Noise Impact Statement for Bakubung Platinum Mine TSF Project near Ledig, North West Province

Project done for Knight Piésold (Pty) Ltd

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Report Details

Report Title	Noise Impact Statement for Bakubung Platinum Mine TSF Project near Ledig, North West Province
Client	Knight Piésold (Pty) Ltd
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Notice	Airshed Planning Professionals (Pty) Ltd is a consulting company located in Midrand, South Africa, specialising in all aspects of air quality, ranging from nearby neighbourhood concerns to regional air pollution impacts as well as noise impact assessments. The company originated in 1990 as Environmental Management Services, which amalgamated with its sister company, Matrix Environmental Consultants, in 2003.
Declaration	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.
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Revision Record

Version	Date	Comments
Draft	May 2020	For client review
Final v0	May 2020	Inclusion of client comments

Competency Profiles

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

Natasha Shackleton started her professional career in Air Quality in 2011 when she joined Airshed Planning Professionals (Pty) Ltd after completing her Undergraduate Degree at the University of Pretoria in Science. In 2011 she completed her Honours Degree at the University of Pretoria in Meteorology. Natasha is also a member of the South African Society for Atmospheric Sciences (SASAS) and is a registered Professional Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) (registration no. 116335). She is currently undertaking her MSc: Applied Science (Environmental Technology) through the University of Pretoria.

Natasha has worked on noise specialist studies between 2015 and 2020. She has experience on the various components including emissions quantification for a range of source types, simulations using DataKustic CadnaA and impacts assessment. All of her noise working experience has been in South Africa.

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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.

Glossary and Abbreviations

ABEC	AB Enviro-Consult T/A
Airshed	Airshed Planning Professionals (Pty) Ltd
BPM	Bakubung Platinum Mine
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
EC	European Commission
EHS	Environmental, Health, and Safety (IFC)
EIA	Environmental Impact Assessment
Hz	Frequency in Hertz
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
Knight Piésold	Knight Piésold (Pty) Ltd
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)
masl	Meters above sea level
m^2	Area in square meters
m/s	Speed in meters per second
MM5	Fifth-Generation Penn State/NCAR Mesoscale Model
NEMA	National Environmental Management Act (No. 107 of 1998)
NEM:AQA	National Environment Management: Air Quality Act (No. 39 of 2004)
NBA	Noise Baseline Assessment
NIA	Noise Impact Assessment
NLG	Noise level guideline
MPRDA	Mineral and Petroleum Resources Development Act (No. 28 of 2002)
NSR	Noise sensitive receptor
NWA	National Water Act (No 36 of 1998)
p	Pressure in Pa
Pa	Pressure in Pascal
µPa	Pressure in micro-pascal
p_{ref}	Reference pressure, 20 µPa
Pty	Proprietary
rpm	Rotational speed in revolutions per minute
SABS	South African Bureau of Standards
SANS	South African National Standards
SLM	Sound Level Meter
SoW	Scope of Work
STRM	Shuttle Radar Topography Mission
TSF	Tailings Storage Facility
USGS	United States Geological Survey
Wesizwe	Wesizwe Platinum Limited
WG-AEN	Working Group – Assessment of Environmental Noise (EC)
WHO	World Health Organisation
WUL	Water Use Licence
%	Percentage

NEMA Regulation (2017), Appendix 6

NEMA Regulations (2017) - 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.	Competency Profiles (page i) Appendix I – Author's Curriculum Vitae (page 72)
A declaration that the person is independent in a form as may be specified by the competent authority.	Report Details (page i)
An indication of the scope of, and the purpose for which, the report was prepared.	Section 1: Introduction (page 1)
An indication of quality and age of base data used.	Section 1.4: Approach and Methodology (page 5) Section 3: Description of the Receiving Environment (page 12)
A description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change.	Section 3: Description of the Receiving Environment (page 12) Section 4: Impact of Proposed Tailings Storage Facility and Associated Infrastructure (page 19)
The date and season of the site investigation and the relevance of the season to the outcome of the assessment.	Section 3.3: Noise Survey and Results(page 16)
A description of the methodology adopted in preparing the report or carrying out the specialised process.	Section 1.4: Approach and Methodology (page 5)
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure.	Section 3.1: Noise Sensitive Receptors (page 12)
An identification of any areas to be avoided, including buffers.	N/A
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers.	Figure 4: Study area, NSRs, and baseline noise measurement sites (page 13)
A description of any assumptions made and any uncertainties or gaps in knowledge.	Section 1.4: Approach and Methodology (page 5)
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: Impact of Proposed Tailings Storage Facility and Associated Infrastructure (page 19)
Any mitigation measures for inclusion in the EMPr.	Section 5: Mitigation, Management and Monitoring Plan Update (page 27)
Any conditions for inclusion in the environmental authorisation	Section 5: Mitigation, Management and Monitoring Plan Update (page 27)
Any monitoring requirements for inclusion in the EMPr or environmental authorisation.	Section 5: Mitigation, Management and Monitoring Plan Update (page 27)
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised.	Executive Summary (page vii)

NEMA Regulations (2017) - Appendix 6	Relevant section in report
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan.	Section 5: Mitigation, Management and Monitoring Plan Update (page 27)
A description of any consultation process that was undertaken during the course of carrying out the study.	N/A
A summary and copies if any comments that were received during any consultation process.	None received
Any other information requested by the competent authority.	N/A

Executive Summary

Wesizwe Platinum Limited (Wesizwe) is the owner of Bakubung Platinum Mine (BPM), currently shaft sinking on the farm Frischgewaagd 96JQ (Portions 3, 4 and 11). Bakubung Minerals (Pty) Ltd holds the mining right for BPM. The mine is located near Ledig, 2 km south of the Pilanesberg Game Reserve and Sun City in the North West Province. Two reefs will be mined for Platinum Group Elements -platinum, palladium, rhodium and gold, with copper and nickel as by-products. The mine falls within the Rustenburg and Moses Kotane Local Municipalities of the Bojanala District Municipality.

In 2008, BPM conducted an Environmental Impact Assessment (EIA) process for the development of the BPM. The mine received Environmental Authorisation in 2009, in terms of both the National Environmental Management Act (No. 107 of 1998) (NEMA) and Mineral and Petroleum Resources Development Act (No. 28 of 2002) (MPRDA). A Water Use Licence (WUL) was issued in terms of the National Water Act (No 36 of 1998) (NWA) in 2010. In 2014 a Basic Assessment process was conducted for the development of mine housing on site. Authorisation for Phase 1 of the Gabonewe Estate mine housing was received in 2015. The Basic assessment was conducted by AB Enviro-Consult T/A (ABEC).

While construction at the mine has commenced, not all facilities have yet been constructed. BPM is now proposing to make several changes required in order to cater for ore processing capacity, as well as additional support infrastructure.

The Noise Impact Assessment (NIA) conducted in 2016 included an environmental noise survey, quantification of sound power levels of noise generating sources at the operations, anticipated impacts due to the operations modelled and assessed and a mitigation, management and monitoring plan compiled.

Airshed Planning Professionals (Pty) Ltd (Airshed) has been requested by Knight Piésold (Pty) Ltd (KP) to conduct environmental noise sampling for Bakubung Platinum Mine (BPM) at several locations representative of the acoustic climate surrounding BPM, including at nearby Noise Sensitive Receptors (NSRs), and to, considering the current acoustic environment, and potential sources associated with the new operations give a specialist opinion on the potential noise impacts and update the mitigation, management and monitoring plan compiled in 2016. This will form part of the mine's application for approval to construct and operate the proposed Tailings Storage Facility (TSF).

The TSF will have a capacity to contain an average tonnage profile of 1 Mtpa for a maximum period of 7 years. The proposed TSF covers an approximate 24 ha area. The mine process plant infrastructure is located 250 m north-east of the site and an electricity sub-station is adjacent to the north-eastern boundary of the footprint. A waste rock stockpile is located 100 m north of the TSF footprint. A 11 kV overhead Eskom powerline forms the eastern boundary of the TSF.

Receiving Environment

NSRs within an 8 kilometre (km) radius of the operations include Ledig to the north, northwest and west as well as Sun City to the northeast, Chaneng to the southeast and Phatsima to the southwest, along with isolated homesteads and the Sundown Ranch Hotel to the south.

MM5 (short for Fifth-Generation Penn State/NCAR Mesoscale Model) meteorological data indicates a wind field dominated by winds from the eastern sector during the day. During the night the wind field is mostly from the east and east-northeast. Day- and night-time average wind speeds are 2.7 m/s and 2.5 m/s respectively. Calm conditions (wind speeds of less than 1 m/s) occur 1.6% of time during the day and 1.1% during the night. The average temperature in the study area over the three-year period was 19°C and the average humidity 60%. Noise impacts are expected to be slightly more notable to the west of the operations during the day and to the west and west-southwest of the operations during the night.

The study area terrain is relatively variable and located between 1 000 masl to the south and east of the operations to 1 480 masl to the north of the operations. The land use in the vicinity of the operations is mostly shrubland with urban to the north, northwest and west, and industrial to the south and southeast (within 3 km) of the operations.

Noise Sampling

Day- and night-time noise measurements were conducted on the 4th and 5th of March 2020 at seven locations. The day-time acoustic climate at six of the sampling points was heavily influenced by local noise generating sources, with the mining activities only audible at two of the seven points during the day. At the other five points the acoustic climate was more heavily influenced by local noise sources.

Average day-time continuous noise levels (LReq,d) at Sites 2, 8 and 14 were typical of rural areas, as described by SANS 10103 while levels at Sites 3 and 5 were more akin to suburban districts with little road traffic. The acoustic climate at Site 4 during the day is mostly determined by local activity, such as community noise and vehicles with noise levels like urban districts. Site 1, as previously discussed, is most significantly influenced by mining operations.

Measured continuous night-time noise levels (LReq,n) were higher than typical rural areas as given by SANS 10103 at Sites 2, 3, 4, 8 and 14 sampling locations, and more akin to suburban districts, while Site 5 was more like an urban environment than rural environments. It was noted that mining activities could be heard at almost all sampling locations during the night. Although Site 1 would be classified as an industrial district, the night-time noise levels were below the typical outdoor noise level for industrial districts and was closer to urban/central business district levels.

The Mitigation, Management and Monitoring Plan

Based on the sampling results, it is recommended that the Noise Management Zone be 750m from the proposed TSF operations.

It is recommended that good engineering practice measures be implemented.

It is recommended that a complaints register be kept and communication channels with nearby NSRs be established. Quarterly liaison meetings with NSRs are recommended.

It is recommended that, as far is as practically feasible, noise generating activities be limited to day-time hours (considered to be between 06:00 and 22:00).

It is recommended that periodic ambient noise measurements be conducted to assess and confirm the project's impact area.

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

Table of Contents

List of Tables

List of Figures

1 Introduction

Wesizwe Platinum Limited (Wesizwe) is the owner of Bakubung Platinum Mine (BPM), currently shaft sinking on the farm Frischgewaagd 96JQ (Portions 3, 4 and 11). Bakubung Minerals (Pty) Ltd holds the mining right for BPM. The mine is located near Ledig, 2 kilometres (km) south of the Pilanesberg Game Reserve and Sun City in the North West Province. Two reefs will be mined for Platinum Group Elements -platinum, palladium, rhodium and gold, with copper and nickel as by-products. The mine falls within the Rustenburg and Moses Kotane Local Municipalities of the Bojanala District Municipality.

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The TSF will have a capacity to contain an average tonnage profile of 1 Mtpa for a maximum period of 7 years. The proposed TSF covers an approximate 24 ha area. The mine process plant infrastructure is located 250 m north-east of the site and an electricity sub-station is adjacent to the north-eastern boundary of the footprint. A waste rock stockpile is located 100 m north of the TSF footprint. A 11 kV overhead Eskom powerline forms the eastern boundary of the TSF. The location of the operational areas (both approved and part of this application), the nearby NSRs, the nearby topographical features as well as the environmental noise sampling locations are shown in Figure 1.

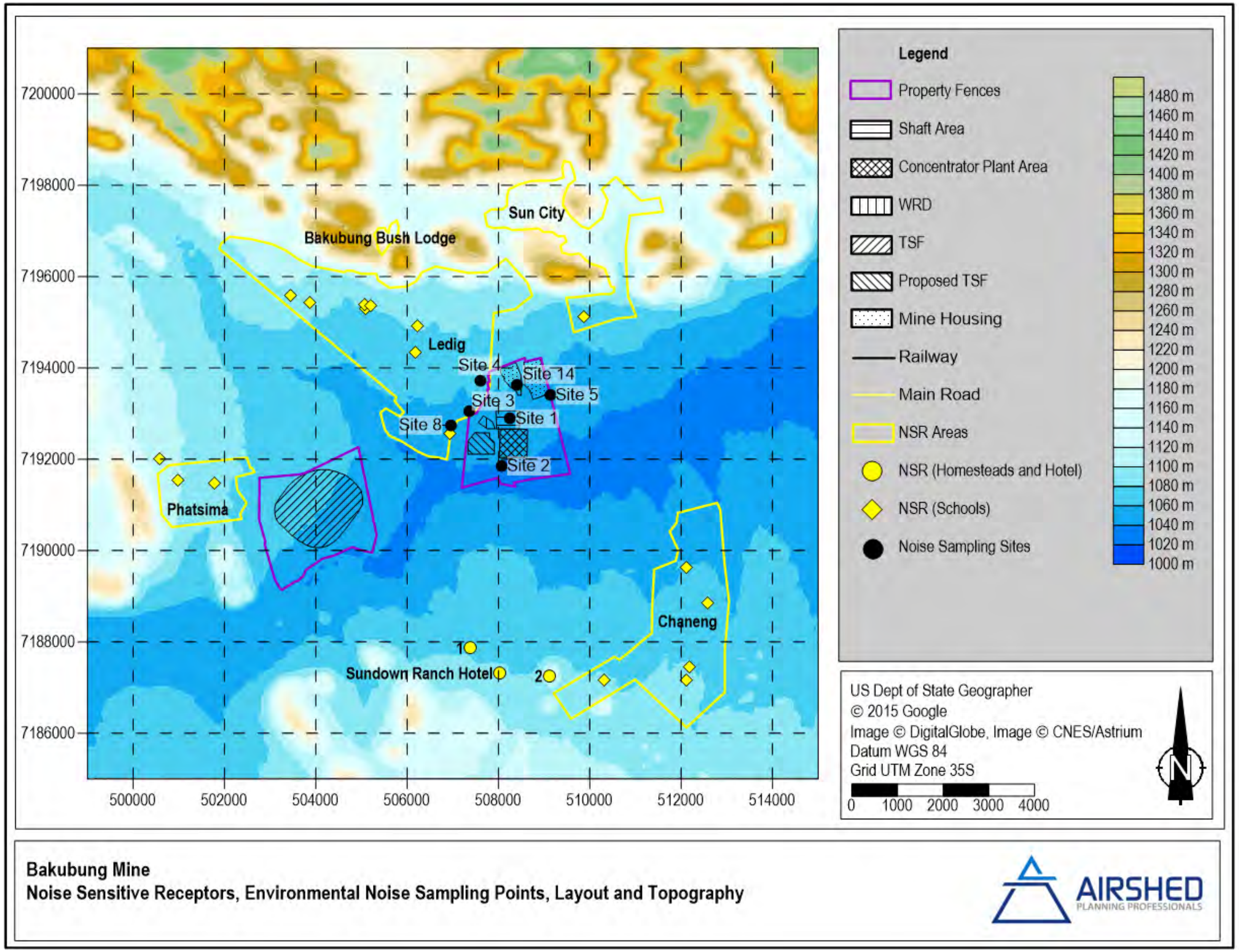

Figure 1: NSRs, sampling locations, layout, and topography

1.1 Study Objective

The main objective of this noise specialist study was to measure the current impacts of the operations on the acoustic environment and NSRs and to discuss the potential impact of the proposed TSF and update the mitigation, management and monitoring plan compiled in 2016 (Cosijn, 2016).

1.2 Scope of Work

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

- A short-term noise sampling campaign (15 minutes per sample) at seven locations during the day and night and in accordance with SANS 10103 (2008) and International Finance Corporation's (IFC) General Environmental, Health and Safety Guidelines (EHS) of 2007 (for the 2016 study baseline noise sampling was undertaken at 13 locations but seven sampling locations were considered applicable for the proposed operation. Six of the locations correspond to the previous study and one additional sampling point was added (site 14).
- Desktop study of the receiving noise environment, incl.:
  - The identification of noise sensitive receptors from available maps.
  - A study of atmospheric noise attenuation by referring to weather records, land use and topography data sources from the air quality study.
  - A review of environmental noise guidelines.
  - Analysis of sampled noise levels.
  - The screening of sampled environmental noise levels against noise criteria.
- An environmental noise report including potential impacts based on the 2016 study and updated management, mitigation and monitoring plan.

1.3 Background to Environmental Noise and the Assessment Thereof

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

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

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

(20 micro-pascals (μPa)) to 130 dB at the threshold of pain (~100 Pa) (Brüel & Kjær Sound & Vibration Measurement A/S, 2000).

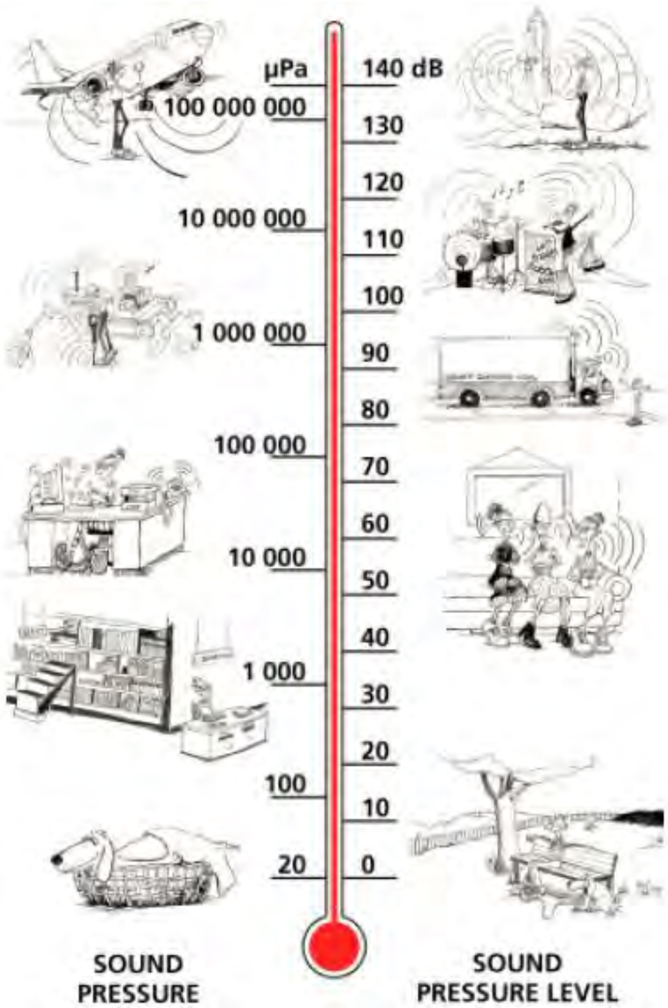

Figure 2: The decibel scale and typical noise levels (Brüel & Kjær Sound & Vibration Measurement A/S, 2000)

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

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

Where:

L_p is the sound pressure level in dB;
p is the actual sound pressure in Pa; and
p_{ref} is the reference sound pressure (p_{ref} in air is 20 μPa).

1.3.1 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).

1.3.2 Frequency Weighting

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

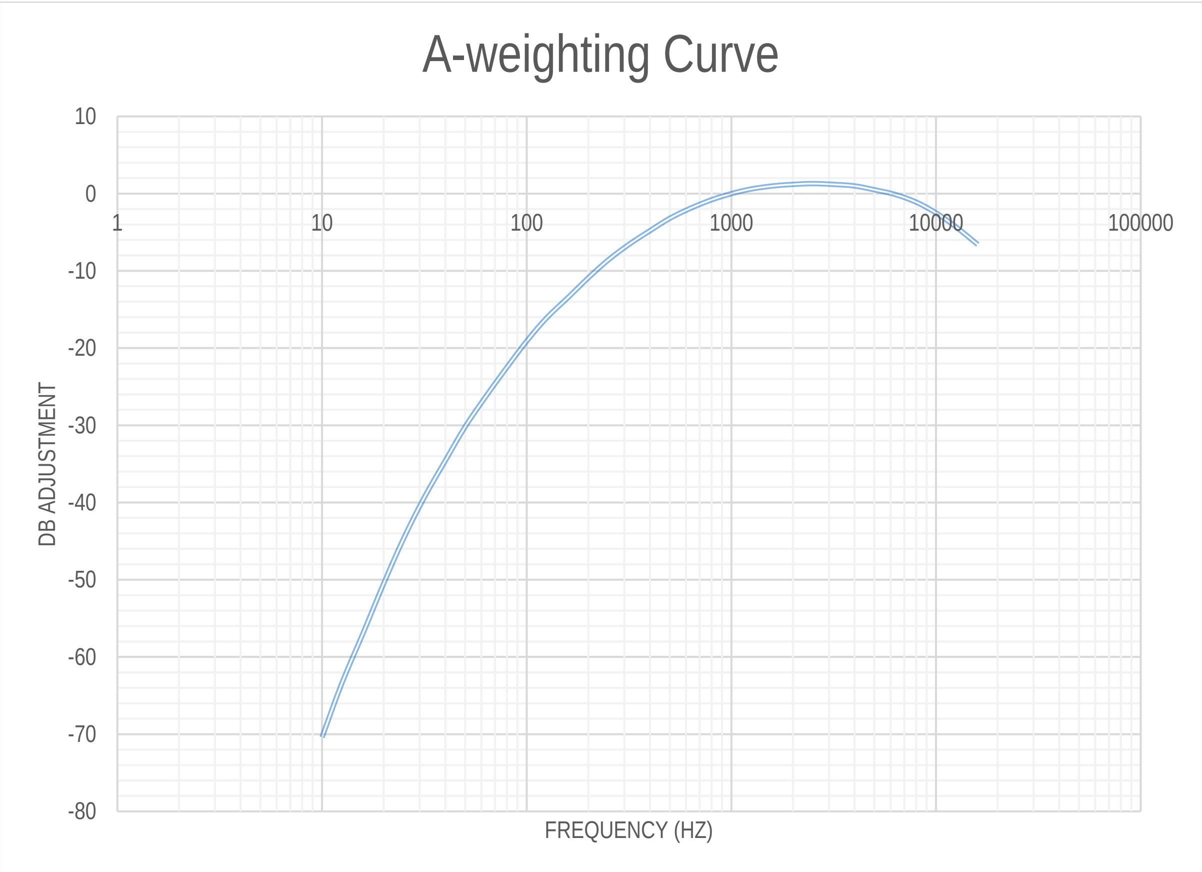

Figure 3: A-weighting curve

1.3.3 Adding Sound Pressure Levels

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

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

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

1.3.4 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).

1.3.5 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.

1.4 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 assessment focused on the measurement and analysis of current sound pressure levels at seven locations surrounding the operations (especially the proposed TSF) as well as an analysis of the receiving environment and its potential for noise attenuation. 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.

1.4.1 Information Review

The following information informed the location of sampling locations as well the updated mitigation, management and monitoring plan:

- Project and site layout maps, including the extent of proposed operations;
- The 2016 Noise Impact Assessment study report (Cosijn, 2016), including the original mitigation, management and monitoring plan compiled for the approved operations and housing.

1.4.2 Review of Assessment Criteria

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

1.4.3 Study of the Receiving Environment

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

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 modelled meteorological parameters from MM5 (short for Fifth-Generation Penn State/NCAR Mesoscale Model) meteorological data for a location on-site. Wind speed, wind direction, temperature and parameters describing atmospheric stability for the period January 2017 to December 2019 were assessed.

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.

1.4.4 Noise Survey

The data from a baseline noise surveys conducted on the 4th and 5th of March 2020 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 minutes) representative and sufficient for statistical analysis were taken with the use of the portable SLM capable of logging data continuously over the sampling time period. Samples representative of the day- and night-time acoustic environment were taken. SANS 10103 defines day-time as between 06:00 and 22:00 and night-time between 22:00 and 06:00 (SANS 10103, 2008).
- L_{Aleq} (T), L_{Aeq} (T); L_{AFmax}; L_{AFmin}; L_{90} and 3rd octave frequency spectra were recorded.
- The SLM was located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface.
- SANS 10103 states that one must ensure (as far as possible) that the measurements are not affected by the residual noise and extraneous influences, e.g. wind, electrical interference and any other non-acoustic interference, and that the instrument is operated under the conditions specified by the manufacturer.
- A detailed log and record were kept. Records included site details, weather conditions during sampling and observations made regarding the acoustic environment of each site.

Table 1: Sound level meter details

Equipment	Serial Number	Purpose	Calibration Date
Brüel & Kjær Type 2250 Lite SLM	S/N 2731851	Attended 30/60-minute sampling.	24 October 2019
Brüel & Kjær Type 4950 ½" Pre-polarized microphone	S/N 2709293	Attended 30/60-minute sampling.	24 October 2019
SVANTEK SV33 Class 1 Acoustic Calibrator	S/N 57649	Testing of the acoustic sensitivity before and after each daily sampling session.	24 October 2019
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 day-time and +10 dB for night-time.

Instrumentation used in this survey can integrate while using the I-time (impulse) weighting and $L_{AIeq,T}$ directly measured. When using $L_{AIeq,T}$, only the tonal character correction and time of day adjustment need to be applied to derive $L_{Req,T}$.

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

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:

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

Where

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

2 Legal Requirements and Noise Level Guidelines

2.1 South African Noise 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, Provincial Environmental Management Framework (GPEMF) was adopted as gazetted on 2 March 2018 (Gazette No.: 41473). The GPEMF included buffer zones for various industrial facilities, sewage treatment works, landfill sites, mine slimes and ash dumps to be adhered to, to ensure healthy and safe environments, and to reduce nuisance to developments, and to protect populations from potential risks.

The specific sizes for the preferred buffer or minimum buffer to be complied with is as follows:

- Best case buffer of 1 500 m and worst-case buffer of 750 m must be maintained in Category 1 industries which include those associated with:
    - Large volumes of air pollution;
    - Producing effluent and / or solid waste;
    - Excessive noise, including those with railway infrastructure incorporating shunting yards; and
    - Power generation sources.
- Best case buffer of 500 m and worst-case buffer of 250 m must be maintained in Category 2 industries which include those associated with:
    - General manufacturing with less significant emissions;
    - Noisy operations;
    - Noisy service industries; and
    - Certain agricultural industries.
- Best case buffer of 100 m and worst-case buffer of 50 m must be maintained in Category 3 industries which include those associated with:
    - Clean manufacturing processes with little effluent or other nuisance factors;
    - High technology research and development activities;
    - Industries centered around warehousing and distribution operations with low noise levels; and
    - Industries centered around packaging operations.
- Best case buffer of 800 m and worst-case buffer of 500 m must be maintained for Sewage treatment works
    - These facilities for the storage of raw sewage, treatment processing and safe disposal or release into the natural environment have the potential for water, groundwater and air pollution.
- Best case buffer of 400 m and worst-case buffer of 200 m must be maintained for General Landfill sites (Communal, small, medium and large).
- Best case buffer of 2000 m and worst-case buffer of 1000 m must be maintained for Hazardous Landfill sites

- Best case buffer of 100 m and worst-case buffer of 0 m must be maintained for Mine dumps (rock dumps or stockpiles)
- Best case buffer of 1000 m and worst-case buffer of 500 m must be maintained for Mine slimes dams and ash dumps
- Best case buffer of 5000 m and worst-case buffer of 2000 m must be maintained for The Pelindaba nuclear facility complex

Although the proposed project site is not located within the Gauteng province, the buffer zone delineation is useful for the qualitative assessment of the project. According to the Gauteng GPEMF the TSF would require a buffer zone of 1 000 m to 500 m.

2.2 South African National Standards

SANS 10103 (2008) successfully addresses the manner in which environmental noise measurements are to be taken and assessed in South Africa, and is fully aligned with the WHO guidelines for Community Noise (WHO, 1999). It should be noted that the values given in Table 3 are typical rating levels that it is recommended should not be exceeded outdoors in the different districts specified. Outdoor ambient noise exceeding these levels may 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'. Δ = 10 dB is subjectively perceived as a doubling in the loudness of the noise;
- 10 dB < $\Delta \leq$ 20 dB: There will be a 'strong' reaction with 'threats of community action'; and
- 15 dB < Δ: There will be a 'very strong' reaction with 'vigorous community action'.

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

2.3 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

3 Description of the Receiving Environment

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

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

3.1 Noise Sensitive Receptors

NSRs generally include places of residence and areas where members of the public may be affected by noise generated by the mining activities. Only those within a 5 km radius of activities are likely to be affected; however, all NSRs within an 8 km radius were identified.

NSRs within an 8 km radius (Figure 4) of the operations include Ledig to the to the north, northwest and west as well as Sun City to the northeast, Chaneng to the southeast and Phatsima to the southwest, along with isolated homesteads and the Sundown Ranch Hotel to the south.

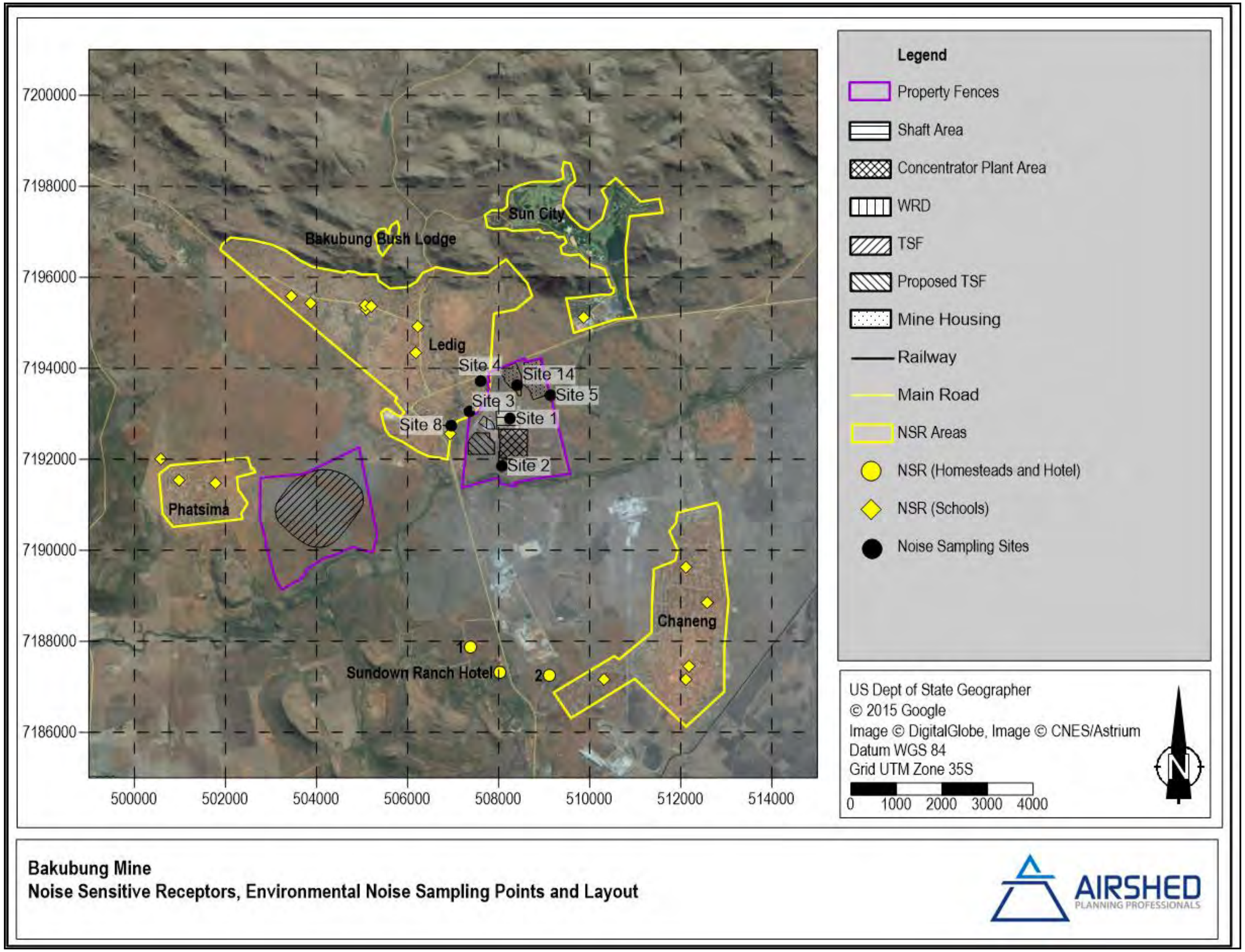

Figure 4: Study area, NSRs, and baseline noise measurement sites

3.2 Environmental Noise Propagation and Attenuation potential

3.2.1 Atmospheric Absorption and Meteorology

Atmospheric absorption and meteorological conditions have already been mentioned with regards to their role in the propagation on noise from a source to receiver (Section 1.3.4). 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 data from MM5 data for the period January 2017 to December 2019.

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 for the area is presented in Figure 5. Wind roses represent wind frequencies for 16 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.

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

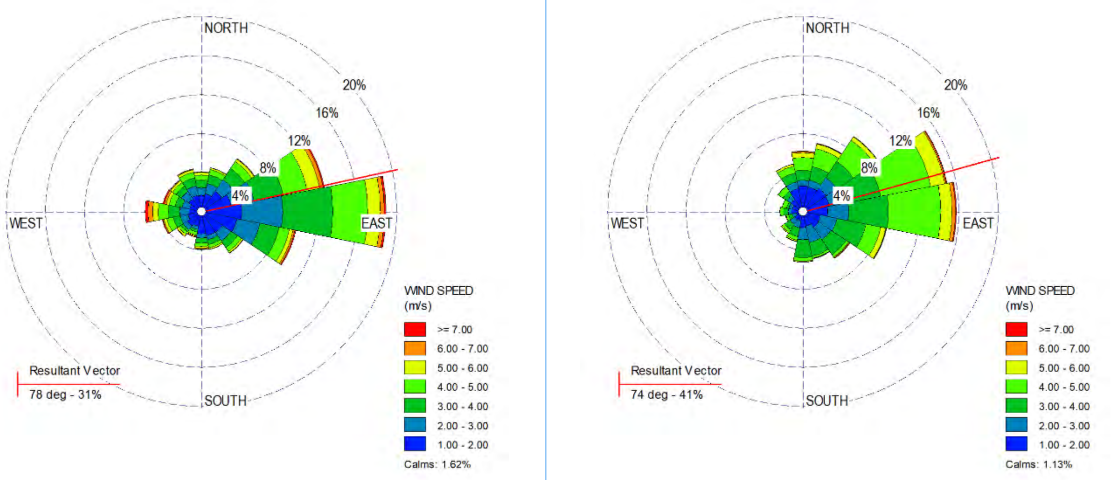

Figure 5: Day- and night-time wind field showing dominant northerly winds for MM5 data (2017-2019)

The MM5 data indicates a wind field dominated by winds from the eastern sector during the day. During the night, the wind field is mostly from the east and east-northeast (Figure 5). Day- and night-time average wind speeds are 2.7 m/s and 2.5 m/s, respectively. Calm conditions (wind speeds of less than 1 m/s) occur 1.6% of time during the day and 1.1% during the night. The average temperature in the study area over the three-year period was 19°C and the average humidity 60%. Noise impacts are expected to be slightly more notable to the west of the operations during the day and to the west and west-southwest of the operations 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. The diurnal temperature profile for the MM5 data is shown in Figure 6.

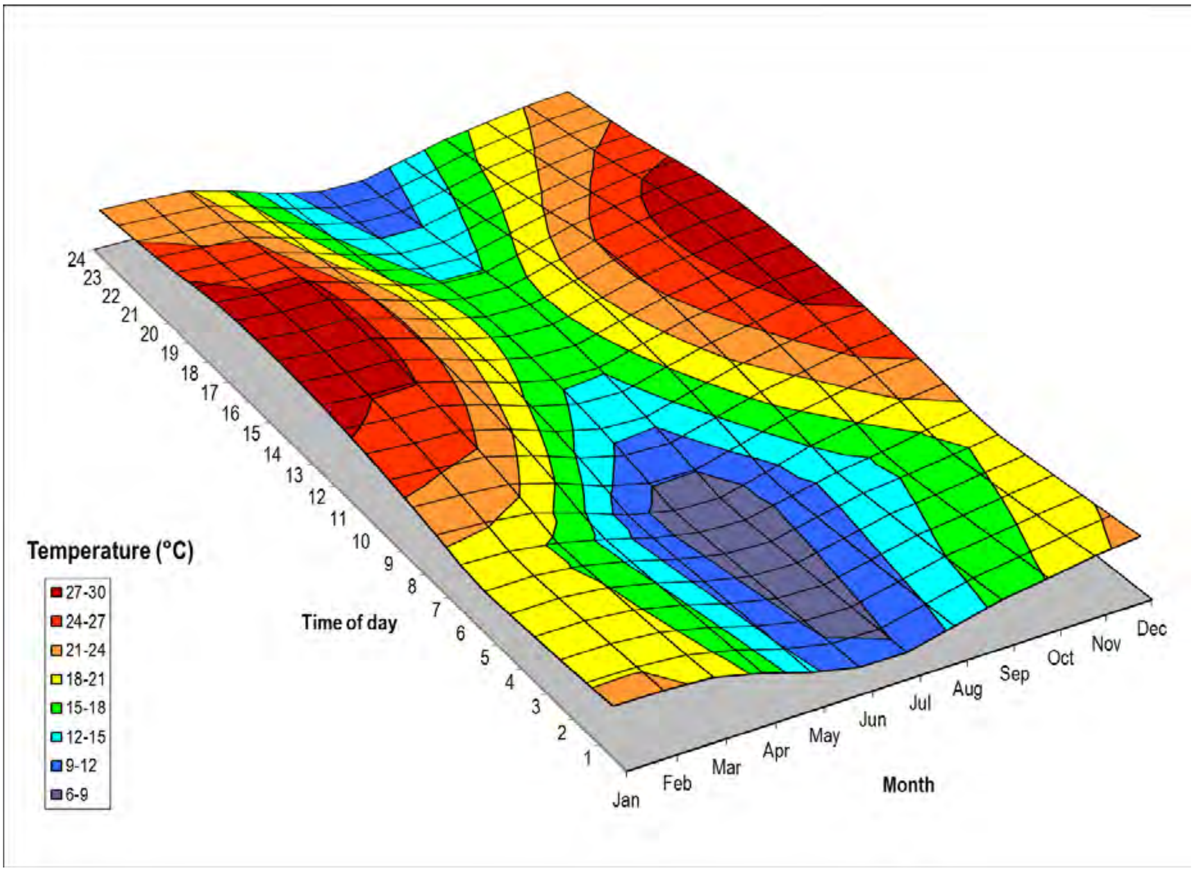

Figure 6: Monthly average temperature profile for MM5 data (2017-2019)

3.2.2 Terrain, Ground Absorption and Reflection

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

The terrain of the study area is shown in Figure 1. The study area terrain is relatively variable and located between 1 000 masl to the south and east of the operations to 1 480 masl to the north of the operations. The land use in the vicinity of the operations is mostly shrubland with urban to the north, northwest and west, and industrial to the south and southeast (within 3 km) of the operations.

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 hard or mixed surrounding the operations.

3.3 Noise Survey and Results

Day- and night-time noise measurements were conducted on the 4th and 5th of March 2020 at seven locations shown in Figure 1 and Figure 4. Survey sites were selected taking into consideration the location of proposed activities, NSRs, accessibility and safety. The coordinates as well as a description of the noise sampling locations is given in Table 5. Time series broadband sampling results, frequency spectra and statistics for each measurement, as well as fieldwork log sheets, photographs of the sampling sites and microphone placement are included in Appendix A to F for each of the sampling Points.

During the day-time survey, temperatures ranged between 26.4°C and 3.2°C, with 10% to 60% cloud cover. Winds were mostly between 0.4 m/s and 2.6 m/s and from an easterly direction; between 0.9 and 1.1 from the southerly direction when site 4 was sampled and between 0.8 and 2.5 m/s from the northerly direction when site 8 was sampled. Humidity was between 38% and 49%. At night, temperatures ranged between 18.3°C and 23.8°C, mostly with clear skies and calm wind conditions.

Table 5: Environmental Noise Sampling Locations

Site	Longitude	Latuitude	Description
1	27.082050	-25.380767	Close to mine crushers, 0.5 km northeast of proposed TSF
2	27.080233	-25.390117	Southeast of the proposed TSF
3	27.073117	-25.379200	0.5 km north-northwest of the proposed TSF
4	27.075533	-25.373217	1.2 km north of the proposed TSF
5	27.090783	-25.376117	1.6 km northeast of proposed TSF
8	27.069117	-25.382050	0.5 km west-northwest of the proposed TSF
14	27.083606	-25.374148	At proposed mine housing, 1.2 km north-northeast of the proposed TSF

Acoustic observations made during the survey are summarised in Table 6 and Figure 7. The day-time acoustic climate at the seven sampling points was heavily influenced by local noise generating sources, with the mining activities only audible at Sites 1 (on-site) and 2 during the day. Noise sources at Sites 3, 4, 8 and 14 which are located either in or nearby Ledig residential area was mostly influenced by local sources such as community activity, vehicle traffic and domestic animals. The acoustic climate at Point 5, located close to a rarely used public road, was predominantly influenced by insects and birds. Air traffic was also noted at Sites 8 and 14. Considering Site 3 lies between these two sites it is also likely to be affected by air traffic but not at the time of the sampling.

Measured day-time L_{A90} levels (Table 7) indicate that, with the exception of Point 1 located on-site and Point 4 which is located within the Ledig residential area, day-time background noise levels are low, and isolated noise incidents, which were observed to have L_{AFmax} values of between 46.4 dBA (Site 2) to 63.5 dBA (Site 5), lead to higher average L_{Req}'s. At Site 1 the mine operations surrounding the sampling point leads to a continuous higher background noise level.

Average day-time continuous noise levels ($L_{Req,d}$) at Sites 2, 8 and 14 (Table 6) were typical of rural areas, as described by SANS 10103 (Table 3) while levels at Sites 3 and 5 were more akin to suburban districts with little road traffic (Table 6). The acoustic climate at Site 4 during the day is mostly determined by local activity, such as community noise and vehicles with noise levels like urban districts. Site 1, as previously discussed, is most significantly influenced by mining operations (the profiles of which can easily be seen on the broadband time series in Figure 21).

The mining activities could be distinguished at Sites 1 and 2 by the sampler it is should be noted that the lowest day-time continuous levels were recorded at Site 2 (Table 6). This Site is located the furthest from the current mining (closets to the proposed TSF) (Figure 4), but is situated away from any other influences, such as the mine's operations, domestic animals, roads or communities.

Measured continuous night-time noise levels ($L_{Req,n}$) were higher than typical rural areas as given by SANS 10103 at Sites 2, 3, 4, 8 and 14 sampling locations (Table 6), and more akin to suburban districts, while Site 5 was more like an urban environment than rural environments. It was noted that mining activities could be heard at almost all sampling locations during the night. Although Site 1 would be classified as an industrial district, the night-time noise levels were below the typical outdoor noise level for industrial districts and was closer to urban/central business district levels.

It should be noted that background noise levels (L_{A90}) were higher at six sampling points (excluding Site 1) (Table 7) during the night compared to during the day. It was also observed by the field technician that while mining operations could generally not be heard during the day (except at Site 1 at the mine operations and the most isolated location, Site 2), some mining operations (not necessarily the BPM operations) could be heard at all sampling points during the night. This could be explained by atmospheric temperature gradients. On a sunny day, temperature decreases with altitude and creates a 'shadowing' effect for sounds. On clear nights, temperatures my increase with altitude thereby 'focusing' sound on the ground surface. Noise impacts are therefore generally more significant during the night. It should also be noted that wind speeds were generally higher during the day-time measurements than during the night-time measurements.

It should be noted that while the operator observed that mining activities could be heard at most of the sampling locations during the night, the sampling was done in March, when insects are abundant, and background noise due to insects was also noted at each sampling location. It is recommended that a noise survey campaign be undertaken in the winter months to estimate the noise impact of mining operations in the absence of insect noise.

Table 6: Baseline noise measurement survey results

Site	Day/night	Day-time	Night-time
	$L_{R,dn}$ (dBA)	$L_{Req,d}$ (dBA)	$L_{Req,n}$ (dBA)
1(c)	61.6	55.6	55.6
2(b)	**47.5**	33.8	**42.2**
3(b)	**55.0**	**47.6**	**49.2**
4(b)	**60.4**	**52.1**	**54.8**
5(b)	**48.3**	**48.0**	**38.7**
8(b)	**47.8**	39.4	**42.1**
14(b)	**49.4**	43.8	**43.3**

Notes: Bold blue figures indicate exceedance of the SANS rating levels for outdoor noise according to district types

(a) Rural district classification

(b) Currently rural district classification but will likely be more like suburban district with little road traffic when fully operational

(c) Industrial district classification

Table 7: Baseline noise measurement survey details and broadband results

Site	Local Start Time	Duration	Noise Climate	L_{AFmax} (dBA)	L_{Aleq} (dBA)	L_{A90} (dBA)
Day-time						
1	10:18	15 Minutes	Mining Operations, Welding, Workshop, Birds, Road traffic	69.1	55.6	51.0
2	11:35	15 Minutes	Mining operations, Crushers, Birds, Wind, Distant road traffic	46.4	33.8	27.0
3	13:35	15 Minutes	Music, Community, Road Traffic, Birds, Insects, Wind Gusts	60.2	47.6	34.3
4	14:12	15 Minutes	Insects, Birds, Community, Road Traffic	59.3	52.1	44.6
5	15:32	15 Minutes	Birds, Insects	63.5	48.0	33.8
8	12:00	15 Minutes	Air Traffic, Birds, Insects, Road Traffic, Wind Gusts, Community	52.8	39.4	28.0
14	14:55	15 Minutes	Wind, Birds, Insects, Community, Air Traffic	58.5	43.8	31.1
Night-time						
1	22:02	15 Minutes	Mining operations, Workshop, Sirens, Insects	57.4	55.6	50.4
2	22:33	15 Minutes	Insects, Mining Operations, Road Traffic	42.7	42.2	33.3
3	1:34	15 Minutes	Mining Operations, Insects, Domestic Animals	49.4	49.2	44.5
4	1:09	15 Minutes	Road Traffic, Music, Insects	55.4	54.8	49.9
5	23:20	15 Minutes	Insects, Distant Mining Operations	39.6	38.7	34.1
8	2:06	15 Minutes	Mining Operations, Road Traffic, Insects, Domestic Animals	42.4	42.1	38.4
14	0:41	15 Minutes	Mining Operations, Insects, Sirens	43.7	43.3	41.1

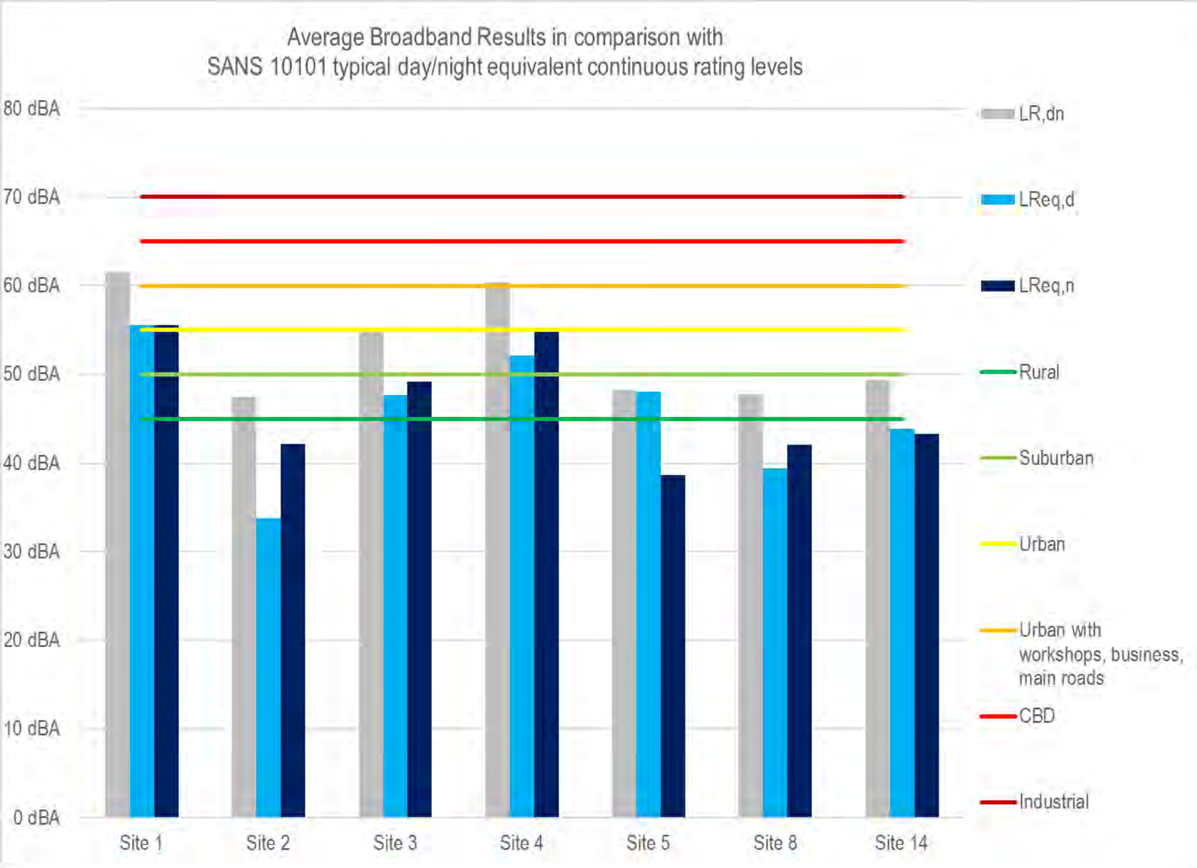

Figure 7: Logged $L_{Req,d}$, $L_{Req,n}$ and $L_{Req,dn}$ – day-time and night-time sampling

4 Impact of Proposed Tailings Storage Facility and Associated Infrastructure

A qualitative assessment of the potential impacts due to the proposed TSF and associated infrastructure is discussed in this section. No environmental noise modelling was undertaken.

4.1 Noise Sources due to Project Activities

The main noise generating operations associated with the construction period for the proposed TSF are:

- Clearing of vegetation;
- Excavation of soil for the proposed TSF liner;
- Construction of the proposed TSF liner;
- Transport of spoil material from vegetation clearing and excavation activities; and,
- Excavation backfilling and compaction, as needed, and topsoil placement.
- Vehicle operations within the construction area consisting of
  - Movement
  - Idling
  - Reversing with reverse hooters.

The main noise generating infrastructure and operations associated with the operation of the proposed TSF are:

- Conveyor consisting of
  - Conveyor drive unit
  - Conveyor feed hopper and
  - Conveyor rollers;
- Materials handing at the TSF;
- Spreader on the TSF;
- Traffic on service roads surrounding the TSF.

Construction and decommissioning activities are expected to result in local noise impacts of limited duration similar to or less significant than impacts associated with the operational phase. As detailed construction and decommissioning activities were not available.

4.2 Description of Noise Generation and Potential Impacts

4.2.1 Construction

Construction and mobile equipment can be described or divided into distinct categories. These are earthmoving equipment, materials handling equipment, stationary equipment, impact equipment, and other types of equipment. The first three categories include machines that are powered by internal combustion engines. Machines in the latter two categories are powered pneumatically, hydraulically, or electrically. Additionally, exhaust noise tends to account for most of the noise emitted by machines in the first three categories (those that use internal combustion engines) whereas engine-related noise is usually secondary to the noise produced by the impact between impact equipment and the material on which it acts (Bugliarello, et al., 1976).

Construction and mobile equipment generally produce noise in the lower end of the frequency spectrum. Reverse or moving beeper alarms emit at higher frequency ranges and are often heard over long distances.

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

4.2.2 Operations

It is unlikely the proposed TSF support operations will differ much from the approved TSF operations. The operations itself include a spreader on the TSF and conveyor to the TSF. According to D Cosijn (2016) a conveyor is likely to have environmental noise levels below the rural districts level at 250 m from the conveyor. The conveyor, material transfer and spreader are likely to result in the main environmental noise impacts. Although the project is not located in the Gauteng Province the buffers for mine slimes dams and ash dumps as per paragraphs 6.2.7 and 7.1 of the Gaute111 Pollution Buffer Zones Guideline, March 2017 is a decent indication of a potential buffer to be used. According to the GPEMF it is endorsed that the best-case buffer of 1 000 m and worst-case buffer of 500 m be maintained.

Based on a stacker and reclaimer project undertaken by Airshed which is based on measurements. All the measurements were carried out in accordance with the procedures specified in SANS 10103. According to this study the noise levels were in excess of the day-time IFC guideline of 55 dBA for residential, institutional and educational receptors (corresponding to SANS 10103 guidelines for urban districts) up to 250 m from the source; noise levels beyond 250 m were below this limit. Based on this and with the closest receptors to the proposed TSF are approximately 400 m from the source it is unlikely that the noise impact at these receptors will be substantial.

4.2.3 Impact Significance Rating

Based on the Knight Piésold significance rating methodology the noise impacts from all operational phases are regarded as “Low” negative at NSRs; with mitigation in place it remains “Low” Negative (Table 8 to Table 10).

Although construction noise may be noticeable during civil works such as site clearance, or the use of pile drivers and the like. However, due to the overall types of activity and distance between main work sites and nearest sensitive receptors, there is a low likelihood of the noise levels exceeding 70 dB LAeq, and if so, this will be of short duration. The negative noise impacts are therefore considered to be of “Low” significance at the nearest receptors.

Given the distance of sensitive receptors, the potential noise impacts from the project are likely to remain below the IFC Guideline Noise Levels, both during the day and night. The overall noise impacts are therefore deemed to be negative and of low significance prior to mitigation.

During decommissioning, much of the work will be broadly similar to construction activities, and as such, similar impacts are expected. Noise from decommissioning activities is likely to be perceptible at the closest noise sensitive properties during the key phases of the work.

Noise levels for decommissioning may be similar to that for construction, but of lesser intensity. Noise levels are unlikely to exceed 70 dB LAeq, which is a broadly acceptable criteria for decommissioning noise impacts given the type of activity and distance between the main work sites and nearest sensitive receptors. Noise impacts during decommissioning are therefore considered to be low prior to mitigation

Table 8: Significance rating with and without mitigation for construction phase

Noise	Description	Rating
Project activity or issue	Construction	N/A
Potential impact	Increase in noise at NSRs	N/A
Nature of the Impact		
Positive or negative	Negative due to increase in noise levels at NSRs	-
Direct/Indirect/Cumulative	Direct	D
Significance Before Mitigation		
Severity / magnitude (M)	Moderate – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 40 – 60 %	3
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Short term - Impacts are predicted to be of short duration (0 – 5 years).	2
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2
Probability (P)	Low probability - 40% likelihood that the impact will occur.	2
Significance (SP)	Low	16
Significance After Mitigation		
Severity / magnitude (M)	Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %	2
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Short term - Impacts are predicted to be of short duration (0 – 5 years).	2
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2

Noise	Description	Rating
Probability (P)	Low probability - 40% likelihood that the impact will occur.	2
Significance (SP)	Low	14
Potential mitigation measures (construction)	• Use temporary noise barriers and use 'low noise' equipment (including alternative reversing alarms), where possible; • Train construction staff on noise control plan during health and safety briefings; • Select 'low noise' equipment, or methods of work; • Use most effective mufflers, enclosures and low-noise tool bits and blades; • Investigate use of alternatives to audible reversing alarms (such as broadband noise emitting models) or configure to maximise forward movements of mobile equipment; • Use temporary noise barriers for small equipment, where required; • Reduce throttle settings and turn off equipment when not used; • Avoid clustering of mobile fleet near receptors and enforce rest periods for unavoidable maximum noise events; • Ensure periods of respite are provided in the case of unavoidable maximum noise level events; • Regular inspection and maintenance of all equipment.	N/A

Table 9: Significance rating with and without mitigation for operational phase

Noise	Description	Rating
Project activity or issue	Operations	N/A
Potential impact	Increase in noise at NSRs	N/A
Nature of the Impact		
Positive or negative	Negative due to increase in noise levels at NSRs	-
Direct/Indirect/Cumulative	Direct	D
Significance Before Mitigation		
Severity / magnitude (M)	Moderate – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 40 – 60 %	3
Reversibility (R)	Reversible	1

Noise	Description	Rating
	Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	
Duration (D)	Medium term - Impacts are predicted to be of medium duration (5 – 15 years).	3
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2
Probability (P)	Low probability - 40% likelihood that the impact will occur.	2
Significance (SP)	Low	18
Significance After Mitigation		
Severity / magnitude (M)	Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %	2
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Medium term - Impacts are predicted to be of medium duration (5 – 15 years)	3
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2
Probability (P)	Low probability - 40% likelihood that the impact will occur.	2
Significance (SP)	Low	16
Potential mitigation measures	• Select 'low noise' equipment, or methods of work; • Avoid dropping from heights; • Regular inspection and maintenance of equipment; • Establish a complaint register.	N/A

Table 10: Significance rating with and without mitigation for decommissioning phase

Noise	Description	Rating
Project activity or issue	Decommissioning	N/A
Potential impact	Increase in noise at NSRs	N/A
Nature of the Impact		
Positive or negative	Negative due to increase in noise levels at NSRs	-
Direct/Indirect/Cumulative	Direct	D
Significance Before Mitigation		
Severity / magnitude (M)	Moderate – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 40 – 60 %	3
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Short term - Impacts are predicted to be of short duration (0 – 5 years).	2
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2
Probability (P)	Low probability - 40% likelihood that the impact will occur.	2
Significance (SP)	Low	16
Significance After Mitigation		
Severity / magnitude (M)	Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %	2
Reversibility (R)	Reversible Environmental - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. Social - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1
Duration (D)	Short term - Impacts are predicted to be of short duration (0 – 5 years).	2
Spatial extent (S)	Local - Impacts that affect an area in a radius of 2 km around the site.	2

Noise	Description	Rating
Probability (P)	Low probability - 40% likelihood that the impact will occur.	2
Significance (SP)	Low	14
Potential mitigation measures	• Use temporary noise barriers and use 'low noise' equipment (including alternative reversing alarms), where possible; • Train construction staff on noise control plan during health and safety briefings; • Select 'low noise' equipment, or methods of work; • Use most effective mufflers, enclosures and low-noise tool bits and blades; • Investigate use of alternatives to audible reversing alarms (such as broadband noise emitting models) or configure to maximise forward movements of mobile equipment; • Use temporary noise barriers for small equipment, where required; • Reduce throttle settings and turn off equipment when not used; • Avoid clustering of mobile fleet near receptors and enforce rest periods for unavoidable maximum noise events; • Ensure periods of respite are provided in the case of unavoidable maximum noise level events; • Regular inspection and maintenance of all equipment.	N/A

5 Mitigation, Management and Monitoring Plan Update

As part of this assessment for the proposed TSF, a mitigation, management and monitoring plan has been compiled. In this section, the recommendations of the mitigation, management and monitoring plan will be re-evaluated based on the findings and conclusions of Sections 3 and 4 above.

5.1 Noise Management Zone

The results from the environmental noise survey (described in Section 3.3) indicate that day-time noise levels, even within the 1 000 m suggested in the GPEMF by the Gauteng Department: Agriculture and Rural Development (GDARD), are typical of suburban areas with little road traffic and rural areas, as per SANS 10103. At sampling points away from the mining activities, noise levels were more significantly influenced by local noise sources.

Conversely, during the night-time sampling, mining activities were audible at nearly all sampling locations. It is therefore recommended that a noise management zone of approximately 750 m from the proposed TSF and mining operations be implemented. As far as could be ascertained during the sampling campaign and from satellite photography, there are a number of NSRs residing within the recommended noise management zone. Future human settlement within the noise management zone should be limited.

5.2 Good Engineering Practice

Several Good Engineering Practice measures can be recommended. The measures that are deemed to be applicable to the proposed TSF operations are:

- All diesel powered equipment must be regularly maintained and kept at a high level of maintenance. This must particularly include the regular inspection and, if necessary, replacement of intake and exhaust silencers. Any change in the noise emission characteristics of equipment must serve as trigger for withdrawing it for maintenance.
- Take advantage of the natural topography or stockpiles as a noise buffer. Establish stockpiles in such a manner as to serve as acoustic barriers.
- Minimising individual vehicle engine, transmission, and body noise/vibration. This is achieved through the implementation of an equipment maintenance program.
- Maintain road surface regularly to avoid corrugations, potholes etc.
- Avoid unnecessary idling times.
- Minimising the need for trucks/equipment to reverse. This will reduce the frequency at which disturbing but necessary reverse warnings will occur.

5.3 Community Liaison

Annoyance is a complicated psychological phenomenon; as with many industrial operations, expressed annoyance with sound can reflect an overall annoyance with the project, rather than a rational reaction to the sound itself.

Mining projects offer an economic benefit to the greater population. A positive community attitude throughout the greater area should be fostered, particularly with those residents near the project. The following is recommended to maintain a good relationship with neighbouring residents:

- Develop and maintain a complaints register and dedicated communication channels to record and respond to complaints. Keep a complaints register on-site and ensure that all NSRs are aware of the channels through which a complaint can be lodged.
- Additional to the complaints register, frequent liaison with nearby NSRs to keep updated on the public's perception and annoyance regarding noise generated by the mining activities is important. NSRs that should be consulted at least quarterly include the residents of Ledig, Phatsima, Sundown Ranch Hotel and Chaneng as well as the other isolated farmsteads to the south of the operations.

5.4 Operational Hours

As shown by the results of the noise survey (Section 3.3) noise impacts from the mining activities are most significant during the night. It is recommended that, as far is as practically feasible, noise generating activities be limited to day-time hours (considered to be between 06:00 and 22:00).

5.5 Noise Monitoring

It is recommended that periodic environmental noise measurements be conducted to assess and confirm the project's impact area. Periodical noise measurements can also serve to assess the efficiency of implemented management and mitigation measures aimed at reducing noise impacts.

The noise measurements should follow a methodology that follows the guidance provided by the IFC (2007) and SANS 10103. A summary of this can be found in Section 1.4.4. The frequency of noise monitoring as well as the parameters that should be determined are summarised in Table 11. Specific attention should be paid to baseline night-time noise at Ledig.

It is recommended that at least every other noise survey campaign be conducted in the winter months between May and August in order to distinguish between the impact of mining activities and insect noise, which is more prevalent in the summer.

In addition to the measurement of sound pressure levels, the 1/3 octave band frequency spectra should also be recorded. Frequency spectrum data can provide useful insight into the nature of recorded sound pressure levels and assist with distinguishing between potential sources of noise that contribute to noise levels at a certain location.

Source noise measurements could be conducted to confirm equipment manufacturer sound power data and assumed sound power data used in the current study.

While the proposed TSF is operational the noise monitoring points included in this assessment would be sufficient; however, once the approved TSF is operational the monitoring network should be revised.

Table 11: Proposed monitoring plan

Parameters to be Measured	Frequency
• L_{Aleq}(T[(a)]), during day-time hours (06:00 to 22:00) • L_{Aleq}(T[(a)]), during night-time hours (22:00 to 06:00) • 1/3 Octave band frequency spectrum	• One campaign a year

Notes:

(a) Measurements duration should be selected to be representative of noise climate, typically between 15 minutes and an hour.

6 References

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Appendix A – Site 1 – Photographs, Logsheets and Survey Results

Figure 8: Photographs of environmental noise survey Site 1

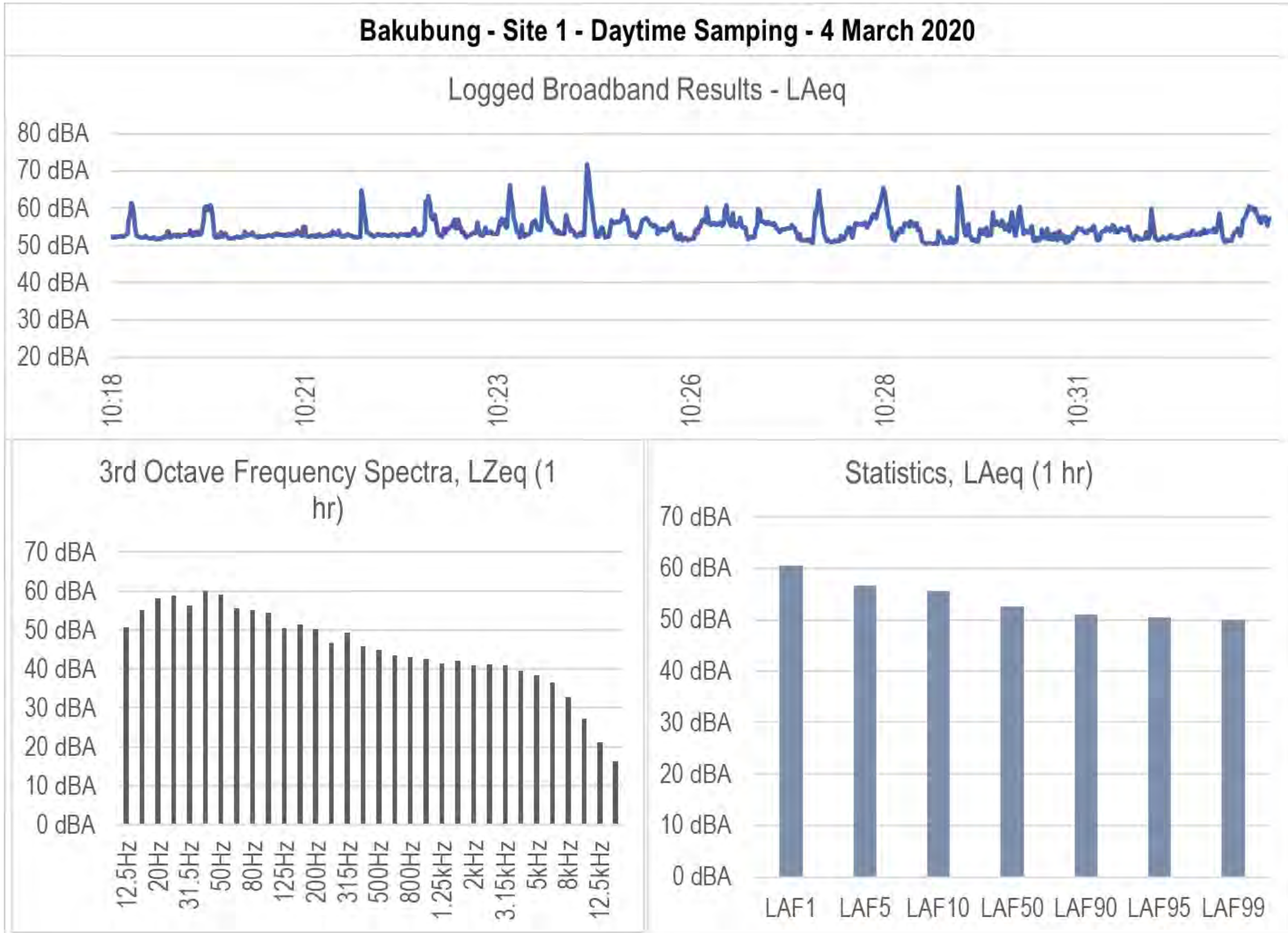

Figure 9: Broadband time series, frequency spectra and statistics – Site 1 – Day-time Sampling

DAY

SITE NUMBER: Site 1	SLM DATA RECORD: baku 002	
Longitude/Easting:	Latitude/Northing:	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: Mine ops ± 50dB welding /workshop ± 52dB Birds 35dB
Start	0.5 – 1.5	E	27.4	46.5	6/10	
Middle						
End						

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

Description: Open area close to access roads and mine operations. Workshop nearby and heavy vehicles pass by

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
10:19:33	Mine ops	26:21	Workshop	31:49	Workshop		
19:52	Siren	26:27	"	31:58	"		
20:03	"	26:46	Heavy vehicle	32:29	"		
22:02	Mine ops	27:12	Mine ops	32:50	Mine ops.		
22:04	"	27:58	Workshop	33:19	Heavy vehicle		
22:31	Workshop	28:47	Vehicle passing	33:23	Workshop		
22:56	Workshop	28:49	"	33:48	"		
24:02	Mine ops	29:05	Workshop				
23:57	People talking	29:22	Mine ops				
22:24	Heavy vehicle	29:46	Workshop				
25:06	People shouting	30:13	"				
25:15	Workshop	30:33	"				
25:29	"	31:01	Siren				
25:41	"	31:15	"				

Page __ of __

Figure 10: Field Logsheet – Site 1 – Day-time Sampling

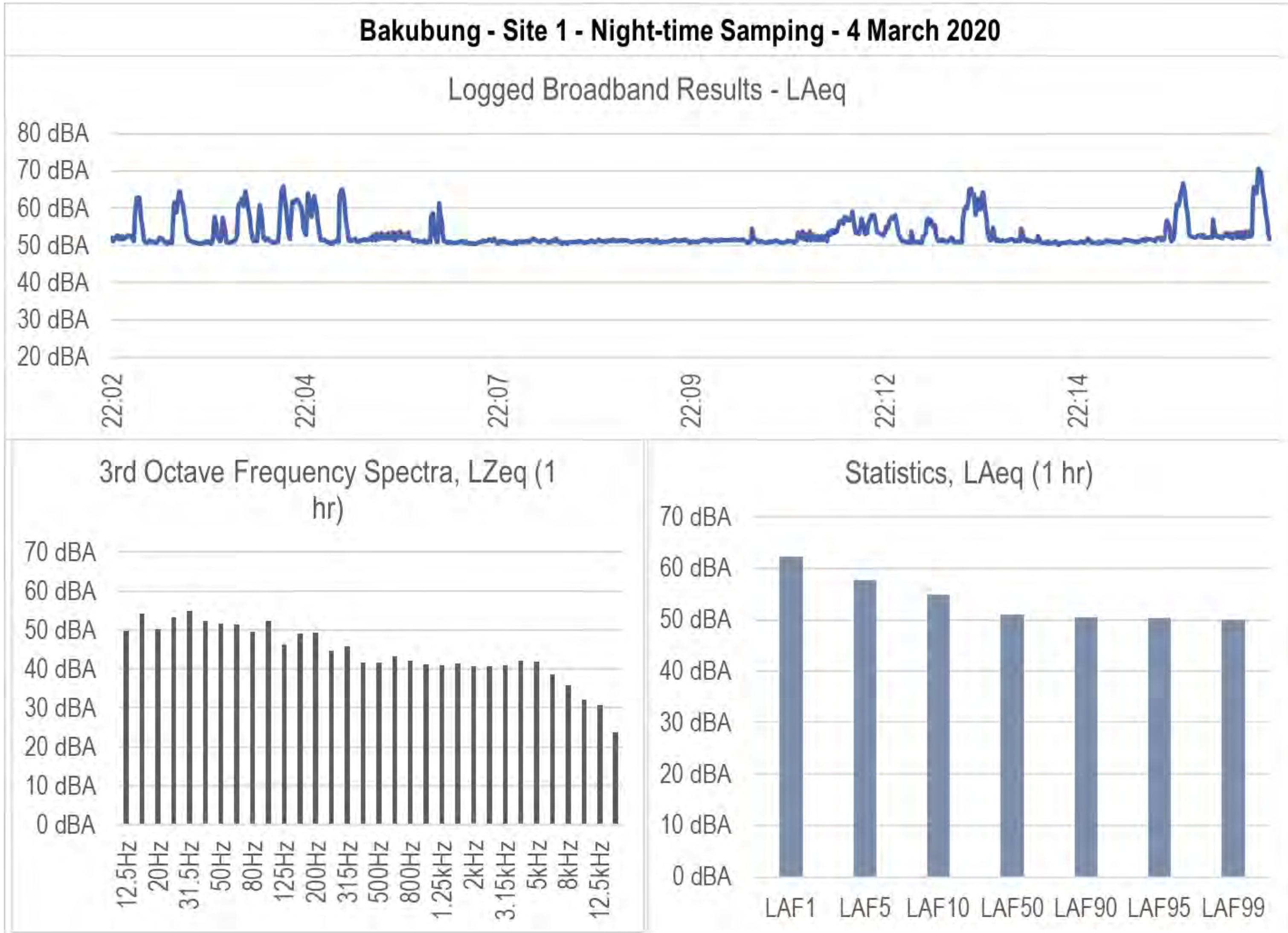

Figure 11: Broadband time series, frequency spectra and statistics – Site 1 – Night-time Sampling

SITE NUMBER: Site 1		SLM DATA RECORD: NYT baku 007
Longitude/Easting:	Latitude/Northing:	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: Mine ops ± 51 dB Workshop ± 60 dB
Start	0,7 – 1 m/s	NE	19,7	71,2	2/10	
Middle						
End						

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

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
20 ! 02:24	Workshop	07:00	Mine ops	15:55	Workshop		
02:52	"	08:53	"	16:19	Mine ops		
02:57	"	10:57	Siren	16:30	Siren		
03:27	"	11:16	"	16:45	"		
03:44	"	11:30	Workshop	16:54	Workshop		
04:17	"	11:41	"				
05:05	"	11:54	"				
05:37	"	12:13	"				
05:44	"	12:38	"				
05:02	"	13:07	"				
05:16	Mine ops	13:12	"				
05:44	"	13:20	"				
06:12	"	14:55	Mine ops				
06:49	"	15:44	Truck				

Page __ of __

Figure 12: Field Logsheet – Site 1 – Night-time Sampling

Appendix B – Site 2 – Photographs, Logsheets and Survey Results

Facing north

Facing east

Facing south

Facing west

Figure 13: Photographs of environmental noise survey Site 2

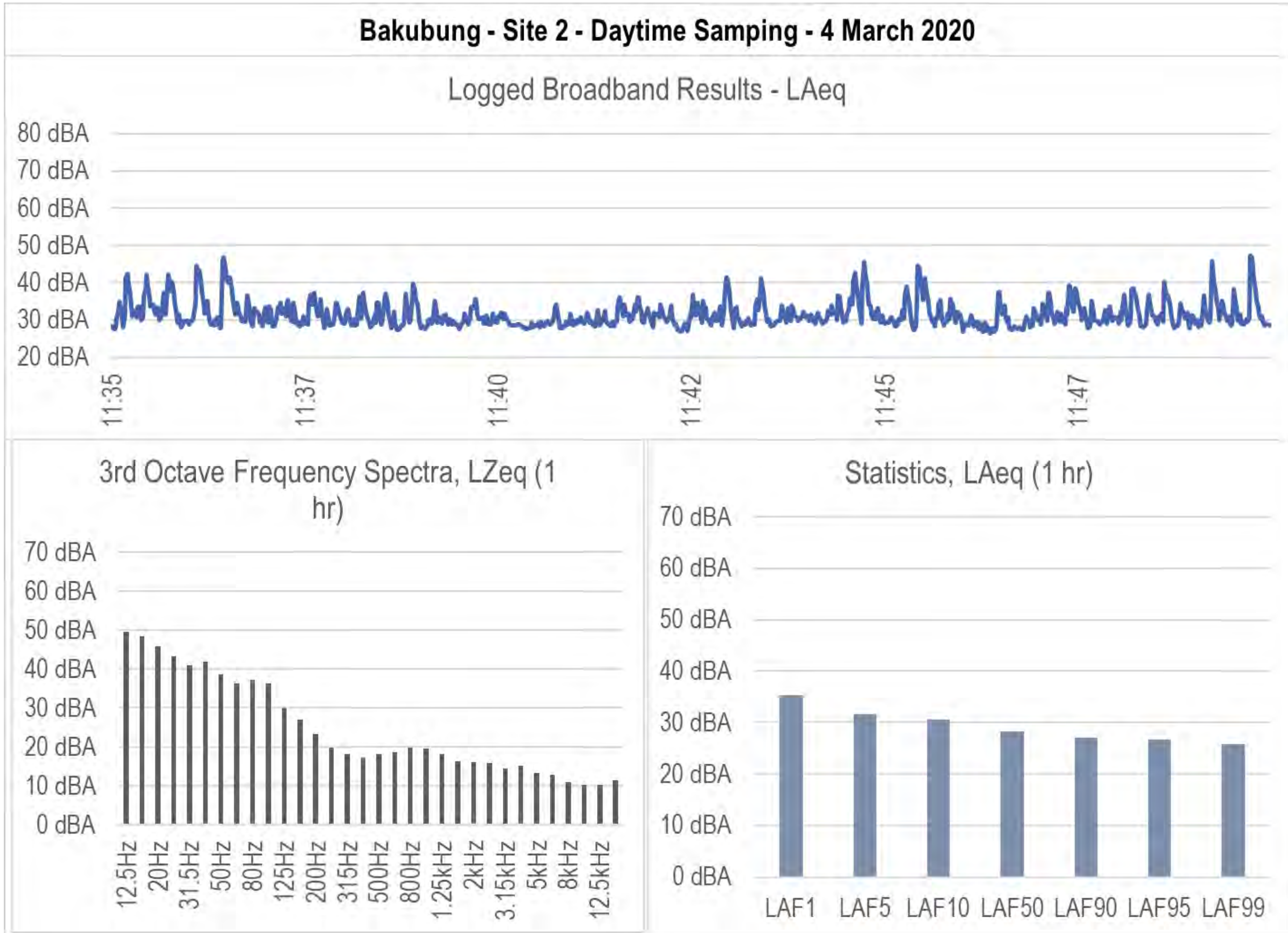

Figure 14: Broadband time series, frequency spectra and statistics – Site 2 – Day-time Sampling

DAY

SITE NUMBER: Site 2		SLM DATA RECORD: Baku 001
Longitude/Easting:	Latitude/Northing:	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	0.4 - 1.1	E	29.6	47,9	4/10	Mine operations ± 30 dB
Middle						Birds ± 28 dB
End						Wind ± 33 dB

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

Description: Open cleared land inside mine boundary close to mine crushers

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
09: 35:25	Birds	45:01	Birds				
35:43	"	45:74	"				
36:25	Mine ops	45:57	"				
36:48	"	47:12	Siren				
37:54	Birds	47:41	Mine ops				
39:24	Mine ops	48:06	Birds				
39:11	Wind ghust	48:42	"				
41:14	Siren	48:54	Mine ops				
41:16	"	49:31	Birds				
41:50	Mine ops	49:48	"				
42:43	"	50:14	"				
43:14	Distant traffic						
43:41	"						
44:53	Birds						

Page __ of __

Figure 15: Field Logsheet – Site 2 – Day-time Sampling

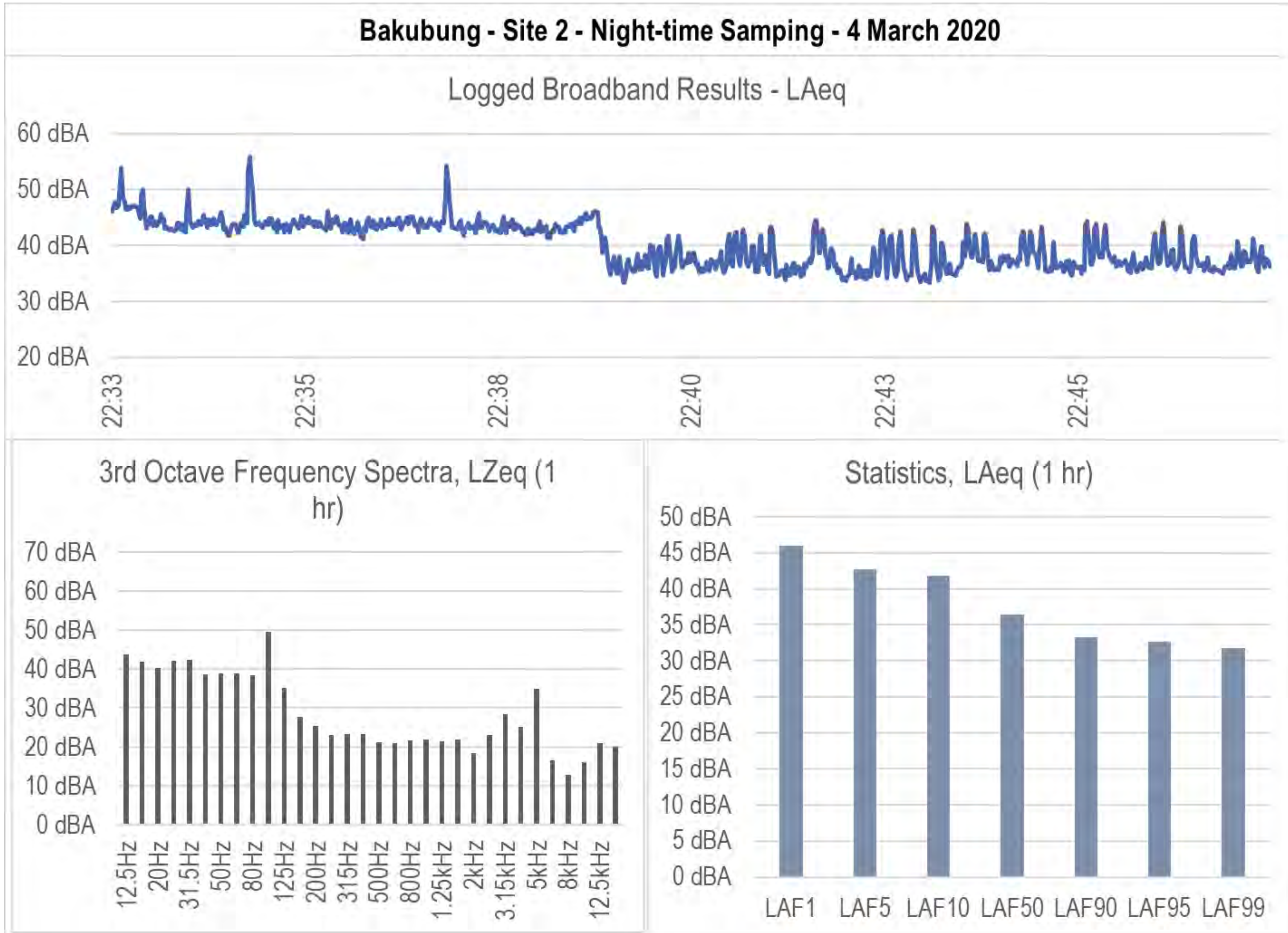

Figure 16: Broadband time series, frequency spectra and statistics – Site 2 – Night-time Sampling

23:22

NYT

SITE NUMBER: Site 2		SLM DATA RECORD: baku 008
Longitude/Easting:	Latitude/Northing:	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: Insects ± 36 dB Distant mine ops ± 35 dB
Start	0.7 – 1.1	E	19.5	68 %	0/10	
Middle						
End						

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

EVENTS							
Time	Description	Time	Description	Time	Description	Time	Description
20 33:16	Car idling	45:15	Insects				
33:38	"	45:25	Distant mine ops				
34:14	Insects	46:54	Insects				
34:	"	46:51	Dist vehicles				
35:01	"	47:14	"				
36:23	"	48:04	Insects				
36:57	"	48:13	"				
38:06	leaves						
40:40	Distant vehicles						
41:18	Insects						
41:47	"						
42:40	"						
43:12	"						
43:53	"						

Page __ of __

Figure 17: Field Logsheet – Site 2 – Night-time Sampling

Appendix C – Site 3 – Photographs, Logsheets and Survey Results

Facing north

Facing east

Facing south

Facing west

Figure 18: Photographs of environmental noise survey Site 3

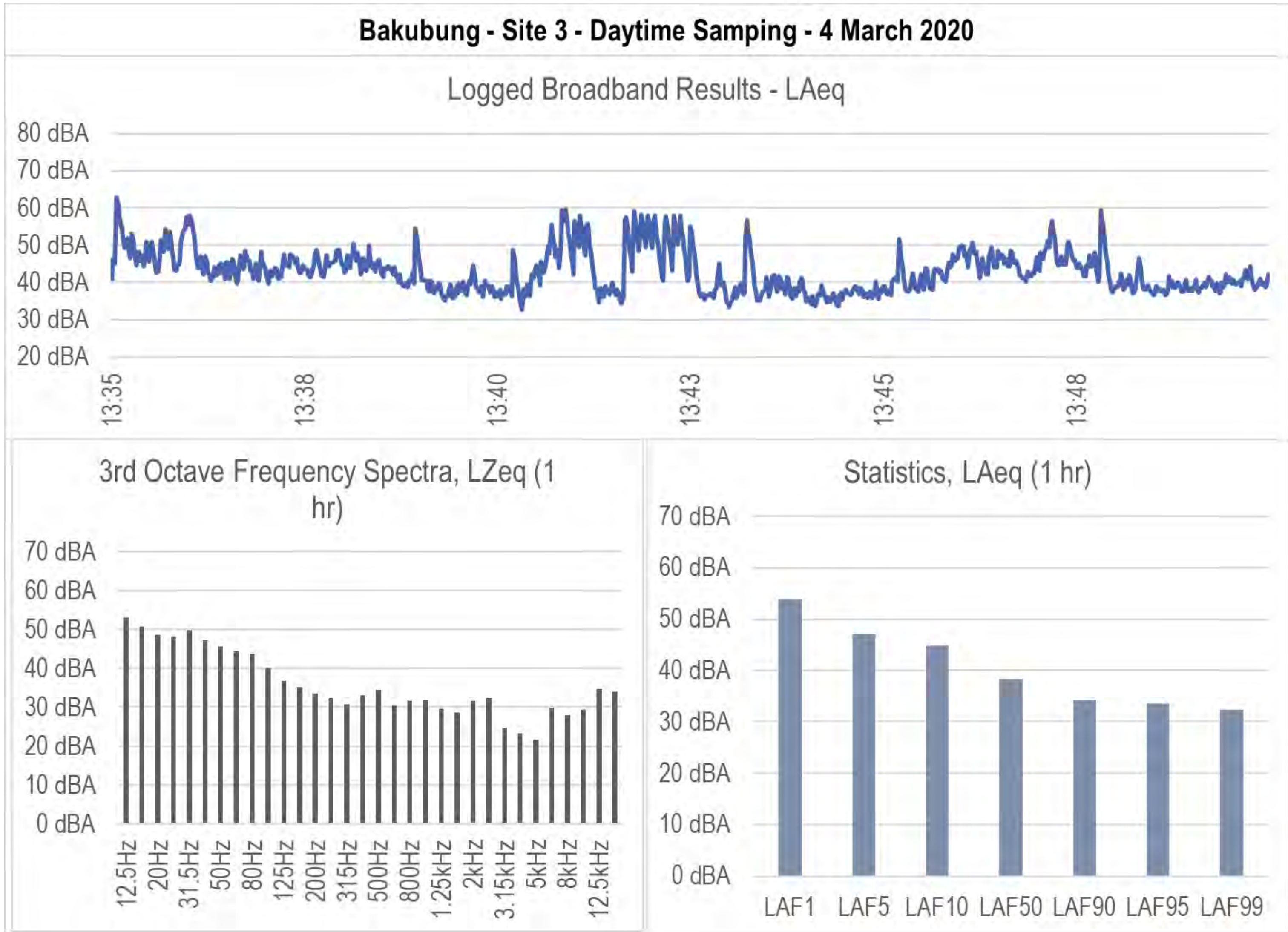

Figure 19: Broadband time series, frequency spectra and statistics – Site 3 – Day-time Sampling

Day

SITE NUMBER: Site 3	SLM DATA RECORD: baku 003

Longitude/Easting:	Latitude/Northing:	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: Music ± 50dB wind ± 43dB birds ± 38dB Community ± 49dB Road traffic ± 50dB
Start	1.8 – 2.6	E	30.2	42.2	4/10	
Middle						
End						

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

Description: Intersection at the edge of the nearby community. Houses nearby and bushes. Uncultivated land

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
11: 35:38	Music	41:44	Community	47:33	Car passing		
36:05	"	42:13	Birds	47:48	"		
36:33	Truck passing	42:20	"	47:58	Music		
36:36	"	42:35	"	48:22	"		
37:14	Music	43:04	"	48:53	Birds		
37:47	Wind ghust	43:27	Music	49:38	Insects		
37:55	"	43:47	Birds				
38:12	Music	44:47	"				
38:38	"	45:27	Music				
39:09	"	45:56	"				
39:31	Birds	46:09	"				
40:53	Music stops	46:33	"				
41:15	community	46:43	"				
41:22	"	47:04	"				

Page __ of __

Figure 20: Field Logsheet – Site 3 – Day-time Sampling

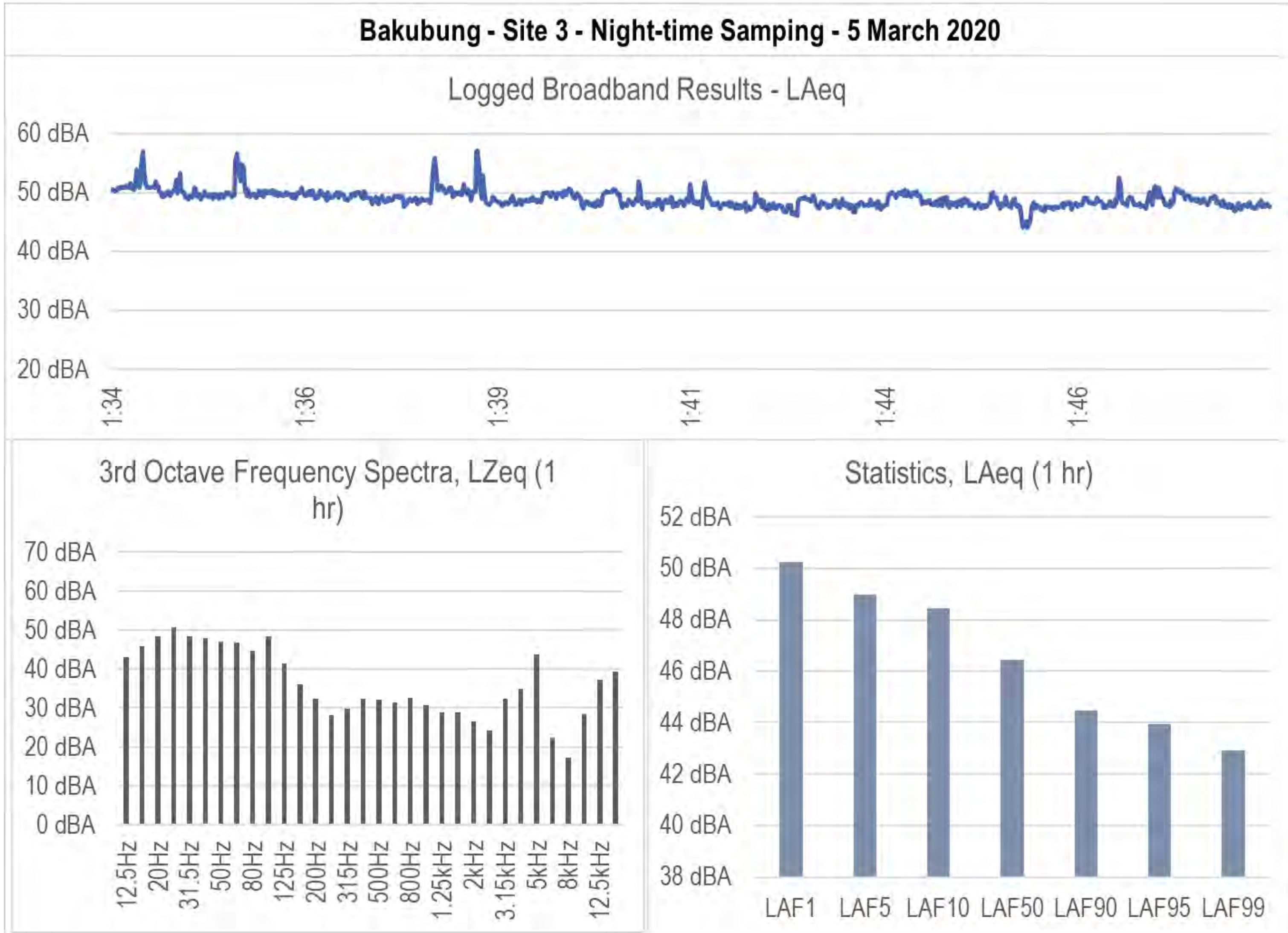

Figure 21: Broadband time series, frequency spectra and statistics – Site 3 – Night-time Sampling

Ny f

SITE NUMBER: Site 3		SLM DATA RECORD: bgku012
Longitude/Easting:	Latitude/Northing:	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	–	18.3	82,4	7/10	Mine ops ± 49 dB Insects ± 45 dB
Middle						
End						

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

EVENTS							
Time	Description	Time	Description	Time	Description	Time	Description
01:34:29	Mine ops	41:38	Insects	48:16	Mine ops		
34:54	"	41:59	"	49:11	Cock crowing		
35:20	"	42:09	Mine ops				
35:33	"	42:47	Insects				
36:04	"	43:22	"				
36:09	"	44:32	Mine ops				
36:54	"	44:55	"				
37:37	"	45:10	"				
38:39	"	45:29	"				
39:06	"	45:51	"				
39:12	"	46:24	"				
40:23	Insects	47:04	"				
40:57	Mine ops	47:30	"				
41:17	"	47:58	"				

Page __ of __

Figure 22: Field Logsheet – Site 3 – Night-time Sampling

Appendix D – Site 4 – Photographs, Logsheets and Survey Results

Figure 23: Photographs of environmental noise survey Site 4

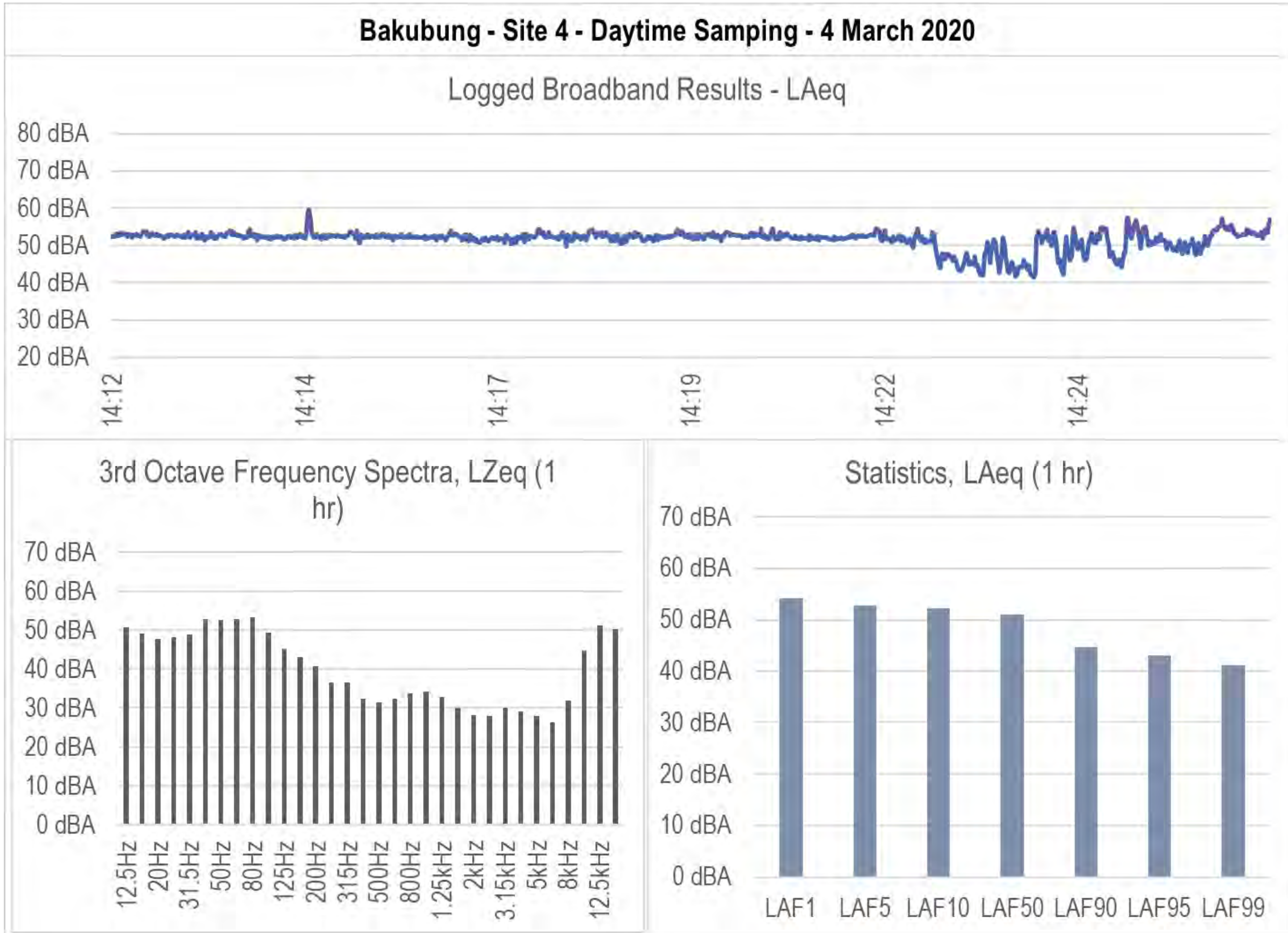

Figure 24: Broadband time series, frequency spectra and statistics – Site 4 – Day-time Sampling

DAY

SITE NUMBER: Site 4		SLM DATA RECORD: baku 004
Longitude/Easting:	Latitude/Northing:	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: Insects ± 49 dB Birds ± community ± 50 dB Traffic ± 52 dB
Start	0.9 – 1.1	S	30	40.1	2/10	
Middle						
End						

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

Description: Gravel road amidst community. Road/highway nearby and grass hence insects

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
12:49	Insects	19:33	Insects	26:57	Insects + Birds		
13:27	"	19:43	"				
12:59	"	20:19	Car passing				
13:32	Birds	21:06	"				
14:06	Community	22:39	"				
14:37	Insects	22:53	Insects				
15:01	Car hooter	23:21	Community (kid)				
15:20	Car passing	24:03	"				
15:24	"	23:47	"				
16:25	Insects	24:25	"				
16:57	Car passing	24:42	"				
17:19	Insects	25:24	Birds				
17:47	Car passing	26:51	"				
18:26	"	27:[illegible]	Road traffic				

Page __ of __

Figure 25: Field Logsheet – Site 4 – Day-time Sampling

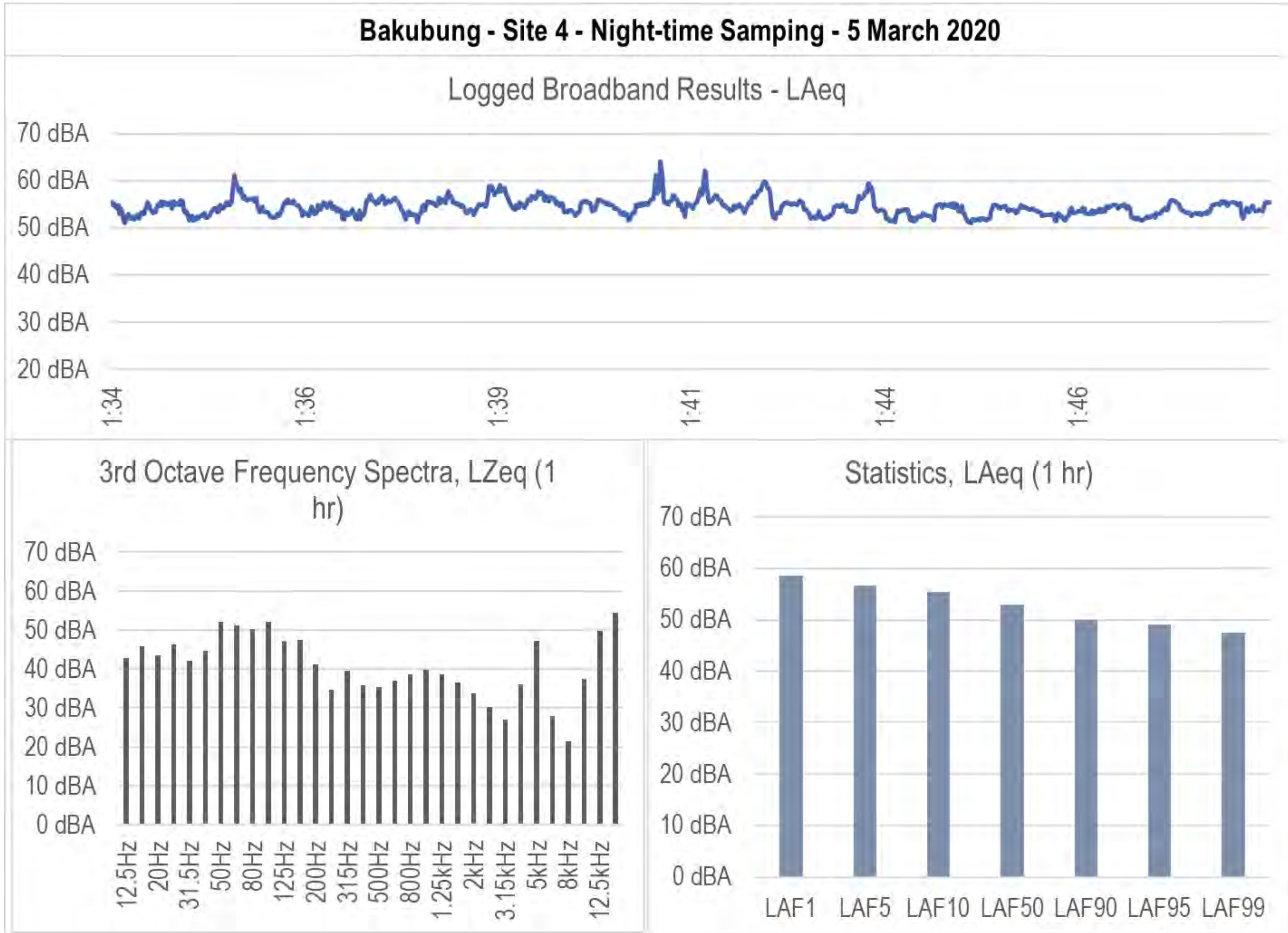

Figure 26: Broadband time series, frequency spectra and statistics – Site 4 – Night-time Sampling

Nyt

SITE NUMBER: Site 4		SLM DATA RECORD: bakuoll
Longitude/Easting:	Latitude/Northing:	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: Road traffic ± 56dB Music ± 48dB
Start	0-0.4	NE	20.4	40.8	4/10	
Middle						
End						

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

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
01; 09:25	Music	17:03	Car passing				
10:31	"	17:49	"				
10:45	"	19:19	"				
10:57	Car passing	19:32	Music				
11:13	"	20:03	"				
11:37	"	20:23	"				
11:46	"	20:45	"				
12:40	Distant truck	21:46	"				
13:02		23:04	"				
13:43	Car passing						
14:15	"						
14:26	"						
16:24	"						
16:38	"						

Page __ of __

Figure 27: Field Logsheet – Site 4 – Night-time Sampling

Appendix E – Site 5 – Photographs, Logsheets and Survey Results

Facing north

Facing east

Facing south

Facing west

Figure 28: Photographs of environmental noise survey Site 5

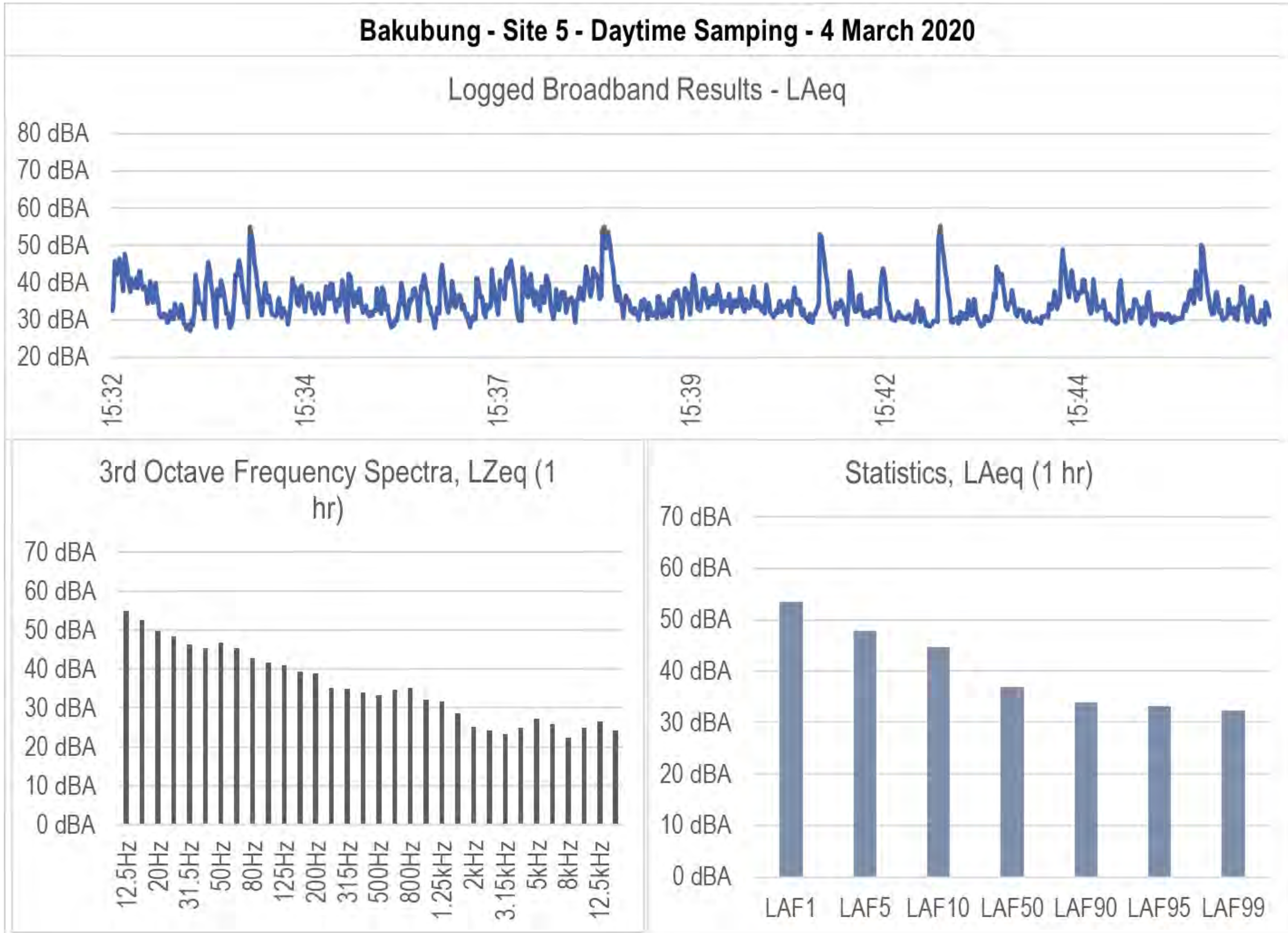

Figure 29: Broadband time series, frequency spectra and statistics – Site 5 – Day-time Sampling

DAY

SITE NUMBER: Site 5		SLM DATA RECORD: baky 006
Longitude/Easting:	Latitude/Northing:	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	0.7 - 1.6	E	29.8	42.4	2/10	Birds ± 35dB
Middle						Insects ± 31dB
End						

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

Description: Roadside on private property with buses on one side and mine boundary on the other

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
13 : 33:36	Birds	40:23	Cricket				
33:38	"	41:05	~~Ins~~ Birds				
34:35	"	41:24	"				
34:03	"	42:14	"				
35:04	Insects	42:41	"				
35:42	Birds	44:54	"				
36:32	Birds	45:18	"				
36:58	"	46:41	"				
37:22	"	46:21	Bees passing (swarm)				
37:52	"	46:52	Birds				
38:23	"						
38:35	"						
39:46	Cricket						
39:56	"						

Page __ of __

Figure 30: Field Logsheet – Site 5 – Day-time Sampling

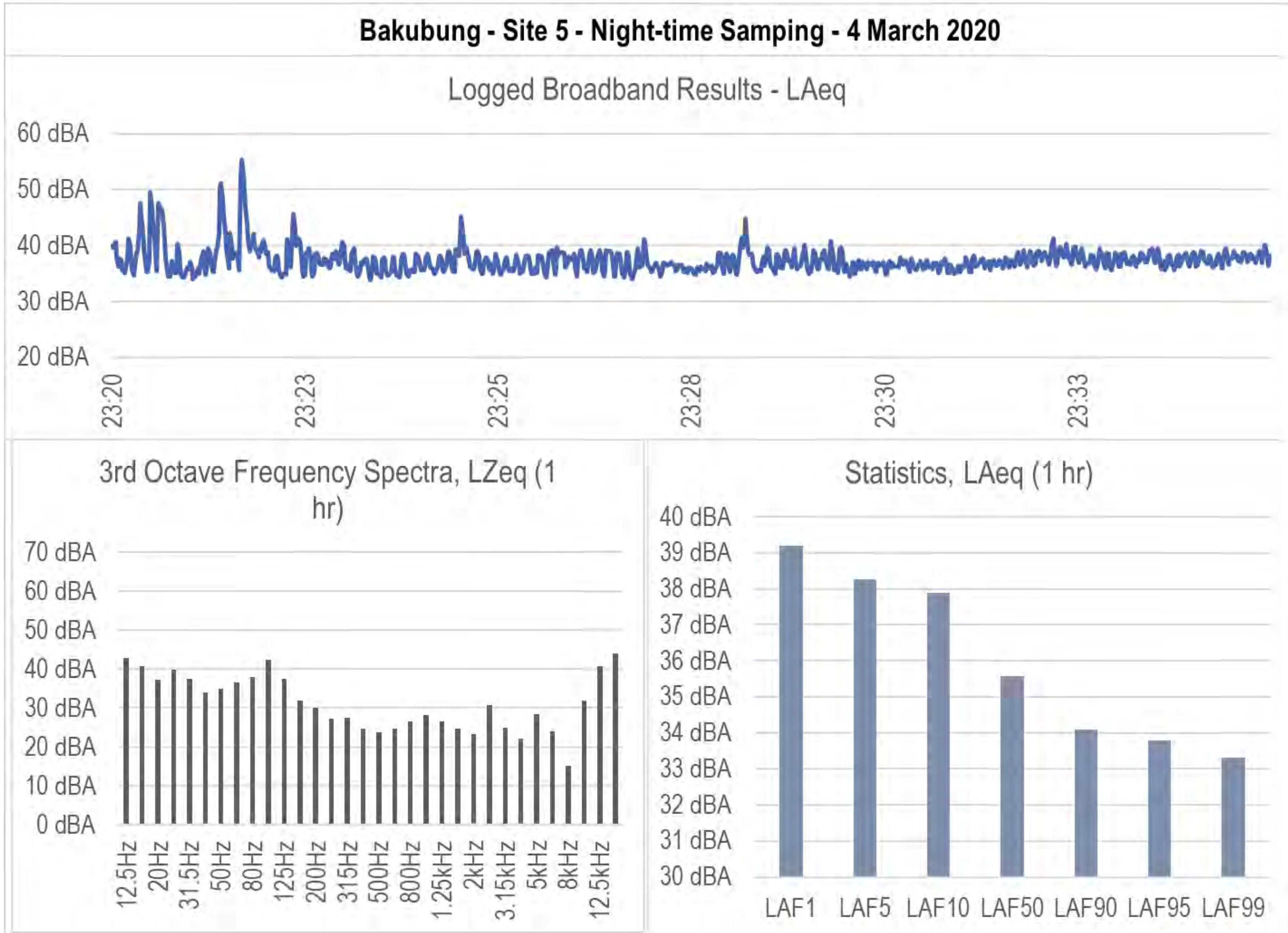

Figure 31: Broadband time series, frequency spectra and statistics – Site 5 – Night-time Sampling

00109

NYt

SITE NUMBER: Site 5		SLM DATA RECORD: baku 009
Longitude/Easting:	Latitude/Northing:	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: Insects ± 35dB
Start	0	–	20.5	75.1	3/10	
Middle						
End						

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

EVENTS							
Time	Description	Time	Description	Time	Description	Time	Description
21:21:50	Distant mine ops						
22:25	Insects						
23:20	"						
24:56	"						
26:49	"						
28:51	"						
29:53	"						
32:43	"						
33:46	"						
36:24	"						

Page __ of __

Figure 32: Field Logsheet – Site 5 – Night-time Sampling

Appendix F – Site 8 – Photographs, Logsheets and Survey Results

Facing north

Facing east

Facing south

Facing west

Figure 33: Photographs of environmental noise survey Site 8

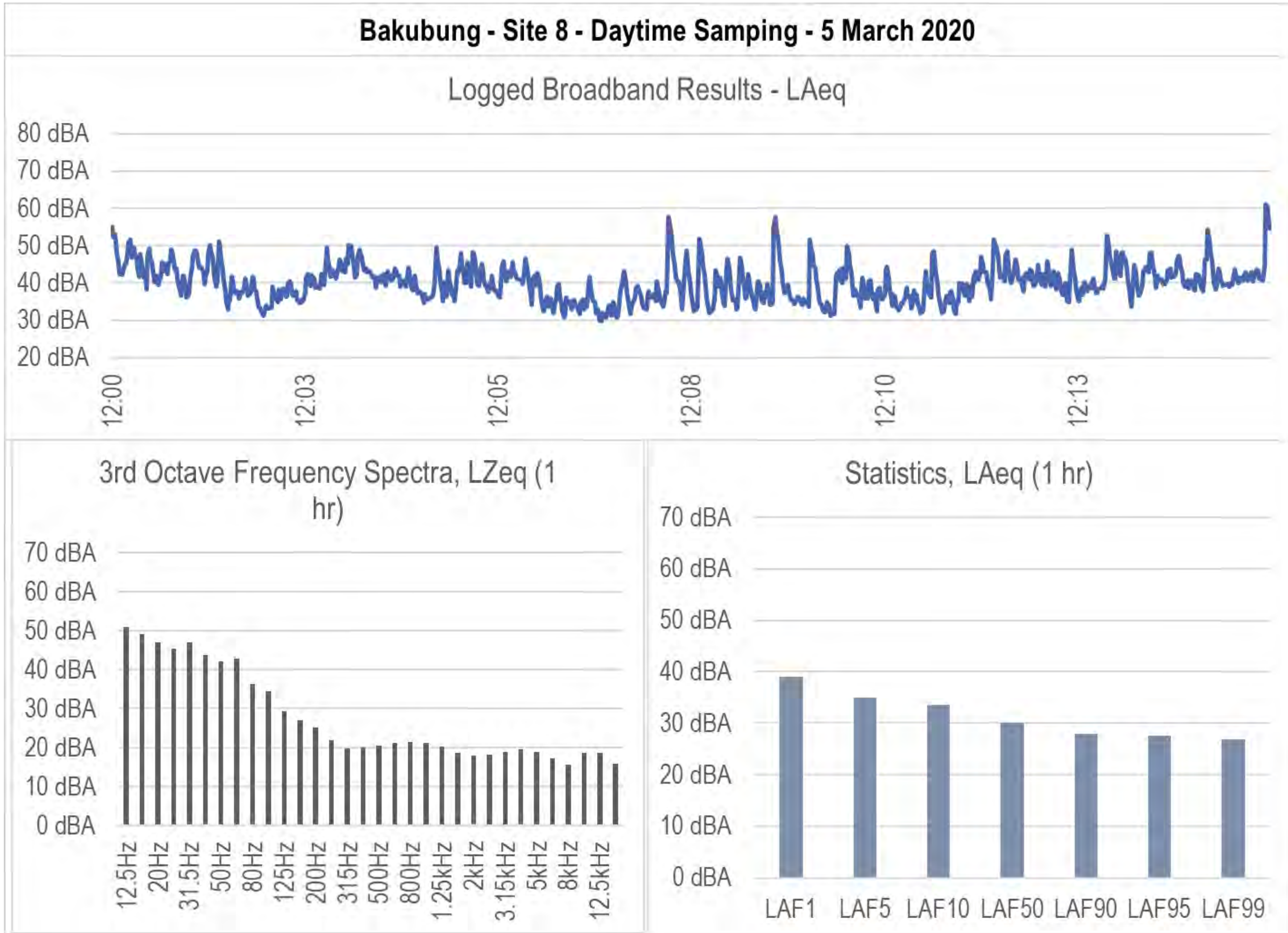

Figure 34: Broadband time series, frequency spectra and statistics – Site 8 – Day-time Sampling

DAY

SITE NUMBER: Site 8		SLM DATA RECORD: baku 014
Longitude/Easting:	Latitude/Northing:	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: Wind ghust ± 45 dB Air traffic ±45 dB Birds ±36 dB Insects ± 39.5 dB Road traffic ±35 dB
Start	0,8 – 2.5	N	26.4	49	1/10	
Middle						
End						

NOISE CLIMATE	☑ Birds	☑ Insects	☐ Dogs	☐ Music	☑ Community	☑ Air Traffic	☐ Road Traffic	☐ Constr.	☐ Other
Description: Open road (gravel) close to households (on both sides)									

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
12: 00:52	Wind ghust	08:58	Birds				
01:08	"	09:25	"				
03:26	Aeroplane	10:39	Road traffic				
03:55	"	11:20	Birds				
04:02	"	11:27	"				
05:20	Insects	12:05	Birds				
05:31	Birds	12:24	"				
05:43	"	13:43.	"				
07:13	"	14:17	"				
07:01	"	15:01	"				
07:38	"						
08:02	Community						
08:15	"						
08:26	Birds						

Page __ of __

Figure 35: Field Logsheet – Site 8 – Day-time Sampling

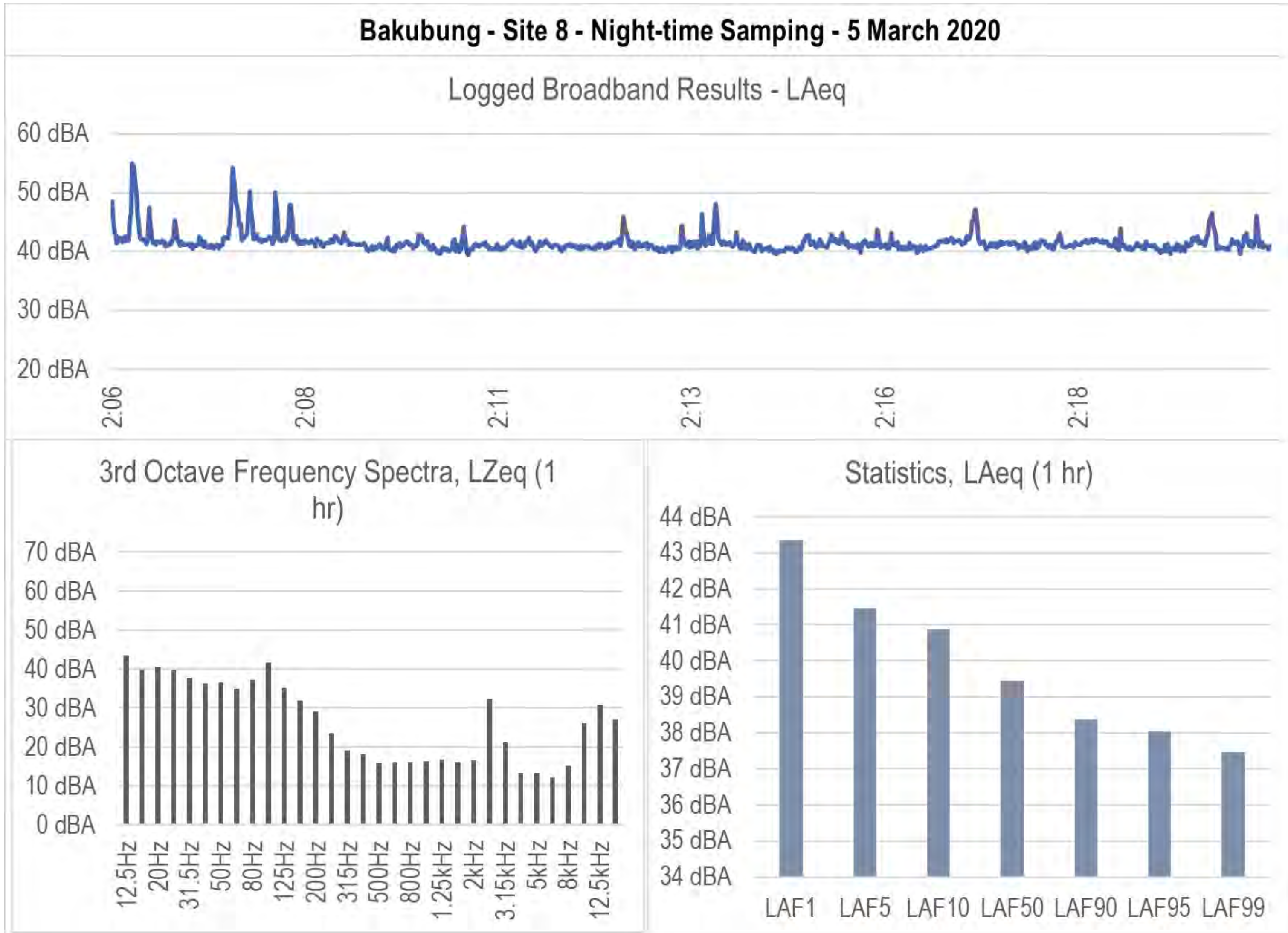

Figure 36: Broadband time series, frequency spectra and statistics – Site 8 – Night-time Sampling

Ngt

SITE NUMBER: Site 8		SLM DATA RECORD: baku013
Longitude/Easting:	Latitude/Northing:	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: Road traffic ± 41 dB Mine ops ± 39 dB Insects ± 38 dB Dogs ± 38 dB
Start	0	–	22.7	~~68.4~~ 70.4	0/10	
Middle						
End						

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

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
02:06:37	Cough	19:25	Mine ops				
07:54	Car passing	20:00	Dogs				
08:08	"	20:23	Mine ops				
08:59	"	20:53	"				
10:20	"	21:01					
11:19	Mine ops						
11:44	Traffic						
12:58	"						
13:43	dogs						
14:23	"						
15:21	Road traffic						
15:47	"						
17:30	"						
18:37	"						

Page __ of __

Figure 37: Field Logsheet – Site 8 – Night-time Sampling

Appendix G – Site 14 – Photographs, Logsheets and Survey Results

Facing north

Facing east

Facing south

Facing west

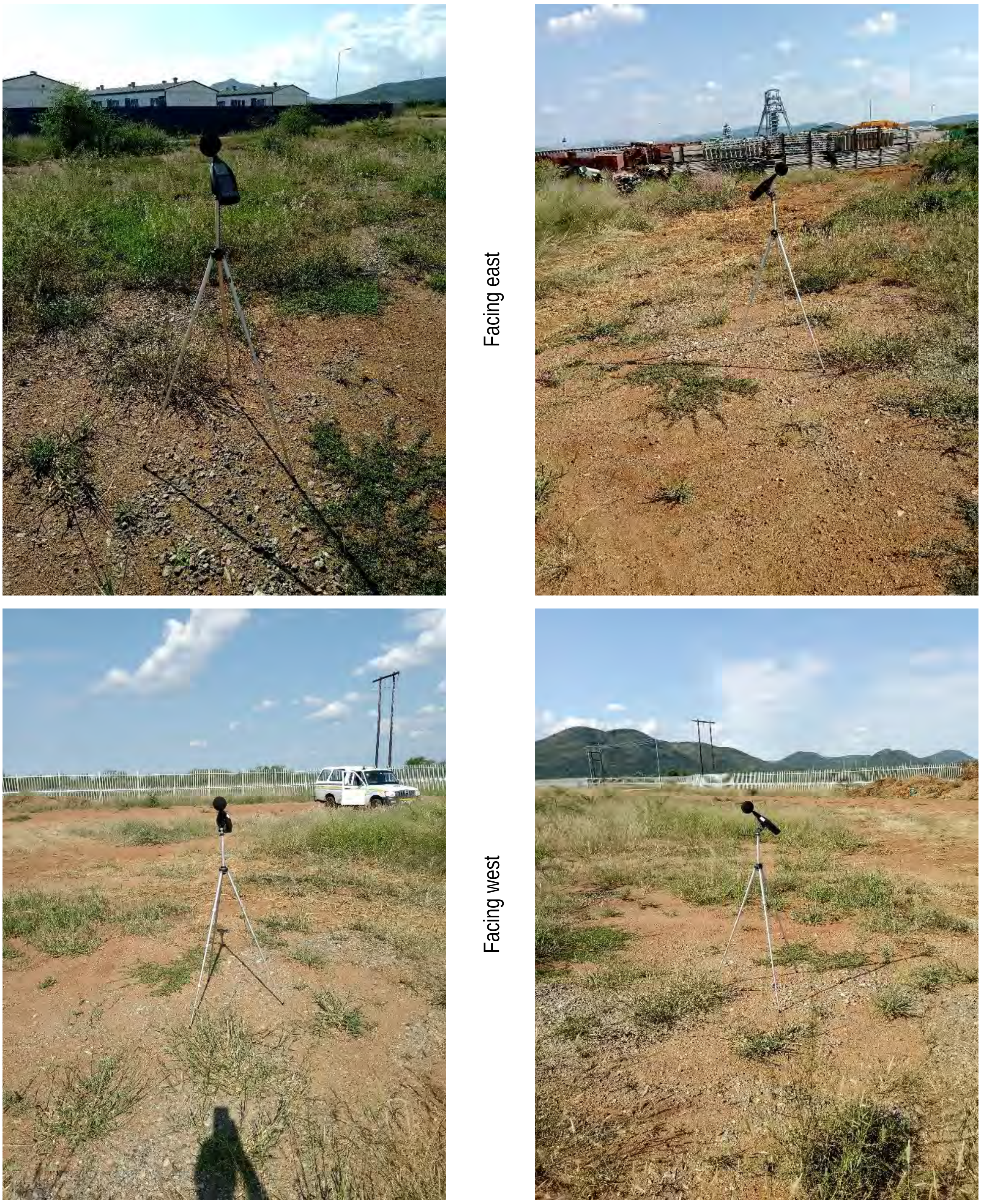

Figure 38: Photographs of environmental noise survey Site 14

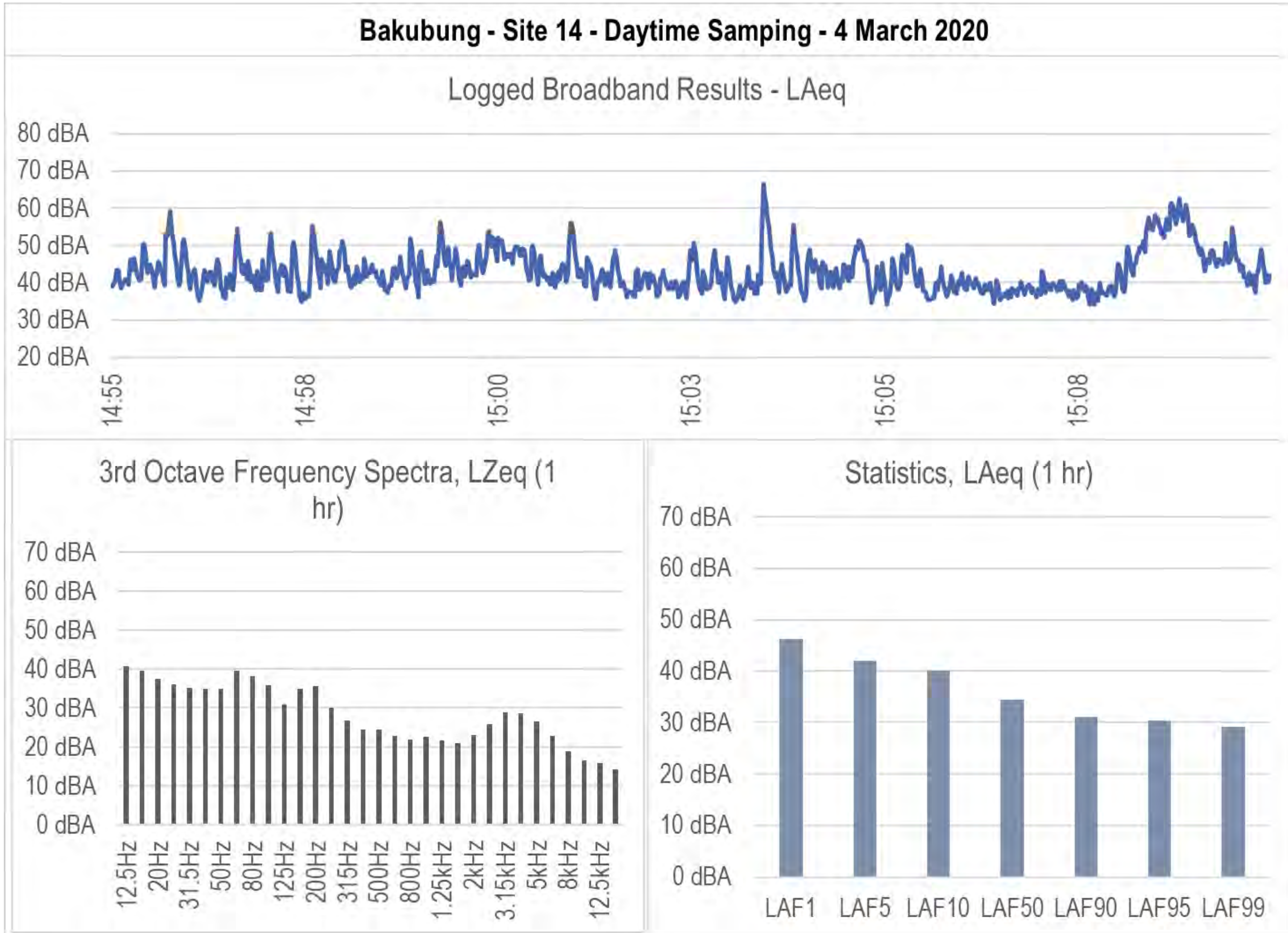

Figure 39: Broadband time series, frequency spectra and statistics – Site 14 – Day-time Sampling

DAY

SITE NUMBER: Site 14	SLM DATA RECORD: baku 005	
Longitude/Easting:	Latitude/Northing:	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: Wind ±36 Birds ±35 dB Insects ± 35dB
Start	0.7 – 1.5		28.8	37.9	1/10	
Middle						
End						

NOISE CLIMATE	☑ Birds	☑ Insects	☐ Dogs	☐ Music	☑ Community	☑ Air Traffic	☐ Road Traffic	☐ Constr.	☐ Other
Description: Open uncultivated land with grasse & bushes									

EVENTS

Time	Description	Time	Description	Time	Description	Time	Description
12: 56:12	People (Workers)	02:15	Birds	09:30	Men talking (Chinese)		
57:24	Wind	03:58	Insects	10:03	"		
56:43	Birds	04:24	Men shouting	10:11	"		
57:56	People talking	04:35	"	10:20	Car passing.		
58:48	"	04:48	Birds				
57:11	Birds	05:16	Truck passing				
59:23	Wind ghust	05:29	"				
59:29	"	05:45.	Birds				
00:01	Workers talking	05:54	"				
00:40	Aeroplane	07:11	"				
00:46	"	07:48	Men talking				
01:14	Birds	08:28	Birds				
01:43	"	08:50	Men talking				
01:56	"	08:56	"				

Page __ of __

Figure 40: Field Logsheet – Site 14 – Day-time Sampling

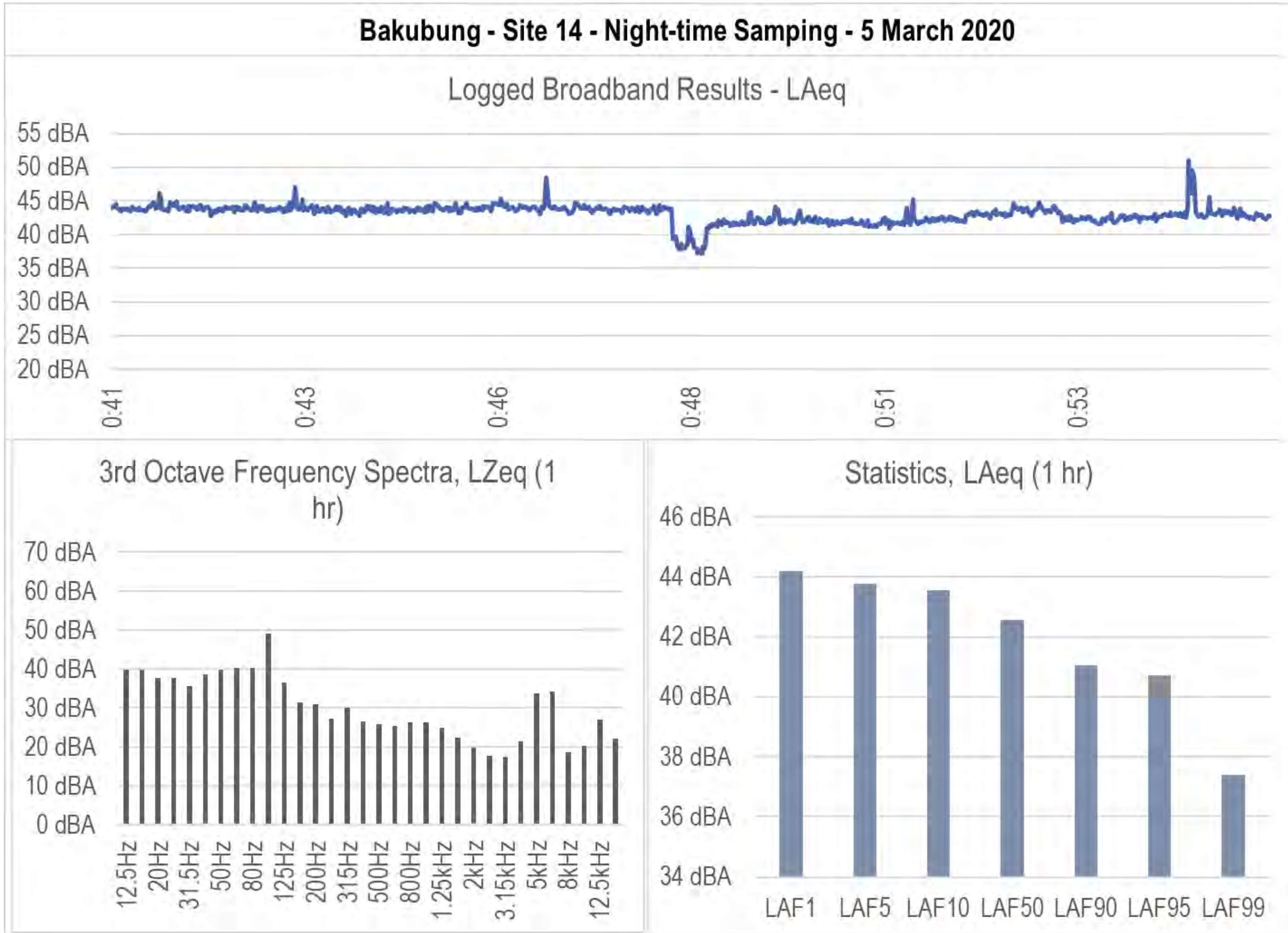

Figure 41: Broadband time series, frequency spectra and statistics – Site 14 – Night-time Sampling

00:40

SITE NUMBER: Site 14	SLM DATA RECORD: baku010	
Longitude/Easting:	Latitude/Northing:	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: Mine ops ± 43dB Insects ± 40dB
Start	0,3 – 0,4	5	23.8	62.6		
Middle						
End						

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

EVENTS							
Time	Description	Time	Description	Time	Description	Time	Description
00:41:04	Mine ops	54:56	Mine ops				
41:33	"						
44:19							
44:47	Siren (mine)						
45:25	Mine ops						
45:28	Insects						
45:38	"						
46:02	Vehicle (distant)						
45:04	Mine ops						
47:01	"						
47:38	Insects						
47:51	"						
49:47	Mine ops						
53:01	Distant car						

Page __ of __

Figure 42: Field Logsheet – Site 14 – Night-time Sampling

Appendix H – Significance Rating Methodology

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Date:	09 March 2020	**File No.:**	301-00509/14
To:	All specialists involved in Bakubung TSF EIA		
Copy To:			
From:	Tania Oosthuizen, Knight Piésold		
Re:	Knight Piésold impact assessment methodology		

1.0 PURPOSE

This memorandum serves to provide a standardised impact assessment methodology for all specialist to apply during the ESIA process.

The purpose of this methodological approach to impact assessments serves to identify economic, environmental and social impacts of a potential project and the implications thereof which need to be taken into account during the planning stages. By predicting possible impacts during project planning and design, it provides the project team with the opportunity to reduce adverse impacts and to provide alternatives to the decision makers of the project. By utilising this methodology, both environmental and economic targets can be reached, such as reducing cost and time of project implementation and design, avoided treatment/clean-up costs and impacts of laws and regulations, and finally, assisting with client approval of proposed projects.

2.0 INTRODUCTION

The adequate assessment and evaluation of the potential impacts and benefits that will be associated with a proposed project necessitates the development of a scientific method that will reduce the subjectivity involved in making such evaluations. Knight Piésold uses a simple, clearly defined method in order to accurately determine the significance of the predicted impact on, or benefit to, the surrounding natural and/or social environment.

Nonetheless, an impact assessment will always contain a degree of subjectivity, as it is based on the value judgment of various specialists and Environmental Assessment Practitioners. The evaluation of significance is thus contingent upon values, professional judgement, and dependent upon the environmental and community context. Ultimately, impact significance involves a process of determining the acceptability of a predicted impact to society.

The purpose of impact assessment is to identify and evaluate the likely significance of the potential impacts on identified receptors and resources according to defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise, reduce or compensate for any potential adverse environmental effects, and to report the significance of the residual impacts that remain following mitigation.

3.0 COMPONENTS OF THE IMPACT RATING

3.1 DEFINING THE NATURE OF THE IMPACT

An impact is essentially any change to a resource or receptor brought about by the presence of the proposed project component or by the execution of a proposed project related activity. The terminology used to define the nature of an impact is detailed in Table 1 below.

Table 1: Impact Nature

Term	Definition
Positive (+)	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Negative (-)	An impact that is considered to represent an adverse change from the baseline or introduces a new undesirable factor.
Direct impact (D)	Impacts that result from a direct interaction between a planned project activity and the receiving environment/receptors (e.g. between occupation of a site and the pre-existing habitats or between an effluent discharge and receiving water quality).
Indirect impact (I)	Impacts that result from other activities that are encouraged to happen as a consequence of the Project (e.g. in-migration for employment placing a demand on resources).
Cumulative impact (C)	Impacts that act together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the Project.

3.2 ASSESSING SIGNIFICANCE

The Knight Piésold impact significance rating system is based on the following equation:

Significance of Environmental / Social Impact = Consequence x Probability

The consequence of an impact can be derived from the following factors:

Severity / Magnitude – the degree of change brought about in the environment

Reversibility - the ability of the receptor to recover after an impact has occurred

Duration - how long the impact may be prevalent

Spatial Extent - the physical area which could be affected by an impact.

The **severity, reversibility, duration, and spatial extent** are ranked using the criteria indicated in Table 2 and then the overall consequence is determined by adding up the individual scores and multiplying it by the **overall probability** (the likelihood of such an impact occurring). Once a score has been determined, this is checked against the **significance** descriptions indicated in Table 3.

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Table 2: Ranking Criteria

Severity / magnitude (M)	Reversibility (R)	Duration (D)	Spatial extent (S)	Probability (P)
5 – Very high – The impact causes the characteristics of the receiving environment/ social receptor to be altered by a factor of 80 – 100 %	**5 – Irreversible** – _Environmental_ - where natural functions or ecological processes are altered to the extent that it will permanently cease. _Social_ - Those affected will not be able to adapt to changes and continue to maintain-pre impact livelihoods.	**5 – Permanent** - Impacts that cause a permanent change in the affected receptor or resource (e.g. removal or destruction of ecological habitat) that endures substantially beyond the Project lifetime.	**5 – International** - Impacts that affect internationally important resources such as areas protected by international conventions, international waters etc.	**5 – Definite** - The impact will occur.
4 – High – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 60 – 80 %		**4 – Long term** - impacts that will continue for the life of the Project, but ceases when the Project stops operating.	**4 – National** - Impacts that affect nationally important environmental resources or affect an area that is nationally important/ or have macro-economic consequences.	**4 – High probability** – 80% likelihood that the impact will occur
3 – Moderate – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 40 – 60 %	**3 – Recoverable** _Environmental_ - where the affected environment is altered but natural functions and ecological processes may continue or recover with human input. _Social_ - Able to adapt with some difficulty and maintain pre-impact	**3 – Medium term** - Impacts are predicted to be of medium duration (5 – 15 years)	**3 – Regional** - Impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries, habitat type/ecosystem.	**3 – Medium probability** – 60% likelihood that the impact will occur u

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Severity / magnitude (M)	Reversibility (R)	Duration (D)	Spatial extent (S)	Probability (P)
	livelihoods but only with a degree of support or intervention.			
2 – Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %		**2 – Short term** - Impacts are predicted to be of short duration (0 – 5 years)	**2 – Local** - Impacts that affect an area in a radius of 2 km around the site.	**2 – Low probability** - 40% likelihood that the impact will occur
1 – Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20 %	**1 – Reversible** *Environmental* - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. *Social* - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	**1 – Temporary** - Impacts are predicted to intermittent/ occasional over a short period.	**1 – Site only** - Impacts that are limited to the site boundaries.	**1 – Improbable** - 20% likelihood that the impact will occur

Table 3: Significance Definitions

Score According to Impact Assessment Matrix	Significance Definitions	Colour Scale Ratings	
		Negative Ratings	Positive Ratings
Between 0 and 29 significance points indicate **Low Significance**	An impact of low significance is one where an effect will be experienced, but the impact magnitude is sufficiently small and well within accepted standards, and/or the receptor is of low sensitivity/value.	Low	Low
Between 30 and 59 significance points indicate **Moderate Significance**	An impact of moderate significance is one within accepted limits and standards. The impact on the receptor will be noticeable and the normal functioning is altered, but the baseline condition prevail, albeit in a modified state. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is As Low As Reasonably Practicable (ALARP). This does not necessarily mean that "moderate" impacts have to be reduced to "low" impacts, but that moderate impacts are being managed effectively and efficiently to not exceed accepted standards.	Moderate	Moderate
60 to 100 significance points indicate **High Significance**	An impact of high significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An impact with high significance will completely modify the baseline conditions. A goal of the ESIA process is to get to a position where the Project does not have any high negative residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for some aspects there may be high residual impacts after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). It is then the function of regulators and stakeholders to weigh such negative factors against the positive factors, such as employment, in coming to a decision on the Project.	High	High

3.3 MITIGATION AND RESIDUAL IMPACTS

It is expected that for the identified significant impacts, the project team will work with the client in identifying suitable and practical mitigation measures that are implementable. Mitigation that can be incorporated into the Project design in order to avoid or reduce the negative impacts or enhance the positive impacts will be developed. A description of these mitigation measures will also be included within the Environmental and Social Management Plan (ESMP).

Residual impacts are those impacts which remain once the mitigation measures have been designed and applied. Once the mitigation is applied, each impact is re-evaluated (assuming that the mitigation measure is effectively applied) and any remaining impact is rated once again using the process outlined above. The result is a significance rating for the residual impact.

4.0 APPLICATION

All specialists are required to conduct their respective impact assessment studies using this standardised procedure. This will ensure standardisation and ease of integration of the various components.

A Microsoft Excel sheet has been developed to facilitate capturing of impacts per environmental receptor. Impacts should be described per facility / activity and rated using the methodology above. The narrative for each impact should be described in the specialist study (Word document). This narrative should describe the reasons for the ratings provided and the overall significance rating. The assigned ratings should be captured in the attached Excel sheet. Where construction phase, operational and closure phase impacts are expected to differ, these impacts should be described separately.

Yours sincerely,
Knight Piésold (Pty) Ltd

Appendix I – Author's Curriculum Vitae

CURRICULUM VITAE

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

MEMBERSHIP OF SOCIETIES

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

EXPERIENCE

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

PROJECTS COMPETED IN VARIOUS SECTORS ARE LISTED BELOW:

Mining Sector

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

Industrial Sector

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

Power Generation, Oil and Gas

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

Waste Disposal and Treatment Sector

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

Petroleum Sector

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

Transport and Logistics Sector

Saldanha Port Project.

Ambient Air Quality and Noise Sampling/Monitoring

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

SOFTWARE PROFICIENCY

Software utilised in conducting air and noise studies:

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

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

EDUCATION

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

CONFERENCES ATTENDED, ARTICLES PUBLISHED AND COURSES COMPLETED

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

COUNTRIES OF WORK EXPERIENCE

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

LANGUAGES

Language	Proficiency
English	Full professional proficiency
Afrikaans	Limited working proficiency

REFERENCES

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

CERTIFICATION

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

22/04/2020

Page 5 of 5 Curriculum Vitae: Natasha Anne Shackleton