



SiVEST SA (PTY) LTD

PROPOSED CONSTRUCTION OF THE 140 MW PATATSKLOOF WIND ENERGY FACILITY, BATTERY ENERGY STORAGE SYSTEM (BESS), GRID CONNECTION AND ASSOCIATED INFRASTRUCTURE, NEAR CERES, WESTERN CAPE PROVINCE, SOUTH AFRICA

Environmental Noise Impact Assessment

DFFE Reference:
Report Prepared by:
Issue Date:
Version No.:

TBA
Morné de Jager (Enviro-Acoustic Research)
July 2021
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SiVEST SA (PTY) LTD

PROPOSED CONSTRUCTION OF THE 140 MW PATATSKLOOF WIND ENERGY FACILITY, BATTERY ENERGY STORAGE SYSTEM (BESS), GRID CONNECTION AND ASSOCIATED INFRASTRUCTURE, NEAR CERES, WESTERN CAPE PROVINCE, SOUTH AFRICA

ENVIRONMENTAL NOISE IMPACT ASSESSMENT

EXECUTIVE SUMMARY

INTRODUCTION AND PURPOSE

Enviro-Acoustic Research cc was commissioned by the SiVEST SA (Pty) Ltd (SiVEST) to identify and assess the potential noise impact from the construction, operation and decommissioning of the proposed Patatskloof Wind Energy Facility (WEF) and associated infrastructure on the surrounding area.

This review considered local and international guidelines, using the terms of reference (ToR) as proposed by SANS 10328:2008 and by the requirements specified in the Assessment Protocol for Noise that were published on 20 March 2020, in Government Gazette 43110, GN 320.

PROJECT DESCRIPTION

South Africa Mainstream Renewable Power Developments (Pty) Ltd (Mainstream) propose to develop the Patatskloof WEF near Ceres in the Western Cape Province. The overall objective of the development is to generate electricity by means of renewable energy technology, capturing wind energy to feed into the national grid.

It is anticipated that the proposed Patatskloof WEF will comprise of up to thirty-five (35) wind turbines, each with a generating capacity of between 4 and 6.6 MW for a maximum total energy generation capacity of up to approximately 140 MW. The electricity generated by the proposed WEF development will be fed into the national grid via a 132kV overhead power line. A Battery Energy Storage System (BESS) will be located next to the onsite 33/132kV substation. The storage capacity and type of technology would be determined at a later stage during the development phase, but most likely will comprise an array of containers, outdoor cabinets and/or storage tanks.

DESCRIPTION OF STUDY AREA

The proposed Patatskloof WEF and associated grid infrastructure will be located in the Cape Winelands District Municipality, approximately 18km and 25 km north-east from Touws River. The topography ranges from plains in the north to "*Low Mountains*", although due to the height of the wind turbines, there are no topographical features that would significantly block the promulgation of noise.

Land use is mostly wilderness (including eco-tourism) with some agricultural activities (game and sheep farming) and existing land use activities are not expected to impact on the ambient sound levels. There are a number of dwellings in the area used for permanent as well as temporary residential purposes.

DESCRIPTION OF AMBIENT SOUND LEVELS

Ambient (background) noise levels were measured in September 2016 and again in September 2020 in accordance with the South African National Standards (SANS), also considering the protocols defined in Government Gazette 43110.

All the data indicated an area with a high potential to be quiet both day and night. The visual character of the study area is rural and it was accepted that the SANS 10103 noise district classification could be rural during low wind conditions. Considering sound level data measured in similar areas, ambient sound levels will increase as wind speeds increase and noise limits were proposed considering all the available data and guidelines.

NOISE IMPACT DETERMINATION AND FINDINGS

The potential noise impact of the proposed Patatskloof WEF and associated grid infrastructure was evaluated using a sound propagation model. Conceptual scenarios were developed for the construction and operation phases. With the modelled input data as used, this assessment indicated a:

- **low significance** for daytime activities related to the construction of the substation, hard standing areas, digging foundations, civil work as well as the erection of the wind turbines;
- **low significance** for night-time activities relating to the construction of civil work as well as the erection of the wind turbines. Mitigation is proposed and available to reduce the significance to **low**;
- **low significance** for both day- and night-time operational activities;
- **low significance** for potential cumulative noises during the operational phase; and,
- **low significance** for potential decommissioning noises.

The potential noise impact of the decommissioning phase is based on the potential noise impact during daytime construction activities (low significance). The development of the Patatskloof WEF and associated grid infrastructure will not increase cumulative noises in the area and the significance of the noise impact will be low.

POTENTIAL MITIGATION MEASURES

The significance of noise during all phases of the project is low and no additional mitigation measures are required to manage the potential noise impact. However, to ensure that potential annoyance with the project is minimized, it is recommended that:

- the applicant minimize night-time construction activities that generate impulsive noises when working within 2,000m from any NSD, planning the completion of noisiest activities (such a pile driving, rock breaking and excavation) during the daytime period;
- where practicable, mobile equipment should be fitted with broadband (white-noise generators/alarms), rather than tonal reverse alarms;
- the applicant (or the environmental control officer) ensure that equipment is well maintained and fitted with the correct and appropriate noise abatement measures. Engine bay covers over heavy equipment could be pre-fitted with sound absorbing material. Heavy equipment that fully encloses the engine bay should be considered, ensuring that the seam gap between the hood and vehicle body is minimised;
- the applicant include a component covering environmental noise in the Health and Safety Induction to sensitize all employees and contractors about the potential impact from noise, especially those employees and contractors that have to travel past receptors at night, or might be required to do work close (within 1,200m) to NSR at night. This should include issues such as minimising the use of vehicle horns; and
- the applicant must minimize night-time construction traffic if the access roads are closer than 150 m from any NSD, alternatively, the access road must be relocated further than 120 m from NSDs (night-time traffic passing occupied houses).

RECOMMENDATIONS

Because the total projected noise levels are less than 42 dBA, active noise monitoring is not required or recommended.

It is also recommended that the developer:

- investigate any reasonable and valid noise complaint if registered by a receptor staying within 2,000 m from the location where construction or operational activities are taking place;
- evaluate the potential noise impact should the layout be revised where any proposed wind turbines are located closer than 1,000 m from a confirmed noise Sensitive Development (NSD);
or
- if the developer decides to use a different wind turbine that has a sound power emission level higher than that of the Wind Turbine Generator (WTG) used in this report (sound power emission level exceeding 115.0 dBA re 1 pW).

Considering the low significance of the potential noise impacts (with mitigation, inclusive of cumulative impacts) for the proposed WEF and associated infrastructure, it is recommended that the proposed Patatskloof WEF and associated grid infrastructure be authorized.

NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998 (ACT NO. 107 OF 1998) AND ENVIRONMENTAL IMPACT REGULATIONS, 2014 (AS AMENDED) - REQUIREMENTS FOR SPECIALIST REPORTS (APPENDIX 6)

Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6	Section of Report
1. (1) A specialist report prepared in terms of these Regulations must contain- a) details of- i. the specialist who prepared the report; and ii. the expertise of that specialist to compile a specialist report including a curriculum vitae;	Appendix A
b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Separate document
c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 1.1
(cA) an indication of the quality and age of base data used for the specialist report;	Section 5
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 7.3.3
d) the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Sections 5.1 and 5.4
e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 1.4 and Appendix C .
f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 5
g) an identification of any areas to be avoided, including buffers;	Section 5.1
h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 5.1 and Figure 6 and Figure 7
i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 2
j) a description of the findings and potential implications of such findings on the impact of the proposed activity, (including identified alternatives on the environment) or activities;	Sections 8, 9 and 12.1

k) any mitigation measures for inclusion in the EMPr;	Section 10.4.1
l) any conditions for inclusion in the Environmental Authorisation;	Section 10.4.2
m) any monitoring requirements for inclusion in the EMPr or Environmental Authorisation;	No monitoring required
n) a reasoned opinion- <ul style="list-style-type: none"> i. (as to) whether the proposed activity, activities or portions thereof should be authorised; <ul style="list-style-type: none"> (iA) regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities 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; 	Sections 12.2 and 10.4
o) a description of any consultation process that was undertaken during the course of preparing the specialist report;	Project discussed with land owners in project focus area
p) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	No comments received regarding noise. To be updated following the Public participation process.
q) any other information requested by the competent authority.	No other information regarding noise requested to date.
2) Where a government notice <i>gazetted</i> by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	See following section

COMPLIANCE WITH THE NOISE SPECIALIST ASSESSMENT REQUIREMENTS AS PER THE PROTOCOL FOR NOISE SPECIALIST ASSESSMENTS: GOVERNMENT GAZETTE 43110

In terms of GNR 320 (20 March 2020), the Noise Specialist Assessment must contain, as a minimum, the following information:

Clause	Reporting Requirements as per the Protocol for Noise Specialist Assessments	Compliance of current report / Reference
2.3.1	Current ambient sound levels recorded at relevant locations over a minimum of two nights and that provide a representative measurement of the ambient noise climate, with each sample being a minimum of ten minutes and taken at two different times of the night on each night, in order to record typical ambient sound levels at these different times of night	Section 5.4 and Figure 31
2.3.2	Records of the approximate wind speed at the time of the measurement	Figure 31

2.3.3	Mapped distance of the receiver from the proposed development that is the noise source	Section 5.1 and Figure 6
2.3.4	Discussion on temporal aspects of baseline ambient conditions	Section 5.1
2.4.1	Characterization and determination of noise emissions from the noise source, where characterization could include types of noise, frequency, content, vibration and temporal aspects	Table 6-1: , Table 6-2 and Table 8-1
2.4.2	Projected total noise levels and changes in noise levels as a result of the construction, commissioning and operation of the proposed development for the nearest receptors using industry accepted models and forecasts	Sections 8.1, 8.3 and 8.4
2.4.3	Desired noise levels for the area	Section 7.3.3, Table 7-1 and Table 7-2
2.5.1	Contact details of the environmental assessment practitioner or noise specialist, their relevant qualifications and expertise in preparing the statement, and a curriculum vitae	Appendix A
2.5.2	a signed statement of independence by the environmental assessment practitioner or noise specialist.	Appendix C
2.5.3	The duration and date of the site inspection and the relevance of the season and weather condition to the outcome of the assessment	Section 5.4
2.5.4	A description of the methodology used to undertake the on-site assessment, inclusive of the equipment and models used, as relevant, together with the results of the noise assessment	Section 5.4
2.5.5	a map showing the proposed development footprint (including supporting infrastructure) overlaid on the noise sensitivity map generated by the screening tool	Figure 7
2.5.6	confirmation that all reasonable measures have been taken through micro- siting to minimize disturbance to receptors	Various layouts previously investigated
2.5.7	a substantiated statement from the specialist on the acceptability, or not, of the proposed development and a recommendation on the approval, or not, of the proposed development	Section 12.2
2.5.8	any conditions to which this statement is subjected	Section 2.5
2.5.9	the assessment must identify alternative development footprints within the preferred site which would be of a “low” sensitivity as identified by the screening tool and verified through the site sensitivity verification and which were not considered	Various layouts assessed by developer before final layout was identified for evaluation
2.5.10	A motivation must be provided if there were development footprints identified as per paragraph 2.5.9 above that were identified as having a “low” noise sensitivity and that were not considered appropriate	
2.5.11	where required, proposed impact management outcomes, mitigation measures for noise emissions during the construction and commissioning phases that may be of relative short duration, or any monitoring requirements for inclusion in the Environmental Management Programme (EMPr), and	Section 10
2.5.12	a description of the assumptions made and any uncertainties or gaps in knowledge or data as well as a statement of the timing and intensity of site inspection observations	Section 2

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ENVIRONMENTAL NOISE IMPACT ASSESSMENT

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List of Abbreviations

ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BA	Basic Assessment
dB/dBA	Decibel
DEFF	Department of Environment, Forestry and Fisheries (now DFFE)
DFFE	Department of Forestry, Fisheries and the Environment
EARES	Enviro Acoustic Research cc
ECA	Environment Conservation Act
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EHS	Environmental Health and Safety
ENIA	Environmental Noise Impact Assessment
ENM	Environmental Noise Monitoring
ENPAT	Environmental Potential Atlas for South Africa
ETSU	Energy Technology Support Unit
EPs	Equator Principles
EPFIs	Equator Principles Financial Institutions
FEL	Front-end Loader
GN	Government Notice
GNR	Government Notice Regulation
I&APs	Interested and Affected Parties
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ISO	International Organization for Standardization
METI	Ministry of Economy, Trade, and Industry
NASA	National Aeronautical and Space Administration
NEMA	National Environmental Management Act
NCR	Noise Control Regulations
NSD	Noise-sensitive Development
PPP	Public Participation Process
PWL	Sound Power Level
SABS	South African Bureau of Standards
SANS	South African National Standards
SPL	Sound Power Level
SR	Significance Rating
TLB	Tractor-Loader-Backhoe (also referred to as a back-actor or backhoe)
UTM	Universal Transverse Mercator
WHO	World Health Organization
WEF	Wind Energy Facility
WTG	Wind Turbine Generator

Glossary of Units

dB	Decibel (expression of the relative loudness of the un-weighted sound level in air)
dBA	Decibel (expression of the relative loudness of the A-weighted sound level in air)
Hz	Hertz (measurement of frequency)
kg/m ²	Surface density (measurement of surface density)
km	kilometre (measurement of distance)
m	Meter (measurement of distance)
m ²	Square meter (measurement of area)
m ³	Cubic meter (measurement of volume)
mamsl	Meters above mean sea level
m/s	Meter per second (measurement for velocity)
°C	Degrees Celsius (measurement of temperature)
µPa	Micro pascal (measurement of pressure – in air in this document)

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Environmental Noise Impact Assessment

1. INTRODUCTION

South Africa Mainstream Renewable Power Developments (Pty) Ltd (hereafter referred to as “Mainstream”), has appointed SiVEST SA (Pty) Ltd (hereafter referred to as “SiVEST”) to undertake the required Basic Assessment (BA) Processes for the proposed construction of the 140MW Patatskloof WEF and associated grid infrastructure near Touws River in the Western Cape Province.

The overall objective of the development is to generate electricity by means of renewable energy technology capturing wind energy to feed into the National Grid.

It is anticipated that the proposed Patatskloof WEF will comprise thirty-five (35) wind turbines with a maximum total energy generation capacity of up to approximately 140MW. The electricity generated by the proposed WEF development will be fed into the national grid via a 132kV overhead power line

In terms of the Environmental Impact Assessment (EIA) Regulations, which was published on 04 December 2014 [Government Notice (GN) R 982, 983, 984 and 985] and amended on 07 April 2017 [promulgated in Government Gazette 40772 and GN R326, R327, R325 and R324 on 7 April 2017], various aspects of the proposed development are considered listed activities under GNR 327 and GNR 324 which may have an impact on the environment and therefore require authorisation from the National Competent Authority (CA), namely the Department of Forestry, Fisheries and the Environment (DFFE), prior to the commencement of such activities. Specialist studies have been commissioned to assess and verify the project under the new Gazetted specialist protocols.

1.1 Purpose of Study

Enviro-Acoustic Research cc was commissioned by SiVEST SA (Pty) Ltd (SiVEST) to identify and assess the potential noise impact from the construction, operation and decommissioning of the proposed Patatskloof Wind Energy Facility (WEF) and associated infrastructure on the surrounding area.

This report describes ambient sound levels in the area, potential worst-case noise rating levels and the potential noise impact that the facility may have on the surrounding environment, highlighting the methods used, potential issues identified, findings and recommendations.

This study considered local regulations and both local and international guidelines, using the terms of reference (ToR) as proposed by SANS 10328:2008 for a comprehensive Environmental Noise Impact Assessment (ENIA) and as proposed by the requirements specified in the Assessment Protocol for Noise that were published on 20 March 2020, in Government Gazette 43110, GN 320. Due to a number of wind turbines proposed within an area with a potential high sensitivity to noise (see **Figure 6**), a full environmental noise impact study will be conducted.

1.2 Terms of Reference

Please see [Appendix C](#).

1.3 Specialist Credentials

Please see [Appendix A](#).

1.4 Assessment Methodology

The environmental noise impact assessment involved:

- An assessment of the project focus area, using the online screening tool as well as available aerial images (Google Earth);
- The use of information gained during site visits from 26 to 28 September 2016, as well as from 8 to 10 September 2020, where ambient sound levels was measured at a number of locations over a 2-night period. The measurement methodology complies with the protocols promoted in Government Notice Regulation (GNR) 320 (promulgated as in Government Gazette 43110 of 20 March 2020). The long-term measurements were also augmented with a number of short-term measurements during the day and night-time period (each measurement having a 10-minute duration);
- The ambient sound level measurement data was processed in the office, with the results included in **Section 5** of this report.
- The layout was provided by the developer was processed, with conceptual scenarios developed for the Construction and Operational phases, as well as for the Cumulative scenario. Factors considered included:
 - o The topography of the project focus and surrounding area;
 - o Ground surface and atmospheric conditions;
 - o The location of identified potential noise-sensitive developments (NSD);
 - o The Wind Turbine Generator (WTG) locations (the latest layout); and

- The Sound Power Emission Levels of a selected WTG (a worst-case scenario was evaluated).
- Evaluating the potential significance of the noise impact;
- The compilation of this noise impact assessment report, considering the requirements of SANS 10328:2008 as well as Government Notice Regulation 320 of 20 March 2020.

2. ASSUMPTIONS AND LIMITATIONS

2.1 Measurements of Ambient Sound Levels

- Ambient sound levels are the cumulative effects of innumerable sounds generated from a variety of noise sources at various instances both far and near from the listener. High measurements may not necessarily mean that noise levels in the area are high. Similarly, a low sound level measurement will not necessarily mean that the area is always quiet, as sound levels will vary over seasons, time of the day, faunal characteristics, vegetation in the area and meteorological conditions (especially wind). This is excluding the potential effect of sounds from anthropogenic origin. It is impossible to quantify and identify the numerous sources that influenced one 10-minute measurement using the reading result at the end of the measurement. Therefore, trying to define ambient sound levels using the result of one 10-minute measurement will be very inaccurate (very low confidence level in the results) for the reasons mentioned above. The more measurements that can be collected at a location the higher the confidence levels in the ambient sound level determined. The more complex the sound environment, the longer the required measurement, especially when at a community or house. It is assumed that the measurement locations represent ambient sound levels in the area (similar environment), yet, in practice this can be highly erroneous as there are numerous factors that can impact on ambient sound levels, including:
 - the distance to the closest trees, number and type of trees as well as the height of the trees;
 - available habitat and food for birds and other animals;
 - distance to residential dwellings, type of equipment used at dwelling (compressors, air-cons, etc.) and people in the area;
 - general maintenance condition of houses (especially during windy conditions), as well as
 - numbers and types of animals kept in the vicinity of the measurement locations.
- Determination of existing road traffic and other noise sources of significance are important (traffic counts, etc.). Traffic, however, is highly dependent on the time of day as well as general agricultural activities taking place at the time of traffic counts. Traffic noise is one of the major components in urban areas and could be a significant source of noise during busy periods. The proposed Patatskloof WEF would be located in an area with a rural character with very low traffic. It cannot however be assumed that it is always low;
- Measurements over wind speeds of 3 m/s could provide data influenced by wind-induced noises. While the windshields used limits the effect of fluctuating pressure across the microphone diaphragm, the effect of wind-induced noises in the trees in the vicinity of the microphone did impact on the ambient sound levels;

- Ambient sound levels are dependent not only on the time of day and meteorological conditions, but also change due to seasonal differences. Ambient sound levels are generally higher in summer months when faunal activity is higher and lower during the winter due to reduced faunal activity;
- Ambient sound levels recorded near rivers, streams, wetlands, trees and bushy areas can be high. This is due to faunal activity which can dominate the sound levels around the measurement location; and
- As a residential area develops the presence of people will result in increased sounds. These are generally a combination of traffic noise, voices, animals and equipment (incl. TV's and Radios). The result is that ambient sound levels will increase as a residential area matures.

2.2 Calculating noise emissions – Adequacy of predictive methods

The noise emissions into the environment from the various sources as defined were calculated for the WEF and grid, using the Sound Propagation Model described in ISO 9613-2 (operation phase) and SANS 10357¹ (construction phase).

The following was considered in the Noise Model:

- The octave band sound pressure emission levels of processes and equipment;
- The distance of the receiver from the noise sources;
- The impact of atmospheric absorption;
- The operational details of the proposed project, such as projected areas where activities will be taking place;
- Topographical layout, as well as
- Acoustical characteristics of the ground. Seventy-five percent (75%) hard ground conditions were modelled considering the recommendation of a number of studies.

The noise emission into the environment due to additional traffic was estimated using the Sound Propagation Model described in SANS 10210². Corrections such as the following will be considered:

- Distance of receptor from the roads;
- Road construction material;
- Average vehicle speeds;
- Vehicle types, and
- Ground acoustical conditions.

It is important to understand the difference between sound, or noise level and the noise rating level (also see **Glossary of Terms – Appendix B**).

¹ [SANS 10357:2004 The calculation of sound propagation by the Concave method'](#)

² [SANS 10210:2004. 'Calculating and predicting road traffic noise'](#)

Sound, or noise levels, generally refers to a sound pressure level as measured using an instrument, whereas the noise rating level refers to a calculated sound exposure level to which various corrections and adjustments was added. These noise rating levels are further processed into a 3D map illustrating noise contours of constant rating levels or noise isopleths. In this project it illustrates the potential extent of the calculated noises of the complete project and not noise levels at a specific moment in time. It is used to define potential issues of concern and not to predict a noise level at a potential noise-sensitive receptor. For this the selected sound propagation model is internationally recognized and considered adequate.

2.3 Adequacy of Underlying Assumptions

Noise experienced at a certain location is the cumulative result of innumerable sounds emitted and generated both far and close, each in a different time domain, each having a different spectral character at a different sound level. Each of these sounds are also impacted differently by surrounding vegetation, structures and meteorological conditions that result in a total cumulative noise level represented by a few numbers on a sound level meter.

As previously mentioned, it is not the purpose of noise modelling to accurately determine a likely noise level at a certain receptor, but to calculate a noise rating level that is used to identify potential issues of concern.

2.4 Uncertainties of Information Provided

While it is difficult to define the character of a measured noise in terms of numbers (third octave sound power levels), it is difficult to accurately model noise levels at a receptor from any operation. The projected noise levels are the output of a numerical model with the accuracy depending on the assumptions made during the setup of the model. The assumptions include the following:

- That octave sound power levels selected for processes and equipment accurately represent the sound character and power levels of these processes and equipment. The determination of octave sound power levels in itself is subject to errors, limitations and assumptions with any potential errors carried over to any model making use of these results;
- Sound power emission levels from processes and equipment changes depending on the load the process and equipment is subject to. While the octave sound power level is the average (equivalent) result of a number of measurements, this measurement relates to a period that the process or equipment was subject to a certain load (work required from the engine or motor to perform action). Normally these measurements are collected when the process or equipment is under high load. The result is that measurements generally represent a worse-case scenario;
- As it is unknown which processes and equipment will be operational (when and for how long), modelling considers a scenario where processes and equipment are under full load for a set time period. Modelling assumptions complies with the precautionary principle and operational time

periods are frequently overestimated. The result is that projected noise levels would be likely over-estimated;

- Modelling cannot capture the potential impulsive character of a noise that can increase the potential nuisance factor;
- The XYZ topographical information is derived from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global DEM data, a product of Japan's Ministry of Economy, Trade, and Industry (METI) and the National Aeronautical and Space Administration (NASA). There are known inaccuracies and artefacts in the data set, yet this is still one of the most accurate data sets to obtain 3D-topographical information;
- The impact of atmospheric absorption is simplified and very uniform meteorological conditions are considered. This is an over-simplification and the effect of this in terms of sound propagation modelling is difficult to quantify. This report will use an average air temperature of 10°C and humidity of 70% (which would slightly over-estimate the potential noise levels); and
- Acoustical characteristics of the ground are over-simplified with ground conditions accepted as uniform. Seventy-five percent (75%) hard ground conditions will be modelled that should allow slightly precautionary values.

2.5 Conditions that this Report may be Subject to

This report is not subject to any conditions.

3. TECHNICAL DESCRIPTION

3.1 Project Location

The proposed WEF and associated grid infrastructure is located approximately 18km and 25km north-east respectively of Touws River in the Western Cape Province and is within the Witzenberg Local Municipality, in the Cape Winelands District Municipality (see **Figure 1**).

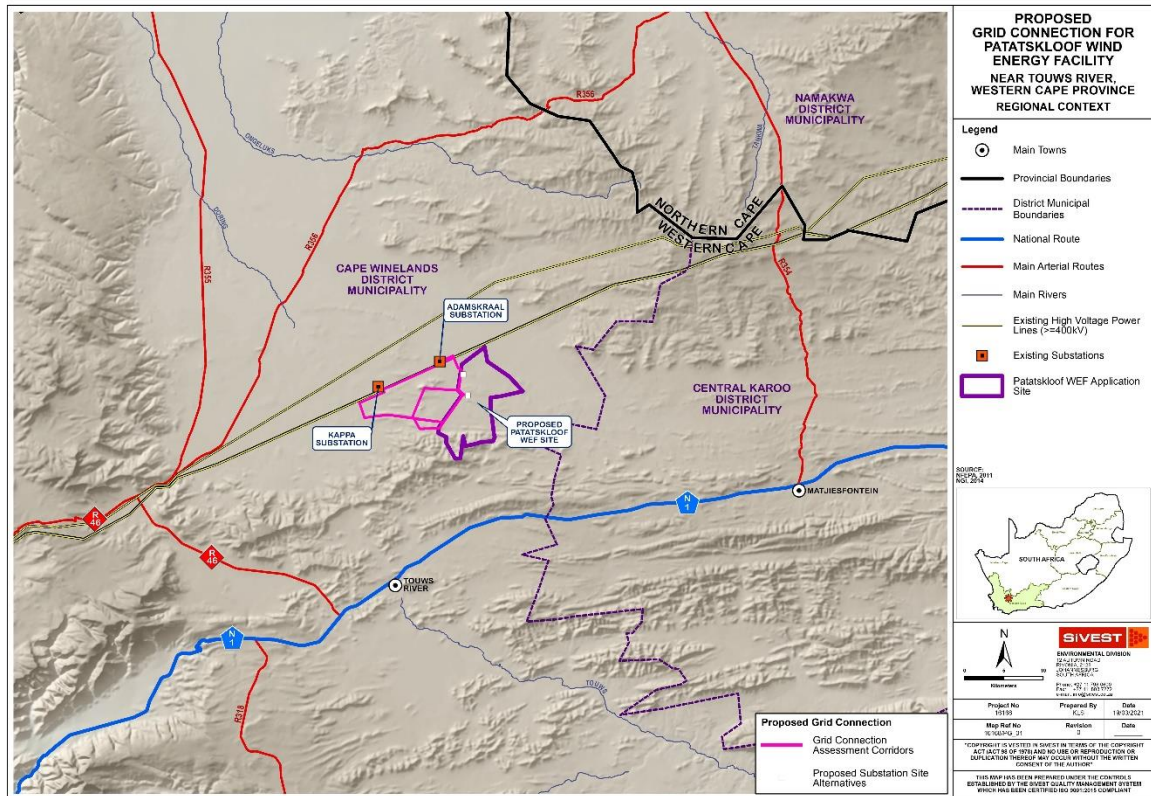


Figure 1: Regional Context Map

3.1.1 WEF

The WEF application site as shown on the locality map below (**Figure 2**) is approximately 6 612 hectares (ha) in extent and incorporates the following farm portions:

- Remainder of the Farm Upper Stinkfontein No 246
- Remainder of the Farm Upper Melkbosch Kraal No 250; and
- Portion 1 of the Farm Drinkwaters Kloof No 251.

A smaller buildable area (2 905.4 ha) has however been identified as a result of a preliminary suitability assessment undertaken by Mainstream and this area is likely to be further refined with the exclusion of sensitive areas determined through various specialist studies being conducted as part of the BA process.

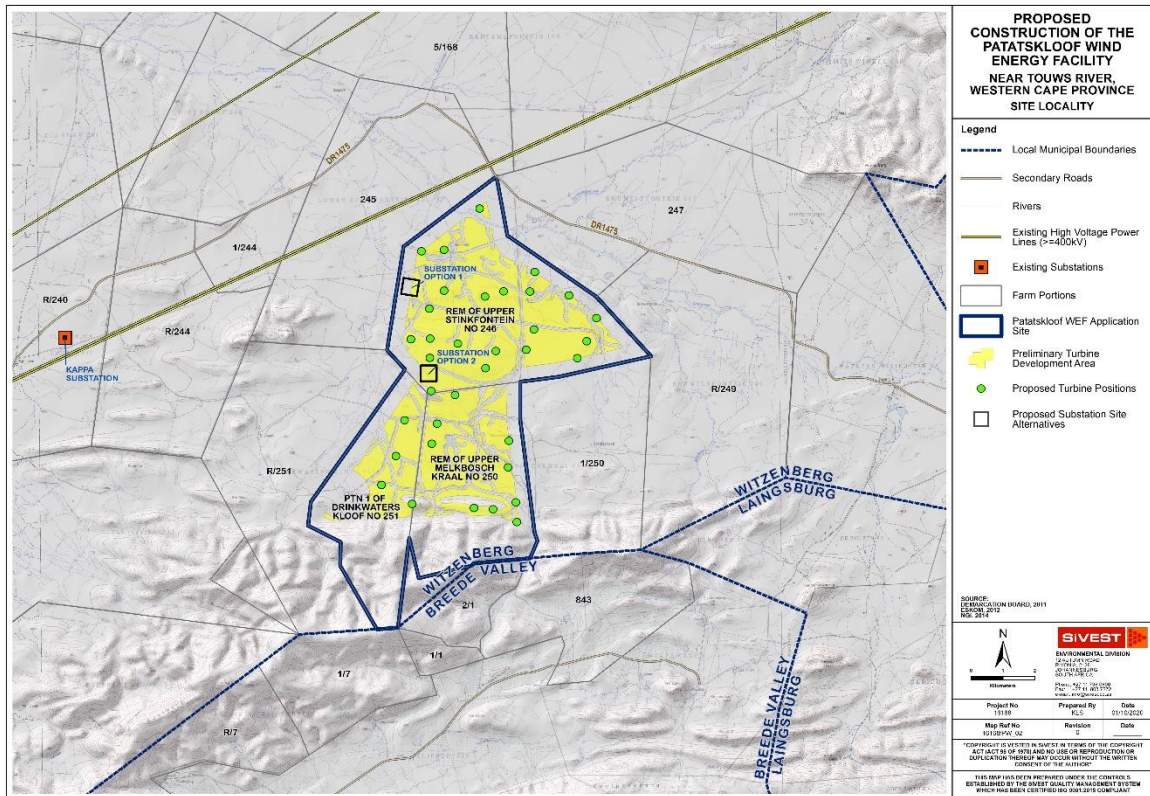


Figure 2: Patatskloof WEF Site Locality

3.1.2 Grid Connection

At this stage, it is proposed that the 132kV power lines will connect the Patatskloof WEF on-site substation to the national grid, either via Kappa Substation or via the Adamskraal substation (**Figure 3**).

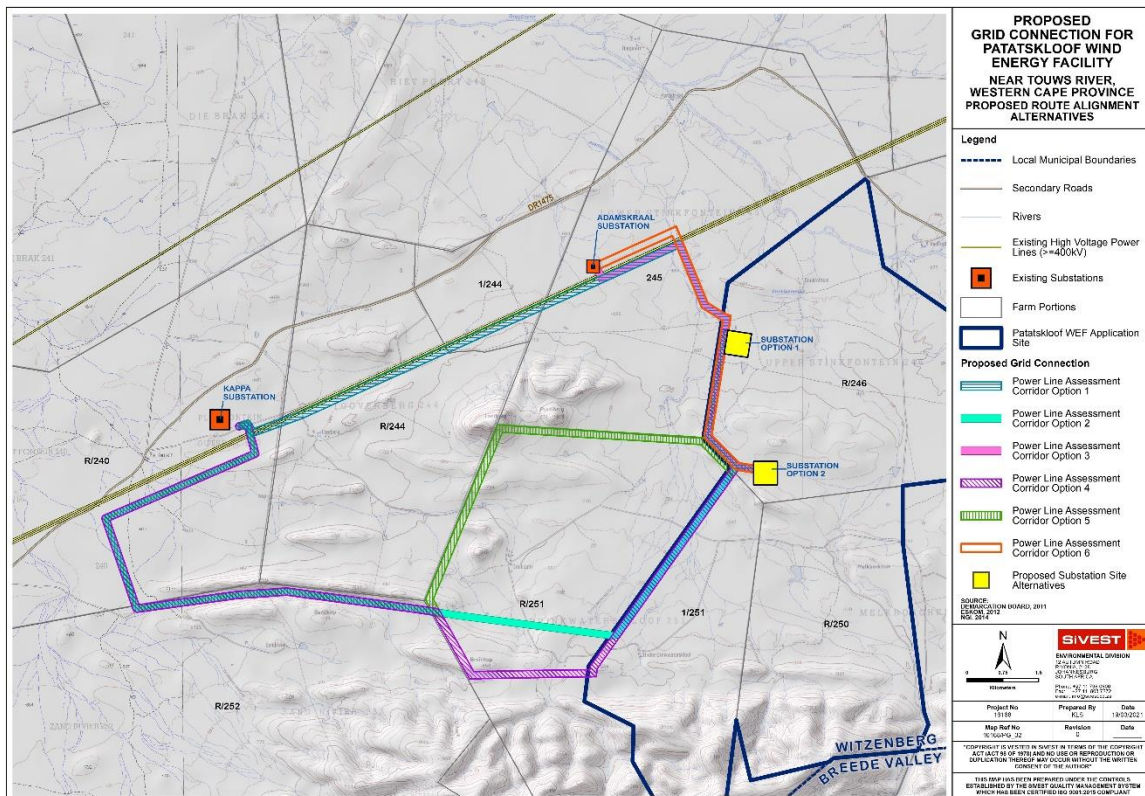


Figure 3: Proposed 132kV Power Line Route Alignment

3.2 Project Description

It is anticipated that the proposed Patatskloof WEF will comprise up to thirty-five (35) wind turbines with a maximum total energy generation capacity of up to approximately 140MW. The electricity generated by the proposed WEF development will be fed into the national grid via a 132kV overhead power line. The 132kV overhead power line will however require a separate Environmental Authorisation (EA) and is subject to a separate BA process, which is currently being undertaken in parallel to the WEF BA process.

3.2.1 Wind Farm Components

- Up to 35 wind turbines, with a maximum export capacity of approximately 140MW. This will be subject to allowable limits in terms of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP).
- Each wind turbine will have a hub height of between 120m and 200m and rotor diameter of up to approximately 200m;
- Permanent compacted hardstanding areas / platforms (also known as crane pads) of approximately 100m x 100m (total footprint of approx. 100 00m²) per turbine during construction and for on-going maintenance purposes for the lifetime of the proposed development;
- Each wind turbine will consist of a foundation of up to approximately 30m in diameter. In addition, the foundations will be up to approximately 4m in depth;

- Electrical transformers (690V/11 to 33kV) adjacent to each wind turbine (typical footprint of up to approximately 3m x 2.5m) to step up the voltage to between 11kV and 33kV;
- One (1) new 11kV - 33/132kV on-site substation consisting of two (2) portions: IPP portion / yard (33kv portion of the shared 33kv/132kv portion) and an Eskom portion (132kv portion of the shared 33kv/132kv portion) including associated equipment and infrastructure, occupying a total area of approximately 25ha (i.e. 250 000m²) i.e. 15.5 ha for the IPP Portion and 15.5 ha for the Eskom Portion. The Eskom portion will be ceded over to Eskom once the IPP has constructed the onsite substation. The necessary Transfer of Rights will be lodged with DFFE when required;
- A Battery Energy Storage System (BESS) will be located next to the IPP portion / yard of the shared onsite 33/132kV substation and will be included as part of the 15.5ha. The storage capacity and type of technology would be determined at a later stage during the development phase, but most likely comprise an array of containers, outdoor cabinets and/or storage tanks;
- The wind turbines will be connected to the proposed substation via 11 to 33kV underground cabling and overhead power lines.
- Road servitude of 8m and a 20m underground cable or overhead line servitude.
- Internal roads with a width of up to approximately 5m wide will provide access to each wind turbine. Existing site roads will be used wherever possible, although new site roads will be constructed where necessary. Turns will have a radius of up to 50m for abnormal loads (especially turbine blades) to access the various wind turbine positions. It should be noted that the proposed application site will be accessed via the N1 National Route and DR1475, MR316 and MR319 WCG provincial Roads; One (1) construction laydown / staging area of up to approximately 3ha to be located on the site identified for the substation. It should be noted that no construction camps will be required in order to house workers overnight as all workers will be accommodated in the nearby town;
- Operation and Maintenance (O&M) buildings, including offices, a guard house, operational control centre, O&M area / warehouse / workshop and ablution facilities to be located on the site identified for the substation. This will be included in the 33kv portion/yard of the substation area i.e.15.5 ha of the IPP portion of the onsite substation.
- A wind measuring lattice (approximately 120m in height) mast has already been strategically placed within the wind farm application site in order to collect data on wind conditions;
- No new fencing is envisaged at this stage. Current fencing is standard farm fence approximately 1-1.5m in height. Fencing might be upgraded (if required) to be up to approximately 2m in height; and
- Water will either be sourced from existing boreholes located within the application site or will be trucked in, should the boreholes located within the application site be limited.
- Optic fibre overhead or underground line from the Adamskraal Substation to the proposed on-site substation.

3.2.2 *Grid Components*

The proposed grid connection infrastructure to serve the Patatskloof WEF will include the following components:

- One (1) new 11-33/132kV on-site substation, situated on a site of occupying an area of up to approximately 2ha. The proposed substation will be a step-up substation and will include an Eskom portion and an IPP portion, hence the substation has been included in both the BA for the WEF and in the BA for the grid infrastructure to allow for handover to Eskom. The applicant will remain in control of the low voltage components (i.e., 33kV components) of the substation, while the high voltage components (i.e., 132kV components) of this substation will likely be ceded to Eskom shortly after the completion of construction; and
- One (1) new 132kV overhead power line connecting the on-site substation to either Kappa Substation or Adamskraal Substation and thereby feeding the electricity into the national grid. Power line towers being considered for this development include self-supporting suspension monopole structures for relatively straight sections of the line and angle strain towers where the route alignment bends to a significant degree. Maximum tower height is expected to be approximately 25m.

3.3 WEF BA Alternatives

3.3.1 Location Alternatives

No other activity or site alternatives are being considered. Renewable Energy development in South Africa is highly desirable from a social, environmental and development point of view and a wind energy facility is considered suitable for this site due to the high wind resource in this area.

3.3.2 Technology Alternatives

The choice of technology selected for the Patatskloof WEF is based on environmental constraints and technical and economic considerations. No other technology alternatives are being considered as wind energy facilities are more suitable for the site than other forms of renewable energy due to the high wind resource.

The size of the wind turbines will depend on the development area and the total generation capacity that can be produced as a result. The choice of turbine to be used will ultimately be determined by technological and economic factors at a later stage.

3.3.3 Layout Alternatives

Design and layout alternatives will be considered and assessed as part of the EIA. These include alternatives for the Substation locations and also for the construction / laydown area. The proposed preliminary layout is shown in **Figure 4** below.

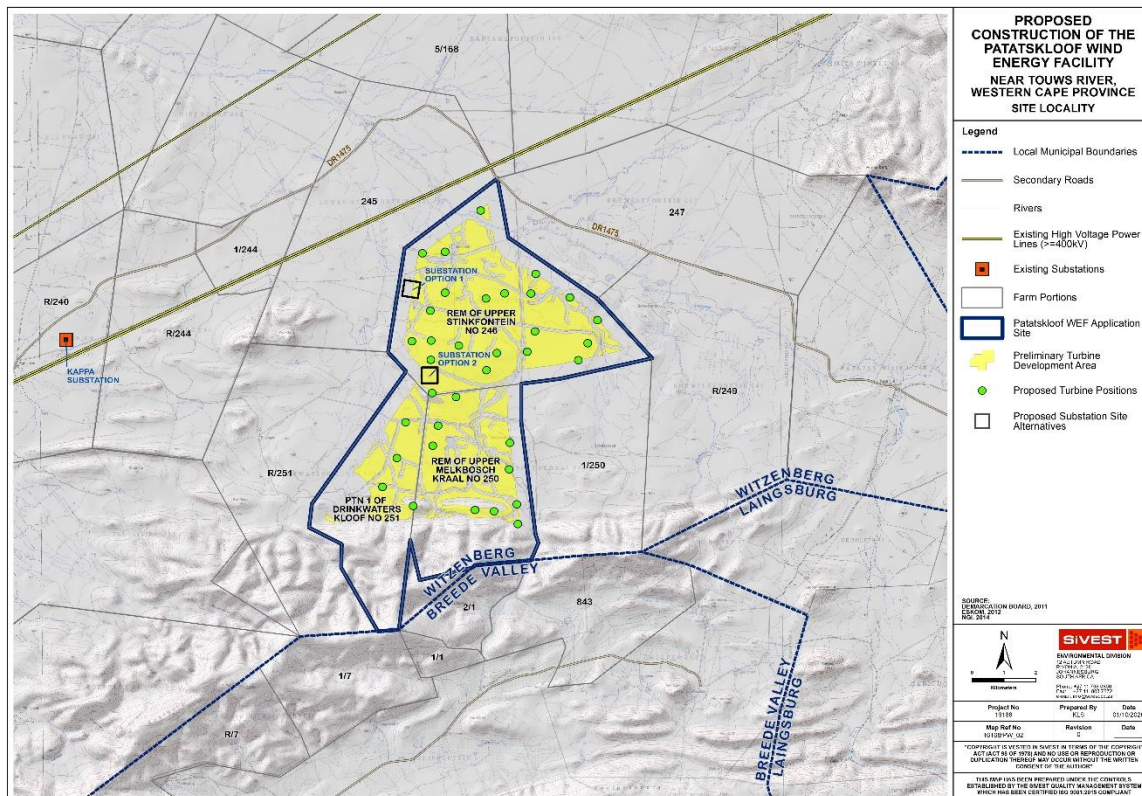


Figure 4: Preliminary turbine layout and development area

3.3.4 No-Go Alternative

The ‘no-go’ alternative is the option of not undertaking the proposed WEF infrastructure project. Hence, if the ‘no-go’ option is implemented, there would be no development. This alternative would result in no environmental impacts from the proposed project on the site or surrounding local area. It provides the baseline against which other alternatives are compared and will be considered throughout the report.

3.4 Grid BA Alternatives

The grid connection infrastructure proposals include two (2) substation site alternatives, each of which are 25 hectares in extent, and six (6) power line route alignment alternatives (**Figure 5**). These alternatives will be considered and assessed as part of the BA process and will be amended or refined to avoid identified environmental sensitivities.

3.4.1 Route Alternatives

All power line route alignments will be assessed within a 150m wide assessment corridor (75m on either side of power line). These alternatives are described below:

- Power Line Corridor Option 1 is approximately 16km in length, linking either Substation Option 1 or Substation Option 2 to Kappa Substation.
- Power Line Corridor Option 2 is approximately 24km in length, linking either Substation Option 1 or Substation Option 2 to Kappa Substation.
- Power Line Corridor Option 3 is approximately 8km in length, linking either Substation Option 1 or Substation Option 2 to Adamskraal Substation.
- Power Line Corridor Option 4 is approximately 25km in length, linking either Substation Option 1 or Substation Option 2 to Kappa Substation.
- Power Line Corridor Option 5 is approximately 24km in length, linking either Substation Option 1 or Substation Option 2 to Kappa Substation. It should be noted that the assessment corridor applied to a short section of this route alignment serving Substation Option 2 has been widened to 300m.
- Power Line Corridor Option 6 is approximately 8km in length, linking either Substation Option 1 or Substation Option 2 to Adamskraal Substation.

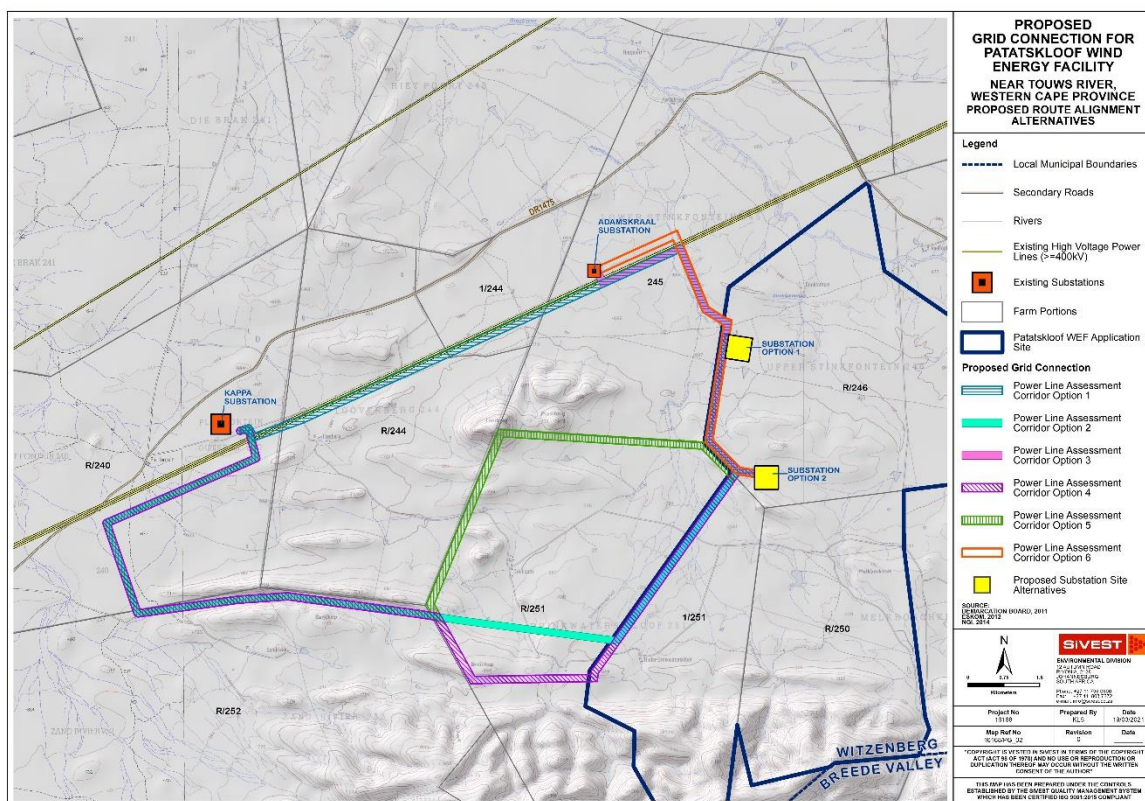


Figure 5: Proposed Substation and Power line options

3.4.2 No-go Alternative

The 'no-go' alternative is the option of not undertaking the proposed grid connection infrastructure projects. Hence, if the 'no-go' option is implemented, there would be no development. This alternative would result in no environmental impacts from the proposed project on the site or surrounding local area. It provides the baseline against which other alternatives are compared and will be considered throughout the report.

The 'no-go' option is a feasible option; however, this would prevent the proposed development from contributing to the environmental, social and economic benefits associated with the development of the renewable energy sector.

4. LEGAL REQUIREMENT AND GUIDELINES

4.1 The Republic of South Africa Constitution Act (“the Constitution”)

The environmental right contained in section 24 of the Constitution provides that everyone is entitled to an environment that is not harmful to his or her well-being. In the context of noise, this requires a determination of what level of noise is harmful to the well-being of humans. The general approach of the common law is to define an acceptable level of noise as that which the reasonable person can be expected to tolerate in the particular circumstances. The subjectivity of this approach can be problematic; however, this has led to the development of noise standards (see **Section 4.4**).

“Noise pollution” is specifically included in Part B of Schedule 5 of the Constitution, which means that noise pollution control is a local authority competence, provided that the local authority concerned has the capacity to carry out this function.

4.2 The National Environmental Management Act, 1998 (Act 107 of 1998)

The National Environmental Management Act, 1998 (Act 107 of 1998), as amended (“NEMA”) defines “pollution” to include any change in the environment, including noise. A duty therefore arises under section 28 of NEMA to take reasonable measures while establishing and operating any facility to prevent noise pollution from occurring. NEMA sets out measures, which may be regarded as reasonable. They include the following measures to:

1. investigate, assess and evaluate the impact on the environment;
2. inform and educate employees about the environmental risks of their work and the manner in which their tasks must be performed to avoid causing significant pollution or degradation of the environment;
3. cease, modify or control any act, activity or process causing the pollution or degradation;
4. contain or prevent the movement of the pollution or degradation;
5. eliminate any source of the pollution or degradation; and
6. remedy the effects of the pollution or degradation.

Regulations have been promulgated in GN R982, R983, R984 and R985 in Government Gazette 38282, dated 4 December 2014, which came into effect on 8 December 2014. These were amended in April 2017, specifically promulgated as GN R326, R327, R325 and R324 in GG 40772, dated 7 April 2017.

Furthermore, Protocols were published in Government Gazette 43110 / GNR 320 on 20 March 2020 for specific environmental themes, including noise. "Requirements for the assessment and minimum criteria

for reporting on identified environmental themes in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, when applying for Environmental Authorisation". These Protocols prescribe the general requirements for undertaking site sensitivity verification and the level of specialist assessment required as well as the assessment reporting requirements per environmental theme. The requirements of the Noise Protocol for the undertaking of a Noise Specialist Assessment have been adhered to. The national web-based Environmental Screening Tool identified the site to be of high noise sensitivity and therefore a full Noise Specialist Assessment has been undertaken.

When the requirements of a protocol apply, the requirements of Appendix 6 of the Environmental Impact Assessment Regulations, as amended, (EIA Regulations), promulgated under sections 24(5) and 44 of the NEMA, are replaced by the requirements of GNR 320.

4.3 The Environment Conservation Act, 1989 (Act 73 of 1989)

The Environment Conservation Act, 1989 (Act 73 of 1989) ("ECA") allowed the Minister of Environmental Affairs and Tourism to make regulations regarding noise, among other concerns. The Minister has implemented Noise Control Regulations under the ECA as discussed below.

4.3.1 Noise Control Regulations (GN R154 of 1992)

In terms of section 25 of the ECA, the national Noise Control Regulations (GN R154 in *Government Gazette* No. 13717 dated 10 January 1992) (NCRs) were promulgated. The NCRs were revised under Government Notice No. R. 55 of 14 January 1994 to make it obligatory for all authorities to apply the regulations. The Minister has implemented the NCR under the ECA as discussed below.

Subsequently, in terms of Schedule 5 of the Constitution of South Africa of 1996 legislative responsibility for administering the NCR was devolved to provincial and local authorities, though the Eastern Cape have not yet promulgated their own regulations and the National NCRs will be used in this report.

4.3.2 Western Cape Provincial Noise Control Regulations: PN 200 of 2013

The control of noise in the Western Cape is legislated in the form of the Noise Control Regulations in terms of Section 25 of the ECA, applicable to the Province of the Western Cape as Provincial Notice 200 of 20 June 2013.

The regulations define:

"ambient noise" means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes".

"disturbing noise" means a noise, excluding the unamplified human voice, which—

(a) exceeds the rating level by 7 dBA;

- (b) exceeds the residual noise level where the residual noise level is higher than the rating level;
 - (c) exceeds the residual noise level by 3 dBA where the residual noise level is lower than the rating level;
- or
- (d) in the case of a low-frequency noise, exceeds the level specified in Annex B of SANS 10103;

“noise sensitive activity” means any activity that could be negatively impacted by noise, including residential, healthcare, educational or religious activities;

“low-frequency noise” means sound which contains sound energy at frequencies predominantly below 100 Hz;

“rating level” means the applicable outdoor equivalent continuous rating level indicated in Table 2 of SANS 10103;

“residual noise” means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes, excluding noise alleged to be causing a noise nuisance or disturbing noise;

“sound level” means the equivalent continuous rating level as defined in SANS 10103, taking into account impulse, tone and night-time corrections;

These Regulations prohibits anyone from causing a disturbing noise (Clause 2) and uses the $L_{Aeq,impulse}$ descriptor to define ambient sound and noise levels.

Also, in terms of regulation 4:

(1) The local authority, or any other authority responsible for considering an application for a building plan approval, business license approval, planning approval or environmental authorisation, may instruct the applicant to conduct and submit, as part of the application—

(a) a noise impact assessment in accordance with SANS 10328 to establish whether the noise impact rating of the proposed land use or activity exceeds the appropriate rating level for a particular district as indicated in SANS 10103; or

(b) where the noise level measurements cannot be determined, an assessment, to the satisfaction of the local authority, of the noise level of the proposed land use or activity.

(2) (a) A person may not construct, erect, upgrade, change the use of or expand any building that will house a noise-sensitive activity in a predominantly commercial or industrial area, unless he or she insulates the building sufficiently against external noise so that the sound levels inside the building will not exceed the appropriate maximum rating levels for indoor ambient noise specified in SANS 10103.

(b) The owner of a building referred to in paragraph (a) must inform prospective tenants or buyers in writing of the extent to which the insulation measures contemplated in that paragraph will mitigate noise impact during the normal use of the building.

(c) Paragraph (a) does not apply when the use of the building is not changed.

(3) Where the results of an assessment undertaken in terms of subregulation (1) indicate that the applicable noise rating levels referred to in that subregulation will likely be exceeded, or will not be exceeded but will likely exceed the existing residual noise levels by 5 dBA or more—

(a) the applicant must provide a noise management plan, clearly specifying appropriate mitigation measures to the satisfaction of the local authority, before the application is decided; and

(b) implementation of those mitigation measures may be imposed as a condition of approval of the application.

(4) Where an applicant has not implemented the noise management plan as contemplated in subregulation (3), the local authority may instruct the applicant in writing to—

(a) cease any activity that does not comply with that plan; or

(b) reduce the noise levels to an acceptable level to the satisfaction of the local authority.

4.4 Noise Standards

There are a few South African Bureau of Standards (SABS) relevant to noise from developments, industry and roads. They are:

- South African National Standards (SANS) 10103:2008. 'The measurement and rating of environmental noise with respect to annoyance and to speech communication'.
- SANS 10210:2004. 'Calculating and predicting road traffic noise'.
- SANS 10328:2008. 'Methods for environmental noise impact assessments'.
- SANS 10357:2004. 'The calculation of sound propagation by the Concave method'.
- SANS 10181:2003. 'The Measurement of Noise Emitted by Road Vehicles when Stationary'.
- SANS 10205:2003. 'The Measurement of Noise Emitted by Motor Vehicles in Motion'.

The relevant standards use the equivalent continuous rating level as a basis for determining what is acceptable. The levels may take single event noise into account, but single event noise by itself does not determine whether noise levels are acceptable for land use purposes. With regards to SANS 10103:2008, the recommendations are likely to inform decisions by authorities, but non-compliance with the standard will not necessarily render an activity unlawful *per se*.

4.5 International Guidelines

While there exists a number of international guidelines and standards that could encompass a document in itself, the three mentioned below were selected as they are used by different countries in the subject of environmental noise management, with a number of the guidelines specifically focusing on the noises associated with WEFs.

4.5.1 *The Assessment and Rating of Noise from Wind Farms (Energy Technology Support Unit, 1997)*

This report describes the findings of a Working Group on Wind Turbine Noise, facilitated by the United Kingdom Department of Trade and Industry. It was developed as an Energy Technology Support Unit³ (ETSU) project. The aim of the project was to provide information and advice to developers and planners on noise from wind turbines. The report represents the consensus view of a number of experts (experienced in assessing and controlling the environmental impact of noise from wind farms). Their findings can be summarised as follow:

1. Absolute noise limits applied at all wind speeds are not suited to wind farms; limits set relative to the background noise (including wind as seen in **Figure 31**) are more appropriate;
2. $L_{A90,10\text{mins}}$ is a much more accurate descriptor when monitoring ambient and turbine noise levels;
3. The effects of other wind turbines in a given area should be added to the effect of any proposed WEF, to calculate the cumulative effect;
4. Noise from a WEF should be restricted to no more than 5 dBA above the current ambient noise level at an NSD. Ambient noise levels are measured onsite in terms of the $L_{A90,10\text{min}}$ descriptor for a period sufficiently long enough for a set period;
5. Wind farms should be limited within the range of 35 dBA to 40 dBA (day-time) in a low noise environment. A fixed limit of 43 dBA should be implemented during all night time noise environments. This should increase to 45 dBA (day and night) if the NSD has financial investments in the WEF; and
6. A penalty system should be implemented for wind turbine/s that operates with a tonal characteristic.

This is likely the guideline used in most international countries to estimate the potential noise impact stemming from the operation of a WEF. It also recommends an improved methodology (compared to a fixed upper noise level) on determining ambient sound levels in periods of higher wind speeds, critical for the development of a wind energy facility. Because of its international importance, the methodologies used in the ETSU R97 document will be recommended in this report for implementation should projected noise levels (from the proposed WEF at NSDs) exceed the zone sound levels as recommended by SANS 10103:2008.

³ ETSU was set up in 1974 as an agency by the United Kingdom Atomic Energy Authority to manage research programmes on renewable energy and energy conservation. The majority of projects managed by ETSU were carried out by external organizations in academia and industry. In 1996, ETSU became part of AEA Technology plc which was separated from the UKAEA by privatisation.

4.5.2 *Guidelines for Community Noise (World Health Organization, 1999)*

The World Health Organization's (WHO) document on the *Guidelines for Community Noise* is the outcome of the WHO- expert task force meeting held in London, United Kingdom, in April 1999. It is based on the document entitled "Community Noise" that was prepared for the WHO and published in 1995 by the Stockholm University and Karolinska Institute.

The scope of the WHO's effort to derive guidelines for community noise is to consolidate actual scientific knowledge on the health impacts of community noise and to provide guidance to environmental health authorities and professionals trying to protect people from the harmful effects of noise in non-industrial environments.

Guidance on the health effects of noise exposure of the population has already been given in an early publication of the series of Environmental Health Criteria. The health risk to humans from exposure to environmental noise was evaluated and the guidelines values were derived. The issue of noise control and health protection was briefly addressed.

The document uses the L_{Aeq} and $L_{A,max}$ descriptors to define noise levels. This document was important in the development of the SANS 10103 standard.

4.5.3 *European Parliament Directive 2000/14/EC (2000)*

Directive 2000/14/EC relating to the noise emission in the environment by equipment for use outdoors was adopted by the European Parliament and the Council and first published in May 2000 and applied from January, 2002. The directive placed sound power limits on equipment to be used outdoors in a suburban or urban setting. Failure to comply with these regulations may result in products being prohibited from being placed on the EU market. The equipment list is vast and includes machinery such as compaction machineries, dozers, dumpers excavators etc. Manufacturers as a result started to consider noise emission levels from their products to ensure that their equipment will continue to have a market in most countries.

4.5.4 *Equator Principles (2003)*

The **Equator Principles** (EPs) are a voluntary set of standards for determining, assessing and managing social and environmental risk in project financing, which were launched in June 2003. Equator Principles Financial Institutions (EPFIs) commit to not providing loans to projects where the borrower will not or is unable to comply with their respective social and environmental policies and procedures that implement the EPs.

The EPs were developed by private sector banks and were launched in June 2003. The banks chose to model the EPs on the environmental standards of the World Bank and the social policies of the International Finance Corporation (IFC). As of March 2021, one hundred and sixteen (116) financial

institutions (in 37 different countries) have adopted the EPs, which have become the de facto standard for banks and investors on how to assess major development projects around the world. The environmental standards of the World Bank have been integrated into the social policies of the IFC since April 2007 as the IFC Environmental, Health and Safety (EHS) Guidelines.

4.5.5 IFC: General EHS Guidelines – Environmental Noise Management (2007)

These guidelines are applicable to noise created beyond the property boundaries of a development that conforms to the EPs.

It states that noise prevention and mitigation measures should be applied where predicted or measured noise impacts from a project facility or operations exceed the applicable noise level guideline at the most sensitive point of reception. The preferred method for controlling noise from stationary sources is to implement noise control measures at the source.

It goes as far as to propose methods for the prevention and control of noise emissions, including:

- Selecting equipment with lower sound power levels;
- Installing silencers for fans;
- Installing suitable mufflers on engine exhausts and compressor components;
- Installing acoustic enclosures for equipment casing radiating noise;
- Improving the acoustic performance of constructed buildings, apply sound insulation;
- Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m² in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective;
- Installing vibration isolation for mechanical equipment;
- Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas;
- Re-locating noise sources to fewer sensitive areas to take advantage of distance and shielding;
- Placement of permanent facilities away from community areas if possible;
- Taking advantage of the natural topography as a noise buffer during facility design;
- Reducing project traffic routing through community areas wherever possible;
- Planning flight routes, timing and altitude for aircraft (airplane and helicopter) flying over community areas; and
- Developing a mechanism to record and respond to complaints.

It sets noise level guidelines (see **Table 4-1**) as well as highlighting the certain monitoring requirements pre- and post-development.

Table 4-1: IFC Table 7.1-Noise Level Guidelines

Receptor type	One-hour L _{Aeq} (dBA)	
	Daytime	Night-time

	07:00 - 22:00	22:00 – 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

The document uses the $L_{Aeq,1\text{ hr}}$ noise descriptor to define noise levels. It does not determine the detection period, but refers to the International Electrotechnical Commission (IEC) Standards, which require the fast detector setting on the Sound Level Meter during measurements for Europe.

4.5.6 Noise Guidelines for Wind Farms (MoE, 2008)

This document establishes the sound level limits for land-based wind power generating facilities and describes the information required for noise assessments and submissions under the ECA and the Environmental Protection Act, Canada.

The document defines:

- Sound Level Limits for different areas (similar to rural and urban areas), defining limits for different wind speeds at 10 m height, refer also **Table 4-2**⁴
- The Noise Assessment Report, including:
 - Information that must be part of the report;
 - Full description of noise sources;
 - Adjustments, due to the wind speed profile (wind shear);
 - The identification and defining of potential sensitive receptors;
 - Prediction methods to be used (ISO 9613-2);
 - Cumulative impact assessment requirements;
 - It also defines specific model input parameters;
 - Methods on how the results must be presented; and
 - Assessment of Compliance (defining magnitude of noise levels).

Table 4-2: Summary of Sound Level Limits for Wind Farms (MoE)

Wind speed (m/s) at 10 m height	4	5	6	7	8	9	10
Wind Turbine Sound Level Limits, Class 3 Area, dBA	40	40	40	43	45	49	51
Wind Turbine Sound Level Limits, Class 1 & 2 Areas, dBA	45	45	45	45	45	49	51

The document used the $L_{Aeq,1h}$ noise descriptor to define noise levels.

It should be noted that these Sound Level Limits are included for the reader to illustrate the criteria used internationally. Due to the lack of local regulations specifically relevant to WEFs this criterion will also be considered during the determination of the significance of the noise impact.

⁴The measurement of wind induced background sound level is not required to establish the applicable limit. The wind induced background sound level reference curve was determined by correlating the A-weighted ninetyth percentile sound level (L90) with the average wind speed measured at a particularly quiet site. The applicable Leq sound level limits at higher wind speeds are given by adding 7 dB to the wind induced background L90 sound level reference values

4.5.7 *Night Noise Guidelines for Europe (WHO, 2009)*

Refining previous Community Noise Guidelines issued in 1999, and incorporating more recent research, the WHO has released a comprehensive report on the health effects of night time noise, along with new (non-mandatory) guidelines for use in Europe. Rather than a maximum of 30 dB inside at night (which equals 45-50 dB max outside), the WHO now recommends a maximum year-round outside night-time noise average of 40 dB to avoid sleep disturbance and its related health effects. The report notes that only below 30 dB (outside annual average) are “*no significant biological effects observed,*” and that between 30 and 40 dB, several effects are observed, with the chronically ill and children being more susceptible; however, “*even in the worst cases the effects seem modest.*” Elsewhere, the report states more definitively; “*There is no sufficient evidence that the biological effects observed at the level below 40 dB (night, outside) are harmful to health.*” At levels over 40 dB, “*Adverse health effects are observed*” and “*many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.*”

The 184-page report offers a comprehensive overview of research into the various effects of noise on sleep quality and health (including the health effects of non-waking sleep arousal), and is recommended reading for anyone working with noise issues. The use of an outdoor noise standard is in part designed to acknowledge that people do prefer to leave windows open when sleeping, though the year-long average may be difficult to obtain (it would require longer-term sound monitoring than is usually budgeted for by either industry or neighbourhood groups).

While recommending the use of the average level, the report notes that some instantaneous effects occur in relation to specific maximum noise levels, but that the health effects of these “cannot be easily established.”

4.5.8 *Environmental Noise Guidelines for the European Region (2018)*

This document identifies levels at which noise has significant health impacts and recommends actions to reduce exposure. Compared to previous WHO guidelines on noise, this version contains five significant developments:

- Stronger evidence of the cardiovascular and metabolic effects of environmental noise;
- Inclusion of new noise sources, namely wind turbine noise and leisure noise, in addition to noise from transportation (aircraft, rail, and road traffic);
- Use of a standardized approach to assess the evidence;
- A systematic review of evidence, defining the relationship between noise exposure and risk of adverse health outcomes;
- Use of long-term average noise exposure indicators to better predict adverse health outcomes.

5. DESCRIPTION OF THE RECEIVING ENVIRONMENT

5.1 Noise-Sensitive Developments or Receptors

Potential NSDs in the area were initially identified using aerial images as well as the Online Environmental Screening Tool, with the statuses of NSDs defined based on the experience gained during previous site visits. The NSDs as identified are highlighted in **Figure 6**.

Also indicated on this figure are generalized 500 m, 1 000 m and 2 000 m buffer zones. Generally, noises from wind turbines:

- Could be significant within 500 m (receptors⁵ staying within 500 m from operational wind turbines potentially subject to noise levels at a sufficient level to be considered disturbing);
- Are normally limited to a distance of approximately 1,000m from operational wind turbines. Night-time ambient sound levels are elevated and the potential noise impact measurable;
- May be audible up to a distance of 2,000m at night; and
- Are of a low concern at distanced greater than 2,000m.

The output of the Screening Tool is presented on **Figure 7**, highlighting a number of areas with a high noise sensitivity. The statuses of the sensitive areas were investigated during a previous site visit as well as using latest available aerial images.

⁵ Depending on the layout as well as the specific sound power emission levels of the selected wind turbine.

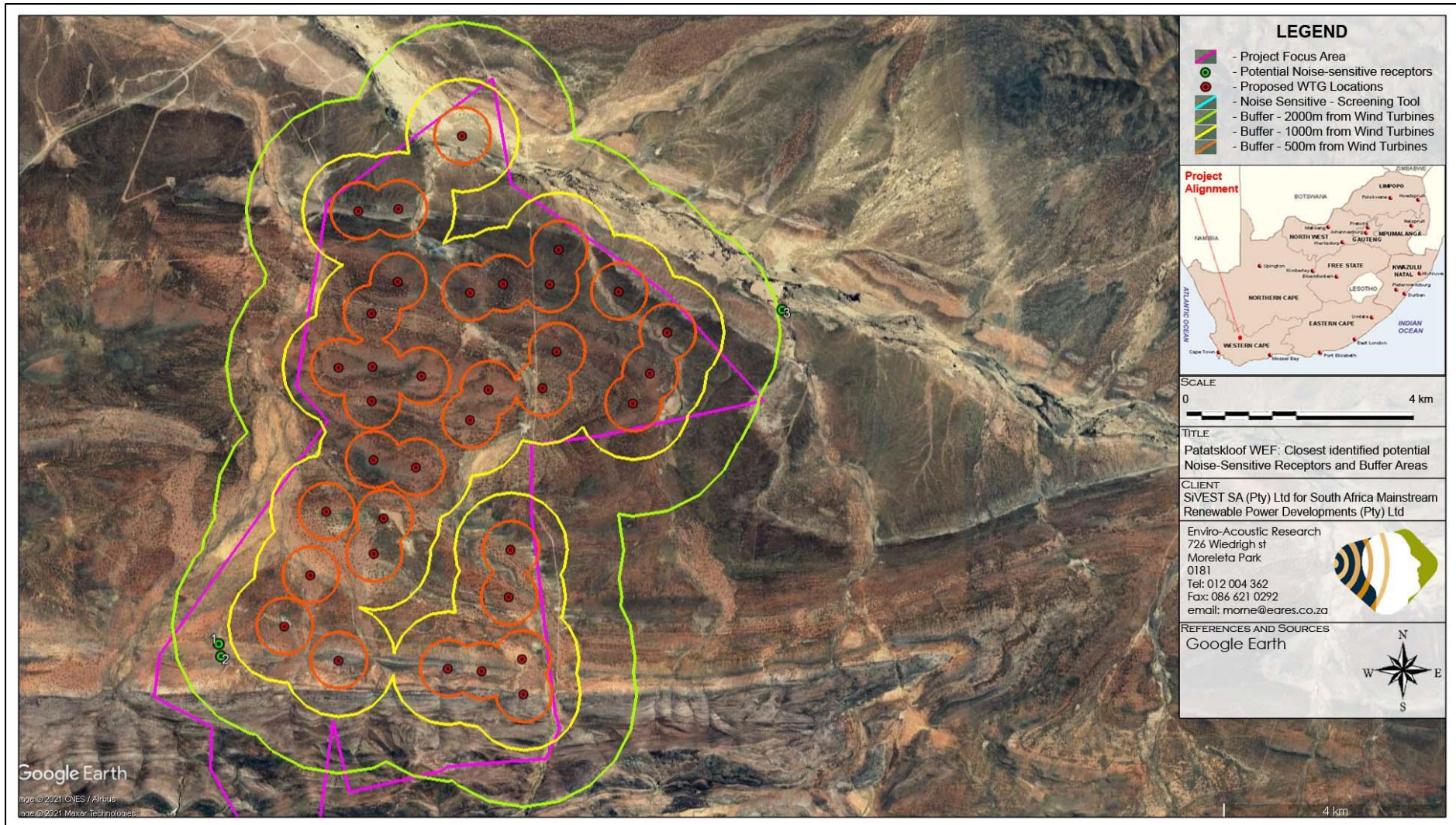


Figure 6: Aerial Image indicating site sensitivity and closest identified Noise-sensitive developments

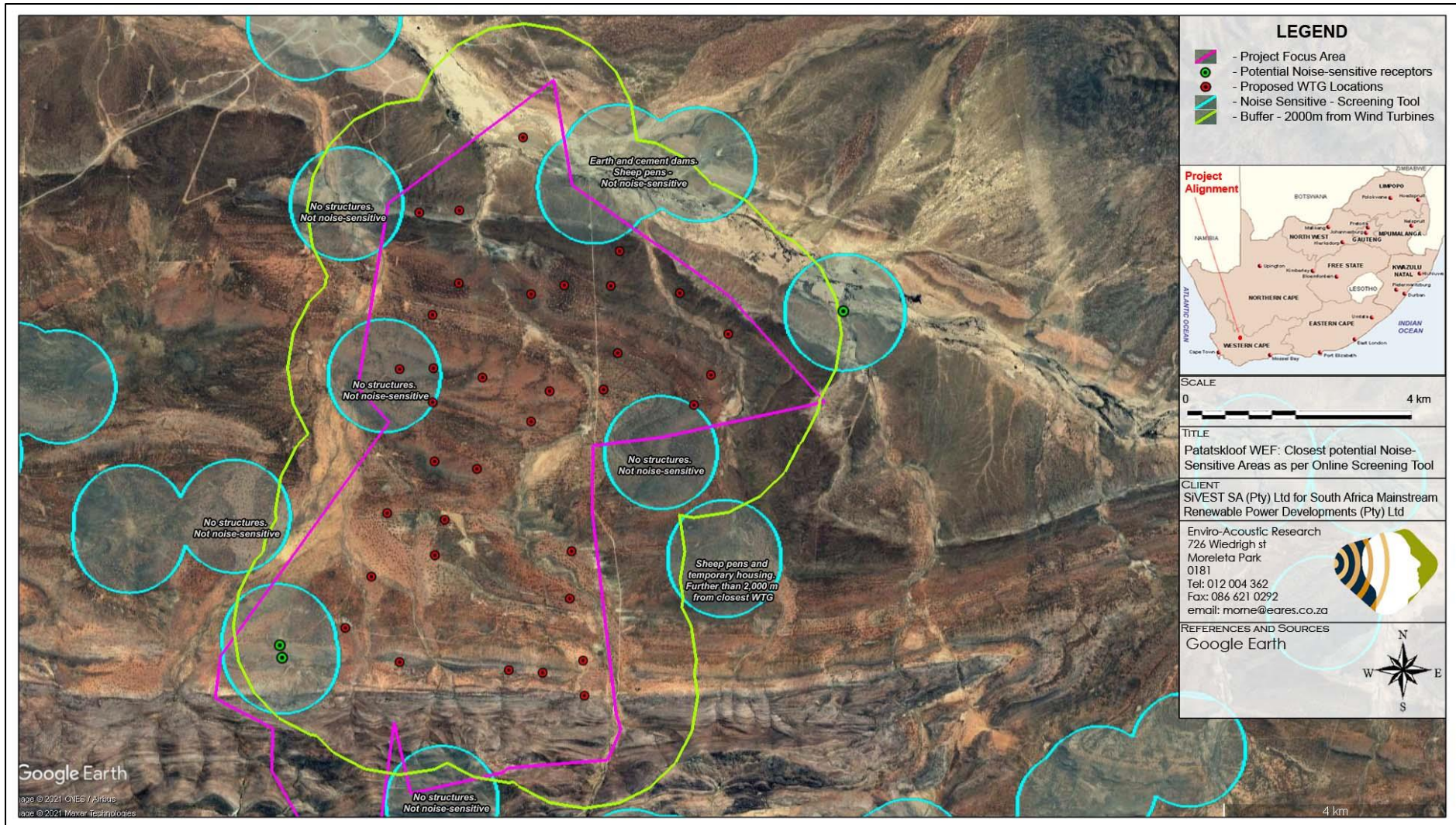


Figure 7: Aerial Image indicating areas with “Very High” sensitivity to noise as per Online Screening Tool

5.2 Influence of Season on Residual Noise Levels

Natural sounds are a part of the environmental noise surrounding humans. In rural areas the sounds from insects and birds would dominate the residual noise character, with noises such as wind flowing through vegetation increasing as wind speed increases. Work by Fégeant (2002) stressed the importance of wind speed and turbulence causing variations in the level of vegetation generated noise. In addition, factors such as the season (e.g., dry or no leaves versus green leaves), the type of vegetation (e.g., grass, conifers, deciduous), the vegetation density and the total vegetation surface all determine both the sound level as well as the spectral characteristics.

Residual noise levels are significantly affected by the area where the sound measurement location (or a listener) is situated. When the sound measurement location is situated within an urban area, close to industrial plants or areas with a constant sound source (ocean, rivers, etc.), seasons and even increased wind speeds have an insignificant to massive impact on residual noise levels.

Sound levels in undeveloped rural areas (away from occupied dwellings), however, are impacted by changes in season for a number of complex reasons. The two main reasons are:

- Faunal communication is more significant during the warmer spring and summer months as various species communicate in an effort to find mates. Faunal communication is normally less during the colder months.
- Seasonal changes in weather patterns, mainly due to increased wind speeds (also see **Sub Section 5.2.1** below) and potential gustiness of the wind.

For environmental noise, weather plays an important role, the greater the separation distance, the greater the influence of the weather conditions, so, from day to day a road 1,000 m away can sound very loud or can be completely inaudible. Other environmental factors that impact on sound propagation includes wind, temperature and humidity, as discussed in the sub-sections below.

5.2.1 *Effect of Wind*

Wind alters sound propagation by the mechanism of refraction, that is, wind bends sound waves. Wind nearer to the ground moves more slowly than wind at higher altitudes, due to surface characteristics such as hills, trees, and man-made structures that interfere with the wind. This wind gradient, with faster wind at higher elevation and slower wind at lower elevation, causes sound waves to bend downward when they are traveling to a location downwind of the source and to bend upward when traveling toward a location upwind of the source. Waves bending downward means that a listener standing downwind of the source will hear louder noise levels than the listener standing upwind of the source. This phenomenon can significantly impact sound propagation over long distances and when wind speeds are high. Over

short distances wind direction has a small impact on sound propagation as long as wind velocities are reasonably slow, i.e., less than 5 m/s.

Wind speed frequently plays a role in increasing sound levels in natural locations. With no wind, there is little vegetation movement that could generate noises and faunal noises (normally birds and insects) will dominate, however, as wind speeds increase, the rustling of leaves increases, which subsequently can increase sound levels. This directly depends on the type of vegetation in a certain area. The impact of increased wind speed on sound levels depends on the vegetation type (deciduous versus conifers), the density of vegetation in an area, seasonal changes (in winter deciduous trees are bare) as well as the height of this vegetation. This excludes unanticipated consequences, as suitable vegetation may create suitable habitats and food sources attracting birds and insects (and the subsequent increase in faunal communication).

5.2.2 *Effect of Temperature and Humidity*

On a typical sunny afternoon, the air is the hottest near the ground surface and temperature decreases at higher altitudes. This temperature gradient causes sound waves to refract upward, away from the ground and results in lower noise levels being heard at a measurement location. In the evening, this temperature gradient will reverse, resulting in cooler temperatures near the ground. This condition, often referred to as a temperature inversion will cause sound to bend downward towards the ground and results in louder noise levels at the listener position. Like wind gradients, temperature gradients can influence sound propagation over long distances and further complicate measurements. Generally, sound propagate better at lower temperatures (down to 10°C), and with everything being equal, a decrease in temperature from 32°C to 10°C could increase the sound level at a listener 600 m away by ± 2.5 dB (at 1,000 Hz).

The effect of humidity on sound propagation is quite complex, but effectively relates to how increased humidity changes the density of air. Lower density translates into faster sound wave travel, so sound waves travel faster at a high humidity⁶. With everything being equal, an increase in humidity from 20% to 80% would increase the sound level at a listener 600 m away by ± 4 dB (at 1,000 Hz at 20°C).

Together, the impact of temperature and humidity (together with air pressure - to a minor extent) are complex and highly dependent on the frequency composition of the noise. This is illustrated in Figure 6 below.

⁶ The addition of water vapor to air (making the air more humid) **reduces the density of the air**. This occurs because the molar mass of water vapor (18 g/mol) is less than the molar mass of dry air (around 29 g/mol).

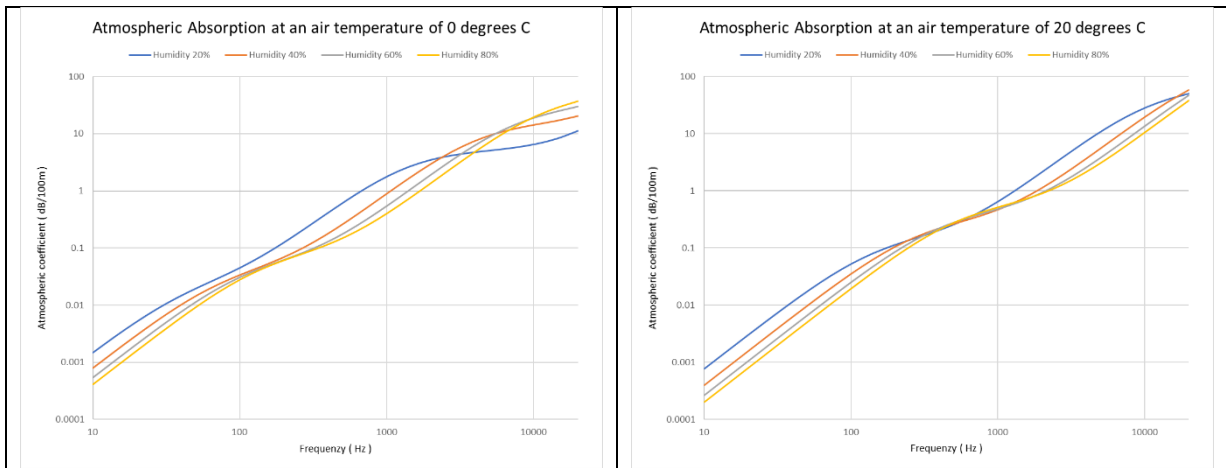


Figure 8: Effect of Temperature and Humidity on propagation of Sound

5.3 Temperature and Humidity Measurements

Temperature and humidity were measured during the site visit in September 2020, with the average, maximum and minimum readings defined in **Table 5-1** below with the various readings further illustrated in **Figure 9** below. For the purpose of modelling, average humidity of 70 % and temperatures of 10 °C at an air pressure of 850 kPa will be used.

Table 5-1: Temperature and Humidity measured onsite

	Humidity	Temperature
Day average	34.3	23.0
Night average	56.6	12.7
Day minimum	22.0	10.5
Day maximum	66.0	36.4
Night minimum	41.0	9.4
Night maximum	66.0	18.0

5.4 Residual noise Levels

Ambient (background) noise levels were measured in September 2016 and again in September 2020 in accordance with the South African National Standards (SANS) 10103:2008 "***The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication***". The long-term measurements were done as per the protocols defined in Government Gazette 43110. A number of short 10-minute measurements were also collected in September 2016 to augment the long-term data.

The guidelines and protocol define the procedures, minimum equipment accuracy and time periods (in which measurements must be collected) such as:

- type of equipment (Class 1) to be used;

- minimum duration of measurement as well as time periods when measurements must take place;
- microphone positions and height above ground level;
- calibration procedures and instrument checks; and
- supplementary weather measurements and observations.

During the site visit, residual noise levels were measured over at least two full night-time periods as per the protocol defined by GNR 320 of 2020 (promulgated as Government Gazette 43110 of March 2020). Measurements were done at seven locations using class-1 Sound Level Meters (SLMs) with the measurement localities presented in **Figure 10** as blue squares. The SLMs would measure “average” sound levels over 10-minute periods, save the data and start with a new 10-minute measurement till the instrument was stopped. The SLMs were referenced at 1,000 Hz directly before and after the measurements were taken. In all cases drift was less than 1.0 dBA.

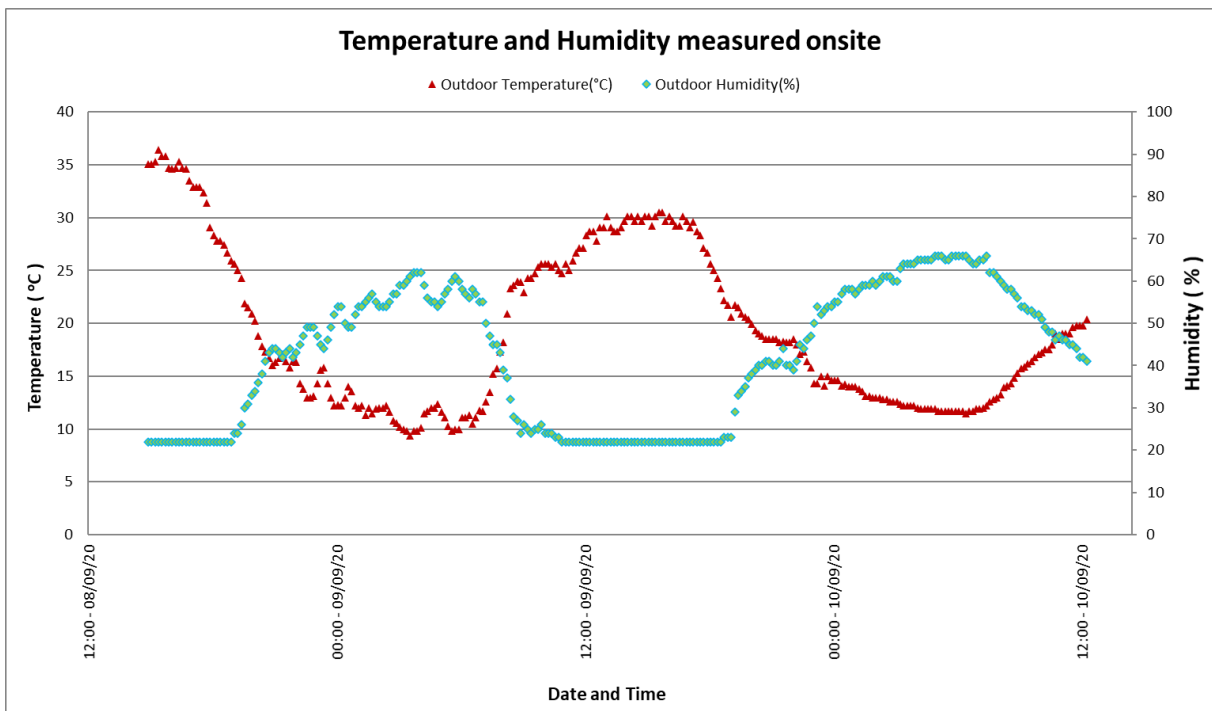


Figure 9: Temperature and Humidity readings measured onsite

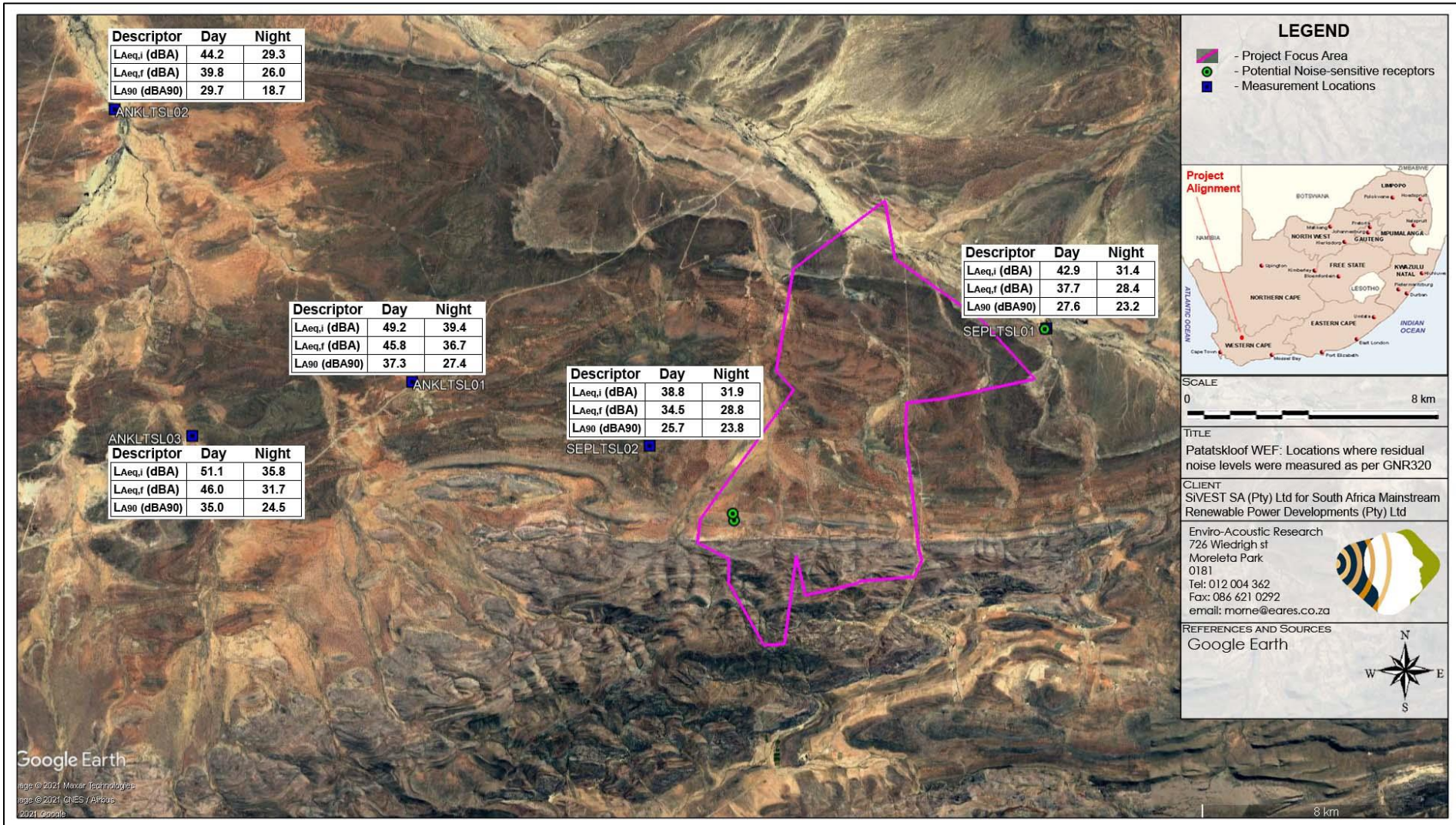


Figure 10: Localities where residual noise and noise levels were measured for at least 2 nights (40 hours)

5.4.1 Long-term Measurement Location – SEPLTSL01

This measurement location is located in an open area just north of the house, with a workshop in the background. There is little vegetation in the area that would raise the ambient sound levels due to Wind-Induced Noises (WIN). The measurement location was selected to be indicative of potential ambient sound levels in the vicinity of the project site.

The equipment defined in **Table 5-2** was used for gathering data, with **Table 5-3** highlighting sounds heard during equipment deployment and collection, with [Appendix E](#) presenting a photo of the measurement location.

Table 5-2: Equipment used to gather data at SEPLTSL01

Equipment	Model	Serial no	Calibration Date
SLM	Svan 977	34849	October 2018
Microphone and Pre-amplifier	ACO 7052E & SV 12L	33077	October 2018
Calibrator	Quest CA-22	J 2080094	June 2020
Weather Station	WH3081PC	-	-

Table 5-3: Noises/sounds heard during site visits at SEPLTSL01

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: <ul style="list-style-type: none"> • Barely Audible • Audible • Dominating 	During equipment deployment	
	Faunal and Natural	WIN. Birds sounds when WIN not dominating.
	Residential	-
	Industrial & transportation	-
	During equipment collection	
	Faunal and Natural	WIN. Birds sounds when WIN not dominating.
	Residential	Chimney turning in wind. Some creaking from corrugated iron on workshop.
	Industrial & transportation	-

Impulse time-weighted equivalent sound levels $L_{Aeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 11** and summarized in **Table 5-4** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 12**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. Fast-weighted equivalent sound levels are included in this report as this is the sound descriptor used in most international countries to define the Ambient Sound Level (residual noise level as used in the Western Cape).

The L_{A90} level is presented in this report to define the “background residual noise level”, or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little noises that would raise

residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

Maximum noise level exceeded 65 dBA at least 2- and 3-times during nights one and two respectively. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep⁷.

Table 5-4: Sound levels considering various sound level descriptors at SEPLTSL01

	L_{Amax, i} (dBA)	L_{Aeq, i} (dBA)	L_{Aeq, f} (dBA)	L_{A90, f} (dBA90)	L_{Amin, f} (dBA)
Day arithmetic average	-	42.9	37.7	27.6	-
Night arithmetic average	-	31.4	28.4	23.2	-
Day Equivalent Levels	-	51.0	48.4	-	-
Night Equivalent Levels	-	49.6	41.5	-	-
Day minimum	-	22.1	18.8	-	17.3
Day maximum	88.3	69.6	59.2	-	-
Night minimum	-	19.1	18.3	-	17.1
Night maximum	84.0	66.2	58.6	-	-
Day 1 equivalent	-	54.4	45.0	-	-
Night 1 Equivalent	-	50.5	42.4	-	-
Day 2 equivalent	-	44.3	37.0	-	-
Night 2 Equivalent	-	48.5	40.4	-	-
Day 3 equivalent	-	50.0	48.1	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 13** (night) and **Figure 14** (day).

⁽⁷⁾ World Health Organization, 2009, 'Night Noise Guidelines for Europe.

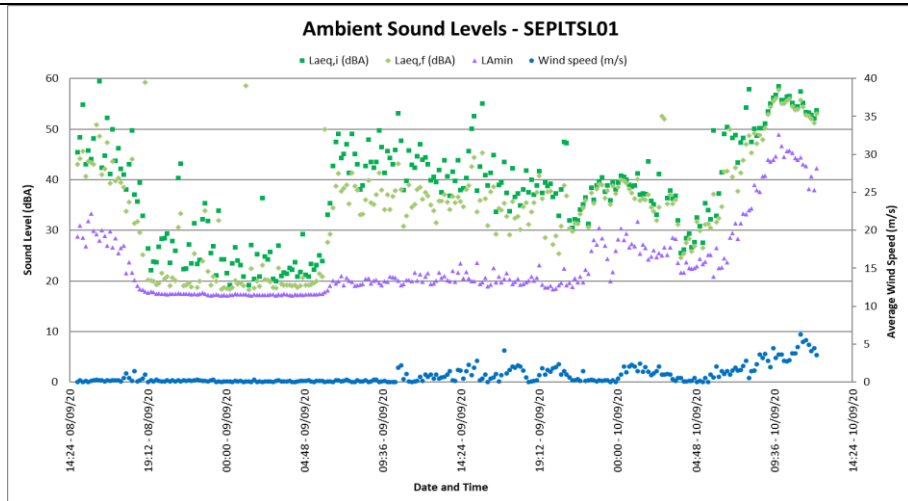


Figure 11: Residual noise Levels at SEPLTSL01

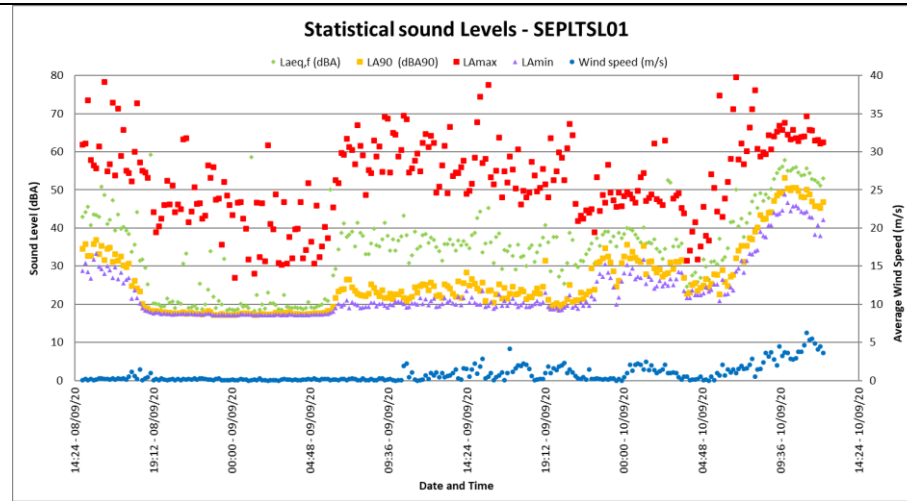


Figure 12: Maximum, minimum and Statistical sound levels at SEPLTSL01

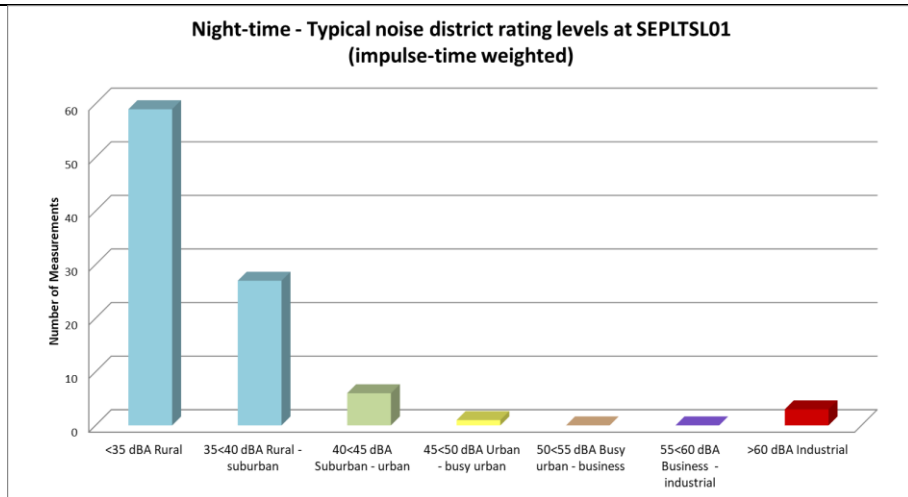


Figure 13: Classification of night-time measurements in typical noise districts at SEPLTSL01

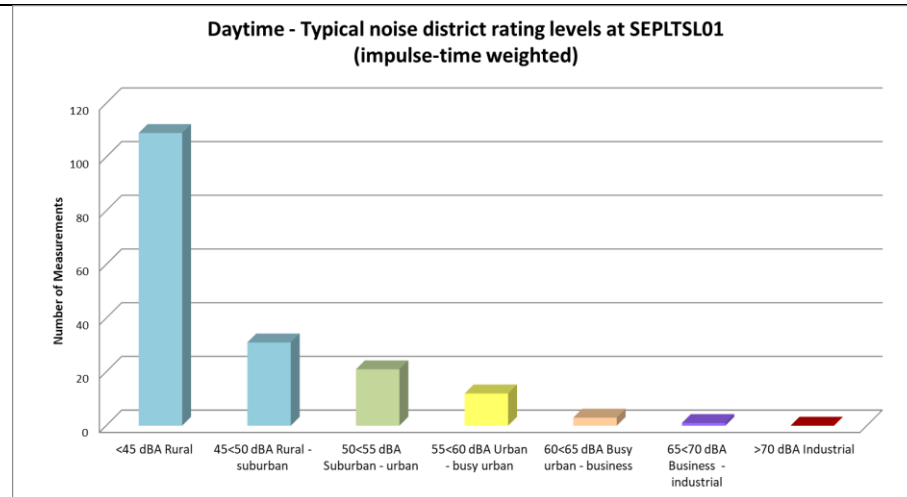


Figure 14: Classification of daytime measurements in typical noise districts at SEPLTSL01

5.4.2 Long-Term Measurement Location - SEPLTSL02

This measurement location is located in an open area just south of the house. Excluding one tree, there is little vegetation in the area that would raise the ambient sound levels due to WIN.

The equipment defined in **Table 5-5** was used for gathering data with **Table 5-6** highlighting sounds heard during equipment deployment and collection, with [Appendix E](#) presenting a photo of the measurement location.

Table 5-5: Equipment used to gather data at SEPLTSL02

Equipment	Model	Serial no	Calibration Date
SLM	Svan 977	34160	March 2019
Microphone and Pre-amplifier	ACO 7052E & SV 12L	54645	March 2019
Calibrator	Quest CA-22	J 2080094	June 2020

Table 5-6: Noises/sounds heard during site visits at SEPLTSL02

Noises/sounds heard during onsite investigations		
Magnitude – Colour Code Used Barely Audible Audible Dominating	During equipment deployment	
	Faunal and Natural	Birds clearly audible and dominant sound. Some WIN at times.
	Residential	Chimney creaking at times (once during site visit).
	Industrial & transportation	-
	During equipment collection	
	Faunal and Natural	WIN. Birds audible.
	Residential	-
Industrial & transportation	-	

Impulse time-weighted equivalent sound levels $L_{Aeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 15** and summarized in **Table 5-7** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 16**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. Fast-weighted equivalent sound levels are included in this report as this is the sound descriptor used in most international countries to define the Residual noise Level.

The L_{A90} level is presented in this report to define the “background sound level”, or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is very low, indicating an area with little noises that would raise residual noise levels. Wind speeds were very low during the measurement period, resulting in very low residual noise levels, especially at night.

The maximum noise level did not exceed 65 dBA at night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep⁸.

Table 5-7: Sound level descriptors as measured at SEPLTSL02

	L_{Amax, i} (dBA)	L_{Aeq, i} (dBA)	L_{Aeq, f} (dBA)	L_{A90, f} (dBA90)	L_{Amin, f} (dBA)
Day arithmetic average	-	38.8	34.5	25.7	-
Night arithmetic average	-	31.9	28.8	23.8	-
Day Equivalent Levels	-	44.6	41.0	-	-
Night Equivalent Levels	-	37.3	34.6	-	-
Day minimum	-	23.3	21.1	-	19.0
Day maximum	74.1	52.9	55.2	-	-
Night minimum	-	19.7	19.5	-	18.7
Night maximum	62.8	46.7	43.3	-	-
Day 1 equivalent	-	31.1	26.3	-	-
Night 1 Equivalent	-	29.9	24.8	-	-
Day 2 equivalent	-	42.3	37.1	-	-
Night 2 Equivalent	-	39.9	37.4	-	-
Day 3 equivalent	-	40.9	38.7	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas (see **Table 7-1**) in **Figure 17** (night) and **Figure 18** (day).

⁽⁸⁾ World Health Organization, 2009, 'Night Noise Guidelines for Europe.

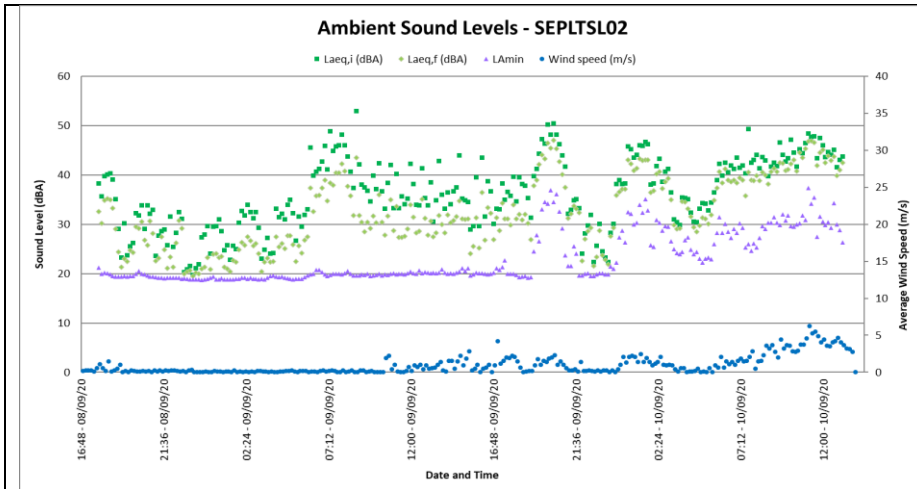


Figure 15: Residual noise levels at SEPLTSL02

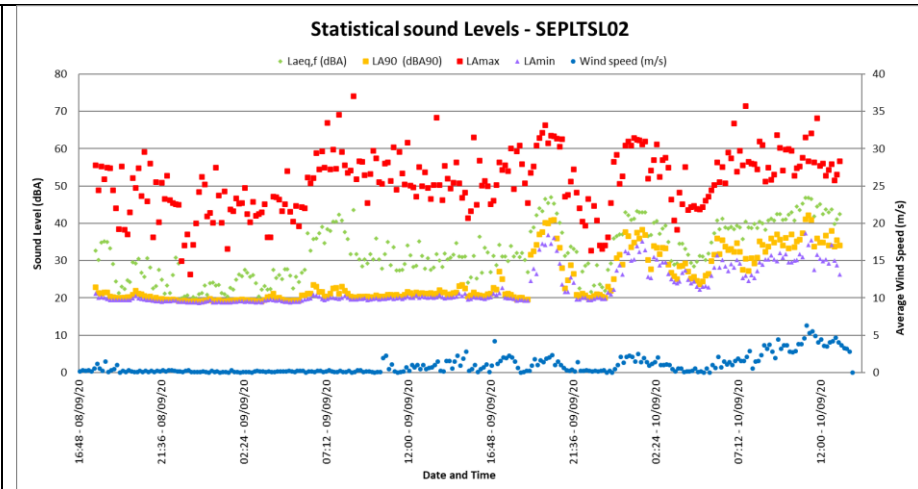


Figure 16: Maximum, minimum and statistical values at SEPLTSL02

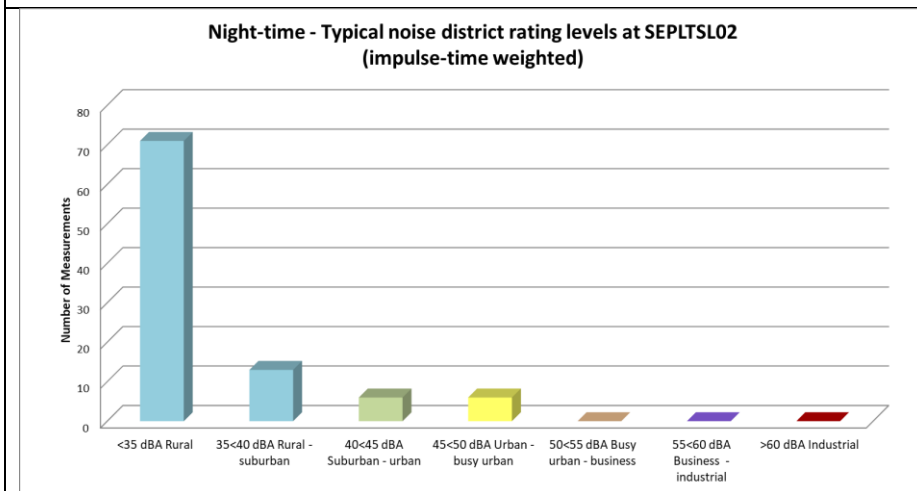


Figure 17: Classification of night-time measurements in typical noise districts at SEPLTSL02

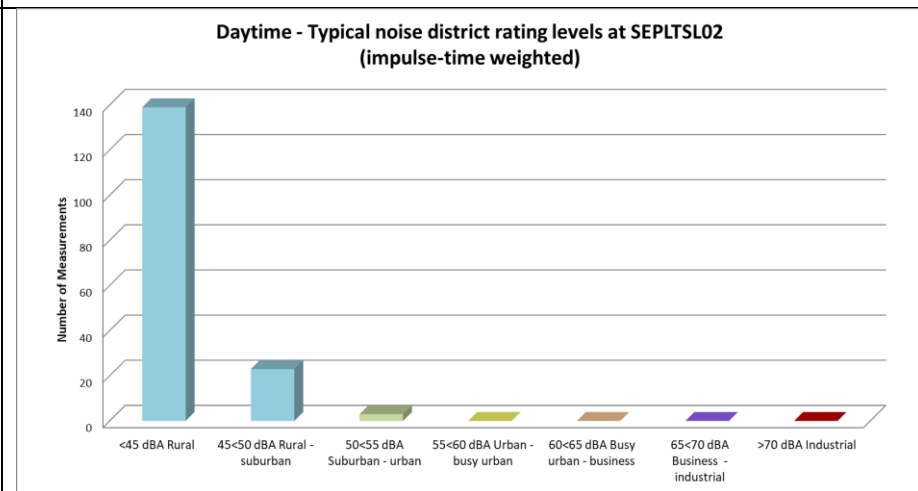


Figure 18: Classification of daytime measurements in typical noise districts at SEPLTSL02

5.4.3 Long-term Measurement Location - AMKLTSL01

The measurement location was selected to be reflective of the typical environmental ambient sound levels that a receptor may experience in the area. The SLM was erected in a relatively open area adjacent to the house in an area likely used by the owner to relax.

The equipment defined in **Table 5-8** was used for gathering data, with **Table 5-9** highlighting sounds heard during equipment deployment and collection, with [Appendix E](#) presenting a photo of the measurement location.

Table 5-8: Equipment used to gather data at AMKLTSL01

Equipment	Model	Serial no	Calibration Date
SLM	Svan 977	34849	May 2015
Microphone	ACO Pacific 7052E	55974	May 2015
Calibrator	Quest CA-22	J 2080094	June 2016
Anemometer	W3081	-	-

Table 5-9: Noises/sounds heard during site visits at AMKLTSL01

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: <ul style="list-style-type: none"> • Barely Audible • Audible • Dominating 	During equipment deployment	
	Faunal and Natural	Birds and wind-induced noises. Rooster and goat.
	Residential	Water sprayers just audible.
	Industrial & transportation	Barely audible drone from power generator or water pump.
	During equipment collection	
	Faunal and Natural	Birds. Wind Induced noises.
	Residential	-
	Industrial & transportation	-

Impulse time-weighted equivalent sound levels $L_{Aeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 19** and summarized in **Table 5-10** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 20**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. Fast-weighted equivalent sound levels are included in this report as this is the sound descriptor used in most international countries to define the Ambient Sound Level (residual noise level as used in the Western Cape).

The L_{A90} level is presented in this report to define the “background residual noise level”, or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The daytime L_{A90} levels are elevated, indicating an area with a constant noise source in the area. Night-time sound levels are also slightly elevated.

The maximum noise level did not exceed 65 dBA at night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep⁹.

Table 5-10: Sound levels considering various sound level descriptors at AMKLTSL01

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	49.2	45.8	37.3	-
Night arithmetic average	-	39.4	36.7	27.4	-
Day Equivalent Levels	-	56.2	50.6	-	-
Night Equivalent Levels	-	45.2	40.9	-	-
Day minimum	-	24.6	22.8	-	16.5
Day maximum	98.9	73.4	63.8	-	-
Night minimum	-	18.5	16.7	-	15.2
Night maximum	64.9	58.0	50.1	-	-
Day 1 equivalent	-	53.2	52.0	-	-
Night 1 Equivalent	-	44.7	41.2	-	-
Day 2 equivalent	-	51.7	49.2	-	-
Night 2 Equivalent	-	45.7	40.5	-	-
Day 3 equivalent	-	54.3	44.8	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 21** (night) and **Figure 22** (day).

⁽⁹⁾ World Health Organization, 2009, 'Night Noise Guidelines for Europe.'

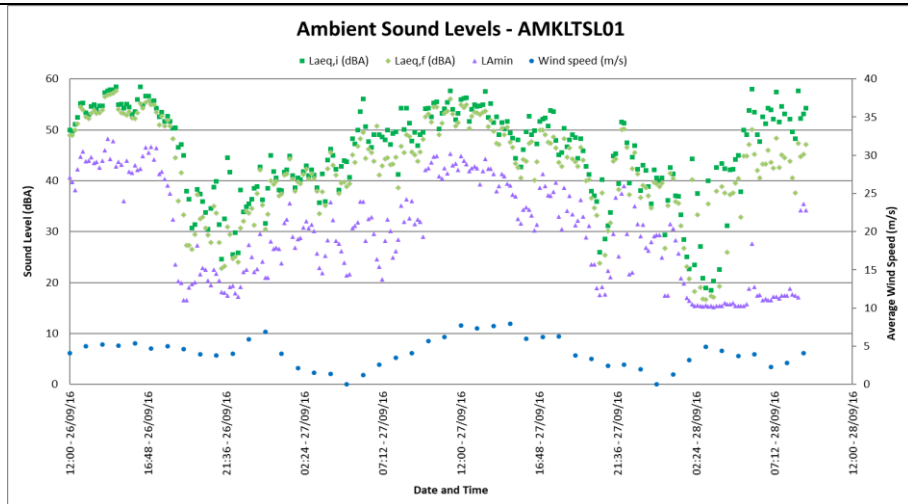


Figure 19: Residual noise Levels at AMKLTSLO1

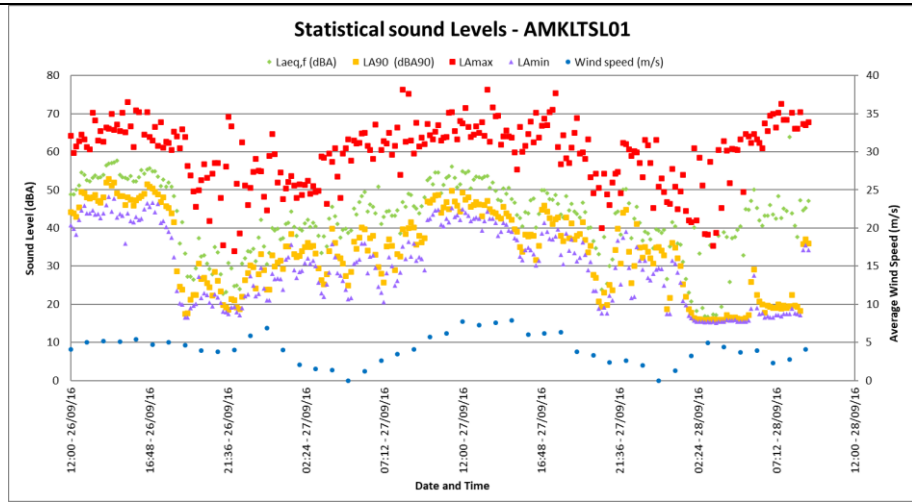


Figure 20: Maximum, minimum and Statistical sound levels at AMKLTSLO1

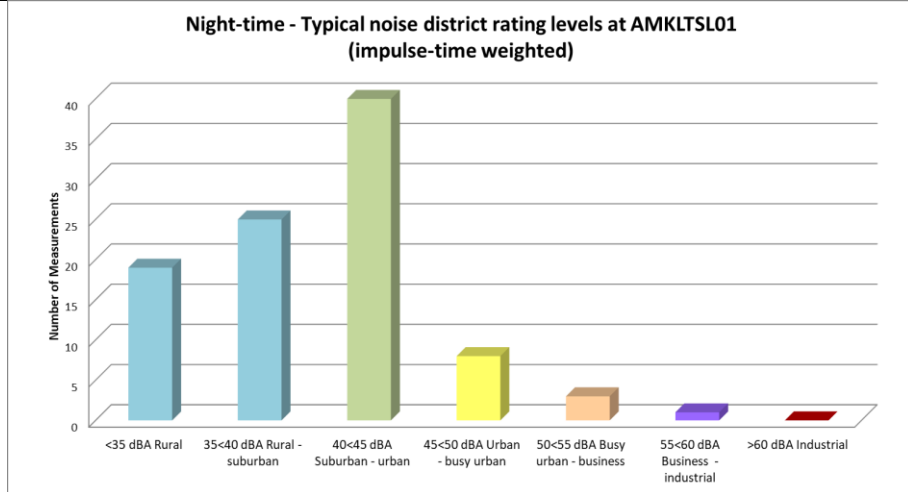


Figure 21: Classification of night-time measurements in typical noise districts at AMKLTSLO1

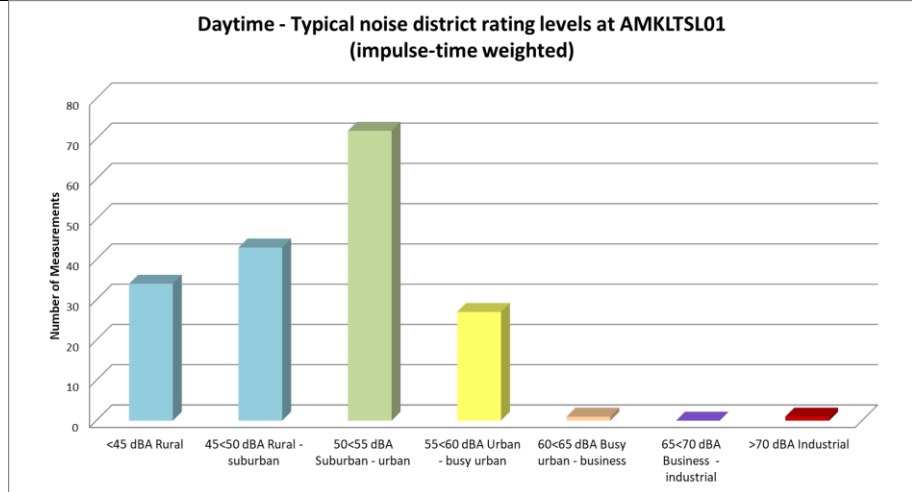


Figure 22: Classification of daytime measurements in typical noise districts at AMKLTSLO1

5.4.4 Long-term Measurement Location - AMKLTSL02

The SLM was erected in a relatively open area close to the parking area. The instrument was relatively sheltered and protected from the influence of wind. There were dogs on the property but they were relatively quiet.

The equipment defined in **Table 5-11** was used for gathering data with **Table 5-12** highlighting sounds heard during equipment deployment and collection, with [Appendix E](#) presenting a photo of the measurement location.

Table 5-11: Equipment used to gather data at AMKLTSL02

Equipment	Model	Serial no	Calibration Date
SLM	SVAN 977	34160	May 2015
Microphone	ACO Pacific 7052E	54645	May 2015
Calibrator	Quest CA-22	J 2080094	June 2016

* Microphone fitted with the RION WS-03 outdoor all-weather windshield.

Table 5-12: Noises/sounds heard during site visits at AMKLTSL02

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: <ul style="list-style-type: none"> • Barely Audible • Audible • Dominating 	During equipment deployment	
	Faunal and Natural	Wind-induced noises. Birds at times.
	Residential	-
	Industrial & transportation	-
	During equipment collection	
	Faunal and Natural	Birds.
	Residential	-
	Industrial & transportation	-

Impulse time-weighted equivalent sound levels $L_{Aeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 23** and summarized in **Table 5-13** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 24**.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. Fast-weighted equivalent sound levels are included in this report as this is the sound descriptor used in most international countries to define the Ambient Sound Level (residual noise level as used in the Western Cape).

The L_{A90} level is presented in this report to define the “background residual noise level”, or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is low, indicating an area with little noises that would raise residual noise levels.

The maximum noise levels only exceeded 65 dBA a few times at night (2 and 1 times first and second night). If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep¹⁰.

Table 5-13: Sound levels considering various sound level descriptors at AMKLTSL02

	L_{Amax,i} (dBA)	L_{Aeq,i} (dBA)	L_{Aeq,f} (dBA)	L_{A90,f} (dBA90)	L_{Amin,f} (dBA)
Day arithmetic average	-	44.2	39.8	29.7	-
Night arithmetic average	-	29.3	26.0	18.7	-
Day Equivalent Levels	-	50.1	47.1	-	-
Night Equivalent Levels	-	41.0	33.8	-	-
Day minimum	-	25.0	20.7	-	10.3
Day maximum	77.1	60.1	55.4	-	-
Night minimum	-	17.3	14.7	-	7.1
Night maximum	72.1	57.0	48.0	-	-
Day 1 equivalent	-	44.8	41.6	-	-
Night 1 Equivalent	-	41.1	34.7	-	-
Day 2 equivalent	-	50.0	47.1	-	-
Night 2 Equivalent	-	40.9	32.7	-	-
Day 3 equivalent	-	34.3	26.7	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 25** (night) and **Figure 26** (day).

⁽¹⁰⁾ World Health Organization, 2009, 'Night Noise Guidelines for Europe.

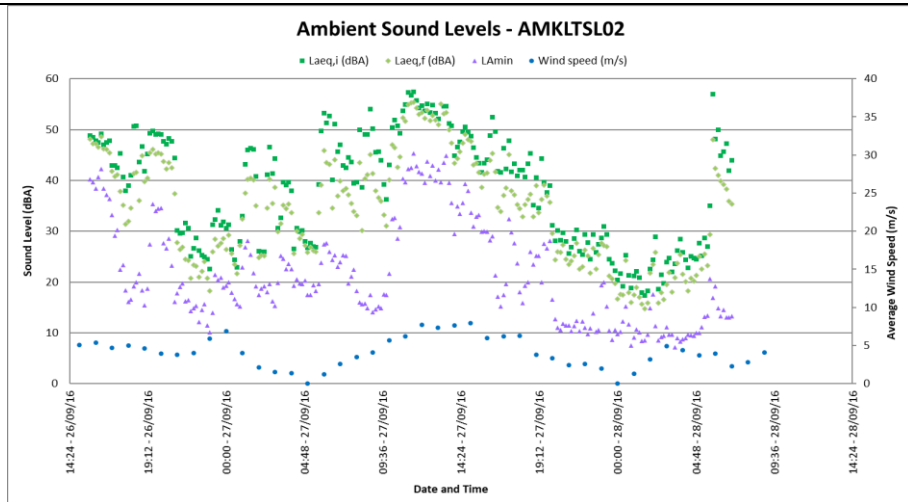


Figure 23: Residual noise Levels at AMKLTSLO2

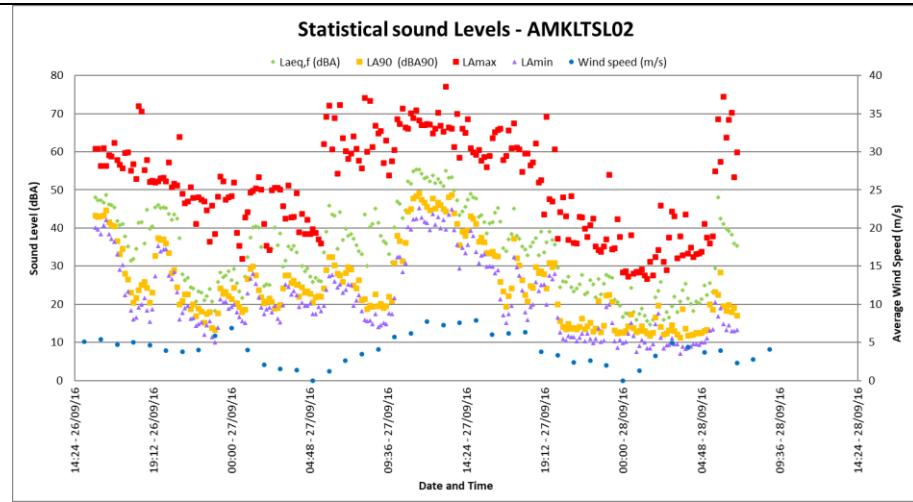


Figure 24: Maximum, minimum and Statistical sound levels at AMKLTSLO2

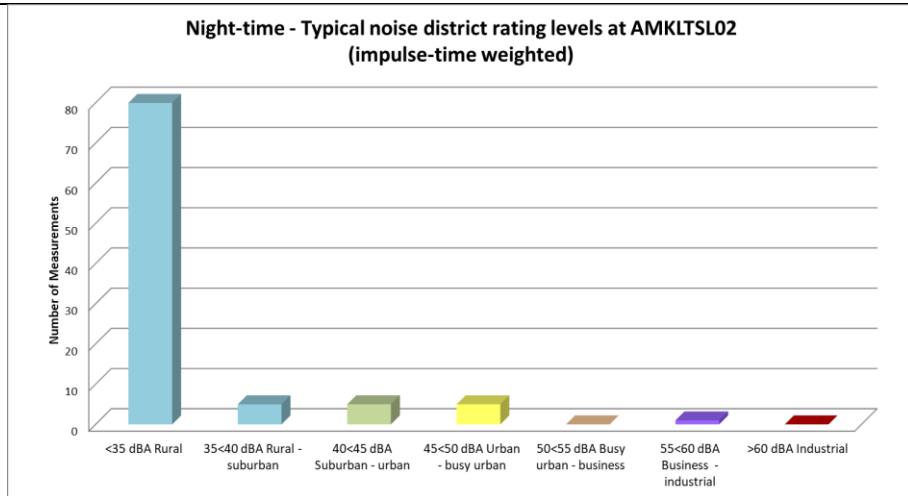


Figure 25: Classification of night-time measurements in typical noise districts at AMKLTSLO2

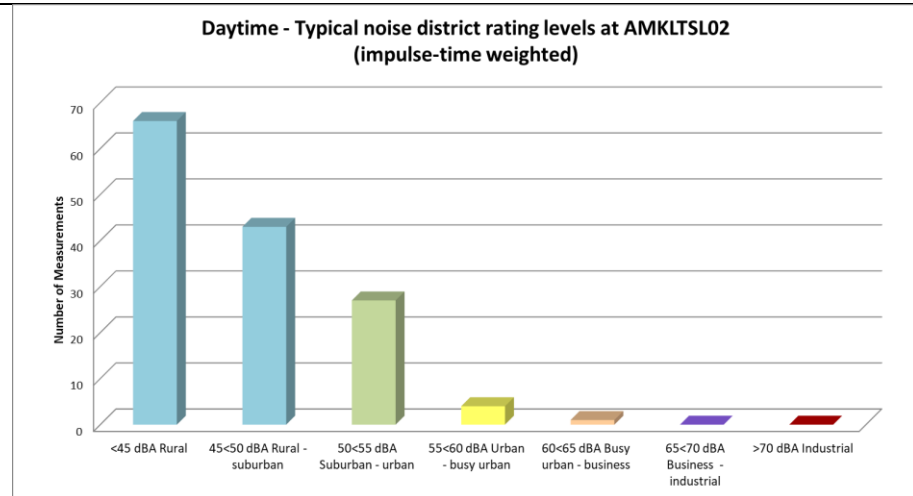


Figure 26: Classification of daytime measurements in typical noise districts at AMKLTSLO2

5.4.5 Long-term Measurement Location - AMKLTSL03

The SLM was erected close to the house, in an area that was relatively unprotected from the wind.

The equipment defined in **Table 5-14** was used for gathering data with **Table 5-15** highlighting sounds heard during equipment deployment and collection, with [Appendix E](#) presenting a photo of the measurement location.

Table 5-14: Equipment used to gather data at AMKLTSL03

SLM	Svan 955	27637	October 2020
Microphone and Pre-amplifier	Svan 977	36176	2 November 2014
Calibrator	ACO Pacific 7052E	49596	2 November 2014
SLM	Quest CA-22	J 2080094	June 2016

Table 5-15: Noises/sounds heard during site visits at AMKLTSL03

Noises/sounds heard during onsite investigations		
Magnitude Scale Code: <ul style="list-style-type: none"> • Barely Audible • Audible • Dominating 	During equipment deployment	
	Faunal and Natural	Wind-induced noises. Sheep bleating. Insects.
	Residential	Wind chime.
	Industrial & transportation	-
	During equipment collection	
	Faunal and Natural	Sheep and birds.
	Residential	Wind chime.
	Industrial & transportation	Small wind turbine attached to the house.

Impulse time-weighted equivalent sound levels $L_{Aeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in Figure 27 and summarized in Table 5-16 below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in Figure 28.

The impulse time-weighted sound descriptor is mainly used in South Africa to define sound and noise levels. Fast-weighted equivalent sound levels are included in this report as this is the sound descriptor used in most international countries to define the Ambient Sound Level (residual noise level as used in the Western Cape).

The L_{A90} level is presented in this report to define the “background sound level”, or the sound level that can be expected if there were little single events (loud transient noises) that impacts on average sound level. The L_{A90} level is generally low, indicating an area with little noises that would raise residual noise levels.

Maximum noise level exceeded 65 dBA at least 1 time each night. If maximum noise levels exceed 65 dBA more than 10 times at night, it may increase the probability where a receptor may be awakened at night, ultimately impacting on the quality of sleep¹¹.

Table 5-16: Sound levels considering various sound level descriptors at AMKLTSL03

	L_{Amax,i} (dBA)	L_{Aeq,i} (dBA)	L_{Aeq,f} (dBA)	L_{A90,f} (dBA90)	L_{Amin,f} (dBA)
Day arithmetic average	-	51.1	46.0	35.0	-
Night arithmetic average	-	35.8	31.7	24.5	-
Day Equivalent Levels	-	60.3	55.7	-	-
Night Equivalent Levels	-	45.3	40.6	-	-
Day minimum	-	26.0	21.1	-	7.5
Day maximum	95.0	73.7	64.1	-	-
Night minimum	-	7.8	7.7	-	7.4
Night maximum	67.7	56.9	52.6	-	-
Day 1 equivalent	-	56.5	48.8	-	-
Night 1 Equivalent	-	47.8	43.2	-	-
Day 2 equivalent	-	59.0	55.4	-	-
Night 2 Equivalent	-	38.3	33.2	-	-
Day 3 equivalent	-	54.4	44.8	-	-

The numerous 10-minute measurements are further classified for the day- and night-time periods in terms of the SANS 10103:2008 typical noise district areas in **Figure 29** (night) and **Figure 30** (day).

⁽¹¹⁾ World Health Organization, 2009, 'Night Noise Guidelines for Europe.

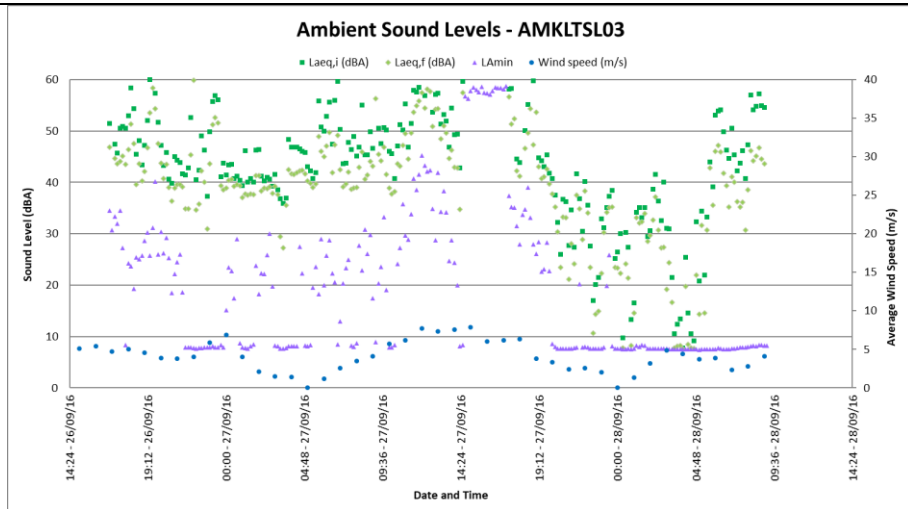


Figure 27: Residual noise Levels at AMKLTL03

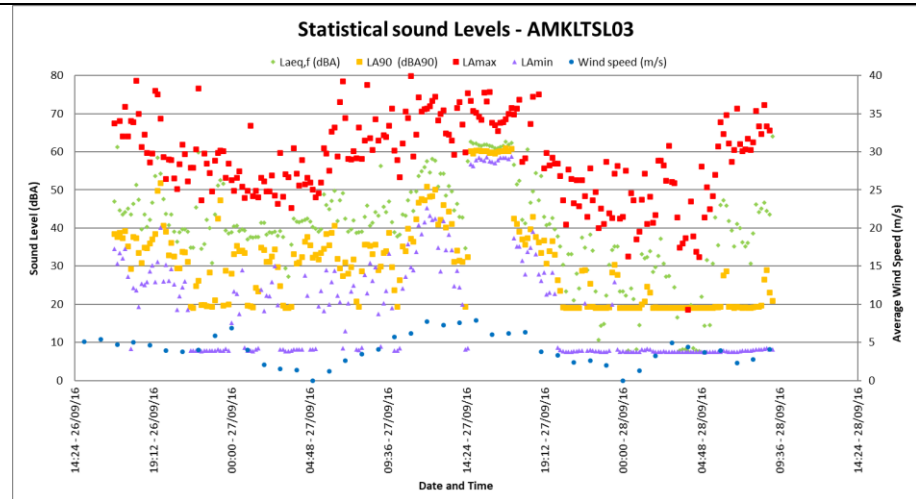


Figure 28: Maximum, minimum and Statistical sound levels at AMKLTL03

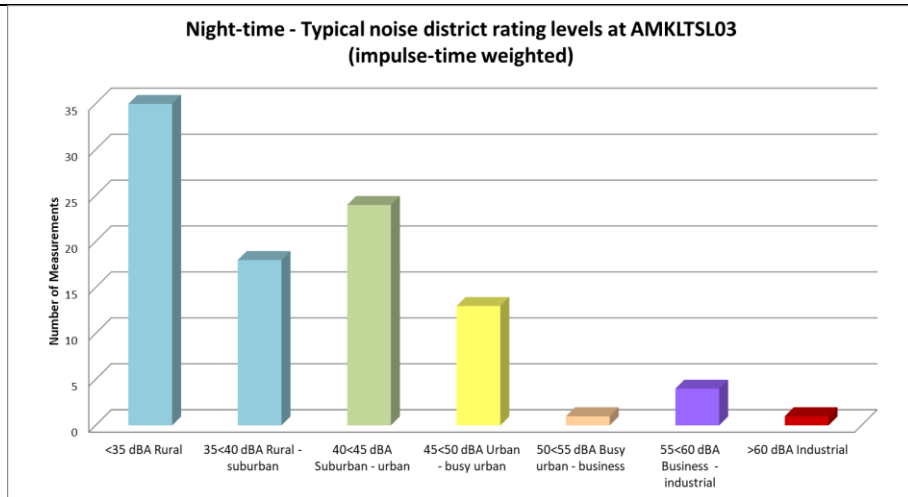


Figure 29: Classification of night-time measurements in typical noise districts at AMKLTL03

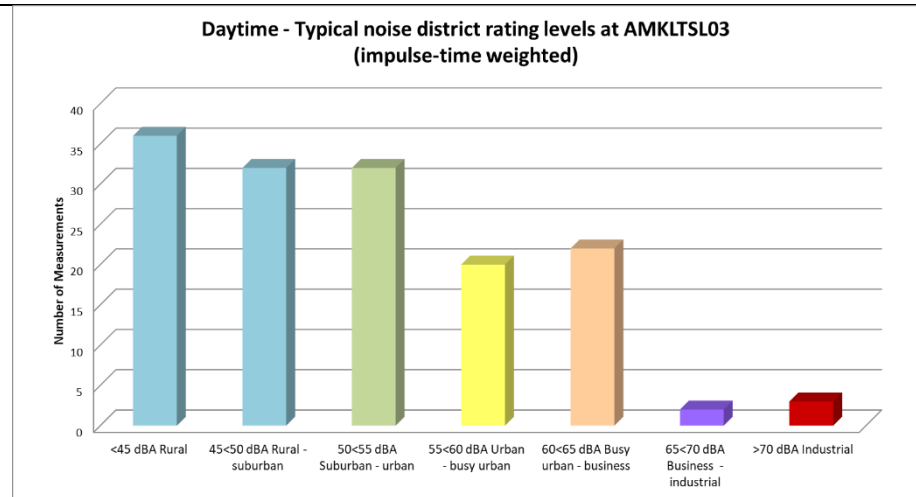


Figure 30: Classification of daytime measurements in typical noise districts at AMKLTL03

5.5 Residual noise Levels – Findings and Summary

The figure below presents approximately 3,000 10-minute sound level measurements collected in quiet environments (mainly Karoo), together with around 480 measurements collected at night in the vicinity of the project site.

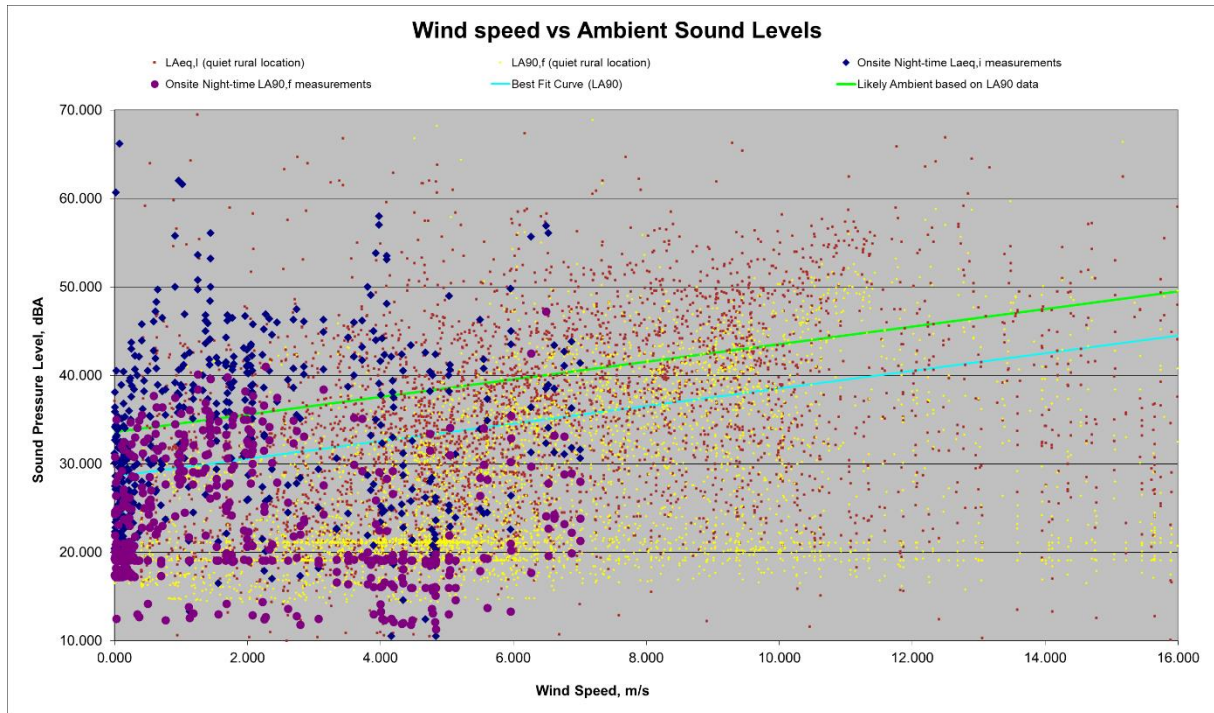


Figure 31: Residual noise levels measured in vicinity of project

Considering the residual noise levels and character of the area, residual noise levels are generally very low and typical of a rural noise district during low wind conditions. Unfortunately, there was limited data available at wind speeds higher than 7 m/s, but considering measurements collected over the past decade at numerous locations during different seasons, residual noise levels will likely increase as wind speeds increase, as illustrated in **Figure 31**. This will be considered when recommending acceptable noise limits for the project area.

6. POTENTIAL NOISE SOURCES

Increased noise levels are directly linked with the various activities associated with the construction of the proposed Patatskloof WEF and related infrastructure, as well as the operation phase of the activity. The potential noise impacts from the activities associated with these phases are discussed in the following sections.

6.1 Potential Noise Sources: Construction Phase

6.1.1 Construction equipment

It is estimated that construction will take approximately 18-24 months subject to the final design of the WEF, weather and ground conditions, including time for testing and commissioning. The construction process will consist of the following principal activities:

- Site survey and preparation;
- Establishment of site entrance, internal access roads, contractors' compound and passing places;
- Civil works to sections of the public roads to facilitate with turbine delivery;
- Site preparation activities will include clearance of vegetation at the footprint of each turbine as well as crane hard-standing areas. These activities will require the stripping of topsoil which will need to be stockpiled, backfilled and/or spread on site;
- Construct foundations – due to the volume of concrete that will be required, an on-site batching plant may be required to ensure a continuous concreting operation. The source of aggregate is yet undefined but is expected to be derived from an offsite source or brought in as ready-mix. If the stones removed during the digging of foundations are suitable as an aggregate this can be used as the aggregate in the concrete mix.
- Transport of components & equipment to site – all components will be brought to site in sections by means of flatbed trucks. Additionally, components of various specialized construction and lifting equipment are required on site to erect the wind turbines and will need to be transported to site. The typical civil engineering construction equipment will need to be brought to the site for the civil works (e.g., excavators, trucks, graders, compaction equipment, cement trucks, etc.). The transportation of ready-mix concrete to site or the materials for onsite concrete batching will result in a temporary increase in heavy traffic (one turbine foundation may require up to 100 concrete trucks, and is undertaken as a continuous pour);
- Establishment of laydown & hard standing areas - laydown areas will need to be established at each turbine position for the placement of wind turbine components. Laydown and storage areas will also be required to be established for the civil engineering construction equipment which will be required on site. Hard standing areas will need to be established for operation of the cranes. Cranes of the size required to erect turbines are sensitive to differential movement during lifting operations and require a hard-standing area;
- Erect turbines - a crane will be used to lift the tower sections into place and then the nacelle will be placed onto the top of the assembled tower. The next step will be to assemble or partially assemble the rotor on the ground; it will then be lifted to the nacelle and bolted in place. A small crane will likely be needed for the assembly of the rotor while the large crane will be needed to put it in place;
- Construct substation - the underground cables carrying the generated power from the individual turbines will connect at the substation. The construction of the substation would require a site

survey; site clearing and levelling (including the removal / cutting of rock outcrops) and construction of access road/s (where required); construction of a substation terrace and foundation; assembly, erection and installation of equipment (including transformers); connection of conductors to equipment; and rehabilitation of any disturbed areas and protection of erosion sensitive areas;

- Establishment of ancillary infrastructure - A workshop as well as a contractor's equipment camp may be required. The establishment of these facilities/buildings will require the clearing of vegetation and levelling of the development site and the excavation of foundations prior to construction. A laydown area for building materials and equipment associated with these buildings will also be required; and
- Site rehabilitation - once construction is completed and all construction equipment are removed; the site will be rehabilitated where practical and reasonable.

There are a number of factors that determine the audibility as well as the potential of a noise impact on receptors. Maximum noises generated can be audible over a large distance, however, are generally of very short duration. If maximum noise levels however exceed 65 dBA at a receptor, or if it is clearly audible with a significant number of instances where the noise level exceeds the prevailing residual noise level with more than 15 dB, the noise can increase annoyance levels and may ultimately result in noise complaints. Potential maximum noise levels generated by various construction equipment as well as the potential extent of these sounds are presented in **Table 6-1**.

Average or equivalent sound levels are another factor that impacts on the residual noise levels and is the constant sound level that the receptor can experience. Typical sound power levels associated with various activities that may be found at a construction site is presented in **Table 6-2**.

Table 6-1: Potential maximum noise levels generated by construction equipment

Equipment Description ¹²	Impact Device?	Maximum Sound Power Levels (dBA)	Operational Noise Level at given distance considering potential maximum noise levels (Cumulative as well as the mitigatory effect of potential barriers or other mitigation not included – simple noise propagation modeling only considering distance) (dBA)											
			5 m	10 m	20 m	50 m	100 m	150 m	200 m	300 m	500 m	750 m	1000 m	2000 m
Auger Drill Rig	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Backhoe	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Chain Saw	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Compactor (ground)	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Compressor (air)	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Concrete Batch Plant	No	117.7	92.7	86.7	80.6	72.7	66.7	63.1	60.6	57.1	52.7	49.2	46.7	40.6
Concrete Mixer Truck	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Concrete Pump Truck	No	116.7	91.7	85.7	79.6	71.7	65.7	62.1	59.6	56.1	51.7	48.2	45.7	39.6
Concrete Saw	No	124.7	99.7	93.7	87.6	79.7	73.7	70.1	67.6	64.1	59.7	56.2	53.7	47.6
Crane	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Dozer	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Drill Rig Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Drum Mixer	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Dump Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Excavator	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Flat Bed Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Front End Loader	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Generator	No	116.7	91.7	85.7	79.6	71.7	65.7	62.1	59.6	56.1	51.7	48.2	45.7	39.6
Generator (<25KVA)	No	104.7	79.7	73.7	67.6	59.7	53.7	50.1	47.6	44.1	39.7	36.2	33.7	27.6
Grader	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Impact Pile Driver	Yes	129.7	104.7	98.7	92.6	84.7	78.7	75.1	72.6	69.1	64.7	61.2	58.7	52.6
Jackhammer	Yes	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Man Lift	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6

¹² Equipment list and Sound Power Level source: http://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook09.cfm

Mounted Impact Hammer	Yes	124.7	99.7	93.7	87.6	79.7	73.7	70.1	67.6	64.1	59.7	56.2	53.7	47.6
Paver	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Pickup Truck	No	89.7	64.7	58.7	52.6	44.7	38.7	35.1	32.6	29.1	24.7	21.2	18.7	12.6
Pumps	No	111.7	86.7	80.7	74.6	66.7	60.7	57.1	54.6	51.1	46.7	43.2	40.7	34.6
Rivit Buster/Chipping Gun	Yes	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Rock Drill	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Roller	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Sand Blasting (single nozzle)	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Scraper	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Sheers (on backhoe)	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Slurry Plant	No	112.7	87.7	81.7	75.6	67.7	61.7	58.1	55.6	52.1	47.7	44.2	41.7	35.6
Slurry Trenching Machine	No	116.7	91.7	85.7	79.6	71.7	65.7	62.1	59.6	56.1	51.7	48.2	45.7	39.6
Soil Mix Drill Rig	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Tractor	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Vacuum Excavator	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Vacuum Street Sweeper	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Ventilation Fan	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Vibrating Hopper	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Vibratory Concrete Mixer	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Vibratory Pile Driver	No	129.7	104.7	98.7	92.6	84.7	78.7	75.1	72.6	69.1	64.7	61.2	58.7	52.6
Warning Horn	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Welder/Torch	No	107.7	82.7	76.7	70.6	62.7	56.7	53.1	50.6	47.1	42.7	39.2	36.7	30.6

Table 6-2: Potential equivalent noise levels generated by various equipment

Equipment Description	Equivalent (average) Sound Levels (dBA)	Operational Noise Level at given distance considering equivalent (average) sound power emission levels (Cumulative as well as the mitigatory effect of potential barriers or other mitigation not included – simple noise propagation modelling only considering distance) (dBA)											
		5 m	10 m	20 m	50 m	100 m	150 m	200 m	300 m	500 m	750 m	1000 m	2000 m
Air compressor	92.6	67.6	61.6	55.5	47.6	41.6	38.0	35.5	32.0	27.6	24.1	21.6	15.5
Bulldozer CAT D10	111.9	86.9	80.9	74.9	66.9	60.9	57.4	54.9	51.3	46.9	43.4	40.9	34.9
Cement truck (with cement)	111.7	86.7	80.7	74.7	66.7	60.7	57.2	54.7	51.2	46.7	43.2	40.7	34.7
Crane	107.5	82.5	76.5	70.5	62.5	56.5	53.0	50.5	46.9	42.5	39.0	36.5	30.5
Diesel Generator (Large - mobile)	106.1	81.2	75.1	69.1	61.2	55.1	51.6	49.1	45.6	41.2	37.6	35.1	29.1
Dumper/Haul truck - Terex 30 ton	112.2	87.2	81.2	75.2	67.2	61.2	57.7	55.2	51.7	47.2	43.7	41.2	35.2
Excavator - Hitachi EX1200	113.1	88.1	82.1	76.1	68.1	62.1	58.6	56.1	52.6	48.1	44.6	42.1	36.1
FEL (988) (FM)	115.6	90.7	84.6	78.6	70.7	64.6	61.1	58.6	55.1	50.7	47.1	44.6	38.6
General noise	108.8	83.8	77.8	71.8	63.8	57.8	54.2	51.8	48.2	43.8	40.3	37.8	31.8
Grader - Operational Hitachi	108.9	83.9	77.9	71.9	63.9	57.9	54.4	51.9	48.4	43.9	40.4	37.9	31.9
Road Truck average	109.6	84.7	78.7	72.6	64.7	58.7	55.1	52.6	49.1	44.7	41.1	38.7	32.6
Rock Breaker, CAT	120.7	95.7	89.7	83.7	75.7	69.7	66.2	63.7	60.2	55.7	52.2	49.7	43.7
Vibrating roller	106.3	81.3	75.3	69.3	61.3	55.3	51.8	49.3	45.8	41.3	37.8	35.3	29.3
Water Dozer, CAT	113.8	88.8	82.8	76.8	68.8	62.8	59.3	56.8	53.3	48.8	45.3	42.8	36.8
Wind Turbine: Acciona AW125/3000	108.4	85.4	79.4	73.4	65.4	59.4	55.9	53.4	49.9	45.4	41.9	39.4	33.4
Wind Turbine: Vestas V150-4.2 MW	104.9	79.9	73.9	67.9	60.0	54.0	50.4	48.0	44.5	40.0	36.5	34.0	28.0
Wind Turbine: Vesta V90 2 MW VCS	104.0	79.0	73.0	67.0	59.0	53.0	49.5	47.0	43.5	39.0	35.5	33.0	27.0
Wind Turbine: Vesta V66, ave	102.6	77.7	71.6	65.6	57.7	51.6	48.1	45.6	42.1	37.7	34.1	31.6	25.6
Wind Turbine: Vesta V66, max	108.0	83.0	77.0	71.0	63.0	57.0	53.5	51.0	47.5	43.0	39.5	37.0	31.0
Wind Turbine: Vesta V66, min	96.3	71.3	65.3	59.3	51.3	45.3	41.8	39.3	35.8	31.3	27.8	25.3	19.3
Wind Turbine: Vestas V117 3.3MW	107.0	82.0	76.0	70.0	62.0	56.0	52.5	50.0	46.4	42.0	38.5	36.0	30.0

The equipment likely to be required to complete the above tasks will typically include excavator/ graders, bulldozer(s), dump trucks(s), vibratory roller, bucket loader, rock breaker(s), drill rig, flatbed truck(s), pile drivers, TLB, concrete truck(s), crane(s), fork lift(s) and various 4WD and service vehicles.

Noise from the contractor's camp will be minimal and will not influence the residual noise levels in the surrounding area.

6.1.2 *Material supply: Concrete batching plants and use of Borrow Pits*

There exist three options for the supply of the concrete to the development site. These options are:

- The transport of "ready-mix" concrete from the closest center to the development.
- The transport of aggregate and cement from the closest center to the development, with the establishment of a small concrete batching plant close to the activities. This would most likely be a movable plant. It may be possible to use some of the material obtained from foundation excavation as aggregate if suitable.
- The development of a small aggregate quarry in the vicinity of the development.

6.1.3 *Blasting*

Blasting may be required as part of the civil works to clear obstacles or to prepare foundations. However, blasting will not be considered in the ENIA for the following reasons:

- Blasting is highly regulated, and control of blasting to protect human health, equipment and infrastructure will ensure that any blasts will use minimum explosives and will occur in a controlled manner. With regards to blasting in borrow pits, explosives are used with a low detonation speed, reducing vibration, sound pressure levels and air blasts. The breaking of obstacles with explosives is also a specialized field, and when correct techniques are used, it causes less noise than using a rock-breaker.
- People are generally more concerned over ground vibration and air blast levels that might cause building damage than the impact of the noise from the blast.
- Blasts are an infrequent occurrence, with a loud but a relative instantaneous character. Potentially affected parties normally receive sufficient notice (siren), and the knowledge that the duration of the siren noise as well as the blast will be over relatively fast, resulting in a higher acceptance of the noise.

6.1.4 *Traffic*

The last significant source of noise during the construction phase is additional traffic to and from the site, as well as traffic on the site. The use of a borrow pit(s), on site crushing and screening and concrete batching plants will significantly reduce heavy vehicle movement to and from the site.

Construction traffic is expected to be generated throughout the entire construction period, however, the volume and type of traffic generated will be dependent upon the construction activities being conducted, which will vary during the construction period. Noise levels due to traffic were estimated using the methodology stipulated in SANS 10210:2004 (Calculating and predicting road traffic noise). Traffic volumes were estimated using:

- Up to 10 trucks and cars each, travelling on a tar road at 80 km/hr.; and
- Up to 10 trucks and cars each, travelling on a gravel road at 40 km/hr.

6.2 Potential Noise Sources: Operation Phase

The proposed development would be designed to have an operational life of up to 25 years with the possibility to further expand the lifetime of the WEF. The only development related activities on-site will be routine servicing (access roads and light traffic) and unscheduled maintenance. The noise impact from maintenance activities is insignificant, with the main noise source being the wind turbine blades and the nacelle (components inside) as highlighted in the following sections.

Noise emitted by wind turbines can be associated with two types of noise sources. These are aerodynamic sources due to the passage of air over the wind turbine blades and mechanical sources which are associated with components of the power train within the turbine, such as the gearbox and generator and control equipment for yaw, blade pitch, etc. These sources normally have different characteristics and can be considered separately. In addition, there are other noise sources of lower levels, such as the substations and traffic (maintenance).

6.2.1 Wind Turbine Noise

6.2.1.1 Wind Turbine Aerodynamic sources¹³

Aerodynamic noise is emitted by a wind turbine blade through a number of sources such as:

- Self-noise due to the interaction of the turbulent boundary layer with the blade trailing edge;
- Noise due to inflow turbulence (turbulence in the wind interacting with the blades);
- Discrete frequency noise due to trailing edge thickness;
- Discrete frequency noise due to laminar boundary layer instabilities (unstable flow close to the surface of the blade); and
- Noise generated by the rotor tips.

Therefore, as the wind speed increases, noises created by the wind turbine also increase. At a low wind speed the noise created by the wind turbine is generally (relatively) low, and increases to a maximum at a certain wind speed when it either remains constant, increase very slightly or even drops as illustrated in **Figure 32**.

¹³ *Renewable Energy Research Laboratory, 2006; ETSU R97: 1996*

The developer is investigating a number of different wind turbine models; not excluding the possibility of larger models that are not yet available in the commercial market. Therefore, for the purpose of this noise assessment a worst-case scenario will be investigated, making use of the **maximum** sound power emission levels of the Nordex N163/5.X wind turbine. It should be noted that the same wind turbine has a maximum sound power emission level of 107.2 dBA (re 1 pW) when using the option with Serrated Trailing Edges (STE).

The author could not source the sound power emission levels at different wind speeds for the Nordex N163/5.X and this data was estimated considering the data for the Nordex N117/3000 WTG. It is assumed that the maximum sound power emission level will be at an 8.0 m/s wind speed.

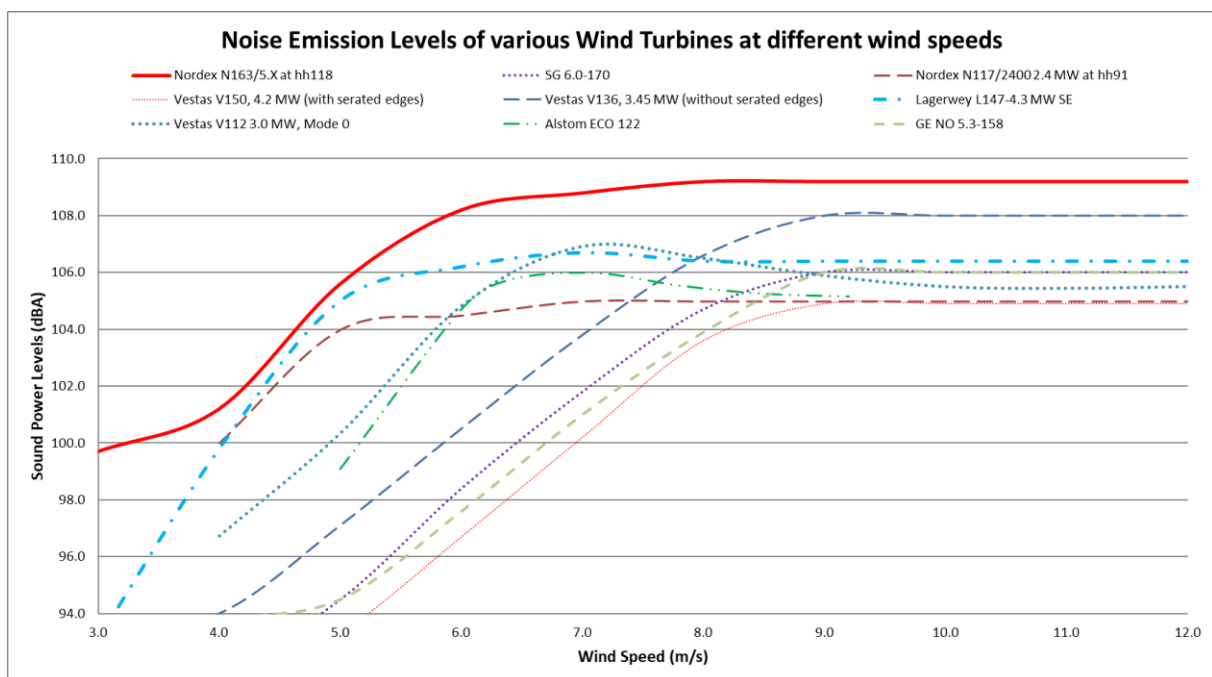


Figure 32: Noise Emissions Curve of a number of different wind turbines (figure for illustration purposes only)

The propagation model also makes use of various frequencies, because these frequencies are affected in different ways as it propagates through air, over barriers and over different ground conditions providing a higher accuracy than models that only use the total sound power level. The octave sound power levels for various wind turbines are presented on **Figure 33**.

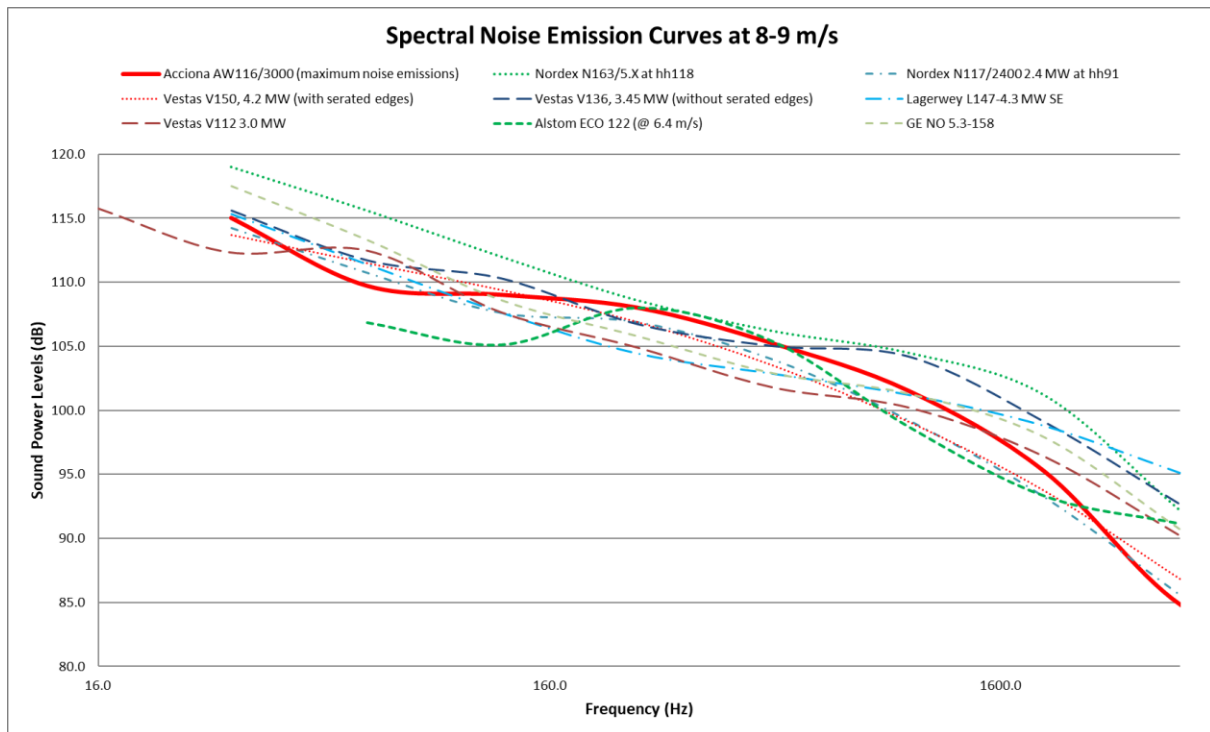


Figure 33: Octave sound power emissions of various wind turbines

6.2.1.2 Wind Turbine Mechanical sources¹⁴

Mechanical noise is normally perceived within the emitted noise from wind turbines as an audible tone(s) which is subjectively more intrusive than a broad band noise of the same sound pressure level. Sources for this noise are normally associated with:

- the gearbox and the tooth mesh frequencies of the step-up stages;
- generator noise caused by coil flexure of the generator windings which is associated with power regulation and control;
- generator noise caused by cooling fans; and
- control equipment noise caused by hydraulic compressors for pitch regulation and yaw control.

Tones are noises with a narrow sound frequency composition (e.g. the whine of an electrical motor). Annoying tones can be created in numerous ways: machinery with rotating parts such as motors, gearboxes, fans and pumps often create tones. An imbalance or repeated impacts may cause vibration that, when transmitted through surfaces into the air, can be heard as tones. Pulsating flows of liquids or gases can also create tones, which may be caused by combustion processes or flow restrictions. The best and most well-known example of a tonal noise is the buzz created by a flying mosquito.

¹⁴ Renewable Energy Research Laboratory, 2006; ETSU R97: 1996; Audiology Today, 2010; HGC Engineering, 2007

Where complaints have been received due to the operation of wind farms, tonal noise from the installed wind turbines appears to have increased the annoyance perceived by the complainants and has indeed been the primary cause for complaint.

6.2.1.3 *However, tones were normally associated with the older models of turbines. All turbine manufacturers have started to ensure that sufficient forethought is given to the design of quieter gearboxes and the means by which these vibration transmission paths may be broken. Through the use of careful gearbox design and/or the use of anti-vibration techniques, it is possible to minimize the transmission of vibration energy into the turbine supporting structure. The benefits of these design improvements have started to filter through into wind farm developments which are using these modified wind turbines. **New generation wind turbine generators do not emit any clearly distinguishable tones.*** Control Strategies to manage Noise Emissions during operation

Wind turbine manufacturers also provide their equipment with control mechanisms to allow for a certain noise reduction during operation that can include:

- A reduction of rotational speed;
- The increase of the pitch angle and/or reduction of nominal generator torque to reduce the angle of attack;
- Implementation of blade technologies such as serrated edges, changing the shape of the blade tips or the edge (proprietary technologies); and
- The insulation of the nacelle.

These mechanisms are used in various ways to allow the reduction of noise levels from the wind turbines, although this may also result in a reduction of power generation.

6.2.1.4 *Concluding Remarks on Wind Turbine Noise Levels*

While algorithms and equations exist to **estimate** sound power levels, these *formulae* do not consider operating modes, specific isolation designed for the nacelle and blade technologies (such as serrated edges), which all contribute to reduce the noise levels. These measures are specific to a particular wind turbine make and model and accurately defined using a method as defined by IEC 61400-11.

The noise report considers the sound power emission levels of the wind turbine generator (WTG) that the client indicated they may consider. However, due to various reasons, a developer does not want to reveal the actual WTG that they may consider, whether for commercial/economic reasons, possible Non-

Disclosure Agreements etc. It should thus be noted that the details of the **actual** WTG are totally irrelevant to a noise analysis, as the major factors that determine the noise levels are:

- The layout of the WEF (which would include the number of WTGs as well as the distance from these WTGs that could individually and cumulatively affect the noise levels at a certain location); and
- The sound power emission levels of the WTG (or noise source) selected/that the developer is considering.

Minor factors in the noise levels are:

- The spectral characteristics of the WTG;
- Temperature and Humidity of the surrounding atmosphere, with this study considering atmospheric conditions optimal for the propagation of noise (Humidity of 70% and air temperature of 10°C);
- Noise abatement technologies implemented by the manufacturer;
- Topography and wind shear effects;
- Ground surface characteristics.

Insignificant factors are:

- The hub height of the WTG;
- The rotor diameter of the WTG;
- The manufacture of the WTG, the model's name or number (the sound power emission levels however relate to a specific make and model and is determined by the manufacturer).

The sound power emission levels are provided by the manufacturer either as the maximum warranted sound power levels, a calculated sound power level (for new WTG where the noise levels were not previously measured) or measured sound power levels (using an internationally recognised protocol as defined by IEC 61400-11). The sound power emission levels are unique for each make and model and already include the effect of the hub height, rotor diameter and abatement technologies.

6.2.2 *Low Frequency Noise*¹⁵

Low frequency sound is the term used to describe sound energy in the region below ~200 Hz. The rumble of thunder and the throb of a diesel engine are both examples of sounds with most of their energy in this low frequency range. Infrasound is often used to describe sound energy in the region below 20 Hz.

Almost all noise in the environment has components in this region although they are of such a low level that they are not significant (wind, ocean, thunder). See also **Figure 34**, which indicates the sound power levels in the different octave bands from measurements taken at different wind speeds with no other

¹⁵ Renewable Energy Research Laboratory, 2006; DELTA, 2008; DEFRA, 2003; HGC Engineering, 2006; Whitford, Jacques, 2008; Noise-con, 2008; Minnesota DoH, 2009; Kamperman, 2008, Van den Berg, 2004

audible noise sources. Sound that has most of its energy in the 'infrasound' range is only significant if it is at a very high level, far above normal environmental levels.

Because of the low rotational rates of the blades of a WTG, the peak acoustic energy radiated by large wind turbines is in the infrasonic range with a peak in the 8-12 Hz range. For smaller machines, this peak can extend into the low-frequency "audible" (20-20KHz) range because of higher rotational speeds and multiple blades.

It should be noted that a number of studies highlighted that these sounds are below the threshold of perception (BWEA, 2005), although this should be clarified. Most acousticians would agree that the low frequency sounds are inaudible to most people, yet, there are a number of studies that highlight that it can be more perceptible to people inside their houses as well as people that are more sensitive to low frequency sounds.

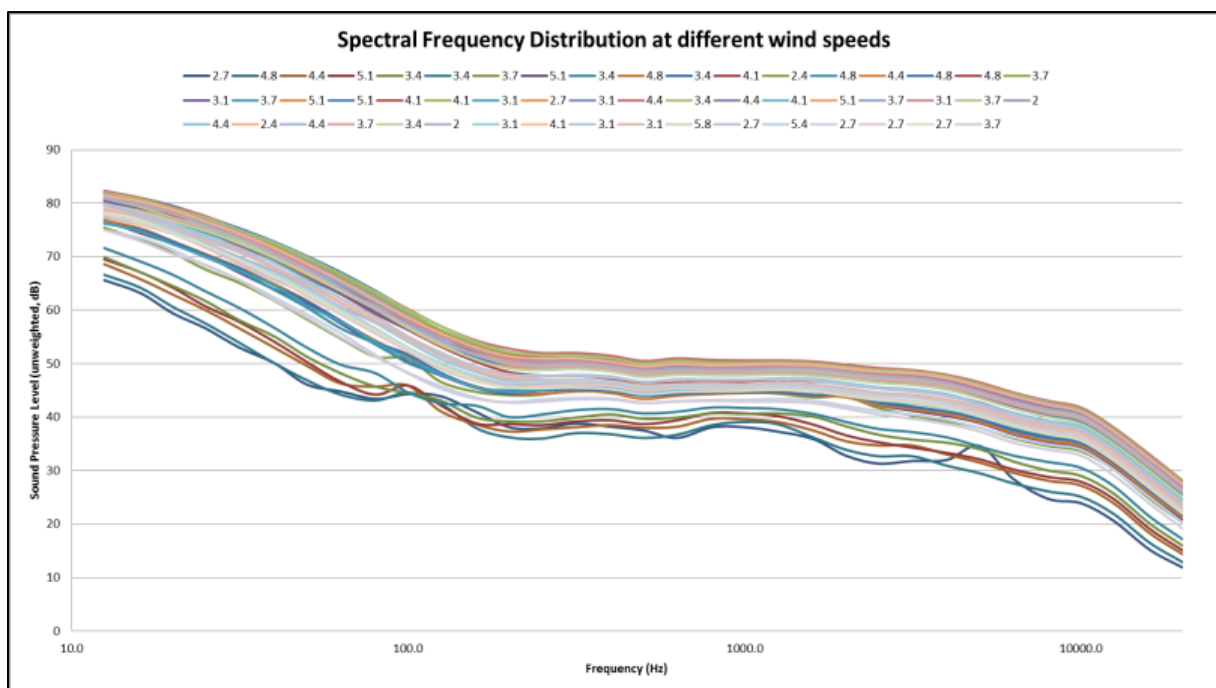


Figure 34: Third octave band sound power levels at various wind speeds at a location where wind induced noises dominate

Low frequency noise is always present around us as it is produced by both man and nature. While problems have been associated with older downwind wind turbines in the 1980s, this has been considered by the wind industry and modern upwind turbines do not suffer from the same problems. Low Frequency Noise however has been very controversial in the last few years with the anti-wind fraternity claiming measurable impacts, with governments and wind-energy supporter studies indicating no link between low-frequency sound and any health impacts. This study notes the various claims and as such follow a more precautionary approach.

6.2.3 Amplitude modulation¹⁶

Although considered rare, there is one other characteristic of wind turbine sound that increases the sleep disturbance potential above that of other long-term noise sources. The amplitude modulation (AM) of the sound emissions from the wind turbines creates a repetitive rise and fall in sound levels synchronized to the blade rotation speed, sometimes referred to as a “swish” or “thump”.

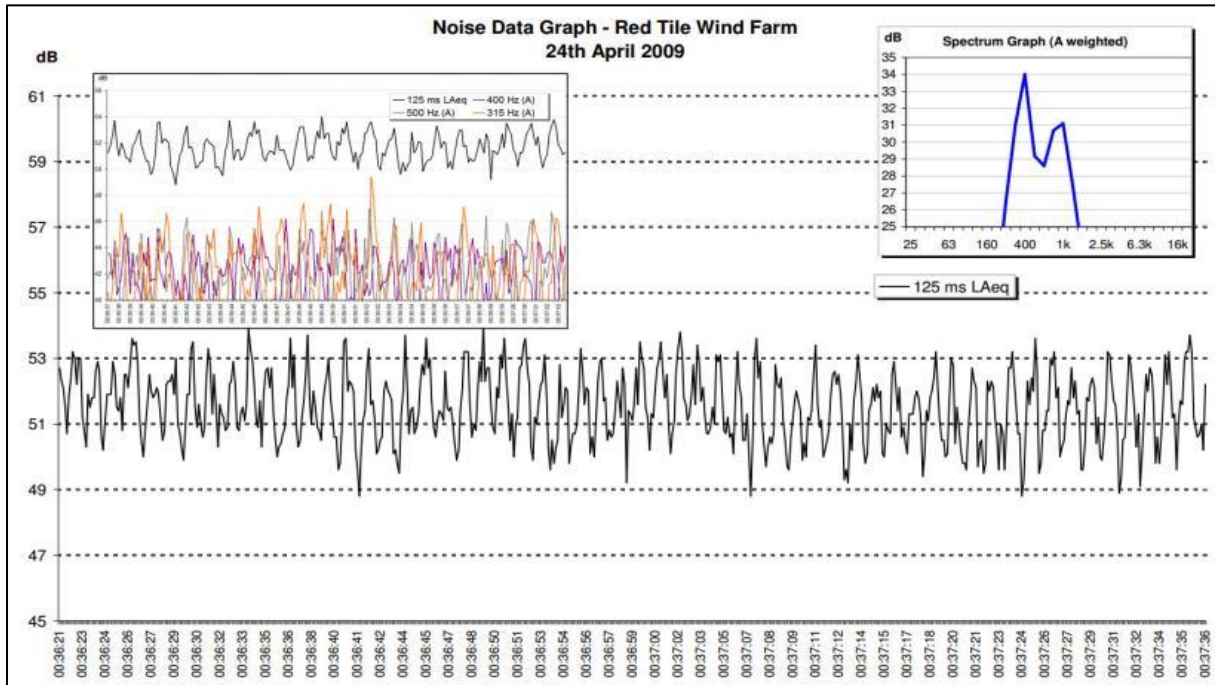


Figure 35: Example time-sound series graph illustrating AM as measured by Stigwood¹⁷ (et al) (2013)

Pedersen (2003) highlighted a weak correlation between sound pressure level and noise annoyance caused by wind turbines. Residents complaining about wind turbines noise perceived more sound characteristics than noise levels. People were able to distinguish between background sounds and the sounds the blades made. The noise produced by the blades lead to most complaints. Most of the annoyance was experienced between 16:00 and midnight. This could be an issue as noise propagation modelling would be reporting an equivalent, or “average” sound pressure level, a parameter that ignores the “character” of the sound.

That AM can be a risk and significantly increase the annoyance with WEFs cannot be disputed. It has been reported with a number of recent studies confirming this significant noise characteristic. However, even though there are thousands of wind turbine generators in the world, amplitude modulation is still one subject receiving the least complaints and due to these very few complaints, little research went into

¹⁶ Renewable Energy Research Laboratory, 2006; Audiology Today, 2010; HGC Engineering, 2007; Whitford, 2008; Noise-con, 2008; DEFRA, 2007; Bowdler, 2008

¹⁷ Stigwood (et al) (2013): “Audible amplitude modulation – results of field measurements and investigations compared to psycho-acoustical assessments and theoretical research”; Paper presented at the 5th International Conference on Wind Turbine Noise, Denver 28 – 30 August 2013

this subject. Studies as recently as 2012 (Smith, 2012) highlight the need for additional studies and data collection.

However, because of these unknown factors (low frequency noises and AM), this noise study adopts a precautionary stance and will consider the worst-case scenario (wind turbine with the maximum sound power emission levels).

7. WHY ENVIRONMENTAL NOISE IS A CONCERN

7.1 Noise Impact on Animals¹⁸

A significant amount of research was undertaken during the 1960's and 70's on the effects of aircraft noise on animals. While aircraft noise has a specific characteristic that might not be comparable with industrial noise, the findings should be relevant to most noise sources. A general animal behavioral reaction to aircraft noise is the startle response with the strength and length of the startle response to be dependent on the following:

- which species is exposed;
- whether there is one animal or a group of animals, and
- whether there have been some previous exposures.

Overall, the research suggests that species differ in their response to noise depending on the duration, magnitude, characteristic and source of the noise, as well as how accustomed the animals are to the noise (previous exposure).

Extraneous noises impact on animals as it can increase stress levels and even impact on their hearing. Masking sounds may affect their ability to react to threats, compete and seek mates and reproduce, hunt and forage, communicate and generally survival.

Unfortunately, there are numerous other factors in the faunal environment that also influence the effects of noise. These include predators, weather, changing prey/food base and ground-based disturbance, especially anthropogenic. This hinders the ability to define the real impact of noise on animals.

The only animal species studied in detail are humans, and studies are still continuing in this regard. These studies also indicate that there is considerable variation between individuals, highlighting the loss of sensitivity to higher frequencies as human's age. Sensitivity also varies with frequency with humans. Considering the variation in the sensitivity to frequencies and between individuals, this is likely similar

¹⁸ Report to Congressional Requesters, 2005; USEPA, 1971; Autumn, 2007; Noise quest, 2010

with all faunal species. Some of these studies are repeated on animals, with behavioral hearing tests being able to define the hearing threshold range for some animals as indicated on **Figure 36** below.

Only a few faunal (animal) species have been studied in a bit more detail so far, with the potential noise impact on marine animals most likely the most researched subject, with a few studies that discuss behavioral changes in other faunal species due to increased noises. Few studies indicate definitive levels where noises start to impact on animals, with most based-on laboratory level research that subject animals to noise levels that are significantly higher than the noise levels these animals may experience in their environment (excluding the rare case where bats and avifauna fly extremely close to an anthropogenic noise, such as from a moving car or the blades of a wind turbine).

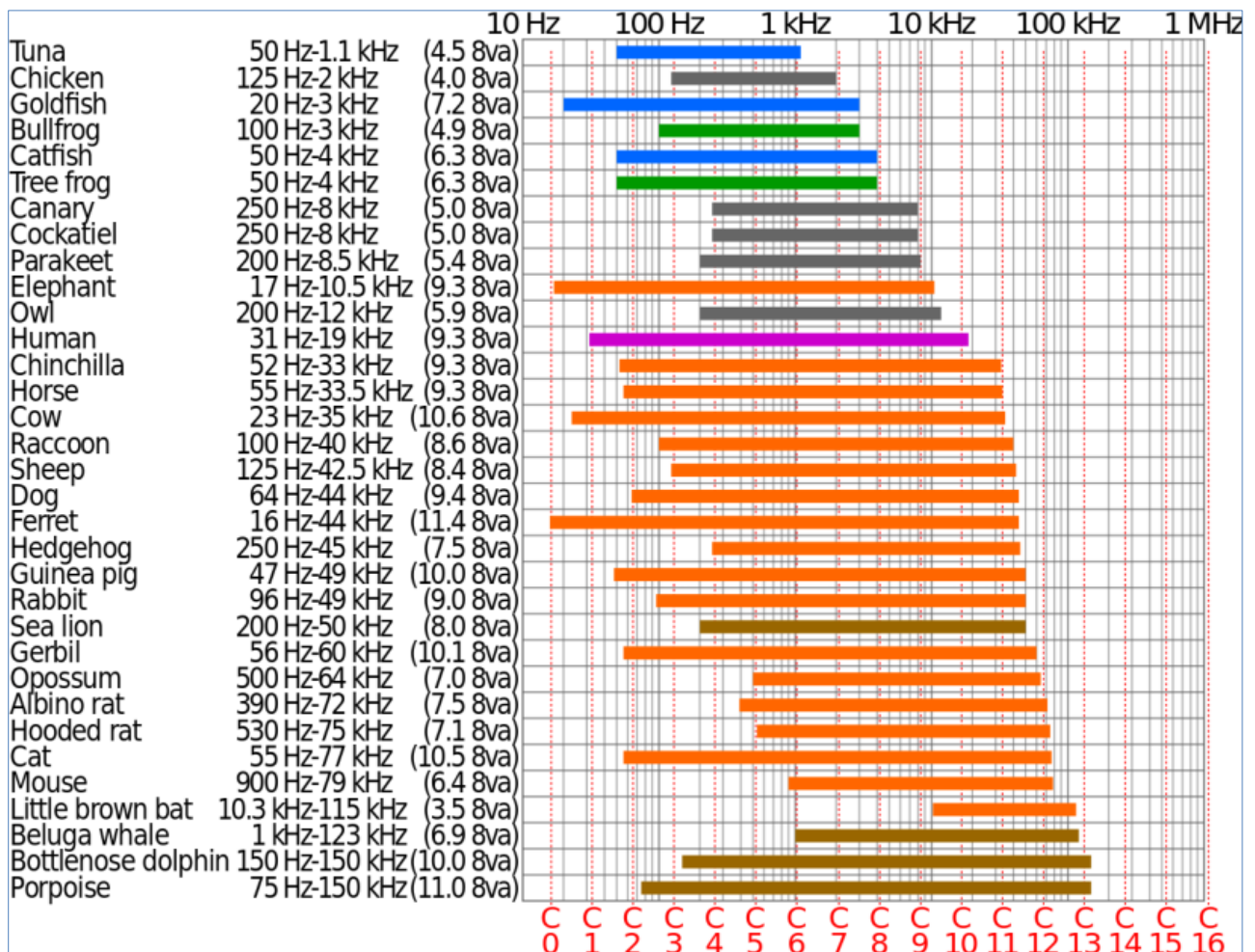


Figure 36: Logarithmic Chart of the Hearing Ranges of Some Animals¹⁹

7.1.1 Domesticated Animals

It has been observed that most domesticated animals are generally not bothered by noise, excluding most impulsive noises (Noise Quest²⁰, Šottník, 2011).

¹⁹ https://en.wikipedia.org/wiki/Hearing_range

²⁰ Noise quest, Aviation Noise Information & Resources, 2010: <https://www.noisequest.psu.edu/noiseeffects-animals.html>

7.1.2 *Wildlife*

Studies indicated that most animals adapt to noises, and would even return to a site after an initial disturbance, even if the noise is continuous. The more sensitive animals that might be impacted by noise would most likely relocate to a quieter area. Noise impacts are therefore very highly species dependent.

7.1.3 *Avifauna*

As with other terrestrial faunal species, noise (character of sound or change in level) will impact on avifauna (birds of a particular region and/or habitat). Anthropogenic noises result in physical damage to ears, increased stress, flight or flushing, changes in foraging and other behavioral reactions. Ortega (2012) summarized those additional responses (with ecological similar controls) include the avoidance of noisy areas, changes in reproductive success and changes in vocal communication. However, as with other faunal species, there are no guidelines to assess at which sound pressure level avifaunal will start to exhibit any response.

7.1.4 *Concluding Remarks - Noise Impacts on Animals*

From these and other studies the following can be concluded that:

- To date there are, however, no guidelines or sound limits with regards to noise levels that can be used to estimate the potential significance of noises on animals.
- Animals respond to impulsive (sudden) noises (higher than 90 dBA) by running away. If the noises continue, animals would try to relocate (Drooling, 2007).
- Animals start to respond to increased noise levels with elevated stress hormone levels and hypertension. These responses begin to appear at exposure levels of 55 to 60 dBA (Baber, 2009).
- Animals of most species exhibit adaptation with noise (Broucek, 2014), including impulsive noises, by changing their behavior.
- More sensitive species would relocate to a quieter area, especially species that depend on hearing to hunt or evade prey, or species that make use of sound/hearing to locate a suitable mate (Drooling, 2007).
- Noises associated with helicopters, motor and quad bikes does significantly impact on animals (startle response). This is due to the sudden and significant increase in noise levels due to these activities.
- There are no published studies in reputable journals that provide support for the negative impacts of noise from wind turbines on animals.
- Animal communication is generally the highest during no and low wind conditions. It has been hypothesized that this is one of the reasons why birds sing so much in the mornings (their voices carry the farthest and there are generally less observable wind).

- Background noise levels (residual noise levels) in remote areas are not always low in space or time. The site is windy and this generates significant noise itself and also significantly changes the ability of fauna to hear the environmental noises around them.
- Infrasound is present in the environment, and is generated by a wide range of natural sources (e.g. wind, waves etc.). In February 2013, the Environmental Protection Authority of South Australia published the results of a study into infrasound levels near wind farms (Evans, 2013). This study measured infrasound levels at urban locations, rural locations with wind turbines close by, and rural locations with no wind turbines in the vicinity. It found that infrasound levels near wind farms are comparable to levels away from wind farms in both urban and rural locations. Infrasound levels were also measured during organized shut-downs of the wind farms; the results showed that there was no noticeable difference in infrasound levels whether the turbines were active or inactive.
- Wind is a significant source of natural noise, with a character similar to the noise generated by wind turbines, with a significant portion of the acoustic energy in the low frequency and infrasound range.
- Wind turbines do not emit broad-band sound on a continual basis as the turbines only turn and generate noise when the wind speeds are above the cut-in speed.
- The wind turbines will only operate during periods of higher wind speeds, a period when background noise levels are already elevated due to wind-induced noises.
- The elevated background noise relating with wind also provide additional masking of the wind turbine noise, with periods of higher winds also correlating with lower faunal activity, particularly with regard to communication.

7.2 Why noise concerns communities²¹

Noise can be defined as "unwanted sound", an audible acoustic energy that adversely affects the physiological and/or psychological well-being of people, or which disturbs or impairs the convenience or peace of any person. One can generalize by saying that sound becomes unwanted when it:

- Hinders speech communication;
- Impedes the thinking process;
- Interferes with concentration;
- Obstructs activities (work, leisure and sleeping); and
- Presents a health risk due to hearing damage.

However, it is important to remember that whether a given sound is "noise" depends on the listener or hearer. The driver playing loud rock music on their car radio hears no noise, but the person in the traffic behind them hears nothing but noise.

Response to noise is unfortunately not an empirical absolute, as it is seen as a multi-faceted psychological concept, including behavioral and evaluative aspects. For instance, in some cases

²¹ World Health Organization, 1999; Noise quest, 2010; Journal of Acoustical Society of America, 2009

annoyance is seen as an outcome of disturbances, in other cases it is seen as an indication of the degree of helplessness with respect to the noise source.

Noise does not need to be loud to be considered “disturbing”. One can refer to a dripping tap in the quiet of the night, or the irritating “thump-thump” of the music from a neighboring house at night when one would like to sleep.

Severity of the annoyance depends on factors such as:

- Background sound levels, and the background sound levels the receptor is used to;
- The manner in which the receptor can control the noise (helplessness);
- The time, unpredictability, frequency, distribution, duration, and intensity of the noise;
- The physiological state of the receptor; and
- The attitude of the receptor about the emitter (noise source).

7.2.1 *Annoyance associated with Wind Energy Facilities*²²

Annoyance is the most widely acknowledged effect of environmental noise exposure, and is considered to be the most widespread. It is estimated that less than a third of the individual noise annoyance is accounted for by acoustic parameters, and that non-acoustic factors plays a major role. Non-acoustic factors that have been identified include age, economic dependence on the noise source, attitude towards the noise source and self-reported noise sensitivity.

On the basis of a number of studies into noise annoyance, exposure-response relationships were derived for high annoyance from different noise sources. These relationships, illustrated in **Figure 37**, are recommended in a European Union position paper published in 2002, stipulating policy regarding the quantification of annoyance. This can be used in an Environmental Health Impact Assessment and cost-benefit analysis to translate noise maps into overviews of the numbers of persons that may be annoyed, thereby giving insight into the situation expected in the long term. It is not applicable to local complaint-type situations or to an assessment of the short-term effects of a change in noise climate.

²² Van den Berg, 2011; Milieu, 2010.

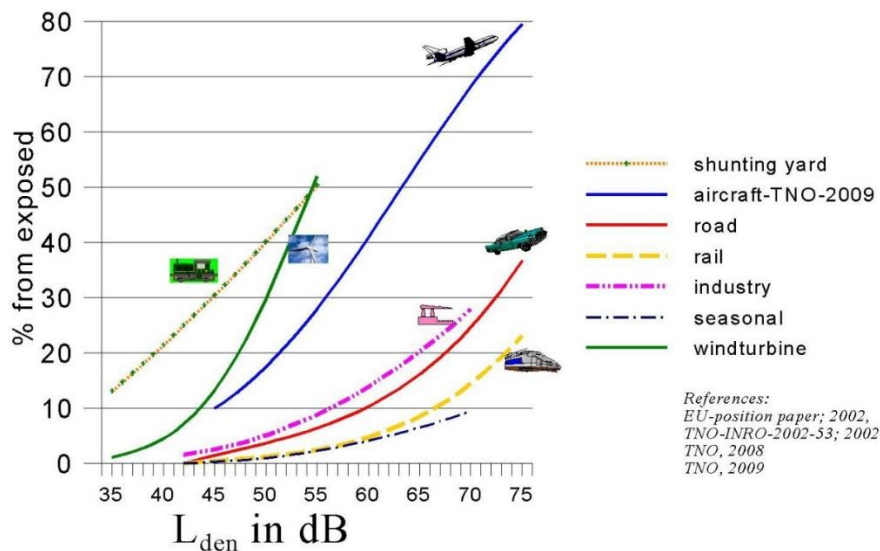


Figure 37: Percentage of annoyed persons as a function of the day-evening-night noise exposure at the façade of a dwelling

While the total residual noise levels are of importance, the spectral characteristics also determines the likelihood that someone will hear external noises that may or may not be similar in spectral characteristics to that of vegetation created noise. Bolin (2006) did investigate spectral characteristics and determined the annoyance might occur at levels where noise generated by wind turbine noise exceeds natural residual noises with 3 dB or more.

7.3 Impact Assessment Criteria

7.3.1 Overview: The common characteristics

The word "noise" is generally used to convey a negative response or attitude to the sound received by a listener. There are four common characteristics of sound, any or all of which determine listener response and the subsequent definition of the sound as "noise". These characteristics are:

- Intensity;
- Loudness;
- Annoyance; and
- Offensiveness.

Of the four common characteristics of sound, intensity is the only one which is not subjective and can be quantified. Loudness is a subjective measure of the effect the sound has on the human ear. As a quantity it is therefore complicated but has been defined by experimentation on subjects known to have normal hearing.

The annoyance and offensive characteristics of noise are also subjective. Whether or not a noise causes annoyance mostly depends upon its reception by an individual, the environment in which it is heard, the type of activity and mood of the person and how acclimatized or familiar that person is to the sound.

7.3.2 Noise criteria of concern

The criteria used in this report were drawn from the criteria for the description and assessment of environmental impacts from the Integrated Environmental Management Information Series (DEAT, 2002).

There are a number of criteria that are of concern for the assessment of noise impacts. These can be summarized in the following manner:

- *Increase in noise levels:* People or communities often react to an increase in the ambient noise level they are used to, which is caused by a new source of noise. With regards to the NCRs, an increase of more than 7 dBA is considered a disturbing noise. See also **Figure 38**.
- *Zone Sound Levels:* Previously referred as the acceptable rating levels, sets acceptable noise levels for various areas. See also **Table 7-1**.
- *Absolute or total noise levels:* Depending on their activities, people generally are tolerant to noise up to a certain absolute level, e.g., 65 dBA. However, anything above this level is considered unacceptable.

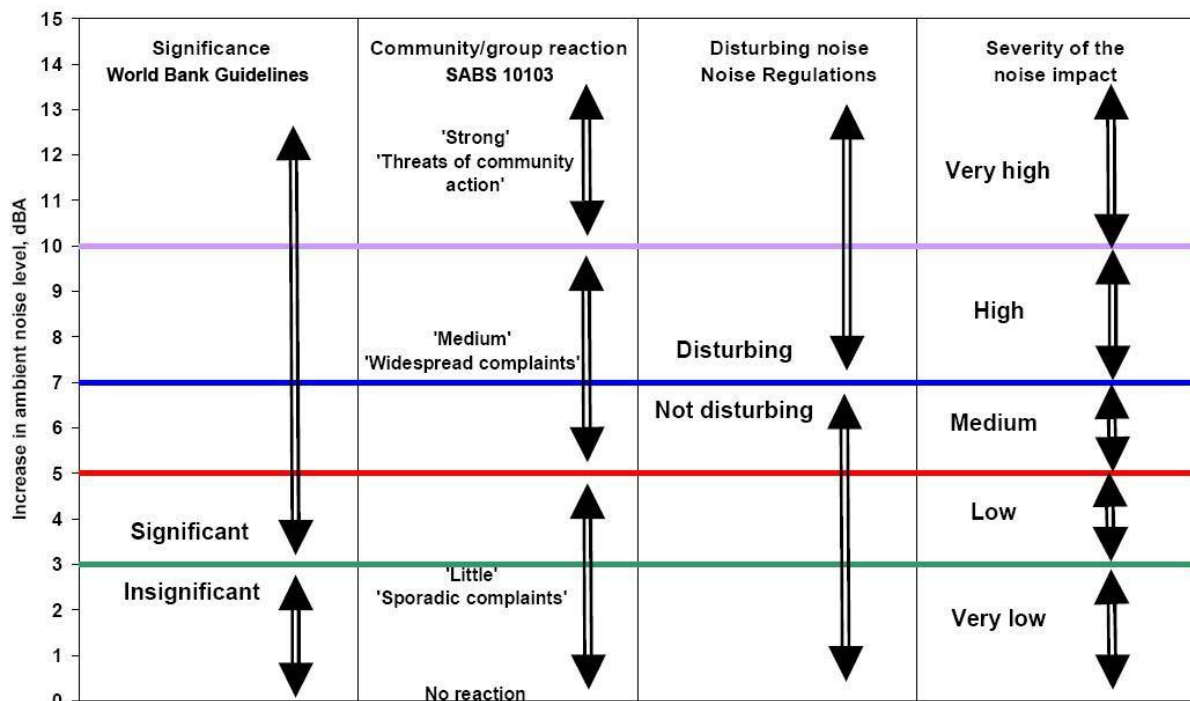


Figure 38: Criteria to assess the significance of impacts stemming from noise

In South Africa the document that addresses the issues concerning environmental noise is SANS 10103. It provides the maximum average ambient noise levels, $L_{Req,d}$ and $L_{Req,n}$, during the day and night

respectively to which different types of developments may be exposed as defined in **Table 7-1**. For rural areas the Zone Sound Levels (Rating Levels) are:

- Day (06:00 to 22:00) - $L_{Req,d} = 45$ dBA, and
- Night (22:00 to 06:00) - $L_{Req,n} = 35$ dBA.

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

- **$\Delta \leq 3$ dBA:** An increase of 3 dBA or less will not cause any response from a community. It should be noted that for a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level would not be noticeable.
- **$3 < \Delta \leq 5$ dBA:** An increase of between 3 dBA and 5 dBA will elicit 'little' community response with 'sporadic complaints'. People will just be able to notice a change in the sound character in the area.
- **$5 < \Delta \leq 15$ dBA:** An increase of between 5 dBA and 15 dBA will elicit a 'medium' community response with 'widespread complaints'. In addition, an increase of 10 dBA is subjectively perceived as a doubling in the loudness of a noise. For an increase of more than 15 dBA the community reaction will be 'strong' with 'threats of community action'.

Table 7-1: Acceptable Zone Sound Levels for noise in districts (SANS 10103)

1	2	3	4	5	6	7
Type of district	Equivalent continuous rating level ($L_{Req,T}$) for noise dBA					
	Outdoors			Indoors, with open windows		
	Day/night $L_{R,dn}^a$	Daytime $L_{Req,d}^b$	Night-time $L_{Req,n}^b$	Day/night $L_{R,dn}^a$	Daytime $L_{Req,d}^b$	Night-time $L_{Req,n}^b$
a) Rural districts	45	45	35	35	35	25
b) Suburban districts with little road traffic	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
d) Urban districts with one or more of the following: workshops; business premises; and main roads	60	60	50	50	50	40
e) Central business districts	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

7.3.3 Determining appropriate Zone Sound Levels

SANS 10103 unfortunately does not cater for instances when background noise levels change due to the impact of external forces. Locations close to the sea for instance always have a background noise level

exceeding 35 dBA, and, in cases where the sea is rather turbulent, it can easily exceed 45 dBA. Similarly, noise induced by high winds is not included.

Setting noise limits relative to the background noise level is relatively straightforward when the prevailing background noise level and source level are constant. However, wind turbines emit noise that is related to wind speed, and the environment within which they are heard will probably also be dependent upon the strength of the wind and the noise associated with its effects. It is therefore necessary to derive a background noise level that is indicative of the noise environment at the receiving property for different wind speeds so that the turbine noise level at any particular wind speed can be compared with the background noise level in the same wind conditions.

7.3.3.1 *Using International Guidelines to set Noise Limits*

When assessing the overall noise levels emitted by a WEF, it is necessary to consider the full range of operating wind speeds of the wind turbines. This covers the wind speed range from around 3-5 m/s (the turbine cut-in wind speed) up to a wind speed range of 25-35 m/s measured at the hub height of a wind turbine. However, ETSU-R97 (1996) proposes that noise limits only be placed up to a wind speed of 12 m/s for the following reasons:

- Wind speeds are not often measured at wind speeds greater than 12 m/s at 10 m height;
- Reliable measurements of background sound levels (the residual noise level as used in the Western Cape) and turbine noise will be difficult to make in high winds due to the effects of wind noise on the microphone and the fact that one could have to wait several months before such winds were experienced;
- Turbine manufacturers are unlikely to be able to provide information on sound power levels at such high wind speeds for similar reasons; and
- If a wind farm meets noise limits at wind speeds lower than 12m/s, it is most unlikely to cause any greater loss of amenity at higher wind speeds. Turbine noise levels increase only slightly as wind speeds increase; however, background sound levels increase significantly with increasing wind speeds due to the force of the wind.

Available data indicates that wind-induced noises start to increase at wind speeds 3 – 4 m/s, becoming a significant (and frequently the dominant noise source in rural areas) at wind speeds higher than 10 – 12 m/s/. Most wind turbines reach their maximum noise emission level at a wind speed of 8 – 10 m/s. At these wind speeds increased wind-induced noises (wind howling around building, rustling of leaves in trees, rattling noises, etc.) could start to drown other noises, including that being generated by wind turbines²³.

²³ It should be noted that this does not mean that the wind turbines are inaudible.

Sound level vs. wind speed data is presented in the following figures (**Figure 31**)²⁴. It is based on approximately 30,000 measurements collected at various quiet locations in South Africa (locations further than 10 km from the ocean). Also indicated are around 480 actual night-time measurements collected within 10 km from the proposed WEF. There were no apparent or observable sounds that would have impacted on the measurements at these locations. There was a lack of higher wind speeds during previous site visits, but as with other sites, background sound levels are expected to increase as the surrounding wind speed increase. This has been found at all locations where measurements have been done for a sufficiently long enough period of time (more than 30 locations comprising of more than 38,000 measurements) with the data agreeing with a number of international studies on the subject.

Considering this data as well as the international guidelines (MOE, see **Table 4-2 above**; IFC, see **Table 4-1 above**), noise limits starting at 40 dB that increases to more than 45 dB (as wind speeds increase) could be acceptable. Project participants could be exposed to noise levels up to 45 dBA (ETSU-R97).

7.3.3.2 *Using local regulations to set noise limits*

Noise limits as set by the NCRs (PN 200 of 2013 – section 4.3.1) defines a "disturbing noise" as the Noise Level which:

- (a) exceeds the rating level by 7 dBA;
 - (b) exceeds the residual noise level where the residual noise level is higher than the rating level;
 - (c) exceeds the residual noise level by 3 dBA where the residual noise level is lower than the rating level;
- or
- (d) in the case of a low-frequency noise, exceeds the level specified in Annex B of SANS 10103;

Accepting that the sound levels in the area may be typical of a rural noise district (considering the low-wind sound levels measured as well as the developmental character of the area), night-time rating levels would be 35 dBA and a noise level exceeding 42 dBA may be a disturbing noise (therefore the potential noise limit).

As can be observed from **Figure 31** above, if residual noise levels were measured at increased wind speeds, residual noise levels will be higher as wind-induced noises increase. These expected sound levels will be used to determine the probability for a noise impact to occur.

How wind-induced noises increase depends significantly on the measuring location and surrounding environment, but it is expected to be higher than 35 dBA closer to dwellings. The noise limit should increase with increased wind-speeds, but, considering international guidelines, an upper limit of 45 dBA

²⁴ The sound level measuring instruments were located at a quiet location in the garden of the various houses. Data was measured in 10-minute bins and then co-ordinated with the 10 m wind speed derived from the wind mast of the developer. This wind mast was not close to the dwellings, being approximately 3,500m from the measurement locations.

must be honored. For modelling and assessing the potential noise impact the values as proposed in **Table 7-2** will be considered.

Table 7-2: Proposed residual noise levels and acceptable rating levels

10-meter Wind Speed (m/s)	Estimated residual noise levels (night-time) (dBA)	MoE Sound Level Limits of Class 3 areas (Table 4-2) (dBA)	ETSU-R97 limit for project participants (dBA)	Night-time Zone Sound Level (SANS 10103:2008) (dBA)	Proposed Night Rating Level (dBA)
4	37.6	40	45	35 (at low wind speeds, this will increase as wind speeds increase)	40
5	38.6	40	45		40
6	39.5	40	45		40
7	40.5	43	45		43
8	41.5	45	45		45
9	42.5	49	45		45

8. SPECIALIST FINDINGS / IDENTIFICATION AND ASSESSMENT OF IMPACTS

8.1 Planning and Preconstruction Phase

Little noises are created during the planning and preconstruction phase, with noises mainly generated during the day, relating to light delivery vehicles travelling onsite. The potential significance of the noise impact is summarized in **Table 8-5**.

8.2 Proposed Construction Phase Noise Impact

This section investigates the conceptual construction activities as discussed in section 6.1. The layout as provided by the developer for the Patatskloof WEF is presented in **Figure 39**. As can be seen from this layout, a number of different activities might take place close to potentially sensitive receptors, each with a specific potential impact.

As it is unknown where the different activities may take place it was selected to model the impact of the noisiest activity (laying of foundation totaling 113.6 dBA cumulative noise impact – various equipment operating simultaneously) at all locations (over the full daytime period of 16 hours) where wind turbines may be erected, calculating how this may impact on noise levels at potential noise-sensitive developments (see **Figure 40**). Noise created due to linear activities (roads) were also evaluated and plotted against distance as illustrated in **Figure 41**²⁵.

Even though most construction activities are projected to take place only during day time, it might be required at times that construction takes place during the night due to:

- Concrete pouring: large portions of concrete do require pouring and vibrating to be completed once started, and work is sometimes required until the early hours of the morning to ensure a

²⁵ Sound level at a receiver set at a certain distance from a road

well-established concrete foundation. However, the work force working at night for this work will be considerably smaller than during the day.

- Working late due to time constraints: Weather plays an important role in time management in construction. A spell of bad weather can cause a construction project to fall behind its completion date. Therefore, it is hard to judge beforehand if a construction team would be required to work late at night.

The potential noise impact due to the various construction activities are defined per NSD in **Appendix F, Table 1** and **Appendix F, Table 2**, with the potential significance of the noise impact summarized in **Table 8-6**.

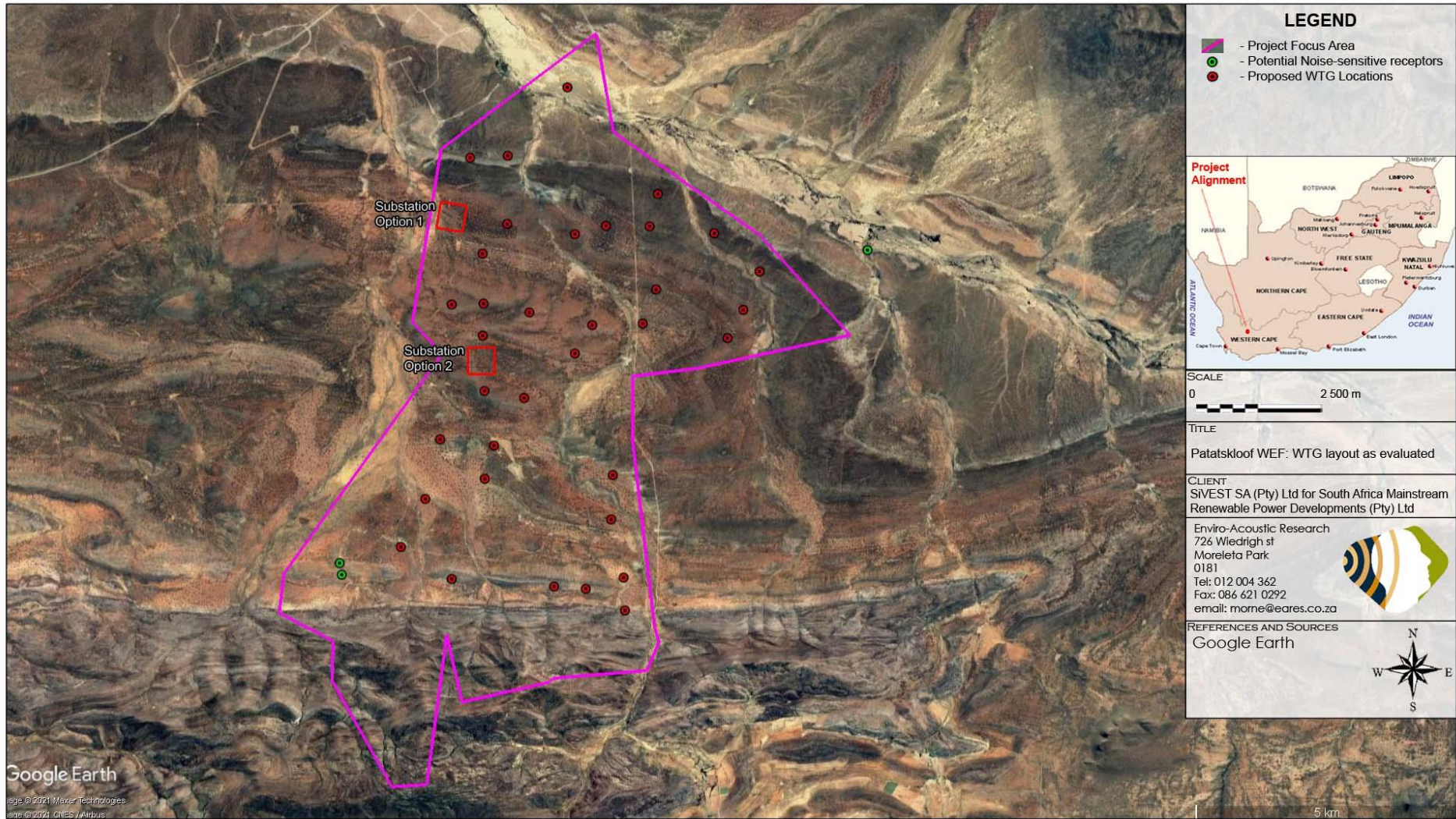


Figure 39: Proposed WTG Layout of the Patatskloof WEF

Decay of noise rating levels due to construction activities - Patatskloof WEF (worst-case, multiple activities at various locations)

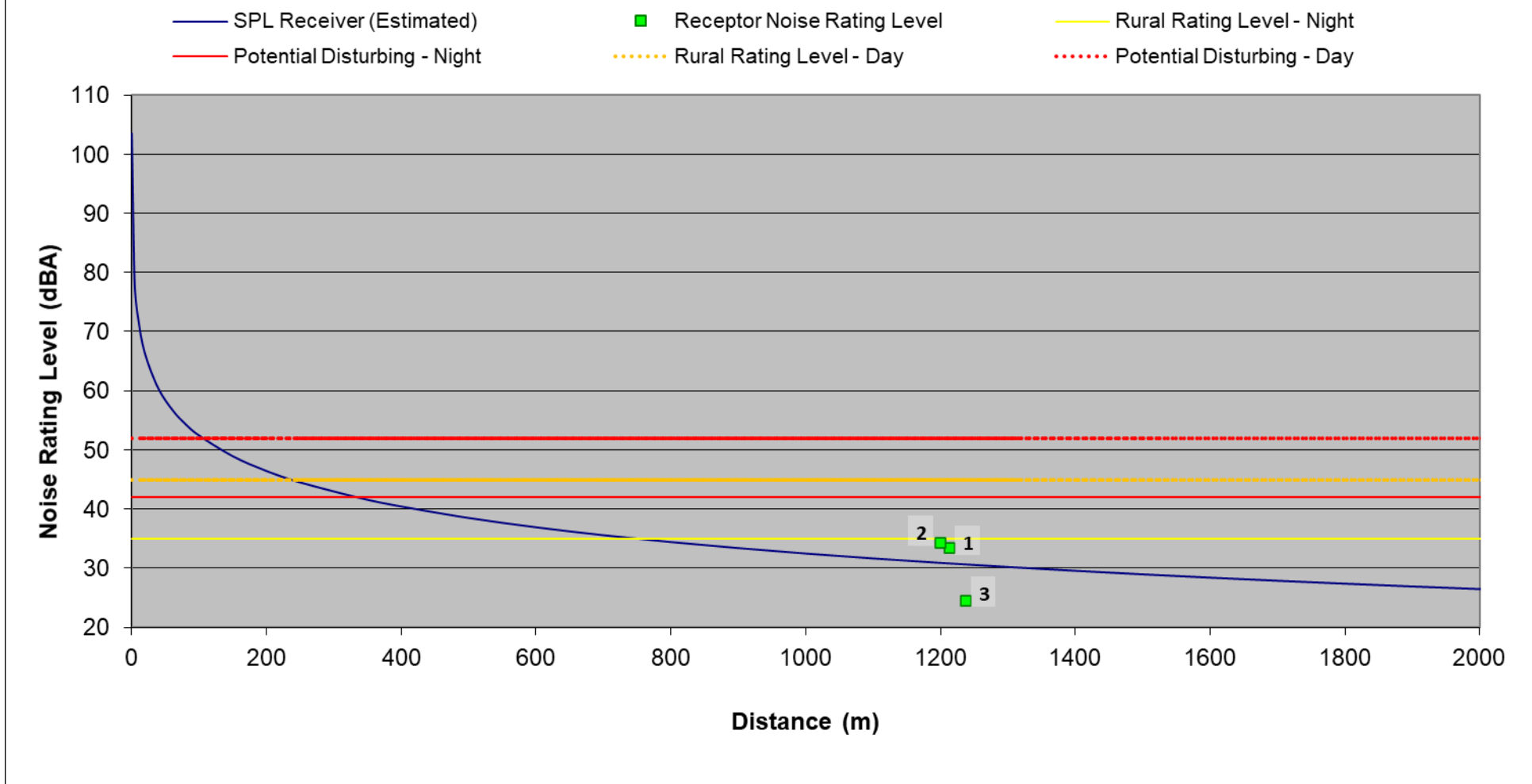


Figure 40: Projected conceptual construction noise levels - Decay of noise from construction activities

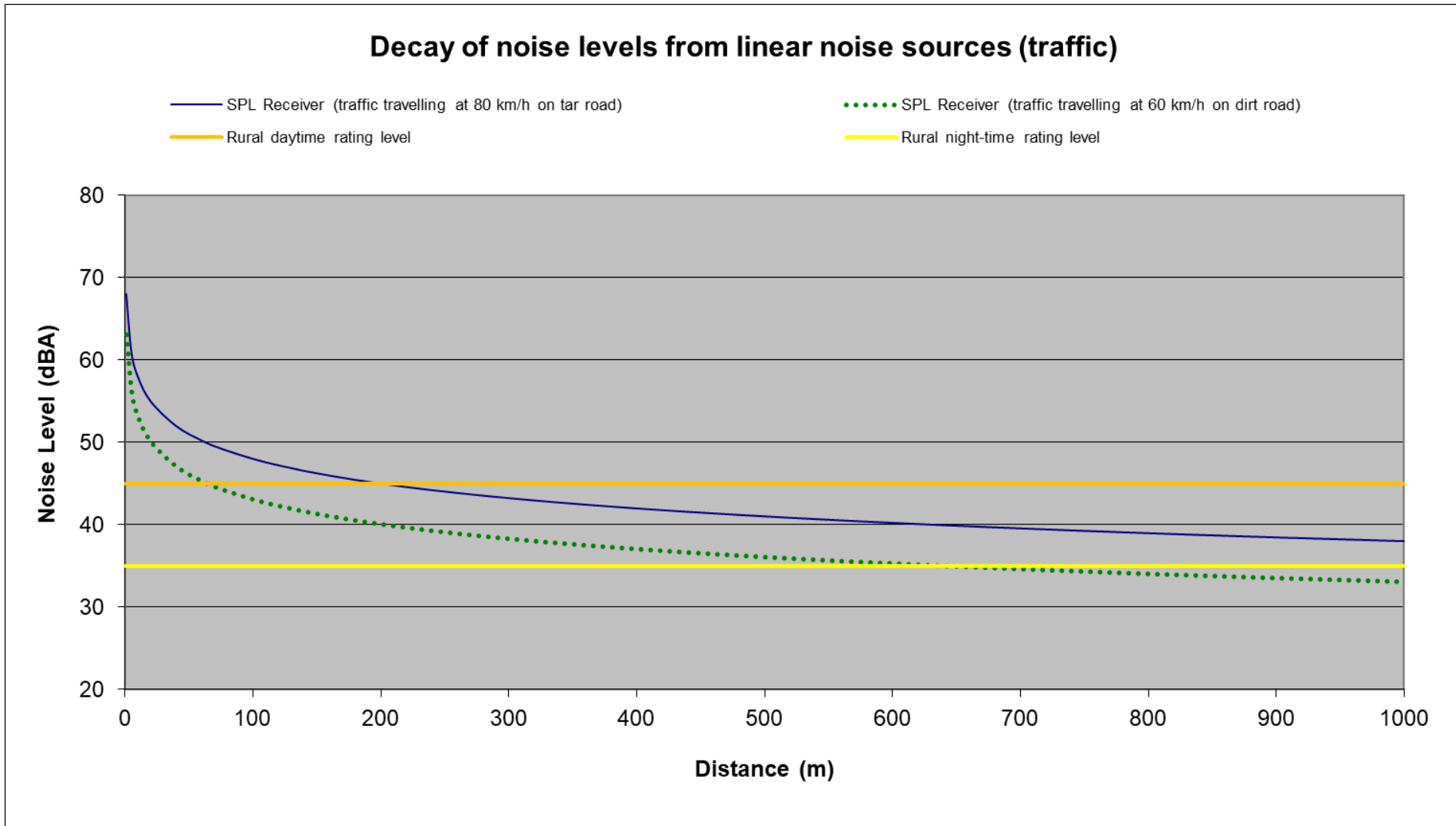


Figure 41: Projected conceptual construction noise levels – Decay over distance from linear activities

8.3 Operation Phase Noise Impact

While the significance of daytime noise impacts was considered, times when a quiet environment is desired (at night for sleeping, weekends etc.) are more critical. Surrounding receptors would desire and require a quiet environment during the night-time (22:00 – 06:00) timeslot and ambient noise levels are critical. It should be noted that maintenance activities normally take place during the day, but normally involve one or two light-delivery vehicles moving around during the course of the day, an insignificant noise source. As such maintenance activities will not be considered.

This noise impact assessment will evaluate the layout presented in **Figure 39** above, using the sound power emission levels presented in **Table 8-1**. The hub height used for modelling 118 m, though the results will be valid for hub heights of 108, 118, 120, 148, 159 and 164 m.

The author could not source the sound power emission levels at different wind speeds for the Nordex N163/5.X and this data was estimated considering the data for the Nordex N117/3000 WTG. It is assumed that the maximum sound power emission level will be at an 8.0 m/s wind speed.

The maximum calculated noise rating level contours are presented in **Figure 42**, with the calculated noise level per NSD presented in **Appendix F, Table 3**. The significance of the noise impact is summarized in **Table 8-7**.

Table 8-1: Octave Sound Power Emission Levels used for operational modelling

A-Weighted Sound Power Levels (at various wind speeds) Wind Turbine: Nordex N163/5.X (maximum noise level from developer with the change in noise emissions at different wind speeds based on the Nordex N117/3000 data) (Ref: F008_244_A04_EN_R00_N117-3000kW_Octave.doc, dated 2012-09-07)									
Wind speed (m/s)	5	6	7	8	9	10	11	11	11
Sound Power Emission Level (dB re 10 ⁻¹² Pa)	105.6	107.2	108.8	109.2	109.2	109.2	109.2	109.2	109.2
Expected A-weighted Octave Sound Power Levels Wind Turbine: Nordex N163/5.X (Ref: Dana, 2019)									
Frequency	31.5	63	125	250.0	500	1000	2000	4000	8000
L _w (dB)	119.0	115.6	112.0	108.6	106.2	104.5	101.2	92.2	83.7

8.4 Potential Cumulative Noise Impacts

Generally, there are only a cumulative effect when a receptor is located within 2,000 m from noise source, and, there may be a cumulative effect if additional noise sources are added within that 2,000 m. The potential cumulative effect significantly reduces farther than 2,000 m, and noise sources located farther than 5 km will not contribute to cumulative noise levels. As such it is not required or necessary to consider the cumulative noise impacts from WEFs or WTGs located farther than 5 km the project focus area (such as Karee, OYA, Kudusberg, Brandvalley, Rietkloof and Witberg WEFs).

The following wind farms are either operational, authorized (but not yet constructed), or proposed in the vicinity of the Patatskloof WEF:

- The existing Perdekraal East WEF is operational to the north-west of the proposed Patatskloof WEF (data from the report ERM-PWEF/ENIA/201607-Rev 4 (2016), using the sound power emission levels of the Siemens SWT 2.3-101 MW WTG – see **Table 8-2**);
- The authorized Perdekraal West WEF will be located to the west (and north-west) of the proposed Patatskloof WEF (data from the report SE-BTPWWEF/ENIA/201707-Rev 1, using the sound power emission levels of the Siemens 3.3-130 WTG – see **Table 8-3**);
- The Pienaarspoort WEF 1 is proposed to the east of the proposed Patatskloof WEF (data from the report SE-PP1WEF/ENIA/202102-Rev 0, using the sound power emission levels of the Siemens Gamesa G132-3.4 MW WTG – see **Table 8-4**);
- The Pienaarspoort WEF 2 is proposed on both the west and east of the proposed Patatskloof WEF (data from the report SE-PP2WEF/ENIA/202110-Rev 1, using the sound power emission levels of the Siemens Gamesa G132-3.4 MW WTG – see **Table 8-4**); and
- The Tooverberg WEF is authorized west of the proposed Patatskloof WEF, with the closest WTG further than 5 km from the WTG of the Patatskloof WEF. The Tooverberg WEF noise study assessed the noise impact in Report 26/5731 (Williams, 2018), using the Nordex N149/4.0. Because the WTG are further than 5 km from the proposed Patatskloof WEF WTG, the potential cumulative effect will be insignificant and will not be assessed in this report.

The latest available layouts of these WEFs (excluding the WTG of the Tooverberg WEF) were included in a cumulative model with the maximum potential noise level contours illustrated in **Figure 44** and the calculated maximum noise levels are defined in **Appendix F, Table 4** and summarized in **Table 8-8**.

Table 8-2: Sound Emission characteristics used for modelling – Perdekraal West WEF

Wind Turbine: Siemens-3.3-130, Rev 0 MW (Ref: E W TE-40-0000-A991-01, Rev 00 dated 2014/10/23)								
Maximum expected A-weighted Octave Sound Power Levels								
Frequency	63	125	250.0	500	1000	2000	4000	8000
L _w (dBA)	84.8	92.9	97.5	99.6	98.7	94.3	91.0	81.8
A-Weighted Sound Power Levels (at wind speeds)								
Wind speed (m/s)	6	7	8	9	10	11	12	
Sound Power Emission Level (dB re 10 ⁻¹² Pa)	97.3	100.9	104.6	106.0	106.0	106.0	106.0	106.0

Table 8-3: Sound Emission Characteristics used for modelling – Perdekraal East WEF

Wind Turbine: Siemens SWT 2.3-101 (Ref: Internet source – Environmental Noise Impact Assessment for KEC Wind Project)									
Maximum expected A-weighted Octave Sound Power Levels									
Frequency	31.5	63	125	250.0	500	1000	2000	4000	8000
L _w (dB)	117.3	111.5	110.9	109.9	107.0	103.3	97.0	86.6	81.3
A-Weighted Sound Power Levels (at wind speeds)									
Wind speed (m/s)	6	7	8	9	10				

Sound Power Emission Level (dB re 10 ⁻¹² Pa)	104.6	106.0	106.0	106.0	106.0
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Table 8-4: Sound Emission Characteristics used for modelling – Pienaarspoort WEFs

Wind Turbine: Gamesa MCG G132-3.465 MW (Ref: GD287601-en, Rev 01 dated 2017/06/15)									
Maximum expected A-weighted Octave Sound Power Levels									
Frequency	31.5	63	125	250.0	500	1000	2000	4000	8000
L _w (dB)	118.9	109.5	108.7	108.3	105.0	99.8	94.4	91.3	92.7
A-Weighted Sound Power Levels (at wind speeds)									
Wind speed (m/s)			6	7	8	9	10	11	12
Sound Power Emission Level (dB re 10 ⁻¹² Pa)			98.2	101.7	105.0	106.1	106.3	106.1	106.1

8.5 Decommissioning and Closure Phase Noise Impact

The potential for a noise impact to occur during the decommissioning and closure phase will be much lower than that of the construction and operation phases. This is due to the reduced urgency to complete this phase, with most activities limited to the daytime period. The potential significance of the noise impact would be similar as the daytime construction impact (see **Appendix F, Table 1**). The potential significance of the noise impact is summarized in **Table 8-9**.

8.6 No-Go Option

For the No-Go option, existing residual noise levels will remain as is within the project focus area. It is difficult to assess how the No-Go option will impact on the soundscape, as different people will value the existing residual noise levels differently. A person that retired to the area (within 2,000 m from the closest wind turbine) will set a high value to the existing residual noise levels, while the land owner that may financially benefit from the project will have a much lower appreciation of existing residual noise levels. Based on the author's opinion, the No-Go option will result in a positive benefit of low significance, as summarized in **Table 8-10**.

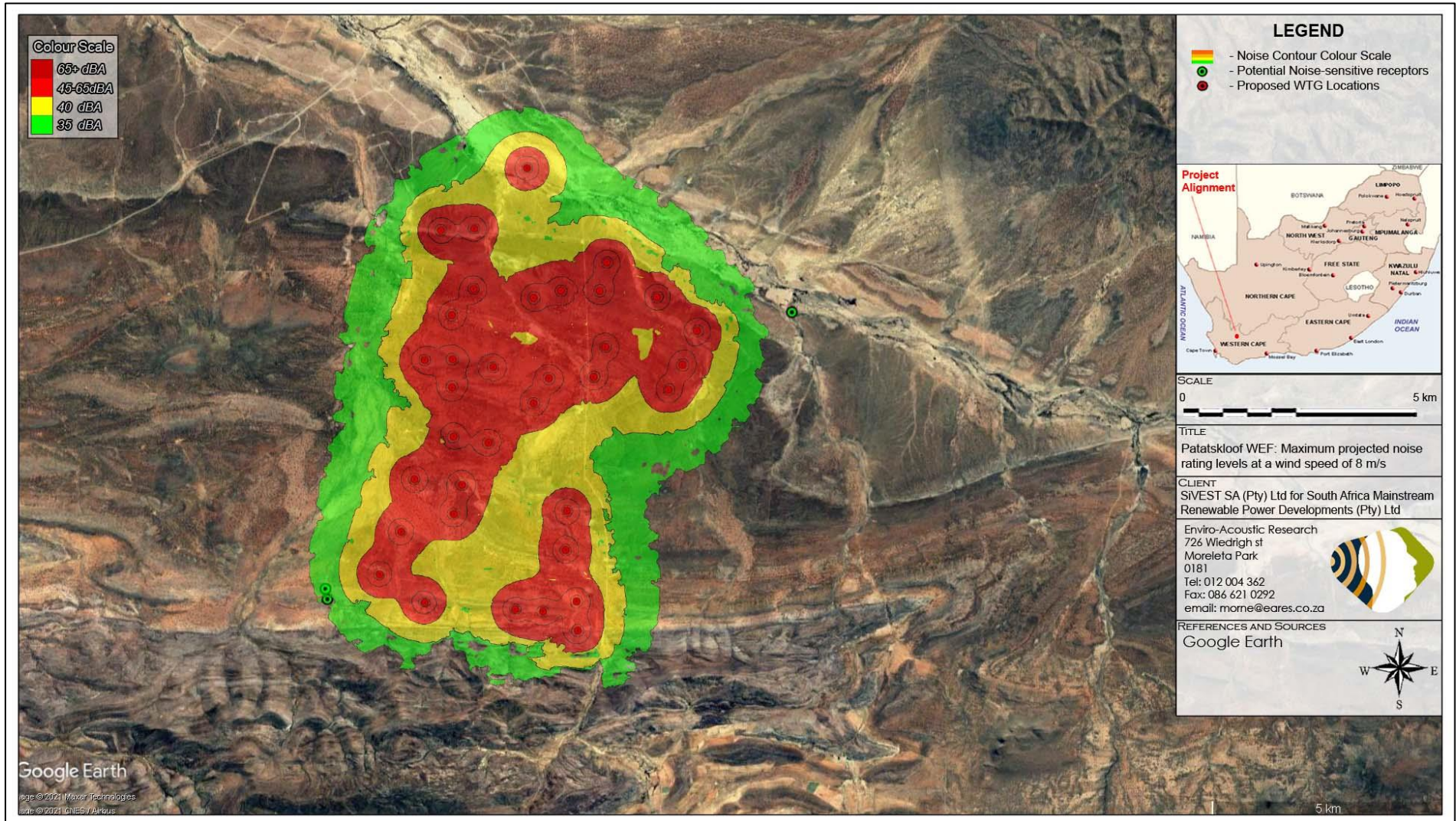


Figure 42: Projected maximum night-time operational noise rating levels due to the operation of the Patatskloof WEF

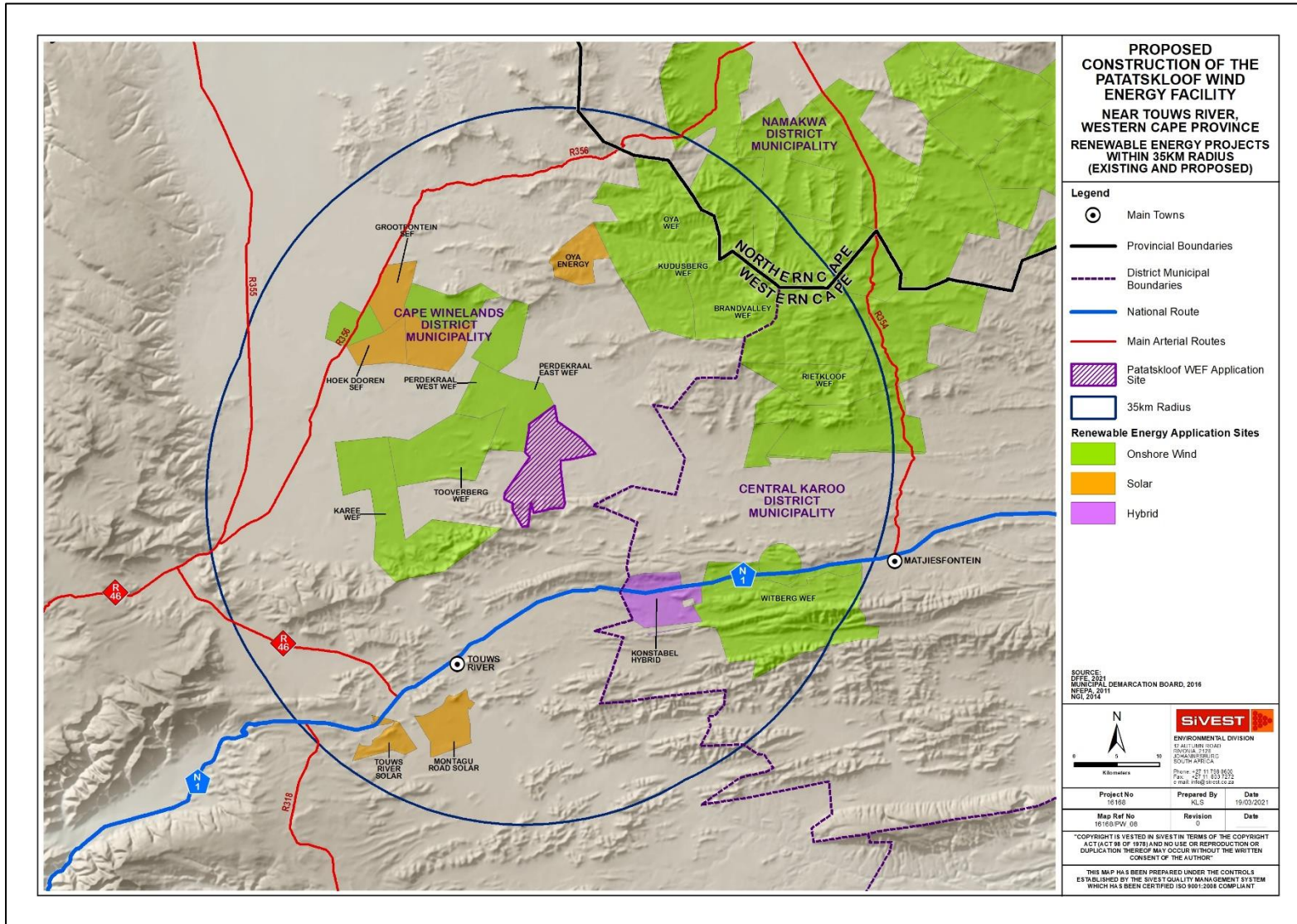


Figure 43: Other Wind Energy Facilities proposed within 35 km of the Proposed Patatskloof WEF

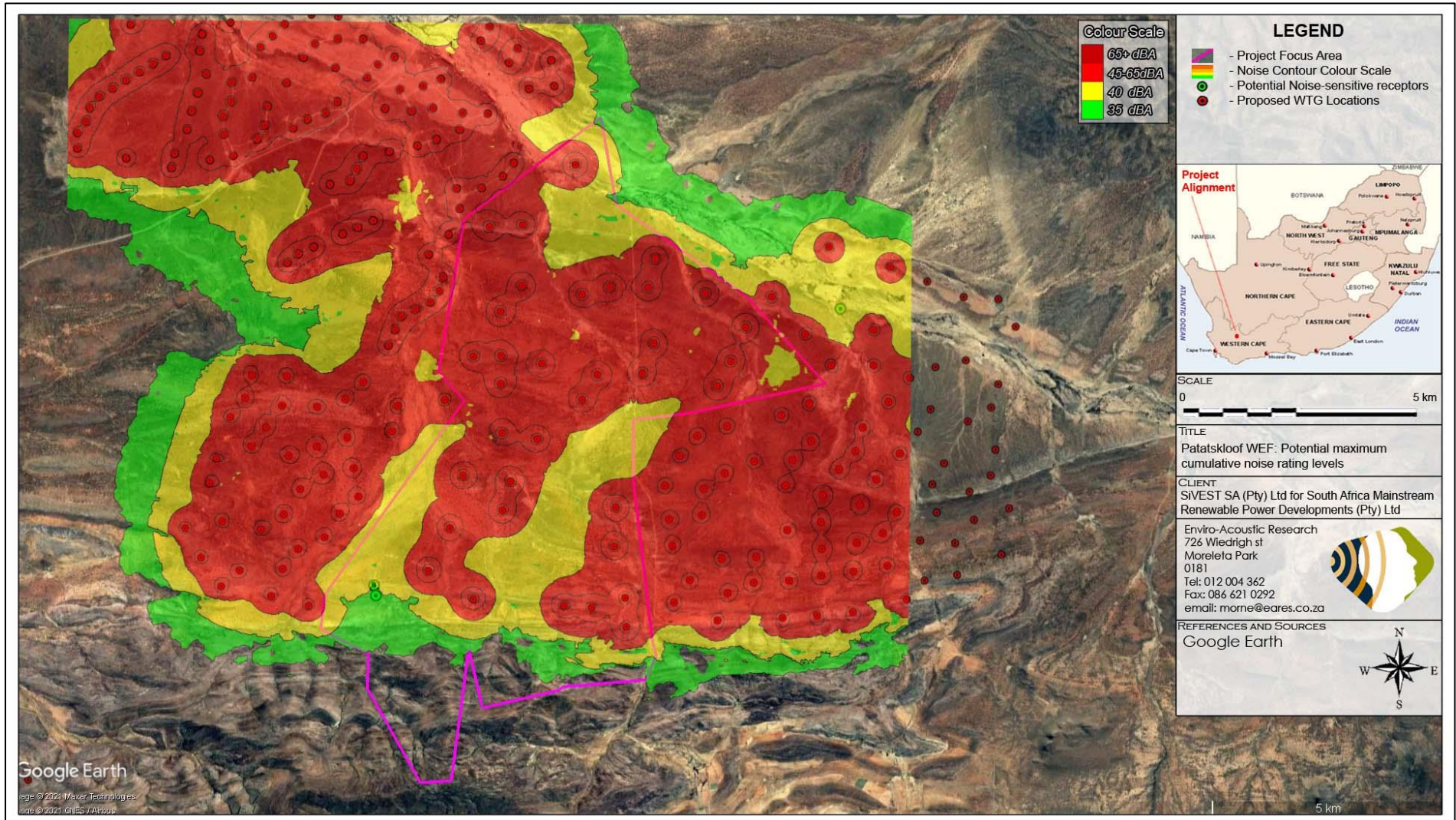


Figure 44: Projected maximum cumulative night-time operational noise rating levels

Table 8-5: Rating of impacts – Planning Phase Noise Impacts

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Planning Phase																				
Noise impacts relating to planning activities	Light delivery vehicles moving around onsite.	1	1	1	1	1	1	5	-	Low	No mitigation measures recommended for the planning stage	1	1	1	1	1	1	5	-	Low

Table 8-6: Rating of impacts – Construction Phase Noise Impact

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Construction Phase																				
Noise impacts during the day	Construction activities relating to hardstand areas, digging of foundations for wind turbines, civil works as well as erection of wind turbines	2	1	1	2	1	1	7	-	Low	No mitigation measures recommended for construction activities at the WTG locations or for substations	2	1	1	2	1	1	7	-	Low
Noise impacts at night	Construction activities relating to civil works as well as erection of wind turbines	2	1	1	2	1	1	8	-	Low	No mitigation measures recommended for construction activities at the WTG locations or for substations.	2	1	1	2	1	1	8	-	Low

Table 8-7: Rating of impacts – Operational noise impact

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Operation Phase																				
Noise Impacts during the day	Noises from operating wind turbines	2	1	1	2	3	1	9	-	Low	No mitigation measures recommended for daytime operational activities	2	1	1	2	3	1	9	-	Low
Noise Impacts at night	Noises from operating wind turbines	2	1	1	3	3	1	10	-	Low	No mitigation measures recommended for night-time operational activities	2	1	1	3	3	1	10	-	Low

Table 8-8: Rating of impacts – Cumulative Noise Impacts

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Cumulative Noise Impacts																				
Increased noise levels	Cumulative noises due to operating wind turbines from other wind energy facilities in the area	2	1	1	3	3	1	10	-	Low	No mitigation measures recommended	2	1	1	3	3	1	10	-	Low

Table 8-9: Rating of impacts – Decommissioning Noise Impacts

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
Decommissioning Noise Impacts																				
Noise impacts during the day	Decommissioning activities relating to removal of infrastructure and wind turbines, rehabilitation of disturbed areas	1	1	1	2	1	1	6	-	Low	No mitigation measures recommended for decommissioning activities for WTGs or substations	1	1	1	2	1	1	6	-	Low

Table 8-10: Rating of impacts – No-Go noise effect

ENVIRONMENTAL PARAMETER	ISSUE / IMPACT / ENVIRONMENTAL EFFECT/ NATURE	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION									RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION								
		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S		E	P	R	L	D	I / M	TOTAL	STATUS (+ OR -)	S
No-Go																				
Residual noise levels to remain unaffected.	Residual noise levels to remain as is.	1	4	1	1	4	1	11	+	Low	No mitigation measures recommended	1	4	1	1	4	1	11	+	Low

9. COMPARATIVE ASSESSMENT OF ALTERNATIVES

9.1 Alternative 1: No-Go Alternative

The residual noise levels will remain as is (relatively low).

9.2 Alternative 2: Proposed Renewable Power Generation activities

The proposed renewable energy activities (worst-case evaluated) will temporarily raise the residual noise levels during the construction phase, with a slight change in residual noise levels during the operational phase. There is no alternative location where the wind farm can be developed as the presence of a viable wind resource determines the viability of a commercial WEF. While the location cannot be moved, the wind turbines within the WEF can be moved around, although this layout is the result of numerous evaluations and modelling to identify the most economically feasible and environmentally sustainable layout.

The developer also proposes two alternative locations for the sub-stations, although both these areas are far from any potential receptors and will not have a noise impact. In terms of acoustics, there is no preference for either of these alternative locations as assessed below.

Alternative	Preference	Reasons (incl. potential issues)
SUBSTATION SITE ALTERNATIVES		
Substation Option 1	No preference	Both options will not result in an insignificant noise impact.
Substation Option 2	No preference	

The proposed Patatskloof WTG layout will result in increased noise levels, but it is highly unlikely to impact on residual noise levels at the closest NSD. Considering the residual noise levels measured in similar areas, the projected noise rating levels will be similar to the on-site residual noise levels during typical periods that the wind turbines will operate (periods with increased wind speeds). There is an insignificant risk of a noise impact, and, while the wind turbines may be audible at night, the noise levels will not be disturbing. However, in terms of acoustics, there is no benefit to the surrounding environment (closest receptors).

The project will greatly assist in the provision of energy, which will allow further economic growth and development in South Africa and locally. The project will generate short and long-term employment and other business opportunities and promote renewable energy in South Africa and locally. People in the area that are not directly affected by increased noises generally have a more positive perception of the renewable projects and understand the need and desirability of the project.

10. MITIGATION MEASURES

This study considers the potential noise impact on the surrounding environment due to construction and operational activities associated with the Patatskloof WEF during the day and night-time periods. It was determined that the potential noise impact would be of a:

- **low significance** for daytime activities related to the construction of the substation, hard standing areas, digging foundations, civil work as well as the erection of the wind turbines;
- **low significance** for night-time activities relating to the construction of civil work as well as the erection of the wind turbines. Mitigation is proposed and available to reduce the significance to **low**;
- **low significance** for both day- and night-time operational activities;
- **low significance** for potential cumulative noises during the operational phase; and,
- **low significance** for potential decommissioning noises.

The developer must know that community involvement needs to continue throughout the project. 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. At all stages, surrounding receptors should be informed about the project, providing them with factual information without setting unrealistic expectations. It is counterproductive to suggest that the activities (or facility) will be inaudible due to existing high residual noise levels. The magnitude of the sound levels will depend on a multitude of variables and will vary from day to day and from place to place with environmental and operational conditions. Audibility is distinct from the sound level, because it depends on the relationship between the sound level from the activities, the spectral character and that of the surrounding soundscape (both level and spectral character).

The developer must implement a line of communication (i.e., a help line where complaints could be lodged). All potential sensitive receptors should be made aware of these contact numbers. The proposed WEF should maintain a commitment to the local community (people staying within 2,000 m from construction or operational activities) and respond to noise concerns in an expedient fashion. Sporadic and legitimate noise complaints could be raised. For example, sudden and sharp increases in sound levels could result from mechanical malfunctions or perforations or slits in the blades. Problems of this nature can be corrected quickly and it is in the developer's interest to do so.

10.1 Mitigation options available to reduce Noise Impact during construction

The significance of noise during the construction phase is low and additional mitigation measures are not required. However, to ensure that potential annoyance with the project is minimized, it is recommended that:

- the applicant minimize night-time construction activities that generate impulsive noises when working within 2,000m from any NSD, planning the completion of noisiest activities (such a pile driving, rock breaking and excavation) during the daytime period;

- where practicable, mobile equipment should be fitted with broadband (white-noise generators/alarms^{26 27}), rather than tonal reverse alarms;
- the applicant (or the environmental control officer) ensure that equipment is well maintained and fitted with the correct and appropriate noise abatement measures. Engine bay covers over heavy equipment could be pre-fitted with sound absorbing material. Heavy equipment that fully encloses the engine bay should be considered, ensuring that the seam gap between the hood and vehicle body is minimised;
- the applicant include a component covering environmental noise in the Health and Safety Induction to sensitize all employees and contractors about the potential impact from noise, especially those employees and contractors that have to travel past receptors at night, or might be required to do work close (within 1,200m) to NSR at night. This should include issues such as minimising the use of vehicle horns; and
- the applicant must minimize night-time construction traffic if the access roads are closer than 150 m from any NSD, alternatively, the access road must be relocated further than 120 m from NSDs (night-time traffic passing occupied houses).

10.2 Mitigation options available to reduce Noise Impact during operation

The significance of noise during the operation phase is low and additional mitigation measures are not required.

10.3 Mitigation options available to reduce Noise Impact during decommissioning

The potential significance of the noise impact would be similar as the daytime construction phase and no further mitigation is recommended or required for the decommissioning phase.

10.4 Special Conditions

10.4.1 *Mitigation options that should be included in the Environmental Management Programme (EMPr)*

- The developer must investigate any reasonable and valid noise complaint if registered by a receptor staying within 2,000 m from the location where construction activities are taking place or operational wind turbine is present. A complaints register must be kept on site.
- The developer must minimize night-time construction traffic if the access roads are closer than 150 m from any NSD, alternatively, the access road must be relocated further than 120 m from NSDs (night-time traffic passing occupied houses).

²⁶White Noise Reverse Alarms: <http://www.brigade-electronics.com/products>.

²⁷<https://www.constructionnews.co.uk/home/white-noise-sounds-the-reversing-alarm/885410.article> - White noise sounds the reversing alarm

10.4.2 *Special conditions that should be considered for the Environmental Authorisation*

- The potential noise impact must be evaluated again should the layout be revised where any wind turbines are located closer than 1,000 m from a confirmed NSD.
- The potential noise impact must be evaluated again should the developer make use of a wind turbine with a maximum sound power emission level exceeding 115.0 dBA re 1 pW (maximum sound power emission level including any uncertainties).
- The developer must investigate any reasonable and valid noise complaint if registered by a receptor staying within 2,000 m from the location where construction or decommissioning activities are taking place or from the operational wind turbine.

11. ENVIRONMENTAL NOISE MONITORING PLAN

Environmental Noise Monitoring can be divided into two distinct categories, namely:

- Passive monitoring – the registering of any complaints (reasonable and valid) regarding noise; and
- Active monitoring – the measurement of ambient sound (or noise) levels at identified locations.

Because the total projected noise levels are less than 42 dBA, active noise monitoring is not required or recommended. Should a reasonable and valid noise complaint be registered, the WEF developer should investigate the noise complaint as per the guidelines below. These guidelines should be used as a rough guideline as site specific conditions may require that the monitoring locations, frequency or procedure be adapted.

11.1 Measurement Localities and Frequency

Should there be a noise complaint, once-off noise measurements must be conducted at the location of the person that registered a valid and reasonable noise complaint. The measurement location should consider the direct surroundings to ensure that other sound sources cannot influence the reading.

11.2 Measurement Procedures

Ambient sound measurements should be collected as defined in SANS 10103:2008, though the protocols as defined by ETSU-R97 (see section 4.5.1) are recommended. Due to the variability that naturally occurs in sound levels at most locations, it is recommended that semi-continuous measurements are conducted over a period of at least 48 hours, covering at least a full day- (06:00 – 22:00) and night-time (22:00 – 06:00) period. Spectral frequencies should also be measured to define the potential origin of noise. When a noise complaint is being investigated, measurements should be collected during a period or in conditions similar to when the receptor experienced the disturbing noise event.

12. CONCLUSION AND SUMMARY

12.1 Summary of Findings

The potential noise impact of the proposed Patatskloof WEF was evaluated using a sound propagation model. Conceptual scenarios were developed for the construction and operation phases. It was determined that the potential noise impact would be of a:

- **low significance** for daytime activities related to the construction of the substation, hard standing areas, digging foundations, civil work as well as the erection of the wind turbines;
- **low significance** for night-time activities relating to the construction of civil work as well as the erection of the wind turbines. Mitigation is proposed and available to reduce the significance to **low**;
- **low significance** for both day- and night-time operational activities;
- **low significance** for potential cumulative noises during the operational phase; and,
- **low significance** for potential decommissioning noises.

The potential noise impact of the decommissioning phase is based on the potential noise impact during daytime construction activities (**low significance**). The development of the Patatskloof WEF will not increase cumulative noises in the area and the significance of the noise impact will be **low**.

12.2 Conclusion and Impact Statement

Considering the **low** significance of the potential noise impacts (with mitigation, inclusive of cumulative impacts) for the proposed WEF and associated infrastructure, it is recommended that the proposed Patatskloof WEF be authorized.

13. REFERENCES

In this report reference was made to the following documentation:

1. Acciona Windpower, 2014: "*General Document – Sound Power Levels AW116/3000*". Document DG200266, Revision D
2. Acoustics, 2008: *A review of the use of different noise prediction models for wind farms and the effects of meteorology*
3. Acoustics Bulletin, 2009: *Prediction and assessment of wind turbine noise*
4. Ambrose, SE and Rand, RW, 2011. *The Bruce McPherson Infrasound and Low Frequency Noise Study: Adverse health effects produced by large industrial wind turbines confirmed*. Rand Acoustics, December 14, 2011.

5. Audiology Today, 2010: *Wind-Turbine Noise – What Audiologists should know*
6. Autumn, Lyn Radle, 2007: *The effect of noise on Wildlife: A literature review*
7. Atkinson-Palombo, C and Hoen, B. 2014: *Relationship between Wind Turbines and Residential Property Values in Massachusetts – A Joint Report of University of Connecticut and Lawrence Berkley National Laboratory*. Boston, Massachusetts
8. Bakker, RH et al. 2011: *Effects of wind turbine sound on health and psychological distress*. Science of the Total Environment (in press, 2012)
9. Barber, J.R., K.R. Crooks, and K. Fristrup. 2010. *The costs of chronic noise exposure for terrestrial organisms*. Trends Ecology and Evolution 25(3): 180–189
10. Bass JH et al, 1996: *Development of a wind farm noise propagation prediction model*. JH Bass, AJ Bullmore, E Sloth. Contract JOR3-CT95-0051. Renewable Energy Systems Limits, Hoare Lea & Partners Acoustics, Acoustica A/S
11. Bayne EM et al, 2008: *Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest*. Conservation Biology 22(5) 1186-1193.
12. Bolin et al, 2011: *Infrasound and low frequency noise from wind turbines: exposure and health effects*. Environ. Res. Lett. 6 (2011) 035103
13. Bowdler, Dick, 2008: *Amplitude modulation of wind turbine noise: a review of the evidence*
14. Bray, W and James, R. 2011. *Dynamic measurements of wind turbine acoustic signals, employing sound quality engineering methods considering the time and frequency sensitivities of human perception*. Noise-Con 2011.
15. Broucek, J. 2014. *Effect of Noise on Performance, Stress and Behaviour of Animals*. Slovak J. Anim. Sci., 47, 2014 (2): 111-123
16. BWEA, 2005: *Low Frequency Noise and Wind Turbines – Technical Annex*
17. Chapman et al. 2013: *Spatio-temporal differences in the history of health and noise complaints about Australian wind farms: evidence for the psychogenic, “communicated disease” hypothesis*. Sydney School of Public Health, University of Sydney
18. Chief Medical Officer of Health, 2010: *The Potential Health Impact of Wind Turbines*, Canada
19. Cooper, 2012: *Are Wind Farms too close to communities*, The Acoustic Group (date posted on Wind-watch.org: Referenced on various anti-wind energy websites)
20. Crichton et al. 2014: *Can expectations produce symptoms from infrasound associated with wind turbines?. Health Psychology, Vol 33(4), Apr 2014, 360-364*
21. CSIR, 2002: *Integrated Environmental Management Information Series: Information Series 5: Impact Assessment*. Issued by the Department of Environmental Affairs and Tourism, Pretoria
22. CSIR, 2015: *The Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa*. Issued by the Department of Environmental Affairs and Tourism, Pretoria
23. Cummings, J. 2012: *Wind Farm Noise and Health: Lay summary of new research released in 2011*. Acoustic Ecology Institute, April 2012 (online resource: http://www.acousticecology.org/wind/winddocs/AEI_WindFarmsHealthResearch2011.pdf)
24. Cummings, J. 2009: *AEI Special Report: Wind Energy Noise Impacts*. Acoustic Ecology Institute, (online resource: <http://acousticecology.org/srwind.html>)

25. De Jager, M. (2016). “*Proposed development of the Perdekraal Wind Energy Facility North of Touws River, Western Cape Province*”, Enviro-Acoustic Research cc, Pretoria
26. De Jager, M. (2018): “*Comparative Noise Impact Assessment for the Establishment of the Perdekraal West Wind Energy Facility North of Touws River, Western Cape*”. Enviro-Acoustic Research CC, Pretoria
27. De Jager, M. 2021: “*Environmental Noise Impact Assessment for the proposed Pienaarspoort Wind Energy Facility 2 and associated infrastructure North of Touws River, Western Cape Province*”. Enviro-Acoustic Research, Pretoria
28. DEFRA, 2003: *A Review of Published Research on Low Frequency Noise and its Effects*, Report for Defra by Dr Geoff Leventhall Assisted by Dr Peter Pelmeare and Dr Stephen Benton
29. DEFRA, 2007: *Research into Aerodynamic Modulation of Wind Turbine Noise: Final Report*
30. DELTA, 2008: *EFP-06 project: Low Frequency Noise from Large Wind Turbines, a procedure for evaluation of the audibility for low frequency sound and a literature study*. Danish Energy Authority
31. Derryberry EP et al, 2016: *Patterns of song across Natural and Anthropogenic Soundscapes suggest that White-Crowned Sparrows minimize acoustic masking and maximize signal content*. PLOS ONE| DOI: 10.1371/journal.pone.0154456, April 29, 2016
32. Dooling, R. 2002. *Avian Hearing and the Avoidance of Wind Turbines*. National Renewable Energy Laboratory, NREL/TP-500-30844
33. Dooling R. J., and A. N. Popper. 2007. *The effects of highway noise on birds*. Report to the California Department of Transportation, contract 43AO139. California Department of Transportation, Division of Environmental Analysis, Sacramento, California, USA
34. Duncan, E. and Kaliski, K. 2008: *Propagation Modelling Parameters for Wind Power Projects*
35. Enertrag, 2008: *Noise and Vibration*. Hempnall Wind Farm (<http://www.enertraguk.com/technical/noise-and-vibration.html>)
36. ETSU R97: 1996. ‘*The Assessment and Rating of Noise from Wind Farms: Working Group on Noise from Wind Turbines*’
37. Evans Tom, Cooper Jonathan, 2012: *Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms*. Acoustics Australia, Vol. 40, No. 1, April 2012.
38. Evans, T. Cooper, J. Lenchine, V. 2013: *Infrasound Levels near Windfarms and in other Environments*. Resonate Acoustics in conjunction with Environment Protection Authority, South Australia
39. Garrad Hassan, 2013: *Summary of results of the noise emission measurement, in accordance with IEC 61400-11, of a WTGS of the type N117/3000*. Doc. GLGH-4286 12 10220 258-S-0002-A (extract from GLGH-4286 12 10220 258-A-0002-A)
40. Gibbons, S. 2014: *Gone with the Wind: Valuing the Visual Impacts of Wind turbines through House Prices*, Spatial Economics Research Centre
41. Guillaume Dutilleux. *Anthropogenic outdoor sound and wildlife: it's not just bioacoustics!*. Société Française d'Acoustique. Acoustics 2012, Apr 2012, Nantes, France
42. Hanning, 2010: *Wind Turbine Noise, Sleep and Health*. (referenced on a few websites, especially anti-wind energy. No evidence that the study has been published formally.)

43. Havas, M and Colling, D. 2011: *Wind Turbines Make Waves: Why Some Residents Near Wind Turbines Become Ill*. *Bulletin of Science Technology & Society* published online 30 September 2011
44. Hessler, D. 2011: *Best Practices Guidelines for Assessing Sound Emissions From Proposed Wind Farms and Measuring the Performance of Completed Projects*. Prepared for the Minnesota Public Utilities Commission, under the auspices of the National Association of Regulatory Utility Commissioners (NARUC)
45. HGC Engineering, 2006: *Wind Turbines and Infrasound*, report to the Canadian Wind Energy Association
46. HGC Engineering, 2007: *Wind Turbines and Sound*, report to the Canadian Wind Energy Association
47. HGC Engineering, 2011: *Low frequency noise and infrasound associated with wind turbine generator systems: A literature review*. Ontario Ministry of the Environment RFP No. OSS-078696.
48. IFC, 2007: '*Environmental, Health, and Safety General Guidelines*'. International Finance Corporation, Washington
49. IFC, 2015: '*Environmental, Health, and Safety Guidelines for Wind Energy*'. International Finance Corporation, Washington
50. ISO 9613-2: 1996. '*Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*'
51. Jeffery *et al*, 2013: *Adverse health effects of industrial wind turbines*, *Can Fam Physician*, 2013 May. 59(5): 473-475
52. Journal of Acoustical Society of America, 2009: *Response to noise from modern wind farms in the Netherlands*
53. Kaliski K & Duncan E, 2008: *Propagation modelling Parameters for Wind Power Projects*.
54. Kaliski K & Wilson DK. 2011: *Improving predictions of wind turbine noise using PE modelling*. Noise-con 2011.
55. Kamperman GW & James RR, 2008: *The "How to" guide to siting wind turbines to prevent health risks from sound*
56. Knopper LD & Ollsen CA. 2011. *Health effects and wind turbines: A review of the literature*. *Environmental Health* 2011, 10:78
57. Kroesen & Schreckenberg, 2011. *A measurement model for general noise reaction in response to aircraft noise*. *J. Acoust. Soc. Am.* 129 (1), January 2011, 200-210
58. Lohr B *et al*, 2003. *Detection and discrimination of natural calls in masking noise by birds: estimating the active space of a signal*. B Lohr, TF Wright & RJ Dooling. *Animal Behavior* 65:763-777
59. McMurtry RY, 2011: *Toward a Case Definition of Adverse Health Effects in the Environs of Industrial Wind Turbines: Facilitating a Clinical Diagnosis*. *Bulletin of Science Technology Society*. August 2011 vol. 31 no. 4 316-320
60. Minnesota Department of Health, 2009: *Public Health Impacts of Wind Farms*
61. Ministry of the Environment, 2008: *Noise Guidelines for Wind Farms, Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities*
62. Møller H, 2010: *Low-frequency noise from large wind turbines*. *J. Acoust. Soc. Am.* 129(6), June 2011, 3727 - 3744

63. Nissenbaum A, 2012: *Effects of industrial wind turbine noise on sleep and health*. Noise and Health, Vol. 14, Issue 60, p 237 – 243.
64. Noise-con, 2008: *Simple guidelines for siting wind turbines to prevent health risks*
65. Noise quest, Aviation Noise Information & Resources, 2010: <http://www.noisequest.psu.edu/pmwiki.php?n=Main.HomePage>
66. Norton, M.P. and Karczub, D.G.: *Fundamentals of Noise and Vibration Analysis for Engineers*, Second Edition, 2003
67. Oud, M. 2012: *Low-frequency noise: a biophysical phenomenon* (http://www.leefmilieu.nl/sites/www3.leefmilieu.nl/files/imported/pdf_s/2012_OudM_Low-frequency%20noise_0.pdf) (unpublished webresource)
68. O'Neal, et al. 2011: *Low frequency noise and infrasound from wind turbines*. Noise Control Eng. J. 59 (2), March-April 2011
69. Parry G, 2008: *A review of the use of different noise prediction models for windfarms and the effect of meteorology*. Acoustics 2008, Paris.
70. Pedersen, Eja; Halmstad, Höskolan I, 2003: *'Noise annoyance from wind turbines: a review'*. Naturvårdsverket, Swedish Environmental Protection Agency, Stockholm
71. Pedersen, E. 2011: *"Health aspects associated with wind turbine noise—Results from three field studies"*, Noise Control Eng. J. 59 (1), Jan-Feb 2011
72. Phillips, CV, 2011: *"Properly Interpreting the Epidemiologic Evidence About the Health Effects of Industrial Wind Turbines on Nearby Residents"*. Bulletin of Science Technology & Society 2011 31: 303 DOI: 10.1177/0270467611412554
73. Pierpont, N. 2009: *"Wind Turbine Syndrome: A Report on a Natural Experiment"*, K Select Books, 2009
74. Punch, et al. 2010: *Wind Turbine Noise. What Audiologists should know*. Audiology Today. JulAug2010
75. Quinn, J.L., M.J. Whittingham, S.J. Butler, and W. Cresswell. 2006. *Noise, predation risk compensation and vigilance in the chaffinch *Fringilla coelebs**. Journal of Avian Biology 37: 601-608
76. Rabin, L.A., R.G. Coss, D.H. Owings. 2006. *The effects of wind turbines on antipredator behavior in California ground squirrels (*Spermophilus beecheyi*)*. Biological Conservation 131: 410-420
77. Renewable Energy Research Laboratory, 2006: *Wind Turbine Acoustic Noise*
78. Report to Congressional Requesters, 2005: *Wind Power – Impacts on Wildlife and Government Responsibilities for Regulating Development and Protecting Wildlife*
79. SANS 10103:2008. *'The measurement and rating of environmental noise with respect to annoyance and to speech communication'*.
80. SANS 10210:2004. *'Calculating and predicting road traffic noise'*.
81. SANS 10328:2008. *'Methods for environmental noise impact assessments'*.
82. SANS 10357:2004. *The calculation of sound propagation by the Concave method'*.
83. Schaub, A, J. Ostwald and B.M. Siemers. 2008. *"Foraging bats avoid noise"*. The Journal of Experimental Biology 211: 3174-3180

84. Šottník, J. 2011: *Influence of noise and object noisiness on animal breeding*. Šiška, B. – Hauptvogel, M. – Eliašová, M. (eds.). Bioclimate: Source and Limit of Social Development International Scientific Conference, 6th – 9th September 2011, Topoľčianky, Slovakia
85. Sheperd, D and Billington, R. 2011: *Mitigating the Acoustic Impacts of Modern Technologies: Acoustic, Health, and Psychosocial Factors Informing Wind Farm Placement*. *Bulletin of Science Technology & Society* published online 22 August 2011, DOI: 10.1177/0270467611417841
86. Shepherd, D et al. 2011: *Evaluating the impact of wind turbine noise on health related quality of life*. *Noise & Health*, September-October 2011, 13:54,333-9.
87. Smith, M (et al) (2012): “*Mechanisms of amplitude modulation in wind turbine noise*”; Proceedings of the Acoustics 2012 Nantes Conference
88. Stigwood (et al) (2013): “*Audible amplitude modulation – results of field measurements and investigations compared to psycho-acoustical assessments and theoretical research*”; Paper presented at the 5th International Conference on Wind Turbine Noise, Denver 28 – 30 August 2013
89. Tachibana, H (et al) (2013): “*Assessment of wind turbine noise in immission areas*”; Paper presented at the 5th International Conference on Wind Turbine Noise, Denver 28 – 30 August 2013
90. Thorne et al, 2010: *Noise Impact Assessment Report Waubra Wind Farm Mr & Mrs N Dean Report No 1537 - Rev 1*
91. Thorne, 2010: *The Problems with "Noise Numbers" for Wind Farm Noise Assessment*. *Bulletin of Science Technology and Society*, 2011 31: 262
92. Tonin, R et al, 2016: *The effect of infrasound and negative expectations to adverse pathological symptoms from wind farms*. *Journal of Low Frequency Noise, Vibration and Active Control* 2016, Vol 35(1) 77-90
93. USEPA, 1971: *Effects of Noise on Wildlife and other animals*
94. Van den Berg, G.P., 2003. ‘*Effects of the wind profile at night on wind turbine sound*’. *Journal of Sound and Vibration*
95. Van den Berg, G.P., 2004. ‘*Do wind turbines produce significant low frequency sound levels?*’. 11th International Meeting on Low Frequency Noise and Vibration and its Control
96. Wang, Z. 2011: *Evaluation of Wind Farm Noise Policies in South Australia: A Case Study of Waterloo Wind Farm*. Masters Degree Research Thesis, Adelaide University 2011
97. Whitford, Jacques, 2008: *Model Wind Turbine By-laws and Best Practices for Nova Scotia Municipalities*
98. Williams, Brett. 2018: *Noise Impact Assessment – Proposed Development of up to 264MW Tooverberg Wind Energy Facility located near Touws River in the Western Cape Province*. Safetech, Port Elizabeth (Report 26/5731 – Version 2 as on 20/11/2018)
99. World Health Organization, 1999: *Protection of the Human Environment; Guidelines for Community Noise*
100. World Health Organization, 2009: *Night Noise Guidelines for Europe*
101. World Health Organization, 2018: *Environmental Noise Guidelines for the European Region*. Copenhagen, Denmark

APPENDIX A

Resumé of the Author

The Author started his career in the mining industry as a bursar Learner Official (JCI, Randfontein), working in the mining industry, doing various mining related courses (Rock Mechanics, Surveying, Sampling, Safety and Health [Ventilation, noise, illumination etc] and Metallurgy. He did work in both underground (Coal, Gold and Platinum) as well as opencast (Coal) for 4 years. He changed course from Mining Engineering to Chemical Engineering after his second year of his studies at the University of Pretoria.

After graduation he worked as a Water Pollution Control Officer at the Department of Water Affairs and Forestry for two years (first year seconded from Wates, Meiring and Barnard), where duties included the perusal (evaluation, commenting and recommendation) of various regulatory required documents (such as EMPR's, Water Use License Applications and EIA's), auditing of license conditions as well as the compilation of Technical Documents.

Since leaving the Department of Water Affairs, Morné has been in private consulting for the last 20 years, managing various projects for the mining and industrial sector, private developers, business, other environmental consulting firms as well as the Department of Water Affairs. During that period he has been involved in various projects, either as specialist, consultant, trainer or project manager, successfully completing these projects within budget and timeframe. During that period he gradually moved towards environmental acoustics, focusing on this field exclusively since 2007.

He has been interested in acoustics as from school days, doing projects mainly related to loudspeaker design. Interest in the matter brought him into the field of Environmental Noise Measurement, Prediction and Control as well as blasting impacts. Since 2007 he has completed more than 400 Environmental Noise Impact Assessments and Noise Monitoring Reports as well as various acoustic consulting services, including amongst others:

Wind Energy Facilities

Full Environmental Noise Impact Assessments for - Bannf (Vidigenix), iNca Gouda (Aurecon SA), Isivunguvungu (Aurecon), De Aar (Aurecon), Kokerboom 1 (Aurecon), Kokerboom 2 (Aurecon), Kokerboom 3 (Aurecon), Kangnas (Aurecon), Plateau East and West (Aurecon), Wolf (Aurecon), Outeniqwa (Aurecon), Umsinde Emoyeni (ARCUS), Komsberg (ARCUS), Karee (ARCUS), Kolkies (ARCUS), San Kraal (ARCUS), Phezukomoya (ARCUS), Canyon Springs (Canyon Springs), Perdekraal (ERM), Scarlet Ibis (CESNET), Albany (CESNET), Sutherland (CSIR), Kap Vley (CSIR), Kuruman (CSIR), Rietrug (CSIR), Sutherland 2 (CSIR), Perdekraal (ERM), Teekloof (Mainstream), Eskom Aberdene (SE), Dorper (SE), Spreeukloof (SE), Loperberg (SE), Penhoek Pass (SE), Amakhala Emoyeni (SE), Zen (Savannah Environmental – SE), Goereesoe (SE), Springfontein (SE), Garob (SE), Project Blue (SE), ESKOM Kleinzee (SE), Namas (SE), Zonnequa (SE), Walker Bay (SE), Oyster Bay (SE), Hidden Valley (SE), Deep River (SE), Tsitsikamma (SE), AB (SE), West Coast One (SE), Hopefield II (SE), Namakwa Sands (SE), VentuSA Gouda (SE), Dorper (SE), Klipheuwel (SE), INCA Swellendam (SE), Cookhouse (SE), Iziduli (SE), Msenge (SE), Cookhouse II (SE), Rhebokfontein (SE), Suurplaat (SE), Karoo Renewables (SE), Koningaas (SE), Spitskop (SE), Castle (SE), Khai Ma (SE), Poortjies (SE), Korana (SE), IE Moorreesburg (SE), Gunstfontein (SE), Boulders (SE), Vredenburg (Terramanzi), Loeriesfontein (SiVEST), Rhenosterberg (SiVEST), Noupoot (SiVEST), Prieska (SiVEST), Dwarsrug (SiVEST), Graskoppies (SiVEST), Philco (SiVEST), Hartebeest Leegte (SiVEST), Ithemba (SiVEST), !Xha Boom (SiVEST), Spitskop West (Terramanzi), Haga Haga (Terramanzi), Vredenburg (Terramanzi), Msenge Emoyeni (Windlab), Wobben (IWP), Trakas (SiVest), Beaufort West (SiVest)

Mining and Industry

Full Environmental Noise Impact Assessments for – Delft Sand (AGES), BECSA – Middelburg (Golder Associates), Kromkrans Colliery (Geovicon Environmental), SASOL Borrow Pits Project (JMA Consulting), Lesego Platinum (AGES), Tweefontein Colliery (Cleanstream Environmental), Evraz Vametco Mine and Plant (JMA), Goedehoop Colliery (Geovicon), Hakra Project (Prescali Environmental), Der Brochen Platinum Project (J9 Environment), Brandbach Sand (AGES), Verkeerdepan Extension (CleanStream Environmental), Dwaalboom Limestone (AGES), Jagdlust Chrome (MENCO), WPB Coal (MENCO), Landau Expansion (CleanStream Environmental), Otjikoto Gold (AurexGold), Klipfontein Colliery (MENCO), Imbabala Coal (MENCO), ATCOM East Expansion (Jones and Wagner), IPP Waterberg Power Station (SE), Kangra Coal (ERM), Schoongesicht (CleanStream Environmental), EastPlats (CleanStream Environmental), Chapudi Coal (Jacana Environmental), Generaal Coal (JE), Mopane Coal (JE), Glencore Boshhoek Chrome (JMA), Langpan Chrome (PE), Vlakpoort Chrome (PE), Sekoko Coal (SE), Frankford Power (REMIG), Strahrae Coal (Ferret Mining), Transalloys Power Station (Savannah), Pan Palladium Smelter, Iron and PGM Complex (Prescali Environmental), Fumani Gold (AGES), Leiden Coal (EIMS), Colenso Coal and Power Station (SiVEST/EcoPartners), Klippoortjie Coal (Gudani), Rietspruit Crushers (MENCO), Assen Iron (Tshikovha), Transalloys (SE), ESKOM Ankerlig (SE), Nooitgedacht Titano Project (EcoPartners), Algoa Oil Well (EIMS), Spitskop Chrome (EMAssistance), Vlakfontein South (Gudani), Leandra Coal (Jacana), Grazvalley and Zoetveld (Prescali), Tjate Chrome (Prescali), Langpan Chromite (Prescali), Vereeniging Recycling (Pro Roof), Meyerton Recycling (Pro Roof), Hammanskraal Billeting Plant 1 and 2 (Unica), Development of Altona Furnace, Limpopo Province (Prescali Environmental), Haakdoordrift Opencast at Amandelbult Platinum (Aurecon), Landau Dragline relocation (Aurecon), Stuart Coal Opencast (CleanStream Environmental), Tetra4 Gas Field Development (EIMS), Kao Diamonds – Tipping Village Relocation (EIMS), Kao Diamonds – West Valley Tailings Deposit (EIMS), Upington Special Economic Zone (EOH), Arcellor Mittal CCGT Project near Saldanha (ERM), Malawi Sugar Mill Project (ERM), Proposed Mooifontein Colliery (Geovicon Environmental), Goedehoop North Residue Deposit Expansion (Geovicon Environmental), Mutsho 600MW Coal-Fired Power Plant (Jacana Environmental), Tshivhaso Coal-Fired Power Plant (Savannah Environmental), Doornhoek Fluorspar Project (Exigo), Royal Sheba Project (Cabanga Environmental), Rietkol Silica (Jacana), Gruisfontein Colliery (Jacana), Lehlabile Colliery (Jaco-K Consulting), Bloemendal Colliery (Enviro-Insight), Rondevly Colliery (REC), Welgedacht Colliery (REC), Kalabasfontein Extension (EIMS), Waltloo Power Generation Project (EScience), Buffalo Colliery (Marang), Balgarthen Colliery (Rayten), Kusipongo Block C (Rayten), Zandheuvel (Exigo), NamPower Walvis Bay (GPT), Eloff Phase 3 (EIMS), Dunbar (Enviro-Insight), Smokey Hills (Prescali), Bierspruit (Aurecon)

Road and Railway

K220 Road Extension (Urbansmart), Boskop Road (MTO), Sekoko Mining (AGES), Davel-Swaziland-Richards Bay Rail Link (Aurecon), Moloto Transport Corridor Status Quo Report and Pre-Feasibility (SiVEST), Postmasburg Housing Development (SE), Tshwane Rapid Transport Project, Phase 1 and 2 (NRM Consulting/City of Tshwane), Transnet Apies-river Bridge Upgrade (Transnet), Gautrain Due-diligence (SiVest), N2 Piet Retief (SANRAL), Atterbury Extension, CoT (Bokomoso Environmental), Riverfarm Development (Terramanzi), Conakry to Kindia Toll Road (Rayten)

Airport

Oudtshoorn Noise Monitoring (AGES), Sandton Heliport (Alpine Aviation), Tete Airport Scoping (Aurecon)

Noise monitoring and Audit Reports

Peerboom Colliery (EcoPartners), Thabametsi (Digby Wells), Doxa Deo (Doxa Deo), Harties Dredging (Rand Water), Xstrata Coal – Witbank Regional (Xstrata), Sephaku Delmas (AGES), Amakhala Emoyeni WEF (Windlab Developments), Oyster Bay WEF (Renewable Energy Systems), Tsitsikamma WEF Ambient Sound Level study (Cennergi and SE), Hopefield WEF (Umoya), Wesley WEF (Innowind), Ncora WEF (Innowind), Boschmanspoort (Jones and Wagner), Nqamakwe WEF (Innowind), Hopefield WEF Noise Analysis (Umoya), Dassiesfontein WEF Noise Analysis (BioTherm), Transnet Noise Analysis (Aurecon), Jeffries Bay Wind Farm (Globeleq), Sephaku Aganang (Exigo), Sephaku Delmas (Exigo), Beira Audit (BP/GPT), Nacala Audit (BP/GPT), NATREF (Nemai), Rappa Resources (Rayten), Measurement Report for Sephaku Delmas (Ages), Measurement Report for Sephaku Aganang (Ages), Bank of Botswana measurements (Linnospace), Skukuza Noise Measurements (Concor), Development noise measurement protocol for Mamba Cement (Exigo), Measurement Report for Mamba Cement (Exigo), Measurement Report for Nokeng Fluorspar (Exigo), Tsitsikamma Community Wind Farm Pre-operation sound measurements (Cennergi), Waainek WEF Operational Noise Measurements (Innowind), Sedibeng Brewery Noise Measurements (MENCO),

	<p><i>Tsitsikamma Community Wind Farm Operational noise measurements (Cennergi), Noupoot Wind Farm Operational noise measurements (Mainstream), Twisdraai Colliery (Lefatshe Minerals), SASOL Prospecting (Lefatshe Minerals), South32 Klipspruit (Rayten), Sibanye Stillwater Kroondal (Rayten), Rooiberg Asphalt (Rooiberg Asphalt), SASOL Shondoni (Lefatshe), SASOL Twisdraai (Lefatshe), Anglo Mototolo (Exigo), Heineken Inyaniga (AECOM), Glencore Izimbiwa (Cleanstream) Glencore Impunzi (Cleanstream), Black Chrome Mine (Prescali) Sibanye Stillwater Ezulwini (Aurecon), Sibanye Stillwater Beatrix (Aurecon), Bank of Botswana (Linspace), Lakeside (Linspace), Skukuza (SiVest), Rietvlei Colliery (Jaco-K Consulting)</i></p>
<p>Small Noise Impact Assessments</p>	<p><i>TCTA AMD Project Baseline (AECOM), NATREF (Nemai Consulting), Christian Life Church (UrbanSmart), Kosmosdale (UrbanSmart), Louwlaridia K220 (UrbanSmart), Richards Bay Port Expansion (AECOM), Babalegi Steel Recycling (AGES), Safika Slag Milling Plant (AGES), Arcelor Mittal WEF (Aurecon), RVM Hydroplant (Aurecon), Grootvlei PS Oil Storage (SiVEST), Rhenosterberg WEF, (SiVEST), Concerto Estate (BPTrust), Ekuseni Youth Centre (MENCO), Kranskop Industrial Park (Cape South Developments), Pretoria Central Mosque (Noman Shaikh), Soshanguve Development (Maluleke Investments), Seshego-D Waste Disposal (Enviroexcellence), Zambesi Safari Equipment (Owner), Noise Annoyance Assessment due to the Operation of the Gautrain (Thornhill and Lakeside Residential Estate), Upington Solar (SE), Ilangaletu Solar (SE), Pofadder Solar (SE), Flagging Trees WEF (SE), Uyekraal WEF (SE), Ruuki Power Station (SE), Richards Bay Port Expansion 2 (AECOM), Babalegi Steel Recycling (AGES), Safika Ladium (AGES), Safika Cement Isando (AGES), RareCo (SE), Struisbaai WEF (SE), Perdekraal WEF (ERM), Kotula Tsatsi Energy (SE), Olievenhoutbosch Township (Nali), , HDMS Project (AECOM), Quarry extensions near Ermelo (Rietspruit Crushers), Proposed uMzimkhulu Landfill in KZN (nZingwe Consultancy), Linksfield Residential Development (Bokomoso Environmental), Rooihuiskraal Ext. Residential Development, CoT (Plandev Town Planners), Floating Power Plant and LNG Import Facility, Richards Bay (ERM), Floating Power Plant project, Saldanha (ERM), Vopak Growth 4 project (ERM), Elandspoot Ext 3 Residential Development (Gibb Engineering), Tiegerpoort Wedding Venue (Henwood Environmental), Monavoni Development (Marindzini), Rezoning of Portion 1 (Primo Properties), Tswaing Mega City (Makole), Mabopane Church (EP Architects), ERGO Soweto Cluster (Kongiwe), Fabio Chains (Marang), GIDZ JMP (Marang), Temple Complex (KWP Create), Germiston Metals (Dorean), Sebenza Metals (Dorean)</i></p>
<p>Project reviews and amendment reports</p>	<p><i>Loperberg (Savannah), Dorper (Savannah), Penhoek Pass (Savannah), Oyster Bay (RES), Tsitsikamma Community Wind Farm Noise Simulation project (Cennergi), Amakhala Emoyeni (Windlab), Spreeukloof (Savannah), Spinning Head (SE), Kangra Coal (ERM), West Coast One (Moyeng Energy), Rhebokfontein (Moyeng Energy), De Aar WEF (Holland), Quarterly Measurement Reports – Dangote Delmas (Exigo), Quarterly Measurement Reports – Dangote Lichtenburg (Exigo), Quarterly Measurement Reports – Mamba Cement (Exigo), Quarterly Measurement Reports – Dangote Delmas (Exigo) Quarterly Measurement Reports – Nokeng Fluorspar (Exigo), Proton Energy Limited Nigeria (ERM), Hartebeest WEF Update (Moorreesburg) (Savannah Environmental), Modderfontein WEF Opinion (Terramanzi), IPD Vredenburg WEF (IPD Power Vredenburg), Paul Puts WEF (ARCUS), Juno WEF (ARCUS), etc.</i></p>

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APPENDIX B

Glossary of Terms

GLOSSARY OF ACOUSTIC TERMS, DEFINITIONS AND GENERAL INFORMATION

<i>1/3-Octave Band</i>	A filter with a bandwidth of one-third of an octave representing four semitones, or notes on the musical scale. This relationship is applied to both the width of the band, and the centre frequency of the band. See also definition of octave band.
<i>A – Weighting</i>	An internationally standardised frequency weighting that approximates the frequency response of the human ear and gives an objective reading that therefore agrees with the subjective human response to that sound.
<i>Air Absorption</i>	The phenomena of attenuation of sound waves with distance propagated in air, due to dissipative interaction within the gas molecules.
<i>Alternatives</i>	A possible course of action, in place of another, that would meet the same purpose and need (of proposal). Alternatives can refer to any of the following, but are not limited hereto: alternative sites for development, alternative site layouts, alternative designs, alternative processes and materials. In Integrated Environmental Management the so-called “no go” alternative refers to the option of not allowing the development and may also require investigation in certain circumstances.
<i>Ambient</i>	The conditions surrounding an organism or area.
<i>Ambient Noise</i>	As defined in SANS 10103: The all-encompassing sound at a point being composed of sounds from many sources both near and far. It includes the noise from the noise source under investigation.
<i>Ambient Sound</i>	The all-encompassing sound at a point being composite of sounds from near and far.
<i>Ambient Sound Level</i>	Means the reading on an integrating impulse sound level meter taken at a measuring point in the absence of any alleged disturbing noise at the end of a total period of at least 10 minutes after such a meter was put into operation as defined by the National Noise Control Regulations (GNR 154 of 1992).
<i>Amplitude Modulated Sound</i>	A sound that noticeably fluctuates in loudness over time.
<i>Applicant</i>	Any person who applies for an authorisation to undertake a listed activity or to cause such activity in terms of the relevant environmental legislation.
<i>Assessment</i>	The process of collecting, organising, analysing, interpreting and communicating data that is relevant to some decision.
<i>Attenuation</i>	Term used to indicate reduction of noise or vibration, by whatever method necessary, usually expressed in decibels.
<i>Audible frequency Range</i>	Generally assumed to be the range from about 20 Hz to 20,000 Hz, the range of frequencies that our ears perceive as sound.
<i>Ambient Sound</i>	The all-encompassing sound at a point being composite of sounds from near and far.
<i>Ambient Sound Level</i>	Means the reading on an integrating impulse sound level meter taken at a measuring point in the absence of any alleged disturbing noise at the end of a total period of at least 10 minutes after such a meter was put into operation as defined by the National Noise Control Regulations (GNR 154 of 1992).
<i>Broadband Noise</i>	Spectrum consisting of a large number of frequency components, none of which is individually dominant.
<i>C-Weighting</i>	This is an international standard filter, which can be applied to a pressure signal or to a <i>SPL</i> or <i>PWL</i> spectrum, and which is essentially a pass-band filter in the frequency range of approximately 63 to 4000 Hz. This filter provides a more constant, flatter, frequency response, providing significantly less adjustment than the A-scale filter for frequencies less than 1000 Hz.
<i>Controlled area (as per National Noise Control Regulations – GNR 154 of 1992)</i>	a piece of land designated by a local authority where, in the case of- (a) road transport noise in the vicinity of a road- (i) the reading on an integrating impulse sound level meter, taken outdoors at the end of a period extending from 06:00 to 24:00 while such meter is in operation, exceeds 65 dBA; or (ii) the equivalent continuous "A"-weighted sound pressure level at a height of at least 1,2 metres, but not more than 1,4 metres, above the ground for a period extending from 06:00 to 24:00 as calculated in accordance with SABS 0210-1986, titled: "Code of Practice for calculating and predicting road traffic noise", published under Government Notice No. 358 of 20 February 1987, and projected for a period of 15 years following the date on which the local authority has made such designation, exceeds 65 dBA;

	<p>(b) aircraft noise in the vicinity of an airfield, the calculated noisiness index, projected for a period of 15 years following the date on which the local authority has made such designation, exceeds 65 dBA; or</p> <p>(c) industrial noise in the vicinity of an industry-</p> <p>(i) the reading on an integrating impulse sound level meter, taken outdoors at the end of a period of 24 hours while such meter is in operation, exceeds 61 dBA; or</p> <p>(ii) the calculated outdoor equivalent continuous "A"-weighted sound pressure level at a height of at least 1,2 metres, but not more than 1,4 metres, above the ground for a period of 24 hours, exceeds 61 dBA;</p>
<i>dB(A)</i>	Sound Pressure Level in decibel that has been A-weighted, or filtered, to match the response of the human ear.
<i>Decibel (db)</i>	A logarithmic scale for sound corresponding to a multiple of 10 of the threshold of hearing. Decibels for sound levels in air are referenced to an atmospheric pressure of 20 μ Pa.
<i>Diffraction</i>	The process whereby an acoustic wave is disturbed and its energy redistributed in space as a result of an obstacle in its path, Reflection and refraction are special cases of diffraction.
<i>Direction of Propagation</i>	The direction of flow of energy associated with a wave.
<i>Disturbing noise</i>	means a noise, excluding the unamplified human voice, which—
	<p>(a) exceeds the rating level by 7 dBA;</p> <p>(b) exceeds the residual noise level where the residual noise level is higher than the rating level;</p> <p>(c) exceeds the residual noise level by 3 dBA where the residual noise level is lower than the rating level; or</p> <p>(d) in the case of a low-frequency noise, exceeds the level specified in Annex B of SANS 10103;</p>
<i>Environment</i>	The external circumstances, conditions and objects that affect the existence and development of an individual, organism or group; these circumstances include biophysical, social, economic, historical, cultural and political aspects.
<i>Environmental Control Officer</i>	Independent Officer employed by the applicant to ensure the implementation of the Environmental Management Plan (EMP) and manages any further environmental issues that may arise.
<i>Environmental impact</i>	A change resulting from the effect of an activity on the environment, whether desirable or undesirable. Impacts may be the direct consequence of an organisation's activities or may be indirectly caused by them.
<i>Environmental Impact Assessment</i>	An Environmental Impact Assessment (EIA) refers to the process of identifying, predicting and assessing the potential positive and negative social, economic and biophysical impacts of any proposed project, plan, programme or policy that requires authorisation of permission by law and that may significantly affect the environment. The EIA includes an evaluation of alternatives, as well as recommendations for appropriate mitigation measures for minimising or avoiding negative impacts, measures for enhancing the positive aspects of the proposal, and environmental management and monitoring measures.
<i>Environmental issue</i>	A concern felt by one or more parties about some existing, potential or perceived environmental impact.
<i>Equivalent continuous A-weighted sound exposure level ($L_{Aeq,T}$)</i>	The value of the average A-weighted sound pressure level measured continuously within a reference time interval T , which have the same mean-square sound pressure as a sound under consideration for which the level varies with time.
<i>Equivalent continuous A-weighted rating level ($L_{Req,T}$)</i>	The Equivalent continuous A-weighted sound exposure level ($L_{Aeq,T}$) to which various adjustments has been added. More commonly used as ($L_{Req,d}$) over a time interval 06:00 – 22:00 ($T=16$ hours) and ($L_{Req,n}$) over a time interval of 22:00 – 06:00 ($T=8$ hours). It is a calculated value.
<i>F (fast) time weighting</i>	<p>(1) Averaging detection time used in sound level meters.</p> <p>(2) Fast setting has a time constant of 125 milliseconds and provides a fast reacting display response allowing the user to follow and measure not too rapidly fluctuating sound.</p>
<i>Footprint area</i>	Area to be used for the construction of the proposed development, which does not include the total study area.
<i>Free Field Condition</i>	An environment where there is no reflective surfaces.
<i>Frequency</i>	The rate of oscillation of a sound, measured in units of Hertz (Hz) or kiloHertz (kHz). One hundred Hz is a rate of one hundred times per second. The frequency of a sound is the property perceived as pitch: a low-frequency sound (such as a bass note) oscillates at a relatively slow rate, and a high-frequency sound (such as a treble note) oscillates at a relatively high rate.

<i>Green field</i>	A parcel of land not previously developed beyond that of agriculture or forestry use; virgin land. The opposite of Greenfield is Brownfield, which is a site previously developed and used by an enterprise, especially for a manufacturing or processing operation. The term Brownfield suggests that an investigation should be made to determine if environmental damage exists.
<i>G-Weighting</i>	An International Standard filter used to represent the infrasonic components of a sound spectrum.
<i>Harmonics</i>	Any of a series of musical tones for which the frequencies are integral multiples of the frequency of a fundamental tone.
<i>I (impulse) time weighting</i>	(1) Averaging detection time used in sound level meters as per South African standards and Regulations. (2) Impulse setting has a time constant of 35 milliseconds when the signal is increasing (sound pressure level rising) and a time constant of 1,500 milliseconds while the signal is decreasing.
<i>Impulsive sound</i>	A sound characterized by brief excursions of sound pressure (transient signal) that significantly exceed the ambient sound level.
<i>Infrasound</i>	Sound with a frequency content below the threshold of hearing, generally held to be about 20 Hz. Infrasonic sound with sufficiently large amplitude can be perceived, and is both heard and felt as vibration. Natural sources of infrasound are waves, thunder and wind.
<i>Integrated Development Plan</i>	A participatory planning process aimed at developing a strategic development plan to guide and inform all planning, budgeting, management and decision-making in a Local Authority, in terms of the requirements of Chapter 5 of the Municipal Systems Act, 2000 (Act 32 of 2000).
<i>Integrated Environmental Management</i>	IEM provides an integrated approach for environmental assessment, management, and decision-making and to promote sustainable development and the equitable use of resources. Principles underlying IEM provide for a democratic, participatory, holistic, sustainable, equitable and accountable approach.
<i>Interested and affected parties</i>	Individuals or groups concerned with or affected by an activity and its consequences. These include the authorities, local communities, investors, work force, consumers, environmental interest groups and the general public.
<i>Key issue</i>	An issue raised during the Scoping process that has not received an adequate response and that requires further investigation before it can be resolved.
<i>L_{A90}</i>	the sound level exceeded for the 90% of the time under consideration
<i>Listed activities</i>	Development actions that is likely to result in significant environmental impacts as identified by the delegated authority (formerly the Minister of Environmental Affairs and Tourism) in terms of Section 21 of the Environment Conservation Act.
<i>L_{AMin} and L_{AMax}</i>	Is the RMS (root mean squared) minimum or maximum level of a noise source.
<i>Loudness</i>	The attribute of an auditory sensation that describes the listener's ranking of sound in terms of its audibility.
<i>Magnitude of impact</i>	Magnitude of impact means the combination of the intensity, duration and extent of an impact occurring.
<i>Masking</i>	The raising of a listener's threshold of hearing for a given sound due to the presence of another sound.
<i>Mitigation</i>	To cause to become less harsh or hostile.
<i>Negative impact</i>	A change that reduces the quality of the environment (for example, by reducing species diversity and the reproductive capacity of the ecosystem, by damaging health, or by causing nuisance).
<i>Noise</i>	a. Sound that a listener does not wish to hear (unwanted sounds). b. Sound from sources other than the one emitting the sound it is desired to receive, measure or record. c. A class of sound of an erratic, intermittent or statistically random nature.
<i>Noise Level</i>	The term used in lieu of sound level when the sound concerned is being measured or ranked for its undesirability in the contextual circumstances.
<i>Noise-sensitive development</i>	developments that could be influenced by noise such as: a) districts (see table 2 of SANS 10103:2008) 1. rural districts, 2. suburban districts with little road traffic, 3. urban districts, 4. urban districts with some workshops, with business premises, and with main roads, 5. central business districts, and 6. industrial districts;

Appendix B: Glossary of Terms

	<p>b) educational, residential, office and health care buildings and their surroundings;</p> <p>c) churches and their surroundings;</p> <p>d) auditoriums and concert halls and their surroundings;</p> <p>e) recreational areas; and</p> <p>f) nature reserves.</p> <p>In this report Noise-sensitive developments is also referred to as a Potential Sensitive Receptor</p>
<i>Octave Band</i>	A filter with a bandwidth of one octave, or twelve semi-tones on the musical scale representing a doubling of frequency.
<i>Positive impact</i>	A change that improves the quality of life of affected people or the quality of the environment.
<i>Property</i>	Any piece of land indicated on a diagram or general plan approved by the Surveyor-General intended for registration as a separate unit in terms of the Deeds Registries Act and includes an erf, a site and a farm portion as well as the buildings erected thereon
<i>Public Participation Process</i>	A process of involving the public in order to identify needs, address concerns, choose options, plan and monitor in terms of a proposed project, programme or development
<i>Rating Level</i>	means the applicable outdoor equivalent continuous rating level indicated in Table 2 of SANS 10103
<i>Reflection</i>	Redirection of sound waves.
<i>Refraction</i>	Change in direction of sound waves caused by changes in the sound wave velocity, typically when sound wave propagates in a medium of different density.
<i>Residual noise</i>	Means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes, excluding noise alleged to be causing a noise nuisance or disturbing noise. In this report the residual noise levels may also be referred to as the ambient sound level (the definition as per the GNR154 of 1992) or the background noise level (as defined in a number of international countries)
<i>Reverberant Sound</i>	The sound in an enclosure which results from repeated reflections from the boundaries.
<i>Reverberation</i>	The persistence, after emission of a sound has stopped, of a sound field within an enclosure.
<i>Significant Impact</i>	An impact can be deemed significant if consultation with the relevant authorities and other interested and affected parties, on the context and intensity of its effects, provides reasonable grounds for mitigating measures to be included in the environmental management report. The onus will be on the applicant to include the relevant authorities and other interested and affected parties in the consultation process. Present and potential future, cumulative and synergistic effects should all be taken into account.
<i>S (slow) time weighting</i>	<p>(1) Averaging times used in sound level meters.</p> <p>(2) Time constant of one [1] second that gives a slower response which helps average out the display fluctuations.</p>
<i>Sound Level</i>	The level of the frequency and time weighted sound pressure as determined by a sound level meter, i.e. A-weighted sound level. It is defined in PN 200 of 2013 as means the equivalent continuous rating level as defined in SANS 10103, taking into account impulse, tone and night-time corrections.
<i>Sound Power</i>	Of a source, the total sound energy radiated per unit time.
<i>Sound Pressure Level (SPL)</i>	Of a sound, 20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level. International values for the reference sound pressure level are 20 micropascals in air and 100 millipascals in water. SPL is reported as L_p in dB (not weighted) or in various other weightings.
<i>Soundscape</i>	Sound or a combination of sounds that forms or arises from an immersive environment. The study of soundscape is the subject of acoustic ecology. The idea of soundscape refers to both the natural acoustic environment, consisting of natural sounds, including animal vocalizations and, for instance, the sounds of weather and other natural elements; and environmental sounds created by humans, through musical composition, sound design, and other ordinary human activities including conversation, work, and sounds of mechanical origin resulting from use of industrial technology. The disruption of these acoustic environments results in noise pollution.
<i>Study area</i>	Refers to the entire study area encompassing all the alternative routes as indicated on the study area map.
<i>Sustainable Development</i>	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and the future needs (Brundtland Commission, 1987).

Appendix B: Glossary of Terms

<i>Tread braked</i>	The traditional form of wheel brake consisting of a block of friction material (which could be cast iron, wood or nowadays a composition material) hung from a lever and being pressed against the wheel tread by air pressure (in the air brake) or atmospheric pressure in the case of the vacuum brake.
<i>Zone of Potential Influence</i>	The area defined as the radius about an object, or objects beyond which the noise impact will be insignificant.
<i>Zone Sound Level</i>	Means a derived dBA value determined indirectly by means of a series of measurements, calculations or table readings and designated by a local authority for an area as defined by the National Noise Control Regulations (GNR 154 of 1992). This is similar to the Rating Level as defined in SANS 10103:2008 and PN 200 of 2013.

APPENDIX C

Terms of Reference

A noise impact assessment must be conducted if the proposed development triggers the following:

- A change in land use as highlighted in SANS 10328:2008, section 3.3;
- If a wind farm (wind turbines - SANS 10328:2008 [5.4 (i)]) or a source of low-frequency noise (such as cooling or ventilation fans - SANS 10328:2008 [5.4 (l)]) is to be established within 2,000 m from a potential NSD *or visa versa*;
- It is generally required by the local or district authority as part of the environmental authorization or planning approval in terms of Regulation 2(d) or GN R154 of 1992;
- It is a controlled activity in terms of the NEMA EIA Regulations, 2014, as amended and an Environmental Noise Impact Assessment (ENIA) is required, because:
 - It may cause a disturbing noise that is prohibited in terms of section 18(1) of the Government Notice 579 of 2010;
 - It is an environmental theme to be further assessed as identified by the National Web-based Environmental Screening Tool as required by GNR 320 of 2020 (promulgated as Government Gazette No. 43110 of 20 March 2020);

Requirements as per Government Gazette 43110 of 20 March 2020 (GNR 320 of 2020)

The Department of Environment, Forestry and Fisheries (DEFF)²⁸ also promulgated Regulation 320, dated 20 March 2020 as published in Government Gazette No. 43110. The Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in Terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, when applying for Environmental Authorisation would be applicable to this project.

This regulation defines the requirements for undertaking a site sensitivity verification, specialist assessment and the minimum report content requirements for environmental impact where a specialist assessment is required but no protocol has been prescribed. It requires that the current land use be considered using the national web based environmental screening tool to confirm the site sensitivity available at: <https://screening.environment.gov.za>.

If an applicant intending to undertake an activity identified in the scope of this protocol for which a specialist assessment has been identified on the screening tool on a site identified as being of:

- "very high" sensitivity for noise, must submit a Noise Specialist Assessment; or
- "low" sensitivity for noise, must submit a Noise Compliance Statement.

On a site where the information gathered from the site sensitivity verification differs from the designation of "very high" sensitivity on the screening tool and it is found to be of a "low" sensitivity, a Noise Compliance Statement must be submitted. On a site where the information gathered from the initial site

²⁸ Now the Department of Forestry, Fisheries and the Environment (DFFE)

sensitivity verification differs from the designation of "low" sensitivity on the screening tool and it is found to be of a "very high" sensitivity, a Noise Specialist Assessment must be submitted.

If any part of the proposed development footprint falls within an area of "very high" sensitivity, the assessment and reporting requirements prescribed for the "very high" sensitivity apply to the entire footprint excluding linear activities for which noise impacts are associated with construction activities only and the noise levels return to the current levels after the completion of construction activities, in which case a compliance statement applies. In the context of this protocol, development footprint means the area on which the proposed development will take place and includes any area that will be disturbed.

GNR 320 also stipulate that the Noise Specialist Assessment must assess the impacts in accordance with SANS 10103:2008 and SANS 10328:2008 (or the latest versions) and must include the following aspects:

- Characterisation and determination of noise emissions from the noise source;
- Projected total noise level and changes in noise levels as a result of construction, commissioning and operation of the proposed developments on the nearest receptors using industry accepted models and forecasts; and
- Desired noise levels for the area.

The minimum requirements for a Noise Impact Assessment are also covered in the form of a checklist (just after the **Executive Summary**).

Requirements as per South African National Standards

In South Africa the document that addresses the issues specifically concerning environmental noise is SANS 10103:2008. It has been revised extensively in 2008 and brought in line with the guidelines of the World Health Organization (WHO). It provides the maximum average ambient noise levels during the day and night to which different types of developments may be exposed indoors.

The SANS 10328:2008 specifies the methodology to assess the potential noise impacts on the environment due to a proposed activity that might impact on the environment. This standard also stipulates the minimum requirements to be investigated for Environmental Impact Assessment (EIA) purposes. These minimum requirements are:

1. The purpose of the investigation;
2. A brief description of the planned development or the changes that are being considered;
3. A brief description of the existing environment;
4. The identification of the noise sources that may affect the particular development, together with their respective estimated sound pressure levels or sound power levels (or both);
5. The identified noise sources that were not taken into account and the reasons why they were not investigated;
6. The identified noise-sensitive developments and the estimated impact on them;

7. Any assumptions made with regard to the estimated values used;
8. An explanation, either by a brief description or by reference, of the methods that were used to estimate the existing and predicted rating levels;
9. The location of the measurement or calculation points, i.e. a description, sketch or map;
10. Estimation of the environmental noise impact;
11. Alternatives that were considered and the results of those that were investigated;
12. A list of all the interested or affected parties that offered any comments with respect to the environmental noise impact investigation;
13. A detailed summary of all the comments received from interested or affected parties as well as the procedures and discussions followed to deal with them;
14. Conclusions that were reached;
15. Recommendations, i.e. if there could be a significant impact, or if more information is needed, a recommendation that an environmental noise impact assessment be conducted, and
16. If remedial measures will provide an acceptable solution which would prevent a significant impact, these remedial measures should be outlined in detail and included in the final record of decision if the approval is obtained from the relevant authority. If the remedial measures deteriorate after time and a follow-up auditing or maintenance programme (or both) is instituted, this programme should be included in the final recommendations and accepted in the record of decision if the approval is obtained from the relevant authority.

APPENDIX D

Site Sensitivity Verification

SITE SENSITIVITY VERIFICATION (IN TERMS OF PART A OF THE ASSESSMENT PROTOCOLS PUBLISHED IN GN 320 ON 20 MARCH 2020

Part A of the Assessment Protocols published in GN 320 on 20 March 2020 (i.e., Site sensitivity verification is required where a specialist assessment is required but no specific assessment protocol has been prescribed) is applicable where the Department of Environment, Forestry and Fisheries (now the DFFE) Screening Tool has the relevant themes to verify.

INTRODUCTION

In accordance with Appendix 6 of the National Environmental Management Act (Act 107 of 1998, as amended) (NEMA) Environmental Impact Assessment (EIA) Regulations of 2014, a site sensitivity verification has been undertaken in order to confirm the current land use and environmental sensitivity of the proposed project area as identified by the National Web-Based Environmental Screening Tool (Screening Tool). The details of the site sensitivity verification are noted below:

Date of Site Visits	8 to 10 September 2020 (Francois Stephanus de Vries) 26 to 28 September 2016 (Morné de Jager)
Specialist Name(s)	Francois Stephanus de Vries Morné de Jager
Professional Registration Number (if applicable)	Not applicable, there is no registration body in South Africa that could allow professional registration for acoustic consultants.
Specialist Affiliation / Company	Enviro-Acoustic Research CC

OUTPUT FROM NATIONAL ENVIRONMENTAL SCREENING TOOL

The site was initially assessed using the National Environmental Screening tool, available at, <https://screening.environment.gov.za>. The output from the National Online Screening tool indicates a number of areas within, and up to 2,000 m from the project boundary is considered to be of a “very high” sensitivity to noise. These potentially “very high” sensitive areas (in terms of noise) are indicated on **Figure D.1** together with the potential noise-sensitive receptors as initially identified.

DESCRIPTION ON HOW THE SITE SENSITIVITY VERIFICATION WAS UNDERTAKEN

The site sensitivity was verified using:

- available aerial images (Google Earth®) (See **Figure D.1** for initially identified potential noise-sensitive receptors);

- the statuses of these structures were verified during the site visit in September 2020 although access could not be obtained to all locations during this period. The statuses or the potential structures located at these locations were discussed with the land owner.

OUTCOME OF THE SITE SENSITIVITY VERIFICATION

The online screening tool identified a number of potential noise-sensitive areas in the vicinity of the proposed development. This area is considered to be noise-sensitive (verified during the June 2021 site visit) due to permanent or temporary residential activities, with the statuses of the areas clarified in **Figure D.1**. The following should be noted:

- There are permanent residential activities at the location marked as location 1, 2 and 3. These locations are located within 2,000 m from a potential wind turbine and considered to have a “Very High” sensitivity to noise.
- There are a number of areas identified (by the online screening tool) to have a “Very High” sensitivity to noise. The site assessment highlighted that these are not sensitive to noise, as there are no structures used for residential activities or any other use that are considered to be noise sensitive.

CONCLUSION

Due to the presence of noise-sensitive receptors or developments located within 2,000 m from the closest wind turbines, with some of the wind turbines located within the buffer area defined to have a “Very High” sensitivity to noise, the potential impact from noise from the project is assessed in this Noise Specialist Study.

Signature

Morné de Jager

2022 – 07 – 13

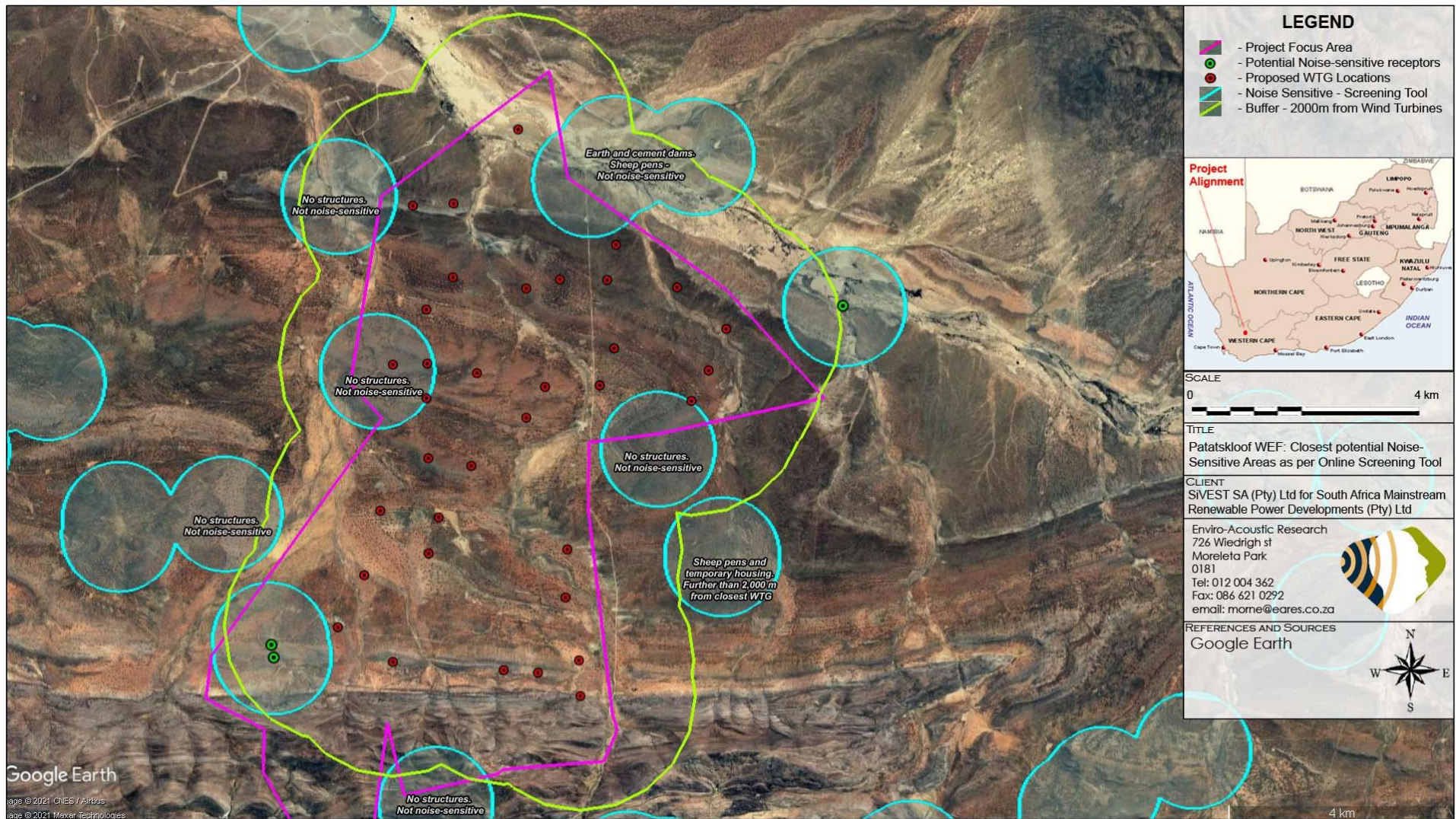


Figure D.1: Areas defined to be of “Very High” sensitivity in terms of noise by the online screening tool

APPENDIX E

Photos of Measurement Locations



Photo B.1: Measurement location at SEPLTSL01



Photo B.2: Measurement location at SEPLTSL02



Photos B.3: Measurement location at AMKLTSL01



Photos B.4: Measurement location at AMKLTSL02



Photos B.5: Measurement location at AMKLTSL03

APPENDIX F

Calculated conceptual noise levels

Appendix F, Table 1: Projected daytime construction activities (Hardstand areas, digging of foundations, civil works and erection of wind turbines)

NSD	Recom. Rating Levels (noise limit - low wind conditions)	Potential Existing Noise Levels (based on the average fast-weighted measurements)	Projected Noise Level	Change in rating level	Ext	Prob	Revers	Irrepl of Resource	Dur	Magnitude	Sig
1	45	40.8	33.4	0.7	2	1	1	2	1	1	7
2	45	40.8	34.3	0.9	2	1	1	2	1	1	7
3	45	40.8	24.5	0.1	2	1	1	2	1	1	7

Appendix F, Table 2: Projected night-time construction activities (Civil works and erection of wind turbines)

NSD	Recom. Rating Levels (noise limit - low wind conditions)	Potential Existing Noise Levels (based on the average fast-weighted measurements)	Projected Noise Level	Change in rating level	Ext	Prob	Revers	Irrepl of Resource	Dur	Magnitude	Sig
1	35	30.3	33.4	4.8	2	1	1	3	1	1	8
2	35	30.3	34.3	5.5	2	1	1	3	1	1	8
3	35	30.3	24.5	1.0	2	1	1	3	1	1	8

Appendix F, Table 3: Projected night-time operational noise levels

NSD	Recom. Rating Levels (noise limit - as recommended for increased wind speeds)	Potential Residual Noise Levels (based on regression analysis on long-term data)	Projected Noise Level	Change in rating level	Ext	Prob	Revers	Irrepl of Resource	Dur	Magnitude	Sig
1	45	41.5	32.0	0.5	2	1	1	3	3	1	10
2	45	41.5	33.9	0.7	2	1	1	3	3	1	10
3	45	41.5	27.5	0.2	2	1	1	3	3	1	10

Appendix F, Table 4: Projected cumulative noise levels

NSD	Potential Noise Level due to operation of other WEFs in area	Potential Noise Level due to operation of Patatskloof WEF	Cumulative Noise Level	Change due to cumulative noise impacts	Ext	Prob	Revers	Irrepl of Resource	Dur	Magnitude	Sig
1	34.5	32.0	36.5	-0.1	2	1	1	3	3	1	10
2	37.3	33.9	38.9	0.0	2	1	1	3	3	1	10
3	41.2	27.5	41.4	0.0	2	1	1	3	3	1	10

End of Report