Mainstream Renewable Power Developments South Africa (Pty) Ltd

NOISE REPORT

FOR SCOPING PURPOSES

Establishment of the !Xhaboom Wind Farm

North of Loeriesfontein, Northern Cape

Study done for:

SiVEST

Prepared by:

EAR
Enviro Acoustic Research

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This report should be cited as:

De Jager, M. 2017: "*Noise Report for Scoping purposes: Establishment of the !Xhaboom Wind Farm North of Loeriesfontein, Western Cape*". Enviro-Acoustic Research, Pretoria

Client:

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for	Rivonia
Mainstream Renewable Power Developments South Africa (Pty) Ltd	2128

Report no:

MRPDSA-LBIWF/SNR/201611-Rev 1

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Date:

May 2017

EXECUTIVE SUMMARY

Enviro-Acoustic Research cc was commissioned to undertake a specialist study to determine the potential noise impact on the surrounding environment due to the proposed establishment of the !Xhaboom Wind Farm (WF) and its grid connection north of Loeriesfontein, Northern Cape.

This report is a Scoping assessment of the predicted noise environment due to the development of this facility. It is based on a desktop assessment, the author's expertise, as well as a predictive model (making use of the worst-case scenario in terms of the precautionary approach) to identify potential issues of concern.

Mainstream Renewable Power Developments South Africa (Pty) Ltd proposes the development of this WEF and its associated grid infrastructure. The footprint of the farm covers an area of app. ±51 km^2, with the study area for the Noise Assessment covering a distance up to 2,000m from the proposed boundary of the facility. The !Xhaboom WF forms part of the larger Leeuberg Wind Energy Facility, which also includes the Itemba, Graskoppies and Hartebeestleegte WF's.

The !Xhaboom WF may have up to 47 wind turbines, each expected to have a hub height (hh) of up to 160m and a rotor diameter of up to 160m. The developer has been evaluating several turbine models, however the selection will only be finalised at a later stage once the meteorological baseline survey is complete. The turbines will be between 3 and 5 megawatts (MW) in rated power to allow for a total generating capacity of 140MW.

This assessment indicates that the proposed project could have a noise impact on the surrounding area, as there are noise-sensitive developments within the (potential) area of acoustical influence of the construction activities and operating wind turbines.

The construction of access roads as well as construction traffic may increase the noise levels sufficiently to result in noise impacts of medium significance. Mitigation measures are available and easy to implement to reduce the potential significance of the noise impact to low.

The potential noise impact of operational activities is of a low significance, similarly the potential cumulative noise effect when all the surrounding wind turbines are operating.

There is a high confidence in the finding of this report, and with the implementation of the mitigation measures there exists a low potential for a noise impact. An additional noise impact assessment is not required for the EIA phase, as it will not provide additional information.

It would therefore not be required to assess the potential noise impact in more detail in the Environmental Impact Assessment phase and the project can be authorized (subject to the implementation of the mitigation measures agreeable with the identified receptors) from a noise perspective.

CONTENTS OF THE SPECIALIST REPORT – CHECKLIST

Contents of this report in terms of Regulation GNR 982 of 2014, Appendix 6	**Cross-reference in this report**
(a) details of— the specialist who prepared the report; and the expertise of that specialist to compile a specialist report including a curriculum vitae;	**Section 13**
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	**See following page**
(c) an indication of the scope of, and the purpose for which, the report was prepared;	**Section 1.1**
(d) the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	**Section 3.1**
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process;	**Section 1.5**
(f) the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	**Sections 3.1**, **3.2**, **3.3** and **3.5**
(g) an identification of any areas to be avoided, including buffers;	Buffers not required. Noise contours modeled. See also **section 9**.
(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Buffers not required. Noise contours modeled. See also **section 9**.
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	**Section 7.4**
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment;	**Sections 8** and **9**
(o) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	No comments received
(p) any other information requested by the competent authority.	Nothing requested

Regulation GNR 982 of 2014, Appendix 2 – Scoping Process	Section of Report
Description of any policies or legislation or guidelines relevant to your field that the applicant will need to comply with.	**Sections 1.5 and 0**
Comment on need/desirability of the proposal in terms of your field and in terms of the proposal's location.	**Section 9.6.2**
Description of methodology used in determining significance.	**Sections 7.3**
Assessment of alternatives including the environmental attributes associated with each alternative.	Site suitable to all alternatives subject to buffer area limits
For each alternative, determine the-- (i) nature, significance, consequence, extent, duration and probability of the impacts occurring to inform identified preferred alternatives; and (ii) degree to which these impacts- (aa) can be reversed; (bb) may cause irreplaceable loss of resources, and (cc) can be avoided, managed or mitigated;	Only one layout evaluated but all alternative layouts with wind turbines outside the buffer areas will be acceptable. There are no receptors close to corridors where the power line will be constructed (all alternatives).
Determine positive and negative impacts that each alternative will have on the environment.	**Section 9**
Identify suitable measures to avoid, manage or mitigate identified impacts.	**Section 9** and **10**
Identify residual risks that need to be managed and monitored.	No residual risks anticipated
A concluding statement indicating a preferred alternative and preferred location in terms of your field.	See statement regarding alternatives above.
State if further study is required and include description of this methodology.	More comprehensive Environmental Noise Impact Assessment recommended.

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

	(For official use only)
File Reference Number:	12/12/20/ or 12/9/11/L
NEAS Reference Number:	DEA/EIA
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010

PROJECT TITLE

!Xhaboom Wind Farm north of Loeriesfontein

Specialist:	Noise		
Contact person:	Morné de Jager		
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Project Consultant:	SiVEST SA (Pty) Ltd		
Contact person:			
Postal address:			
Postal code:		Cell:	
Telephone:		Fax:	
E-mail:			

The specialist appointed in terms of the Regulations

I, **Morné de Jager**, declare that –

General declaration

- I act as the independent specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Signature of the specialist:

Enviro-Acoustic Research cc
Name of company (if applicable):

Date:

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Appendix A Glossary of Terms

GLOSSARY OF ABBREVIATIONS

ECA	Environment Conservation Act (Act 78 of 1989)
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
EARES	Enviro-Acoustics Research
hh	hub height
IAP's	Interested and Affected Parties
i.e.	that is
km	kilometres
m	Meters (measurement of distance)
m^2	Square meter
m^3	Cubic meter
mamsl	Meters above mean sea level
MW	Megawatt
NEMA	National Environmental Management Act, 1998 (Act 107 of 1998)
NCR	Noise Control Regulations (under Section 25 of the ECA)
NSD	Noise-Sensitive Developments
SABS	South African Bureau of Standards
SANS	South African National Standards
SHEQ	Safety Health Environment and Quality
WF	Wind Farm
WEF	Wind Energy Facility
WHO	World Health Organisation
WTG	Wind Turbine Generator

1 INTRODUCTION

1.1 INTRODUCTION AND PURPOSE

Enviro-Acoustic Research cc (EARES) was commissioned to undertake a specialist study to determine the potential noise impact on the surrounding environment due to the proposed establishment of the !Xhaboom Wind Farm (WF) north of Loeriesfontein in the Northern Cape.

This report is the result of the initial phase scoping study (desktop) of the Environmental Impact Assessment (EIA) process investigating the potential noise impact that such a facility may have on the surrounding environment. The aim of the report is to highlight methodologies, potential issues to be investigated, as well as preliminary findings and recommendations.

1.2 BRIEF PROJECT DESCRIPTION

Mainstream Renewable Power Developments South Africa (Pty) Ltd proposes the development of a commercial WF and associated grid infrastructure north of Loeriesfontein in the Northern Cape province (refer to **Figure 1.1**).

The footprint of the farms covers an area of app. ±51 km^2, with the study area for the Noise Assessment covering a distance up to 2,000m from the proposed boundary of the WF. The !Xhaboom WF forms part of the larger Leeuberg Wind Energy Facility, which also includes the Itemba, Graskoppies and Hartebeestleegte WFs.

The !Xhaboom WEF may have up to 47 wind turbines, each expected to have a hub height (hh) of up to 160m and a rotor diameter of up to 160m. The developer has been evaluating several turbine models, however the selection will only be finalised at a later stage once the meteorological baseline survey is complete. The turbines will be between 3 and 5 megawatts (MW) in rated power to allow for a total generating capacity of 140MW.

Other infrastructure associated with the proposed WF will include:

- A laydown area next to the locations of the proposed wind turbines;
- Foundations to support the wind turbines;
- Cabling between the turbines, to be laid underground where practical, which will connect to an on-site substation;
- Overhead power lines to connect the facility to the Eskom grid;

- Existing roads will be used as far as possible. However, where required, internal access roads/tracks will be constructed between the turbines;
- Temporary infrastructure consisting of a site camp, contractors office and batching plant; and
- Site offices and a workshop area for control, maintenance and storage purposes.

1.3 STUDY AREA

The development is situated in the Hantam Local Municipality which falls within the Namakwa District Council Municipal area in the Northern Cape Province. This is of relevance due the fact that this province has not yet promulgated Provincial Noise Control Regulations. The study area is further described in terms of environmental components that may contribute to or change the sound character in the area.

1.3.1 Topography

The topography in the vicinity of the development is generally flat plains. There are no topographical features that will assist in the blocking of sound propagation. The larger area is classified by the Environmental Potential Atlas of South Africa as plains. Due to the height of the wind turbines, topographical features will not significantly limit the propagation of sound from the wind turbines.

1.3.2 Roads and rail roads

There are a few small gravel roads in the area, mainly used but the local land owners. Traffic volumes on these roads are very low and sporadic and will not be of any significance in terms of noise.

1.3.3 Land use

Land use in the area is mostly wilderness and agricultural activities (sheep and game).

1.3.4 Residential areas

Excluding structures identified (see **Section 1.4**) that may be occupied, either permanently or temporary, there are no residential areas close to the proposed wind farm.

1.3.5 Ground conditions and vegetation

The area falls within the arid Karoo and desert false grassveld vegetation regions within the Nama Karoo biome. The area consists mostly of low growing shrubs and grasses with hard ground conditions typical of an arid area. Ground conditions are unlikely to assist in the attenuation of noise (fraction of sound waves hitting and being reflected from the ground).

1.3.6 Existing Ambient Sound Levels

Ambient sound levels were previously measured in the area for the Loeriesfontein and Kokerboom WEF's.

Excluding the measurements collected near construction activities of the Loeriesfontein WEF, ambient sound levels is very low in the area. Sound levels are higher at the dwellings in the area, mainly due to the modified environment around the residential dwellings (see also **section 6.1**). Sound levels previously measured are discussed in **section 3.5**.

1.4 NOISE-SENSITIVE DEVELOPMENTS

An assessment of the area was done using the Google Earth® as well as available topographical maps to identify potential Noise-sensitive Developments in the area (within area proposed, as well as potential NSD's within around 2km from the boundary of the proposed WF).

A desktop assessment identified seven (7) potential noise-sensitive developments in the area (see **Figure 1.2** and **Table 1-1**). The statuses of these structures were confirmed by Mrs. Nicolene Venter of Imaginative Africa (Pty) Ltd after discussions with land owners.

Table 1-1: Status of identified potential noise-sensitive developments

Potential receptor	Status of the developments identified in Figure 1.2 and comments
NSD01	Owner – Mr. Christo van der Merwe. Status unknown.
NSD02	Owner – Mr. Herman Nel. Single room with carport, loading platform and kraal occupied up to 4 months per year by a shepherd.
NSD03	Owner – Mr. Herman Nel. House used very temporary (one night) on occasion. Also single room for shepherd.
NSD04	Owner - Mr. Albi Louw. House being used on a temporary basis by Albi's shepherds during sheering time.
NSD05	Owner – Mr. Gys Lombaard. The house is occupied in the summer time, usually from January to June.
NSD06	Owner - Mr. Nico Louw. Occupied only in summer time (lambing period) and for a weekend at a time. He commented that noise will not be an issue for them.
NSD07	Owner – Mr. Kallie van Zyl.

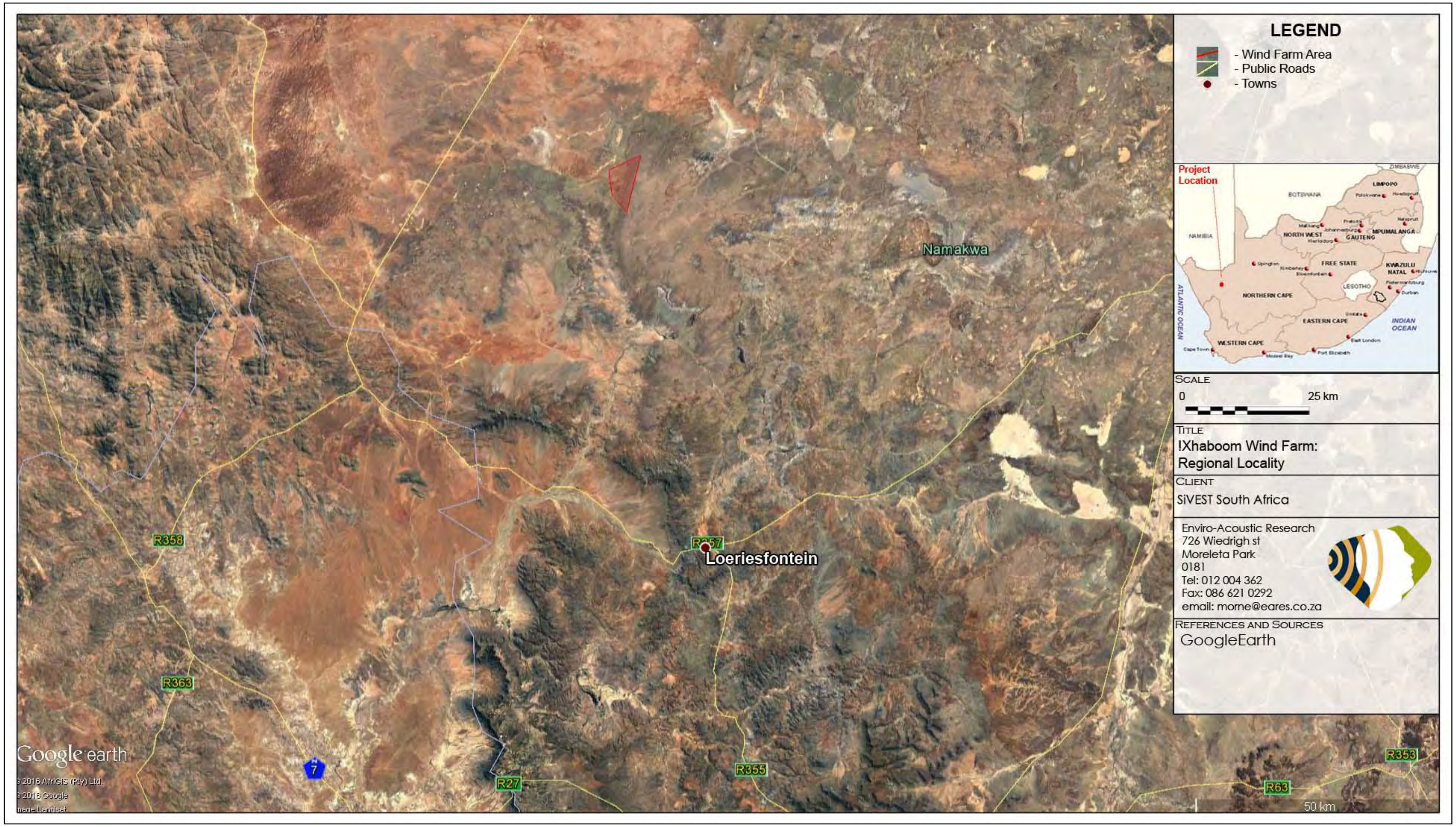

Figure 1.1: Site map indicating the location of proposed WEF

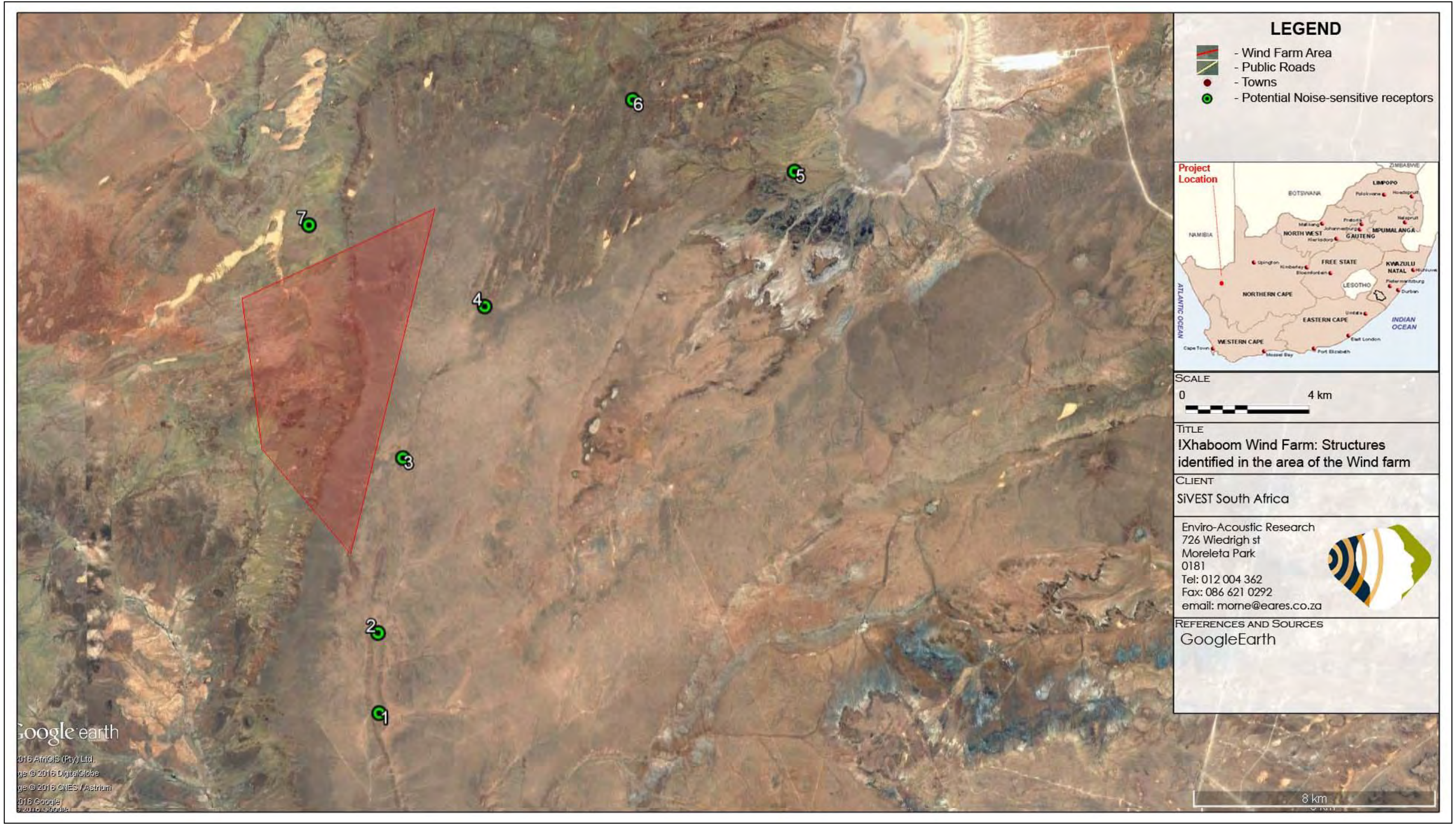

Figure 1.2: Aerial Image indicating identified potential Noise-sensitive developments identified during scoping

1.5 TERMS OF REFERENCE

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

- If there are potential noise-sensitive receptors staying within 1,000 m from industrial activities (SANS 10328:2008)
- If there are potential noise-sensitive receptors staying within 2,000 m from a source of low frequency sounds (SANS 10328:2008)
- It is generally required by the local or district authority as part of the environmental authorization or planning approval in terms of the Noise Control Regulations (Regulation 2(d) of GN R154 of 1992).
- There is a General prohibition in terms of Noise Control Regulations (Regulation 3(c) of GN R154 of 1992) unless precautionary measures to prevent the disturbing noise have been taken to the satisfaction of the local authority.
- It is a controlled activity in terms of the National Environmental Management Act (No. 107 of 1998) (NEMA) 2014 Environmental Impact Assessment (EIA) Regulations and an ENIA is required, because:
  - It may cause a disturbing noise that is prohibited in terms of the Noise Control Regulations (Regulation 4 of Government Notice R154 of 1992

In addition, Appendix 6 of GN 982 of December 2014 (Gov. Gaz. 38282), issued in terms of the National Environmental Management Act, No. 107 of 1998 also defines minimum information requirements for specialist reports.

In South Africa the document that addresses the issues specifically concerning environmental noise is SANS 10103:2008. It has recently been thoroughly revised 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.

SANS 10328:2008 (Edition 3) specifies the methodology to assess the noise impacts on the environment due to a proposed activity that might have an impact on the environment. The standard also stipulates the minimum requirements to be investigated for Scoping purposes. These minimum requirements are:

1. The purpose of the investigation;
2. A brief description of the planned development or the changes that are being considered;
3. A brief description of the existing environment;

4. The identification of the noise sources that may affect the particular development, together with their respective estimated sound pressure levels or sound power levels (or both);
5. The identified noise sources that were not taken into account and the reasons why they were not investigated;
6. The identified noise-sensitive developments and the estimated impact on them;
7. Any assumptions made with regard to the estimated values used;
8. An explanation, either by a brief description or by reference, of the methods that were used to estimate the existing and predicted rating levels;
9. The location of the measurement or calculation points, i.e. a description, sketch or map;
10. Estimation of the environmental noise impact;
11. Alternatives that were considered and the results of those that were investigated;
12. A list of all the interested or affected parties that offered any comments with respect to the environmental noise impact investigation;
13. A detailed summary of all the comments received from interested or affected parties as well as the procedures and discussions followed to deal with them;
14. Conclusions that were reached;
15. Recommendations, i.e. if there could be a significant impact, or if more information is needed, a recommendation that an environmental noise impact assessment be conducted, and;
16. If remedial measures will provide an acceptable solution which would prevent a significant impact, these remedial measures should be outlined in detail and included in the final record of decision if the approval is obtained from the relevant authority. If the remedial measures deteriorate after time and a follow-up auditing or maintenance programme (or both) is instituted, this programme should be included in the final recommendations and accepted in the record of decision if the approval is obtained from the relevant authority.

In addition, the Scoping report should contain sufficient information to allow the Environmental Assessment Practitioner (EAP) to compile the Plan of Study for Environmental Impact Assessment (EIA), including the Noise component of the study.

In this regard the following will be included in order to assist the EAP in the compilation of the Plan of Study (PoS) for the EIA:

- The potential impacts will be evaluated (where possible) in terms of the nature (description of what causes the effect, what/who might be affected and how it/they might be affected), as well as the extent of the impact. This will be done by means of a site visit, where appropriate ambient sound levels will be determined and the identification of potential noise-sensitive developments/areas;

- Evaluating the layout(s) considering the location, as well as the sound power emission levels of the wind turbines and grid connections using the a sound propagation algorithm;
- A statement regarding the potential significance of the identified issues based on the evaluation of the issues/impacts;
- The identification of issues to be investigated in more detail during the Environmental Impact Assessment phase; and
- Details regarding the methodology followed to estimate and assess the potentially significant impacts during the EIA phase.

2 POLICIES AND THE LEGAL CONTEXT

2.1 THE REPUBLIC OF SOUTH AFRICA CONSTITUTION ACT ("THE CONSTITUTION")

The environmental right contained in section 24 of the Constitution provides that everyone is entitled to an environment that is not harmful to his or her well-being. In the context of noise, this requires a determination of what level of noise is harmful to the well-being of humans. The general approach of the common law is to define an acceptable level of noise as that which the reasonable person can be expected to tolerate in the particular circumstances. The subjectivity of this approach can be problematic, however, which has led to the development of noise standards (see Section 2.5).

"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.

2.2 THE ENVIRONMENT CONSERVATION ACT

The Environment Conservation Act ("ECA") allows the Minister of Environmental Affairs and Tourism ("now the Minister of Water and Environmental Affairs") to make regulations regarding noise, among other concerns. No provincial noise control regulations have been promulgated in the Northern Cape provinces and the National Noise Control Regulations will be relevant in this province.

2.2.1 National Noise Control Regulations: GN R154 of 1992 (NCR)

In terms of section 25 of the ECA, the national noise-control regulations (GN R154 in *Government Gazette* No. 13717 dated 10 January 1992) were promulgated.

Subsequently, in terms of Schedule 5 of the Constitution of South Africa of 1996 legislative responsibility for administering the NCR was devolved to provincial and local authorities. Most of the properties that forms part of the wind farm are located in the Western Cape Province, however the western part of the area lies within the Northern Cape Province. The Northern Cape Province has not promulgated their own noise control regulations and the national regulations will be in effect.

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

"**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.*

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 lever 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".

2.3 THE NATIONAL ENVIRONMENTAL MANAGEMENT ACT

The National Environmental Management Act ("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 the WEF to prevent noise pollution occurring. NEMA sets out measures which may be regarded as reasonable. They include measures:

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

In addition, Appendix 6 of GN 982 of December 2014 (Gov. Gaz. 38282), issued in terms of this Act, have general requirements for EAPs and specialists. It also defines minimum information requirements for specialist reports.

2.4 NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY ACT ("AQA")

Section 34 of the National Environmental Management: Air Quality Act (Act 39 of 2004) makes provision for:

(1) the Minister to prescribe essential national noise standards -

(a) for the control of noise, either in general or by specified machinery or activities or in specified places or areas; or

(b) for determining –

(i) a definition of noise; and

(ii) the maximum levels of noise.

(2) When controlling noise the provincial and local spheres of government are bound by any prescribed national standards.

This section of the Act is in force but no such standards have yet been promulgated.

An atmospheric emission license issued in terms of section 22 may contain conditions in respect of noise. This however will not be relevant to the WEF nor the grid connection.

2.4.1 Draft Model Air Quality Management By-law for adoption and adaptation by Municipalities

Draft model air quality management by-laws for adoption and adaptation by municipalities was published by the Department of Environmental Affairs in the Government Gazette of 15 July 2009 as General Notice (for comments) 964 of 2009. Section 18 specifically focuses on Noise Pollution Management, with sub-section 1 stating:

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

The draft regulations differs from the current provincial Noise Control Regulations as it defines a disturbing noise as a noise that is measurable or calculable of which the rating level exceeds the equivalent continuous rating level as defined in SANS 10103:2008.

2.5 NOISE STANDARDS

Four South African Bureau of Standards (SABS) scientific standards are considered relevant to noises from a Wind Energy Facility. They are:

- SANS 10103:2008. '*The measurement and rating of environmental noise with respect to annoyance and to speech communication*'.
- SANS 10210:2004. '*Calculating and predicting road traffic noise*'.
- SANS 10328:2008. '*Methods for environmental noise impact assessments*'.
- SANS 10357:2004. '*The calculation of sound propagation by the Concave method*'.

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

2.6 INTERNATIONAL GUIDELINES

While there exist a number of international guidelines and standards that could encompass a document in itself, the three mentioned below were selected as they are used by different countries in the subject of environmental noise management, with the last two documents specifically focussing on the noises associated by wind energy facilities.

2.6.1 Guidelines for Community Noise (WHO, 1999)

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

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

The document uses the L_{Aeq} and $L_{A,max}$ descriptors to define noise levels with the instrument likely using the "Fast"-time weighting. This document was important in the development of the SANS 10103 standard.

2.6.2 The Assessment and Rating of Noise from Wind Farms (ETSU, 1997)

This report describes the findings of a Working Group on Wind Turbine Noise, facilitated by the United Kingdom Department of Trade and Industry. It was developed as an Energy Technology Support Unit[1] (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] 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.

1. Absolute noise limits applied at all wind speeds are not suited to wind farms; limits set relative to the background noise are more appropriate
2. $L_{A90,10mins}$ is a much more accurate descriptor when monitoring ambient and turbine noise levels
3. The effects of other wind turbines in a given area should be added to the effect of any proposed wind energy facility, to calculate the cumulative effect
4. Noise from a wind energy facility should be restricted to no more than 5 dBA above the current ambient noise level at a NSD. Ambient noise levels is 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 to 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 wind energy facility
6. A penalty system should be implemented for wind turbine/s that operates with a tonal characteristic

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

The document uses the $L_{Aeq,f}$ and L_{A90} descriptors to define noise levels using the “Fast”-time weighting.

2.6.3 Noise Guidelines for Wind Farms (MoE, 2008)

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

The document defines:

- Sound Level Limits for different areas (similar to rural and urban areas), defining limits for different wind speeds at 10 m height, refer also **Table 2-1**[2]
- The Noise Assessment Report, including:
    - Information that must be part of the report;
    - Full description of noise sources;
    - Adjustments, such as 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 2-1: 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

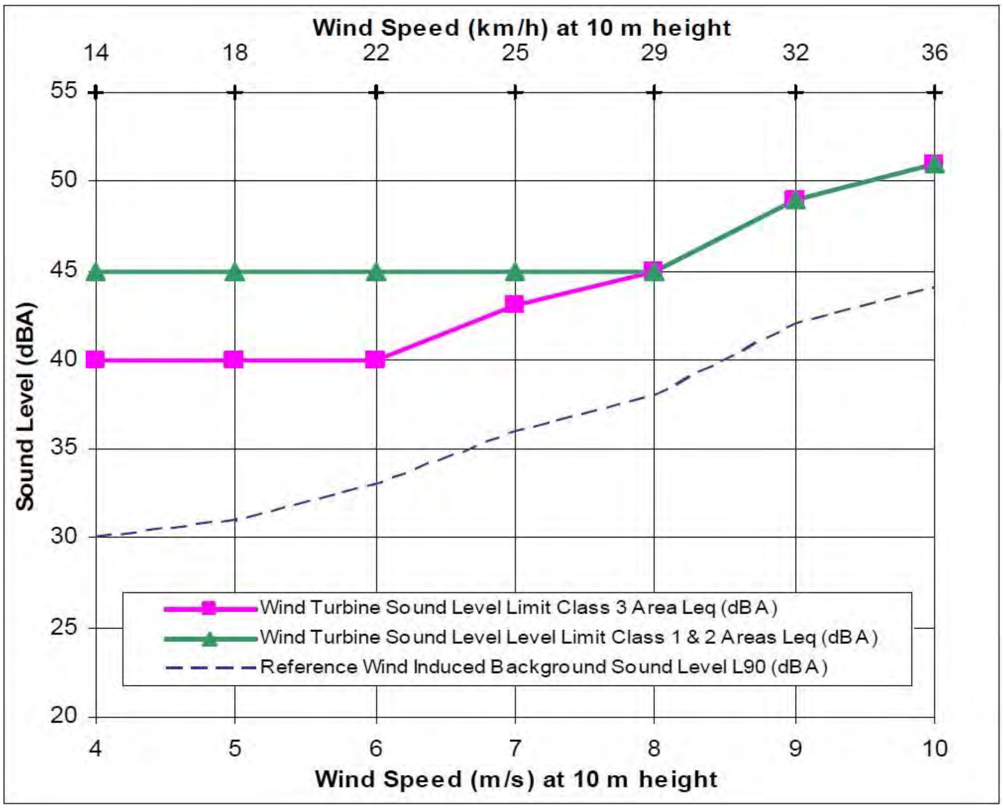

Figure 2.1: Summary of Sound Level Limits for Wind Turbines (MoE Canada)

[2]The 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 document used the $L_{Aeq,1h}$ noise descriptor to define noise levels. It is not clear whether the instrument must be set to the "Fast" or "Impulse" time weighing setting, but, as the "Fast" setting is used in most international countries it is assumed that the instrument will be set to the "Fast" setting.

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 wind energy facilities this criteria will also be considered during the determination of the significance of the noise impact.

2.6.4 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. The banks chose to model the Equator Principles on the environmental standards of the World Bank and the social policies of the International Finance Corporation (IFC). 67 financial institutions (October 2009) have adopted the Equator Principles, which have become the de facto standard for banks and investors on how to assess major development projects around the world. The environmental standards of the World Bank have been integrated into the social policies of the IFC since April 2007 as the International Finance Corporation Environmental, Health and Safety (EHS) Guidelines.

2.6.5 IFC: General EHS Guidelines – Environmental Noise Management

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

It states that noise prevention and mitigation measures should be applied where predicted or measured noise impacts from a project facility or operations exceed the applicable noise level guideline at the most sensitive point of reception. The preferred method for controlling noise from stationary sources is to implement noise control measures at 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/m^2 in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective;
- Installing vibration isolation for mechanical equipment;
- Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas ;
- Re-locating noise sources to 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 2-2**) as well as highlighting the certain monitoring requirements pre- and post-development.

Table 2-2: 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 for Europe.

3 ENVIRONMENTAL SOUND CHARACTER

3.1 EFFECT OF SEASON ON SOUND LEVELS

Natural sounds have been 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 as wind flowing through vegetation increasing as wind speed increase. Work by Fégeant (2002) stressed the importance of wind speed and turbulence causing variations in the level of vegetation generated noise. In addition, factors such as the season (e.g. dry or no leaves versus green leaves), the type of vegetation (e.g. grass, conifers, deciduous), the vegetation density as well as 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 is located. When the sound measurement location is located 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 a small to insignificant impact on 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 during the warmer spring and summer months as various species communicate in an effort to find mates; and
- Seasonal changes in weather patterns, mainly wind (also see **section 3.2**).

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 1,000m away can sound very loud or can be completely inaudible.

Other, factors that impact on sound propagation includes wind, temperature and humidity, discussed in the following sections.

3.1.1 Effect of wind on sound propagation

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

Over short distances, wind direction has a small impact on sound propagation as long as wind velocities are reasonably slow, less than 3 – 5 m/s.

3.1.2 Effect of temperature on sound propagation

On a typical sunny afternoon, air is warmest near the ground 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 toward the ground and results in louder noise levels at the listener position. Like wind gradients, temperature gradients can influence sound propagation over long distances and further complicate measurements.

Generally sound propagate better at lower temperatures (down to 10°C), and with everything being the same, a decrease in temperature from 32°C to 10°C would decrease the sound level at a listener 600m away by 3 dB (at 1,000 Hz).

3.1.3 Effect of humidity on sound propagation

The effect of humidity on sound propagation is quite complex, but effectively relates how increased humidity changes the density of air. Lower density translates into faster sound wave travel, so sound waves travel faster at high humidity. With everything being the same, an increase in humidity from 20% to 80% would increase the sound level at a listener 600m away by 3 dB (at 1,000 Hz).

3.2 EFFECT OF WIND SPEEDS ON VEGETATION AND SOUND LEVELS

Wind speed is a determining factor for sound levels at most rural locations. With no wind, there is little vegetation movement that could generate noises, 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 speeds on sound levels depends on the vegetation type (deciduous versus connivers), 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 the effect of faunal communication as vegetation may create suitable habitats and food sources.

3.3 INFLUENCE OF WIND ON NOISE LIMITS

Current local regulations and standards do not consider changing ambient (background) sound levels due to natural events such as can be found near the coast or areas where wind-induced noises are prevalent. This is unfeasible with wind energy facilities as these facilities will only operate when the wind is blowing. It is therefore important that the contribution of wind-induced noises be considered when determining the potential noise impact from such as a facility. Care should be taken when taking this approach due to other factors that complicate noise propagation from wind turbines (see also **Section 4.2**).

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

Low frequency noises can also be associated with some wind turbines. Separating the potential low frequency noise from wind turbines from that generated by natural sources as well as other anthropogenic sources can and will be a challenge. This is further discussed in **section 4.2.5**.

There are a number of factors that determine how ambient sound levels close to a dwelling (or the low-frequency noise levels inside the house) might differ from the ambient sound levels further away (or even at another dwelling in the area), including:

- Type of activities taking place in the vicinity of the dwelling;
- Equipment being use near the dwelling, especially equipment such as water pumps, compressors and air conditioners;
- Whether there are any windmill (*"windpomp"*) close to the dwelling as well as their general maintenance condition;
- Type of trees around dwelling (conifers vs. broad-leaved trees, habitat that it provides to birds, food that it may provide to birds);
- The number, type and distance between the dwelling (measuring point) and trees. This is especially relevant when the trees are directly against the house (where the branches can touch the roof);
- Distance to large infrastructural development, including roads, railroads and even large diameter pipelines;

- Distances to other noise sources, whether anthropogenic or natural (such as the ocean or running water);
- The material used in the construction of the dwelling;
- The design of the building, including layout and number of openings;
- How well the dwelling was maintained; and
- The type and how many farm animals are in the vicinity of the dwelling.

3.4 AMBIENT SOUND MEASUREMENTS PROCEDURE

The measurement of ambient sound levels is defined by the South African National Standard SANS 10103:2008 as: "***The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication***". The standard specifies the acceptable techniques for sound measurements including:

- type of equipment;
- minimum duration of measurement;
- microphone positions;
- calibration procedures and instrument checks; and
- weather conditions.

As discussed in the previous section, ambient sound measurements are ideally collected when wind speeds are less than 3 m/s with no measurements collected when wind speeds exceed 5 m/s. Due to the fact that wind energy facilities will only be in operation during periods that the wind is blowing, it is critical that ambient sound level measurements reflect expected sound levels at various wind speeds. Because of the complexity of these measurements the following methodology is followed:

- Compliance with the latest version of SANS 10103;
- The sound measuring equipment was calibrated directly before, and directly after the measurements was collected. In all cases drift[3] was less than 0.2 dBA between these two measurements.
- The measurement equipment made use of a windshield specifically designed for outdoor use during increased wind speeds;
- The areas where measurements were recorded was selected so as to minimize the risks of direct impacts by the wind on the microphone;
- Measurements took place in 10-minute bins for at least two full night-time periods;
- Noise data was synchronised with the wind data measured onsite using an anemometer at a 1.5 m height.

[3] Changes in instrument readings due to a change in altitude (air pressure), temperature and humidity

3.5 Onsite Ambient Sound Level Measurements

Ambient sound levels were measured in the area for the Loeriesfontein and Kokerboom WEF's. The sound levels are discussed in the following sections.

3.5.1 Loeriesfontein measurements

Measurements were collected at seven (7) locations during the day and night of 13th June 2011. The results are presented in **Table 3.1** below.

Table 3.1: Results of ambient sound level monitoring (Datum type: WGS 84, Decimal Degrees)

Point name	Location, Latitude	Location, Longitude	$L_{Aeq,T}$ (dBA)	$L_{A, max}$ (dBA)	$L_{A, min}$ (dBA)	$L_{A, 90}$ (dBA)	Wind speed Ave. (m/s)
LBN01 (N)	-30.336740°	19.584582°	25.7	32.1	16.3	18.8	1.1
LBN02 (N)	-30.420516°	19.561455°	23.6	36.6	16.1	16.9	0.9
LBN03 (N)	-30.485515°	19.557087°	29.7	43.1	17	19.4	0.9
LBN04 (D)	-30.497410°	19.557970°	54.3	64.2	48.9	50.8	4.2
LBN05 (D)	-30.498541°	19.559391°	74.1	74.5	72.7	73.5	3.2
LBN06 (D)	-30.476170°	19.563890°	30.6	38.9	18.3	23.3	0.4
LBN07 (D)	-30.428747°	19.605808°	42.2	55.7	25.4	33.5	3.4
LBN07 (D)(T)	-30.428747°	19.605808°	51.3	61.2	28.4	33.1	3.2

Notes:

- The Sound Level Meter was fitted with the WS-03 all-weather windshield during times when the average wind speed exceeded 3 m/s
- (D) = Day, (N) = Night, (R) = Road, (T) = Train moving slowly through station
- The Rion Sound Level Meter NL 32 minimum limit is at 18 dBA.
- LBN05 taken approximately 1m from Transformer inside the substation perimeter.

Measurements indicated an area with very low ambient sound levels (away from dwellings and industrial activities - the Eskom substation). During the period that measurements were collected sound levels in the area ranged from less than 18 dBA (L_{A90}) upwards, indicating that this area is very quiet (with no wind blowing and away from anthropogenic activities). All samples illustrate the rural character of the area during periods with light winds, with mainly natural sounds defining the acoustic character. Measurements closer to one dwelling and the Eskom substation indicated significantly increased sound levels.

3.5.2 Kokerboom Measurements

A number of additional measurements were collected during the day and night of 17 June 2016, with the site visit confirming the very low ambient sound levels in the area. Sound levels closer to construction activities and the substation (where the Loeriesfontien WEF contractor's camp are located) are significantly elevated.

Equipment used at this location is defined in the following table.

Table 3-2: Equipment used to do singular measurements

Equipment	Model	Serial no	Calibration
SLM	RION NA-28	00901489	May 2015
Microphone	UC-59	02087	May 2015
Calibrator	Quest CA-22	J 2080094	June 2016

Note: SLM fitted at all times with appropriate windshield

The data collected and information about the measurement locations are presented in **Table 3-3**[4]. All the 10-minute measurements indicated an area with a potential to be quiet, although traffic on the roads as well as natural (birds, insects and wind-induced noises) did increased the noise levels.

3.6 AMBIENT SOUND LEVELS – SUMMARY

Daytime measured data indicate an area with elevated noise levels, but, considering the spectral data and sounds heard, these sounds are mainly due to natural activities (wind-induced). Night-time measurements indicated a very quiet environment, even with low winds (around 0 – 2 m/s). Considering the measurements, and measurements conducted in the last few years at similar areas, acceptable rating levels for the area would be typical of a rural noise district.

There is a high confidence in the ambient sound levels measured and the subsequent Rating Levels determined. For the purpose of the future Environmental Noise Impact Assessment study, the strictest rating level (rural) will be used as defined in SANS 10103:2008 (35 dBA at night, 45 dBA during the day) for all the receptors living in the area.

[4] Note:
$L_{Aeq,i}$ - Equivalent (average) A-weighted impulse-time-weighted noise level
$L_{Aeq,f}$ - Equivalent (average) A-weighted fast-time-weighted noise level
L_{A90} - Noise level that is exceeded 90% or more of the time, A-weighted fast-time-weighted noise level

Table 3-3: Summary of singular noise measurement

Measurement location	$L_{Aeq,i}$ level (dBA)	$L_{Aeq,f}$ level (dBA)	L_{A90} Level (dBA90)	Spectral character	Comments
Daytime data					
MKWEFSTASL101 (-30.314288°, 19.590754°)	37 39	36 37	30 26	**Figure 3-1**	Very quiet with wind induced noises dominating. Aeolian noises from fence wires just audible at times. Wind speed ranging between 4 and 8 m/s at 2m height.
MKWEFSTASL102 (-30.328244°, 19.497512°)	37 41	35 39	31 27	**Figure 3-2**	Wind induced noises, grass rustling. Very quiet environment. 3 m/s average wind with a few gusts.
MKWEFSTASL103 (-30.392800°, 19.569415°)	41 45	38 40	30 29	**Figure 3-3**	Quiet location. Wind induced noises with 6 to 8 m/s wind. Truck in distance barely audible 2nd measurement. Bird call second measurement was audible. Wind noise dominant.
MKWEFSTASL104 (-30.431132°, 19.558799°)	72 68	68 64	41 37	**Figure 3-4**	Construction area. Excavator in distance barely audible. Other trucks passing measurement location. Reverse alarms audible in area. 4 - 6 m/s wind. 4 Cars, 4 trucks first measurement, 2 cars and 3 trucks second measurement.
MKWEFSTASL105 (-30.524433°, 19.517243°)	36 35	34 32	17 25	**Figure 3-5**	Wind induced noises dominant. Crows flying in area, squawking audible first measurement. 3 - 5 m/s wind.
MKWEFSTASL106 (-30.498437°, 19.557166°)	55 59	53 56	49 49	**Figure 3-6**	Sounds from construction camp. Vehicle idling at sub-station. Voices. Running engine and impulsive sounds (material dropping) dominant sound. Reverse alarms. Vehicles entering contractor's area. Frequently. Vehicles travelling between camp and sub-station. 3 - 5 m/s wind. 3 cars and 4 cars first and second measurement.
MKWEFSTASL107 (-30.554480°, 19.550756°)	60 61	58 59	26 26	**Figure 3-7**	Some wind-induced noises. Very quiet with bird calls. End of shift and passing vehicles generate significant noises. 4 cars, 1 trucks first measurement, 3 cars and 1 truck second measurement. Vehicles driving fast.
MKWEFSTASL108 (-30.668283°, 19.526764°)	20 21	17 18	15 15	**Figure 3-8**	Extremely quiet. No sounds observable. No wind.
Night-time data					
MKWEFSTASL101 (-30.314288°, 19.590754°)	18 20	16 18	15 16	**Figure 3-9**	Possible corona discharge type sound from somewhere, source unknown (just audible). Crickets just audible. Bird in distance at times. Very quiet.
MKWEFSTASL107 (-30.554480°, 19.550756°)	16 19	15 15	14 14	**Figure 3-10**	Very quiet location. No audible sounds.

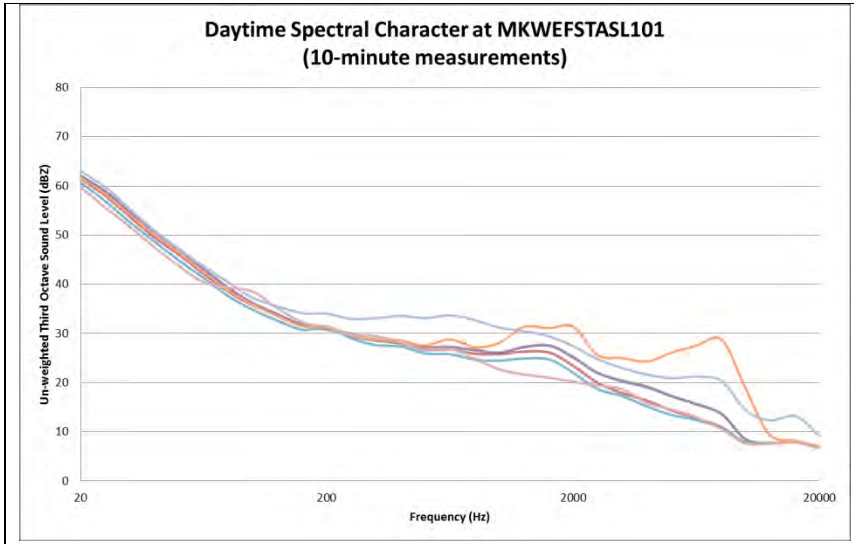

Figure 3-1: Spectral frequencies at MKWEFSTASL101

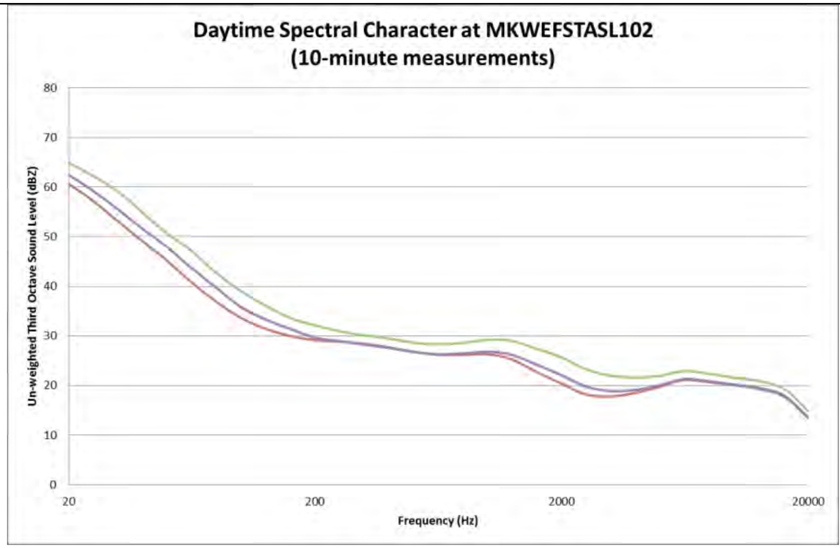

Figure 3-2: Spectral frequencies at MKWEFSTASL102

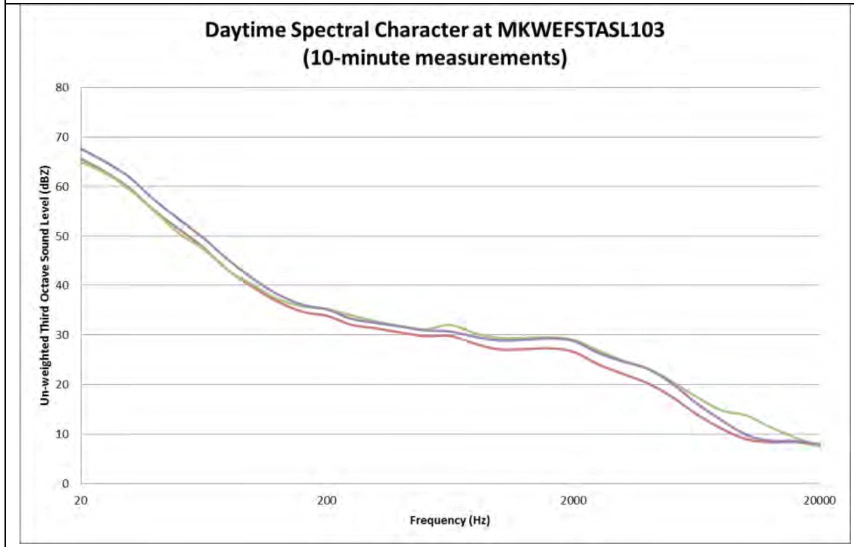

Figure 3-3: Spectral frequencies at MKWEFSTASL103

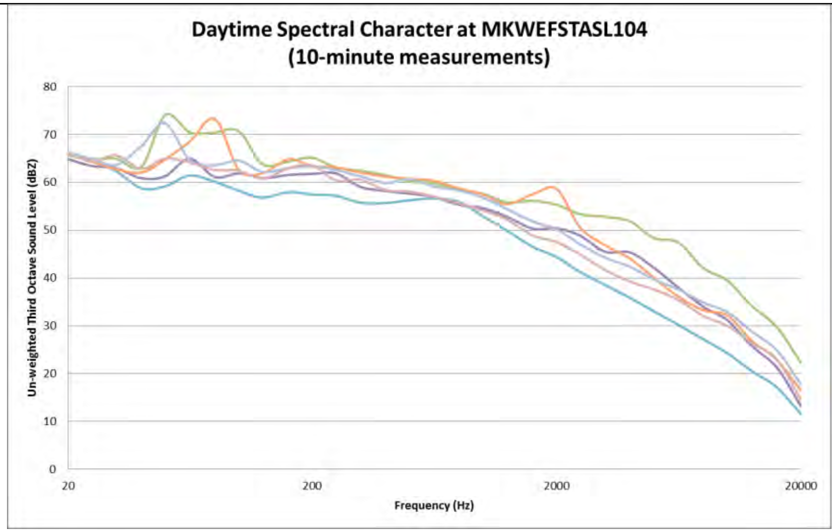

Figure 3-4: Spectral frequencies at MKWEFSTASL104

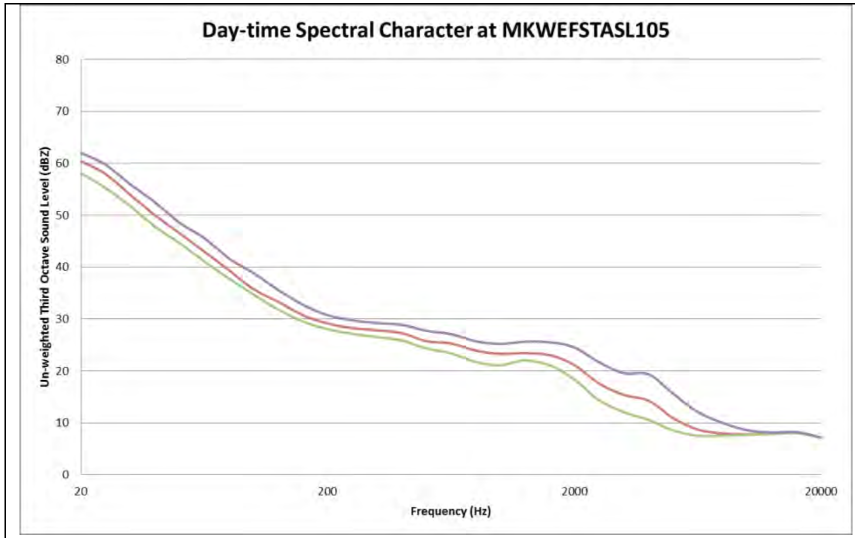

Figure 3-5: Spectral frequencies at MKWEFSTASL105

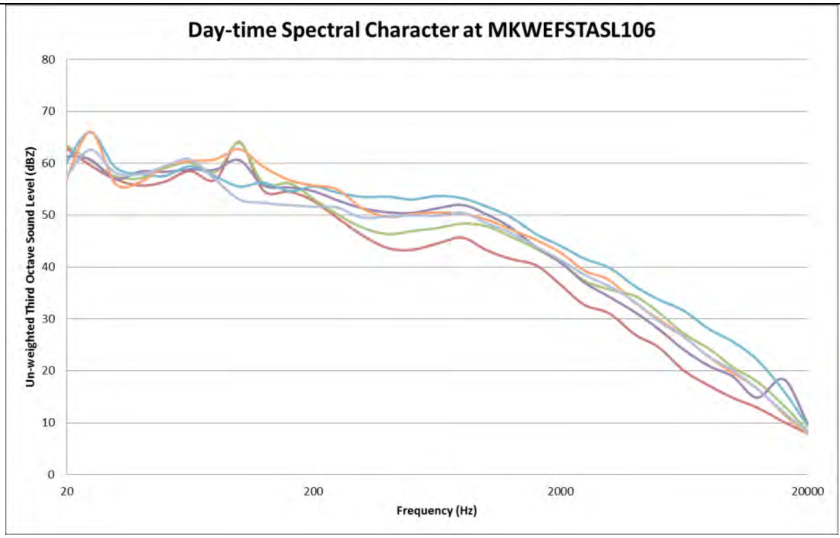

Figure 3-6: Spectral frequencies at MKWEFLTASL106

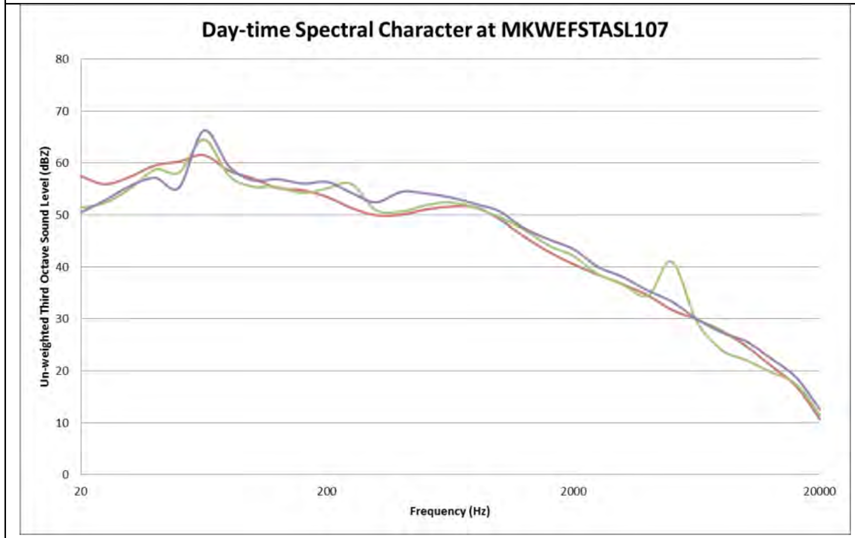

Figure 3-7: Spectral frequencies at MKWEFSTASL107

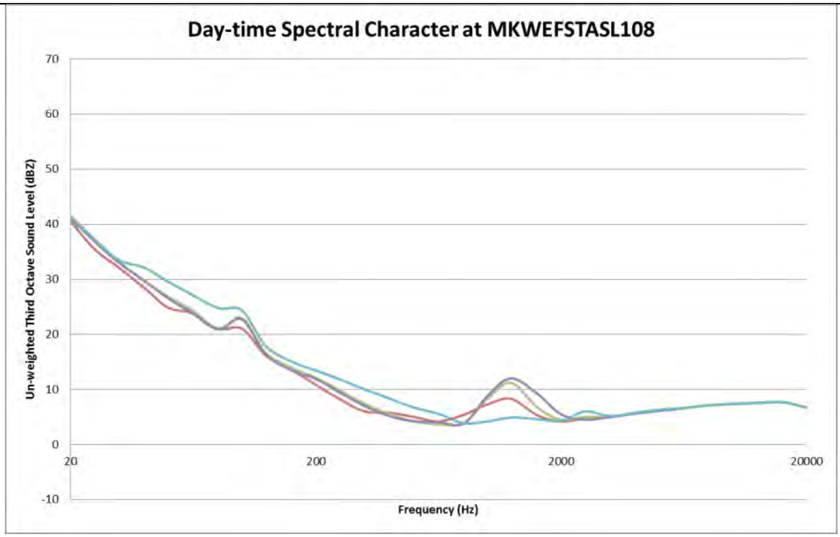

Figure 3-8: Spectral frequencies at MKWEFLTASL108

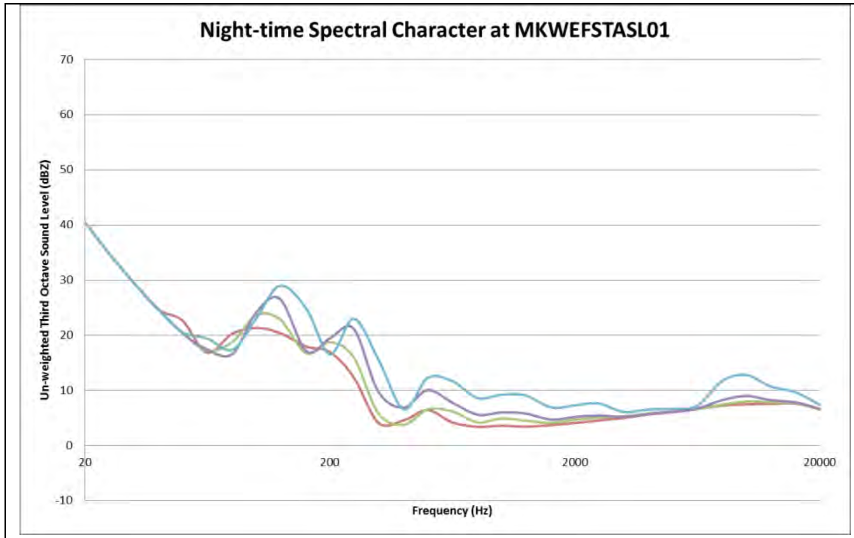	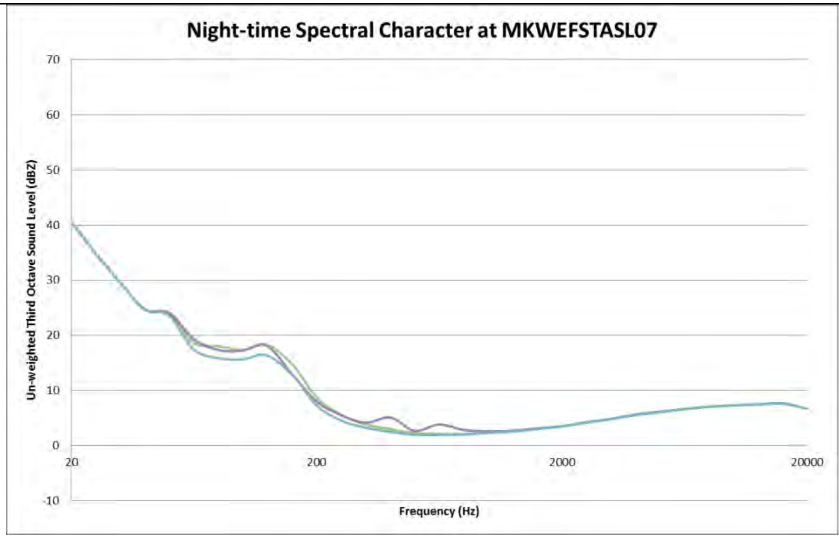
Figure 3-9: Spectral frequencies at MKWEFSTASL101	**Figure 3-10: Spectral frequencies at MKWEFLTASL107**

4 POTENTIAL NOISE SOURCES

Increased noise levels are directly linked with the various activities associated with the construction of the WEF's and related infrastructure, as well as the operational phase of the wind farms. The activities relating to construction of the WEF's are discussed in a generalised manner in the following sections.

The most significant stage relating to noise is generally the operational phase, and not the construction phase. This is due to the relatively short duration of construction activities.

4.1 POTENTIAL NOISE SOURCES: CONSTRUCTION PHASE

4.1.1 Construction equipment

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 large distances, they 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 4-1**.

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 are presented in **Table 4-2**.

Table 4-1: Potential maximum noise levels generated by construction equipment (for illustration purposes)

Equipment Description[5]	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 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**
Auger Drill Rig	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Backhoe	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Chain Saw	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Compactor (ground)	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Compressor (air)	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Concrete Batch Plant	No	117.7	92.7	86.7	80.6	72.7	66.7	63.1	60.6	57.1	52.7	49.2	46.7	40.6
Concrete Mixer Truck	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Concrete Pump Truck	No	116.7	91.7	85.7	79.6	71.7	65.7	62.1	59.6	56.1	51.7	48.2	45.7	39.6
Concrete Saw	No	124.7	99.7	93.7	87.6	79.7	73.7	70.1	67.6	64.1	59.7	56.2	53.7	47.6
Crane	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Dozer	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Drill Rig Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Drum Mixer	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Dump Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Excavator	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Flat Bed Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Front End Loader	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Generator	No	116.7	91.7	85.7	79.6	71.7	65.7	62.1	59.6	56.1	51.7	48.2	45.7	39.6
Generator (<25KVA)	No	104.7	79.7	73.7	67.6	59.7	53.7	50.1	47.6	44.1	39.7	36.2	33.7	27.6
Grader	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Impact Pile Driver	Yes	129.7	104.7	98.7	92.6	84.7	78.7	75.1	72.6	69.1	64.7	61.2	58.7	52.6
Jackhammer	Yes	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Man Lift	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
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

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

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

Table 4-2: Potential equivalent noise levels generated by various equipment (for illustration purposes)

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
Bulldozer CAT D11	113.3	88.4	82.3	76.3	68.4	62.3	58.8	56.3	52.8	48.4	44.8	42.3	36.3
Bulldozer CAT D9	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
Bulldozer CAT D6	108.2	83.3	77.3	71.2	63.3	57.3	53.7	51.2	47.7	43.3	39.8	37.3	31.2
Bulldozer CAT D5	107.4	82.4	76.4	70.4	62.4	56.4	52.9	50.4	46.9	42.4	38.9	36.4	30.4
Bulldozer Komatsu 375	114.0	89.0	83.0	77.0	69.0	63.0	59.5	57.0	53.4	49.0	45.5	43.0	37.0
Bulldozer Komatsu 65	109.5	84.5	78.5	72.4	64.5	58.5	54.9	52.4	48.9	44.5	41.0	38.5	32.4
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
Dumper/Haul truck - Bell 25 ton (B25D)	108.4	83.5	77.5	71.4	63.5	57.5	53.9	51.4	47.9	43.5	40.0	37.5	31.4
Excavator - Cat 416D	103.9	78.9	72.9	66.8	58.9	52.9	49.3	46.8	43.3	38.9	35.4	32.9	26.8
Excavator - Hitachi 870 (80 t)	108.1	83.1	77.1	71.1	63.1	57.1	53.6	51.1	47.5	43.1	39.6	37.1	31.1
Excavator - Hitachi 270 (30 t)	104.5	79.6	73.5	67.5	59.6	53.5	50.0	47.5	44.0	39.6	36.0	33.5	27.5
FEL - CAT 950G	102.1	77.2	71.2	65.1	57.2	51.2	47.6	45.1	41.6	37.2	33.7	31.2	25.1
FEL - Komatsu WA380	100.7	75.7	69.7	63.7	55.7	49.7	46.2	43.7	40.1	35.7	32.2	29.7	23.7
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
Grader	110.9	85.9	79.9	73.9	65.9	59.9	56.4	53.9	50.3	45.9	42.4	39.9	33.9
JBL TLB	108.8	83.8	77.8	71.8	63.8	57.8	54.3	51.8	48.3	43.8	40.3	37.8	31.8
Road Transport Reversing/Idling	108.2	83.3	77.2	71.2	63.3	57.2	53.7	51.2	47.7	43.3	39.7	37.2	31.2
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
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 (Vestas V90 maximum)	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

Construction activities include:

- construction of access roads;
- establishment of turbine tower foundations and electrical substation(s);
- the possible establishment, operation and removal of concrete batching plants;
- the construction of any buildings;
- digging of trenches to accommodate underground power cables; and
- the erection of turbine towers and assembly of WTG's.

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.

4.1.2 Material supply: Concrete batching plants and use of Borrow Pits

Instead of transporting the required material to the site using concrete trucks, portable concrete batching plants may be required to supply concrete onsite. Batching plant equipment may be relocated between the sites as the works progress to different areas of the site. Materials from cuttings and excavations will be reused where possible. If not available, materials will be sourced from registered and licensed burrow pits in the area.

4.1.3 Blasting

Blasting may be required as part of the civil works to clear obstacles or to prepare foundations.

Blasting will not be considered during the EIA phase for the following reasons:

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

4.1.4 Traffic

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

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

4.2 POTENTIAL NOISE SOURCES: OPERATIONAL PHASE

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 lesser noise sources, such as the sub-stations, traffic (maintenance) and transmission line noise.

4.2.1 Wind Turbine Noise: Aerodynamic sources[6]

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); and
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, increases very slightly or even drops as illustrated in **Figure 4.1**.

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[6] Renewable Energy Research Laboratory, 2006; ETSU R97: 1996

The propagation model makes use of various frequencies, because these frequencies are affected in different ways as it propagates through air, over barriers and over different ground conditions providing a higher accuracy than models that only use the total sound power level. The octave sound power levels for various wind turbines are presented on **Figure 4-2**.

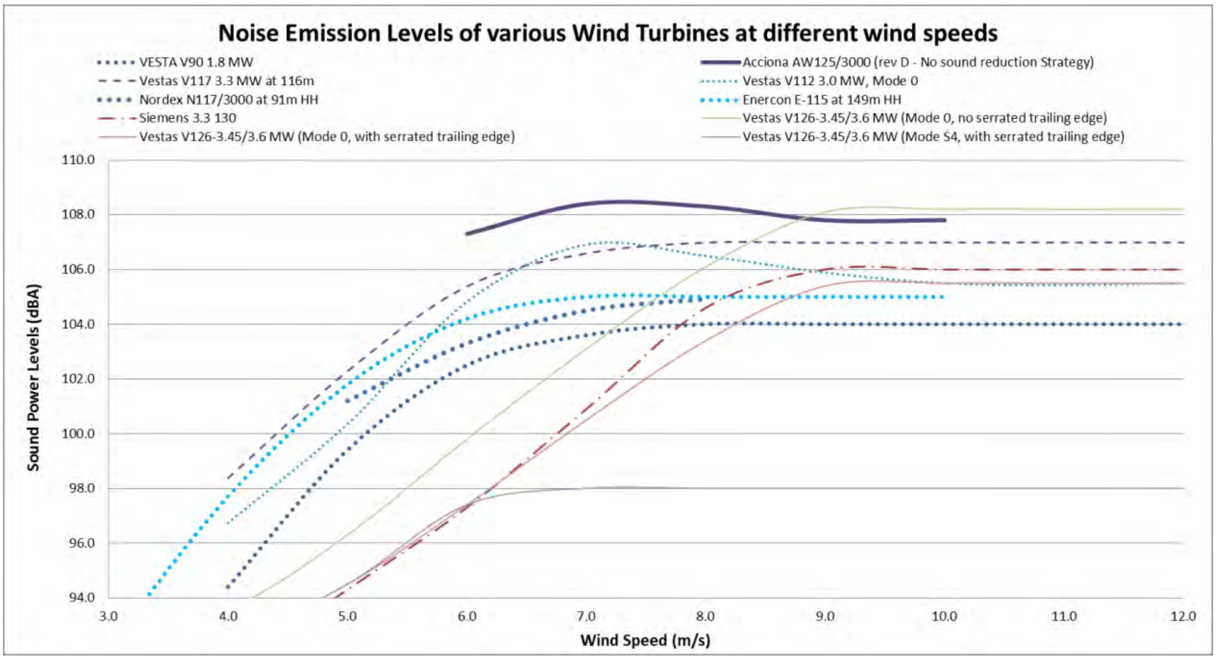

Figure 4.1: Noise Emissions Curve of a number of different wind turbines

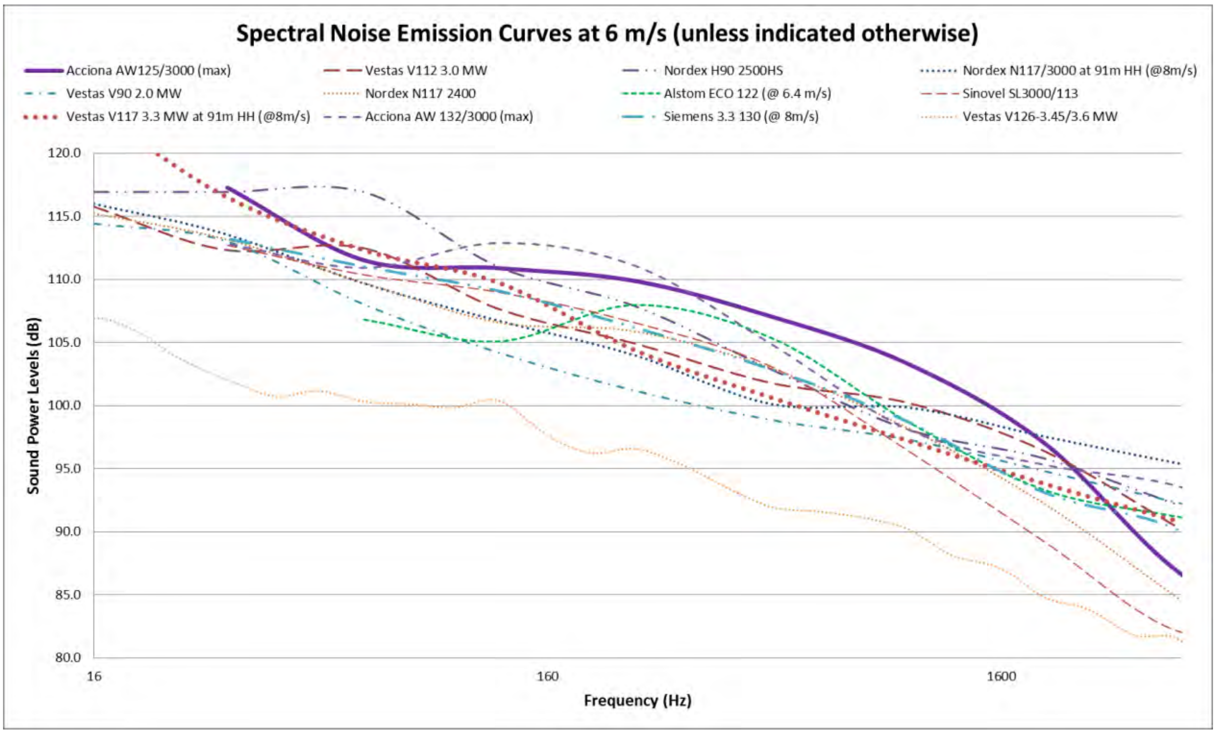

Figure 4-2: Octave sound power emissions of various wind turbines

4.2.2 Wind Turbine: Mechanical sources[7]

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[8] 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 indeed has 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 minimise 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[9] do not emit any clearly distinguishable tones***.

4.2.3 Transformer noises (Sub-stations)

Also known as magnetostriction, this is when the sheet steel used in the core of the transformer tries to change shape when being magnetised. When the magnetism is taken

[7] Renewable Energy Research Laboratory, 2006; ETSU R97: 1996; Audiology Today, 2010; HGC Engineering, 2007.
[8] Yaw is the angle of rotation of the nacelle (containing the gearbox and generator) around its vertical axis, essential to ensure that wind turbines always face directly into the wind.
[9] The wind turbines considered by the client will mostly likely fall in this category.

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 is taking place erratically all over each sheet, and each sheet is behaving erratically with respect to its neighbour. The result is the "hum" frequently associated with transformers. While this may be a soothing sound in small home appliances, various complaints are lodged 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. ***This is a relative easy noise to mitigate with the use of acoustic shielding and/or placement of the transformer and will not be considered further in this noise scoping report nor in the ENIA study.***

4.2.4 Transmission Line Noise (Corona noise) (Grid connection impact)

Corona noise 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 70 kV 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 characterized as broadband 'crackling' or 'buzzing', and ***it is generally only a feature during fog or rain***.

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

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

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.

4.2.5 Low Frequency Noise[10]

4.2.5.1 Background and Information

"Low frequency sound" is the term used to describe sound energy in the region below ~200Hz. The rumble of thunder and the throb of a diesel engine are both examples of sounds with most of their energy in this low frequency range. Infrasound is often used to describe sound energy in the region below 20 Hz. Almost all noise in the environment has components in this region although they are of such a low level that they are not significant (wind, ocean, thunder).

While significant work has been done in this field, uncertainties exist around Infrasound and Low Frequency Noise.

4.2.5.2 The generation of Low Frequency Sounds

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.

4.2.5.3 Detection of Low Frequency Sounds

Investigations have shown that the perception and the effects of sounds differ considerably at low frequencies as compared to mid- and high frequencies. The main aspects to these differences are:

- a weakening of pitch sensation as the frequency of the sound decreases below 60 Hz;
- perception of sounds as pulsations and fluctuations;
- a much more rapid increase of loudness and annoyance with increasing sound level at low frequencies than at mid- or high frequencies;
- complaints about the feeling of ear pressure;
- annoyance caused by secondary effects like rattling of building elements, e.g. windows and doors or the tinkling of bric-a-brac;
- other psycho acoustic effects, e.g. sleep deprivation, a feeling of uneasiness; and
- reduction in building sound transmission loss at low frequencies compared to mid- or high frequencies.

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

4.2.5.4 Measurement, Isolation and Assessment of Low Frequency Sounds

Significant debate remains regarding the noise from WTG's, public response to that noise, as well as the presence or absence of low frequency sound and how it affects people. While low frequency sounds can be measured, it is far more difficult to isolate low frequency sounds, due to the numerous sources generating these sounds.

From sound power level emission tables (for Wind Turbines) it can be seen that a wind turbine has the potential to generate low frequency sounds with sufficient energy to warrant the need to investigate WTG as a source of low frequency sounds. Each turbine make, model and size has a specific noise emission characteristic. The larger a wind turbine (especially the blades), the higher the acoustical energy in the lower frequencies and the potential for low frequency sounds should be evaluated for each project and turbine proposed.

SANS 10103:2004 proposes a method to identify whether low frequency noise could be an issue. It proposes that if the difference between the A-frequency weighted and the C-frequency weighted equivalent continuous ($L_{Aeq} >> L_{Ceq}$) sound pressure levels is greater than 10 dB, a predominant low frequency component **may** be present.

4.2.5.5 Summary: Low Frequency Noise[11]

Low frequency noise is always present around us, as it is produced by both man and nature. While problems have been associated with older downwind wind turbines in the 1980s, this has been considered by the wind industry and modern upwind turbines do not suffer from the same problems.

4.2.6 Amplitude modulation[12]

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

Regrettably, the mechanism of this noise is not known though various possible reasons have been put forward. Although the prevalence of complaints about amplitude modulation is relatively small, it is not clear whether this is because it does not occur often enough or whether it is because housing is not in the right place to observe it. Furthermore the fact that the mechanism is unverified means that it is not possible to predict when or whether it will occur.

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[11] BWEA, 2005
[12] Renewable Energy Research Laboratory, 2006; Audiology Today, 2010; HGC Engineering, 2007; Whitford, 2008; Noise-con, 2008; DEFRA, 2007; Bowdler, 2008

Even though there are thousands of wind turbine generators in the world, amplitude modulation is one subject receiving the least complaints and due to these very few complaints, little research has gone into this subject. ***It is included in this report to highlight all potential risks, albeit extremely low risks such as this (low significance due to very low probability)***.

5 METHODOLOGY: CALCULATION OF FUTURE NOISE EMISSIONS DUE TO PROPOSED PROJECT

5.1 NOISE EMISSIONS INTO THE SURROUNDING ENVIRONMENT

The noise emissions into the environment from the various sources as defined by the project developer will be calculated during this scoping phase using the sound propagation models described by ISO 9613-2 (operational phase) and SANS 10357[13] (construction phase). The following will be taken into account:

- The octave band sound pressure emission levels of processes and equipment;
- The distance of the receiver from the noise sources;
- The impact of atmospheric absorption;
- The layout details of the proposed project;
- The height of the noise source under investigation;
- Topographical layout; and
- Acoustical characteristics of the ground.

The potential impact from traffic will be considered during the Scoping phase using the sound propagation model described in SANS 10210:2004[14]. Corrections such as the following will be considered:

- Distance of a noise-sensitive development from roads;
- Road construction material;
- Average speeds of travel; and
- Types of vehicles used.

The layout as presented will be assessed in detail and used to assess the magnitude, the extent of potential noises as well as the potential significance of the noise impact. As the details of the preferred wind turbine are unknown, the sound power emission levels of a relatively noisy wind turbine will be used (see **Figure 4.1**). The scoping assessment therefore leans towards a worst-case approach.

[13] SANS 10357:2004 The calculation of sound propagation by the Concave method'
[14] SANS 10210:2004. 'Calculating and predicting road traffic noise'

6 LIMITATIONS AND ASSUMPTIONS

6.1 MEASUREMENTS OF AMBIENT SOUND LEVELS

The selection of measurement locations is critical to provide information on the soundscape. Sound levels closer to dwellings are generally significantly higher than the sounds away from these dwellings. This is due to residents of the dwellings significant altering the surrounding dwelling sound environment, develop infrastructure and alter vegetation (that also attracts other animals) that also changes the sound character. Activities associated with the dwelling (agricultural, equipment operating, etc.) would also increase the noise levels. Factors that need to be considered include:

- Ambient sound levels are the cumulative effects of innumerable sounds generated at various instances both far and near. High measurements may not necessarily mean that noise levels in the area are high. Similarly, a low sound level measurement will not necessarily mean that the area is always quiet, as sound levels will vary over seasons, time of the day, faunal characteristics, vegetation in the area and meteorological conditions (especially wind). This is excluding the potential effect of sounds from anthropogenic origin. It is impossible to quantify and identify the numerous sources that influenced one 10-minute measurement using the reading result at the end of the measurement. Therefore trying to define ambient sound levels using the result of one 10-minute measurement will be very inaccurate (very low confidence level in the results) for the reasons mentioned above. The more measurements that can be collected at a location the higher the confidence levels in the ambient sound level determined. The more complex the sound environment, the longer the required measurement. It is assumed that the measurement locations represents other residential dwellings in the area (similar environment), yet, in practice this can be highly erroneous as there are numerous factors that can impact on ambient sound levels, including;
    - the distance to closest trees, number and type of trees as well as the height of trees;
    - available habitat and food for birds and other animals;
    - distance to residential dwelling, type of equipment used at dwelling (compressors, air-cons);
    - general maintenance condition of house (especially during windy conditions); and
    - a number and type of animals kept in the vicinity of the measurement locations.
- Measurement locations for this project were selected to be in a relative quiet area, away from the residential dwelling to minimize the potential of extraneous noises impacting on the ambient sound levels,

- Exact location of a sound level meter in an area in relation to structures, infrastructure, vegetation and external noise sources will influence measurements. It may determine whether one is measuring anthropogenic sounds from a receptors dwelling, or environmental ambient soundscape contributors of significance (faunal, roads traffic, railway line movement etc.). At times there are extraneous noises that cannot be heard during deployment, or not operational, that can significantly impact on readings (such as water pumps, transformers, faunal communication, etc.);
- Determination of existing road traffic and other noise sources of significance are important (traffic counts etc.) – when close to any busy or significant roads. Traffic however is highly dependent on the time of day as well as general agricultural activities taking place during the site investigation. Traffic noise is one of the major components in urban areas and could be a significant source of noise during busy periods. This study found that traffic in the area was very low, yet it cannot be assumed that it is always low.
- Measurements over wind speeds of 3 m/s could provide data influenced by wind-induced noises. While the windshields used limits the effect of fluctuating pressure across the microphone diaphragm, the effect of wind-induced noises in the trees in the vicinity of the microphone did impact on the ambient sound levels. The site visit unfortunately coincided with a relatively windy period;
- Ambient sound levels are depended not only time of day and meteorological conditions, but also change due to seasonal differences. Ambient sound levels are generally higher in summer months when faunal activity is higher and lower during the winter due to reduced faunal activity. Winter months unfortunately also coincide with lower temperatures and very stable atmospheric conditions, ideal conditions for propagation of noise. Many faunal species are more active during warmer periods than colder periods. Certain cicada species can generate noise levels up to 120 dB for mating or distress purposes, sometimes singing in synchronization, magnifying noise levels they produce from their tymbals[15];
- Ambient sound levels recorded near rivers, streams, wetlands, trees and bushy areas can be high. This is due to faunal activity which can dominate the sound levels around the measurement location. This generally is still considered naturally quiet and understood and accepted as features of the natural soundscape, and in various cases sought after and pleasing;
- Considering one or more sound descriptor or equivalent can improve an acoustical assessment. Parameters such as L_{AMin}, L_{AIeq}, L_{AFeq}, L_{Ceq}, L_{AMax}, L_{A10}, L_{A90} and spectral analysis forms part of the many variables that can be considered; and

[15] Clyne, D. *"Cicadas: Sound of the Australian Summer, Australian Geographic"* Oct/Dec Vol 56. 1999.

- As a residential area develops the presence of people will result in increased sounds. These are generally a combination of traffic noise, voices, animals and equipment (incl. TV's and Radios). The result is that ambient sound levels will increase as an area matures.

6.2 ADEQUACY OF UNDERLYING ASSUMPTIONS

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

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

6.3 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 a NSD), or the mitigation may result in the project not being economically viable. These mitigation measures may be engineered, technological or due to management commitment.

For the purpose of this report (determination of the significance of the noise impact) mitigation measures will be selected that is feasible, mainly focusing 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 will be assumed the mitigation measures proposed for the construction phase will be implemented and continued during the operational phase. If mitigation proposed in this report will be adequate to manage the significance of the noise impact to low, no further noise studies will be recommended in the EIA phase.

6.4 Uncertainties of Information Provided and sound propagation modelling

It is important to understand the difference between sound or noise level as well as the noise rating level (also see Glossary of Terms). Sound or noise levels generally refers to a sound pressure level as measured using an instrument, whereas the noise rating level refers to a calculated noise level to which various corrections and adjustments was added.

These noise rating levels are further processed into a 3D map illustrating noise contours of constant rating levels or noise isopleths. In this project it illustrates the potential extent of the calculated noises of the complete project and not noise levels at a specific moment in time. It is used to define potential issues of concern and not to predict a noise level at a potential noise-sensitive receptor. For this the selected model is internationally recognised and considered adequate.

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

- The octave sound power levels selected for processes and equipment accurately represent the sound character and power levels of this processes/equipment. The determination of these 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 change depending on the load the process and equipment is subject too. 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. Normally 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 (and when operational and for how long), modelling considers a scenario where all 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 over-estimate noise levels;
- Ambient sound levels vary over time of day, season and largely depend on the complexity and development character of the surrounding environment. To allow the calculation of change in ambient sound levels, a potential ambient sound level of 35 dBA is assumed. This level represents a quiet environment;

- Modelling cannot capture the potential impulsive character of a noise that can increase the potential nuisance factor;
- Topography impacts on sound propagation as it can allow the reflection of sound from the surface and result in refraction effects due to wind gradients. Studies in this regard indicated that it is difficult to model noise levels accurately when facing complex topography challenges (especially deep valleys and canyons);
- 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; and
- Acoustical characteristics of the ground are over-simplified with ground conditions accepted as uniform. 75% hard ground conditions will be modelled even though the area is where the facility will be located is relatively well vegetated and uneven. This will allow a more precautious worst-case scenario.

7 METHODOLOGY: ENVIRONMENTAL NOISE IMPACT ASSESSMENT AND SIGNIFICANCE

7.1 NOISE IMPACT ON ANIMALS[16]

While there are few specific studies focusing on noises from wind turbines, there are a number of publications where the effects of increased noises on certain species were studied. This is because hearing is critical to an animal's ability to:

- React;
- Compete;
- Seek mates and reproduce;
- Hunt and forage;
- Communicate; and
- Survive.

Overall, the research suggests that species differ in their response to:

- Various types of noise;
- Durations of noise; and
- Sources of noise.

The only animal species studied in detail are humans, and studies are still continuing today. 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 (see **Figure 7-1**).

Only a few faunal 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 do indicate definitive levels where noises start to impact on animals, with most based on laboratory level research that subject animals to noise levels that are significantly higher than the noise levels these animals may experience in the 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).

[16] Report to Congressional Requesters, 2005; USEPA, 1971; Autumn, 2007; https://en.wikipedia.org/wiki/Hearing_range; Noise quest, 2010; http://www.noisequest.psu.edu/noiseeffects-animals.html; Schaub, 2008; Dooling, 2007; Dooling, 2002; Guillaume, 2012; Bayne, 2008; Barber, 2009; Habib, 2007; Derryberry, 2016; Lohr, 2003; Rabin, 2006

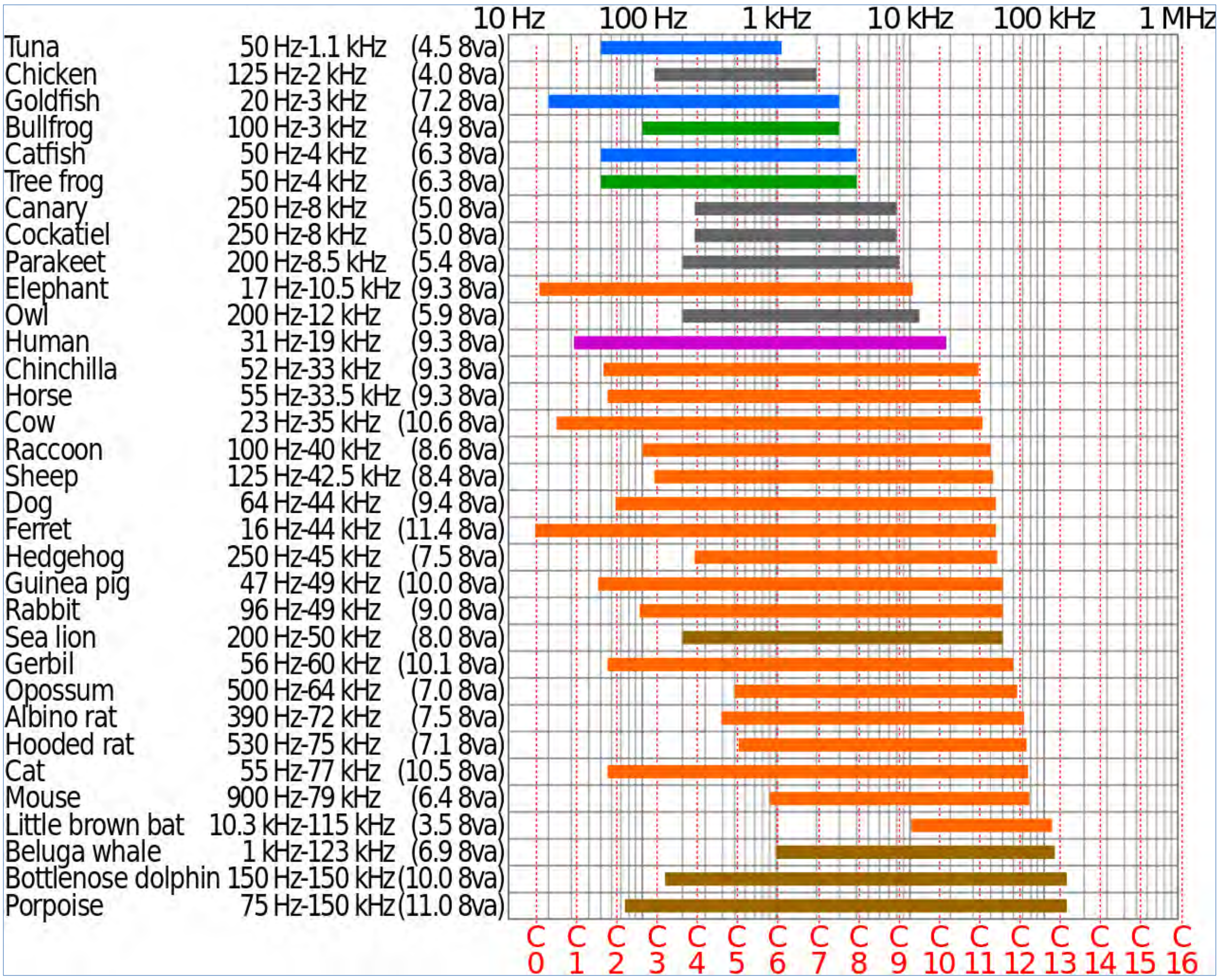

Figure 7-1: Logarithmic chart of the hearing ranges of some animals

A general animal behavioural reaction to impulsive is the startle response. However, the strength and length of the startle response appears to be dependent on:

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

Unfortunately, there are numerous other factors in the environment of animals 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.

From these and other studies the following can be concluded:

- Animals respond to impulsive (sudden) noises (higher than 90 dBA) by running away. If the noises continue, animals would try to relocate.

- Animals of most species exhibit adaptation with noise, including impulsive noises by changing their behaviour;
- More sensitive species would relocate to a more quiet 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; and
- Noises associated with helicopters, motor- and quad bikes does significantly impact on animals.

To date there however no guidelines or sound limits with regards to noise levels that can be used to estimate the potential significance of noises on animals.

7.1.1 Domestic Animals

It has been observed that most domestic animals are generally not bothered by noise and can easily adjust to increased noise levels. As with all animals, impulsive noises will affect them as previously discussed.

7.1.2 Wildlife

Studies showed that most animals adapt (leave noise area, change communication, change times when they forage/hunt, etc.) to noises but may even return to a site after an initial disturbance, even if the noise is continuing. The availability of habitat, water and food sources are more important than environmental factors such as noise. The more sensitive animals that might be impacted by noise would most likely relocate to a quieter area unless they are restricted in movement. As mentioned, noise impacts are very highly species dependent.

7.2 WHY NOISE CONCERNS COMMUNITIES[17]

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

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

[17] World Health Organization, 1999; Noise quest, 2010; Journal of Acoustical Society of America, 2009

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

Response to noise is unfortunately not an empirical absolute, as it is seen as a multi-faceted psychological concept, including behavioural and evaluative aspects. For instance, in some cases annoyance is seen as an outcome of disturbances, in other cases it is seen as an indication of the degree of helplessness with respect to the noise source.

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

Severity of the annoyance depends on factors such as:

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

7.2.1 Annoyance associated with Wind Energy Facilities[18]

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

On the basis of a number of studies into noise annoyance, exposure-response relationships were derived for high annoyance from different noise sources. These relationships, illustrated in Figure 7.2, 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 climate.

[18] Van den Berg, 2011; Milieu, 2010.

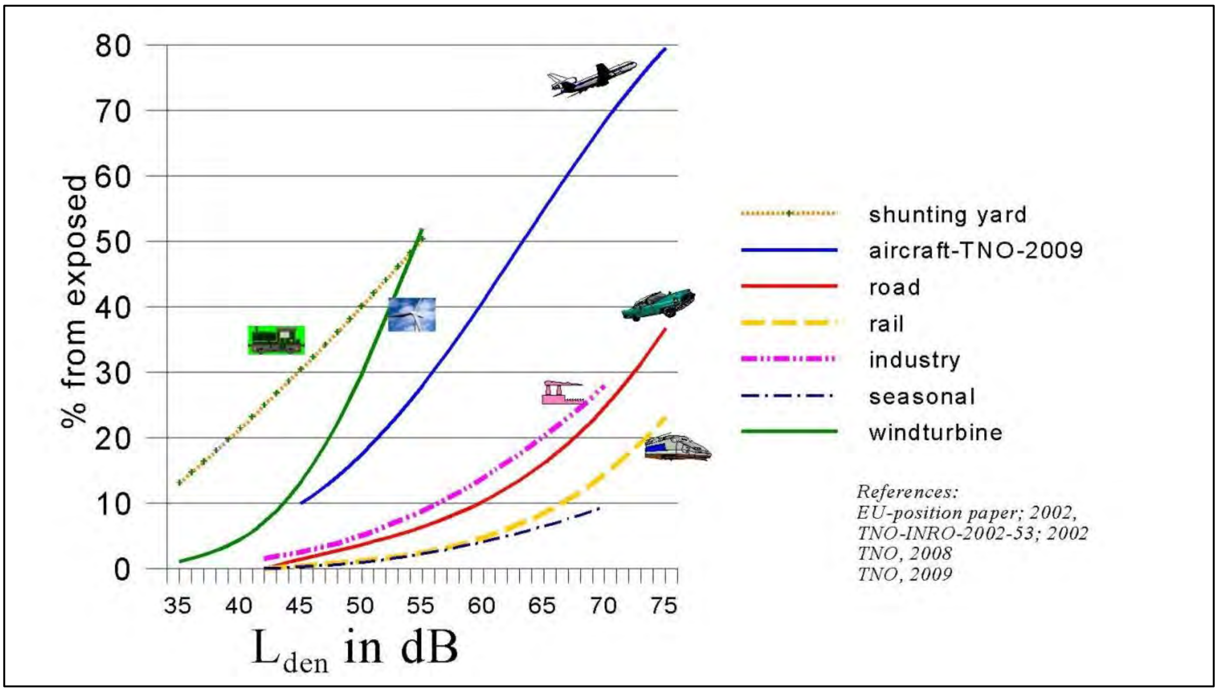

Figure 7.2: Percentage of annoyed persons as a function of the day-evening-night noise exposure at the façade of a dwelling

7.3 IMPACT ASSESSMENT CRITERIA

7.3.1 Overview: The common characteristics

In 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
- Offensiveness

Of the four common characteristics of sound, intensity is the only one which is not subjective and can be quantified. Loudness is a subjective measure of the effect 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.

7.3.2 Noise criteria of concern

The criteria used in this report were drawn from the criteria for the description and assessment of environmental impacts from the EIA Regulations, published by the Department of Environmental Affairs and Tourism (April 1998) in terms of the NEMA, SANS 10103 as well as guidelines from the World Health Organization (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, which is caused by a new source of noise. With regards to the Noise Control Regulations, **an increase of more than 7 dBA** is considered a disturbing noise. See also **Figure 7.3**.
- *Zone Sound Levels:* Previously referred as the acceptable rating levels, it sets acceptable noise levels for various areas. See also **Table 7-1**.
- *Absolute or total noise levels:* Depending on their activities, people generally are tolerant to noise up to a certain absolute level, e.g. **65 dBA**. However, anything above this level is considered unacceptable.

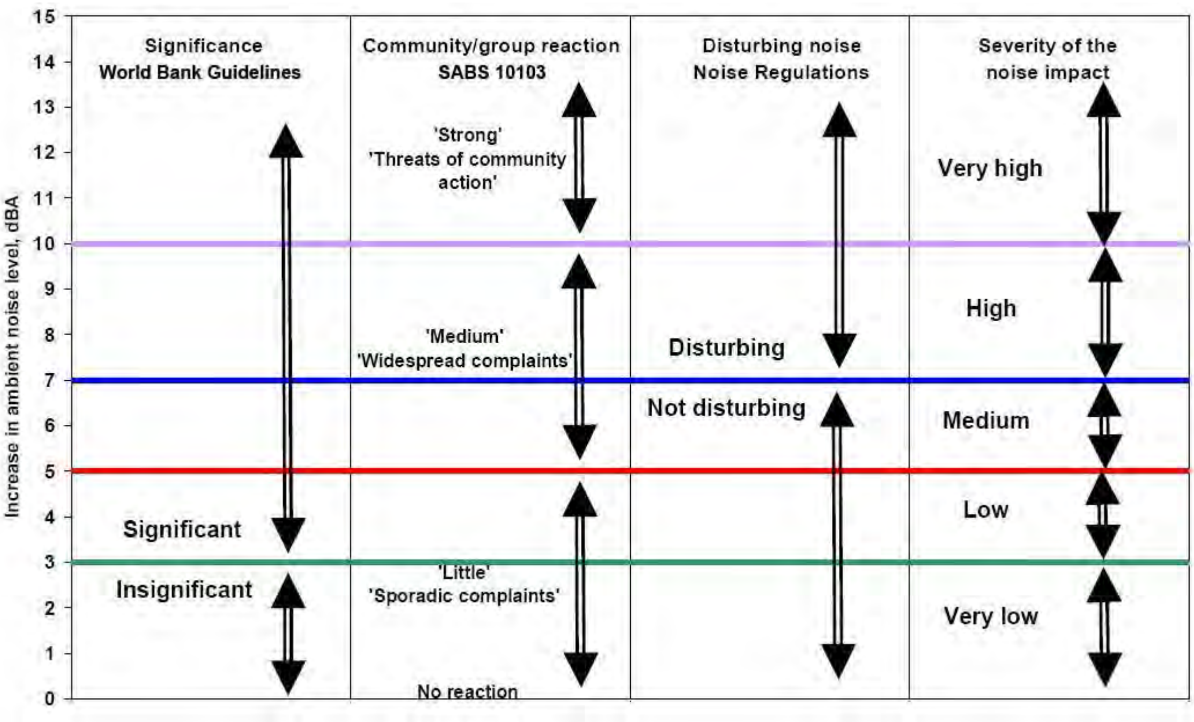

Figure 7.3: Criteria to assess the significance of impacts stemming from noise

In South Africa the document that addresses the issues concerning environmental noise is SANS 10103. See also **Table 6.1**. It provides the maximum average ambient noise levels, $L_{Req,d}$ and $L_{Req,n}$, during the day and night respectively to which different types of developments may be exposed. **For rural areas the Zone Sound Levels** (Rating Levels) are:

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

These levels are based on numerous measurements collected in relatively undeveloped areas, away from identifiable sound sources with no or low wind speeds. These levels may not be applicable in wind energy projects, as the wind turbines will only be operating in conditions where the wind is blowing. As such the noise rating levels (as calculated) should be evaluated in terms of the expected ambient sound levels for conditions typical when the wind-induced noises may be dominant (also refer to **Figure 7-4**).

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

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

In addition, it should be noted that the Noise Control Regulations defines disturbing noise to be any change in the ambient noise levels higher than 7 dBA than the background.

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

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

7.3.3 Determining appropriate Zone Sound Levels

SANS 10103, unfortunately, does not cater for instances when background noise levels change due to the impact of external forces. Locations close to the sea for instance always have a background noise level exceeding 35 dBA, and, in cases where the sea is rather turbulent, it can easily exceed 45 dBA. Similarly, noise induced by high winds again is not included.

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

7.3.3.1 Using International Guidelines to set Noise Limits

When assessing the overall noise levels emitted by a Wind Energy Facility, 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 turbines[19].

Ambient sound vs. wind speed data is presented in **Figure 7-4**[20]. This is a quiet (as per the opinion of the author) location[21] where there were no apparent or observable sounds that would have impacted on the measurements, presenting the A-Weighted sound levels at an inland area. The figures clearly indicate a trend where sound levels increase if the wind speed increases. This has been found at all locations where measurements have been done for a sufficiently long enough period of time (more than 30 locations – more than 38,000 measurements).

[19] It should be noted that this does not mean that the wind turbines are inaudible.

[20] The sound level measuring instruments were located at a quiet location in the garden of the various houses. Data was measured in 10-minute bins and then co-ordinated with the 10 m wind speed derived from the wind mast of the developer. This wind mast normally was not close to the dwelling, at times being further than 5,000 meters from the measurement location. It is possible that the wind may be blowing at the location of the wind mast with no wind at the measurement location, resulting in low sound levels recorded.

[21] Different area where longer measurements were collected.

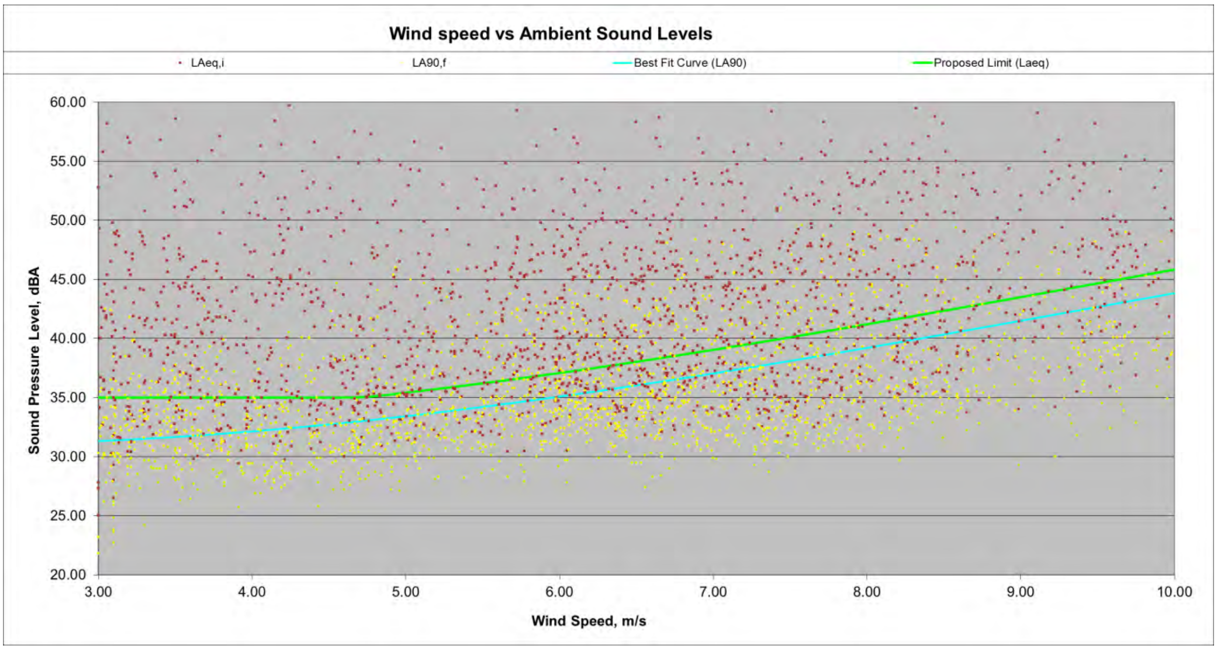

Figure 7-4: Ambient sound levels – quiet inland location (A-Weighted)

Considering this data as well as the international guidelines (MOE and IFC Noise Limits, see **sections 2.6.3** and **2.6.5**), noise limits starting at 40 dB that increases to more than 45 dB (as wind speeds increase) is acceptable. In addition, project participants could be exposed to noise levels up to 45 dBA (ETSU-R97) at lower wind speeds.

7.3.3.2 Using local regulations to set noise limits

Noise limits as set by the National Noise Control Regulations (GN R154 of 1992 – **section 2.2.1**) defines a "**disturbing noise**" as the 'n 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.

Accepting that the area is a rural district, night-time rating levels would be 35 dBA and a noise level exceeding 42 dBA could be a disturbing noise (therefore the noise limit). The daytime rating level is 45 dBA (52 dBA for a disturbing noise). This would however be for conditions with no or low winds (less than 3 m/s).

As can be observed from **Figure 7-4**, if ambient sound levels were measured at increased wind speeds, ambient sound levels will be higher as wind-induced noises increase. How wind-induced noises increase depends significantly on the measuring location and surrounding environment, but it is expected to be significantly higher than 35 dBA close to dwellings. The 42 dBA noise limit will increase, but, considering international guidelines, an upper limit of 45 dBA must be honoured. For the purpose of this report, an upper limit of 42dBA will be used.

7.3.4 Determining the Significance of the Noise Impact

Impact assessment criteria were supplied by the main consultant SiVEST, and considered for the Noise Impact Assessment (NIA). These tables were updated to suit the needs of an acoustical assessment. Updated tables were fine-tuned as depicted in the EIA regulations.

Significance is determined through a synthesis of impact characteristics. Significance is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. This describes the significance of the impact on the environmental parameter. The calculation of the significance of an impact uses the following formula:
(Extent, **Table 7-2**) + (Probability, **Table 7-3**) + (Reversibility, **Table 7-4**) + (Irreplaceability, **Table 7-5**) + (Duration, **Table 7-6**) + (Cumulative effect, **Table 7-7**). The summation of the different criteria will produce a non-weighted value. By multiplying this value with the Magnitude/intensity (**Table 7-8**), the resultant value acquires a weighted characteristic which can be measured and assigned a significance rating. An explanation of the impact assessment criteria is defined in the following tables.

Table 7-2: Impact Assessment Criteria – Geographical extent

This is defined as the area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment of a project in terms of further defining the determined.		
Rating	**Description**	**Score**
Site	The impact will only affect the site	1
Local/district	Will affect the local area or district	2
Province/region	Will affect the entire province or region	3
International and National	Will affect the entire country	4

Table 7-3: Impact Assessment Criteria – Probability

This describes the chance of occurrence of an impact.		
Rating	**Description**	**Score**
Unlikely	The chance of the impact occurring is extremely low (Less than a 25% chance of occurrence).	1
Possible	The impact may occur (Between a 25% to 50% chance of occurrence).	2
Probable	The impact will likely occur (Between a 50% to 75% chance of occurrence).	3
Definite	Impact will certainly occur (Greater than a 75% chance of occurrence).	4

Table 7-4: Impact Assessment Criteria - Reversibility

This describes the degree to which an impact on an environmental parameter can be successfully reversed upon completion of the proposed activity.		
Rating	**Description**	**Score**
Completely reversible	The impact is reversible with implementation of minor mitigation measures	1
Partly reversible	The impact is partly reversible but more intense mitigation measures are required.	2
Barely reversible	The impact is unlikely to be reversed even with intense mitigation measures.	3
Irreversible	The impact is irreversible and no mitigation measures exist.	4

Table 7-5: Impact Assessment Criteria – Irreplaceable loss of resources

This describes the degree to which resources will be irreplaceably lost as a result of a proposed activity.		
Rating	**Description**	**Score**
No loss of resource.	The impact will not result in the loss of any resources.	1
Marginal loss of resource	The impact will result in marginal loss of resources.	2
Significant loss of resources	The impact will result in significant loss of resources.	3
Complete loss of resources	The impact is result in a complete loss of all resources.	4

Table 7-6: Impact Assessment Criteria - Duration

This describes the duration of the impacts on the environmental parameter. Duration indicates the lifetime of the impact as a result of the proposed activity.		
Rating	**Description**	**Score**
Short term	The impact and its effects will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase (0 – 1 years), or the impact and its effects will last for the period of a relatively short construction period and a limited recovery time after construction, thereafter it will be entirely negated (0 – 2 years). This will be further defined (in terms of acoustics) as impacts are predicted to be of short duration (portion of construction period) and intermittent/occasional.	1
Medium term	The impact and its effects will continue or last for some time after the construction phase but will be mitigated by direct human action or by natural processes thereafter (2 – 10 years). This will be further defined (in terms of acoustics) as impacts that are predicted to last only for the duration of the construction period.	2
Long term	The impact and its effects will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter (10 – 50 years). This will be further defined (in terms of acoustics) as impacts that will continue for the life of the Project, but ceases when the Project stops operating.	3
Permanent	The only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or such a time span that the impact can be considered transient (Indefinite). This will be further defined (in terms of acoustics) as impacts that cause a permanent change in the affected receptor or resource (e.g. removal or destruction of ecological habitat) that endures substantially beyond the Project lifetime.	4

Table 7-7: Impact Assessment Criteria – Cumulative effect

This describes the cumulative effect of the impacts on the environmental parameter. A cumulative effect/impact is an effect which in itself may not be significant but may become significant if added to other existing or potential impacts emanating from other similar or diverse activities as a result of the project activity in question.		
Rating	**Description**	**Score**
Negligible Cumulative Impact	The impact would result in negligible to no cumulative effects	1
Low Cumulative Impact	The impact would result in insignificant cumulative effects	2
Medium Cumulative impact	The impact would result in minor cumulative effects	3
High Cumulative Impact	The impact would result in significant cumulative effects	4

Table 7-8: Impact Assessment Criteria – Intensity/Magnitude

Describes the severity of an impact.		
Rating	**Description**	**Score**
Low	Impact affects the quality, use and integrity of the system/component in a way that is barely perceptible. This will be determined by an increase in average sound pressure levels between 0 and 3 dB from the expected wind induced ambient sound level (proposed rating level), or for construction phase ambient sound levels only. No change in ambient sound levels discernible. Total projected noise level is less than the Zone Sound Level in wind-still conditions.	1
Medium	Impact alters the quality, use and integrity of the system/component but system/ component still continues to function in a moderately modified way and maintains general integrity (some impact on integrity). This will be determined by an increase in average sound pressure levels between 3 and 5 dB from the (expected) ambient sound level (proposed rating level), or for construction phase ambient sound levels only. The change is barely discernible, but the noise source might become audible.	2
High	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component is severely impaired and may temporarily cease. High costs of rehabilitation and remediation. This will be determined by an increase in average sound pressure levels between 5 and 7 dB from the (expected) ambient sound level (proposed night rating level), or for construction phase ambient sound levels only. Sporadic complaints expected. Any point where the zone sound levels are exceeded during wind still conditions.	3
Very high	Impact affects the continued viability of the system/component and the quality, use, integrity and functionality of the system or component permanently ceases and is irreversibly impaired (system collapse). Rehabilitation and remediation often impossible. If possible rehabilitation and remediation often unfeasible due to extremely high costs of rehabilitation and remediation. This will be determined by an increase in average sound pressure levels higher than 7 dB from the (expected) ambient sound level (proposed night rating level), or for construction phase ambient sound levels only. Medium to widespread complaints expected.	4

7.3.5 Identifying the Potential Impacts

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned factors. Significance is rated on the following scale:

Points	Impact Significance Rating	Description
6 to 28	**Negative Low impact**	The anticipated impact will have negligible negative effects and will require little to no mitigation.
6 to 28	**Positive Low impact**	The anticipated impact will have minor positive effects.
29 to 50	**Negative Medium impact**	The anticipated impact will have moderate negative effects and will require moderate mitigation measures.
29 to 50	**Positive Medium impact**	The anticipated impact will have moderate positive effects.
51 to 73	**Negative High impact**	The anticipated impact will have significant effects and will require significant mitigation measures to achieve an acceptable level of impact.
51 to 73	**Positive High impact**	The anticipated impact will have significant positive effects.
74 to 96	**Negative Very high impact**	The anticipated impact will have highly significant effects and are unlikely to be able to be mitigated adequately. These impacts could be considered "fatal flaws".
74 to 96	**Positive Very high impact**	The anticipated impact will have highly significant positive effects.

7.4 EXPRESSION OF THE NOISE IMPACTS

Noise impacts can be expressed in terms of the increase in present ambient noise levels caused by noise emissions from the proposed project or as total noise rating levels. Sound or noise levels generally refers to a level as measured using an instrument, whereas the noise rating level refers to a calculated sound exposure level to which various corrections and adjustments was added.

This report makes use of the total noise rating levels as a means of defining the potential magnitude of a noise level. This will be presented using contours of constant noise rating levels to illustrate the projected noise levels and used to estimate the potential significance of the noise impact.

Should the significance of the noise impact be low for all identified receptors in the area, or, if feasible mitigation measures can be identified that will reduce the significance of the noise impact to low, no further noise studies will be recommended for the EIA phase.

8 RESULTS AND PRELIMINARY IMPACT ASSESSMENT

8.1 CURRENT SOUND LEVELS

Considering the location of the project site in relation to roads or industrial activities, the current low developmental character and measurements done in the area indicates very low ambient sound levels. There is very high confidence that the ambient sound levels will also be very low on the project site.

Agricultural and other anthropogenic activities may raise ambient sound levels in the vicinity of the dwellings and agricultural structures in the area, but, as the night-time soundscape is of interest, these activities are unlikely to influence night-time sound levels.

8.2 PROPOSED CONSTRUCTION PHASE NOISE IMPACT

This section investigates the noise of conceptual construction activities as discussed in **section 4.1**. Noise from construction activities are dependent on the final operational layout, the type of activity taking place as well as the number of activities taking place simultaneously. The layout as provided by the developer for the !Xhaboom WEF is presented in **Figure 8-1**.

The following construction activities could take place simultaneously and were considered:

- General work at a temporary workshop area. This would be activities such as equipment maintenance, off-loading and material handling. All vehicles will travel to this site where most equipment and material will be off-loaded (general noise, crane). Material, such as aggregate and building sand, will be taken directly to the construction area (foundation establishment). It was assumed that activities will be taking place for 16 hours during the 16 hour daytime period.
- Surface preparation prior to civil work. This could be the removal of topsoil and levelling with compaction, or the preparation of an access road (bulldozer/grader). Activities will be taking place for 8 hours during the 16 hour daytime period.
- Preparation of foundation area (sub-surface removal until secure base is reached – excavator, compaction, and general noise). Activities will be taking place for 10 hours during the 16 hour daytime period.
- Pouring and compaction of foundation concrete (general noise, electric generator/compressor, concrete vibration, mobile concrete plant, TLB). As foundations must be poured in one go, the activity is projected to take place over the full 16 hour day time period.
- Erecting of the wind turbine generator (general noise, electric generator/compressor and a crane). Activities will be taking place for 16 hours during the 16 hour daytime period.

- Traffic on the site (trucks transporting material, aggregate/concrete, work crews) moving from the workshop/store area to the various activity sites. Up to 20 heavy and light vehicles may travel between 40 and 60 km/h on the access roads.

There will be a number of smaller equipment, but the addition of the general noise source (at each point) covers most of these noise sources. It is assumed that all equipment would be operating under full load (generate the most noise) at a number of locations and that atmospheric conditions would be ideal for sound propagation. This is likely the worst case scenario that can occur during the construction of the facility.

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 emission level – various equipment operating simultaneously) at all locations (over the full daytime period of 16 hours) where wind turbines may be erected for both layouts, calculating how this may impact on potential noise-sensitive developments (see **Figure 8-2**). Noise created due to linear activities (roads) were also evaluated and plotted against distance as illustrated in **Figure 8-3**[22].

Even though construction activities are projected to take place only during day time, it might be required at times that construction activities take place during the night (particularly for a large project). Construction activities that may occur during night time:

- Concrete pouring: Large portions of concrete do require pouring and vibrating to be completed once started, and work is sometimes required until the early hours of the morning to ensure a well-established concrete foundation. However the work force working at night for this work will be considerably smaller than during the day.
- Working late due to time constraints: Weather plays an important role in time management in construction. A spell of bad weather can cause a construction project to fall behind its completion date. Therefore, it is hard to judge beforehand if a construction team would be required to work late at night.

[22] Sound level at a receiver set at a certain distance from a road

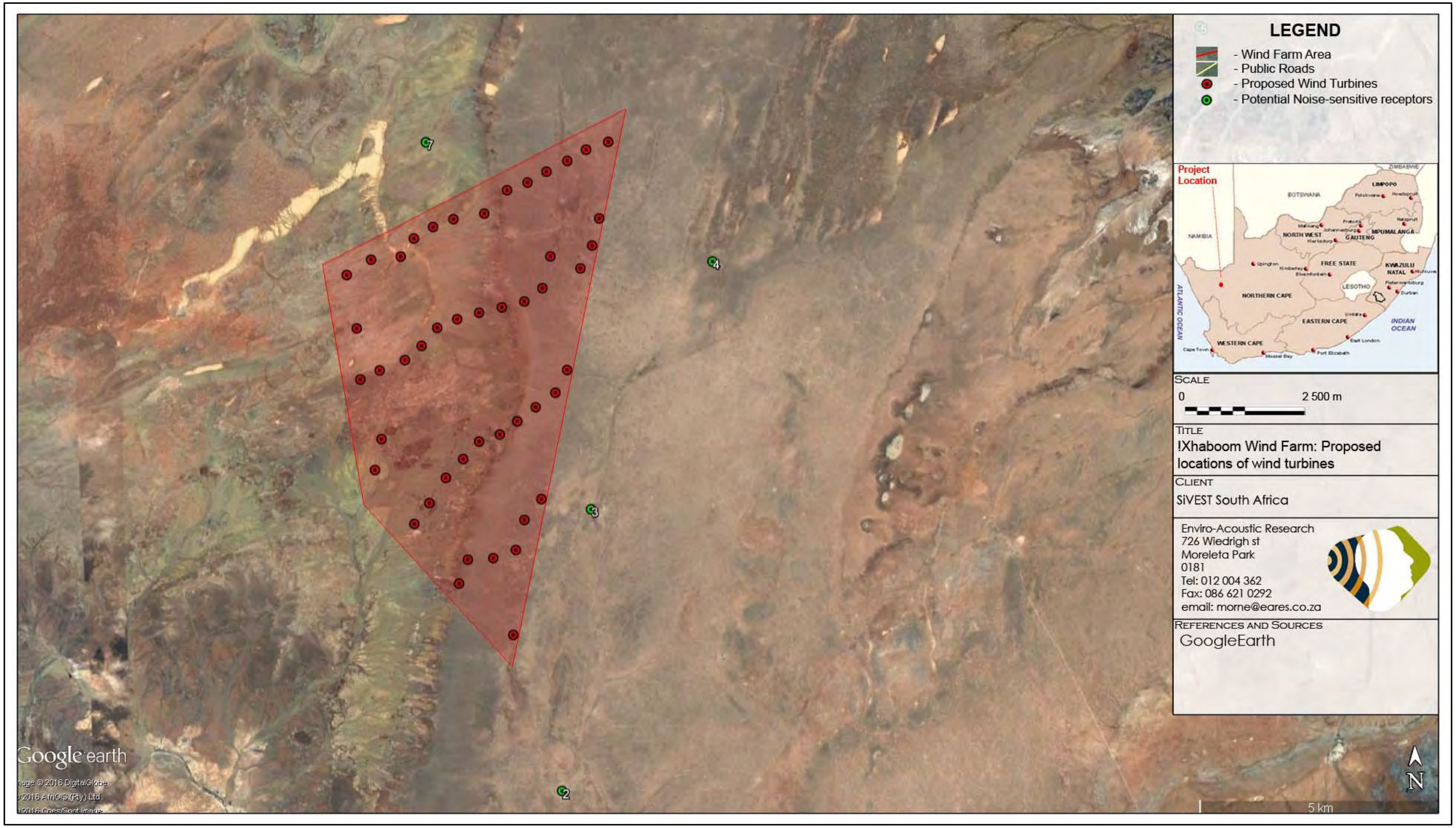

Figure 8-1: Proposed infrastructure (Wind Turbine Locations)

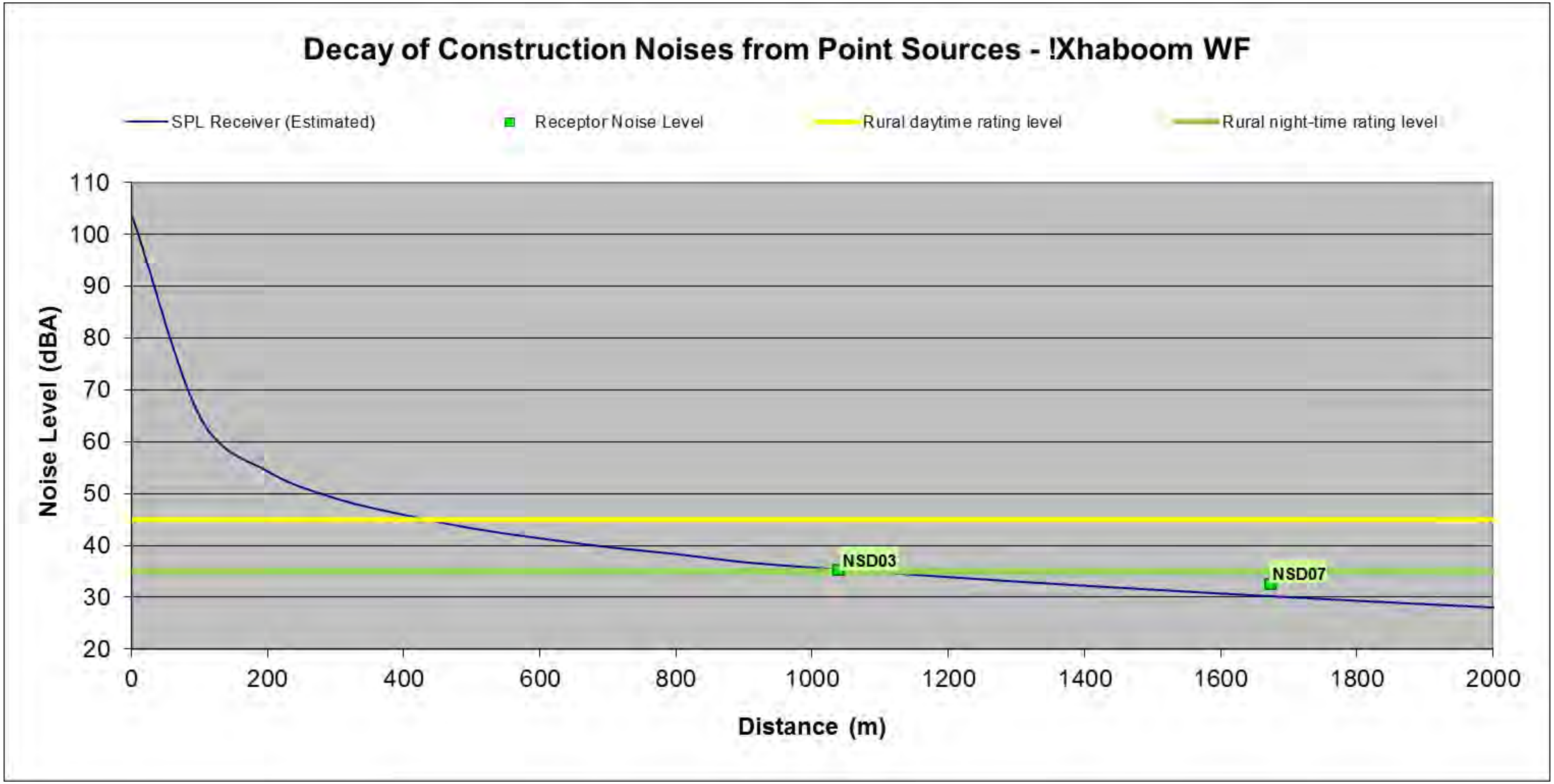

Figure 8-2: Projected conceptual construction noise levels[23] – Decay of noise from construction activities

[23] The SPL Receiver graph can also be used for the construction of an overhead power line to allow connection to the ESKOM grid as well as the construction of access routes. Any activities further than 500 m from any receiver will have a noise impact of low significance (daytime activity, based on a 45 dBA acceptable rating level).

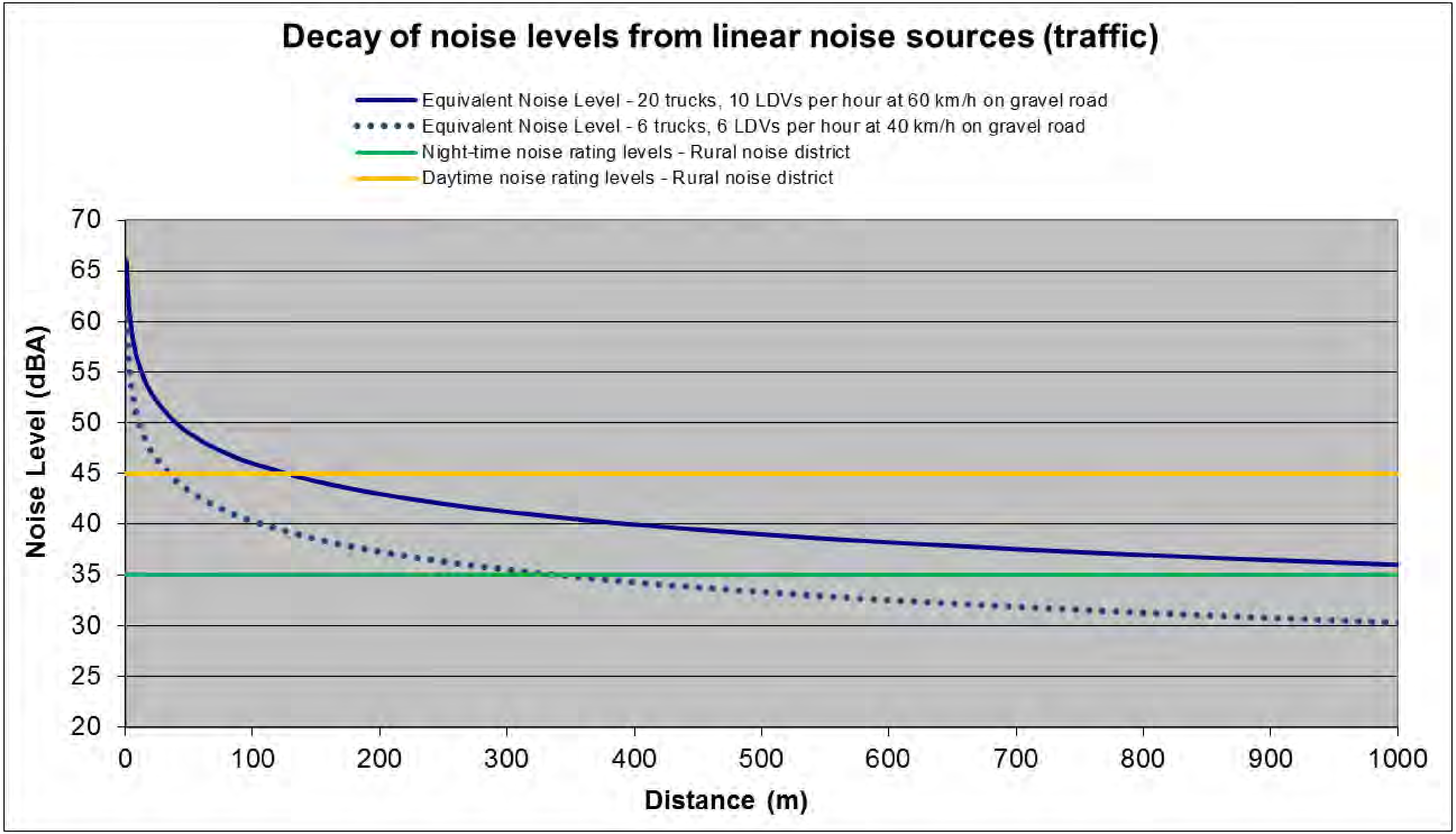

Figure 8-3: Projected conceptual construction traffic noise levels – Decay over distance from linear activities

8.3 OPERATIONAL PHASE NOISE IMPACT

Typical day time activities would include:

- The operation of the various Wind Turbines,
- Maintenance activities (relatively insignificant noise source).

While the daytime period was considered, it is not considered critical in this assessment because noises generated during the day is generally masked by other noises from a variety of sources surrounding potentially noise-sensitive developments. However, times when a quiet environment is desired (at night for sleeping, weekends etc.) ambient sound levels are more critical. The time period investigated therefore would be a quieter period, normally associated with the 22:00 – 06:00 timeslot. Maintenance activities would therefore not be considered, concentrating on the ambient sound levels created due to the operation of the various Wind Turbine Generators (WTG's) at night.

The presented layout (see **Figure 8-1**) was modeled in detail. While the developer have not yet identified a wind turbine to use, this report makes use of the sound power emission levels for an Acciona AW125 3000 wind turbine as defined in **Table 8-1**. This wind turbine was selected as it is a relatively loud wind turbine and it will illustrate a worst-cast scenario (precautionary principle).

Table 8-1: Sound Power Emission Levels used for modelling: Acciona AW125

Wind Turbine: Acciona AW125/3000 at hub height 120										
Source Reference: Acciona Windpower. General Document DG200383, Rev D dated 04/04/14										
Maximum expected A-weighted Octave Sound Power Levels										
Frequency	**16**	**31.5**	**63**	**125**	**250.0**	**500**	**1000**	**2000**	**4000**	**8000**
Lpa (dB)	*not reported*	117.3	111.5	110.9	109.9	107.0	103.3	97.0	86.6	81.3
L_{WA} (dBA)	*not reported*	77.4	85.3	94.7	101.2	103.8	103.3	98.2	87.6	81.3

A-Weighted Sound Power Levels (at wind speeds)		
Wind speed at 10 m height	**Wind speed at hub height**	**Sound Power Level**
6 m/s	8.5 m/s	107.3 dBA
7 m/s	9.9 m/s	108.4 dBA
8 m/s	11.3 m/s	108.2 dBA
9 m/s	12.7 m/s	107.8 dBA
10 m/s	14.1 m/s	107.7 dBA

Contours of the total noise rating levels are presented in **Figure 8-4**. **Table 8-2** defines the maximum noise rating levels at the closest potential noise-sensitive receptors.

Table 8-2: Maximum noise rating levels at closest potential noise-sensitive receptors

NSD	Maximum A-weighted Noise Rating Levels (dBA)	Comments
3	34.6	Dwelling only used temporary
4	31.4	Dwelling only used a few nights in summer during sheering
7	37.5	Dwelling, status unknown

8.4 POTENTIAL CUMULATIVE NOISE IMPACTS

Should all the wind farms of the larger Leeuberg WEF be developed noise levels could increase due to cumulative effects. Total cumulative noise levels were calculated and are defined in **Table 8-3**. The Dwarsrug and Loeriesfontein WEFs are also proposed in the area, but the wind turbines from these facilities are too far to contribute to the cumulative effect.

Table 8-3: Maximum cumulative noise rating levels at closest potential noise-sensitive receptors

NSD	Maximum cumulative noise level, dBA	Contribution, Itemba (dBA)	Contribution, Xhaboom (dBA)	Contribution, Graskoppies (dBA)	Contribution, Hartebeestleegte (dBA)	Comments
1	41.6	< 30	< 30	< 30	41.6	Status unknown
2	50.8	< 30	21.9	< 30	50.8	Temporary used
3	43.0	41.3	34.6	19.7	35.4	Temporary used
4	44.6	44.2	31.4	31.4	< 30	Temporary used
5	27.5	< 30	< 30	27.5	< 30	Temporary used
6	39.6	29	< 30	39.2	< 30	Temporary used
7	37.7	23.1	37.5	< 30	< 30	Status unknown

8.5 DECOMMISSIONING AND CLOSURE PHASE NOISE IMPACT

The potential for a noise impact to occur during the decommissioning and closure phase will be much lower than that of the construction and operational phases and noise from the decommissioning and closure phases will therefore not be investigated further.

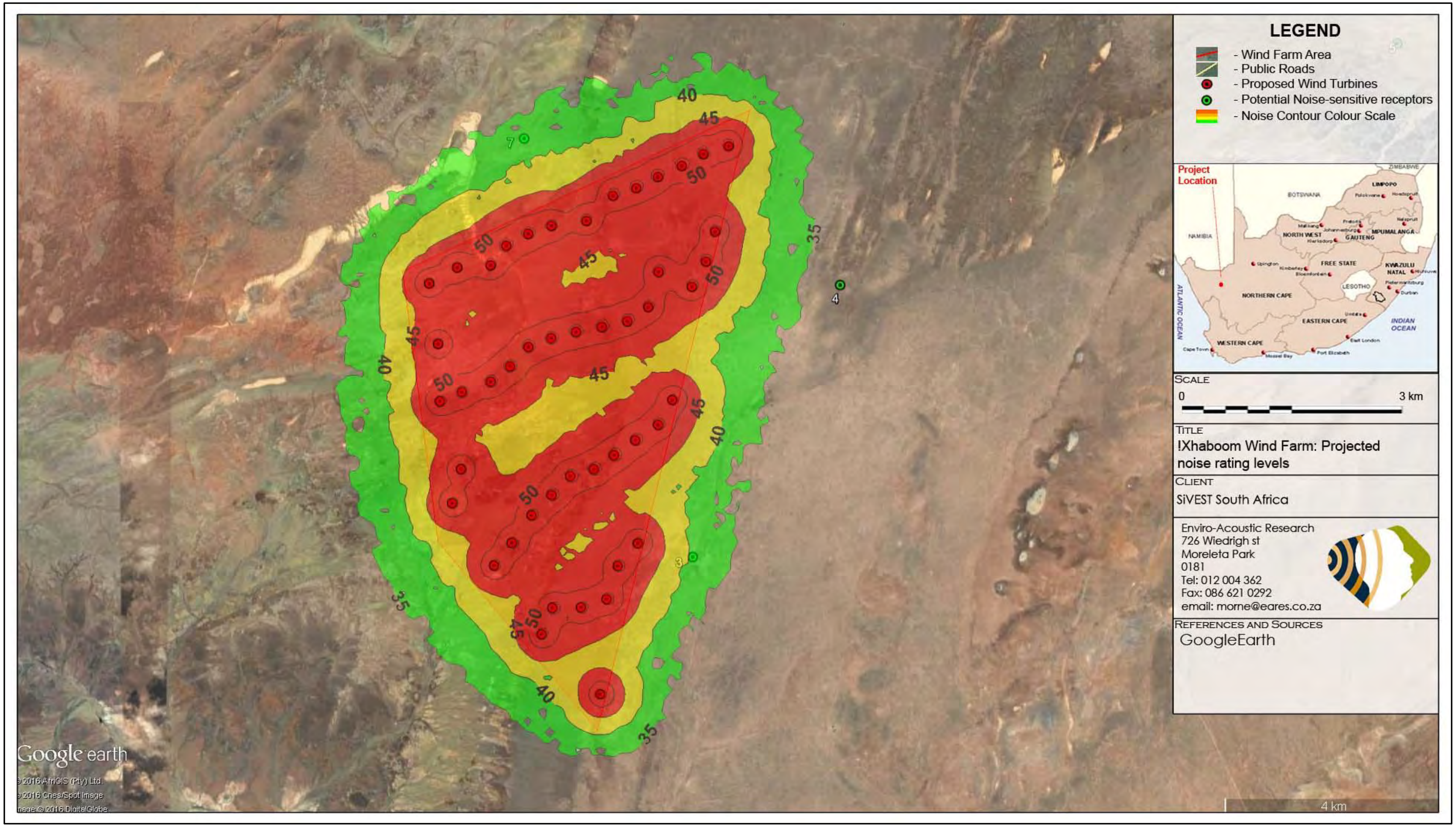

Figure 8-4: Projected conceptual night-time maximum noise rating levels during operation

9 SIGNIFICANCE OF THE NOISE IMPACT

9.1 PLANNING PHASE NOISE IMPACT

No noise is associated with the planning phase and this will not be investigated in further.

9.2 CONSTRUCTION PHASE NOISE IMPACT

The impact assessment for the various construction activities are described in **section 4.1**, defined and assessed in **section 8.2**. Considering the projected noise levels for the construction of wind turbines (all significantly less than 45 dBA) as well as the expected daytime ambient sound level (possibly higher than 45 dBA), there is a very low risk for a noise impact from this source.

Noise issues may however be associated with the construction of access routes as well as construction traffic noises (considering potential routes of access roads, location of potential receptors as well as **Figure 8-2** and **Figure 8-3**).

The noise impacts are summarized in the following tables (**Table 9-1** to **Table 9-6**).

9.3 OPERATIONAL PHASE NOISE IMPACT

The impact assessment for the various activities defined in **section 4.2** with the projected noise levels calculated in **section 8.3**.

As can be seen from **Table 8-2**, the projected noise levels will be just higher (insignificant levels) than the night-time rural rating level (of 35 dBA) at NSD07 (projected at 37 dBA). It is important to note that this would be at a 10m wind speed of 7 m/s when ambient sound levels would be ranging between 35 and 55 dBA, averaging at 41 dBA (refer **Figure 7-4**).

Considering the MoE guideline noise levels (see also **section 2.6.3**) the noise levels will not be higher than the MoE guideline levels. The significance of the noise impact is assessed and summarized in **Table 9-7** and **Table 9-8** while cconsidering the ambient sound levels measured onsite, ambient sound levels measured at other locations as well as international guidelines.

9.4 CUMULATIVE NOISE IMPACT

Wind turbines generally have a cumulative impact on the acoustic environment when they are located closer than 2,000m from receptors that can experience a cumulative effect of the turbines of two or more developments. Considering the location of the proposed wind turbines as well as the location of the closest NSD (to these turbines), the potential of a cumulative noise impact is very low (see **Table 8-3**). Potential cumulative impacts was assessed and presented in **Table 9-9** (night-time assessment only).

The proposed wind farm will be too far from the Loeriesfontein and Dwarsrug Wind Farms for cumulative noises to be of any concern.

9.5 DECOMMISSIONING PHASE NOISE IMPACT

Final decommissioning activities will have a noise impact lower than either the construction or operational phases. This is because decommissioning and closure activities normally take place during the day using minimal equipment (due to the decreased urgency of the project). While there may be various activities, there is a very small risk for a noise impact.

9.6 EVALUATION OF ALTERNATIVES

9.6.1 Alternative 1: No-go option

The ambient sound levels will remain as is (relatively low).

9.6.2 Alternative 2: Proposed Renewable Power Generation activities (Need and Desirability of the Proposed Renewable Energy Project)

The proposed renewable power generation activities (worst-case evaluated) will raise the noise levels at a number of potential noise-sensitive developments in the area. These noises can be disturbing and may impact on the quality of living for the receptors. In terms of acoustics there is no benefit to the surrounding environment (closest receptors), although the closest receptors are also financial beneficiaries to the project. The potential noise impacts would increase night-time noise levels higher than the rural rating level of 35 dBA at the closest dwellings and these receptors may find these increases annoyance.

The project will however 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 is not directly affected by increased noises will have a positive perception of the project and will see the need and desirability of the project.

Table 9-1: Noise Impact Assessment – Daytime Construction (and Upgrade) of access roads and other infrastructure

<table>
<tr><td colspan="9">Impact Phase: Construction of the access roads and grid infrastructure during the day</td></tr>
<tr><td colspan="9"><u>Possible</u> Impact or Risk: Increase in sound levels at the dwellings of receptors during the day. Construction activities will generate noises up to 45 dBA at 450m and 52 dBA (potential disturbing noise) at 220m. Impulsive noises are associated with construction activities and these noises may be intrusive and increase annoyance with the project. The route of the access roads or grid infrastructure was not defined but could go past structures.

Considering the location of existing roads, there may be an access road (if accessing from the south) approximately 600m from NSD01, directly passing NSD02 and 160m from NSD03.

If the access road is developed from the Buchufontein road (if accessing from the east), it could pass as close as 85m from NSD05. It should be noted, while most of the NSDs only use the farms for a few months during the year, this assessment will assume that the dwellings will be used for residential purposes during the construction phase.</td></tr>
<tr><th>Without Mitigation</th><th>Extent</th><th>Probability</th><th>Reversibility</th><th>Loss of Resource</th><th>Duration</th><th>Cumulative</th><th>Magnitude</th><th>Significance</th></tr>
<tr><td>Receptors closer than 220m from access road</td><td>Site</td><td>Definite</td><td>Completely</td><td>None</td><td>Short</td><td>Negligible</td><td>Very high</td><td>Medium</td></tr>
<tr><th rowspan="2">With Mitigation</th><th>Extent</th><th>Probability</th><th>Reversibility</th><th>Loss of Resource</th><th>Duration</th><th>Cumulative</th><th>Magnitude</th><th>Significance</th></tr>
<tr><td>Site</td><td>Unlikely</td><td>Completely</td><td>None</td><td>Short</td><td>Negligible</td><td>Low</td><td>Low</td></tr>
<tr><td colspan="3">Can the impact be reversed?</td><td colspan="6">Yes – Impact will stop once activities stop.</td></tr>
<tr><td colspan="3">Will impact cause irreplaceable loss or resources?</td><td colspan="6">No – The increase in noise levels can increase annoyance levels with the project but will not result in the loss of any resource or an irreplaceable loss.</td></tr>
<tr><td colspan="3">Can impact be avoided, managed or mitigated?</td><td colspan="6">Mitigation are recommended to ensure that the risk of noise impact remain low.</td></tr>
<tr><td colspan="9">General mitigation measures to reduce residual risk:
• Relocate access roads further from houses. To minimize noise levels below a low significance ensure that roads (or grid lines) are further than 220m from dwellings used for residential purposes during the construction period.
• Construct the access roads during a period when receptors are not using their dwellings.
• Locate contractors camp and storage areas at locations where construction traffic will pass occupied dwellings minimally. Develop a separate road or upgrade an existing access road to the contractors camp to minimise traffic past residents.</td></tr>
<tr><td colspan="3">Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?</td><td colspan="6">With the implementation of the mitigation measures it would be possible to reduce the noise impact to a low significance. It will not be required to investigate this further in a Noise Impact Assessment.</td></tr>
</table>

Table 9-2: Noise Impact Assessment – Night-time Construction (and Upgrade) of access roads and other infrastructure

Impact Phase: *Construction of the access roads and grid infrastructure at night*								
<u>Possible</u> Impact or Risk: *Increase in sound levels at the dwellings of receptors during at night. Construction activities will generate noises up to 35 dBA at 1,100m and 42 dBA (potential disturbing noise) at 580m. Ambient sound levels are very low in this area at night and these noises may be intrusive and increase annoyance with the project, especially if impulsive noises are present. The route of the access roads or grid infrastructure was not defined but could go past structures.* *Considering the location of existing roads, there may be an access road (if accessing from the south) approximately 600m from NSD01, directly passing NSD02 and 160m from NSD03.* *If the access road is developed from the Buchufontein road (if accessing from the east), it could pass as close as 85m from NSD05. It should be noted, while most of the NSDs only use the farms for a few months during the year, this assessment will assume that the dwellings will be used for residential purposes during the construction phase.*								
Without Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
Receptors closer than 580m from access road	Site	Definite	Completely	None	Short	Negligible	Very high	Medium
With Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
	Site	Unlikely	Completely	None	Short	Negligible	Low	Low
Can the impact be reversed?	*Yes – Impact will stop once activities stop.*							
Will impact cause irreplaceable loss or resources?	*No – The increase in noise levels can increase annoyance levels with the project but will not result in the loss of any resource or an irreplaceable loss.*							
Can impact be avoided, managed or mitigated?	*Mitigation are recommended to ensure that the risk of noise impact remain low.*							
General mitigation measures to reduce residual risk: • *Due to the low ambient sound levels, it is highly recommended that no construction activities are allowed within 580m from occupied dwellings at night. This includes construction of roads, power lines or construction of wind turbines.* • *Construct the access roads during a period when receptors are not using their dwellings.* • *Locate contractors camp and storage areas at locations where construction traffic will pass occupied dwellings minimally. Develop a separate road or upgrade an existing access road to the contractors camp to minimise traffic past residents.*								
Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?	*With the implementation of the mitigation measures it would be possible to reduce the noise impact to a low significance. It will not be required to investigate this further in a Noise Impact Assessment.*							

Table 9-3: Noise Impact Assessment – Daytime Construction Traffic

Impact Phase: *Construction traffic passing residential dwellings during the day*								
Possible Impact or Risk: *Increase in sound levels at the dwellings of receptors during the day due to traffic passing the dwellings. This activity could take place for up to 3 years. Construction traffic can generate noises up to 45 dBA at 130m during busy periods. These noises may be intrusive and increase annoyance with the project. Route of the access roads was not defined but could go past structures.* *Considering the location of existing roads, there may be an access road (if accessing from the south) approximately 600m from NSD01, directly passing NSD02 and 160m from NSD03.* *If the access road is developed from the Buchufontein road (if accessing from the east), it could pass as close as 85m from NSD05. It should be noted, while most of the NSDs only use the farms for a few months during the year, this assessment will assume that the dwellings will be used for residential purposes during the construction phase.*								
Without Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
Receptors closer than 130m from access road	Site	Probable	Completely	None	Medium	Negligible	High	Low
With Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
	Site	Unlikely	Completely	None	Medium	Negligible	Low	Low
Can the impact be reversed?	*Yes – Impact will stop once activities stop.*							
Will impact cause irreplaceable loss or resources?	*No – The increase in noise levels can increase annoyance levels with the project but will not result in the loss of any resource or an irreplaceable loss.*							
Can impact be avoided, managed or mitigated?	*Mitigation are recommended to ensure that the risk of noise impact remain low.*							
General mitigation measures to reduce residual risk: • *If possible, the relocation of access roads to be further than 160m from any dwelling to be used for residential purposed during the construction phase.*								
Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?	*It will not be required to investigate this further in a Noise Impact Assessment.*							

Table 9-4: Noise Impact Assessment – Night-time Construction Traffic

<table>
<tr><td colspan="9">Impact Phase: Construction traffic passing residential dwellings at night</td></tr>
<tr><td colspan="9"><u>Possible</u> Impact or Risk: Increase in sound levels at the dwellings of receptors at night due to traffic passing the dwellings. This activity could take place for up to 3 years. Construction traffic can generate noises up to 35 dBA at 1,200m during busy periods and higher than 42 dBA when closer than 250m. These noises may be intrusive and increase annoyance with the project. Route of the access roads was not defined but could go past structures.

Considering the location of existing roads, there may be an access road (if accessing from the south) approximately 600m from NSD01, directly passing NSD02 and 160m from NSD03.

If the access road is developed from the Buchufontein road (if accessing from the east), it could pass as close as 85m from NSD05. It should be noted, while most of the NSDs only use the farms for a few months during the year, this assessment will assume that the dwellings will be used for residential purposes during the construction phase.</td></tr>
<tr><th>Without Mitigation</th><th>Extent</th><th>Probability</th><th>Reversibility</th><th>Loss of Resource</th><th>Duration</th><th>Cumulative</th><th>Magnitude</th><th>Significance</th></tr>
<tr><td>Receptors closer than 250m from access road</td><td>Site</td><td>Definite</td><td>Completely</td><td>None</td><td>Medium</td><td>Negligible</td><td>Very High</td><td>Medium</td></tr>
<tr><th rowspan="2">With Mitigation</th><th>Extent</th><th>Probability</th><th>Reversibility</th><th>Loss of Resource</th><th>Duration</th><th>Cumulative</th><th>Magnitude</th><th>Significance</th></tr>
<tr><td>Site</td><td>Unlikely</td><td>Completely</td><td>None</td><td>Medium</td><td>Negligible</td><td>Low</td><td>Low</td></tr>
<tr><td colspan="3">Can the impact be reversed?</td><td colspan="6">Yes – Impact will stop once activities stop.</td></tr>
<tr><td colspan="3">Will impact cause irreplaceable loss or resources?</td><td colspan="6">No – The increase in noise levels can increase annoyance levels with the project but will not result in the loss of any resource or an irreplaceable loss.</td></tr>
<tr><td colspan="3">Can impact be avoided, managed or mitigated?</td><td colspan="6">Mitigation are recommended to ensure that the risk of noise impact remain low.</td></tr>
<tr><td colspan="9">General mitigation measures to reduce residual risk:
• Ideally, do not allow construction traffic to drive past dwellings used for residential purposes at night. If people, material or equipment must be moved at night, no traffic should be allowed closer than 250m from receptors. Minimize night-time traffic as much as possible.
• If significant traffic is anticipated at night, access roads must be located further than 580m from receptors.
• Locate contractor's camp and storage areas at locations where construction traffic will not need to pass occupied dwellings (or pass them minimally). Develop a separate or upgrade an existing access road to the contractors camp to minimise traffic past residents.
• Noise impact would depend if night-time activities are anticipated. If significant traffic are anticipated at night, access roads must be located further than 250m from receptors. Lower traffic may allow the development of access roads closer to the NSD.</td></tr>
<tr><td colspan="3">Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?</td><td colspan="6">With the implementation of the mitigation measures it would be possible to reduce the noise impact to a low significance. It will not be required to investigate this further in a Noise Impact Assessment.</td></tr>
</table>

Table 9-5: Noise Impact Assessment – Daytime Construction of Wind Turbines and other infrastructure

Impact Phase: *Construction activities of the Wind Turbine Generators and other infrastructure during the day*								
Possible Impact or Risk: *Increase in sound levels at the dwellings of receptors during the day. Construction activities will generate noises up to 45 dBA at 450m and 52 dBA (potential disturbing noise) at 220m. Impulsive noises are associated with construction activities and these noises may be intrusive and increase annoyance with the project.* *There are no receptors or dwellings closer than 1,000m from any wind turbine and construction activities would not be significant.*								
Without Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
	Site	Unlikely	Completely	None	Short	Negligible	Low	Low
With Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
	Site	Unlikely	Completely	None	Short	Negligible	Low	Low
Can the impact be reversed?	*Yes – Impact will stop once activities stop.*							
Will impact cause irreplaceable loss or resources?	*No – The increase in noise levels can increase annoyance levels with the project but will not result in the loss of any resource or an irreplaceable loss.*							
Can impact be avoided, managed or mitigated?	*Mitigation not required.*							
Mitigation not required as the locations were the wind turbines will be constructed are too far from potential noise-sensitive receptors.								
Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?	*With the implementation of the mitigation measures it would be possible to reduce the noise impact to a low significance. It will not be required to investigate this further in a Noise Impact Assessment.*							

Table 9-6: Noise Impact Assessment – Night-time Construction of Wind Turbines and other infrastructure

Impact Phase: *Construction of the Wind Turbine Generators and other infrastructure at night*								
<u>Possible</u> Impact or Risk: *Increase in sound levels at the dwellings of receptors during at night. Construction activities will generate noises up to 35 dBA at 1,100m and 42 dBA (potential disturbing noise) at 580m. Ambient sound levels are very low in this area at night and these noises may be intrusive and increase annoyance with the project, especially if impulsive noises are present. The route of the access roads or grid infrastructure was not defined but could go past structures.* *There are no receptors or dwellings closer than 1,000m from any wind turbine and construction activities would not be significant.*								
Without Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
	Site	Possible	Completely	None	Short	Negligible	Medium	Low
With Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
	Site	Unlikely	Completely	None	Short	Negligible	Low	Low
Can the impact be reversed?	*Yes – Impact will stop once activities stop.*							
Will impact cause irreplaceable loss or resources?	*No – The increase in noise levels can increase annoyance levels with the project but will not result in the loss of any resource or an irreplaceable loss.*							
Can impact be avoided, managed or mitigated?	*Mitigation are recommended to ensure that the risk of noise impact remain low.*							
Mitigation measures to reduce residual risk: • *The residential dwelling is seldom used and the developer can ensure that the construction of Wind Turbines take place during a period when the owners are not using the property.*								
Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?	*With the implementation of the mitigation measures it would be possible to reduce the noise impact to a low significance. It will not be required to investigate this further in a Noise Impact Assessment.*							

Table 9-7: Impact Assessment: Operation of Wind Farm – Daytime

Impact Phase: *Noise from operating wind turbines.*								
<u>Possible</u> Impact or Risk: *Increase in sound levels at the dwellings of receptors during the day. Operating wind turbines will generate noises less than 40 dBA at all NSD.*								
Without Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
	Site	Unlikely	Completely	None	Long	Negligible	Low	Low
With Mitigation	**Extent**	**Probability**	**Reversibility**	**Loss of Resource**	**Duration**	**Cumulative**	**Magnitude**	**Significance**
	Site	Unlikely	Completely	None	Long	Negligible	Low	Low
Can the impact be reversed?	*Yes – Impact will stop once activities stop.*							
Will impact cause irreplaceable loss or resources?	*No.*							
Can impact be avoided, managed or mitigated?	*Mitigation not required.*							
Mitigation not required as the potential daytime noise impact would be insignificant.								
Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?	*Low significance of an impact and it will not be required to investigate this further in a Noise Impact Assessment.*							

Table 9-8: Impact Assessment: Operational Activities – Night-time

<table>
<tr><td colspan="9">Impact Phase: Noise from operating wind turbines.</td></tr>
<tr><td colspan="9"><u>Possible</u> Impact or Risk: Increase in sound levels at the dwellings of receptors at night. Operating wind turbines will generate noise levels less than 40dBA at all NSD.</td></tr>
<tr><td rowspan="2">Without Mitigation</td><td>Extent</td><td>Probability</td><td>Reversibility</td><td>Loss of Resource</td><td>Duration</td><td>Cumulative</td><td>Magnitude</td><td>Significance</td></tr>
<tr><td>Site</td><td>Probable</td><td>Completely</td><td>None</td><td>Long</td><td>Negligible</td><td>Very High</td><td>Medium</td></tr>
<tr><td rowspan="2">With Mitigation</td><td>Extent</td><td>Probability</td><td>Reversibility</td><td>Loss of Resource</td><td>Duration</td><td>Cumulative</td><td>Magnitude</td><td>Significance</td></tr>
<tr><td>Site</td><td>Unlikely</td><td>Completely</td><td>None</td><td>Long</td><td>Negligible</td><td>Low</td><td>Low</td></tr>
<tr><td colspan="3">Can the impact be reversed?</td><td colspan="6">Yes – Impact will stop once activities stop.</td></tr>
<tr><td colspan="3">Will impact cause irreplaceable loss or resources?</td><td colspan="6">No.</td></tr>
<tr><td colspan="3">Can impact be avoided, managed or mitigated?</td><td colspan="6">Mitigation required.</td></tr>
<tr><td colspan="9">Mitigation is recommended if the owner will use this property for residential purposes:
- This noise level must be discussed with the owner. It is not recommended that this dwelling be used for residential purposes if the !Xhaboom WF is developed with the current layout. The owner should provide an alternative location for the worker staying at this location during the sheering period.
- The developer can change the layout and not develop any wind turbines within approximately 1,000m from this dwelling (alternatively relocate or remove wind turbine 25).
- The developer can use a different wind turbine that have a sound power emission level of less than 106dBA (maximum).
- The developer can confirm periods when the dwelling will be used for residential purposes, and the three closest wind turbines can be operated in a noise mode that generates less noise (less than 106dBA) or one or more of these wind turbines can be switched off.</td></tr>
<tr><td colspan="3">Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?</td><td colspan="6">Medium significance of a noise impact can be mitigated to low with implementation of management measures. It will not be required to investigate this further in a Noise Impact Assessment.</td></tr>
</table>

Table 9-9: Impact Assessment: Cumulative noise levels for the Leeuberg Wind Energy Facility – Night-time

<table>
<tr><td colspan="9">Impact Phase: Cumulative noises from operating wind turbines for the Graskoppies, Itemba, !Xhaboom and Hartebeestleegte Wind Farms (see also Table 8-3).</td></tr>
<tr><td colspan="9"><u>Possible</u> Impact or Risk: Increase in sound levels at the dwellings of receptors at night due to cumulative noises. This will be very low for the !Xhaboom WF.</td></tr>
<tr><td rowspan="2">Without Mitigation</td><td>Extent</td><td>Probability</td><td>Reversibility</td><td>Loss of Resource</td><td>Duration</td><td>Cumulative</td><td>Magnitude</td><td>Significance</td></tr>
<tr><td>Site</td><td>Possible</td><td>Completely</td><td>None</td><td>Long</td><td>Negligible</td><td>High</td><td>Low</td></tr>
<tr><td rowspan="2">With Mitigation</td><td>Extent</td><td>Probability</td><td>Reversibility</td><td>Loss of Resource</td><td>Duration</td><td>Cumulative</td><td>Magnitude</td><td>Significance</td></tr>
<tr><td>Site</td><td>Unlikely</td><td>Completely</td><td>None</td><td>Long</td><td>Negligible</td><td>Low</td><td>Low</td></tr>
<tr><td colspan="3">Can the impact be reversed?</td><td colspan="6">Yes – Impact will stop once activities stop.</td></tr>
<tr><td colspan="3">Will impact cause irreplaceable loss or resources?</td><td colspan="6">No.</td></tr>
<tr><td colspan="3">Can impact be avoided, managed or mitigated?</td><td colspan="6">Mitigation not required.</td></tr>
<tr><td colspan="9">Mitigation not required as the potential cumulative night-time noise impact would be insignificant.</td></tr>
<tr><td colspan="3">Impact to be addressed/ further investigated and assessed in Impact Assessment Phase?</td><td colspan="6">Low significance of a cumulative noise impact and it will not be required to investigate this further in a Noise Impact Assessment.</td></tr>
</table>

10 MITIGATION OPTIONS

These general statements are included in this report for the developer to note, and include:

- Ensure that noise as a component is included in the induction of employees and contractors, and how their activities and actions can impact on residents in the area (reverse alarms and reversing close to dwellings, driving fast past residential dwellings at night, maintenance of equipment). All contractors and employees should receive this induction.
- Good public relations are essential. At all stages surrounding receptors should be informed about the sound generated by wind turbines. The information presented to stakeholders should be factual and should not set unrealistic expectations. It is counterproductive to suggest that the wind turbines will be inaudible, or to use vague terms like "quiet". Modern wind turbines produce a sound due to the aerodynamic interaction of the wind with the turbine blades, audible as a "swoosh", which can be heard at some distance from the turbines. The magnitude of the sound will depend on a multitude of variables and will vary from day to day and from place to place with environmental and operational conditions. Similarly, potential annoyance levels have been linked to visibility and audibility. Audibility is distinct from the sound level, because it depends on the relationship between the sound level from the wind turbines and the ambient background sound level and character.
- Community involvement needs to continue throughout the project. Annoyance is a complicated psychological phenomenon; as with many industrial operations, expressed annoyance with sound can reflect an overall annoyance with the project, rather than a rational reaction to the sound itself. Wind projects offer a benefit to the environment and the energy supply for the greater population, and offer economic benefits to the land owners leasing installation sites to the wind farm. A positive community attitude throughout the greater area should be fostered, particularly with those residents near the wind farm, to ensure they do not feel that advantage have been taken of them.
- 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 Wind Energy Facility should maintain a commitment to the local community and respond to concerns in an expedient fashion. Sporadic and legitimate noise complaints could develop. 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.

Specific conditions are defined below for the construction phase (noise impact of medium significance), with no specific conditions for the operational phase (noise impact of low significance).

10.1 CONSTRUCTION PHASE

The significance of potential noise impacts during the construction phase is **medium** and mainly relates to the construction of the access roads as well as construction traffic. While the access roads were not indicated, these findings are based on the location of existing roads.

General mitigation measures to reduce residual risk:

- Confirm with the residents in the area when they will be using their dwellings. Plan construction activities close to their dwellings when they are not at their houses. Construct the access roads close to their dwellings during a period when receptors are not using their dwellings.
- Locate contractors camp and storage areas at locations where construction traffic will pass occupied dwellings minimally.
- Relocate access roads further from houses. To minimize noise levels below a low significance ensure that roads (or grid lines) are further than 220m from dwellings used for residential purposes during the construction period if only daytime construction activities are proposed. Due to the low ambient sound levels, it is highly recommended that no construction activities are allowed within 580m from occupied dwellings if night-time construction activities are anticipated. This includes construction of roads, power lines or construction of wind turbines.
- Ideally, do not allow construction traffic to drive past dwellings used for residential purposes at night. If people, material or equipment must be moved at night, no traffic should be allowed closer than 250m from receptors. Minimize night-time traffic as much as possible. If significant traffic (more than 10 vehicles per hour) is anticipated at night, access roads must be located further than 580m from receptors.

10.2 OPERATIONAL PHASE

The noise impact is considered to be of a **low significance** for the surrounding receptors for the operation of the wind farm as well as the cumulative situation. Mitigation is not required and not recommended.

10.3 SPECIAL CONDITIONS

10.3.1 Mitigation options that should be included in the EMP

1. Confirm with the residents in the area when they will be using their dwellings. Construct the access roads close to their dwellings during a period when receptors are not using their dwellings.
2. Locate contractor's camp and storage areas at locations where minimal construction traffic will pass occupied dwellings.

10.3.2 Special conditions that should be included in the Environmental Authorization

1. The potential noise impact must again be evaluated should the layout be changed where any wind turbines are located closer than 1,000m from a confirmed NSD.
2. The developer must investigate any reasonable and valid noise complaint if registered by a receptor staying within 2,000m from location where construction activities are taking place or operational wind turbine.
3. No access roads should be developed closer than 250m from dwellings that will be occupied during the construction period.

11 ENVIRONMENTAL MANAGEMENT PLAN

11.1 Construction Phase

Projected noise levels during construction of the Wind Energy Facility were modelled using a sound propagation model. The resulting future noise projections indicated that construction activities, as modelled for the worst case scenario may result in a noise impact of medium significance. Mitigation was proposed and will reduce the significance of the noise impact to low.

While this study investigated likely and significant noisy activities, it did not evaluate all potential activities that could result in a noise impact. These activities could include temporary or short-term activities where small equipment is used (such as the digging of trenches to lay underground power-lines). The impact of such activities however is generally low.

The following measures are recommended to define the performance of the developer in mitigating the projected impacts and reducing the significance of the noise impact.

OBJECTIVE	**Control noise pollution stemming from construction activities**
Project Component(s)	Construction of infrastructure, including but not limited to: turbine system (foundation, tower, nacelle and rotor), substation(s), access roads and electrical power cabling.
Potential Impact	• Increased noise levels at potentially sensitive receptors • Potentially changing the acceptable land use capability.
Activity/Risk source	Any construction activities taking place within 500m from any potentially noise-sensitive developments (NSDs).
Mitigation Target/Objective	• Ensure equivalent A-weighted noise levels below 45 dBA at potentially sensitive receptors (direct project beneficiaries). • Ensure equivalent A-weighted noise levels below 42 dBA at potentially sensitive receptors (people that are not project beneficiaries). • Ensure that maximum noise levels at potentially sensitive receptors be less than 65 dBA; • Prevent the generation of disturbing or nuisance noises; • Ensure acceptable noise levels at surrounding stakeholders and potentially sensitive receptors; • Ensuring compliance with the National Noise Control Regulations.

Mitigation: Action/Control	Responsibility	Timeframe
Relocate access roads further than 250m from dwellings that will be occupied during the construction period. If these roads will be used during the night, these roads should be further from occupied dwellings.	Developer	Planning phase
Establish a line of communication and notify all stakeholders and NSDs of the means of registering any issues, complaints or comments.	- Environmental Control Officer	All phases of project
Identify and compile a list of potential noise-sensitive receptors and when they will be using their houses for residential purposes. Plan construction activities close to their dwellings when they are not staying in the dwellings (within 500m).	-Environmental Control Officer	At least 2 days, but not more than 5 days before activity is to commence
Notify potentially sensitive receptors about work to take place at least 2 days before the activity in the vicinity (within 500 meters) of the NSD is to start. Following information to be presented in writing: - Description of Activity to take place; - Estimated duration of activity; - Working hours; - Contact details of responsible party.	- Contractor -Environmental Control Officer	At least 2 days, but not more than 5 days before activity is to commence
Relocate access roads further than 250m from dwellings that will be occupied during the construction period. If these roads will be used during the night, these roads should be further from occupied dwellings.	Developer	Planning phase
Ensure that all equipment is maintained and fitted with the required noise abatement equipment.	- Contractor Environmental Control Officer	Weekly inspection
When any noise complaints are received, noise monitoring should be conducted at the complainant, followed by feedback regarding noise levels measured.	- Acoustical Consultant	Within 7 days after complaint was registered
The construction crew must abide by the local by-laws regarding noise.	- Contractor - Environmental Control Officer	Duration of construction phase
Where possible construction work should be undertaken during normal working hours (06H00 – 22H00), from Monday to Saturday; If agreements can be reached (in writing) with the all the surrounding (within a 1,000 distance) potentially sensitive receptors, these working hours can be extended.	- Contractor	As required

Performance indicator	• **Equivalent A-weighted noise levels below 45 dBA at potentially sensitive receptors (over 8 hours) due to construction activities.** • **Ensure that maximum noise levels at potentially sensitive receptors are less than 65 dBA.** • **No noise complaints are registered**
Monitoring	No routine sound or noise measurements are recommended.

11.2 OPERATIONAL PHASE

Projected noise levels during operation of the Wind Energy Facility were modelled using the methodology as proposed by ISO 9613-2.

The resulting future noise projections indicated that the operation of the facility will comply with the acceptable rating levels proposed in this report (refer **Table 2-2**).

The following measures are recommended to define the performance of the developer in terms of best international practice.

OBJECTIVE	**Control noise pollution stemming from operation of WEF**
Project Component(s)	Operational Phase
Potential Impact	• Increased noise levels at potentially sensitive receptors; • Changing ambient sound levels could change the acceptable land use capability; and • Disturbing character of noise from the wind turbines.
Activity/Risk source	Simultaneous operation of a number of Wind Turbines
Mitigation Target/Objective	• Prevent the generation of nuisance noises; • Ensure equivalent A-weighted noise levels below 45 dBA at potentially sensitive receptors (direct project beneficiaries). • Ensure equivalent A-weighted noise levels below 42 dBA at potentially sensitive receptors (people that are not project beneficiaries).

Mitigation: Action/Control	**Responsibility**	**Timeframe**
Add noise monitoring points at any complainants that registered a valid noise complaint relating to the operation of the WF.	- Acoustical Consultant	With monitoring programme

Performance indicator	**Ensure that the change in ambient sound levels as experienced by Potentially Sensitive Receptors is less than 5 dBA**
Monitoring	If a valid and reasonable complaint is registered relating to the operation of the facility additional noise monitoring should be undertaken as recommended by an acoustic consultant.

12 CONCLUSIONS AND RECOMMENDATIONS

This report is a Scoping assessment of the predicted noise environment due to the development of the proposed !Xhaboom WF and its grid infrastructure north of Loeriesfontein, Northern Cape. It is based on a desktop assessment, the author's expertise, as well as a basic predictive model (making use of the worst case scenario in terms of the precautionary approach) to identify potential issues of concern.

This assessment indicates that the proposed project could have a noise impact on the surrounding area, as there are Noise-sensitive developments within the (potential) area of acoustical influence of the construction activities and operating wind turbines.

The construction of access roads as well as construction traffic may increase the noise levels sufficiently to result in noise impacts of medium significance. Mitigation measures are available and easy to implement to reduce the potential significance of the noise impact to low.

The potential noise impact of operational activities is of low significance, similarly the potential cumulative effects when all the surrounding wind turbines are operating.

There is a high confidence in the finding of this report, and with the implementation of the mitigation measures there exists a low potential for a noise impact. An additional noise impact assessment is not required for the EIA phase, as it will not provide additional information. Subject to the implementation of the mitigation measures as highlighted, this project can be authorized from a noise perspective. It would not be required to assess the potential noise impact in more detail in the Environmental Impact Assessment phase.

13 THE AUTHOR

Morné 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 Licence Applications and EIA's), auditing of licence 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 15 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. He has been doing work in this field for the past 8 years, and was involved with the following projects in the last few years:

Wind Energy Facilities	*Full Environmental Noise Impact Assessments for - Bannf (Vidigenix), iNCa Gouda (Aurecon SA), Kangnas (Aurecon), Plateau East and West (Aurecon), Wolf (Aurecon), Outeniqwa (Aurecon), Zen (Savannah Environmental – SE), Goereesoe (SE), Springfontein (SE), Garob (SE), Project Blue (SE), ESKOM Kleinzee (SE), Walker Bay (SE), Oyster Bay (SE), Hidden Valley (SE), Happy Valley (SE), Deep River (SE), Tsitsikamma (SE), AB (SE), West Coast One (SE), Hopefield II (SE), Namakwa Sands (SE), VentuSA Gouda (SE), Dorper (SE), Amakhala Emoyeni (SE), Klipheuwel (SE), Cookhouse (SE), Cookhouse II (SE), Rheboksfontein (SE), Suurplaat (SE), Karoo Renewables (SE), Koningaas (SE), Eskom Aberdene (SE), Spitskop (SE), Castle (SE), Khai Ma (SE), Poortjies (SE), Korana (SE), IE Moorreesburg (SE), Saldanha (Terramanzi), Loeriesfontein (SiVEST), , Rhenosterberg (SiVEST), Noupoort (SiVEST), Prieska (SiVEST), Canyon Springs (Canyon Springs), Msenge Kromberg (Windlab)*

Mining and Industry	*Full Environmental Noise Impact Assessments for - BECSA – Middelburg (Golder Associates), Kromkrans Colliery (Geovicon Environmental), SASOL Borrow Pits Project (JMA Consulting), Lesego Platinum (AGES), Tweefontein Colliery (Cleanstream), Evraz Vametco Mine and Plant (JMA), Goedehoop Colliery (Geovicon), Hacra Project (Prescali Environmental), Der Brochen Platinum Project (J9 Environment), Delft Sand (AGES), Brandbach Sand (AGES), Verkeerdepan Extension (CleanStream), Dwaalboom Limestone (AGES), Jagdlust Chrome (MENCO), WPB Coal (MENCO), Landau Expansion (CleanStream), 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), EastPlats (CleanStream), Chapudi Coal (Jacana Environmental), Generaal Coal (JE), Mopane Coal (JE), Glencore Boshoek Chrome (JMA), Langpan Chrome (PE), Vlakpoort Chrome (PE), Sekoko Coal (SE), Frankford Power (REMIG), Strahrae Coal (Ferret Mining), Transalloys Power Station (Savannah), Pan Palladum Smelter, Iron and PGM Complex (Prescali), Fumani Gold (AGES), Leiden Coal (EIMS), Colenso Coal and Power Station (SiVEST), Klippoortjie Coal (Gudani), Rietspruit Crushers (MENCO), Assen Iron (Tshikovha), Transalloys (SE)*
Road and Railway	*K220 Road Extension (Urbansmart), Boskop Road (MTO), Sekoko Mining (AGES), Davel-Swaziland-Richards Bay Rail Link (Aurecon), Moloto Transport Corridor Status Quo Report and Pre-Feasibility (SiVEST), Postmasburg Housing Development (SE), Tshwane Rapid Transport Project, Phase 1 and 2 (NRM Consulting/City of Tshwane), Transnet Apies-river Bridge Upgrade (Transnet)*
Airport	*Oudtshoorn Noise Monitoring (AGES), Sandton Heliport (Alpine Aviation), Tete Airport Scoping*
Noise monitoring	*Peerboom Colliery (EcoPartners), Thabametsi (Digby Wells), Doxa Deo (Doxa Deo), Harties Dredging (Rand Water), Xstrata Coal – Witbank Regional (Xstrata), Sephaku Delmas (AGES), Amakhala Kromberg WEF (Windlab Developments), Oyster Bay WEF (Renewable Energy Systems), Tsitsikamma WEF (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)*
Small Noise Impact Assessments	*TCTA AMD Project Baseline (AECOM), NATREF (Nemai Consulting), Christian Life Church (UrbanSmart), Kosmosdale (UrbanSmart), Louwlardia K220 (UrbanSmart), Richards Bay Port Expansion (AECOM), Babalegi Steel Recycling (AGES), Safika Slag Milling Plant (AGES), Arcelor Mittal WEF (Aurecon), RVM Hydroplant (Aurecon), Grootvlei PS Oil Storage (SiVEST), Rhenosterberg WEF, (SiVEST), Concerto Estate (BPTrust), Ekuseni Youth Centre (MENCO), Kranskop Industrial Park (Cape South Developments), Pretoria Central Mosque (Noman Shaikh), Soshanguve Development (Maluleke Investments), Seshego-D Waste Disposal (Enviroxcellence), Zambesi Safari Equipment (Owner), Noise Annoyance Assessment due to the Operation of the Gautrain (Thornhill and Lakeside Residential Estate), Upington Solar (SE), Ilangalethu Solar (SE), Pofadder Solar (SE), Flagging Trees WEF (SE), Uyekraal WEF (SE), Ruuki Power Station (SE), Richards Bay Port Expansion (AECOM), Babalegi Steel Recycling (AGES), Safika Ladium (AGES), Safika Cement Isando (AGES), RareCo (SE), Struisbaai WEF (SE), Perdekraal WEF (ERM), Kotula Tsatsi Energy (SE)*
Project reviews and amendment reports	*Loperberg (Savannah), Dorper (Savannah), Penhoek Pass (Savannah), Oyster Bay (RES), Tsitsikamma (Cennergi), Amakhala Kromberg (Windlab), Spreeukloof (Savannah), Spinning Head (SE), Kangra Coal (ERM), West Coast One (Moyeng Energy), Rheboksfontein (Moyeng Energy)*

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APPENDIX A

Glossary of Acoustic Terms, Definitions and General Information

1/3-Octave Band	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.
A – Weighting	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.
Air Absorption	The phenomena of attenuation of sound waves with distance propagated in air, due to dissipative interaction within the gas molecules.
Alternatives	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.
Ambient	The conditions surrounding an organism or area.
Ambient Noise	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.
Ambient Sound	The all-encompassing sound at a point being composite of sounds from near and far.
Ambient Sound Level	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.
Amplitude Modulated Sound	A sound that noticeably fluctuates in loudness over time.
Applicant	Any person who applies for an authorisation to undertake a listed activity or to cause such activity in terms of the relevant environmental legislation.
Assessment	The process of collecting, organising, analysing, interpreting and communicating data that is relevant to some decision.
Attenuation	Term used to indicate reduction of noise or vibration, by whatever method necessary, usually expressed in decibels.
Audible frequency Range	Generally assumed to be the range from about 20 Hz to 20,000 Hz, the range of frequencies that our ears perceive as sound.
Ambient Sound Level	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.
Broadband Noise	Spectrum consisting of a large number of frequency components, none of which is individually dominant.
C-Weighting	This is an international standard filter, which can be applied to a pressure signal or to a *SPL* or *PWL* 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.
Controlled area (as per National Noise Control Regulations)	a piece of land designated by a local authority where, in the case of- (a) road transport noise in the vicinity of a road- (i) the reading on an integrating impulse sound level meter, taken outdoors at the end of a period extending from 06:00 to 24:00 while such meter is in operation, exceeds 65 dBA; or (ii) the equivalent continuous "A"-weighted sound pressure level at a height of at least 1,2 metres, but not more than 1,4 metres, above the ground for a period extending from 06:00 to 24:00 as calculated in accordance with SABS 0210-1986, titled: "Code of Practice for calculating and predicting road traffic noise", published under Government Notice No. 358 of 20 February 1987, and projected for a

	period of 15 years following the date on which the local authority has made such designation, exceeds 65 dBA; (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 (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 metres, but not more than 1,4 metres, above the ground for a period of 24 hours, exceeds 61 dBA;
dB(A)	Sound Pressure Level in decibel that has been A-weighted, or filtered, to match the response of the human ear.
Decibel (db)	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.
Diffraction	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.
Direction of Propagation	The direction of flow of energy associated with a wave.
Disturbing noise	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.
Environment	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.
Environmental Control Officer	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.
Environmental impact	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.
Environmental Impact Assessment	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.
Environmental issue	A concern felt by one or more parties about some existing, potential or perceived environmental impact.
Equivalent continuous A-weighted sound exposure level ($L_{Aeq,T}$)	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.
Equivalent continuous A-weighted rating level ($L_{Req,T}$)	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.
F (fast) time weighting	(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.

Footprint area	Area to be used for the construction of the proposed development, which does not include the total study area.
Free Field Condition	An environment where there is no reflective surfaces.
Frequency	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.
Green field	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.
G-Weighting	An International Standard filter used to represent the infrasonic components of a sound spectrum.
Harmonics	Any of a series of musical tones for which the frequencies are integral multiples of the frequency of a fundamental tone.
I (impulse) time weighting	(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.
Impulsive sound	A sound characterized by brief excursions of sound pressure (transient signal) that significantly exceed the ambient sound level.
Infrasound	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.
Integrated Development Plan	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).
Integrated Environmental Management	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.
Interested and affected parties	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.
Key issue	An issue raised during the Scoping process that has not received an adequate response and that requires further investigation before it can be resolved.
L_{A90}	the sound level exceeded for the 90% of the time under consideration
Listed activities	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.
L_{AMin} *and* L_{AMax}	Is the RMS (root mean squared) minimum or maximum level of a noise source.
Loudness	The attribute of an auditory sensation that describes the listener's ranking of sound in terms of its audibility.
Magnitude of impact	Magnitude of impact means the combination of the intensity, duration and extent of an impact occurring.
Masking	The raising of a listener's threshold of hearing for a given sound due to the presence of another sound.
Mitigation	To cause to become less harsh or hostile.

Negative impact	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).
Noise	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.
Noise Level	The term used in lieu of sound level when the sound concerned is being measured or ranked for its undesirability in the contextual circumstances.
Noise-sensitive development	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
Octave Band	A filter with a bandwidth of one octave, or twelve semi-tones on the musical scale representing a doubling of frequency.
Positive impact	A change that improves the quality of life of affected people or the quality of the environment.
Property	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
Public Participation Process	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
Reflection	Redirection of sound waves.
Refraction	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.
Reverberant Sound	The sound in an enclosure which results from repeated reflections from the boundaries.
Reverberation	The persistence, after emission of a sound has stopped, of a sound field within an enclosure.
Significant Impact	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.
S (slow) time weighting	(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.
Sound Level	The level of the frequency and time weighted sound pressure as determined by a sound level meter, i.e. A-weighted sound level.
Sound Power	Of a source, the total sound energy radiated per unit time.
Sound Pressure Level (SPL)	Of a sound, 20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level. International values for the reference sound pressure level are 20 micropascals in air and

	100 millipascals in water. SPL is reported as L_p in dB (not weighted) or in various other weightings.
Soundscape	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.
Study area	Refers to the entire study area encompassing all the alternative routes as indicated on the study area map.
Sustainable Development	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).
Tread braked	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.
Zone of Potential Influence	The area defined as the radius about an object, or objects beyond which the noise impact will be insignificant.
Zone Sound Level	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.

End of Report