Environmental Noise Baseline Assessment – Pure Source Mine Project in the Free State

Project done for: **Shango Solutions**

Report prepared by:
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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.
EC	European Commission
EHS	Environmental, Health, and Safety (IFC)
Hz	Frequency in Hertz
IEC	International Electro Technical Commission
IFC	International Finance Corporation
ISO	International Standards Organisation
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_{Aleq} (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)
Ltd	Limited
L_W	Sound Power Level (in dB)
MM5	Fifth-Generation Penn State/NCAR Mesoscale Model
m^3	Cubic metre
m/s	Speed in meters per second
NR	Noise receptor
p	Pressure in Pa
Pa	Pressure in Pascal
µPa	Pressure in micro-pascal
p_{ref}	Reference pressure, 20 µPa
SABS	South African Bureau of Standards

SANS	South African National Standards
SLM	Sound Level Meter
STRM	Shuttle Radar Topography Mission
TSF	Tailings storage facility
UCAR	University Corporation for Atmospheric Research
USGS	United States Geological Survey
WG-AEN	Working Group – Assessment of Environmental Noise (EC)
WHO	World Health Organisation

Executive Summary

The proposed Pure Source Mine Project, located approximately 20 km north-east of Parys in the Free State Province along a stretch of the Vaal river, will involve the development of an open pit sand and gravel mine, topsoil stockpiles, run-of-mine stockpiles, conveyors, mobile crushers, mobile screening plants and product stockpiles. Mined material will be processed in a processing plant comprising a sand washing plant, a sand drying plant, a diamond sorting plant and product stockpiles. Additional associated infrastructure includes change houses, offices, workshops, stores and clean and dirty water management infrastructure.

Noise will be generated by the open pit surface mining and processing activities. Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Shango Solutions to undertake an environmental noise specialist study for the project as part of the Environmental Impact Report (EIR) process. This report outlines the findings of the **baseline** component of the noise specialist study for inclusion in the environmental impact scoping report.

The main objective of the noise specialist study will be to determine the significance of impacts on the acoustic environment and noise receptors (NRs) given noise generated by activities proposed as part of the project. The objective of the baseline component of the study is to identify NRs in the study area, assess the noise propagation and attenuation potential of the study area and to survey and study existing environmental noise levels in the study area. The following was found:

- NRs:
    - Include places of residence and areas where members of the public may be affected by noise generated by proposed activities.
    - NRs within a 2 km radius of the proposed operations include several residences on the both banks of the Vaal river to the west and east of the proposed operations, as well as the residential area of Vaal Oewer to the north of the operations.
- On average, noise impacts are expected to be slightly more notable to the south of the project activities. Terrain may affect noise propagation between sources and NRs by acting as noise barriers.
- The acoustic climate at NRs is currently affected by community activities, music, light vehicle and motorcycle traffic, domesticated animals as well as natural noises such as birds, insects and noise created by the Vaal river.
- Recorded $L_{Req,d}$ at all sampling locations during the daytime survey are similar to those given in SANS 10103 as typical for rural districts (45 dBA). Recorded night-time $L_{Req,n}$ =sampling locations 1, 4 and 5 are typical for rural districts at (35 dBA) as described by SANS 10103. Recorded night time $L_{Req,n}$ at sampling location 2 and 3 are however more akin to those typical for urban districts (45 dBA) as described by SANS 10103.

During the impact assessment phase of the specialist study, all sources of noise associated with the Pure Source Mine will be quantified and noise propagation modelling undertaken using the CadnaA model. Three scenarios have been identified to assess the worst case noise impacts when the mining operations are closest to noise receptor locations. These three scenarios will be for mining operations during years 12, 18 and 29. Contour plots will be generated for the three scenarios and simulated noise levels (both cumulative and increase from baseline) compared to standards and guidelines as described in Section 2. Based on the impact assessment management and mitigation measures will be recommended and suitable monitoring locations identified and recommended.

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1 Introduction

The proposed Pure Source Mine Project is located on portion 3 of the farm Woodlands 407, the remaining extent of portion 1 of the farm Woodlands 407 and the remaining extent of the farm Woodlands 407, located approximately 20 km north-east of Parys in the Free State Province (Figure 1). The properties are located along a stretch of the Vaal river and covers an area of approximately 875 hectares.

The proposed Pure Source Mine Project will involve opencast mining with trucks and shovels, of sand, gravel and possibly diamonds (based on potential established via exploration). Reject material will be backfilled into mined voids and topsoil stockpiles established for rehabilitation. Mined sand will either be screened in the pit or transported by truck to the washing plant. Once the sand is removed the underlying gravel will be exposed and test pits established to ascertain gravel quality and diamond potential. Where appropriate the gravel will be excavated and crushed in the pit by a mobile crusher and then either loaded onto customer's trucks or transported to the plant to extract diamonds. In the areas where there is no silica sand the topsoil will be stripped and stockpiled to expose the underlying aggregate. Where the presence of high yield diamondiferous gravel is anticipated the silica sand will be stockpiled. The sand from the northern pit is expected to be screened and loaded at the location and will be sold as unprocessed sand directly. The sand from the main and east pit is exclusively identified to be beneficiated and sold as specialised sand.

A portion of the mined sand will be beneficiated in a washing plant where it will be washed and dried. The material will be transported from the northern pit via a conveyor system or by dump trucks. Mined aggregates will be crushed in-pit before loading onto customer's vehicles. If diamond potential is established a mobile rotary pan plant will be used as a sampling plant. Concentrate will be conveyed to the final recovery circuit for x-ray and hand sorting. Additional associated infrastructure includes change houses, offices, workshops, stores and clean and dirty water management infrastructure.

Noise will be generated by the open pit surface mining and processing activities. Airshed Planning Professionals (Pty) Ltd (Airshed) was appointed by Shango Solutions to undertake an environmental noise specialist study for the project as part of the Environmental Impact Report (EIR) process. This report outlines the findings of the **baseline** component of the noise specialist study for inclusion in the environmental impact scoping report.

1.1 Study Objective

The main objective of the noise specialist study will be to determine the significance of impacts on the acoustic environment and noise receptors (NRs) given noise generated by activities proposed as part of the project. The objective of the baseline component of the study is to identify NRs in the study area, assess the noise propagation and attenuation potential of the study area and to survey and study existing environmental noise levels in the study area.

1.2 Scope of Work

To meet the objective of the baseline assessment, the following tasks were included in the Scope of Work:

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 NRs from available maps, field observations and information supplied by the client;
    b. A study of environmental noise attenuation potential by referring to available weather records, land use, and topography; and
    c. Determining representative baseline noise levels through the analysis of measured environmental noise levels obtained from an on-site noise survey;
4. The preparation of a comprehensive specialist noise baseline assessment report.

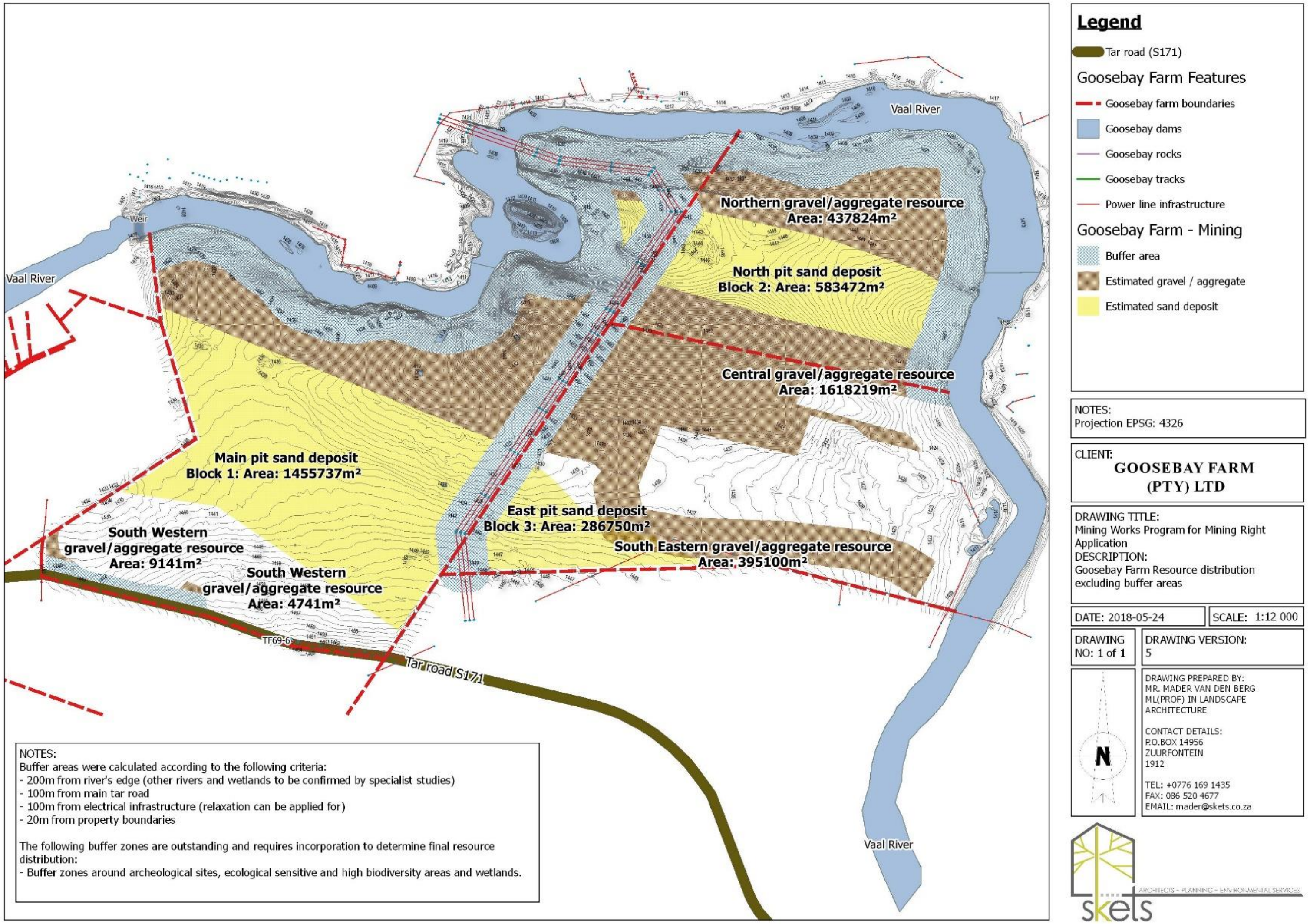

Figure 1: Project location and local setting

1.3 Description of Activities from a Noise Perspective

Construction phase activities will include bulk earthworks (for the establishment of the open pits, stockpiles, conveyors, access routes, water management infrastructure, the washing and drying plant and infrastructure such as offices, change houses and workshops), as well as metal and concrete works for the erection of the processing plant and other infrastructure. The construction phase is expected to take approximately 6 months to complete.

Access to site will be via the Vaal Eden Road (S171) located south of the project area. An access road to the mine will be established at the start of construction and will be utilised throughout the life of the project. Existing dirt roads traverse the property; these may be used in addition to the main access road during the construction phase.

The operational phase of the project will include open pit surface mining using excavators and loaders. Mobile screening plants and mobile crushers will be utilised in the open pit. Gravel and sand not directly trucked to market will be hauled to a processing plant comprising a sand washing plant, a sand drying plant, a diamond sorting plant and product stockpiles. The anticipated mining rates and processing rates are as follows: 810 000 m³ sand per year (from year 3 to year 11) and 740 000 m³ sand per year (from year 12 onwards), 130 000 m³ gravel per year (from year 2 to year 10) and 416 502 m³ gravel per year (from year 11 onwards). Because of the nature of the sand and gravel mine, no drilling or blasting will be conducted. The anticipated life of mine is 30 years.

During decommissioning, bulk earthworks and demolishing activities are expected. Very little information regarding specific activities during 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.

Noise generating sources are very similar for the construction and mining phase of surface mining operations. Noise is emitted by construction equipment used for activities such as land clearing, site preparation, excavation, clean-up, and landscaping. The same types of equipment (diesel mobile equipment) will be used for the liberation, excavation, handling and transport of mined sand, gravel and diamond gravel.

Construction and diesel mobile mining equipment can be described or divided into distinct categories. These are 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).

Construction and 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 mine construction and surface mining activities is highly variably since it is characterised by variations in the power expended by equipment. Besides having daily variations in activities, the mining operations will be conducted in different phases and different locations where each phase has a specific equipment mix depending on the work to be accomplished during that phase.

Sound fields in an industrial setting such as an operational 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 will include crushers; screens; grizzly feeders; feed hoppers; flotation and thickener cells; 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.

Employee transport (20 to 50 construction workers and 30 to 80 full time employees) and the export of product via road, may further add to noise levels. The impact of these are however generally minimal because of its intermittent nature.

Mining operations will take place on a 5.5-day work week with a two-shift system, operating hours will be from 6:00 to 18:00. Diamond sorting alone will be operating 24 hours per day with a 6-day work week.

1.4 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).*

1.4.1 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).

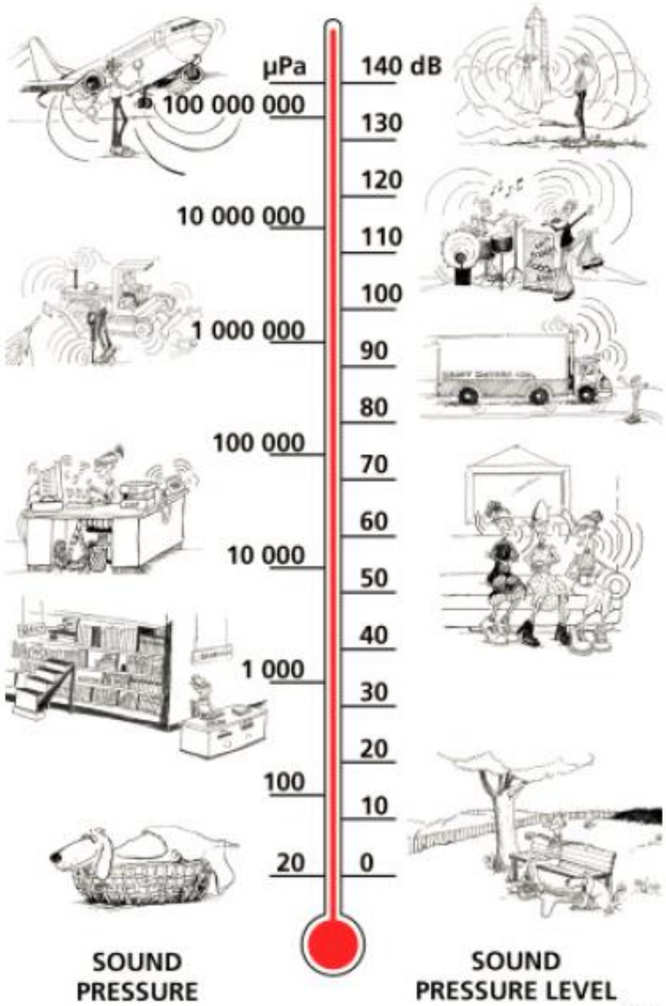

Figure 2: The decibel scale and typical noise levels (Brüel & Kjær Sound & Vibration Measurement A/S, 2000)

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 3, page 8). "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.

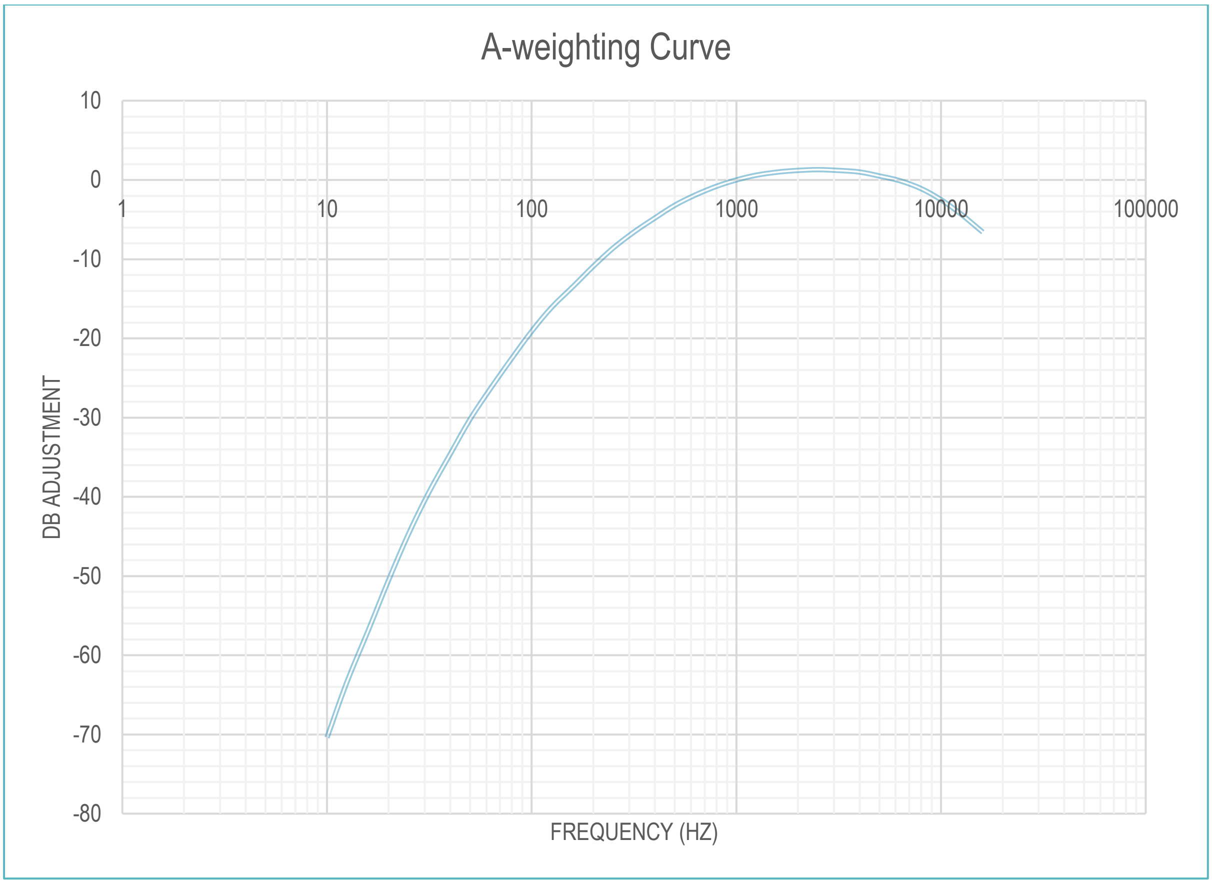

Figure 3: A-weighting curve

1.4.3 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).

1.4.4 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).

1.4.5 Environmental Noise Indices

In assessing environmental noise either by measurement or calculation, reference is 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 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

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 will focus on the estimation of L_W's (noise 'emissions') and L_P's (noise impacts) associated with the operational phase. The findings of the impact assessment component will inform recommendations of management measures, including mitigation and monitoring. Individual aspects of the noise impact assessment methodology are discussed in more detail below.

1.5.1 Study of the Receiving Environment

NRs 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 included in the assessment as NRs were identified from available maps and satellite imagery.

The ability of the environment to attenuate noise as it travels through the air was studied by considering local meteorology, land use, and terrain data. Atmospheric attenuation potential was described based on a simulated MM5[1] data set for an on-site location. Data for the 2015 to 2017 period was considered.

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.

1.5.2 Data Analysis

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 can integrate 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 $L_{Req,T}$.

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. **Note however that the method described in SANS 10103 is only recommended if there is uncertainty as to the presence of pitch and is considered a recommendation, not a requirement. The correction is predominantly the result of the subjective opinion of the specialist.**

[1] The MM5 (short for Fifth-Generation Penn State/NCAR Mesoscale Model) is a regional mesoscale model used for creating weather forecasts and climate projections. It is a community model maintained by Penn State University and the National Centre for Atmospheric Research. The MM5 is a limited-area, terrain-following sigma coordinate model that is used to replicate or forecast mesoscale and regional scale atmospheric circulation (UCAR, 2015).

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 1 to indicate the presence of a tonal component.

NOTE: the adjustment for tonality was only applied if the tone was clearly identifiable as being generated by human activities and not birds or insects.

Table 1: 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.

NOTE: If no tonal correction is made, L_{Aleq} is equivalent to $L_{Req,T}$.

1.5.3 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 survey was studied to determine current noise levels within the area. Measurement locations were selected to be representative of the general noise climate and noise levels at nearby NRs.

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

- The survey was designed by a trained specialist.
- Measurements were 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 will tested with a portable acoustic calibrator before and after each measurement session.
- Baseline measurements, 30 minutes in duration (15 minutes for night-time measurements), representative and sufficient for statistical analysis, were taken with the use of the portable SLM capable of logging data continuously over the time. Measurements representative of the day- and night-time conditions were taken. The IFC defines day-time as between 07:00 and 22:00, and night-time between 22:00 and 07:00.
- As generally recommended, the following acoustic indices were recoded: L_{Zeq} (T), L_{Aeq} (T), L_{AIeq} (T); L_{AFmax}; L_{AFmin}; statistics and 3rd octave frequency spectra.
- The SLM was located approximately 1.5 m above the ground and at least 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. A detailed field log and record was kept (Annex B).

Table 2: SLM details

Equipment	Serial Number	Purpose	Calibration Date
Brüel & Kjær Type 2250 Lite SLM	S/N 2731851	Attended 30-minute sampling.	10 May 2017
Brüel & Kjær Type 4950 ½" Pre-polarized microphone	S/N 2709293	Attended 30-minute sampling.	10 May 2017
SVANTEK SV33 Class 1 Acoustic Calibrator	S/N 57649	Testing of the acoustic sensitivity before and after each daily sampling session.	10 May 2017
Kestrel 4000 Pocket Weather Tracker	S/N 559432	Determining wind speed, temperature and humidity during sampling.	Not Applicable

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 World Health Organisation (WHO) guidelines for Community Noise (WHO, 1999). It should be noted that the values given in Table 3 (page 13) 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 as per SANS 10103

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'. 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'.

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 Gauteng Noise Control Regulations

The 1992 Noise Control Regulations (The Republic of South Africa, 1992) published in terms of Section 25 of the Environment Conservation Act (Act no. 73 of 1989) defines a "disturbing noise" as a noise level which exceeds the zone sound level or, if no zone sound level has been designated, a noise level which exceeds the ambient sound level at the same measuring point by 7 dBA or more.

In Gauteng, the 1992 Noise Control Regulations were replaced by the Gauteng Noise Control Regulations in 1999 (The Gauteng Provincial Government, 1999). It defines "controlled" areas as areas where calculations or measurements over 24-hours indicate noise levels in exceedance of 60 dBA. It defines a "disturbing noise" as a noise level that causes the ambient noise level to rise above the designated zone level, or if no zone level has been designated, the typical rating levels for ambient noise in districts, as per SANS 10103 (2008).

2.3 International Finance Corporation 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. It 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). It is understood that these guidelines, or noise levels at the guideline levels, are largely related to nuisance impacts and not health impacts. 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.

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

3 Description of the Receiving Environment

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

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

3.1 Noise Sensitive Receptors

NRs generally include places of residence and areas where members of the public may be affected by noise generated by proposed activities. Only those within a 2 km radius of activities are likely to be affected.

NRs within a 2 km radius of the Pure Source Mine Project (Figure 4) include several residences on the both banks of the Vaal river to the west and east of the proposed operations, as well as the village of Vaal Oewer to the north of the operations.

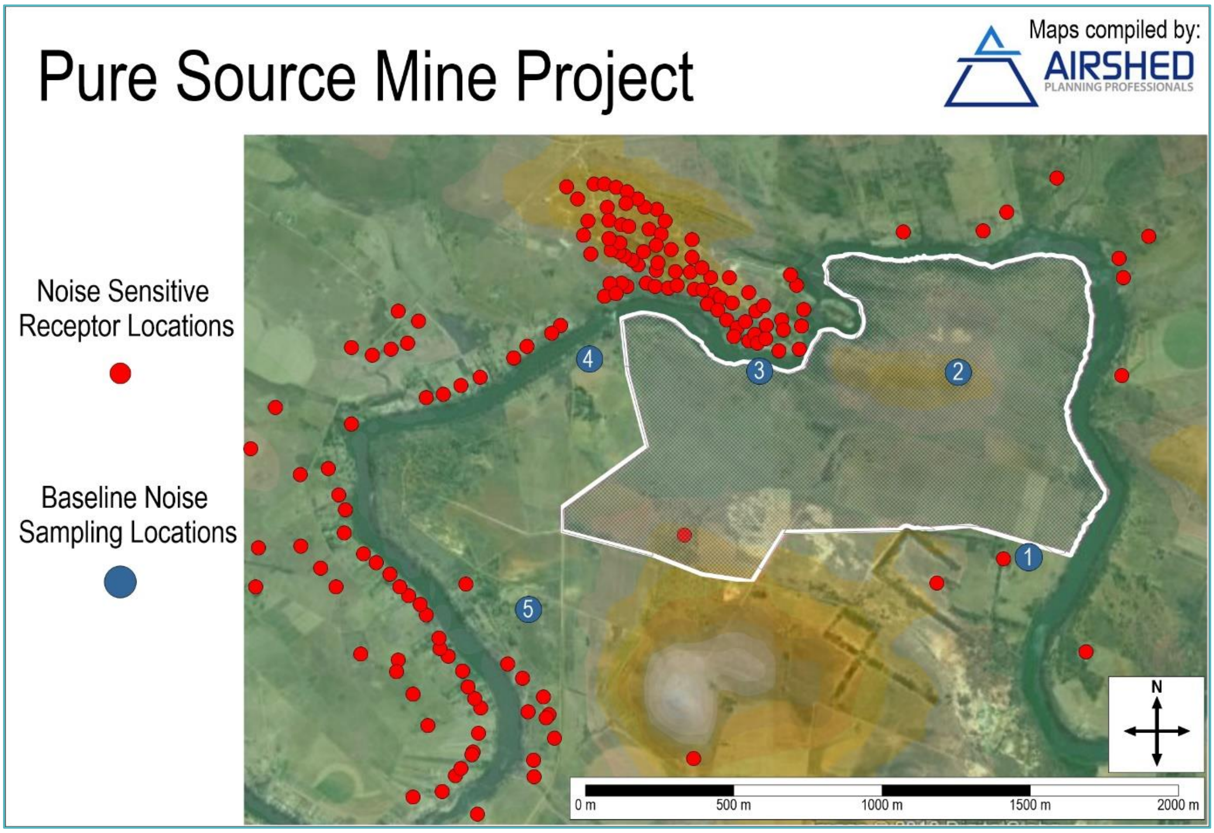

Figure 4: Environmental noise impact study area, NRs, and baseline noise measurement sites

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 1.4.4). 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.

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 wind field of an area can be presented using wind roses. Wind roses represent wind frequencies for the 16 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.

(a) Day-time wind field (07:00 to 22:00)	**(b) Night-time wind field (22:00 to 07:00)**

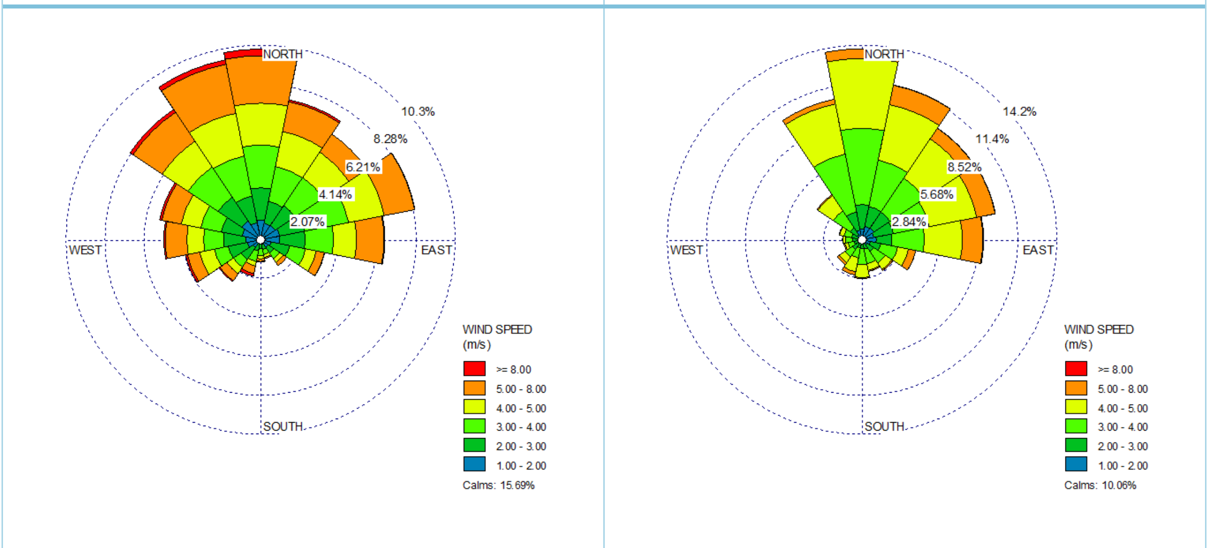

Figure 5: Day- and night-time wind field showing dominant northerly winds (MM5, 2014 to 2016)

MM5 data for the study area indicates a wind field dominated by winds from the northern sector during the day- and night (Figure 5), with very little wind from the south. Day- and night-time average wind speeds are 3.2 m/s and 3.3 m/s respectively. Calm conditions occur 15.7% of time during the day 10.0% during the night. The average temperature in the study area over the three-year period was 17.2°C and the average humidity 62%. Noise impacts are expected to be slightly more notable to the south of the project activities.

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.

3.2.2 Terrain, Ground Absorption and Reflection

Noise reduction caused by a barrier (i.e. natural terrain, installed acoustic barrier, building) 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). The terrain of the study area is shown in Figure 6. The noise impact study area is located between 1400 and 1500 meters above sea level (masl).

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, only somewhat conducive to noise attenuation.

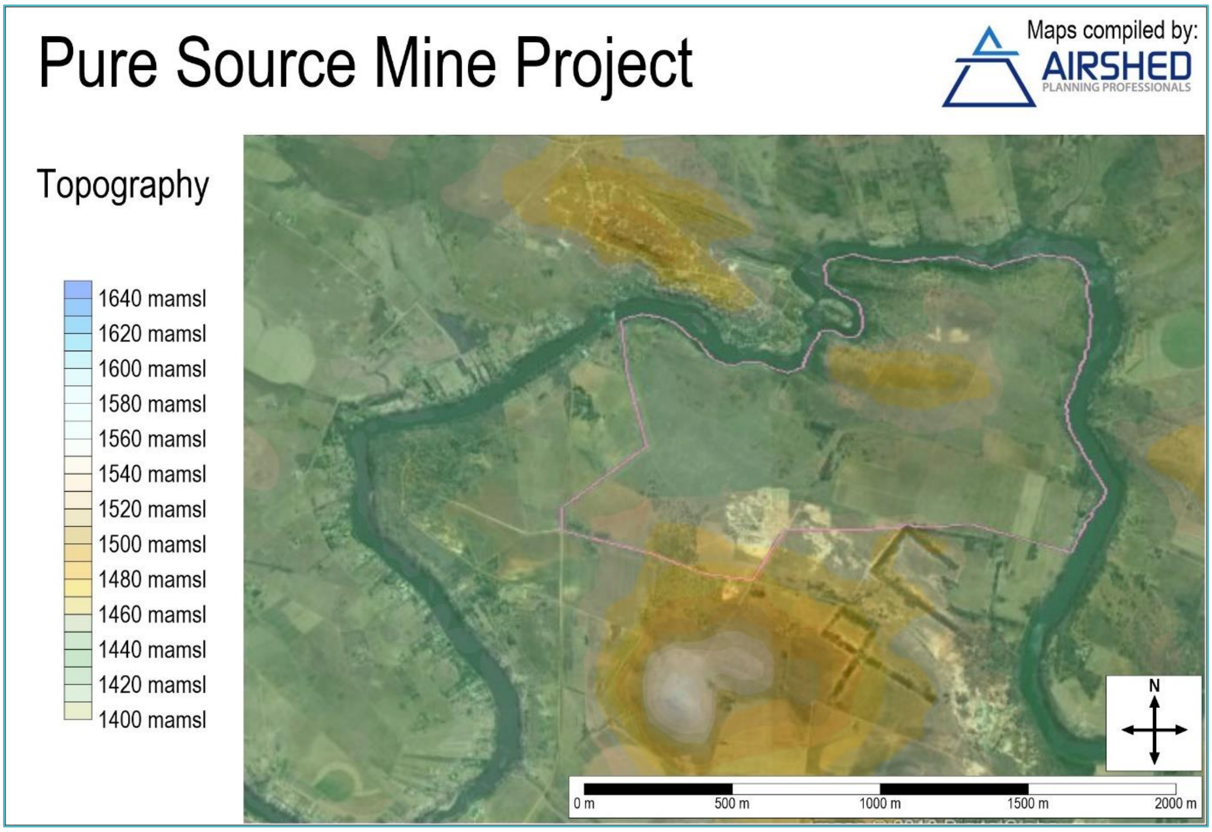

Figure 6: Topography of the local study area

3.3 Noise Survey and Results

Day- and night-time noise measurements were conducted at the five locations shown in Figure 4 (page 15). Survey sites were selected taking into consideration existing and proposed activities, NRs, accessibility and safety.

During the day-time survey, temperatures ranged between 27.3°C and 31.0°C, with 5% to 70% cloud cover. Winds were between 0 m/s and 1.7 m/s and from a north-north-easterly and south-south-easterly direction. Humidity was between 32.5% and 49.6%. At night, temperatures ranged between 15.1°C and 18.4°C, mostly with clear skies and calm wind conditions.

Acoustic observations made during the survey are summarised in Table 5 and Table 6. The acoustic climate at NRs is currently affected by community activities, vehicle traffic, domesticated animals as well as natural noises such as birds, insects and the Vaal river. Additionally, a mining operation to the west of the project location contributes to baseline noise levels on the west of the study area.

$L_{Req,d}$ at all sampling locations during the daytime survey are similar to those given in SANS 10103 as typical for rural districts (45 dBA). The $L_{Req,n}$ at sampling locations 1, 4 and 5 are typical for rural districts at night-time (35 dBA) as described by SANS 10103. Night-time $L_{Req,n}$ at sampling location 2 and 3 are however more akin to those typical for urban districts (45 dBA). According to the account of the SLM operator, birds and antelope (possibly disturbed by the SLM operator), as well as the Vaal river to the north, were the main source of audible noise at sampling location 2 during the night-time survey. The main sources of audible noise at sampling location 3 during the night-time survey were birds, insects, barking dogs in the Vaal Oewer residential area, as well as splashes and water noise from the Vaal river. An analysis of the frequency spectra (Figure 9 and Figure 10) for each sampling location shows a very high contribution in the high frequency (12.5 and 16kHz) bands at sampling location 3 during the night, indicative of insect noise.

Logged broadband results are shown in Figure 7 for the daytime survey and in Figure 8 for the night-time survey.

Table 5: Baseline noise measurement survey results – Comparison to SANS 10103

Site	Day/night	Day-time	Night-time
	$L_{R,dn}$ (dBA)	$L_{Req,d}$ (dBA)	$L_{Req,n}$ (dBA)
1	43.7	39.8	36.3
2	52.2	39.4	45.8
3	53.3	41.0	47.0
4	42.3	39.3	34.6
5	43.4	39.8	35.9

Table 6: Baseline noise measurement survey details and broadband results

Site	Description	Coordinates	Local Start Time	Duration	Noise Climate	L_{AFmax} (dBA)	L_{Aleq} (dBA)	L_{A90} (dBA)
Day-time								
Site 1	SE	26° 45.296'S 27° 37.596'E	13:15	30 min	Birds, insects, air traffic, agricultural vehicles	52.3	39.8	24.2
Site 2	NE	26° 44.575'S 27° 37.280'E	14:45	30 min	Birds, insects, road vehicles (north of river)	56.9	39.4	24.0
Site 3	N	26° 44.527'S 27° 36.100'E	16:00	30 min	Birds, insects, community noise, dogs, road traffic	57.0	41.0	31.1
Site 4	NW	26° 44.512'S 27° 35.320'E	11:48	30 min	Birds, insects, dogs, mining, electrical equipment	84.0	39.3	29.9
Site 5	SW	26° 45.701'S 27° 34.985'E	12:43	30 min	Birds, insects, air traffic	51.9	39.8	28.5
Night-time								
Site 1	SE	26° 45.296'S 27° 37.596'E	1:27	15 min	Birds, insects, river	51.8	36.3	31.1
Site 2	NE	26° 44.575'S 27° 37.280'E	2:00	15 min	Birds, insects, road traffic, alarms, dogs, animals	56.3	45.8	31.5
Site 3	N	26° 44.527'S 27° 36.100'E	2:41	15 min	Birds, insects, dogs, river	78.8	47.0	33.2
Site 4	NW	26° 44.512'S 27° 35.320'E	3:28	15 min	Birds, insects, river, electrical equipment	43.9	34.6	30.6
Site 5	SW	26° 45.701'S 27° 34.985'E	3:56	15 min	Birds, insects, dogs, river	56.1	35.9	23.7

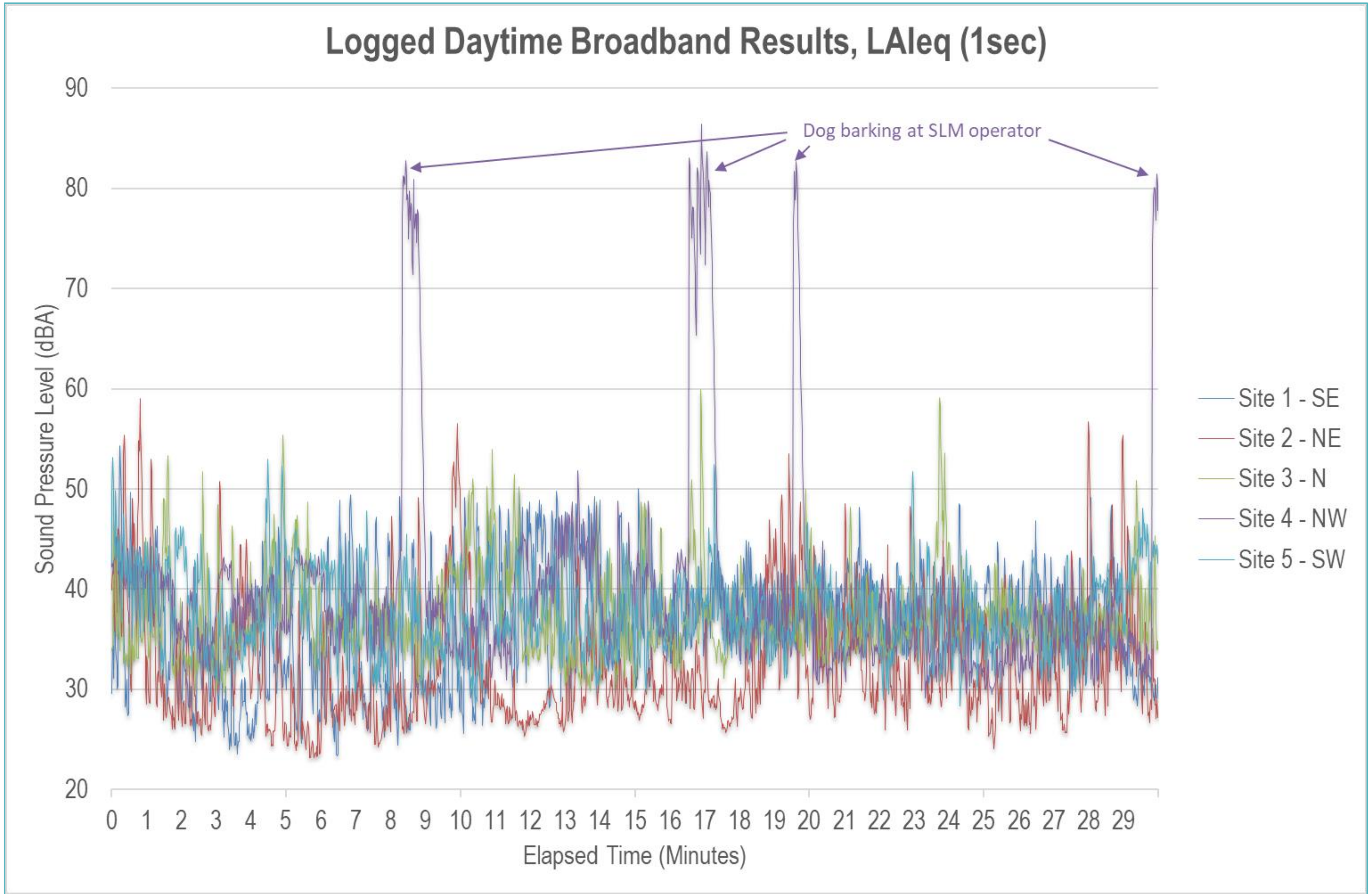

Figure 7: Logged Daytime Broadband Results

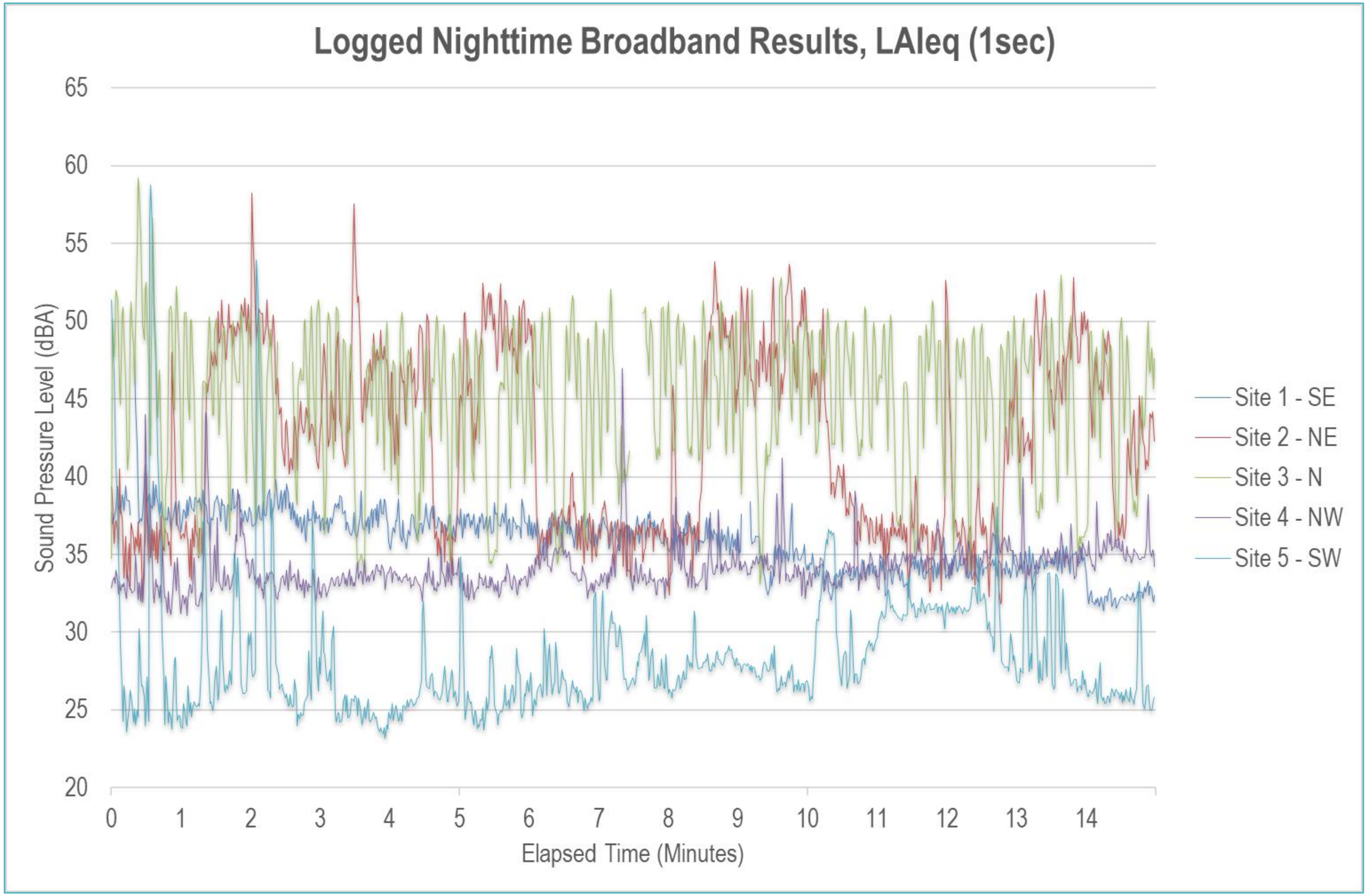

Figure 8: Logged Night-time Broadband Results

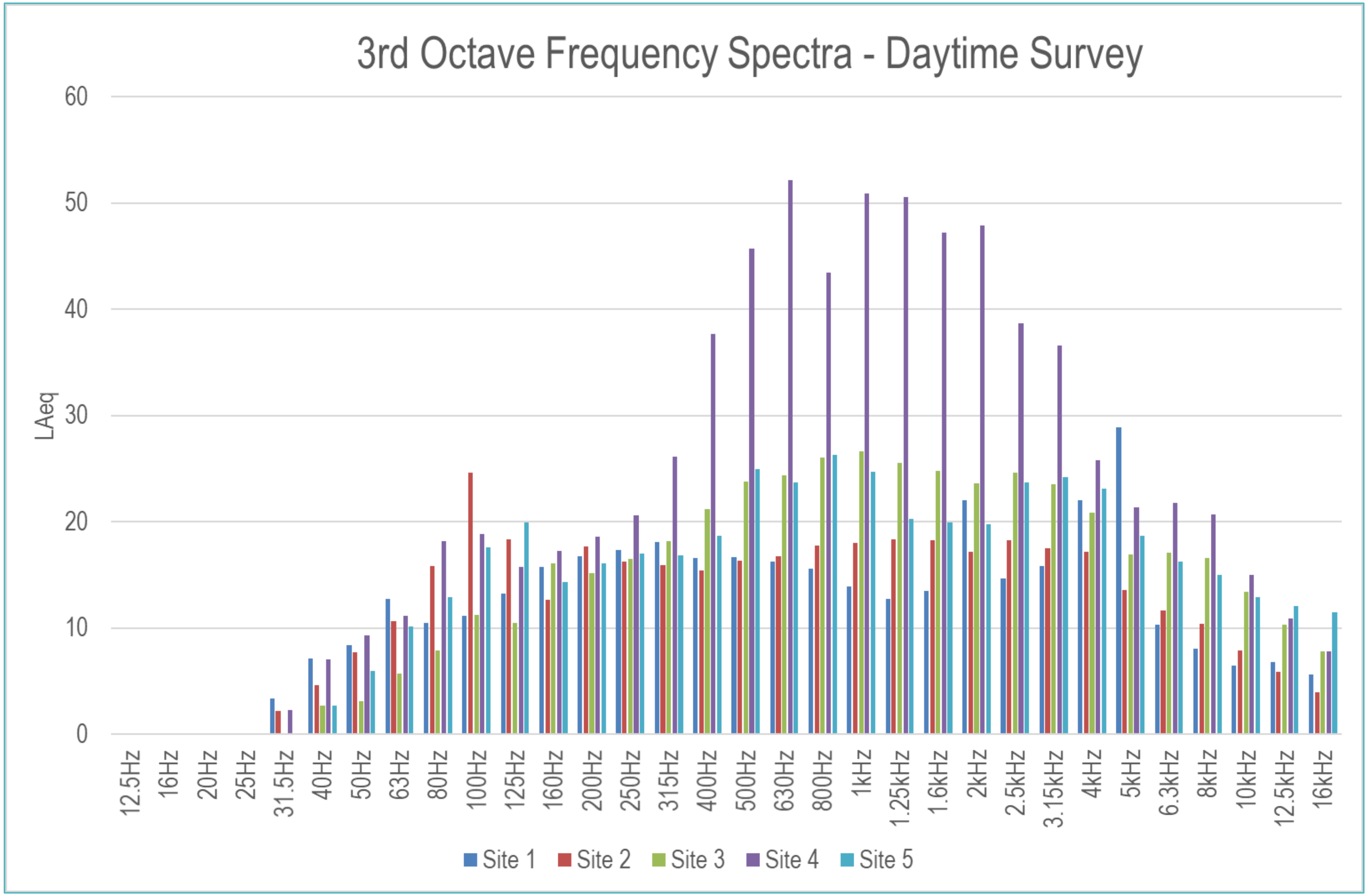

Figure 9: Daytime Frequency Spectra

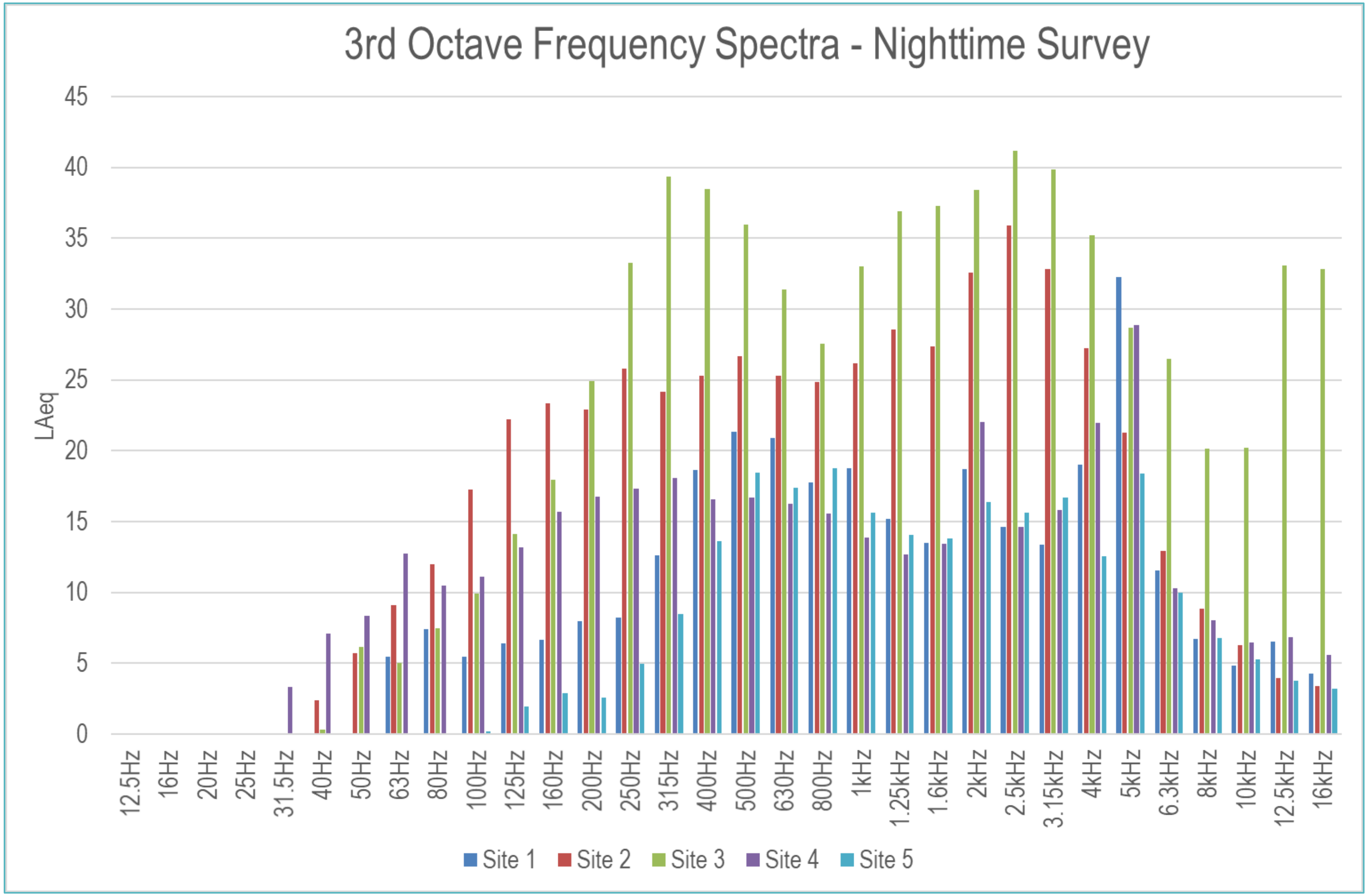

Figure 10: Nighttime Frequency Spectra

4 References

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5 Annex A – Noise Survey Photographs

Site 1

Facing East

Facing West

Facing North

Facing South

<table>
<tr><th colspan="2">Site 2</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Facing East</td><td>Facing West</td></tr>
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Site 3	
	
Facing East	Facing West
	
Facing North	Facing South

<table>
<tr><th colspan="2">Site 4</th></tr>
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<tr><td>Facing North</td><td>Facing South</td></tr>
</table>

Site 5	
	
Facing East	Facing West
	
Facing North	Facing South

6 Annex B – Sound Level Meter Calibration Certificates

nmisa
National Metrology Institute of South Africa

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

Certificate of Conformance

Calibration of:	SOUND LEVEL METER, OCTAVE BAND FILTER, THIRD OCTAVE BAND FILTER & MICROPHONE
Manufacturer:	BRÜEL & KJÆR
Model number:	2250-L, 4950
Serial number:	2731851, 2709293
Calibrated for:	AIRSHED PLANNING PROFESSIONALS (PTY) LTD Midrand
Calibration procedure:	AV\AS-0007 AV\AS-0010
Period of calibration:	10 – 11 May 2017

1 PROCEDURE

The sound level meter was electrically calibrated according to the relevant clauses of SANS 656 and 658 specifications. The microphone with the sound level meter was acoustically calibrated according to the relevant clauses of SANS 656 specifications. The instrument complete with filters was electrically calibrated according to IEC 61260 specification.

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

The following equipment was used:

Brüel & Kjær 4226 Multi-function calibrator	(AS-52)
Inline Capacitor	(AS-98)
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)**	**H Potgieter** **Metrologist**	
Date of Issue **11 May 2017**	**Page 1 of 3**	Certificate number **AV\AS-4634**

Your measure of excellence

CALIBRATION OF A SOUND LEVEL METER, OCTAVE BAND FILTER,
THIRD OCTAVE BAND FILTER & MICROPHONE
(2731851, 2709293)

2 RESULTS

2.1 The following parameters of the sound level meter were calibrated and conformed to the SANS 656 and SANS 658 specifications, type 1:

Indication under reference conditions (SANS 656 clause 11.2)		*U* = 0,20 dB
Electrical self generated noise		
A-weighted	(12,9 dB)	*U* = 0,30 dB
C-weighted	(13,7 dB)	*U* = 0,30 dB
Linear	(19,2 dB)	*U* = 0,30 dB
Linearity range (primary indicator range) (SANS clause 9.9, table 11)		
1 kHz		*U* = 0,12 dB
4 kHz		*U* = 0,12 dB
8 kHz		*U* = 0,12 dB
Frequency Weightings (SANS 656 clauses 8.1, 11.2, tables 4 & 5)		
A-weighting	(25 Hz – 16 kHz)	*U* = 0,12 dB
C-weighting	(25 Hz – 16 kHz)	*U* = 0,12 dB
Linear	(25 Hz – 16 kHz)	*U* = 0,12 dB
Time weightings (SANS 656 clauses 9.2, 9.3, 9.5, 11.4, table 9, 7 & 10)		
Slow and Fast		*U* = 0,11 dB
Impulse		*U* = 0,11 dB
Peak		*U* = 0,09 dB
Time averaging, L_{Aeq} (SANS 658 clause 11.3.3, table 4)		*U* = 0,12 dB
Impulse weighted time averaging, L_{AIeq} (SANS 658 Annex C, table C1)		*U* = 0,12 dB
Overload indication (SANS 656 clause 11.3)		*U* = 0,31 dB

2.2 The following parameter of the microphone with the sound level meter were calibrated and conformed to the SANS 656 specifications, type 1:

Frequency response (SANS 656 clauses 8.1, tables 4 & 5)	
31,5 Hz – 12,5 kHz	*U* = 0,20 dB @ 1 kHz

Calibrated by **R Nel** **Metrologist (Technical Signatory)**	Checked by **H Potgieter** **Metrologist**	For Chief Executive Officer
Date of Issue **11 May 2017**	**Page 2 of 3**	Certificate number **AV\AS-4634**

2.3 The following parameter of the octave band filter was calibrated and conformed to the IEC 61260 specification, class 0 base 2:

Relative attenuation — U = 0,10 dB @ f_m
(IEC 61260 clause 4.4, 5.3)
16 Hz - 8 kHz

2.4 The following parameter of the third octave band filter was calibrated and conformed to the IEC 61260 specification, class 0 base 2:

Relative attenuation — U = 0,10 dB @ f_m
(IEC 61260 clause 4.4, 5.3)
12,5 Hz - 16 kHz

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, 2.2, 2.3 and 2.4 were 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 versions of the sound measuring device at the time of calibration were: BZ7130 V4.4; BZ7131 V4.4; BZ7132 V4.4.

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

Calibrated by	Checked by	For Chief Executive Officer
R Nel **Metrologist (Technical Signatory)**	**H Potgieter** **Metrologist**	
Date of Issue **11 May 2017**	**Page 3 of 3**	Certificate number **AV\AS-4634**

7 Annex D – Specialist CV

CURRICULUM VITAE

Name	Nick Brian Grobler
Date of Birth	14 August 1986
Nationality	South African
Employer	Airshed Planning Professionals (Pty) Ltd
Position	Senior Air Quality Specialist
Profession	Chemical Engineer employed as an Air Quality Specialist
Years with Firm	6 Years

MEMBERSHIP OF PROFESSIONAL SOCIETIES

- Institution of Chemical Engineers (IChemE) – Associate Member – 2014 to present.
- Golden Key International Honour Society - 2011 to present.

EXPERIENCE

- Emissions inventory compilation
- Meteorological, topographical and land use data processing and preparation
- Dispersion modelling experienced in SCREEN, AERMOD, ADMS, CALPUFF and HAWK dispersion models.
- Impact and compliance assessment
- Air quality and dust management plan preparation
- Air quality monitoring program design and implementation
- Air quality monitoring set-up, training and processing of: dustfallout, PM_{10}, $PM_{2.5}$, SO_2, NO_2, H_2S, O_3, NH_3, HCl, VOCs, BTEX, CO, CO_2, CH_4, PAHs as well as meteorological station setup
- Environmental noise monitoring
- Atmospheric emission license application
- Industry sectors in which experience have been gained with specific reference to air quality include:
    - Opencast and underground mining of: copper, platinum, chrome, gold, iron, coal, limestone, potash, lead and zinc.
    - Production of: copper, platinum, gold, base metals, iron, coal, heavy mineral sands, vanadium, solder, lime, gypsum, asphalt, acetylene, vegetable oil, fertilizer, wood pulp, cement, oil recycling, tyre pyrolysis as well as meat processing and rendering at abattoirs and animal waste incineration.

Page 1 of 3

SOFTWARE PROFICIENCY

- Atmospheric Dispersion Models: AERMOD, ISC, CALPUFF, ADMS (United Kingdom), HAWK, TANKS
- Other: Golden Software Surfer, Lakes Environmental WRPlot, MS Word, MS Excel, MS PowerPoint, Adobe Dreamweaver

EDUCATION

- BEng (Chemical Engineering) University of Pretoria – Completed in 2009
- BEng (Hons) (Environmental Engineering) University of Pretoria – Completed in 2010

COURSES COMPLETED

- Spreadsheets as an Engineering Tool, Presented by the University of Pretoria, RSA (September 2012)

COURSES PRESENTED

- NWU Centre for Environmental Management Essential Air Quality Management Course

COUNTRIES OF WORK EXPERIENCE

South Africa, Zimbabwe, Namibia, Mozambique, Zambia, Democratic Republic of Congo, Republic of Congo, Ghana, Mali, Guinea, Saudi Arabia

LANGUAGES

Language	Proficiency
English	Full proficiency
Afrikaans	Full proficiency

REFERENCES

Name	Position	Contact Number
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Dr Lucian Burger	Director at Airshed Planning Professionals	+27 (82) 491 0385 lucian@airshed.co.za
Dr. Hanlie Liebenberg Enslin	Managing Director at Airshed Planning Professionals	+27 (83) 416 1955 hanlie@airshed.co.za

CERTIFICATION

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

17/08/2017

Page 3 of 3