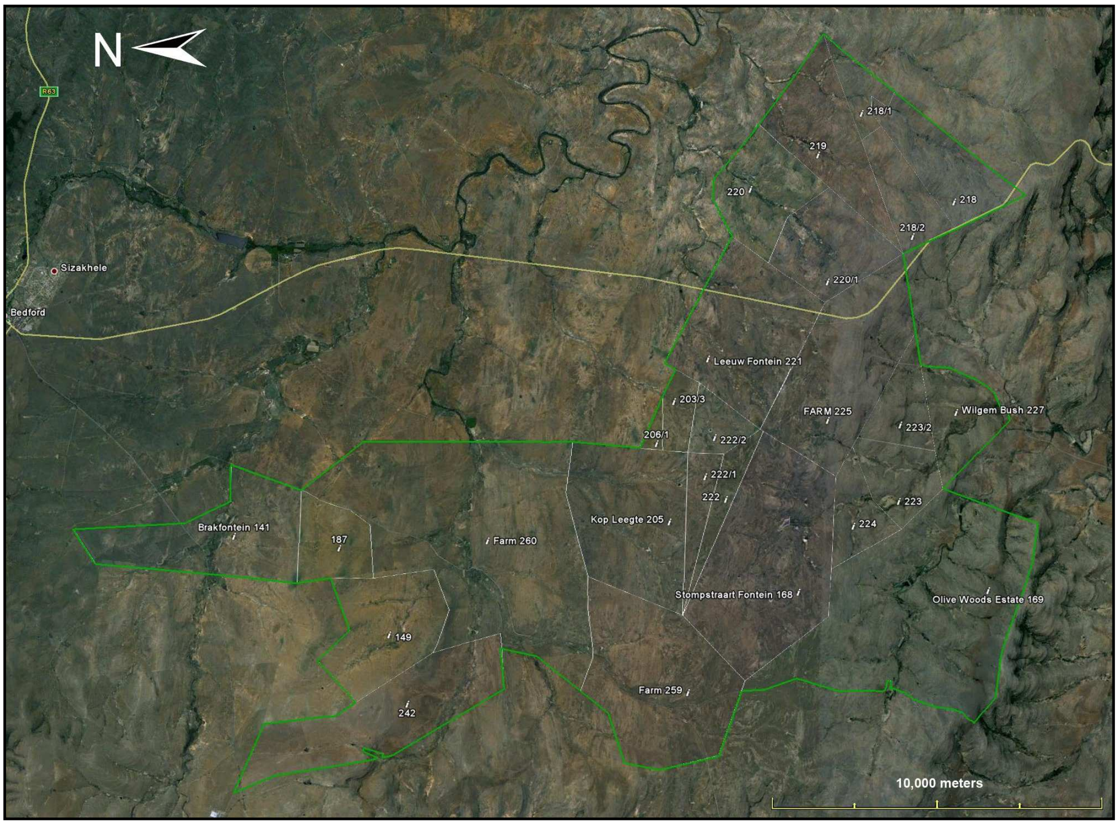
Windlab Developments South Africa (Pty) Ltd

NOISE IMPACT STUDY

FOR ENVIRONMENTAL IMPACT ASSESSMENT

Establishment of the Amakhala Emoyeni Wind Energy Facility on various farms near the town of Bedford, Eastern Cape



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Noise Impact Study for Environmental Impact Assessment: Establishment of the Amakhala Emoyeni Wind Energy Facility on various farms near Bedford, Eastern Cape.

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GLOSSARY OF ABBREVIATIONS

DEA	Department of Environmental Affairs
DEDEA	(Eastern Cape Provincial) Department of Economic Development and 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
TLB	Tip Load Bucket
WEF	Wind Energy Facility
WHO	World Health Organisation
WTG	Wind Turbine Generator

GLOSSARY OF TERMS

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

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

	approach.
Interested and affected parties	Individuals or groups concerned with or affected by an activity and its consequences. These include the authorities, local communities, investors, work force, consumers, environmental interest groups and the general public.
Key issue	An issue raised during the Scoping process that has not received an adequate response and which requires further investigation before it can be resolved.
Listed activities	Development actions that is likely to result in significant environmental impacts as identified by the delegated authority (formerly the Minister of Environmental Affairs and Tourism) in terms of Section 21 of the Environment Conservation Act.
Loudness	The attribute of an auditory sensation which describes the listener's ranking of sound in terms of its audibility.
Magnitude of impact	Magnitude of impact means the combination of the intensity, duration and extent of an impact occurring.
Masking	The raising of a listener's threshold of hearing for a given sound due to the presence of another sound.
Mitigation	To cause to become less harsh or hostile.
Negative impact	A change that reduces the quality of the environment (for example, by reducing species diversity and the reproductive capacity of the ecosystem, by damaging health, or by causing nuisance).
Noise	a. Sound 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.
Noise Level	The term used in lieu of sound level when the sound concerned is being measured or ranked for its undesirability in the contextual circumstances.
Octave Band	A filter with a bandwidth of one octave, or twelve semi-tones on the musical scale representing a doubling of frequency.
Positive impact	A change which improves the quality of life of affected people or the quality of the environment.
Property	Any piece of land indicated on a diagram or general plan approved by the Surveyor-General intended for registration as a separate unit in terms of the Deeds Registries Act and shall include an erf, a site and a farm portion as well as the buildings erected thereon
Public Participation Process	A process of involving the public in order to identify needs, address concerns, choose options, plan and monitor in terms of a proposed project, programme or development
Reverberant Sound	The sound in an enclosure excluding that which is received directly from the source.
Reverberation	The persistence, after emission of a sound has stopped, of a sound field within an enclosure.
Significant Impact	An impact can be deemed significant if consultation with the relevant authorities and other interested and affected parties, on the context and intensity of its effects, 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.
Sound Level	The level of the frequency weighted and time weighted sound pressure as determined by a sound level meter.
Sound Power	Of a source, the total sound energy radiated per unit time.
Sound Pressure Level (SPL)	Of a sound, 20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level. International values for the reference sound pressure level are 20 micropascals in air and 100 millipascals in water. SPL is reported as L_p in dB (not weighted) or in various other weightings.
Soundscape	Sound or combination of sounds that forms or arises from an immersive environment. The study of soundscape is the subject of acoustic ecology. The

	idea of soundscape refers to both the natural acoustic environment, consisting of natural sounds, including animal vocalizations and, for instance, the sounds of weather and other natural elements; and environmental sounds created by humans, through musical composition, sound design, and other ordinary human activities including conversation, work, and sounds of mechanical origin resulting from use of industrial technology. The disruption of these acoustic environments results in noise pollution.
Study area	Refers to the entire study area encompassing all the alternative routes as indicated on the study area map.
Sustainable Development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and the future needs (Brundtland Commission, 1987).
Zone of Potential Influence	The area defined as the radius about an object, or objects beyond which the noise impact will be insignificant.
Zone Sound Level	Means a derived dBA value determined indirectly by means of a series of measurements, calculations or table readings and designated by a local authority for an area. This is similar to the Rating Level as defined in 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 Amakhala Emoyeni Wind Energy Facility (WEF) on various farms close to the town of Bedford, Eastern Cape.

This report describes the potential impact that such a Wind Energy Facility may have on the surrounding environment, highlighting the methodologies used, potential issues identified, findings and recommendations.

1.2 BRIEF PROJECT DESCRIPTION

Windlab Developments South Africa (Pty) Ltd proposes the establishment of a wind energy facility and associated infrastructure on various farms near the town of Bedford, Eastern Cape. This facility will be known as the Amakhala Emoyeni Wind Energy Facility.

The Amakhala study area is approximately 275 km^2. The facility and associated infrastructure includes:

- Up to 350 wind turbines and associated foundations,
- Underground cables between the wind turbine generators,
- Up to three Substations,
- Power line(s) linking to the transmission grid,
- A maintenance/control building; and
- Access Roads, into and between the turbines.

It should also be noted that Environmental Authorization has been granted for the proposed Cookhouse WEF (200 wind turbines) directly next to the Amakhala WEF. This EIA study will therefore investigate the potential noise impact of the proposed Amakhala WEF alone as well as the potential cumulative noise impact should both facilities be operational.

Application for Environmental Authorization has also been submitted for the proposed Terra Power Cookhouse project. As this project is in application, potential cumulative effects will not be considered.

1.3 TERMS OF REFERENCE

SANS 10328:2003 (Edition 2) specifies the methodology to assess the noise impacts on the environment due to a proposed activity that might impact on the environment. The standard also stipulates the minimum requirements to be investigated for EIA. These minimum requirements are:

1. the purpose of the investigation;
2. a description of the planned development or the changes that are being considered;
3. a description of the existing development including, where relevant, the topography, surface conditions and meteorological conditions during measurements;
4. the identified noise sources together with their respective sound pressure levels or sound power levels (or both) and, where applicable, operating cycles, nature of sound emission, spectral composition and directional characteristics;
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 noise impact on them;
7. where applicable, any assumptions, with references, made with regard to any calculations or determination of source and propagation characteristics;
8. an explanation, either by description or by reference, of all calculation and measuring procedures that were followed, as well as any possible adjustments to existing measuring methods that had to be made, together with the results of calculations;
9. an explanation, either by description or reference, of all measuring or calculation methods (or both) that were used to determine existing and predicted rating levels, as well as other relevant information, including a statement of how the data were obtained and applied to determine the rating level for the area in question;
10. the location of measuring or calculating points in a sketch or on a map;
11. quantification of the noise impact with, where relevant, reference to the literature consulted and the assumptions made;
12. alternatives that were considered and the results of those that were investigated;
13. conclusions that were reached; and
14. recommendations.

1.4 STUDY AREA

The wind energy facility is proposed on the following farms near the town of Bedford, Western Cape:

- Portion 1, 2 and remainder of Farm 222,
- Portion 3 of Farm 203 (Platt House),
- Remainder of Farm 205 (Kop Leegte),
- Portion 1 of Farm 206 (Normandale),
- Remainder of Farm 168 (Stompstaart Fontein),
- Remainder of Farm 224 (Taai Fontein),
- Remainder of Farm 221 (Leeuw Fontein),
- Portion 2 and remainder of Farm 223 (Paarde Kloof),
- Remainder of Farm 227 (Wilgem Bush),
- Remainder of Farm 225,
- Portion 1, 2 and remainder of Farm 218 (Brakke Fonteyn),
- Remainder of Farm 259,
- Remainder of Farm 260,
- Portion 5 of Farm 149 (Great Knoffel Fonteyn),
- Remainder of Farm 242,
- Portion 1 and remainder of Farm 220 (Brak Fontein),
- Remainder of Farm 219 (Vogel Fonteyn),
- Remainder of Farm 169 (Olive Woods Estate),
- Portion 3 of Farm 141 (Brakfontein),
- Portion 1 of Farm 187 (Kleine Knoffel Fonteyn).

The proposed WEF will be situated in an area that has a rural character within an elevated plateau. The topography is hilly, ranging from more than 850 mamsl to less than 600 mamsl. The farm Brakfontein lays at 600 mamsl in the south eastern section, moving up to 850 mamsl on the Farm 242. The various farm portions can be seen in **Figure 1-1**.

The R350 traverse the area where the WEF is proposed in the east, with the R63 just north of the site. Significant agricultural activity (irrigation) was identified along the Larger Fish River, and mostly sheep and cattle farming activities taking place in areas where there is less access to water. There is two gravel roads of note in the study site, yet they were very quiet during the site visit.

As highlighted in the Scoping Document, the study area has a rural character in terms of the ambient sound levels, with ambient sound levels being approximately 30 dBA during the day and less than 20 dBA at night (areas away from any activity with wind speeds below 5 m/s).

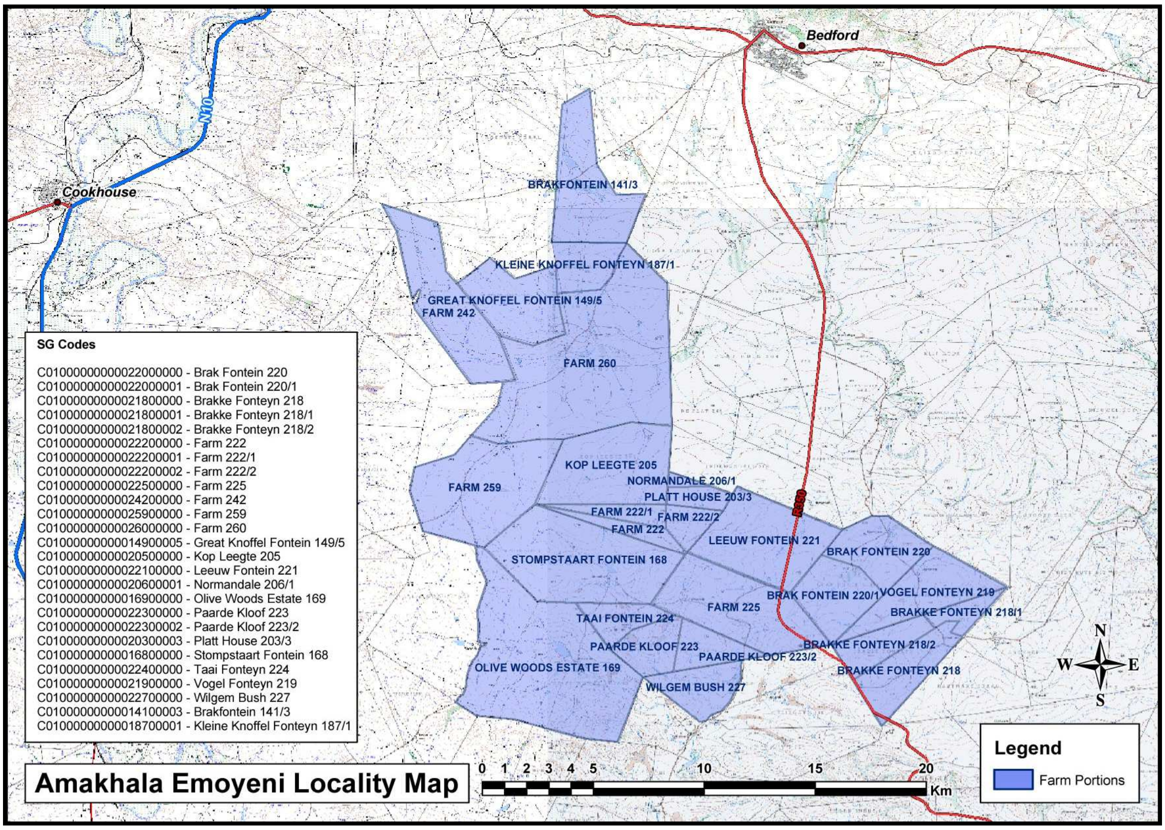

Figure 1-1: Site map indicating locations of the various portions proposed to be used for the WEF

1.5 AVAILABLE INFORMATION

Apart for the Scoping report (2010) compiled for this proposed project by this author, the two other Noise Impact Assessments are available, namely:

- The Noise Impact Assessment report compiled by this Author for the Cookhouse Wind Energy Facility,
- The report compiled by Brett (2010) for the proposed Terra Power Wind Energy project.

1.6 POTENTIAL SENSITIVE RECEPTORS

Potentially sensitive receptors were identified using Google Earth®, supported by a site visit to confirm the status of the identified dwellings. The reason for the site visit, apart from sampling ambient sound levels, is that there could be a number of derelict or abandoned dwellings that could be seen as a sensitive receptor, or small dwellings that could not be identified on the aerial image, or those that were built after the date of the aerial photograph.

Potential receptors within 2 km of the edge of the proposed WEF were identified, and are presented in **Figure 1-2**, (with the latitude and longitude locations of the Potential receptor in **Table 1-1** - Datum type: Universal Transverse Mercator, zone 35). This assessment indicated the presence of a number of potential sensitive receptors, mainly various farmsteads around, and within the boundaries of the proposed WEF portions. One receptor (SR106), a substation, was also identified as a potentially sensitive receptor as maintenance personnel is staying onsite (observed during site visit).

It should also be noted that while only one receptor is indicated per site, it should rather be seen as a small community of receptors. This is because most of the farm dwellings are surrounded by a number of other houses, occupied by farm workers and their families. The towns of Cookhouse and Bedford were identified north-west and north-east respectively from the proposed WEF site, but they range from 6 to 10 km's from the closest wind turbine, thus a noise or sound impact is not expected on any of these towns.

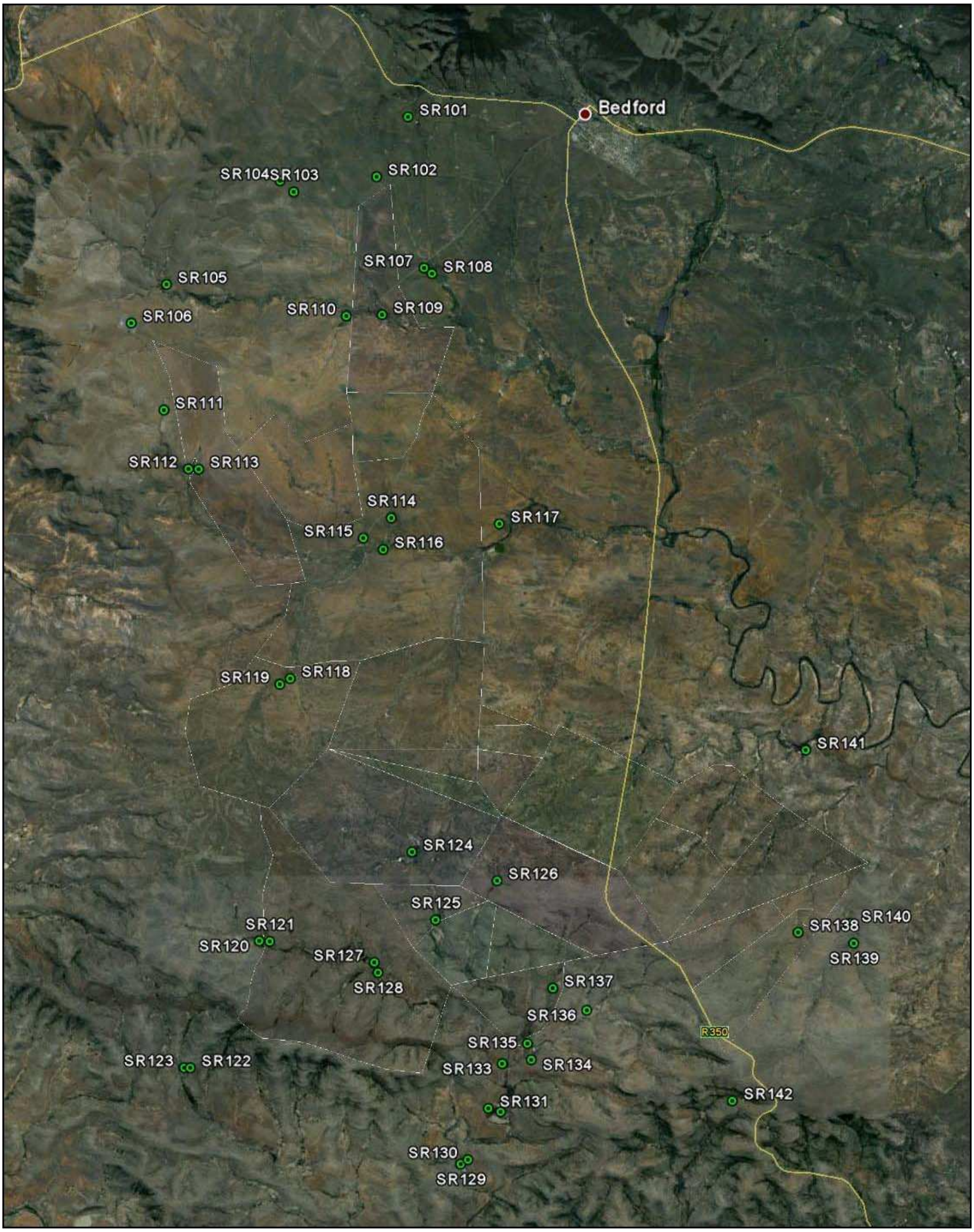

Figure 1-2: Aerial image indicating sensitive receptors (marked as green dots) and locations of the farm and portions of the proposed WEF.

Table 1-1: Locations of the identified receptors (Datum type: Universal Transverse Mercator, zone 35)

Receptor	Location X	Location Y
SR101	408476.55	6383618.18
SR102	407429.15	6381619.46
SR103	404497.58	6381550.94
SR104	404201.27	6381410.83
SR105	400500.67	6377977.71
SR106	399344.53	6376697.14
SR107	409009.58	6378580.30
SR108	409306.66	6378443.54
SR109	407700.34	6376988.50
SR110	406486.23	6376977.71
SR111	400475.14	6373825.73
SR112	401288.00	6371896.24
SR113	401658.51	6371910.34
SR114	405072.45	6370268.78
SR115	407080.59	6369621.65
SR116	407701.55	6369248.95
SR117	411660.82	6370064.45
SR118	404770.46	6364919.80
SR119	404368.19	6364726.97
SR120	403777.88	6356346.96
SR121	404117.07	6356343.97
SR122	401524.52	6352147.96
SR123	401328.57	6352148.53
SR124	408807.82	6359322.39
SR125	409602.24	6357078.82
SR126	411628.85	6358404.05
SR127	407594.07	6355675.50
SR128	407718.88	6355342.85
SR129	410522.59	6349041.92
SR130	410754.35	6349179.40
SR131	411419.69	6350887.40
SR132	411825.66	6350779.81
SR133	411859.18	6352367.03
SR134	412824.03	6352502.53
SR135	412704.33	6353028.70
SR136	414658.51	6354163.02
SR137	413522.20	6354873.69
SR138	421671.18	6356756.42
SR139	423478.38	6356375.40
SR140	423387.49	6357069.43
SR141	421830.87	6362800.91
SR142	419513.70	6351206.19

2 POLICIES AND THE LEGAL CONTEXT

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

The environmental rights contained in section 24 of the Constitution provide that everyone is entitled to an environment that is not harmful to his or her well-being. In the context of noise, this requires a determination of what level of noise is harmful to well-being. The general approach of the common law is to define an acceptable level of noise as that which the reasonable person can be expected to tolerate in the particular circumstances. The subjectivity of this approach can be problematic which has led to the development of noise standards (see Section 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 Ministry of Water and Environmental Affairs") to make regulations regarding noise, among other concerns. The Minister has made noise control regulations under the ECA adopted by the Western Cape Province.

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. Draft regulations however have been promulgated for adoption by Local Authorities.

An atmospheric emission licence issued in terms of section 22 may contain conditions in respect of noise. This however will not be relevant to the WEF, as no atmospheric emissions will take place.

2.5 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.

2.6 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 noise control regulations was devolved to provincial and local authorities. Provincial Noise Control Regulations exist in the Free State, Western Cape and Gauteng provinces. No Noise Control Regulations have been promulgated in the Eastern Cape.

2.7 NOISE STANDARDS

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

- SANS 10103:2004. 'The measurement and rating of environmental noise with respect to annoyance and to speech communication'.
- SANS 0210:2004. 'Calculating and predicting road traffic noise'.
- SANS 10328:2003. 'Methods for environmental noise impact assessments'.
- SANS 0357:2004. '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.*

3 CURRENT ENVIRONMENTAL SOUND CHARACTER

3.1 MEASUREMENT PROCEDURE

Ambient (background) noise levels were measured during night time in accordance with the South African National Standard SANS 10103:2003 "The measurement and rating of environmental noise with respect to land use, health, annoyance and to speech communication". The standard specifies the acceptable techniques for sound measurements including:

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

It should be noted that wind induced noises are normally seen as unwanted noises, and samples reflecting significant background interference due to wind induced noises are normally discarded. However, for the purpose of this study it was selected to include these samples as the typical operating noise of the wind energy facility will only be emitted during times when wind induced noise levels are relevant.

The equipment defined in **Table 3-1** was used for gathering data:

Table 3-1: Equipment used to gather data

Equipment	Model	Serial no	Calibration
SLM	Rion NL-32	01182945	12 May 2009
Microphone*	Rion UC-53A	315479	12 May 2009
Preamplifier	Rion NH-21	28879	12 May 2009
Calibrator	Rion NC-74	34494286	3 April 2009
Wind meter	Kestrel 4000	587391	Calibrated[1]

* Microphone fitted with the WS-01/ WS-03/WS-10 windshield.

3.2 ONSITE MEASUREMENTS

Measurements were taken on the 21 and 22 October 2009 (for the Cookhouse WEF) as well as on the 23 and 24 March 2010, with the sound measuring

1 Certificate of Conformity issued by Nielsen-Kellerman Co.

instrument calibrated directly before, and directly after the measurement was taken. In all cases drift was less than 1 dBA.

The locations used to measure ambient (background) sound levels are presented in Figure 3-1. These points are considered sufficient to determine the ambient (background) sound levels in the area. The results are presented in **Table 3-2** below, with the more detailed graphs presented in **Appendix A**.

Table 3-2: Results of ambient sound level monitoring

Point name	Latitude, Longitude	Wind speed Ave. (m/s)	$L_{Aeq,T}$ (dBA)	$L_{A, max}$ (dBA)	$L_{A, min}$ (dBA)	Temp (°C)	Humidity (%)
AAN-01(D)	-32.753958 26.036832	3.1	34.98	50.1	19	26	45
AAN-01(N)	-32.753958 26.036832	0.6	19.00	34.9	15.3	14.9	98
AAN-02(N)	-32.807241 26.077955	0.5	20.82	15.6	15.6	14.5	100
AAN-03(N)	-32824518 25.987631	0.8	20.89	26.7	16.6	14.6	100
AAN-04(N)	-32.934843 25.968295	1.8	22.62	34.9	18.4	14.9	100
AAN-05(N)	-32.893620 26.097843	2.0	27.49	47.7	19.5	19.5	75
AAN-06(N)	-32.929495 26.079430	1.5	28.73	44.1	19.5	19.8	74.3
CH-5	-32.763605 25.875510	*2.9***	30.40	42.1	21.3	22.1	40.7
CH-6	-32.759844 25.909363	*5.4***	37.88	48.8	30.9	22.1	40.4
CH-6(N)	-32.759844 25.909363	*6.3***	38.74	48.8	32.7	22.1	40.7

** Readings less than 20 dBA are below Instrument's lowest range.*

*** Only maximum wind speeds were recorded at Cookhouse*

Please note that the monitoring points CH-5 and Ch-6 found in **Figure 3-1**, was sound monitoring data obtained from a previous project (Cookhouse WEF) done by the author (on the 2009/10/21), and was considered for the NEIA (Noise Environmental Impact Assessment) Amakhala project.

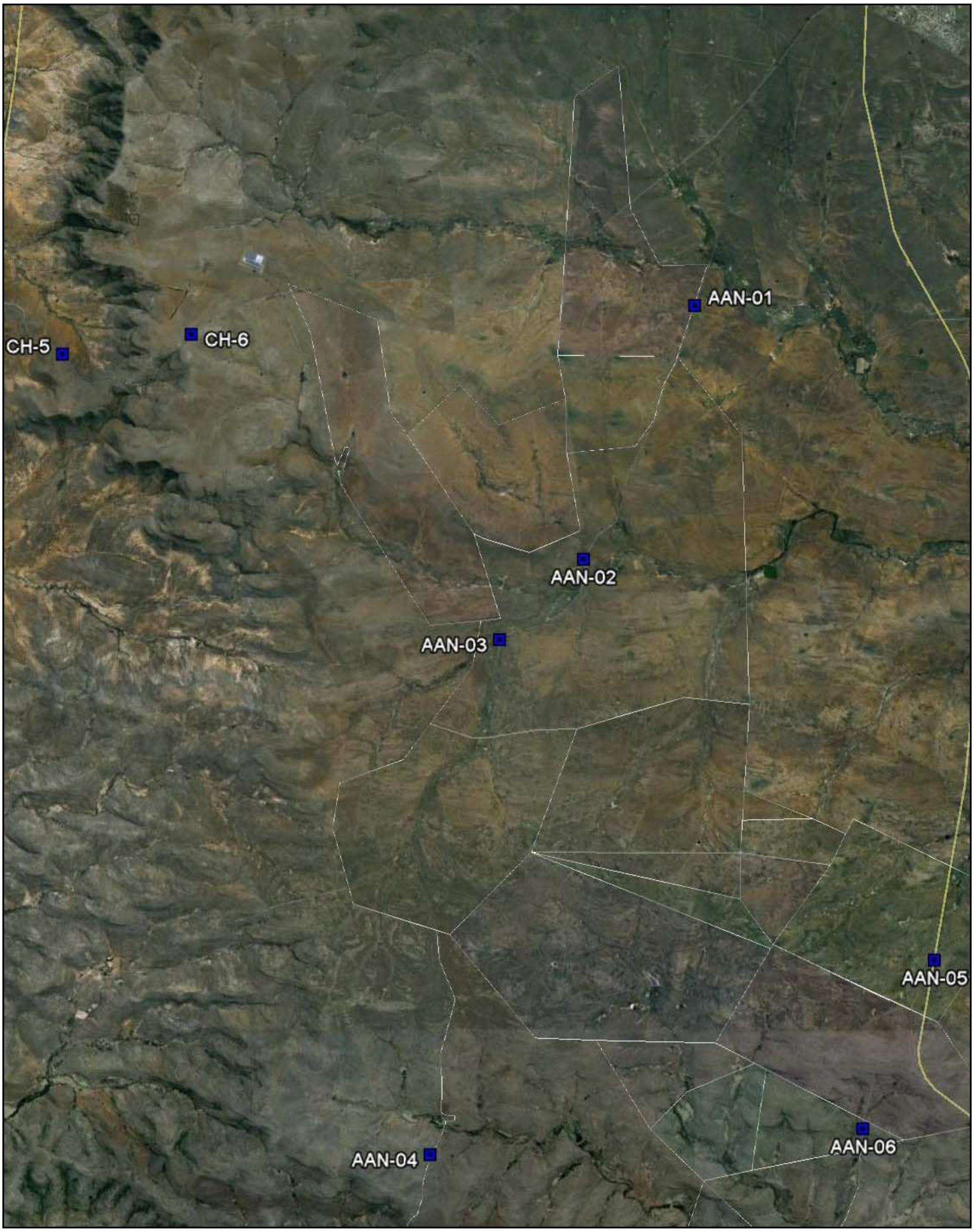

Figure 3-1: Monitoring points selected near the proposed Amakhala Emoyeni WEF

From the data it can be observed that the ambient (background) sound levels are extremely low at night, ranging to less than 20 ($L_{A,min}$) – 23 ($L_{Aeq,10min}$) dBA during times when there is no wind, or very little air movement, with increasing ambient sound levels with increasing wind speeds.

3.3 Influence of wind on Ambient Sound Levels

Unfortunately, current regulations and standards do not consider changing ambient (background) sound levels due to natural events, such as can be found near the coast or areas where wind induced noises are prevalent, which is unfeasible with wind energy facilities, as these facilities will only operate when the wind is blowing. It is therefore important that the impact of wind-induced noises be considered when determining the impact of an activity such as a wind energy facility. However, care should be taken when taking this approach due to other factors that complicates noise propagation from wind turbines (see also **section 4.2**).

Figure 3-2 illustrates this situation where the sound pressure levels associated with wind action increase as wind speeds increase. The sound levels measured (mainly wind impacting on the background ambient sound levels) is also indicated on this Figure (in yellow).

The curve developed is based on the noise measurements collected at a number of sites in South Africa. While not site specific, principle is to fit a curve using the available data that can be used to estimate cautious ambient sound levels during times when wind is blowing. The curve used is based on a curve developed near the Silverton Wind Farm in Australia. Sound Pressure Levels ($L_{Aeq,10min}$) were plotted against wind speed, and the estimated curve adjusted downward to be below the lowest ambient sound levels measured at wind speeds higher than 3 m/s. For the modelling the appropriate ambient sound levels from this curve will be used. Because of the downward adjustment, the potential full effect of the wind-related ambient noise levels will be reduced.

It should be noted that all the monitoring points were at least 200 meters from any dwelling, and in most cases more than 500 meters. In addition the points were selected to be away from structures (buildings, trees, etc.) that could significantly impact the ambient sound levels during high winds. During times when a wind is blowing, ambient sound levels are generally higher near dwellings or other structures than at areas away from such structures. Samples collected closer to structures such as these could be up to 3 dBA higher.

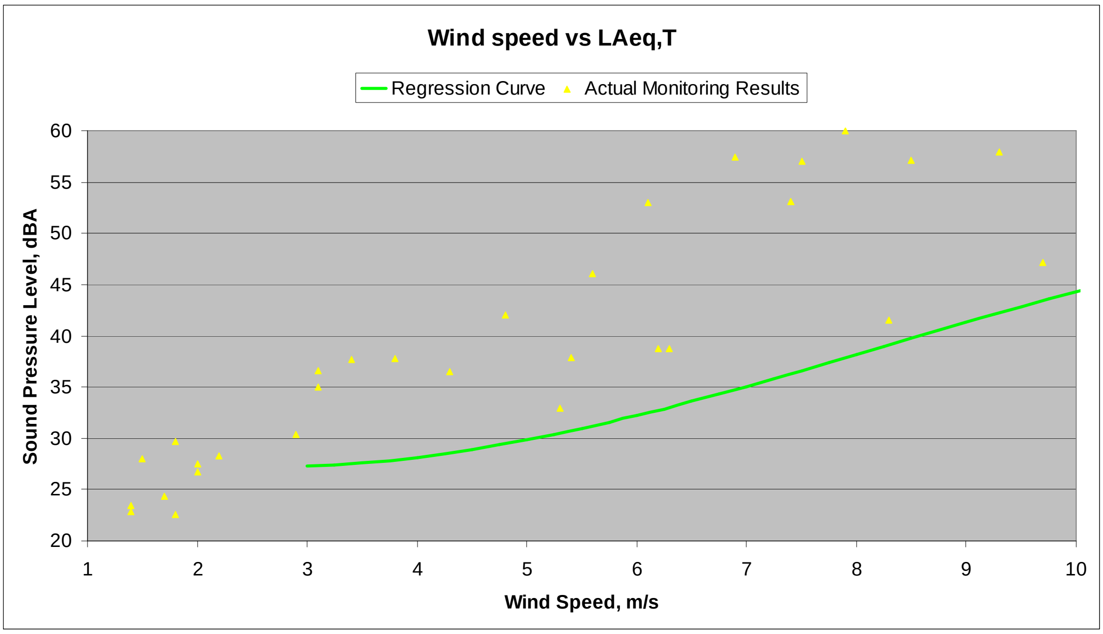

Figure 3-2: Ambient sound levels as wind speed increase[2]

Reasons for a 3dBA penalty used in **Figure 3-2** include the following:

- Uncertainty factors, such as the small inaccuracies/interference that can incurred during monitoring; This should cover the following points:
    1. Instrument Accuracy and chain of instruments (tripod, cables, Sound Level Meter, Pre-amplifier, Microphone, Calibration – 1 dBA);
    2. Wind shield used to do measurements (2 dBA);
    3. Wind Turbulence and Gustyness making sampling more difficult and reducing repeatability (2 dBA);
    4. Wind Shear effects (Refer to **Figure 5-2** and its associated text in **section 5.3.3.1** – 2 dBA).

The RMS value of these uncertainties is approximately 3 dBA.

3.4 AMBIENT SOUND MAP

An ambient sound level map was compiled illustrating the observed scenario, being:

- Day-time (06:00 – 22:00) ambient background sound levels in wind-still conditions (*Peak traffic assumed as counted*):
    - *96 vehicles/hour (30% trucks) on N10, travelling at 110 km/h;*

[2] Curve based on findings from Silverton Wind Energy Facility in Australia. The curve was adjusted downwards to be at least 3 dBA lower than the lowest ambient measurements associated with wind.

Figure 3-3: Daytime (06:00 – 22:00) ambient sound levels: Contours of constant sound levels

- *36 vehicles/hour (5% trucks) on R63 travelling at 110 km/h;*
- *24 vehicles/hour (0% trucks) on R350 travelling at 110 km/h;*
- *6 vehicles/hour (0% trucks) on the gravel road through the proposed site, travelling at 50 km/h.*

Various smaller roads were identified in, and around the proposed area, connecting farmers and various other small holdings to the secondary and main roads. However these roads due not contribute much too ambient sound levels during the day and was not considered in the ambient day sound map.

The night-time sample revealed:

- Night-time (22:00 – 06:00) ambient background sound levels in wind-still conditions. Measurements were taken after 2 am indicated very little traffic on the various roads in the area. *Night-time traffic will therefore not be considered for the operational phase.*

3.4.1 Daytime Ambient Noise Levels

For background modelling purposes ambient sound levels associated with low wind speeds were selected with the output represented in **Figure 3-3**.

A reader should note that the A-weighted noise levels as illustrated is the "average" or "equivalent" noise level that receptors could experience. While receptors close enough to the road will detect vehicles travelling on the road, they experience that peak noise levels only for a short while. The rest of the time noise levels would return to the ambient sound level. The A-weighted Equivalent noise levels as illustrated are therefore used to "average" the exposure that receptors experience due to traffic in a set time period and is used to define the potential impact that receptors are experiencing.

As can be expected, most of the ambient day time noise can be seen coming from the roads (N10, R63 and R350) in the area. The smaller road traversing the site was modelled, but it does not impact significantly on the surrounding ambient sound levels. Roads therefore do not contribute significantly to ambient daytime sound levels in the area proposed for the WEF, and natural sounds (animals, wind) as well as other agricultural activities defines the soundscape in the area.

It should be noted that other noise sources were not added to this ambient sound map. Typical sources during the day would be:

- Dogs barking and farm animals,
- Radios or TVs playing in the background,

- People speaking,
- Other activities, such as farming activities.

While some of these noise sources cannot be considered insignificant, the shear task of adding all noise sources makes this task almost impossible. In addition, the more other noise sources are added, the lower the projected impact of the activity under investigation, due to the increased ambient sound levels. This is however considered during the impact assessment phase when the probability is estimated, because these types of ambient sounds tend to mask noises during the day.

4 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.

4.1 POTENTIAL NOISE SOURCES: CONSTRUCTION PHASE

4.1.1 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,
- delivery of turbines, substation and power line components to the site,
- digging of trenches to accommodate underground power cables; and
- the construction of turbine towers and assembly of wind turbine generators.

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

- excavator/graders, bulldozer(s), dump trucks(s), vibratory roller, bucket loader, rock breaker(s), drill rig, flat bed truck(s), pile drivers, concrete truck(s), crane(s), fork lift(s) and various 4WD and service vehicles.

Octave sound power levels typical for this equipment are presented in **Appendix B**.

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

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

1. The transport of "ready-mix" concrete from the closest centre to the development,
2. The transport of aggregate and cement from the closest centre to the development, with the establishment of a small concrete batching plant close to the activities. This would most likely be a movable plant.
3. The establishment of a small quarrying activity, where aggregate will be mined, crushed and screened and used onsite. Cement will still be transported to the site, where there will be a small movable concrete batching plant.

For the purpose of the EIA option 2 has been assumed to be the option which will be implemented.

4.1.3 Blasting

Blasting may be required as part of the civil works to clear obstacles or to prepare foundations. However, blasting will not be considered 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. The breaking of obstacles with explosives is also a specialized field, and when correct techniques are used, causes significantly 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. However, these are normally associated with close proximity mining/quarrying.
- 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 result in a higher acceptance of the noise. Note that with the selection of explosives and blasting methods, noise levels from blasting is relatively easy to control.

4.1.4 Traffic

A significant source of noise during the construction phase is additional traffic to and from the site, as well as traffic on the site. This will include trucks transporting equipment, aggregate and cement as well as various components used to develop the wind turbine.

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).

4.2 Potential Noise Sources: Operational Phase

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

4.2.1 Wind Turbine Noise: Aerodynamic sources

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.

Noise due to aerodynamic instabilities (mechanisms 3 and 4) can be reduced to insignificant levels by careful design. The other mechanisms are an inescapable consequence of the aerodynamics of the turbine which produces the power and between them they will make up most if not all of the aerodynamic noise radiated by the wind turbine. The relative contribution of each source will depend upon the detailed design of the turbine and the wind speed and turbulence at the time.

The mechanisms responsible for tip noise (mechanism 5) are currently under investigation but it appears that methods for its control through design of the tip shape may be available. Self noise (mechanism 1) is most significant at low wind speeds whereas noise due to inflow turbulence (mechanism 2) becomes the dominant source at the higher wind speeds. Both mechanisms increase in strength as the wind speed increases, particularly inflow turbulence. The overall result is that at low to moderate wind speeds the noise from a fixed speed wind turbine increases at a rate of 0.5-1.5 dBA /m/s up to a maximum at wind speeds of 7 -12 m/s (noise generated by the WTG does not increase significantly at wind speeds above 12 m/s).

Therefore, as the wind speed increases, noises created by the wind turbine also increases. At a low wind speed the noise created by the wind turbine is generally (relatively) low, and increases to a maximum at a certain wind speed when it either remains constant, increase very slightly or even drops as illustrated in **Figure 4-1**.

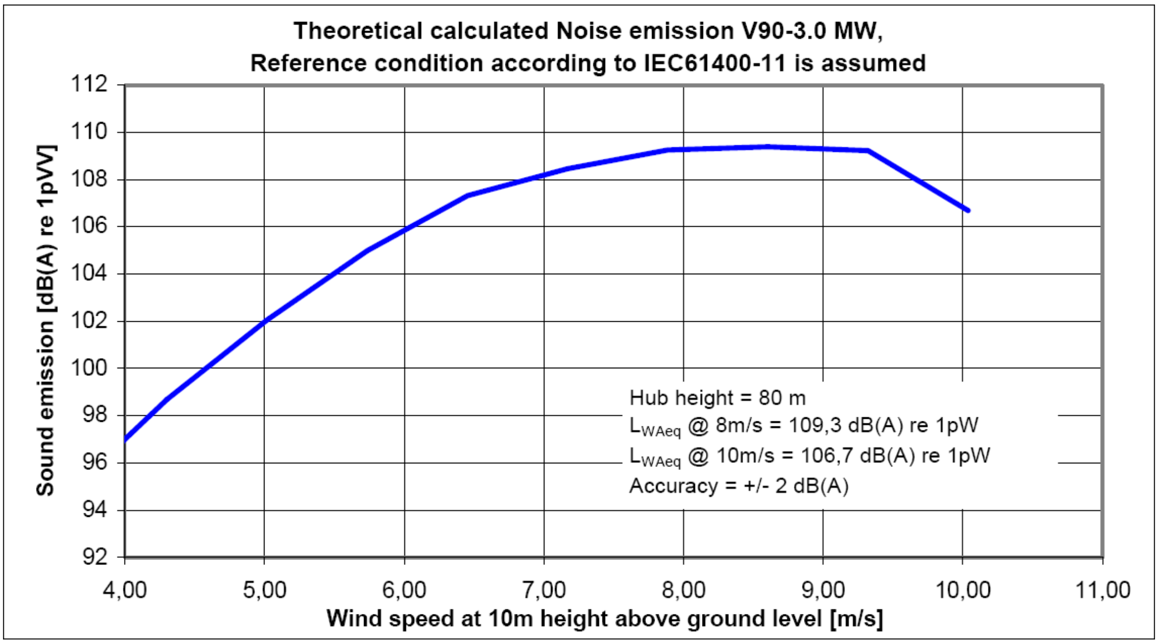

Figure 4-1: Noise Curve Vestas V90 – 3.0 MW, 60Hz (figure for illustration purposes)

Typical noise characteristics can be measured for each type of wind turbine, and minimum/average/maximum curves as seen in Figure 4-2 can be compiled. The more accurate the data, the more accurate the modelling would be.

The developer highlighted that the Vestas V90 1.8/2.0MW wind turbine could possibly be considered for use at the WEF. For the purpose of this investigation therefore this wind turbine was selected.

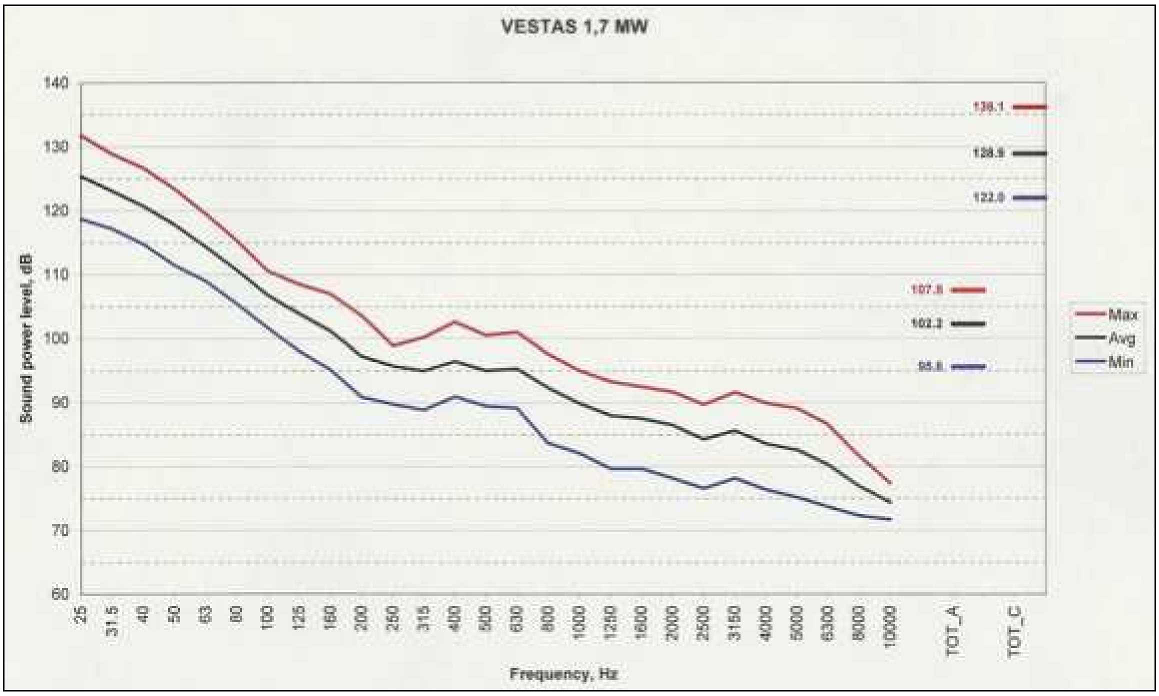

Figure 4-2: Sound power level emission of a Vestas, V66 wind turbine (for illustration purposes only)

Sound power emissions (in octave sound power levels) for the Vestas 90 1.8 MW wind turbine are presented in **Table 4-1**. The propagation model makes use of various frequencies because these frequencies are affected in different ways as it propagates through air, over barriers and over different ground conditions.

Table 4-1: Sound Power Emissions of the VESTA V90 1.8MW

Wind Speed (m/s)	Frequency (Hz)	63 (dB)	125 (dB)	250 (dB)	500 (dB)	1000 (dB)	2000 (dB)	4000 (dB)	L_{WA} (dBA)
4	$L_{WA,P}$	76.4	80.9	84.2	86.6	89.3	87.7	85.7	94.38
	$L_{W,P}$	102.5	96.9	92.8	89.38	89.3	86.5	84.7	
7	$L_{WA,P}$	86.2	90.8	93.5	95.2	98.3	96.8	95.3	103.58
	$L_{W,P}$	112.3	106.8	102.1	98.4	98.3	95.6	94.3	

4.2.2 Wind Turbine: Mechanical sources

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 do not emit any clearly distinguishable tones***.

4.2.3 Transformer noises (Substations)

Also known as magnetostriction, this is when the sheet steel used in the core of the transformer tries to change shape when being magnetised. When the magnetism is taken 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" takes place 100 times a second, resulting in a tonal noise at 100Hz. This is normally not an issue if the substation is further than 200 meters from a potentially sensitive receptor.

This is a relative easy noise to mitigate with the use of acoustic shielding and/or placement of the transformer equipment and will not be considered further in the EIA study.

4.2.4 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.

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.

In addition this is associated with high voltage transmission lines, and not the lower voltage distribution lines proposed for construction by the developer.

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

4.2.5 Low Frequency Noise

4.2.5.1 Background and Information

Low frequency sound is the term used to describe sound energy in the region below ~200Hz. The rumble of thunder and the throb of a diesel engine are both examples of sounds with most of their energy in this low frequency range. Infrasound is often used to describe sound energy in the region below 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). See also **Figure 4-3**, which indicates the sound power levels in the different octave bands from measurements taken at different wind speeds with no other audible noise sources present. Sound which has most of its energy in the 'infrasound' range is only significant if it is at a very high level, far above normal environmental levels.

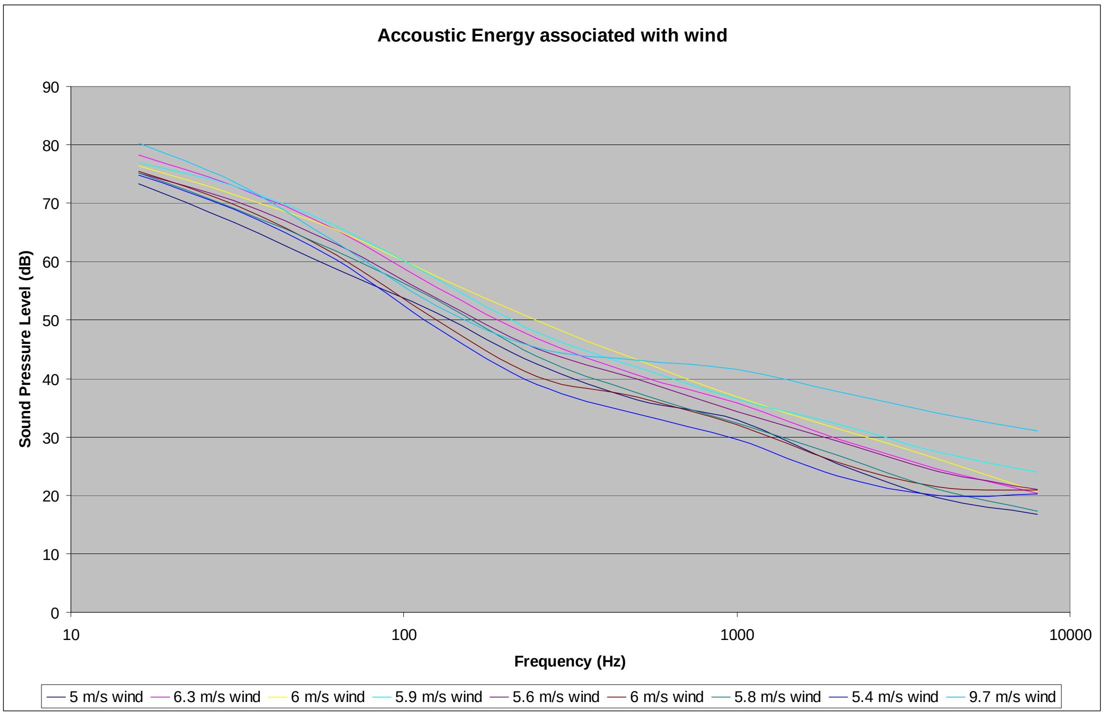

Figure 4-3: Third octave band sound power levels at various wind speeds

4.2.5.2 The generation of Low Frequency Sounds

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

4.2.5.3 Detection of Low Frequency Sounds

The levels of infrasound radiated by the largest wind turbines are very low in comparison to other sources of acoustic energy in this frequency range such as sonic booms, shock waves from explosions, etc. The danger of hearing damage from wind turbine low-frequency emissions is remote to non-existent. However, sounds in a frequency range less than 100Hz can, under the right circumstances, be responsible for annoying nearby residents. Typically, except very near the source, most people outside cannot detect the presence of low-frequency noise from a wind turbine. It should be noted that there are people more sensitive for these low frequency sounds.

People however can, if the noise has an impulsive characteristic, "hear" it within homes in nearby dwellings under the right set of circumstances. Often it is not clear with low-frequency noise if people are hearing or feeling it or some combination of both stimuli. Because of the impulsive nature of the acoustic low-frequency energy being emitted, there is an interaction between the incident acoustic pulses and the resonance's of the homes which serve to amplify the stimuli creating vibrations as well as redistributing the energy higher into the audible frequency region. Thus the annoyance is often connected with the periodic nature of the emitted sounds rather than the frequency of the acoustic energy.

Impulsive noise generation is generally confined to turbines whose rotors operate downwind of the support tower (downwind machine). In this case, impulses are generated by the interaction of the aerodynamic lift created on the rotor blades and the wake vortices being shed from the tower elements. In the past 20 years modern wind turbines have nearly exclusively been designed as machines that have their rotors upstream of the tower. Those, except in very rare circumstances, do not generate impulses since there is nothing blocking the flow upwind of the rotor. The low-frequency noise generated from an upwind turbine is primarily the result of the interaction of the aerodynamic lift on the blades and the atmospheric turbulence in the wind. Because atmospheric turbulence is a random phenomenon, the radiated low-frequency noise also exhibits a random or non-coherent characteristic. Impulsive noise generated by the tower wake/rotor interaction, on the other hand, tends to be much less random or coherent and therefore much more detectable when it interacts with an intervening resonant structure.

For a healthy young adult the range of hearing is often quoted as extending from 20Hz to 20,000Hz although the sensitivity of the ear varies significantly with frequency and is most sensitive to sounds with frequencies between around 500Hz and 4,000Hz where the majority of information in speech signals is contained. Above and below this, the ear becomes decreasingly sensitive and is very insensitive at very low frequencies, meaning that sound levels have to be very high for such sounds to be perceived. Refer also to **Figure 4-4**.

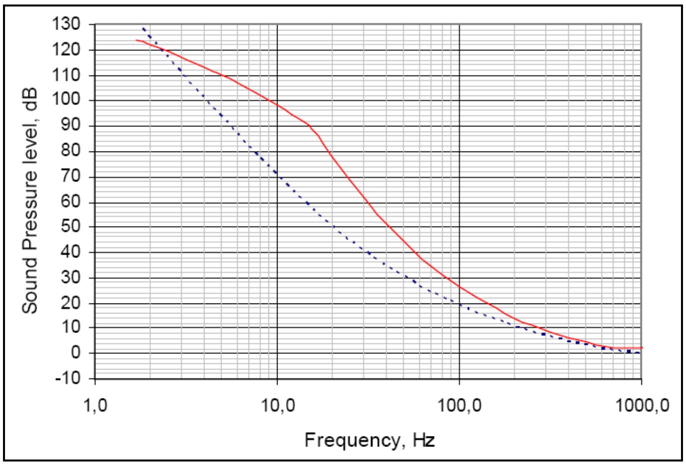

Figure 4-4: The average hearing threshold for humans (pure tones) in a free field (red line). The A-weighting line is the broken line.

However, 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.

4.2.5.4 Measurement, Isolation and Assessment of Low Frequency Sounds

There remain 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.

However, from sound power level emission graphs such as **Figure 4-2** and the data contained in **Table 4-1**, it can be seen that a wind turbine has significant potential to generate low frequency sounds with sufficient energy to warrant the need to investigate WTG as a source of low frequency sounds. However, the reader is also referred to **Figure 4-3** and **Figure 4-5** for examples of various sources and associated levels of low frequency sounds. From these two figures it is clear that there is significant acoustic energy in the lower frequencies (less than 100 Hz) in the environment around us.

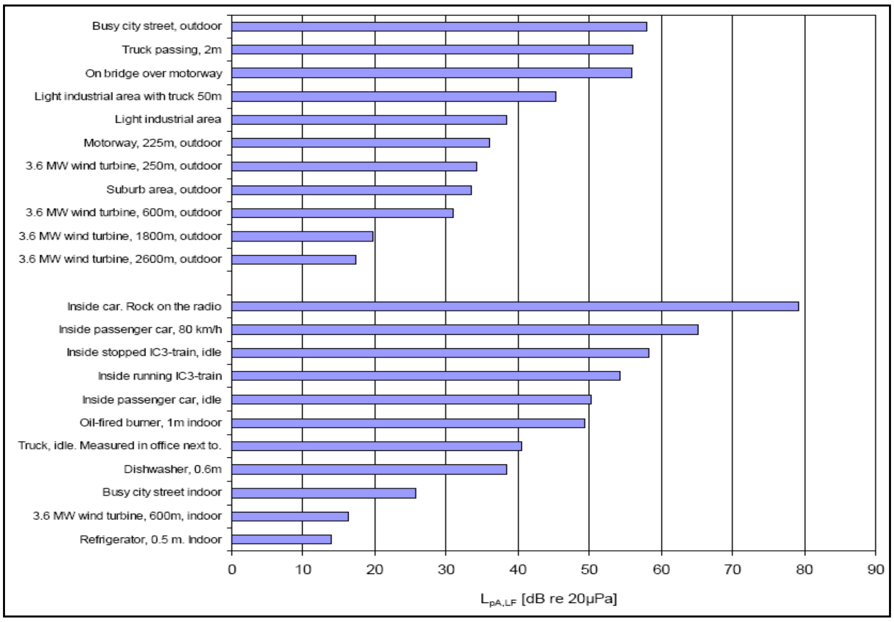

Figure 4-5: Examples on A-weighted low frequency levels $L_{pA,LF}$ from a number of indoor and outdoor sources.

Unfortunately there isn't a standardised test, nor an assessment procedure available for the assessment of low frequency sounds, neither is there an accepted methodology on how low frequency sounds can be modelled or predicted. This is because low frequency sound can travel large distances, and are present all around us, with a significant component generated by nature itself (ocean, wind, etc.).

SANS 10103:2004 proposes a method to identify whether low frequency noise could be an issue. It proposes that if the difference between the A-frequency weighted and the C-frequency weighted equivalent continuous ($L_{Aeq} >> L_{Ceq}$) sound pressure levels is greater than 10 dB, a predominant low frequency component **may** be present. However, at all cases existing acoustic energy in low frequencies associated with wind must be considered.

4.2.6 Amplitude modulation

There is one other characteristic of wind turbine sound that increases the sleep disturbance potential above that of other long-term noise sources. The amplitude modulation of the sound emissions from the wind turbines create a repetitive rise and fall in sound levels synchronised to the blade rotation speed, sometimes referred too as a "swish" or "thump". Many common weather conditions increase the magnitude of amplitude modulation. Unfortunately most of these occur at night.

The threshold for detection of a sound with a modulation frequency of 1 Hz was in one experimental study found to be 1-2 dB below a masking noise (white noise). The masking noise had its energy within the same frequency band as the modulated sound, thus providing optimal possibilities for masking. Modulating characteristics of the sound from a wind turbine therefore makes it more likely to be noticed and less masked by background noise.

Pederson (2003) highlighted a weak correlation between sound pressure level and noise annoyance caused by wind turbines. Residents complaining about wind turbines noise perceived more sound characteristics than noise levels. People were able to distinguish between background ambient sounds and the sounds that the blades made. The noise produced by the blades lead to most complaints. Most of the annoyance was experienced between 16.00 p.m. and midnight. This could be an issue as noise propagation modelling would be reporting an equivalent, or "average" sound pressure level, a parameter that ignores the "character" of the sound.

The graph in **Figure 4-6** shows this effect in the first floor bedroom of a farm home in the U.K. The home is located 930 meters from the nearest turbine (type or details of turbine unknown). The conditions documented by an independent acoustical consultant show the sound level varying over a 9 dBA range from 28 to 37 dBA. The pattern repeats approximately every second often for hours at a time. It is also reported that for many people, especially seniors, children and those with pre-existing medical conditions, this represents a major challenge to restful sleep.

This statement was also confirmed by Delta (2008, reference 2), stating that sounds from modern large wind turbines are dominated by the aerodynamic noise from the blades rotating in the air. The mid and high frequency aerodynamic noise is modulated by the low blade passage frequency (~1 Hz).

Unfortunately 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.

Even though there are thousands of wind turbine generators in the world, amplitude modulation is one subject receiving the least complaints and due to this very few complaints, little research went 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).

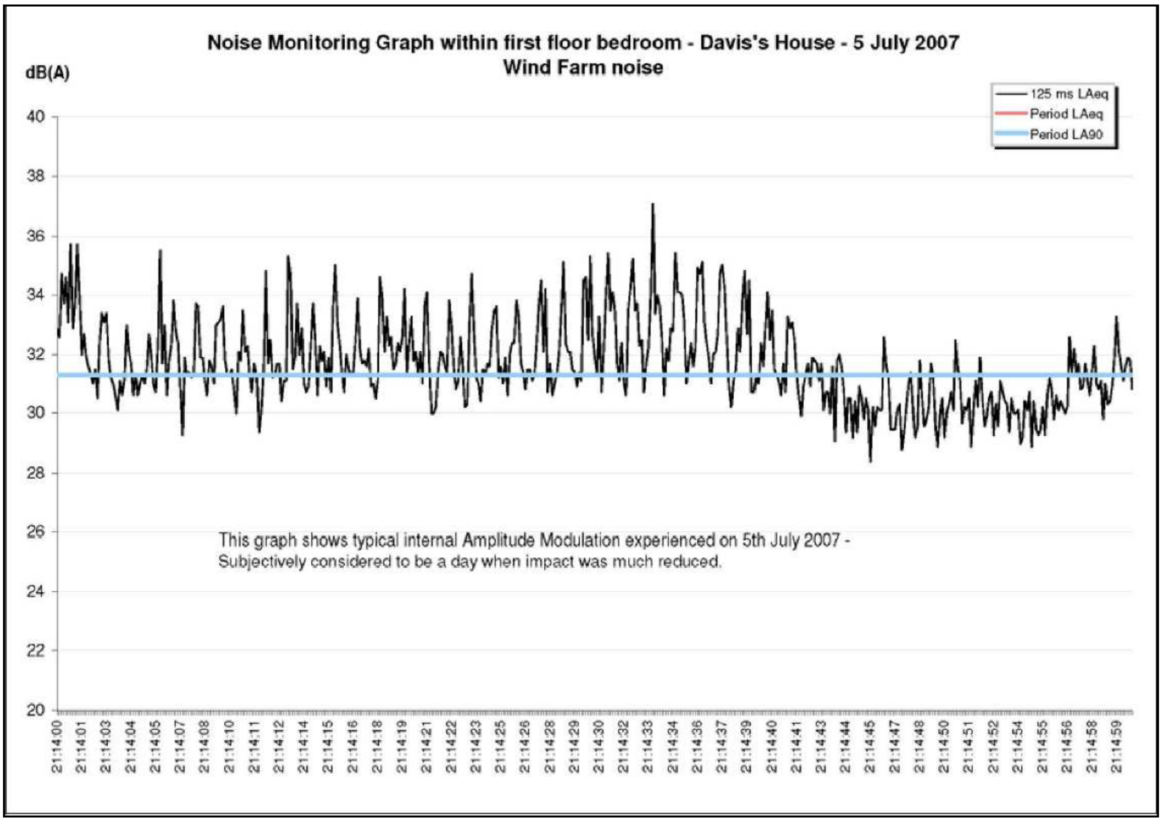

Figure 4-6: Amplitude modulation in a home 930 meters away from a WTG.

5 METHODOLOGY: NOISE IMPACT ASSESSMENT AND SIGNIFICANCE

5.1 NOISE IMPACT ON ANIMALS

A great deal of research was conducted in the 1960's and 1970's on the effects of aircraft noise on animals. Overall, the research suggests that species differ in their response to:

- Various types of noise,
- Durations of noise,
- Sources of noise.

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

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

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

From this and other studies the following can be concluded:

- Animals respond to impulsive (sudden) noises (higher than 90 dBA) by running away. If the noises continue animals would try to relocate. This is not relevant to wind energy facilities because the turbines do not generate impulsive noises close to these sound levels.
- Animals of all species exhibit adaptation with noise, including aircraft noise and sonic booms (far worse than noises associated with Wind Turbines).
- More sensitive species would relocate to a more quiet area, especially species that depend on hearing to hunt or evade prey, or species that makes use of sound/hearing to locate a suitable mate.
- Noises associated with helicopters, motor- and quad bikes significantly impacts on animals.

5.1.1 Domestic Animals

It has been observed that most domestic animals are generally not bothered by noise, excluding most impulsive noises. In the intensity range that a Wind Turbine generates noise it should not impact on any domestic animal.

5.1.2 Wildlife

Depending on the turbine, some may create significant enough acoustic energy in the low frequency range that might impact on animals that makes use of vibrations to hunt. But in general most anthropogenic activities already disturbed sensitive animals that might have been impacted by the noise from a wind turbine.

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

Unfortunately there are only a few specific studies discussing the potential impacts of noise associated wind turbines on wildlife. It is suspected that noises from wind turbines may mask the sounds of a predator approaching; similarly predators depending on hearing would not be able to locate their prey. However, due to significant background ambient sounds during periods when the wind turbines are operating (wind induced noises), the potential impact from a wind turbine on such animals are questioned.

A noteworthy study was conducted by Stephen Pearce-Higgins *et al* (2009). This survey of breeding birds in non-agricultural British uplands (moors and grassland) included weekly surveys during the breeding season at 12 different wind farm sites, along with comparable nearby landscapes without turbines. Half the wind farms were from the previous generation (way back in the '90s), with hub heights of 40m and less; the other half had hub heights of 60-70m. Of the twelve species that were observed often enough to provide good data, five seemed relatively unaffected by turbines (including kestrel, lapwing, grouse, skylark, and stonechat), while 7 species were less likely to nest within 500m of turbines, with smaller (i.e., not statistically significant) effects extending to 800m, or roughly half a mile. For six of the species (buzzard, hen harrier, plover, snipe, curlew, and wheatear), numbers were reduced by 39-52%.

The authors note that there is a pressing need for examination of the reasons for the depressed numbers and state: "*we do not know whether our observations of avoidance of turbines reflect a behavioural displacement, the local population consequences of collision mortality or reduced productivity, or both. The distinction is important. If there is high mortality of birds breeding close to the turbines associated with collision, then a wind farm may become a population sink if repeatedly colonized by naive birds. If, however, the birds simply avoid breeding close to the turbines, then displaced birds may settle elsewhere with little cost.*"

They also note that "*species occupying remote semi-natural habitats may be more sensitive to wind farm development than species occupying intensive production landscapes*."

This indicates that the potential significance of a noise impact would depend on the species concerned. Less sensitive species would not be bothered by the noises from the wind turbines, whereas the more sensitive species might relocate. Unfortunately there is no database of potential sensitive species in South Africa. Taking the precautionary route, it is suggested that construction do not take place within 500 meters from any sensitive species as identified by the Fauna/Avifauna study during the breeding season.

5.2 WHY NOISE CONCERNS COMMUNITIES

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

- Hinders speech communication,
- Impedes the thinking process,
- Interferes with concentration,
- Obstructs activities (work, leisure and sleeping),
- 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 only music, but the person in the traffic behind them hears nothing but noise.

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

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

Severity of the annoyance depends on factors such as:

- Background sound levels, and the background sound levels the receptor is used to,

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

5.3 IMPACT ASSESSMENT CRITERIA

5.3.1 Overview: The common characteristics

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

- Intensity
- Loudness
- Annoyance
- 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.

5.3.2 Noise criteria of concern

The criteria used in this report were drawn from the criteria for the description and assessment of environmental impacts from the EIA Regulations, published by the Department of Environmental Affairs and Tourism (April 1998) in terms of the NEMA, SANS 10103 as well as guidelines from the World Health Organization.

There are 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 (promulgated in terms of the ECA), an increase of more than 7 dBA is considered a disturbing noise. See also **Figure 5-1**.

- *Zone Sound Levels:* Previously referred to as the acceptable rating levels, it sets acceptable noise levels for various areas. See also **Table 5-1**.
- *Absolute or total noise levels:* Depending on their activities, people generally are tolerant to noise up to a certain absolute level, e.g. 65 dBA. Anything above this level will be considered unacceptable.

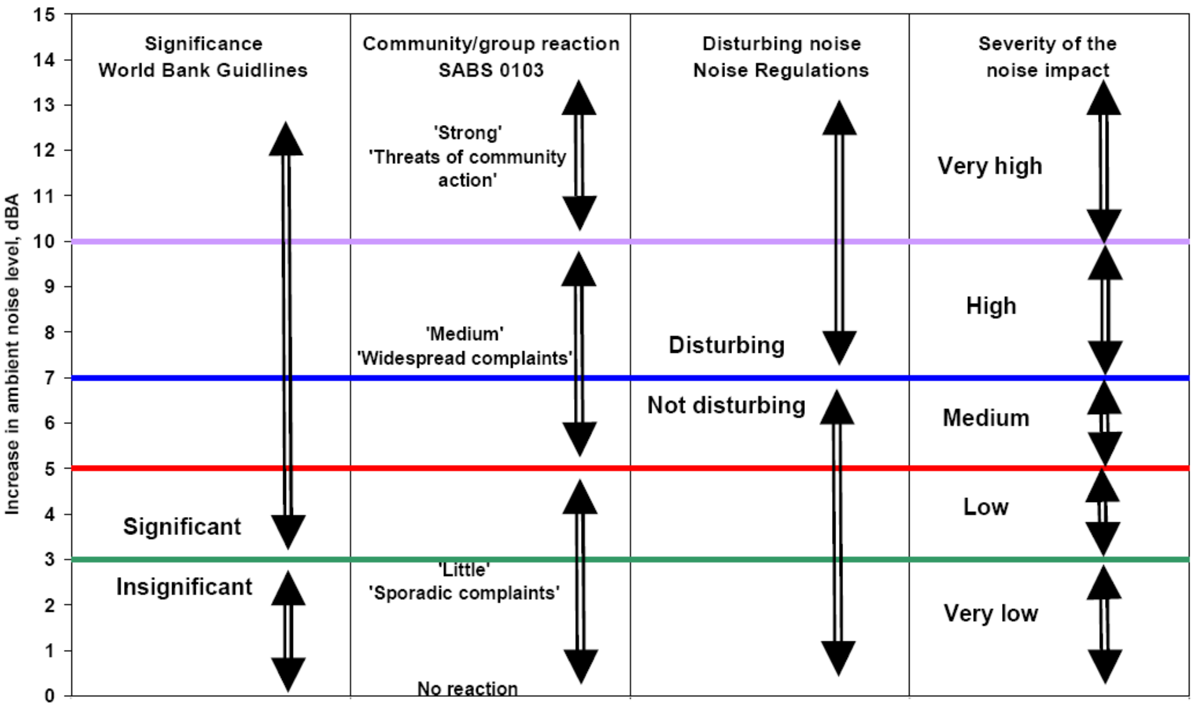

Figure 5-1: Criteria to assess the significance of impacts stemming from noise

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 background ambient sound levels (referred to as Rating Levels), $L_{Req,d}$ and $L_{Req,n}$, during the day and night respectively to which different types of developments may be exposed. 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.

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

- **Δ ≤ 3 dBA:** An increase of 3 dBA or less will not cause any response from a community. It should be noted that for a person with average hearing acuity an increase of less than 3 dBA in the general ambient noise level would not be noticeable.

- **3 < Δ ≤ 5 dBA:** An increase of between 3 dBA and 5 dBA will elicit 'little' community response with 'sporadic complaints'. People will just be able to notice a change in the sound character in the area.
- **5 < Δ ≤ 15 dBA:** An increase of between 5 dBA and 15 dBA will elicit a 'medium' community response with 'widespread complaints'. In addition, an increase of 10 dBA is subjectively perceived as a doubling in the loudness of a noise. For an increase of more than 15 dBA the community reaction will be 'strong' with 'threats of community action'.

Table 5-1: Acceptable Zone Sound Levels for noise in districts (SANS 10103)

1	2	3	4	5	6	7
Type of district	**Equivalent continuous rating level ($L_{Req,T}$) for noise,** dBA					
	Outdoors			**Indoors, with open windows**		
	Day-night $L_{R,dn}$[a]	**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

5.3.3 Determining appropriate Zone Sound Levels

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

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

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

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

Available data indicates that noises from a Wind Turbine is drowned by other noises (wind howling around building, rustling of leaves in trees, rattling noises, etc) above a wind speed of 10 m/s, even if the wind blows in the direction of the receiver.

A cautious ambient sound vs. wind speed regression curve is illustrated in **Figure 5-2**. It should be noted that curves for daytime (6:00 – 22:00) and night time (22:00 – 6:00) would be different, but as wind speeds increase, the wind induced noise levels approach the noise emitted by the wind turbine(s).

For the purpose of the EIA, **Figure 5-2** will be considered, the change in sound levels that the receptors may experience together with the zone sound levels as stipulated in SANS 10103.

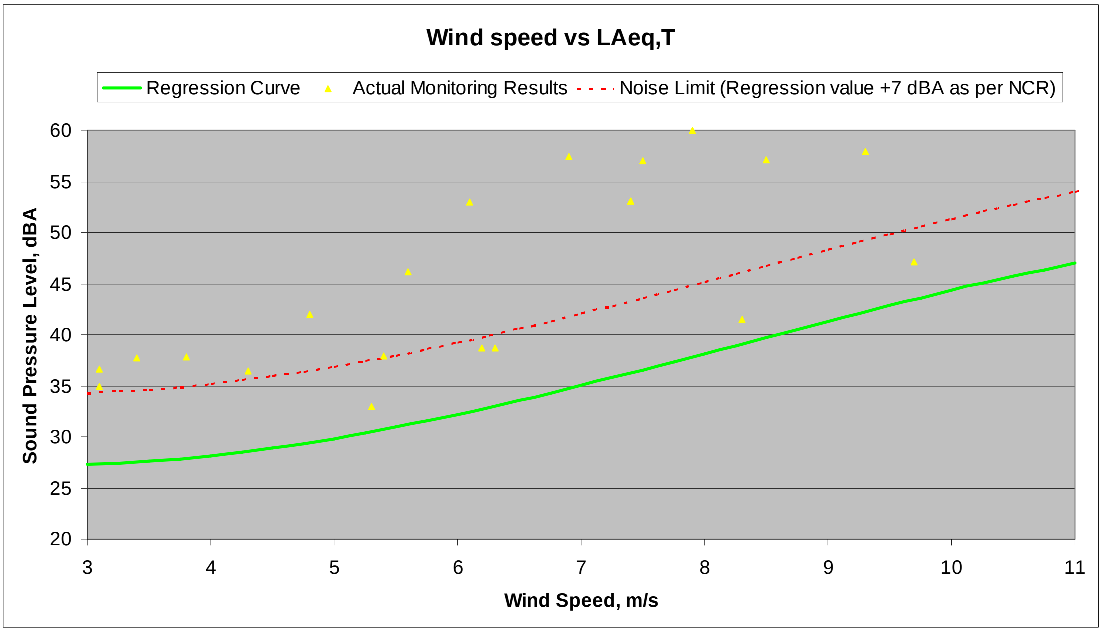

Figure 5-2: Background ambient sound levels associated with increased wind speeds

5.3.3.1 Relationship between wind speed at different levels and noise at ground level

Normally, as the height above ground level increase, wind speed also increases. For acoustical purposes prediction of the wind speed at hub height is based on the wind speed v_{ref} at the reference height (normally 10 meters) for wind speed measurements, extrapolated to a wind speed v_h at hub height, using the widely used formula:

$$v_h = v_{ref} \times \frac{\log\left(h/m\right)}{\log\left(h_{ref}/m\right)}$$

However, depending on topographical layout, this relationship may not be true at all times. Authors such as Van den Berg (2003) indicated that wind speeds at hub height could be significantly higher that expected, at the same time being significantly higher than ground level wind speeds. In these cases the wind turbines are operational and emitting noise, yet the wind induced ambient sound levels is less than expected (less masking of turbine noise). This is one of the reasons the ambient curve (**Figure 5-2**) is adjusted with -3 dBA, allowing the ambient sound levels to be less at all times than potential "real" ambient sound levels.

This should be considered when evaluating the significance of the impact, especially when the wind turbines are situated on a hill, with the prevailing wind direction being in the direction of potential sensitive receptors living in a valley downwind of the wind energy facility. It is proposed by this author that the precautionary approach be considered, and when there is one or more turbines within 1,000 metres from a downwind receptor(s), that the probability of this impact occurring be elevated with at least one step/factor (e.g. from ***Likely*** to ***Highly Likely***). This is one of the reasons the ambient curve (**Figure 5-2**) is adjusted with -3 dBA, allowing the ambient sound levels to be less at all times than potential "real" ambient sound levels.

5.3.3.2 Other noise sources of significance

In addition other noise sources that may be present should also be considered. During the day all living beings are bombarded with the sounds from numerous sources considered "normal", such as animal sounds, conversation, amenities and appliances (TV/Radio/CD playing in background, computer(s), freezers/fridges, etc). This excludes activities that may generate additional noise associated with normal work.

At night sounds that are present are natural sounds from animals, wind as well as other sounds we consider "normal", such as the hum from variety of appliances (magnetostriction) drawing standby power, freezers and fridges.

Figure 5-3 illustrates the sound levels associated with some equipment, or at certain places.

5.3.4 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 is defined in **Table 5-2**.

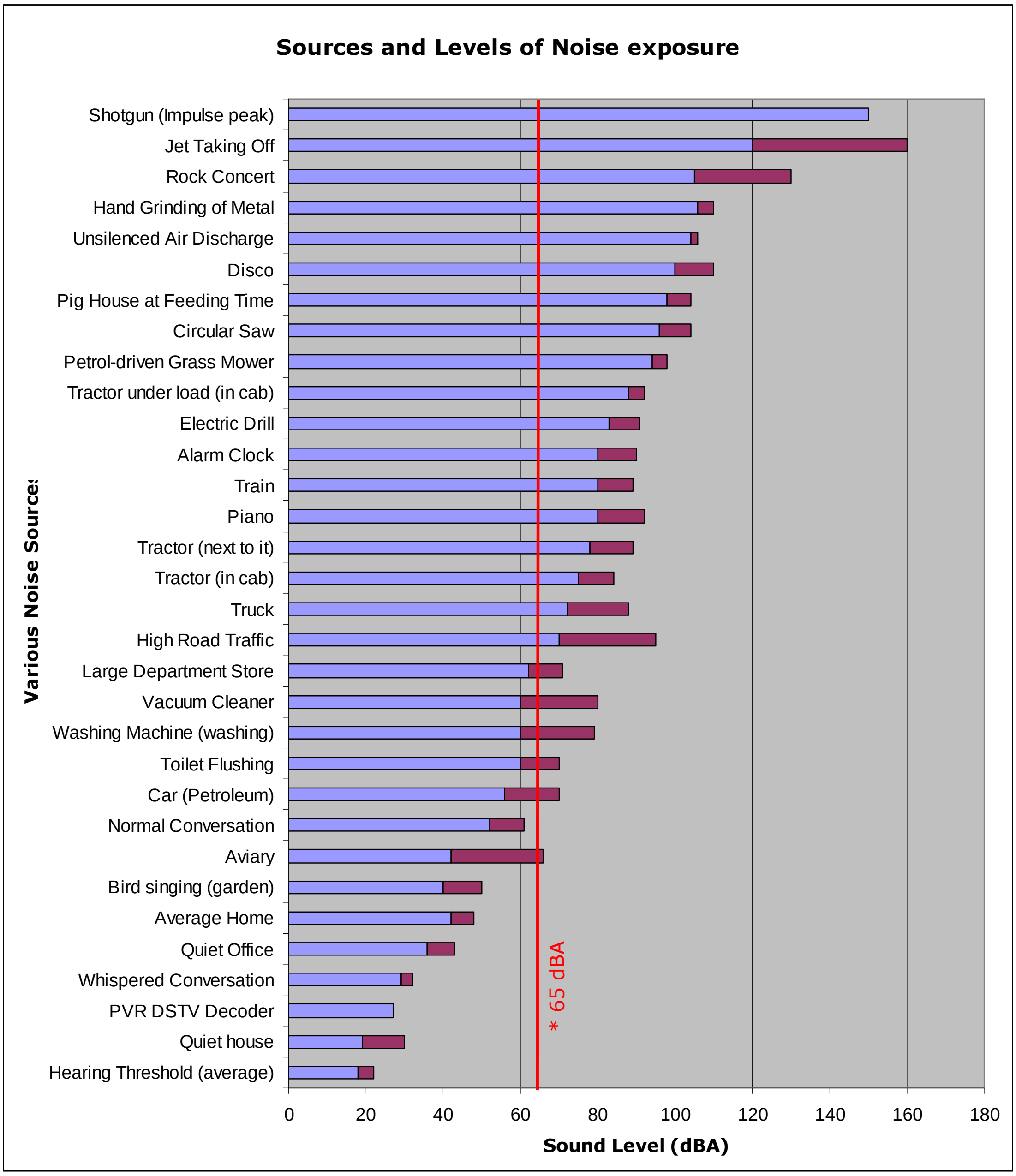

Figure 5-3: Typical Noise Sources and associated Sound Pressure Level

Table 5-2: 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.	
Temporary	The impact will either disappear with mitigation, will be mitigated through a natural process, or will last less than an hour.
Short term	The impact will be applicable less than 24 hours.
Medium term	The impact will last up to a week.
Long term	The impact will last up to a month.
Permanent	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	
Site	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.
Local	The impact could affect the local area (within 1,000 m from site).
Regional	The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns.
National	The impact could have an effect that expands throughout the country (South Africa).
International	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:	
Improbable	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 %).
Possible	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 %.
Likely	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 %.
Highly Likely	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 %.
Definite	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.	
Low	Increase in sound pressure levels between 0 and 3 from the expected wind induced ambient sound level (**Figure 5-2**). The change is just discernable. Total projected noise level is less than the Zone Sound Level in wind-still conditions.
Low Medium	Increase in sound pressure levels between 4 and 6 from the expected wind induced ambient sound level (**Figure 5-2**). The change is easily discernable. Total projected noise level is less than the Zone Sound Level in wind-still conditions.
Medium	Increase in sound pressure levels between 7 and 9 from the expected wind induced ambient sound level (**Figure 5-2** – point above red line). Sporadic complaints. Defined by the National Noise Regulations as being legally 'disturbing'. Any point where the zone sound levels are exceeded during wind still conditions.
High	Increase in sound pressure levels between 10 and 15. Change of 10 dBA is perceived as 'twice as loud', leading to widespread complaints. Any point where noise levels exceed zone sound level during wind still conditions.
Very High	Increase in sound pressure levels higher than 15. 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 5-3** will be used.

Table 5-3: 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

5.3.5 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.

5.3.6 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.

5.4 EXPRESSION OF THE NOISE IMPACTS

The noise impacts can be expressed in terms of the increase in present background ambient sound levels caused by noise emissions from the proposed project. For this purpose, the following contours of equal increases in background ambient sound levels will be used during the EIA phase:

- 0 – 3 dBA,
- 4 – 6 dBA,
- 7 – 9 dBA,
- 10 – 15 dBA,
- Higher than 15 dBA.

In addition predicted ambient sound levels will be presented in appropriate contours of constant sound pressure levels to illustrate the projected noise levels in the area.

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

6.1 NOISE EMISSIONS INTO THE SURROUNDING ENVIRONMENT

The noise emissions into the environment from the various sources as defined by the project developer were calculated for the construction and operational phases in detail, using the sound propagation model described in SANS 10357.

The following was considered:

- The octave band sound pressure emission levels of processes and equipment;
- The distance of the receiver from the noise sources;
- The impact of atmospheric absorption;
- The meteorological conditions in terms Pasquill stability;
- The operational details of the proposed project, such as the location of each Wind Turbine Generator.
- Topographical layout (-3 dB penalty will be imposed due to the height of the WTG – Defined by SANS 10357:2004),
- Acoustical characteristics of the ground. Soft ground conditions were modelled, as the area where the WEF is proposed to be constructed is well vegetated and sufficiently uneven to allow the consideration of soft ground conditions. This is because the use of hard ground conditions together with the topographical penalty just represents a far too precautionary situation.

The noise emission into the environment due to additional traffic will be calculated using the sound propagation model described in SANS 10210. Corrections such as the following will be considered:

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

6.2 Factors that must be considered that could complicate the accuracy of noise propagation modelling

Reviewing numerous literatures, the following factors were highlighted to complicate noise propagation modelling and prediction when working with wind turbines:

- The accuracy of determining the Sound Power Levels of the Wind Turbine Generator considering all uncertainties.
- As previously discussed, a wind turbine can cause a modulation of sound when the blades of the hub rotate, and depend on where the receptor to this sound is located. The threshold for detection of this modulation could be as much as 2 dB below a masking noise (white noise). Modulating sound characteristics from a wind turbine therefore makes it more likely to be noticed and less likely to be masked by background noise. This not considered by predictive models.
- Residents complaining about wind turbine noise perceived the sound characteristics as more annoying than noise levels. People were able to distinguish between background ambient sounds, and the sounds that the blades made. The noise produced by the blades leads to most complaints. Most of the annoyance was experienced between 16.00 p.m. and midnight. This could be an issue as noise propagation modelling would be reporting an equivalent, or "average" sound pressure level, a parameter that ignores the "character" of the sound.
- Night-time meteorological conditions might be significantly different from the conditions assumed in noise propagation models. This is because of temperature gradients in the atmosphere. On a typical sunny afternoon, air is warmest near the ground and temperature decreases at higher altitudes. This temperature gradient causes sound waves to refract upward (due to the relative higher density of colder air), away from the ground and results in lower noise levels being heard at the listener's position. At night this temperature gradient will reverse, resulting in cooler temperatures near the ground. This condition often referred to as a temperature inversion, will cause sound to be bent downward towards the ground and results in louder noise levels at a potentially sensitive receptor. Temperature gradients can and will influence sound propagation over long distances and further complicate predictive modelling. The result is that predictive models will under-estimate noise levels.
- The noise emission characteristics of the proposed wind turbines at the height at which the turbine will be installed. Available data for wind turbines shows that height above ground level does have an impact on the sound pressure levels at a receptor on ground level. Higher turbines can be heard further than lower turbines.

- Due to the height of these wind turbines, trees and other structures do not assist with the sound attenuation. It is therefore more difficult to model the effect of ground attenuation. This can result in significant under or over-estimation.
- Apart from the fact that higher turbines are constructed to optimally "harvest" wind energy, higher wind turbines is normally fitted with larger blades. The result is that the sound power levels associated with the wind turbine also increase.
- Wind speeds at hub (nacelle) height could be significantly higher than the wind speeds at ground level (the "van den Berg Effect"). The "real" noise generated by the wind turbine would therefore be significantly higher than expected. In addition, as the wind speed at ground level is less than expected, ambient sound levels at the potentially sensitive receptors will be less, resulting in less "masking" potential from the wind at ground level.
- Downwind effects. Wind alters sound propagation by the mechanism of refraction; that is, wind bends sound waves. These wind gradients, with faster winds at higher elevation and slower winds at lower elevation causes sound waves to be bent downwards as they propagate downwind of the source and to bend upwards when propagating upwind.
- Noise propagation models are only accurate some of the time, for certain conditions. Unfortunately all possible conditions can never be considered. Therefore there may be times when noise levels in practice exceed those predicted. If these conditions occur with any regularity, it would impact on closer receptors.
- There is no model that can predict the acceptability of a sound from a source by an individual. While sound pressure level is an important factor, is certainly not the only one.
- The background sound in an area is important as it directly affects audibility through masking. However, background sound levels summarized as an equivalent sound level ignores the random character of the sound. Background sound levels is a variable and typically changes from moment to moment, such as when vehicles pass nearby, birds chirp and the wind gusts. During these instances a noise might be less noticeable, possibly inaudible at times. However, other times a noise source might be highly detectable.
- Cumulative effects from a number of wind turbines must be considered. A large wind farm (100+ turbines) cannot be treated the same way as a small wind farm (less than 20 turbines). Similarly, the cumulative effects from a number of wind turbines close to potentially sensitive receptors must be considered for the appropriate wind directions and speed.

- There is significant acoustic energy in the lower frequencies in the sounds generated by a wind turbine. With the possible effects of amplitude modulation, it remains an unknown factor.
- The location where the wind farm is to be developed. Areas close to urban development effectively removes these areas for residential use due to the increased rating levels.
- Topographical layout should be considered. This is especially important when the turbines are to be installed on a ridge, with potential receptors being situated in a valley downwind from the turbines.

Due to these complicating factors, a precautionary stance should be taken.

7 RESULTS AND IMPACT ASSESSMENT

7.1 CONSTRUCTION PHASE IMPACT

Construction activities highly depend on the final operational layout. A provisional layout as provided by the developer is presented in **Figure 7-4**. As can be seen from this proposal, a number of different activities will take place, each with a specific impact on the closest potential sensitive receptor. The following activities are proposed:

- The development of access roads: While the main access roads follow existing roads, the internal roads must be constructed. However, being gravel roads, the construction of these internal roads is a fast (temporary) and an uncomplicated process, with a small noise footprint. In addition, as this will take place during the day-time, the probability of impact on receptors is very low.
- Construction of the wind turbines, and lesser extent, the substation and workshop: This involves the clearing and levelling of the surface, the digging of foundations, concreting (mixing and pouring) and the erection of the towers, fixing of turbines and blades. The noisiest activity is normally bulldozing and excavation. The geological and geotechnical characteristics, project constraints and schedules would determine the size of the equipment. For the purpose of this assessment very large equipment was selected for modelling purposes. If these activities take place closer than 500 meters from sensitive receptors, they could impact on receptors, as the activities could be noisy and takes place over a period of days.
- The development of the internal power lines to the substation: The developer indicated that these would comprise underground cables where practical, which requires the digging of trenches and the laying of trunking (sleeve). The excavation is normally with a small TLB/Bobcat excavator. These activities are also relatively fast with a low risk of impacting on potential receptors.
- Development of overland power lines: The cabling is normally overland, carried by a number of pylons to the closest feed-in substation (Eskom). The potential impact on receptors again depends on the distance between the area where a pylon is constructed and a potential receptor, but in general this noise impact is considered relatively insignificant, due to the temporary nature as well as low probability to impact on receptors.

7.1.1 Description of Construction Activities Modelled

Construction activities highly depend on the final operational layout. The following construction activities are assumed to take place simultaneously with the normal activities observed during the site visit (see Figure 7-1). Worst case would be five sites where various activities are taking place simultaneously. For the purpose of the EIA the activities that are most likely to create the most noise are:

- General work at the workshop area. This would be activities such as equipment maintenance, off-loading and material handling. All vehicles will travel to this site where most equipment and material will be off-loaded (General noise, crane). Material such as aggregate and various building sand will be taken directly to the construction area (foundation establishment). Activities are taking place for 16 hours during the 16 hour day-time period.
- Phase 1: Surface preparation prior to civil work. This could be the removal of topsoil and levelling with compaction, or the preparation of an access road (bulldozer). Activities are taking place for 8 hours during the 16 hour day-time period.
- Phase 2: Preparation of foundation area (sub-surface removal until secure base is reached – excavator, compaction, and general noise). Activities are taking place for 10 hours during the 16 hour day-time period.
- Phase 3: Pouring and compaction of foundation concrete (general noise, electric generator/compressor, concrete vibration, mobile concrete plant, TLB). As foundations must be poured in one go, the activity is projected to take place over the full 16 hour day-time period.
- Phase 4: Erecting of the wind turbine generator (general noise, electric generator/compressor and a crane). Activities are taking place for 16 hours during the 16 hour day-time period.
- Traffic on the site (trucks transporting material, aggregate/concrete, work crews) moving from the workshop/store area to the various activity sites. All vehicles to travel less than 40 km/h, with a maximum of 5 trucks and 5 vehicles per hour to be modelled travelling to the areas where work is taking place.

The following equipment is presumed to be onsite:

- 1x Bulldozer,
- 1x Grader,
- 1x Front-end loader and/or 1x Excavator,
- 1x Drilling machine (blasting purposes),
- 2x Electric Generator/Air Compressor and vibrators,
- 1x TLB,
- 1x Mobile Concrete Batching Plant/Truck,
- 2x Cranes,
- 2x Load haul dumpers.

- 5x light delivery vehicles/people carriers (travelling onsite).

There will be a number of smaller equipment, but the addition of the general noise source covers most of these noise sources. All equipment would be operating under full load (generate the most noise). Atmospheric conditions would be ideal for sound propagation. There is also general noise included on during the construction activities, which covers the other smaller noise levels such as talking from the manpower on the construction site.

Note that this scenario is selected to present the worse case scenario, with all equipment operating under full load, and with the construction activities selected/positioned to be close to a sensitive receptor. The various sound power levels in the octave bands can be found in **Appendix B**.

7.1.2 Results: Construction Phase

The scenario as defined in the previous section (**section 7.1**) was modelled with the output presented in **Figure 7-2** and **Figure 7-3**. Only the calculated day-time ambient noise levels are presented, as construction activities that might impact on sensitive receptors will be limited to the 06:00 – 22:00 time period. The worst case scenario is presented with the entire activities take place simultaneously during wind-still conditions, in good sound propagation conditions (20°C and 80% humidity).

Even though construction activities are projected to take place only during daytime, it is required at times for various reasons that construction activities take place during the night (particularly for a large project such as this). Below is a list of construction activities which might occur during night time:

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

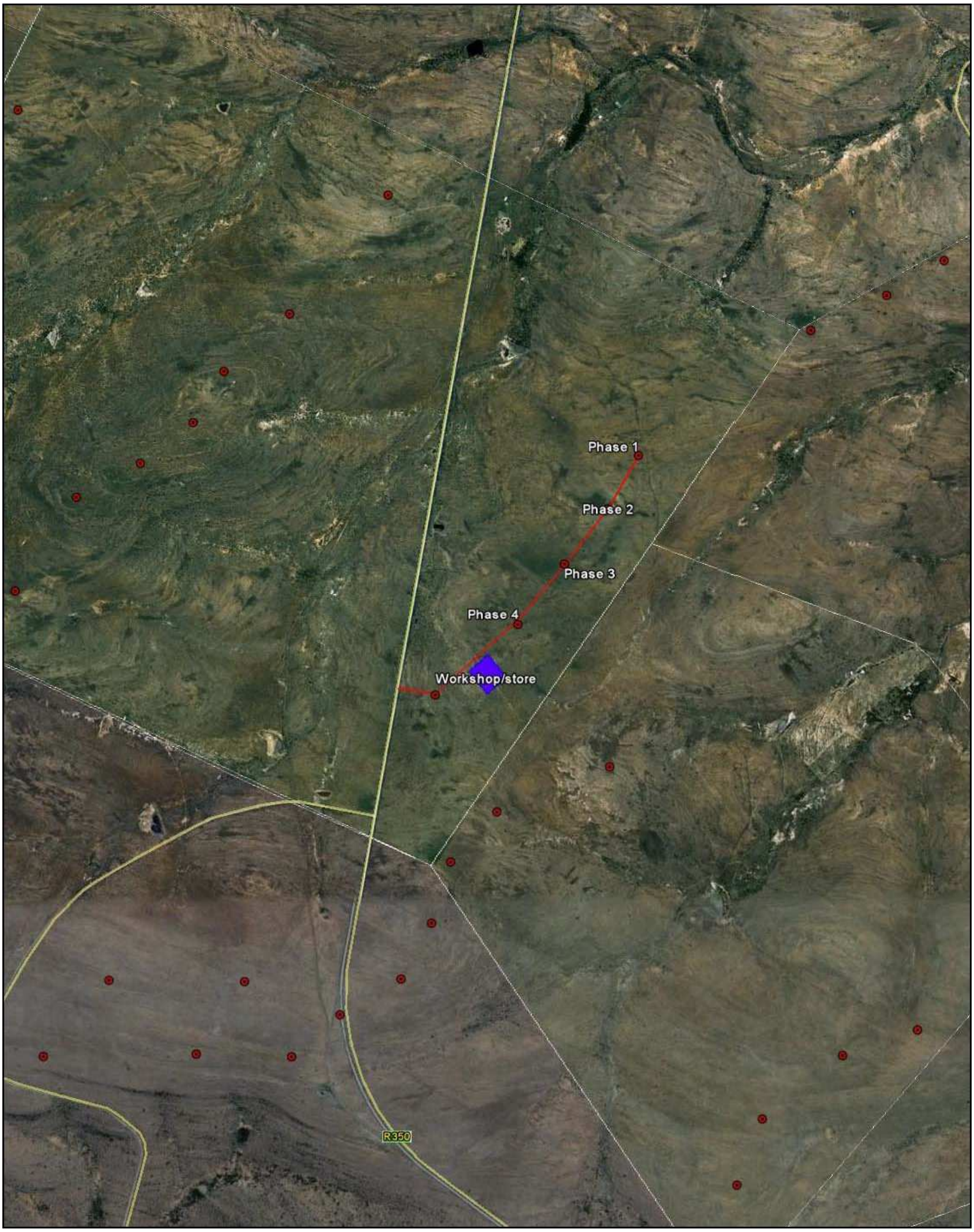

Figure 7-1: Illustration of location of various construction activities with workshop within 4km's of closest receptor

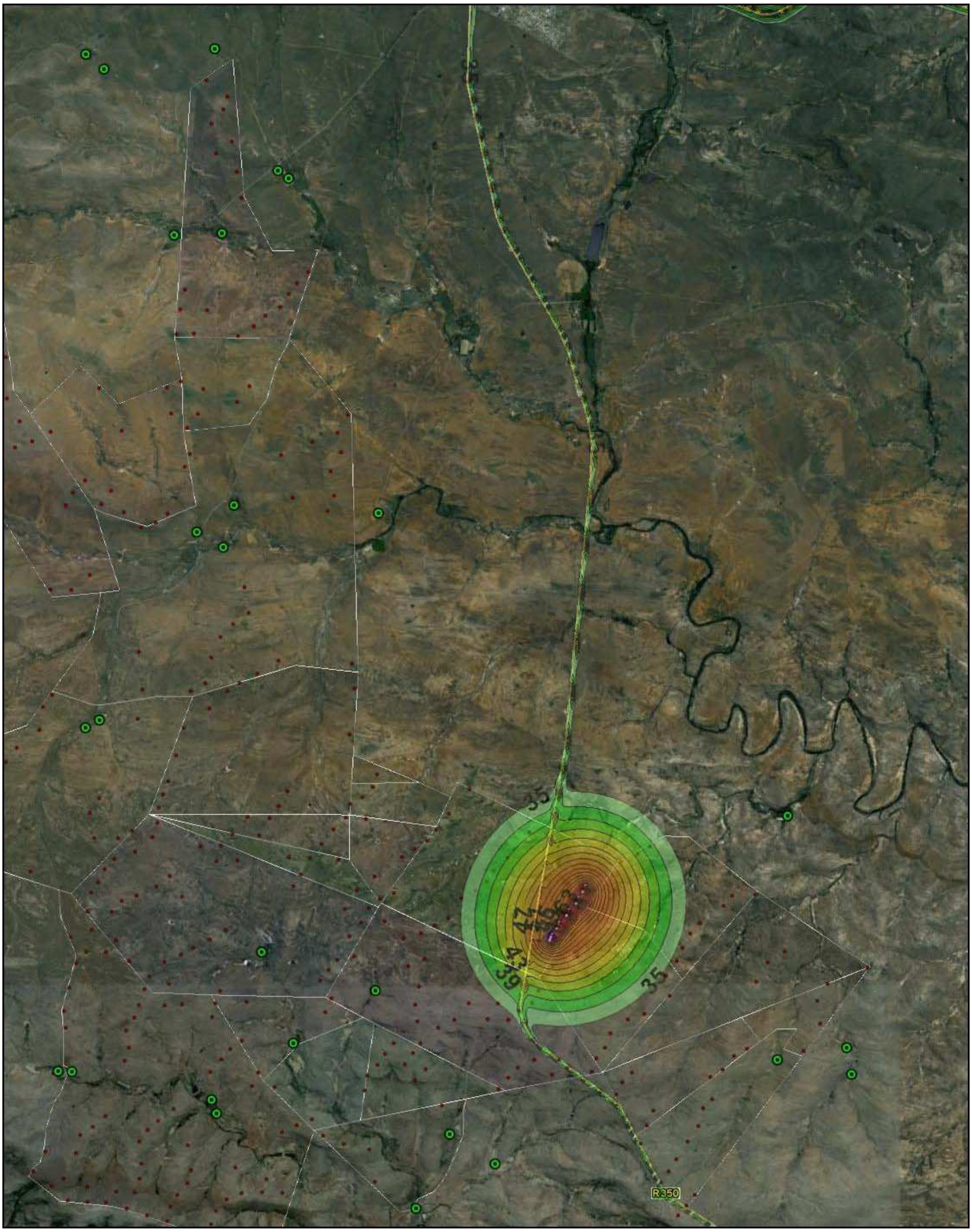

Figure 7-2: Construction noise: Contours of constant noise levels

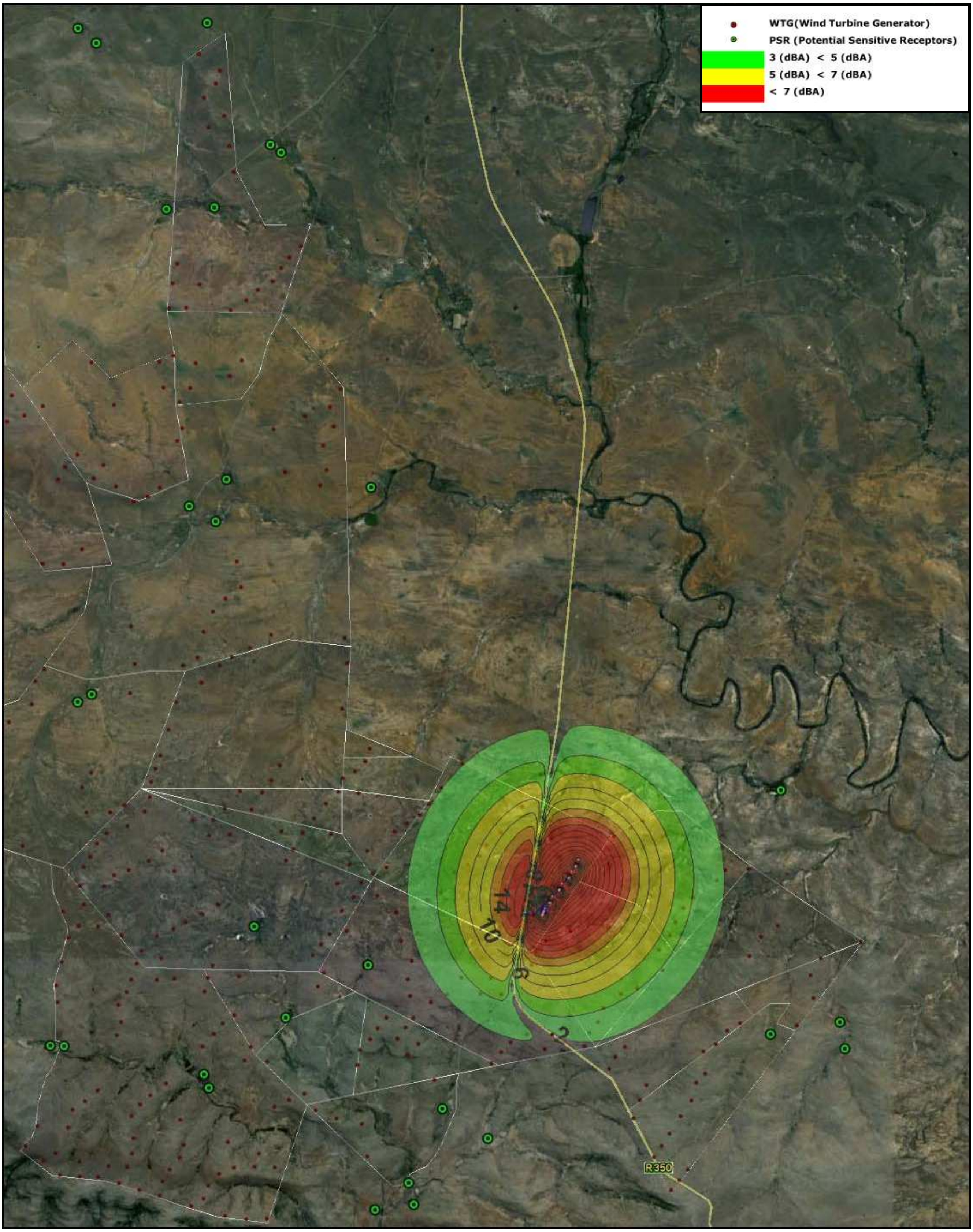

Figure 7-3: Construction noise: Change in ambient sound levels

7.1.3 Impact Assessment: Construction Phase

The impact assessment for the various construction activities that may impact on the surrounding environment is presented in the following **Tables**.

Table 7-1: Impact Assessment: Construction Activities without Mitigation

Nature:	Numerous simultaneous construction activities that could impact on PSR's
Acceptable Rating Level	Rural district with little road traffic near the construction activities: 45 dBA outside during day (refer **Table 5-1**). Use $L_{Req,D}$ of 45 dBA.
Extent ($\Delta L_{Aeq,D}$>7dBA)	**Regional** – Change in ambient sound levels will extent more than 1,000 meters from activity **(3)**
Duration	**Long term** – Noisy activities in the vicinity of the receptor could last up to a month **(4).**
Magnitude	***Estimated noise level*** ($L_{Aeq,D}$) ***up to 52 dBA (SR138)*** $\Delta L_{Aeq,D}$ = 0 - 24 dBA. **High (8).**
Probability	This noise impact is projected to take place mainly during the day when the potential sensitive receptors are either away or busy with their normal daily activities. Noises created by their normal daily activities would mask most construction related noises. This will minimizes the possibility that this additional noise would impact on their quality of living. **Likely (3)**
Significance	**45 (Medium)**
Status	Negative
Reversibility	High
Irreplaceable loss of resources?	Not relevant
Comments	*As all the WTG's are further than 500 meters from a PSR, the potential risk in terms of noise impact during the construction phase is relatively low. However, when more than one activity is taking place close to receptors, this risk will increase. Selection of noisy equipment working at full load 100% of the time represents worst case scenario.*
Can impacts be mitigated?	Yes. While it has been identified that mitigation is not critical, the following mitigation is still highlighted.
Mitigation:	*Depending on the findings and recommendations of the Operational phase noise analysis, it might be required to relocate one or more turbines further away from the potential sensitive receptor. If a turbine is relocated, the construction activity would also be relocated in so reducing both the intensity and probability of the noise impact.* *Other mitigation options includes:* • Reducing the number simultaneous activities when working close to a receptor. ***Noise reduction between 3 and 6 dBA.*** • Ensuring that all equipment and machinery are well maintained and equipped with silencers (where possible). ***Noise reduction between 1 and 5 dBA.*** • Considering the noise emission characteristics of equipment when selecting equipment for a project/operation, and select the smallest machine available to do the specific work. ***Noise reduction between 3 – 15 dBA.*** • Working together with the local communities, and provide prior warning when a noisy activity is to take place. ***Higher acceptance to the noise when a receptor knows when a loud activity is to take place, less annoyance.*** • Only conduct very noisy activities between 10 am and 4 pm. ***Reduce probability that it will impact on receptors due to unfavourable sound propagation due to atmospheric conditions.*** • Co-ordinate noisy activities (when working closer than 500

	meters) with PSRs to allow work to take place in periods when they are not at home, or busy with daily activities, e.g. limiting noisy work between 8 am and 2 pm. ***Reduce probability of impact happening as PSRs are not at home.*** • Conduct noisy activities in the shortest possible time (especially site preparation with bulldozer and civil work using an excavator). ***Noise reduction between 2 and 3 dBA*** • Move the closest turbines further from the receptors, or do not construct any turbines within 500 meters from potential receptors. This will move the construction sites. The increased distanced from the activities and the receptors could have the single most significant reduction in noise levels. *Note that while a general setback distance of 1,000 meters is recommended in this report, work within 500 meters from a PSR could result in a noise impact with a high significance.* ***Variable, depends on distance between receptor and noise source****.*
Cumulative impacts:	This impact is cumulative with existing ambient background noises as well as other noisy activities conducted in the same area.
Residual Impacts:	This impact will only disappear once construction activities cease.

Table 7-1: defines the significance of construction impacts as medium. This is mainly due to the following factors:

- The layout of the Wind Energy Facility, where the distance between the potentially sensitive receptors and the proposed wind turbines (where the construction activities would be taking place) is very large. The projected total noise levels at the potentially sensitive receptors due to the construction activities (when activities take place within 1,000 meters from a PSR with the current layout) could be as high as 52 dBA. However, due to the selected low ambient conditions (associated with no or little wind) the change in ambient sound levels is very high.
- Other noises associated with normal daytime activities would likely mask the construction noises.

As the construction noise impact is projected to be of medium significance, the following mitigation measures are highlighted to ensure that the significance of construction noises is reduced to a more acceptable low. Measures proposed:

- When working close to a potentially sensitive receptor, (within 1,000 meters) limit simultaneous noisy activities far as possible (due to cumulative effects for a number of simultaneous activities),
- For modelling purposes the noise emission characteristics of both a large bulldozer and excavator (typically used in mining operations) was used, that would most likely over-estimate the noise levels. The use of smaller equipment therefore would have a lesser noise impact.
- When work is to take place close to potentially sensitive receptors, co-ordinate the working time with periods when the receptors are not at

home. An example would be to work within the 8am to 2pm time-slot to minimise the significance of the impact because:
    - Potential receptors are most likely at school or at work, minimizing the probability of an impact occurring.
    - Normal daily activities will generate other noises that would most likely mask construction noises, minimizing the probability of an impact occurring.
- If this is not possible, and the activity could be potentially noisy and disturbing, the construction activity should be co-ordinated with the sensitive receptor with sufficient prior notification. See also the Environmental Management Plan in **Section 9**.
- The establishment of a line of communication between the developer, his site agents and potentially sensitive receptors is critical. Regular feedback and updates with regards to any activities that might impact on them will reduce the risk of any annoyances or negative attitudes.

While the significance of the construction noise impacts are medium, implementing mitigation measures as proposed would result in a further reduction of the significance of the potential impact to a much more acceptable low significance (see **Table 7-2**). In general the management of construction related noises are relatively easy to manage and minimise. It should be noted that the proximity of construction activities would depend on the layout used, investigated in the following section.

Table 7-2: Impact Assessment: Construction Activities with Mitigation

Nature:	*Numerous simultaneous construction activities at a number of receptors.*
Acceptable Rating Level	Rural district with little road traffic: 45 dBA outside during day (refer **Table 5-1**). Use $L_{Req,D}$ of 45 dBA.
Extent (Δ$L_{Aeq,D}$>7dBA)	**Regional** – Change in ambient sound levels will extent more than 1,000 meters from activity (3)
Duration	**Long term** – Noisy activities in the vicinity of the receptor could last up to a month (4)
Magnitude	***Critically depends on the equipment selected as well as which mitigation measures are implemented. However, making use of grader instead of a bulldozer for site preparation and allowing only one noisy activity to take place close to a potential receptor would reduce the noise levels at PSRs, in so reducing the change in ambient sound levels the PSRs may detect.*** ***A good relationship with the closest receptors will also minimise any potential for annoyance, as it reduces the probability that people will get annoyed. Due to the temporary nature of the construction of access roads and trenches the consideration of the mitigation measures as proposed would be sufficient.***

	Estimated noise level ($L_{Aeq,D}$) ***below 45 dBA depending on mitigation options implemented*** $\Delta L_{Aeq,D}$ = 0 – 10 dBA **Medium** (6)
Probability	Improbable (1)
Significance	**13 (Low)**
Comments	Good relations are of critical importance. With correct mitigation, the positive attitude of potential receptors as well as the masking effect from existing farming noises makes it unlikely that the activities will annoy the closest receptor. See also **section 8.1**.

7.2 OPERATIONAL PHASE IMPACT (AMAKHALA EMOYENI WEF ALONE)

7.2.1 Description of Operational Activities Modelled

The Operational Phase Impact has been divided into two different models. Firstly is the impact the Amakhala WEF has on PSR's, and secondly is the combined impact the Amakhala and Cookhouse WEF has on PSR's. Typical daytime activities would include:

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

The day-time period (working day) was not considered for the EIA because noise generated during the day by the WEF is normally masked by other noises from a variety of sources surrounding potential sensitive receptors. The reader is also referred to **Figure 5-3**.

However, times when a quiet environment is desired (at night for sleeping, weekends etc.) noise levels are more critical. The time period investigated therefore would be the quiet period, normally associated with the 22:00 – 06:00 slot. Maintenance activities would therefore not be considered, concentrating on the ambient sound levels created due to the operation of the various WTGs at night.

The developer has suggested that the Vestas 90 1.8/2.0 MW turbine may be selected for the Amakhala Emoyeni WEF. The sound power emission levels for Vestas 90 1.8 MW turbine are presented in **Table 7-4**. These characteristics will be used for both the Amakhala WEF and the combined Amakhala/Cookhouse projects (potential cumulative impact). *After this study was concluded, it was pointed out to the author that the Suzlon S88 – 2.1 MW is proposed for the Cookhouse WEF. A table of sound power emissions for the Suzlon is provided in* ***Table*** 7-5, *for comparative purposes with the Vesta turbine.*

Modelling will be done for both a north-west and south-east wind for Amakhala only, each for a number of wind speeds, using the layout presented in **Figure 7-4** at all times considering associated ambient sound levels due to wind. The atmospheric conditions as per **Table 7-3** will be used to determine atmospheric attenuation.

Table 7-3: Selected parameters for the night time Noise Prediction Model: EIA Phase

Meteorological conditions	Temperature	Atmospheric Pressure	Humidity
	10°C	93 kPa	90%

As mentioned in the Scoping Report, potential impacts due to low frequency sounds must be considered. For this purpose the sound power level at both the 16 and 31.5 Hz frequency band will also be estimated and used to calculate the C-Weighted Noise Levels. Existing acoustic energy in the low frequency range will however also be considered (refer **Figure 4-3**).

Table 7-4: Sound Power Emission Levels for the Vestas V90 1.8 MW Turbine

Wind Speed (m/s)	Associated Ambient Sound (dBA)	Frequency (Hz)	63 (dB)	125 (dB)	250 (dB)	500 (dB)	1000 (dB)	2000 (dB)	4000 (dB)	L_{WA} (dBA)
4	**28.14**	$L_{wA,P}$	76.4	80.9	84.2	86.6	89.3	87.7	85.7	**94.4**
		$L_{w,P}$	102.5	96.9	92.8	89.8	89.3	86.5	84.7	
5	**29.85**	$L_{wA,P}$	81.4	85.9	89.2	91.6	94.3	92.7	90.7	**99.4**
		$L_{w,P}$	107.5	101.9	97.8	94.8	94.3	91.5	89.7	
6	**32.21**	$L_{wA,P}$	84.5	89	92.3	94.7	97.4	95.8	93.8	**102.5**
		$L_{w,P}$	110.6	105	100.9	97.9	97.4	94.6	92.8	
7	**35.05**	$L_{wA,P}$	86.2	90.8	93.5	95.2	98.3	96.8	95.3	**103.6**
		$L_{w,P}$	112.3	106.8	102.1	98.4	98.3	95.6	94.3	
8	**38.14**	$L_{wA,P}$	86.1	90.7	93.3	95.7	98.6	97.5	96	**104.0**
		$L_{w,P}$	112.2	106.7	101.9	98.9	98.6	96.3	95	

Table 7-5: Sound Power Emission Levels for the Suzlon S88 – 2.1 MW turbine

Wind Speed (m/s)	Associated Ambient Sound (dBA)	Frequency (Hz)	63 (dB)	125 (dB)	250 (dB)	500 (dB)	1000 (dB)	2000 (dB)	4000 (dB)	L_{WA} (dBA)
6	**32.21**	$L_{wA,P}$	78.05	92.46	96.56	95.42	95.50	93.12	83.79	**102.3**
		$L_{w,P}$	102.75	108.27	105.07	99.55	95.60	92.04	82.73	

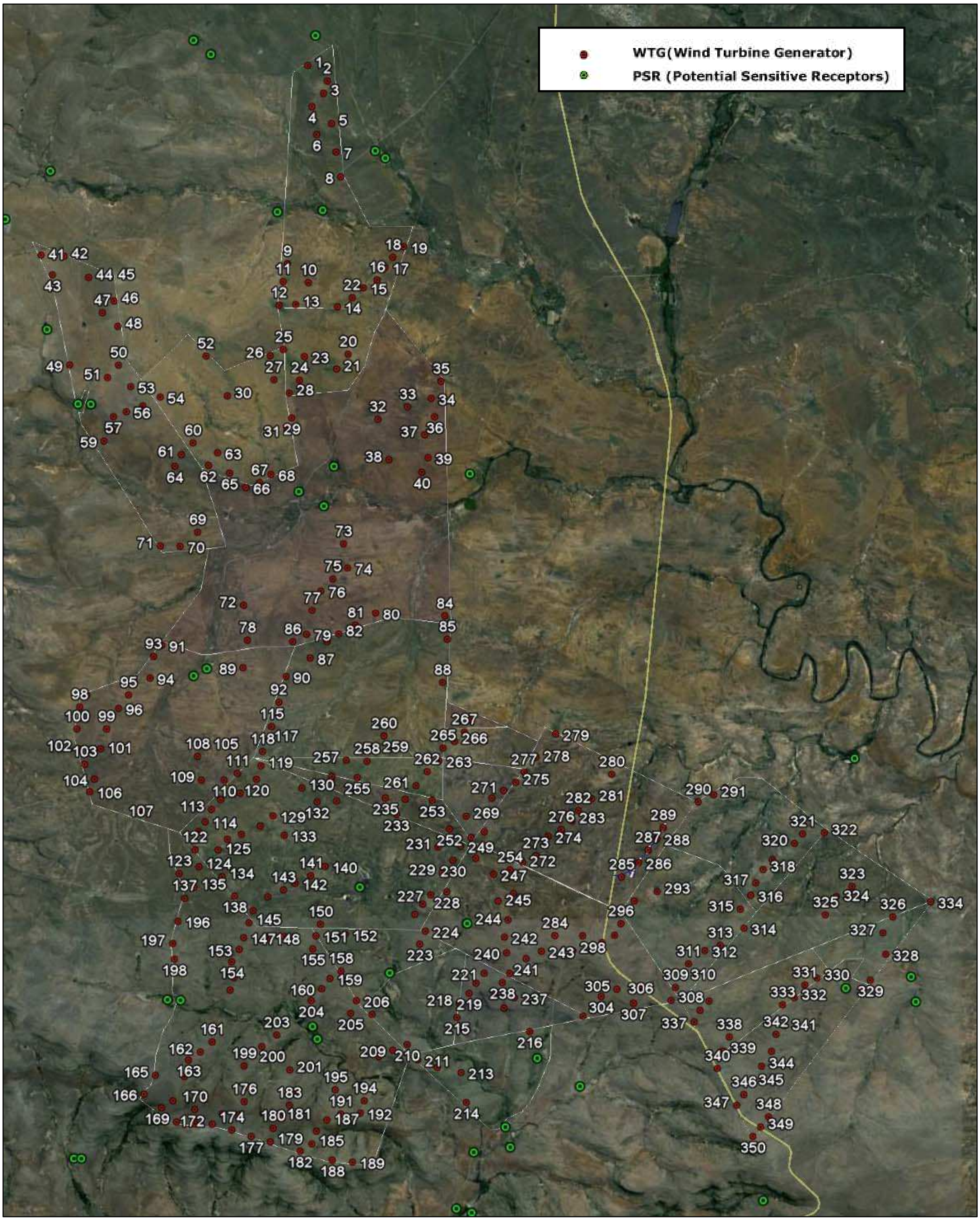

Figure 7-4: Layout of WEF as modelled with turbines numbered

It should be noted that SANS 10357:2004 does not provide methods to estimate sound propagation below 63 Hz. While this report does calculate the sound power levels at lower frequency bands (to allow the calculation of the C-weighted Sound Power Levels to estimate the potential/probability for low frequency noises), the reader should know that this is for information purposes only. In terms of accuracy, the sound power level at these frequency bands is estimated at ±5 dBA (due to the unknown adjustment factor for meteorological effects at that octave band frequency).

7.2.2 Results: Operational Phase

Noise in the area due to the operation of the wind energy facility is illustrated in and **Figure 7-5** modelled **Figure 7-6** for a south-east wind blowing at 4 m/s. Other wind speeds (South-east direction) are illustrated in **Figure 7-7** to **Figure 7-14**.

Maps were not developed for the other wind directions, as in terms of the scale of the project; the maps would looks very similar to the maps for the South-east winds. The data however is presented in table format in **Appendix C**.

These tables present the sound pressure levels (both $L_{Aeq,N}$ and estimated $L_{C,N}$) at the various identified receptors. As per SANS 10103:2004, if the difference between the A-frequency weighted and the C-frequency weighted equivalent continuous sound pressure levels is greater than 10 dB, a predominant low frequency component **might** be present.

As can be seen from these tables in **Appendix C**, low frequency noises are present, as the estimated C-weighted sound pressure levels are significantly higher than the corresponding A-weighted sound pressure levels. However, it should also be noted that the estimated ambient C-weighted sound levels at the modeled wind speed are already high with the C-weighted sound pressure levels associated with the wind turbines being lower than the wind induced noise levels at the relevant wind speeds. Therefore most of the acoustic energy in the low frequencies would be due to wind induced noises, and not from the wind turbines.

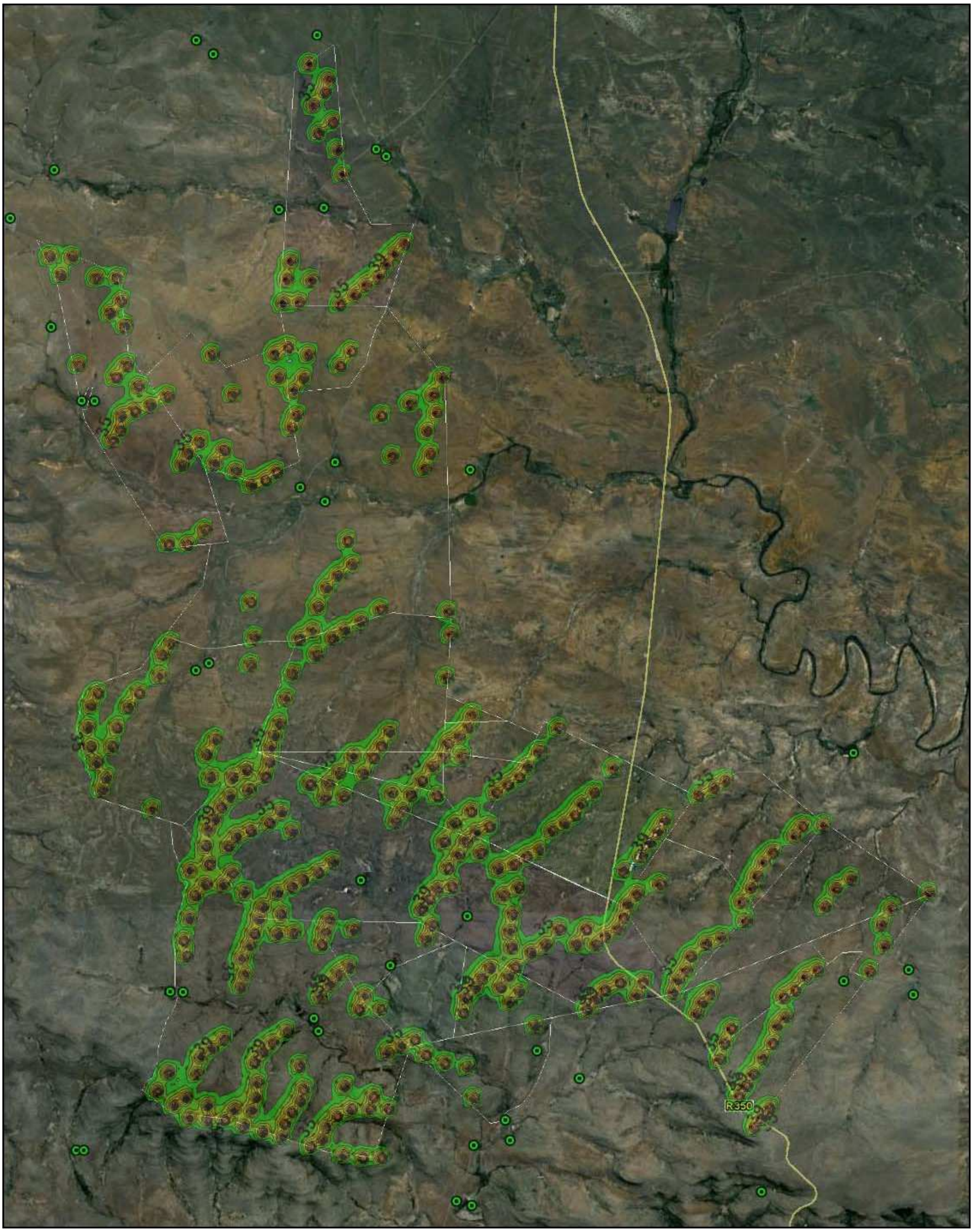

Figure 7-5: Operational Phase: Sound Levels from WEF, Contours of constant sound levels with a south-easterly wind blowing at 4 m/s

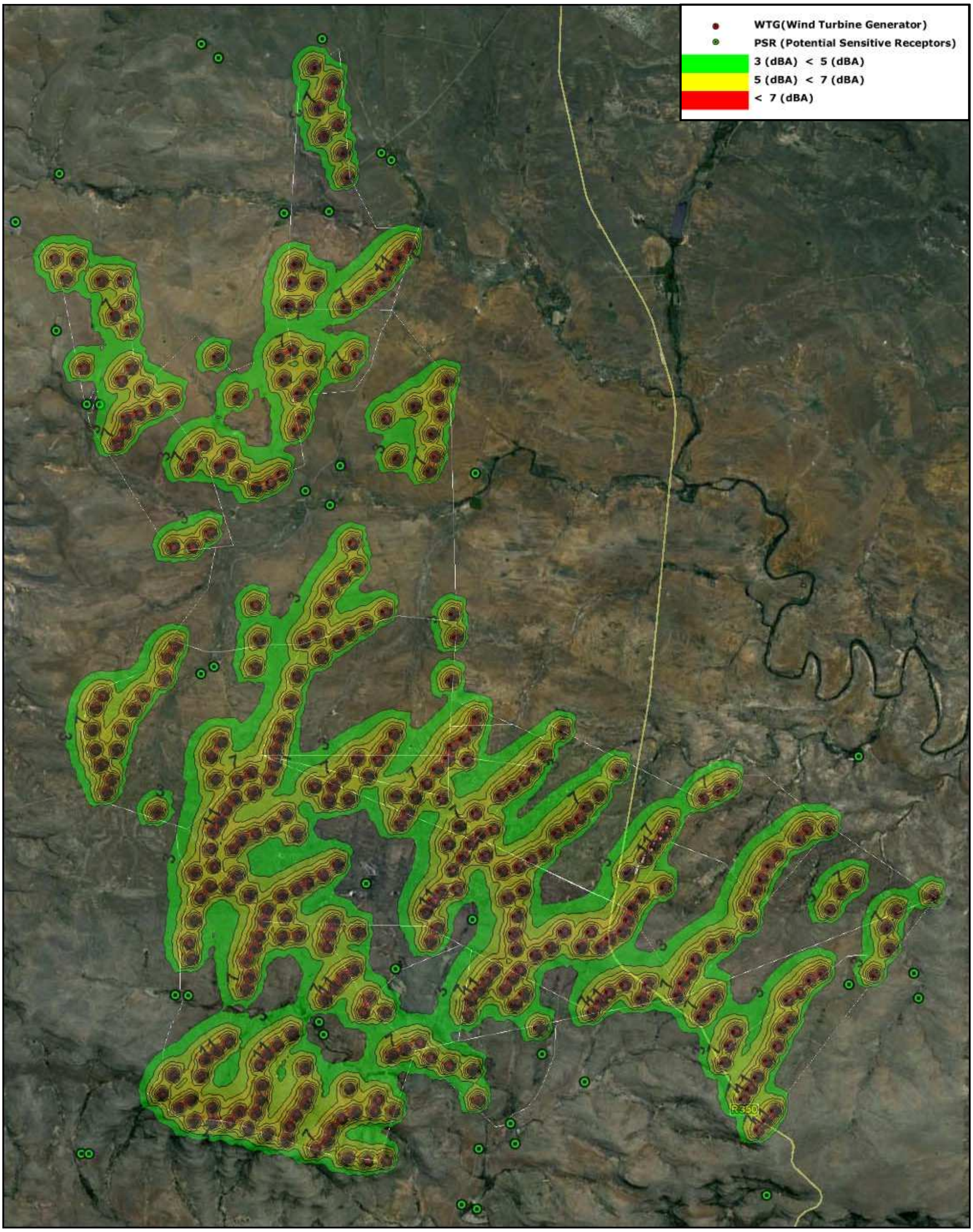

Figure 7-6: Change in ambient sound levels, contours of constant noise levels with a south-east wind blowing at 4 m/s

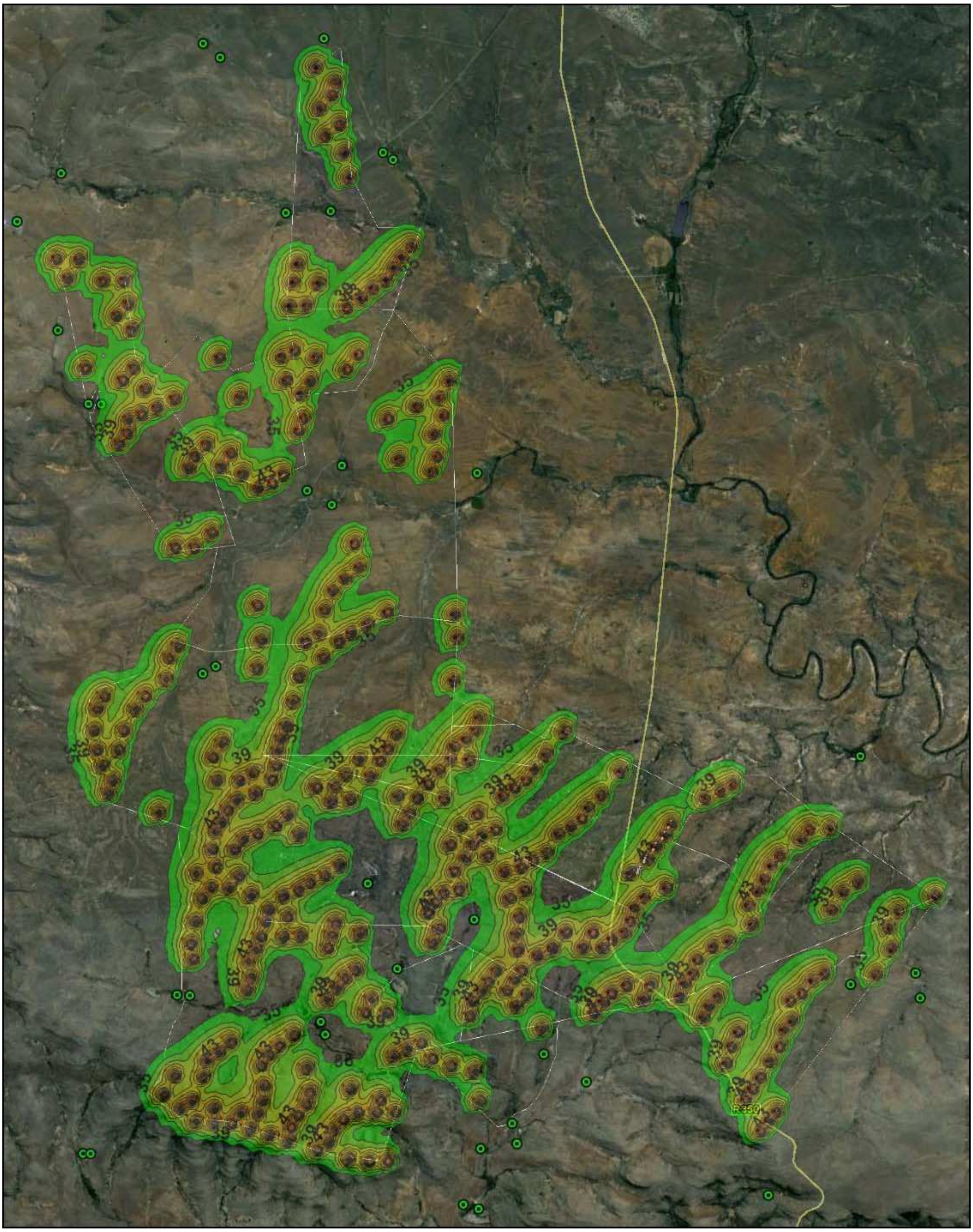

Figure 7-7: Operational Phase: Sound Levels from WEF, Contours of constant sound levels with a south-easterly wind blowing at 5 m/s

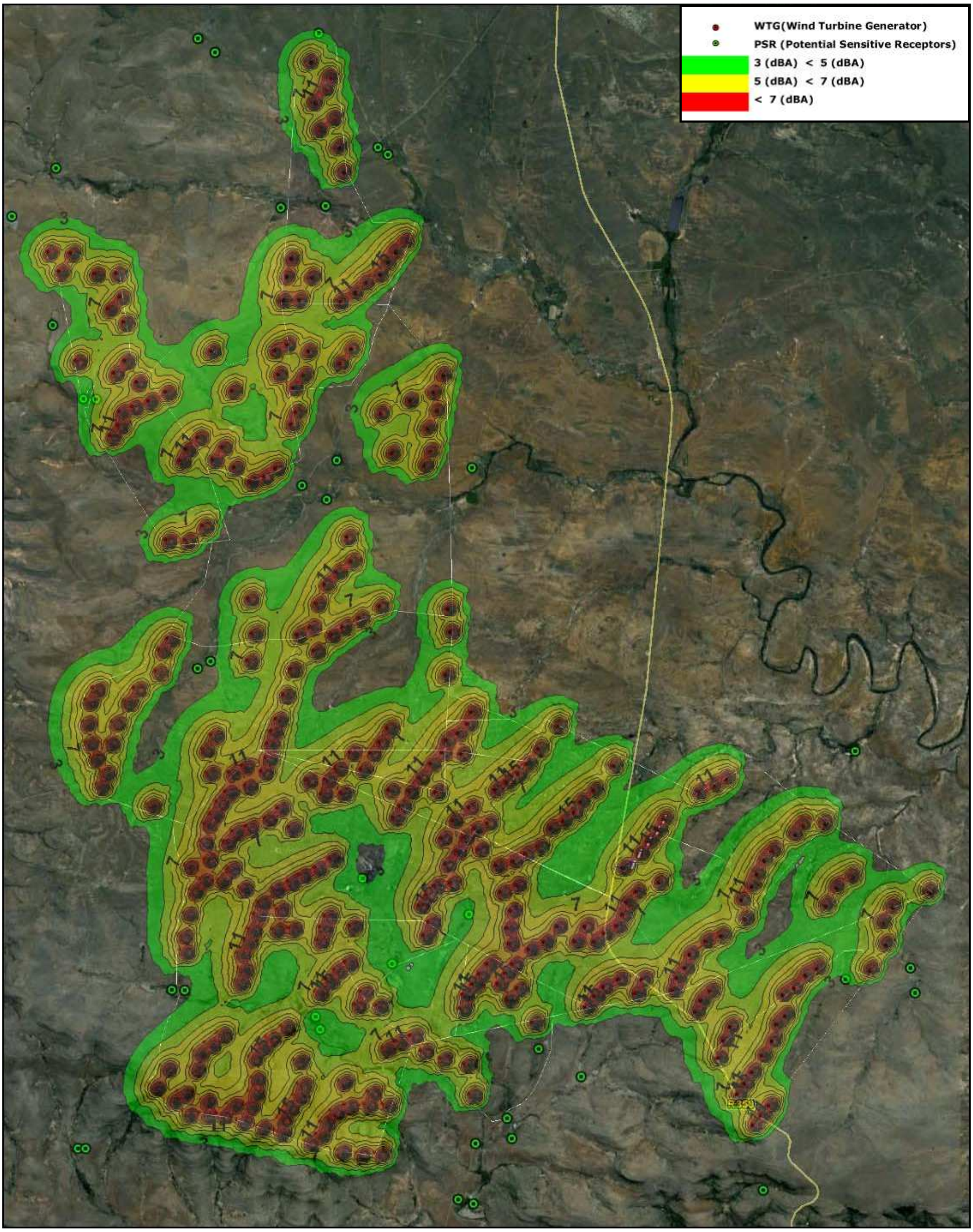

Figure 7-8: Change in ambient sound levels, contours of constant noise levels with a south-east wind blowing at 5 m/s

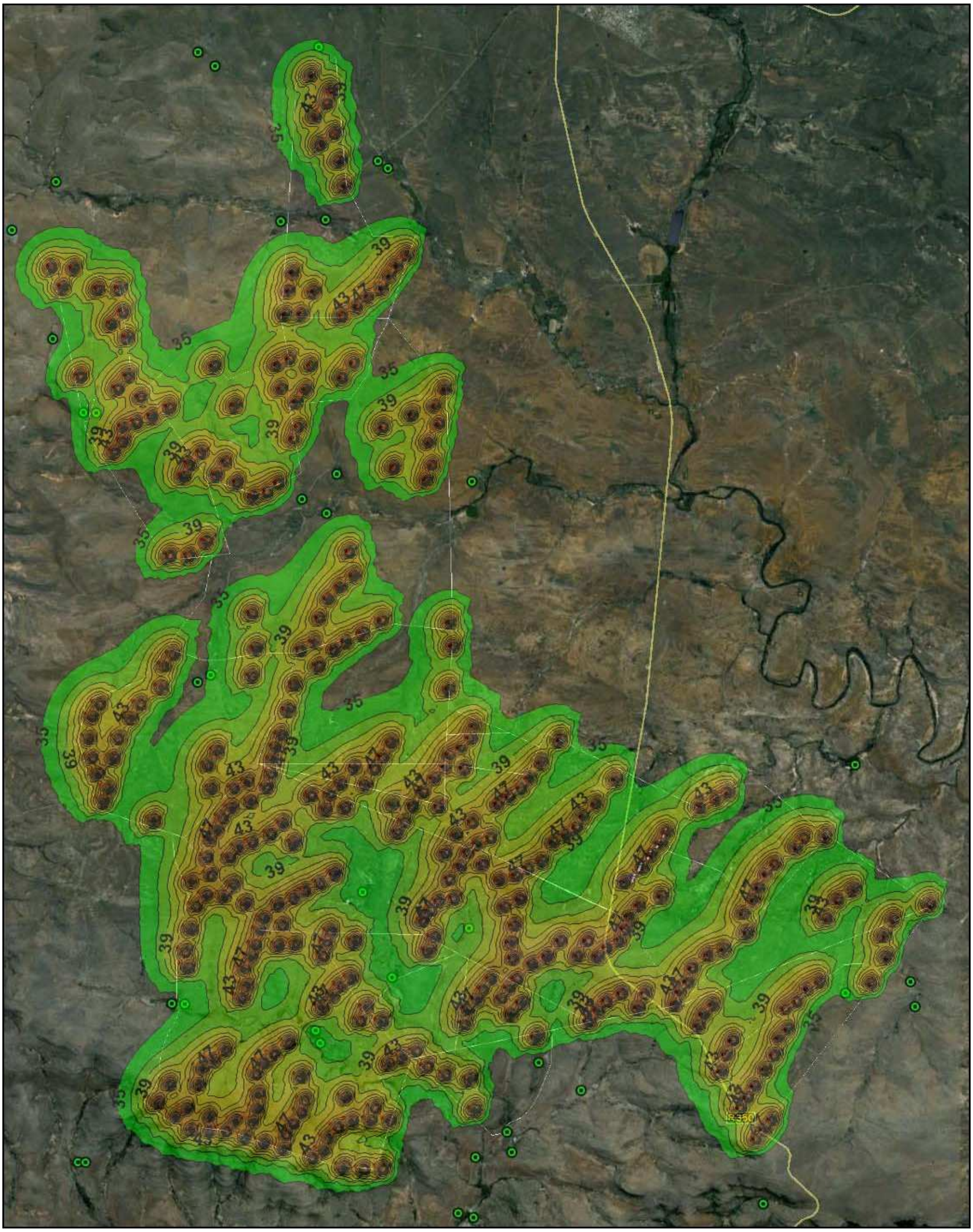

Figure 7-9: Operational Phase: Sound Levels from WEF, Contours of constant sound levels with a south-easterly wind blowing at 6 m/s

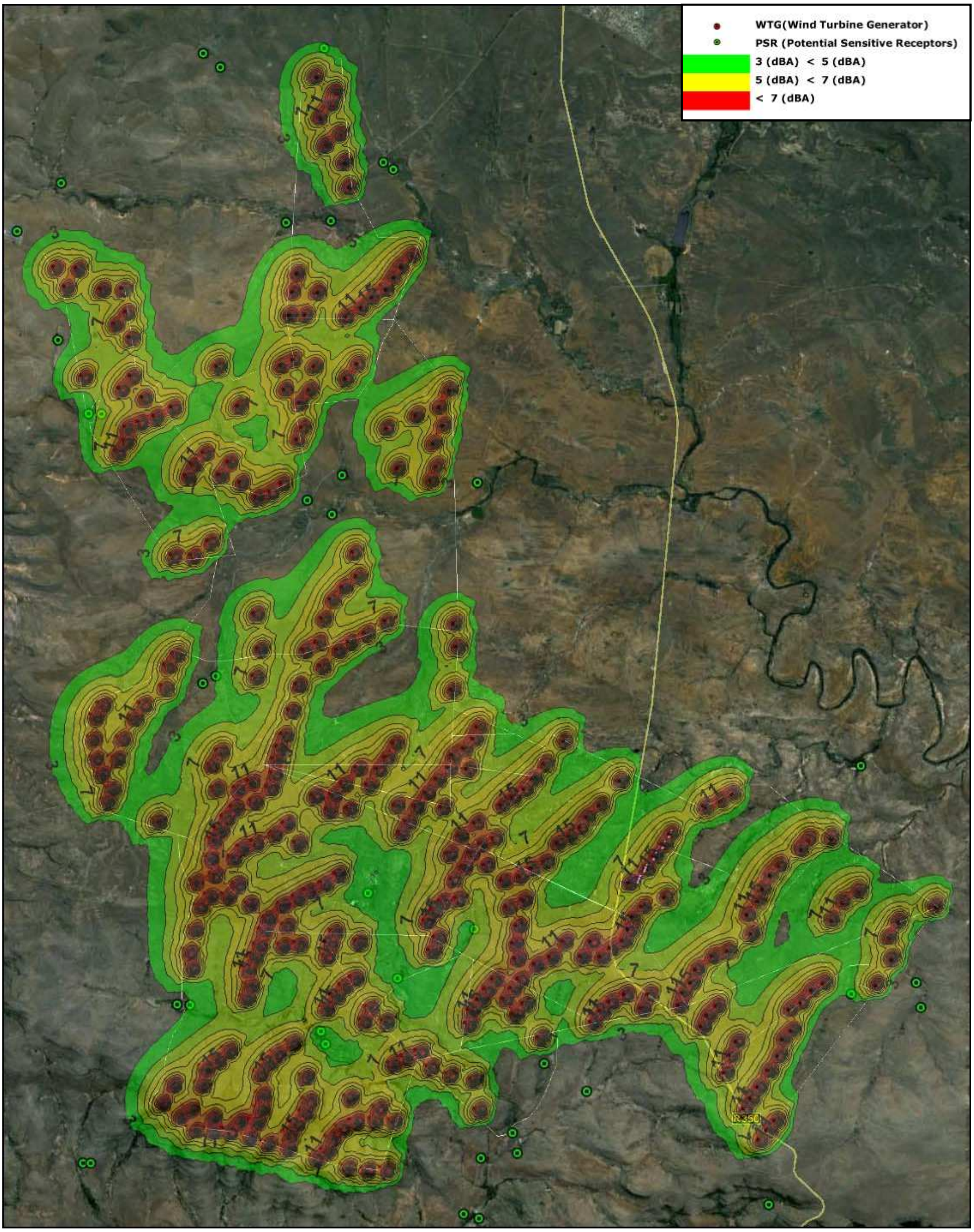

Figure 7-10: Change in ambient sound levels, contours of constant noise levels with a south-east wind blowing at 6 m/s

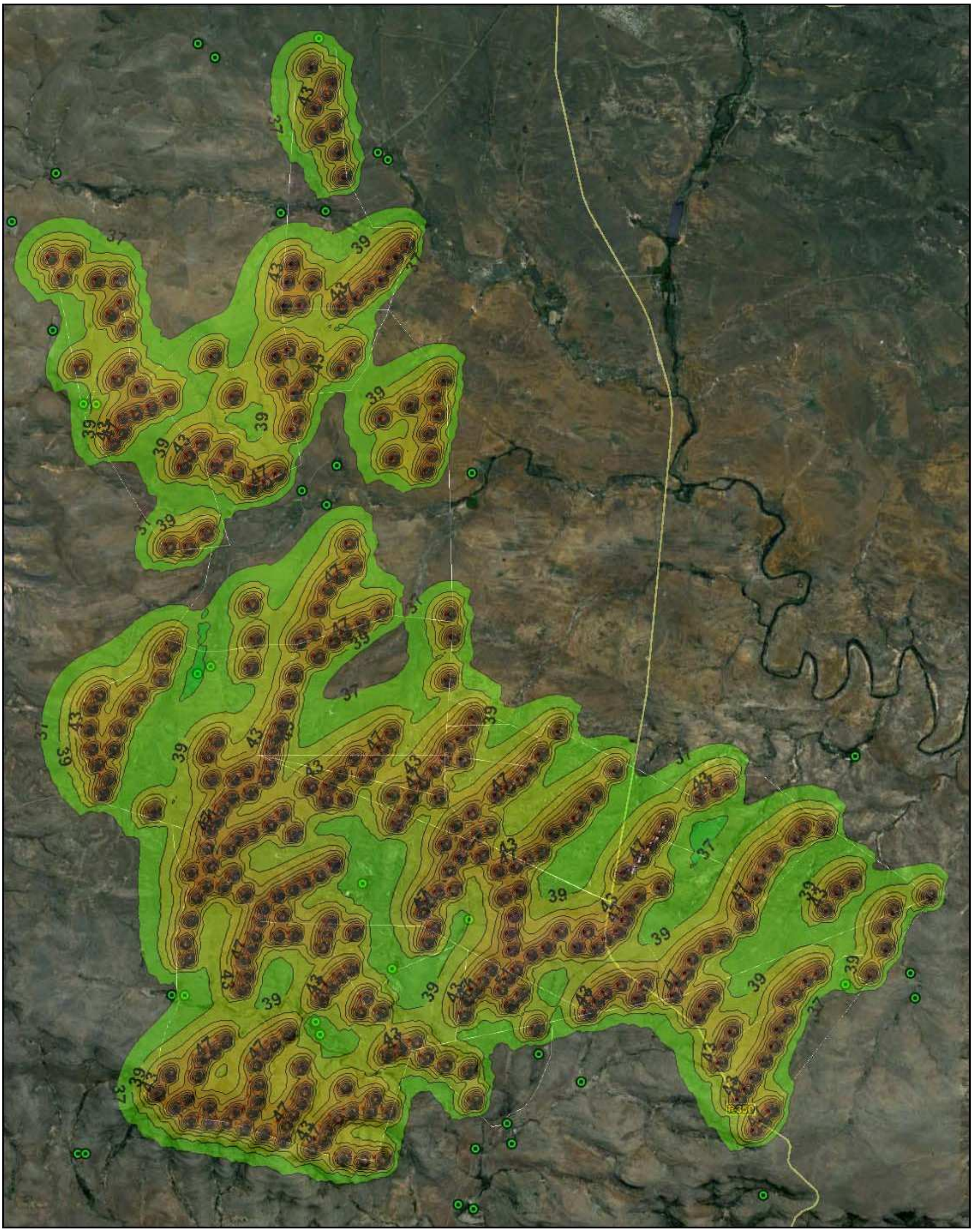

Figure 7-11: Operational Phase: Sound Levels from WEF, Contours of constant sound levels with a south-easterly wind blowing at 7 m/s

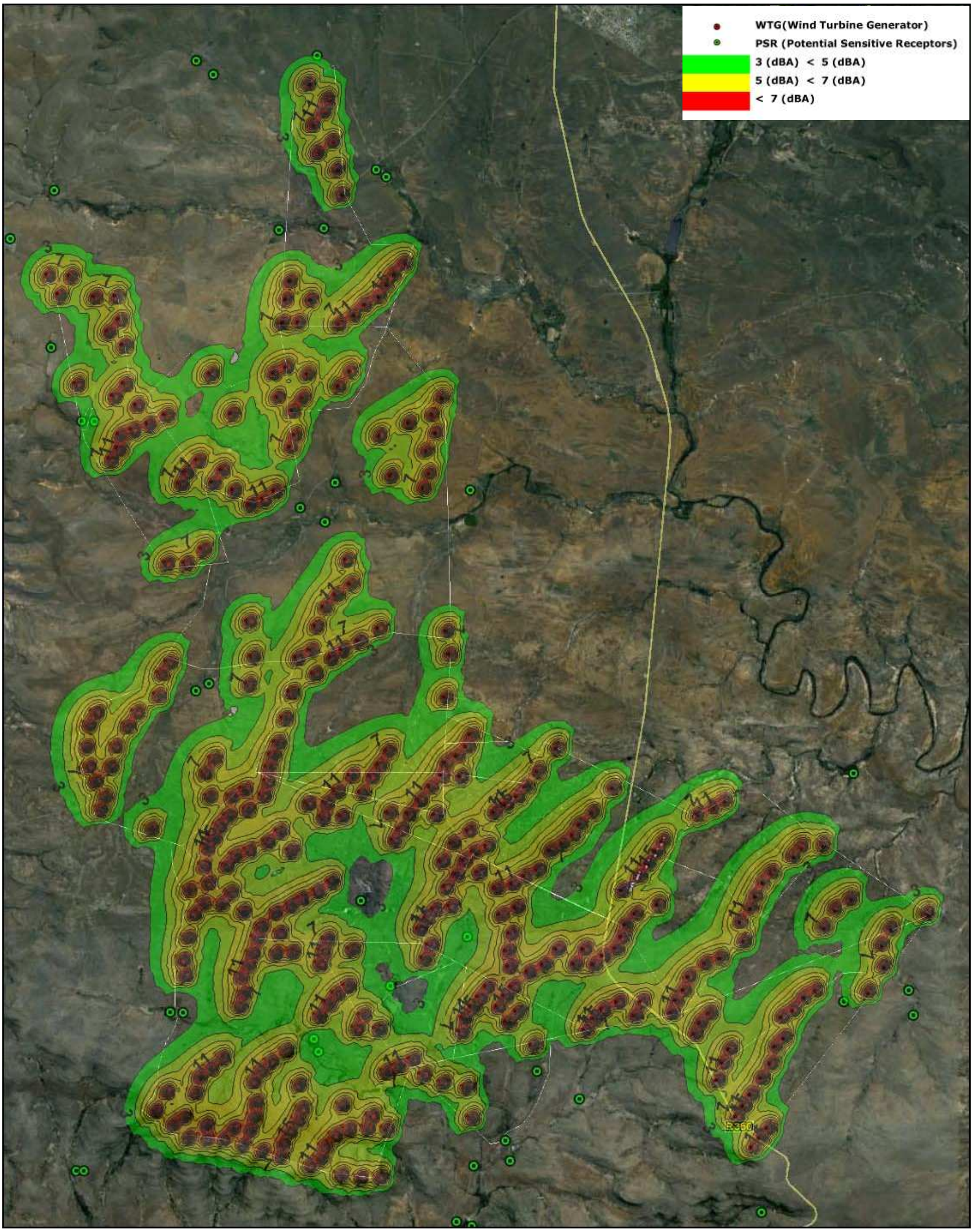

Figure 7-12: Change in ambient sound levels, contours of constant noise levels with a south-east wind blowing at 7 m/s

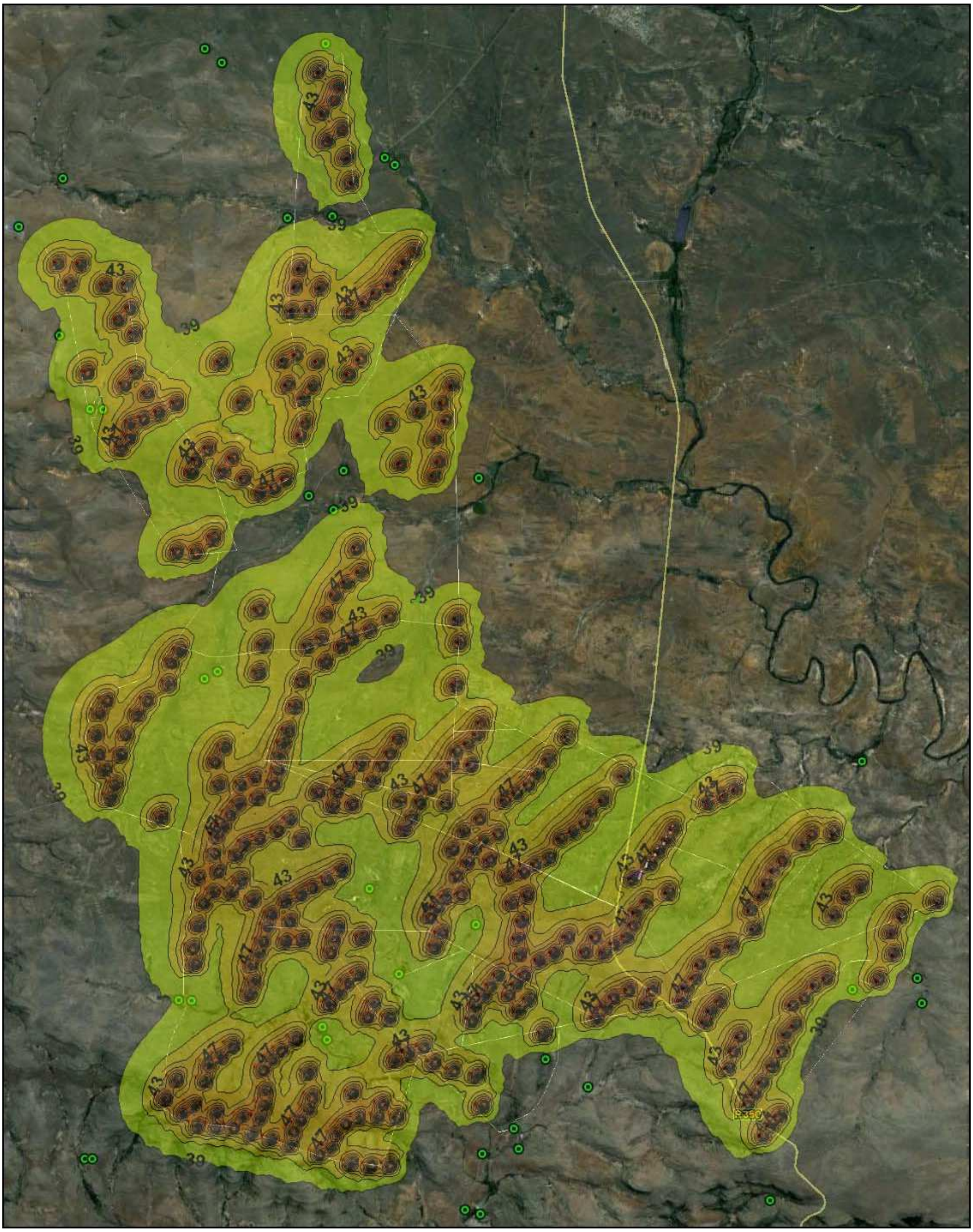

Figure 7-13: Operational Phase: Sound Levels from WEF, Contours of constant sound levels with a south-easterly wind blowing at 8 m/s

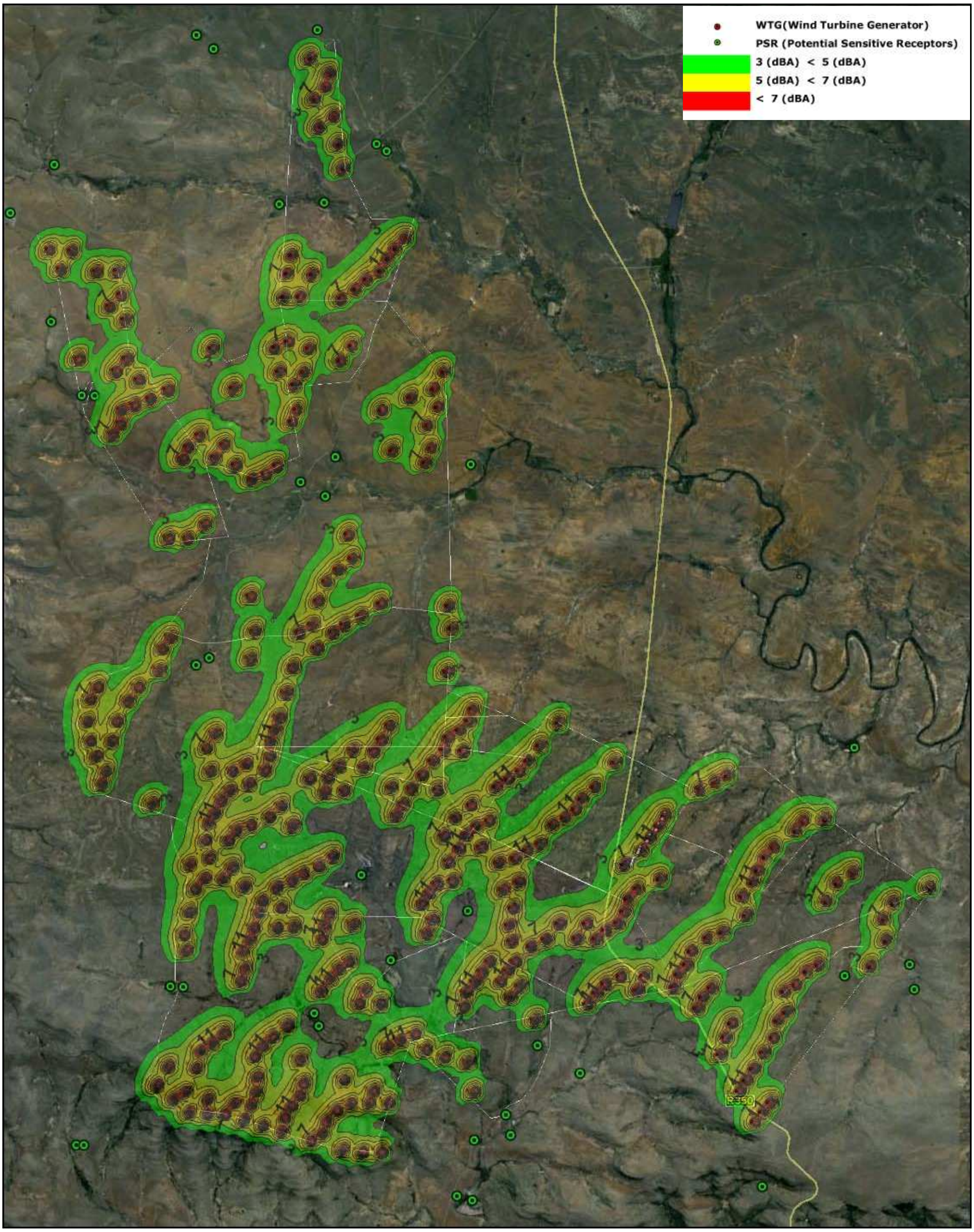

Figure 7-14: Change in ambient sound levels, contours of constant noise levels with a south-east wind blowing at 8 m/s

Table 7-6: Sound Pressure Levels and change in ambient sound levels at surrounding PSR's for a south easterly wind blowing at 4 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	28.14	76	28.21	0.06	40.95
SR102	28.14	76	29.83	1.69	55.6
SR103	28.14	76	28.3	0.16	44.73
SR104	28.14	76	28.24	0.09	42.67
SR105	28.14	76	28.37	0.23	46.31
SR106	28.14	76	28.83	0.69	51
SR107	28.14	76	28.5	0.36	52.05
SR108	28.14	76	28.42	0.28	50.15
SR109	28.14	76	28.98	0.84	53.45
SR110	28.14	76	29	0.86	52.42
SR111	28.14	76	29.43	1.29	54.61
SR112	28.14	76	30.64	2.49	58.23
SR113	28.14	76	32.32	4.17	61.28
SR114	28.14	76	28.83	0.69	52.82
SR115	28.14	76	28.81	0.66	54.18
SR116	28.14	76	29.25	1.11	54.08
SR117	28.14	76	28.33	0.18	50.08
SR118	28.14	76	29.8	1.66	56.2
SR119	28.14	76	29.37	1.23	55.38
SR120	28.14	76	29.59	1.45	55.58
SR121	28.14	76	29.98	1.83	56.62
SR122	28.14	76	28.34	0.19	46.59
SR123	28.14	76	28.31	0.16	45.88
SR124	28.14	76	29.77	1.62	56.76
SR125	28.14	76	29.87	1.73	57.35
SR126	28.14	76	31.34	3.2	60.09
SR127	28.14	76	30.39	2.24	59
SR128	28.14	76	30.18	2.03	58.24
SR129	28.14	76	28.17	0.02	39.74
SR130	28.14	76	28.17	0.02	39.85
SR131	28.14	76	28.19	0.04	43.2
SR132	28.14	76	28.18	0.04	42.26
SR133	28.14	76	28.24	0.09	47.42
SR134	28.14	76	28.22	0.07	45.72
SR135	28.14	76	28.26	0.11	48.19
SR136	28.14	76	28.32	0.17	48.57
SR137	28.14	76	28.6	0.45	53.95
SR138	28.14	76	30.1	1.96	57.88
SR139	28.14	76	28.23	0.09	47.6
SR140	28.14	76	28.39	0.24	52.04
SR141	28.14	76	28.33	0.19	46.09
SR142	28.14	76	28.2	0.06	44.84

Table 7-7: Sound Pressure Levels at surrounding Receptors for a South-east wind blowing at 7 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	35.05	86	35.18	0.13	53.17
SR102	35.05	86	37.98	2.93	67.84
SR103	35.05	86	35.32	0.27	56.27
SR104	35.05	86	35.21	0.16	54.21
SR105	35.05	86	35.47	0.42	58.16
SR106	35.05	86	36.15	1.1	62.54
SR107	35.05	86	35.62	0.57	63.39
SR108	35.05	86	35.56	0.51	61.86
SR109	35.05	86	36.43	1.38	65.07
SR110	35.05	86	36.44	1.39	64.04
SR111	35.05	86	37.12	2.07	66.22
SR112	35.05	86	38.78	3.73	69.9
SR113	35.05	86	40.81	5.76	72.88
SR114	35.05	86	36.33	1.28	64.68
SR115	35.05	86	36.16	1.11	65.72
SR116	35.05	86	36.85	1.8	65.74
SR117	35.05	86	35.35	0.3	61.45
SR118	35.05	86	37.87	2.82	68.2
SR119	35.05	86	37.09	2.04	67.06
SR120	35.05	86	37.38	2.33	67.2
SR121	35.05	86	37.94	2.89	68.36
SR122	35.05	86	35.41	0.36	58.45
SR123	35.05	86	35.36	0.31	57.75
SR124	35.05	86	37.69	2.64	68.5
SR125	35.05	86	37.57	2.52	68.68
SR126	35.05	86	39.68	4.63	71.72
SR127	35.05	86	38.55	3.5	70.65
SR128	35.05	86	38.29	3.24	69.85
SR129	35.05	86	35.09	0.04	51.06
SR130	35.05	86	35.09	0.04	51.17
SR131	35.05	86	35.12	0.07	54.54
SR132	35.05	86	35.11	0.06	53.6
SR133	35.05	86	35.21	0.16	58.82
SR134	35.05	86	35.17	0.12	57.12
SR135	35.05	86	35.24	0.19	59.65
SR136	35.05	86	35.34	0.29	59.95
SR137	35.05	86	35.82	0.77	65.5
SR138	35.05	86	38.6	3.55	70.1
SR139	35.05	86	35.19	0.14	59.03
SR140	35.05	86	35.4	0.35	63.3
SR141	35.05	86	35.39	0.34	57.84
SR142	35.05	86	35.13	0.08	55.99

As can be seen from the previous figures and tables, the highest risk in terms of a noise impact is during times when the wind blows between 6 and 7 m/s. From these figures it can be observed that, while the total projected noise levels increase as the wind speed increase, the change in ambient sound levels increased to a peak at a wind speed between 6 and 7 m/s, from where the change in ambient sound levels would actually decrease.

The specified wind turbine used for modelling generates almost its peak noise at a wind speed of 7 m/s, but wind induced noise does not yet dominate the soundscape. At higher wind speeds the noise generated by the wind turbines does not increase significantly (refer Figure 4-1), however, wind induced noise levels increases significantly (refer Figure 5-2). For that purpose a wind speed of 7 m/s will be used for further modelling.

7.2.3 Impact Assessment: Operational Phase without mitigation

This Environmental Noise Impact Assessment focuses on the impacts on the surrounding sound environment during times when a quiet environment is highly desirable. Noise limits are therefore appropriate for the most noise-sensitive activity, such as sleeping, or areas used for relaxation or other activities (places of worship, school, etc).

Appropriate Zone Sound Levels is therefore important, yet it has been indicated that the SANS recommended Night Rating Level ($L_{Req,N}$) of 35 dBA might be inappropriate due to the increased ambient sounds relating to wind action.

A more appropriate method to determine the potential impact would be to make use of the change in ambient sound levels that receptors may experience. Using the $\Delta L_{Aeq,N}$ of 3 dBA (or higher), it can be seen that a number of receptors could be impacted.

Using the model parameters as outlined, the following can be concluded:

- The ambient noise level will exceed the zone sound level of 35 dBA, but total noise levels would most likely be due to the existing high ambient sound level relating to the wind speed (at 7 m/s and higher).
- There are a number of receptors that would detect the change in ambient sound levels. Because of the existing high ambient sound levels, potential changes in ambient sound levels would be the important factor to consider.

- The operation of the wind turbines will slightly add to the acoustical energy in the low frequencies. However most of the acoustical energy in the low frequencies is due to the wind induced noise.

Table 7-8 highlights receptors that might be impacted by the surrounding wind turbines with the current layout (see also **Appendix C**).

Table 7-8: Receptors that might be impacted by the wind turbines in the Amakhala WEF with a 7 m/s wind

Wind direction	**Sensitive Receptors**		
	3 < $\Delta L_{Aeq,N}$ < 5 dBA	**5 < $\Delta L_{Aeq,N}$ < 7 dBA**	**7 < $\Delta L_{Aeq,N}$**
South-east	SR112, SR126, SR127, SR128, SR138	**SR113**	-
South-west	SR115, SR124, SR125, SR126, SR127, SR128, SR138	**-**	-
North-east	SR112, SR121, SR128, SR137, SR138	**SR113, SR126, SR127**	-
North-west	SR113, SR115, SR124, SR125, SR126, SR128, SR137, SR138, SR140	**SR127**	-

**** Only SR113, SR126 and SR127 to be investigated in detail further***

Table 7-9 presents the Wind Turbines identified that might have a noise impact on the investigated potential sensitive receptors (see also **Appendix C**).

Table 7-9: Wind Turbines that might be problematic in terms of noise impact on potential sensitive receptors with a 7 m/s wind

Wind direction	**Wind Turbines (Sensitive Receptor impacted in brackets)**	
	Direct impact	**Impact due to cumulative effect**
South-east	57 (SR113)	56, 57, 58, 59 (SR113) 242, 244, 245 (SR126) 205 (SR127)
South-west	-	58, 59 (SR113) 203 (SR127)
North-east	204 (SR127)	51, 56, 57 (SR113) 228, 244, 245 (SR126) 160, 204, 205 (SR127)
North-west	204 (SR127)	51 (SR113) 228 (SR126) 160, 203, 204 (SR127)

Applying the precautionary principle, the assessment of potential impacts is presented in Table 7-10.

Table 7-10: Impact Assessment: Operational phase without mitigation

Nature:	*Numerous turbines in the Amakhala Emoyeni WEF operating simultaneously.*
Acceptable Rating Level	Rural district with little road traffic: 35 dBA outside during day (refer **Table 5-1**). Use $L_{Req,N}$ of 35 dBA.
Extent ($\Delta L_{Aeq,N}$>7dBA)	**Local** – Impact will extend less than 1,000 meters from activity. **(2).**
Duration	**Permanent** – WEF will operate for a number of years **(5)**
Magnitude	***Estimated noise level*** ($L_{Aeq,N}$) ***as high as 40.8 dBA*** 5 < $\Delta L_{Aeq,N}$ < 7 dBA **Medium - (6)**
Probability	**Likely - (3)**
Significance	**39 (Medium)**
Status	Negative
Reversibility	High
Irreplaceable loss of resources?	*Not relevant*
Comments	*Wind directions of North-west, North-east and South-east could impact on a number of Receptors .*
Can impacts be mitigated?	Yes
Mitigation:	• It is recommended that wind turbines that could have a potential direct impact (**Table 7-9**) be moved to a location where it is more than 1,000 meters from receptors. If these turbines are moved to a different area, yet still within 1,000 meters from a receptor, independent noise modelling should be conducted again. • It is recommended that a setback of at least 1,000 meters be considered by the developer; • If a turbine is to be developed within 1,000 meters from a downwind receptor, the developer must highlight the potential noise impact on the receptor(s) that might be impacted, as well as the estimated percentage that the wind blows into the direction of the PSR, together with the results of the independent noise modelling. • The noise emission specifications of wind turbine generators must be considered when selecting the equipment. This could be smaller equipment, more quiet equipment or both. If there are turbines within a 1,000 meter setback distance from PSRs, quieter WTGs is suggested. • A combination of the options proposed above.
Cumulative impacts:	This impact is cumulative with existing ambient background noises.
Residual Impacts:	This impact will only disappear once the operation of the Wind Energy Facility stops, or the sensitive receptor no longer exists.

As can be seen from the detailed analysis in **Appendix C**, the individual contribution of the various different wind turbines are frequently less than the Acceptable Night Rating Level of 35 dBA, but the cumulative effect (background ambient sounds as well as other turbines) could result in a total noise level that could significantly exceed the Acceptable Night Rating Level/Zone Sound Level at the identified receptors (**Table 7-8**).

7.2.4 Impact Assessment: Operational Phase with mitigation

With the implementation of the mitigation options as presented in **section 8**, the significance of the potential impact would be reduced to a low significance (Table 7-11).

Table 7-11: Impact Assessment: Operational Phase, with mitigation

Nature:	*Numerous turbines operating simultaneously.*
Acceptable Rating Level	Rural district with little road traffic: 35 dBA outside at night (refer **Table 5-1**). Use $L_{Req,N}$ of 35 dBA.
Extent ($\Delta L_{Aeq,D}$>7dBA)	**Local** – Impact would not extend further than 1,000 meters from activity **(2)**
Duration	**Permanent** – WEF will operate for a number of years **(5)**
Magnitude	*By modelling the proposed mitigation, where problematic turbines were relocated further than 1,000 meters from potential sensitive receptors:* • $\Delta L_{Aeq,N}$ < 5 dBA **Medium (6)**
Probability	**Improbable (1)**
Significance	**13 (Low)**
Comments	With adequate and correct mitigation measures, especially regarding the layout of the WTG's near the PSR's affected, the significance of the impact can be reduced significantly (**Table 7-8**).

With the implementation of the mitigation options (see **section 8.2**) as presented, the significance of the potential impacts during the construction phase could be reduced to an acceptable low.

7.3 OPERATIONAL PHASE IMPACT (AMAKHALA AND COOKHOUSE WEFS)

7.3.1 Description of Operational Activities Modelled

The potential cumulative impacts with both the Amakhala Emoyeni and Cookhouse wind energy facilities operational were evaluated. The modelling parameters for the Cookhouse wind turbines and atmospheric conditions as used for the Amakhala WEF. This assessment specifically focuses on the boundary area between the two wind energy facilities (see also).

As cumulative impacts must be considered as per the EIA guidelines, it should be noted that:

- The Cookhouse layout used is not the final layout, and considered unrealistic. The layout could result in an exaggerated noise level.
- It was indicated (after this report (revision 0) was compiled) that the Cookhouse WEF is considering the Suzlon WTG, a turbine that differs in noise emission character than the Vestas used.

These two factors could significantly change the resultant noise impact prediction, and the reader should consider this in perusing the results and findings of this section.

7.3.2 Results: Operational Phase

The noise impact from the two combined WEFs is illustrated in **Figure 7-16**, with a south-east wind blowing at 7 m/s, with the projected change in ambient sound levels as experienced by the receptors indicated by **Figure 7-17**. The data is presented in **Appendix D**.

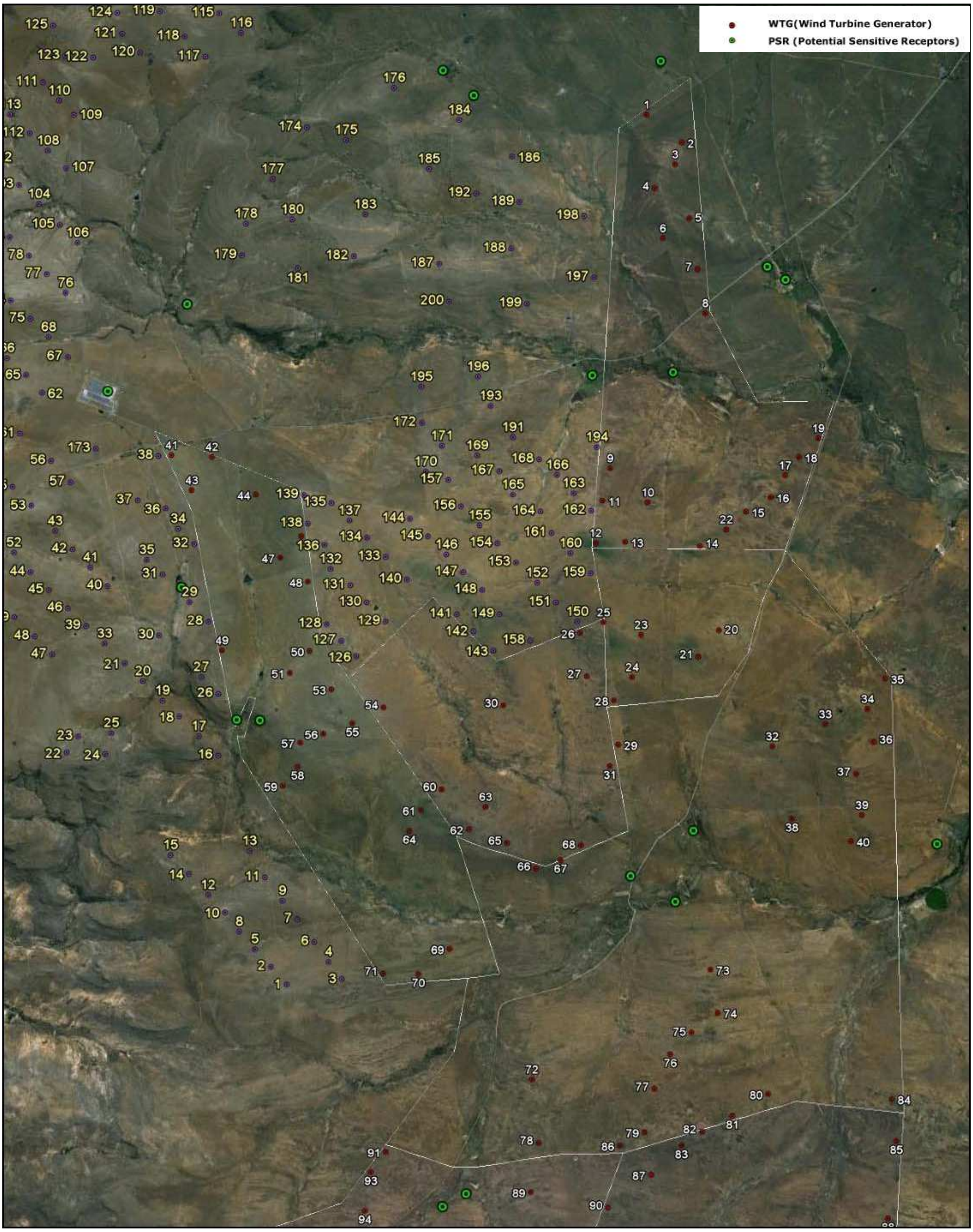

Figure 7-15: Operational Phase: Area investigated (Amakhala WTGs numbered in white, Cookhouse WTGs numbered in yellow)

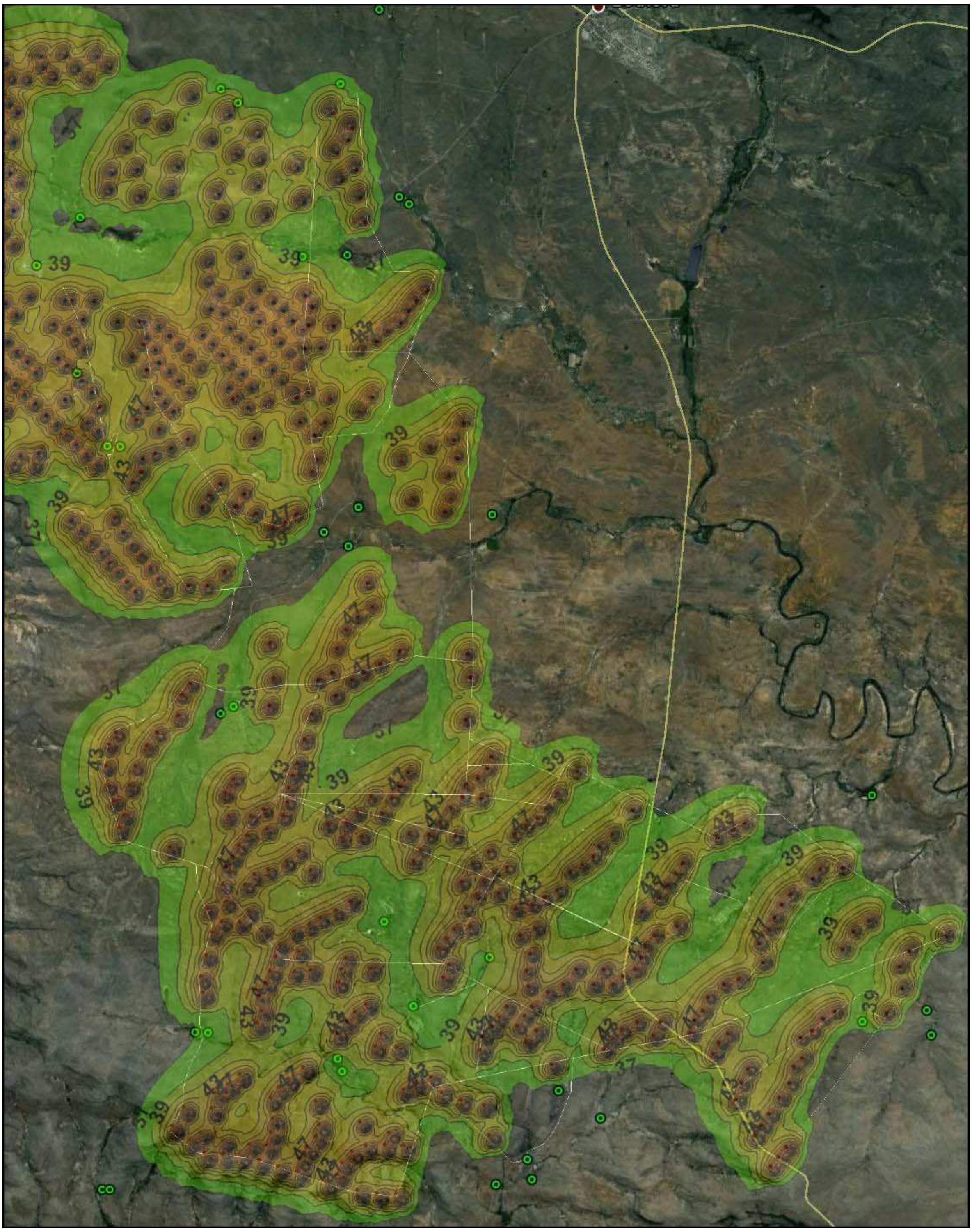

Figure 7-16: Operational Phase: Sound Levels from combined Amakhala and Cookhouse WEF's; Contours of constant sound levels with a south-east wind blowing at 7 m/s

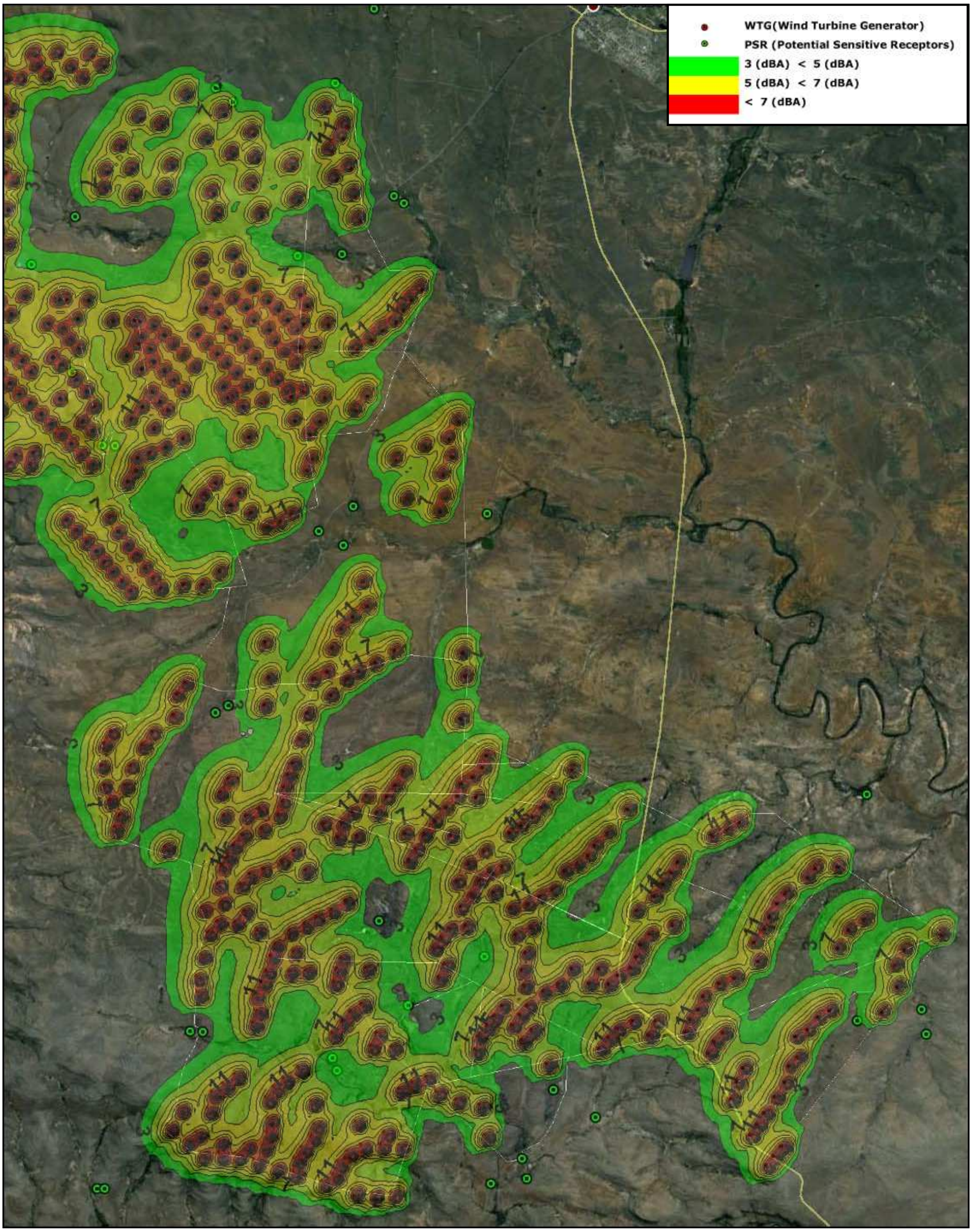

Figure 7-17: Operational Phase: Change in ambient sound levels due to Amakhala and Cookhouse WEF's; Contours of constant sound levels with a south-east wind blowing at 7 m/s

Table 7-12 highlights receptors that might be impacted by the wind turbines during times that the two facilities are operational using the available layouts (see also **Appendix D** for detailed analysis).

Table 7-12: Receptors that might be impacted by the wind turbines from the two facilities with south-east wind at 7 m/s

Wind direction	**Sensitive Receptors: Amakhala only**		
	$3 < \Delta L_{Aeq,N} < 5$ dBA	**$5 < \Delta L_{Aeq,N} < 7$ dBA**	**$7 < \Delta L_{Aeq,N}$**
South-east	SR112, SR126, SR127, SR128, SR138	SR113	-
South-west	SR115, SR124, SR125, SR126, SR127, SR128, SR138	-	-
North-east	SR112, SR121, SR128, SR137, SR138	SR113, SR126, SR127	-
North-west	SR113, SR115, SR124, SR125, SR126, SR128, SR137, SR138, SR140	SR127	-
Wind direction	**Sensitive Receptors: Both Facilities operational**		
	$3 < \Delta L_{Aeq,N} < 5$ dBA	**$5 < \Delta L_{Aeq,N} < 7$ dBA**	**$7 < \Delta L_{Aeq,N}$**
South-east	**SR102**, **SR104**, ***SR106***, **SR110**, SR112, SR126, SR127, SR138	**SR103**, **SR112**, SR113	**SR111**
South-west	**SR102**, **SR104**, **SR110**, SR115, SR124, SR125, SR126, SR127, SR128, SR138	**SR106**, **SR113**	**SR103**, **SR111**, **SR112**
North-east	SR112, SR121, SR128, SR137, SR138	SR113, SR126, SR127	**SR111**, **SR112**
North-west	SR113, SR115, SR124, SR125, SR126, SR128, SR137, SR138, SR140	**SR106**, SR127	**SR111**, **SR112**, **SR113**

* Receptors in bold are at risk to experience a noise impacted when the cumulative effect of the Cookhouse WEF is considered with the Amakhala Emoyeni WEF.

Table 7-13 presents the Wind Turbines identified that might have a noise impact on the surrounding potential sensitive receptors (see also **Appendix C**). It should be noted that this analysis was only conducted on the potential receptors where the change in ambient sound levels exceeds 5 dBA (**$5 < \Delta L_{Aeq,N}$**).

Table 7-13: Wind Turbines that might be problematic in terms of noise impact on potential sensitive receptors with a 7 m/s wind

Wind direction	**Amakhala Emoyeni Wind Turbines (Sensitive Receptors impacted in brackets)**	
	Direct impact	**Impact due to cumulative effect**
South-east	57 (SR113)	56, 57, 58, 59 (SR113) 242, 244, 245 (SR126) 205 (SR127)
South-west	-	58, 59 (SR113) 203 (SR127)
North-east	204 (SR127)	51, 56, 57 (SR113)

		228, 244, 245 (SR126) 160, 204, 205 (SR127)
North-west	204 (SR127)	51 (SR113) 228 (SR126) 160, 203, 204 (SR127)
Wind direction	**Both facilities operational: Potential Problematic Wind Turbines (Sensitive Receptors impacted in brackets)**	
	Direct impact	**Impact due to cumulative effect**
South-east	*C184 (SR103)* *C28, C29 (SR111)* *C16 (SRSR112)* 57 (SR113)	*C186 (SR103)* *C173 (SR173)* *C30, C31 (SR111)* 57 (SR112) 56, 57, 58, 59 (SR113) 242, 244, 245 (SR126) 205 (SR127)
South-west	*C184 (SR103)* *C29, C31 (SR111)* -	*C62, C67, C173 (SR106)* *C28, C30, C35, C40 (SR111)* *C18, C26 (SR112)* *C16, C17, C26 (SR113)* 58, 59 (SR113) 203 (SR127)
North-east	*C29, C31, C32 (SR111)* *C26 (SR112)* 204 (SR127)	*C34 (SR111)* *C27 (SR112)* 51, 56, 57 (SR113) 228, 244, 245 (SR126) 160, 204, 205 (SR127)
North-west	*C29, C31, C32, C35 (SR111)* *C17, C26 (SR112)* 204 (SR127)	*C184 (SR103)* *C62, C67 (SR106)* *C34, C40 (SR111)* *C18, C27 (SR112)* *C16, C17, C26, C27 (SR113)* 49 (SR112) 51 (SR113) 228 (SR126) 160, 203, 204 (SR127)

As can be seen from **Table 7-12** and **Table 7-13**, there is significant potential that the cumulative effect from the two operational facilities would increase the potential noise impact experienced by potentially sensitive receptors.

However, subject that the developer of the Cookhouse implement appropriate mitigation measures, the mitigation measures as proposed in **section 8.2** would ensure that any cumulative impacts due to the operation of the Amakhala Emoyeni WEF is minimized.

Again it should be pointed out that the results and findings of this section is based on both facilities making use of the Vestas WTG, as well as a very preliminary WEF layout for Cookhouse.

8 MITIGATION OPTIONS

8.1 CONSTRUCTION PHASE

The mitigation of noise during the construction phase is normally relatively easy to achieve. Mitigation options included both management measures as well as technical changes.

However, depending on the findings and recommendations of the Operational phase noise analysis, it is highly recommended to relocate a number of turbines (as identified, see **Table 7-9** and **Table 7-13**) further away from potential sensitive receptors. If turbines are relocated, the construction activity would also be relocated, which would also reduce both the intensity and probability of the noise impact.

Management options to reduce the noise impact during the construction phase include:

- Ensure a good working relationship between the developer and all potential sensitive receptors. Communication channels should be established to ensure prior notice to the sensitive receptor if work is to take place close them. Information that should be provided to the potential sensitive receptor(s) include:
  - Proposed working times,
  - how long the activity is anticipated to take place,
  - what is being done, or why the activity is taking place, and
  - contact details of a responsible person where any complaints can be lodged should there be an issue of concern.
- When working close (within 500 meters – potential construction of access roads and trenches) to a potential sensitive receptor(s), limit the number of simultaneous activities to the minimum (due to cumulative effects for a number of simultaneous activities),
- When working very close to potentially sensitive receptors, co-ordinate the working time with periods when the receptors are not at home. An example would be to work within the 8am to 2pm time-slot to minimize the significance of the impact because:
  - Potential receptors are most likely at school or at work, minimizing the probability of an impact happening.

- Normal daily activities will generate other noises that would most likely mask construction noises, minimizing the probability of an impact happening.

Technical solutions to reduce the noise impact during the construction phase include:

- Using the smallest/quietest equipment for the particular purpose. For modelling purposes the noise emission characteristics of both a large bulldozer and excavator (typically used in mining operations) were used, that would most likely over-estimate the noise levels. The use of smaller equipment therefore would have a far lower noise impact.
- Ensuring that equipment is well-maintained and fitted with the correct and appropriate noise abatement measures.

8.2 Operational Phase

There are various ways in which the impact from the Wind Energy Facility on the surrounding environment (including sensitive receptors) can be reduced during the operational phase.

Mitigation measures that would reduce the impact include:

- Potential problematic turbines were identified in **Table 7-9** for a number of wind directions at 7 m/s. The same turbines could also be problematic at different wind speeds. Turbines that are indicated in red and yellow (**Appendix C**) could be removed or relocated further from the potential sensitive receptors. If these turbines are relocated, but still closer than 1,000 meters the new layout should be re-analysed to determine the potential risk to the potential receptors.
- When wind blows in a different direction than the wind directions modelled, other wind turbines may become problematic. Due to this a general setback of 1,000 meters is recommended.
- Problematic wind turbines could also be disabled, or the rotational speeds decreased during periods when a quieter environment is desirable should the current layout be implemented.

General mitigation options would be:

- Reducing the number of wind turbines in areas where there are sensitive receptors.

- Developing the same number of wind turbines over a larger area.
- Ensuring a larger setback around potential sensitive receptors taking cognisance of prevailing wind directions. It is recommended that the developer consider a setback of at least 1,000 meters between a wind turbine and a potential sensitive receptor.
- The relocation of the receptors that are impacted.
- A combination of the above options.

In addition:

1. Good public relations are essential, and at all stages surrounding receptors should be educated with respect to the sound generated by wind turbines. The information presented to stakeholders should be factual and should not set unrealistic expectations. It is counterproductive to suggest that the wind turbines will be inaudible, or to use vague terms like "quiet". Modern wind turbines produce a sound due to the aerodynamic interaction of the wind with the turbine blades, audible as a "swoosh", which can be heard at some distance from the turbines. The magnitude of the sound will depend on a multitude of variables and will vary from day to day and from place to place with environmental and operational conditions. Audibility is distinct from the sound level, since it depends on the relationship between the sound level from the wind turbines and the ambient background sound level.
2. Community involvement needs to continue throughout the project. Annoyance is a complicated psychological phenomenon; as with many industrial operations, expressed annoyance with sound can reflect an overall annoyance with the project, rather than a rational reaction to the sound itself. Wind projects offer a benefit to the environment and the energy supply for the greater population, and offer economic benefits to the land owners leasing installation sites to the wind farm. A positive community attitude throughout the greater area should be fostered, particularly with those residents near the wind farm, to ensure they do not feel taken advantage of.
3. The developer must implement a line of communication (i.e. a help line where complaints could be lodged. All potential sensitive receptors should be made aware of these contact numbers. The wind energy facility should maintain a commitment to the local community and respond to concerns in an expedient fashion. Sporadic and legitimate noise complaints could develop. For example, sudden and sharp increases in sound levels could

result from mechanical malfunctions or perforations or slits in the blades. Problems of this nature can be corrected quickly, and it is in the developer's interest to do so.

9 ENVIRONMENTAL MANAGEMENT PLAN

9.1 CONSTRUCTION PHASE

Projected noise levels during construction of the Wind Energy Facility were modelled using the methodology as proposed by SANS 10357:2004. The resulting future noise projections indicated that the construction activities as modelled for the worst case scenario would not comply with both the Noise Control Regulations (GN R154) as well as the SANS 10103:2004 guidelines (projected noise levels higher than the acceptable day rating level).

Various other construction activities would be taking place during the development of the facility and there exists a risk that some of these activities could have a noise impact on surrounding residents. The significance of this noise impact was defined to be of a medium significance. However, mitigation measures were proposed that would reduce the significance to a more acceptable low level.

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

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

Mitigation: Action/Control	**Responsibility**	**Timeframe**
Establish a line of communication and notify all stakeholders and PSRs of the means of registering any issues, complaints or comments.	- Environmental Control Officer	All phases of project

Notify potentially sensitive receptors about work to take place at least 2 days before the activity in the vicinity (within 500 meters) of the PSR is to start. Following information to be presented in writing: - Description of Activity to take place - Estimated duration of activity - Working hours - Contact details of responsible party	- Contractor - Environmental Control Officer	At least 2 days, but not more than 5 days before activity is to commence
Ensure that all equipment are maintained and fitted with the required noise abatement equipment.	- Environmental Control Officer	Weekly inspection
Measure the peak noise levels of equipment used when operational and keep database of noise levels	- Acoustical Consultant / Approved Noise Inspection Authority	Start of project Quarterly during construction phase
When any noise complaints are received noise monitoring should be conducted at the complainant, followed by feedback regarding noise levels measured	- Acoustical Consultant / Approved Noise Inspection Authority	Within 7 days after complaint was registered
The construction crew must abide by the local by-laws regarding noise.	- Contractor - Environmental Control Officer	Duration of construction phase
Where possible construction work should be undertaken during normal working hours (06H00 – 18H00), from Monday to Saturday; If agreements can be reached (in writing) with the all the surrounding (within a 1,000 distance) potentially sensitive receptors, these working hours can be extended.	- Contractor	As required

Performance indicator	• **Equivalent A-weighted noise levels below 45 dBA at potentially sensitive receptors (8 hours).** • **Ensure that maximum noise levels at potentially sensitive receptors are less than 65 dBA.** • **No noise complaints are registered**
Monitoring	Quarterly noise monitoring by an Approved Noise Inspection Authority. Noise monitoring to be conducted 500 meters downwind from all noisy activities or at PSRs when work is taking place within 500 meters from a potentially sensitive receptor. Monitoring to take place every time that a noise complaint is registered.

9.2 OPERATIONAL PHASE

Projected noise levels during operation of the Wind Energy Facility were modelled using the methodology as proposed by SANS 10357:2004. The resulting future noise projections indicated that the operation of the facility would comply with the Noise Control Regulations (GN R154), yet would not comply with the guidelines as proposed by SANS 10103:2004. The significance of this noise impact was determined to be medium. Mitigation measures were proposed that would reduce the significance to a more acceptable low.

When considering the potential cumulative effected when the proposed Cookhouse WEF is added indicates non-compliance with both the Noise Control Regulations as well as the SANS 10103:2004 guidelines. It becomes critical that both developers implement appropriate mitigation measures, especially for the boundary area between the two facilities.

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

OBJECTIVE	**Control noise pollution stemming from operation of WEF**
Project Component(s)	Operational Phase
Potential Impact	• Increased noise levels at potentially sensitive receptors • Changing ambient sound levels could change the acceptable land use capability • Disturbing character of sound
Activity/Risk source	Simultaneous operation of a number of Wind Turbines
Mitigation Target/Objective	• Ensure that the change in ambient sound levels as experienced by Potentially Sensitive Receptors is less than 5 dBA. • Prevent the generation of nuisance noises • Ensure acceptable noise levels at surrounding stakeholders and potentially sensitive receptors.

Mitigation: Action/Control	**Responsibility**	**Timeframe**
Defining the ambient sound levels over a 24 hour period before the operational phase starts inside and outside of the dwellings of at least 3 Potentially Sensitive Receptors	- Acoustical Consultant / Approved Noise Inspection Authority	Before operational phase commence
Design and implement a noise monitoring programme	- Acoustical Consultant / Approved Noise Inspection Authority	Before operational phase commence
Add additional noise monitoring points at any complainants that registered a noise complaint relating to the operation of the WEF.	- Acoustical Consultant / Approved Noise Inspection Authority	With quarterly monitoring

Performance indicator	**Ensure that the change in ambient sound levels as experienced by Potentially Sensitive Receptors is less than 7 dBA**
Monitoring	Quarterly noise monitoring by an Acoustic Consultant or Approved Noise Inspection Authority for the first year of operation. Noise monitoring programme to be developed and implemented at the start of operation.

10 CONCLUSIONS

This report is an Environmental Noise Impact Assessment of the predicted noise environment for the Amakhala Emoyeni wind energy facility near the town of Bedford, making use of a predictive model to identify issues of concern. With the input data as used, this assessment indicated that the proposed project will have an impact of ***medium significance*** on specific receptors in the area. However, with the implementation of the proposed mitigation measures, the significance of this impact can be reduced to an acceptable low for all receptors. The implementation of these mitigation measures would also ensure that any cumulative effects are minimized.

With its potential for environmental and economic advantages, wind power generation have significant potential to become a large industry in South Africa. However, when wind farms come close to potential sensitive receptors, consideration must be given to ensuring a compatible co-existence. The potential sensitive receptors should not be adversely affected and yet, at the same time the wind farms need to reach an optimal scale in terms of layout and number of units.

Wind turbines produce sound, primarily due to mechanical operations and aerodynamics effects at the blades. Modern wind turbine manufacturers have virtually eliminated the noise impact caused by mechanical sources, and instituted measures to reduce the aerodynamic effects. But, as with many other activities, the wind turbines emit sound power levels at a level that does impact areas at some distance away. When potential sensitive receptors are nearby, care must be taken to ensure that the operations at the wind farm do not unduly cause annoyance or otherwise interfere with the quality of life of the receptors.

It should be noted that this does not suggest that the sound from the wind turbines should be inaudible under all circumstances - this is an unrealistic expectation that is not required or expected from any other agricultural, commercial, industrial or transportation related noise source – but rather that the sound due to the wind turbines should be at a reasonable level in relation to the ambient sound levels.

11 RECOMMENDATIONS

The current impact that the proposed WEF could have on the surrounding environment is considered to be of medium significance. It is importance that the developer considers the various mitigation options as proposed in this document to reduce the significance of the impact to a more acceptable low.

Considering the preliminary layout used for Cookhouse, the potential cumulative noise impact could be significant. Specifically, the layout of turbines around SR111, SR112 and SR113 should be considered, and the two developers could discuss turbine placement around these sensitive receptors. The receptors and wind turbine layout in the boundary area between the two facilities should be especially considered.

Should the layout change significantly, it is recommended that the new layout be remodelled/reviewed in terms of the potential noise impact by an independent acoustics specialist. This includes the situation when the existing layout is slightly modified, yet some of the potentially problematic turbines are still within a radius of 1,000 meters from a potentially sensitive receptor.

Quarterly monitoring noise monitoring at the potential sensitive receptors is recommended on a quarterly basis, to be conducted by an approved noise inspection authority for the first year of operation. This monitoring is to take place during late afternoon (16:00 – 18:00), late evening (20:00 – 24:00) as well as early in the morning (03:00 – 06:00). At least two of these samples should be during times when the wind energy facility is operational. Quarterly monitoring is recommended at SR113, SR126 and SR127 for the first year, as well as any other receptors that have complained to the developer regarding noise originating from the facility. Annual feedback regarding noise monitoring should be presented to all stakeholders and other interested and affected parties in the area. Noise monitoring must be continued as long as noise complaints are registered.

This report should also be made available to all potential sensitive receptors in the area, or the contents explained to them to ensure that they understand all the potential risks that the development of a wind energy facility may have on them and their families.

With the implementation of the proposed mitigation actions the significance of the impact would be reduced.

12 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. Since 2007 he has been involved with the following projects:

- Noise Impact Assessment for the Cookhouse Wind Energy Facility.
- Noise Impact Assessment for Skychrome (Pty) Ltd (A Ferro-chrome mine),
- Noise Impact Assessment for Mooinooi Chrome Mine (Western Chrome Mines),
- Noise Impact Assessment for Buffelsfontein East and West (Western Chrome Mines),
- Noise Impact Assessment for Elandsdrift (Sylvania),
- Noise Impact Assessment for Jagdlust Chrome Mine (Eastern Chrome Mines),
- Noise Impact Assessment Apollo Brick (Pty) Ltd (Clay mine and brick manufacturer).
- Noise Impact Assessment for the proposed expansion at Arthur Taylor Collieries (X-Strata Coal SA).

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.

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In this report reference was made to the following documentation:

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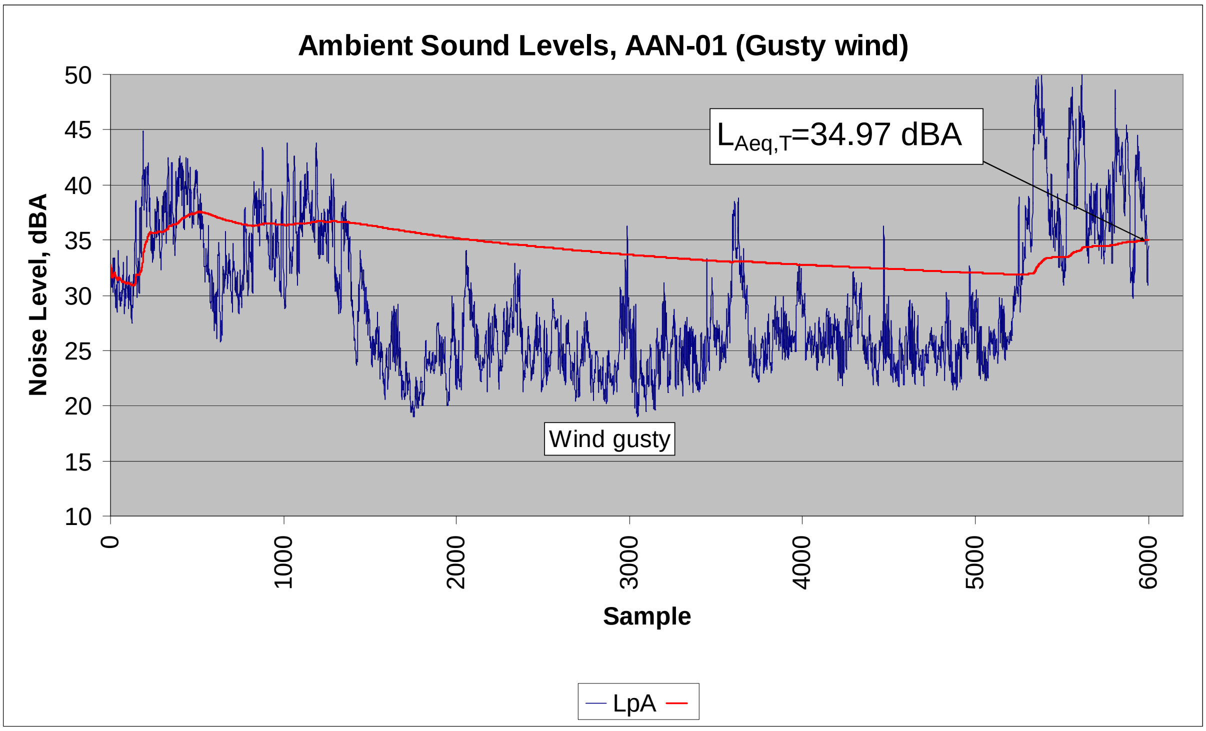
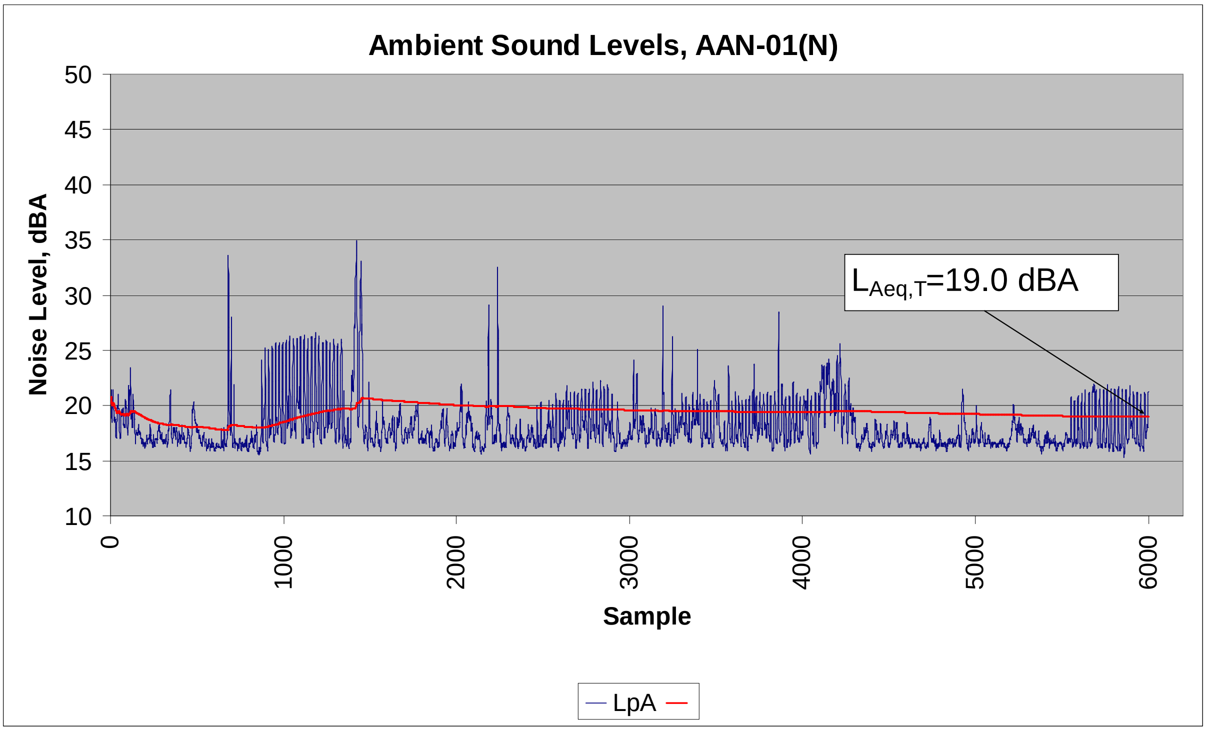
20. Working Group on Noise from Wind Turbines, (1996): *The Assessment and Rating of Noise from Wind Farms*.

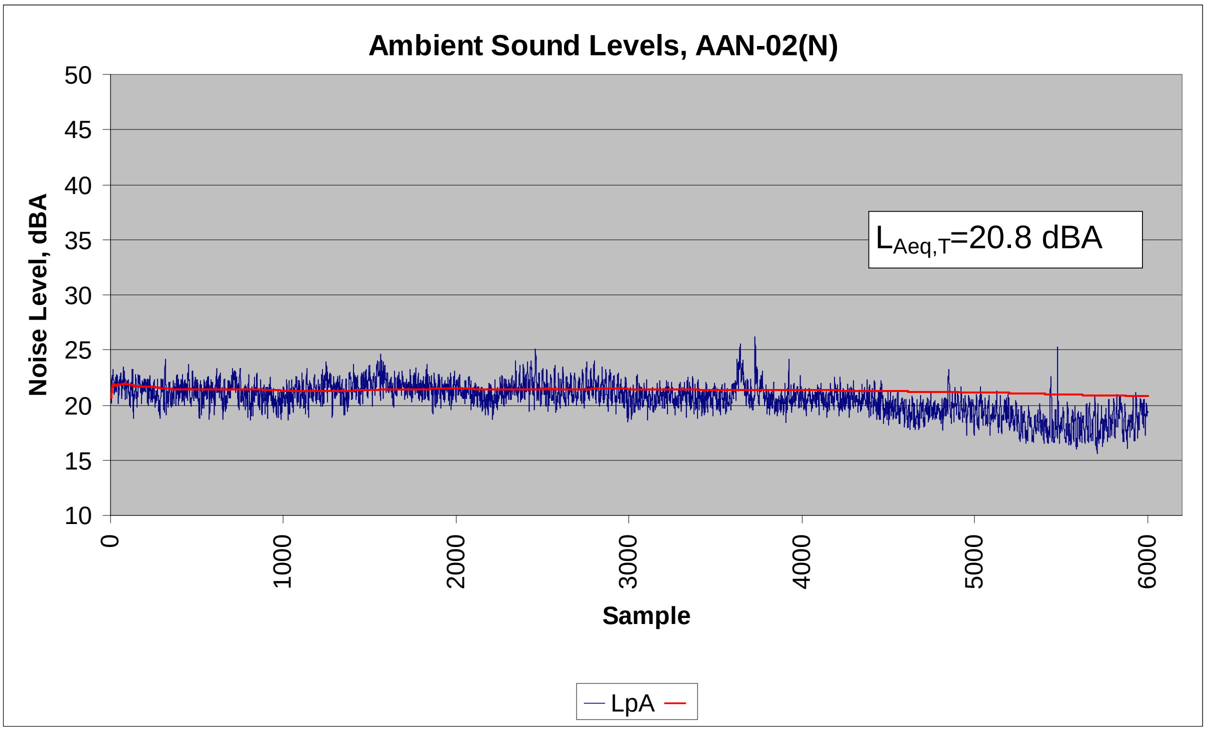
APPENDIX A

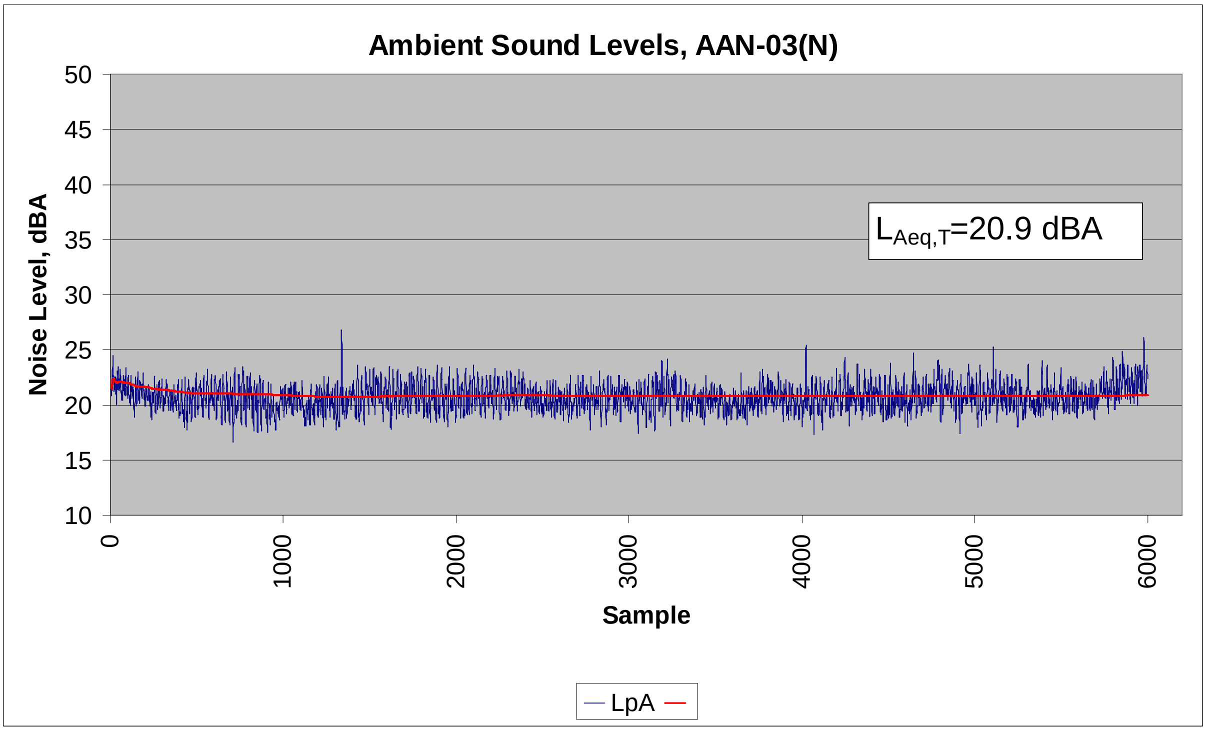
Monitoring Results:

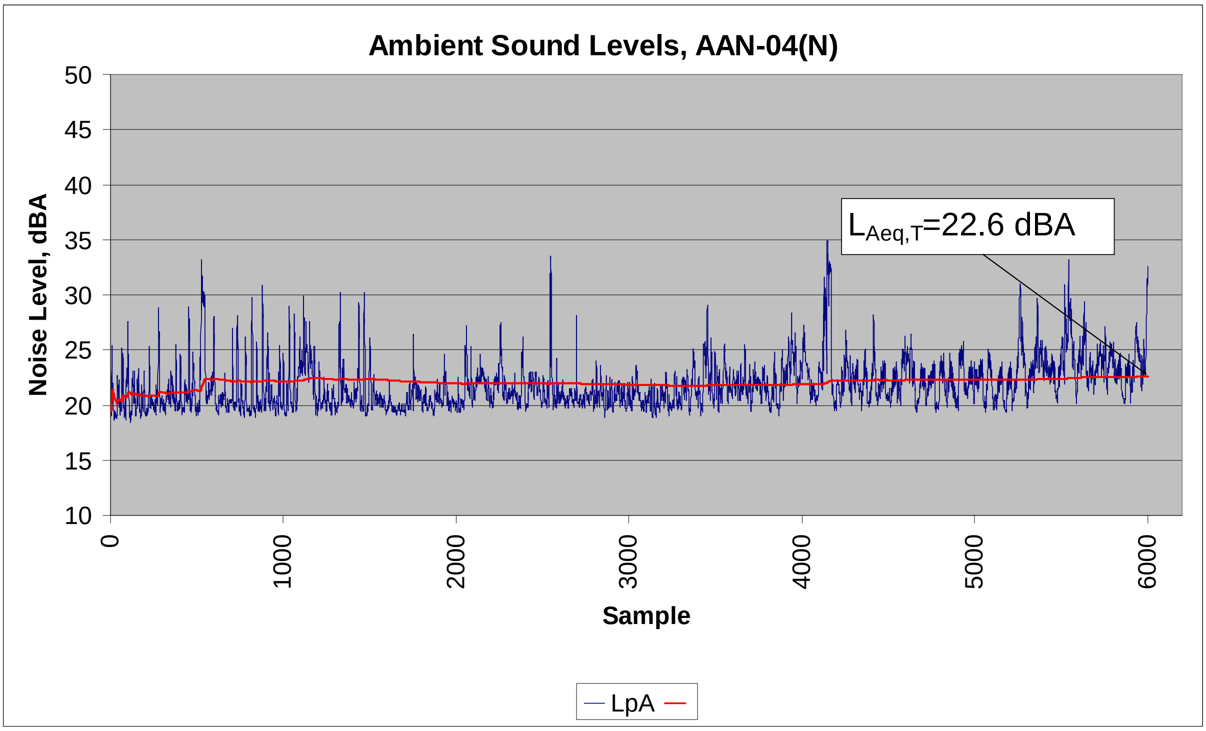
Ambient Sound Level

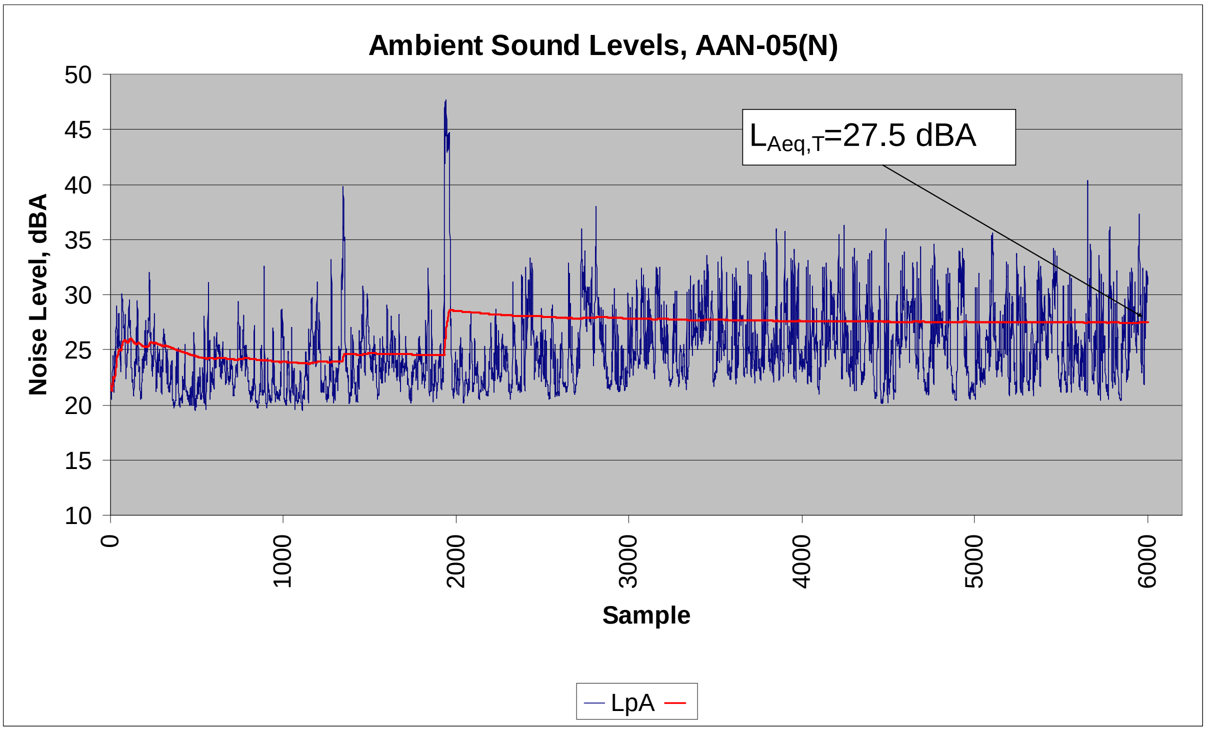

Ambient Sound Levels, AAN-01 (Gusty wind)
Noise Level, dBA
50
45
40
35
30
25
20
15
10
LAeq,T=34.97 dBA
Wind gusty
0
1000
2000
3000
4000
5000
6000
Sample
LpA

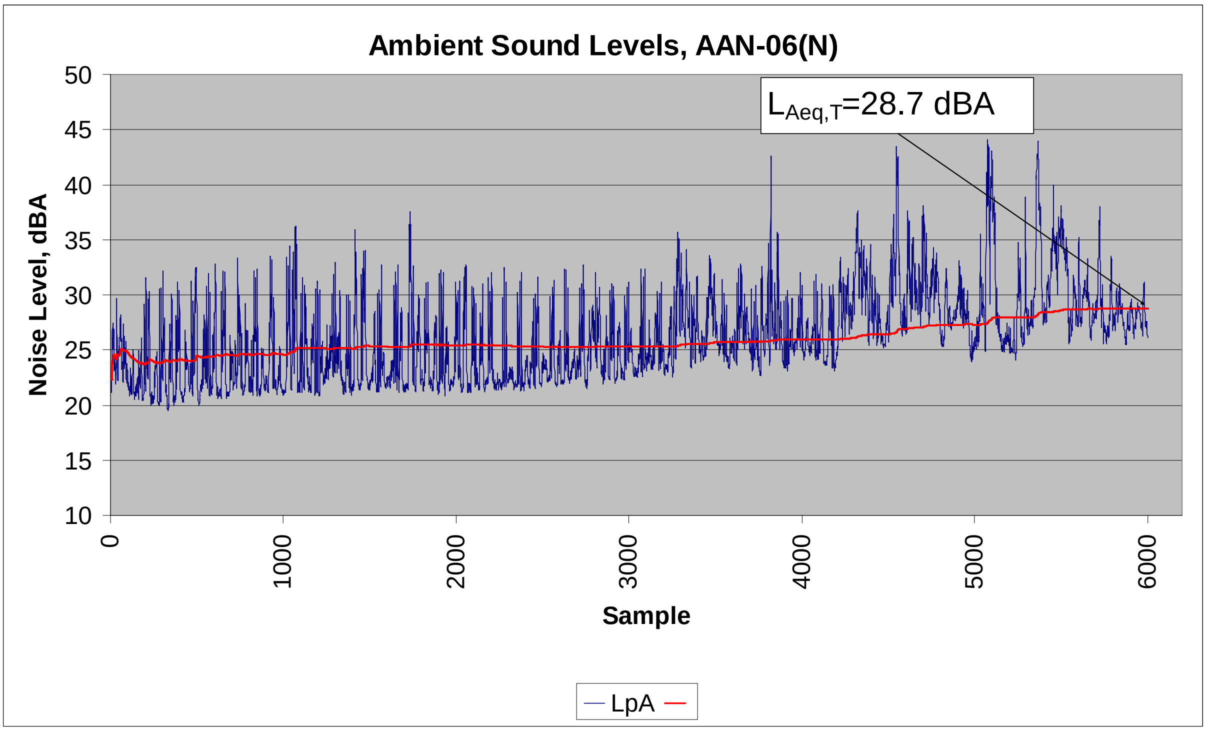

Ambient Sound Levels, AAN-01(N)
Noise Level, dBA
50
45
40
35
30
25
20
15
10
LAeq,T=19.0 dBA
0
1000
2000
3000
4000
5000
6000
Sample
LpA

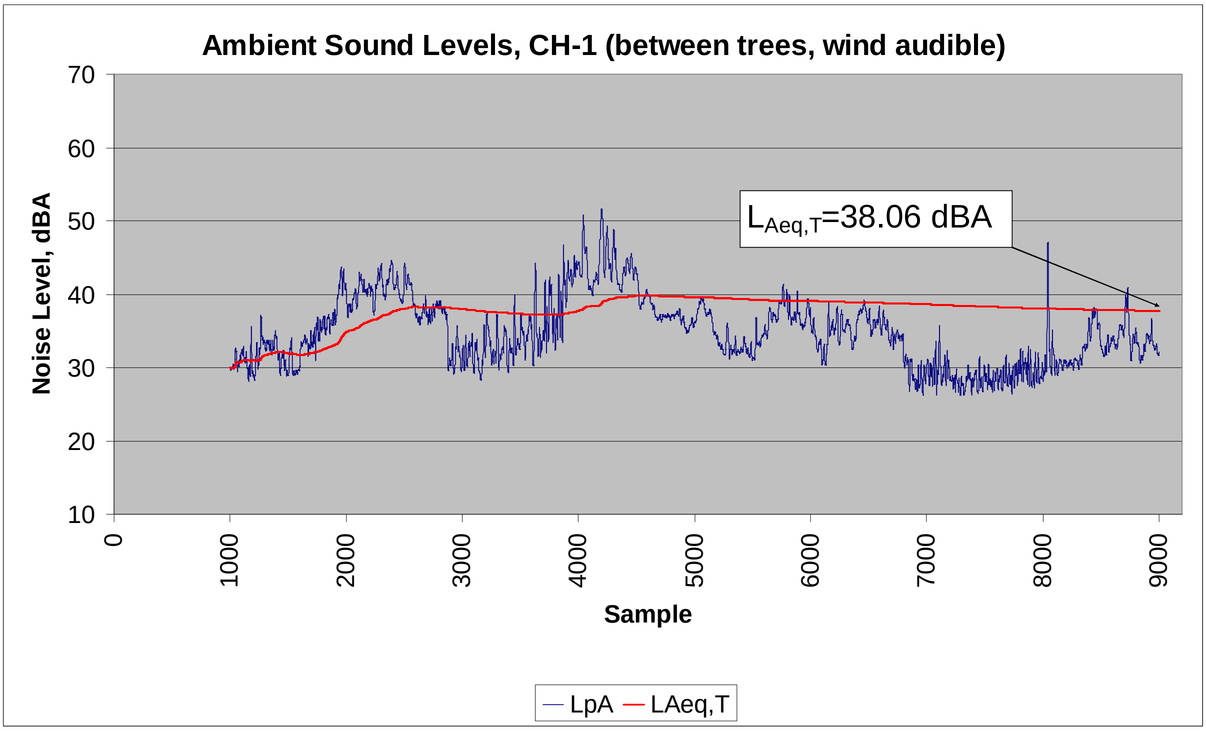

Ambient Sound Levels, AAN-02(N)
Noise Level, dBA
50
45
40
35
30
25
20
15
10
$L_{Aeq,T}$=20.8 dBA
0
1000
2000
3000
4000
5000
6000
Sample
LpA

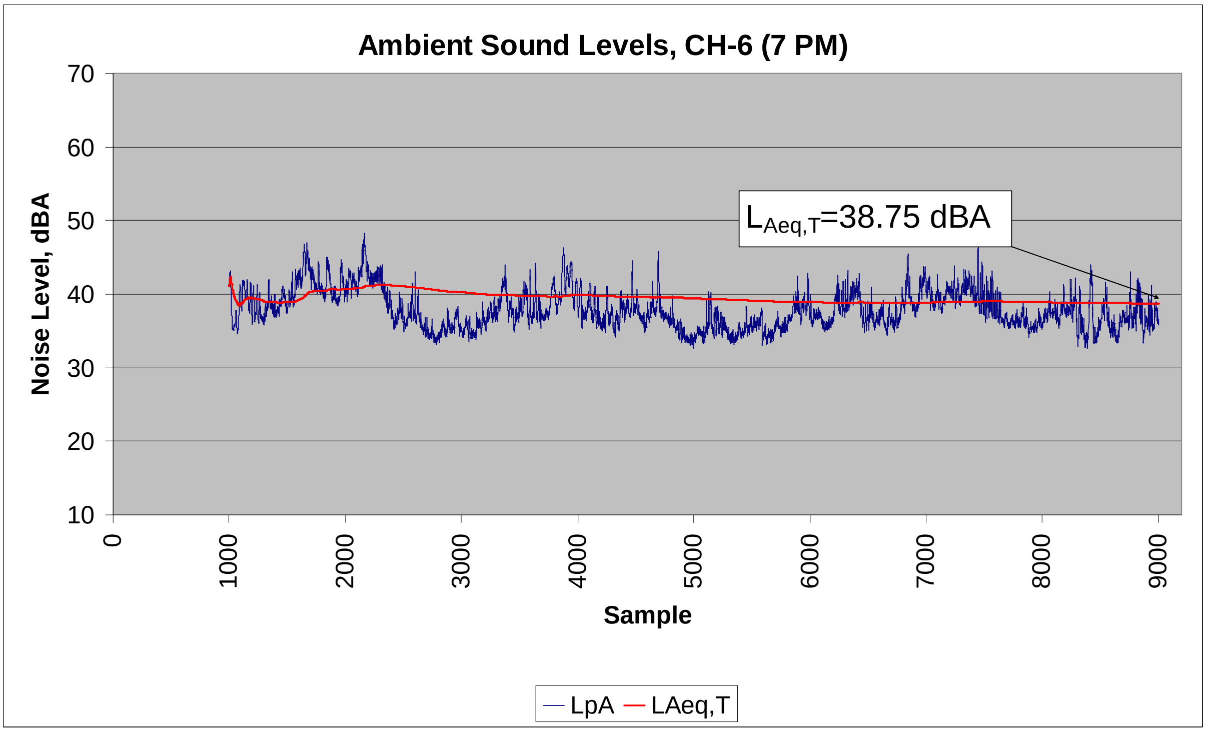

Ambient Sound Levels, AAN-03(N)
Noise Level, dBA
50
45
40
35
30
25
20
15
10
$L_{Aeq,T}$=20.9 dBA
0
1000
2000
3000
4000
5000
6000
Sample
LpA

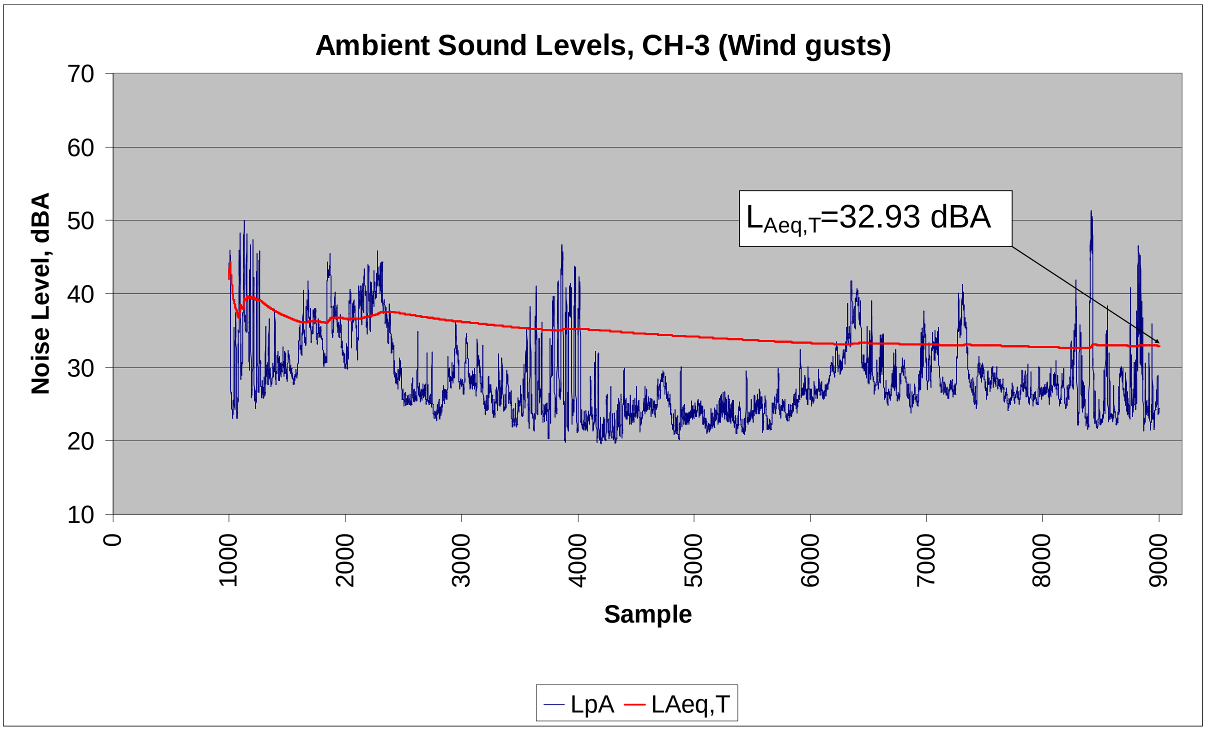

Ambient Sound Levels, AAN-04(N)
Noise Level, dBA
50
45
40
35
30
25
20
15
10
0
1000
2000
3000
4000
5000
6000
Sample
$L_{Aeq,T}$=22.6 dBA
LpA

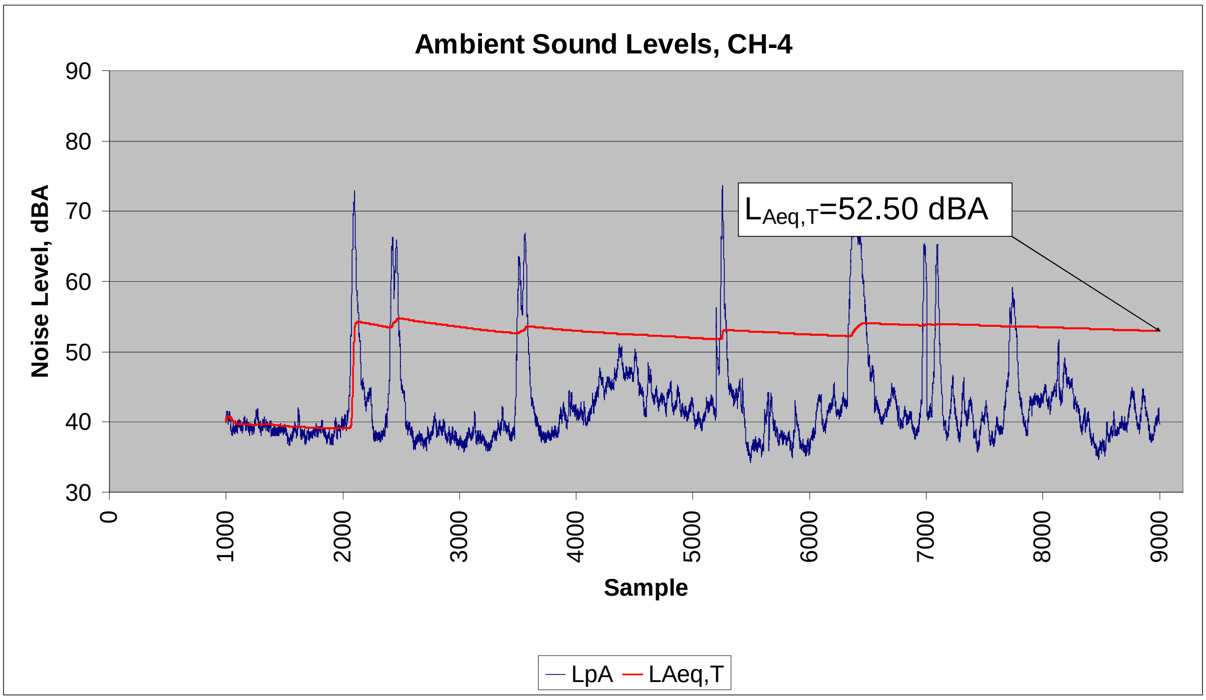

Ambient Sound Levels, AAN-05(N)
Noise Level, dBA
50
45
40
35
30
25
20
15
10
0
1000
2000
3000
4000
5000
6000
Sample
$L_{Aeq,T}$=27.5 dBA
LpA

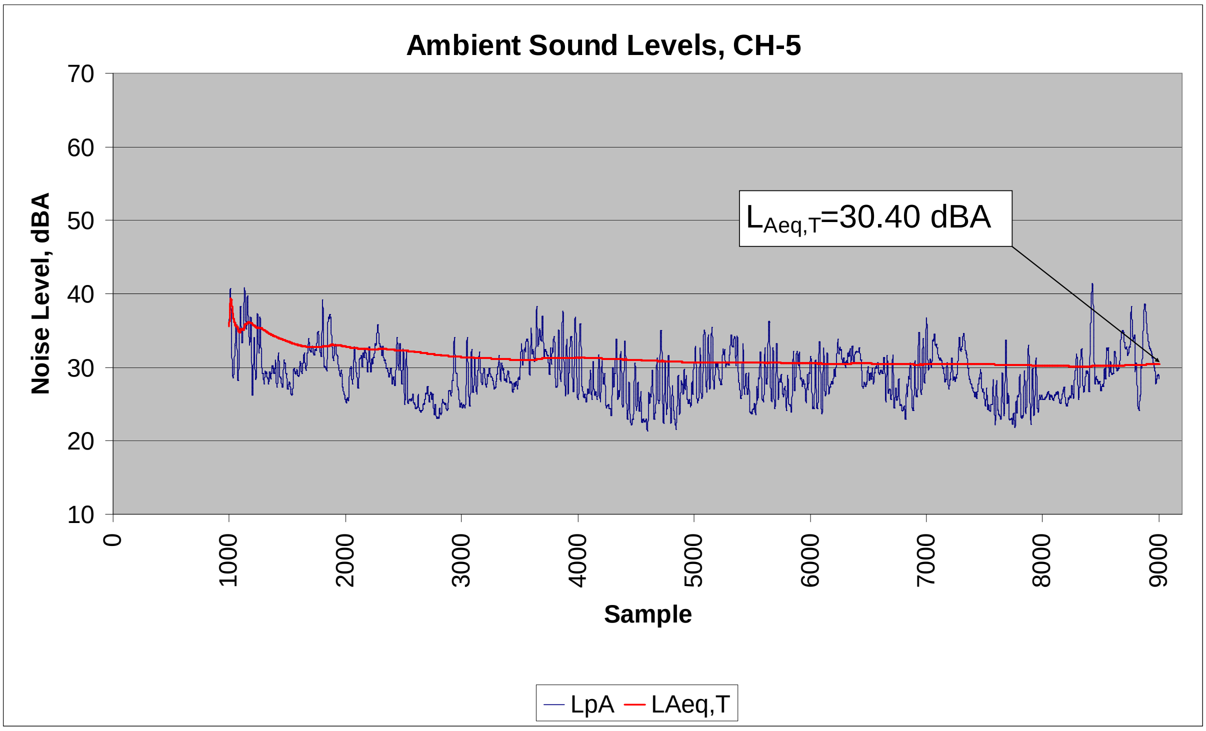

Ambient Sound Levels, AAN-06(N)
LAeq,T=28.7 dBA
Noise Level, dBA
50
45
40
35
30
25
20
15
10
0
1000
2000
3000
4000
5000
6000
Sample
LpA

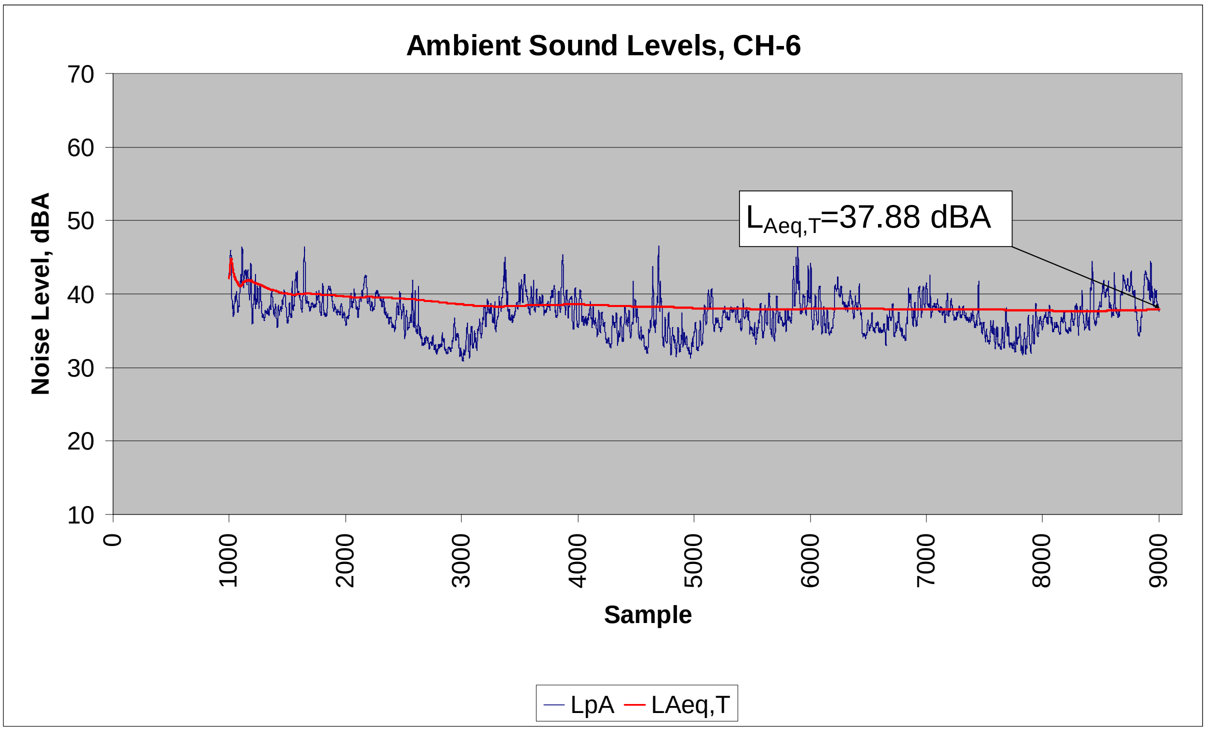

Ambient Sound Levels, CH-1 (between trees, wind audible)
LAeq,T=38.06 dBA
Noise Level, dBA
70
60
50
40
30
20
10
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Sample
LpA
LAeq,T


Ambient Sound Levels, CH-6 (7 PM)
Noise Level, dBA
70
60
50
40
30
20
10
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Sample
LAeq,T=38.75 dBA
LpA
LAeq,T


Ambient Sound Levels, CH-3 (Wind gusts)
Noise Level, dBA
70
60
50
40
30
20
10
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Sample
LAeq,T=32.93 dBA
LpA
LAeq,T


Ambient Sound Levels, CH-4
Noise Level, dBA
90
80
70
60
50
40
30
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Sample
LAeq,T=52.50 dBA
LpA
LAeq,T


Ambient Sound Levels, CH-5
Noise Level, dBA
70
60
50
40
30
20
10
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Sample
LAeq,T=30.40 dBA
LpA
LAeq,T


Ambient Sound Levels, CH-6
Noise Level, dBA
70
60
50
40
30
20
10
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Sample
LAeq,T=37.88 dBA
LpA
LAeq,T

APPENDIX B

TYPICAL SOUND POWER LEVELS, VARIOUS TYPES OF EQUIPMENT

Table B.1: Sound power level in various octave bands

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

APPENDIX C

SOUND PRESSURE LEVELS AT RECEPTORS ASSOCIATED WITH WIND TURBINES WITH ONLY AMAKHALA EMOYENI OPERATIONAL

Table C.1: Sound Pressure Levels at surrounding Receptors for a south-east wind blowing at 4 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	28.14	76	28.21	0.06	40.95
SR102	28.14	76	29.83	1.69	55.6
SR103	28.14	76	28.3	0.16	44.73
SR104	28.14	76	28.24	0.09	42.67
SR105	28.14	76	28.37	0.23	46.31
SR106	28.14	76	28.83	0.69	51
SR107	28.14	76	28.5	0.36	52.05
SR108	28.14	76	28.42	0.28	50.15
SR109	28.14	76	28.98	0.84	53.45
SR110	28.14	76	29	0.86	52.42
SR111	28.14	76	29.43	1.29	54.61
SR112	28.14	76	30.64	2.49	58.23
SR113	28.14	76	32.32	4.17	61.28
SR114	28.14	76	28.83	0.69	52.82
SR115	28.14	76	28.81	0.66	54.18
SR116	28.14	76	29.25	1.11	54.08
SR117	28.14	76	28.33	0.18	50.08
SR118	28.14	76	29.8	1.66	56.2
SR119	28.14	76	29.37	1.23	55.38
SR120	28.14	76	29.59	1.45	55.58
SR121	28.14	76	29.98	1.83	56.62
SR122	28.14	76	28.34	0.19	46.59
SR123	28.14	76	28.31	0.16	45.88
SR124	28.14	76	29.77	1.62	56.76
SR125	28.14	76	29.87	1.73	57.35
SR126	28.14	76	31.34	3.2	60.09
SR127	28.14	76	30.39	2.24	59
SR128	28.14	76	30.18	2.03	58.24
SR129	28.14	76	28.17	0.02	39.74
SR130	28.14	76	28.17	0.02	39.85
SR131	28.14	76	28.19	0.04	43.2
SR132	28.14	76	28.18	0.04	42.26
SR133	28.14	76	28.24	0.09	47.42
SR134	28.14	76	28.22	0.07	45.72
SR135	28.14	76	28.26	0.11	48.19
SR136	28.14	76	28.32	0.17	48.57
SR137	28.14	76	28.6	0.45	53.95
SR138	28.14	76	30.1	1.96	57.88
SR139	28.14	76	28.23	0.09	47.6
SR140	28.14	76	28.39	0.24	52.04
SR141	28.14	76	28.33	0.19	46.09
SR142	28.14	76	28.2	0.06	44.84

Table C.2: Sound Pressure Levels at surrounding Receptors for a north-west wind blowing at 4 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	28.14	76	28.16	0.01	36.8
SR102	28.14	76	28.32	0.17	51.18
SR103	28.14	76	28.17	0.03	40.42
SR104	28.14	76	28.16	0.02	38.28
SR105	28.14	76	28.17	0.03	41.67
SR106	28.14	76	28.21	0.07	46.22
SR107	28.14	76	29.06	0.91	53.84
SR108	28.14	76	28.81	0.67	51.79
SR109	28.14	76	29.39	1.25	54.48
SR110	28.14	76	28.49	0.35	49.9
SR111	28.14	76	29.1	0.96	53.57
SR112	28.14	76	30.01	1.87	57.22
SR113	28.14	76	30.97	2.82	59.86
SR114	28.14	76	29.16	1.02	53.88
SR115	28.14	76	30.18	2.03	56.84
SR116	28.14	76	28.93	0.79	53.07
SR117	28.14	76	29.14	0.99	53.36
SR118	28.14	76	29.51	1.37	55.84
SR119	28.14	76	29.5	1.35	55.71
SR120	28.14	76	29.61	1.47	55.61
SR121	28.14	76	29.8	1.65	56.35
SR122	28.14	76	28.39	0.24	47.09
SR123	28.14	76	28.34	0.2	46.37
SR124	28.14	76	29.94	1.79	57.03
SR125	28.14	76	29.97	1.83	57.35
SR126	28.14	76	31.5	3.36	60.35
SR127	28.14	76	31.92	3.77	60.77
SR128	28.14	76	30.83	2.69	58.94
SR129	28.14	76	28.27	0.12	44.43
SR130	28.14	76	28.27	0.12	44.49
SR131	28.14	76	28.4	0.26	47.48
SR132	28.14	76	28.34	0.2	46.49
SR133	28.14	76	28.89	0.75	51.87
SR134	28.14	76	28.62	0.48	49.98
SR135	28.14	76	28.94	0.79	52.2
SR136	28.14	76	28.91	0.76	52.03
SR137	28.14	76	30.76	2.61	58.09
SR138	28.14	76	31.31	3.16	59.42
SR139	28.14	76	28.93	0.79	51.87
SR140	28.14	76	29.73	1.58	55.72
SR141	28.14	76	28.19	0.04	43.05
SR142	28.14	76	28.63	0.48	49.53

Table C.3: Sound Pressure Levels at surrounding Receptors for a South-east wind blowing at 7 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	35.05	86	35.18	0.13	53.17
SR102	35.05	86	37.98	2.93	67.84
SR103	35.05	86	35.32	0.27	56.27
SR104	35.05	86	35.21	0.16	54.21
SR105	35.05	86	35.47	0.42	58.16
SR106	35.05	86	36.15	1.1	62.54
SR107	35.05	86	35.62	0.57	63.39
SR108	35.05	86	35.56	0.51	61.86
SR109	35.05	86	36.43	1.38	65.07
SR110	35.05	86	36.44	1.39	64.04
SR111	35.05	86	37.12	2.07	66.22
SR112	35.05	86	38.78	3.73	69.9
SR113	35.05	86	40.81	5.76	72.88
SR114	35.05	86	36.33	1.28	64.68
SR115	35.05	86	36.16	1.11	65.72
SR116	35.05	86	36.85	1.8	65.74
SR117	35.05	86	35.35	0.3	61.45
SR118	35.05	86	37.87	2.82	68.2
SR119	35.05	86	37.09	2.04	67.06
SR120	35.05	86	37.38	2.33	67.2
SR121	35.05	86	37.94	2.89	68.36
SR122	35.05	86	35.41	0.36	58.45
SR123	35.05	86	35.36	0.31	57.75
SR124	35.05	86	37.69	2.64	68.5
SR125	35.05	86	37.57	2.52	68.68
SR126	35.05	86	39.68	4.63	71.72
SR127	35.05	86	38.55	3.5	70.65
SR128	35.05	86	38.29	3.24	69.85
SR129	35.05	86	35.09	0.04	51.06
SR130	35.05	86	35.09	0.04	51.17
SR131	35.05	86	35.12	0.07	54.54
SR132	35.05	86	35.11	0.06	53.6
SR133	35.05	86	35.21	0.16	58.82
SR134	35.05	86	35.17	0.12	57.12
SR135	35.05	86	35.24	0.19	59.65
SR136	35.05	86	35.34	0.29	59.95
SR137	35.05	86	35.82	0.77	65.5
SR138	35.05	86	38.6	3.55	70.1
SR139	35.05	86	35.19	0.14	59.03
SR140	35.05	86	35.4	0.35	63.3
SR141	35.05	86	35.39	0.34	57.84
SR142	35.05	86	35.13	0.08	55.99

Table C.4: Sound Pressure Levels at surrounding Receptors for a north-west wind blowing at 7 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	35.05	86	35.07	0.02	48.28
SR102	35.05	86	35.36	0.31	62.77
SR103	35.05	86	35.09	0.04	51.65
SR104	35.05	86	35.07	0.02	49.41
SR105	35.05	86	35.09	0.04	53.18
SR106	35.05	86	35.15	0.1	57.49
SR107	35.05	86	36.59	1.54	65.54
SR108	35.05	86	36.2	1.15	63.57
SR109	35.05	86	36.97	1.92	66
SR110	35.05	86	35.65	0.6	61.52
SR111	35.05	86	36.61	1.56	65.23
SR112	35.05	86	38.02	2.97	68.97
SR113	35.05	86	38.97	3.92	71.19
SR114	35.05	86	36.81	1.76	65.75
SR115	35.05	86	38.37	3.32	68.85
SR116	35.05	86	36.43	1.38	64.89
SR117	35.05	86	36.88	1.83	65.31
SR118	35.05	86	37.3	2.25	67.57
SR119	35.05	86	37.59	2.54	67.82
SR120	35.05	86	37.37	2.32	67.24
SR121	35.05	86	37.81	2.76	68.16
SR122	35.05	86	35.54	0.49	59.22
SR123	35.05	86	35.46	0.41	58.49
SR124	35.05	86	37.96	2.91	68.79
SR125	35.05	86	38.21	3.16	69.28
SR126	35.05	86	40.02	4.97	72.12
SR127	35.05	86	40.4	5.35	72.41
SR128	35.05	86	39.09	4.04	70.65
SR129	35.05	86	35.27	0.22	55.99
SR130	35.05	86	35.28	0.23	56.09
SR131	35.05	86	35.54	0.49	59.35
SR132	35.05	86	35.43	0.38	58.36
SR133	35.05	86	36.29	1.24	63.5
SR134	35.05	86	35.86	0.81	61.62
SR135	35.05	86	36.52	1.47	64.29
SR136	35.05	86	36.31	1.26	63.65
SR137	35.05	86	38.93	3.88	69.76
SR138	35.05	86	39.55	4.5	70.98
SR139	35.05	86	36.43	1.38	63.8
SR140	35.05	86	37.74	2.69	67.77
SR141	35.05	86	35.12	0.07	54.45
SR142	35.05	86	35.85	0.8	61.08

Table C.5: Sound Pressure Levels at surrounding Receptors for a north-east wind blowing at 7 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	35.05	86	35.07128	0.021276	48.28694
SR102	35.05	86	35.3615	0.311498	62.77624
SR103	35.05	86	35.2526	0.202596	55.19436
SR104	35.05	86	35.15736	0.107363	52.70192
SR105	35.05	86	35.11713	0.067132	53.86031
SR106	35.05	86	35.54664	0.496642	60.49477
SR107	35.05	86	35.51242	0.462419	63.05606
SR108	35.05	86	35.34398	0.29398	60.93941
SR109	35.05	86	37.08511	2.035114	66.22222
SR110	35.05	86	35.78289	0.732889	62.08008
SR111	35.05	86	37.05986	2.009857	66.1321
SR112	35.05	86	39.39504	4.345039	70.49009
SR113	35.05	86	40.76035	5.710346	72.7704
SR114	35.05	86	36.58203	1.532026	65.18627
SR115	35.05	86	36.44252	1.392518	66.33126
SR116	35.05	86	35.95418	0.904177	64.01901
SR117	35.05	86	35.64833	0.598328	62.53013
SR118	35.05	86	37.65708	2.607081	67.93227
SR119	35.05	86	36.91884	1.868842	66.95143
SR120	35.05	86	37.72873	2.678732	67.80627
SR121	35.05	86	38.13327	3.083273	68.658
SR122	35.05	86	35.61399	0.563991	59.68131
SR123	35.05	86	35.52541	0.475413	58.95337
SR124	35.05	86	37.46358	2.413583	68.1934
SR125	35.05	86	37.8624	2.812403	68.86047
SR126	35.05	86	40.08722	5.037217	72.08118
SR127	35.05	86	40.49795	5.447953	72.48189
SR128	35.05	86	38.91381	3.86381	70.44167
SR129	35.05	86	35.22694	0.176936	55.14783
SR130	35.05	86	35.22308	0.173082	55.14395
SR131	35.05	86	35.33727	0.287271	57.78289
SR132	35.05	86	35.28819	0.23819	56.93061
SR133	35.05	86	36.08871	1.038709	62.81193
SR134	35.05	86	35.53917	0.489168	60.27883
SR135	35.05	86	35.74293	0.692931	62.1268
SR136	35.05	86	36.1113	1.061303	63.10363
SR137	35.05	86	38.71808	3.668082	69.47171
SR138	35.05	86	38.92634	3.876342	70.41897
SR139	35.05	86	35.7646	0.714604	61.71486
SR140	35.05	86	36.22292	1.172917	65.14407
SR141	35.05	86	35.11213	0.062129	54.12994
SR142	35.05	86	35.8166	0.766599	60.91434

Table C.6: Sound Pressure Levels at surrounding Receptors for a south-west wind blowing at 7 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	35.05	86	35.19712	0.14712	53.43465
SR102	35.05	86	37.98153	2.931528	67.84432
SR103	35.05	86	35.13208	0.082082	53.10833
SR104	35.05	86	35.11565	0.065648	51.50198
SR105	35.05	86	35.42071	0.37071	57.63359
SR106	35.05	86	35.48259	0.432593	60.21468
SR107	35.05	86	37.63383	2.58383	67.20075
SR108	35.05	86	36.84049	1.790487	65.13585
SR109	35.05	86	36.25252	1.202521	64.64301
SR110	35.05	86	36.19093	1.140927	63.35979
SR111	35.05	86	36.05495	1.004955	64.06983
SR112	35.05	86	36.21201	1.162005	66.6429
SR113	35.05	86	38.0329	2.982899	70.42385
SR114	35.05	86	36.4788	1.428796	65.01776
SR115	35.05	86	38.13511	3.085106	68.5555
SR116	35.05	86	37.00664	1.956638	65.98196
SR117	35.05	86	36.73292	1.682924	65.13238
SR118	35.05	86	37.1707	2.120701	67.17346
SR119	35.05	86	37.59477	2.544771	67.83186
SR120	35.05	86	36.41488	1.364877	65.64305
SR121	35.05	86	36.82699	1.77699	66.736
SR122	35.05	86	35.11733	0.067326	54.56359
SR123	35.05	86	35.10953	0.059526	53.82959
SR124	35.05	86	38.38063	3.330631	69.24418
SR125	35.05	86	38.61279	3.562792	69.66346
SR126	35.05	86	39.03717	3.987172	71.18194
SR127	35.05	86	38.70769	3.657693	70.78583
SR128	35.05	86	38.91576	3.865763	70.39978
SR129	35.05	86	35.10349	0.053491	51.98382
SR130	35.05	86	35.10882	0.058816	52.28642
SR131	35.05	86	35.25965	0.209653	56.71256
SR132	35.05	86	35.20368	0.15368	55.58389
SR133	35.05	86	35.45841	0.408412	60.39419
SR134	35.05	86	35.37999	0.329986	59.26713
SR135	35.05	86	35.93496	0.884961	62.47206
SR136	35.05	86	35.43012	0.380125	60.53205
SR137	35.05	86	36.08927	1.039272	65.87652
SR138	35.05	86	38.70732	3.657324	70.18571
SR139	35.05	86	35.84314	0.793145	62.12999
SR140	35.05	86	37.42428	2.374284	67.13338
SR141	35.05	86	35.56079	0.510786	59.1924
SR142	35.05	86	35.15052	0.100519	56.29877

Table C.7: Wind Turbines with a risk to impact of sensitive receptors: South-east wind at 7 m/s

Location X	Location Y	Turbine	113	126	127
402674	6372388	53	27.3	0.0	0.0
402985	6371893	55	26.2	0.0	0.0
402559	6371737	56	30.9	0.0	0.0
402221	6371605	57	35.2	0.0	0.0
402184	6371252	58	31.9	0.0	0.0
401969	6370969	59	30.0	0.0	0.0
407004	6354550	201	0.0	0.0	25.7
408587	6356027	205	0.0	1.5	29.6
408737	6356364	206	0.0	2.9	25.3
412097	6357113	221	0.0	25.9	6.2
412681	6357658	240	0.0	26.9	2.0
412622	6358067	242	0.0	29.7	1.6
412712	6358517	244	0.0	29.3	0.7
412447	6359010	245	0.0	29.0	0.6

Table C.8: Wind Turbines with a risk to impact of sensitive receptors: South-west wind at 7 m/s

Location X	Location Y	Turbine	113	126	127
402221	6371605	57	26.4	0.0	0.0
402184	6371252	58	30.7	0.0	0.0
401969	6370969	59	30.0	0.0	0.0
407004	6354550	201	0.0	1.8	27.0
406256	6355146	202	0.0	1.1	25.4
406649	6355448	203	0.0	2.5	30.5
412097	6357113	221	0.0	25.9	0.0
410392	6357865	223	0.0	26.1	1.2
410540	6358205	224	0.0	28.7	0.0
410259	6358644	225	0.0	25.8	0.0
410462	6358913	226	0.0	25.8	0.0
410673	6359159	227	0.0	26.4	0.0

Table C.9: Wind Turbines with a risk to impact of sensitive receptors: North-east wind at 7 m/s

Location X	Location Y	Turbine	113	126	127
401055	6372944	49	27.0	0.0	0.0
402346	6372947	50	27.4	0.0	0.0
402058	6372623	51	32.8	0.0	0.0
402674	6372388	53	28.5	0.0	0.0
402985	6371893	55	26.2	0.0	0.0
402559	6371737	56	30.9	0.0	0.0
402221	6371605	57	34.0	0.0	0.0
408037	6356938	159	0.0	0.0	26.5
407819	6356674	160	0.0	0.0	30.1
407546	6356358	204	0.0	0.0	35.3
408587	6356027	205	0.0	0.0	29.6
408737	6356364	206	0.0	1.1	26.5

411092	6359242	228	0.0	29.2	5.2
412681	6357658	240	0.0	25.7	3.6
412622	6358067	242	0.0	28.5	3.3
412712	6358517	244	0.0	29.3	2.4
412447	6359010	245	0.0	30.3	2.3
412848	6359211	246	0.0	25.4	1.0
412322	6359710	247	0.0	25.3	1.3

Table C.10: Wind Turbines with a risk to impact of sensitive receptors: North-west wind at 7 m/s

Location X	Location Y	Turbine	113	126	127
401055	6372944	49	28.3	0.0	0.0
402346	6372947	50	26.1	0.0	0.0
402058	6372623	51	31.6	0.0	0.0
408037	6356938	159	0.0	8.2	26.5
407819	6356674	160	0.0	6.8	30.1
406649	6355448	203	0.0	0.8	30.5
407546	6356358	204	0.0	5.2	35.3
410540	6358205	224	0.0	28.7	1.5
410259	6358644	225	0.0	25.8	4.6
410462	6358913	226	0.0	27.0	3.2
410673	6359159	227	0.0	27.7	1.9
411092	6359242	228	0.0	30.4	0.7
410968	6359737	229	0.0	25.1	2.6

APPENDIX D

SOUND PRESSURE LEVELS AT RECEPTORS ASSOCIATED WITH WIND TURBINES WITH BOTH AMAKHALA EMOYENI AND COOKHOUSE OPERATIONAL

Table D.1: Sound Pressure Levels at surrounding Receptors for a south-east wind blowing at 7 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	35.05	86	35.2	0.2	44.0
SR102	35.05	86	38.1	3.0	57.2
SR103	35.05	86	41.8	6.7	62.9
SR104	35.05	86	38.5	3.4	58.7
SR105	35.05	86	37.0	2.0	56.4
SR106	35.05	86	39.5	4.5	60.9
SR107	35.05	86	35.7	0.7	53.0
SR108	35.05	86	35.6	0.6	51.6
SR109	35.05	86	36.8	1.8	55.9
SR110	35.05	86	38.4	3.3	58.6
SR111	35.05	86	49.0	14.0	70.3
SR112	35.05	86	41.4	6.4	64.2
SR113	35.05	86	41.4	6.4	63.6
SR114	35.05	86	36.4	1.3	54.0
SR115	35.05	86	36.2	1.1	55.0
SR116	35.05	86	36.9	1.8	55.0
SR117	35.05	86	35.4	0.3	50.7
SR118	35.05	86	37.9	2.8	57.4
SR119	35.05	86	37.1	2.1	56.2
SR120	35.05	86	37.4	2.3	56.3
SR121	35.05	86	38.0	2.9	57.5
SR122	35.05	86	35.4	0.4	47.6
SR123	35.05	86	35.4	0.3	46.9
SR124	35.05	86	37.7	2.7	57.6
SR125	35.05	86	37.6	2.5	57.8
SR126	35.05	86	39.7	4.6	60.8
SR127	35.05	86	38.6	3.5	59.8
SR128	35.05	86	38.3	3.2	59.0
SR129	35.05	86	35.1	0.0	40.2
SR130	35.05	86	35.1	0.0	40.3
SR131	35.05	86	35.1	0.1	43.7
SR132	35.05	86	35.1	0.1	42.7
SR133	35.05	86	35.2	0.2	47.9
SR134	35.05	86	35.2	0.1	46.2
SR135	35.05	86	35.3	0.2	48.8
SR136	35.05	86	35.3	0.3	49.1
SR137	35.05	86	35.8	0.8	54.6
SR138	35.05	86	38.6	3.6	59.2
SR139	35.05	86	35.2	0.2	48.1
SR140	35.05	86	35.4	0.4	52.4
SR141	35.05	86	35.4	0.4	47.0
SR142	35.05	86	35.1	0.1	45.1

Table D.2: Sound Pressure Levels at surrounding Receptors for a north-west wind blowing at 7 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	35.05	86	35.1	0.1	41.5
SR102	35.05	86	35.6	0.5	52.8
SR103	35.05	86	37.8	2.8	60.1
SR104	35.05	86	37.4	2.4	57.3
SR105	35.05	86	37.5	2.5	57.0
SR106	35.05	86	40.6	5.5	61.9
SR107	35.05	86	37.8	2.7	56.6
SR108	35.05	86	36.8	1.8	54.4
SR109	35.05	86	37.6	2.5	56.8
SR110	35.05	86	38.0	2.9	58.1
SR111	35.05	86	46.9	11.8	69.3
SR112	35.05	86	44.1	9.0	66.1
SR113	35.05	86	42.1	7.0	64.0
SR114	35.05	86	37.0	1.9	55.3
SR115	35.05	86	38.7	3.6	58.5
SR116	35.05	86	36.5	1.5	54.4
SR117	35.05	86	37.2	2.2	55.2
SR118	35.05	86	37.0	2.0	56.2
SR119	35.05	86	37.8	2.7	57.2
SR120	35.05	86	36.9	1.9	55.6
SR121	35.05	86	37.1	2.0	56.3
SR122	35.05	86	35.2	0.2	45.5
SR123	35.05	86	35.2	0.1	44.8
SR124	35.05	86	38.2	3.1	58.2
SR125	35.05	86	38.4	3.3	58.6
SR126	35.05	86	39.7	4.7	60.9
SR127	35.05	86	40.5	5.4	61.6
SR128	35.05	86	39.1	4.0	59.8
SR129	35.05	86	35.3	0.2	45.0
SR130	35.05	86	35.3	0.2	45.1
SR131	35.05	86	35.5	0.5	48.4
SR132	35.05	86	35.4	0.4	47.4
SR133	35.05	86	36.3	1.3	52.7
SR134	35.05	86	35.9	0.8	50.7
SR135	35.05	86	36.5	1.5	53.4
SR136	35.05	86	36.3	1.2	52.6
SR137	35.05	86	38.8	3.8	58.8
SR138	35.05	86	38.9	3.9	59.5
SR139	35.05	86	36.5	1.5	53.2
SR140	35.05	86	38.2	3.2	57.4
SR141	35.05	86	35.2	0.2	45.3
SR142	35.05	86	35.9	0.8	50.2

Table D.3: Sound Pressure Levels at surrounding Receptors for a north-east wind blowing at 7 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	35.05	86	35.1	0.0	39.9
SR102	35.05	86	35.4	0.4	52.4
SR103	35.05	86	36.7	1.7	59.0
SR104	35.05	86	35.8	0.7	55.2
SR105	35.05	86	37.4	2.3	56.6
SR106	35.05	86	37.7	2.7	59.7
SR107	35.05	86	35.6	0.5	52.6
SR108	35.05	86	35.4	0.3	50.6
SR109	35.05	86	37.3	2.3	56.4
SR110	35.05	86	36.9	1.8	56.8
SR111	35.05	86	44.1	9.0	68.2
SR112	35.05	86	43.0	8.0	65.2
SR113	35.05	86	41.6	6.6	63.7
SR114	35.05	86	36.7	1.6	54.7
SR115	35.05	86	36.6	1.5	55.8
SR116	35.05	86	36.0	1.0	53.5
SR117	35.05	86	35.7	0.6	51.7
SR118	35.05	86	37.7	2.7	57.2
SR119	35.05	86	37.0	1.9	56.2
SR120	35.05	86	37.7	2.7	56.9
SR121	35.05	86	38.1	3.1	57.8
SR122	35.05	86	35.6	0.6	48.8
SR123	35.05	86	35.5	0.5	48.1
SR124	35.05	86	37.5	2.4	57.3
SR125	35.05	86	37.9	2.8	58.0
SR126	35.05	86	40.1	5.0	61.2
SR127	35.05	86	40.5	5.5	61.6
SR128	35.05	86	38.9	3.9	59.5
SR129	35.05	86	35.2	0.2	44.3
SR130	35.05	86	35.2	0.2	44.3
SR131	35.05	86	35.3	0.3	46.9
SR132	35.05	86	35.3	0.2	46.1
SR133	35.05	86	36.1	1.0	51.9
SR134	35.05	86	35.5	0.5	49.4
SR135	35.05	86	35.8	0.7	51.2
SR136	35.05	86	36.1	1.1	52.2
SR137	35.05	86	38.7	3.7	58.6
SR138	35.05	86	38.9	3.9	59.5
SR139	35.05	86	35.8	0.7	50.8
SR140	35.05	86	36.2	1.2	54.2
SR141	35.05	86	35.1	0.1	43.3
SR142	35.05	86	35.8	0.8	50.0

Table D.4: Sound Pressure Levels at surrounding Receptors for a south-west wind blowing at 7 m/s

PSR	Associated A-Weighted Background Sound Level (dBA)	Estimated C-Weighted Background Sound Level (dBC)	A-weighted Sound Pressure Level due to WEF (dBA)	Change in A-weighted Sound Pressure Level due to WEF (dBA)	C-weighted Sound Pressure Level due to WEF (dBC)
SR101	35.05	86	35.3	0.2	45.1
SR102	35.05	86	38.2	3.2	57.4
SR103	35.05	86	42.8	7.7	63.8
SR104	35.05	86	39.7	4.6	60.0
SR105	35.05	86	37.5	2.4	56.8
SR106	35.05	86	41.3	6.2	62.5
SR107	35.05	86	37.9	2.8	56.8
SR108	35.05	86	37.1	2.0	55.0
SR109	35.05	86	37.4	2.4	56.6
SR110	35.05	86	39.2	4.2	59.5
SR111	35.05	86	49.1	14.0	70.5
SR112	35.05	86	42.8	7.7	65.2
SR113	35.05	86	41.7	6.6	63.7
SR114	35.05	86	36.6	1.5	54.5
SR115	35.05	86	38.2	3.1	57.8
SR116	35.05	86	37.1	2.0	55.3
SR117	35.05	86	36.8	1.7	54.3
SR118	35.05	86	37.2	2.1	56.4
SR119	35.05	86	37.6	2.6	57.0
SR120	35.05	86	36.4	1.4	54.7
SR121	35.05	86	36.8	1.8	55.8
SR122	35.05	86	35.1	0.1	43.7
SR123	35.05	86	35.1	0.1	43.0
SR124	35.05	86	38.4	3.3	58.3
SR125	35.05	86	38.6	3.6	58.8
SR126	35.05	86	39.0	4.0	60.3
SR127	35.05	86	38.7	3.7	59.9
SR128	35.05	86	38.9	3.9	59.5
SR129	35.05	86	35.1	0.1	41.1
SR130	35.05	86	35.1	0.1	41.4
SR131	35.05	86	35.3	0.2	45.8
SR132	35.05	86	35.2	0.2	44.7
SR133	35.05	86	35.5	0.4	49.5
SR134	35.05	86	35.4	0.3	48.4
SR135	35.05	86	35.9	0.9	51.6
SR136	35.05	86	35.4	0.4	49.6
SR137	35.05	86	36.1	1.0	55.0
SR138	35.05	86	38.7	3.7	59.3
SR139	35.05	86	35.8	0.8	51.2
SR140	35.05	86	37.4	2.4	56.2
SR141	35.05	86	35.6	0.5	48.3
SR142	35.05	86	35.2	0.1	45.4

Table D.5: Both facilities operational: Wind Turbines with a risk to impact of sensitive receptors: South-east wind at 7 m/s

Location X	Location Y	Amakhala Turbine	SR103	SR106	SR111	SR112	SR113	SR126	SR127
400287	6375803	41	0.0	26.6	9.8	0.0	0.0	0.0	0.0
401055	6372944	49	0.0	8.5	29.0	18.4	16.9	0.0	0.0
402058	6372623	51	0.0	5.4	20.5	25.2	24.0	0.0	0.0
402674	6372388	53	0.0	3.5	16.3	25.3	27.3	0.0	0.0
402985	6371893	55	0.0	1.7	13.1	23.1	26.2	0.0	0.0
402559	6371737	56	0.0	2.1	14.3	27.0	30.9	0.0	0.0
402221	6371605	57	0.0	2.3	15.0	30.4	35.2	0.0	0.0
402184	6371252	58	0.0	1.4	13.5	28.7	31.9	0.0	0.0
401969	6370969	59	0.0	1.0	12.8	28.1	30.0	0.0	0.0
407004	6354550	201	0.0	0.0	0.0	0.0	0.0	0.0	25.7
408587	6356027	205	0.0	0.0	0.0	0.0	0.0	1.5	29.6
408737	6356364	206	0.0	0.0	0.0	0.0	0.0	2.9	25.3
412097	6357113	221	0.0	0.0	0.0	0.0	0.0	25.9	6.2
412681	6357658	240	0.0	0.0	0.0	0.0	0.0	26.9	2.0
412622	6358067	242	0.0	0.0	0.0	0.0	0.0	29.7	1.6
412712	6358517	244	0.0	0.0	0.0	0.0	0.0	29.3	0.7
412447	6359010	245	0.0	0.0	0.0	0.0	0.0	29.0	0.6
Location X	**Location Y**	**Cookhouse Turbine**	**SR103**	**SR106**	**SR111**	**SR112**	**SR113**	**SR126**	**SR127**
401014	6371406	16	0.0	3.2	17.1	35.5	24.1	0.0	0.0
400730	6371686	17	0.0	4.3	19.3	27.6	19.9	0.0	0.0
401010	6372306	26	0.0	6.2	23.4	28.9	23.2	0.0	0.0
400758	6372552	27	0.0	7.4	26.2	21.6	18.0	0.0	0.0
400854	6373362	28	0.0	10.7	35.7	13.5	12.3	0.0	0.0
400573	6373652	29	0.0	12.6	48.0	10.4	9.3	0.0	0.0
400128	6373155	30	0.0	10.8	32.0	11.8	9.8	0.0	0.0
400174	6374053	31	0.0	15.4	33.0	6.8	5.8	0.0	0.0
400096	6375790	38	0.0	27.8	9.8	0.0	0.0	0.0	0.0
398515	6375702	56	0.0	25.3	5.3	0.0	0.0	0.0	0.0
399172	6375887	173	0.0	32.0	6.9	0.0	0.0	0.0	0.0
404480	6380751	184	39.7	0.0	0.0	0.0	0.0	0.0	0.0
404039	6380031	185	25.9	1.1	0.0	0.0	0.0	0.0	0.0
405261	6380223	186	29.5	0.0	0.0	0.0	0.0	0.0	0.0
404742	6379676	192	25.4	0.0	0.0	0.0	0.0	0.0	0.0

Table D.6: Both facilities operational: Wind Turbines with a risk to impact of sensitive receptors: South-west wind at 7 m/s

Location X	Location Y	Amakhala Turbine	SR103	SR106	SR111	SR112	SR113	SR126	SR127
402221	6371605	57	0.0	0.6	13.6	19.1	26.4	0.0	0.0
402184	6371252	58	0.0	0.0	12.1	19.8	30.7	0.0	0.0
401969	6370969	59	0.0	0.0	11.4	26.8	30.0	0.0	0.0
407004	6354550	201	0.0	0.0	0.0	0.0	0.0	1.8	27.0
406256	6355146	202	0.0	0.0	0.0	0.0	0.0	1.1	25.4
406649	6355448	203	0.0	0.0	0.0	0.0	0.0	2.5	30.5
412097	6357113	221	0.0	0.0	0.0	0.0	0.0	25.9	0.0
410392	6357865	223	0.0	0.0	0.0	0.0	0.0	26.1	1.2
410540	6358205	224	0.0	0.0	0.0	0.0	0.0	28.7	0.0
410259	6358644	225	0.0	0.0	0.0	0.0	0.0	25.8	0.0
410462	6358913	226	0.0	0.0	0.0	0.0	0.0	25.8	0.0
410673	6359159	227	0.0	0.0	0.0	0.0	0.0	26.4	0.0
Location X	**Location Y**	**Cookhouse Turbine**	**SR103**	**SR106**	**SR111**	**SR112**	**SR113**	**SR126**	**SR127**
401014	6371406	16	0.0	3.2	17.1	36.7	32.9	0.0	0.0
400730	6371686	17	0.0	4.3	19.3	36.4	31.1	0.0	0.0
400437	6371974	18	0.0	5.6	21.5	32.3	27.9	0.0	0.0
400187	6372202	19	0.0	6.6	23.2	28.6	25.2	0.0	0.0
399630	6372742	21	0.0	9.2	25.8	20.6	18.3	0.0	0.0
401010	6372306	26	0.0	4.6	23.4	31.2	33.1	0.0	0.0
400758	6372552	27	0.0	7.4	26.2	24.0	28.1	0.0	0.0
400854	6373362	28	0.0	9.2	34.5	13.5	14.7	0.0	0.0
400573	6373652	29	0.0	11.1	46.5	12.8	11.6	0.0	0.0
400128	6373155	30	0.0	10.8	33.2	18.5	19.9	0.0	0.0
400174	6374053	31	0.0	15.4	42.6	9.1	8.0	0.0	0.0
399329	6373027	33	0.0	10.6	25.7	17.7	15.6	0.0	0.0
399938	6374265	35	0.0	17.0	34.4	7.3	6.2	0.0	0.0
400096	6375790	38	0.0	26.5	9.8	0.0	0.4	0.0	0.0
399363	6373876	40	0.0	15.1	29.0	11.1	13.0	0.0	0.0
399108	6374149	41	0.0	16.7	26.0	8.9	7.6	0.0	0.0
398515	6375702	56	0.0	26.5	11.4	0.0	0.0	0.0	0.0
398807	6375392	57	0.0	25.3	14.2	0.0	0.0	0.0	0.0
398053	6376099	61	0.0	25.4	8.0	0.0	0.0	0.0	0.0
398375	6376700	62	0.0	30.6	3.1	0.0	0.0	0.0	0.0
398136	6376960	65	0.0	27.5	1.6	0.0	0.0	0.0	0.0
398751	6377226	67	0.0	32.3	2.0	0.0	0.0	0.0	0.0
399172	6375887	173	0.0	32.0	9.1	0.0	0.0	0.0	0.0
403515	6381213	176	28.0	0.0	0.0	0.0	0.0	0.0	0.0
404480	6380751	184	41.0	0.0	0.0	0.0	0.0	0.0	0.0
404039	6380031	185	27.1	0.0	0.0	0.0	0.0	0.0	0.0
405261	6380223	186	28.3	0.0	0.0	0.0	0.0	0.0	0.0
404742	6379676	192	25.4	0.0	0.0	0.0	0.0	0.0	0.0

Table D.7: Wind Turbines with a risk to impact of sensitive receptors: North-east wind at 7 m/s

Location X	Location Y	Amakhala Turbine	SR103	SR106	SR111	SR112	SR113	SR126	SR127
400590	6375292	43	0.0	12.5	25.6	12.0	11.5	0.0	0.0
401055	6372944	49	0.0	0.4	20.0	29.8	27.0	0.0	0.0
402346	6372947	50	0.0	0.0	18.7	25.2	27.4	0.0	0.0
402058	6372623	51	0.0	0.0	19.2	29.8	32.8	0.0	0.0
402674	6372388	53	0.0	0.0	14.9	25.3	28.5	0.0	0.0
402985	6371893	55	0.0	0.0	11.7	23.1	26.2	0.0	0.0
402559	6371737	56	0.0	0.0	9.5	27.0	30.9	0.0	0.0
402221	6371605	57	0.0	0.0	6.3	30.4	34.0	0.0	0.0
402184	6371252	58	0.0	0.0	4.9	27.5	23.1	0.0	0.0
408037	6356938	159	0.0	0.0	0.0	0.0	0.0	0.0	26.5
407819	6356674	160	0.0	0.0	0.0	0.0	0.0	0.0	30.1
407546	6356358	204	0.0	0.0	0.0	0.0	0.0	0.0	35.3
408587	6356027	205	0.0	0.0	0.0	0.0	0.0	0.0	29.6
408737	6356364	206	0.0	0.0	0.0	0.0	0.0	1.1	26.5
411092	6359242	228	0.0	0.0	0.0	0.0	0.0	29.2	5.2
412681	6357658	240	0.0	0.0	0.0	0.0	0.0	25.7	3.6
412622	6358067	242	0.0	0.0	0.0	0.0	0.0	28.5	3.3
412712	6358517	244	0.0	0.0	0.0	0.0	0.0	29.3	2.4
412447	6359010	245	0.0	0.0	0.0	0.0	0.0	30.3	2.3
412848	6359211	246	0.0	0.0	0.0	0.0	0.0	25.4	1.0
412322	6359710	247	0.0	0.0	0.0	0.0	0.0	25.3	1.3
Location X	Location Y	Cookhouse Turbine	SR103	SR106	SR111	SR112	SR113	SR126	SR127
401014	6371406	16	0.0	0.0	6.1	25.7	21.7	0.0	0.0
400730	6371686	17	0.0	0.0	8.0	25.3	19.9	0.0	0.0
401010	6372306	26	0.0	0.0	12.0	38.6	25.5	0.0	0.0
400758	6372552	27	0.0	0.0	14.8	31.6	20.4	0.0	0.0
400854	6373362	28	0.0	2.3	27.0	24.9	22.4	0.0	0.0
400573	6373652	29	0.0	4.0	39.1	20.5	19.3	0.0	0.0
400174	6374053	31	0.0	4.6	35.2	16.7	15.5	0.0	0.0
400635	6374504	32	0.0	8.0	35.6	16.3	14.3	0.0	0.0
400396	6374725	34	0.0	9.9	32.2	14.7	12.6	0.0	0.0
399938	6374265	35	0.0	6.0	26.8	14.7	13.6	0.0	0.0
400208	6375023	36	0.0	12.4	28.1	12.8	10.7	0.0	0.0

Table D.8: Wind Turbines with a risk to impact of sensitive receptors: North-west wind at 7 m/s

Location X	Location Y	Amakhala Turbines	SR103	SR106	SR111	SR112	SR113	SR126	SR127
400590	6375292	43	0.0	10.1	25.6	12.0	11.5	0.0	0.0
401055	6372944	49	0.0	0.0	17.6	29.8	28.3	0.0	0.0
402346	6372947	50	0.0	0.0	8.7	20.5	26.1	0.0	0.0
402058	6372623	51	0.0	0.0	9.2	25.2	31.6	0.0	0.0
408037	6356938	159	0.0	0.0	0.0	0.0	0.0	8.2	26.5
407819	6356674	160	0.0	0.0	0.0	0.0	0.0	6.8	30.1
406649	6355448	203	0.0	0.0	0.0	0.0	0.0	0.8	30.5
407546	6356358	204	0.0	0.0	0.0	0.0	0.0	5.2	35.3
410540	6358205	224	0.0	0.0	0.0	0.0	0.0	28.7	1.5
410259	6358644	225	0.0	0.0	0.0	0.0	0.0	25.8	4.6
410462	6358913	226	0.0	0.0	0.0	0.0	0.0	27.0	3.2
410673	6359159	227	0.0	0.0	0.0	0.0	0.0	27.7	1.9
411092	6359242	228	0.0	0.0	0.0	0.0	0.0	30.4	0.7
410968	6359737	229	0.0	0.0	0.0	0.0	0.0	25.1	2.6
Location X	**Location Y**	**Cookhouse Turbines**	**SR103**	**SR106**	**SR111**	**SR112**	**SR113**	**SR126**	**SR127**
401014	6371406	16	0.0	0.0	6.1	27.9	31.7	0.0	0.0
400730	6371686	17	0.0	0.0	8.0	35.2	31.1	0.0	0.0
400437	6371974	18	0.0	0.0	10.1	32.3	27.9	0.0	0.0
400187	6372202	19	0.0	0.0	11.7	28.6	25.2	0.0	0.0
401010	6372306	26	0.0	0.0	12.0	39.9	34.3	0.0	0.0
400758	6372552	27	0.0	0.0	14.8	32.8	29.4	0.0	0.0
400573	6373652	29	0.0	2.1	37.0	21.8	20.6	0.0	0.0
400174	6374053	31	0.0	4.6	44.0	18.0	16.8	0.0	0.0
400635	6374504	32	0.0	5.8	35.6	16.3	15.7	0.0	0.0
400396	6374725	34	0.0	7.6	32.2	14.7	14.0	0.0	0.0
399938	6374265	35	0.0	6.0	35.6	16.1	15.0	0.0	0.0
400208	6375023	36	0.0	10.0	28.1	12.8	12.1	0.0	0.0
399797	6375135	37	0.0	12.0	25.6	11.5	10.7	0.0	0.0
399363	6373876	40	0.0	4.3	29.0	15.8	14.4	0.0	0.0
399108	6374149	41	0.0	5.7	26.0	13.7	12.4	0.0	0.0
398375	6376700	62	0.0	30.6	11.6	3.2	2.6	0.0	0.0
398136	6376960	65	0.0	27.5	9.9	2.1	1.6	0.0	0.0
398751	6377226	67	0.0	33.5	10.3	2.3	1.8	0.0	0.0
398464	6377516	68	0.0	28.1	8.6	1.2	0.8	0.0	0.0
403515	6381213	176	28.0	0.0	0.0	0.0	0.0	0.0	0.0
404480	6380751	184	32.3	0.0	0.0	0.0	0.0	0.0	0.0