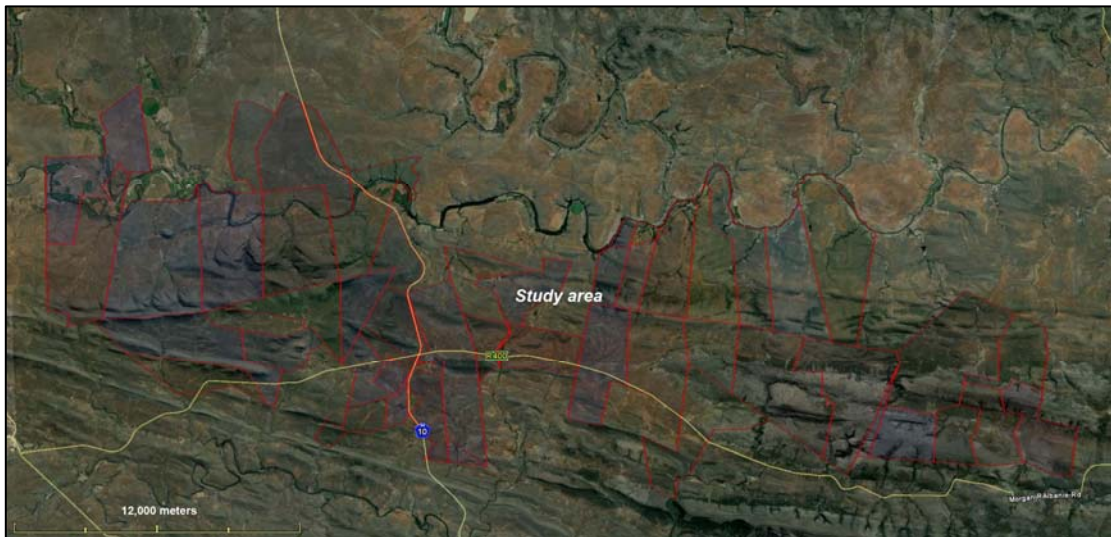


Renewable Energy Systems Southern Africa
NOISE IMPACT ASSESSMENT
FOR SCOPING PURPOSES

**Establishment of the Spitskop Wind Energy Facility
on various farms near the town of Riebeek East,
Eastern Cape Province**



Study done for:



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GLOSSARY OF ABBREVIATIONS

| | |
|----------------|---|
| DEADP | Department of Environmental Affairs and Development Planning |
| DENC | Department of Environment and Nature Conservation |
| DEA | Department of Environmental Affairs |
| EAP | Environmental Assessment Practitioner |
| ECA | Environment Conservation Act (Act 78 of 1989) |
| ECO | Environmental Control Officer |
| EIA | Environmental Impact Assessment |
| EMP | Environmental Management Plan |
| EMS | Environmental Management System |
| FEL | Front End Loader |
| IAPs | Interested and Affected Parties |
| i.e. | that is |
| IEM | Integrated Environmental Management |
| km | kilometres |
| LHD | Load haul dumper |
| m | Meters (measurement of distance) |
| m ² | Square meter |
| m ³ | Cubic meter |
| mamsl | Meters above mean sea level |
| MENCO | M ² Environmental Connections cc |
| NEMA | National Environmental Management Act, 1998 (Act 107 of 1998) |
| NCR | Noise Control Regulations (under Section 25 of the ECA) |
| NGO | Non-government Organisation |
| PPE | Personal Protective Equipment |
| PPP | Public Participation Process |
| SABS | South African Bureau of Standards |
| SANS | South African National Standards |
| SHEQ | Safety Health Environment and Quality |
| REF | Wind Energy Facility |
| WHO | World Health Organisation |
| WTG | Wind Turbine Generator |



GLOSSARY OF TERMS

| | |
|---------------------------------------|---|
| <i>1/3-Octave Band</i> | A filter with a bandwidth of one-third of an octave representing four semitones, or notes on the musical scale. This relationship is applied to both the width of the band, and the center frequency of the band. See also definition of octave band. |
| <i>A – Weighting</i> | An internationally standardised frequency weighting which approximates the frequency response of the human ear and gives an objective reading, which therefore agrees with the subjective human response to that sound. |
| <i>Air Absorption</i> | The phenomena of attenuation of sound waves with distance propagated in air, due to dissipative interaction within the gas molecules. |
| <i>Alternatives</i> | A possible course of action, in place of another, that would meet the same purpose and need (of proposal). Alternatives can refer to any of the following but are not limited hereto: alternative sites for development, alternative site layouts, alternative designs, alternative processes and materials. In Integrated Environmental Management the so-called “no go” alternative refers to the option of not allowing the development and may also require investigation in certain circumstances. |
| <i>Ambient</i> | The conditions surrounding an organism or area. |
| <i>Ambient Noise</i> | The all-encompassing sound at a point being composed of sounds from many sources both near and far. It includes the noise from the noise source under investigation. |
| <i>Ambient Sound</i> | The all-encompassing sound at a point being composite of sounds from near and far. |
| <i>Ambient Sound Level</i> | Means the reading on an integrating impulse sound level meter taken at a measuring point in the absence of any alleged disturbing noise at the end of a total period of at least 10 minutes after such a meter was put into operation. In this report the term Background Ambient Sound Level will be used. |
| <i>Amplitude Modulated Sound</i> | A sound which noticeably fluctuates in loudness over time. |
| <i>Applicant</i> | Any person who applies for an authorisation to undertake a listed activity or to cause such activity in terms of the relevant environmental legislation. |
| <i>Assessment</i> | The process of collecting, organising, analysing, interpreting and communicating data that is relevant to some decision. |
| <i>Audible Frequency Range</i> | Generally assumed to be the range from about 20 Hz to 20,000 Hz, the range of frequencies which our ears perceive as sound. |
| <i>Background Ambient Sound Level</i> | The level of the ambient sound indicated on a sound level meter in the absence of the sound under investigation (e.g. sound from a particular noise source or sound generated for test purposes). Ambient sound level as per Noise Control Regulations. |
| <i>C-Weighting</i> | This is an international standard filter, which can be applied to a pressure signal or to a <i>SPL</i> or <i>PWL</i> spectrum, and which is essentially a pass-band filter in the frequency range of approximately 63 to 4000 Hz. This filter provides a more constant, flatter, frequency response, providing significantly less adjustment than the A-scale filter for frequencies less than 1000 Hz. |
| <i>dB(A)</i> | Sound Pressure Level in decibel which has been A-weighted, or filtered, to match the response of the human ear. |
| <i>Decibel (db)</i> | A logarithmic scale for sound corresponding to a multiple of 10 of the threshold of hearing. Decibels for sound levels in air are referenced to an atmospheric pressure of 20 μ Pa. |
| <i>Diffraction</i> | Modification of the progressive wave distribution due to the presence of obstacles in the field. Reflection and refraction are special cases of diffraction. |
| <i>Direction of Propagation</i> | The direction of flow of energy associated with a wave. |
| <i>Disturbing noise</i> | Means 'n noise level which exceeds the zone sound level or, if no zone sound |



| | |
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| | level has been designated, a noise level which exceeds the ambient sound level at the same measuring point by 7 dBA or more. |
| <i>Environment</i> | The external circumstances, conditions and objects that affect the existence and development of an individual, organism or group; these circumstances include biophysical, social, economic, historical, cultural and political aspects. |
| <i>Environmental Control Officer</i> | Independent officer employed by the applicant to ensure the implementation of the Environmental Management Plan (EMP) and manage any further environmental issues that may arise. |
| <i>Environmental impact</i> | A change resulting from the effect of an activity on the environment, whether desirable or undesirable. Impacts may be the direct consequence of an organisation's activities or may be indirectly caused by them. |
| <i>Environmental Impact Assessment</i> | An Environmental Impact Assessment (EIA) refers to the process of identifying, predicting and assessing the potential positive and negative social, economic and biophysical impacts of any proposed project, plan, programme or policy which requires authorisation of permission by law and which may significantly affect the environment. The EIA includes an evaluation of alternatives, as well as recommendations for appropriate mitigation measures for minimising or avoiding negative impacts, measures for enhancing the positive aspects of the proposal, and environmental management and monitoring measures. |
| <i>Environmental issue</i> | A concern felt by one or more parties about some existing, potential or perceived environmental impact. |
| <i>Equivalent continuous A-weighted sound exposure level ($L_{Aeq,T}$)</i> | The value of the average A-weighted sound pressure level measured continuously within a reference time interval T , which have the same mean-square sound pressure as a sound under consideration whose level varies with time. |
| <i>Equivalent continuous A-weighted rating level ($L_{Req,T}$)</i> | The Equivalent continuous A-weighted sound exposure level ($L_{Aeq,T}$) to which various adjustments has been added. More commonly used as ($L_{Req,d}$) over a time interval 06:00 – 22:00 ($T=16$ hours) and ($L_{Req,n}$) over a time interval of 22:00 – 06:00 ($T=8$ hours). |
| <i>Footprint area</i> | Area to be used for the construction of the proposed development, which does not include the total study area. |
| <i>Frequency</i> | The rate of oscillation of a sound, measured in units of Hertz (Hz) or kilohertz (kHz). One hundred Hz is a rate of one hundred times per second. The frequency of a sound is the property perceived as pitch: a low-frequency sound (such as a bass note) oscillates at a relatively slow rate, and a high-frequency sound (such as a treble note) oscillates at a relatively high rate. |
| <i>Green field</i> | A parcel of land not previously developed beyond that of agriculture or forestry use; virgin land. The opposite of Greenfield is brownfield, which is a site previously developed and used by an enterprise, especially for a manufacturing or processing operation. The term brownfield suggests that an investigation should be made to determine if environmental damage exists. |
| <i>G-Weighting</i> | An International Standard filter used to represent the infrasonic components of a sound spectrum. |
| <i>Infrasound</i> | Sound with a frequency content below the threshold of hearing, generally held to be about 20 Hz. Infrasonic sound with sufficiently large amplitude can be perceived, and is both heard and felt as vibration. Natural sources of infrasound are waves, thunder and wind. |
| <i>Integrated Development Plan</i> | A participatory planning process aimed at developing a strategic development plan to guide and inform all planning, budgeting, management and decision-making in a Local Authority, in terms of the requirements of Chapter 5 of the Municipal Systems Act, 2000 (Act 32 of 2000). |
| <i>Integrated Environmental Management</i> | IEM provides an integrated approach for environmental assessment, management, and decision-making and to promote sustainable development and the equitable use of resources. Principles underlying IEM provide for a democratic, participatory, holistic, sustainable, equitable and accountable approach. |



| | |
|--|--|
| <i>Interested and affected parties</i> | Individuals or groups concerned with or affected by an activity and its consequences. These include the authorities, local communities, investors, work force, consumers, environmental interest groups and the general public. |
| <i>Key issue</i> | An issue raised during the Scoping process that has not received an adequate response and which requires further investigation before it can be resolved. |
| <i>Listed activities</i> | Development actions that is likely to result in significant environmental impacts as identified by the delegated authority (formerly the Minister of Environmental Affairs and Tourism) in terms of Section 21 of the Environment Conservation Act. |
| <i>Loudness</i> | The attribute of an auditory sensation which describes the listener's ranking of sound in terms of its audibility. |
| <i>Magnitude of impact</i> | Magnitude of impact means the combination of the intensity, duration and extent of an impact occurring. |
| <i>Masking</i> | The raising of a listener's threshold of hearing for a given sound due to the presence of another sound. |
| <i>Mitigation</i> | To cause to become less harsh or hostile. |
| <i>Negative impact</i> | A change that reduces the quality of the environment (for example, by reducing species diversity and the reproductive capacity of the ecosystem, by damaging health, or by causing nuisance). |
| <i>Noise</i> | a. Sound which a listener does not wish to hear (unwanted sounds). b. Sound from sources other than the one emitting the sound it is desired to receive, measure or record. c. A class of sound of an erratic, intermittent or statistically random nature. |
| <i>Noise Level</i> | The term used in lieu of sound level when the sound concerned is being measured or ranked for its undesirability in the contextual circumstances. |
| <i>Noise-sensitive development</i> | Developments that could be influenced by noise such as – rural, suburban, urban, business or industrial districts – educational, residential, office and health care buildings and their surroundings – churches, auditoriums, concert halls and their surroundings – recreational areas – nature reserves. In this document a noise-sensitive development is referred to as a Potentially Sensitive Receptor (PSR) |
| <i>Octave Band</i> | A filter with a bandwidth of one octave, or twelve semi-tones on the musical scale representing a doubling of frequency. |
| <i>Positive impact</i> | A change which improves the quality of life of affected people or the quality of the environment. |
| <i>Property</i> | Any piece of land indicated on a diagram or general plan approved by the Surveyor-General intended for registration as a separate unit in terms of the Deeds Registries Act and shall include an erf, a site and a farm portion as well as the buildings erected thereon |
| <i>Public Participation Process</i> | A process of involving the public in order to identify needs, address concerns, choose options, plan and monitor in terms of a proposed project, programme or development |
| <i>Reverberant Sound</i> | The sound in an enclosure excluding that which is received directly from the source. |
| <i>Reverberation</i> | The persistence, after emission of a sound has stopped, of a sound field within an enclosure. |
| <i>Significant Impact</i> | An impact can be deemed significant if consultation with the relevant authorities and other interested and affected parties, on the context and intensity of its effects, provide reasonable grounds for mitigating measures to be included in the environmental management report. The onus shall be on the applicant to include the relevant authorities and other interested and affected parties in the consultation process. Present and potential future, cumulative and synergistic effects should all be taken into account. |
| <i>Sound Level</i> | The level of the frequency weighted and time weighted sound pressure as determined by a sound level meter. |
| <i>Sound Power</i> | Of a source, the total sound energy radiated per unit time. |
| <i>Sound Pressure Level (SPL)</i> | Of a sound, 20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level. International |



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| | | values for the reference sound pressure level are 20 micropascals in air and 100 millipascals in water. SPL is reported as L_p in dB (not weighted) or in various other weightings. |
| <i>Soundscape</i> | | Sound or combination of sounds that forms or arises from an immersive environment. The study of soundscape is the subject of acoustic ecology. The idea of soundscape refers to both the natural acoustic environment, consisting of natural sounds, including animal vocalizations and, for instance, the sounds of weather and other natural elements; and environmental sounds created by humans, through musical composition, sound design, and other ordinary human activities including conversation, work, and sounds of mechanical origin resulting from use of industrial technology. The disruption of these acoustic environments results in noise pollution. |
| <i>Study area</i> | | Refers to the entire study area encompassing all the alternative routes as indicated on the study area map. |
| <i>Sustainable Development</i> | | Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and the future needs (Brundtland Commission, 1987). |
| <i>Zone of Potential Influence</i> | <i>of</i> | The area defined as the radius about an object, or objects beyond which the noise impact will be insignificant. |
| <i>Zone Level</i> | <i>Sound</i> | Means a derived dBA value determined indirectly by means of a series of measurements, calculations or table readings and designated by a local authority for an area. This is similar to the Rating Level as defined in SANS10103. |



1 INTRODUCTION

1.1 INTRODUCTION AND PURPOSE

M2 Environmental Connections was commissioned to undertake a specialist study to determine the potential noise impact on the surrounding environment due to the establishment of the proposed Spitskop Wind Energy Facility (WEF) on nearby properties close to the town of Riebeek East.

This report is the result of a first phase study (desktop) on the potential impact of such a facility on the surrounding environment, highlighting methodologies, potential issues to be investigated as well as preliminary findings and recommendations.

It is important to note this document is only the Scoping Document. Being preliminary, the report presents methodologies to be followed during the Environmental Noise Impact Assessment and uses scenarios to illustrate important concepts.

1.2 BRIEF PROJECT DESCRIPTION

Renewable Energy Systems Southern African (hereafter referred as RES Southern Africa) proposes the establishment of a commercial wind energy facility and associated infrastructure on various farms just north-east of the town of Riebeek East. Riebeek East is situated approximately 35 km north-east of Grahamstown in the Eastern Cape. This facility will be known as the Spitskop Wind Energy Facility and will consist of up to 200 wind turbines. The study area is approximately 264 km². The facility and associated infrastructure includes:

- Up to 200 wind turbines and associated concrete foundations,
- Underground cables (where possible) between the project components,
- An onsite substation to facilitate the connection between the WEF and the national grid,
- New overhead power lines linking to Eskom's existing Poseidon Substation near Cookhouse,
- A workshop/maintenance/control building; and
- Access Roads, into and between the turbines.



1.3 TERMS OF REFERENCE

SANS 10328:2008 (Edition 3) specifies the methodology to assess the noise impacts on the environment due to a proposed activity that might result in a noise 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 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.



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.

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

- The potential impact 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, and, where appropriate, background noise levels and appropriate noise criteria will be determined using the ETSU R97 methodology and the identification of potential sensitive areas.
- 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,
- Details regarding the methodology followed to estimate and assess the potentially significant impacts during the EIA phase.

1.4 STUDY AREA

The proposed WEF will be situated in an area with a rural character. The topography east of the N10 can be considered hilly with a number of hills forming a continuous ridge through the middle of the eastern part of the properties considered for the WEF. The height above sea-level range between 480 meters in the low-lying areas to more than 700 meters on the hills.

West of the N10 the hills forms a toe of the larger Swartwatersberg. Height above sea-level range between 430 and 850 meters.

Agriculture plays an important role in the area, especially for farms bordering the Greater Fish river. Apart from the N10 traversing the site, there are little other significant noise sources in the area.

Based by previous work done in the area by the author the study area should have a rural character in terms of the background noise levels. Ambient Sound levels less



than 35 dBA can be expected (areas away from any activity in windless conditions) during the day and night. A site locality map is presented in **Figure 1-1**.

1.5 AVAILABLE INFORMATION

The author has conducted a number of Noise studies for Wind Energy Facilities north of the proposed site, including:

- Environmental Noise Impact Assessment for the Cookhouse Wind Energy Facility,
- Environmental Noise Impact Assessment for the Amakhala Emoyeni Wind Energy Facility.

1.6 POTENTIAL SENSITIVE RECEPTORS

An assessment of the area was done using available topographical maps to identify potentially sensitive receptors in the area (within area proposed, as well as receptors up to 2 km from boundary of facility). The data was imported into GoogleEarth® to allow a more visual view of the areas where potentially sensitive receptors were identified. The presence of these potentially sensitive receptors (PSR) will be confirmed during a future site visit. The assessment indicated there are a significant number of potentially sensitive receptors living in the area.

Receptors identified are highlighted in **Figure 1-2**. It is believed that available topographical maps, GoogleEarth® imagery, information that can be gained during a site visit as well as discussions with the developer should be sufficient to identify and confirm potential sensitive receptors.

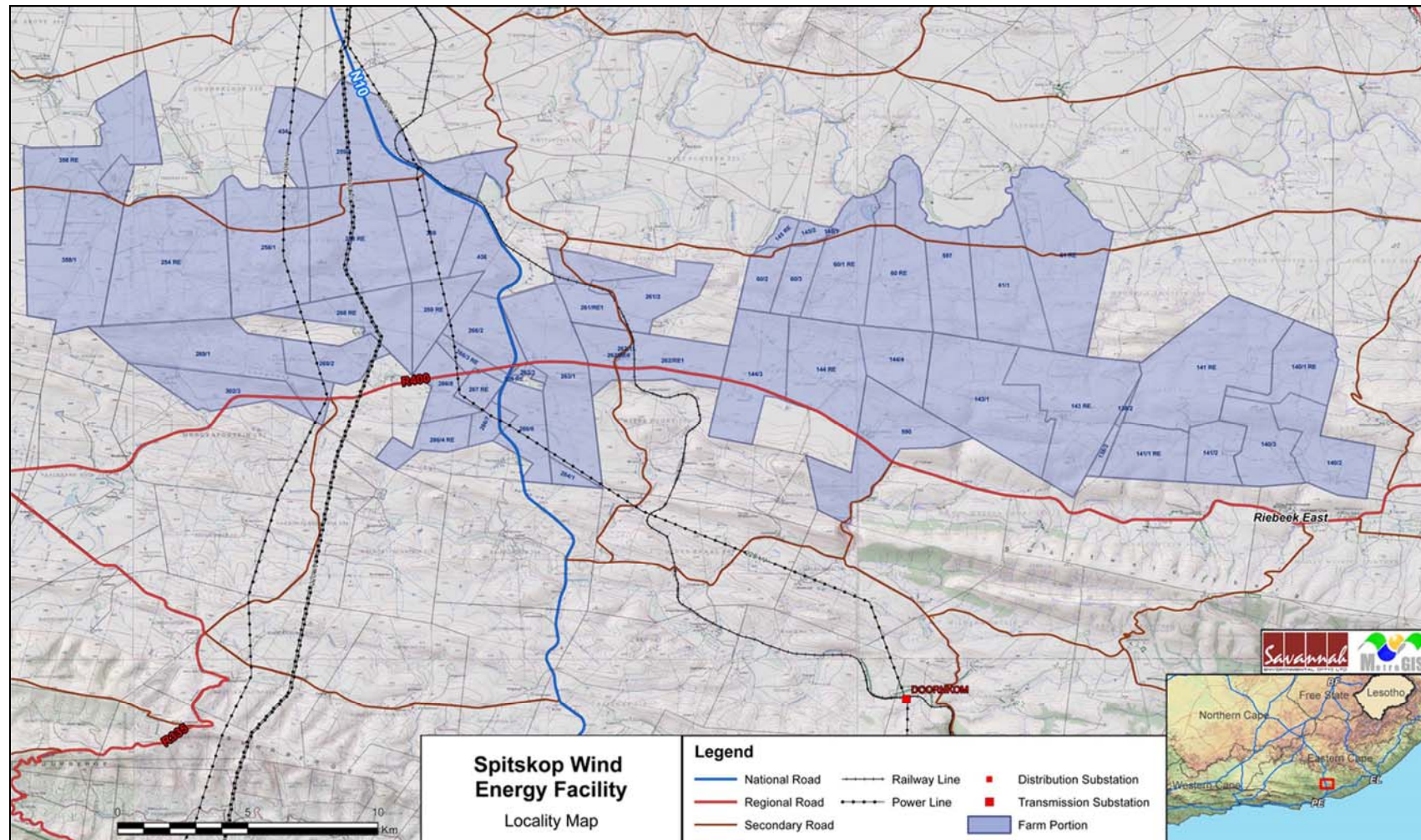


Figure 1-1: Locality map indicating locations of the proposed Spitskop Wind Energy Facility

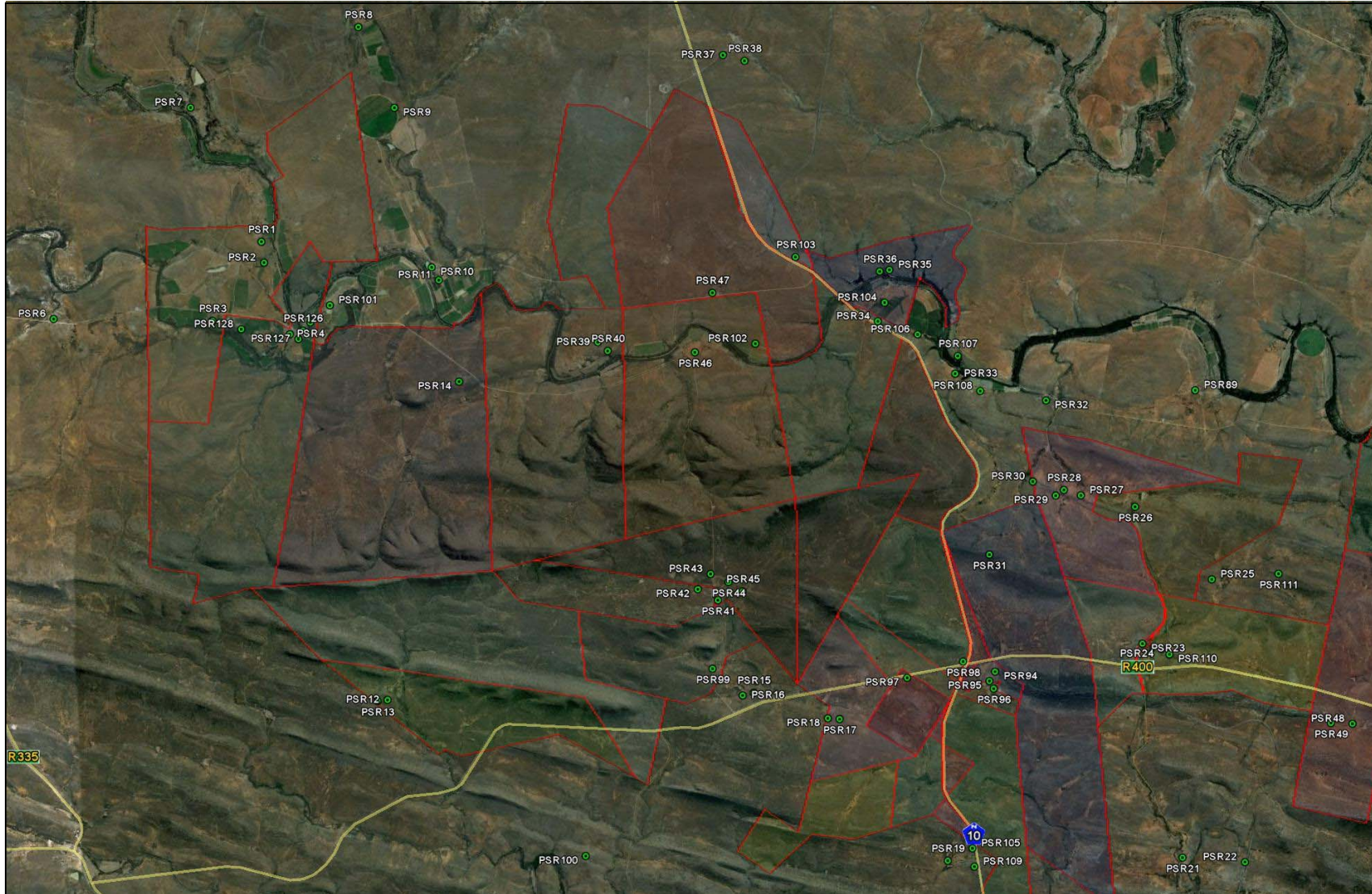


Figure 1-2: Aerial Image indicating potentially sensitive receptors in and around the proposed WEF: Western Properties

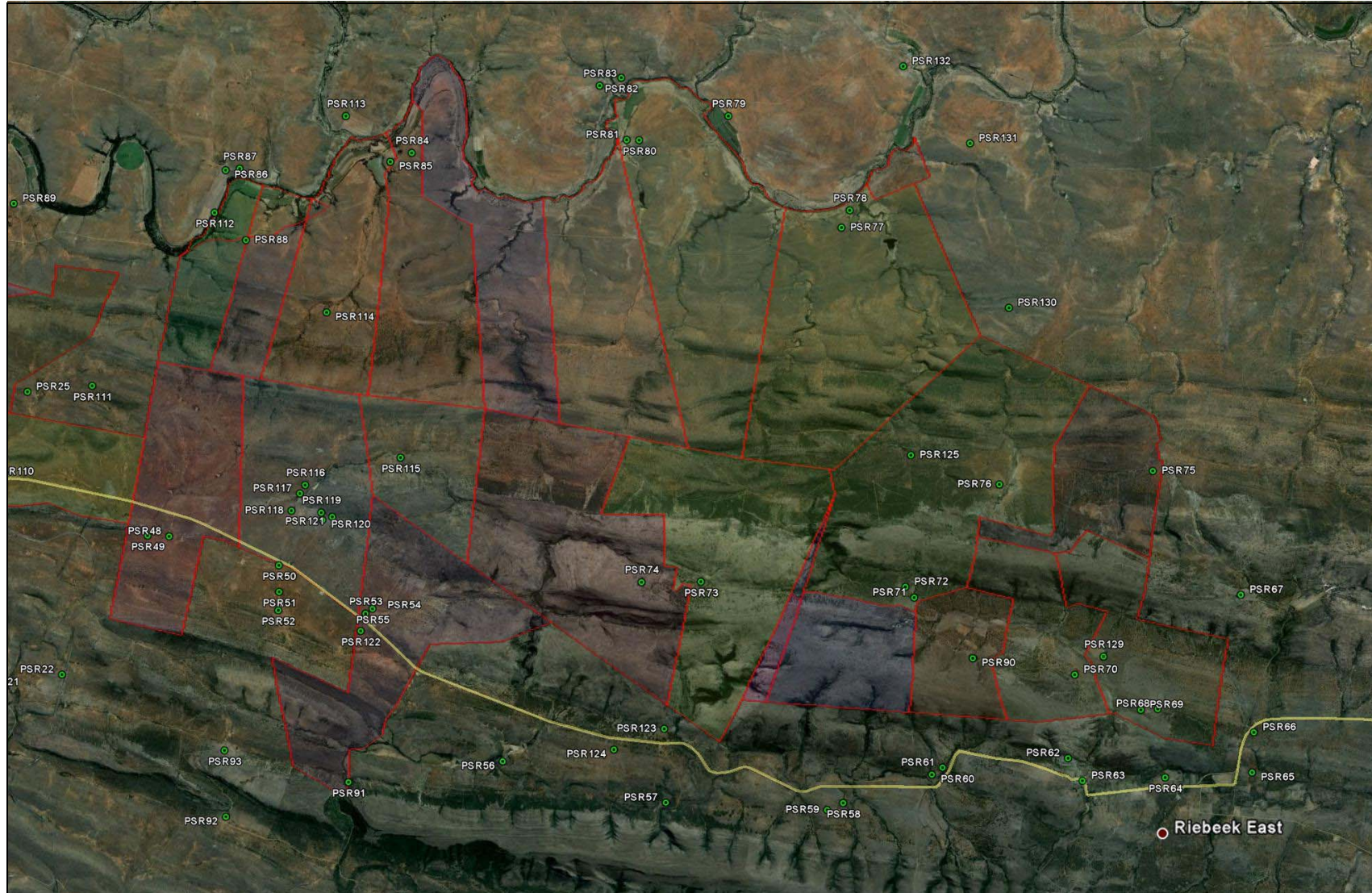


Figure 1-3: Aerial Image indicating potentially sensitive receptors in and around the proposed WEF: Eastern Properties



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 well-being. The general approach of the common law is to define an acceptable level of noise as that which the reasonable person can be expected to tolerate in the particular circumstances. The subjectivity of this approach can be problematic, however, which has led to the development of noise standards (see Section 2.7).

“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. The Minister has made noise control regulations under the ECA, adopted only by the Western Cape, Gauteng and Free-state provinces.

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.

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.

2.5 NOISE CONTROL REGULATIONS

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. The NCRs were revised under Government Notice Number R. 55 of 14 January 1994 to make it obligatory for all authorities to apply the regulations.

Subsequently, in terms of Schedule 5 of the Constitution of South Africa of 1996 legislative responsibility for administering the NCR was devolved to provincial and local authorities. Provincial Noise Control Regulations exist in the Western Cape, Gauteng and Free-state provinces. The Eastern Cape does not have any provincial Noise Control Regulations.



In terms of this regulation a "Disturbing noise" is defined as a noise levels that exceeds the zone sound level or, if no zone sound level has been designated, a noise level which exceeds the ambient sound level with more than 7 dBA. The regulation specifically prohibit the making, production or causing of such a disturbing noise.

2.6 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.

2.7 NOISE STANDARDS

Four South African Bureau of Standards (SABS) scientific standards may be 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*.

2.8 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.

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

2.8.2 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 Unit¹ (ETSU) project. The aim of the project was to provide information and advice to developers and planners on noise from wind turbines. The report represents the consensus view of a number of experts (experienced in assessing and controlling the environmental impact of noise from wind farms). Their findings can be summarised as follows:

1. Absolute noise limits applied at all wind speeds are not suited to wind farms; limits set relative to the background noise (including wind as seen in **Figure 5-2**) are more appropriate
2. $L_{A90,10\text{mins}}$ is a much more accurate descriptor when monitoring ambient and turbine noise levels
3. The effects of other wind turbines in a given area should be added to the effect of any proposed 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 potential sensitive receptor. Ambient noise levels is measured onsite in terms of the $L_{A90,10\text{min}}$ descriptor for a period sufficiently long enough for a set period
5. Wind farms should be limited to within the range of 35dBA to 40dBA (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 potential receptor 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

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 organisations in academia and industry. In 1996, ETSU became part of AEA Technology plc which was separated from the UKAEA by privatisation.



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.

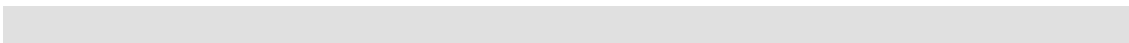
2.8.3 Noise Guidelines for Wind Farms (MoE, 2008)

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 a 10 m height
- 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
 - Assessment of Compliance (defining magnitude of noise levels)

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





3 POTENTIAL NOISE SOURCES

Increased noise levels are directly linked with the various activities associated with the construction of the WEF and related infrastructure, as well as the operational phase of the activity. The specific activities relating to construction of the WEF will only be known during the EIA phase of the project, and therefore will only be discussed in a generalised manner in the following sections.

However, commonly the most significant stage relating to noise is the operational phase, and not the construction phase. This is because the duration of activities during the construction phase are generally short.

In addition, the exact locations of the various Wind Turbine Generators (WTGs) will only be defined during the EIA phase, and only then can their noise impact be modeled in detail.

3.1 POTENTIAL NOISE SOURCES: CONSTRUCTION PHASE

3.1.1 Construction equipment

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 WTGs.

The equipment likely to be required to complete the above tasks will typically include:

- excavator/grader, bulldozer, dump trucks, vibratory roller, bucket loader, rock breaker, (*potentially*) drill rig, excavator/grader, bulldozer, dump truck, flat bed trucks, concrete truck(s), cranes, fork lift and various 4WD and service vehicles.



3.1.2 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. The need for such batching plants, the number, and whether they will be moved is yet unknown and shall be determined in the EIA phase.

It is not known whether the developer may make use of a borrow pit (for aggregate material) and a portable rock crusher plant and screen.

3.1.3 Blasting

Blasting may also be required as part of the civil works to clear obstacles or to prepare foundations. Should a borrow pit be used to supply rocks for construction purposes, blasting could also be expected. However, no information regarding the use, or even the feasibility of such a borrow pit is known.

However, 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.



3.1.4 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 dependant 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).

3.2 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.

3.2.1 Wind Turbine Noise: Aerodynamic sources²

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

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

² [Reference source 15](#)



3.2.2 Wind Turbine: Mechanical sources³

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

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

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

Where complaints have been received due to the operation of wind farms, tonal noise from the installed wind turbines appears to have increased the annoyance perceived by the complainants and 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 should not emit any clearly distinguishable tones (turbine manufacturers can supply warranty in this regard).***

³ [Reference source 15](#)



3.2.3 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 magnetized. When the magnetism is taken away, the shape returns, only to try and deform in a different manner when the polarity is changed.

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

3.2.4 Transmission Line Noise (Corona noise)

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 characterised as broadband 'crackling' or 'buzzing', but ***fortunately it is generally only a feature during fog or rain (high humidities).***

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

- Power losses,
- Audible noises,



- Electromagnetic interference,
- A purple glow,
- Ozone production; and
- Insulation damage.

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

3.2.5 Low Frequency Noise

Low frequency noise will be covered in more detail in the Environmental Noise Impact Report.

3.2.5.1 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 20Hz. 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 on this field, there exist uncertainties around Infrasound and Low Frequency Noise (e.g. when it might occur, its propagation, contribution from natural sources, the sensitivities of different people).

3.2.5.2 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.

3.2.5.3 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.

3.2.5.4 Measurement, Isolation and Assessment of Low Frequency Sounds

There remains significant debate regarding the noise from WTG's, public response to that noise, as well as the presence or not 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 potential to generate low frequency sounds with sufficient energy to warrant the need to investigate WTG as a source of low frequency sounds. Of particular note in this regard is the low frequency sounds associated with a 3.6 MW wind turbine at 250 m outdoors (red) and the same turbine at 600 m indoors (green). Note that this should not be seen as a rule for all turbines, as each turbine make, model and size have 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 ($L_{Aeq} \gg L_{Ceq}$) sound pressure levels is greater than 10 dB, a predominant low frequency component **may** be present.



3.2.6 Amplitude modulation

This is when the sound emissions from the wind turbines create a repetitive rise and fall in sound levels synchronized 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 unknown means that it is not possible to predict when or whether it will occur.

Studies have showed that important factors to consider when evaluating the probability whether amplitude modulation may occur include:

- The relevant orientation of the blades of the wind turbine in relation to the location of the PSR.
- Certain weather conditions could increase probabilities that it might occur and its relative magnitude.

It is also reported that for many people, especially seniors, children and those with pre-existing medical conditions, that amplitude modulated noises represents a major challenge to restful sleep.

However, while there are thousands of wind turbine generators in the world, amplitude modulation are one subject receiving the least complaints and due to this 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). It will be covered in more detail during the Environmental Noise Impact Report.





4 METHODOLOGIES TO BE FOLLOWED DURING THE ENVIRONMENTAL NOISE IMPACT ASSESSMENT PHASE

4.1 MEASUREMENT PROCEDURE

Current ambient sound levels will be determined as per SANS 10103:2008. In addition, if predicted noise levels at PSRs exceed the zone sound levels (see **Table 5-1**, e.g. 35 dBA L_{Aeq} outside for night-time period) additional measurements will be carried out in accordance with the procedures specified in ETSU R97 to determine prevailing ambient sound levels.

The measurement procedure involves:

- The erection of a Sound Level Meter (SLM) at a number of monitoring sites. The monitoring sites will be selected after considering the location of PSRs, the proposed location of the Wind Turbine Generators as well as local conditions
- Sampling will be conducted as per the requirements of SANS 10103:2008
- The variation in ambient sound level with wind speed will be determined by correlating $L_{A90,10min}$ noise level measurements taken over a period of time with the average wind speeds measured over the same 10-minute periods from a meteorological mast situated on the proposed wind facility site and a best-fit curve fitted to these data.
- A best-fit curve will be developed for each monitoring site for both night and day.

4.2 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 using two different models described by ISO 9613-2 and SANS 10357⁴ during the EIA phase only. The following will be taken into account:

- The octave band sound pressure emission levels of processes and equipment (both models);
- The distance of the receiver from the noise sources (both models);
- The impact of atmospheric absorption (both models);

⁴ [SANS 10357:2004 The calculation of sound propagation by the Concave method'](#)



- The meteorological conditions in terms Pasquill stability (only SANS CONCAWE model);
- The preliminary layout details of the proposed project (both models);
- Topographical layout (both models);
- Acoustical characteristics of the ground and height differences (both models albeit a very different approach);
- Potential barrier effects (both models, albeit the ISO 9613 would be a simplified methodology).

The potential impact from traffic will not be considered during the Scoping phase, but only in the EIA phase. During the EIA phase the noise emission into the environment from the various traffic options will be calculated using the sound propagation model described in SANS 10210⁵. Corrections such as the following will be considered:

- Distance of receptor from roads;
- Road construction material;
- Average speeds of travel;
- Types of vehicles used;
- Ground acoustical conditions.

⁵ [SANS 10210:2004. 'Calculating and predicting road traffic noise'](#)



5 METHODOLOGY: NOISE IMPACT ASSESSMENT AND SIGNIFICANCE

5.1 DIFFERENCE BETWEEN SOUND AND NOISE

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.

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

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

Noise does not need to be loud to be considered "disturbing". One can refer to a dripping tap in the quiet of the night, or the irritating "thump-thump" of the music from a neighboring house at night when one would like to sleep. Severity of the annoyance depends on factors such as:

- The manner in which the receptor can control the noise (helplessness),
- The time, unpredictability, duration, and intensity of the noise,
- The physiological state of the receptor.



5.2 IMPACT ASSESSMENT CRITERIA

5.2.1 Overview: The common characteristics

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

- Intensity
- Loudness
- Annoyance
- 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.

5.2.2 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 10103:2008 as well as ETSU R97.

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 5-1**.
- *Zone Sound Levels:* Previously referred as the acceptable rating levels, it sets acceptable noise levels for various areas. See also **Table 5-2**.



- *Absolute or total noise levels:* Depending on their activities, people generally are tolerant to noise up to a certain absolute level, e.g. 65 dBA. However, anything above this level is considered unacceptable.

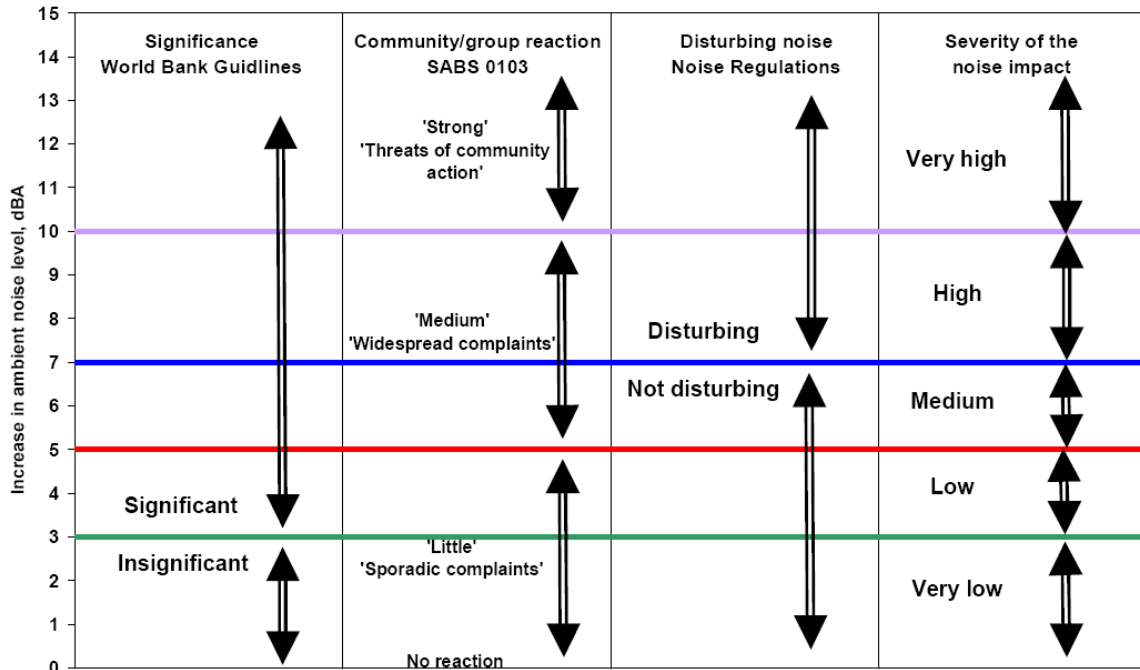


Figure 5-1: Criteria to assess the significance of impacts stemming from noise

In South Africa the document that addresses the issues concerning environmental noise is SANS 10103 (see also **Table 5.1**). It provides the maximum average ambient noise levels, $L_{Req,d}$ and $L_{Req,nr}$ during the day and night respectively to which different types of developments may be exposed. For rural areas the Zone Sound 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.

5.2.3 Determining appropriate Zone Sound Levels

The SANS guideline unfortunately does not consider potential impacts during periods when the wind exceeds 3 m/s, due to the higher ambient sound levels associated with wind-induced noises (*leaves rustling, aerodynamic/turbulence noises, various bric-a-brac noises, etc*). As this would be the only period during which the Wind Energy Facility would be operational it is critical to consider the potential effects of



wind on the soundscape in the area. In this regard the international practice would be to either:

- Measure the ambient sound levels on a site specific basis for an appropriately long period to determine the ambient sound levels for a variety of wind speeds and directions (such as the ETSU R97 methodology).
- Set a specific acceptable noise level for different land uses at different wind speeds (such as the Canadian Ministry of Environment method).

Because the ETSU R97 guideline is used in more international countries than any other methods, the ETSU R97 method would be considered during the environmental noise impact assessment stage should the projected ambient noise exceed the Zone Sound Levels at any Potentially Sensitive Receptor.

This method includes:

- Plotting the 10 minute average wind speed versus the measured 10 minute L_{A90} noise levels (Actual monitoring data (red), **Figure 5-2**).
- Developing a polynomial best fit curve through the data (Regression curve (green), **Figure 5-2**).
- Setting an acceptable noise margin above the regression curve (+5 dBA as per **Figure 5-1**, see purple dotted line in **Figure 5-3**).
- Setting a lower noise limit for the appropriate time period (see **Table 5-1**) and yellow line **Figure 5-3**).
- Combining the noise margin and lower noise limit to develop acceptable noise criterion (blue line, **Figure 5-3**).



Table 5-1: Developing acceptable noise level criteria

| Time of Day (ETSU R97) | Zone sound levels SANS (dBA LAeq) | | Zone sound levels – SANS (dBA LA90) ⁶ | | Maximum/Absolute Ambient Noise Levels – SANS (dBA LAeq) | | Maximum/Absolute Ambient Noise Levels – SANS (dBA LA90) | |
|----------------------------|--------------------------------------|------------------------------|---|------------------------------|---|------------------------------|---|------------------------------|
| | Outside dwelling | Inside* dwelling | Outside dwelling | Inside* dwelling | Outside dwelling | Inside* dwelling | Outside dwelling | Inside* dwelling |
| 07:00 – 18:00 every day | 45 (06:00 – 22:00) | 35 (06:00 – 22:00) | 43 (06:00 – 22:00) | 33 (06:00 – 22:00) | 50 (06:00 – 22:00) | 40 (06:00 – 22:00) | 48 (06:00 – 22:00) | 38 (06:00 – 22:00) |
| 18:00 - 23:00 every day | 45 (06:00 – 22:00) | 35 (06:00 – 22:00) | 43 (06:00 – 22:00) | 33 (06:00 – 22:00) | 50 (06:00 – 22:00) | 40 (06:00 – 22:00) | 48 (06:00 – 22:00) | 38 (06:00 – 22:00) |
| 13:00 - 18:00 Saturday | 35 (22:00 – 06:00) | 25 (22:00 – 06:00) | 33 (22:00 – 06:00) | 23 (22:00 – 06:00) | 40 (22:00 – 06:00) | 30 (22:00 – 06:00) | 38 (22:00 – 06:00) | 28 (22:00 – 06:00) |
| 07:00 - 18:00 Sunday | | | | | | | | |
| 23:00 – 07:00 every day | 35 (22:00 – 06:00) | 25 (22:00 – 06:00) | 33 (22:00 – 06:00) | 23 (22:00 – 06:00) | 40 (22:00 – 06:00) | 30 (22:00 – 06:00) | 38 (22:00 – 06:00) | 28 (22:00 – 06:00) |

* Assuming a 10 dBA attenuation from outside the building to inside building with one window open.

⁶ It should be noted that LA90 levels are generally 1.5 – 2.5 dBA lower than LAeq levels. In this and the Environmental Noise Impact Report LA90 levels will be calculated by subtracting 2 dBA from the LAeq levels.

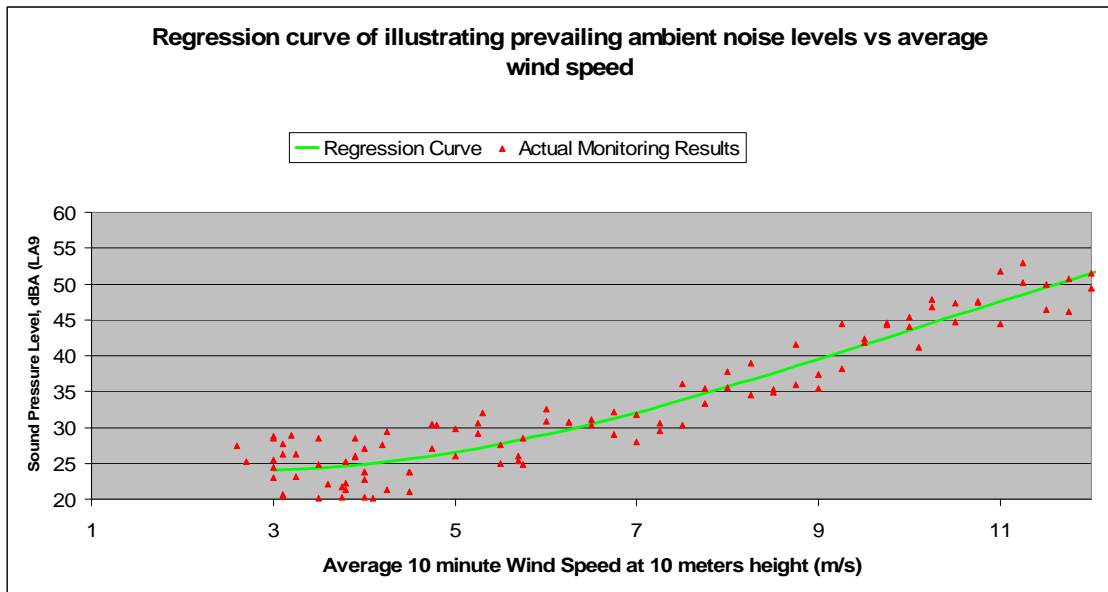


Figure 5-2: Example: Developing best fit curve through data

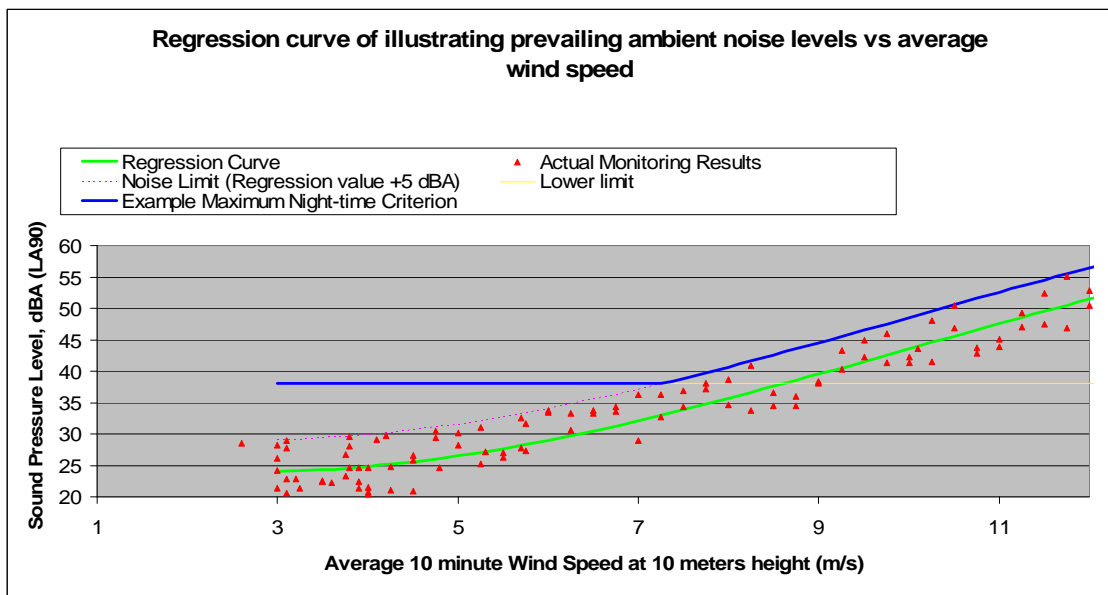


Figure 5-3: Example: Developing best fit curve through data

This method would be in line with the SANS 10103:2008 guideline, considering both the Zone Sound Levels (Table 5-2) and changes in ambient sound level (Figure 5-1).



Table 5-2: 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 $L_{R,dn}^a$ | Day-time $L_{Req,d}^b$ | Night-time $L_{Req,n}^b$ | Day-night $L_{R,dn}^a$ | Day-time $L_{Req,d}^b$ | Night-time $L_{Req,n}^b$ |
| RESIDENTIAL DISTRICTS | | | | | | |
| 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 |
| NON RESIDENTIAL DISTRICTS | | | | | | |
| d) Urban districts with some workshops, with business premises, and with 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 |

5.2.4 Determining the Significance of the Noise Impact

The level of detail as depicted in the EIA regulations was fine tuned by assigning specific values to each impact. In order to establish a coherent framework within which all impacts could be objectively assessed, it was necessary to establish a rating system, which was applied consistently to all the criteria. For such purposes each aspect was assigned a value, ranging from one (1) to five (5), depending on its definition. This assessment is a relative evaluation within the context of all the activities and the other impacts within the framework of the project. An explanation of the impact assessment criteria to be used during the Environmental Noise Impact Assessment stage is defined in **Table 5-3**.

Table 5-3: Impact Assessment Criteria

| Duration | |
|---|--|
| The lifetime of the impact that is measured in relation to the lifetime of the proposed development (construction, operational and closure phases). Will the receptors be subjected to increased noise levels for the lifetime duration of the project, or only infrequently. | |
| <i>Temporary</i> | The impact will either disappear with mitigation, will be mitigated through a natural process, or will last less than an hour. |
| <i>Short term</i> | The impact will be applicable less than 24 hours. |
| <i>Medium term</i> | The impact will last up to a week. |
| <i>Long term</i> | The impact will last up to a month. |
| <i>Permanent</i> | Any impacts lasting more than a month. It is considered non-transitory. Mitigation either |



| | by man or natural process will not occur in such a way or in such a time span that the impact is transient. |
|---|--|
| Spatial scale | |
| Classification of the physical and spatial scale of the impact | |
| <i>Site</i> | The impacted area extends only as far as the activity, such as footprint occurring within the total site area. |
| <i>Local</i> | The impact could affect the local area (within 1.0 km from footprint of activity). |
| <i>Regional</i> | The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns. |
| <i>National</i> | The impact could have an effect that expands throughout the country (South Africa). |
| <i>International</i> | Where the impact has international ramifications that extend beyond the boundaries of South Africa. |
| Probability | |
| This describes the likelihood of the impacts actually occurring, and whether it will impact on an identified receptor. The impact may occur for any length of time during the life cycle of the activity, and not at any given time. The classes are rated as follows: | |
| <i>Improbable</i> | The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0 %). |
| <i>Possible</i> | The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chances of this impact occurring is defined as 25 %. |
| <i>Likely</i> | There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of this impact occurring is defined as 50 %. |
| <i>Highly Likely</i> | It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined as 75 %. |
| <i>Definite</i> | The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100 %. |
| Magnitude | |
| This defines the impact as experienced by any receptor. In this report the receptor is defined as any resident in the area, but excludes faunal species. | |
| <i>Low</i> | Increase in sound pressure levels between 0 and 3. The change is just discernable. |
| <i>Low Medium</i> | Increase in sound pressure levels between 3 and 5. The change is easily discernable. |
| <i>Medium</i> | Increase in sound pressure levels between 5 and 7. Any point where noise levels exceed acceptable zone sound criteria as developed regression curve. |
| <i>High</i> | Increase in sound pressure levels between 7 and 10. Any point where noise levels exceed acceptable zone sound criteria as developed regression curve. |
| <i>Very High</i> | Increase in sound pressure levels higher than 10. Threats of community or group action. Any point where noise levels exceed 65 dBA at any receptor. |

In order to assess each of these factors for each impact, the following ranking scales as contained in **Table 5-4** will be used.



Table 5-4: Assessment Criteria: Ranking Scales

| PROBABILITY | | MAGNITUDE | |
|-----------------------|-------|-----------------------|-------|
| Description / Meaning | Score | Description / Meaning | Score |
| Definite/don't know | 5 | Very high/don't know | 10 |
| Highly likely | 4 | High | 8 |
| Likely | 3 | Medium | 6 |
| Possible | 2 | Low Medium | 4 |
| Improbable | 1 | Low | 2 |
| DURATION | | SPATIAL SCALE | |
| Description / Meaning | Score | Description / Meaning | Score |
| Permanent | 5 | International | 5 |
| Long Term | 4 | National | 4 |
| Medium Term | 3 | Regional | 3 |
| Short term | 2 | Local | 2 |
| Temporary | 1 | Footprint | 1 |

5.2.5 Identifying the Potential Impacts without Mitigation Measures (WOM)

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned probabilities, resulting in a value for each impact (prior to the implementation of mitigation measures). Significance without mitigation is rated on the following scale:

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



5.2.6 Identifying the Potential Impacts with Mitigation Measures (WM)

In order to gain a comprehensive understanding of the overall significance of the impact, after implementation of the mitigation measures, it will be necessary to re-evaluate the impact. Significance with mitigation is rated on the following scale:

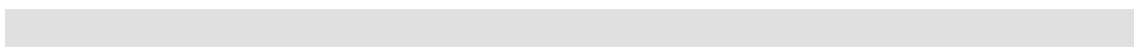
| | | |
|---------------------|------------|--|
| SR < 30 | Low (L) | The impact is mitigated to the point where it is of limited importance. |
| 30 < SR < 60 | Medium (M) | Notwithstanding the successful implementation of the mitigation measures, to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw. |
| SR > 60 | High (H) | The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance, after mitigation could render the entire development option or entire project proposal unacceptable. |

5.3 EXPRESSION OF THE NOISE IMPACTS

The noise impacts can be expressed in terms of the increase in present ambient noise levels caused by noise emissions from the proposed project. The background ambient noise level used will be 28 dBA for the purpose of the Scoping report.

This report as well as the Environmental Noise Impact Report will present predicted ambient noise levels in an appropriate scale using contours of constant sound pressure levels.

For the purpose of this Scoping document, predicted sound levels have only been included for illustrative purposes, as well as to indicate the potential overall spatial extent of noise impacts that wind turbines may have. The purpose is to identify areas of possible concern for both the developer as well as stakeholders, highlighting important criteria for the EIA phase.





6 RESULTS AND PRELIMINARY IMPACT ASSESSMENT

6.1 CONSTRUCTION PHASE

Projected impacts from the construction phase can only be modelled once more information regarding the duration of construction and equipment used are known. Therefore the construction phase will only be dealt with in detail during the Environmental Impact Assessment phase.

During the EIA phase construction activities such as the (potential) borrow pit, concrete batching/delivery, foundation preparation, the digging of trenches and increased traffic (deliveries and movement onsite) will be considered, taking cognisance of the worst-case scenario (simultaneous activities close to a potentially sensitive receptor(s)).

6.2 OPERATIONAL PHASE: ESTIMATED IMPACT AND IMPORTANT CONCEPTS

For the purpose of the Scoping phase the impact that traffic may have on the surrounding noise environment are excluded, only to be considered during the EIA phase.

Unfortunately no preliminary layout was available for evaluation. Conceptual scenarios were therefore modelled to illustrate the potential spatial extent of noise impacts that wind turbines may have on a potential receptor.

Five different scenarios were investigated, and the Concawe model ran for the worst case scenario as well as a more realistic scenario.

In all cases other variables were the same, being:

- Height penalty of -3 dBA,
- Atmospheric pressure of 85 kPa,
- Air temperature of 20 °C,
- Relative humidity of 80%,
- Westerly wind (selected to illustrate the issues),
- Pasquill stability category D (Night/early evening, fast winds, little cloud cover);



- Background noise levels at 28 dBA;
- Wind speed 6 m/s (noise from wind turbines dominating sound character)

In addition each scenario was run with hard ground conditions (-3 dBA penalty) as well as soft ground conditions (potential impact that ground conditions such as vegetation could have). The first scenario illustrates the worst case scenario (the **A**-case) where sound propagates undisturbed, with the second illustration per scenario (the **B**-case) being a more realistic situation where vegetation and/or surface conditions assist in the attenuation of noise.

6.2.1 One Wind Turbine operating

In this scenario there is one wind turbine operating at point 500, 1000 (x, y) with a potential receptor at point 2000, 1000. Unit of measure is meters. The potential receptor is therefore 1500 meters from this conceptual wind turbine.

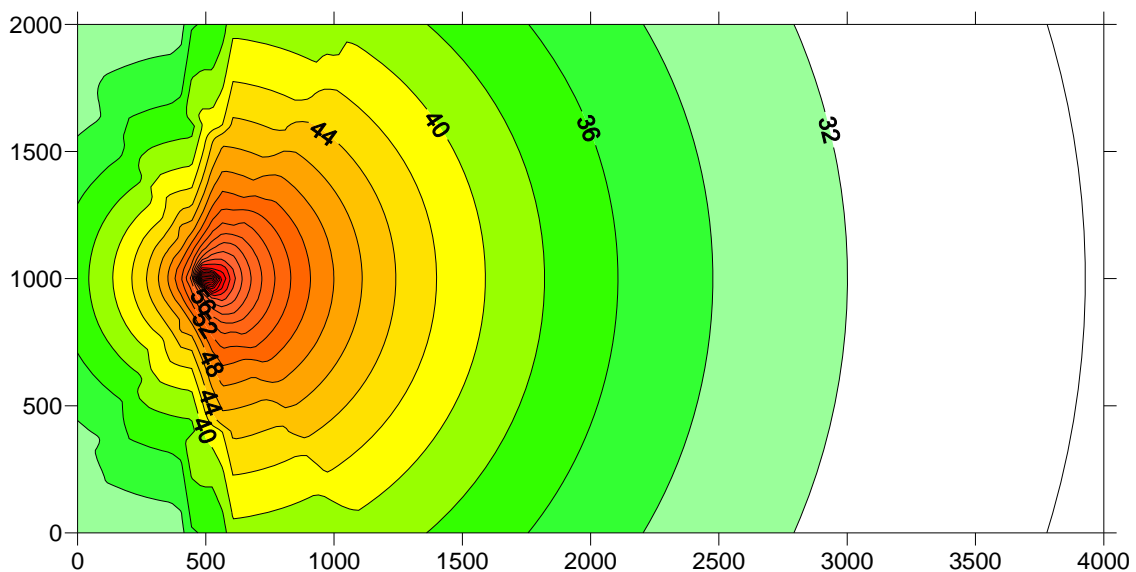


Figure 6-1: One WTG operating, worst case scenario

In this scenario (**Figure 6-1**) the potential receptor would be subject to noise in the order **36.7** dBA, and if one accept a background ambient noise level of **28** dBA, it represents a change of **8.7** dBA.

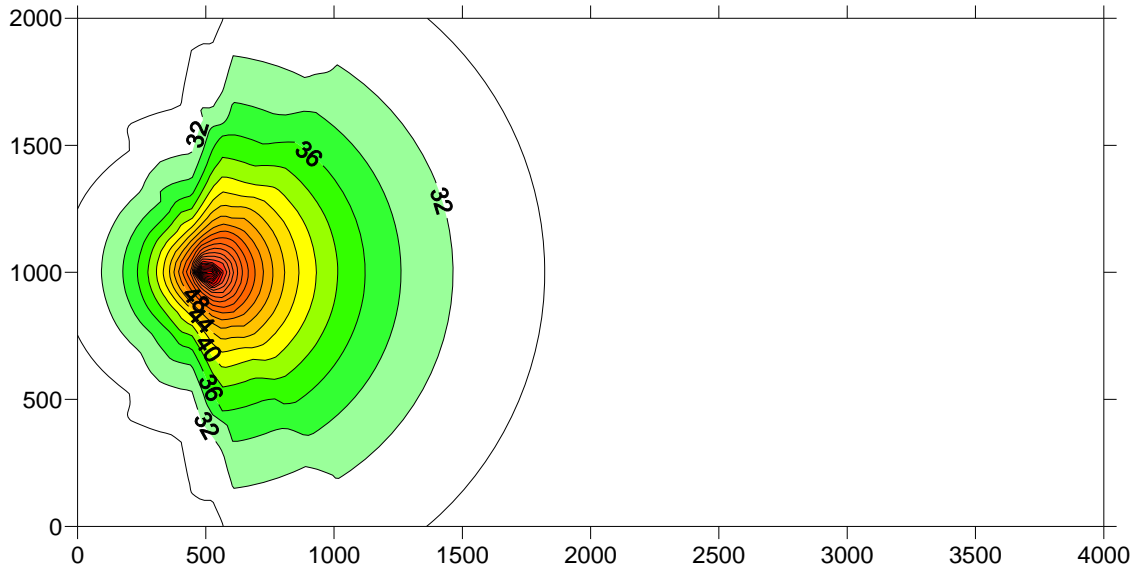


Figure 6-2: One WTG operating, more realistic scenario

Figure 6-2 illustrates the situation where ground surface assist in the attenuation of the noise. This would be factors such as vegetation, ploughed fields or even a very uneven ground surface. In this scenario it would be difficult for the potential receptor to “hear” the sounds from the wind turbine as it would be part of the background ambient noise levels.

6.2.2 Five (5) Wind Turbines

However, when adding 4 more wind turbines (2 north, 2 south of the existing conceptual wind turbine of **Figure 6-1**), all on the 500 meter X-axis, the impact on the potential receptor (still at 2000, 1000) changes significantly (**Figure 6-3**). At **42.9** dBA, the *cumulative effect* from the 4 additional WTGs is approximately **5.4** dBA.

The more realistic scenario is illustrated in **Figure 6-4**, again indicating that soft ground conditions can significantly reduce the propagation of sound.

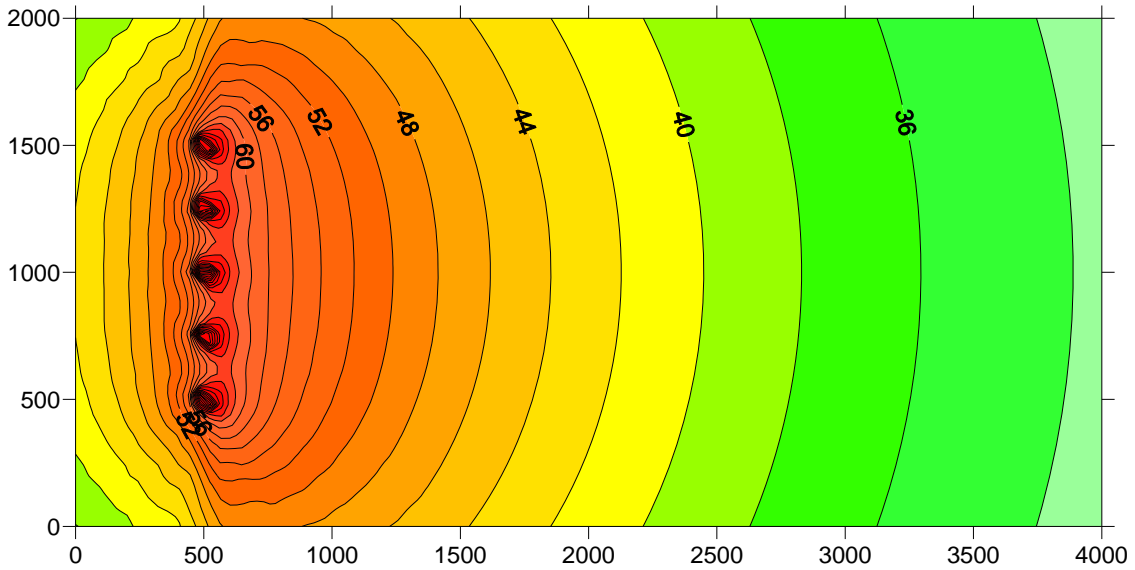


Figure 6-3: 5 WTGs operating, worst case scenario

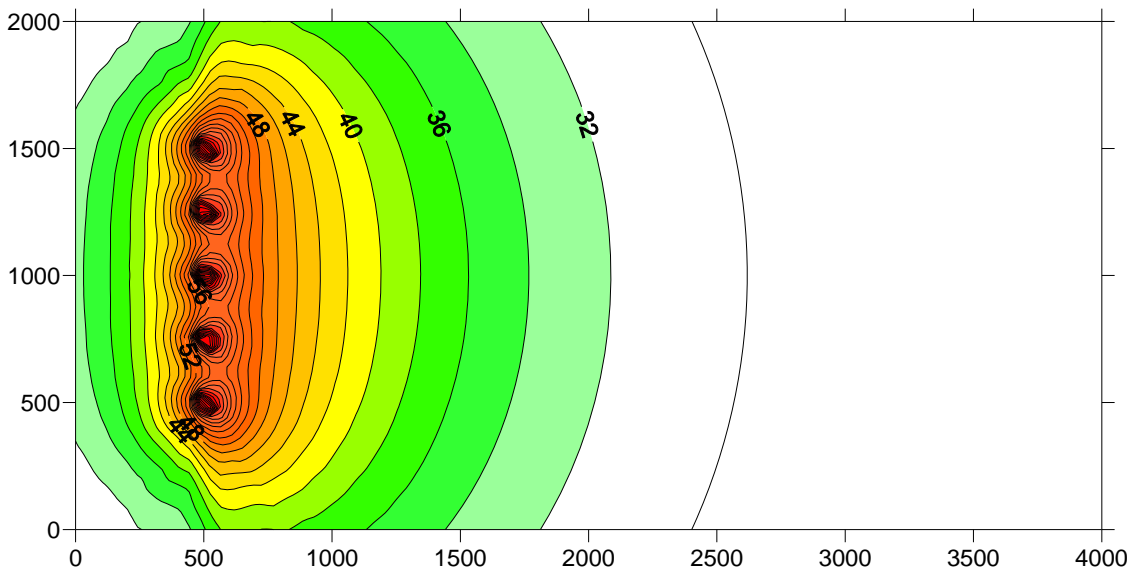


Figure 6-4: 5 WTGs operating, more realistic case scenario

6.2.3 13 Wind Turbines in one line

Adding 8 more turbines in the 500m X-axes (a total of 13 turbines in one line), the cumulative impact further increases to more than **45.7 dBA** at the potential receptor (see **Figure 6-5**), a change of **2.8 dBA** from the 5 turbine situation (**Figure 6-3**).

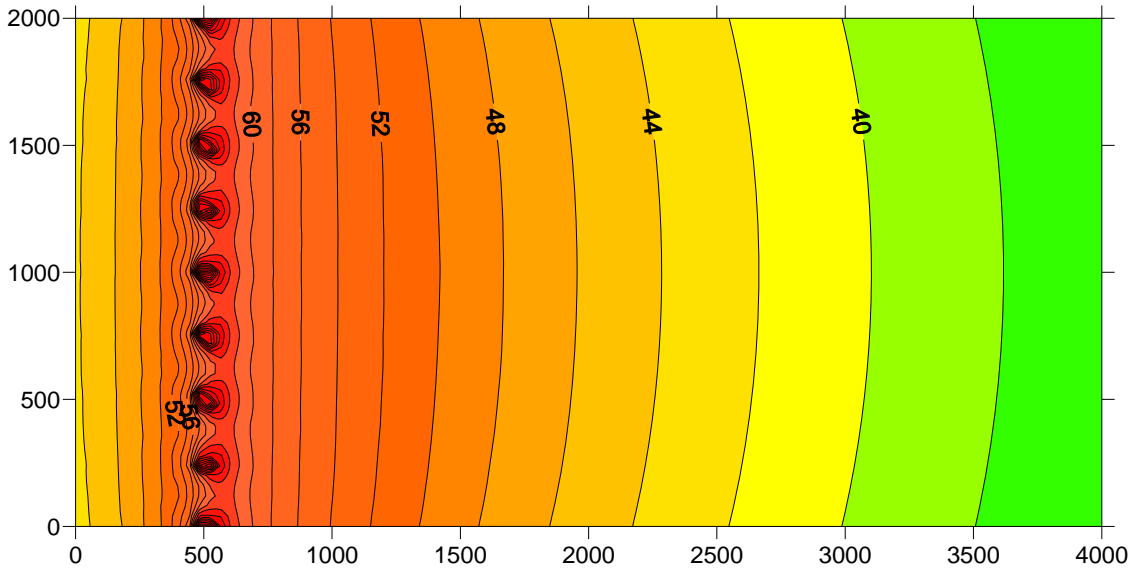


Figure 6-5: 13 WTGs operating, WTGs in one line on 500 m X-axes, worst case scenario

Again soft ground conditions could significantly reduce sound propagation (Figure 6-6). As per the 5 wind turbine scenario, it must be observed that a cumulative impact can be identified in both of these scenarios (Figure 6-5 and Figure 6-6).

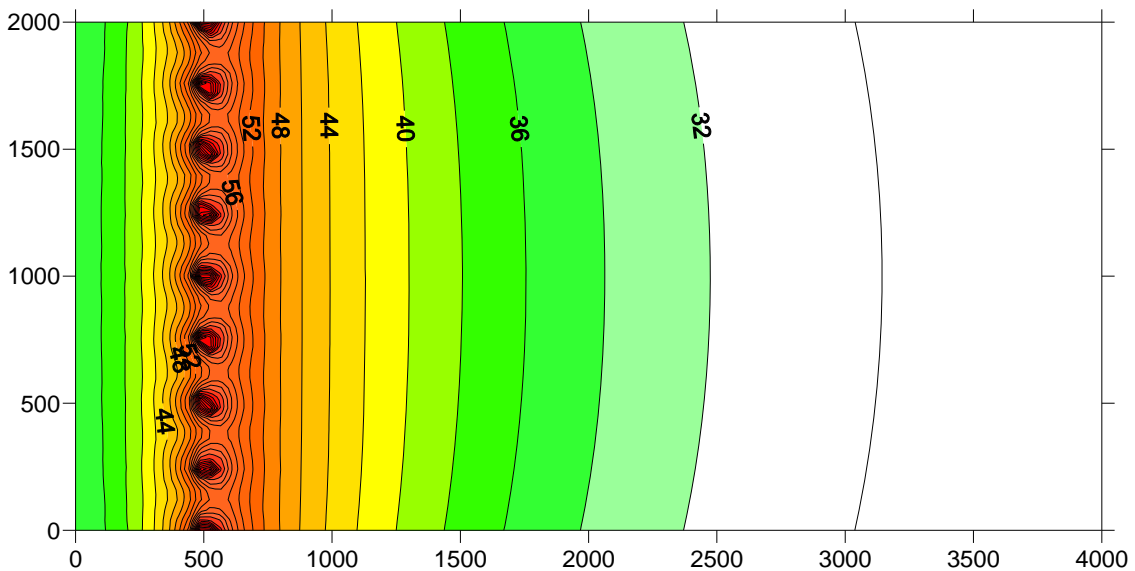


Figure 6-6: 13 WTGs operating. WTGs in one line on 500 m X-axes, more realistic case scenario



6.2.4 52 Wind Turbines upwind from receptor

While unlikely in reality that such a high number of turbines could impact on a PSR, this conceptual scenario evaluates the potential noise impact when 52 turbines was added upwind from the receptor in X-axes lines 500m, 250m, 0m and -250m (13 wind turbines in each line).

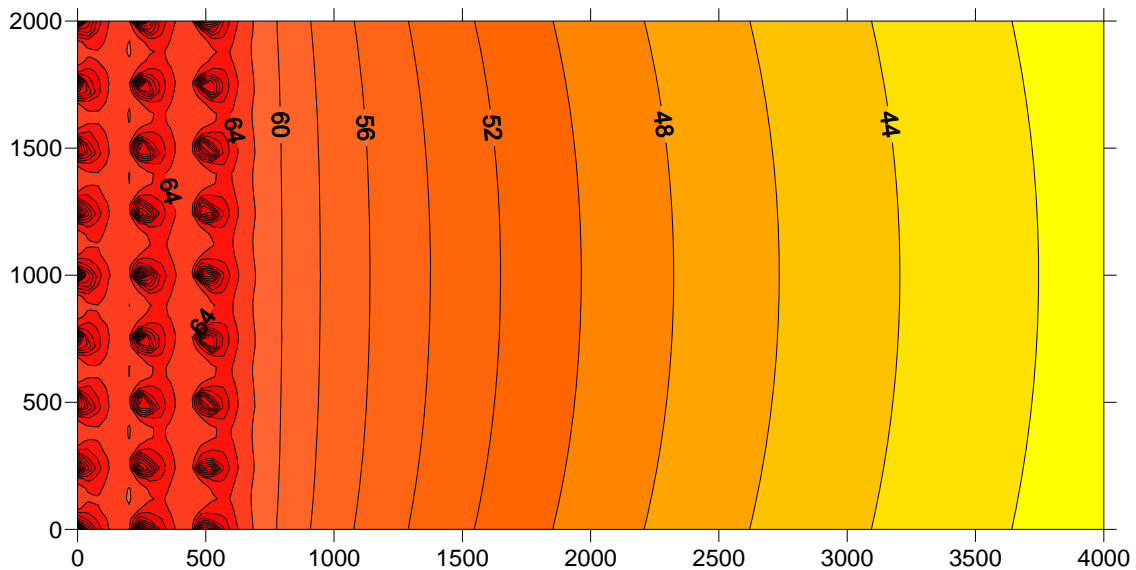


Figure 6-7: 52 WTGs operating in 4 lines (500, 250, 0, -250 on X-axes), worst case scenario

In this improbable scenario the total (estimated) cumulative impact on the potential receptor increases to **49.8 dBA (Figure 6-7)**, adding an additional **4.1 dBA** from the situation where there is only one line with 13 turbines (**Figure 6-5**). While the additional lines are further from the potential receptor, they still contribute to the cumulative noise impact, again illustrating that the cumulative impact (total number as well as locations of WTGs) must be considered with larger Wind Energy Facilities.

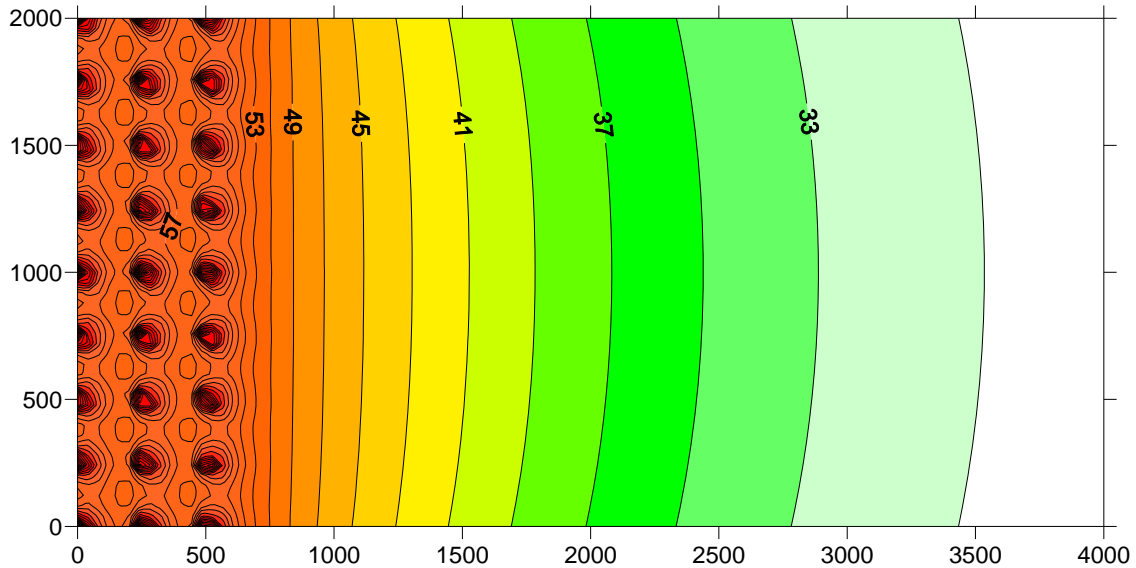


Figure 6-8: 52 WTGs operating in 4 lines (500, 250, 0, -250 on X-axes), more realistic case scenario

Similarly, **Figure 6-8** presents the more realistic scenario for 52 wind turbines, where the attenuation from soft ground (vegetation, uneven ground such as ploughed lands etc.) is considered.

6.2.5 52 Wind Turbines downwind from receptor

The previous figures illustrate the impact on a potential receptor when the wind is blowing from the wind turbines to the receptor, with the following figure (**Figure 6-9**) illustrating the situation where the wind is blowing from the receptor to the facility. In this scenario there are again 52 turbines operating downwind from a potential receptor with a buffer zone (setback) of 1500 meters.

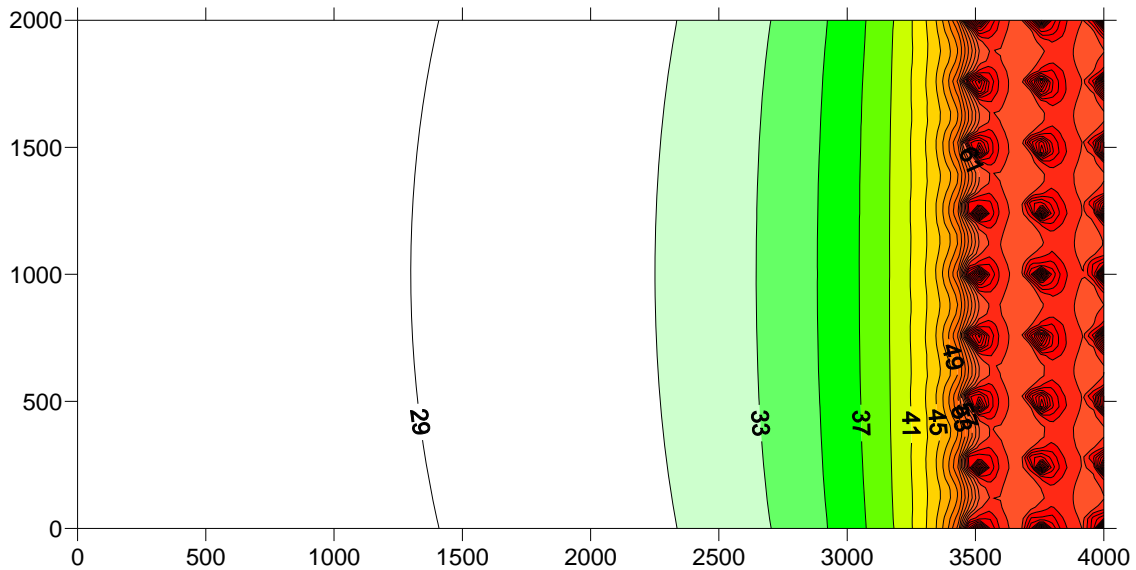


Figure 6-9: 52 WTGs operating in 4 lines (3500m, 3750m, 4000m and 4250m on X-axis) downwind from receptor, worst case scenario

However, in this case the potential impact is only **30.2 dBA (Figure 6-9)**, even less than the impact that one wind turbine could have on a downwind receptor. This illustrates that the prevailing wind direction is of critical importance to allow the estimation of the impact on potential receptors. Prevailing wind directions and the percentage of total time that the wind blows in a particular direction will be important to determine the probability of the noise impact occurring.

6.2.6 Estimation of Impacts

This Scoping document focuses (as will the Environmental Noise Impact Assessment) on the noise impacts on the surrounding environment during times when a quiet environment is highly desirable. Noise limits should therefore be appropriate for the most noise-sensitive activity.

Noise-sensitive activities such as sleeping, or areas used for relaxation or other activities (places of worship, school, etc) should determine appropriate Zone Sound Levels. However, for this Scoping report the $L_{Req,N}$ of **35dBA** as proposed by SANS 10103 is used.

The previous conceptual scenarios (worst case) illustrates the situation where atmospheric conditions are favorable for sound propagation, with the wind speeds



above the cut-in speeds of the WTG, but before wind induced noises start to mask the noises from the WTG.

Depending on the background noise levels, total number of wind turbines to be constructed, their distance from potential sensitive receptors and the prevailing meteorological conditions, there might be a number of potential receptors that could be affected by the facility. The potential impact from low frequency noises will only be considered during the EIA phase.

Applying the precautionary principle, due to the various unknowns and uncertainties, a first assessment of potential impacts is presented in **Table 6-1**.

Table 6-1: Preliminary Impact Estimation: Operational Phase

| Component | Scenario 1 | Scenario 2 |
|-------------------------------|---|------------|
| Magnitude | Low to high. The noise will be a combination of the cumulative effects of a number of WTGs operating at night (see section 3.2 for nature of noise). | |
| Spatial Extent | Regional. In terms of the set definition, the noise could impact on receptors further than 1,000 meters from the boundary of the WEF (worst case scenario – wind blowing from wind turbines to receptor). | |
| Potential Significance | Low to High. | |

Once more information is available, this preliminary impact estimate can be reviewed. However, based on the current identified significance, further investigation is required.





7 CONCLUSIONS

This report is a Scoping assessment of the predicted noise environment due to the development of the proposed Spitskop Wind Energy Facility on various properties north-west of the town of Riebeek East. It is based on a desktop assessment as well as a predictive model (making use of the worst case scenario in terms of the precautionary approach, as well as a more realistic scenario) to identify potential issues of concern. This assessment indicated that the proposed project could have an impact of a low to high significance on the noise climate in the surrounding area in the unmanaged situation, as there are numerous potentially sensitive receptors within the area of influence.

As no preliminary layout was available for evaluation (in terms of the potential noise impact), five scenarios were used to illustrate that a potential receptor could be impacted by the development proposed facility. The results of the scenarios indicated that the following information is critical in order to estimate the impact on potential receptors during the EIA phase:

1. For any modeling the total number of wind turbines proposed for the area should be considered (cumulative impact).
2. The noise emission characteristics of the proposed wind turbine generators are critical.
3. The total area over which the turbines are developed is important.
4. The number and location of receptors is critical (distance between the receptor and closest turbines).
5. Prevailing wind direction(s) and speed(s) are critical.
6. Topographical layout of the terrain.
7. Existing ambient sound levels must be considered. This is because ambient sound levels have been measured during previous field work ranging between 16 dBA (no wind or light winds) to more than 70 dBA (wind blowing at 17 m/s). With wind energy facilities only operating during windy periods, the SANS 10103 guideline is not strictly applicable and the ETSU R97 method would be more appropriate.

With the implementation of mitigation measures, it would be possible to manage potential noise impacts to a more acceptable low significance.



8 RECOMMENDATIONS

It is recommended that the potential environmental noise impact associated with the Spitskop Wind Energy Facility be investigated in more detail in the Environmental Impact Assessment phase. The following information is considered critical:

1. The prevailing ambient sound levels must be measured as per the requirements of SANS 10103. However, if the projected noise levels due to the operation of the WEF (at the PSRs) exceed the SANS 10103:2008 zone sound levels, the ambient sound levels will also be measured as per the ETSU R97 methodology at selected PSRs
2. The available meteorological data,
3. The exact locations of the various WTGs in the WEF
4. The full specifications of the WTGs,
5. The confirmation of the Potential Sensitive Receptors, and;
6. An overview of the equipment, processes and schedules for the construction phase.

The following work is planned for the Environmental Impact Assessment phase:

1. A site visit to obtain information regarding ambient sound levels, the prevailing meteorological conditions during this ambient sound level survey, as well as confirming and identifying potential sensitive receptors,
2. Currently identified (potential) sensitive receptors will be investigated during the EIA phase, and any additional receptors will be identified. Their relative sensitivity to noise impacts will be determined. This will be based on the SANS 10103 guideline, as well as current land uses on the properties (residential vs business/industrial).
3. Using the data (proposed processes, noise characteristics of the selected equipment, locations of the WTG) as provided by the project developer, the predicted impact of the WEF on receptors will be predicted using both the ISO 9613-2 and CONCAWE method for the operational phases. The potential noise impact during the construction phase will be predicted using the CONCAWE model.
4. Using the calculated noise levels at the identified sensitive receptors, the projected significance the noise impact of the WEF (whether construction or



- operational) will be determined using the criteria as proposed in this Scoping Report (subject to possible changes after any stakeholder input).
5. The ETSU R97 Guideline would be followed if required.





9 THE AUTHOR

The author of this report, M. de Jager (B. Ing (Chem), UP) graduated in 1998 from the University of Pretoria. He has been interested in acoustics since school days, doing projects mainly related to loudspeaker enclosure design. Interest in the matter brought him into the field of Environmental Noise Measurement, Prediction and Control. As from 2007 he has been involved with the following projects:

- Full Noise Impact Studies for a number of Wind Energy Facilities, including: Cookhouse, Amakhala Emoyeni, Dassiesfontein/Klipheuwel, Rhebokfontein, AB, Dorper, Suurplaat, West Coast and West Coast One.
- Full Noise Impact Studies for a number of mining projects, including: Skychrome (Pty) Ltd (A Ferro-chrome mine), Mooinooi Chrome Mine (WCM), Buffelsfontein East and West (WCM), Elandsdrift (Sylvania), Jagdlust Chrome Mine (ECM), Apollo Brick (Pty) Ltd (Clay mine and brick manufacturer), Arthur Taylor Expansion project (X-Strata Coal SA), Klipfontein Colliery (Coal mine), Landau Expansion project (Coal mine), Noise Modelling for Tweefontein Colliery Expansion.

The author is an independent consultant to the project, the developer as well as Savannah Environmental (Pty) Ltd. He,

- does not and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations;
- have and will not have no vested interest in the proposed activity proceeding;
- have no, and will not engage in conflicting interests in the undertaking of the activity;
- undertake to disclose all material information collected, calculated and/or findings, whether favourable to the developer or not;
- will ensure that all information containing all relevant facts be included in this report.



10 REFERENCES

In this report reference was made to the following documentation:

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15. ETSU R97: 1996. *'The Assessment and Rating of Noise from Wind Farms: Working Group on Noise from Wind Turbines'*
16. World Health Organization, *Protection of the Human Environment; Guidelines for Community Noise*



APPENDIX A

TYPICAL SOUND POWER LEVELS, VARIOUS TYPES OF EQUIPMENT



| Frequency | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 |
|----------------------------------|--|--------|--------|--------|--------|--------|-------|
| A-Weight Factor | -26.22 | -16.19 | -8.67 | -3.25 | 0 | 1.2 | 0.96 |
| Equipment / Process | Sound power level, dB re1 pW, in octave band, Hz | | | | | | |
| Crusher | 121.1 | 122.3 | 120.1 | 120 | 117.3 | 112.5 | 106.3 |
| Mobile Crusher/Screen (Rock) | 114.2 | 109.5 | 106.2 | 106 | 104.1 | 102.2 | 101 |
| Crushing/Screening (Coal, small) | 100.5 | 96.9 | 97.3 | 99.2 | 98.4 | 98.8 | 94.3 |
| CAT D10 Bulldozer | 118.3 | 115.2 | 111 | 109.1 | 107.5 | 103 | 97 |
| CAT D11 Bulldozer | 121.22 | 112.2 | 111.4 | 110.9 | 110.4 | 101.45 | 93.67 |
| Front End Loader | 105 | 117 | 113 | 114 | 111 | 107 | 101 |
| Road Truck average | 90 | 101 | 102 | 105 | 105 | 104 | 99 |
| Drilling Machine | 107.2 | 109.4 | 109.2 | 106.1 | 104.7 | 101.2 | 99.8 |
| CAT Water Dozer | 112.9 | 114.5 | 111.45 | 109.7 | 108.35 | 107.2 | 104 |
| Excavator | 110 | 112 | 118 | 105 | 106 | 99 | 95 |
| Terex 30 ton haul dumper | 102.4 | 105.3 | 108.9 | 108.8 | 108.2 | 105.1 | 99.2 |
| Hitachi EX1200 Excavator | 113.2 | 116 | 119.7 | 112.5 | 109.8 | 108.4 | 105.4 |
| Cement truck (with cement) | 104 | 107 | 106 | 108 | 107 | 105 | 102 |
| Operational Hitachi Grader | 107.7 | 107.9 | 106.8 | 106.2 | 104.2 | 101.1 | 97.2 |
| Grader | 100 | 111 | 108 | 108 | 106 | 104 | 98 |
| Haul truck | 107.9 | 113.2 | 116.9 | 114.4 | 110.6 | 106.8 | 100.2 |
| Road Transport Reversing/Idling | 108.2 | 104.6 | 101.2 | 99.7 | 105.4 | 100.7 | 98.7 |
| Vesta V66, max | 125.1 | 113.6 | 106.3 | 106.2 | 100.4 | 96.4 | 95.3 |
| Vesta V66, ave | 120.1 | 109.4 | 100.9 | 100.5 | 95.3 | 91.3 | 88.8 |
| Vesta V66, min | 114.4 | 104 | 94.84 | 94.8 | 87.5 | 83.3 | 80.7 |
| Nordex N90 2.5MW at 4m/s | 110.42 | 104.49 | 101.37 | 96.35 | 91.6 | 89.3 | 85.54 |
| Nordex N90 2.5MW at 7m/s | 117.92 | 111.99 | 108.87 | 103.85 | 99.1 | 96.8 | 93.04 |
| Vestas V90 2.0 MW at 5m/s | 105.9 | 100.7 | 97.2 | 94.8 | 94.1 | 91.7 | 89.7 |
| Vestas V90 2.0 MW at 7m/s | 111.4 | 106.9 | 102.2 | 99.5 | 98.7 | 96.3 | 94.2 |
| RePower MM92 at 7.5m/s | 109.25 | 107.41 | 105.63 | 101.9 | 96.73 | 89.81 | 83.09 |
| General noise | 100 | 100 | 103 | 105 | 105 | 100 | 100 |
| CAT Rock Breaker | 119.1 | 118.2 | 115.2 | 115.7 | 114.9 | 115.7 | 110.4 |
| Crane | 89 | 98 | 101 | 103 | 102 | 102 | 98 |
| Portable Diesel Generator | 96.7 | 99.5 | 101.2 | 97.4 | 91.3 | 89.6 | 81.1 |