

Appendix G.8

NOISE ASSESSMENT



ABO Uvemvane Wind Energy Facility 1 (Pty) Ltd

ENVIRONMENTAL NOISE IMPACT ASSESSMENT

for the proposed

**ABO Uvemvane Wind Energy Facility 1
and associated Infrastructure near Balfour,
Gauteng and Mpumalanga Provinces**



Study done for:



Prepared by:



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EXECUTIVE SUMMARY

INTRODUCTION

Enviro-Acoustic Research cc was commissioned by WSP South Africa (Pty) Ltd (the Environmental Assessment Practitioner or “EAP”) to identify and assess the potential noise impact from the construction, operation and decommissioning of the proposed ABO Uvemvane Wind Energy Facility (WEF) 1 and associated infrastructure on the surrounding soundscape.

Due to a number of wind turbines proposed within an area with a potential high sensitivity to noise, a full environmental noise impact study will be conducted.

PROJECT DESCRIPTION

The Applicant, ABO Uvemvane Wind Energy Facility 1 (Pty) Ltd (Uvemvane), proposes the development of a commercial Wind Farm, known as the ABO Uvemvane WEF 1. The proposed WEF is located approximately 9 km west of Balfour, Mpumalanga (with the project located across the border of the Gauteng and Mpumalanga provinces).

The proposed Uvemvane WEF will comprise several wind turbine generators (WTG) and associated infrastructure and may have a contracted capacity of up to 170 MW. It should be noted that the exact specifications of the proposed project components will be determined during the detailed engineering design phase prior to construction (subsequent to the issuing of an Environmental Authorization (EA), should such an authorisation be granted), but that the information provided below is seen as the maximum development scenario for the proposed development.

The proposed facility would comprise the following (to be located within the proposed development footprint):

- Up to 20 WTG with the following maximum specifications:
 - Maximum hub height 180 m;
 - Maximum blade length 100 m;
 - Maximum rotor diameter 200 m;
 - Maximum capacity per turbine 10 MW;
 - A transformer at the base of each turbine;
 - Concrete turbine foundations up to 1 ha each;
 - Turbine, crane, and blade hardstands (included in the abovementioned 1 ha).
- Primary/main access roads as well as internal road reticulation (note that existing roads/disturbed areas would be used as far as possible, and for the proposed roads,

a corridor of up to 12 m wide may be temporarily impacted upon during construction and be rehabilitated to up to 10 m wide after construction), inclusive of stormwater infrastructure where relevant. The length of the proposed roads could be up to 31 km, including approximately 18 km of existing roads to be widened.

- 4 Temporary laydown areas/ construction compounds (includes concrete batching), totalling up to 15 ha, would be fenced with access control; and/or
- Battery Energy Storage System (BESS) to be located within the electrical infrastructure hub.

DESCRIPTION OF THE SURROUNDING LAND USE

Land use within the Project Focus Area (PFA) is complex, being a combination of suburban residential, agriculture and animal husbandry, commercial and other business activities as well as wilderness areas (including undeveloped areas and ecotourism). Residential structures are scattered in a heterogeneous manner within the PFA, with minor noise associated with commercial activities, agricultural and typical household activities.

DESCRIPTION OF THE CLOSEST POTENTIAL NOISE SENSITIVE RECEPTORS

Residential areas and potential noise-sensitive developments/receptors/communities (NSR) were identified using aerial images as well as a physical site visit, with the site visit verifying numerous locations within the PFA where residential activities are taking place. The potential noise impacts are assessed on these NSR in this noise study.

BASELINE SOUND LEVELS

Ambient sound levels were measured from 14 – 20 November 2024 in a semi-continuous manner over a period of 6-nights at four locations. Ambient sound level measurement resulted in sound levels higher than expected, significantly higher than a rural noise district. Based on sounds heard and spectral information, ambient sound levels were mainly due to a combination of wind-induced, faunal and farming related noises (with cattle noises – relative constant moos, bawling and snorts audible at two measurement locations). Passing traffic was also audible at measurement locations two and three, and passing traffic may have influenced the measurements during the quieter periods at measurement location three.

Based on the sound measurements:

- 2,192 10-minute measurements were collected during the day (all the 10-minute measurements during the period 06:00 – 22:00), with sound levels ranging between 27.6 and 72.1 dBA. The average daytime ambient sound level was

calculated at 47.0 dBA (typical of a rural to suburban noise district) for the four measurement locations; and

- 1,152 10-minute measurements were collected during the night-time period, with sound levels ranging between 22.2 and 68.1 dBA. The average night-time ambient sound level was calculated at 43.4 dBA (typical of a suburban to urban noise district) for the four measurement locations. When excluding night-time data for measurement location WAULTSL04, the average sound level was 40.6 dBA for the 3 “quieter” locations.

Considering measurements collected over the past decade at numerous locations during different seasons, ambient sound levels will likely increase as wind speeds increase, with noise limits as recommended by the World Bank Group used during the operational phase.

ACCEPTABLE NOISE LIMITS

The development of the proposed WEF will result in changes in the ambient sound levels during the construction and operational phases. With the project located within both the Gauteng and Mpumalanga Provinces, it should be noted that noise control regulations are different, which will be considered in this assessment.

In addition, when considering desired rating levels, two scenarios must be considered for a WEF, because, while construction activities may take place during periods with no-, low- and high-winds, WTG will only operate during periods when wind speeds are elevated. As such, two sets of desired rating levels should be considered.

Considering the average fast-weighted sound levels as measured, for the construction period, the likely rating levels would be:

- 45 – 50 dBA for the daytime period (typical of a rural to sub-urban noise district); and
- 40 – 45 dBA for the night-time period (typical of a suburban to urban noise district).

Because the WTG will only operate during periods with increased winds, this report will consider the requirements of the provincial noise control regulations as well as the noise limits recommended by the World Bank Group and the International Finance Corporation, with desired noise limits for Uvemvane WEF being:

- 50 dBA for the daytime period– for the construction phase; and
- 45 dBA for the night-time period.

FINDINGS

This study considers the potential noise impact on the surrounding environment due to the construction, operational and future decommissioning activities associated with the Uvemvane WEF 1. This assessment considers the impact assessment criteria of both the author as well as that of the Environmental Assessment Practitioner (EAP).

Critical factors that meaningfully affect the significance assessment considers the potential future noise levels (estimated or calculated) as well as the probability of a noise impact occurring. Probability specifically is difficult to define, as noise from the operational WTG will be audible to clearly audible, though the audibility is not necessary a noise impact, with this assessment using reported dose-response relationships as well as various guidelines levels to predict a potential probability per NSR.

It was determined that the potential noise impacts, without mitigation, would be:

- of a **low significance** for the daytime construction (or upgrading) of the access roads;
- of a **low significance** for the daytime construction traffic passing NSR;
- of a **low significance** for the daytime construction activities (hard standing areas, excavation and concreting of foundations and the erecting of the WTG and other infrastructure) at this WEF;
- of a **low significance** for the night-time construction activities (such as the pouring of concrete, erecting the WTG);
- of a **low significance** for the daytime operational activities; and
- of a **medium significance** for operational activities (noises from WTG) when considering the worst-case PWL, with mitigation measures recommended that would reduce the potential significance to **low**.

There is no potential for a cumulative noise impact.

MANAGEMENT & MITIGATION OF NOISE IMPACT

The significance of the noise impact associated with future construction activities was estimated to have a **very low to low** noise impact, and additional mitigation measures would not be required for the future construction phase. However, noise annoyance is the complex result of numerous factors, and the following measures are recommended for the applicant to consider and implement to reduce potential noise annoyance issues:

- The potential noise levels associated with road construction activities must be discussed with the NSR staying within 120 m from any access roads, highlighting

that the road construction / upgrading activities noises would be high when near NSR, but the high noise levels will be very temporary;

- If practical, road construction or upgrading activities (when working closer than 120 m from NSR) should ideally be planned for when NSR are not at home (children at school, adults at work or busy). Ideally work near NSR should be planned to take place between 08:00 and 14:00;
- Construction vehicles should reduce speeds to the minimum when passing NSR staying closer than 60 m from the road;
- NSR should be provided with the contact details of the environmental representative (Environmental Control Officer “ECO”) to register potential complaints about noise;
- Access roads passing within 120 m from NSR should ideally not be used at night by construction vehicles (trucks and heavy construction equipment);
- Developer/Applicant to ensure that noise as environmental impact are included in the typical Health, Safety & Environment induction. All employees and contractors must receive this induction training;
- When construction activities must take place near NSR (500m during the day; 1,000m at night), the number of simultaneous activities within these buffer zones should be minimized;
- Should night-time construction activities be required within 1,000m from any NSR, these NSR should be notified in time of the proposed construction activities, including the anticipated duration of these activities;
- Should night-time construction activities be required within 1,000m from any NSR, the developer must minimise active equipment at night, especially planning the completion of noisiest activities (such a pile driving, rock breaking and excavation) during the daytime period; and
- When selecting construction equipment to be used at this project, the developer should consider the sound power levels of equipment that will be used on the project. Newer equipment, or equipment that complies with an international directive or movement (such as Buy Quiet), are generally much quieter than older equipment, or equipment that does not consider noise criteria.

While the significance of the daytime operational noises will have a low impact, night-time operational noises are projected to be of a **medium** significance and additional mitigation measures are required and recommended. It is critical that potential noise impacts be addressed during the planning stage, as noise impacts during the operational phase are expensive to correct, or would result in financial penalties (e.g. the requirement to implement a NAP, need to disable one or more WTG from operating at night, etc.).

Once the developer selected a final WTG model and manufacturer, and the PWL of the selected WTG are higher than 110.5 dBA (re 1 pW) (including uncertainty as defined by the manufacturer), potential noise levels should be recalculated to ensure that future noise levels will be less than 45 dBA at all NSR. Should noise levels exceed 45 dBA at any NSR, the developer can:

- Relocate certain WTG further from NSR affected by increased noise levels (as part of amendment process post EA);
- Consider the use of a WTG with a higher power generation capacity, allowing the reduction in the number of WTG to ensure the same nameplate export capacity for the WEF. WTG (e.g. WT3 and 5) near NSR (e.g. NSR08) where noise levels may be high can subsequently be eliminated;
- The developer can relocate certain NSR to locations where noise levels are lower, or reach agreement with the land owner that the structures (where noise levels exceed the recommended noise limits) will not be used for permanent residential purposes;
- Certain WTG could be fitted with serrated trailing edges (STE) on the blades;
- The developer can design a noise abatement plan (NAP) that would allow the operation of certain WTG in a reduced noise emission mode during certain times and/or conditions; and/or
- A combination of the above-mentioned mitigation measures.

The developer must design a noise monitoring program at representative NSR locations where the modelled worst-case noise rating levels exceed 42 dBA. This should include the measurement of ambient sound levels prior to the development of the WEF, followed by noise measurements once the WEF is operational to confirm that noise levels are less than 45 dBA. Ambient sound level measurements can be used to design a NAP for potential implementation.

It should be the intention to manage noise levels during the Planning Phase, however, if noise measurements determine actual noise levels exceed the recommended noise limits, the developer should design and implement a NAP that will further reduce the noise emission levels during certain wind speeds, wind directions, time periods or meteorological conditions.

For the current layout and a WTG with a PWL of 110.5 dBA (re 1 pW), mitigation will be required for the operational phase for any WTG with a PWL higher than 107.0 dBA (re 1 pW). Noise monitoring will be required at representative NSR locations where modelled noise levels exceed 42 dBA.

Should noise levels slightly exceed the recommended noise level, or any NSR complain about operational noise levels impacting on their sleep, the developer can consider acoustic treatment of residential dwellings to ensure that noise levels inside bedrooms comply with the equivalent continuous rating levels as defined in Table 1 of SANS 10103.

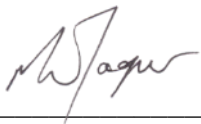
RECOMMENDATIONS

With the implementation of appropriate mitigation measures, the proposed layout (turbine placement) is considered acceptable from a noise perspective and there is no restriction in the WTG that the developer could use (subject that the calculated noise levels are less than 45 dBA at NSR locations used for residential purposes). Noise monitoring is required should the developer select to use a WTG with a PWL higher than 105 dBA (re 1 pW). It is therefore recommended that the proposed Uvemvane WEF 1 (and associated infrastructure) be authorised.

It should be noted that the developer should re-evaluate the noise impact should:

- the layout be revised (as part of amendment process post EA) where any WTG, located within 2,500 m from a confirmed NSR, are moved closer to the NSR;
- the layout be revised (as part of amendment process post EA) where any new WTG are introduced within 2,500m from an NSR;
- the layout be revised (as part of amendment process post EA) where the number of WTG within 2,500m from an NSR are increased; and
- the developer selects to use a WTG with PWL higher than 110.5 dBA (re 1 pW).

It is proposed that the developer recommend to landowners that no new residential dwellings be developed within areas enveloped by the 42 dBA noise level contour.



Signature

Morné de Jager

2026 – 10 – 07

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Appendix D	Photos of Measurement Locations
Appendix E	NSR, Author EIA criteria and calculated conceptual noise levels

GLOSSARY OF ABBREVIATIONS

ADT	Articulated Dump Trucks
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
CSP	Concentrated Solar Plant
DEFRA	Department for the Environment, Food and Rural Affairs
DEM	Digital Elevation Model
DFFE	Department of Forestry, Fisheries and the Environment
EA	Environmental Authorization
EAP	Environmental Assessment Practitioner
EARES	Enviro Acoustic Research cc
ECA	Environment Conservation Act
EO	Environmental Officer
EIA	Environmental Impact Assessment
EHS	Environmental Health and Safety
EMPr	Environmental Management Programme
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
HNI	House Not Inhabited

I&APs	Interested and Affected Parties
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ISO	International Organization for Standardization
LAN	Local Authority Notice
METI	Ministry of Economy, Trade, and Industry
NASA	National Aeronautical and Space Administration
NAP	Noise Abatement Program (or Noise Curtailment Programme)
NEMA	National Environmental Management Act
NCR	Noise Control Regulations
NSR	Noise-sensitive Receptor
PPP	Public Participation Process
PWL	Sound Power Level
SABS	South African Bureau of Standards
SANS	South African National Standards
SPL	Sound Pressure Level (or sound level)
SR	Significance Rating
TLB	Tractor-Loader-Backhoe (also referred to as a backhoe)
UTM	Universal Transverse Mercator
WHO	World Health Organization
WEF	Wind Energy Facility
WF	Wind Farm
WIN	Wind Induced Noises
WTG	Wind Turbine Generator
WTN	Wind Turbine Noise

GLOSSARY OF UNITS

°C	Degrees Celsius (measurement of temperature)
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)
pW	pico Watt (10 ⁻¹²) (measurement of power – sound power in air)
μPa	Micro pascal (measurement of pressure – in air in this document)

1 CHECKLIST: GG43110 MINIMUM REQUIREMENTS

The National Web based Environmental Screening Tool¹ was used to screen the proposed site for the noise environmental sensitivity as per the requirements of GNR320 (20 March 2020), considering the site location illustrated in **Figure 2-1**.

The site report generated by the Screening Tool highlighted that a Noise Impact Assessment must be completed and appended to the Environmental Authorization (EA) documentation.

The screening report was developed for *Utilities Infrastructure => Electricity => Generation => Renewable => Wind* category, with the noise sensitive areas illustrated on **Figure 2-3**. The areas defined to have a potential “very high” sensitivity to noise were downloaded as a layer from the online screening tool.

In terms of GNR320 (20 March 2020), a Noise Study must contain, as a minimum, the following information:

Clause	Requirement	Comment / 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	Sections 4.1 and 4.3
2.3.2	Records of the approximate wind speed at the time of the measurement	Section 4.3
2.3.3	Mapped distance of the receiver from the proposed development that is the noise source	Section 2.6 and 9
2.3.4	Discussion on temporal aspects of baseline ambient conditions	Section 4.1
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 5-2, Table 5-3 and Table 5-1
2.4.2	Projected total noise levels and changes in noise levels as a result of the construction, commissioning and operation of the proposed	Section 9

¹ <https://screening.environment.gov.za/screeningtool/#/pages/welcome>

	development for the nearest receptors using industry accepted models and forecasts	
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.	Separate document
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	See section 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	See section 4.1
2.5.5	a map showing the proposed development footprint (including supporting infrastructure) overlaid on the noise sensitivity map generated by the screening tool	See Figure 2-1
2.5.6	confirmation that all reasonable measures have been taken through micro- siting to minimize disturbance to receptors	Site development limited to wind resource
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	See section □
2.5.8	any conditions to which this statement is subjected	See section 8.7
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	Site development limited to the location of the wind resource
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	Site development limited to the location of the wind resource
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	See section 0 and 0
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	See section 8

2 INTRODUCTION

2.1 INTRODUCTION AND PURPOSE

Enviro-Acoustic Research cc was commissioned by WSP South Africa (Pty) Ltd (the Environmental Assessment Practitioner or “EAP”) to identify and assess the potential noise impact from the construction, operation and decommissioning of the proposed ABO Umemvane Wind Energy Facility (WEF) 1 and associated infrastructure on the surrounding soundscape.

This report describes ambient sound levels in the area, potential worst-case noise rating levels and the potential noise impact that the Project 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. The study also considers the noise limits as proposed by the International Finance Corporation (IFC) which is based on studies completed by the World Health Organization (WHO).

Due to a number of wind turbines proposed within an area with a potential high sensitivity to noise, a full environmental noise impact study will be conducted.

2.2 BRIEF PROJECT DESCRIPTION

The Applicant, ABO Umemvane Wind Energy Facility 1 (Pty) Ltd (Umemvane), proposes the development of a commercial Wind Farm, known as the ABO Umemvane WEF 1. The proposed WEF is located approximately 9 km west of Balfour, Mpumalanga (with the project located across the border of the Gauteng and Mpumalanga provinces), with the regional location presented in **Figure 2-1**.

The proposed Umemvane WEF will comprise several wind turbine generators (WTG) and associated infrastructure and may have a contracted capacity of up to 170 MW. It should be noted that the exact specifications of the proposed project components will be determined during the detailed engineering design phase prior to construction (subsequent to the issuing of an Environmental Authorization (EA), should such an authorisation be granted), but that the information provided below is seen as the maximum development scenario for the proposed development.

The proposed facility would comprise the following (to be located within the proposed development footprint):

- Up to 20 WTG with the following maximum specifications:
 - Maximum hub height 180 m;
 - Maximum blade length 100 m;
 - Maximum rotor diameter 200 m;
 - Maximum capacity per turbine 10 MW;
 - A transformer at the base of each turbine;
 - Concrete turbine foundations up to 1 ha each;
 - Turbine, crane, and blade hardstands (included in the abovementioned 1 ha).
- Primary/main access roads as well as internal road reticulation (note that existing roads/disturbed areas would be used as far as possible, and for the proposed roads, a corridor of up to 12 m wide may be temporarily impacted upon during construction and be rehabilitated to up to 10 m wide after construction), inclusive of stormwater infrastructure where relevant. The length of the proposed roads could be up to 31 km, including approximately 18 km of existing roads to be widened.
- 4 Temporary laydown areas/ construction compounds (includes concrete batching), totalling up to 15 ha, would be fenced with access control; and/or
- Battery Energy Storage System (BESS) to be located within the electrical infrastructure hub described under “associated infrastructure” below.

Associated infrastructure would include the following (to be located within the proposed development footprint):

- Associated internal electrical reticulation/ cabling (i.e., low- and medium voltage powerlines), underground as far as is feasible, and to run within the proposed road footprint/route as far as possible;
- A 33kV overhead/underground line to connect the northern and southern portions of the facility; and
- On-site electrical infrastructure hub up to 7 ha in extent (note there are 3 locations to be assessed as options, however only 1 will be constructed) consisting of:
 - On-site substation and associated infrastructure,
 - Additional step-up/ transformation/ collector/switchyard infrastructure,
 - Auxiliary buildings (including, but not limited to, Operation and Maintenance (O&M) building/s, admin building/s, workshop/s, gatehouse/s, security building/s, control centre/s, office/s, visitor centre/s, warehouse/s, etc.),
 - May include the installation of a communications tower and lighting mast on site with a maximum height of 32 m and 25m respectively, and/or
 - BESS.

Five access points are proposed, four of these are off existing unnamed farm roads (originating from the D1220 and P243/1) and one from the Lagerspoort Road. The details of the access would be as per the recommendations in the Transport Impact Assessment. Access roads would be developed both to the site and within the site (i.e., between project components).

2.3 PROPOSED WIND TURBINE

The wind energy market is fast changing and adapting to new technologies and site-specific constraints. Optimising the technical specifications can add value through, for example, minimizing environmental impact and maximizing energy yield. As such the applicant has been evaluating several turbine models, however the selection will only be finalised at a later stage once a most optimal wind turbine is identified (factors such as meteorological data, price and financing options, guarantees and maintenance costs, etc. must be considered).

The applicant indicated that they are considering a number of different wind turbines, however, due to various reasons, a developer may not want to reveal the actual WTG that they may consider, whether for commercial/economic reasons, possible Non-Disclosure Agreements etc.

The applicant indicated that they are considering a number of different wind turbines, including the Goldwind GWH182-6.2 WTG [62] with a warranted sound power emission level (PWL) of 110.5 dBA (re 1 pW).

It is important to note that the exact details of the actual WTG are **not** irrelevant to noise analysis, as the major factors that determine the noise levels are:

- The layout of the WEF (which would include the number of WTG as well as the distance from various receptors);
- The PWL of the WTG (or noise source) selected/that the developer is considering; and
- Noise abatement technologies implemented by the manufacturer.

Minor factors in the noise levels are:

- The spectral characteristics of the WTG;
- Temperature and Humidity;
- The hub height of the WTG (the declared PWL level already includes this factor);
- Topography and wind shear effects;
- The rotor diameter of the WTG (the declared PWL level already includes this factor);
- Ground surface characteristics; and

- The noise propagation algorithm used.

Factors that do not influence PWL are the manufacture of the WTG, the model name/number (the declared PWL level already include this factor).

The PWL are provided by the manufacturer either as the apparent PWL, maximum warranted PWL, a calculated PWL (for new WTG where the noise levels were not previously measured) or measured sound power levels as reported in terms of IEC 61400-11 or IEC 61400-14. It is unique for each make and model and the sound power levels already include the effect of the hub height, rotor diameter and abatement technologies.

There are smaller WTG with higher PWL, with larger WTG with a lower PWL. Therefore, the generating capacity, hub height or rotor diameter of the potential WTG should not be used to assume the noise levels.

Therefore, due to these factors, the total generating capacity of the WEF project may be less or more, when considering the individual generating capacity of the WTG (used for this noise specialist study) as well as the number of WTG in the layout. This however will not influence the findings of this noise specialist study (valid for this layout as evaluated).

2.4 STUDY AREA

The proposed WEF would be located approximately 9km west of the town of Balfour in the Mpumalanga Province in the Dipaleseng Local Municipality within the Gert Sibande District Municipality and approximately 14km south-east of the town Heidelberg in the Gauteng Province in the Lesedi & Midvaal Local Municipalities within the Sedibeng District Municipality.

The Project Focus Area (PFA) is the conceptual study area selected to enclose all potential project infrastructure (excluding the main project access road(s)) approximately to 2,500 m from the main noise-generating infrastructure of this WEF (the WTG). The PFA is further described in terms of environmental components that may contribute to or change the sound character in the area.

2.4.1 Topography

The Environmental Potential Atlas of South Africa (ENPAT) [159] describes the topography as "*Hills and Lowlands*". The project is situated at approximately 1,580 - 1,700 meters above sea level (mamsl). Due to the height of the WTG, as well as the position where they may be

developed, it is unlikely that topographical features will limit the propagation of sound from the WTG.

2.4.2 Surrounding Land Use

Land use within the Project Focus Area (PFA) is complex, being a combination of suburban residential, agriculture and animal husbandry, commercial and other business activities as well as wilderness areas (including undeveloped areas and ecotourism). Residential structures are scattered in a heterogeneous manner within the PFA, with minor noise associated with commercial activities, agricultural and typical household activities.

Minor noise sources are associated with typical household activities and associated subsistence farming. Noise from these sources will not be investigated or considered in this environmental noise impact assessment (ENIA).

2.4.3 Transportation Networks

The N3 passes the PFA to the west, with the R23 branching from the N3 national road. The N3 road does carry significant traffic both day and night, with the R23 carrying significantly less traffic, mostly during the daytime period.

There are also numerous small roads, mainly used by the local farmers/community. Traffic volumes on these small roads are very low and it is not expected that traffic noises would be of any significance in this area.

While vehicular traffic would increase noise levels near the N3 road, the potential effect from increased ambient sound levels due to traffic noise will not be considered in this ENIA.

2.4.4 Other commercial, industrial or mining activities

Based on a desktop assessment as well as information gained during the site visits, there are no major industrial and mines located near the PFA that would impact on the ambient sound levels in the area. There are a few light industrial projects in the area, including, amongst others, two bottling plants and at least three poultry farms. These facilities may influence noise levels near these activities, but will not impact ambient sound levels over the PFA. These potential noise sources will not be considered in this assessment.

2.4.5 Ground conditions and vegetation

The area falls within the Grassland biome, with the natural vegetation type described as “*Highveld Grassland*” [159]. The vegetation growth is typical of the grassland biome, with vegetation consisting of crops, grasses, shrubs and some trees.

The natural veld has been impacted by various anthropogenic activities, especially farming activities. Taking into consideration available information it is the opinion of the author that the ground conditions (when considering acoustic propagation on a ground surface) can be classified as medium. A worst-case scenario will be investigated, considering a ground surface factor of both 50 and 75% hard ground (with the 75% hard ground surface implying that the ground surface is not very acoustically absorbent) for operational modelling and 50% for construction modelling.

It should be noted that this factor is only relevant for air-borne waves being reflected from the ground surface, with certain frequencies slightly absorbed by the vegetation.

2.4.6 Existing Ambient Sound Levels

Ambient sound levels were measured within the PFA in a semi-continuous manner over a period of around 6 nights in November 2024 (resulting in more than 2,000 daytime and 1,000 night-time measurements – each with a minimum duration of 10-minutes).

Daytime ambient sound levels ranged between 27 and 72 dBA, with the average daytime sound levels for the 2,192 10-minute measurements being 47 dBA. Night-time ambient sound levels ranged between 22 and 68 dBA, with the average night-time sound levels for the 1,152 10-minute measurements being 43 dBA.

Ambient sound level measurement resulted in sound levels higher than expected, significantly higher than a rural noise district. Based on sounds heard and spectral information, ambient sound levels were mainly due to a combination of wind-induced, faunal and farming related noises (with cattle noises – relative constant moos, bawling and snorts audible at two measurement locations). Passing traffic was also audible at measurement locations two and three, and passing traffic may have influenced the measurements during the quieter periods at measurement location three.

Ambient sound level data collected during these measurement periods indicated ambient sound levels typical of a suburban noise district, even though the area may be considered rural. The results and findings of the ambient sound level measurements are summarised in **Section 4.3**.

2.4.7 Desired Rating Levels

The development of the proposed WEF will result in changes in the ambient sound levels during the construction and operational phases. With the project located within both the

Gauteng and Mpumalanga Provinces, it should be noted that noise control regulations are different, which will be considered in this assessment.

In addition, when considering desired rating levels, two scenarios must be considered for a WEF, because, while construction activities may take place during periods with no-, low- and high-winds, WTG will only operate during periods when wind speeds are elevated. As such, two sets of desired rating levels should be considered.

Considering the average fast-weighted sound levels as measured, for the construction period, the likely rating levels would be:

- 45 – 50 dBA for the daytime period (typical of a rural to sub-urban noise district); and
- 40 – 45 dBA for the night-time period (typical of a suburban to urban noise district).

Because the WTG will only operate during periods with increased winds, this report will consider the requirements of the noise control regulations (see **section 3.3**) as well as the noise limits recommended by the World Bank Group (WBG) and the International Finance Corporation (IFC – see **section 3.5.6**), with desired upper noise limits for WEF being:

- 55 dBA for the daytime period; and
- 45 dBA for the night-time period.

The relevant Noise Control Regulations are also discussed in detail in **section 3.3** (specific legislation for Mpumalanga [**section 3.3.1**] and Gauteng [**section 3.3.2**]) as well as **section 6.4** (setting appropriate noise limits).

2.5 ENVIRONMENTAL SENSITIVITY – NOISE THEME

The project site was assessed in terms of the Noise Sensitivity Theme using the online Environmental Screening Tool².

Potential noise-sensitive areas with a “very high” sensitivity were obtained from the online screening tool using the Utilities Infrastructure => Electricity => Generation => Renewable => Wind category, with the potential noise-sensitive areas illustrated on **Figure 2-3**.

The screening report generated for the category Utilities Infrastructure => Electricity => Generation => Renewable => Wind does stipulate:

² <https://screening.environment.gov.za/screeningtool/#/pages/welcome>

- that a Noise Specialist Study should be appended to the Environmental Impact Assessment (EIA), and
- that the GNR320 Assessment Protocol be followed when doing the noise impact assessment.

2.6 NOISE-SENSITIVE RECEPTORS

Potential noise-sensitive developments, receptors and communities (NSR) were identified using tools such as Google Earth® within, and near the PFA, with the status of the NSR verified during site visits on 14 and 20 November 2024, as well as on 23 February 2025. These receptors are highlighted in **Figure 2-4** (Scoping phase) and **Figure 2-5** (EIA phase), with the perceived or assumed use of the structures at these NSR defined in **Appendix E, Table 1**.

Generally³, noises from wind turbines:

- could be significant within 500 m, with receptors staying within 500 m from operational WTG subject to noises at a potentially sufficient level to be considered disturbing. There are no NSR staying within 500m from any WTG;
- are normally limited to a distance of approximately 1,000m from operational wind turbines. Night-time ambient sound levels could be elevated and the potential noise impact measurable. There are 11 NSR locations within this zone; and
- likely to be audible up to a distance of 2 500m at night. Noises from the WTG are of a low concern at distances greater than 2 500m, although the sound of the WTGs may be audible at greater distances during certain metrological phenomena.

2.7 COMMENTS RECEIVED DURING THE EIA

The author is not aware of any comments raised by the authorities or interested and affected parties at the date this report was compiled. It should however be noted that the Noise Assessment is part of a suite of studies commissioned by the EAP, who is undertaking the Public Participation Process (PPP) as part of the Scoping and Environmental Impact Assessment (EIA) process. Comments regarding noise may only be available during the EIA and PPP process.

³ Depending on the layout as well as the specific sound power emission levels of the selected wind turbine. Multiple WTG located within 1,000 - 2,000m from an NSR may result in a higher noise level at an NSR than the case with the same singular WTG located 500m from an NSR.

2.8 TERMS OF REFERENCE

A noise impact assessment must be completed for the following reasons:

- It was identified as an environmental theme needing further investigation in terms of (i.t.o.) the National Screening Tool as per the procedures of Government Gazette 43110 of 20 March 2020;
- A change in land use as highlighted in SANS 10328:2008, section 5.3;
- If an industry is to be established within 1,000 m from a potential noise sensitive development (SANS 10328:2008 [5.4 (h)]);
- 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 noise sensitive development *or vice versa*;
- It is a controlled activity in terms of the NEMA regulations and an 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 generally required by the local or district authority as part of the EA or planning approval in terms of Regulation 2(d) or GN R154 of 1992;

2.8.1 Requirements as per Government Gazette 43110 of March 2020

The Department of Forestry, Fisheries and Environment (DFFE) 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 EA 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 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.

The minimum requirements for a Noise Specialist Study (i.t.o. GNR 320 of 2020) are also covered in **Section 1** in the form of a checklist.

This assessment will be comprehensive and a Noise Specialist Assessment will be submitted because there are a number of potential NSR living within 2,500 m from the project area.

2.8.2 Requirements as per South African National Standards (SANS)

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

In addition, SANS 10328:2008 (Edition 3) [132] 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 EIA purposes. These minimum requirements are:

- a) the purpose of the investigation (see **section 2.1**);
- b) a brief description of the planned development or the changes that are being considered (see **section 2.2**);

- c) a brief description of the existing environment including, where relevant, the topography, surface conditions and meteorological conditions during measurements (see **section 2.4 and 4**);
- d) the identified noise sources together with their respective sound pressure levels or sound power levels (or both) and, where applicable, the operating cycles, the nature of sound emission, the spectral composition and the directional characteristics (see **section 5**);
- e) the identified noise sources that were not taken into account and the reasons as to why they were not investigated (see **section 5 and 8**);
- f) the identified noise-sensitive developments and the noise impact on them (see **section 2.6, 9 and 10**);
- g) where applicable, any assumptions, with references, made with regard to any calculations or determination of source and propagation characteristics (see **section 8**);
- h) an explanation, either by a brief description or by reference, of all measuring and calculation procedures that were followed, as well as any possible adjustments to existing measuring methods that had to be made, together with the results of calculations (see **sections 8 and 9**);
- i) an explanation, either by description or by reference, of all measuring or calculation methods (or both) that were used to determine existing and predicted rating levels, as well as other relevant information, including a statement of how the data were obtained and applied to determine the rating level for the area in question (see **section 4, 7 and 9**);
- j) the location of measuring or calculating points in a sketch or on a map (see **Figure 9-6 and Figure 9-7**);
- k) quantification of the noise impact with, where relevant, reference to the literature consulted and the assumptions made (see **section 9**);
- l) alternatives that were considered and the results of those that were investigated (see **section 10.6**);
- m) a list of all the interested or affected parties that offered any comments with respect to the environmental noise impact investigation (see **section 2.7**);
- n) 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 (see **section 2.7**);
- o) conclusions that were reached (see **section 14**);
- p) proposed recommendations (see **section 14**);
- q) 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 (see **section 0**); and

- r) any follow-up investigation which should be conducted at completion of the project as well as at regular intervals after the commissioning of the project so as to ensure that the recommendations of this report will be maintained in the future (see **section 14**).

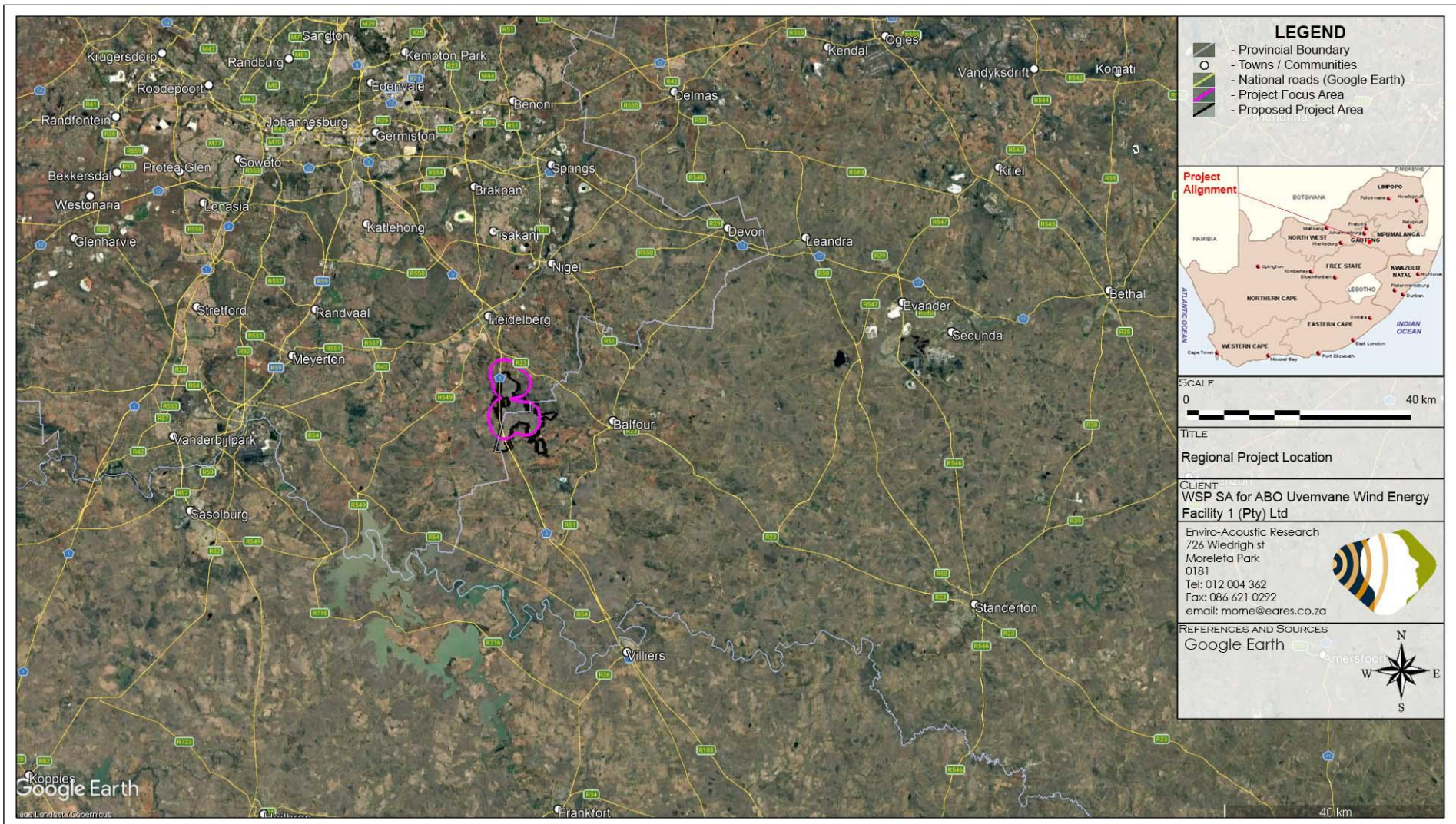


Figure 2-1: Regional Location of the proposed Uvmvane WEF

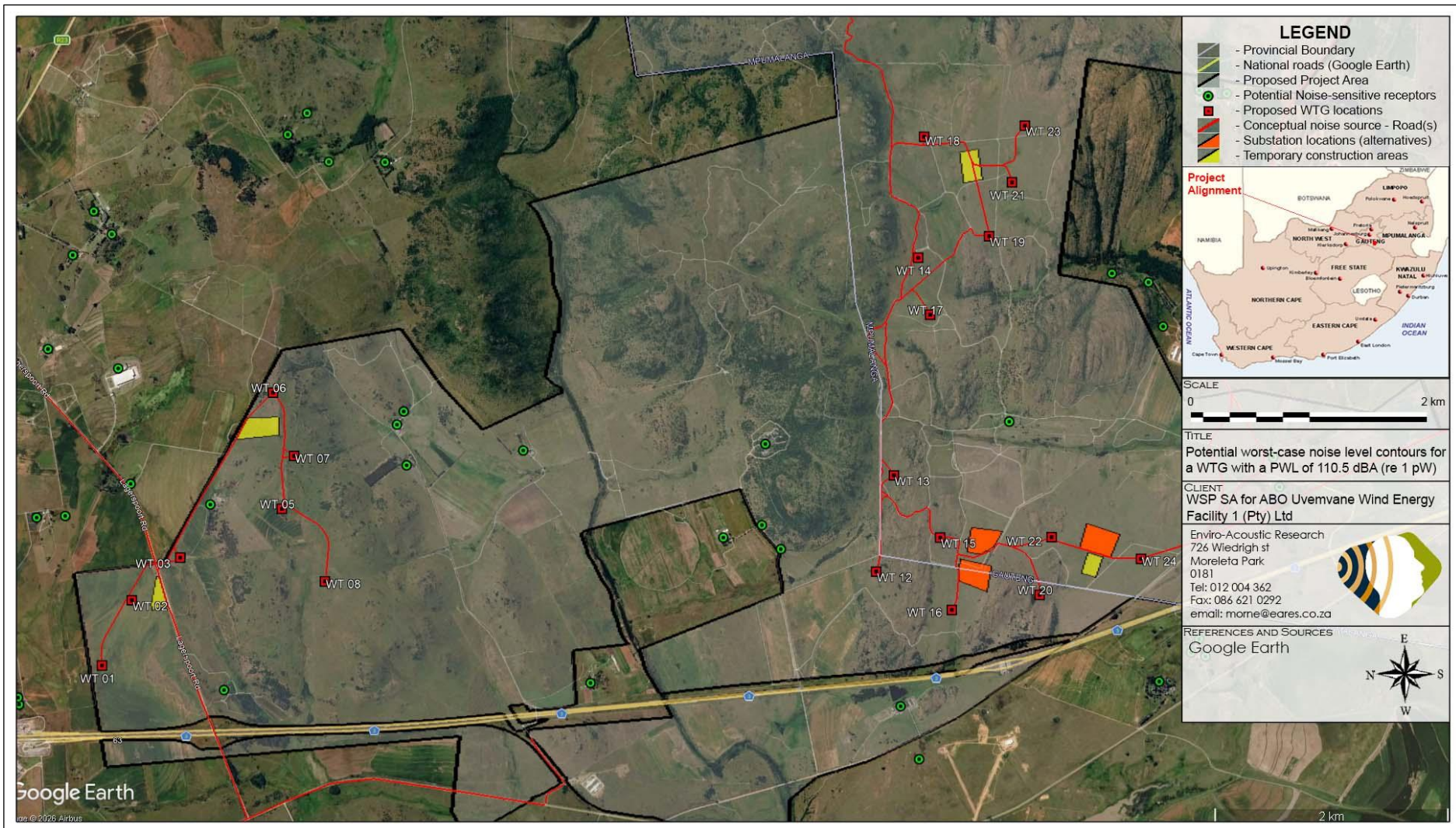


Figure 2-2: Project infrastructure of the proposed Uvemvane WEF

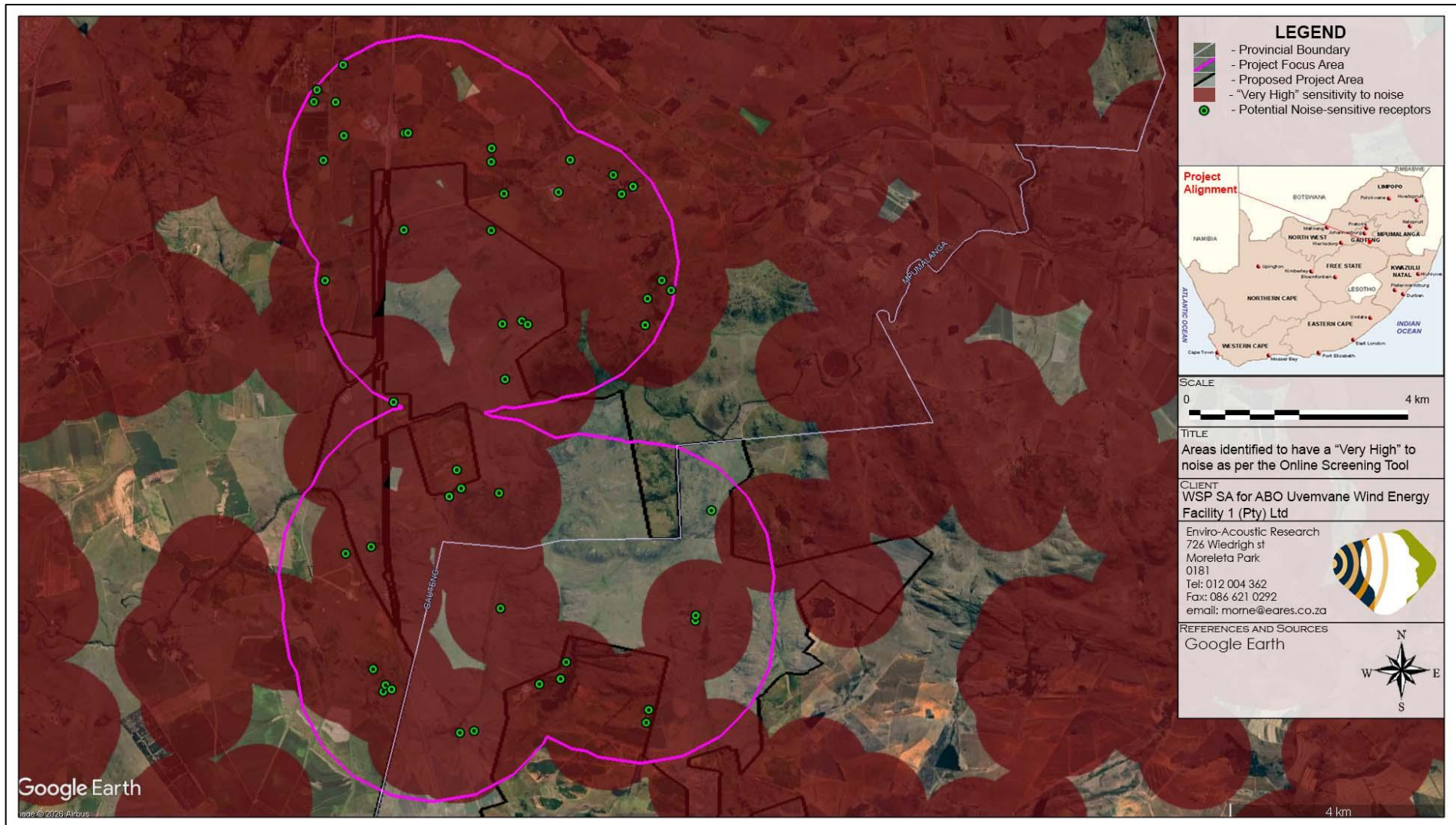


Figure 2-3: Study area and potential noise-sensitive areas identified by the online screening tool

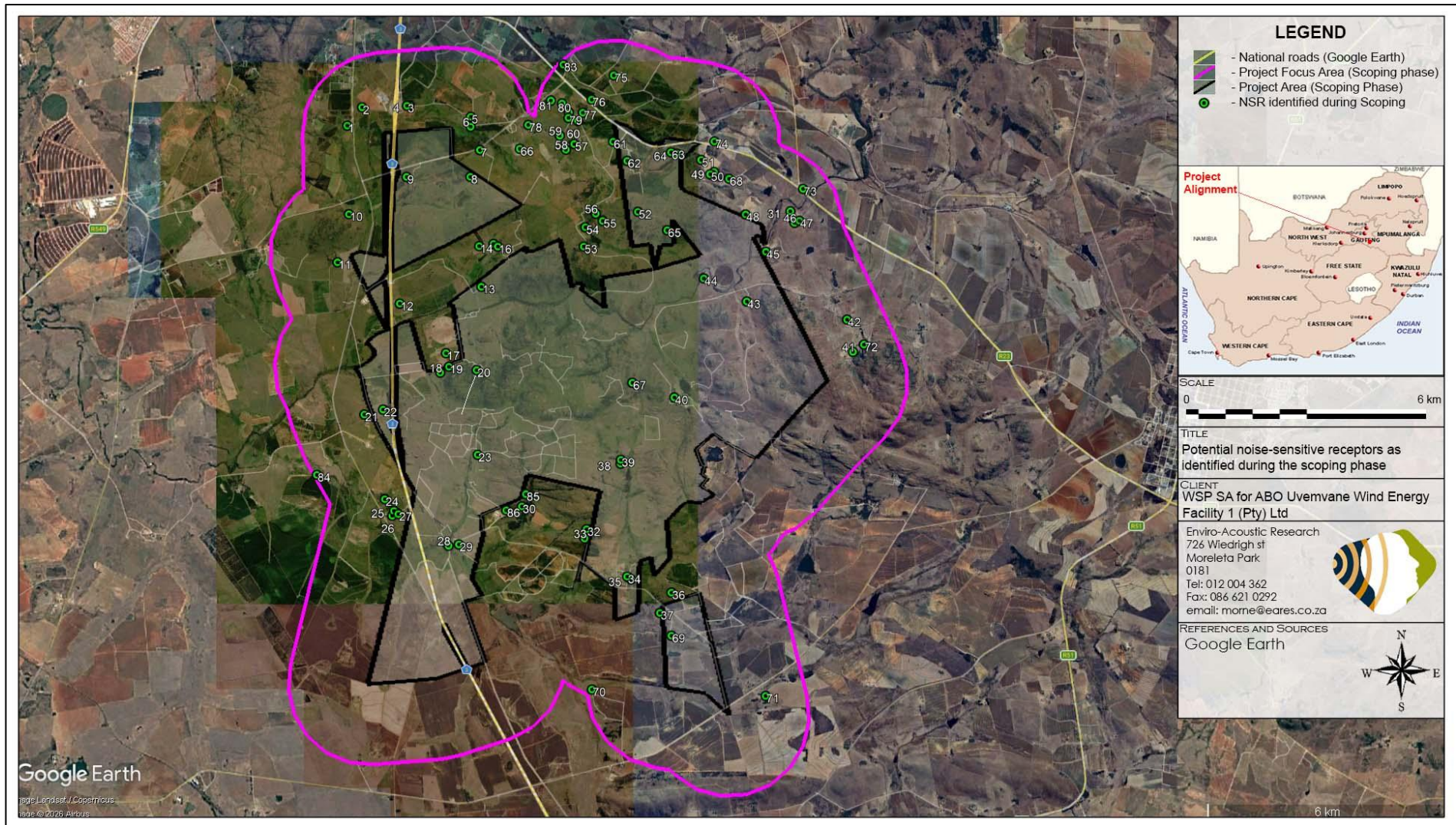


Figure 2-4: Potential noise-sensitive receptors identified during Scoping Phase

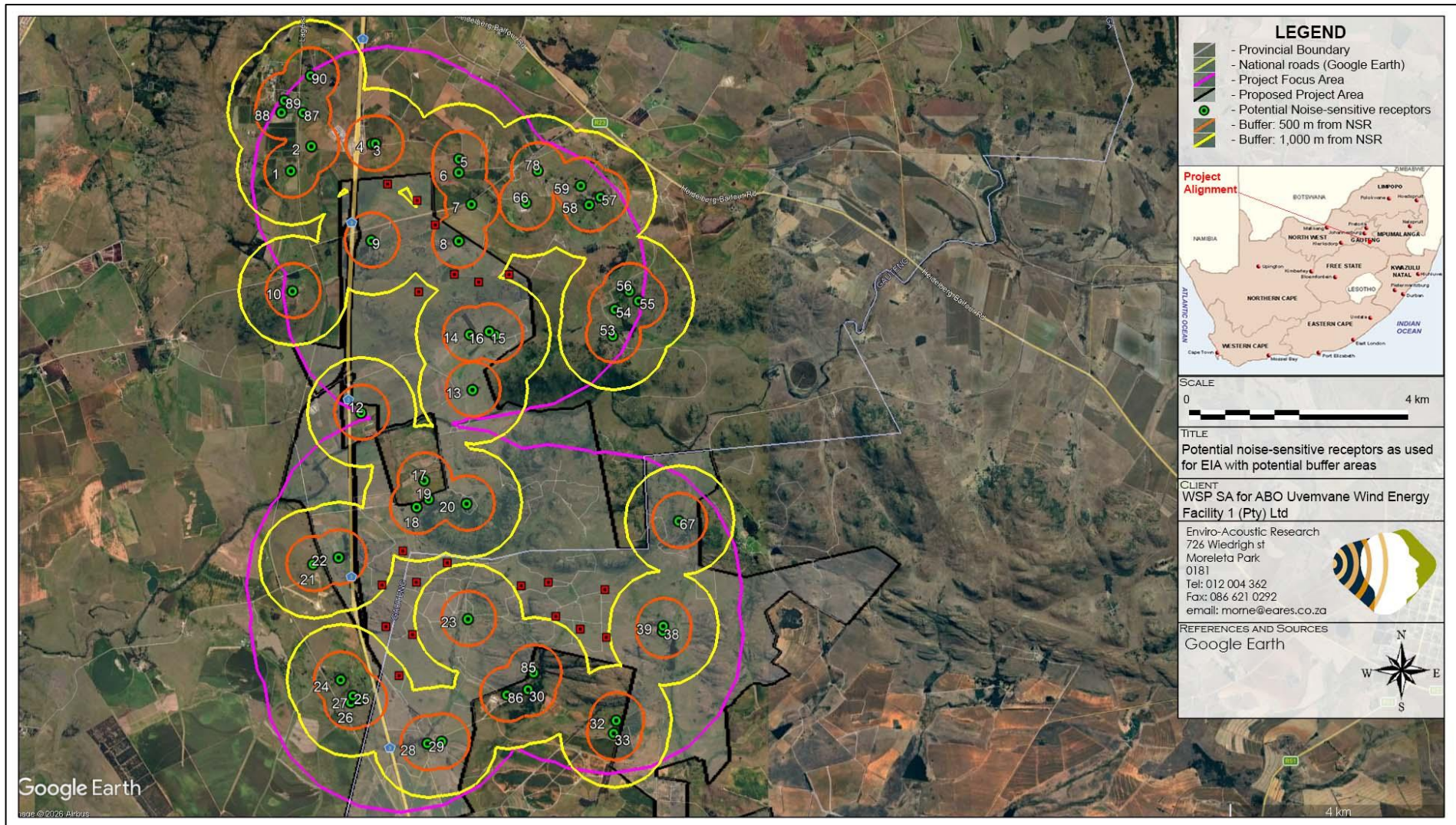


Figure 2-5: Potential noise-sensitive receptors assessed during the EIA phase

3 LEGAL CONTEXT, POLICIES AND GUIDELINES

3.1 THE REPUBLIC OF SOUTH AFRICA CONSTITUTION ACT (“THE CONSTITUTION”)

The environmental rights contained in section 24 of the Constitution provide 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 well-being. 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, which has led to the development of noise standards (see **Section 3.4**).

“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.

3.2 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 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 GG 38282, dated 4 December 2014, which came into effect on 8 December 2014. These were amended in April 2017, specifically promulgated in 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 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 National Environmental Management Act, 1998 (Act No. 107 of 1998), are replaced by the requirements of GNR 320 of 2020.

3.3 THE ENVIRONMENT CONSERVATION ACT (ACT 73 OF 1989)

The Environment Conservation Act (ECA) allows the Minister of Environment, Forestry and Fisheries to make regulations regarding noise, among other concerns. While most sections of this Act have been repealed with the promulgation of the NEMA, Section 25 of this Act is still in effect.

3.3.1 National Noise Control Regulations (GN R154 of 1992)

In terms of section 25 of the ECA, the National Noise Control Regulations (GN R 154 of 1992) were promulgated. The NCRs were revised under Government Notice Number R. 55 of 14 January 1994 to make it obligatory for all authorities to apply the regulations.

Subsequently, in terms of Schedule 5 of the Constitution of South Africa of 1996 legislative responsibility for administering the noise control regulations was devolved to provincial and local authorities. The National Regulations will be in effect in the North West Province.

The National Noise Control Regulations (GN R154 1992) define:

"Controlled area" as:

A piece of land designated by a local authority where, in the case of--

- c) Industrial noise in the vicinity of an industry-
 - 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
 - ii. the calculated outdoor equivalent continuous "A"-weighted sound pressure level at a height of at least 1,2 meters, but not more than 1,4 meters, above the ground for a period of 24 hours, exceeds 61 dBA;

"disturbing noise" as:

Noise level which exceeds the zone sound level or, if no zone sound level has been designated, a noise level which exceeds the ambient sound level at the same measuring point by 7 dBA or more.

"zone sound level" as:

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. *This is the same as the Rating Level as defined in SANS 10103:2008.*

In addition:

In terms of Regulation 2 -

"A local authority may –

(c): if a noise emanating from a building, premises, vehicle, recreational vehicle or street is a disturbing noise or noise nuisance, or may in the opinion of the local authority concerned be a disturbing noise or noise nuisance, instruct in writing the person causing such noise or who is responsible therefor, or the owner or occupant of such building or premises from which or from where such noise emanates or may emanate, or all such persons, to discontinue or cause to be discontinued such noise, or to take steps to lower the level of the noise to a level conforming to the requirements of these Regulations within the period stipulated in the instruction: Provided that the provisions of this paragraph shall not apply in respect of a disturbing noise or noise nuisance caused by rail vehicles or aircraft which are not used as recreational vehicles;

(d): before changes are made to existing facilities or existing uses of land or buildings, or before new buildings are erected, in writing require that noise impact assessments or tests are conducted to the satisfaction of that local authority by the owner, developer, tenant or occupant of the facilities, land or buildings or that, for the purposes of regulation 3(b) or (c), reports or certificates in relation to the noise impact to the satisfaction of that local

authority are submitted by the owner, developer, tenant or occupant to the local authority on written demand”;

In terms of Regulation 4 of the Noise Control Regulations:

"No person shall make, produce or cause a disturbing noise, or allow it to be made, produced or caused by any person, machine, device or apparatus or any combination thereof".

3.3.2 Noise Control Regulations: Gauteng Province (GN 5479 of 20 August 1999)

The Gauteng Noise Control Regulations is based on the National Noise Control Regulations and most of the regulations are the same. It prohibits the generation of a disturbing noise in any manner (Regulation 8) and defines and prohibits activities that can result in a noise nuisance (Regulation 9). Regulation 11(1) allows a local authority to designate a controlled area as well as zone sound levels for specific areas and during specific times.

The difference between the National Noise Control Regulations and the Gauteng Province is the criteria set out for a controlled area, namely:

“controlled area” means a piece of land designed by a local authority where, in the case of-

(a) road traffic 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 of 24 hours while such meter was in operation, exceeds 60 dBA; or
- (ii) the outdoor equivalent continuous "A" -weighed 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 as calculated in accordance with SABS 0210, and projected for a period of 15 years following the date on which the local authority has made such designation, exceeds 60 dBA.

It should be noted that the regulations define:

"ambient sound level⁴" - 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 meter was put into operation;

⁴ This is the same as the Residual Noise Level as defined in the later SANS 10103:2008 and SANS 10328:2008 guidelines

"disturbing noise" - means a noise level that causes the ambient noise level to rise above the designated zone level, or if no zone level has been designated, the typical rating levels for ambient noise in districts, indicated in table 2 of SABS 0103;

"noise level" - means the reading on an integrating impulse sound level meter taken at a measuring point in the presence of any alleged disturbing noise at the end of a total period of at least 10 minutes after such meter was put into operation, and, if the alleged disturbing noise has a discernible pitch, for example, a whistle, buzz, drone or music, to which 5 dBA has been added;

In addition:

In terms of Regulation 8 of the Noise Control Regulations:

"No person shall make, produce or cause a disturbing noise, or allow it to be made, produced or caused by any person, machine, device or apparatus or any combination thereof".

In terms of Regulation 10(1):

"No person shall –

- (b) make changes to existing facilities or existing uses of land or buildings or erect new buildings, if these will house or cause activities, that will, after such changes or erection, cause a disturbing noise, unless precautionary measures to prevent the disturbing noises have been taken to the satisfaction of the local authority;*
- (d) if required by a local authority, install, replace or modify a plant with a total input power exceeding 10 kilowatts on any premises, unless the local authority has been notified by the owner of the plant in writing at least 14 days before such installation, replacement or modification;*

In terms of Regulation 10(2):

"The local authority may –

- (a) before changes are made to existing facilities or existing uses of land or buildings or before new buildings are erected, in writing require that noise impact assessments or tests be conducted to the satisfaction of that local authority by the owner, developer, tenant or occupant of the facilities, land or buildings and that reports or certificates relating to the noise impact to the satisfaction of that local authority be submitted by the owner, developer, tenant or occupant to the local authority on written demand.*

3.4 NOISE STANDARDS

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

- SANS 10103:2008. 'The measurement and rating of environmental noise with respect to annoyance and to speech communication' [130].
- SANS 10210:2004. 'Calculating and predicting road traffic noise' [131].
- SANS 10328:2008. 'Methods for environmental noise impact assessments' [132].
- 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' [133].

The relevant standards use the equivalent continuous rating level (calculated from the sound pressure levels over the reference time, see [Appendix B](#)) 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*.

3.4.1 SANS 10103:2008

SANS 10103 provide standard procedures to measure and define rating levels with respect to annoyance and speech communication, mainly focusing on subsections:

- clause 4.1 - Ambient indoor noise;
- clause 4.2 – Typical noise in various districts; and
- clause 4.5 – Assessment of annoyance.

3.4.1.1 Clause 4.1 – Ambient indoor noise

This is a critical section, frequently ignored by authorities and even acoustic specialists. This clause provide recommended rating levels ($L_{Req,T}$) for ambient noise for different areas of occupancy during the time periods when the areas are used for their intended purposes and with the building services (e.g. ventilation systems, air-conditioning systems, lifts, plumbing and lighting) under normal operating conditions. The rating levels given in column 2 of the table are design values, while those given in column 3 are the maximum levels beyond which the ambient noise can be considered to be annoying or otherwise intrusive. Note 2 highlights that, where these levels are used as guidance for the design of buildings in non-

residential areas where the ambient noise exceeds the typical level for the type of development, the building design should provide sufficient acoustic isolation to result in the occupancy level specified in Table 1 of SANS 10103 (see example for residential use in **Table 3-1**).

Table 3-1: Recommended ambient noise for different areas of occupancy indoors (Table 2 - SANS 10103:2008)

1	2	3
Types of occupancy or activity	Design equivalent continuous rating level ($L_{Req,T}$) ^a for ambient noise dBA	Maximum equivalent continuous rating level ($L_{Req,T}$) ^a for ambient noise dBA
9. Residential buildings		
Living rooms	35	45
Kitchens and service areas	45	55
Bathrooms and toilets	40	55
Bedrooms	30	40

3.4.1.2 Clause 4.2 – Typical noise in various districts

This section covers typical rating levels ($L_{Req,T}$) for ambient noise in different districts in Table 2 (duplicated in **Table 3-2**). This standard recommends that these values not be exceeded, and outdoor ambient noise exceeding these levels will be considered to be annoying to the community.

The levels may be used as a guide for zoning purposes and assumes that a building with natural ventilation and open windows will provide sound insulation of about 10 dBA, with the rating levels considering Table 1 rating levels (duplicated in **Table 3-1**). This standard highlights in note 1 that, where occupancies have to be allowed within areas where the acceptable outdoor values are exceeded for the particular type of occupancy, the sound insulation of the building housing the occupancy should be proven to comply to the indoor levels defined in Table 1 (see example for residential use in **Table 3-1**) of this standard.

3.4.1.3 Clause 4.5 – Assessment of annoyance

This section recommends investigation only when the rating level ($L_{Req,T}$) of the ambient noise exceeds the rating level ($L_{Req,T}$) of the residual noise (ambient sound levels) at the same location during the relevant time period. The ambient indoor or outdoor sound level should be compared with the appropriate level given in Table 1 (see **section 3.4.1.1**) or Table 2 (see **section 3.4.1.2**). This standard state that it is probable that the noise is

annoying or otherwise intrusive to the community or to a group of persons if the rating level of the ambient noise under investigation exceeds the applicable of the following:

- a) the rating level of the residual noise (determined in the absence of the specific noise under investigation);
- b) the maximum rating level for the ambient noise given in table 1 (see example for residential use in **Table 3-1**); or

the typical rating level for the ambient noise for the applicable environment given in table 2 (duplicated in **Table 3-2**). The probable community or group response to the excess ($\Delta L_{Req,T}$) is given in **Figure 3-1**.

Table 3-2: Acceptable Zone Sound Levels for noise in districts (Table 2 - SANS 10103:2008)

Type of district	Equivalent continuous rating level ($L_{Req,T}$) for noise dBA					
	Outdoors			Indoors, with open windows		
	Day/night $L_{R,dn}$	Daytime $L_{Req,d}$	Night-time $L_{Req,n}$	Day/night $L_{R,dn}$	Daytime $L_{Req,d}$	Night-time $L_{Req,n}$
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

3.4.2 SANS 10328:2008

SANS 10328 provide methods for environmental noise impact assessment, with relevant regulations (see **section 3.3.1**) and GNR320 (see **section 2.8.1** and checklist in **section 1**) stipulating that this standard be followed when doing a noise specialist study.

SANS 10328 recommends that the procedures given in clause 6 to clause 8 (inclusive) be followed if:

- a) an application, in respect of any activities identified in terms of the current relevant legislation are proposed, if noise sources listed in clauses 3.17 and 3.18 (of SANS

- 10328) are to be developed, or the issues listed in clause 5 (of SANS 10328) may take place, is made to the relevant authority;
- b) an application for a noise-sensitive development (see 3.16 of SANS 10328) is made to the relevant authority;
 - c) an application for a change in land use is made to the relevant authority; or
 - d) an environmental noise impact investigation is requested by an applicant or any interested or affected party.

The minimum contents of the noise specialist study are also included in **section 2.8.2** of this report.

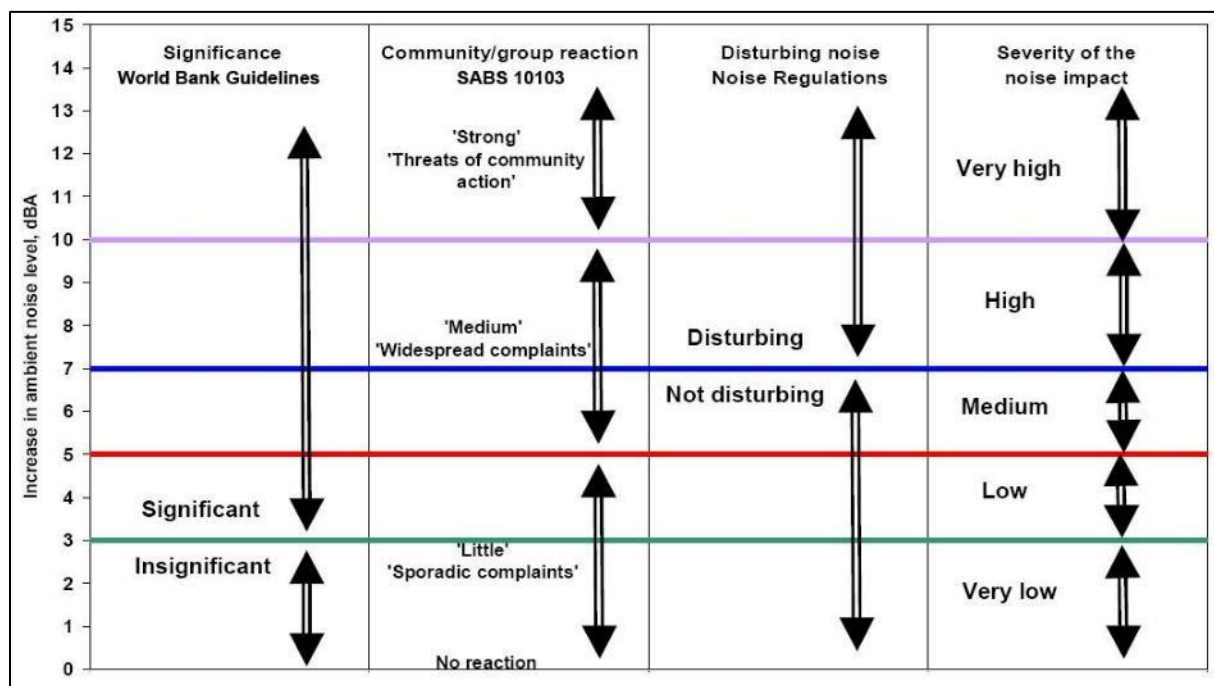


Figure 3-1: Criteria to assess the significance of impacts stemming from noise

3.5 INTERNATIONAL GUIDELINES

While a number of international guidelines and standards exists, those selected below are used by numerous countries for environmental noise management.

3.5.1 Guidelines for Community Noise (WHO, 1999) [167]

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 [167]. 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 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. It discusses the specific effects of noise on communities including:

- Interference with communication, noise-induced hearing impairment, sleep disturbance effects, cardiovascular and psychophysiological effects, mental health effects, effects on performance, annoyance responses and effects on social behavior.

It further discusses how noise can affect (and propose guideline noise levels) specific environments such as residential dwellings, schools, preschools, hospitals, ceremonies, festivals and entertainment events, sounds through headphones, impulsive sounds from toys, fireworks and firearms, and parklands and conservation areas.

To protect the majority of people from being affected by noise during the daytime, it proposes that sound levels at outdoor living areas should not exceed 55 dB L_{Aeq} for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the day, the outdoor sound pressure level should not exceed 50 dB L_{Aeq} . At night, equivalent sound levels at the outside façades of the living spaces should not exceed 45 dBA and 60 dBA L_{Amax} so that people may sleep with bedroom windows open. It is critical to note that this guideline requires the sound level measuring instrument to be set on the "fast" detection setting.

3.5.2 Night Noise Guidelines for Europe (WHO, 2009) [168]

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 [168]. 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.”

3.5.3 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 [51]. It was developed as an Energy Technology Support Unit⁵ (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 follows:

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 4-26** and **Figure 4-27**) are more appropriate;
2. LA90,10mins is a much more accurate descriptor when monitoring ambient and turbine noise levels;

⁵ 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.

3. The effects of other wind turbines in a given area⁶ should be added to the effect of any proposed Wind Farm (WF), 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 a receptor. Ambient noise levels are measured onsite in terms of the $L_{A90,10min}$ 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.

While this guideline may be 25 years old, planning policy in England, Scotland, Wales and Northern Ireland still refer to the ETSU-R97 for guidance on the assessment of wind turbine noise [29, 50, 75, 148, 151]. In Australia and New Zealand, ETSU-R-97 has been adopted as the base assessment method of assessment [29, 49]. The ETSU-R97 is referenced in NARUC (2011) [105] as well as the recommended method in IFC (2015) [74]. Because of its international importance, the methodologies used in the ETSU R97 document will be considered in this report for implementation should projected noise levels (from the proposed WEF at NSR) exceed the zone sound levels as recommended by SANS 10103:2008.

3.5.4 Noise Guidelines for Wind Farms (MoE, 2008) [101]

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.

This 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 3-3**⁷

⁶ Though the area has not been defined, it is the opinion of the author that this would be withing the potential area of effect, defined as 2,000m in SANS 10328:2008. Considering that WTG from two adjacent WEFs may have a slight influence at 2,000m, this area typically would be a maximum of 4,000m from two or more WEFs

⁷The 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 ninetieth 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

- The requirements of 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 3-3: 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.

3.5.5 Equator Principles

The **Equator Principles** (EPs) are a voluntary set of standards for determining, assessing and managing social and environmental risk in project financing. 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 Equator Principles were developed by private sector banks and were launched in June 2003. Revision III of the EPs has been in place since June 2013. As of March 2021, 116 financial institutions in 37 countries have officially adopted the Equator Principles, covering the majority of international project finance debt in emerging and developed markets.

The participating banks chose to model the Equator Principles on the environmental standards of the World Bank (1999) and the social policies of the International Finance Corporation (IFC). As of beginning 2022:

- More than 90 banks and financial institutions have voluntarily adopted the Equator Principles, which are based on IFC's Performance Standards⁸.
- 32 export credit agencies of the Organization of Economic Co-operation and Development countries benchmark private sector projects against IFC's Performance Standards.
- The Multilateral Investment Guarantee Agency applies IFC's Performance Standards in its operations.
- The World Bank applies IFC's Performance Standards (known as World Bank Performance Standards) to projects supported by IBRD/IDA (International Bank for Reconstruction and Development/International Development Association) that are owned, constructed and/or operated by the private sector.

3.5.6 IFC: General EHS Guidelines – Environmental Noise Management [73]

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

Document 1.7⁹ of the IFC: General EHS Guidelines states that noise prevention and mitigation measures should be applied where predicted or measured noise impacts from project facilities/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 source. It goes as far as to proposed 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

8

https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/performance-standards/performance-standards

9 <https://www.ifc.org/wps/wcm/connect/4a4db1c5-ee97-43ba-99dd-8b120b22ea32/1-7%2BNoise.pdf?MOD=AJPERES&CVID=nPtgwZY>

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 less-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 3-4**) and highlights certain monitoring requirements pre- and post-development. It adds another criterion in that the existing background ambient noise level should not rise by more than 3 dBA. This criterion will effectively sterilize large areas of any development. Therefore, it is the author's considered opinion that this criterion was introduced to address cases where the existing ambient noise level is already at, or in excess of the recommended limits.

Table 3-4: IFC Table 7.1-Noise Level Guidelines

Receptor type	One-hour L_{Aeq} (dBA)	
	Daytime 07:00 - 22:00	Night-time 22:00 - 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

The document uses the $L_{Aeq,1hr}$ noise descriptors to define noise levels. It does not determine the detection period, but refers to the IEC standards, which requires the fast detector setting on the Sound Level Meter during measurements in Europe.

3.5.7 European Parliament Directive 2000/14/EC [44]

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 3 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.

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.

3.5.8 Environmental, Health, and Safety Guidelines for Wind Energy [74]

The EHS Guidelines for wind energy include information relevant to environmental, health, and safety aspects of onshore and offshore wind energy facilities. It should be applied to wind energy facilities from the earliest feasibility assessments, as well as from the time of the environmental impact assessment, and continue to be applied throughout the construction and operational phases.

It provides a brief overview of construction and operational noises, potential operational mitigation measures and a number of principles on the assessment of noise impacts, including:

- Receptors should be chosen according to their environmental sensitivity (human, livestock, or wildlife);
- Preliminary modelling should be carried out to determine whether more detailed investigation is warranted. The preliminary modelling can be as simple as assuming hemispherical propagation (i.e., the radiation of sound, in all directions, from a source point). Preliminary modelling should focus on sensitive receptors within 2,000 meters (m) of any of the turbines in a wind energy facility;
- If the preliminary model suggests that turbine noise at all sensitive receptors is likely to be below an L_{A90} of 35 dBA at a wind speed of 10 meters/second (m/s) at 10 m height during day and night times, then this preliminary modelling is likely to be sufficient to assess noise impact; otherwise it is recommended that more detailed modelling be carried out, which may include background ambient noise measurements;
- All modelling should take account of the cumulative noise from all wind energy facilities in the vicinity having the potential to increase noise levels;
- If noise criteria based on ambient noise are to be used, it is necessary to measure the background noise in the absence of any wind turbines. This should be done at one or more noise-sensitive receptors. Often the critical receptors will be those closest to the wind energy facility, but if the nearest receptor is also close to other significant noise sources, an alternative receptor may need to be chosen; and

- The background noise should be measured over a series of 10-minute intervals, using appropriate wind screens. At least five of these 10-minute measurements should be taken for each integer wind speed from cut-in speed to 12 m/s.

3.5.9 Environmental Noise Guidelines for the European Region (2018) [169]

This document identifies levels at which noise has “adverse health effects” 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.

The WHO (2018) [169] considers adverse health effects in section 2.4.3.2 of that report, dividing these effects into the following health outcomes:

- Cardiovascular disease – Ischaemic heart disease and hypertension;
- Cognitive impairment – Reading and oral comprehension;
- Permanent hearing impairment; and
- Self-reported sleep disturbance and annoyance.

While the WHO (2018) [169] highlights that there is insufficient evidence of adverse health effects at noise levels below 40 dBA L_{night} , adverse health effects were reported at levels starting from 40 dB L_{night} . At 40 dB, about 3–4% of the population still reported being highly sleep-disturbed due to noise, which was considered relevant to health. It recommends that the guideline level should minimise adverse health effects to less than:

- 3% of the population experiencing sleep disturbances; and
- 10% of the population being highly annoyed.

This report recommends, that, for average noise exposure, the WHO Guideline Development Group conditionally recommends reducing noise levels produced by wind turbines below 45 dB L_{den}¹⁰, as wind turbine noise above this level is associated with adverse health effects.

3.5.10 Concluding remarks on the use of International Guidelines in this Assessment

As highlighted in **section 6.4**, South African guidelines (such as SANS 10103) or regulations (such as GNR.154 of 1992), does not cater for instances when background noise levels change due to the impact of external forces (such as the influence of increased winds). As such this report considers both local legislation, regulations and guidelines as well as international guidelines. Of the more than 340,000 WTG¹¹ operation in the rest of the world (more than 15,000 wind farms¹²), less than 500 WTG are currently operational in South Africa (34 - 37 wind farms, depending on source). The rest of the world therefore have had experience with the effects and impacts of wind farms since 1980; South Africa only since 2002.

As such, almost all the scientific articles, papers, publications and presentations available are based on the research and experiences gained from these international wind farms. Therefore, discarding the knowledge and experiences gained by the rest of the world would be irresponsible and unwise. In summary:

- The WHO Guidelines for Community Noise recommends that night-time equivalent sound levels (at the outside façades of the living spaces) not exceed 45 dBA with L_{Amax} less than 60 dBA so that people may sleep with bedroom windows open **(Section 3.5.1)**;
- The Night Noise Guidelines for Europe revised noise levels, recommending a maximum year-round outside night-time noise average of 40 dB to avoid sleep disturbance and its related health effects **(Section 3.5.2)**;
- The ETSU-R97 guideline recommends an upper noise limit of 45 dBA for project participants, and a noise limit of 40 dBA for external parties **(Section 3.5.3)**;

¹⁰ Day-evening-night noise level is a European standard to express noise level over an entire day. It imposes a penalty on sound levels during evening and night and it is primarily used for noise assessments of airports, busy main roads, main railway lines and in cities over 100,000 residents. This equates to a night-time equivalent noise level of approximately 38.7 dBA.

¹¹ <https://gwec.net/there-are-over-341000-wind-turbines-on-the-planet-heres-how-much-of-a-difference-theyre-actually-making/#:~:text=According%20to%20the%20Global%20Wind,were%20spinning%20and%20generating%20energy.>

¹² <https://globalenergymonitor.org/projects/global-wind-power-tracker/>

- The MoE guideline propose a changing noise limit at different wind speeds for wind farm developments, varying from 40 dBA (at a wind speed of 4 m/s) to a maximum of 51 dBA (at a wind speed of 10 m/s or more) **(Section 3.5.4)**;
- The environmental standards of the World Bank have been integrated into the social policies of the IFC since April 2007, with the guidelines recommending a night-time noise limit of 45 dBA **(Section 3.5.6)**;
- The European Directives does not set noise limits, but there are a number that obligate equipment manufacturers to define and indicate the sound power emission levels of their equipment. When presented with a number of equipment options, applicants can use this data to select the quietest piece of equipment, in such to minimize noise levels **(Section 3.5.7)**;
- While the IFC EHS Guidelines for Wind Energy does not stipulate specific noise limits, it does recommend the measurement of ambient sound levels at different speeds (referring to the ETSU-R97 guidelines discussed in **Section 3.5.3** should noise criteria based on ambient sound levels be used **(Section 3.5.8)**; and
- The Environmental Noise Guidelines for the European Region report recommends that, for average noise exposure, noise levels produced by wind turbines should remain below 45 dBA L_{den} (an L_{Aeq} of ± 38.7 dBA) **(Section 3.5.9)**.

As WTGs only operate during a period when wind speeds are elevated, a period that generally coincide with increased noise levels (due to wind-induced noises), this report recommends an upper noise limit of 45 dBA, at the same time considering the international recommended levels (as further motivated in **sections 6.4.1.1** and **6.4.1.3**) and summarized in **Table 6-2**.

4 CURRENT ENVIRONMENTAL SOUND CHARACTER

4.1 INFLUENCE OF SEASON ON AMBIENT SOUND LEVELS

Natural sounds are a part of the environmental noise surrounding humans. In rural areas the sounds from insects and birds would dominate the ambient sound character, with noises such as wind flowing through vegetation increasing as wind speed increase. Work by Fégeant (2002) [55] 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 spectral characteristics.

Ambient sound 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 ambient sound 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 4.1.1** 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.

Ambient sound levels are generally less during the colder months (due to less faunal communication) and higher during the warmer months.

4.1.1 Effect of Temperature inversions

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. The potential effect of refraction is illustrated in **Figure 4-1**.

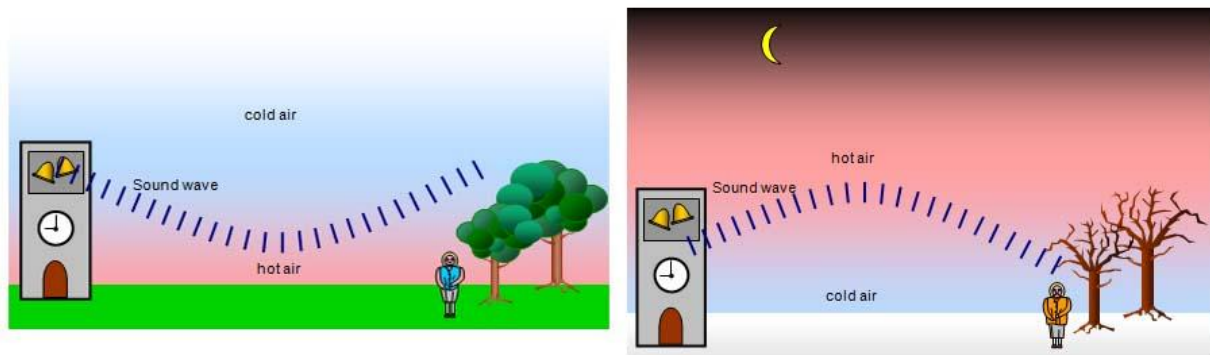


Figure 4-1: Influence of temperature inversions on the propagation of sound

In the evening, this temperature gradient will reverse, but, during certain meteorological conditions, the normal vertical temperature gradient could be inverted so that the air is colder near the surface, with a warmer layer blanketing the lower layer. This inversion layer may result in the reflection of some of the sound waves as illustrated in **Figure 4-2** below.

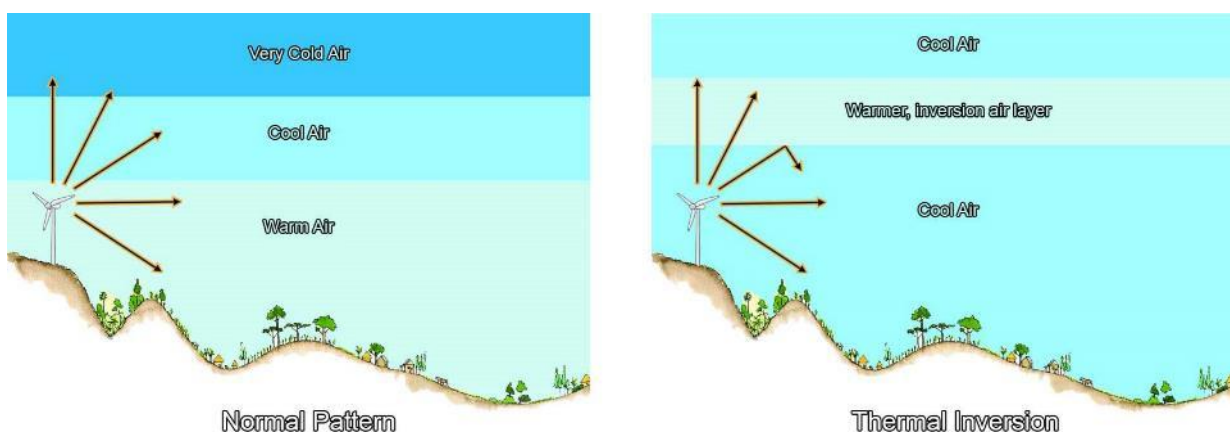


Figure 4-2: Influence of temperature inversions on the propagation of sound

When such an inversion layer is present, some of the sound waves will be refracted¹³ by the temperature gradient, with the refracted sound waves returned to the ground. This effect has been noticed near airports and roads, where noises can be heard over greater distances at night than other times of day (Parnell, 2015, [114]; Saurenman, 2005, [134]), and reported by Van der Berg (2003) [153] for WEF noises.

Like wind gradients, temperature gradients can influence sound propagation over long distances, complicate sound level measurements as well as propagation modelling.

4.1.2 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 as illustrated in **Figure 4-3**. 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) 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).

¹³ Redirecting the wave propagation direction due to a change in the density of the air which influence the speed of sound.

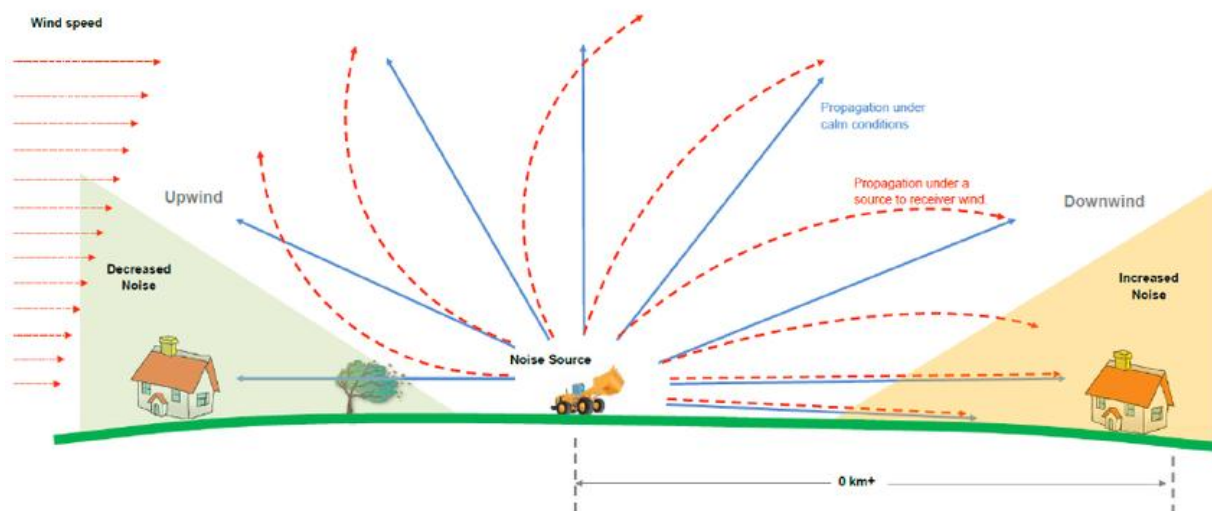


Figure 4-3: Influence of wind on sound propagation

4.1.3 Effect of Humidity and Temperature

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 is 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, complicate sound level measurements as well as propagation modelling. 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 higher high humidity. 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 4-4**.

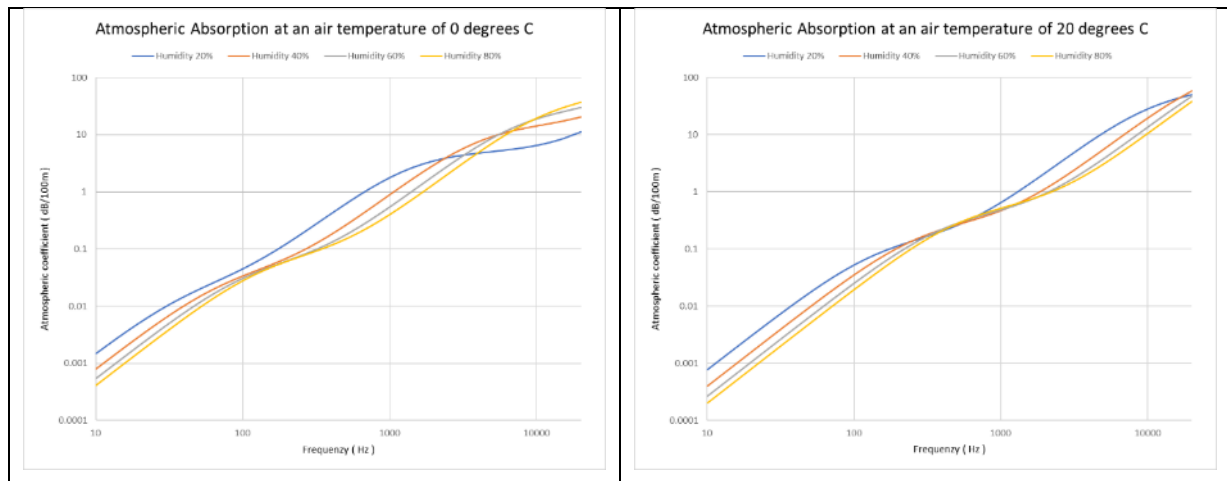


Figure 4-4: Effect of Temperature and Humidity on propagation of Sound

4.2 TEMPERATURE AND HUMIDITY MEASUREMENTS

Temperature and humidity were measured during the site visit from 14 – 20 November 2024, with the average, minimum and maximum temperature and air humidities defined in **Table 4-1**.

Table 4-1: Temperature and air humidity measured during the site visit

	Humidity	Temperature
Day average	36.0	23.3
Night average	63.2	13.6
Day minimum	14.0	8.5
Day maximum	89.0	33.6
Night minimum	42.0	8.1
Night maximum	90.0	20.0

4.3 RESULTS OF THE VARIOUS SOUND LEVEL MEASUREMENTS

Ambient sound levels were measured in the vicinity of the project area in a semi-continuous manner over a period of 6-nights from 14 till 20 November 2024.

All the measurements were done in accordance with the South African National Standard SANS 10103:2008 "***The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication***".

The sound levels were measured using class-1 Sound Level Meters (SLMs, details **Table 4-2**) with the measurement localities presented in **Figure 4-5**. The SLMs would measure "average" sound levels over 10-minute periods, save the data and start with a new 10-minute measurement until the instruments were stopped.

Table 4-2: Equipment used to measure ambient sound levels

Equipment	Model	Serial no	Calibration Date
WAULTSL01			
Sound Level Meter	SVAN 977	36176	Feb 2024
Pre-amplifier	SV 12L	25685	Feb 2024
Microphone	ACO 7052E	49596	Feb 2024
Calibrator	Quest CA-22	J 2080094	July 2024
WAULTSL02			
Sound Level Meter	NA-28	00901489	March 2023
Pre-amplifier	NH-21	28879	March 2023
Microphone	UC-53A	315479	March 2023
Calibrator	Quest CA-22	J 2080094	July 2024
WAULTSL03			
Sound Level Meter	Larson Davis 824	824A0896	Feb 2023
Pre-amplifier	PRM902	1345	Feb 2023
Microphone	2541	6427	Feb 2023
Calibrator	Quest CA-22	J 2080094	July 2024
WAULTSL04			
Sound Level Meter	Svan 977	34849	January 2023
Pre-amplifier	SV 12L	32395	January 2023
Microphone	ACO 7052E	33077	January 2023
Calibrator	Quest CA-22	J 2080094	July 2024

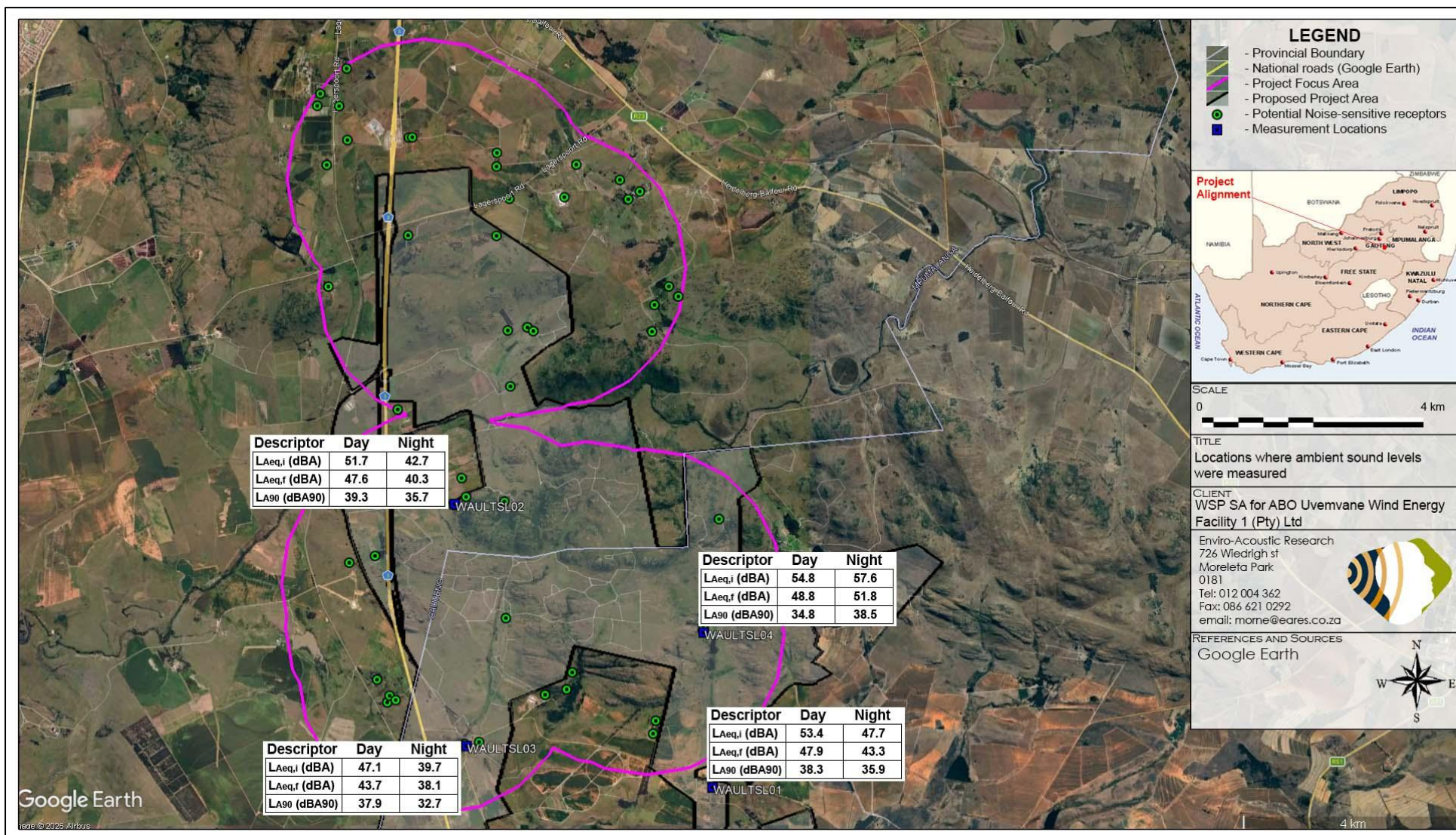


Figure 4-5: Localities where ambient sound levels were measured during November 2024

4.3.1 Long-term Measurement Location WAULTSL01

The SLM was deployed in the garden in the corner of the property near a large tree. Natural noises were dominant (bird communication), with cattle audible at times. Noises from cattle did impact measurements during event. [Appendix D](#) presents photos of the measurement location.

4.3.1.1 Sound level data

Impulse time-weighted equivalent sound levels ($L_{A_{Ieq,10min}}$) and fast time-weighted equivalent sound levels ($L_{A_{Feq,10min}}$) are presented in **Figure 4-6** and summarized in **Table 4-3** below. 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. While the developmental character is rural, L_{A90} levels were elevated.

Table 4-3: Sound levels considering various sound level descriptors at WAULTSL01

	$L_{A_{max,i}}$ (dBA)	$L_{A_{eq,i}}$ (dBA)	$L_{A_{eq,f}}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{A_{min,f}}$ (dBA)
Day arithmetic average	-	53.4	47.9	38.3	-
Night arithmetic average	-	47.7	43.3	35.9	-
Day Equivalent Levels	-	59.5	53.0	-	-
Night Equivalent Levels	-	53.4	47.6	-	-
Day minimum	-	38.7	35.1	-	24.1
Day maximum	104.7	80.8	72.1	-	-
Night minimum	-	34.3	30.4	-	23.9
Night maximum	83.9	66.3	57.8	-	-

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 4-8** (day) and **Figure 4-9** (night).

4.3.1.2 Spectral Frequencies

Lower frequencies (20 – 250 Hz): This frequency band is generally dominated by noises originating from anthropogenic activities (vehicles idling and driving, pumps and motors, etc.) as well as certain natural phenomena (wind, ocean surf splash etc.).

Middle frequencies surrounding 1,000 Hz (200 – 2,000 Hz) – This range contains energy mostly associated with human speech (350 Hz – 2,000 Hz; mostly below 1,000 Hz) and dwelling noises, including sounds from animals such as chickens, dogs, sheep etc.

Higher frequency (2,000 Hz upwards) – Smaller faunal species such as birds, crickets and cicada use this range to communicate and hunt etc.

The spectral character is illustrated in **Figure 4-10** to **Figure 4-13**.

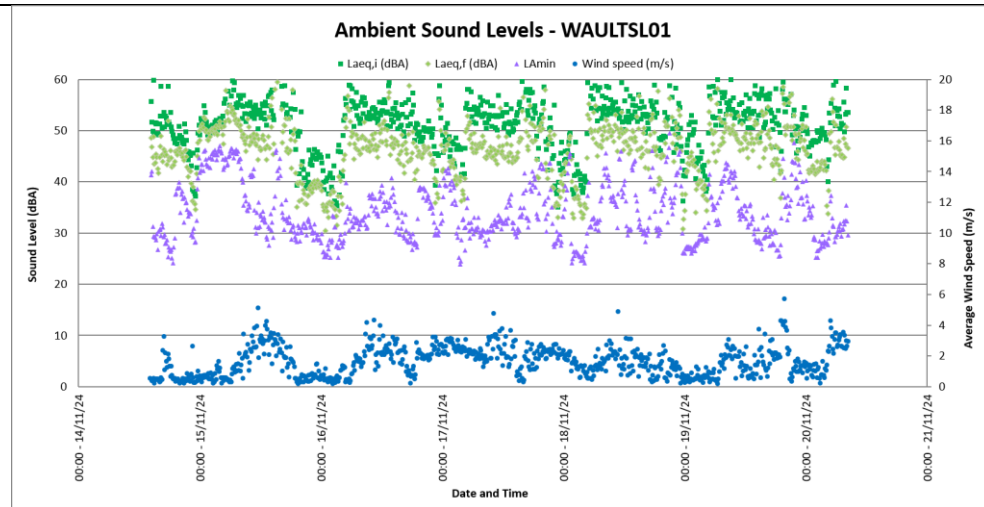


Figure 4-6: Ambient Sound Levels at WAULTSL01

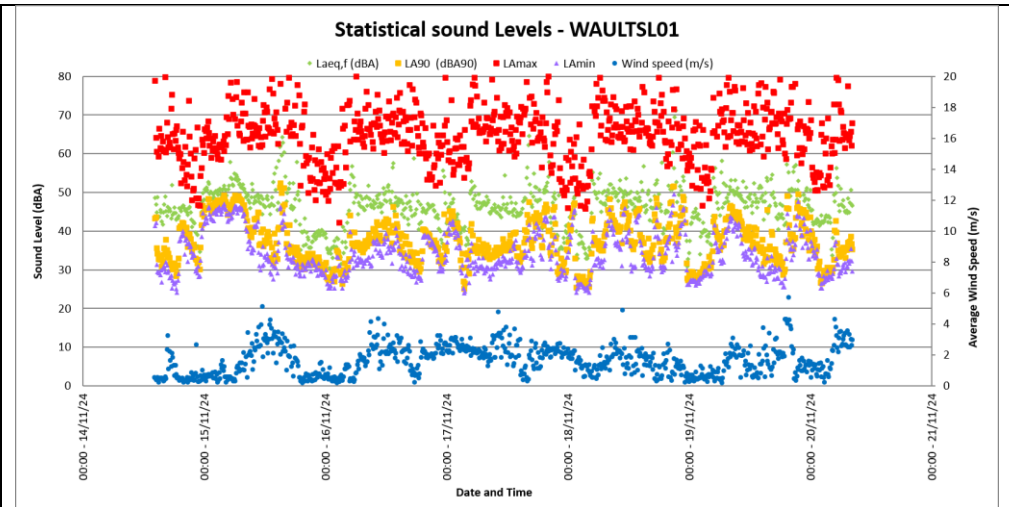


Figure 4-7: Various sound level descriptors for WAULTSL01

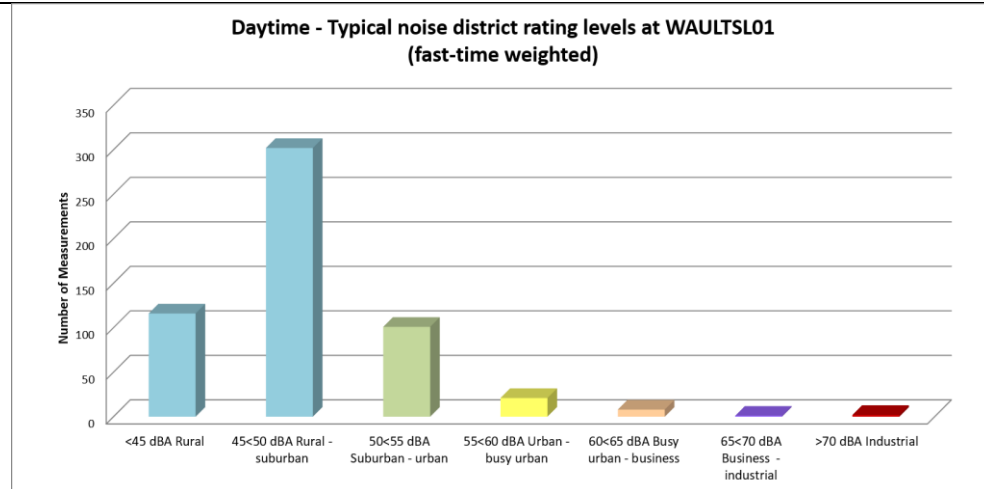


Figure 4-8: Classification of daytime measurements in typical noise districts at WAULTSL01

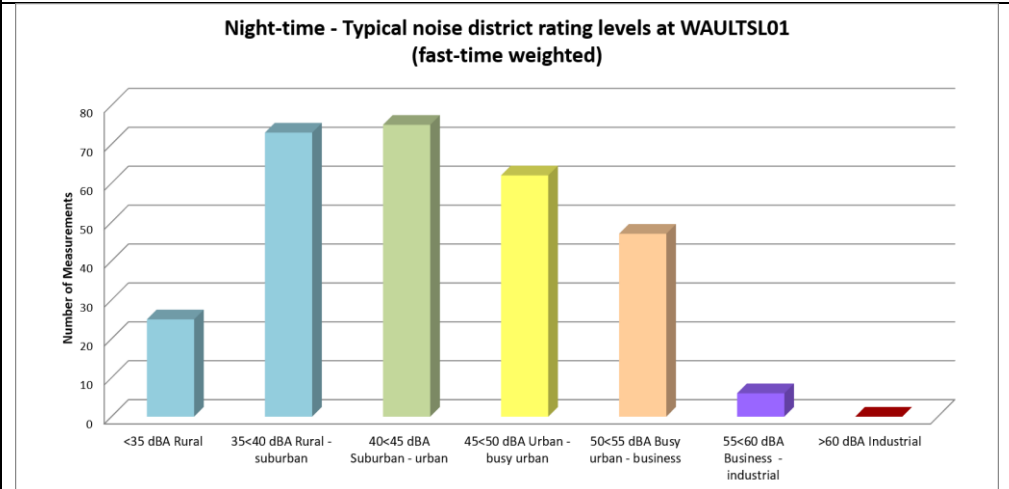


Figure 4-9: Classification of night-time measurements in typical noise districts at WAULTSL01

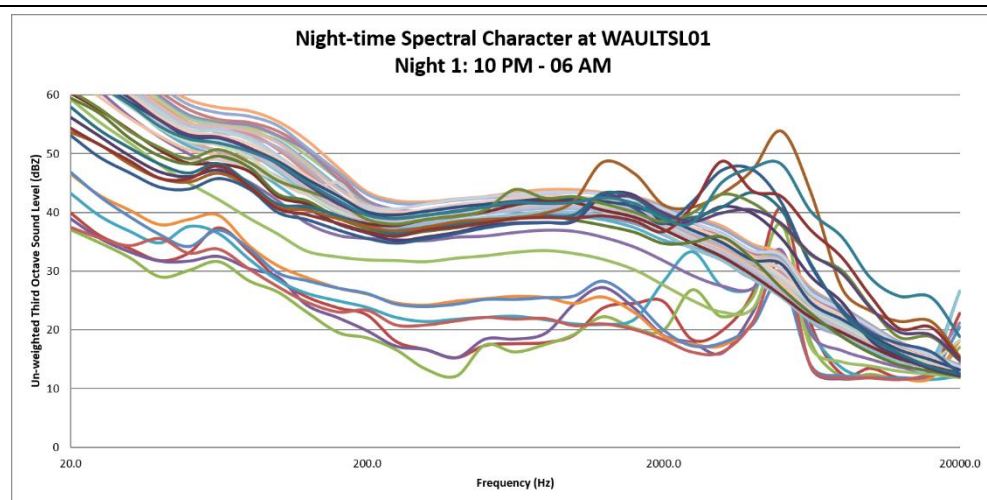


Figure 4-10: Spectral frequencies – WAULTSL01, Night 1

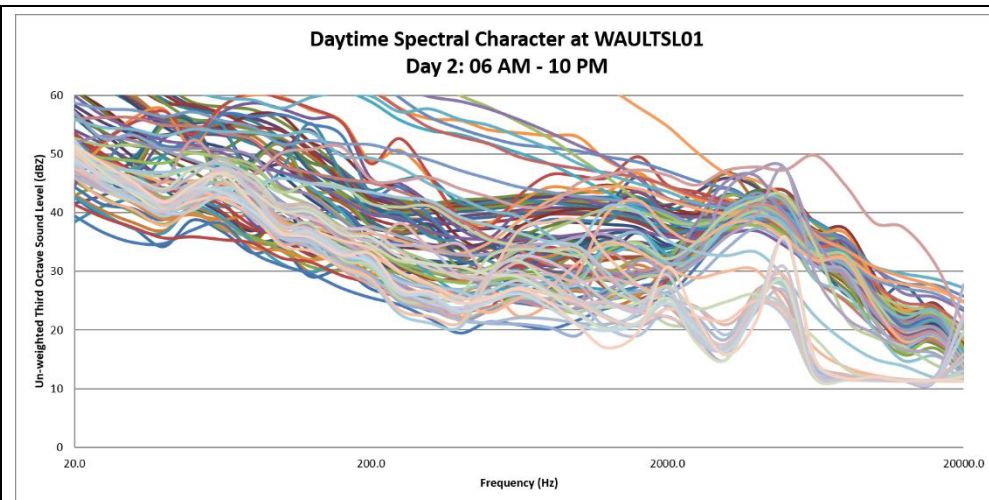


Figure 4-11: Spectral frequencies - WAULTSL01, Day 2

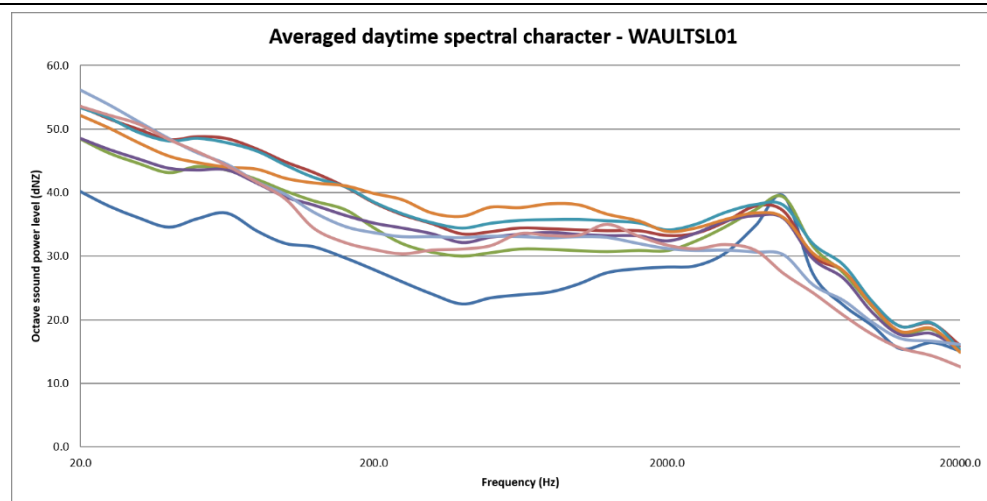


Figure 4-12: Average daytime frequencies - WAULTSL01

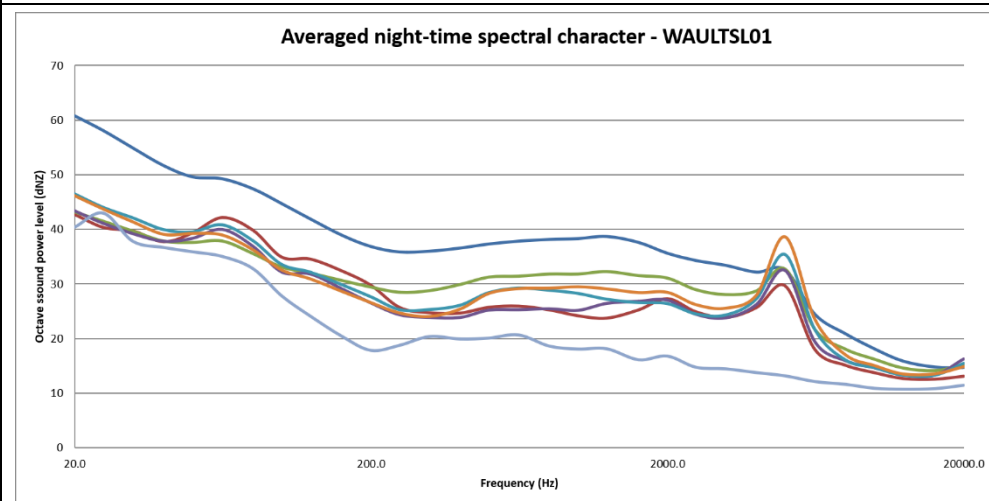


Figure 4-13: Average night-time frequencies - WAULTSL01

4.3.2 Long-Term Measurement Location - WAULTSL02

The SLM was deployed near a large tree in the corner of the property. Though bird communication was generally dominant, road traffic noises were audible and constant.

[Appendix D](#) presents photos of the measurement location.

4.3.2.1 Sound level data

Impulse time-weighted equivalent sound levels $L_{Aeq,10min}$ and fast time-weighted equivalent sound levels $L_{Aeq,10min}$ are presented in **Figure 4-14** and summarized in **Table 4-4** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-15**.

As with WAULTSL01, while the developmental character is rural, L_{A90} levels were elevated and more typical of the L_{A90} levels expected for a suburban to urban noise district.

Table 4-4: Sound level descriptors as measured at WAULTSL02

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	51.7	47.6	39.3	-
Night arithmetic average	-	42.7	40.3	35.7	-
Day Equivalent Levels	-	57.5	54.3	-	-
Night Equivalent Levels	-	54.8	47.8	-	-
Day minimum	-	28.3	27.6	-	22.1
Day maximum	99.3	74.1	67.8	-	-
Night minimum	-	24.0	22.2	-	19.2
Night maximum	95.2	72.6	60.9	-	-

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 4-16** (night) and **Figure 4-17** (day).

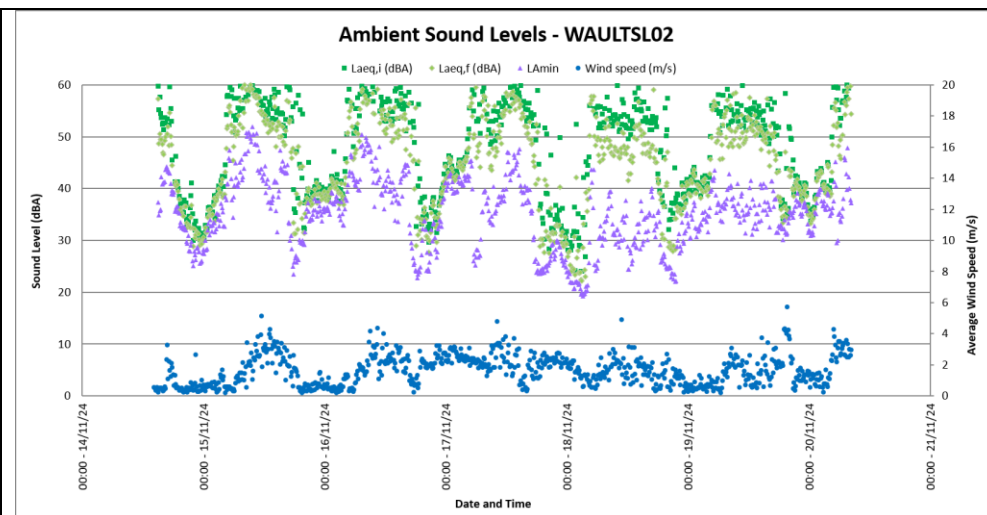


Figure 4-14: Ambient sound levels at WAULTSL02

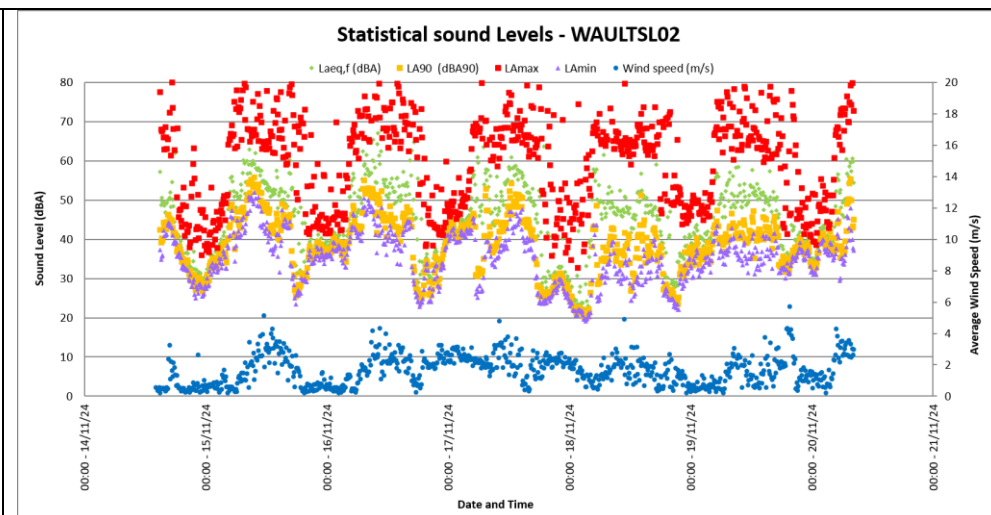


Figure 4-15: Maximum, minimum and statistical values at WAULTSL02

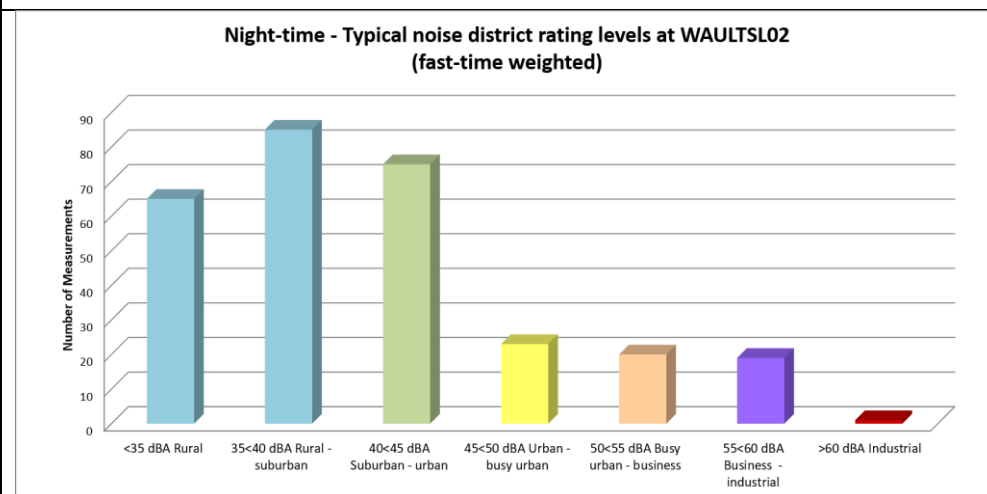


Figure 4-16: Classification of night-time measurements in typical noise districts at WAULTSL02

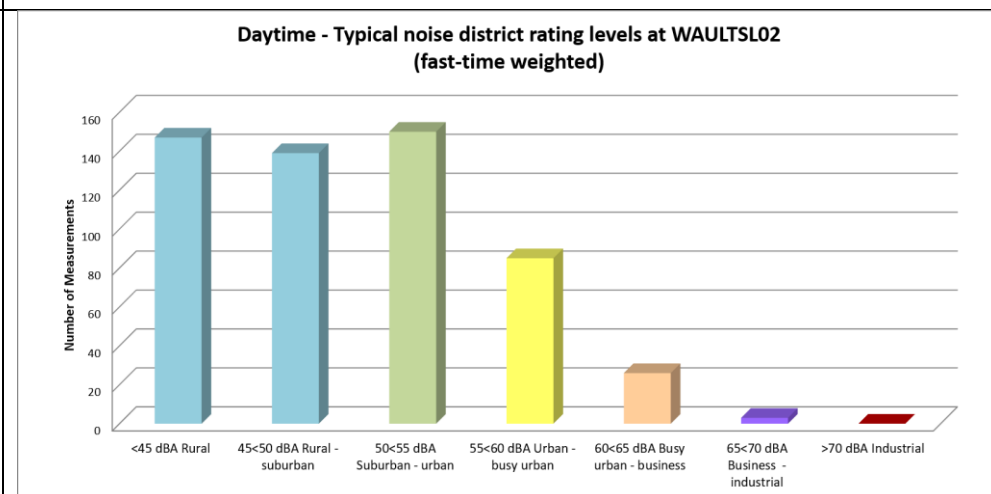


Figure 4-17: Classification of daytime measurements in typical noise districts at WAULTSL02

4.3.3 Long-Term Measurement Location - WAULTSL03

The SLM was deployed in the corner of the property, away from the house and any audible sources of noise. The main sources of noise were birds, with the noise from traffic on the N3 just audible (did not influence the measurements). Barking dogs and voices were audible at times. There were a number of large trees in the area. [Appendix D](#) presents photos of the measurement location.

4.3.3.1 Sound level data

Impulse time-weighted equivalent sound levels $L_{Aeq,10min}$ and fast time-weighted equivalent sound levels $L_{AFeq,10min}$ are presented in **Figure 4-18** and summarized in **Table 4-5** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-19**.

As with WAULTSL01 and WAULTSL02, while the developmental character is rural, L_{A90} levels were elevated and more typical of the L_{A90} levels expected for a suburban noise district.

Table 4-5: Sound level descriptors as measured at WAULTSL03

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	47.1	43.7	37.9	-
Night arithmetic average	-	39.7	38.1	32.1	-
Day Equivalent Levels	-	50.8	46.2	-	-
Night Equivalent Levels	-	47.0	43.6	-	-
Day minimum	-	33.9	31.7	-	24.6
Day maximum	86.5	66.1	58.0	-	-
Night minimum	-	31.6	30.5	-	21.2
Night maximum	75.6	63.1	62.5	-	-

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 4-20** (night) and **Figure 4-21** (day).

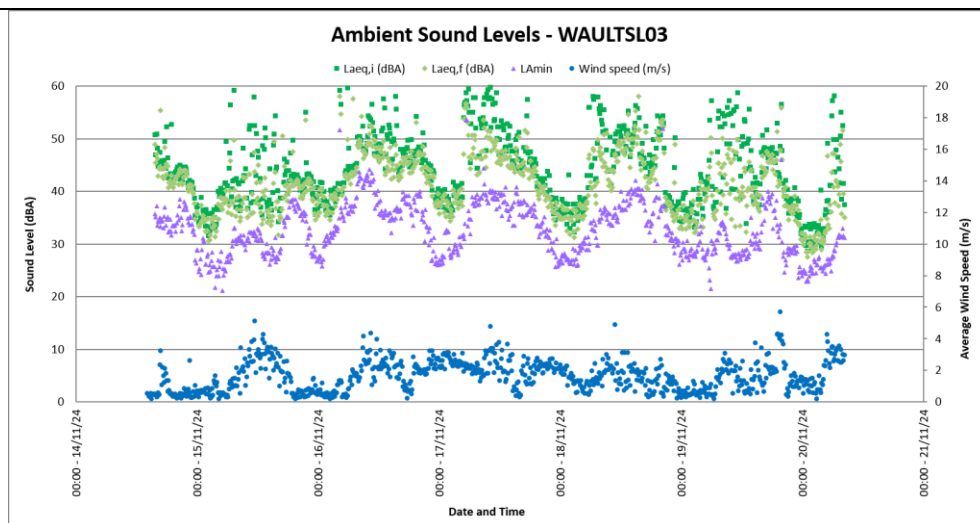


Figure 4-18: Ambient sound levels at WAULTSL03

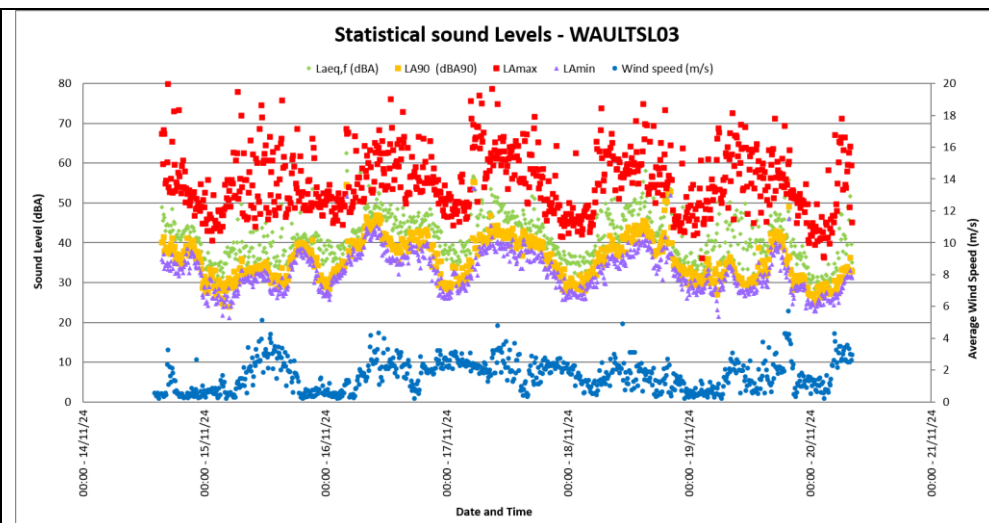


Figure 4-19: Maximum, minimum and statistical values at WAULTSL03

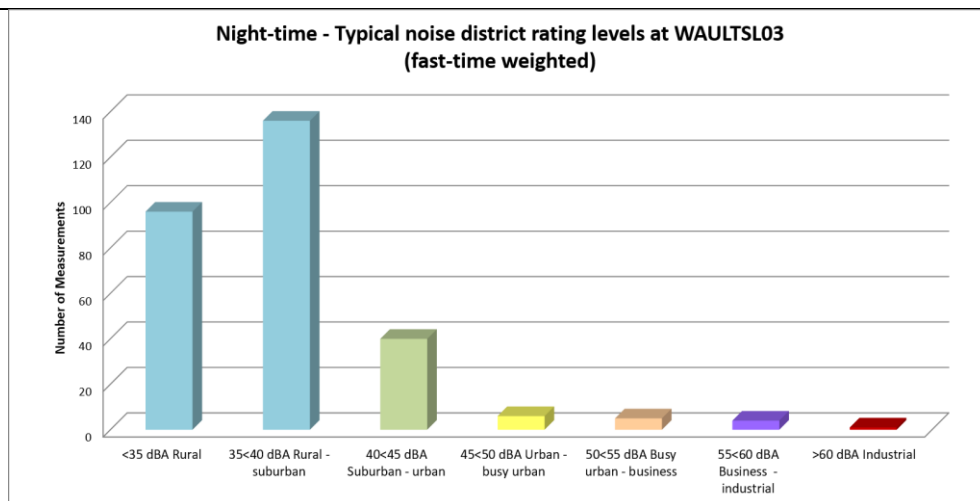


Figure 4-20: Classification of night-time measurements in typical noise districts at WAULTSL03

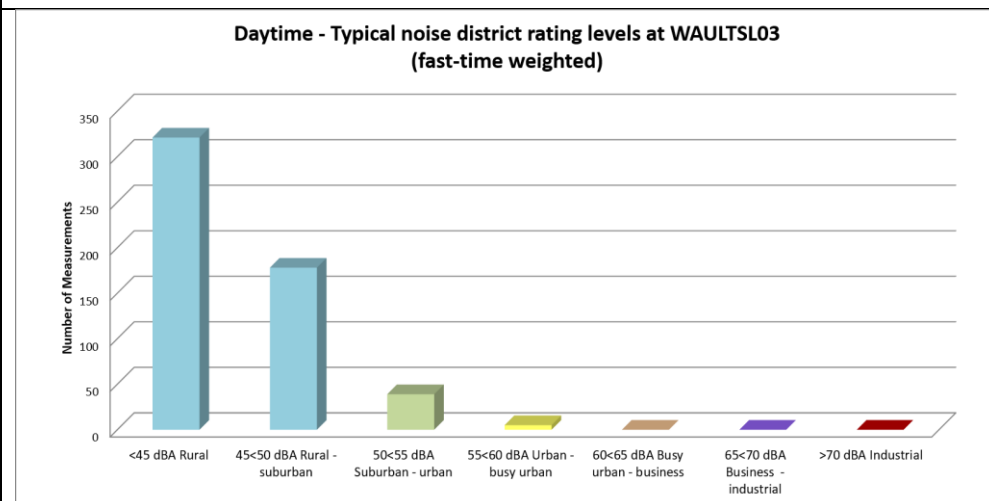


Figure 4-21: Classification of daytime measurements in typical noise districts at WAULTSL03

4.3.4 Long-Term Measurement Location - WAULTSL04

The SLM was deployed just outside the fence of a residential building, in a fairly open area with no vegetation near the microphone. Faunal noises were the dominant source of noise, with dogs barking in the area. [Appendix D](#) presents photos of the measurement location.

4.3.4.1 Sound level data

Impulse time-weighted equivalent sound levels $L_{Aeq,10min}$ and fast time-weighted equivalent sound levels $L_{Aeq,10min}$ are presented in **Figure 4-18** and summarized in **Table 4-5** below. The maximum (L_{Amax}), minimum (L_{Amin}) and 90th percentile (L_{A90}) statistical values are illustrated in **Figure 4-19**.

While the daytime L_{A90} levels were typical of a rural noise district, night-time L_{A90} levels were elevated. Based on spectral information, this likely relates to faunal communication due to a significant peak in the 4 – 6.3 kHz frequency band.

Table 4-6: Sound level descriptors as measured at WAULTSL04

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)
Day arithmetic average	-	54.8	48.8	34.8	-
Night arithmetic average	-	57.6	51.8	38.5	-
Day Equivalent Levels	-	60.0	55.4	-	-
Night Equivalent Levels	-	62.1	56.4	-	-
Day minimum	-	37.9	32.1	-	23.1
Day maximum	103.1	77.6	71.1	-	-
Night minimum	-	41.3	38.6	-	25.1
Night maximum	93.0	74.1	68.1	-	-

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 4-20** (night) and **Figure 4-21** (day).

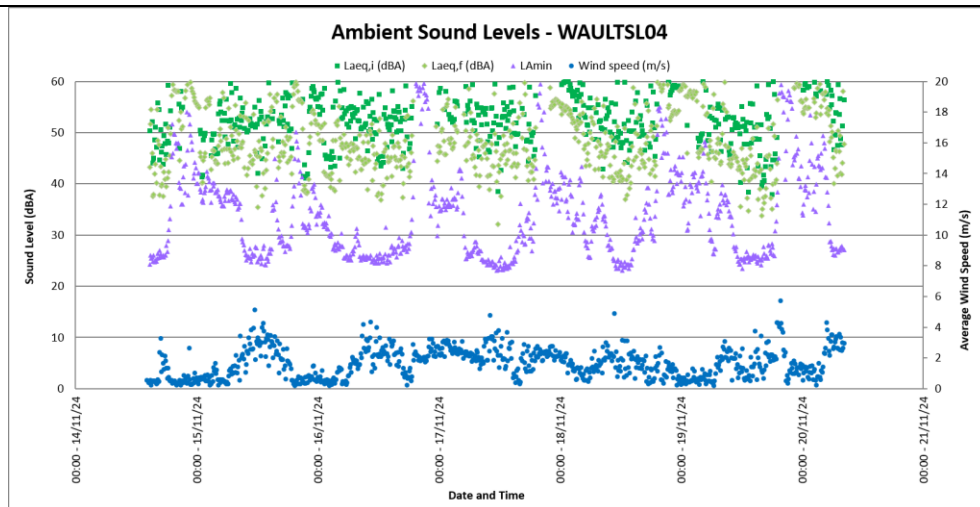


Figure 4-22: Ambient sound levels at WAULTSL04

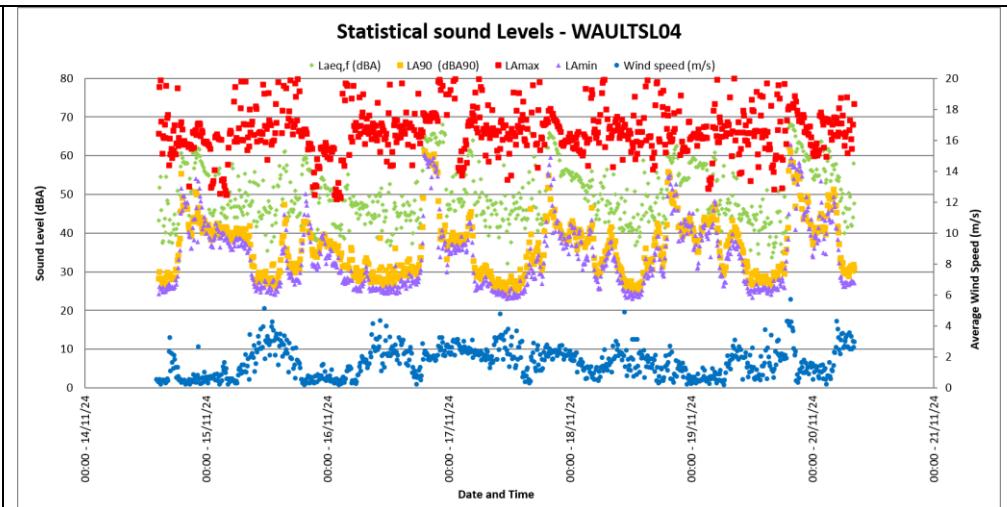


Figure 4-23: Maximum, minimum and statistical values at WAULTSL04

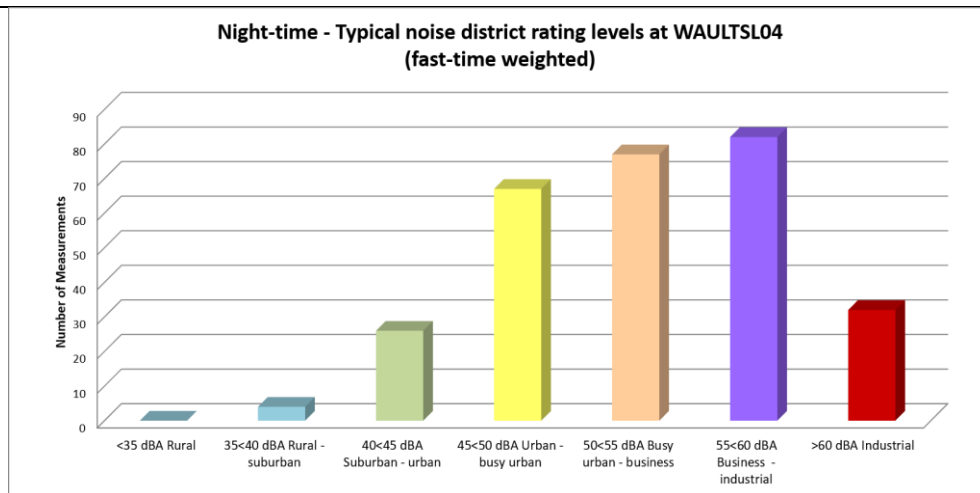


Figure 4-24: Classification of night-time measurements in typical noise districts at WAULTSL04

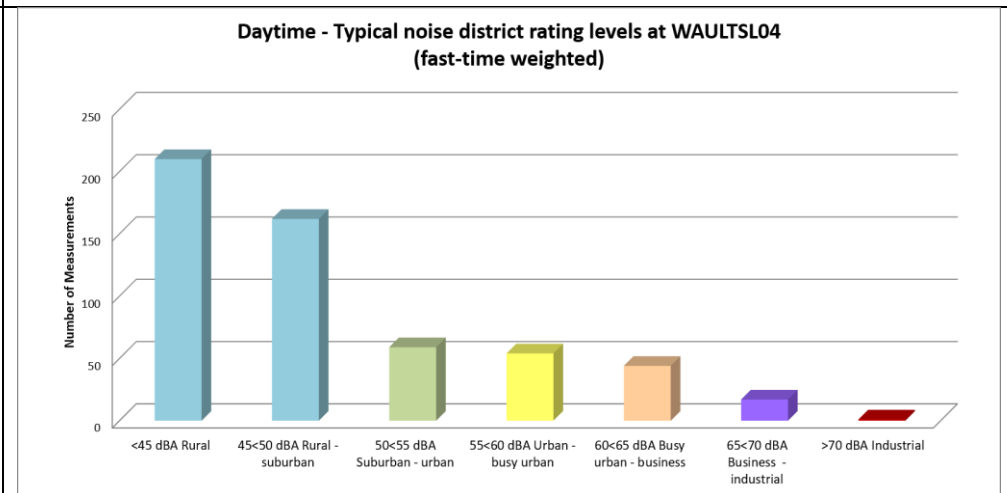


Figure 4-25: Classification of daytime measurements in typical noise districts at WAULTSL04

4.4 SUMMARY OF SOUND LEVEL DATA MEASURED

This report mainly discusses the average fast-weighted sound level ($L_{Aeq,f}$), as this sound descriptor is generally used internationally to define the ambient sound levels. Using the arithmetic average minimizes the risk of underreporting ambient sound levels during quieter periods and overreporting during brief loud events, ultimately leading to more informed decisions regarding noise mitigation strategies that protect both human health and wildlife. The fast-weighted weighted sound descriptor is also used instead of the impulse-weighted sound level, as the impulse-weighted sound level can easily be 10 dBA higher than the fast-weighted level, especially in an area with significant bird communication.

The difference between the impulse- and fast-weighted, as well as the arithmetic averages versus the equivalent values can be easily be discerned in the various tables presented in **Section 4.3**.

Based on the sound measurements:

- 2,192 10-minute measurements were collected during the day (all the 10-minute measurements during the period 06:00 – 22:00), with sound levels ranging between 27.6 and 72.1 dBA. The average daytime ambient sound level was calculated at 47.0 dBA (typical of a rural to suburban noise district) for the four measurement locations; and
- 1,152 10-minute measurements were collected during the night-time period, with sound levels ranging between 22.2 and 68.1 dBA. The average night-time ambient sound level was calculated at 43.4 dBA (typical of a suburban to urban noise district) for the four measurement locations. When excluding night-time data for measurement location WAULTSL04, the average sound level was 40.6 dBA for the 3 “quieter” locations.

Considering the developmental character as well as the ambient sound levels measured, the acceptable zone sound level (noise rating level) during low and no-wind conditions would be expected to be that of a suburban noise district for the day- and night-time periods, setting rating levels of:

- **50 dBA for the daytime period;** and,
- **40 dBA for the night-time period.**

Considering measurements collected over the past decade at numerous locations during different seasons, ambient sound levels will likely increase as wind speeds increase, as

illustrated in **Figure 4-26** (daytime period) and **Figure 4-27** (night-time period). The sound level data collected for this project is also illustrated on these figures.

This trend of the increased ambient sound levels as wind speed increase is also illustrated on these figures, with this data considered for the operational phase (as the wind turbines will only operate during a period with increased wind speeds).

In addition, considering international guidelines, the IFC (projects financed by the World Bank Group - see **section 3.5.6**) the following upper noise levels should not be exceeded during either the construction and/or operational phase:

- 55 dBA (as recommended by the IFC) for daytime residential use; and
- 45 dBA (as recommended by the IFC) for night-time residential use.

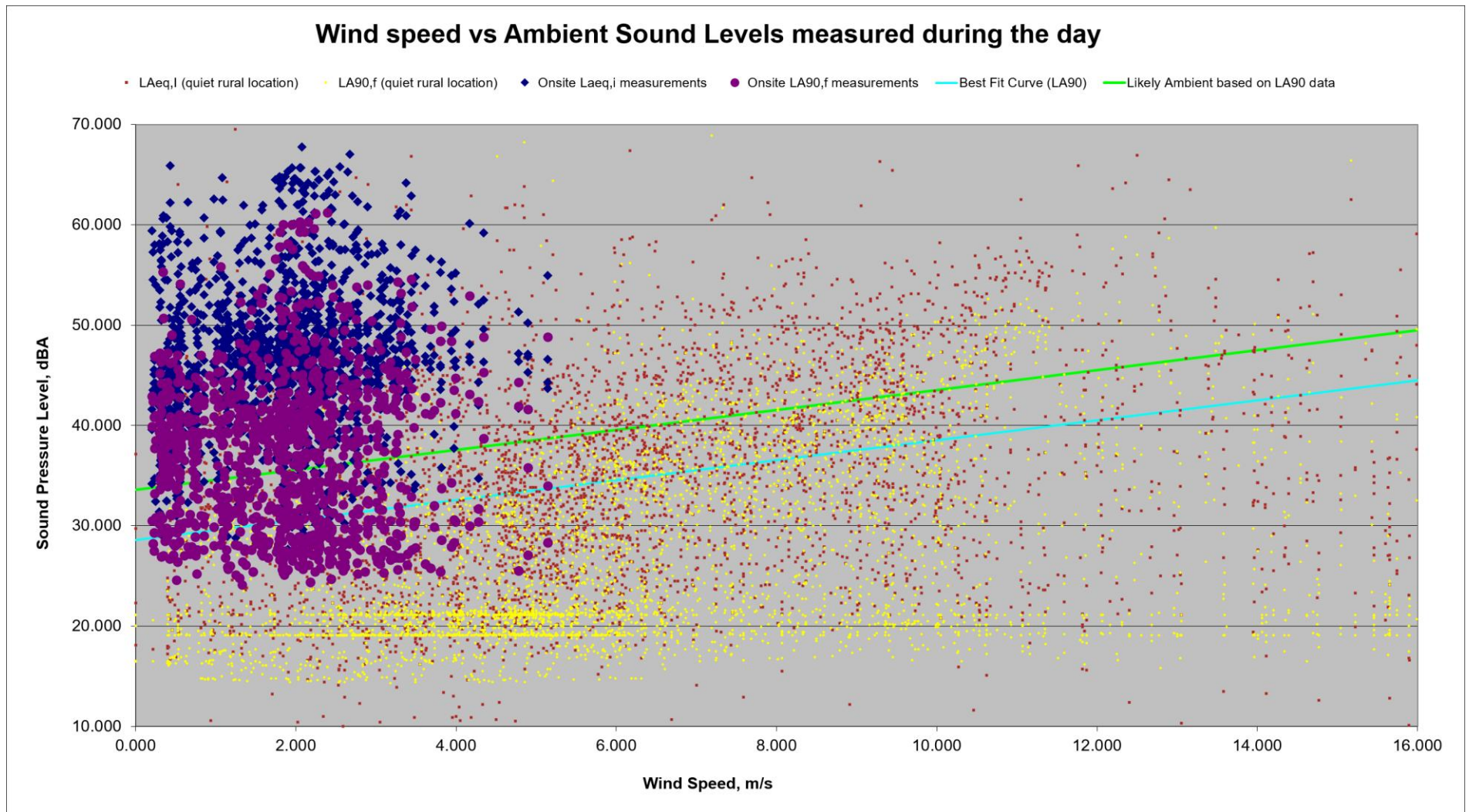


Figure 4-26: Daytime ambient sound levels measured in vicinity of project

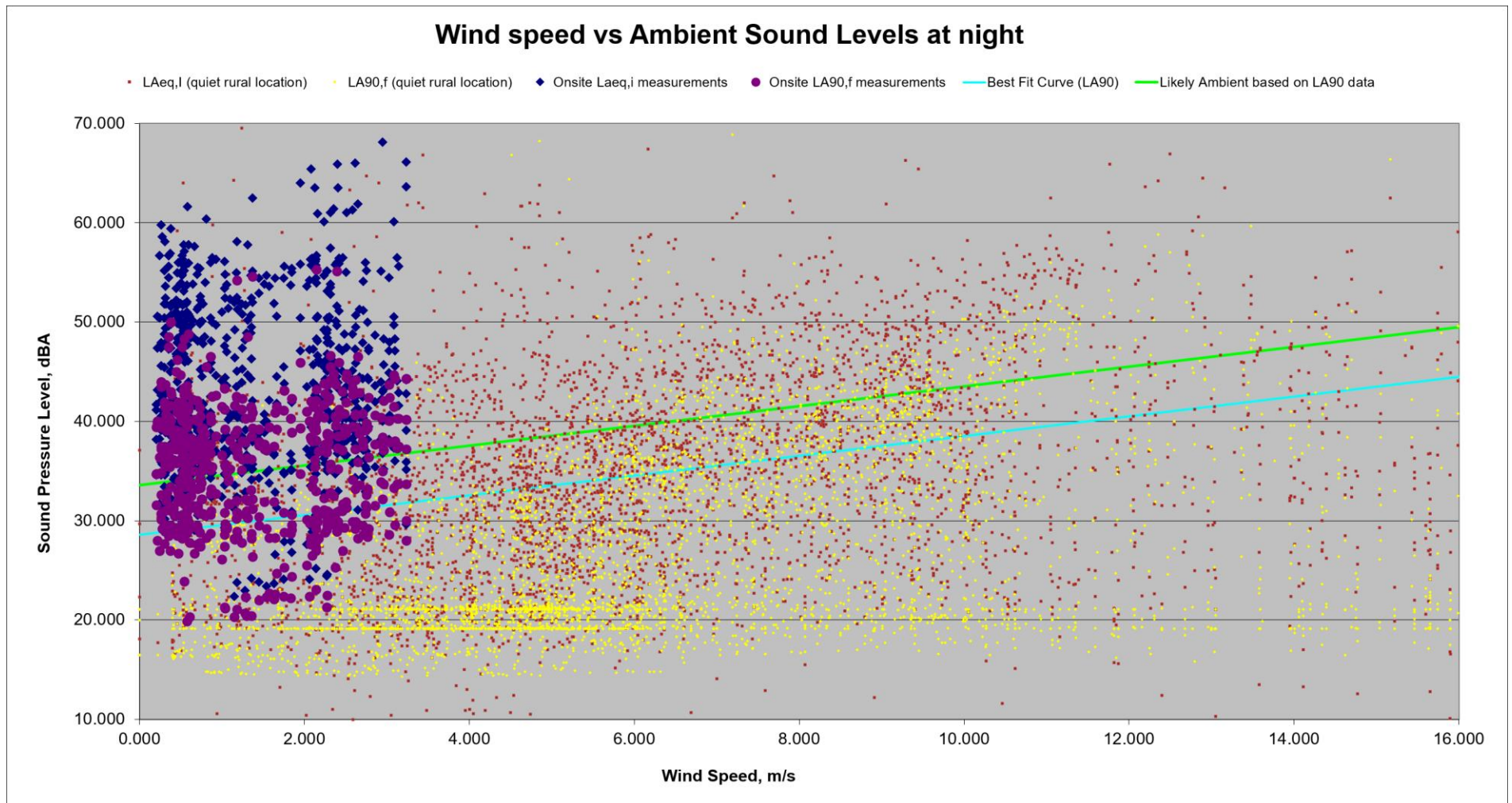


Figure 4-27: Night-time ambient sound levels measured in vicinity of project

5 INVESTIGATION OF EXISTING AND FUTURE NOISE LEVELS

Increased noise levels are directly linked with the various activities associated with the construction of the proposed Uvemvane WEF development 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.

5.1 POTENTIAL NOISE SOURCES: CONSTRUCTION PHASE

5.1.1 Construction equipment

It is estimated that construction will take up to 24 months subject to the final design of the Project, 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 WTG component 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 will 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.
- 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 ambient sound 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 5-2**.

Average or equivalent sound levels are another factor that impacts on the ambient sound 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 5-3**.

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.

The noise levels and the octave sound power emission levels used for modelling for the construction (and operational) phase are highlighted in **Table 5-1**.

Table 5-1: Equipment list and Sound power emission levels used for modelling

Equipment	Sound power level, dB re1 pW, in octave band, Hz							Max PWL
Centre frequency	63	125	250	500	1000	2000	4000	(dBA)
Construction and WTG equipment and activities								
Bulldozer CAT D5	107.4	105.9	104.8	104.5	104.4	97.5	90.2	107.4
Diesel Generator (Large - mobile)	107.2	104.0	102.4	102.7	100.2	99.5	97.4	106.1
Excavator and truck	111.0	112.2	109.3	106.4	105.4	101.6	98.4	112.0
General noise (Construction)	95.0	100.0	103.0	105.0	105.0	100.0	100.0	113.6
Goldwind GWH182-6.2	117.2	114.7	113.1	110.1	103.9	96.6	84.2	110.5
Road Transport Reversing/Idling	108.2	104.6	101.2	99.7	105.4	100.7	98.7	108.2
Area noise sources (using the octave sound power characteristics of General Noise)								
General noise (dBA/m² re 1 pW)	95.0	100.0	103.0	105.0	105.0	100.0	100.0	65.0

5.1.2 Material supply: Concrete batching plants

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

1. The transport of "ready-mix" concrete from the closest centre to the development.
2. The transport of aggregate and cement from the closest centre to the development, with the establishment of a small concrete batching plant close to the activities. This would most likely be a movable plant.

This noise study will consider the use of a concrete batching plant.

5.1.3 Blasting

Though unlikely, blasting may be required as part of the civil works to clear obstacles or to prepare foundations (of either the WEF, power pylons or other infrastructure).

However, blasting will not be considered 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. The breaking of rocks and 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.

5.1.4 Construction 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.

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 30 trucks and cars each per hour, travelling on a gravel road at 40 km/hr.

Table 5-2: Potential maximum noise levels generated by construction equipment

Equipment Description ¹⁴	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 (TLB)	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
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
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
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
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
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
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

¹⁴ Equipment list and Sound Power Level source: http://www.fhwa.dot.gov/environment/noise/construction_noise/handbook/handbook09.cfm

Table 5-3: 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

5.2 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 Project. 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).

The noise levels and the octave sound power emission levels of the Goldwind GWH182-6.2 WTG [62] was used for the operational noise model are highlighted in **Table 5-1**.

5.2.1 Wind Turbine Noise: Aerodynamic sources [11, 24, 37, 48, 125]

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

1. Self-noise due to the interaction of the turbulent boundary layer with the blade trailing edge.
2. Noise due to inflow turbulence (turbulence in the wind interacting with the blades).
3. Discrete frequency noise due to trailing edge thickness.
4. Discrete frequency noise due to laminar boundary layer instabilities (unstable flow close to the surface of the blade).
5. 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 5-1**.

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 the sound power emission levels of the Goldwind GWH182-6.2 WTG [62] will be used.

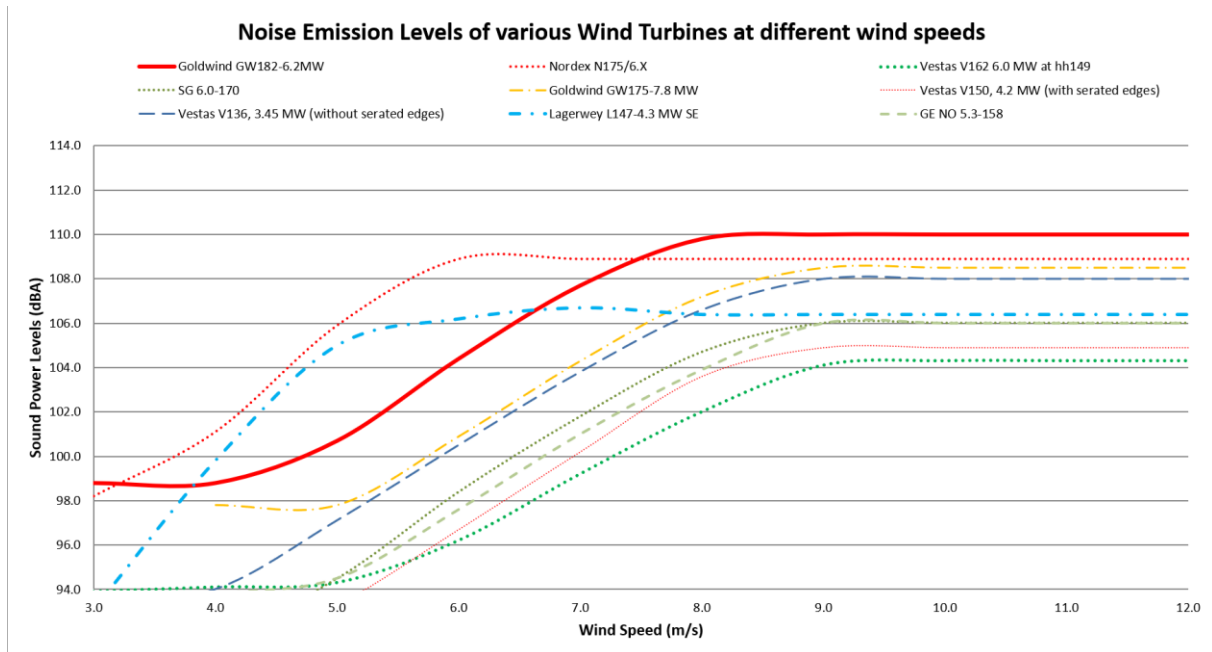


Figure 5-1: Noise Emissions Curve of a number of different wind turbines (figure for illustration purposes only)

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 emission levels for various wind turbines are presented on **Figure 5-2**.

5.2.1.1 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.

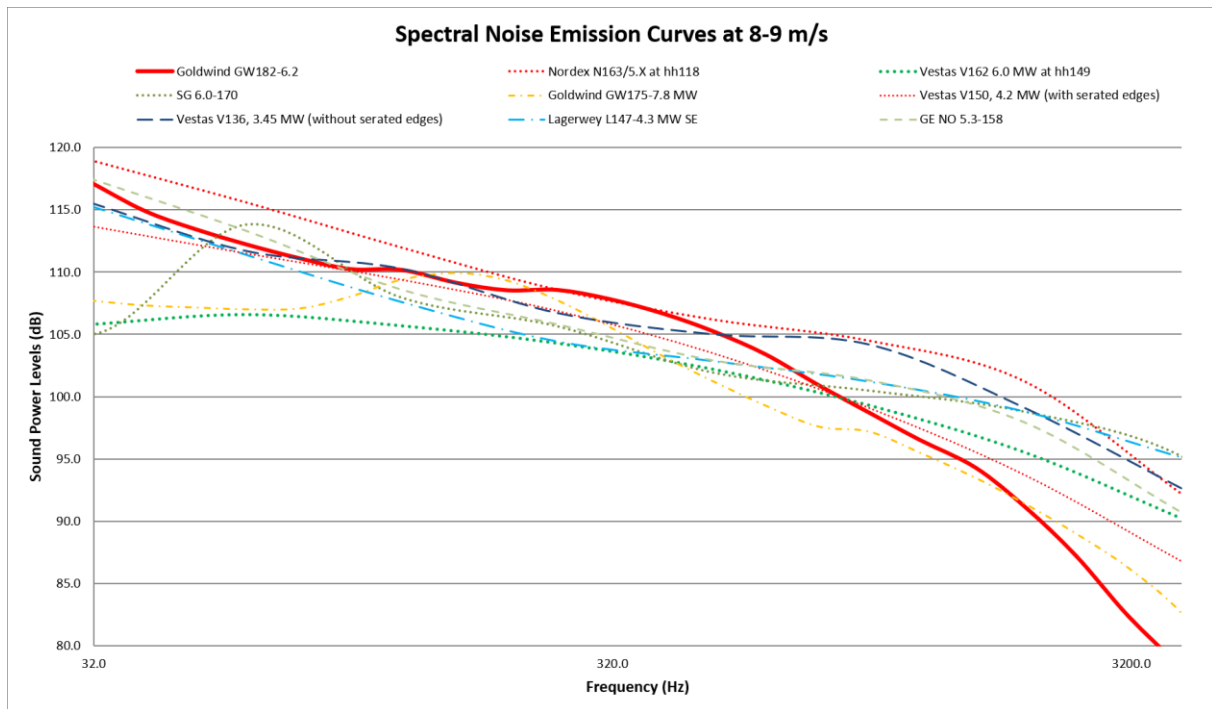


Figure 5-2: Octave sound power emissions of various wind turbines

5.2.2 Wind Turbine: Mechanical sources [51, 71, 125, 128]

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.

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.

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.***

5.2.3 Low Frequency Noise

Low frequency noise (LFN) is the term used to describe sound energy in the region below ~200 Hz, and in this assessment, include the infrasound range. 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 [**40, 70, 111, 154**].

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 5-3**, which indicates the sound power levels in the different octave bands from measurements taken at different wind speeds with no other 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 [**16, 40, 82**].

Ambrose (2011) [**3**] and other authors have confirmed modulations consistent with the frequency that the blade pass the tower. 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 [**23, 36, 70**].

The British Wind Energy Association (BWEA) [**23**] highlighted that these sounds are below the threshold of perception, 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 [38, 54, 72, 113].

In February 2013, the Environmental Protection Authority of South Australia published the results of a study into low-frequency noise near wind farms [53, 54]. 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.

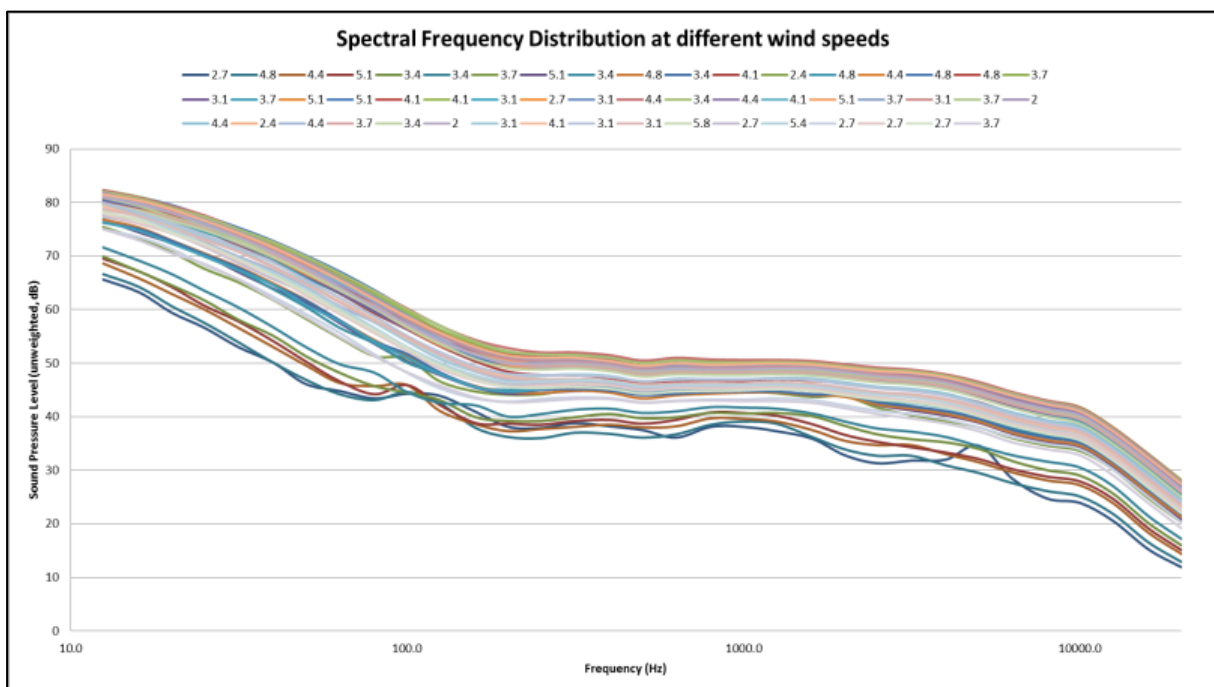


Figure 5-3: Third octave band sound power levels at various wind speeds at a location where wind induced noises dominate

LFN 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. Leventhall (Leventhall, 2003) [87] summarised LFN annoyance as follows:

- The problems arose in quite rural or suburban environments.
- The noise was often close to inaudibility and heard by a minority of people.
- The noise was typically audible indoors and not outdoors.
- The noise was more audible at night than during the day.
- The noise had a throbbing and rumbling characteristic.

- The main complaints came from the 55–70 years age group.
- The complainants had normal hearing.
- Medical examination excluded tinnitus.

While there are a few scientific papers that tries to use different numerical methods to predict LFN, none agree which method should be used. Currently, no country has adopted any universal protocol to estimate LFN and none can agree on what criteria should be used. In South Africa, not SANS 10103, SANS 10328 or SANS 10357 provide a protocol, procedure or method to calculate a dBG value or LFN. SANS 10103:2008 however does recognize LFN, and does provide an informative annex on the matter, this is mainly to assist in the identification of LFN as well as a recommendation on how a sound can be adjudicated as disturbing. This however is based on a measured spectral data and not calculated spectral data.

This assessment considers two potential methods to screen the potential of LFN from a WEF, considering an estimated G-weighted value (Jakobsen, 2001) [77] as well as the difference between the dBA and dBC level (Leventhall, 2003) [87]. It should however be noted that this is only for information purposes.

This assessment does recommend noise monitoring if potential worst-case noise levels exceed 42 dBA at any NSR.

5.2.4 Amplitude modulation

Wind Turbine Noise (WTN) includes a steady component (see also the preceding section **5.2.1** and **5.2.2**) as well as, in some circumstances, a periodically fluctuating or Amplitude Modulated (AM) component or character [129]. Although generally considered rare, it is a characteristic of WTN that increases the annoyance with a project above that of other long-term noise sources [18, 27, 39, 107, 141].

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 rotational speed, sometimes referred to as a “swish” or “thump”.

Pedersen (2003) [119] 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, with people able to distinguish between background ambient sounds and the sounds that 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.

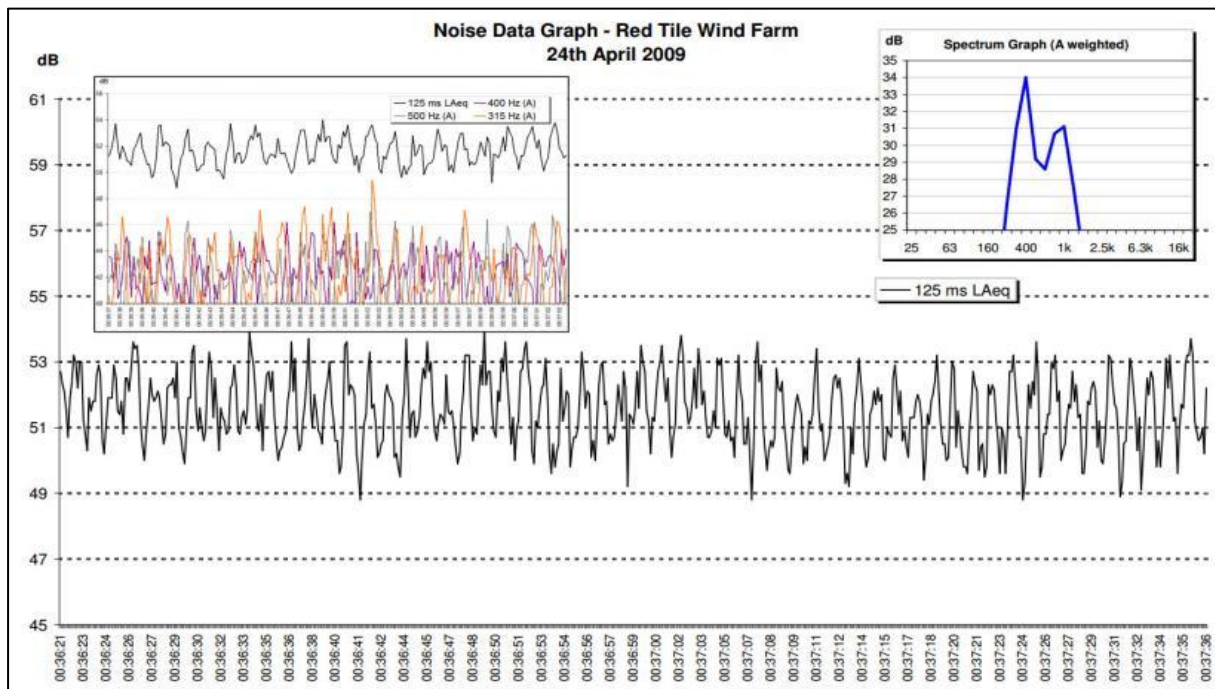


Figure 5-4: Example time-sound series graph illustrating AM as measured by Stigwood (2013) [142]

That AM can be a risk and significantly increase the annoyance with WEFs that cannot be disputed. It has been reported with a number of recent studies confirming this significant noise characteristic [119]. 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, less research went into this subject. It is also a complex source of wind turbine noise, with studies highlighting that time of year, atmospheric conditions, wind direction and atmospheric conditions all play a role in the generation of AM [24, 36, 37, 129].

How people may respond to AM is also complex. WSP (2016) [170], in a study done for the Department of Energy and Climate Change summarized that:

- Within both laboratory and field test environments there is a strong association between increasing overall time-average levels of AM WTN-like sounds with increasing ratings of annoyance.
- Within a laboratory test environment:

- subjects rated noticeable modulating WTN-like sounds as more annoying than similar noise without significant modulation;
- the onset of fluctuation sensation for a modulating WTN-like sound appeared to be in the region of around 2 dB modulation depth;
- increasing modulation depth above the onset of fluctuation sensation showed a broadly increasing trend in mean ratings of annoyance, but changes in mean annoyance rating tended to be relatively small and, in some cases, inconsistent;
- equivalent annoyance ratings of AM and steady WTN-like sounds derived by level adjustment did not show a strong increasing trend with increasing depth of modulation; and
- equivalent 'noisiness perception' of WTN-like AM sounds compared with a steady sound showed a gradually increasing trend with modulation depth.

WSP (2016) also concluded that the results from both the laboratory and field studies should be approached with caution, since they may not readily translate to how people respond to WTN exposure in their homes [170]. The WSP report does recommend that: *"It is recommended that excessive AM is controlled through a suitably worded planning condition which will control it during periods of complaint."*

Unfortunately, AM cannot be calculated or predicted, but this assessment notes the various findings from studies on AM and recommend noise monitoring if potential worst-case noise levels exceed 42 dBA at any NSR.

5.2.5 Transformer noises (Substations)

Also known as magnetostriction¹⁵, is when the sheet steel used in the core of the transformer tries to change shape when being magnetised. When the magnetism is taken away, the shape returns, only to try and deform in a different manner when the polarity is changed.

This deformation is not uniform; consequently, it varies all over a sheet. With a transformer core being composed of many sheets of steel, these deformations are taking place erratically all over each sheet, and each sheet is behaving erratically with respect to its neighbour. The resultant is the "hum" frequently associated with transformers. While this may be a soothing sound in small home appliances, various complaints are logged in areas where people stay close to these transformers. At a voltage frequency of 50 Hz, these "vibrations" take place 100 times a second, resulting in a tonal noise at 100Hz.

¹⁵ <https://en.wikipedia.org/wiki/Magnetostriction>

However, this is a relatively easy noise to mitigate with the use of acoustic shielding and/or placement of the transformer and will not be considered further in this ENIA study. Substations in addition generate low noise levels, with the hum from the transformers inaudible further than 200 m from the transformers.

5.2.6 Transmission Line Noise (Corona noise)

Corona noise¹⁶ is caused by the partial breakdown of the insulation properties of air surrounding the conducting wires. It can generate an audible and radio-frequency noise, but generally only occurs in humid conditions, as provided by fog or rain. A minimum line potential of 70kV or higher is generally required to generate corona noise depending on the electrical design. Corona noise does not occur on domestic distribution lines.

Corona noise has two major components: a low frequency tone associated with the frequency of the AC supply (100 Hz for 50 Hz source) and broadband noise. The tonal component of the noise is related to the point along the electric waveform at which the air begins to conduct. This varies with each cycle and consequently the frequency of the emitted tone is subject to great fluctuations. Corona noise can be characterised as broadband 'crackling' or 'buzzing', but ***fortunately it is generally only a feature that occurs during fog or rain.***

It will not be further investigated, as corona discharges results in:

- Power losses,
- Audible noises,
- Electromagnetic interference,
- A purple glow,
- Ozone production; and
- Insulation damage.

As such Electrical Service Providers, such as ESKOM, go to great lengths to design power transmission equipment to minimise the formation of corona discharges. In addition, it is an infrequent occurrence with a relatively short duration compared to other operational noises.

¹⁶ https://en.wikipedia.org/wiki/Corona_discharge

5.2.7 Battery Energy Storage Systems

The applicant proposes to include a BESS at their WEF to store energy for use at a later time or date. Depending on the technology available at the time, this might be either Redox-flow, or Lithium-ion systems. The main noise source for a redox flow system is pumps, fans and transformers, with the typical noise-generating components of a Lithium-ion BESS being:

- The battery system which could consist of multiple cells, the battery management system; and the battery thermal management system.
- Components required for the reliable operation of the overall system, including the energy management system; and
- Power electronics that can be grouped into the conversion unit (such as an inverter), which manage the power flow between the grid and battery, including the required control and monitoring components, voltage sensing units and thermal management of power electronic components (fans or climate control system).

There could be numerous such BESS modules running in parallel to increase the total storage capacity of the system up to the desired or needed capacity. The typical components of a lithium-ion BESS are illustrated in **Figure 5-5**.

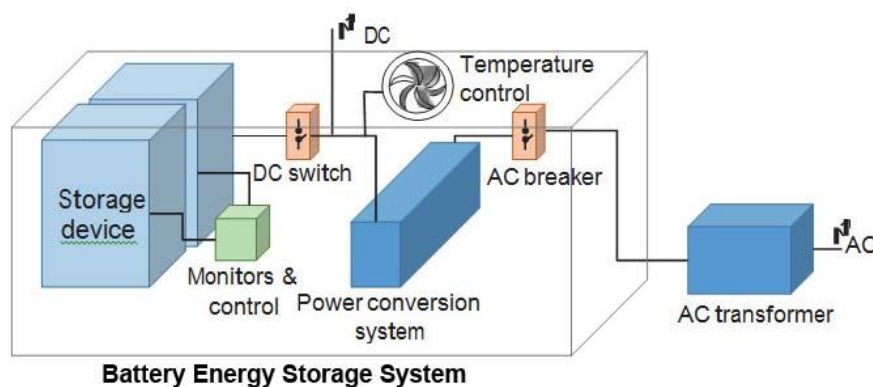


Figure 5-5: Conceptual BESS components¹⁷

While certain components of a lithium-ion BESS may generate a slight hum under load, the dominant source of noise is from the fans or climate control system used to manage heat in the system and/or to maintain the BESS within its optimal operating temperature range. Noise emission levels from lithium-ion BESS differs between different manufacturers, with Noise Monitoring Services¹⁸ reporting levels of 70 – 92 decibels when measured at 1 m. Noise impacts are generally limited to areas within 500m of the BESS, though, noise

¹⁷ Source: <http://www.amdcenergy.com/battery-energy-storage-system.html>

¹⁸ <https://www.noisemonitoringservices.com/battery-energy-storage-system-bess-noise-challenges-and-solutions/>

emissions from this source should be considered once a BESS technology and manufacturer was selected, as the noise emission levels from different BESS varies depending on the type of technology used as well as the acoustic treatment implemented by the manufacturer. Assuming that the BESS would be located in the areas proposed for the substation(s), the BESS would be well further than 500m from all NSR and noises from the BESS would be insignificant.

6 METHODS: NOISE IMPACT ASSESSMENT

6.1 NOISE IMPACT ON ANIMALS

Autumn (2007) summarized available literature on the significant research undertaken during the 1960's and 70's on the effects of aircraft noise on animals [5, 108]. 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 behavioural 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 to survive.

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 humans age. Sensitivity also varies with frequency with humans. Considering the variation in the sensitivity to frequencies and between individuals, this is likely similar with all faunal species. Some of these studies are repeated on animals, with behavioural hearing tests being able to define the hearing threshold range for some animals as indicated on **Figure 6-1**.

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 behavioural 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 (USEPA, 1971) [152] 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).

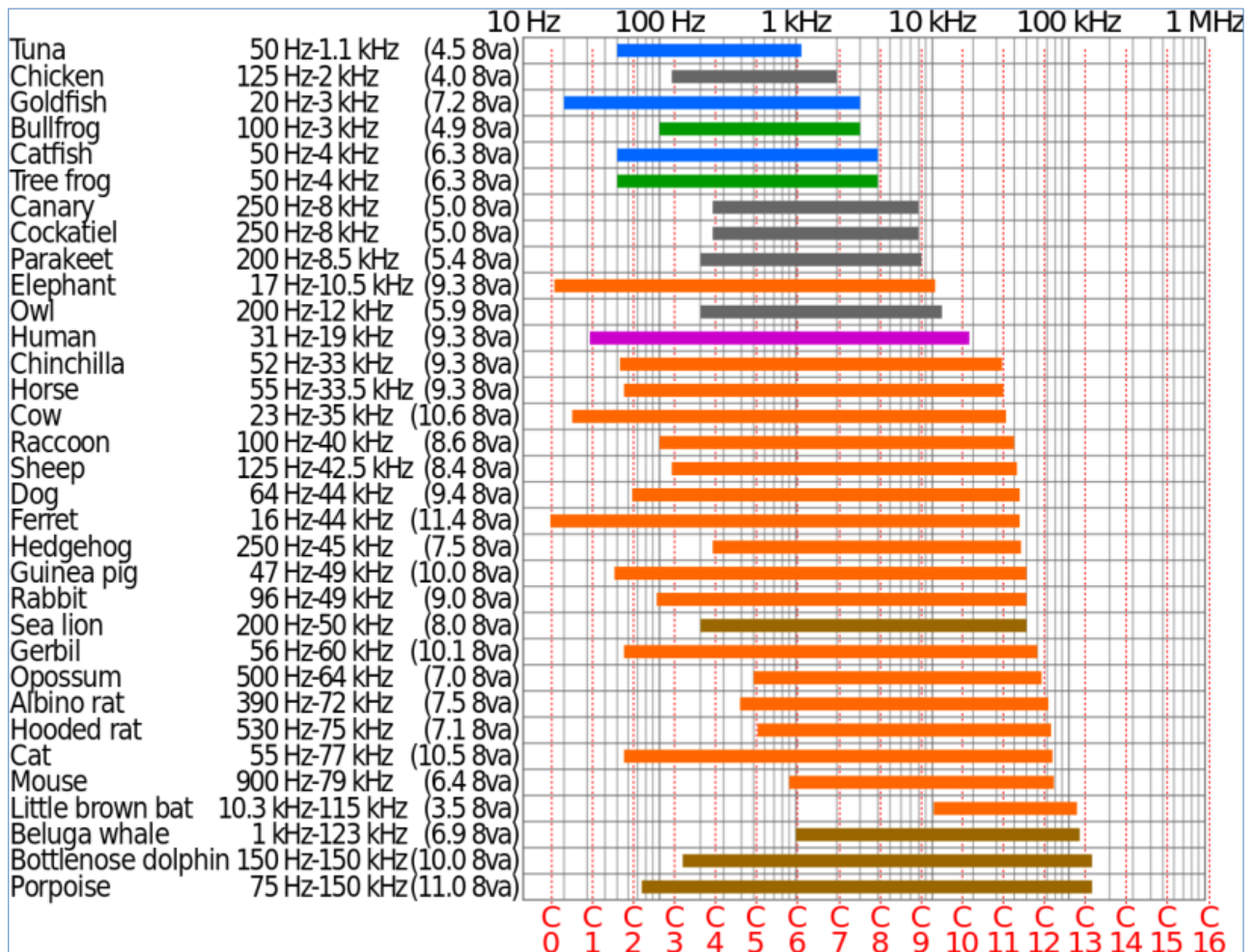


Figure 6-1: Logarithmic Chart of the Hearing Ranges of Some Animals¹⁹

6.1.1 Domesticated Animals

Excluding loud impulsive noises, considering the environmental noise levels (the noise levels were not defined, but levels of up to 100 dB were reported), it has been observed that most domesticated animals are generally not bothered by noise and generally can acclimatize relatively quickly to loud noises [137]. Considering the expected wind turbine noise (WTN) levels (well less than 60 dBA at all locations), WTN will not impact on domestic animals [108]. This is because the noise from WTG is normally a constant, broadband noise, with no impulsive character that may startle domestic animals. Based on available information:

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

- Horses: The prominent aerodynamic sound of wind turbines (63–4,000 Hz) slightly overlaps with a horse's hearing range (55–33,500 Hz). Horses should clearly hear wind turbines, though research show that they quickly adapt (see Helldin (2012) [68]; Wiśniewska (2022) [165]);
- Ruminants (Cattle, sheep, goats): When first introduced to a new noise, livestock may experience temporary elevated stress levels. Ruminant s however possesses an excellent capacity for habituation. Extensive agricultural experience in the western United States and Europe shows that cattle, sheep, and goats routinely graze directly underneath operational wind turbines without long-term adverse effects on their health, reproductive systems, or meat/milk production (EURCAW [52]; Teff-seker [147]). In addition, operating noise levels from wind farms rarely reaches the high intensity levels (above 70–90 dB) required to cause discomfort or physiological harm to livestock; and
- Chickens and Ducks: Studies on small-scale and commercial farm integrations indicate that poultry habituate rapidly to the continuous mechanical hum of turbines. There is no verified scientific link suggesting that turbine noise decreases egg-laying rates or impacts flock growth when standard farm setbacks are maintained (Ben Sassi [13]; Mikolajczak [99]).

6.1.2 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. Helldin (2012) [68] however highlights that the network of access road could be a significant factor impacting on animals. Noise impacts are therefore very highly species-dependent (Blickley and Patricelli, 2010; Cummings, 2012; Cummings, 2009; Łopucki, Klich and Gielarek, 2017; Noise quest, 2010; Rabin, Coss and Owings, 2006) [15, 36, 37, 89, 108, 127], but there are also other factors that could impact on animals (such as visibility and increased movement of people and vehicles).

It had been claimed that LFN from WTG may have an influence on animals that use lower frequencies to communicate. A number of studies that are frequently cited include:

- Larom (1997) [86] suggest that elephants can communicate over ranges in excess of 10 km under optimum atmospheric conditions. It also states that optimal conditions occur when winds are the lowest and inversion strongest (Larom, 1997);
- Muggenthaler *et al* (1992) [103] focused on frequencies between 0 and 100Hz, using Fast Fourier Transforms to analyses the data. They identified a number of common

frequencies from 6 – 80 Hz and suggest that rhinoceroses may communicate at these low frequencies (Muggenthaler (von), 1992);

- Also studied the sounds created by Sumatran Rhinos, recording sounds between 70 – 4 kHz (at 57 – 92 dB) (Muggenthaler, 2003) [**104**].

A later paper by Policht (2008) [**124**] however state that (Policht, 2008):

- Rhinos do use acoustic communication and identified a number of distinct calls;
- Referred to a study by Budde & Klump (2003) [**21**], highlighting the lack of evidence that Black rhino calls had energy predominantly in the infrasonic range (Budde, 2003);
- State that, though snarls of white rhinos might be audible 1 km or more away, no rhino was ever seen to be responding to such sounds at a distance;
- Confirmed that some white rhino calls may reach into the infrasound range, however, also iterate that there is no evidence for long-distance communication by these calls;
- States that the “grouch”-call does has the highest proportion of infrasonic energy, but this call is emitted by white rhinos usually when the conspecifics are in close proximity;
- Refer to McComb et al. (2003) [**96**], stating that, even in the case of elephants, the transmission properties of long-distance calls and hearing abilities of receivers are determined by frequencies of about 100 Hz rather than those below 30 Hz (McComb, 2003). While McComb did measure social recognition at distances up to a maximum of 2.5 km, the ability to recognize social calls further than 1 km were limited; and
- Concludes that the infrasound component of the calls emitted by large animals may be alternatively explained as a byproduct of their extreme body size.

6.1.3 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 behavioural reactions. Ortega (2012) [**112**] summarized that 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 (Autumn, 2007) [**5**], (Cummings, 2009) [**37**], (Dooling and Popper, 2007) [**43**], (Lohr, Wright and Dooling, 2003) [**88**], (Ortega, 2021) [**112**], (Schaub, Ostwald and Siemers, 2008) [**135**], (Zwart *et al.*, 2014) [**171**].

6.1.4 Concluding Remarks - Noise Impacts on Animals

From these and other studies the following can be concluded:

- To date there are no guidelines or sound limits with regards to noise levels that can be used to estimate the potential significance of noises on animals (Blickley *et al.* 2010) [**15**].
- Animals respond to impulsive (sudden) noises (higher than 90 dBA) by running away. If the noises continue, animals would try to relocate (Dooling, 2007) [**43**].
- Terrestrial wildlife responses begin at noise levels of approximately 40 dBA, with 20% of papers documenting impacts below 50 dBA (Shannon *et al.* 2015) [**138**].
- 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, 2010) [**9**], with Helldin *et al.* (2012) [**68**] reporting that levels of 60–75 dBA have been shown to cause stress, e.g., increased respiration and heart rate, increased vigilance, and decreased time for grazing in domestic animals such as sheep and horses.
- Animals of most species exhibit adaptation with noise (Broucek, 2014) [**22**], including impulsive noises, by changing their behaviour.
- There may be a possible impact on the health of animals (Mikolajczak, 2013; Karwowska, 2015) caged very close to an operating WTG (within 500 m) [**83, 99**];
- Songbirds may change the spectral character of songs and calls used for communication and defence in areas very close to WTGs. This is similar to the effects of other anthropogenic noise sources such as traffic, which can disrupt bird 'chatter' to the point of being detrimental to reproductive success (Szymański, 2017; Zwart, 2014) [**144, 171**];
- More sensitive species would relocate to a quieter area, especially species that depend on hearing to hunt or evade prey, or species that makes use of sound/hearing to locate a suitable mate (Dooling, 2007) [**43, 89**].
- Noises associated with helicopters, motor- and quad bikes significantly impact on animals (startle response). This is due to the sudden and significant increase in noise levels due to these activities [**5, 152**];
- Łopucki (2016) [**89**] studied tracks from various species (Roe deer, European hare, Common pheasant and Red fox), from as close as 100m from WTG to 700m away. That study determined that
 - Roe deer and European hare visit the areas closer to WTG less frequently than areas further away,
 - Common pheasant appear to visit the areas closer to WTG more frequently, and
 - Red fox showed the most neutral response to WTG; and

- Helldin *et al.* (2012) [68] also report that large terrestrial mammals appear to acclimatise to wind farms during the operational phase.

With regard to Low-Frequency Noise (LFN) and Infrasound, it is summarized that:

- There are no scientific papers available in reputable journals highlighting the impact of LFN from WTG on wildlife;
- Background noise levels (ambient sound 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;
- 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; and
- 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.

It should be noted that LFN and 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.

6.2 WHY NOISE CONCERNS COMMUNITIES [6, 20, 26, 31, 37, 59, 84, 107, 125, 139]

Noise can be defined as "unwanted sound", and 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 generalise 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.

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 only music, 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 behavioural and evaluative aspects. For instance, in some cases, annoyance is seen as an outcome of disturbances, and 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 neighbouring house at night when one would prefer to sleep. Noise impacts are also complex to evaluate as numerous issues could cumulatively contribute to the severity of the impact, as discussed in the following subsections.

How a noise may impact (with this assessment using annoyance about the noise) on a receptor is also very complex to assess for the reasons highlighted in **section 6.2.1** below. Only considering the intensity of a sound (or noise) level, some people may become annoyed without hearing any noise (perceived impacts) where others may not even be reporting noise to be a concern, even when subjected to very high levels.

6.2.1 Noise Annoyance

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 the non-acoustic factors play 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 (Bakker *et al.*, 2012 [8]; Council of Canadian Academies, 2015 [30]; Ellenbogen *et al.*, 2012 [47]; Halfwerk *et al.*, 2011 [64]; Hanning, 2010 [65]; Janssen *et al.*, 2011 [78]; Knopper *et al.*, 2014 [84]; Merlin *et al.*, 2013 [95]; Miedema and Vos, 2003 [97];

Minnesota Department of Health, 2009; [100]; Nissenbaum, 2012 [106]; Pedersen, 2007 [117]; Pedersen *et al.*, 2007 [118]; Pedersen *et al.*, 2003 [119]; Pedersen, 2011 [120]; Pierpont, 2009 [123]; Schmidt and Klokke, 2014 [136]; Van den Berg *et al.*, 2008 [155]; Van den Berg *et al.*, 2014 [156]; WHO, 2009 [168]).

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 6-2**, are recommended in a European Union position paper published in 2002, stipulating policy regarding the quantification of annoyance. This can be used in 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 levels.

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 and health state of the receptor; and
- The attitude of the receptor about the emitter (noise source).

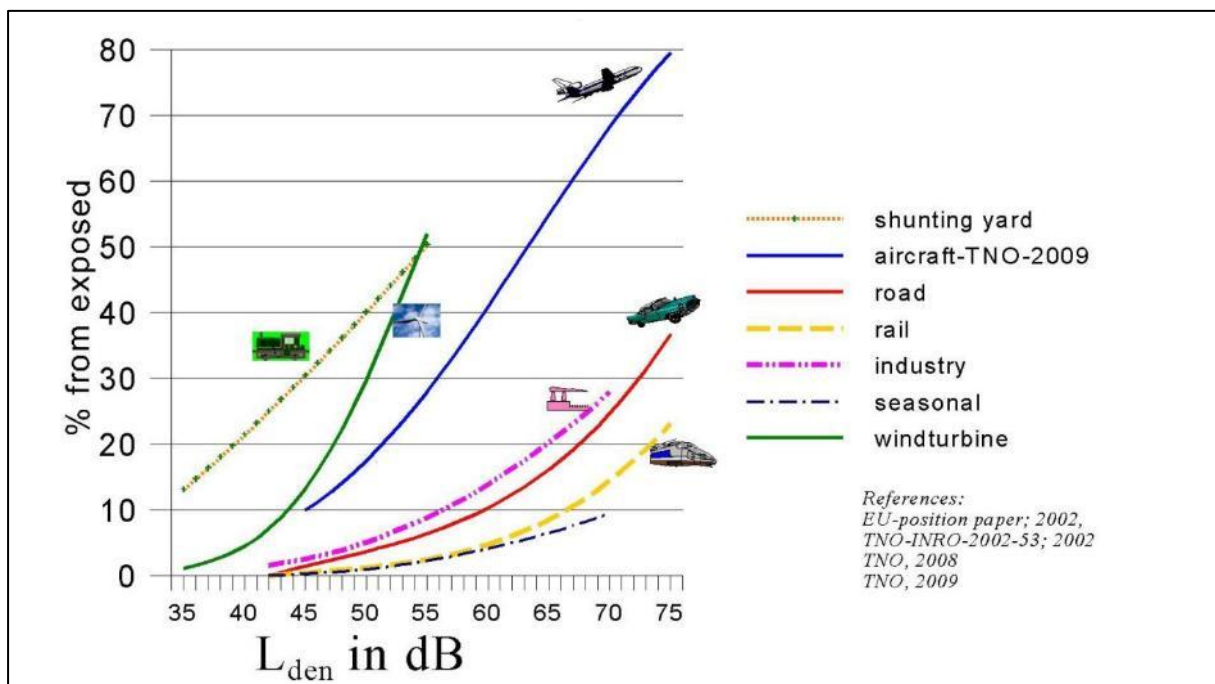


Figure 6-2: Percentage of annoyed persons as a function of the day-evening-night noise exposure at the façade of a dwelling²⁰

6.2.1.1 Disturbance to Sleep

Sleep is essential for mental and physical health, and noise is one of the most reported reasons why people may experience sleep interruptions at night. This may be sudden loud noises, with the WHO (2009) [168] reporting that, when maximum noises exceed 60 dBA, with average noise levels exceeding 40 dBA, it may increase the probability of being awakened. People report that quality of life suffer with increased instances of disturbed sleep that may also increase annoyance with a project (Bakker *et al* (2012) [8]; Van den Berg *et al* (2014) [156]). It should be noted that (Van den Berg *et al* (2008) [155]; Van den Berg *et al* (2014) [156]) showed an indirect effect between sleep disturbances and annoyance, but not between sleep disturbance and the noise level. It is postulated that this is due to increased annoyance due to the visual impact from WTG.

6.2.1.2 Potential Health Effects from WTN

While there has been a number of complaints about the impact of WTN on the health of people living close to WTG (Halfwerk *et al.*, 2011 [64]; Hanning, 2010 [65]; Janssen *et al.*, 2011 [78]; Nissenbaum, 2012 [106]; Pierpont, 2009 [123]) other than annoyance and sleep disturbances, there is no evidence of any direct health effects (Council of Canadian Academies, 2015 [30]; Ellenbogen *et al.*, 2012 [47]; Knopper *et al.*, 2014 [84]; Łopucki, R *et al*, 2016 [90]; Maijala, P.P. *et al*, 2021 [91]; MDEP [94]; Merlin *et al.*, 2014 [95]; Minnesota Department of Health, 2009 [100]; Pedersen, Halmstad and Högskolan, 2003 [119]; Schmidt and Klokke, 2014 [136]; van Kamp, I. *et al*, 2021 [158]).

The WHO (2009 [168]) however does report threshold levels where people may report or experience effects from noise, with these thresholds highlighted in **Table 6-1**. The WHO does use the L_{Amax} and L_{night} ²¹ descriptors to describe these levels.

Table 6-1: Threshold levels reported by the WHO (2009)

Effect	Indicator	Threshold (dBA)
EEG awakening	$L_{Amax,inside}$	35
Onset of motility	$L_{Amax,inside}$	32
Changes in sleep patterns	$L_{Amax,inside}$	35

²⁰ Image from <https://rigolett.home.xs4all.nl/ENGELS/topic.htm>. Wind Turbine Annoyance curve from Pedersen (2007)

²¹ Refers to the European Union definition in Directive 2002/49/EC – equivalent outdoor sound pressure level associated with a particular type of noise source to which a receptor is exposed to over the 8-hour night-time period, calculated over a period of a year

Waking up in the night and/or too early in the morning	L _{Amax,inside}	42
Increased average motility when sleeping	L _{night,outside}	42
Self-reported sleep disturbances	L _{night,outside}	42
Environmental insomnia	L _{night,outside}	42
Hypertension	L _{night,outside}	50
Myocardial infarction	L _{night,outside}	50
Psychic disorders	L _{night,outside}	60

6.2.1.3 Situational and Personal Factors

There are a few other aspects, collectively referred to as non-acoustical factors that may increase annoyance with a project [Miedema and Vos, 2003 [97]; Pedersen *et al.*, 2007 [118]]. These could include:

- Situational factors (visual issues, attractiveness of area) (Merlin *et al.*, 2014 [95]; Michaud *et al.* (2016) [98]; Van den Berg *et al* (2008) 155)];
- Socio-economic factors (age, gender, income, level of education) [Miedema and Vos, 2003 [97]; Michaud *et al.* (2016) [98]],
- Social factors (attitude towards the applicant/producer/government, media coverage) (Pedersen *et al.*, 2007 [118]; Superior Health Council, (2013) [143]),
- Personal factors (fear or worry in relation to noise source, sensitivity to noise, economic benefit from project, existing health condition) (Miedema and Vos, 2003 [97]; Taylor *et al* (2013) [146]; Van Kamp and Davies (2013) 157), and
- Attitude towards the project and exposure to negative sentiment (Bernstein *et al* (2024) [14]; Crichton *et al.* (2014) [31], Crichton *et al* (2014) 32).

6.3 IMPACT ASSESSMENT CRITERIA

6.3.1 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 that is not subjective and can be quantified. Loudness is a subjective measure of the effect 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 acclimatised or familiar that person is to the sound.

6.3.2 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 EIA Regulations of 2014 in terms of the NEMA, SANS 10103:2008, and guidelines from the WHO.

There are a number of criteria that are of concern for the assessment of noise impacts. These can be summarised 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, caused by a new source of noise. With regards to the NCR, an increase of more than 7 dBA is considered a disturbing noise. See also **Figure 3-1**.
- *Zone Sound Levels:* Previously referred to as the acceptable rating levels, sets acceptable noise levels for various areas. See also **Table 3-2**.
- *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. Anything above this level will be considered unacceptable.

In South Africa, the document that addresses the issues concerning environmental noise is SANS 10103:2008 (See also **Table 3-2**). It provides the equivalent ambient noise levels (referred to as Rating Levels), $L_{Req,d}$ and $L_{Req,n}$, during the day and night respectively to which different types of developments may be exposed.

6.4 SETTING APPROPRIATE NOISE LIMITS

Onsite ambient sound measurements (see **Section 4.3**) indicated an area with a potential to be very quiet, with ambient sound levels typical of a rural noise district.

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 considered.

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 ambient sound levels in the environment within which they are heard will probably also be dependent on 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.

6.4.1.1 Using International Guidelines to set Noise Limits – ETSU-R97

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:

1. Wind speeds are not often measured at wind speeds greater than 12 m/s at 10 m height;
2. Reliable measurements of background ambient sound levels 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;
3. Turbine manufacturers are unlikely to be able to provide information on sound power levels at such high wind speeds for similar reasons; and
4. 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 ambient 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 turbines²².

Sound level vs. wind speed data is presented in **Figure 4-26** (daytime period) and **Figure 4-27** (night-time period)²³. It is based on approximately 38,000 measurements collected at various quiet locations in South Africa (locations further than 10 km from the ocean). Also indicated are the more than 1,200 and 750 actual day- and night-time measurements measured near the proposed WEF. There were no apparent or observable sounds that would have impacted on the measurements at these locations. There was generally lack of higher wind speeds during the night-time periods (only a few measurements were collected when the wind speeds exceeded 6 m/s), but as with other sites, ambient 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 3-3; IFC, see **Table 3-4**), 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) at night. In most cases, this will ensure a noise level less than 35 dBA inside bedroom of NSR.

6.4.1.2 Considering the latest WHO (2018) recommendations

The WHO (2018) [**169**] recommends a guideline night-time noise level of 38.7 dBA (based on the 45 dBA L_{DEN} level) to minimize sleep-disturbance and receptors being highly-annoyed (see **section 3.5.9**).

6.4.1.3 Using the NCR to set noise limits

The National NCRs (GN R154 of 1992 – **section 3.3.1**) defines a "**disturbing noise**" as the Noise Level which exceeds the zone sound level or, if no zone sound level has been designated, a noise level which exceeds the ambient sound level at the same measuring point by 7 dBA or more. The Gauteng NCR (GN 5479 of 2020 - **section 3.3.2**) however define a noise as potentially disturbing, of the noise level exceed the rating level.

²² It should be noted that this does not mean that the wind turbines are inaudible.

²³ The sound level measuring instruments were located at quiet locations near 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 developers.

Therefore, considering the developmental character as well as the ambient sound levels measured, this assessment will recommend the following rating levels for the construction phase:

- 50 dBA for the daytime period (typical of a sub-urban noise district); and
- 40 dBA for the night-time period (typical of a suburban noise district).

However, as can be observed from **Figure 4-26** (daytime period) and **Figure 4-27** (night-time period), if ambient sound levels were measured at increased wind speeds, ambient sound levels will be higher as wind-induced noises increase. These potential ambient sound levels will be used to determine the probability for a noise impact to occur (during the operational phase). Appropriate noise limit should consider changing ambient sound levels, and the noise limits will increase as wind speed increase. For modelling and assessing the potential noise impact, the values as proposed in **Table 6-2** will be recommended.

Table 6-2: Proposed ambient sound levels and acceptable rating levels (operational phase only)

10 meter Wind Speed (m/s)	Estimated ambient sound levels (night-time) (dBA)	MoE Sound Level Limits of Class 3 areas (Table 3-3) (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

6.4.1.4 Potential LFN Levels and Impact

This assessment only reports on potential LFN from the WEF, considering an estimated G-weighted value (Jakobsen, 2001) [77] as well as the difference between the dBA and dBC level (Leventhall, 2003) [87]. This should only be used for information purposes, as the calculation of the dBC and dBG values are generally inaccurate, with current LFN criteria considering the evaluation of LFN after the measurement of actual spectral data.

6.5 DETERMINING THE SIGNIFICANCE OF THE NOISE IMPACT

The level of detail as depicted in the EIA Guidelines (CSIR, 2002) [34] was fine-tuned by assigning specific values to each impact, considering the impact rating methodology

developed by the EAP as well as the author²⁴ (see [Appendix E](#)). In order to establish a coherent framework within which all impacts could be objectively assessed, it was necessary to establish a rating system, which was applied consistently to all the criteria. The following criteria were considered:

- **Nature**: Whether the activity have a negative or positive impact on the environment.
- **Magnitude**: The intensity of the impact on the surrounding receptors.
- **Extent**: the spatial scale defines the physical extent of the impact.
- **Duration**: The temporal scale defines the significance of the impact at various time scales, as an indication of the duration of the impact.
- **Reversibility**: The degree to which an environment can be returned to its original/partially original state.
- **Probability**: The likelihood of impacts taking place as a result of project actions arising from the various alternatives.
- **Significance**: The criteria in **Table 6-4** are used to determine the overall significance of an activity. The impact effect (which includes duration; extent; consequence and probability) and the reversibility/mitigation of the impact are then read off the significance matrix in order to determine the overall significance of the issue. The overall significance is either negative or positive and will be classified as low, moderate or high.
- **Irreplaceable loss**: The degree of irreplaceable loss which an impact may cause, e.g., loss of non-regenerative vegetation or removal of rocky habitat or destruction of wetland.
- **Mitigation potential**: The degree of difficulty of reversing and/or mitigating the various impacts ranges from very difficult to easily achievable. Both the practical feasibility of the measure, the potential cost and the potential effectiveness is taken into consideration when determining the appropriate degree of difficulty.

The Magnitude, Extent, Duration, Reversibility and Probability criteria are defined in **Table 6-3**, with the Significance score calculated and defined in **Table 6-4**.

Table 6-3: Impact Assessment Criteria and Scoping System

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Impact Magnitude (M) The degree of alteration of the affected environmental receptor	Very low: No impact on processes	Low: Slight impact on processes	Medium: Processes continue but in a modified way	High: Processes temporarily cease	Very High: Permanent cessation of processes

²⁴ Due to the differences in methodology, both EIA criterion (that of the EAP and Author) will be considered to ensure that potential impacts are not over- or under rated.

CRITERIA	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5
Impact Extent (E) The geographical extent of the impact on a given environmental receptor	Site: Site only	Local: Inside activity area	Regional: Outside activity area	National: National scope or level	International: Across borders or boundaries
Impact Reversibility (R) The ability of the environmental receptor to rehabilitate or restore after the activity has caused environmental change	Reversible: Recovery without rehabilitation		Recoverable: Recovery with rehabilitation		Irreversible: Not possible despite action
Impact Duration (D) The length of permanence of the impact on the environmental receptor	Immediate: On impact	Short term: 0-5 years	Medium term: 5-15 years	Long term: Project life	Permanent: Indefinite
Probability of Occurrence (P) The likelihood of an impact occurring in the absence of pertinent environmental management measures or mitigation	Improbable	Low Probability	Probable	Highly Probability	Definite

Table 6-4: Impact Assessment Criteria – Significance Rating

Significance (S) is determined by combining the above criteria in the following formula:	$[S = (E + D + R + M) \times P]$ $Significance = (Extent + Duration + Reversibility + Magnitude) \times Probability$				
Total Score	4 to 15	16 to 30	31 to 60	61 to 80	81 to 100
Environmental Significance Rating (Negative (-))	Very low	Low	Moderate	High	Very High
Environmental Significance Rating (Positive (+))	Very low	Low	Moderate	High	Very High

7 METHODS: CALCULATION OF NOISE LEVELS

7.1 POINT²⁵ AND AREA²⁶ NOISES – CONSTRUCTION AND OPERATIONAL ACTIVITIES

The noise emissions from various sources were calculated in detail for the conceptual construction and operational activities by using the sound propagation algorithms described by the ISO 9613-2 model. The following were considered:

- The octave band sound pressure emission levels of processes and equipment;
- The distance of the receivers 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;
- Screening corrections where applicable;
- Topographical layout; and
- Acoustical characteristics of the ground.

Potential operational cycles were not considered and a worst-case scenario was evaluated, assuming that all activities and equipment generate the maximum noise level 100% of the time.

The ISO 9613-2 noise propagation model is used, as it is the noise model most recommended to calculate WTN. The uncertainties and limitations of the ISO 9613 model is well defined; and while there are a number of different noise propagation models that one can use, all of them have uncertainties and limitations.

Therefore, the ISO 9613 noise propagation model is the model most frequently recommended, with this noise propagation model preferred in Australia (EPA, 2009) [49], the United Kingdom (IOA, 2013) [75], Canada (CanWEA, 2007) [24], United States of America (NARUC, 2011) [105] and the European Union (Directive 2002/49/EC)²⁷ [33, 44].

This assessment considers two potential operational scenarios, including a potential worst-case as well as a potential “average” case scenario, with the main difference being receiver height and ground surface constant. During periods with high noise emission levels (WTG emitting highest noise levels), actual noise levels is expected to be between these two

²⁵ Typically a WTG, or a stationary noise generating activity or piece of equipment.

²⁶ Such as a large surface vibrating, up to a defined area where equipment is moving around. It can include an industrial project where the locations of noise generating activities or equipment cannot be defined. This is used as a worst-case, as the inclusion of a large area source(s) tend to over model noise levels.

²⁷ This directive does not recommend but actually stipulate the use of this noise model for industrial noise sources.

values, with site specific parameters such as ground level wind speeds and wind speed profile (at different heights), vegetation characteristics in the area between the WTG and the calculation location, air temperature and humidity influencing actual noise levels (from the WTG). The modelling parameters used are:

- Worst-case scenario: Receiver height 4m and a ground surface constant of 25% (ground surface medium-hard); and,
- "Average"-case scenario: Receiver height 2m and a ground surface constant of 50% (ground surface medium-hard).

The ISO 9613 noise propagation model was also used to estimate potential dBC and dBG levels, though this is only included in this report for information purposes (due to the uncertainties associated with LFN calculations).

7.2 ROAD TRAFFIC NOISE LEVELS

The noise emission into the environment due to project road traffic (mainly construction traffic) will be estimated using a simplified noise propagation model described in SANS 10210:2004. It mainly considers the distance of receptor from the road as well as average speeds of travel. Factors that are not considered include:

- Topography and barrier effects (noise levels could be over-estimated);
- Road construction material (noise levels could be over-estimated);
- Types of vehicles used (noise levels could be under-estimated);
- Road gradient (noise levels could be over- or under-estimated); and
- Ground acoustical conditions (noise levels could be over-estimated).

8 ASSUMPTIONS AND LIMITATIONS

8.1 LIMITATIONS - ACOUSTICAL MEASUREMENTS

Ambient sound levels are the cumulative effects of innumerable sounds generated at various instances both far and near. A high measurement may not necessarily mean that the area is always noisy. 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 day, dependant on faunal characteristics (mating season, dawn chorus⁽²⁸⁾ early hours of the morning, temperature etc.), vegetation in the area and meteorological conditions (especially wind).

Selecting an ideal measurement location could be difficult, with various criteria assessed to identify the viability of a certain location as a point to define ambient sound levels. When selecting a measurement location, the most important criteria would be:

1. Security of the instrument (minimise risk to the technician; prevent theft; sabotage of the equipment);
2. Safety of the equipment (ensure that it does not prevent, interfere or limit typical agricultural or household activities; ensure that the instrument are not in a location where an animal could damage the instrument); and lastly,
3. The suitability of the measurement location to define ambient sound levels (the presence of certain trees or equipment, wetland or other water resources will influence ambient sound level significantly).

As such, after ensuring that the instrument is safe and secure, there are various environmental factors that could influence ambient sound levels measured. These constraints and limitations are discussed below and could include:

- Seasonal changes in the surrounding environment can influence typical ambient sound levels, as many faunal species are more active during warmer periods than the colder periods. As an example, cicada is usually only active during warmer periods. Certain cicada species can generate noise levels up to 120 dB for mating or distress purposes, sometimes singing in synchronisation magnifying noise levels they produce from their tymbals⁽²⁹⁾;
- Defining ambient sound levels using the result of one 10-minute measurement may be very inaccurate (very low confidence level in the results) relating to the reasons mentioned above, and measurements over a longer-term period is critical;

⁽²⁸⁾ Environ. We Int. Sci. Tech. *Ambient noise levels due to dawn chorus at different habitats in Delhi*. 2001. Pg. 134.

⁽²⁹⁾ Clyne, D. "Cicadas: Sound of the Australian Summer, *Australian Geographic*" Oct/Dec Vol 56. 1999.

- Some equipment that could influence measurements may be missed when deploying instruments, or the equipment may not be audible. This could include equipment such as hidden water pumps and associated pipelines and outflows, ESKOM stepdown transformers, hidden compressors, inverters, condensers or other electrical equipment, etc. While not audible during deployment, such equipment may significantly influence ambient sound levels during quiet periods;
- Type, the number and sizes of trees in the vicinity of the instrument, as well as the distances between the microphone and these trees. Certain trees, especially fruiting trees could attract birds and other animals that will significantly impact on ambient sound levels;
- Type and number of animals in the vicinity of the microphone. Dogs, chickens, geese, etc. generate different noises randomly both night and day, and other livestock (sheep, goats, cattle, horses, etc.) kept in enclosures will also raise noise levels, especially if these animals are penned in large numbers;
- Measurements over wind speeds of 3 m/s could provide data influenced by wind-induced noises. However, when determining the ambient sound levels associated with increased wind speeds, it is desired to measure ambient sound levels at higher wind speeds;
- Ambient sound levels recorded near rivers, streams, wetlands, trees and bushy areas can be high due to faunal activity which can dominate the sound levels around the measurement point (specifically during summertime, rainfall event or during dawn chorus of bird songs). This generally is still considered naturally quiet and accepted as features of the natural environment, and in various cases sought after and pleasing. Ambient sound level data measured in such area however should not be used to develop an opinion in the potential prevailing ambient sound levels in the larger area;
- Exact location of a sound level meter in an area in relation to structures, infrastructure, vegetation, wetlands and external noise sources will influence measurements. It may determine whether you are measuring anthropogenic sounds from a receptors dwelling, or environmental ambient baseline contributors of significance (faunal, roads traffic, railway traffic movement etc.); and
- As a residential area develops the presence of people will result in increased dwelling related 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 an area matures.

8.2 CALCULATING NOISE EMISSIONS – ADEQUACY OF PREDICTIVE METHODS

Limitations due to the calculations of the noise emissions into the environment include the following:

- Many sound propagation models do not consider sound characteristics as calculations are based on an equivalent level (with the appropriate correction implemented e.g. tone or impulse). These other characteristics include intrusive sounds or amplitude modulation;
- Most sound propagation models do not consider refraction through the various temperature layers (specifically relevant during the night-times);
- Most sound propagation models do not consider the low frequency range (third octave 16 Hz – 31.5 Hz). This would be relevant to facilities with a potentially low frequency issue;
- Many environmental models consider sound to propagate in hemi-spherical way. Certain noise sources (e.g. a speaker, exhausts, fans) emit sound power levels in a directional manner;
- 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;
- Many environmental models are not highly suited for close proximity calculations; and
- Acoustical characteristics of the ground are over-simplified, with ground conditions accepted as uniform.

8.3 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 is 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.

8.4 UNCERTAINTIES ASSOCIATED WITH MITIGATION MEASURES

Any noise impact can be mitigated to have a low significance; however, the cost of mitigating this impact may be prohibitive, or the measure may not be socially acceptable (such as the relocation of an NSR). These mitigation measures may be engineered, technological or due to management commitment. The potential significance of a noise impact can be reduced

by reducing noise levels, but also by changing the probability that the increased noise levels annoy NSR (by improving attitudes towards the project).

For the purpose of the determination of the significance of the noise impact mitigation measures were selected that are feasible, mainly focussing on management of noise impacts using rules, policy and require a management commitment. This, however, does not mean that noise levels cannot be reduced further, only that to reduce the noise levels further may require significant additional costs (whether engineered, technological or management).

It was assumed the mitigation measures proposed for the construction phase, if any is included and proposed in this report, will be considered during the planning phase, implemented during the construction phase and continued during the operational phase.

8.5 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 especially challenging 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:

- It is technically difficult and time-consuming to improve the measurement of spectral distribution of large equipment in an industrial setting. This is due to the many correction factors that need to be considered (e.g., other noise sources active in the area, adequacy of average time setting, surrounding field non-uniformity etc.³⁰ as per SANS 9614-3:2005);
- 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 are 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

³⁰ SANS 9614-3:2005. "Determination of sound power levels of noise sources using sound intensity – Part 3: Precision method for measurement by scanning".

these measurements are collected when the process or equipment is under high load. The result is that measurements generally represent a worst-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 comply with the precautionary principle and operational time periods are frequently overestimated. The result is that projected noise levels would likely be over-estimated;
- Modelling cannot capture the potential impulsive character of a noise that can increase the potential nuisance factor, nor the potential effect of the modulation of amplitude of the noise;
- The XYZ topographical information is derived from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (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;
- Receiver height will be assumed at a 4m height above surface level as recommended by the Institute of Acoustics (IOA, 2013) [75] for the worst-case scenario;
- Atmospheric conditions relating to an air temperature of 10°C and a 70% air humidity will be used to minimize the effect of air absorption as recommended (Bass JH *et al*, (1996) 10; IOA (2013) [75]; Kaliski K & Duncan E (2008) [80]); and
- Acoustical characteristics of the ground are over-simplified with ground conditions accepted as uniform. Fifty (50%) and Seventy-five percent (75%) hard ground conditions will be modelled for the construction (50%) and operational (both 50% and 75% will be considered) phases respectively, representing a potential worst-case scenario (Bass JH *et al*, (1996) 10; IOA (2013) [75]; Kaliski K & Duncan E (2008) [80]).

Due to the uncertainties highlighted in **sections 8.2** and **8.5**, modelling generally could be out with as much as 10 dBA (the potential noise level is rather over-modelled), although realistic values ranging from less than 1 dBA to 5 dBA are more common in practice.

8.6 UNCERTAINTY ON HOW NOISE COULD AFFECT PEOPLE

Though discussed in **section 6.2**, how noise may annoy receptors are the crux of any noise impact assessment, and this is again summarized in this section, as annoyance is the complex result of numerous factors, which include both acoustical and non-acoustical issues.

Acoustic factors would be:

- Noise levels substantially exceeding ambient sound levels, directly linked to the noise sources of the project and the noise level is higher than the background levels to which the NSR are accustomed. High noise levels can be easily modelled or predicted, and should be mitigated during the planning phase for the project. During the operational phase this is measurable;
- Noise levels are not significant, but the character of the sound is different, or the noise source may be audible. It is not easy to model or predict this during the planning stage of a project, nor may it be easy to measure during the operational phase;
- WTG may generate a certain sound at times (during certain wind conditions), not easily replicated (an amplitude modulated noise, potential low-frequency noises, tonal effects, impulsive bangs, etc.). This cannot be modelled or predicted, and could be difficult to measure as the noise cannot be replicated easily.

Irrespective of the noise levels, NSR may use noise to express their dissatisfaction with a project, with these non-acoustic factors varying and generally unpredictable. As discussed in **section 6.2.1** (specifically **6.2.1.3**), these factors may be:

- Situational factors (visual issues, the attractiveness of the area);
- Personal factors (fear or worry in relation to the wind farm, sensitivity to noise, economic benefit or impacts from the project, any health conditions, stress levels);
- Social factors (attitude towards the applicant or project, any negative media coverage); and
- Socio-economic factors (the age, gender, income and even the level of education).

Because non-acoustic factors cannot be modelled, this assessment cannot rule out complaints/annoyance even where predicted levels are below relevant criteria.

As such this assessment does consider a number of studies and guidelines such as:

- Cooper and Chan [29] that discuss and present a number of dose-effect relationships as well as summarize a number of international guidelines and standards that can be used to assess noise effects from wind farms;

- Crichton *et al* [31 & 32] that studied how expectations can influence symptom and mood reports in both positive and negative directions;
- Directive 2002/49/EC [44], directing members of the European Union with a guideline on the assessment and management of environmental noise. This directive recommends the use of dose-effect relationships to assess the effect of noise on populations;
- Miedema and Vos [97], that integrated the findings from a number of studies on the relationship between noise sensitivities and exposure to noise;
- People that have a negative view of a project, or are exposed to negative sentiment are more likely to complain about noise (Bernstein *et al* (2024) [14]; Crichton *et al*. (2014) [31], Crichton *et al* (2014) [32]); and
- SANS 10103 [130] that can be used to assess how environmental noise can be measured and used to assess annoyance in communities.

It is important to understand that guidelines and dose-effect relationship studies focus on how communities respond to noise however it is difficult to predict or foresee how an individual may respond to noise.

8.7 CONDITIONS TO WHICH THIS STUDY IS SUBJECT

This study is not subject to any conditions.

9 PROJECTED NOISE RATING LEVELS

9.1 CONCEPTUAL SCENARIOS – NOISE DUE TO FUTURE CONSTRUCTION ACTIVITIES

A noise model was developed considering the conceptual construction activities as discussed in **Section 5.1**. The proposed layout as provided by the applicant for the Uvemvane WEF development is presented in **Figure 9-1**. As can be seen from this layout, a number of different construction activities might take place close to potentially sensitive receptors, each activity with a specific noise level.

Potential noises associated with the construction (or upgrading) of access roads were calculated using a basic noise model (illustrated in **Figure 9-2**), assuming an equivalent noise level of 105 dBA (re 1 pW), with noises created due to construction traffic (road traffic noises) estimated and plotted against distance as illustrated in **Figure 9-3**³¹.

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 totalling 113.6 dBA cumulative noise impact – various equipment operating simultaneously – see **Table 5-1**) at all locations where wind turbines may be erected, calculating how this may impact on noise levels at NSR³² (see **Figure 9-4**).

The projected noise levels relating to the various construction activities are defined in:

- **Appendix E, Table 7** for the construction of the access roads;
- **Appendix E, Table 8** relating to daytime construction traffic passing receptors in the area;
- **Appendix E, Table 9** for daytime construction activities at Uvemvane WEF; and
- **Appendix E, Table 10** for night-time construction activities at Uvemvane WEF (even though night-time construction activities are unlikely to occur).

³¹ Sound level at a receiver set at a certain distance from a road

³² The potential cumulative (worst-case) noise level due to construction activities at an NSR are plotted against the distance from the NSR and a potential construction activity. As the expected noise level is expected to be less than 35 dBA at NSR further than a 1,500m from a construction activity or an operational WTG, NSR further than 1,500m from the closest WTG were not included in this figure

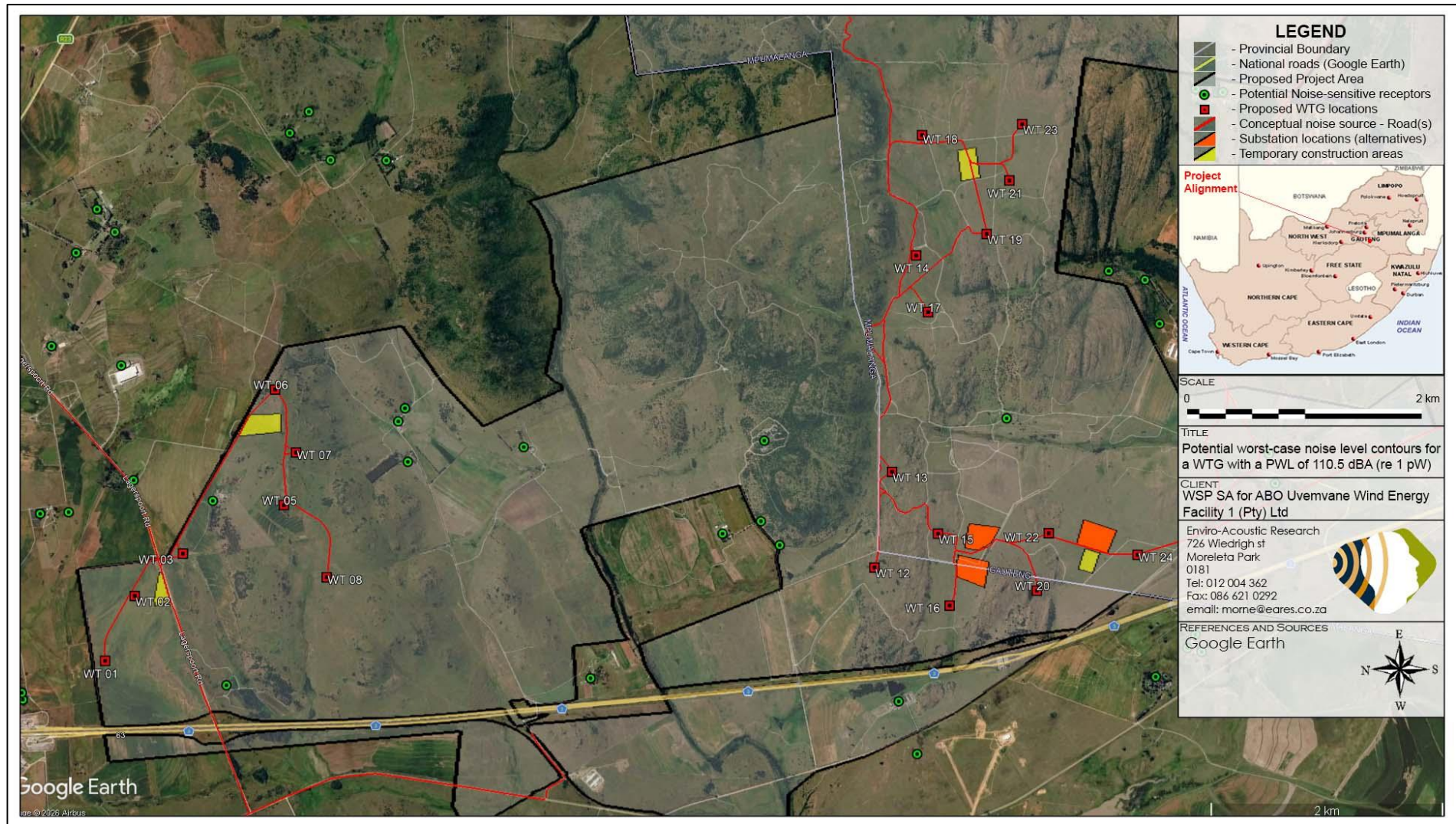


Figure 9-1: Project layout, proposed roads and other infrastructure locations for Uvemvane WEF

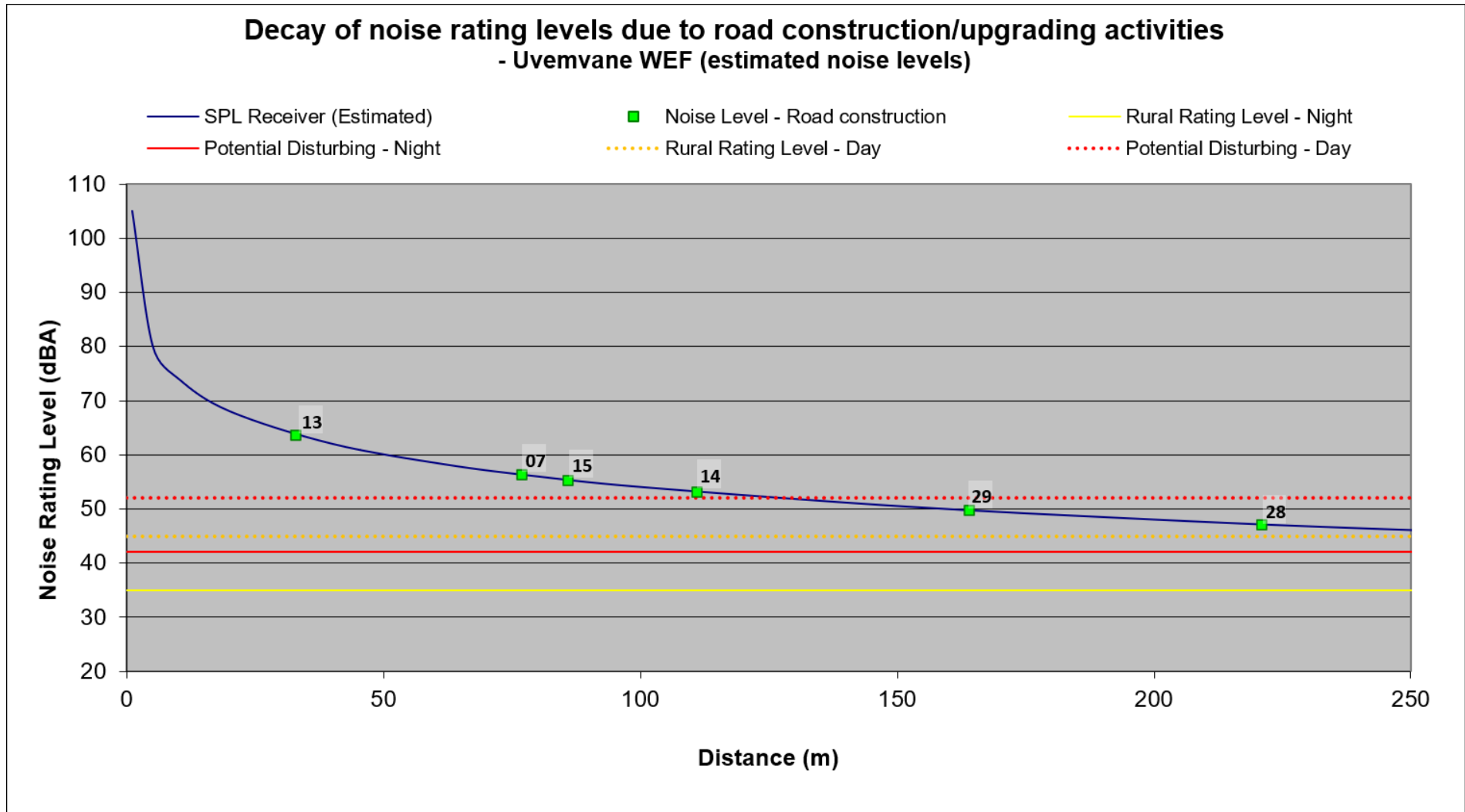


Figure 9-2: Projected conceptual construction noise levels – Brief construction or upgrading of access roads

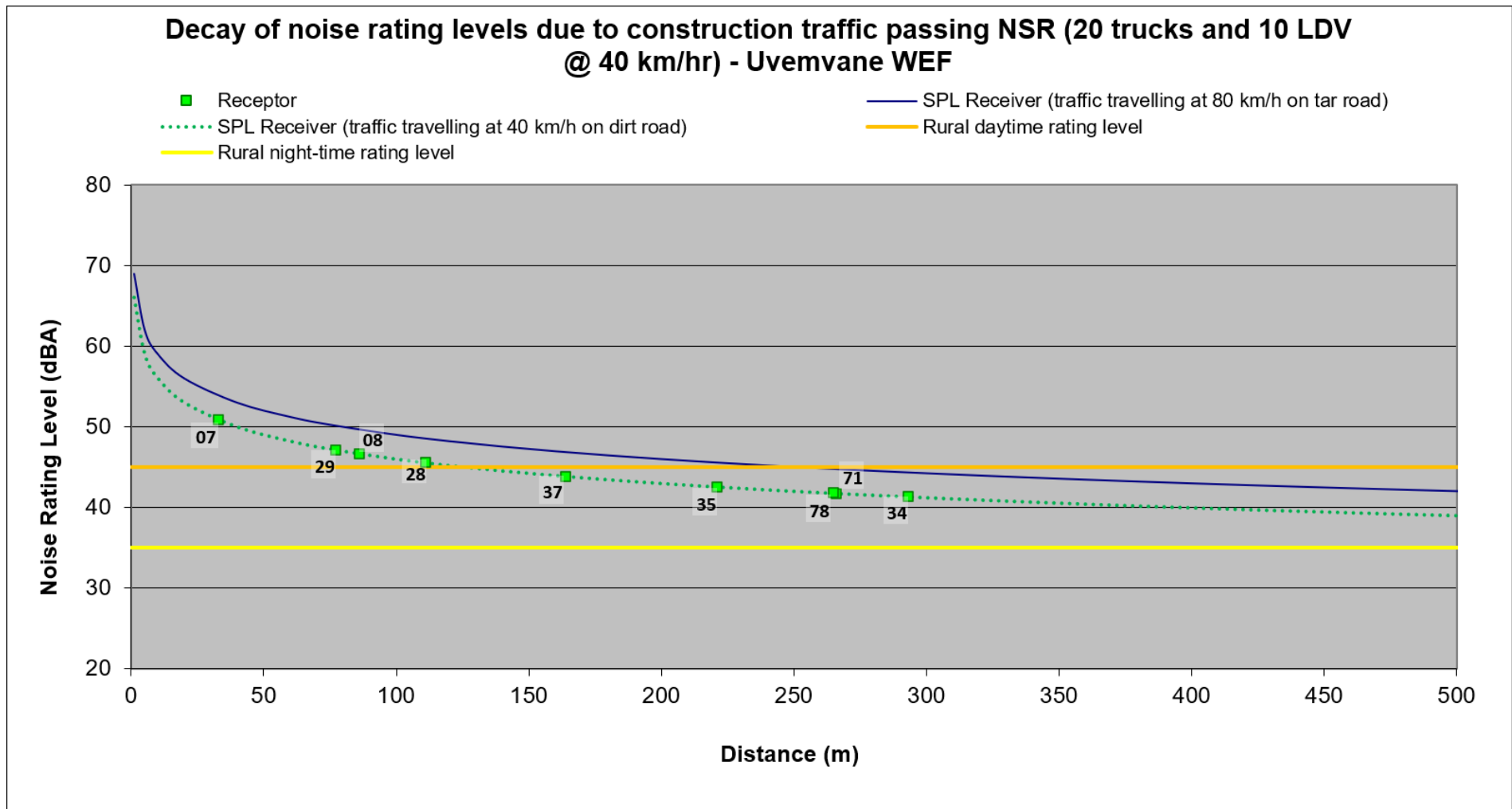


Figure 9-3: Projected conceptual construction noise levels – Decay over distance from linear activities (roads)

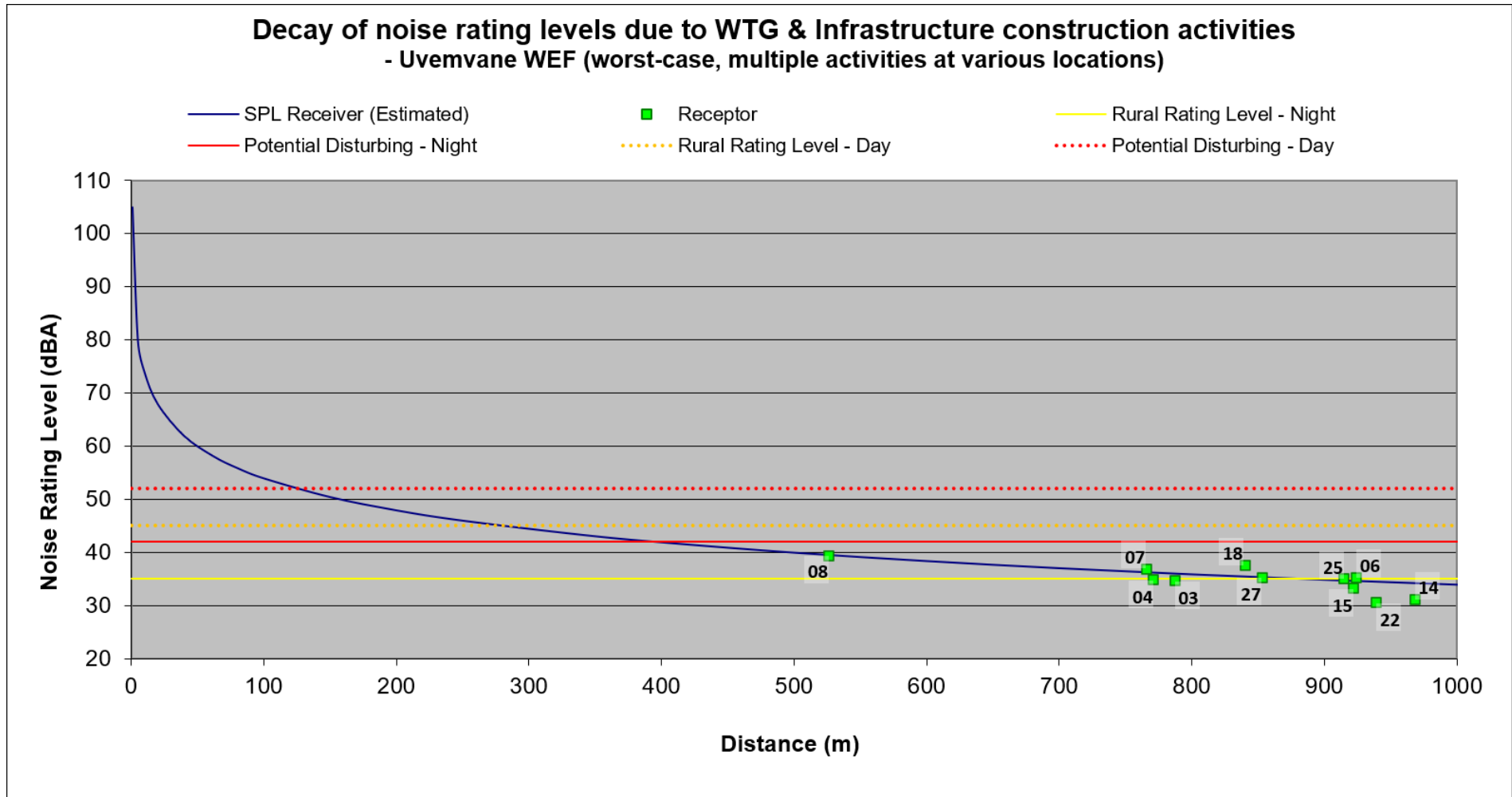


Figure 9-4: Projected conceptual construction noise levels – Construction of Uvemvane WEF infrastructure

9.2 CONCEPTUAL SCENARIOS – NOISE DUE TO FUTURE OPERATIONAL ACTIVITIES

While the significance of daytime noise impacts was considered (**Appendix E, Table 11**), times when a quiet environment is desired (at night for sleeping, relaxation in the evenings and weekends) are more critical. Surrounding receptors would desire and require a quiet environment during the night-time (22:00 – 06:00) timeslot and noise levels during the night-time period is critical. It should be noted that maintenance activities normally take place during the day, but normally involve a few light-delivery vehicles moving around during the course of the day, an insignificant noise source. As such maintenance activities will not be considered.

An “average” and “worst”-case scenario were considered (discussed in **sections 5.2.1** and **7.1**) and included in this report to illustrate the effect of the WTG operating simultaneously, with the noise levels defined per NSR in **Appendix E, Table 12**. How the noise levels may change as wind speeds change are illustrated in **Figure 9-5** (considering the worst-case scenario). The potential expected noise levels (for the average-case scenario) are illustrated in **Figure 9-6**, with the potential worst-case noise rating levels illustrated in **Figure 9-7**; using the assumed PWL (110.5 dBA re 1 pW) for the Goldwind GWH182-6.2 WTG [62].

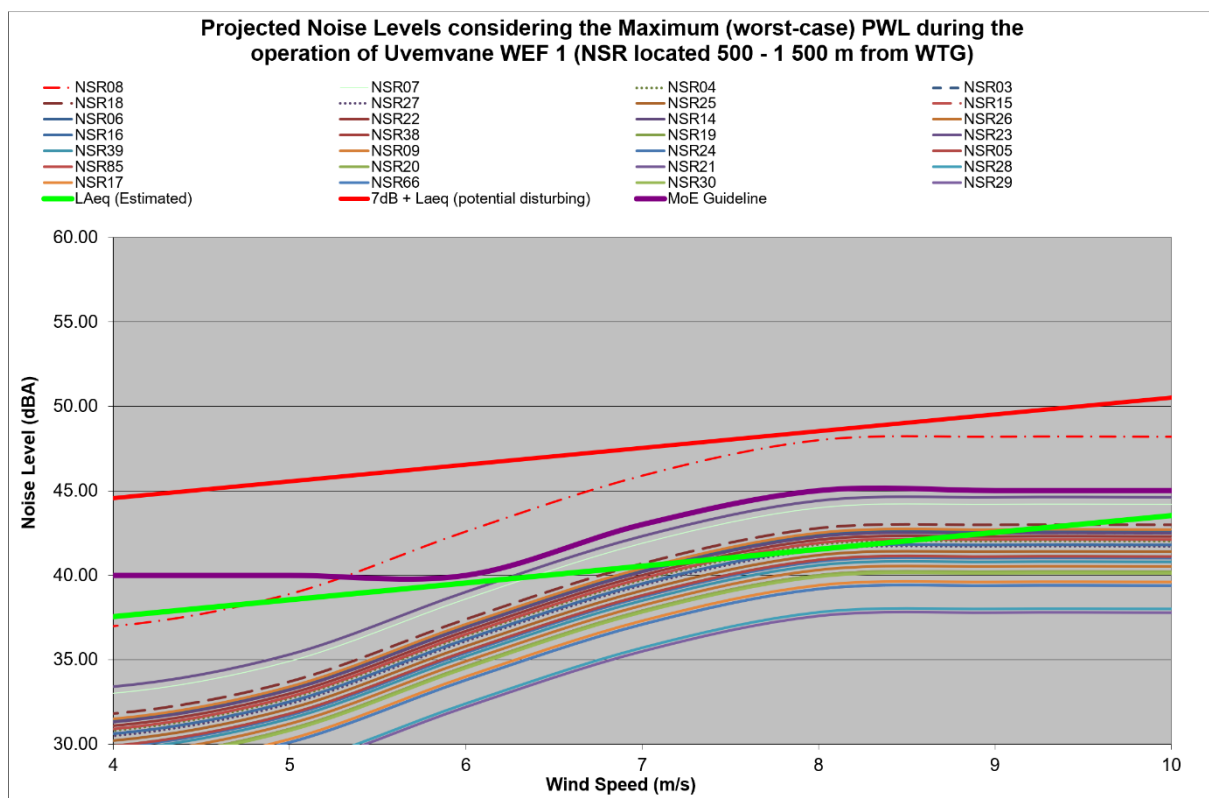


Figure 9-5: Projected noise levels at different wind speeds (worst-case PWL)

9.3 POTENTIAL CUMULATIVE NOISE IMPACTS

Cumulative noise impacts generally only occur when noise sources (such as other wind turbines) are closer than 5,000m from each other (less than 2,500m from the conceptual receptor located between them). The cumulative impact also only affects the area between the wind turbines of the various wind farms and normally only relate to the operational phase. If the distance between the wind turbines of two wind farms is further than 5,000m, cumulative noise impacts will be non-existent. This is illustrated in **Figure 9-8**.

At the time this report was drafted, there were no other wind farms (in process of approval or authorized) located within 35km from the Uvemvane WEF.

In terms of Solar Photo-voltaic (PV) projects, noise is generally limited to less than 500m from such projects, with the noise mainly relating to the hum from inverters, BESS units and substation components. With these infrastructure locations (all alternatives) being further than 500m from any NSR, noise from these sources will be insignificant.

Similarly, concentrated solar plants (SCP) make use of large fans for cooling, though the noise impact is generally limited within 2,000m from the central power plant (of the CSP). There are no CSP proposed near the Uvemvane WEF.

Little noise is associated with transmission lines, and noise from transmission lines will not be considered as motivated in **Section 5.2.6**.

The locations of known renewable projects (only PV projects) are illustrated in **Figure 9-9**.

9.4 POTENTIAL DECOMMISSIONING, CLOSURE AND POST-CLOSURE NOISE LEVELS

The potential for a noise impact to occur during the decommissioning and closure phase will be much lower than that of the construction and/or operational phases. This is because:

- Decommissioning activities normally are limited to the daytime period, due to the lower urgency to complete this phase; and
- Decommissioning activities normally use smaller and less equipment, generating less noise than the typical construction or operational phases.

If required, the noise levels for decommissioning can be compared with the daytime construction phase noise level and the noise impact is similar or less.

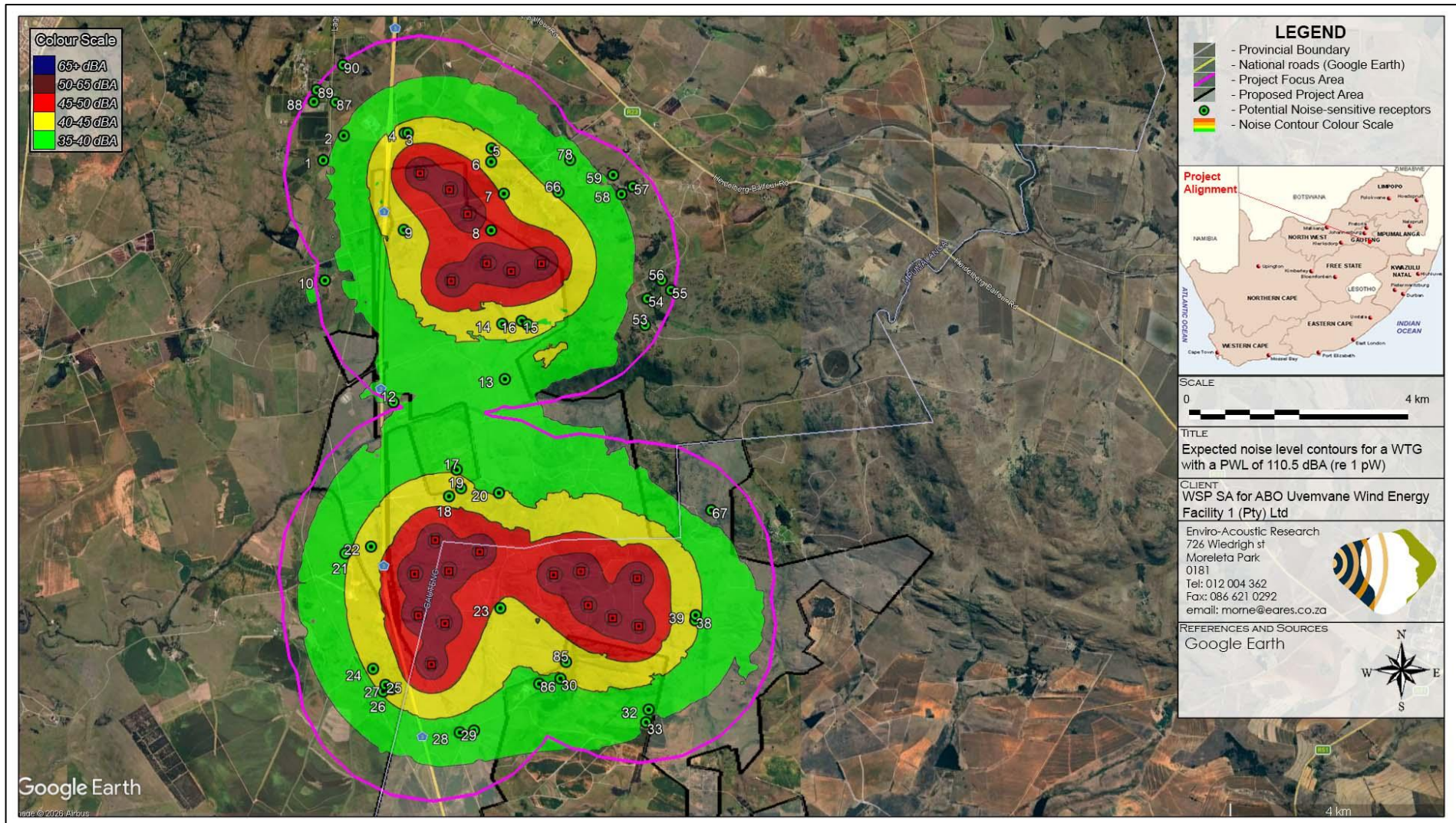


Figure 9-6: Expected future noise level contours – Operation of the Uvemvane WEF

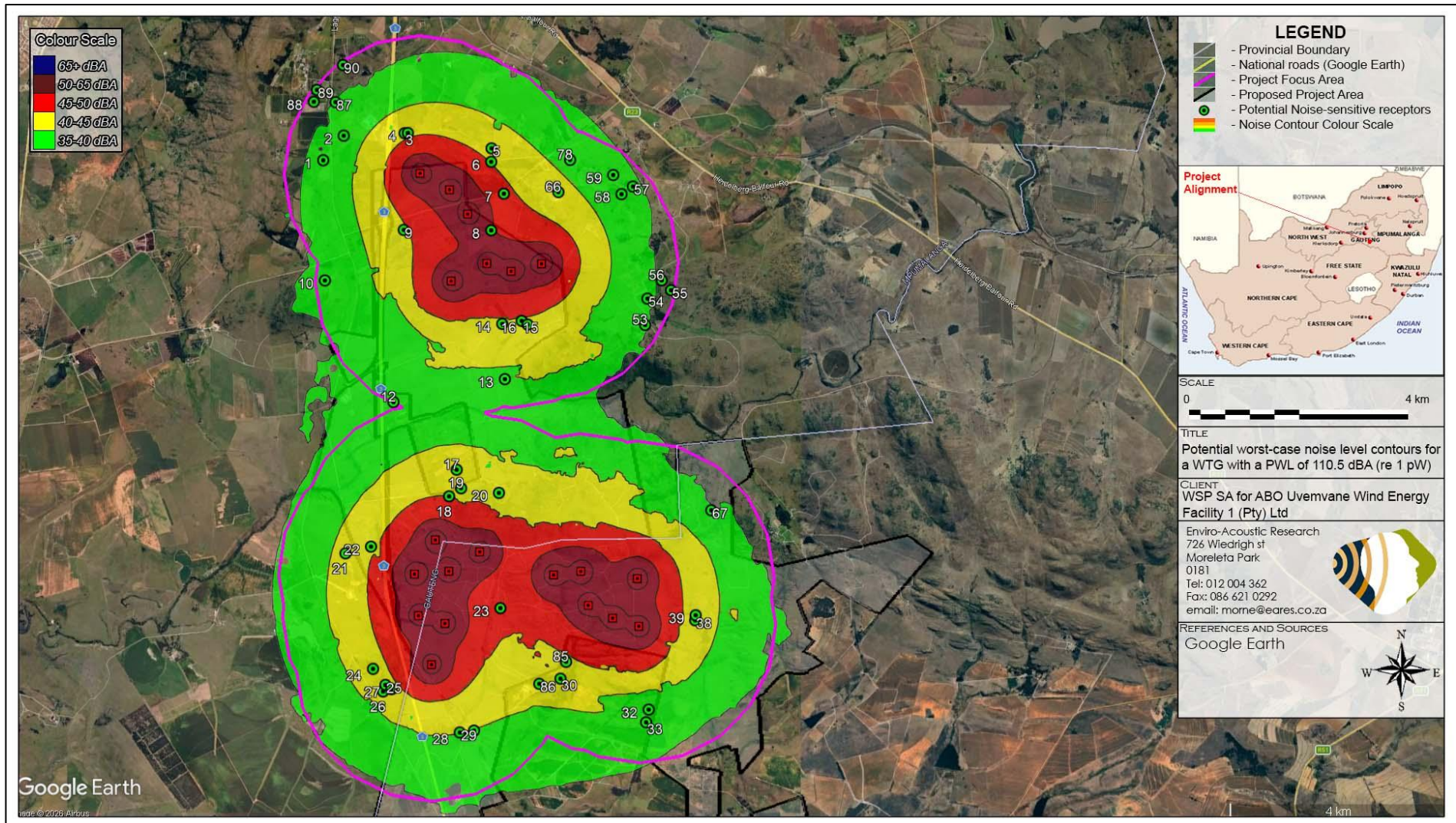


Figure 9-7: Projected worst-case noise rating level contours – Operation of the Uvemvane WEF

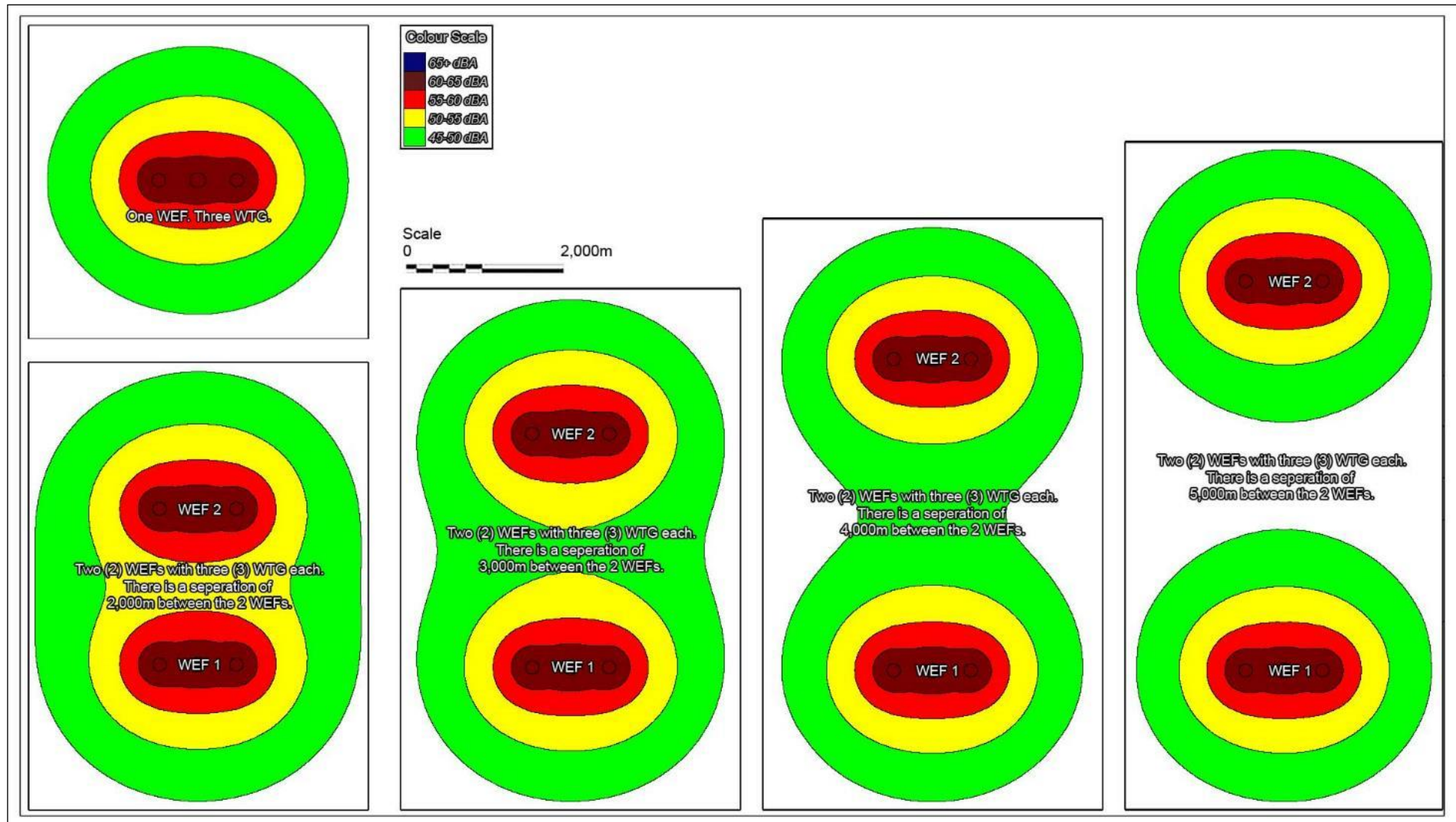


Figure 9-8: Effect of distance between wind turbines – potential cumulative noise

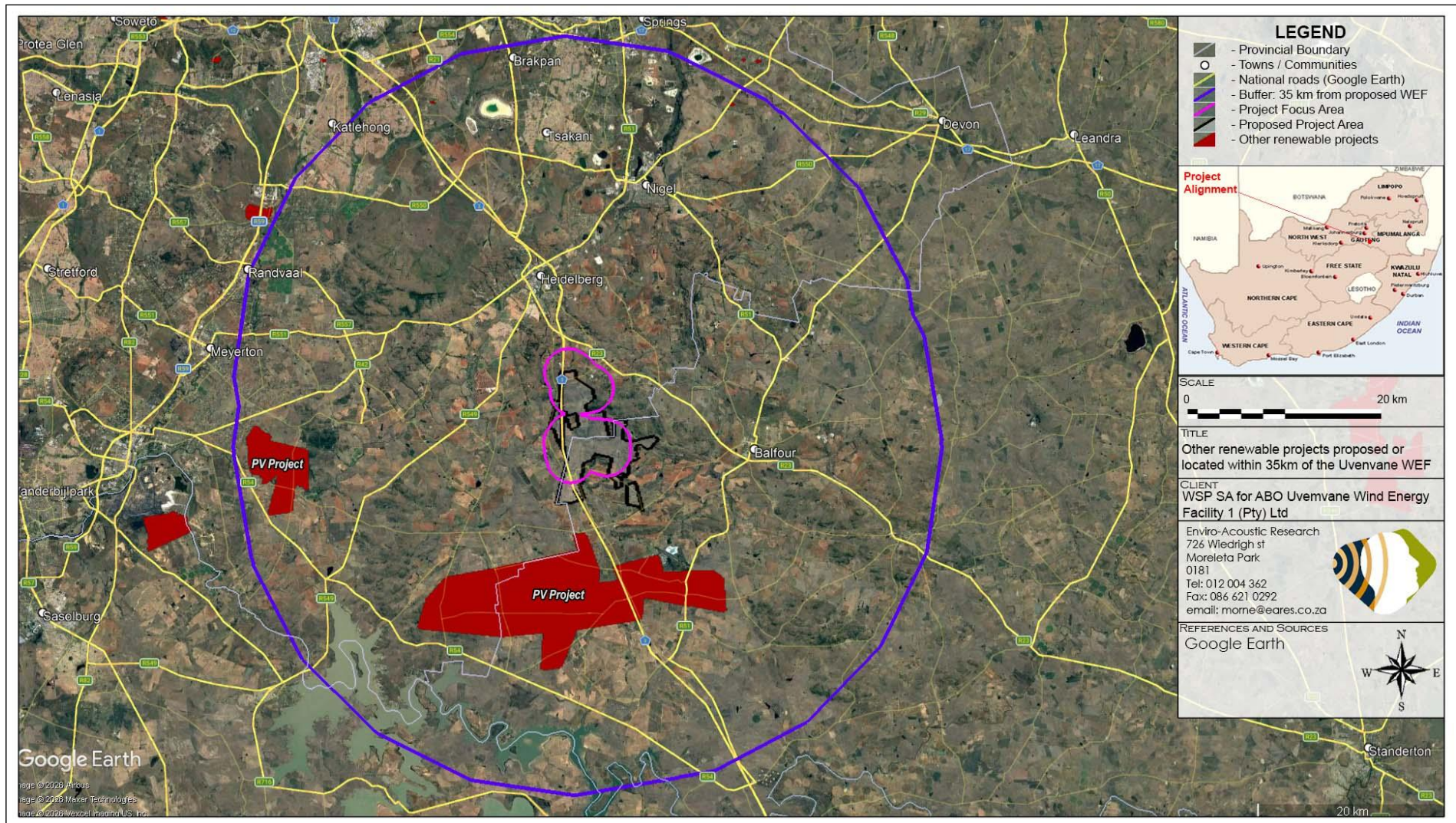


Figure 9-9: Renewable projects located within 35 km from the proposed Uvemvane WEF

10 SIGNIFICANCE OF THE NOISE IMPACT

This assessment will consider the impact assessment criteria from both the author ([Appendix E](#)) and EAP (defined in **section 6.5**), considering the experience of the author.

10.1 NOISES IMPACT RELATING TO THE PLANNING AND DESIGN PHASE

Activities that relate to the planning and design phases are normally limited to surveying and site visits. These activities are normally limited to the daytime period, with the activities normally having temporary noise impacts of a minor consequence. The significance of the noise impact for the planning and design phase will be negative low and will not be considered in this assessment.

10.2 NOISE IMPACT DUE TO FUTURE CONSTRUCTION ACTIVITIES

10.2.1 Construction activities relating to the Access Roads

The possible noise levels due to the construction or upgrading of the access roads was estimated in **section 9.1**, with the noise levels and potential significance estimated per NSR in **Appendix E, Table 7**. The potential significance of the noise impact summarized in **Table 10-1** considering the potential highest noise level.

10.2.2 Noises relating to Construction Traffic passing NSR

The possible noise impact relating to construction traffic passing NSR were estimated in **section 9.1**, with the noise levels and potential significance estimated per NSR in **Appendix E, Table 8**. The potential significance of the noise impact summarized in **Table 10-2**.

10.2.3 Construction of WEF infrastructure

The potential noise levels for the various construction activities at the Uvemvane WEF (as conceptualised) was calculated in **section 9.1**, with the potential noise levels and significance estimated in **Appendix E, Table 9** (daytime period) and **Appendix E, Table 10** (night-time period) at this WEF.

The potential significance of the noise impacts is summarized in **Table 10-3** for the daytime scenario and **Table 10-4** for the night-time scenario.

10.3 NOISE IMPACT DUE TO FUTURE OPERATIONAL ACTIVITIES

The noise levels associated with numerous operating WTG was calculated in **section 9.2**, with the potential noise levels and significance calculated in **Appendix E, Table 11** and **Appendix E, Table 12** per NSR.

The potential significance of daytime scenario is summarized in **Table 10-5** (valid for both scenarios), with the night-time operational noise impacts summarized in **Table 10-6** for the average expected scenario, and **Table 10-7** for the potential worst-case scenario.

10.4 CUMULATIVE NOISE IMPACT

The potential effect of cumulative noises during the construction phase was considered, evaluating the impact from numerous simultaneous activities taking place at all locations where WTG will be developed.

Considering the operational noise levels, there are no other WEFs within the potential area of influence and there is no risk of cumulative noise impacts, and the significance of the impact would be the same as the noise impact as defined for the operational phase (see also summary as defined in **Table 10-8**).

10.5 NOISE IMPACT DUE TO FUTURE DECOMMISSIONING ACTIVITIES

The potential for a noise impact to occur during the decommissioning and closure phase will be much lower than that of the construction and/or operational phases, with the potential significance summarized in **Table 10-9**.

10.6 EVALUATION OF ALTERNATIVES

10.6.1 Alternative 1: No-go option

The ambient sound levels will remain as is and the area would keep the rural noise character.

10.6.2 Alternative 2: Proposed Renewable Power Generation activities

The proposed renewable energy activities (worst-case evaluated) will slightly raise the noise levels at a number of the closest potential NSR. 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.

Considering the ambient sound levels measured on-site, the projected noise rating levels will be similar or less than the on-site ambient sound levels. It is slightly possible that the noise rating levels could exceed the ambient sound levels during certain periods although it is unlikely to impact on the quality of living (at night) for the closest receptors. The closest receptors should not lose the peace or quiet that they are used to.

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.

10.7 IMPACT ASSESSMENT TABLES

Table 10-1: Impact Assessment: Daytime activities relating to the construction of access roads

Nature of Impact: Construction of roads during the day may increase ambient sound levels temporarily, though this impact is mainly limited to NSR staying within 100m from future access roads. Potential noise levels as well as the significance per NSR are defined in Appendix E, Table 7 .		
	Without mitigation	With mitigation
Extent (Table 6-3)	Site [Footprint of activity] (1)	Site [Footprint of activity] (1)
Duration (Table 6-3)	Immediate (1)	Immediate (1)
Magnitude (Table 6-3)	Very High (5)	Very High (5)
Reversibility (Table 6-3)	Reversible (1)	Reversible (1)
Probability (Table 6-3)	Possible (2)	Possible (2)
Significance (Table 6-4)	Low (16)	Low (16)
Status	Negative	Negative
Irreplaceable resource loss	No	
Can impact be mitigated	No, though additional mitigation measures not required or recommended.	
Mitigation: Significance of road construction activities is low for the scenario as conceptualized and additional mitigation measures are not required.		
Residual Risks: There is a low residual risk of a noise impact once access road construction activities cease.		

Table 10-2: Impact Assessment: Daytime construction traffic passing NSR

Nature of Impact: Various construction vehicles passing close to potential NSR may increase ambient sound levels and create disturbing noises for a portion of the construction period. Construction traffic passing within 50m from the identified NSR could result in noise levels exceeding 50dBA (depending on the speed and number of vehicles), higher than the IFC recommended noise limits for daytime residential use, though there are no NSR staying this close to the access roads. Potential noise levels as well as the significance per NSR are defined in Appendix E, Table 8.		
	Without mitigation	With mitigation
Extent (Table 6-3)	Local (2)	Local (2)
Duration (Table 6-3)	Short (2)	Short (2)
Magnitude (Table 6-3)	Medium (3)	Medium (3)
Reversibility (Table 6-3)	Reversible (1)	Reversible (1)
Probability (Table 6-3)	Possible (2)	Possible (2)
Significance (Table 6-4)	Low (16)	Low (16)
Status	Negative	Negative
Irreplaceable resource loss	No	
Can impact be mitigated	Yes.	
Mitigation: Significance of the construction traffic noise impacts would be low for the scenario as conceptualized and additional mitigation measures will not be required.		
Residual Risks: There is a low residual risk of a noise impact once construction activities cease.		

Table 10-3: Impact Assessment: Daytime WTG construction activities

Nature of Impact: Various construction activities (development of the hard standing areas, excavation and concreting of foundations and the erection of the wind turbines) taking place simultaneously during the day will increase ambient sound levels due to air-borne noise. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in **Appendix E, Table 9** and summarized in this table.

	Without mitigation	With mitigation
Extent (Table 6-3)	Local (2)	Local (2)
Duration (Table 6-3)	Short (2)	Short (2)
Magnitude (Table 6-3)	Very Low (1)	Very Low (1)
Reversibility (Table 6-3)	Reversible (1)	Reversible (1)
Probability (Table 6-3)	Improbable (1)	Improbable (1)
Significance (Table 6-4)	Very Low (6)	Very Low (6)
Status	Negative	Negative
Irreplaceable resource loss	No	
Can impact be mitigated	Yes, though no mitigation required.	
Mitigation: Significance of the construction noise impact is low for daytime construction activities and additional mitigation measures are not required.		
Residual Risks: There is a low residual risk of a noise impact once construction activities cease.		

Table 10-4: Impact Assessment: Night-time WTG construction activities

Nature of Impact: Various construction activities (likely limited to the pouring of concrete as well as erection of WTG components) taking place simultaneously night will increase ambient sound levels due to air-borne noise. The projected noise levels, the change in ambient sound levels as well as the potential noise impact is defined per NSR in Appendix E, Table 10 and summarized in this table.		
	Without mitigation	With mitigation
Extent (Table 6-3)	Local (2)	Local (2)
Duration (Table 6-3)	Short (2)	Short (2)
Magnitude (Table 6-3)	Low (2)	Low (2)
Reversibility (Table 6-3)	Reversible (1)	Reversible (1)
Probability (Table 6-3)	Improbable (1)	Improbable (1)
Significance (Table 6-4)	Very Low (7)	Very Low (7)
Status	Negative	Negative
Irreplaceable resource loss	Medium, during quiet times at night	
Can impact be mitigated	Yes, though no mitigation required.	
Mitigation: Significance of the construction noise impact is low for night-time construction activities and additional mitigation measures are not required.		
Residual Risks: There is a low residual risk of a noise impact once construction activities cease.		

Table 10-5: Impact Assessment: Daytime operation of WTG considering a PWL of 110.5 dBA re 1 pW (relevant for the average expected and worst-case noise levels)

Nature of Impact: Wind turbines operating simultaneously during the day. Increases in residual noise levels due to air-borne noise from the WTG. Considering **Figure 9-5**, noise from the operating WTG will exceed the potential ambient sound levels (using a SPL of 110.5 dBA re 1 pW).

The projected noise levels and the potential change in ambient sound levels is defined per NSR in **Appendix E, Table 11** and summarized in this table. Probability of a daytime noise impacting on an NSR is normally lower than with a night-time impact. It should be noted that noises from the WTG may be audible during the day but daytime noises are unlikely to be a disturbing noise.

	Without mitigation	With mitigation
Extent (Table 6-3)	Local (2)	Local (2)
Duration (Table 6-3)	Long (4)	Long (4)
Magnitude (Table 6-3)	High (4)	High (4)
Reversibility (Table 6-3)	Reversible (1)	Reversible (1)
Probability (Table 6-3)	Improbable (1)	Improbable (1)
Significance (Table 6-4)	Very Low (11)	Very Low (11)
Status	Negative	Negative
Irreplaceable resource loss	No	
Can impact be mitigated	Yes, though no mitigation required.	
Mitigation: Significance of the operational noise impact is low for scenario as conceptualised and additional mitigation measures are not required.		
Residual Risks: There is a low residual risk of a noise impact once construction activities cease.		

Table 10-6: Impact Assessment: Night-time operation of WTG considering a PWL of 110.5 dBA re 1 pW (Average expected noise levels)

Nature of Impact: Wind turbines operating simultaneously at night and there would be an increase in the residual noise levels due to air-borne noise from the WTG. Considering the average expected noise levels as defined in **Appendix E, Table 12**, for an average scenario, noise from the operating WTG will exceed the potential ambient sound levels (using a PWL of 110.5 dBA re 1 pW) and the noise levels from the WTG will be more than 45 dBA (recommended IFC/WBG noise limit) at NSR08.

The projected noise levels and the potential change in ambient sound levels is defined per NSR in **Appendix E, Table 12** and summarized in this table.

	Without mitigation	With mitigation
Extent (Table 6-3)	Regional (3)	Regional (3)
Duration (Table 6-3)	Long (4)	Long (4)
Magnitude (Table 6-3)	High (4)	Low (2)
Reversibility (Table 6-3)	Reversible (1)	Reversible (1)
Probability (Table 6-3)	Highly Probable (4)	Probable (3)
Significance (Table 6-4)	Medium (48)	Low (30)
Status	Negative	Negative
Irreplaceable resource loss	Medium, during quiet times at night	
Can impact be mitigated	Yes	

Mitigation:

Significance of the operational noise impact could be **medium** for the average expected scenario as conceptualised (use of a WTG with a PWL of 110.5 dBA re 1 pW); additional mitigation measures are required which could include a combination of the following:

- The developer can implement serrated trailing edges (STE) on the blades of selected WTG (WTG within 2,000m from NSR08 [WT01, WT02, WT03, WT05, WT06, WT07, WT08]);
- The developer to develop and implement a noise monitoring programme; and
- The developer can design a noise abatement programme (NAP) – operating the WTG such as WT03 and WT05 in a reduced noise mode during certain times at night, during certain wind speeds/directions or operating conditions.

Residual Risks:

There is a low residual risk for a noise impact with the implementation of the recommended mitigation measures.

Table 10-7: Impact Assessment: Night-time operation of WTG considering a PWL of 110.5 dBA re 1 pW (Potential worst-case noise levels)

<p>Nature of Impact: Wind turbines operating simultaneously at night and there would be an increase in the residual noise levels due to air-borne noise from the WTG. Considering the worst-case noise levels as defined in Appendix E, Table 12, for an worst-case scenario, noise levels will exceed the potential ambient sound levels (using a worst-case SPL of 110.5 dBA re 1 pW), and the noise levels from the WTG will be more than 45 dBA (recommended IFC/WBG noise limit) at NSR07, NSR08 and NSR23.</p> <p>The projected noise levels and the potential change in ambient sound levels is defined per NSR in Appendix E, Table 12 and summarized in this table.</p>		
	Without mitigation	With mitigation
Extent (Table 6-3)	Regional (3)	Regional (3)
Duration (Table 6-3)	Long (4)	Long (4)
Magnitude (Table 6-3)	Very High (5)	Low (2)

Reversibility (Table 6-3)	Reversible (1)	Reversible (1)
Probability (Table 6-3)	Highly Probable (4)	Probable (3)
Significance (Table 6-4)	Medium (60)	Low (30)
Status	Negative	Negative
Irreplaceable resource loss	Medium, during quiet times at night	
Can impact be mitigated	Yes	
Mitigation: Significance of the operational noise impact could be medium for the worst-case scenario as conceptualised (use of a WTG with a PWL of 110.5 dBA re 1 pW); additional mitigation measures are required which could include a combination of the following: <ul style="list-style-type: none">• The developer can implement STE on the blades of selected WTG (WTG within 2,000 m from NSR08 [WT01, WT02, WT03, WT05, WT06, WT07, WT08]). This will also reduce the noise level at NSR07;• The developer can implement STE on the blades of selected WTG (WTG within 2,000 m from NSR23;• The developer to develop and implement a noise monitoring programme; and• The developer can design a noise abatement programme (NAP) – operating the WTG closest to NSR08 and NSR23 in a reduced noise mode during certain times at night, during certain wind speeds/directions or operating conditions.		
Residual Risks: There is a low residual risk for a noise impact with the implementation of the recommended mitigation measures.		

Table 10-8: Impact Assessment: Potential cumulative noise impacts

Nature of Impact: There are no other wind farms proposed within 5km from Uvemvane WEF 1, and there is no risk of cumulative effects from other renewable projects in the area. The significance will be the same as the typical operational noise impacts as defined in **Table 10-5** (daytime scenario), with the night-time operational noise impacts summarized in **Table 10-6**.

	Overall impact of the proposed project considered in isolation (after mitigation)	Cumulative impact of the project and other projects in the area (after mitigation)
Extent (Table 6-3)	Regional (3)	Regional (3)
Duration (Table 6-3)	Long (4)	Long (4)
Magnitude (Table 6-3)	Low (2)	Low (2)
Reversibility (Table 6-3)	Reversible (1)	Reversible (1)
Probability (Table 6-3)	Probable (3)	Probable (3)
Significance (Table 6-4)	Low (30)	Low (30)
Status	Negative	Negative
Irreplaceable resource loss	Medium, during quiet times at night	
Can impact be mitigated	Yes	
Mitigation: Significance for the cumulative scenario would be low , additional mitigation would not be required.		
Residual Risks: There is a low residual risk for a noise impact with the implementation of the recommended mitigation measures.		

Table 10-9: Impact Assessment: Potential future decommissioning activities

Nature of Impact: Various infrastructure decommissioning activities may increase ambient sound levels due to air-borne noise. Noise levels during decommissioning is generally less than construction noises, and the potential significance of the noise impact would be similar to daytime construction activities.
--

	Without mitigation	With mitigation
Extent (Table 6-3)	Local (2)	Local (2)
Duration (Table 6-3)	Short (2)	Short (2)
Magnitude (Table 6-3)	Very Low (1)	Very Low (1)
Reversibility (Table 6-3)	Reversible (1)	Reversible (1)
Probability (Table 6-3)	Improbable (1)	Improbable (1)
Significance (Table 6-4)	Very Low (6)	Very Low (6)
Status	Negative	Negative
Irreplaceable resource loss	No	
Can impact be mitigated	Yes, though no mitigation required.	
Mitigation: Significance of the noise impact is low for decommissioning activities and additional mitigation measures are not required.		
Residual Risks: There is a low residual risk of a noise impact once decommissioning activities cease.		

11 MITIGATION OPTIONS

This study considers the potential noise impact on the surrounding environment due to the construction, operational and future decommissioning activities associated with the Uvemvane WEF. This assessment considers the impact assessment criteria of both the author (see [Appendix E](#)) as well as that of the EAP (also see **section 6.5**). Critical factors that meaningfully affect the significance assessment considers the potential future noise levels (estimated or calculated) as well as the probability of a noise impact occurring.

Defining probability is especially difficult, as noise from the operational WTG will be audible to clearly audible, though the audibility is not necessary a noise impact, with this assessment using reported dose-response relationships (such as illustrated in **Figure 6-2**) as well as guideline noise levels (see **Table 3-1, Table 3-2, Table 3-3 & Table 3-4**) to predict a potential probability per NSR.

It was determined that the potential noise impacts, without mitigation, would be:

- of a **low significance** for the daytime construction (or upgrading) of the access roads;
- of a **low significance** for the daytime construction traffic passing NSR;
- of a **low significance** for the daytime construction activities (hard standing areas, excavation and concreting of foundations and the erecting of the WTG and other infrastructure) at this WEF;
- of a **low significance** for the night-time construction activities (such as the pouring of concrete, erecting the WTG);
- of a **low significance** for the daytime operational activities; and
- of a **medium significance** for operational activities (noises from WTG) when considering the worst-case PWL, with mitigation measures recommended that would reduce the potential significance to **low**.

There is no potential for a cumulative noise impact.

The project developer must know that community involvement (feedback on project: timelines for construction and start of operations) 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 will be inaudible due to existing high ambient sound levels, nor to state that complaints or concerns are unwarranted (or to refer to the “nocebo” effect).

Even when noise levels may be elevated, the magnitude of the sound levels will depend on a multitude of variables which 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 WEFs 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 and it is the responsibility of the developer to investigate. 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. In cases where valid noise complaints are verified, the developer must consider appropriate mitigation measures to address the issues or concerns.

Concentrating on the night-time period (when a quieter environment is more desired), continuing management objectives would be:

- Ensure that total night-time noise levels are less than 45 dBA at all potential NSRs (dwellings used for residential purposes);
- Prevent the generation of nuisance noises.

11.1 MITIGATION OPTIONS AVAILABLE TO REDUCE NOISE IMPACT DURING THE CONSTRUCTION PHASE

The significance of the noise impact associated with future construction activities was estimated to have a **very low** to **low** noise impact, and additional mitigation measures would not be required for the future construction phase. However, as discussed in **section 8.6**, noise annoyance is the complex result of numerous factors, and the following measures are recommended for the developer to consider and implement to reduce potential noise annoyance issues:

- The potential noise levels associated with road construction activities must be discussed with the NSR staying within 120 m from any access roads, highlighting that the road construction / upgrading activities noises would be high when near NSR, but the high noise levels will be very temporary;
- If practical, road construction or upgrading activities (when working closer than 120 m from NSR) should ideally be planned for when NSR are not at home (children at school, adults at work or busy). Ideally work near NSR should be planned to take place between 08:00 and 14:00;
- Construction vehicles should reduce speeds to the minimum when passing NSR staying closer than 60 m from the road;
- NSR should be provided with the contact details of the environmental representative (Environmental Control Officer “ECO”) to register potential complaints about noise;
- Access roads passing within 120 m from NSR should ideally not be used at night by construction vehicles (trucks and heavy construction equipment);
- Developer/Applicant to ensure that noise as environmental impact are included in the typical Health, Safety & Environment induction. All employees and contractors must receive this induction training;
- When construction activities must take place near NSR (500m during the day; 1,000m at night), the number of simultaneous activities within these buffer zones should be minimized;
- Should night-time construction activities be required within 1,000m from any NSR, these NSR should be notified in time of the proposed construction activities, including the anticipated duration of these activities;
- Should night-time construction activities be required within 1,000m from any NSR, the developer must minimise active equipment at night, especially planning the completion of noisiest activities (such a pile driving, rock breaking and excavation) during the daytime period; and
- When selecting construction equipment to be used at this project, the developer should consider the sound power levels of equipment that will be used on the project. Newer equipment, or equipment that complies with an international directive or movement (such as Buy Quiet), are generally much quieter than older equipment, or equipment that does not consider noise criteria.

11.2 MITIGATION OPTIONS AVAILABLE TO REDUCE NOISE IMPACT DURING OPERATION

While the significance of the daytime operational noises will have a low impact, night-time operational noises are projected to be of a **medium** significance and additional mitigation

measures are required and recommended. It is critical that potential noise impacts be addressed during the planning stage, as noise impacts during the operational phase are expensive to correct, or would result in financial penalties (e.g. the requirement to implement a NAP, need to disable one or more WTG from operating at night, etc.).

11.2.1 Planning Phase

Once the developer selected a final WTG model and manufacturer, and the PWL of the selected WTG are higher than 110.5 dBA (re 1 pW) (including uncertainty as defined by the manufacturer), potential noise levels should be recalculated to ensure that future noise levels will be less than 45 dBA at all NSR. Should noise levels exceed 45 dBA at any NSR, the developer can:

- Relocate certain WTG further from NSR affected by increased noise levels (as part of amendment process post EA);
- Consider the use of a WTG with a higher power generation capacity, allowing the reduction in the number of WTG to ensure the same nameplate export capacity for the WEF. WTG (e.g. WTs 3 and 5) near NSR (e.g. NSR08) where noise levels may be high can subsequently be eliminated;
- The developer can relocate certain NSR to locations where noise levels are lower, or reach agreement with the land owner that the structures (where noise levels exceed the recommended noise limits) will not be used for permanent residential purposes;
- Certain WTG could be fitted with serrated trailing edges (STE) on the blades;
- The developer can design a noise abatement plan (NAP) that would allow the operation of certain WTG in a reduced noise emission mode during certain times and/or conditions; and/or
- A combination of the above-mentioned mitigation measures.

The developer must design a noise monitoring program at representative NSR locations where the modelled worst-case noise rating levels exceed 42 dBA. This should include the measurement of ambient sound levels prior to the development of the WEF, followed by noise measurements once the WEF is operational to confirm that noise levels are less than 45 dBA. Ambient sound level measurements can be used to design a NAP for potential implementation.

11.2.2 Operational Phase

It should be the intention to manage noise levels during the Planning Phase, however, if noise measurements determine actual noise levels exceed the recommended noise limits, the developer should design and implement a NAP that will further reduce the noise

emission levels during certain wind speeds, wind directions, time periods or meteorological conditions.

For the current layout and a WTG with a PWL of 110.5 dBA (re 1 pW), mitigation will be required for the operational phase for any WTG with a PWL higher than 107.0 dBA (re 1 pW). Noise monitoring will be required at representative NSR locations where modelled noise levels exceed 42 dBA.

Should noise levels slightly exceed the recommended noise level, or any NSR complain about operational noise levels impacting on their sleep, the developer can consider acoustic treatment of residential dwellings to ensure that noise levels inside bedrooms comply with the equivalent continuous rating levels as defined in Table 1 of SANS 10103.

11.3 MITIGATION OPTIONS AVAILABLE TO REDUCE NOISE IMPACT DURING DECOMMISSIONING

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

11.4 MITIGATION AND MANAGEMENT CONDITIONS TO BE INCLUDED IN THE EMPR AND ENVIRONMENTAL AUTHORIZATION

It is recommended that the project developer:

1. Re-evaluate the noise impact should the layout be revised (as part of amendment process post EA) where:
 - a. any WTG, located within 2,500 m from a confirmed NSR, are moved closer to the NSR;
 - b. any new WTG are introduced within 2,500m from an NSR;
 - c. the number of WTG within 2,500m from an NSR are increased;
2. Re-evaluate the noise impact should the developer make use of a WTG with a maximum PWL exceeding 110.5 dBA re 1 pW;
3. 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;

4. Include a component covering environmental noise in the Health, Safety & Environmental 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 1,000m) to NSRs at night. This should include issues such as minimising the use of vehicle horns;
5. Investigates any reasonable and valid noise complaint if registered by a receptor staying within 2,500 m from the location where construction activities are taking place, or where an operational WTG are located. A complaint register, keeping a full record of the complaint, must be kept by the developer; and
6. Where practicable, mobile equipment should be fitted with broadband (white-noise generators/alarms ^{33 34}), rather than tonal reverse alarms.

³³White Noise Reverse Alarms: <http://www.brigade-electronics.com/products>.

³⁴ <https://www.constructionnews.co.uk/home/white-noise-sounds-the-reversing-alarm/885410.article> - White noise sounds the reversing alarm

12 ENVIRONMENTAL MONITORING PLAN

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

- Passive monitoring – the registering of any complaints (reasonable and valid from NSR living within 2,500m from any WTG of the Uvemvane WEF) regarding noise; and
- Active monitoring – the measurement of noise levels at identified locations.

Because potential noise levels would be higher than 42 dBA (which is 7 dB higher than the 35 dBA night-time rating level) active noise monitoring is recommended. Noise monitoring may be required for any WTG with a PWL exceeding 105.0 dBA (re 1 pW). The developer should investigate the noise complaint as per the guidelines in **sub-section 12.1** and **12.2**. These guidelines should be used as a rough guideline as site-specific conditions may require that the monitoring locations, frequency or procedure be adapted.

12.1 MEASUREMENT LOCALITIES AND FREQUENCY

For active monitoring, it is recommended that ambient sound levels be measured at NSRs 08, 07, 18, 23 & possibly NSRs 15, 06, 14 and 09 before the development of the WEF, with the measurements repeated after the first year of operation. The procedures are described in the sub-section below. In addition, should there be a valid and reasonable noise complaint, once-off noise measurements must be conducted at the location of the person that registered a valid and reasonable noise complaint. If any of these NSR locations are not used for residential purposes, noise monitoring at these locations is not required.

12.2 MEASUREMENT PROCEDURES

If required, noise level measurements should be collected considering the requirements of SANS 10103:2008 (or an internationally recognised method such as ISO 1996, IEC 61400-11 or ETSU R97, considering the limitations of measuring the noise from WTG). 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. It should be noted that the correct protocol should be selected to ensure quality data, with:

- SANS 10103 or ISO 1996 are recommended for use to measure noise levels due to construction activities (low wind conditions); and
- IEC 61400-11 or ETSU-R97 are recommended for use to measure operational noise levels (where increased winds may influence the measurements). Measurements done in terms of SANS 10103 or ISO 1996 would report elevated noise levels due to wind-induced noises impacting on the measurement

13 ENVIRONMENTAL MANAGEMENT

Environmental Management Objectives are difficult to be defined for noise because ambient sound levels would slowly increase as developmental pressures increase in the area. This is due to increased traffic associated with increased development, human habitation, agriculture and even eco-tourism. While these increases in ambient sound levels may be low (and insignificant) it has the effect of cumulatively increasing the ambient sound levels over time.

The moment the WEF facility stops operation, ambient sound levels will drop to levels similar to the pre-WEF levels, or to new levels (typical of other areas with a similar developmental character) if other developments have occurred in the interim.

For the purpose of this report potential environmental management objectives would be:

- That the development (construction and operational phase) of the WEF project does not result in noise levels exceeding 50 dBA (when measured over a period of at least 1 hour) during the day; and
- That the development (construction and operational phase) of the WEF project should not result in noise levels exceeding 45 dBA (when measured over a period of at least 1 hour) at night. If the existing night-time ambient sound levels are already higher than 45 dBA, the development of the Uvemvane WEF should not change the existing ambient sound levels with more than 3 dBA (IFC requirements, see **section 3.5.6**).

As potential noise levels will be low during both the construction and operational phases, Environmental Management is mainly focusing on the night-time period as summarized in:

- **Table 13-1** for the planning phase (to ensure that noise levels are with the acceptable limits during the future operational phase:
- **Table 13-2** for night-time activities during the construction phase; and
- **Table 13-3** for the operational of the WTG.

Table 13-1: Environmental Management for planning phase

Objective: Future construction, operational and decommissioning activities should not generate noises that may annoy or disturb identified NSR.	
Project Components:	Future construction and operational activities of WTG of the Uvemvane WEF
Potential Impact:	Noise levels impacting on the quality of living of NSR
Activity/Risk source	Future construction and operational activities

Mitigation: Target	<ul style="list-style-type: none"> Daytime noise levels less than 50 dBA. If existing ambient sound levels exceed the IFC noise limits, the change in ambient sound levels should be less than 3 dBA; Night-time noise levels less than 40 dBA (construction phase) and 45 dBA (operational phase) at locations used for residential purposes. If existing ambient sound levels exceed the IFC noise limits, the change in ambient sound levels should be less than 3 dBA. 		
Mitigation: Action / Control	Responsibility	Timeframe	
Developer to re-evaluate the noise impact once the WTG specifications are finalised and the selected WTG have a maximum PWL exceeding 110.5 dBA (re 1 pW)	Developer	Planning phase, before development of WEF	
If noise levels, after the evaluation of the final selected WTG are higher than 45 dBA, the developer must design a noise abatement programme (or implement appropriate mitigation measures) that will ensure that operational noise levels are less than 45 dBA at all verified NSR (to be used for residential purposes during the operational phase);	Developer	Planning phase, before development of WEF	
Developer to re-evaluate the noise impact should the layout be revised (as part of an amendment process post EA) where any WTG, located within 2,500 m from a confirmed NSR, are moved closer to the NSR.	Developer	Planning phase, before development of WEF	
Developer to re-evaluate the noise impact should the layout be revised (as part of an amendment process post EA) where any new WTG are introduced within 2,500 m from an NSR	Developer	Planning phase, before development of WEF	
Developer to re-evaluate the noise impact should the layout be revised (as part of an amendment process post EA) where the number of WTG within 2,500 m from an NSR are increased	Developer	Planning phase, before development of WEF	
Developer to plan and design a noise monitoring program should the developer select to use a WTG with a PWL higher than 105.0 dBA (re 1 pW). This should may include the measurement of ambient sound levels prior to the development of the WEF, followed by noise measurements once the WEF is operational.	Developer	Planning phase, before development of WEF	
Performance Indicator	Calculated daytime noise levels should be less than 50 dBA, with night-time noise levels being less than 40 dBA (construction phase) and 45 dBA (operational phase) at structures used residential purposes		
Monitoring	No monitoring required during planning phase		

Table 13-2: Environmental Management for construction activities

Objective: Construction activities should not result in daytime noise levels exceeding 50 dBA, nor night-time noise levels 40 dBA (at locations used for residential purposes). If existing ambient sound levels exceed the IFC noise limits, the change in ambient sound levels should be less than 3 dBA.		
Project Components:	Construction activities and construction equipment generating disturbing and nuisance noises	
Potential Impact:	Day- and night-time noise levels impacting on the quality of living of NSR	
Activity/Risk source	Construction activities	
Mitigation: Target	Daytime noise levels less than 50 dBA at locations used for residential purposes Night-time noise levels less than 40 dBA (construction phase) and 45 dBA (operational phase) at locations used for residential purposes If existing ambient sound levels already exceed the IFC noise limits, introduced noises should not change the ambient sound levels with more than 3 dBA (IFC requirement)	
Mitigation: Action / Control	Responsibility	Timeframe
Ensure that equipment is well maintained and fitted with the correct and appropriate noise abatement measures;	Contractor	Ongoing during construction phase
Health, Safety & Environmental Induction to include a component covering environmental noise to sensitise all employees and contractors about the potential impact from noise, with special reference to night-time activities within 1,000m of NSRs;	Contractor / Environmental Officer (EO)	Ongoing during construction phase

Complaints register kept on site, to register any noise complaints.	Contractor	Ongoing during construction phase
Notify NSR (and/or land owner(s)) before night-time construction activities are to take place within 1,000 m from an NSR (if the structures are used for residential activities during the proposed construction period).	Contractor	Construction activities within 1 000 m from NSR, if NSR is used for residential purposes
Performance Indicator	Daytime noise levels less than 50 dBA, night-time noise levels less than 40 dBA at locations used for residential purposes. If existing ambient sound levels exceed the IFC noise limits, the change in ambient sound levels should be less than 3 dBA.	
Monitoring	Inspection of equipment by EO. Measurement of noise levels at dwellings of NSR after noise complaints.	

Table 13-3: Environmental Management for operational period

Objective: Operational activities should not result in daytime noise levels exceeding 50 dBA, nor night-time noise levels less than 45 dBA (at locations used for residential purposes). If existing ambient sound levels exceed the IFC noise limits, the change in ambient sound levels should be less than 3 dBA.		
Project Components:	Operation of WTG within 2,500 m from structure used for residential purposes	
Potential Impact:	Noises from WTG impacting on the quality of living of NSR	
Activity/Risk source	Operation of WTG	
Mitigation: Target	Daytime noise levels from operational activities less than 50 dBA at NSR Night-time noise levels from operational activities less than 45 dBA at NSR	
Mitigation: Action / Control	Responsibility	Timeframe
Developer to conduct noise monitoring when a reasonable and valid noise complaint are received from an NSR living within 2,500 m from a WTG of the project.	EO / Developer	Within 2 months after a noise complaint is registered
Conduct active operational noise monitoring at relevant NSR if modelling suggests that the noise levels of the final layout are above 42 dBA.	EO	During the first year, once the project is operational. Noise specialist to confirm need for future measurements.
Performance Indicator	Daytime noise levels from operating WTG less than 50 dBA, with night-time noise levels due to operating WTG being less than 45 dBA	

14 CONCLUSIONS AND RECOMMENDATIONS

This report is an Environmental Noise Impact Assessment of the noise impacts due to the proposed development, operation and decommissioning of the Uvemvane WEF 1 (and associated infrastructure) west of Balfour (Mpumalanga). It is based on a predictive model to estimate potential noise levels due to the various activities and to assist in the identification of potential issues of concern.

It was determined that the potential noise impacts, without mitigation, would be:

- of a **low significance** for the daytime construction (or upgrading) of the access roads;
- of a **low significance** for the daytime construction traffic passing NSR;
- of a **low significance** for the daytime construction activities (hard standing areas, excavation and concreting of foundations and the erecting of the WTG and other infrastructure) at this WEF;
- of a **low significance** for the night-time construction activities (such as the pouring of concrete, erecting the WTG);
- of a **low significance** for the daytime operational activities; and
- of a **medium significance** for operational activities (noises from WTG) when considering the worst-case PWL, with mitigation measures recommended that would reduce the potential significance to **low**.

There is no potential for a cumulative noise impact.

With the implementation of appropriate mitigation measures, the proposed layout (turbine placement) is considered acceptable from a noise perspective and there is no restriction in the WTG that the developer could use (subject that the calculated noise levels are less than 45 dBA at NSR locations used for residential purposes). Noise monitoring is required should the developer select to use a WTG with a PWL higher than 105 dBA (re 1 pW). It is therefore recommended that the proposed Uvemvane WEF 1 (and associated infrastructure) be authorised.

It should be noted that the developer should re-evaluate the noise impact should:

- the layout be revised (as part of amendment process post EA) where any WTG, located within 2,500 m from a confirmed NSR, are moved closer to the NSR;
- the layout be revised (as part of amendment process post EA) where any new WTG are introduced within 2,500m from an NSR;

- the layout be revised (as part of amendment process post EA) where the number of WTG within 2,500m from an NSR are increased; and
- the developer selects to use a WTG with PWL higher than 110.5 dBA (re 1 pW).

It is proposed that the developer recommend to landowners that no new residential dwellings be developed within areas enveloped by the 42 dBA noise level contour.

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APPENDIX A

About the Author (short resume)

Details for the Author are:

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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 25 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 500 Environmental Noise Impact Assessments and Noise Monitoring Reports as well as various acoustic consulting services, including amongst others:

<p>Wind Energy Facilities</p>	<p><i>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), Outeniqua (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 Kleinsee (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)</i></p>
<p>Mining and Industry</p>	<p><i>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), Hacra 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 Boshoeck 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), Haakdoorn drift 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</i></p>

		<p>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)</p>
Road and Railway		<p>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)</p>
Airport		<p>Oudtshoorn Noise Monitoring (AGES), Sandton Heliport (Alpine Aviation), Tete Airport Scoping (Aurecon)</p>
Noise monitoring and Audit Reports		<p>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 (LinnSpace), 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), 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)</p>
Small Noise Impact Assessments		<p>TCTA AMD Project Baseline (AECOM), NATREF (Nemai Consulting), Christian Life Church (UrbanSmart), Kosmosdale (UrbanSmart), Louwlandia 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 (BPTTrust), 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), Elandspoort 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)</p>

**Project reviews
and
amendment
reports**

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), Rheboksfontein (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.

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>	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. In this report the term Background Ambient Sound Level will be used.
<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 Level</i>	The level of the ambient sound indicated on a sound level meter in the absence of the sound under investigation (e.g. sound from a particular noise source or sound generated for test purposes). Ambient sound level as per Noise Control Regulations.
<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)</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

	<p>(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> <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 level that exceeds the zone sound level or, if no zone sound level has been designated, a noise level that exceeds the ambient sound level at the same measuring point by 7 dBA or more.
<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>	(1) Averaging detection time used in sound level meters. (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.
<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; b) educational, residential, office and health care buildings and their surroundings; c) churches and their surroundings; d) auditoriums and concert halls and their surroundings; e) recreational areas; and f) nature reserves. In this report Noise-sensitive developments is also referred to as a Potential Sensitive Receptor
<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>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>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>	(1) Averaging times used in sound level meters. (2) Time constant of one [1] second that gives a slower response which helps average out the display fluctuations.
<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.
<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 micro pascals 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).
<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. This is similar to the Rating Level as defined in SANS 10103:2008.

APPENDIX C

Site Sensitivity Verification

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

Site sensitivity verification is required for All environmental themes as identified by the online screening tool (whether a protocol has been published or not).

Section 2 of the Noise Protocol in terms of this GNR320 requires that:

2. Prior to commencing with a specialist assessment, the current use of the land and the potential environmental sensitivity of the site under consideration as identified by the screening tool must be confirmed by undertaking a site sensitivity verification.
 - 2.1. The site sensitivity verification must be undertaken by an environmental assessment practitioner (EAP) or a noise specialist, where noise specialist means someone with relevant academic qualifications and with expertise in the domain of acoustic assessments and noise management.
 - 2.2. The site sensitivity verification must be undertaken through the use of:
 - (a) a desktop analysis, using satellite imagery;
 - (b) a preliminary on-site inspection; and
 - (c) any other available and relevant information.
 - 2.3. The outcome of the site sensitivity verification must be recorded in the form of a report that:
 - (a) confirms or disputes the current use of the land and environmental sensitivity as identified by the screening tool, such as new developments or infrastructure etc.;
 - (b) contains a motivation and evidence (e.g. photographs) of either the verified or different use of the land and environmental sensitivity; and
 - (c) is submitted together with the relevant assessment report prepared in accordance with the requirements of the Environmental Impact Assessment Regulations

The details of the specialist that visited the site are noted below:

Date of Site Visit	2024/11/14 & 2024/11/20 (FS de Vries) 2025/02/23 (M de Jager)
Specialist Name	Francois Stephanus de Vries (Site Visit and ambient sound level measurements) Morné de Jager (data processing, modelling, noise report, verification of NSR)
Professional Registration Number (if applicable) – M. de Jager	SACNASP (South African Council for Natural Scientific Professions) - 117253

	SAIOSH (SA Institute of Occupation Safety & Health) – 72765282
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 that a number of areas within, and up to 2 500 m from, the project boundary to have a “very high” sensitivity to noise. These potentially “very high” sensitive areas (in terms of noise) are indicated on **Figure C.1**.

Description on how the site sensitivity verification was undertaken

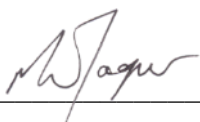
The site sensitivity was verified using:

- a) available aerial images (Google Earth®) (See **Figure C.1** for identified potential noise-sensitive receptors);*
- b) the statuses of areas that may have a “very high” sensitivity to noise and identified structures were verified during the site visit.*

Outcome of the Site Sensitivity Verification

Potential noise-sensitive activities were identified (verified during the site visit) and marked on **Figure C.1**. There are a number of structures used for residential purposes associated with the areas identified to have a “very high” sensitivity to noise (within the project focus area) and the site sensitivity verification agrees with the findings of the online screening tool (only for the areas marked in **Figure C.1**). There are however also a few areas, identified to have a “very high” sensitivity to noise, that are not noise-sensitive and the classification of having a “very high” sensitivity to noise are disputed for these areas.

Because of a number of potential noise-sensitive receptors within the project focus area, the potential impact of noise from the project is assessed in this Noise Specialist Study.



Signature

Morné de Jager

2026 – 10 – 07

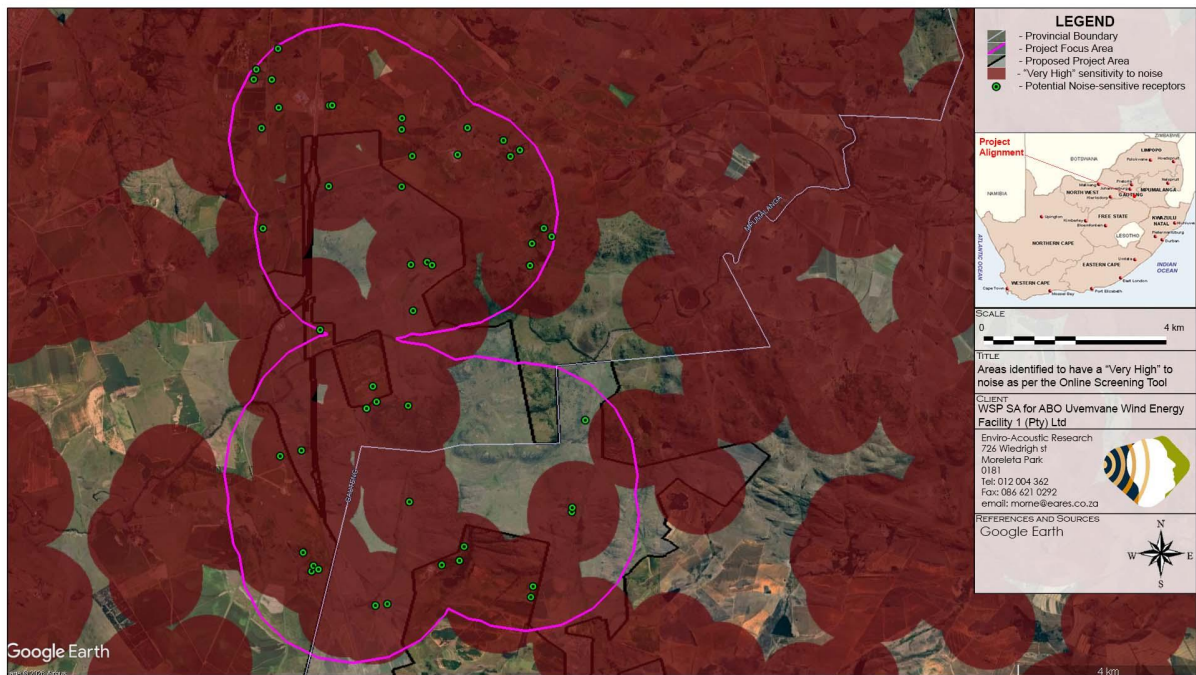


Figure C.1: Areas defined to be of "Very High" sensitivity in terms of noise by the online screening tool

APPENDIX D

Photos of Measurement Locations



Photo D.1: Measurement location at WAULTSL01



Photo D.2: Measurement location at WAULTSL02



Photo D.3: Measurement location at WAULTSL03



Photo D.4: Measurement location at WAULTSL04

APPENDIX E

NSR Locations, EIA criteria of Author,
calculated conceptual noise levels and
significance (as per author criteria)

Appendix E, Table 1: Potential receptors and their statuses (as per scoping phase)

NSR	WGS-84		UTM-35S		Distance between NSR and closest WTG (m)	Comment
	Longitude	Latitude	X	Y		
NSR01	28.37816	-26.5922	637232	7057990	1786	Assume residential.
NSR02	28.38193	-26.5882	637612.5	7058434	1555	Assume residential.
NSR03	28.39312	-26.5878	638727.3	7058467	787	Assume residential.
NSR04	28.39373	-26.5877	638787.8	7058471	771	Assume residential.
NSR05	28.40913	-26.5903	640318.6	7058174	1084	Assume residential.
NSR06	28.40907	-26.5925	640310.2	7057929	924	Assume residential.
NSR07	28.4114	-26.5977	640535.8	7057345	766	Assume residential.
NSR08	28.40908	-26.6037	640297	7056680	526	Assume residential.
NSR09	28.39299	-26.6037	638694.7	7056705	1068	Assume residential.
NSR10	28.37848	-26.612	637240.2	7055799	2309	Assume residential. Guest farm.
NSR11	28.37551	-26.6227	636931.4	7054612	2858	Assume residential.
NSR12	28.3911	-26.632	638473.3	7053570	2440	Assume residential.
NSR13	28.41161	-26.6282	640519.4	7053966	1965	Assume residential.
NSR14	28.41113	-26.6191	640482.3	7054974	968	Assume residential.
NSR15	28.4147	-26.6186	640838.8	7055025	922	Assume residential.
NSR16	28.41579	-26.6192	640946.5	7054957	1015	Assume residential.
NSR17	28.40275	-26.6431	639618.7	7052324	1343	Assume residential.
NSR18	28.40136	-26.6475	639475.2	7051842	840	Assume residential.
NSR19	28.40356	-26.6462	639696	7051985	1059	Assume residential.
NSR20	28.41053	-26.6469	640389.2	7051894	1135	Assume residential. Guest farm/Wedding Venue.
NSR21	28.38229	-26.6569	637566.4	7050822	1316	Assume residential.
NSR22	28.38699	-26.6558	638035	7050939	939	Assume residential.
NSR23	28.41081	-26.6659	640393.7	7049794	1059	Assume residential.
NSR24	28.38736	-26.6759	638048	7048712	1069	Assume residential. Guest farm/Wedding Venue.
NSR25	28.38964	-26.6785	638271.8	7048418	915	Assume residential.
NSR26	28.38922	-26.6796	638227.8	7048298	1007	Assume residential.
NSR27	28.39075	-26.6792	638381.1	7048338	853	Assume residential.
NSR28	28.40334	-26.6863	639625.1	7047536	1339	Assume residential.
NSR29	28.40596	-26.686	639886.1	7047567	1432	Assume residential.
NSR30	28.42188	-26.6775	641481.2	7048498	1424	Assume residential.
NSR31	28.4892	-26.6113	648265.8	7055757	7063	Assume residential.
NSR32	28.43813	-26.6826	643091.5	7047917	1526	Assume residential.
NSR33	28.43765	-26.6847	643040.9	7047685	1752	Assume residential.
NSR34	28.44828	-26.6932	644088.4	7046724	2950	Assume residential.
NSR35	28.44927	-26.6939	644185.7	7046652	3055	Assume residential.
NSR36	28.45939	-26.6968	645189.4	7046316	3855	Assume residential.
NSR37	28.4565	-26.7014	644896.4	7045810	4126	Assume residential.
NSR38	28.44667	-26.6679	643960.4	7049535	1044	Assume residential.
NSR39	28.44675	-26.667	643969.4	7049628	1066	Assume residential.
NSR40	28.46013	-26.6531	645318.8	7051161	2564	Assume residential.
NSR41	28.50485	-26.6428	649783.5	7052241	7149	Assume residential.
NSR42	28.5034	-26.6356	649647.8	7053044	7281	Assume residential.
NSR43	28.47827	-26.6315	647151.3	7053526	5333	Assume residential.
NSR44	28.46748	-26.6263	646083.9	7054114	4965	Assume residential.
NSR45	28.48306	-26.6203	647642.9	7054758	6505	Assume residential.
NSR46	28.49024	-26.6139	648366.4	7055467	7182	Assume residential.
NSR47	28.49147	-26.6134	648489.7	7055517	7301	Assume residential.
NSR48	28.47797	-26.612	647146.8	7055685	5949	Assume residential. Guest farm.
NSR49	28.46907	-26.6031	646272.3	7056684	5102	Assume residential.
NSR50	28.46681	-26.5999	646050.5	7057042	4940	Assume residential.
NSR51	28.45099	-26.6115	644461.2	7055771	3265	Assume residential.

NSR52	28.43741	-26.6193	643099.4	7054926	2203	Assume residential.
NSR53	28.43783	-26.615	643146.5	7055406	2044	Assume residential. Guest farm.
NSR54	28.44217	-26.6136	643580.4	7055554	2424	Assume residential.
NSR55	28.44045	-26.612	643411.1	7055736	2226	Assume residential.
NSR56	28.43515	-26.5965	642902.1	7057451	2193	Assume residential.
NSR57	28.47005	-26.6026	646370.3	7056739	5206	Assume residential.
NSR58	28.43305	-26.5978	642691.9	7057315	1944	Assume residential.
NSR59	28.43152	-26.5946	642542.8	7057665	2088	Assume residential.
NSR60	28.43603	-26.5913	642996.5	7058029	2661	Assume residential.
NSR61	28.44482	-26.5959	643865.9	7057505	3026	Assume residential. Guest farm.
NSR62	28.44834	-26.6002	644211.3	7057028	3155	Assume residential.
NSR63	28.45928	-26.5982	645303.3	7057235	4260	Assume residential. Guest farm.
NSR64	28.46069	-26.5985	645443.3	7057201	4386	Assume residential.
NSR65	28.45834	-26.6157	645187.7	7055305	4049	Assume residential.
NSR66	28.42143	-26.5975	641535	7057363	1345	Commercial, bottling plant.
NSR67	28.44962	-26.6498	644276	7051537	1847	Assume residential.
NSR68	28.47381	-26.6041	646742.9	7056573	5558	Assume residential.
NSR69	28.4594	-26.7065	645178.1	7045241	4761	Assume residential.
NSR70	28.43943	-26.7186	643176	7043923	5516	Assume residential.
NSR71	28.48308	-26.7199	647517	7043727	7327	Assume residential.
NSR72	28.50759	-26.6412	650058	7052420	7462	Assume residential. Guest farm/Wedding Venue.
NSR73	28.49237	-26.6062	648588	7056309	7383	Assume residential.
NSR74	28.47013	-26.5957	646387	7057503	5376	Assume residential.
NSR75	28.44496	-26.5811	643899	7059152	4100	Assume residential.
NSR76	28.43946	-26.5865	643344	7058554	3285	Assume residential.
NSR77	28.43725	-26.5895	643120	7058229	2892	Assume residential.
NSR78	28.42358	-26.5922	641756	7057948	1968	Assume residential.
NSR79	28.43367	-26.5906	642762	7058104	2569	Assume residential.
NSR80	28.43377	-26.5894	642774	7058239	2684	Assume residential.
NSR81	28.43202	-26.5874	642602	7058465	2781	Assume residential.
NSR82	28.42925	-26.5867	642327	7058543	2725	Assume residential.
NSR83	28.43235	-26.5787	642646	7059428	3664	Assume residential.
NSR84	28.37014	-26.6704	636341	7049334	2565	Assume residential.
NSR85	28.4229	-26.6747	641586	7048803	1102	Assume residential.
NSR86	28.41797	-26.6783	641091	7048407	1683	Assume residential.
NSR87	28.38041	-26.5826	637468	7059049	2021	Assume residential.
NSR88	28.37644	-26.5826	637072	7059059	2341	Assume residential.
NSR89	28.377	-26.5806	637130	7059279	2428	Assume residential.
NSR90	28.38181	-26.5765	637614	7059726	2430	Assume residential.

Appendix E, Table 2: Impact Assessment Criteria – Spatial extent (Author Criteria)

Classification of the physical and spatial scale of the impact		
Rating	Description	Score
<i>Footprint</i>	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.	1
<i>Site</i>	The impact could affect the whole, or a significant portion of the site.	2
<i>Regional</i>	The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns (further than 1,000 m from site).	3
<i>National</i>	The impact could have an effect that expands throughout the country (South Africa).	4
<i>International</i>	Where the impact has international ramifications that extend beyond the boundaries of South Africa.	5

Appendix E, Table 3: Impact Assessment Criteria – Duration (Author Criteria)

The lifetime of the impact that is measured in relation to the lifetime of the proposed development (construction, operational and closure phases). Will the receptors be subjected to increased noise levels for the lifetime duration of the project, or only infrequently.		
Rating	Description	Score
<i>Temporary</i>	The impact will either disappear with mitigation or will be mitigated through a natural process in a period significantly shorter than that of the construction phase (less than 6 months).	1
<i>Short term</i>	The impact will be relevant through to the end of a construction phase (less than 5 years).	2
<i>Medium term</i>	The impact will last up to the end of the development phases, where after it will be entirely negated. The impact could last between 5 and 20 years.	3
<i>Long term</i>	The impact will continue or last for the entire operational lifetime i.e., exceed 20 years of the development.	4
<i>Permanent</i>	This is the only class of impact, which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient.	5

Appendix E, Table 4: Impact Assessment Criteria – Magnitude (Author Criteria)

This defines the impact as experienced by any receptor. In this report, the NSR is defined as any resident in the area but excludes faunal species (because guideline levels are not available for animals).		
Rating	Description	Score
<i>Minor</i>	Increase in average sound pressure levels between 0 and 3 dB from the expected ambient sound levels. Ambient sound levels are defined by the lower of the measured $L_{Aeq,8hr}$ or $L_{Aeq,16hr}$ during measurement dates. Total projected noise level is less than the Zone Sound Level and/or noise limits defined by the IFC/WHO in wind-still conditions.	2
<i>Low</i>	Increase in average sound pressure levels between 3 and 5 dB from the expected ambient sound levels. Total projected noise levels between 3 and 5 above the Zone Sound Level and/or noise limits defined by the IFC/WHO (wind-less conditions).	4
<i>Medium / Moderate</i>	Increase in average sound pressure levels between 5 and 7 dB from the ambient sound levels. Increase in sound pressure levels between 5 and 7 above the Zone Sound Level and/or noise limits defined by the IFC/WHO (wind-less conditions). Sporadic complaints expected.	6
<i>High</i>	Increase in average sound pressure levels between 7 and 10 from the ambient sound level. Total projected noise levels between 7 and 10 dBA above the Zone Sound Level and/or noise limits defined by the IFC/WHO (wind-less condition). Medium to widespread complaints expected.	8
<i>Very High</i>	Increase in average ambient sound pressure levels higher than 10 dBA. Total projected noise levels higher than 10 dB above the Zone Sound Level and/or noise limits defined by the IFC/WHO (wind less-conditions). Change of 10 dBA is perceived as 'twice as loud', leading to widespread complaints and even threats of community or group action. Any point where instantaneous noise levels exceed 65 dBA at any receptor.	10

Appendix E, Table 5: Impact Assessment Criteria – Probability (Author Criteria)

<p>This describes the likelihood of a noise impact (receptors being annoyed) actually occurring and whether it will impact on an identified receptor. The impact may occur for any length of time during the life cycle of the activity, and not at any given time. The classes are rated as follows:</p>		
Rating	Description	Score
<i>Improbable</i>	The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0%).	1
<i>Possible</i>	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. In a rural environment, once noise levels exceed 38.7 dBA (see also section 3.5.9) less than 10% of receptors may be annoyed with WTN.	2
<i>Probable</i>	There is a possibility that the impact will occur to the extent that provisions must be made. At noise levels exceeding 45 dBA up to 50% of people may become annoyed with WTN at night.	3
<i>Highly Likely</i>	It is most likely that the impacts will occur at some stage of the development. At noise levels ranging between 45 and 52 dBA, between 50% and 75% of receptors may become annoyed with WTN.	4
<i>Definite</i>	The impact will take place regardless of any prevention plans and only mitigation actions or contingency plans to contain the effect can be relied on. Any noise levels higher than 52 dBA is expected to annoy most receptors in the vicinity of a WEF.	5

Appendix E, Table 6: Impact Assessment Criteria – Significance (Author Criteria)

SR<30	Low (L)	Impacts with little real effect and which should not have an influence on or require modification of the project design or alternative mitigation. No mitigation is required.
30<SR <60	Medium (M)	Where it could have an influence on the decision unless it is mitigated. An impact or benefit which is sufficiently important to require management. Of moderate significance - could influence the decisions about the project if left unmanaged.
SR>60	High (H)	The impact is significant, mitigation is critical to reduce impact or risk. Resulting impact could influence the decision depending on the possible mitigation. An impact which could influence the decision about whether or not to proceed with the project.

Appendix E, Table 7: Projected noise rating levels and daytime significance – Construction of Access Roads at the Uvemvane WEF

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - daytime rating level, Rural)	Distance between NSR and road construction / upgrading activities (m)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted, as measured)	Projected Noise Level, Worst-case access road construction scenario (dBA)	Change in rating level or ambient sound levels	Magnitude / Intensity	Duration	Extent	Probability of Impact Occurring	Significance
NSR07	45	33	47.0	63.6	16.7	Very High	Immediate	Site only	Possible	Low
NSR08	45	86	47.0	55.3	8.9	High	Immediate	Site only	Possible	Very Low
NSR28	45	111	47.0	53.1	7.1	High	Immediate	Site only	Possible	Very Low
NSR29	45	77	47.0	56.3	9.8	High	Immediate	Site only	Possible	Very Low
NSR34	45	293	47.0	44.7	2.0	Very Low	Immediate	Site only	Improbable	Very Low
NSR35	45	221	47.0	47.1	3.1	Low	Immediate	Site only	Improbable	Very Low
NSR37	45	164	47.0	49.7	4.6	Low	Immediate	Site only	Improbable	Very Low
NSR71	45	266	47.0	45.5	2.3	Very Low	Immediate	Site only	Improbable	Very Low
NSR78	45	265	47.0	45.5	2.3	Very Low	Immediate	Site only	Improbable	Very Low

Appendix E, Table 8: Projected noise rating levels and daytime significance – Construction traffic for Uvemvane WEF

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - daytime rating level, Rural)	Distance between NSR and potential access roads (m)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted, as measured)	Projected Noise Level, Worst-case construction traffic scenario (dBA)	Change in rating level or ambient sound levels	Magnitude / Intensity	Duration	Extent	Probability of Impact Occurring	Significance
NSR07	45	33	47.0	50.8	5.3	Medium	Short	Local	Possible	Low
NSR08	45	86	47.0	46.7	2.8	Very Low	Short	Local	Improbable	Very Low
NSR28	45	111	47.0	45.5	2.3	Very Low	Short	Local	Improbable	Very Low
NSR29	45	77	47.0	47.1	3.1	Low	Short	Local	Improbable	Very Low
NSR34	45	293	47.0	41.3	1.0	Very Low	Short	Local	Improbable	Very Low
NSR35	45	221	47.0	42.6	1.3	Very Low	Short	Local	Improbable	Very Low
NSR37	45	164	47.0	43.9	1.7	Very Low	Short	Local	Improbable	Very Low
NSR71	45	266	47.0	41.8	1.1	Very Low	Short	Local	Improbable	Very Low
NSR78	45	265	47.0	41.8	1.1	Very Low	Short	Local	Improbable	Very Low

Appendix E, Table 9: Projected construction noise rating levels and daytime significance - Uvemvane WEF

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - daytime rating level, Rural)	Distance between NSR and potential construction activities (m)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted, as measured)	Projected Noise Level (dBA) (construction of infrastructure)	Potential change in ambient sound levels due to cumulative effects from all WEFs operating	Magnitude / Intensity	Duration	Extent	Probability of Impact Occurring	Significance
NSR08	45	526	47.0	37.9	0.5	Very Low	Short	Local	Improbable	Very Low
NSR07	45	766	47.0	37.5	0.5	Very Low	Short	Local	Improbable	Very Low
NSR04	45	771	47.0	37.4	0.5	Very Low	Short	Local	Improbable	Very Low
NSR03	45	787	47.0	37.8	0.5	Very Low	Short	Local	Improbable	Very Low
NSR18	45	840	47.0	38.4	0.6	Very Low	Short	Local	Improbable	Very Low
NSR27	45	853	47.0	37.0	0.4	Very Low	Short	Local	Improbable	Very Low
NSR25	45	915	47.0	38.3	0.5	Very Low	Short	Local	Improbable	Very Low
NSR15	45	922	47.0	37.7	0.5	Very Low	Short	Local	Improbable	Very Low
NSR06	45	924	47.0	34.5	0.2	Very Low	Short	Local	Improbable	Very Low
NSR22	45	939	47.0	29.4	0.1	Very Low	Short	Local	Improbable	Very Low
NSR14	45	968	47.0	26.7	0.0	Very Low	Short	Local	Improbable	Very Low
NSR26	45	1007	47.0	37.5	0.5	Very Low	Short	Local	Improbable	Very Low
NSR16	45	1015	47.0	35.6	0.3	Very Low	Short	Local	Improbable	Very Low
NSR38	45	1044	47.0	26.1	0.0	Very Low	Short	Local	Improbable	Very Low
NSR19	45	1059	47.0	25.9	0.0	Very Low	Short	Local	Improbable	Very Low
NSR23	45	1059	47.0	25.0	0.0	Very Low	Short	Local	Improbable	Very Low
NSR39	45	1066	47.0	25.2	0.0	Very Low	Short	Local	Improbable	Very Low
NSR09	45	1068	47.0	25.0	0.0	Very Low	Short	Local	Improbable	Very Low
NSR24	45	1069	47.0	27.1	0.0	Very Low	Short	Local	Improbable	Very Low
NSR05	45	1084	47.0	15.6	0.0	Very Low	Short	Local	Improbable	Very Low
NSR85	45	1102	47.0	15.7	0.0	Very Low	Short	Local	Improbable	Very Low
NSR20	45	1135	47.0	15.1	0.0	Very Low	Short	Local	Improbable	Very Low
NSR21	45	1316	47.0	14.2	0.0	Very Low	Short	Local	Improbable	Very Low
NSR28	45	1339	47.0	15.3	0.0	Very Low	Short	Local	Improbable	Very Low
NSR17	45	1343	47.0	15.7	0.0	Very Low	Short	Local	Improbable	Very Low
NSR66	45	1345	47.0	15.8	0.0	Very Low	Short	Local	Improbable	Very Low
NSR30	45	1424	47.0	21.0	0.0	Very Low	Short	Local	Improbable	Very Low
NSR29	45	1432	47.0	20.4	0.0	Very Low	Short	Local	Improbable	Very Low

Appendix E, Table 10: Projected construction noise rating levels and night-time significance - Uvemvane WEF

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - night-time rating level, suburban)	Distance between NSR and potential construction activities (m)	Potential Existing Ambient Sound Levels (long-term average - Fast-weighted)	Projected Noise Level (dBA) (construction of infrastructure)	Potential change in ambient sound levels due to cumulative effects from all WEFs operating	Magnitude / Intensity	Duration	Extent	Probability of Impact Occurring	Significance
NSR08	40	526	38.1	37.9	2.9	Very Low	Short	Local	Improbable	Very Low
NSR07	40	766	38.1	37.5	2.7	Very Low	Short	Local	Improbable	Very Low
NSR04	40	771	38.1	37.4	2.7	Very Low	Short	Local	Improbable	Very Low
NSR03	40	787	38.1	37.8	2.9	Very Low	Short	Local	Improbable	Very Low
NSR18	40	840	38.1	38.4	3.2	Low	Short	Local	Improbable	Very Low
NSR27	40	853	38.1	37.0	2.5	Very Low	Short	Local	Improbable	Very Low
NSR25	40	915	38.1	38.3	3.1	Low	Short	Local	Improbable	Very Low
NSR15	40	922	38.1	37.7	2.8	Very Low	Short	Local	Improbable	Very Low
NSR06	40	924	38.1	34.5	1.6	Very Low	Short	Local	Improbable	Very Low
NSR22	40	939	38.1	29.4	0.6	Very Low	Short	Local	Improbable	Very Low
NSR14	40	968	38.1	26.7	0.3	Very Low	Short	Local	Improbable	Very Low
NSR26	40	1007	38.1	37.5	2.7	Very Low	Short	Local	Improbable	Very Low
NSR16	40	1015	38.1	35.6	1.9	Very Low	Short	Local	Improbable	Very Low
NSR38	40	1044	38.1	26.1	0.3	Very Low	Short	Local	Improbable	Very Low
NSR19	40	1059	38.1	25.9	0.3	Very Low	Short	Local	Improbable	Very Low
NSR23	40	1059	38.1	25.0	0.2	Very Low	Short	Local	Improbable	Very Low
NSR39	40	1066	38.1	25.2	0.2	Very Low	Short	Local	Improbable	Very Low
NSR09	40	1068	38.1	25.0	0.2	Very Low	Short	Local	Improbable	Very Low
NSR24	40	1069	38.1	27.1	0.3	Very Low	Short	Local	Improbable	Very Low
NSR05	40	1084	38.1	15.6	0.0	Very Low	Short	Local	Improbable	Very Low
NSR85	40	1102	38.1	15.7	0.0	Very Low	Short	Local	Improbable	Very Low
NSR20	40	1135	38.1	15.1	0.0	Very Low	Short	Local	Improbable	Very Low
NSR21	40	1316	38.1	14.2	0.0	Very Low	Short	Local	Improbable	Very Low
NSR28	40	1339	38.1	15.3	0.0	Very Low	Short	Local	Improbable	Very Low
NSR17	40	1343	38.1	15.7	0.0	Very Low	Short	Local	Improbable	Very Low
NSR66	40	1345	38.1	15.8	0.0	Very Low	Short	Local	Improbable	Very Low
NSR30	40	1424	38.1	21.0	0.1	Very Low	Short	Local	Improbable	Very Low
NSR29	40	1432	38.1	20.4	0.1	Very Low	Short	Local	Improbable	Very Low

Appendix E, Table 11: Projected operational noise rating levels and daytime significance - Uvemvane WEF (PWL of 110.5 dBA re 1 pW)

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - night-time rating level,	Distance between NSR and WTG locations (m)	Potential Existing Ambient Sound Levels (Estimated considering an	Projected Noise Level (average expected) - dBA	Projected Noise Level (worst-case, including ± 2 uncertainty) - dBA	Potential Low-frequency Noise Level - dBG	Potential Low-frequency Noise Level issues - dBC - dBA	Change in rating level	Magnitude / Intensity	Duration	Extent	Probability of Impact Occurring	Significance
NSR08	55	526	41.5	48.2	50.1	73.9	15.0	7.5	High	Long	Local	Improbable	Very Low
NSR07	55	766	41.5	44.2	46.2	64.1	15.5	4.6	Low	Long	Local	Improbable	Very Low
NSR04	55	771	41.5	42.0	44	68.4	15.6	3.3	Low	Long	Local	Improbable	Very Low
NSR03	55	787	41.5	41.8	43.8	68.5	15.6	3.2	Low	Long	Local	Improbable	Very Low
NSR18	55	840	41.5	43.0	45	68.2	16.1	3.8	Low	Long	Local	Improbable	Very Low
NSR27	55	853	41.5	41.7	43.7	69.3	16.2	3.1	Low	Long	Local	Improbable	Very Low
NSR25	55	915	41.5	41.4	43.4	70.7	16.2	3.0	Very Low	Long	Local	Improbable	Very Low
NSR15	55	922	41.5	42.5	44.6	73.9	15.9	3.5	Low	Long	Local	Improbable	Very Low
NSR06	55	924	41.5	42.6	44.6	69.5	15.7	3.6	Low	Long	Local	Improbable	Very Low
NSR22	55	939	41.5	42.3	44.3	63.1	16.0	3.4	Low	Long	Local	Improbable	Very Low
NSR14	55	968	41.5	42.5	44.6	63.6	16.0	3.5	Low	Long	Local	Improbable	Very Low
NSR26	55	1007	41.5	40.5	42.5	65.4	16.4	2.5	Very Low	Long	Local	Improbable	Very Low
NSR16	55	1015	41.5	41.8	43.8	66.3	16.1	3.2	Low	Long	Local	Improbable	Very Low
NSR38	55	1044	41.5	40.2	42.4	69.6	16.1	2.4	Very Low	Long	Local	Improbable	Very Low
NSR19	55	1059	41.5	41.1	43.2	69.5	16.6	2.8	Very Low	Long	Local	Improbable	Very Low
NSR23	55	1059	41.5	44.6	46.6	68.9	16.0	4.8	Low	Long	Local	Improbable	Very Low
NSR39	55	1066	41.5	40.8	42.8	68	16.2	2.7	Very Low	Long	Local	Improbable	Very Low
NSR09	55	1068	41.5	42.7	44.7	70.1	15.8	3.7	Low	Long	Local	Improbable	Very Low
NSR24	55	1069	41.5	41.0	43.1	68.9	16.3	2.8	Very Low	Long	Local	Improbable	Very Low
NSR05	55	1084	41.5	41.1	43.1	68.2	16.0	2.8	Very Low	Long	Local	Improbable	Very Low
NSR85	55	1102	41.5	42.1	44.2	67.3	16.2	3.3	Low	Long	Local	Improbable	Very Low
NSR20	55	1135	41.5	40.2	42.3	69.3	16.8	2.4	Very Low	Long	Local	Improbable	Very Low
NSR21	55	1316	41.5	39.4	41.5	71.6	16.7	2.1	Very Low	Long	Local	Improbable	Very Low
NSR28	55	1339	41.5	38.0	40.1	68.4	17.2	1.6	Very Low	Long	Local	Improbable	Very Low
NSR17	55	1343	41.5	39.6	41.7	68.7	17.1	2.2	Very Low	Long	Local	Improbable	Very Low
NSR66	55	1345	41.5	39.4	41.4	68	16.5	2.1	Very Low	Long	Local	Improbable	Very Low
NSR30	55	1424	41.5	40.1	42.2	68.9	16.6	2.4	Very Low	Long	Local	Improbable	Very Low
NSR29	55	1432	41.5	37.8	39.9	66.5	17.3	1.5	Very Low	Long	Local	Improbable	Very Low
NSR32	55	1526	41.5	35.8	37.9	66.4	17.4	1.0	Very Low	Long	Local	Improbable	Very Low
NSR02	55	1555	41.5	35.6	37.7	67.9	17.2	1.0	Very Low	Long	Local	Improbable	Very Low
NSR86	55	1683	41.5	38.3	40.6	0	17.0	1.7	Very Low	Long	Local	Improbable	Very Low
NSR33	55	1752	41.5	35.3	37.4	64.5	17.6	0.9	Very Low	Long	Local	Improbable	Very Low
NSR01	55	1786	41.5	34.6	36.7	64.1	17.5	0.8	Very Low	Long	Local	Improbable	Very Low
NSR67	55	1847	41.5	33.1	35.3	60	17.6	0.6	Very Low	Long	Local	Improbable	Very Low
NSR58	55	1944	41.5	34.5	36.7	60	17.6	0.8	Very Low	Long	Local	Improbable	Very Low
NSR13	55	1965	41.5	37.2	39.3	57.5	17.8	1.4	Very Low	Long	Local	Improbable	Very Low
NSR78	55	1968	41.5	36.3	38.4	57.1	17.3	1.1	Very Low	Long	Local	Improbable	Very Low
NSR87	55	2021	41.5	33.1	35.2	67.5	18.0	0.6	Very Low	Long	Local	Improbable	Very Low

NSR53	55	2044	41.5	33.1	35.2	68	18.3	0.6	Very Low	Long	Local	Improbable	Very Low
NSR59	55	2088	41.5	34.3	36.4	59.4	17.8	0.8	Very Low	Long	Local	Improbable	Very Low
NSR56	55	2193	41.5	32.2	34.3	0	18.1	0.5	Very Low	Long	Local	Improbable	Very Low
NSR52	55	2203	41.5	27.2	29.7	0	19.3	0.0	Very Low	Long	Local	Improbable	Very Low
NSR55	55	2226	41.5	31.4	33.6	0	18.4	0.0	Very Low	Long	Local	Improbable	Very Low
NSR10	55	2309	41.5	33.8	35.9	50.6	17.9	0.7	Very Low	Long	Local	Improbable	Very Low
NSR88	55	2341	41.5	29.6	33.6	0	18.3	0.0	Very Low	Long	Local	Improbable	Very Low
NSR54	55	2424	41.5	33.2	35.4	0	17.9	0.6	Very Low	Long	Local	Improbable	Very Low
NSR89	55	2428	41.5	31.0	33.2	0	18.5	0.0	Very Low	Long	Local	Improbable	Very Low
NSR90	55	2430	41.5	31.0	33.2	0	18.5	0.0	Very Low	Long	Local	Improbable	Very Low
NSR12	55	2440	41.5	35.8	37.7	0	18.4	1.0	Very Low	Long	Local	Improbable	Very Low

Appendix E, Table 12: Projected operational noise rating levels and night-time significance - Uvemvane WEF (PWL of 110.5 dBA re 1 pW)

Potential Noise-sensitive development / Receptor(s)	Recommended Rating Levels (noise limit - night-time rating level,	Distance between NSR and WTG locations (m)	Potential Existing Ambient Sound Levels (Estimated considering an	Projected Noise Level (average expected) - dBA	Projected Noise Level (worst-case, few times per year) - dBA	Potential Low-frequency Noise Level - dBG	Potential Low-frequency Noise Level issues - dBA - dBC	Change in rating level	Magnitude / Intensity	Duration	Extent	Probability of Impact Occurring	Significance
NSR08	45	526	41.5	48.2	50.1	73.9	15.0	7.5	High	Long	Regional	Highly Probable	Moderate
NSR07	45	766	41.5	44.2	46.2	64.1	15.5	4.6	Low	Long	Regional	Probable	Low
NSR04	45	771	41.5	42.0	44.0	68.4	15.6	3.3	Low	Long	Regional	Probable	Low
NSR03	45	787	41.5	41.8	43.8	68.5	15.6	3.2	Low	Long	Regional	Possible	Low
NSR18	45	840	41.5	43.0	45.0	68.2	16.1	3.8	Low	Long	Regional	Probable	Low
NSR27	45	853	41.5	41.7	43.7	69.3	16.2	3.1	Low	Long	Regional	Possible	Low
NSR25	45	915	41.5	41.4	43.4	70.7	16.2	3.0	Very Low	Long	Regional	Possible	Low
NSR15	45	922	41.5	42.5	44.6	73.9	15.9	3.5	Low	Long	Regional	Probable	Low
NSR06	45	924	41.5	42.6	44.6	69.5	15.7	3.6	Low	Long	Regional	Probable	Low
NSR22	45	939	41.5	42.3	44.3	63.1	16.0	3.4	Low	Long	Regional	Probable	Low
NSR14	45	968	41.5	42.5	44.6	63.6	16.0	3.5	Low	Long	Regional	Probable	Low
NSR26	45	1007	41.5	40.5	42.5	65.4	16.4	2.5	Very Low	Long	Regional	Possible	Low
NSR16	45	1015	41.5	41.8	43.8	66.3	16.1	3.2	Low	Long	Regional	Possible	Low
NSR38	45	1044	41.5	40.2	42.4	69.6	16.1	2.4	Very Low	Long	Regional	Possible	Low
NSR19	45	1059	41.5	41.1	43.2	69.5	16.6	2.8	Very Low	Long	Regional	Possible	Low
NSR23	45	1059	41.5	44.6	46.6	68.9	16.0	4.8	Low	Long	Regional	Probable	Low
NSR39	45	1066	41.5	40.8	42.8	68.0	16.2	2.7	Very Low	Long	Regional	Possible	Low
NSR09	45	1068	41.5	42.7	44.7	70.1	15.8	3.7	Low	Long	Regional	Probable	Low
NSR24	45	1069	41.5	41.0	43.1	68.9	16.3	2.8	Very Low	Long	Regional	Possible	Low
NSR05	45	1084	41.5	41.1	43.1	68.2	16.0	2.8	Very Low	Long	Regional	Possible	Low
NSR85	45	1102	41.5	42.1	44.2	67.3	16.2	3.3	Low	Long	Regional	Probable	Low
NSR20	45	1135	41.5	40.2	42.3	69.3	16.8	2.4	Very Low	Long	Regional	Possible	Low
NSR21	45	1316	41.5	39.4	41.5	71.6	16.7	2.1	Very Low	Long	Regional	Possible	Low
NSR28	45	1339	41.5	38.0	40.1	68.4	17.2	1.6	Very Low	Long	Regional	Improbable	Very Low
NSR17	45	1343	41.5	39.6	41.7	68.7	17.1	2.2	Very Low	Long	Regional	Possible	Low

NSR66	45	1345	41.5	39.4	41.4	68.0	16.5	2.1	Very Low	Long	Regional	Possible	Low
NSR30	45	1424	41.5	40.1	42.2	68.9	16.6	2.4	Very Low	Long	Regional	Possible	Low
NSR29	45	1432	41.5	37.8	39.9	66.5	17.3	1.5	Very Low	Long	Regional	Improbable	Very Low
NSR32	45	1526	41.5	35.8	37.9	66.4	17.4	1.0	Very Low	Long	Regional	Improbable	Very Low
NSR02	45	1555	41.5	35.6	37.7	67.9	17.2	1.0	Very Low	Long	Regional	Improbable	Very Low
NSR86	45	1683	41.5	38.3	40.6	0.0	17.0	1.7	Very Low	Long	Regional	Improbable	Very Low
NSR33	45	1752	41.5	35.3	37.4	64.5	17.6	0.9	Very Low	Long	Regional	Improbable	Very Low
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NSR58	45	1944	41.5	34.5	36.7	60.0	17.6	0.8	Very Low	Long	Regional	Improbable	Very Low
NSR13	45	1965	41.5	37.2	39.3	57.5	17.8	1.4	Very Low	Long	Regional	Improbable	Very Low
NSR78	45	1968	41.5	36.3	38.4	57.1	17.3	1.1	Very Low	Long	Regional	Improbable	Very Low
NSR87	45	2021	41.5	33.1	35.2	67.5	18.0	0.6	Very Low	Long	Regional	Improbable	Very Low
NSR53	45	2044	41.5	33.1	35.2	68.0	18.3	0.6	Very Low	Long	Regional	Improbable	Very Low
NSR59	45	2088	41.5	34.3	36.4	59.4	17.8	0.8	Very Low	Long	Regional	Improbable	Very Low
NSR56	45	2193	41.5	32.2	34.3	0.0	18.1	0.5	Very Low	Long	Regional	Improbable	Very Low
NSR52	45	2203	41.5	27.2	29.7	0.0	19.3	0.0	Very Low	Long	Regional	Improbable	Very Low
NSR55	45	2226	41.5	31.4	33.6	0.0	18.4	0.0	Very Low	Long	Regional	Improbable	Very Low
NSR10	45	2309	41.5	33.8	35.9	50.6	17.9	0.7	Very Low	Long	Regional	Improbable	Very Low
NSR88	45	2341	41.5	29.6	33.6	0.0	18.3	0.0	Very Low	Long	Regional	Improbable	Very Low
NSR54	45	2424	41.5	33.2	35.4	0.0	17.9	0.6	Very Low	Long	Regional	Improbable	Very Low
NSR89	45	2428	41.5	31.0	33.2	0.0	18.5	0.0	Very Low	Long	Regional	Improbable	Very Low
NSR90	45	2430	41.5	31.0	33.2	0.0	18.5	0.0	Very Low	Long	Regional	Improbable	Very Low
NSR12	45	2440	41.5	35.8	37.7	0.0	18.4	1.0	Very Low	Long	Regional	Improbable	Very Low

End of Report