NOISE SPECIALIST STUDY:
Proposed Glass Bottle Manufacturing Facility
Vereeniging, Gauteng

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

Report compiled by:
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Report Details

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Revision Record

Version	Date	Comments
Rev 0	June 2018	For client review
Rev 0.1	June 2018	Incorporation of client's comments
Rev 0.2	September 2018	Incorporation of client's comments

NEMA Regulation (2014), Appendix 6

NEMA Regulations (2014) - Appendix 6	**Relevant section in report**
Details of the specialist who prepared the report.	Report details (page i)
The expertise of that person to compile a specialist report including curriculum vitae.	Section 1.3: Specialist Details Appendix B
A declaration that the person is independent in a form as may be specified by the competent authority.	Report details (Executive Summary)
An indication of the scope of, and the purpose for which, the report was prepared.	Introduction and background (Executive Summary) Section 1.3: Specialist Details
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Section 3.3: Baseline Noise Survey and Results
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 1.6: Approach and Methodology
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 3.1: Noise Sensitive Receptors
An identification of any areas to be avoided, including buffers.	Not applicable
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Section 3.1: Noise Sensitive Receptors
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.7: Limitations and Assumptions
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment.	Section 4.2: Noise propagation and simulated noise levels
Any mitigation measures for inclusion in the environmental management programme report	Section 5: Management Measures
Any conditions for inclusion in the environmental authorisation	Section 5: Management Measures
Any monitoring requirements for inclusion in the environmental management programme report or environmental authorisation.	Section 5: Management Measures
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Section 7: Conclusion
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 5: Management Measures
A description of any consultation process that was undertaken during the course of carrying out the study.	Not applicable.
A summary and copies if any comments that were received during any consultation process.	No comments received.
Any other information requested by the competent authority.	Not applicable.

Glossary and Abbreviations

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

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

Executive Summary

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by SLR Consulting (South Africa) (Pty) Ltd (SLR) to undertake a specialist environmental noise impact study for a proposed facility which intends to manufacture 920 tonnes per day of glass containers using two production lines for the two glass colour variants: amber and green (hereafter referred to as the project). The proposed location is near Lager Street, Vereeniging, on Portion 238 of the farm Leeuwkuil 596 IQ, Gauteng.

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

1. A review of available technical project information.
2. A review of the legal requirements and applicable environmental noise guidelines.
3. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of NSRs from available maps and field observations;
    b. A study of environmental noise attenuation potential by referring to available weather records, land use and topography data sources; and
    c. Determining representative baseline noise levels through the analysis of sampled environmental noise levels obtained from surveys conducted on 21 November 2017.
4. An impact assessment, including:
    a. The establishment of a source inventory for proposed activities.
    b. Noise propagation simulations to determine environmental noise levels as a result of the project.
    c. The screening of simulated noise levels against environmental noise criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. The preparation of a comprehensive specialist noise impact assessment report.

In the assessment of simulated noise levels, reference was made to the IFC noise level guidelines for residential, institutional and educational receptors (55 dBA during the day and 45 dBA during the night) which is also in line with the SANS 10103 rating for urban districts. For industrial areas reference was made to IFC noise level guidelines for industrial sites (70 dBA during the day and night), in line with SANS 10103 day and day/night rating for industrial sites.

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

- The closest NSRs include a pre-school, industrial operations, a Correctional Services facility and residential areas.
- Birds, insects and vehicles are the main contributors to the baseline acoustic environment of the area.
- The lowest baseline noise levels (as measured during the survey) was 47.7 dBA during the day and 45.3 dBA during the night.

Noise levels for various activities at the project site were provided by the proponent. Noise emissions from diesel powered mobile equipment were estimated using L_W predictions for industrial machinery (Bruce & Moritz, 1998), where L_W estimates are a function of the power rating of the equipment engine.

The source inventory, local meteorological conditions and information on local land use were used to populate the noise propagation model (CadnaA, ISO 9613). The propagation of noise was calculated over an area of 5.4 km east-west by 5.3 km north-south. The area was divided into a grid matrix with a 50-m resolution and NSRs were included as discrete receptors.

The main findings of the impact assessment are:

- A management and mitigation plan are recommended to minimise noise impacts from the project on the surrounding area.
- The noise levels from the project operations exceed the selected noise criteria up to a distance of 300 m for day-time activities and up to 1800 m for night-time activities. According to SANS 10103 (2008); the predicted increase in noise levels are expected to result in 'little' to 'sporadic' reaction from the pre-school, and Correctional Services during the day and from Correctional Services and Roods Gardens AH during the night. 'Strong' community reaction is expected from the from the informal livestock fairgrounds during the day and night.
- Construction and closure phase impacts are expected to be similar or slightly lower than simulated noise impacts of the operational phase.

The following key recommendations should be included in the project environmental management programme:

- A monitoring programme as per the requirements of the International Finance Corporation (IFC) and SANS 10103:
    - Annually during the operational phase at the pre-school (~300m north of the project site) and at the staff accommodation at the Correctional Services; and
    - In response to complaints received.

Based on the findings of the assessment and provided the recommended management and mitigation measures are in place, it is the specialist opinion that the project may be authorised.

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1 Introduction

Airshed Planning Professionals (Pty) Ltd (Airshed) was commissioned by SLR Consulting (South Africa) (Pty) Ltd (SLR) to undertake a specialist environmental noise impact study for a proposed facility which intends to manufacture 920 tonnes per day of glass containers using two production lines for the two glass colour variants: amber and green (hereafter referred to as the project). The proposed location is near Lager Street, Vereeniging, on Portion 238 of the farm Leeuwkuil 596 IQ, Gauteng.

1.1 Study Objective

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

1.2 Scope of Work

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

1. A review of available technical project information.
2. A review of the legal requirements and applicable environmental noise guidelines.
3. A study of the receiving (baseline) acoustic environment, including:
    a. The identification of NSRs from available maps and field observations;
    b. A study of environmental noise attenuation potential by referring to available weather records, land use and topography data sources; and
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    a. The establishment of a source inventory for proposed activities.
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    c. The screening of simulated noise levels against environmental noise criteria.
5. The identification and recommendation of suitable mitigation measures and monitoring requirements.
6. The preparation of a comprehensive specialist noise impact assessment report.

1.3 Specialist Details

1.3.1 Specialist Details

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

1.3.2 Competency Profile of Specialist

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

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

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

She has extensive experience on the various components of air quality management including emissions quantification for a range of source types, simulations using a range of dispersion models, impacts assessment and health risk screening assessments. Reneé has been the principal air quality specialist and manager on several Air Quality Impact Assessment between 2006 to present and Noise Assessment projects between 2015 and present and her project experience range over various countries in Africa, providing her with an inclusive knowledge base of international legislation and requirements pertaining to air quality and noise impacts.

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

1.4 Description of Activities from a Noise Perspective

Sources of noise at the proposed glass bottle manufacturing facility are expected to include:

- Traffic associated with staff transport, raw material delivery, product export, and on-site material movement.
- Facility warning and information signals including mobile equipment reverse warning hooters.
- Rotating machinery such as motors, pumps, fans, compressors, etc. For a given machine, the sound pressure level ('emission') depends on the proportion of the total mechanical or electrical energy that is transformed into acoustical energy.
- Turbulent fluid flow e.g. pipe flow and within tanks at the water treatment facility and in cooling systems. Fluid (gasses and liquids) turbulence and vortices generate noise, especially at high flow velocities. Turbulence can be generated by a moving or rotating solid objects, such as the blade tip of a ventilator fan, by changing high pressure discharge fluid to low (or atmospheric) pressure or by introducing an obstacle into a high-speed fluid flow.
- Electrical equipment such as the transformer yard.

- Furnaces and production lines.
- Other: Handling of materials, maintenance works etc.

It is understood that several of the listed noise generating activities/sources will be located within buildings with factory walls and construction materials providing acoustic shielding to the outside through absorption of acoustic energy and transmission losses. Heavy vehicle movement on-site and facility cooling systems are likely to be the most notable external noise sources.

1.5 Background to Environmental Noise and the Assessment Thereof

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

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

A direct application of linear scales (in pascal (Pa)) to the measurement and calculation of sound pressure leads to large and unwieldy numbers. 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 micro-pascals (µPa)) to 130 dB at the threshold of pain (~100 Pa) (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

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

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

Where:

L_p *is the sound pressure level in dB;*

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

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

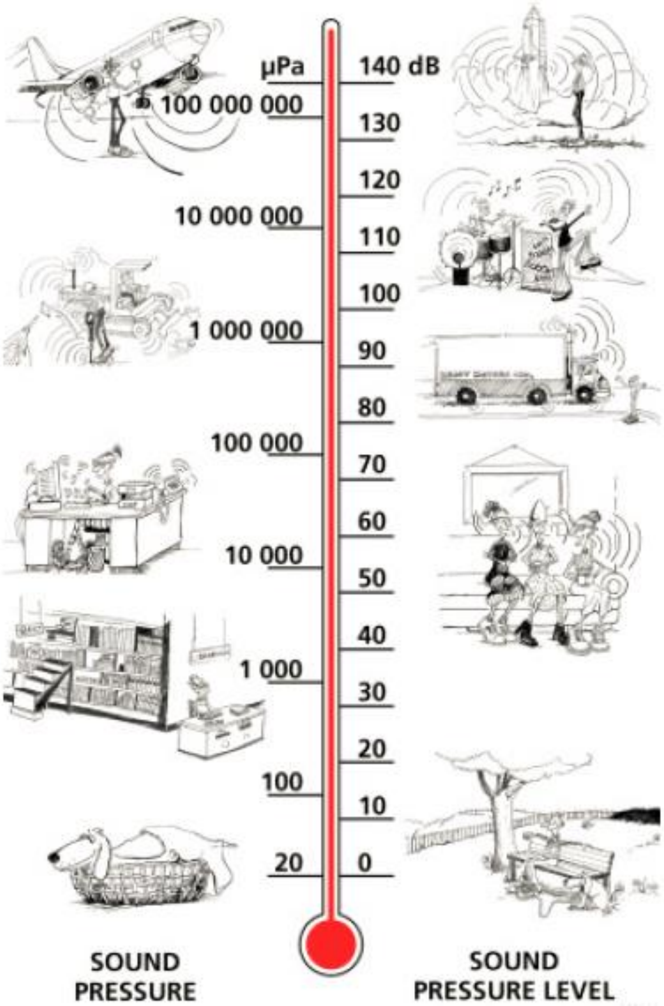


Figure 1: The decibel scale and typical noise levels (Brüel & Kjær Sound & Vibration Measurement A/S, 2000)

1.5.1 Perception of Sound

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

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

1.5.2 Frequency Weighting

Since human hearing is not equally sensitive to all frequencies, a 'filter' has been developed to simulate human hearing. The 'A-weighting' filter simulates the human hearing characteristic, which is less sensitive to sounds at low frequencies than at high frequencies (Figure 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) and have been A-weighted.

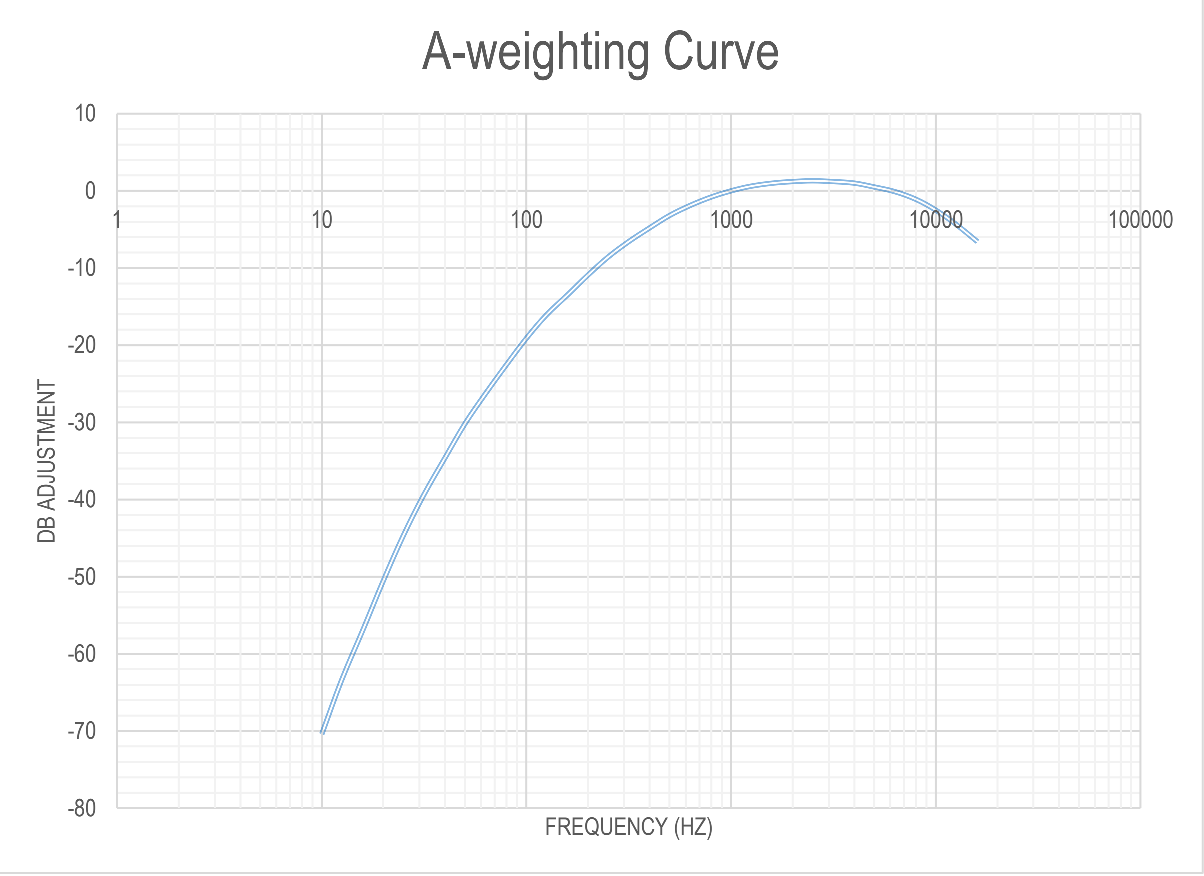


Figure 2: A-weighting curve

1.5.3 Adding Sound Pressure Levels

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

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

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

1.5.4 Environmental Noise Propagation

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

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

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

1.5.5 Environmental Noise Indices

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

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

1.6 Approach and Methodology

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

1.6.1 Information Review

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

- Project and site layout maps;
- Material throughputs; and,
- List of indoor noise levels and sound power levels for various areas.

1.6.2 Review of Assessment Criteria

In South Africa, provision is made for the regulation of noise under the National Environmental Management Air Quality Act (NEMAQA) (Act. 39 of 2004) but environmental noise limits have yet to be set. It is believed that when published, national criteria will make extensive reference to SANS 10103 of 2008 '*The measurement and rating of environmental noise with respect to annoyance and to speech communication'*. This standard has been widely applied in South Africa and is frequently used by local authorities when investigating noise complaints. These guidelines, which are in line with those published by the IFC in their *General EHS Guidelines* (IFC 2007) and World Health Organisation (WHO) *Guidelines for Community Noise* (WHO 1999), were considered in the assessment.

1.6.3 Study of the Receiving Environment

NSRs generally include private residences, community buildings such as schools, hospitals and any publicly accessible areas outside an industrial facility's property.

The ability of the environment to attenuate noise as it travels through the air was studied by considering local meteorology, land use and terrain. Atmospheric attenuation potential was described based on the Sharpeville Air Quality Station meteorological data for the period 2014 to 2016.

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

1.6.4 Noise Survey

The extent of noise impacts as a result of an intruding noise depends largely on existing noise levels in an area. Higher ambient noise levels will result in less noticeable noise impacts and a smaller impact area. The opposite also holds true. Increases in noise will be more noticeable in areas with low ambient noise levels. The data from a baseline noise surveys conducted on 21 November 2017 was studied to determine current noise levels within the area.

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

- The survey was designed and conducted by a trained specialist.
- Sampling was carried out using a Type 1 sound level meter (SLM) that meet all appropriate International Electrotechnical Commission (IEC) standards and is subject to calibration by an accredited laboratory (Appendix A). Equipment details are included in Table 1.
- The acoustic sensitivity of the SLM was tested with a portable acoustic calibrator before and after each sampling session.
- Samples, 15 to 45 minutes in duration, representative and sufficient for statistical analysis were taken with the use of the portable SLM capable of logging data continuously over the sampling time period. Samples representative of the day- and night-time acoustic environment were taken. SANS 10103 defines day-time as between 06:00 and 22:00 and night-time between 22:00 and 06:00 (SANS 10103, 2008).
- L_{Aleq} (T), L_{Aeq} (T); L_{AFmax}; L_{AFmin}; L_{90} and 3^{rd} octave frequency spectra were recorded.
- The SLM was located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface.
- SANS 10103 states that one must ensure (as far as possible) that the measurements are not affected by the residual noise and extraneous influences, e.g. wind, electrical interference and any other non-acoustic interference, and that the instrument is operated under the conditions specified by the manufacturer.
- A detailed log and record was kept. Records included site details, weather conditions during sampling and observations made regarding the acoustic environment of each site (Appendix C).

Table 1: Sound level meter details

Equipment	Serial Number	Purpose	Last Calibration Date
Brüel & Kjær Type 2250 Lite SLM	S/N 2731851	Attended 20-minute sampling.	10 May 2017
Brüel & Kjær Type 4950 ½" Pre-polarized microphone	S/N 2709293	Attended 20-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

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 as capable of integrating while using the I-time (impulse) weighting and $L_{AIeq,T}$ is 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.**

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

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

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

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

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

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

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 $L_{Req,T}$.

1.6.5 Source Inventory

Noise emissions from indoor noise levels for various areas onsite was provided. Conservative assumptions were made of the building material. Noise levels from transport trucks was estimated using L_W predictions for industrial machinery (Bruce & Moritz, 1998), where L_W estimates are a function of the power rating of the equipment engine.

Construction and decommissioning activities are expected to result in noise impacts similar to or less significant than impacts associated with the operational phase. A source inventory was therefore only developed for the operational phase of the project.

1.6.6 Noise Propagation Simulations

The propagation of noise from proposed activities was simulated with the DataKustic CadnaA software. Use was made of:

(a) The International Organisation for Standardization's (ISO) 9613 module for outdoor noise propagation from industrial noise sources; and

(b) The German "Richtlinien für den Lärmschutz an Straßen" or RLS90 traffic noise module (for the access road).

1.6.6.1 ISO 9613

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

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

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

Where;

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

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

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

1.6.6.2 RLS90

The RLS90 road traffic noise module included in CadnaA requires average hourly traffic flow, separated into heavy and light vehicles, the average speed for each group, the dimension, geometry and type of the road and of any natural and artificial obstacles. As with ISO 9613, the module also takes also into account the main features which influence the propagation of noise namely obstacles, vegetation, air absorption, reflections and diffraction.

1.6.6.3 Simulation Domain

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

The propagation of noise was calculated over an area of 5.4 km east-west by 5.3 km north-south and encompasses the proposed project site. The area was divided into a grid matrix with a 50 m resolution. NSRs and survey locations were included as discrete receptors. The model was set to calculate L_P's at each grid and discrete receptor point at a height of 1.5 m above ground level.

1.6.7 Presentation of Results

Noise impacts were calculated in terms of:

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

Results are presented in isopleth form. An isopleth is a line on a map connecting points at which a given variable (in this case sound pressure, L_P) has a specified constant value. This is analogous to contour lines on a map showing terrain elevation. In the assessment of environmental noise, isopleths present lines of constant noise level as a function of distance.

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

1.6.8 Recommendations of Management and Mitigation

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

1.6.9 Impact Significance Assessment

The significance of environmental noise impacts was assessed according to the methodology adopted by SLR and considered both an unmitigated and mitigated scenario. Refer to Appendix D of this report for the methodology.

1.7 Limitations and Assumptions

The following limitations and assumptions should be noted:

- Estimates of road traffic were made with the provided truck information. The vehicle speeds and road conditions were assumed. Trucks were assumed to travel at 40 km/h on access road and 15 km/h onsite.
- The quantification of sources of noise was limited to the operational phase of the project. Construction and closure phase activities are expected to be similar or less significant and its impacts only assessed qualitatively. Noise impacts will cease post-closure.
- All activities were assumed to be 24 hours per day, 7 days per week.
- Although other existing sources of noise within the area were identified, such sources were not quantified but were taken into account during the baseline survey.

2 Legal Requirements and Noise Level Guidelines

2.1 South African National Standards

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 the South African Bureau of Standards (SABS) standard SANS 10103 (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. The standard is also fully aligned with the WHO guidelines for Community Noise (WHO, 1999). It should be noted that the values given in Table 3 are typical rating levels that it is recommended should not be exceeded outdoors in the different districts specified. Outdoor ambient noise exceeding these levels will be annoying to the community.

Table 3: Typical rating levels for outdoor noise

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

Notes

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

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

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

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

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

- 15 dB < Δ: There will be a 'very strong' reaction with 'vigorous community action'.

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

2.2 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 Noise By-Laws for Emfuleni Municipality

Noise limits or by-laws for the Emfuleni Municipality could not be sourced.

2.4 International Finance Corporation Guidelines on Environmental Noise

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

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

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

Table 4: IFC noise level guidelines

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

2.5 Criteria Applied in This Assessment

Reference is made to the IFC noise guideline level for industrial and residential, institutional and educational receptors and the increase in noise levels of 3 dBA above background levels.

2.6 Impact of Noise on Cattle

Cattle hear high-frequency sounds much better than humans, their high-frequency hearing limit being 37 kHz, compared with only 18 kHz for humans (Heffner, 1998). Their best audible sound is also at a higher frequency, at about 8 kHz, compared with 4 kHz for humans (Phillips, 2009). However, thresholds for discomfort for cattle was noted at 90-100 dB, with physical damage to the ear occurring at 110 dB (Phillips, 2009). Indeed, cattle, with an auditory range between 25 Hz and 35 kHz, can detect lower pitched sounds than other farm species (Heffner & Heffner, Auditory perception, 1993). Dairy breeds are more sensitive to noise than beef breeds (Lanier, Grandin, Green, Avery, & McGee, 2000).

According to Kovalčík and Šottník (1971), noise as high as 80 dB had no negative effect on dairy cows. Feed intake was increased, milk yield was unchanged, and indices of the rate of milk-releasing were improved. However, immediate exposure to a high-intensity noise (105 dB) resulted in decreased feed consumption, milk yield, and intensity of milk release. Gradual increase of noise to 105 dB resulted in a less-negative response. Gygax and Nosal (2006) investigated on 50 dairy farms the effect of vibration and noise on somatic cell counts in milk. Somatic cell counts increased with an increasing intensity of vibration but not with acoustic noise.

Unexpected high intensity noise (above 110 dB), such as low altitude jet aircraft overflights at milking time could reduce effectiveness of the milk ejection reflex, decrease efficiency of milk removal, increase residual milk, and lead to overall reduction in milk yield. However, a majority of the studies reviewed suggests that there is little or no effect of aircraft noise on cattle. Adverse effects of low-altitude flights have been noted in some studies but have not been uniformly reproduced in other reports (Manci, Gladwin, Villella, & Cavendish, 1988). A number of studies investigated the effects of aircraft noise and sonic booms on the milk production of dairy cows. Milk yields were not affected. Beyer (1983) found that helicopters caused worse reaction than other low-aircraft overflights. However, helicopters at 9 to 18 m overhead did not affect milk production and abortion rates of cows and heifers (Dufour, 1980; Gladwin et al., 1988). Cows exposed to recorded jet noise just before milking showed no behavioural or productivity responses during 21 days treatment periods (Head, et al., 1993).

Sounds produced by humans might also be stressful for farm animals. Loud cry causes stress responses in farm animals (Hemsworth, 2003). Shouting on dairy cows appears to be very aversive (Pajor, Rushen, & De Passille, 2000). Noise made by humans shouting and slamming of metal gates increases heart rate and activity in cattle (Waynert, Stookey, Schwartzkopf-Genswein, Watts, & Waltz, 1999). Lanier et al. (2000) also noted that cattle appeared more stressed by intermittent loud human vocalisation, particularly when high-pitched like a child's. Unexpected high intensity noise, such as low altitude jet aircraft overflights with more than 110 dB at milking time could provoke increase peripheral or mammary release of catecholamines (Albright & Arave, 1997).

Many studies indicate that sudden, novel sounds seem to affect cattle behaviour more than continuous high noise (Head et al., 1993; Grandin, 1998; Arnold et al., 2007). When the aircraft was 152 m above ground level, the cattle ran for less than 10 meters and resumed normal activity within one minute. Unexpected high intensity noise, such as low altitude jet aircraft overflights (above 110 dB), at milking parlour could provoke adverse behaviour, such as kicking or stomping (Morgan and Tromborg, 2007).

The noise threshold expected to cause a behavioural response by cattle is 85 to 90 dB (Manci et al., 1988). Noises greater than threshold have provoked retreat, freezing, or strong startle response (Morgan and Tromborg, 2007). When the transmitter of ultrasound was switched on at a distance of 1 m, calves got up and orientated towards the sound source. After 30 s, all calves had their ears directed away from the sound source. After 10 min, some calves started to scratch their ears repeatedly. During the 10 minutes period of exposure, none of the calves would lay down again (Algers, 1984).

Arnold et al. (2008) examined the effect of noise on the choice behaviour of dairy heifers in a maze. The percentage of heifers that chose the quiet side of maze was increasing as the experiment progessed. Heifers exposed to the noise from milking parlour show escape-type behaviours, consistent with a fear response. They learned to avoid the noise. Pajor et al. (2000) assessed responses of dairy cows to various handling treatments. Exposure to noise increased avoidance behaviour, as indicated by increases in stopping and amount of required handler intervention. Broucek et al. (1988) observed the effect of sire lineage on movement activity in dairy cows tested during noise at open-field arena.

Noise in the milking facility has direct implications for on-farm efficiency related to improving cow behaviour and human-animal interactions. Faster movement in response to noise persisted for the first 4 days of the treatment phase, with some evidence of habituation of this response on the fifth day (Waynert et al., 1999). Responses to noise in commercial milking facilities may be influenced by processes of habituation. As dairy cows are regularly exposed to the milking environment, there is opportunity for reduction of any fear responses arising from exposure to noise.

Dairy heifers were exposed to the noise of 85 dB during the 23 m long transfer test raceway. Exposure to noise resulted in increases in heart rate and faster transit times. There were no significant effects of noise on latency to enter the raceway, or animal handling parameters (Arnold et al., 2007). These data indicate that anthropogenic noise generated in the course of routine human activity may have adverse effects on cattle welfare.

3 Description of the Receiving Environment

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

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

3.1 Noise Sensitive Receptors

Noise sensitive receptors generally include places of residence and areas where members of the public may be affected by noise generated processing and transport activities. Industrial operations surrounding the site may also be affected.

As mentioned in Section 1.5.4, the impact of an intruding industrial/mining noise on the environment rarely extends over more than 5 km from the source. Noise sensitive receptors within 5 km of the project, indicated in Figure 3, include:

- General public:
  - Residents of Sharpeville, Vereeniging, Leeuhof, Unitas Park, Homer, and Steelpark;
  - Individual dwellings at the informal livestock fairground; and,
  - The Roods Gardens Agricultural Holdings.
- Industrial and commercial activities:
  - Industrial activities just north of the project site;
  - Industrial activities just northwest of the project site; and,
  - Leeukuil.
- Receptors located near the project site:
  - Pre-school[1] ~300 m north of project site; and,
  - Correctional services facilities (and the staff accommodation) ~600 m north of the project site.

3.2 Environmental Noise Propagation and Attenuation potential

3.2.1 Atmospheric Absorption and Meteorology

Atmospheric absorption and meteorological conditions have already been mentioned with regards to their role in the propagation on noise from a source to receiver (Section 1.5.4). The main meteorological parameters affecting the propagation of noise include wind speed, wind direction and temperature. These along with other parameters such as relative humidity, air pressure, solar radiation and cloud cover affect the stability of the atmosphere and the ability of the atmosphere to absorb sound energy. Use is made of the Sharpeville Air Quality Monitoring Station for the period 2014 to 2016.

[1] The commitment is that the pre-school will be relocated. This receptor has been included as a noise sensitive receptor and the potential impacts have been discussed at this location. However, due to the relocation, no further mitigation or monitoring is required.

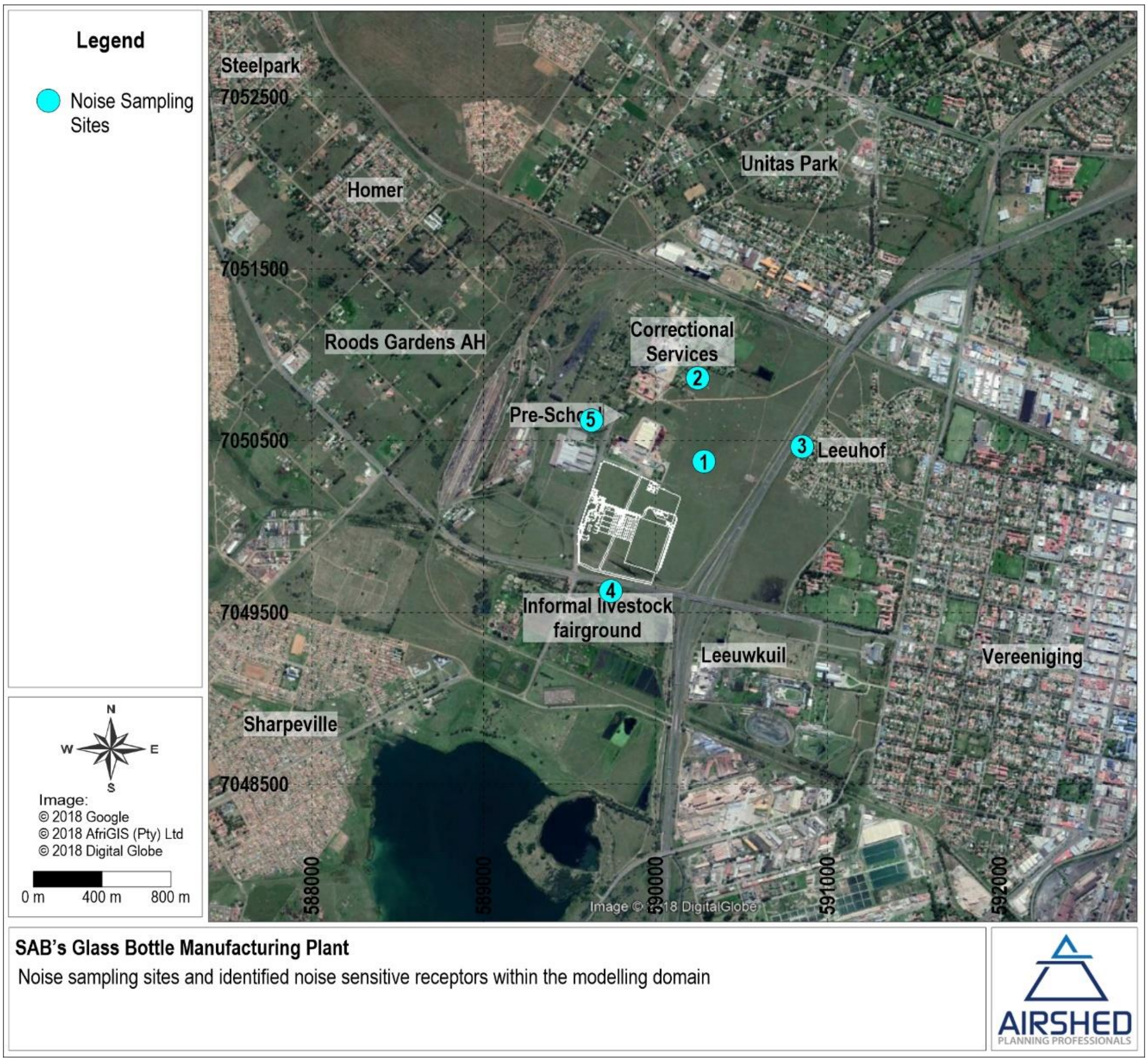


Figure 3: Location of potential NSRs and noise sampling points

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 4. 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.

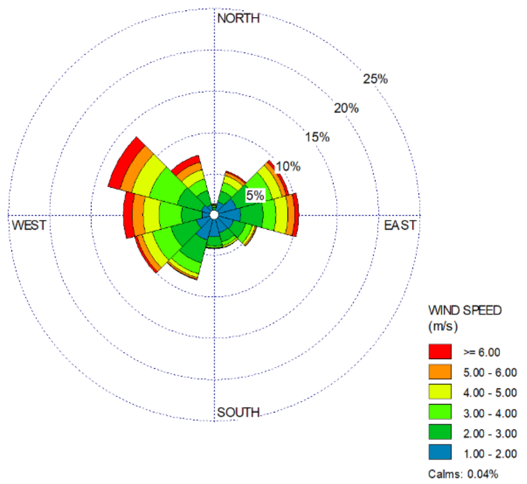
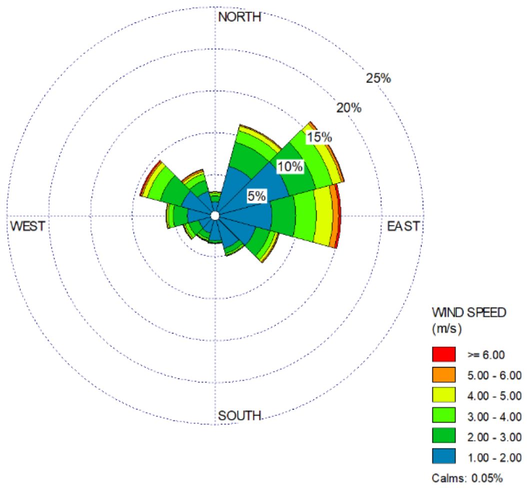
Day-time wind field (06:00 to 22:00)	Night-time wind field (22:00 to 06:00)
	

Figure 4: Day- and night-time wind field (Sharpeville Air Quality Monitoring Station: 2014 to 2016)

On average, noise impacts are expected to be more notable to the south-east during the day and to the south-west 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. CadnaA allows the input of the average temperature and relative humidity. Use was made of average temperatures for the period of 18°C in simulations, as obtained from the Sharpeville Air Quality Monitoring Station and an average relative humidity of 40% as obtained from the South African Atlas of Agrohydrology and Climatology (Schulze, 1997).

3.2.2 Terrain, Ground Absorption and Reflection

Noise reduction caused by a barrier (i.e. natural terrain, installed acoustic barrier, building) feature depends on two factors namely the path difference of a sound wave as it travels over the barrier compared with direct transmission to the receiver and the frequency content of the noise (Brüel & Kjær Sound & Vibration Measurement A/S, 2000). Readily available terrain data was obtained from the United States Geological Survey (USGS) web site (https://earthexplorer.usgs.gov/). A study made use of Shuttle Radar Topography Mission (STRM) 1 arc-sec data (Figure 5).

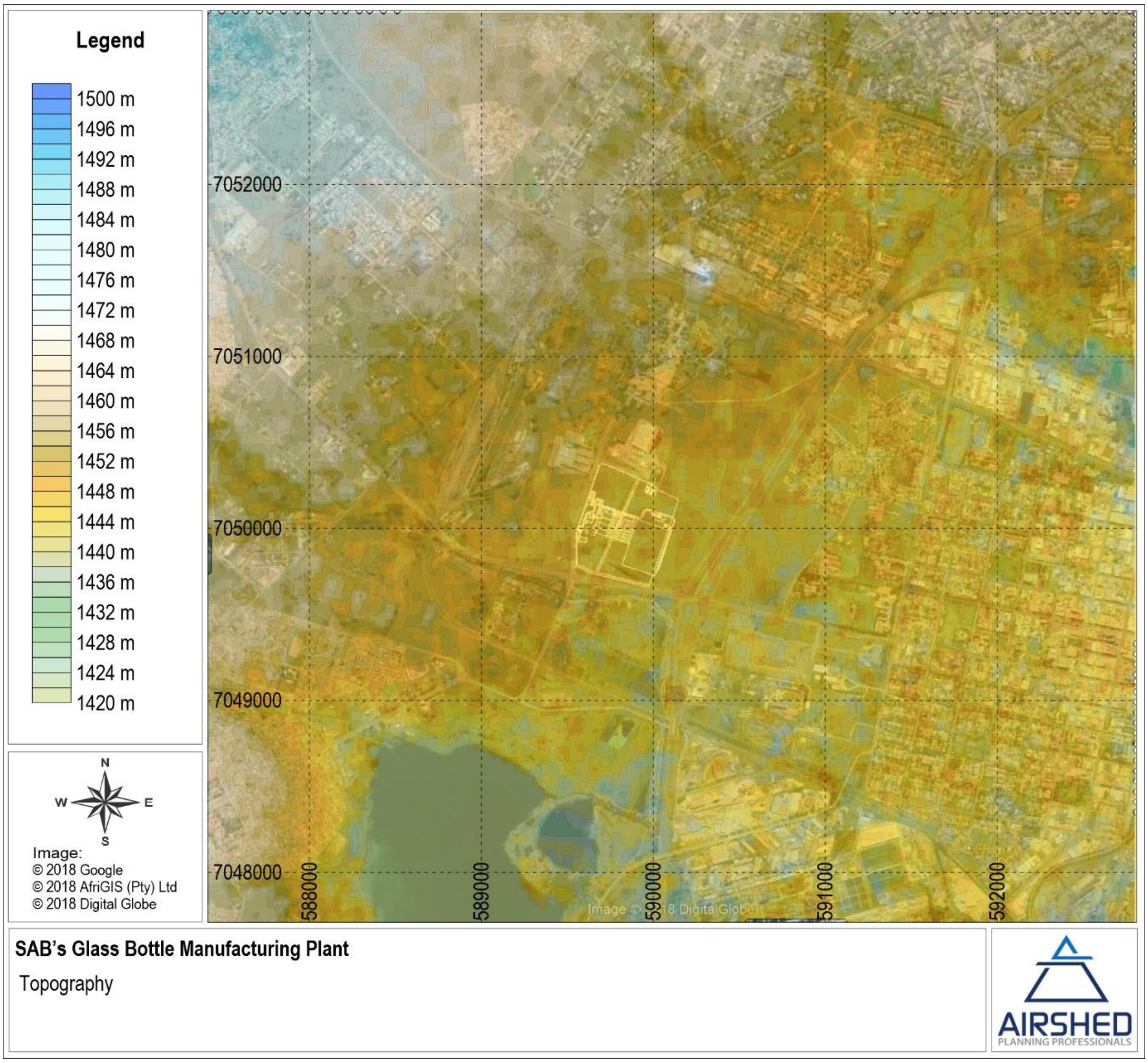


Figure 5: Topography for the study area

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.

3.3 Baseline Noise Survey and Results

Survey results are summarised in Table 5 and for comparison purposes, visually presented in Figure 6 (day-time results) and Figure 7 (night-time results).

Table 5: The project baseline environmental noise survey results summary

Site	Description	Day-time L_{Aeq} (45 min) (dBA)	Night-time L_{Aeq} (15 min) (dBA)	SANS 10103 district equivalent
Site 1	Open field, 175 m within site alternative 2 footprint area	46.2	47.5	Day ~Suburban Night ~Urban
Site 2	On-site, at closest residential receptor to the north (Correctional Services staff accommodation)	47.7	48.6	Day ~Suburban Night ~Urban
Site 3	Off-site, near residential receptor at 31 Gazelle St, 50 m east of R59	67.9	61.8	Day ~CBD Night ~Industrial
Site 4	Off-site, directly south of R28, near residential structures	54.3	51.1	Day ~Urban Night ~Urban with main roads
Site 5	Off-site, open field, 80 m east of Lager Rd	51.1	45.3	Day ~Suburban to urban Night ~Urban

The following is noted:

- Measurements were conducted on 21 November 2017.
- Weather conditions:
    - During the day weather conditions were partly cloudy and sunny, with temperatures between 29°C and 34°C. Slight to moderate wind conditions with wind speeds between 0.5 and 5 m/s mostly from the north-easterly directions, prevailed.
    - At night, skies were clear with temperatures between 20°C and 23°C. Slight wind conditions with wind speeds between 0.2 and 0.9 m/s mostly from the north-easterly and northerly directions, prevailed.
- Day-time baseline noise levels:
    - On-site levels are comparable to what is typically expected within rural/suburban areas (Site 1), as are levels at the closest residential establishments (correctional services staff accommodation, Site 2), and off-site east of Lager Rd (Site 5). At Site 4 near informal residential structures south of the R28 day-time noise levels typical of urban areas prevailed primarily due to traffic noise. As expected, the highest day-time noise levels were recorded at Site 3, representative of closest receptors east of the project.
    - With the exception of Site 3, all recorded L_{Aeq}'s were in compliance with IFC guidelines for residential, institutional and educational receptors (55 dBA).
- Night-time baseline noise levels:
    - Due to the presence of main roads and high traffic volumes (R59 and R28), baseline night-time noise levels are somewhat higher (between 48.6 dBA and 61.8 dBA) at the closest residential areas than typically expected within suburban areas.

Field log sheets containing weather records are included in Appendix C.

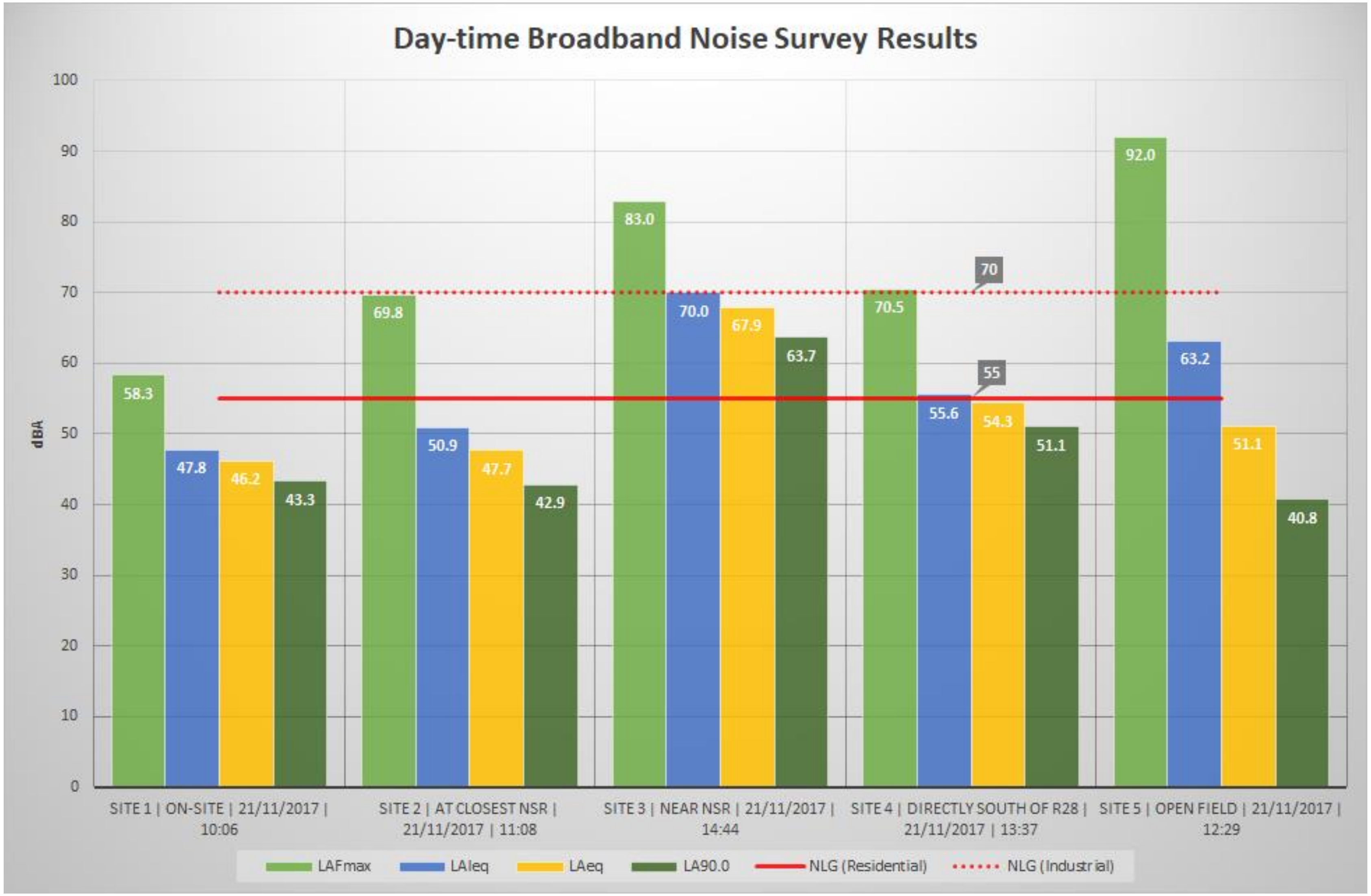


Figure 6: Day-time broadband survey results

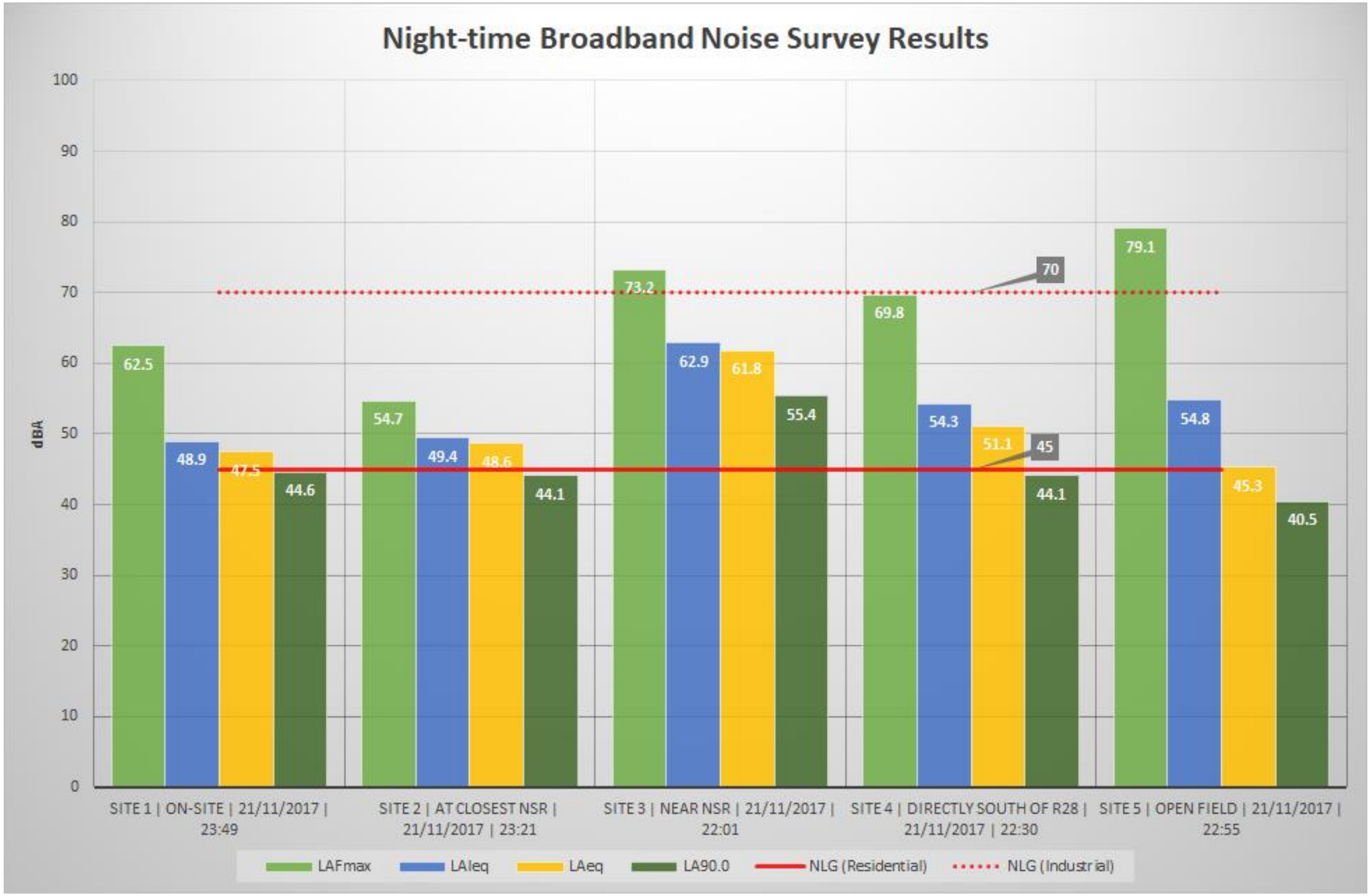


Figure 7: Night-time broadband survey results

For the purpose of this assessment, given the description of the baseline acoustic environment and survey results, it was decided that sampled on-site L_{Aeq} values would be more representative of prevailing baseline conditions and provide the specialist with a slightly more conservative estimate of the project's noise impact.

4 Impact Assessment

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

4.1 Noise Sources and Sound Power Levels

Source noise levels were provided by the proponent for various areas of the project operations. These are provided in Table 6.

Steel sheeting building material was assumed. The absorption coefficients and sound reduction indices used in the modelling is provided in Table 7.

Truck traffic noise as well as access road traffic were included. Traffic parameters used in the assessment are provided in Table 8. Truck speeds of 15 km/hr on-site and 40 km/hr off-site were assumed.

Table 6: Noise source inventory for the project

Production Areas	Indoor Noise Levels (dBA)	Single Sound Power Level (dBA)	Total Sound Power Level (dBA)	Peak Sound Power Level (dBA)
Batch Plant	80			
Furnace	90			
IS Machine	101			
Lehr	88			
Single Line and Inspection Machine	88			
Stacking and Packing	81			
Compressed Air	93			
IS Media Supply	97			
Cullet Transport	94			
Ventilation System		100		
Truck Delivery Cullets			120	133
Truck Delivery Pneumatic Unloading			104	
Outdoor Cooling Systems		85	90	
Furnace Exhaust Control		95-96	95-96	

Table 7: Building material absorption coefficients and sound reduction indices

Parameters		Octave band frequency spectra (dB)						
		63	125	250	500	1000	2000	4000
Absorption coefficient	Mineral wool		0.1	0.4	0.8	0.9	0.9	0.9
Absorption coefficient	20g Galvanised sheet steel (enclosure)	0.35	0.35	0.39	0.44	0.49	0.54	0.57
Sound Reduction Indices	20g Galvanised sheet steel (enclosure)		8	14	20	26	32	38

Table 8: Truck noise emission source

Truck Trips per Hour	Engine Power Rating (kW)	L_W octave band frequency spectra (dB)								L_W (dB)	L_{WA} (dBA)	Source
		63	125	250	500	1000	2000	4000	8000			
Green Line (raw material) = 2 Green Line (product) = 1.8 Amber Line (raw material) = 2.8 Amber Line (product) = 2.3	202	111.1	116.1	119.1	114.1	112.1	109.1	103.1	97.1	122.7	117.3	L_W Predictions (Bruce & Moritz, 1998)

4.2 Noise Propagation and Simulated Noise Levels

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

4.2.1 Simulated Noise Levels due to Project Operations

Table 9 provides a summary of simulated noise levels at NSRs. Results are also presented in isopleth form (Figure 8 to Figure 10). The simulated equivalent continuous day-time rating level ($L_{Req,d}$) due to project operations of 55 dBA (guideline level) extends ~700 m from the project boundary. The simulated equivalent continuous night-time rating level ($L_{Req,n}$) of 45 dBA (guideline level) due to project operations extends ~1800 m from the project boundary .

The proposed operational phase related noise due to the project is predicted to exceed the selected noise guidelines at the pre-school (~300m north of the site) and the informal livestock fairgrounds to the south during the day and at the pre-school (~300m north of the site), correctional services, Sharpville, the informal livestock fairgrounds and Roods Gardens AH during the night.

For a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level is not detectable. According to SANS 10103 (2008); 'little' to 'medium' reaction with 'sporadic' to 'widespread' complaints expected from the community for increased noise levels up to 10 dBA. 'Strong' community reaction is expected for increase noise levels of more than 10 dBA. With the conservative approach adopted for the assessment (detailed in Section 1.6) the predicted increase in noise levels are expected to result in 'little' to 'sporadic' reaction from the pre-school and the Correctional Services during the day and from Correctional Services and Roods Gardens AH during the night. Assuming little to no operations occur during the night-time at the Pre-school and industrial facilities, 'strong' community reaction is expected from the industrial activities to the north and northwest of the site during the day. It should be noted however that the baseline noise level for these two sites was conservatively assumed to be the same as measured at the pre-school and does not take into account the industrial operational noise at the specific sites. 'Strong' community reaction may also arise from the informal livestock fairgrounds during the day and night.

Table 9: Summary of simulated noise levels (provided as dBA) due to the project and baseline noise measurements at NSR within the study area

Noise Sensitive Receptor	Project operations		Baseline		Increase Above Baseline [h]	
	Day	Night	Day	Night	Day	Night
Industrial operations directly north of site [a]	63.1	62.5	51.1 [c]	45.3 [c]	12.3	17.3 [g]
Industrial operations directly northwest of site [a]	60.9	60.6	51.1 [c]	45.3 [c]	10.2	15.4 [g]
Pre-school (~300m north of site) [b]	56.5 [e]	56 [f]	51.1	45.3	6.5	11.1 [g]
Correctional services staff accommodation (~600m north of site) [b]	52.6	51.8 [f]	47.7	48.6	6.1	4.9
Correctional services [b]	53.8	53.2 [f]	47.7 [c]	48.6 [c]	7.1	5.9
Sharpeville [b]	48.6	49.5 [f]	54.3 [c]	51.1 [c]	1.0	2.3
Informal livestock fairground [b]	64.1 [e]	64.5 [f]	54.3	51.1	10.2	13.6
Leeukuil [a]	50	50.2	54.3 [c]	51.1 [c]	1.4	2.6 [g]
Vereeniging [b]	42.8	41.9	67.9 [c]	61.8 [c]	0.0	0.0
Leeuhof [b]	48.2	47.3	67.9	61.8	0.0	0.2
Unitas Park [b]	44.4	43.5	47.7 [c]	48.6 [c]	1.7	1.2
Roods Gardens AH [b]	50	50.5 [f]	51.1 [c]	45.3 [c]	2.5	6.3
Homer [b]	39.5	39.9	45.8 [c]	45.3 [c]	0.9	1.1
Steelpark [b]	0	0	51.1 [c]	45.3 [c]	0.0	0.0

Notes:

(a) Industrial NSR
(b) Residential/ educational NSR
(c) Assumed based on closest noise sampling location
(d) Exceeds IFC guideline of 70 dBA for industrial areas
(e) Exceeds day-time IFC guideline of 55 dBA for residences
(f) Exceeds night-time IFC guideline of 45 dBA for residences
(g) Activities at facility not likely to occur during night-time
(h) Likely community response:

0 to 1 dBA – No reaction, increase not detectable
1 to 3 dBA – Increase just detectable to persons with average hearing acuity, annoyance unlikely.
3 to 5 dBA – There will be 'little' reaction with 'sporadic complaints'.
5 to 10 dBA – There will be 'little' to 'medium' reaction with 'sporadic' to 'widespread' complaints.
10 to 15 dBA – There will be a 'strong' reaction with 'threats of community action'.
> 15 dBA – There will be a 'very strong' reaction with 'vigorous community action'.

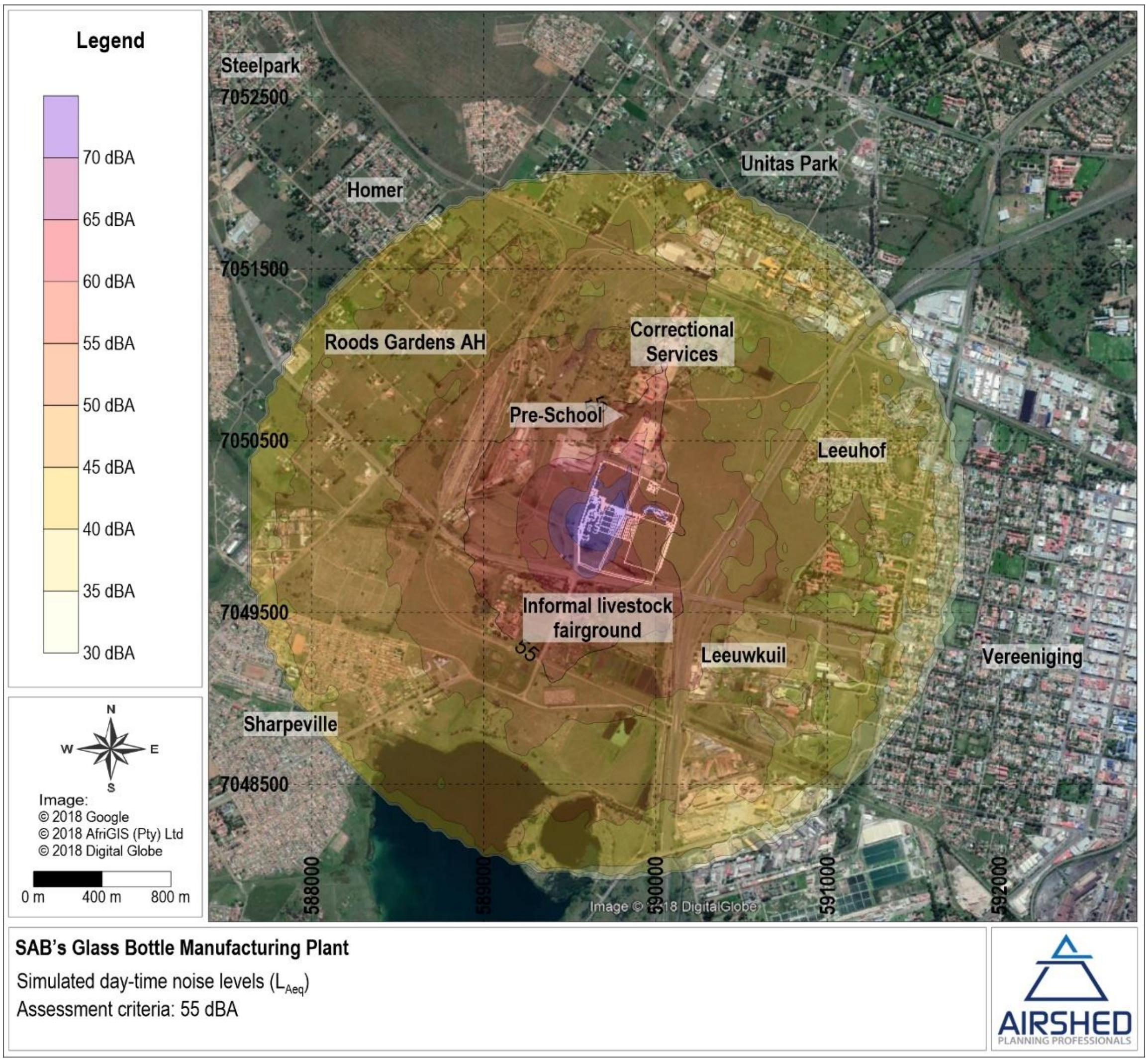


Figure 8: Simulated equivalent continuous day-time rating level ($L_{Req,d}$) for project activities

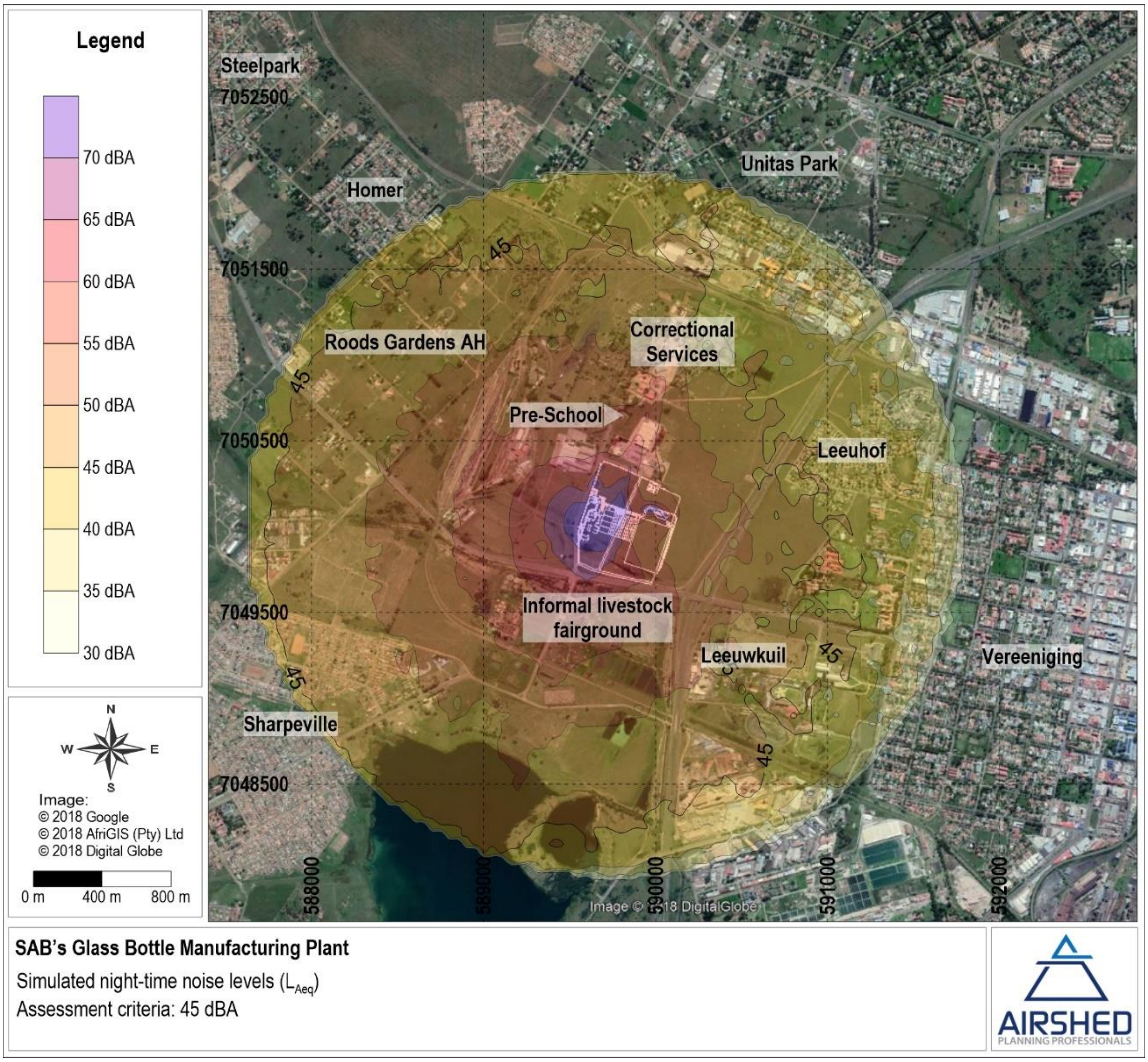


Figure 9: Simulated equivalent continuous night-time rating level ($L_{Req,n}$) for project activities

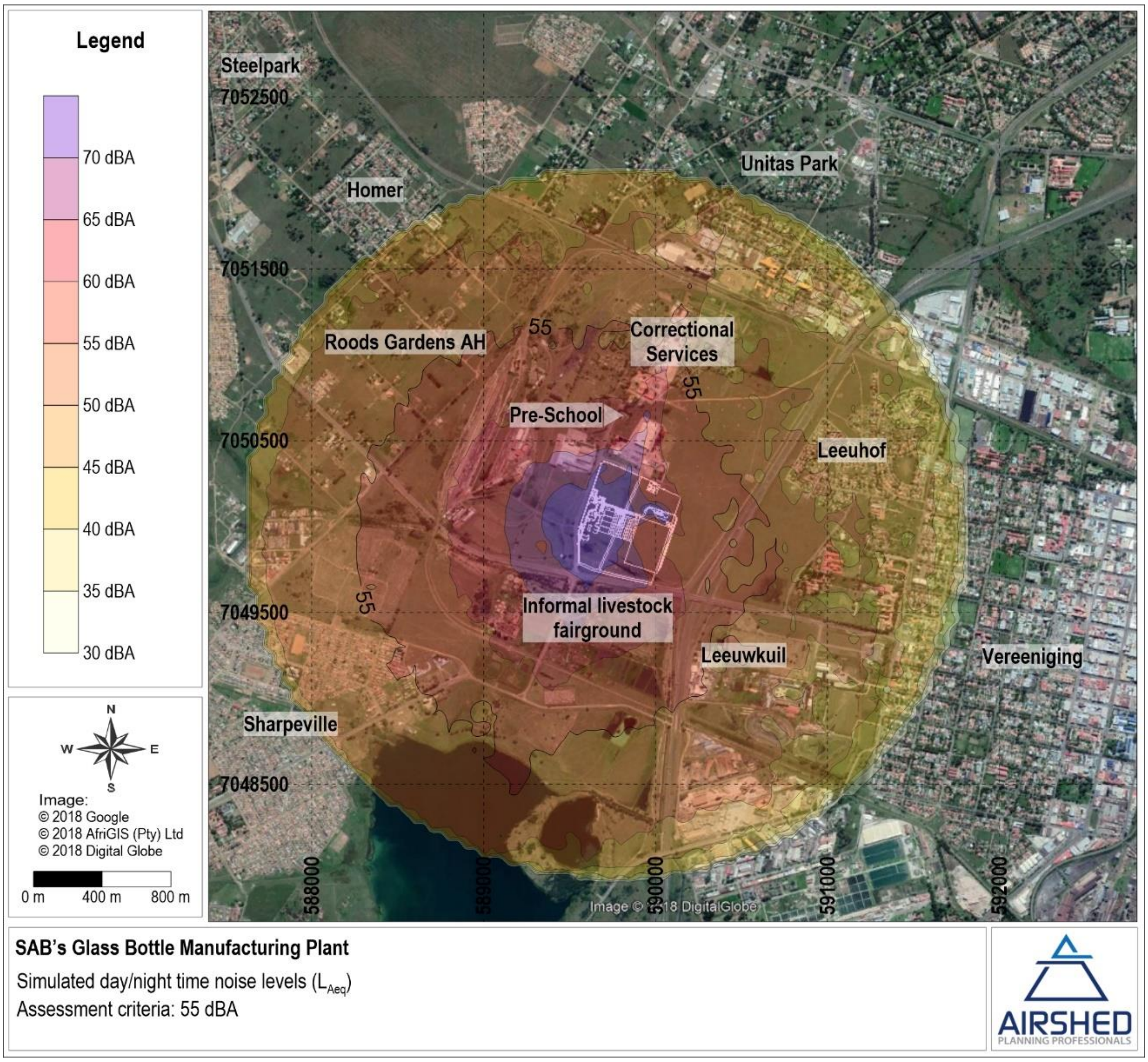


Figure 10: Simulated equivalent continuous day/night time rating level ($L_{Req,dn}$) for project activities

4.2.2 Simulated Noise Levels due to Project Operations and Additional Project Activities Proposed for the Site

A maize wet mill plant is potentially proposed ~250 m north of the project activities. The cumulative impacts from both facilities have been assessed to understand cumulative noise impacts.

Table 10 provides a summary of simulated noise levels at NSRs. Results are also presented in isopleth form (Figure 11 to Figure 13). The simulated equivalent continuous day-time rating level ($L_{Req,d}$) of 55 dBA (guideline level) extends ~700 m from the project boundary due to project operations and other proposed activities for the area. The simulated equivalent continuous night-time rating level ($L_{Req,n}$) of 45 dBA (guideline level) extends ~1800 m from the project boundary due to project and additional proposed operations.

The proposed operational phase related noise due to the project is predicted to exceed the selected noise guidelines at the pre-school (~300m north of the site) and the informal livestock fairgrounds to the south during the day and at the pre-school (~300m north of the site), correctional services, Sharpeville, the informal livestock fairgrounds, Vereeniging, Leeuhof, Unitas Park and Roods Gardens AH during the night.

The predicted increase in noise levels are expected to result in 'little' to 'sporadic' reaction from the pre-school and the Correctional Services during the day and from Roods Gardens AH during the night. Assuming little to no operations occur during the night-time at the Pre-school and industrial facilities, 'strong' community reaction is expected from the industrial activities to the north and northwest of the site during the day. It should be noted however that the baseline noise level for these two sites was conservatively assumed to be the same as measured at the pre-school and does not take into account the industrial operational noise at the specific sites. 'Strong' community reaction may also arise from the informal livestock fairgrounds during the day and night and from Correctional Services during the night.

Table 10: Summary of simulated noise levels (provided as dBA) due to the project and proposed operations for the site and baseline noise measurements at NSR within the study area

Noise Sensitive Receptor	Project operations		Baseline		Increase Above Baseline (h)	
	Day	Night	Day	Night	Day	Night
Industrial operations directly north of site (a)	63.9	69.5	51.1	45.3	13.0	24.2 (g)
Industrial operations directly northwest of site (a)	61.5	67.1	51.1	45.3	10.8	21.8 (g)
Pre-school (~300m north of site) (b)	58.2 (e)	64 (f)	51.1	45.3	7.9	18.8 (g)
Correctional services staff accommodation (~600m north of site) (b)	53.8	59.2 (f)	47.7	48.6	7.1	11.0
Correctional services (b)	55.6 (e)	61.4 (f)	47.7	48.6	8.6	13.0
Sharpeville (b)	48.6	55.5 (f)	54.3	51.1	1.0	5.7
Informal livestock fairground (b)	64.1 (e)	64.6 (f)	54.3	51.1	10.2	13.7
Leeukuil (a)	50	50.2	54.3	51.1	1.4	2.6 (g)
Vereeniging (b)	43	48.2 (f)	67.9	61.8	0.0	0.2
Leeuhof (b)	48.2	49.7 (f)	67.9	61.8	0.0	0.3
Unitas Park (b)	44.9	50.2 (f)	47.7	48.6	1.8	3.9
Roods Gardens AH (b)	50.3	50.5 (f)	51.1	45.3	2.6	6.3
Homer (b)	39.5	39.9	45.8	45.3	0.9	1.1
Steelpark (b)	0	0	51.1	45.3	0.0	0.0

Notes:

(a) Industrial NSR
(b) Residential/ educational NSR
(c) Assumed based on closest noise sampling location
(d) Exceeds IFC guideline of 70 dBA for industrial areas
(e) Exceeds day-time IFC guideline of 55 dBA for residences
(f) Exceeds night-time IFC guideline of 45 dBA for residences
(g) Activities at facility not likely to occur during night-time
(h) Likely community response:

- 0 to 1 dBA – No reaction, increase not detectable
- 1 to 3 dBA – Increase just detectable to persons with average hearing acuity, annoyance unlikely.
- 3 to 5 dBA – There will be 'little' reaction with 'sporadic complaints'.
- 5 to 10 dBA – There will be 'little' to 'medium' reaction with 'sporadic' to 'widespread' complaints.
- 10 to 15 dBA – There will be a 'strong' reaction with 'threats of community action'.
- > 15 dBA – There will be a 'very strong' reaction with 'vigorous community action'.

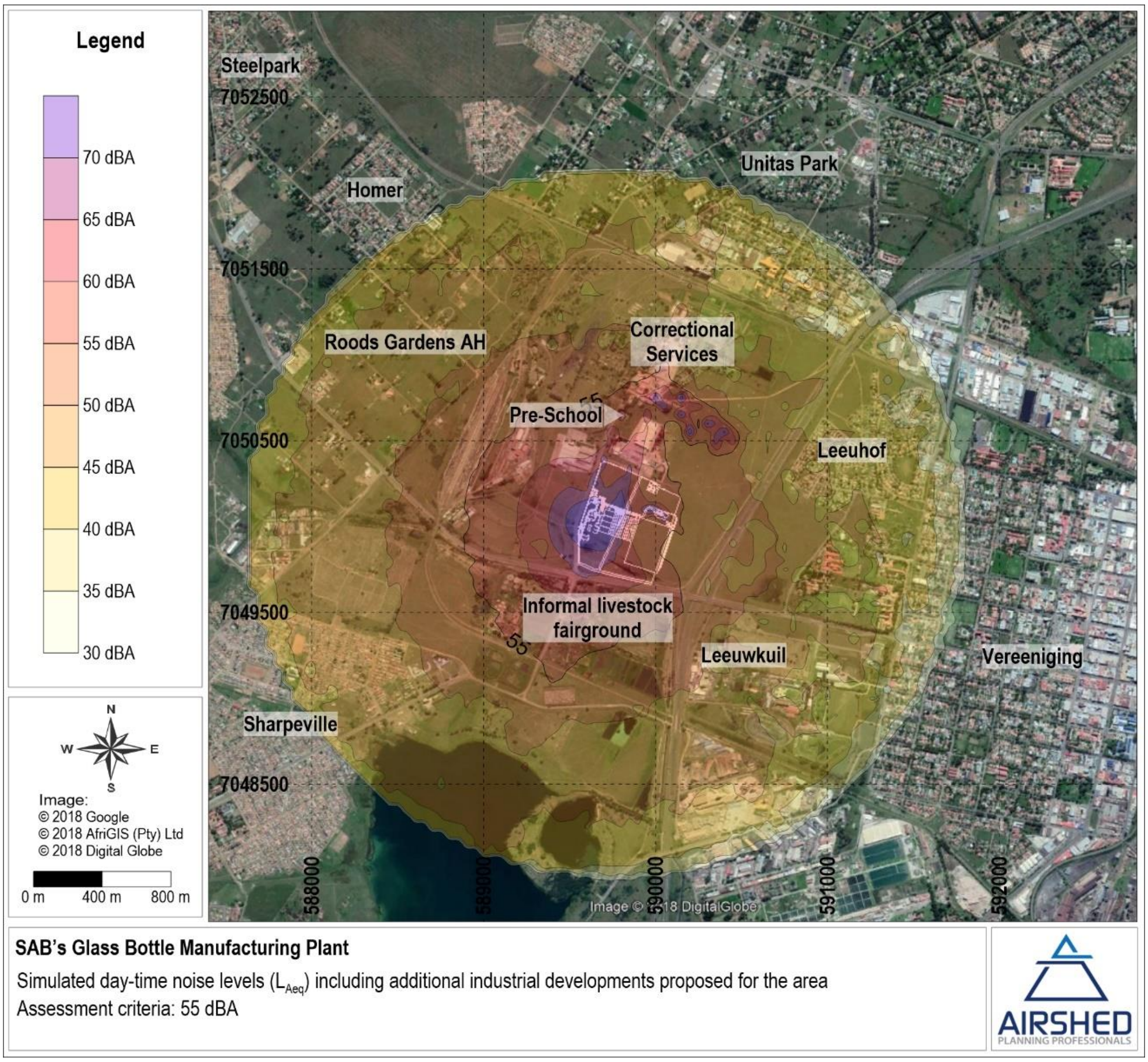


Figure 11: Simulated equivalent continuous day-time rating level ($L_{Req,d}$) for project activities, including additional industrial developments proposed for the area

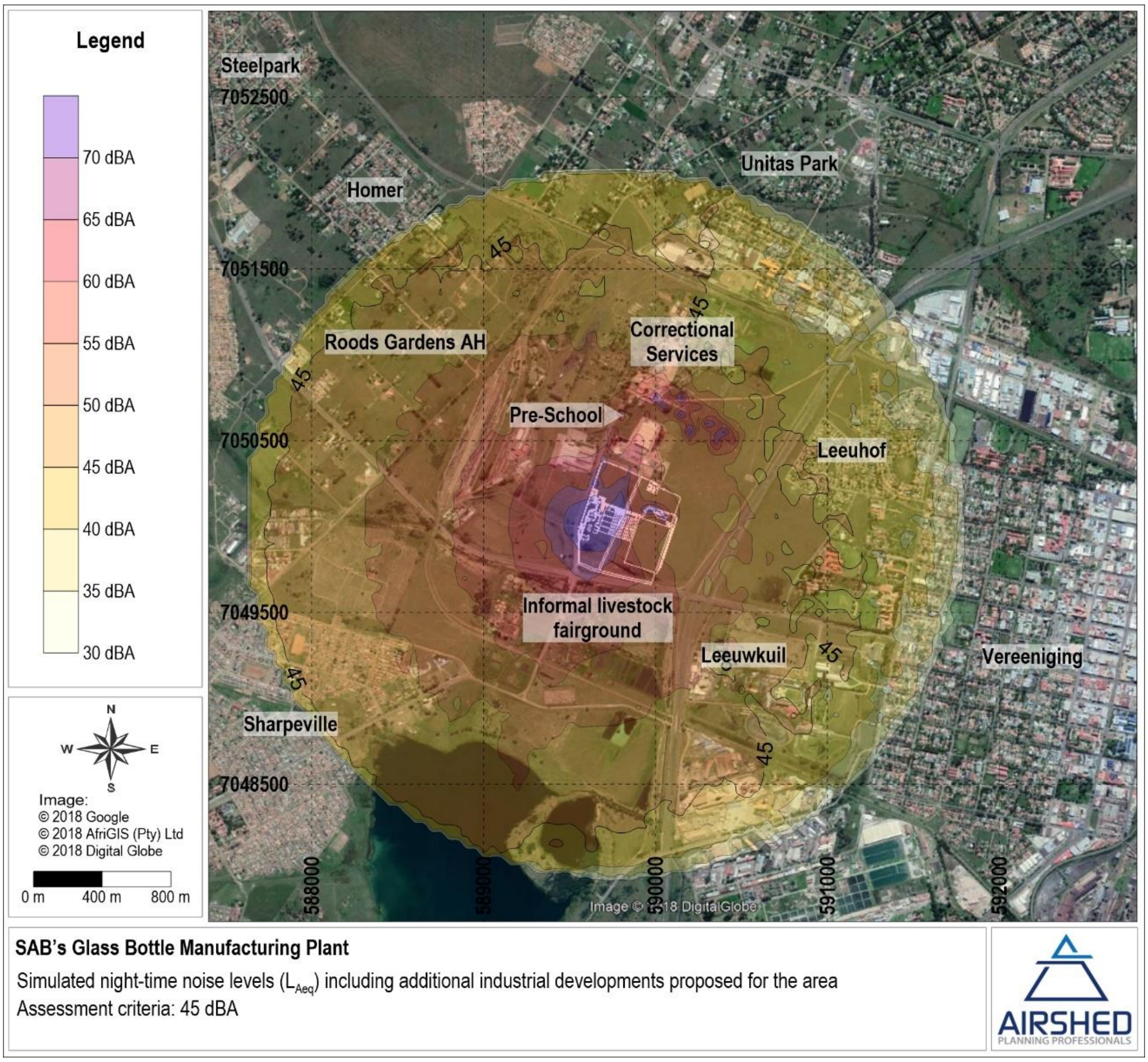


Figure 12: Simulated equivalent continuous night-time rating level ($L_{Req,n}$) for project activities, including additional industrial developments proposed for the area

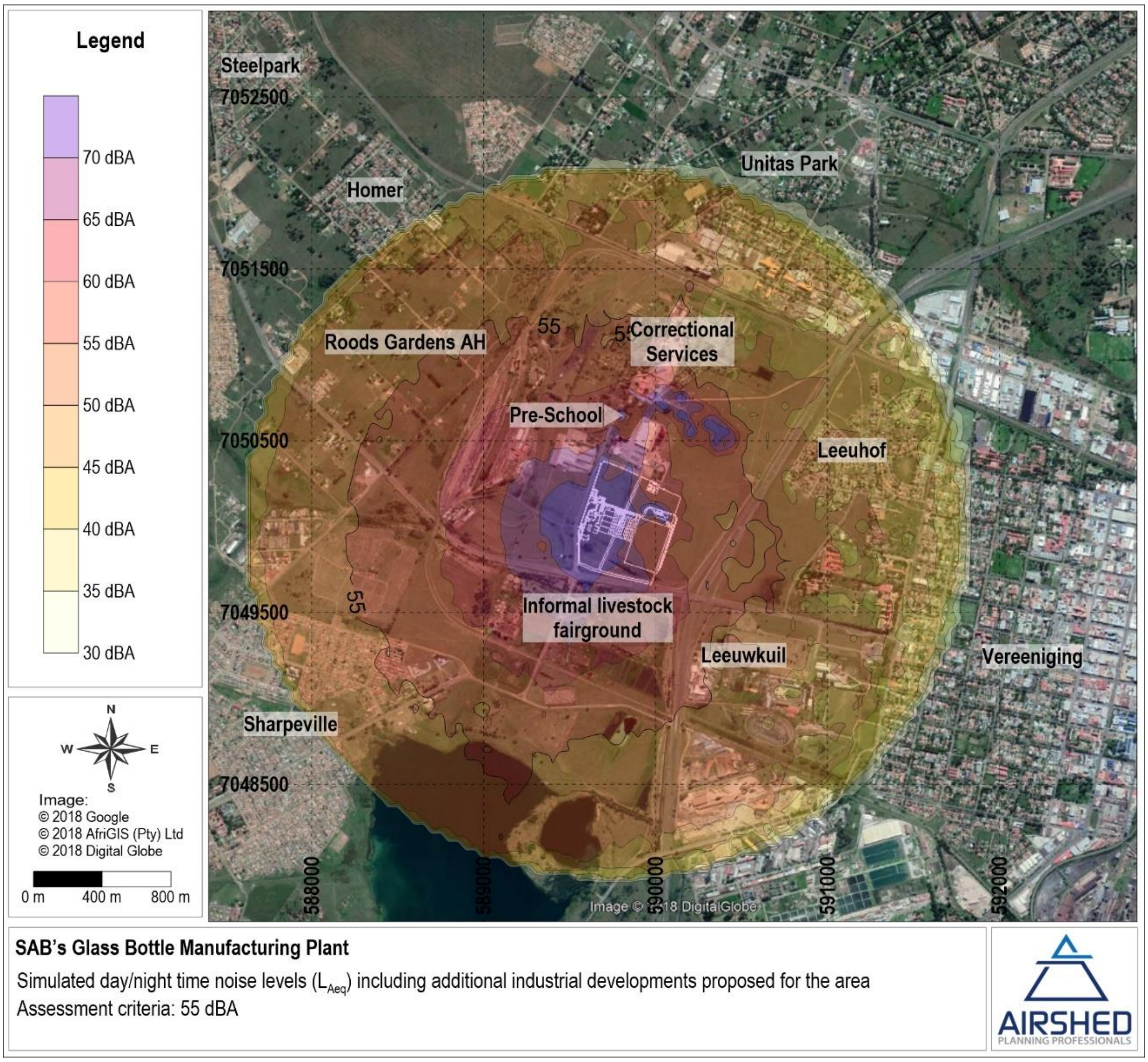


Figure 13: Simulated equivalent continuous day/night time rating level ($L_{Req,dn}$) for project activities, including additional industrial developments proposed for the area

5 Management Measures

In the quantification of noise emissions and simulation of noise levels as a result of the project, it was found that environmental noise evaluation criteria for residential, educational, and institutional receptors will not be met up to a distance of ~700 m from the site for day-time conditions and up to a distance of ~1800 m for night-time conditions. Increases in ambient noise levels may also be annoying to nearby NSRs.

The measures discussed in this section are measures typically applicable to industrial sites and traffic noise and are considered good practice by the IFC (2007) and British Standard BSI (2008). Noise control measures can be applied at the source, at the receiver, or the path from source to receiver.

5.1 Controlling Noise at the Source

5.1.1 General Good Practice Measures

Good engineering and operational practices will reduce levels of annoyance. For general activities, the following good engineering practice **should** be applied to **all project phases**:

- All diesel-powered equipment and plant vehicles should be kept at a **high level of maintenance**. This should particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment should serve as trigger for withdrawing it for maintenance.
- In managing noise specifically related to 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. Service providers (i.e. cullet suppliers) and contractors should be required to implementation of an equipment maintenance programs.
    - Maintain road surfaces regularly to repair potholes etc.
    - Keep all roads well maintained and avoid steep inclines or declines to reduce acceleration/brake noise.
    - Avoid unnecessary idling times at all 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). Also, when reversing, vehicles should travel in a direction away from NSR's if possible.
    - Limiting traffic, specifically heavy vehicle traffic, to hours between 06:00 and 18:00 as far as possible.

- Where possible, other non-routine noisy activities such as construction, decommissioning, start-up and maintenance, should be limited to day-time hours.
- A noise complaints register must be kept.

5.1.2 Specifications and Equipment Design

As the site or activity is in close proximity to NSRs, equipment and methods to be employed should be reviewed to ensure the quietest available technology is used. Equipment with lower sound power levels must be selected in such instances and vendors/contractors should be required to guarantee optimised equipment design noise levels.

5.1.3 Enclosures

As far as is practically possible, source of significant noise should be enclosed. The extent of enclosure will depend on the nature of the machine and their ventilation requirements. Generators, pumps and blowers are examples of such equipment.

It should be noted that the effectiveness of partial enclosures and screens can be reduced if used incorrectly, e.g. noise should be directed into a partial enclosure and not out of, there should not be any reflecting surfaces such as parked vehicles opposite the open end of a noise enclosure.

5.1.4 Use and Siting of Equipment

Plant and equipment should be sited as far away from NSRs as possible. Also:

a) Machines used intermittently should be shut down between work periods or throttled down to a minimum and not left running unnecessarily. This will reduce noise and conserve energy.
b) Plants or equipment from which noise generated is known to be particularly directional, should be orientated so that the noise is directed away from NSRs.
c) Acoustic covers of engines and compressors should be kept closed when in use or idling.
d) Doors to pump houses, and generators should be kept closed at all times.
e) Construction materials such as beams should be lowered and not dropped.

5.1.5 Maintenance

Regular and effective maintenance of equipment and plants are essential to noise control. Increases in equipment noise are often indicative of eminent mechanical failure. Also, sound reducing equipment/materials can lose effectiveness before failure and can be identified by visual inspection.

Noise generated by vibrating machinery and equipment with vibrating parts can be reduced through the use of vibration isolation mountings or proper balancing. Cutting tools and saws must be kept sharp to reduce frictional noise. Noise generated by friction in conveyor rollers, trolley etc. can be reduced by sufficient lubrication.

5.2 Controlling the Spread of Noise

Naturally, if noise activities can be minimised or avoided, the amount of noise reaching NSRs will be reduced. Alternatively, the distance between source and receiver must be increased, or noise reduction screens, barriers, or berms must be installed.

5.2.1 Distance

To increase the distance between source and receiver is often the most effective method of controlling noise since, for a typical point source at ground level, a 6-dB decrease can be achieved with every doubling in distance. It is however conceded that it might not always be possible.

5.2.2 Screening

If noise control at the source and the use of distance between source and receiver is not possible, screening methods must be considered. The effectiveness of a noise barrier is dependent on its length, effective height, and position relative to the source and receiver as well as material of construction. To optimize the effect of screening, screens should be located close to either the source of the noise, or the receiver.

The careful placement of barriers such as screens or berms can significantly reduce noise impacts but may result in additional visual impacts. Although vegetation such as shrubs or trees may improve the visual impact of construction sites, it will not significantly reduce noise impacts and should not be considered as a control measure.

Earth berms can be built to provide screening for large scale earth moving operations and can be landscaped to become permanent features once construction is completed. Care should be taken when constructing earth berms since it may become a significant source dust.

Screens can also be implemented at the cattle fairground to assist in the dampening of noise levels if they are above 85 to 90 dB.

5.3 Controlling Noise at the Receiver

Receiver noise control is mostly achieved through building design. Good hearing conditions are very important in especially institutional, business and educational buildings and adequate airborne sound insulation may necessary in areas of the development likely to be exposed to road and air traffic noise. In any building, there are many possible transmission paths of sound and in most cases part of the sound produced in a room is transmitted indirectly via flanking elements, e.g. side walls, windows, ceiling and floors into adjacent rooms or to the outside.

Since the outside walls of buildings have a relatively low weight in comparison with that of the floor and the ceiling, outside walls can be considered as the main flanking path. Windows are the most important item of flanking paths of outside walls owing to the high sound transmission coefficient of glass panes (Elmallawany, 1983).

Suitable engineering methods for sound insulation of buildings typically include the consideration of single or double glazed of windows for classrooms and acoustically absorbent building materials. The introduction of sealed multiple glazed windows and doorways will necessitate the installation of air conditioning units properly designed, placed and maintained so as to minimize noise associate with such sources.

5.4 Monitoring

Although the assessment focused on the impacts of noise on humans, concerns have been raised that the impacts of noise on cattle at the cattle fairgrounds south of operations will be substantial. From literature, there is a discomfort level observed in cattle at 90 to 100 dB and a behavioural response observed at 85 to 90 dB. Based on this, the noise levels at the cattle should be kept below 85 to 90 dB where possible.

Based on the concerns and the location of additional sensitive receptors to operations, it is recommended that noise monitoring at sites where noise is an issue or may become an issue is essential. Noise sampling at the cattle fairground and the staff accommodation at the Correctional Services should be incorporated in an annual environmental noise monitoring programme. Noise levels at the cattle fairground should be assessed against the 85 to 90 dB level and the measured noise levels at the Correctional Services assessed against the IFC guidelines of 55 dBA during the day and 45 dBA during the night. If noise levels exceed these guidelines, additional mitigation measures as listed in the Section 5.1, Section 5.2 and Section 5.3 can be implemented.

Also, in the event that noise related complaints are received short term (24-hour) ambient noise measurements should be conducted as part of investigating the complaints. The results of the measurements should be used to inform any follow up interventions. The investigation of complaints should include an investigation into equipment or machinery that likely result or resulted in noise levels annoying to the community. This could be achieved with source noise measurements.

The following procedure should be adopted for all noise surveys:

- Any surveys should be designed and conducted by a **trained specialist**.
- Sampling should be carried out using a **Type 1** SLM that meets all appropriate IEC standards and is subject to **annual calibration** by an accredited laboratory.
- The **acoustic sensitivity of the SLM should be tested** with a portable acoustic calibrator before and after each sampling session.
- Samples of 30 min to 24 hours in duration and sufficient for statistical analysis should be taken with the use of portable SLM's capable of logging data continuously over the time period. Samples representative of the day- and night-time acoustic environment should be taken.
- The following acoustic indices should be recoded and reported: L_{Aeq} (T), statistical noise level L_{A90}, L_{AFmin} and L_{AFmax}, octave band or 3rd octave band frequency spectra.
- The SLM should be located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface.
- Efforts should be made to ensure that 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 is good practice to avoid conducting measurements when the wind speed is more than 5 m/s, while it is raining or when the ground is wet.

- A detailed log and record should be kept. Records should include site details, weather conditions during sampling and observations made regarding the acoustic environment of each site.

6 Impact Significance Rating

The significance of environmental noise impacts was assessed according to the methodology adopted by SLR Consulting Africa (Pty) Ltd refer to Appendix D of this report for the methodology.

The significance of the noise impacts due to project activities were found to be ***moderate*** (Table 11). Assuming the adoption of good practice noise mitigation and management measures as recommended, the significance of project noise impacts may be reduced to ***low*** (Table 11).

As the project activities are expected to be the main contributor of the noise impacts in the area (as simulated based on available information), the significance rating of the project activities with the proposed maize wet mill plant is ***high***, reducing to ***low*** with mitigation (Table 11).

No noise impacts are expected post-closure.

Table 11: Significance rating for noise impacts due to project activities

Project Activity	Noise		Probability	Consequence				Significance Rating
	Description	Impacts	Probability	Intensity	Duration	Extent	Conse-quence	Significance Rating
Project activities	Resulting Impact from Project Activity	Noise impacts generated may impact on the social environment, especially residential areas adjacent to the facility	Without Mitigation					
Project activities	Resulting Impact from Project Activity	Noise impacts generated may impact on the social environment, especially residential areas adjacent to the facility	H	M	H	M	M	Medium
Project activities	Resulting Impact from Project Activity	Noise impacts generated may impact on the social environment, especially residential areas adjacent to the facility	With Mitigation					
Project activities	Resulting Impact from Project Activity	Noise impacts generated may impact on the social environment, especially residential areas adjacent to the facility	H	VL	H	L	L	Low
Project activities	Resulting Impact from Project Activity and Other Operations Proposed for the Site	Noise impacts generated may impact on the social environment, especially residential areas adjacent to the facilities	Without Mitigation					
Project activities	Resulting Impact from Project Activity and Other Operations Proposed for the Site	Noise impacts generated may impact on the social environment, especially residential areas adjacent to the facilities	H	M	H	H	H	High
Project activities	Resulting Impact from Project Activity and Other Operations Proposed for the Site	Noise impacts generated may impact on the social environment, especially residential areas adjacent to the facilities	With Mitigation					
Project activities	Resulting Impact from Project Activity and Other Operations Proposed for the Site	Noise impacts generated may impact on the social environment, especially residential areas adjacent to the facilities	H	VL	H	L	L	Low

Table 12 provides a summary of the general effectiveness of various mitigation techniques.

Table 12: A summary of general effectiveness of various mitigation techniques

Mitigation Technique	General Effectiveness	Monetary Costs	Conditions where feasible
Vehicle components	Fair	N/A	N/A
Operational factors	Fair	Low	Local roads/site
Engineering considerations	Good/excellent	Medium	New construction
Barriers	Excellent (5-15 dBA reduction)	Medium	Almost always
Earth Berms	Excellent (5-15 dBA reduction)	Low	Wide corridors
Buildings and other man-made structures	Good (up to 10 dBA reduction)	N/A	Requires local/site planning
Vegetative screening	Fair/average	Medium	Almost always
Sound Insulation	Average	Medium	Case by case

7 Conclusion

Based on the findings of the assessment and provided the recommended management and mitigation measures are in place, it is the specialist opinion that the project may be authorised.

8 References

Aaberg, D., 2007. *Generator Set Noise Sollutions: Controlling Unwanted Noise from On-site Power Systems,* s.l.: Cummins Power Generation Inc..

Albright, J. & Arave, C., 1997. *The behaviour of cattle.,* s.l.: CAB International.

Algers, B., 1984. A note on behavioural responses of farm animals to ultrasound.. *Applied Animal Behavior Science, vol. 12,* pp. 387-391.

Aloui, M., Bleuzen, Y., Essefi, E. & Abbes, C., 2016. Ground Vibrations and Air Blast Effects Induced by Blasting in Open Pit Mines: Case of Metlaoui Mining Basin, Southwestern Tunisia. *Journal of Geology and Geophysics,* 5(3).

Arnold, N. A., Kim, T. N., Jongman, E. C. & Hemsworth, P. H., 2007. The behavioural and physiological responses of dairy heifers to tape-recorded milking facility noise with and without a pre-treatment adaptation phase.. *Applied Animal Behaviour Science, vol. 106,* pp. 13-25.

Arnold, N. A., Kim, T. N., Jongman, E. C. & Hemsworth, P. H., 2008. Avoidance of tape-recorded milking facility noise by dairy heifers in a Y maze choice task.. *Applied Animal Behaviour Science, vol. 109,* pp. 201-210.

Beyer, D., 1983. *Studies of the Effects of Low-Flying Aircraft on Endocrinological and Physiological Parameters in Pregnant Cows..* München, Germany: Diss. Veterinary College of Hannover.

Broucek, J., Kovalcikova, M. & Kovalcik, K., 1988. Effect of noise load on changes of biochemical indicators in differently relative first-calf cows.. *Polnohospodarstvo, vol. 34,* pp. 647-654.

Bruce, R. D. & Moritz, C. T., 1998. Sound Power Level Predictions for Industrial Machinery. In: M. J. Crocker, ed. *Handbook of Acoustics.* Hoboken: John Whiley & Sons, Inc, pp. 863-872.

Brüel & Kjær Sound & Vibration Measurement A/S, 2000. *www.bksv.com.* [Online] Available at: http://www.bksv.com [Accessed 14 October 2011].

BSI, 2008. *Code of practice for noise and vibration control on construction and open sites - Part 1: Noise.* s.l.:s.n.

Bugliarello, G., Alexandre, A., Barnes, J. & Wakstein, C., 1976. *The impact of noise pollution | A socio-technological introduction.* s.l.:Pergamon Press.

Burgess, M. & McCarty, M., 2009. *Review of Alternatives to 'Beeper' Alarms for Construction Equipment,* Canberra: University of New South Wales.

Dufour, P., 1980. *Effects of noise on wildlife and other animals: review of research since 1971.,* s.l.: U.S. Environmental Protection Agency, EP A 550/9-80-100.

Earth Resources | Victoria State Government, 2015. *Ground Vibration and Airblast Limits for Blasting in Mines and Quarries.* [Online] Available at: http://earthresources.vic.gov.au/earth-resources-regulation/licensing-and-approvals/minerals/guidelines-and-codes-of-practice/ground-vibration-and-airblast-limits-for-blasting-in-mines-and-quarries [Accessed 5 January 2018].

EC WG-AEN, 2006. *Position Paper | Final Draft | Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure,* Brussels: European Commission.

Elmallawany, A., 1983. Field Investigations of the Sound Insulation in School Buidlings. *Buidling and Environments,* Volume 18, pp. 85-89.

Gladwin, D. N., Manci, K. M. & Villella, R., 1988. *Effects of aircraft noise and sonic booms on domestic animals and wildlife: bibliographic abstracts.,* Ft. Collins, CO. NER C-88/32.: U.S. Fish Wildlife Servise National Ecology Research Center.

Grandin, T., 1998. The feasibility of using vocalization scoring as an indicator of poor welfare during cattle slaughter.. *Applied Animal Behaviour Science, vol. 56,* pp. 121-128.

Gygax, L. & Nosal, D., 2006. Short Communication: Contribution of Vibration and Noise During Milking to the Somatic Cell Count of Milk.. *Journal of Dairy Science, vol. 89,* pp. 2499-2502.

Head, H. H. et al., 1993. Milk yield, milk composition, and behavior of Holstein cows in response to jet aircraft noise before milking. *Journal of Dairy Science, vol. 76,* pp. 1558-1567.

Heffner, H. E., 1998. Auditory awareness. *Applied Animal Behaviour Science, vol. 57,* pp. 259-268.

Heffner, H. E. & Heffner, R. S., 1993. Auditory perception. In: *Farm Animals and the Environment.* Wallingford: CAB International, pp. 159-184.

Hemsworth, P. H., 2003. Human-animal interactions in livestock production.. *Applied Animal Behaviour Science, vol. 81,* pp. 185-198.

IFC, 2007. *General Environmental, Health and Safety Guidelines,* s.l.: s.n.

Kovalčík, K. & Šottník, J., 1971. The effect of noise on the milk efficiency of cows. *Zivocisna Vyroba, vol. 16,* pp. 795-804.

Lanier, J. L. et al., 2000. The relationship between reaction to sudden, intermittent movements and sounds and temperament. *Journal of Animal Science, vol. 78,* pp. 1467-1474.

Manci, K. M., Gladwin, D. N., Villella, R. & Cavendish, M. G., 1988. *Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: A Literature Synthesis..* Ft. Collins, CO, NER C-88/29.: U.S. Fish and Wildlife Service National Ecology Research Center.

Morgan, K. & Tromborg, C., 2007. Sources of stress in captivity.. *Applied Animal Behaviour Science, vol. 102,* pp. 262-302.

Pajor, E. A., Rushen, J. & De Passille, A. M. B., 2000. Aversion learning techniques to evaluate dairy cattle handling practices.. *Applied Animal Behaviour Science, vol. 69,* pp. 89-102.

Phillips, C. J. C., 2009. Principles of cattle production. In: *Housing, handling and the environment for cattle.* s.l.:ISBN 978-1-84593-397-5, pp. 95-128.

SANS 10103, 2008. *The measurement and rating of environmental noise with respect to annoyance and to speech communication,* Pretoria: Standards South Africa.

Schulze, R. E., 1997. *South African Atlas of Agrohydrology and Climatology.* Report TT82/96 ed. Pretoria: Water Research Comission.

The Gauteng Provincial Government, 1999. *Noise Control Regulations under Section 25 of the Environment Conservation Act (ActNno. 73 of 1989), General Notice 5479 of 1999, Provincial Gazette Extraordinary No. 75, 20 August 1999.* s.l.:s.n.

The Republic of South Africa, 1992. *Noise Control Regulations in terms of Section 25 of the Environment Conservation Act, Notice R154, Government Gazette 13717, 10 January 1992.* s.l.:Government Printing Works.

Waynert, D. E. et al., 1999. Response of beef cattle to noise during handling.. *Applied Animal Behaviour Science, vol. 62,* pp. 27-42.

WHO, 1999. *Guidelines to Community Noise.* s.l.:s.n.

Appendix A – Sound Level Meter 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, 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

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

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 CALIBRATOR
Manufacturer:	SVANTEK
Model number:	SV33
Serial number:	57649
Calibrated for:	AIRSHED PLANNING PROFESSIONALS Midrand
Calibration procedure:	AV\AS-0008
Period of calibration:	10 April 2017

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-59)
MadgeTech PRHTemp2000	(AS-106)
Brüel & Kjær 3630 Calibration platform	(AS-109)
Brüel & Kjær 4228 Pistonphone	(AS-WSTD-10)
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 10 April 2017	Page 1 of 2	Certificate number AV\AS-4635

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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* = 0,13 %

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 **R Nel** **Metrologist (Technical Signatory)**	Checked by **H Potgieter** **Metrologist**	For Chief Executive Officer
Date of Issue **10 April 2017**	**Page 2 of 2**	Certificate number **AV\AS-4635**

Appendix B – Specialist Curriculum Vitae

FULL CURRICULUM VITAE

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

MEMBERSHIP OF PROFESSIONAL SOCIETIES

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

KEY QUALIFICATIONS

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

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

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

RELEVANT EXPERIENCE

Mining and Ore Handling

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

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

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

Metal Recovery

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

Chemical Industry

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

Petrochemical Industry

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

Pulp and Paper Industry

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

Power Generation

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

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

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

Waste Disposal

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

Cement Manufacturing

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

Management Plans

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

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

Other Experience (2001)

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

EDUCATION

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

ADDITIONAL COURSES

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

COUNTRIES OF WORK EXPERIENCE

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

EMPLOYMENT RECORD

January 2002 - Present

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

2001

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

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

1999 - 2000

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

CONFERENCE AND WORKSHOP PRESENTATIONS AND PAPERS

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

LANGUAGES

	Speak	Read	Write
English	Excellent	Excellent	Excellent
Afrikaans	Fair	Good	Good

CERTIFICATION

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

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

Full name of staff member: René Georgeinna von Gruenewaldt

Appendix C – Fieldwork Log Sheets and Photos

SITE NUMBER: Site 1		SLM DATA RECORD: Iman 001 (Day)	
Longitude/Easting: 27.906694	Latitude/Northing: -26.664499°	Elevation:	
Short Location Description & Notes:			

SETUP	Start Date & Time:	End Date & Time:	Sensitivity Before:	Sensitivity After:

METEOROLOGY	Wind Speed (m/s)	Wind Direction (°)	Temperature (°C)	Humidity (%)	Clouds (%)	Remarks:
Start	±0.5 - 5	North-Easterly	± 29	± 29.3	3/10	
Middle						
End						

NOISE CLIMATE	☐ Birds	☐ Insects	☐ Dogs	☐ Music	☐ Community	☐ Air Traffic	☐ Road Traffic	☐ Constr.	☐ Other

Description: Open area, uncultivated land, non residential, small grass. Very windy @ background 44-49dB, lots of Birds, ±500m to mean road

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
10:08:59	Bird		~~FR~~	35:32	Bird		
10:10:31	Bird	10:22:04		35:21	Wind		
12:00	"	-10:22:23	Wind	35:46	Wind		
14:16	"	24:42	lawnmove	37:52	"		
13:53	"	25:29		38:54			
~~15:18~~	"	28:22	~~lawnmove~~ lawnmore	40:22	Bird		
14:36-	Gust Wind	29:02		43:15-	Truck		
15:02		29:22		43:46			
17:18	Gust Wind	29:50	Gust Wind	44:21	Bird		
17:35	"	30:37		43:33	Truck hooted		
19:16	Gust Bird	~~32:08~~		48:32-			
20:04		~~34:25~~		48:46	Wind		
-20:36	Gust Wind	32:59	lawnmore	~~50:42~~	Gust wind		
~~22:43~~		34:30	Birds	49:58			
				-50:42			

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SITE NUMBER:	Site 2		SLM DATA RECORD:	Iman 002 (Day)
Longitude/Easting: 27.906798°		Latitude/Northing: -26.660369	Elevation:	
Short Location Description & Notes:				

SETUP	Start Date & Time:	End Date & Time:	Sensitivity Before:	Sensitivity After:

METEOROLOGY	Wind Speed (m/s)	Wind Direction (°)	Temperature (°C)	Humidity (%)	Clouds (%)	Remarks:
Start	0.9 – 3.2	North eastly	±30 - 31.2	±30	4/10	
Middle						
End						

NOISE CLIMATE	☐ Birds	☐ Insects	☐ Dogs	☐ Music	☐ Community	☐ Air Traffic	☐ Road Traffic	☐ Constr.	☐ Other

Description: Close to residental area ±100m (same conditions as site 1), lawnmore Background noise @ 49-52dB
Birds @ 50-60dB
Could hear sugar factory operations @ 46-48dB
snow flake (flour)

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
11:08:49	Cows	31:39	Birds	51:47	Birds		
11:14:52	Truck passing	33:04		-52:59			
15:45	"	-33:					
	Birds	-33:51	Gust wind				
16:21-	"	34:10-	lawnmore				
16:46	"	34:37	"				
	"	37:27-	Gust wind				
19:07	Birds	-38:39					
22:39	Cow	-39:50-					
19:41	"	40:23					
18:12	Birds	45:09	Gust Wind				
23:06	Gust wind	-45:38					
-23:56		49:44	Birds				

11:18:03 – 11:18:20 → lawnmover

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SITE NUMBER: Site 3		SLM DATA RECORD: Imani ~~003~~ 005 (Day)
Longitude/Easting: 27.912799°	Latitude/Northing: -26.664440°	Elevation:
Short Location Description & Notes:		

SETUP	Start Date & Time:	End Date & Time:	Sensitivity Before:	Sensitivity After:

METEOROLOGY	Wind Speed (m/s)	Wind Direction (°)	Temperature (°C)	Humidity (%)	Clouds (%)	Remarks:
Start	±0.6 - 3.8	N. Eastely	±30.7	±22.6	8/10	
Middle						
End						

NOISE CLIMATE	☐ Birds	☐ Insects	☐ Dogs	☐ Music	☒ Community	☐ Air Traffic	☒ Road Traffic	☒ Constr.	☐ Other

Description: Close residitial area ±10m, close to main road R59 ±50m, uncultivated land lots of vehicles, Trucks & Vehicles @ ±74dB

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
14:45:13	Truck passing	19:01	Vehicle passing				
46:01	"	19:34	"				
50:34	Truck hooter	20:27	Birds				
54:47	"	21:08	Birds				
59:26	Car hooter	15:21:34	Truck hooter				
59:38		24:44	"				
15:05:08		25:23	"				
05:45	"	25:46	"				
09:09	Gust wind	22:19	Motor Bike				
09:05		27:48	Vehicle passing				
12:29	~~Traffic~~ Vehicle passing	15:29:21	Gust wind				
13:25							
16:50	"						
17:34	"						

Page

SITE NUMBER: Site 4		SLM DATA RECORD: ~~Training~~ / Imani 004 (Day)
Longitude/Easting: 27,902188°	Latitude/Northing: -26,671692°	Elevation:
Short Location Description & Notes:		

SETUP	Start Date & Time:	End Date & Time:	Sensitivity Before:	Sensitivity After:

METEOROLOGY	Wind Speed (m/s)	Wind Direction (°)	Temperature (°C)	Humidity (%)	Clouds (%)	Remarks:
Start	± 1.5	North	± 31.2	± 23.5	7/10	
Middle						
End						

NOISE CLIMATE	☒ Birds	☐ Insects	☐ Dogs	☐ Music	☐ Community	☐ Air Traffic	☒ Road Traffic	☐ Constr.	☐ Other

Description: Uncultivated land, shrubs & trees, semi-residential area, ~~Close~~ near the road ± 150m Rooster @ ± 59dB, Gust wind @ ± 61dB

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
13:38:14	Gust wind	13:59:29	Truck passing				
39:31	"	14:00:34	wind				
40:16	"	6:05–	} Gust wind				
42:49		6:46					
43:13							
44:01		10:46	Truck hooter				
45:31		~~18~~ 14:12:52	} Wind				
48:27	Rooster	-14:13:53	"				
49:23	Truck hooter	13:54	"				
49:43	Rooster	-14:16	"				
51:30	Rooster	16:41	Birds				
53:02	Gust wind	20:30	Rooster →	14:19:02	Truck passing		
54:00	"	20:53	"				
55:07	"	21:13	"				

~~14:19:02~~ Vel

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SITE NUMBER: Site 5		SLM DATA RECORD: Irvin 003 (Day)
Longitude/Easting: 27.901117°	Latitude/Northing: -26.662397°	Elevation:
Short Location Description & Notes:		

SETUP	Start Date & Time:	End Date & Time:	Sensitivity Before:	Sensitivity After:

Pressure : 854

METEOROLOGY	Wind Speed (m/s)	Wind Direction (°)	Temperature (°C)	Humidity (%)	Clouds (%)	Remarks:
Start	±1.2 - 3.3	Eastely	±33.6	±23	5/10	
Middle						
End						

NOISE CLIMATE	☒ Birds	☒ Insects	☐ Dogs	☐ Music	☒ Community	☐ Air Traffic	☒ Road Traffic	☐ Constr.	☐ Other

Description: Shrubs & trees, uncultivated land, ± 200m to primary school, Windy area | Cattle:

EVENTS							
Time	Description	Time	Description	Time	Description	Time	Description
12:31:10	Gust wind	52:59	Birds				
-32:38		53:11	Birds				
34:16-	Gust wind	57:27	Gust wind				
35:07		-58:40					
39:27	Cow moo	13:03:34	Motorbike				
40:02-	Birds.	-03:51					
40:20		07:07	Taxi				
42:19	Gust wind	07:18	"				
42:43	"	08:00	Taxi				
46:28	"	10:03	Taxi hooter				
47:10	Gust	12:11	Birds				
-48:49	wind	12:36	Birds				
		13:40-	Winds				
52:14	Gust wind	14:29	"				

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SITE NUMBER: Site 1		**SLM DATA RECORD:** Imani 010 (Night)	
Longitude/Easting: 27.906694°	**Latitude/Northing:** -26.664497°		**Elevation:**
Short Location Description & Notes:			

SETUP	**Start Date & Time:**	**End Date & Time:**	**Sensitivity Before:**	**Sensitivity After:**

METEOROLOGY	**Wind Speed (m/s)**	**Wind Direction (°)**	**Temperature (°C)**	**Humidity (%)**	**Clouds (%)**	**Remarks:**
Start	±0 – 0.3	North Easterly	±22.1	±50.1	1/10	
Middle						
End						

NOISE CLIMATE	☐ Birds	☐ Insects	☐ Dogs	☐ Music	☐ Community	☐ Air Traffic	☒ Road Traffic	☐ Constr.	☐ Other
Description: Background noise of traffic @ ± 49dB									

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
23:50:05	Birds						
50:45	Vehicle passing						
53:15	Vehicle hooting						
54:31	"						
23:58:08	Vehicle passing						
-23:59:38	"						
59:42-	"						
00:48	"						
03:13	"						

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SITE NUMBER: Site 2		SLM DATA RECORD: 1/Imani 009 (Night)	
Longitude/Easting: 27.906798°	Latitude/Northing: -26.660369		Elevation:
Short Location Description & Notes:			

SETUP	Start Date & Time:	End Date & Time:	Sensitivity Before:	Sensitivity After:

METEOROLOGY	Wind Speed (m/s)	Wind Direction (°)	Temperature (°C)	Humidity (%)	Clouds (%)	Remarks:
Start	±0 - 0.9	~~1-20~~ North Easterly	± 20	±53.4	1	
Middle						
End						

NOISE CLIMATE	☐ Birds	☐ Insects	☐ Dogs	☐ Music	☐ Community	☐ Air Traffic	☐ Road Traffic	☐ Constr.	☐ Other
Description: Cars passing @ ±50dB									

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
23:22:52	Dog bark						
23:01	Car passing						
24:51	Truck						
-25:48							
26:15-	Car passing						
26:56							
27:39	"						
28:40	"						
32:25	Truck hooter						
32:51	Car						
34:53	Truck passing						

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SITE NUMBER: Site3		SLM DATA RECORD: Imani006 (Night)	
Longitude/Easting: 27.912799°	Latitude/Northing: -26.664440°	Elevation:	
Short Location Description & Notes:			

SETUP	Start Date & Time:	End Date & Time:	Sensitivity Before:	Sensitivity After:

METEOROLOGY	Wind Speed (m/s)	Wind Direction (°)	Temperature (°C)	Humidity (%)	Clouds (%)	Remarks:
Start	±0-0.2	North	±23.1	±44.3	1	
Middle						
End						

NOISE CLIMATE	☐ Birds	☐ Insects	☐ Dogs	☐ Music	☐ Community	☐ Air Traffic	☒ Road Traffic	☐ Constr.	☐ Other

Description: Vehicles passing @±68dB, Background noise of Vehicle passing ±68dB

EVENTS							
Time	Description	Time	Description	Time	Description	Time	Description
22:02:07	Truck passing						
02:56	Gust Wind						
04:01-							
- 04:48	Vehicle passing						
05:03-	"						
05:54	"						
06:00	"						
06:44	"						
07:57	"						

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SITE NUMBER: Site 4		SLM DATA RECORD: I man.007 (Night)	
Longitude/Easting: 27.902188°	Latitude/Northing: -26.671692°	Elevation:	
Short Location Description & Notes:			

SETUP	Start Date & Time:	End Date & Time:	Sensitivity Before:	Sensitivity After:

METEOROLOGY	Wind Speed (m/s)	Wind Direction (°)	Temperature (°C)	Humidity (%)	Clouds (%)	Remarks:
Start	0 - 0.7	North	± 20	50.2	1	
Middle						
End						

NOISE CLIMATE	☐ Birds	☐ Insects	☒ Dogs	☐ Music	☐ Community	☐ Air Traffic	☐ Road Traffic	☐ Constr.	☒ Other
Description: Vehicles passing @ ± 62.9dB									

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
22:31:15	Goats bell	42:31	Cars				
30:53	Cars	43:50	"				
31:24	Goats bell	44:41					
33:18	Dog peek						
33:37-	Car						
34:06	Car						
35:06	"						
35:34							
36:29	Car						
37:54	"						
39:15	Goat bell						
39:48	Cow moo						
40:40	Car						

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SITE NUMBER:	Site 5	SLM DATA RECORD: ~~[illegible]~~ Imani 008 (Night)
Longitude/Easting: 27.901117°	Latitude/Northing: -26.662397°	Elevation:
Short Location Description & Notes:		

SETUP	Start Date & Time:	End Date & Time:	Sensitivity Before:	Sensitivity After:

METEOROLOGY	Wind Speed (m/s)	Wind Direction (°)	Temperature (°C)	Humidity (%)	Clouds (%)	Remarks:
Start	± 0-0.2	North	± 21.1	± 50.4	/	
Middle						
End						

NOISE CLIMATE	☐ Birds	☐ Insects	☐ Dogs	☐ Music	☐ Community	☐ Air Traffic	☒ Road Traffic	☐ Constr.	☐ Other
Description: Vehicle passing @ ± 44dB									

EVENTS							
Time	Description	Time	Description	Time	Description	Time	Description
22:55:17	Truck hooter						
01:07	"						
01:51	Car hooter						
06:06	"						
08:06	"						
08:15	"						
08:49	"						
09:46	Truck hooter						

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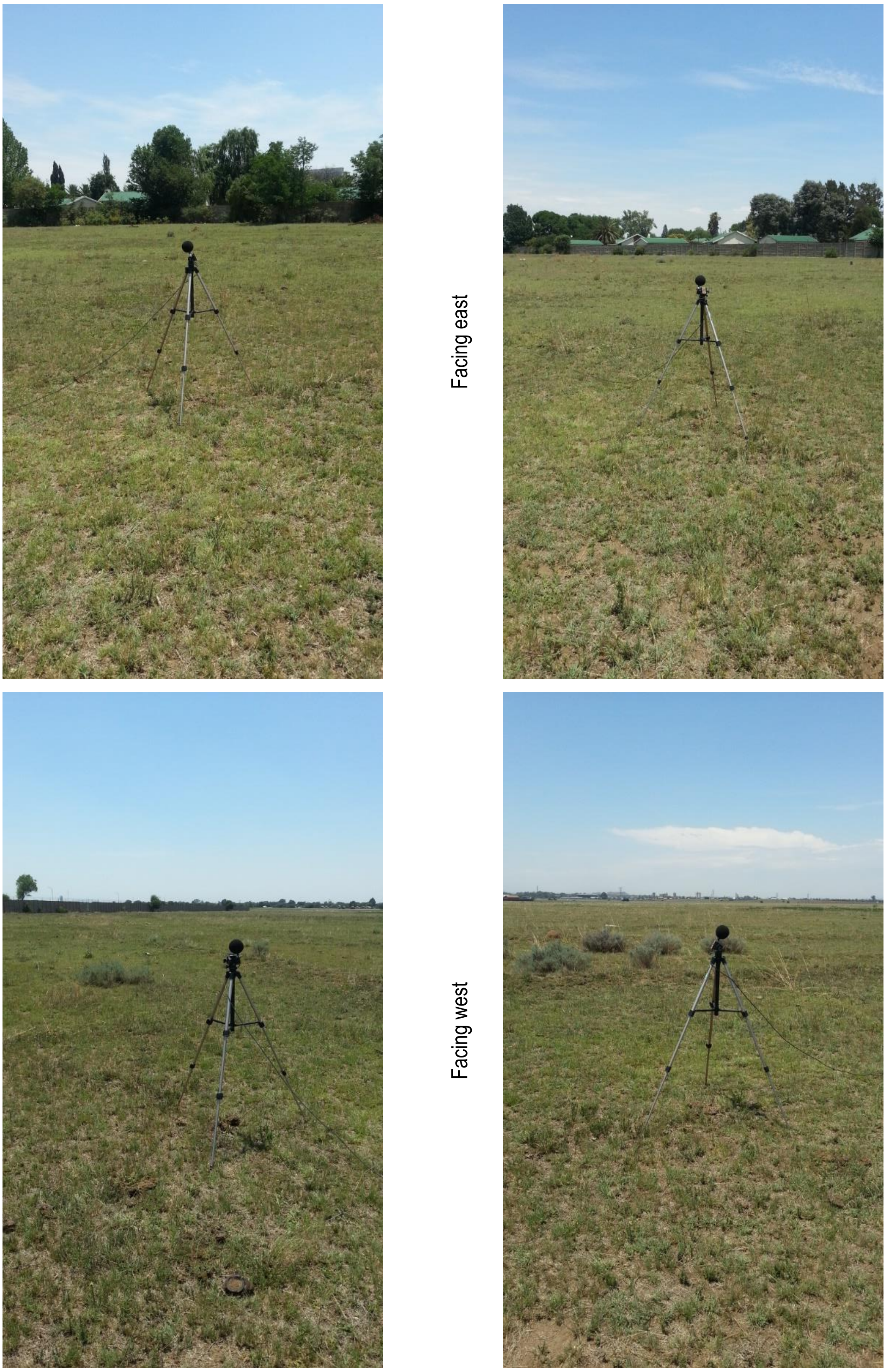
Facing north

Facing east

Facing south

Facing west

Figure 14: Photographs of environmental noise survey Site 1



Facing north

Facing east

Facing south

Facing west

Figure 15: Photographs of environmental noise survey Site 2

Facing north

Facing east

Facing south

Facing west

Figure 16: Photographs of environmental noise survey Site 3

Figure 17: Photographs of environmental noise survey Site 4

Figure 18: Photographs of environmental noise survey Site 5

Appendix D – Significance Rating Methodology

The methodology used for assessing the significance of the impact was obtained from the SLR.

PART A: DEFINITIONS AND CRITERIA		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of intensity, spatial extent and duration**
Criteria for ranking of the INTENSITY of environmental impacts	**VH**	Severe change, disturbance or degradation. Associated with severe consequences. May result in severe illness, injury or death. Targets, limits and thresholds of concern continually exceeded. Substantial intervention will be required. Vigorous/widespread community mobilization against project can be expected. May result in legal action if impact occurs.
	H	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.
	M	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.
	L	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.
	VL	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.
	VL+	Negligible change or improvement. Almost no benefits. Change not measurable/will remain in the current range.
	L+	Minor change or improvement. Minor benefits. Change not measurable/will remain in the current range. Few people will experience benefits.
	M+	Moderate change or improvement. Real but not substantial benefits. Will be within or marginally better than the current conditions. Small number of people will experience benefits.
	H+	Prominent change or improvement. Real and substantial benefits. Will be better than current conditions. Many people will experience benefits. General community support.
	VH+	Substantial, large-scale change or improvement. Considerable and widespread benefit. Will be much better than the current conditions. Favourable publicity and/or widespread support expected.
Criteria for ranking the DURATION of impacts	**VL**	Very short, always less than a year. Quickly reversible
	L	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.
	M	Medium-term, 5 to 10 years.
	H	Long term, between 10 and 20 years. (Likely to cease at the end of the operational life of the activity)
	VH	Very long, permanent, +20 years (Irreversible. Beyond closure)
Criteria for ranking the EXTENT of impacts	**VL**	A part of the site/property.
	L	Whole site.
	M	Beyond the site boundary, affecting immediate neighbours
	H	Local area, extending far beyond site boundary.
	VH	Regional/National

PART B: DETERMINING CONSEQUENCE							
			EXTENT				
			A part of the site/property	Whole site	Beyond the site, affecting neighbours	Local area, extending far beyond site.	Regional/ National
			VL	**L**	**M**	**H**	**VH**
INTENSITY = VL							
DURATION	Very long	**VH**	**Low**	**Low**	**Medium**	**Medium**	**High**
	Long term	**H**	**Low**	**Low**	**Low**	**Medium**	**Medium**
	Medium term	**M**	**Very Low**	**Low**	**Low**	**Low**	**Medium**
	Short term	**L**	**Very low**	**Very Low**	**Low**	**Low**	**Low**
	Very short	**VL**	**Very low**	**Very Low**	**Very Low**	**Low**	**Low**
INTENSITY = L							
DURATION	Very long	**VH**	**Medium**	**Medium**	**Medium**	**High**	**High**
	Long term	**H**	**Low**	**Medium**	**Medium**	**Medium**	**High**
	Medium term	**M**	**Low**	**Low**	**Medium**	**Medium**	**Medium**
	Short term	**L**	**Low**	**Low**	**Low**	**Medium**	**Medium**
	Very short	**VL**	**Very low**	**Low**	**Low**	**Low**	**Medium**
INTENSITY = M							
DURATION	Very long	**VH**	**Medium**	**High**	**High**	**High**	**Very High**
	Long term	**H**	**Medium**	**Medium**	**Medium**	**High**	**High**
	Medium term	**M**	**Medium**	**Medium**	**Medium**	**High**	**High**
	Short term	**L**	**Low**	**Medium**	**Medium**	**Medium**	**High**
	Very short	**VL**	**Low**	**Low**	**Low**	**Medium**	**Medium**
INTENSITY = H							
DURATION	Very long	**VH**	**High**	**High**	**High**	**Very High**	**Very High**
	Long term	**H**	**Medium**	**High**	**High**	**High**	**Very High**
	Medium term	**M**	**Medium**	**Medium**	**High**	**High**	**High**
	Short term	**L**	**Medium**	**Medium**	**Medium**	**High**	**High**
	Very short	**VL**	**Low**	**Medium**	**Medium**	**Medium**	**High**
INTENSITY = VH							
DURATION	Very long	**VH**	**High**	**High**	**Very High**	**Very High**	**Very High**
	Long term	**H**	**High**	**High**	**High**	**Very High**	**Very High**
	Medium term	**M**	**Medium**	**High**	**High**	**High**	**Very High**
	Short term	**L**	**Medium**	**Medium**	**High**	**High**	**High**
	Very short	**VL**	**Low**	**Medium**	**Medium**	**High**	**High**
			VL	**L**	**M**	**H**	**VH**
			A part of the site/property	Whole site	Beyond the site, affecting neighbours	Local area, extending far beyond site.	Regional/ National
			EXTENT				

PART C: DETERMINING SIGNIFICANCE							
PROBABILITY (of exposure to impacts)	Definite/ Continuous	**VH**	**Very Low**	**Low**	**Medium**	**High**	**Very High**
	Probable	**H**	**Very Low**	**Low**	**Medium**	**High**	**Very High**
	Possible/ frequent	**M**	**Very Low**	**Very Low**	**Low**	**Medium**	**High**
	Conceivable	**L**	**Insignificant**	**Very Low**	**Low**	**Medium**	**High**
	Unlikely/ improbable	**VL**	**Insignificant**	**Insignificant**	**Very Low**	**Low**	**Medium**
			VL	**L**	**M**	**H**	**VH**
			CONSEQUENCE				

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
Very High	Potential fatal flaw unless mitigated to lower significance.
High	It must have an influence on the decision. Substantial mitigation will be required.
Medium	It should have an influence on the decision. Mitigation will be required.
Low	Unlikely that it will have a real influence on the decision. Limited mitigation is likely to be required.
Very Low	It will not have an influence on the decision. Does not require any mitigation
Insignificant	Inconsequential, not requiring any consideration.

***VH = very high, H = high, M= medium, L= low and VL= very low and + denotes a positive impact.**