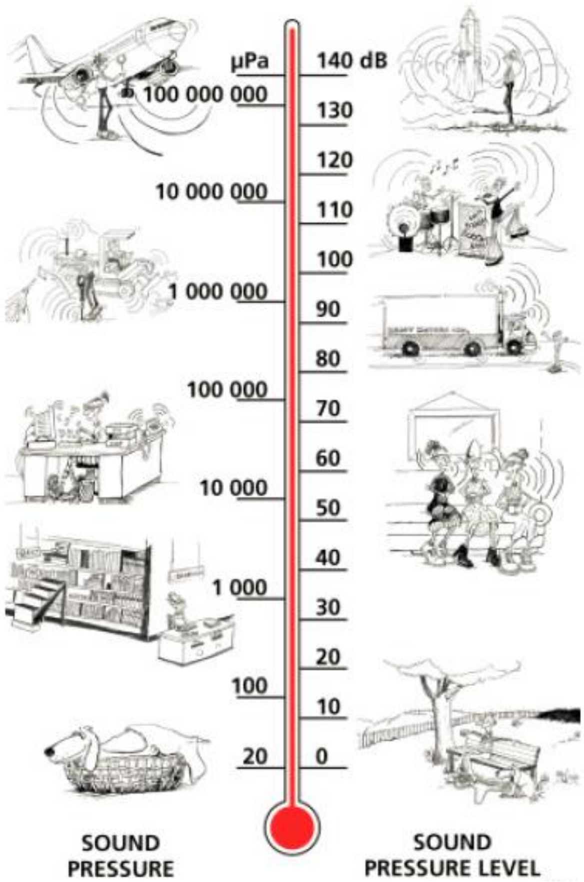


Figure 1: The decibel scale, typical noise levels (Brüel & Kjær Sound & Vibration Measurement A/S, 2000)

1.4.1 Perception of Sound

Sound is 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 20 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).

1.4.2 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 2). "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.

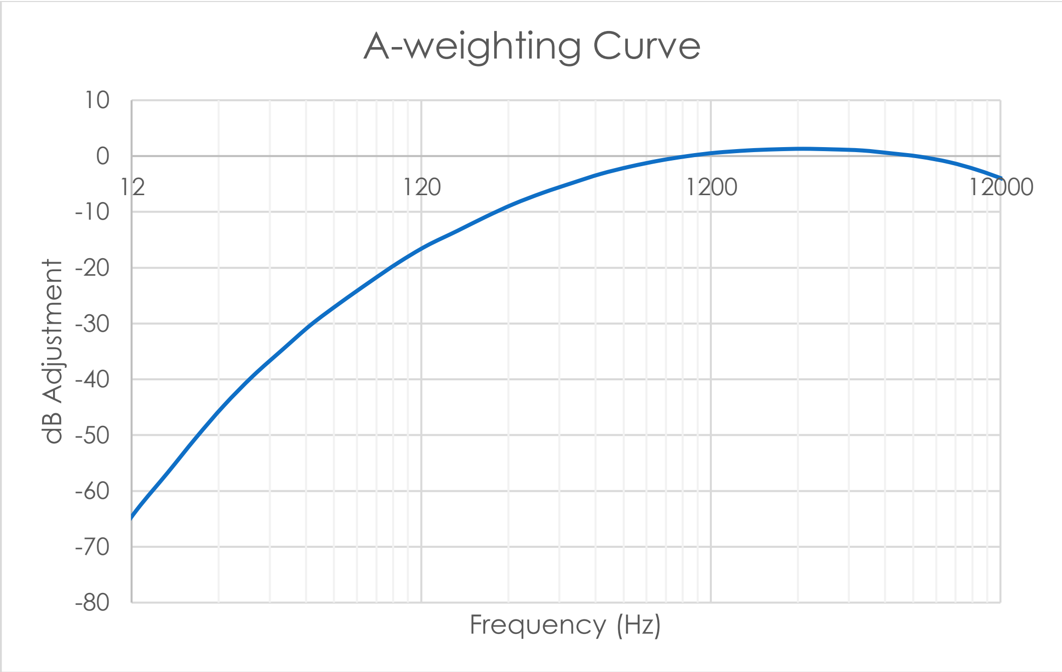


Figure 2: A-weighting curve (Beech & Zacharov, 2006)

1.4.3 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).

1.4.4 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_{Aleq} (T).

- **$L_{Req,d}$** – The L_{Aeq} rated for impulsive sound (**L_{Aleq}**) 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_{Aleq}**) 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_{Aleq}) 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 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.
- **L_{AFmin}** – The minimum A-weighted noise level measured with the fast time weighting. It's the lowest level of noise that occurred during a sampling period.

1.5 Approach and Methodology

1.5.1 Site Selection

Environmental noise sampling was conducted at five baseline locations (Table 1 and Figure 3). The noise survey was conducted on 3 December 2018 at all sampling locations.

Table 1: Baseline - Survey coordinates

Site	Coordinates	
Site 1	27°23'18.44"S	22°58'33.66"E
Site 2	27°22'50.92"S	22°56'7.64"E
Site 3	27°23'50.77"S	22°57'57.83"E
Site 4	27°23'39.71"S	22°56'51.67"E
Site 5	27°24'14.14"S	22°57'22.66"E

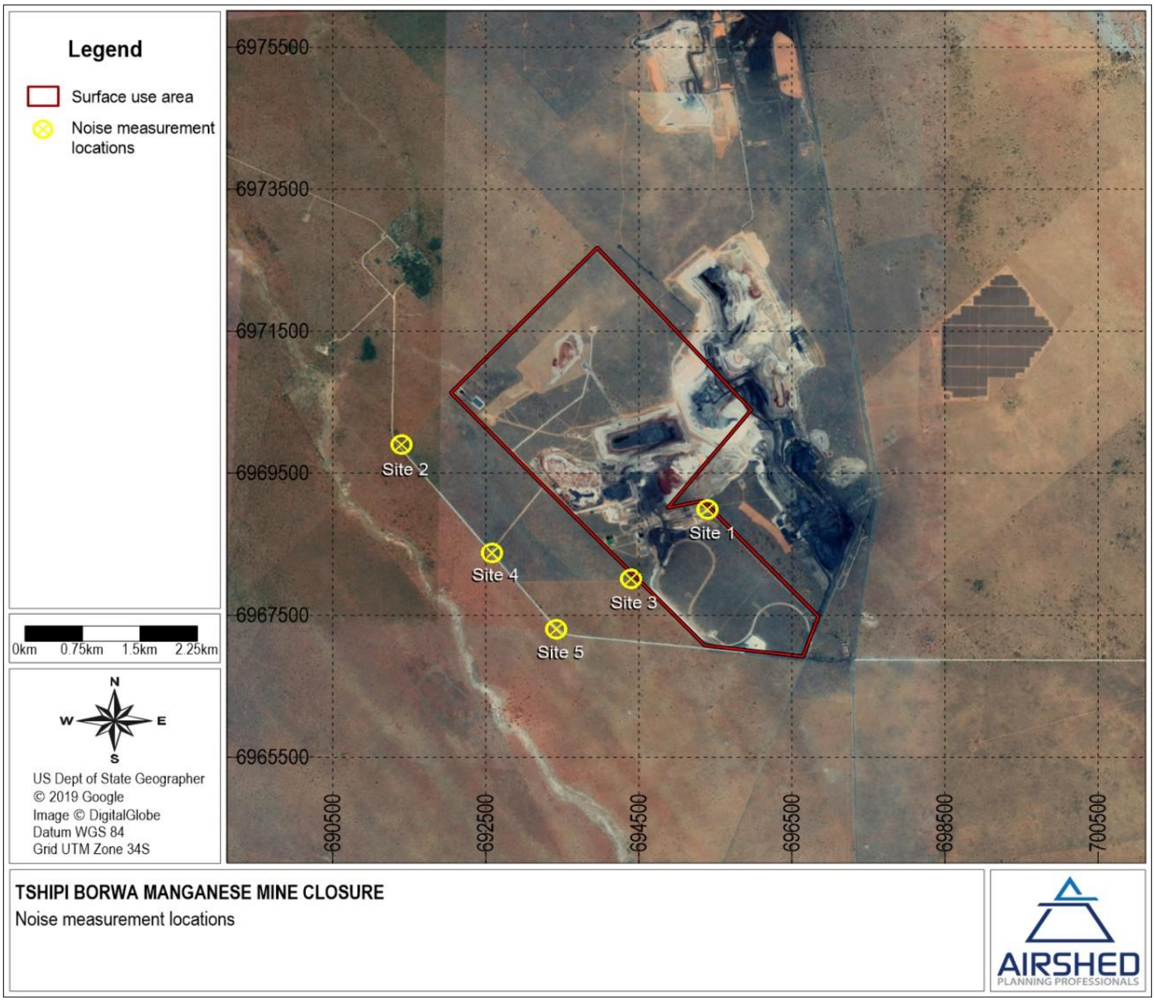


Figure 3: Baseline - Noise survey sites

1.5.2 Survey Methodology

The survey methodology, which closely follows guidance provided by the IFC General Environmental, Health and Safety (EHS) Guidelines (IFC, 2007) and SANS 10103 (2008), is summarised below:

- The survey was designed by a trained specialist.
- Sampling was carried out using a Type 1 sound level meter (SLM) that meets all appropriate International Electrotechnical Commission (IEC) standards and is subject to annual calibration by an accredited laboratory. Equipment details are included in Table 2. Calibration certificates are included in Annex A.
- The acoustic sensitivity of the SLM was tested with a portable acoustic calibrator before and after each sampling session.
- Samples, 10 to 15 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 time.
- As generally recommended, the following acoustic indices were recoded: L_{Aeq} (T), L_{AIeq} (T); L_{AFmax}; L_{AFmin}; L_{90} and 3rd octave frequency spectra.
- Wherever possible the SLM was located approximately 1.5 m above the ground and 10 m from reflecting surfaces.

- 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. It does not specify a wind speed limit or weather condition limitations.
- A detailed electronic log and record was kept. Records included site details, weather conditions during sampling and observations made regarding the acoustic climate of each site. Logs are included in Annex C.

Table 2: SLM details

Equipment	Serial Number	Purpose	Last Calibration Date
SVANTEK Type 977 SLM	S/N 36183	Attended 30-minute sampling.	16 July 2018
SVANTEK Type 7052E ½" Pre-polarized microphone	S/N 71175	Attended 30-minute sampling.	28 March 2018
SVANTEK SV33 Class 1 Acoustic Calibrator	S/N 43170	Testing of the acoustic sensitivity before and after each daily sampling session.	10 April 2017
Kestrel 3500 Pocket Weather Tracker	S/N 2263089	Determining wind speed, temperature and humidity during sampling.	Not Applicable

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.

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 period (06:00 to 22:00);

- $L_{Req,d}$ is the equivalent continuous rating level determined for the day-time reference 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.

1.5.3 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 legally enforceable 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.

1.6 Assumptions and Limitations

The conclusion of this report assumes that activities during the survey on 3 December 2018 are representative of normal operational activities at Tshipi Mine.

2 Noise Level Guidelines

2.1 SANS 10103 (2008)

SANS 10103 (2008) successfully addresses the way environmental noise measurements are to be taken and assessed in South Africa, and is fully aligned with the World Health Organization guidelines for Community Noise (WHO, 1999). It should be noted that the values given in Table 4 are *typical rating levels that it is recommended should not be exceeded outdoors in the different districts specified*. Outdoor ambient noise exceeding these levels may be annoying to the community.

Table 3: Typical rating levels for outdoor noise, SANS 10103 (2008)

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}[1] 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 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'. Δ = 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'.

[1] $L_{Aeq,T}$ is the A-weighted equivalent sound pressure level, where T indicates the time over which the noise is averaged (calculated or measured).

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 IFC Guidelines on Environmental Noise

The IFC General EHS 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. $\Delta = 3$ 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 guideline level for residential, institutional and educational receptors 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; and
- The local environmental noise propagation and attenuation potential.

3.1 Noise Sensitive Receptors

Noise sensitive receptors (NSRs) generally include places of residence and areas where members of the public may be affected by noise generated by mining, processing and transport activities. Office workers and employees, and contractor accommodation on-site may also be affected.

The impact of an intruding industrial/mining noise on the environment rarely extends over more than 5 km from the source. Noise sensitive receptors around Tshipi Mine is shown in Figure 4:

- General public:
  - Farmhouses towards the northwest, west and south of Tshipi Mine.
- Industrial and commercial activities within the area:
  - Mamatwan Manganese Mine directly east of Tshipi Mine;
  - UMK Mine to the north of Tshipi Mine, and
  - Solar Plant to the east.
- Other:
  - Traffic on the R380 to the west of Tshipi Mine.

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 1.4.3). 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 was made of data from the South African Weather Services (SAWS) Kuruman Weather Station (located approximately 43 km to the west of Tshipi Borwa Manganese Mine). Data for the period 1 January 2015 – 31 December 2017 was obtained for inclusion in the report.

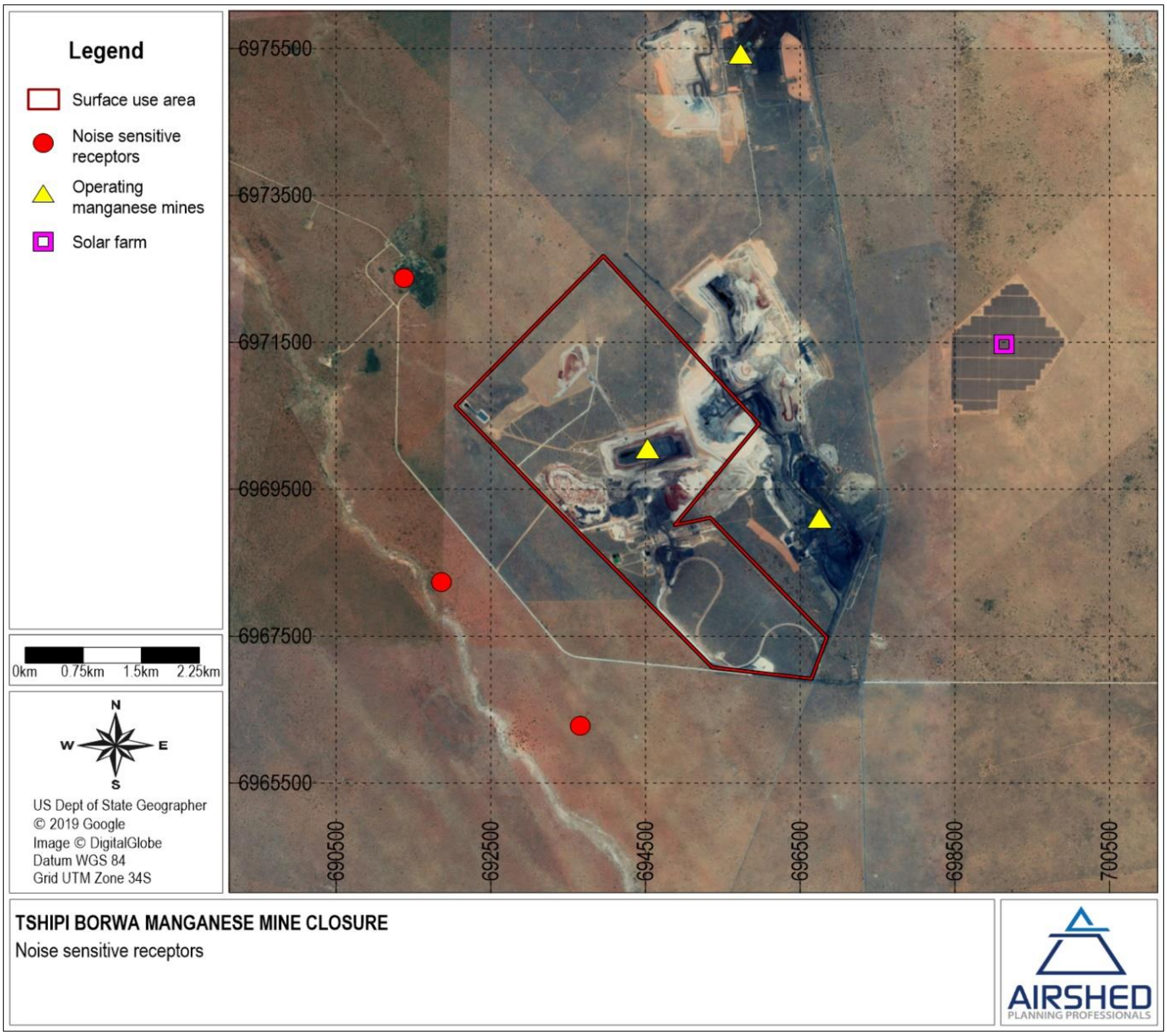
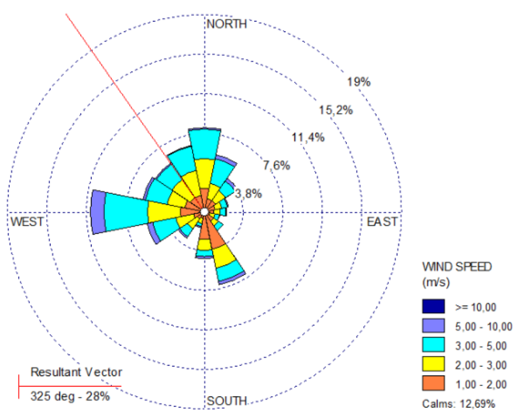


Figure 4: Noise sensitive receptors near the Tshipi Borwa Manganese Mine

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 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)

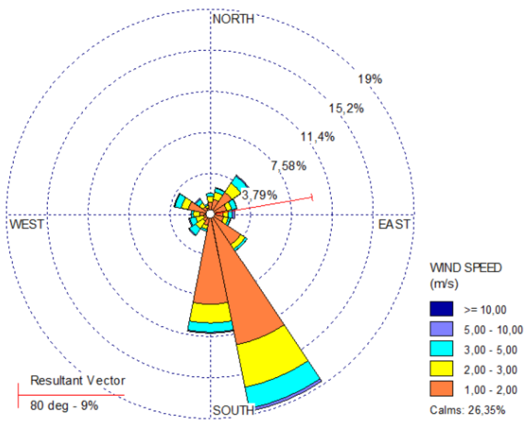


Figure 5: Day- and night-time wind field (SAWS data: 2016 to 2017)

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

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.

4 Noise Assessment

4.1 Baseline Survey Results

A summary of the survey results is given in Figure 6 and Table 5. The complete survey results for the baseline sampling locations are given in the following sections.

Table 5: Logged Broadband Results at all Sampling Locations

	Site 1	Site 2	Site 3	Site 4	Site 5
L_{AFmin}	31.1	34.6	29.9	40.9	42.1
L_{A90}	34.6	43.8	35.2	47.2	49.3
L_{Aeq}	44.1	51.2	45.8	49.7	53.4
L_{AFmax}	73.7	69.6	81.0	55.4	63.0

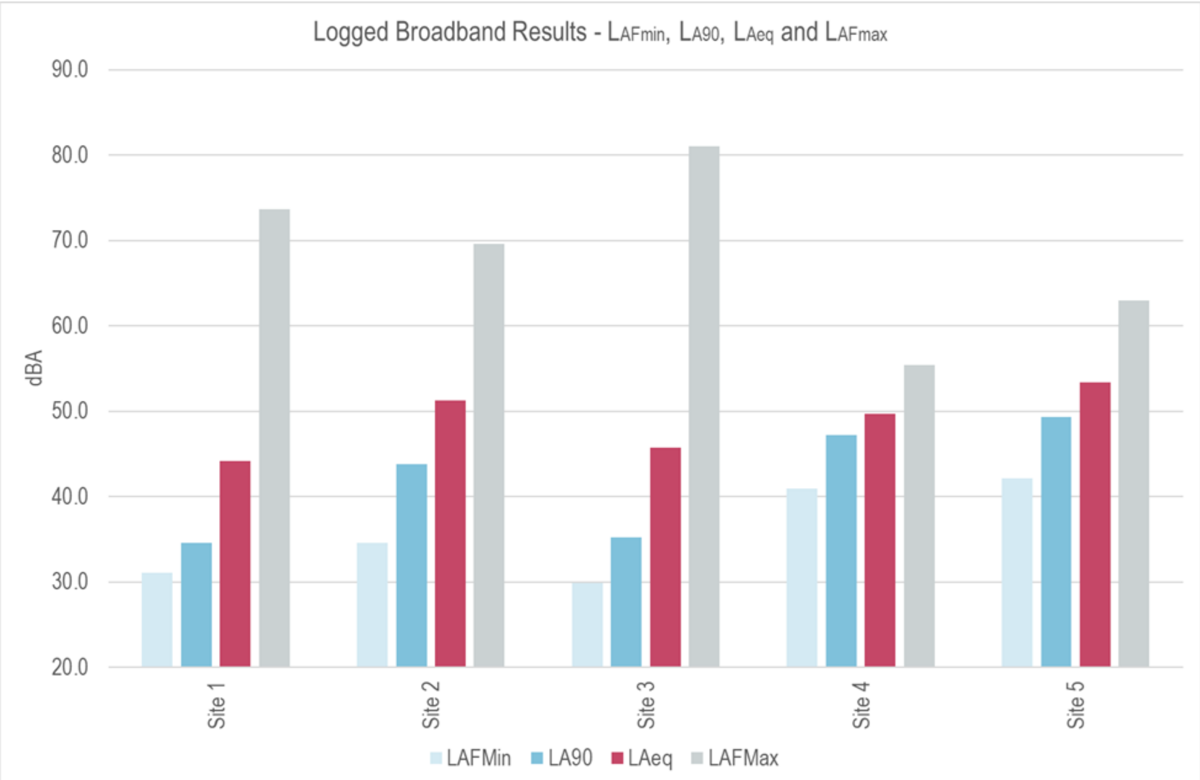


Figure 6: Logged Broadband Results at Baseline Sampling Locations

4.1.1 Baseline Noise Locations

Baseline environmental noise levels were sampled at five baseline locations as described in Figure 6 and Table 5. Recorded average sound pressure levels (L_{Aeq}) were below the IFC guideline for residential areas (Table 4) at all five sampling locations. Recorded baseline sound pressure levels at sampling locations 1 and 3 were typical of rural locations (Table 5) while sound pressure levels at locations 2, 4 and 5 were slightly higher (equivalent to typical suburban noise levels) due to the presence of cicadas close to the sampling locations. The presence of cicadas can very clearly be seen as peaks in the 5000Hz and 6300Hz ranges on the frequency spectra graphs in Figure 9, Figure 11 and Figure 12. No audible mining noises were noted.

Recorded average sound pressure levels were below the IFC guideline for residential areas (55dBA) at all five baseline sampling locations.

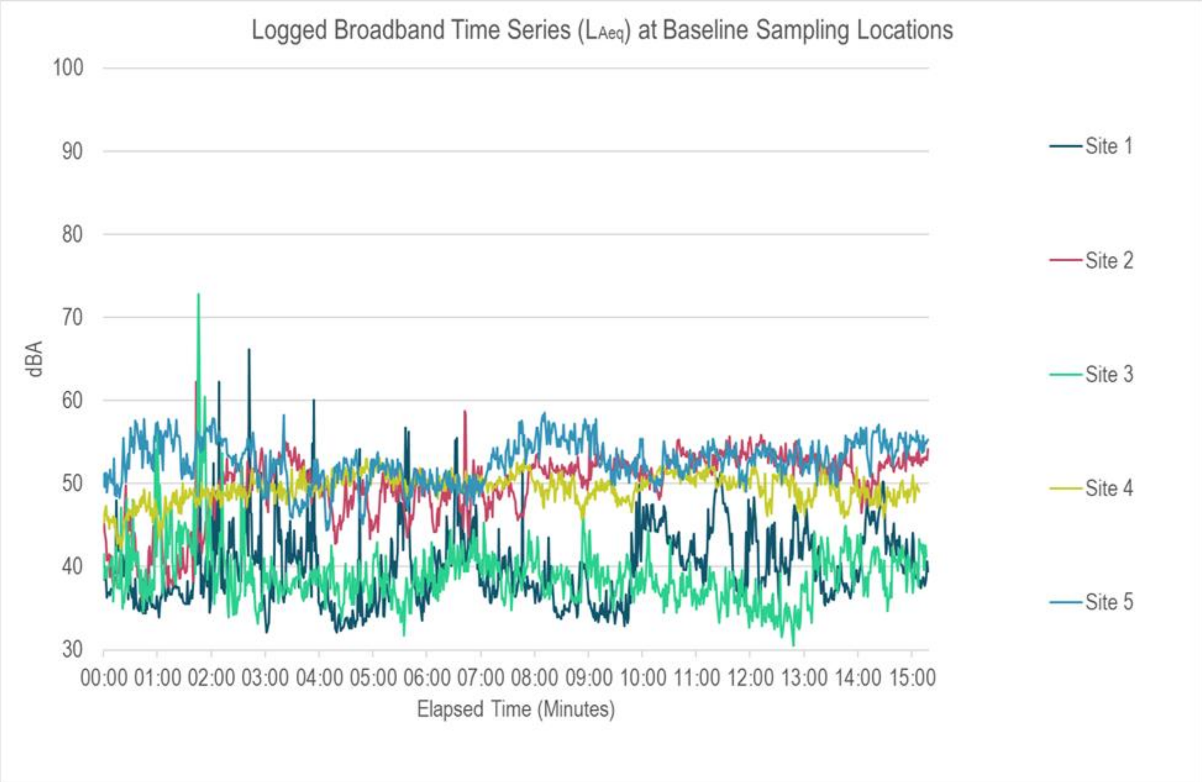


Figure 7: Logged broadband results (LA_{eq}) – All Baseline Locations

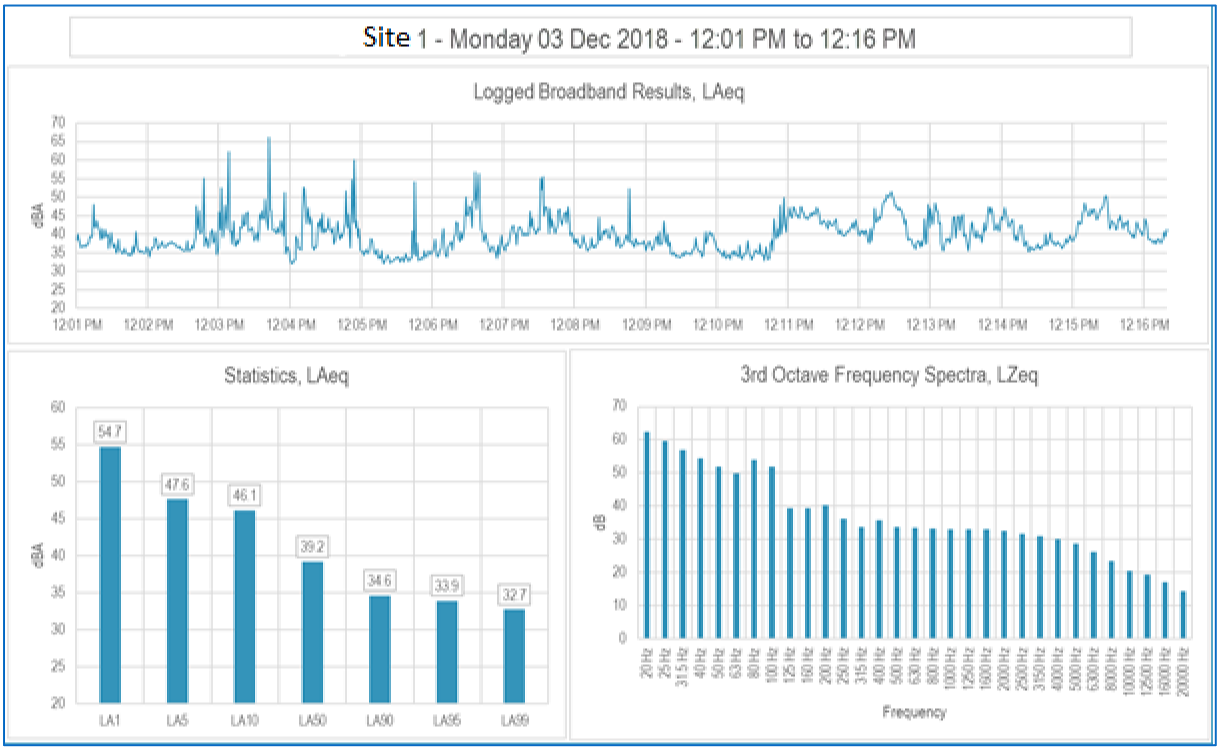


Figure 8: Broadband time series, Logged broadband results and Logged frequency spectra – Site 1

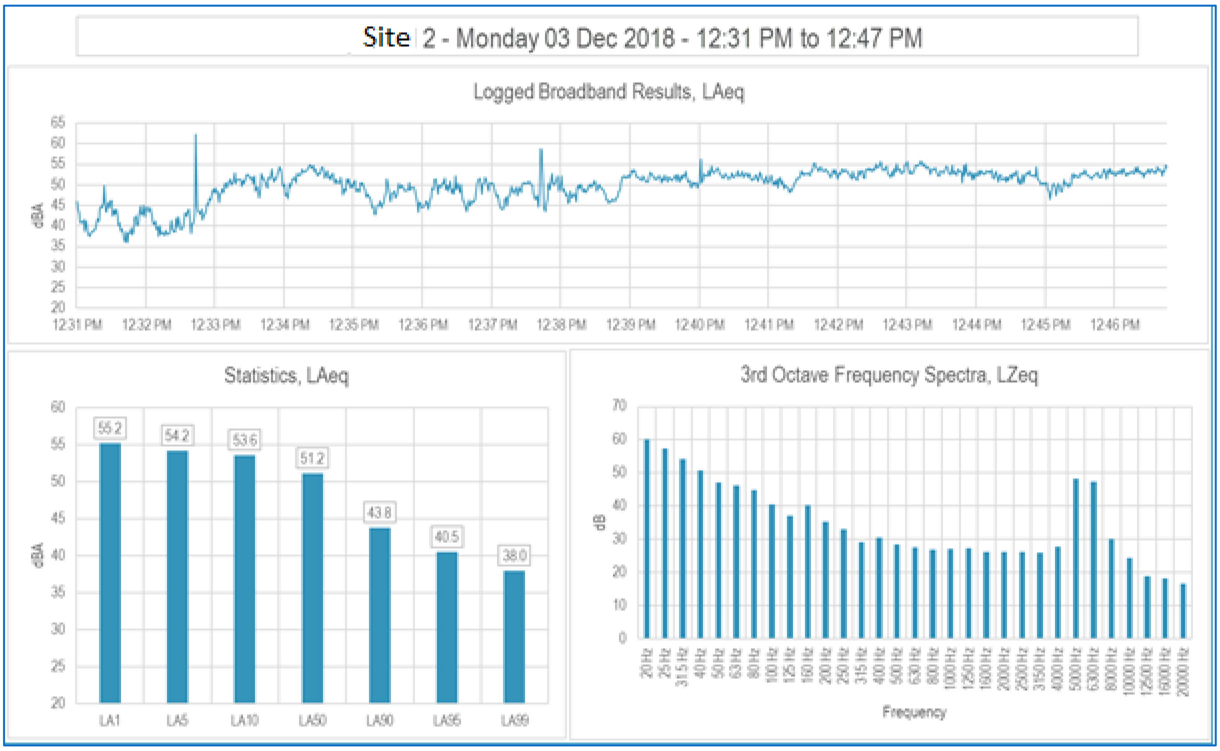


Figure 9: Broadband time series, Logged broadband results and Logged frequency spectra – Site 2

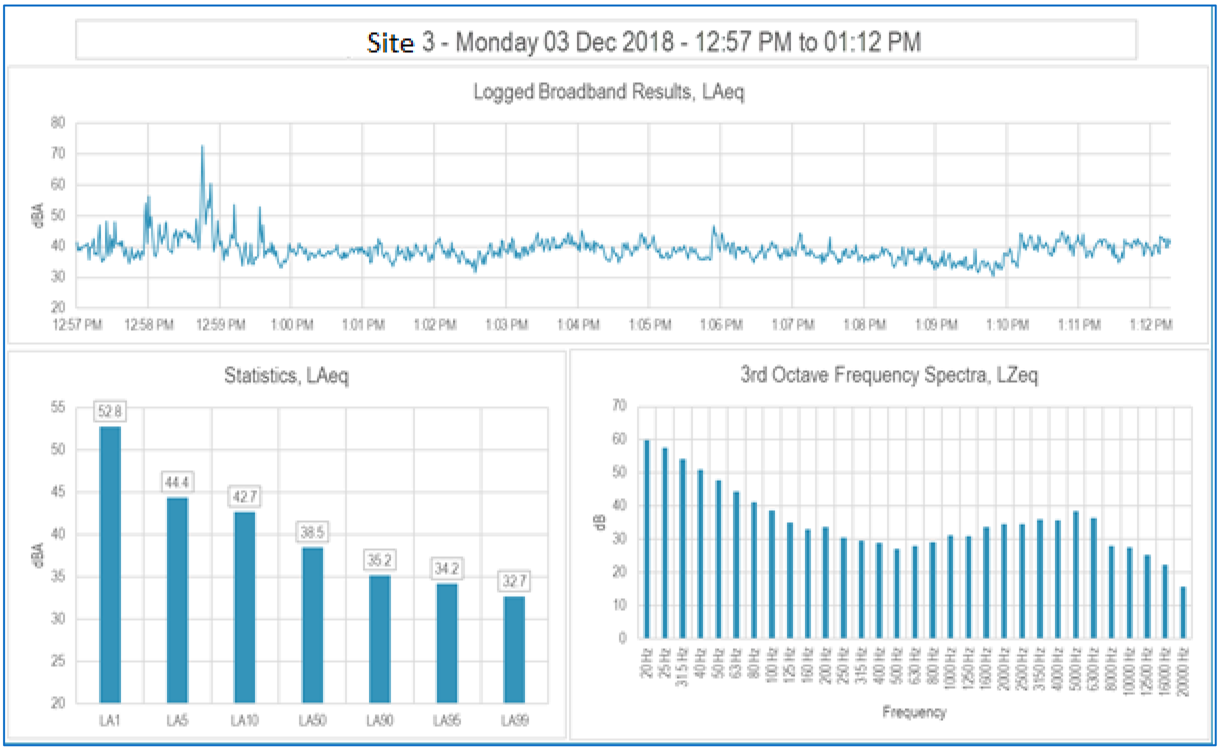


Figure 10: Broadband time series, Logged broadband results and Logged frequency spectra – Site 3

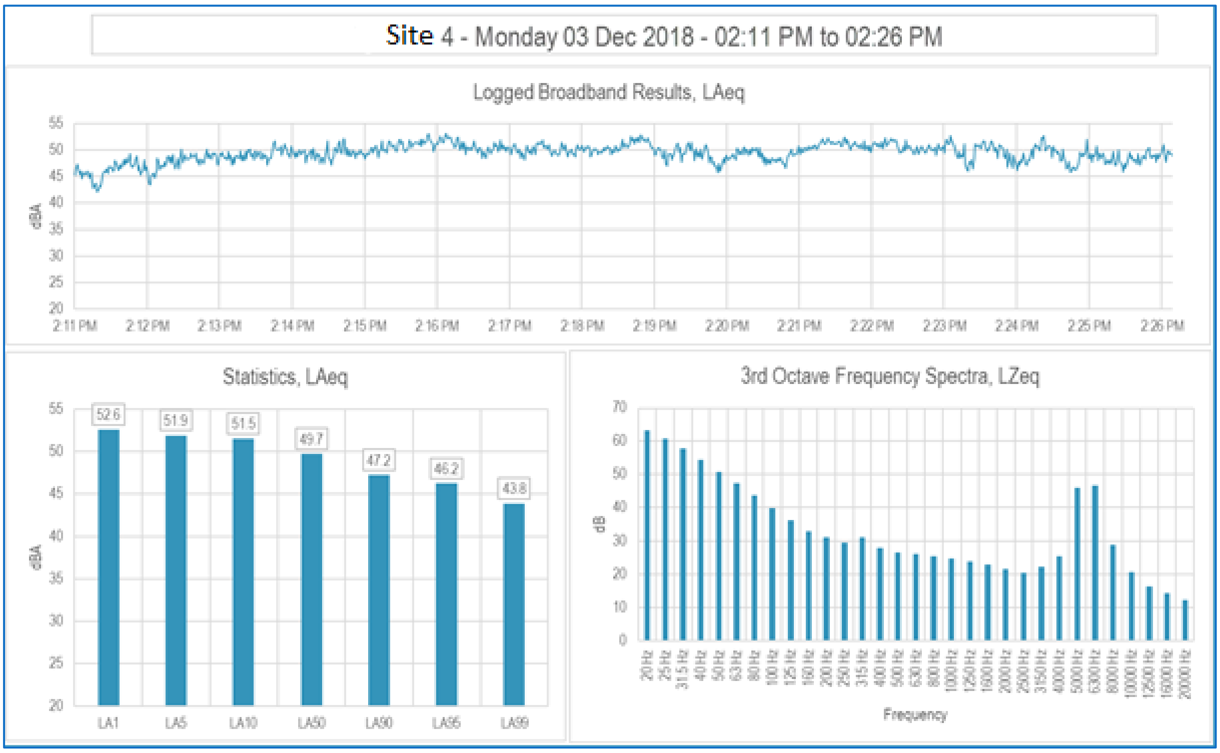


Figure 11: Broadband time series, Logged broadband results and Logged frequency spectra – Site 4

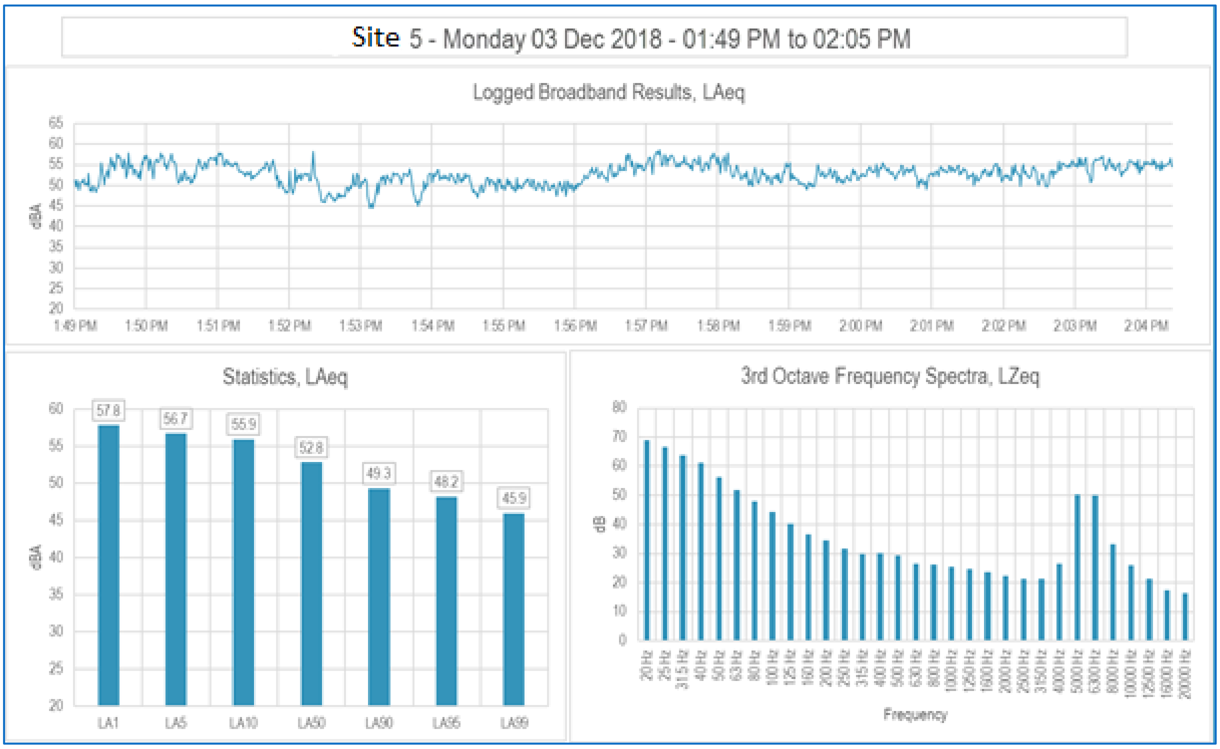


Figure 12: Broadband time series, Logged broadband results and Logged frequency spectra – Site 5

4.2 Qualitative Noise Assessment for the preferred Closure Option

In-pit dumping is the preferred closure option. Most of the in-pit dumping will be done during the operational phase, leaving intermittent truck and vehicle activity as part of the rehabilitation efforts. This would likely include some materials handling and demolition activities. This section qualitatively describes the likely change in noise impacts during the closure phase.

During closure phase all mining operations would have ceased, with most of the noise generating mining equipment removed. As indicated some earthmoving equipment, materials handling equipment and stationary equipment might remain as part of the final rehabilitation efforts. The number of equipment used, and the intensity of activities would be significantly less than during the operational phase resulting in fewer noise points and lower noise levels. When compared to the baseline measurements (Section 3.1.1), the noise levels should reduce during the closure phase. Given that the main source of noise at locations 4 and 5 were influenced by to local noise sources (the presence of cicadas), these levels will either decrease or remain the same since it’s not significantly influenced by mining operations.

4.2.1 Alternative Closure Phase Options

Other closure phase options considered include partial backfill to the post closure groundwater rebound level, in pit dumping only, and no backfill or in pit dumping (Figure 13).

The main source of noise for all these closure options would be vehicle activity, although the duration, frequency and spatial distribution would vary. “Concurrent in-pit dumping” and “No backfill and no in-pit dumping” are likely to have similar noise impacts to that of the preferred closure option of “In-pit Dumping only (i.e. no backfill following mine closure)” because all associated activities would occur mostly during the operational phase, with only final rehabilitation left for closure. “Complete backfill” would have higher impacts due to the fact that it will only occur after mining operations cease, and the duration for this closure option would be longer. Even though the noise levels would be higher than the other options, it would still be lower than the current mining activities. “Partial backfill” is also likely to only occur after mining ceases but should require less activity than “Complete backfill”.

The other phases would happen co-current with mining operation and might not be noticeable above the current mining noises.

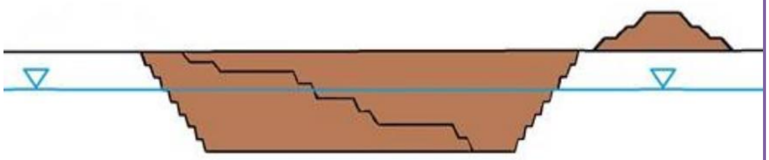
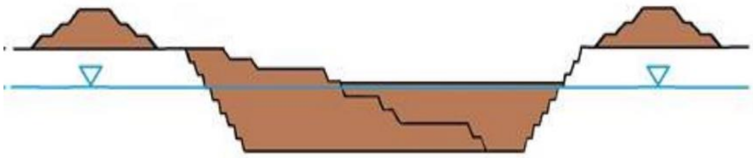
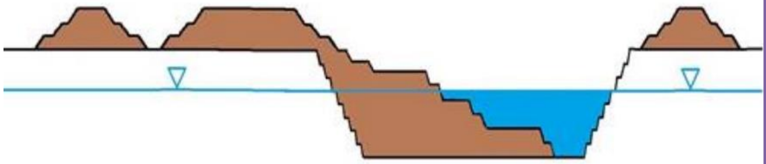
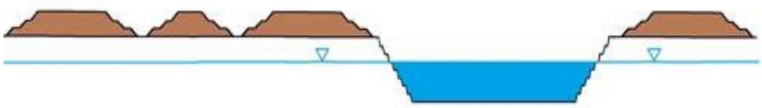
Options considered	Illustration	Detail
Complete backfill		Backfill of the final pit void post mining to original ground level, before rehabilitation of the surface as per the current approved EMPr
Partial backfill		Backfill of the final pit void post mining to a level just above the rebound water-table level, approximately 50m below original ground level, before rehabilitation of the surface.
Concurrent backfill (in-pit dumping)		Backfill of the pit void concurrent with mining only, also called in-pit dumping, which results in a final pit void which will be ‘made safe’ (profiled) before rehabilitation of the surface.
No backfill		No backfill of the pit either concurrent with mining or post mining i.e. all waste rock to surface dumps. The pit side-walls and end-walls will only be ‘made safe’.

Figure 13: The four closure options that were considered

There is an additional option of post closure aggregate rock crushing. This is likely to last longer for option 4 where all WRDs will provide available material for crushing, and the shortest for option 1 where most waste rock will be moved into the pit. The noise impacts would thus be the most significant (based on duration) for option 4, followed by similar impacts from options 2 and 3, and the least significant from option 1.

5 Impact Significance

The significance of noise impacts was assessed according to a generic impact significance rating methodology. Refer to Annex C of this report for the methodology.

The potential for noise risk impacts during the preferred closure option is provided in Table 6. The environmental significance of these impacts is VERY LOW; with mitigation applied it would reduce further to remain VERY LOW.

Table 6: Ambient Noise impact significance summary table for the proposed Closure Phase

Criteria	Without Mitigation	With Mitigation
Intensity	Low	Low
Duration	Short term	Short term
Extent	Local	Local
Loss of resource	Low	Low
Probability	Probable	Probable
Confidence	High	High
Significance	VERY LOW (a)	VERY LOW (a)
Cumulative significance	LOW	LOW
Nature of cumulative impact	Other activities that may contribute to the cumulative risk impact include vehicles on regional paved and unpaved roads; farming activities and natural noises such as the presence of cicadas.	
Degree in which impact can be reversed	Partially reversable	Partially reversable
Degree to which impact may cause irreplaceable loss of resources	Low	Low
Degree to which impact can be mitigated	High	-
Recommended mitigation measures: • Good engineering practice should be applied such as: regular inspection; implementation of an equipment maintenance program and use equipment with lower sound power levels. • Limit traffic to daytime hours.		

Notes: (a) of ***low to medium intensity*** at a ***local level*** and endure in the ***short term.***

6 Conclusions

6.1 Main Findings

The findings of the noise assessment are:

- Noise is currently generated by the open pit surface mining and processing activities.
- The main Noise Sensitive receptors (NSRs) are farmsteads located to the northwest, west and south of Tshipi Mine.
- Based on the prevailing wind field (2015-2017), noise impacts are expected to be more notable to the east and south during the day and to the north and north-northwest during the night.
- Ambient baseline noise levels were below the IFC guideline for residential areas (55dBA) at all five sampling locations, and no audible noise from the mining operations were noted in the filed log sheets, only noise from cicadas.
- The preferred closure option is likely to result in lower noise impacts due to fewer activities and the use of less equipment. The significance of the impacts expected during the preferred closure option, with mitigation in place, is VERY LOW.
- The potential for noise impacts from the other closure options considered would have similar noise impacts, with slight changes due to locations and operational intensity. All closure options would result in lower noise levels than the operational phase.

In conclusion, ambient baseline sound pressure levels were below the IFC guideline for residential areas which included influencing from the natural environment. The preferred closure option is likely to result in lower noise impacts due to fewer activities and the use of less equipment, resulting in overall lower noise levels. The significance of the impacts expected during the preferred closure option, with mitigation in place, is VERY LOW.

6.2 Recommendations

For general activities, and activities during the closure phase, the following good engineering practice should be applied:

- 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 likely to occur during decommissioning and closure, should be limited.
- Should aggregate crushing be implemented during post-closure, this should be located as far as possible from sensitive receptors.
- A noise complaints register must be kept.

In addition, short term ambient noise measurements could be conducted during the closure phase at the five sampling locations to confirm noise levels remain similar or lower to surveyed baseline levels.

7 References

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8 Annex A | Site Photographs

Figure 14: Baseline Sampling Location 1

Figure 15: Baseline Sampling Location 2

Figure 16: Baseline Sampling Location 3

Figure 17: Baseline Sampling Location 4

Figure 18: Baseline Sampling Location 5

9 Annex B | Calibration Certificates

nmisa
National Metrology Institute of South Africa

Certificate of Conformance

Private Bag X34, Lynnwood Ridge, Pretoria, 0040
CSIR Campus, Meiring Naude Road, Brummeria, 0184
Calibration office: +27 12 841 4623
Reception: +27 12 841 4152
Fax: +27 12 841 4458
E-mail enquiries: info@nmisa.org

Calibration of:	SOUND LEVEL METER & MICROPHONE
Manufacturer:	SVANTEK, ACO PACIFIC
Model number:	977, 7052E
Serial number:	36183, 71175
Calibrated for:	AIRSHED PLANNING PROFESSIONALS (PTY) LTD 480 Smuts Drive, Halfway Gardens, Midrand
Calibration procedure:	AV\AS-0007
Period of calibration:	16 July 2018

1 PROCEDURE

The sound level meter was electrically calibrated according to the relevant clauses of IEC 61672-3: 2006 specification. The microphone with the sound level meter was acoustically calibrated according to the relevant clauses of IEC 61672-3: 2006.

The results of the measurements are traceable to the national measurement standards.

The following equipment was used:

Brüel & Kjær 4226 Multi-function calibrator	(AS-131)
Inline Capacitor	(AS-95)
Madgetech PRHTemp 2000	(AS-106)
Brüel & Kjær 3630 Calibration platform	(AS-109)

Calibrated by	Checked by	For Chief Executive Officer
R Nel **Metrologist (Technical Signatory)**	**AE Karsten** **Metrologist**	
Date of Issue **16 July 2018**	**Page 1 of 3**	Certificate number **AV\AS-4750**

Your measure of excellence

2 RESULTS

2.1 The following parameters of the sound level meter were calibrated and conformed to the IEC 61672-3: 2006 specifications, class 1:

Indication at the calibration check frequency
(IEC 61672-3 clause 9)

Self-generated noise, microphone installed
(IEC 61672-3 clause 10.1)

A-weighted	(18,9 dB)	U = 0,30 dB

Self-generated noise, electrical
(IEC 61672-3 clause 10.2)

A-weighted	(7,7 dB)	U = 0,30 dB
C-weighted	(8,3 dB)	U = 0,30 dB
Z-weighted	(12,7 dB)	U = 0,30 dB

Acoustical signal tests of a frequency weighting
(IEC 61672-3 clause 11)

125 Hz	U = 0,20 dB
1 kHz	U = 0,20 dB
4 kHz	U = 0,30 dB
8 kHz	U = 0,40 dB

Electrical signal tests of a frequency weighting
(IEC 61672-3 clause 12)

A-weighting	(63 Hz – 16 kHz)	U = 0,12 dB
C-weighting	(63 Hz – 16 kHz)	U = 0,12 dB
Z-weighting	(63 Hz – 16 kHz)	U = 0,12 dB

Frequency and time weightings at 1 kHz
(IEC 61672-3 clause 13) U = 0,12 dB

Level linearity on the reference level range
(IEC 61672-3 clause 14) U = 0,24 dB

Level linearity including the level range control
(IEC 61672-3 clause 15) U = 0,13 dB

Tone burst response
(IEC 61672-3 clause 16)

F time weighting	U = 0,12 dB
S time weighting	U = 0,12 dB
L_{eq}	U = 0,11 dB

Peak C sound level
(IEC 61672-3 clause 17) U = 0,12 dB

Overload indication U = 0,30 dB
(IEC 61672-3 clause 18)

Calibrated by **R Nel** **Metrologist (Technical Signatory)**	Checked by **AE Karsten** **Metrologist**	For Chief Executive Officer
Date of Issue **16 July 2018**	**Page 2 of 3**	Certificate number **AV\AS-4750**

3 REMARKS

3.1 The reported uncertainties of measurement were calculated and expressed in accordance with the BIPM, IEC, ISO, IUPAP, OIML document entitled "A Guide to the Expression of Uncertainty in Measurement" (International Organisation for Standardisation, Geneva, Switzerland, 1993).

3.2 The reported expanded uncertainty of measurement, *U*, is stated as the standard uncertainty of measurement multiplied by a coverage factor of $k = 2$, which for a normal distribution approximates a level of confidence of 95,45 %. The reported expanded uncertainty of measurements is at the reference points.

3.3 Certain of the NMISA certificates are consistent with the capabilities that are included in appendix C of the MRA (Mutual Recognition Arrangement) drawn up by the CIPM. Under the MRA, all participating institutes recognise the validity of each other's calibration and measurement certificates for the quantities and ranges and measurement uncertainties specified in Appendix C. For details see http://www.bipm.org.

3.4 The calibrations were carried out at an ambient temperature of 23 °C ± 2 °C and a relative humidity of 50 %RH ± 20 %RH.

3.5 Only parameters given in 2.1 was calibrated.

3.6 The above statement of conformance is based on the measurement value(s) obtained, extended by the estimated uncertainty of measurement, being within the appropriate specification limit(s).

3.7 The firmware version of the sound measuring device at the time of calibration was: 1.11.2

------------------ *end of certificate* ------------------

Calibrated by	Checked by	For Chief Executive Officer
R Nel **Metrologist (Technical Signatory)**	**AE Karsten** **Metrologist**	
Date of Issue **16 July 2018**	**Page 3 of 3**	Certificate number **AV\AS-4750**

Certificate of Conformance

Private Bag X34, Lynnwood Ridge, Pretoria, 0040
CSIR Campus, Meiring Naude Road, Brummeria, 0184
Calibration office: +27 12 841 4623
Reception: +27 12 841 4152
Fax: +27 12 841 4458
E-mail enquiries: info@nmisa.org

Calibration of:	SOUND CALIBRATOR
Manufacturer:	SVANTEK
Model number:	SV33
Serial number:	43170
Calibrated for:	AIRSHED PLANNING PROFESSIONALS (PTY) LTD Midrand
Calibration procedure:	AV\AS-0008
Period of calibration:	29 May 2018

1 PROCEDURE

The sound calibrator was calibrated according to IEC 60942: 2003 specification.

The results of the measurements are traceable to the national measurement standards.

The following equipment was used:

Brüel & Kjær 2673 preamplifier	(AS-146)
MadgeTech PRHTemp2000	(AS-106)
Brüel & Kjær 3630 Calibration platform	(AS-109)
Brüel & Kjær 4228 Pistonphone	(AS-WSTD-13)
Brüel & Kjær 4192 Pressure Microphone	(AS-WSTD-15)

Calibrated by **R Nel** **Metrologist (Technical Signatory)**	Checked by **H Potgieter** **Metrologist**	For Chief Executive Officer
Date of Issue **29 May 2018**	**Page 1 of 2**	Certificate number **AV\AS-4723**

Your measure of excellence

2 RESULTS

2.1 The following parameters of the sound calibrator were calibrated and conformed to IEC 60942: 2003 specification, class 1:

Frequency (IEC 60942 clause B.3.5) 1 000 Hz	*U* = 0,10 Hz
Sound Pressure Level (IEC 60942 clause B.3.4) 114 dB	*U* = 0,15 dB
Total Distortion (IEC 60942 clause B.3.6)	*U* = 0,10 %

3 REMARKS

3.1 The reported uncertainties of measurement were calculated and expressed in accordance with the BIPM, IEC, ISO, IUPAP, OIML document entitled "A Guide to the Expression of Uncertainty in Measurement" (International Organisation for Standardisation, Geneva, Switzerland, 1993).

3.2 The reported expanded uncertainty of measurement, *U*, is stated as the standard uncertainty of measurement multiplied by a coverage factor of $k = 2$, which for a normal distribution approximates a level of confidence of 95,45 %.

3.3 Certain of the NMISA certificates are consistent with the capabilities that are included in appendix C of the MRA (Mutual Recognition Arrangement) drawn up by the CIPM. Under the MRA, all participating institutes recognise the validity of each other's calibration and measurement certificates for the quantities and ranges and measurement uncertainties specified in Appendix C. For details see http://www.bipm.org.

3.4 The calibrations were carried out at an ambient temperature of 23 °C ± 2 °C and a relative humidity of 50 %RH ± 20 %RH.

3.5 The above statement of conformance is based on the measurement value(s) obtained, extended by the estimated uncertainty of measurement, being within the appropriate specification limit(s).

------------------ *end of certificate* ------------------

Calibrated by	Checked by	For Chief Executive Officer
R Nel **Metrologist (Technical Signatory)**	**H Potgieter** **Metrologist**	
Date of Issue **29 May 2018**	**Page 2 of 2**	Certificate number **AV\AC 4720**

10 Annex C | Noise Field Logs

Field log locations corresponds as follows:

- Site 1 – Bucket 1
- Site 2 – Bucket 2
- Site 3 – Bucket 3
- Site 4 – House 1
- Site 5 – House 2

Sample Description	
Date	3/12/18
Time	12.01
File no	L 112
Source	
Location (coordinates/waypoint name)	Bucket 1 -27,388456 , 22.976018
Sample distance from source	
Size of imaginary box containing source	
Pictures	
Comments/character of noise	

Sample Description	
Date	3/12/18
Time	12:31
File no	L113
Source	Bucket 2
Location (coordinates/waypoint name)	-27.380810, 22.935456
Sample distance from source	
Size of imaginary box containing source	
Pictures	
Comments/character of noise	Cicades, operator 12:40

Sample Description	
Date	3/12/18
Time	12:57
File no	L114
Source	Bucket 3
Location (coordinates/waypoint name)	-27.397532 , 22.766064
Sample distance from source	
Size of imaginary box containing source	
Pictures	
Comments/character of noise	12:58

↳ papers in the wind

Sample Description	
Date	3/12/18
Time	13:43
File no	115
Source	
Location (coordinates/waypoint name)	House 2
Sample distance from source	-27.403929, 22.956295
Size of imaginary box containing source	
Pictures	
Comments/character of noise	Cicadas

Sample Description	
Date	3/12/18
Time	14:11
File no	L116
Source	House 1
Location (coordinates/waypoint name)	~~-27.94364, 22.94~~
Sample distance from source	-27.394364, 22.947685
Size of imaginary box containing source	
Pictures	
Comments/character of noise	Cicadas

11 Annex D | Impact Significance Methodology

Specialists must consider ten rating scales when assessing potential impacts. These include:

- Extent of impact;
- Duration of impact;
- Intensity of impact;
- Status of impact;
- Probability of impact occurring;
- Degree of confidence of assessment;
- Significance of impact;
- Degree to which a resource is lost;
- Degree to which impact can be mitigated; and
- Reversibility of impact.

In assigning significance ratings to potential impacts before and after mitigation specialists are instructed to follow the approach presented below:

1. The core criteria for determining significance ratings are "extent" (Section 0), "duration" (Section 11.2) and "intensity" (Section 11.1). The preliminary significance ratings for combinations of these three criteria are given in Section 11.4.
2. Additional criteria to be considered, which could "increase" the significance rating if deemed justified by the specialist, with motivation, are the following:
   - Permanent / irreversible impacts (as distinct from long-term, reversible impacts);
   - Potentially substantial cumulative effects (see Item 9 below); and
   - High level of risk or uncertainty, with potentially substantial negative consequences.
3. Additional criteria to be considered, which could "decrease" the significance rating if deemed justified by the specialist, with motivation, is the following:
   - Improbable impact, where confidence level in prediction is high.
4. The status of an impact is used to describe whether the impact will have a negative, positive or neutral effect on the surrounding environment. An impact may therefore be negative, positive (or referred to as a benefit) or neutral (Section 11.5).
5. Describe the degree to which a resource is impacted (Section 11.4).
6. Describe the impact in terms of the probability of the impact occurring (Section 11.6) and the degree of confidence in the impact predictions, based on the availability of information and specialist knowledge (Section 11.7).
7. When assigning significance ratings to impacts *after mitigation*, the specialist needs to:
   - First, consider probable changes in intensity, extent and duration of the impact after mitigation, assuming effective implementation of mitigation measures, leading to a revised significance rating; and
   - Then moderate the significance rating after taking into account the likelihood of proposed mitigation measures being effectively implemented. Consider:
     - Any potentially significant risks or uncertainties associated with the effectiveness of mitigation measures;
     - The technical and financial ability of the proponent to implement the measure; and
     - The commitment of the proponent to implementing the measure or guarantee over time that the measures would be implemented.
8. Describe the degree to which an impact can be mitigated or enhanced (Section 11.9) and reversed (Section 11.10).
9. The cumulative impacts of a project should also be considered. "Cumulative impacts" refer to the impact of an activity that may become significant when added to the existing activities currently taking place within the surrounding environment.

10. Where applicable, assess the degree to which an impact may cause irreplaceable loss of a resource. A resource assists in the functioning of human or natural systems, i.e. specific vegetation, minerals, water, agricultural land, etc.

The significance ratings are based on largely objective criteria and inform decision-making at a project level as opposed to a local community level. In some instances, therefore, whilst the significance rating of potential impacts might be "low" or "very low", the importance of these impacts to local communities or individuals might be extremely high. The importance which I&APs attach to impacts must be taken into consideration, and recommendations should be made as to ways of avoiding or minimising these negative impacts through project design, selection of appropriate alternatives and / or management.

The relationship between the significance ratings after mitigation and decision-making can be broadly defined as follows (see below):

Significance rating	Effect on decision-making
INSIGNIFICANT; VERY LOW; LOW	Will not have an influence on the decision to proceed with the proposed project, provided that recommended measures to mitigate negative impacts are implemented.
MEDIUM	Should influence the decision to proceed with the proposed project, provided that recommended measures to mitigate negative impacts are implemented.
HIGH; VERY HIGH	Would strongly influence the decision to proceed with the proposed project.

11.1 Intensity

"Intensity" establishes whether the impact would be destructive or benign.

Rating	Description
ZERO TO VERY LOW	Where the impact affects the environment in such a way that natural, cultural and social functions and processes are not affected.
LOW	Where the impact affects the environment in such a way that natural, cultural and social functions and processes continue, albeit in a slightly modified way.
MEDIUM	Where the affected environment is altered, but natural, cultural and social functions and processes continue, albeit in a modified way.
HIGH	Where natural, cultural and social functions or processes are altered to the extent that it will temporarily or permanently cease.

11.2 Duration

"Duration" gives an indication of how long the impact would occur.

Rating	Description
SHORT-TERM	0 - 5 years
MEDIUM-TERM	5 - 15 years
LONG-TERM	Where the impact will cease after the operational life of the activity, either because of natural processes or by human intervention.
PERMANENT	Where mitigation either by natural processes or by human intervention will not occur in such a way or in such time span that the impact can be considered transient.

11.3 Extent

"Extent" defines the physical extent or spatial scale of the impact.

Rating	Description
LOCAL	Extending only as far as the activity, limited to the site and its immediate surroundings. Specialist studies to specify extent.
REGIONAL	Western Cape. Specialist studies to specify extent.
NATIONAL	South Africa
INTERNATIONAL	

11.4 Loss of Resources

"Loss of resource" refers to the degree to which a resource is permanently affected by the activity, i.e. the degree to which a resource is irreplaceable.

Rating	Description
LOW	Where the activity results in a loss of a particular resource but where the natural, cultural and social functions and processes are not affected.
MEDIUM	Where the loss of a resource occurs, but natural, cultural and social functions and processes continue, albeit in a modified way.
HIGH	Where the activity results in an irreplaceable loss of a resource.

11.5 Status of Impact

The status of an impact is used to describe whether the impact would have a negative, positive or zero effect on the affected environment. An impact may therefore be negative, positive (or referred to as a benefit) or neutral.

11.6 Probability

"Probability" describes the likelihood of the impact occurring.

Rating	Description
IMPROBABLE	Where the possibility of the impact to materialise is very low either because of design or historic experience.
PROBABLE	Where there is a distinct possibility that the impact will occur.
HIGHLY PROBABLE	Where it is most likely that the impact will occur.
DEFINITE	Where the impact will occur regardless of any prevention measures.

11.7 Degree of Confidence

This indicates the degree of confidence in the impact predictions, based on the availability of information and specialist knowledge.

Rating	Description
HIGH	Greater than 70% sure of impact prediction.
MEDIUM	Between 35% and 70% sure of impact prediction.
LOW	Less than 35% sure of impact prediction.

11.8 Significance

"Significance" attempts to evaluate the importance of a particular impact, and in doing so incorporates the above three scales (i.e. extent, duration and intensity).

Rating	Description
VERY HIGH	Impacts could be EITHER: of ***high intensity*** at a ***regional level*** and endure in the ***long term***[2]; OR of ***high intensity*** at a ***national level*** in the ***medium term***; OR of ***medium intensity*** at a ***national level*** in the ***long term.***
HIGH	Impacts could be EITHER: of ***high intensity*** at a ***regional level*** and endure in the ***medium term***; OR of ***high intensity*** at a ***national level*** in the ***short term***; OR of ***medium intensity*** at a ***national level*** in the ***medium term;*** OR of ***low intensity*** at a ***national level*** in the ***long term***; OR of ***high intensity*** at a ***local level*** in the ***long term***; OR of ***medium intensity*** at a ***regional level*** in the ***long term.***
MEDIUM	Impacts could be EITHER: of ***high intensity*** at a ***local level*** and endure in the ***medium term***; OR of ***medium intensity*** at a ***regional level*** in the ***medium term***; OR of ***high intensity*** at a ***regional level*** in the ***short term***; OR of ***medium intensity*** at a ***national level*** in the ***short term***; OR of ***medium intensity*** at a ***local level*** in the ***long term***; OR of ***low intensity*** at a ***national level*** in the ***medium term;*** OR of ***low intensity*** at a ***regional level*** in the ***long term.***
LOW	Impacts could be EITHER of ***low intensity*** at a ***regional level*** and endure in the ***medium term***; OR of ***low intensity*** at a ***national level*** in the ***short term***; OR of ***high intensity*** at a ***local level*** and endure in the ***short term***; OR of ***medium intensity*** at a ***regional level*** in the ***short term***; OR of ***low intensity*** at a ***local level*** in the ***long term***; OR of ***medium intensity*** at a ***local level*** and endure in the ***medium term.***
VERY LOW	Impacts could be EITHER of ***low intensity*** at a ***local level*** and endure in the ***medium term***; OR of ***low intensity*** at a ***regional level*** and endure in the ***short term***; OR of ***low to medium intensity*** at a ***local level*** and endure in the ***short term.***
INSIGNIFICANT	Impacts with: ***Zero to very low intensity*** with any combination of extent and duration.
UNKNOWN	In certain cases it may not be possible to determine the significance of an impact.

[2] For any impact that is considered to be "Permanent" apply the "Long-Term" rating.

11.9 Degree to which an Impact Can Be Mitigated

This indicates the degree to which an impact can be reduced / enhanced.

Rating	Description
NONE	No change in impact after mitigation.
VERY LOW	Where the significance rating stays the same, but where mitigation will reduce the intensity of the impact.
LOW	Where the significance rating drops by one level, after mitigation.
MEDIUM	Where the significance rating drops by two to three levels, after mitigation.
HIGH	Where the significance rating drops by more than three levels, after mitigation.

11.10 Reversibility of An Impact

This refers to the degree to which an impact can be reversed.

Rating	Description
IRREVERSIBLE	Where the impact is permanent.
PARTIALLY REVERSIBLE	Where the impact can be partially reversed.
FULLY REVERSIBLE	Where the impact can be completely reversed.

12 Annex E - Specialist Curriculum Vitae

CURRICULUM VITAE	**HANLIE LIEBENBERG-ENSLIN**

FULL CURRICULUM VITAE

Name of Firm	Airshed Planning Professionals (Pty) Ltd
Name of Staff	Hanlie Liebenberg-Enslin
Profession	Managing Director / Air Quality Scientist
Date of Birth	09 January 1971
Years with Firm/ entity	19 years
Nationalities	South African

MEMBERSHIP OF PROFESSIONAL SOCIETIES

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

KEY QUALIFICATIONS

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

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

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

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

RELEVANT EXPERIENCE

Air Quality Management Plans and Strategies

Provincial Air Quality Management Plan for the Limpopo Province (March 2013); Mauritius Road Development Agency Proposed Road Decongestion Programme (July 2013); Transport Air Quality Management Plan for the Gauteng Province (February 2012); Gauteng Green Strategy (2011); Air Quality and Radiation Assessment for the Erongo Region Namibia as part of a Strategic Environmental Assessment (June, 2010); Vaal Triangle Airshed Priority Area AQMP (March, 2009); Gauteng Provincial AQMP (January 2009); North West Province AQMP (2008); City of Tshwane AQMP (April 2006); North West Environment Outlook 2008 (December 2007); Ambient Monitoring Network for the North West Province (February 2007); Spatial Development Framework Review for the City of uMhlathuze (August 2006); Ambient Particulate Pollution Management System (Anglo Platinum Rustenburg):

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

Mining and Ore Handling

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

Metal Recovery

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

Chemical Industry

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

Petrochemical Industry

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

Pulp and Paper Industry

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

Power Generation

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

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

Waste Disposal

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

Cement Manufacturing

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

Vehicle emissions

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

Government Strategy Projects

Hanlie was the project Director on the APPA Registration Certificate Review Project for Department of Environmental Affairs (DEA); Green Strategy for Gauteng (2011).

EDUCATION

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

ADDITIONAL COURSES AND ACADEMIC REVIEWS

External Examiner (May 2018)	MSc Candidate: Ms A Quta Characterisation of Particulate Matter and Some Pollutant Gasses in the City of Tshwane Department of Environmental Sciences, University of South Africa
External Examiner (December 2017)	MSc Candidate: Ms B Wernecke Ambient and Indoor Particulate Matter Concentrations on the Mpumalanga Highveld Faculty of Natural and Agricultural Sciences, North-West University
External Examiner (January 2016)	MSc Candidate: Ms M Grobler Evaluating the costs and benefits associated with the reduction in SO_2 emissions from Industrial activities on the Highveld of South Africa Department of Chemical Engineering, University of Pretoria
External Examiner (August 2014)	MSc Candidate: Ms Seneca Naidoo Quantification of emissions generated from domestic fuel burning activities from townships in Johannesburg Faculty of Science, University of the Witwatersrand
Air Quality Law– Lecturer (2012 - 2016)	Environmental Law course: Centre of Environmental Management.
Air Quality law for Mining – Lecturer (2014)	Environmental Law course: Centre of Environmental Management.
Air Quality Management – Lecturer (2006 -2012)	Air Quality Management Short Course: NACA and University of Johannesburg, University of Pretoria and University of the North West
ESRI SA (1999)	ARCINFO course at GIMS: Introduction to ARCINFO 7 course
ESRI SA (1998)	ARCVIEW course at GIMS: Advanced ARCVIEW 3.1 course

COUNTRIES OF WORK EXPERIENCE

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

EMPLOYMENT RECORD

March 2003 - Present

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

January 2000 – February 2003

Environmental Management Services CC, Senior Air Quality Scientist.

May 1998 – December 1999

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

February 1997 – April 1998

GIS Business Solutions (PQ Africa), GIS Analyst

January 1996 – December 1996

Annegarn Environmental Research (AER), Student Researcher

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Excellent	Excellent	Excellent

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

- Understanding the Atmospheric Circulations that lead to high particulate matter concentrations on the west coast of Namibia. Hanlie Liebenberg-Enslin, Hannes Rauntenbach, Reneé von Gruenewaldt, and Lucian Burger. Clean Air Journal, 27, 2, 2017, 66-74.

- Cooperation on Air Pollution in Southern Africa: Issues and Opportunities. SLCPs: Regional Actions on Climate and Air Pollution. Liebenberg-Enslin, H. 17th IUAPPA World Clean Air Congress and 9th CAA Better Air Quality Conference. Clean Air for Cities - Perspectives and Solutions. 29 August - 2 September 2016, Busan Exhibition and Convention Center, Busan, South Korea.

- A Best Practice prescription for quantifying wind-blown dust emissions from Gold Mine Tailings Storage Facilities. Liebenberg-Enslin, H., Annegarn, H.J., and Burger, L.W. VIII International Conference on Aeolian Research, Lanzhou, China. 21-25 July 2014.

- Quantifying and modelling wind-blown dust emissions from gold mine tailings storage facilities. Liebenberg-Enslin, H. and Annegarn, H.J. 9^{th} International Conference on Mine Closure, Sandton Convention Centre, 1-3 October 2014.

- Gauteng Transport Air Quality Management Plan. Liebenberg-Enslin, H., Krause,N., Burger, L.W., Fitton, J. and Modisamongwe, D. National Association for Clean Air Annual Conference, Rustenburg. 31 October to 2 November 2012. Peer reviewed.

- Developing an Air Quality Management Plan: Lessons from Limpopo. Bird, T.; Liebenberg-Enslin, H., von Gruenewaldt, R., Modisamongwe, D. National Association for Clean Air Annual Conference, Rustenburg. 31 October to 2 November 2012. Peer reviewed.

- Modelling of wind eroded dust transport in the Erongo Region, Namibia, H. Liebenberg-Enslin, N Krause and H.J. Annegarn. National Association for Clean Air (NACA) Conference, October 2010. Polokwane.

- The lack of inter-discipline integration into the EIA process-defining environmental specialist synergies. H. Liebenberg-Enslin and LW Burger. IAIA SA Annual Conference, 21-25 August 2010. Workshop Presentation. Not Peer Reviewed.

- A Critical Evaluation of Air Quality Management in South Africa, H Liebenberg-Enslin. National Association for Clean Air (NACA) IUAPPA Conference, 1-3 October 2008. Nelspuit.

- Vaal Triangle Priority Area Air Quality Management Plan – Baseline Characterisation, R.G. Thomas, H Liebenberg-Enslin, N Walton and M van Nierop. National Association for Clean Air (NACA) conference, October 2007, Vanderbijl Park.

- Air Quality Management plan as a tool to inform spatial development frameworks – City of uMhlathuze, Richards Bay, H Liebenberg-Enslin and T Jordan. National Association for Clean Air (NACA) conference, 29 – 30 September 2005, Cape Town.

CERTIFICATION

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

26/04/2019

Full name of staff member: Hanlie Liebenberg-Enslin