Appendix 8.5

Noise Impact Assessment

SAFETECH

ENVIRONMENT
HEALTH
SAFETY

ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED KERRIE FONTEIN AND DARLING WIND FARM IN THE WESTERN CAPE PROVINCE

SPECIALIST STUDY ON NOISE IMPACTS

Health and Welfare Sector Education and Training Authority
HWSETA
HW592PA0600140

Northern Office: PO Box 80171, Doornpoort, Pretoria, 0017
Tel: +27 (0)82 411 1571/ Fax: +27 (0)86 6579864
Southern Office: PO Box 27607, Greenacres, Port Elizabeth 6057
Tel: +27 (0)41 3656846 / Fax: +27 (0)41 3652123
info@safetechsa.co.za /
www.safetechsa.co.za
Safetrain cc T/A Safetech Reg. No CK /92/34818/23
VAT No. 4180135461

DOL Approved Inspection Authority (CI049)

TABLE OF CONTENTS

List of Tables

List of Figures

Amendment History

Version 1	Original Issue	5th June 2011
Version 2	First review changes, Modelling Option 2 Turbine change to Nordex N60 Turbine	24th June 2011
Version 3	Second review changes. No substantive changes were made.	15th July 2011

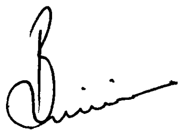
INFORMATION PAGE

CLIENT NAME	University of Cape Town - EEU
PROJECT	Kerrie Fontein and Darling Wind Farm in the Western Cape
CONTACT PERSON	Mrs Sandra Rippon
TYPE OF SURVEY	Noise Specialist Study as part of the Environmental Impact Assessment for the Kerrie Fontein and Darling Wind Farm
DATE OF FIELD SURVEY	28th April 2011
REPORT PREPARED BY	Brett Williams

This report only pertains to the conditions found at the above site at the time of the survey. This report may not be copied electronically, physically or otherwise, except in its entirety. If sections of the report are to be copied the approval of the author, in writing, is required.

....

B WILLIAMS

DECLARATION OF INDEPENDENCE	
Noise Impact Assessment	I Brett Williams declare that I am an independent consultant and have no business, financial, personal or other interest in the proposed Kerriefontein And Darling Wind Farm in the Western Cape province, application or appeal in respect of which I was appointed, other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of my performing such work.  SIGNATURE:

EXECUTIVE SUMMARY

Safetech were appointed to conduct a specialist noise study for an environmental impact assessment for construction of Kerriefontein And Darling Wind Farm in the Western Cape province. The project will generate electricity and will be operated by the Oelsner Group.

The study considered the site location as described in the Final Scoping Report (University of Cape Town Environmental Management Unit Report Number 8/10/306 of 14th December 2010: Final Scoping Report Kerrie Fontein And Darling Wind Farm). A literature review and desktop modelling was conducted. Baseline monitoring was conducted of the ambient noise levels at and adjacent to the site.

The results of the study indicate that the following conclusions can be drawn:

1) There will be a short term increase in noise in the vicinity of the site during the construction phase as the ambient level will be exceeded. The impact during the construction phase will difficult to mitigate.

2) The impact of low frequency noise and infra sound will be negligible and there is no evidence to suggest that adverse health effects will occur as the sound power levels generated in the low frequency range are not high enough to cause physiological effects.

3) Option 1 - The noise produced by the wind turbines will exceed the 45dB(A) day/night limit at the Windhoek Farm Workers homes at 12m/s wind speed.
4) Option 2 - The noise produced by the wind turbines will exceed the 45dB(A) day/night limit at the Windhoek Farm Workers homes at 11m/s and 12m/s wind speed.
5) The location of the Option 1 & 2 wind turbine generators all met the recommended 500m setback distance from the existing noise sensitive receptors.

As the wind speed increases, the ambient noise also increases and masks the wind turbine noise. The critical wind speeds are thus between 4-8m/s when there is a possibility of little masking. At 11m/s and 12m/s the wind speed is such that it is highly unlikely that the turbine noise will be heard.

The following is recommended:

Construction Activities

a) All construction operations should only occur during daylight hours if possible.

b) No construction piling should occur at night. Piling should only occur during the day to take advantage of unstable atmospheric conditions.
c) Construction staff should receive “noise sensitivity” training.
d) An ambient noise survey should be conducted during the construction phase.

Operational Activities

a) The noise impact from the wind turbine generators should be measured during the operational phase, to ensure that the impact is within the recommended rating limits.

Brett Williams

GLOSSARY OF TERMS & DEFINITIONS	
Ambient noise	Totally encompassing sound in a given situation at a given time, and usually composed of sound from many sources, both near and far. **Note:** Ambient noise includes the noise from the noise source under investigation.
Annoyance	General negative reaction of the community or person to a condition creating displeasure or interference with specific activities
A-weighted sound pressure level (L_{pA} and $L_{Aeq,T}$)	A-weighted sound level L_{pA} which is the sound pressure level at specific frequencies and is given using the following equation: $L_{pA} = 10\text{Log}\left(\frac{P_A}{P_O}\right)^2$ Where: *PA* = is the root-mean-square sound pressure, using the frequency weighting network A *PO* = is the reference sound pressure (*PO* = 20 μPa). A-weighted sound pressure level is expressed in decibels dBA **Note:** For clarity in this study L_{pA} shall equal $L_{Aeq,T}$
dBA	The decibel is the unit used to measure sound pressure levels. The human ear does not perceive all sound pressures equally at all frequencies. The "A" weighted scale adjusts the measurement to approximate a human ear response.
Equivalent continuous day/night rating level ($L_{R,dn}$)	Equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$) during a reference time interval of 24 h, plus specified adjustments for tonal character, impulsiveness of the sound and the time of day; and derived from the following equation: $L_{R,dn} = 10Log\left[\left(\frac{d}{24}\right)10^{L_{Req,d}/10} + \left(\frac{24-d}{24}\right)10^{(L_{Req,n}+K_n)/10}\right]$dB Where: $L_{R,dn}$ is the equivalent continuous day/night rating level; *d* is the number of daytime hours; $L_{Req,d}$ is the rating level for daytime; $L_{Req,n}$ is the rating level for night-time; K_n is the adjustment of 10 dB added to the night-time rating level.

GLOSSARY OF TERMS & DEFINITIONS	
High-energy impulsive sound	Sound from one of the following categories of sound sources: quarry and mining explosions, sonic booms, demolition and industrial processes that use high explosives, explosive industrial circuit breakers, military ordnance (e.g. armour, artillery, mortar fire, bombs, explosive ignition of rockets and missiles), or any other explosive source where the equivalent mass of TNT exceeds 25 g, or a sound with comparable characteristics and degree of intrusiveness
Highly impulsive sound	sound from one of the following categories of sound sources: small arms fire, metal hammering, wood hammering, drop-hammer pile driver, drop forging, pneumatic hammering, pavement breaking, or metal impacts of rail yard shunting operations, or sound with comparable characteristics and degree of intrusiveness
Infra sound	Sound which predominantly contains sound energy at frequencies below 10 Hz
Low frequency noise	Sound which predominantly contains sound energy at frequencies below 100 Hz
MW	Mega Watt of electricity (1000 kilowatts)
NSA	Noise Sensitive Area
Reference time interval	Representative duration of time periods that are regarded as typical for sound exposure of the community within a period of 24 h: – Daytime: 06:00 to 22:00 – Night-time: 22:00 to 06:00
Residual noise	Totally encompassing sound in a given situation at a given time, and usually composed of sound from many sources, both near and far, excluding the noise under investigation
Specific noise	Component of the ambient noise which can be specifically identified by acoustical means and which may be associated with a specific source **Note:** Complaints about noise usually arise as a result of one or more specific noises.
WTG	Wind Turbine Generator

1.0 INTRODUCTION

1.1 Introduction

The Oelsner Group plans to develop a wind power generation facility on the farms known as Kerriefontein (0/555) and a portion of the farm Slangkop (3/552) known as Windhoek, in the Darling district in the Western Cape of South Africa. The proposed project is an extension of the existing four Fuhrländer Wind Turbine Generators.

1.2 Project Description

Two options have been investigated, namely 14 additional WTG's (referred to as Option 1) and 16 additional WTG's (referred to as Option 2). The additional turbines will be the Nordex S77 model (this unit is the same as the Nordex N77) for the Option 1 layout. The Option 2 layout will use the Nordex N60 turbine.

1.2.1 Site Location

The location and position of the various wind turbines are contained in the table and figures below. The initial locations have changed as the modelling showed where the various impacts would occur.

Table 1- WTG co-ordinates proposed for the project

WTG #	Longitude (E)	Latitude (S)
Existing Turbines		
E1	18°15'42.98"	33°18'56.41"
E2	18°15'36.93"	33°18'59.42"
E3	18°15'31.07"	33°19'02.14"
E4	18°15'24.69"	33°19'05.00"
Option 1		
1	18°15'31.46"	33°18'41.09"
2	18°15'23.34"	33°18'45.03"
3	18°15'15.35"	33°18'48.73"
4	18°15'07.12"	33°18'52.55"
5	18°14'59.13"	33°18'56.25"
6	18°14'51.01"	33°18'59.94"

WTG #	Longitude (E)	Latitude (S)
7	18°14'42.90"	33°19'03.76"
8	18°14'35.03"	33°19'07.58"
9	18°14'26.79"	33°19'11.52"
10	18°14'44.57"	33°19'24.52"
11	18°14'52.44"	33°19'20.70"
12	18°15'00.68"	33°19'16.89"
13	18°15'08.55"	33°19'13.19"
14	18°15'16.78"	33°19'09.37"
Option 2		
1	18°15'31.48"	33°18'41.10"
2	18°15'23.37"	33°18'44.72"
3	18°15'15.41"	33°18'48.74"
4	18°15'07.30"	33°18'52.52"
5	18°14'59.19"	33°18'56.30"
6	18°14'51.08"	33°19'00.08"
7	18°14'42.96"	33°19'03.87"
8	18°14'34.83"	33°19'07.52"
9	18°14'26.58"	33°19'11.37"
10	18°14'18.39"	33°19'15.19"
11	18°14'47.25"	33°19'22.28"
12	18°14'53.29"	33°19'19.43"
13	18°14'59.37"	33°19'16.55"
14	18°15'05.42"	33°19'13.66"
15	18°15'11.50"	33°19'10.78"
16	18°15'17.54"	33°19'07.93"

Figure 1 - NSA's & Wind turbine locations (Option 1 and Existing Turbines)

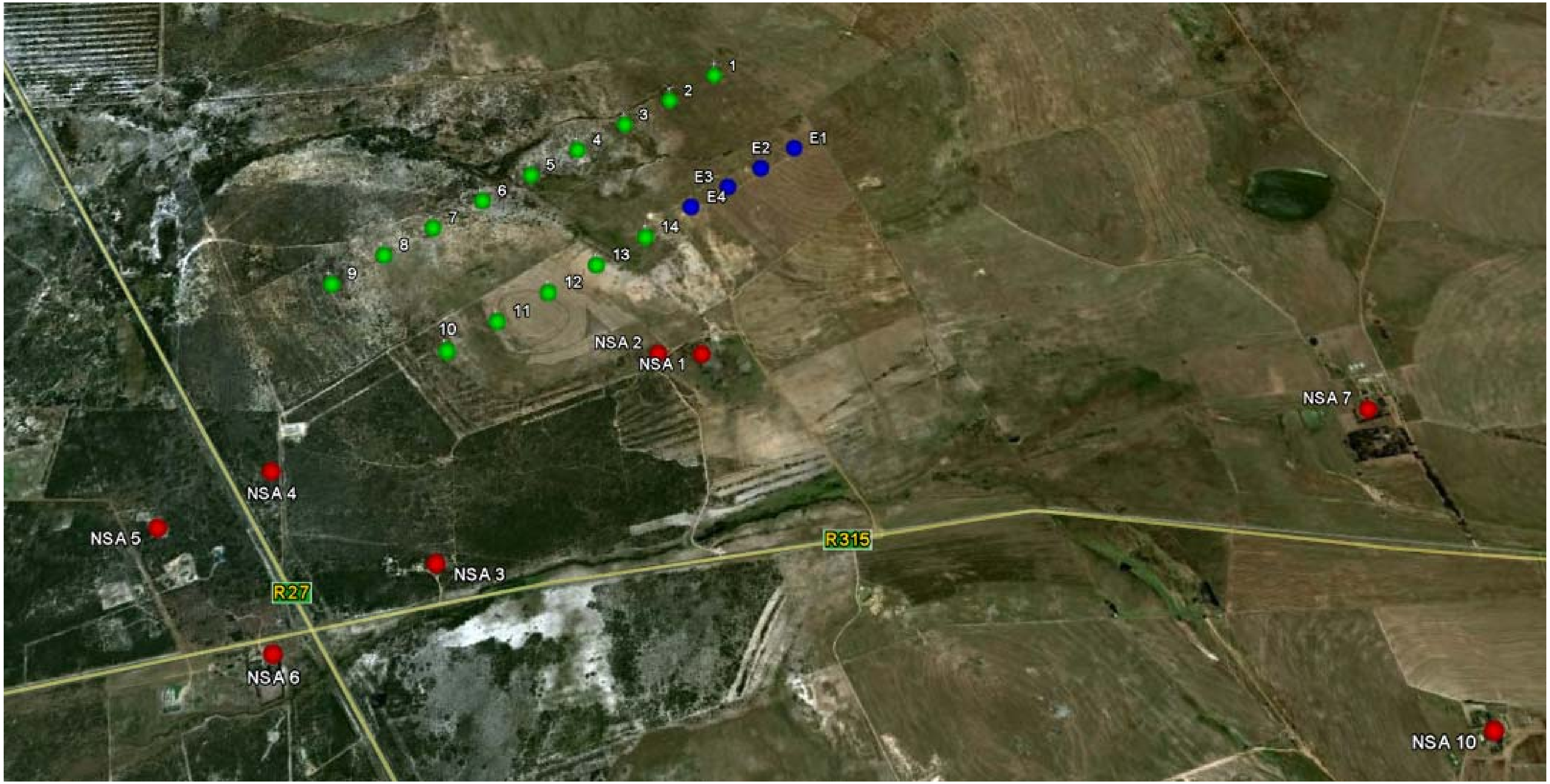
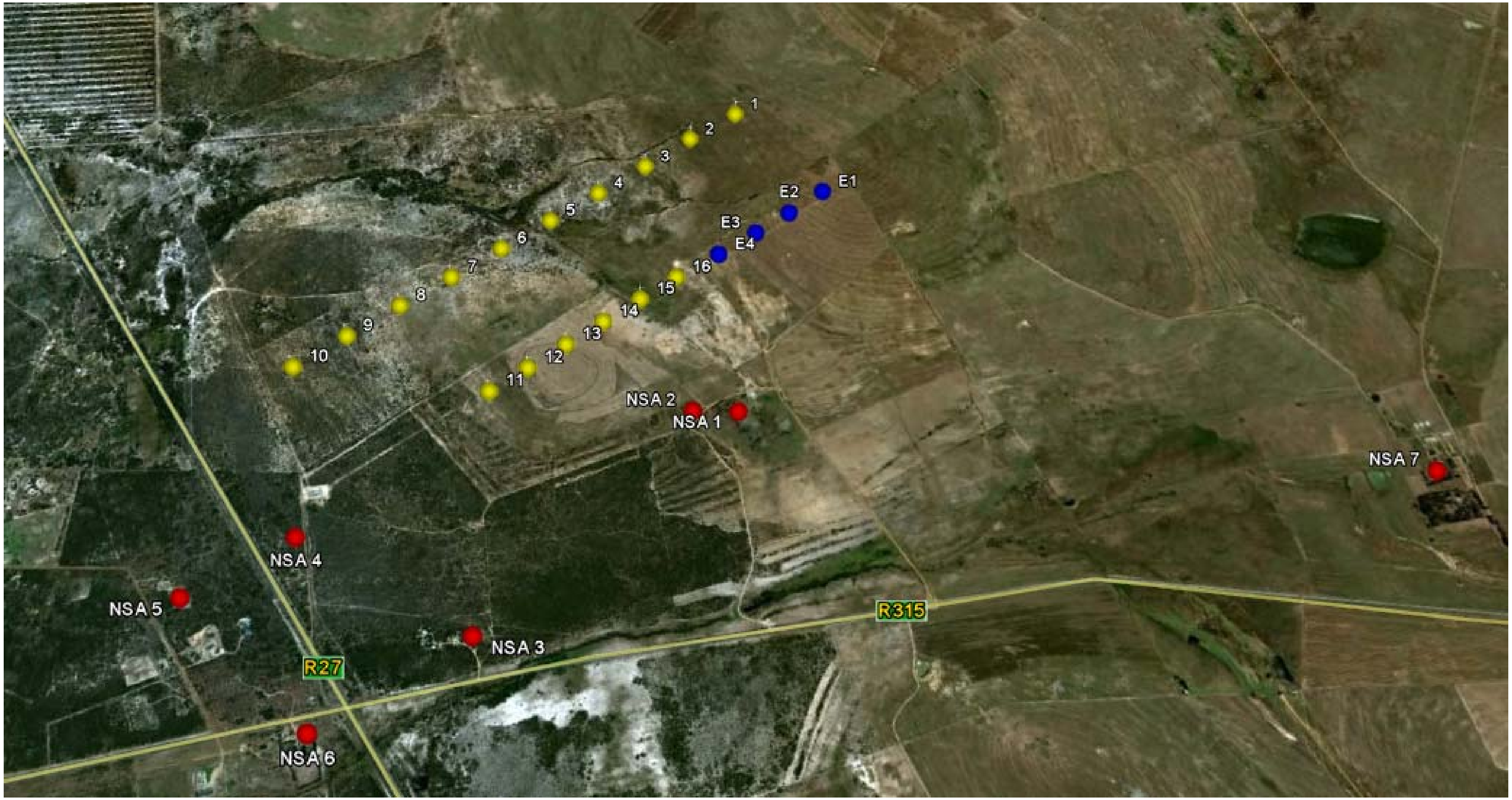


Figure 2 - NSA's & Wind turbine locations (Layout 2 + Existing Turbines)



2.0 APPLICABLE LEGISLATION & STANDARDS

South Africa has noise legislation or standards that could be applicable to the project. The final scoping report has identified that the applicable environmental legislation places a general onus on the developer to ensure that the environment is not affected negatively by the development.

The following legislation and standards have been used to aid the study and guide the decision making process with regards to noise pollution:

National

- South Africa - GNR.154 of January 1992: Noise control regulations in terms of section 25 of the Environment Conservation Act (ECA), 1989 (Act No. 73 of 1989).
- South Africa - GNR.155 of 10 January 1992: Application of noise control regulations made under section 25 of the Environment Conservation Act, 1989 (Act No. 73 of 1989).

Provincial

- Provincial Government of the Western Cape - Strategic Initiative to Introduce Commercial Land Based Wind Energy Development to the Western Cape- Towards a Regional Methodology for Wind Energy Site Selection (May 2006).
- Provincial Government of the Western Cape – PN 627 (1998) Noise Control Regulations.

National Standards

- South Africa - SANS 10103:2008 Version 6 - The measurement and rating of environmental noise with respect to annoyance and to speech communication.
- South Africa - SANS 10210:2004 Edition 2.2 – Calculating and predicting road traffic noise.
- South Africa - SANS 10357:2004 Version 2.1 - The calculation of sound propagation by the Concawe method.
- International Finance Corporation – 2007 General EHS Guidelines: Environmental Noise.

2.1 Discussion – National & Provincial Legislation

The South African noise control regulations (National and Provincial) describe a *disturbing noise* as **any** noise that exceeds the ambient noise by more than 7dB. This difference is usually measured at the complainants location should a noise complaint arise. Therefore, if a new noise source is introduced into the environment, irrespective of the current noise levels, and the new source is louder than the existing ambient environmental noise by more than 7dB, the complainant will have a legitimate complaint. A noise *disturbance or nuisance* as defined in the national and provincial legislation means any sound which disturbs or impairs the convenience of any person. The Western Cape Strategic Wind Initiative Document (May 2006) does not prescribe any noise limits other than to recommend a setback distance of 400m from residences. It is recommended that a setback distance of 500m be used for this project. This is based on this authors experience on similar projects.

2.2 Discussion National Standards

The most applicable standard for use in this study is SANS 10103:2008 which provides typical rating levels for noise in various types of districts, as described in Table 2 below.

Table 2 - Typical rating levels for noise in various types of districts

Type of District	**Equivalent Continuous Rating Level, LReq.T for Noise**					
	Outdoors (dB(A))			**Indoors, with open windows (dB(A))**		
	Day-night	**Daytime**	**Night-time**	**Day-night**	**Daytime**	**Night-time**
Rural Districts	45	45	35	35	35	25
Suburban districts with little road traffic	50	50	40	40	40	30
Urban districts	55	55	45	45	45	35
Urban districts with one or more of the following: Workshops; business premises and main roads	60	60	50	50	50	40
Central business districts	65	65	55	55	55	45
Industrial districts	70	70	60	60	60	50

SANS 10103:2008 defines Daytime as 06:00 to 22:00 hours and night time as 22:00 to 06:00 hours. The rating levels in the table above indicate that in rural districts the ambient noise should not exceed 35 dB(A) at night and 45 dB(A) during the day. The day / night (24hour) rating limit is 45 dB(A). These levels can thus be seen as the maximum target levels for any noise pollution sources.

SANS 10103: 2004 also provides a guideline for expected community responses to excess environmental noise above the ambient noise. These are reflected in the table below.

Table 3 - Categories of environmental community / group response (SANS 10103:2008)

EXCESS Lr dB (A)	ESTIMATED COMMUNITY/GROUP RESPONSE	
	CATEGORY	DESCRIPTION
0 - 10	Little	Sporadic complaints
5 - 15	Medium	Widespread complaints
10 - 20	Strong	Threats of community / group action
> 15	Very Strong	Vigorous community / group action

International Standards

There are various international criteria levels for ambient sound from wind turbines. These are listed below:

- New Zealand – 40dB(A)
- Denmark – 40dB(A)
- United Kingdom (L_{A90}) 35 - 40dB(A)

Australia has set the following limits that wind turbine noise should not exceed:

- 35dB(A) at relevant receivers in localities which are primarily intended for rural living, or
- 40dB(A) at relevant receivers in localities in other zones, or
- the background noise (L_{A90}) by more than 5dB(A)

Germany has set the following standards

- Purely residential areas with no commercial developments 50 dBA (Day) and 35 dBA (Night)
- Areas with hospitals, health resorts, etc. 45 dBA (Day) 35 dBA (Night)

The rationale behind the criteria levels is that the design limit should be 5 dB below the natural ambient limit. This corresponds well with the South African guideline limit of 45 dB(A) for rural districts.

3.0 METHODOLOGY & APPROACH

The methodology used in the study consisted of two approaches to determine the noise impact from the proposed project and associated infrastructure:

- A desktop study to model the likely noise emissions from the site;
- Field measurements of the existing ambient noise at different locations in the vicinity of the project.

3.1 Technical Scope

A Noise Impact Assessment (NIA) for the EIA phase is to be conducted in accordance with Section 8 of SANS 10328. The scope of the project is described below:

- Determine the land use zoning on surrounding land and identify noise sensitive receptors that could be impacted upon by activities relating to the construction, operation and decommissioning of the wind farm.
- Determine the existing ambient levels of noise within the study area.
- Determine the typical rating level for noise on surrounding land at identified noise sensitive receptors.
- Identify all noise sources, relating to the establishment and operation of the proposed wind farm that could potentially result in a noise impact on surrounding land and at the identified noise sensitive receptors.
- Determine the sound power emission levels and nature of the sound emission from the identified noise sources.
- Calculate the expected rating level of noise on surrounding land and at the identified noise sensitive receptors from the combined sound power levels emanating from identified noise sources in accordance with procedures contained in SANS 10357 or similar.
- Calculate and assess the noise impact on surrounding land and at the identified noise sensitive receptors in terms of SANS 10103; the Noise Control Regulations; and the World Health Organisation (WHO).
- Investigate alternative noise mitigation procedures, if required, in collaboration with the design engineers of the facility and estimate the impact of noise upon implementation of such procedures.
- Prepare and submit an environmental noise impact report containing the procedures and findings of the investigation.
- Prepare and submit recommended noise mitigation procedures as part of a separate environmental noise management plan, if relevant.

3.2 Desktop study methodology

The desktop study was conducted using the available literature on noise impacts as well as numerical calculations using EMD WindPro Software Version 2.7 which is specifically developed for wind turbine noise. The method described in SANS 10357:2004 version 2.1 (The calculation of sound propagation by the Concawe method) was used a reference for further calculations where required. WindPro uses the methods described in ISO 9613-2 (Acoustics – Attenuation of sound during propagation outdoors. Part 2 – General method of calculation). This method is very comparable to SANS 10357:2004.

The numerical results were then used to produce a noise map that visually indicates the extent of the noise emissions from the site. The noise emissions were modelled for various wind speeds. The direction of the wind is not taken into consideration as the wind could blow from any direction at the speeds that were modelled. The modelling conducted for Option 1 and Option 2 included the existing four turbines. The following data was used for the WTG's that were modeled.

Table 4- Nordex N77 Data (Proposed Turbines)

	Option 1	Option 2
Manufacturer	Nordex	Nordex
Type / Version	N77 (Same as Nordex S77)	N 60
Rated Power	1500kW	1300kW
Rotor Diameter	77m	60
Tower	Tubular	Tubular
Grid Connection	50 Hz	50 Hz
Country (Origin)	Germany	Germany
Blade Type	NR 37.5 (LM 37.3)	LM 29.0
Generator Types	Variable	Variable
Rated	17.3 rpm	19.2 rpm
Initial	9.9 rpm	12.8
Hub Height	70m	60m

	Option 1	Option 2
Maximum Sound Power Level used in the model	107.4 dB(A)	104.5 dB(A)
Cut-in Wind Speed	3m/s	3m/s

Table 5- Fuhrländer FL1250 Data (Existing Turbines)

Manufacturer	Fuhrländer
Type / Version	FL 1250
Rated Power	1250kW
Rotor Diameter	62m
Tower	Tubular
Grid Connection	50/60 Hz
Country (Origin)	Germany
Blade Type	LM 29
Generator Types	One generator
Rated	18.9 rpm
Initial	14.0 rpm
Hub Height	50m
Maximum Sound Power Level used in the model	106.4 dB(A)
Cut-in Wind Speed	3m/s

3.3 Field Study – Proposed Site

A field study to the proposed site was conducted on the 28th – 29th April 2011.

Two ambient monitoring points were chosen based on their proximity to sensitive receptors as well as the location of the proposed wind turbines. The location of the ambient measurement positions are as follows:

Table 6 - Measurement Point Positions

Test Point #	Location Description	South	East
NSA 1	Windhoek Farmworkers Houses	33º 19' 27.5"	18º 15' 18.0"
NSA 2	Windhoek Main Farm House	33º 19' 28.5"	18º 15' 23.2"

The test environment contained the following noise sources:

- Vehicular traffic that included trucks and cars on the R27 and R315.
- Farm animals.
- Wind induced noise.
- Noise from the existing four wind turbine generators.

A number of measurements were taken by placing the noise meter on a tripod and ensuring that it was at least 1.2 m from floor level and 3.5 m from any large flat reflecting surface.

All measurement periods were at least over 10 minutes, except where indicated. The noise meter was calibrated before and after the survey. At no time was the difference more than one decibel (If the difference is more than 1 decibel the meter is not calibrated properly and the measurement is discarded). The weighting used was on the A scale and the meter placed on impulse correction, which is the preferred method as per Section 5 of SANS 10103:2008. No tonal correction was added to the data. Measurements were taken during the day and night-time. The meter was fitted with a windscreen, which is supplied by the manufacturer. The screen is designed so as to reduce wind noise around the microphone and not bias the measurements.

The instrumentation that was used to conduct the study is as follows:

- Rion Precision Sound Level Meter (NL32) with 1/3 Octave Band Analyzer.
- Serial No. 00151075
- Microphone (UC-53A) Serial No. 307806
- Preamplifier (NH-21) Serial No. 13814

All equipment was calibrated in October 2010 by M & N Acoustic Services. The sound level meter was calibrated before and after use with a sound level calibrator. Equipment complied with the specifications of Section 8.1 of SANS Code of Practice 10083:2004 Ed 5. Equipment complied with the specifications of Section 8.1 of SANS Code of Practice 10083:2004 Edition 5. (See Appendix B)

3.4 Introduction to Noise

3.4.1 Sound Propagation

Noise is defined as any unwanted sound and is measured in decibels. Sounds are characterized by their magnitude (loudness) and frequency. There can be loud low frequency sounds, soft high frequency sounds and loud sounds that include a range of frequencies. The human ear can detect a very wide range of both sound levels and frequencies, but it is more sensitive to some frequencies than others.

Sound frequency denotes the "pitch" of the sound and, in many cases, corresponds to notes on the musical scale (Middle C is 262 Hz). An octave is a frequency range between a sound with one frequency and one with twice that frequency, a concept often used to define ranges of sound frequency values. The frequency range of human hearing is quite wide, generally ranging from about 20 to 20 kHz (about 10 octaves). Sounds experienced in daily life are usually not a single frequency, but are formed from a mixture of numerous frequencies, from numerous sources (See Appendix C).

Concerns about environmental noise depend on:

- the level of intensity, frequency, frequency distribution and patterns of the noise source;
- background sound levels;
- the terrain between the emitter and receptor
- the nature of the receptor; and
- the attitude of the receptor about the emitter.

In general, the effects of noise on people can be classified into three general categories:

- Subjective effects including annoyance, nuisance, dissatisfaction
- Interference with activities such as speech, sleep, and learning
- Physiological effects such as anxiety, tinnitus, or hearing loss.

It is important to distinguish between the various measures of the magnitude of sounds, namely sound power level and sound pressure level. Sound power level is the power per unit area of the sound pressure wave; it is a property of the source of the sound and it gives the total acoustic power emitted by the source. Sound pressure is a property of sound at a given observer location and can be measured there by a microphone.

In order to predict the sound pressure level at a distance from source with a known power level, one must determine how the sound waves propagate. In general, as sound propagates without obstruction from a point source, the sound pressure level decreases. The initial energy in the sound is distributed over a larger and larger area as the distance from the source increases. Thus, assuming spherical propagation, the same energy that is distributed over a square meter at a distance of one meter from a source is distributed over 10,000 m^2 at a distance of 100 meters away from the source. With spherical propagation, the sound pressure level is reduced by 6 dB per doubling of distance.

This simple model of spherical propagation must be modified in the presence of reflective surfaces and other disruptive effects. For example, if the source is on a perfectly flat and reflecting surface, then hemispherical spreading has to be assumed, which also leads to a 6 dB reduction per doubling of distance, but the sound level would be 3 dB higher at a given distance than with spherical spreading.

Sound propagation is generally influenced by the following factors:

- Source characteristics (e.g., directivity, height, etc.)
- Distance of the source from the observer
- Air absorption, which depends on frequency
- Ground effects (i.e., reflection and absorption of sound on the ground, dependent on source height, terrain cover, ground properties, frequency, etc.)
- Blocking of sound by obstructions and uneven terrain
- Weather effects (i.e., wind speed, change of wind speed or temperature with height). The prevailing wind direction can cause differences in sound pressure levels between upwind and downwind positions.
- Shape of the land; certain land forms can also focus sound

3.4.2 Sources of Wind Turbine Noise

The sources of sounds emitted from operating wind turbines can be divided into two categories, firstly mechanical sounds, from the interaction of turbine components, and secondly Aerodynamic sounds, produced by the flow of air over the blades.

Mechanical Sounds

Mechanical sounds originates from the relative motion of mechanical components and the dynamic response among them. Sources of such sounds include:

- Gearbox
- Generator
- Yaw Drives
- Cooling Fans
- Auxiliary Equipment (e.g., hydraulics)

Since the emitted sound is associated with the rotation of mechanical and electrical equipment, it tends to be tonal (of a common frequency), although it may have a broadband component. For example, pure tones can be emitted at the rotational frequencies of shafts and generators, and the meshing frequencies of the gears.

In addition, the hub, rotor, and tower may act as loudspeakers, transmitting the mechanical sound and radiating it. The transmission path of the sound can be air-borne or structure-borne. Air-borne means that the sound is directly propagated from the component surface or interior into the air. Structure-borne sound is transmitted along other structural components before it is radiated into the air.

Figure 3 shows the type of transmission path and the sound power levels for the individual components for a typical 2 MW wind turbine.

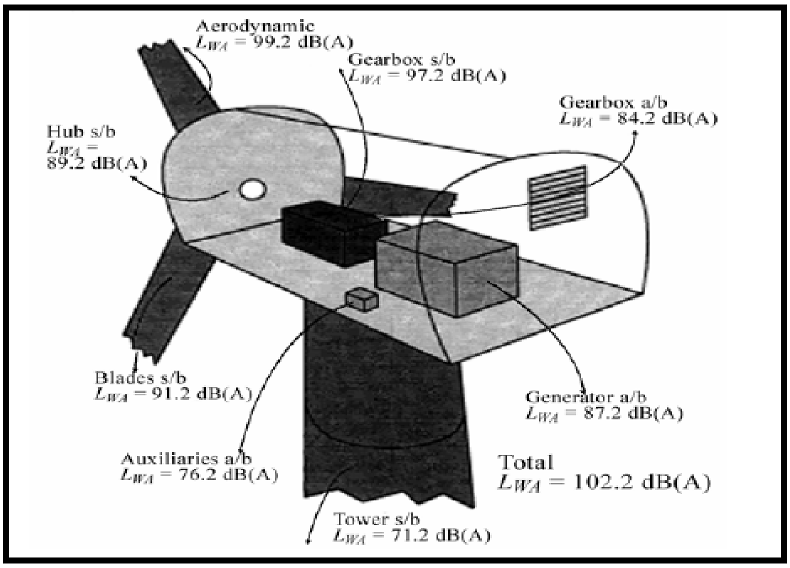


Figure 3 - Typical Sound Power Levels of a 2MW Turbine

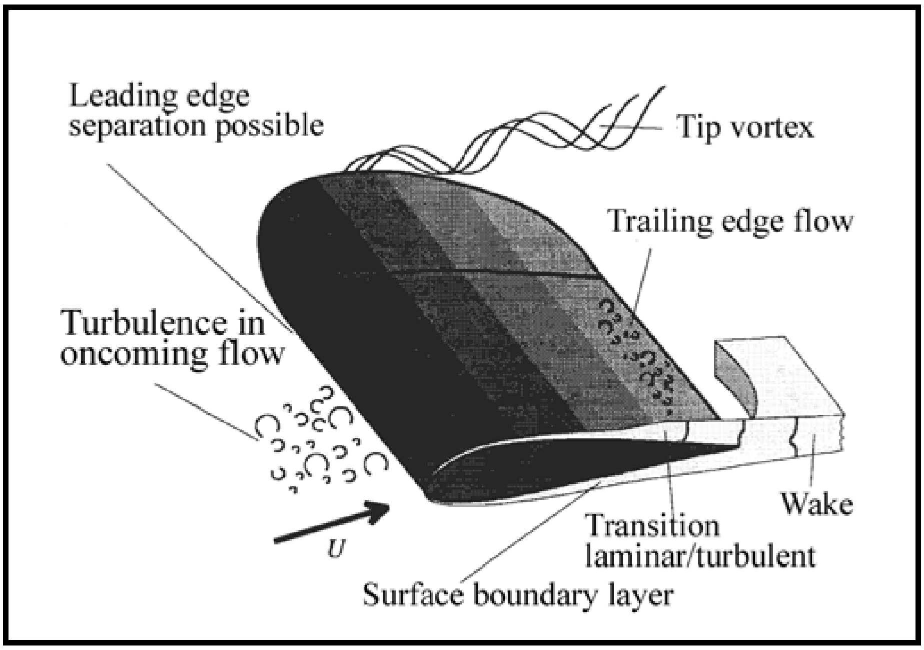
Aerodynamic Sound

Aerodynamic broadband sound is typically the largest component of wind turbine acoustic emissions. It originates from the flow of air around the blades. As shown in Figure 3, a large number of complex flow phenomena occur, each of which might generate some sound. Aerodynamic sound generally increases with rotor speed. The various aerodynamic sound generation mechanisms that have to be considered are divided into three groups:

- *Low Frequency Sound:* Sound in the low frequency part of the sound spectrum is generated when the rotating blade encounters localized flow deficiencies due to the flow around a tower, wind speed changes, or wakes shed from other blades.
- *Inflow Turbulence Sound:* Depends on the amount of atmospheric turbulence. The atmospheric turbulence results in local force or local pressure fluctuations around the blade.

- *Airfoil Self Noise:* This group includes the sound generated by the air flow right along the surface of the airfoil. This type of sound is typically of a broadband nature, but tonal components may occur due to blunt trailing edges, or flow over slits and holes.

Figure 4 - Sources of Aerodynamic Noise



Modern airfoil design takes all of the above factors into account and is generally much quieter that the first generation of bade design.

3.4.3 Ambient Sound & Wind Speed

The ability to hear a wind turbine in a given installation depends on the ambient sound level. When the background sounds and wind turbine sounds are of the same magnitude, the wind turbine sound gets lost in the background. Both the wind turbine sound power level and the ambient sound pressure level will be functions of wind speed. Thus whether a wind turbine exceeds the background sound level will depend on how each of these varies with wind speed.

The most likely sources of wind-generated sounds are interactions between wind and vegetation. A number of factors affect the sound generated by wind flowing over vegetation. For example, the total magnitude of wind-generated sound depends more on the size of the windward surface of the vegetation than the foliage density or volume.

The sound level and frequency content of wind generated sound also depends on the type of vegetation. For example, sounds from deciduous trees tend to be slightly lower and more broadband than that from conifers, which generate more sounds at specific frequencies. The equivalent A-weighted broadband sound pressure generated by wind in foliage has been shown to be approximately proportional to the base 10 logarithm of wind speed.

Sound levels from large modern wind turbines during constant speed operation tend to increase more slowly with increasing wind speed than ambient wind generated sound. As a result, wind turbine noise is more commonly a concern at lower wind speeds and it is often difficult to measure sound from modern wind turbines above wind speeds of 8 m/s because the background wind-generated sound masks the wind turbine sound above 8 m/s.

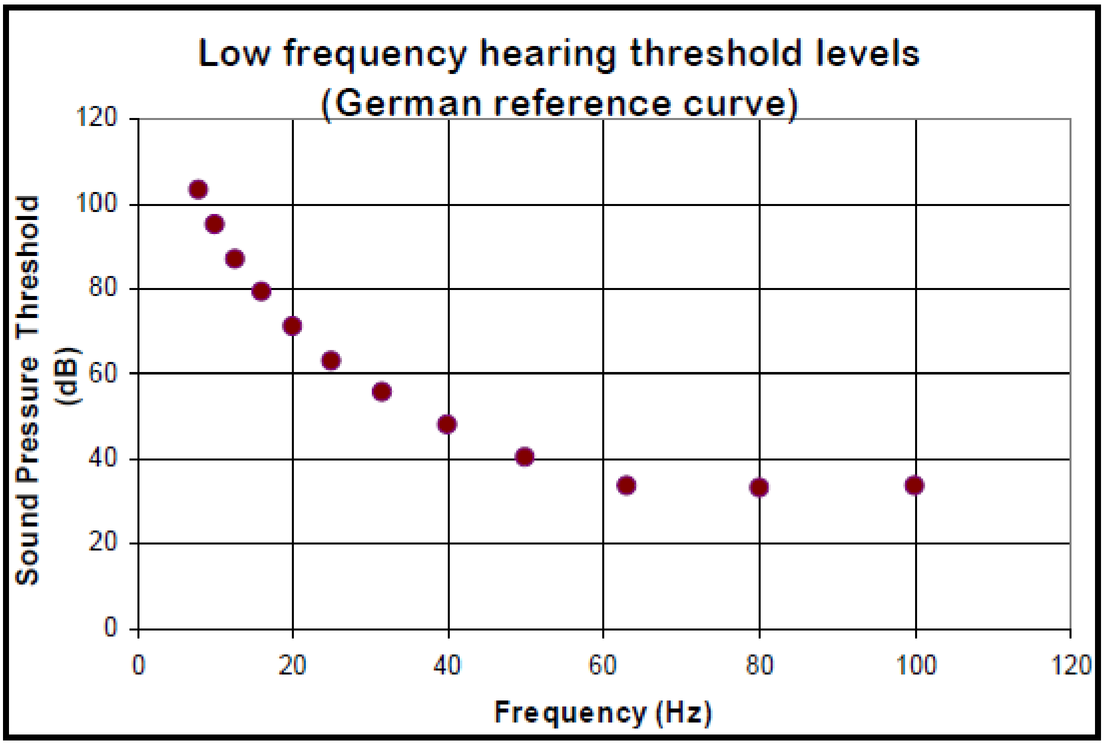
It should be remembered that average sound pressure measurements might not indicate when a sound is detectable by a listener. Just as a dog's barking can be heard through other sounds, sounds with particular frequencies or an identifiable pattern may be heard through background sounds that is otherwise loud enough to mask those sounds. Sound emissions from wind turbines will also vary as the turbulence in the wind through the rotor changes. Turbulence in the ground level winds will also affect a listener's ability to hear other sounds. Because fluctuations in ground level wind speeds will not exactly correlate with those at the height of the turbine, a listener might find moments when the wind turbine could be heard over the ambient sound.

3.4.4 Low Frequency Noise and Infrasound

Infrasound was a characteristic of some wind turbine models that has been attributed to early designs in which turbine blades were downwind of the main tower. The effect was generated as the blades cut through the turbulence generated around the downwind side of the tower. Modern designs generally have the blades upwind of the tower. Wind conditions around the blades and improved blade design minimise the generation of the effect.

Low frequency pressure vibrations are typically categorized as low frequency sound when they can be heard near the bottom of human perception (10-200 Hz), and infrasound when they are below the common limit of human perception. Sound below 20 Hz is generally considered infrasound, even though there may be some human perception in that range. Because these ranges overlap in these ranges, it is important to understand how the terms are intended in a given context.

Figure 5 - Low frequency Hearing Threshold Levels



Infrasound is always present in the environment and stems from many sources including ambient air turbulence, ventilation units, waves on the seashore, distant explosions, traffic, aircraft, and other machinery. Infrasound propagates farther (i.e. with lower levels of dissipation) than higher frequencies. To place infrasound in perspective, when a child is swinging high on a swing, the pressure change on its ears, from top to bottom of the swing, is nearly 120 dB at a frequency of around 1 Hz. Some characteristics of the human perception of infrasound and low frequency sound are:

- Low frequency sound and infrasound (2-100 Hz) are perceived as a mixture of auditory and tactile sensations.
- Lower frequencies must be of a higher magnitude (dB) to be perceived, e.g. the threshold of hearing at 10 Hz is around 100 dB; see Figure 5above.
- Tonality cannot be perceived below around 18 Hz
- Infrasound may not appear to be coming from a specific location, because of its long wavelengths.

The primary human response to perceived infrasound is annoyance, with resulting secondary effects. Annoyance levels typically depend on other characteristics of the infrasound, including intensity, variations with time, such as impulses, loudest sound, periodicity, etc. Infrasound has three annoyance mechanisms:

- A feeling of static pressure

- Periodic masking effects in medium and higher frequencies
- Rattling of doors, windows, etc. from strong low frequency components

Human effects vary by the intensity of the perceived infrasound, which can be grouped into these approximate ranges:

- 90 dB and below: No evidence of adverse effects
- 115 dB: Fatigue, apathy, abdominal symptoms, hypertension in some humans
- 120 dB: Approximate threshold of pain at 10 Hz
- 120 – 130 dB and above: Exposure for 24 hours causes physiological damage

There is no reliable evidence that infrasound below the perception threshold produces physiological or psychological effects.

The typical range of sound power level for wind turbine generators is in the range of 100 to 105dBA – a much lower sound power level (10dB or more) than the majority of construction machinery such as dozers. In order for infrasound to be audible even to a person with the most sensitive hearing at a distance of, say, 300m would require a sound power level of at least 140dB at 10Hz and even higher emission levels than this at lower frequencies and at greater distances. There is no information available to indicate that wind turbine generators emit infrasound anywhere near this intensity(2).

Several studies have confirmed that there are no physiological effects from low frequency or infrasound from wind turbines (2),(4),(5),(9),(15),(16),(17).

3.5 Potential Noise Sources - Construction Phase

Noise pollution will be generated during the construction phase as well as the operational phase.

3.5.1 Potential Noise Sources (General Equipment and Vehicles)

The construction phase could generate noise during different activities such as:

- Site preparation and earthworks to gain access using bulldozers, trucks etc.
- Foundation construction using mobile equipment, cranes, concrete mixing and pile driving equipment (if needed).
- Heavy vehicle use to deliver construction material and the turbines.

The number and frequency of use of the various types of vehicles has not been determined but an indication of the type and level of noise generated is presented below.

Table 7 – Typical types of vehicles and equipment to be used on site (Construction Phase)

Type	Description	Typical Sound Power Level (dB)
Passenger Vehicle	Passenger vehicle or light delivery vehicle such as bakkies	85
Trucks	10 ton capacity	95
Cranes	Overhead and mobile	109
Mobile Construction Vehicles	Front end loaders	100
Mobile Construction Vehicles	Excavators	108
Mobile Construction Vehicles	Bull Dozer	111
Mobile Construction Vehicles	Dump Truck	107
Mobile Construction Vehicles	Grader	98
Mobile Construction Vehicles	Water Tanker	95
Stationary Construction Equipment	Concrete mixers	110
Compressor	Air compressor	100
Compactor	Vibratory compactor	110
Pile Driver	Piling machine (mobile)	115

Source: GCDA 2006

3.6 Potential Noise Sources – Operational Phase

The project will install either 14 or 16 wind turbine generators that are manufactured by Nordex. The WTG is usually a pitch regulated upwind wind turbine with active yaw and three blade rotor. The turbine consists of three main parts that may produce noise:

Rotor
- 3 blades and hub, electrical pitch control

Integrated power unit
- roller bearing, planetary gear and variable speed
- generator with permanent magnets

Nacelle
- frequency converter, transformer and accessories

3.7 Description of the Affected Environment

The project site is situated is zoned for agricultural land use. The potential sensitive receptors are discussed below. The main noise sensitive receptors that could be impacted by noise pollution are the terrestrial fauna, the avifauna and human receptors. This report only deals with the human receptors.

3.8 Sensitive Receptors

3.8.1 Human Sensitive Receptors

The site is situated in a rural farming community. Several homesteads are located on the property where the turbines will be erected as well as on neighbouring farms.
The locations of the various human sensitive receptors are indicated in Figures 1&2 and the positions recorded in Table 8.

Table 8 - Location of Noise Sensitive Receptors.

NSA	Longitude (E)	Latitude (S)	Distance to closest WTG (m)
NSA 1 - Windhoek (Main House)	18°15'23.43"	33°19'29.54"	634
NSA 2 – Windhoek (Workers Cottage)	18°15'16.80"	33°19'28.68"	523
NSA 3 - Kleinwindhoek	18°14'42.14"	33°19'55.48"	956
NSA 4 - Rory Richard	18°14'18.39"	33°19'39.75"	844
NSA 5 - Jacobus Kraal	18°14'02.42"	33°19'45.91"	1233
NSA 6 - Die Padstal	18°14'19.52"	33°20'04.80"	1821
NSA 7 - Slangkop	18°17'01.98"	33°19'49.64"	2621
NSA 8 - Droevlei	18°18'34.33"	33°17'54.93"	4822
NSA 9 - Swartwater	18°15'49.93"	33°17'01.05"	3120
NSA 10 - Grootberg	18°17'03.00"	33°20'33.48"	3638

3.8.2 Natural Environment Receptors

The fauna includes bats, birds, commercial livestock and a variety of buck. These impacts are dealt with in separate studies.

4.0 Results of the Field Study

4.1 Ambient Noise at Proposed Site

The ambient noise was measured at two locations as described in the above methodology (Section 3.3) and results thereof are contained in the tables below.

Table 9 - Ambient Noise Results – (Daytime)

Location	Start Time	Duration (minutes)	L_{eq} dB(A)	L_{10} dB(A)	L_{90} dB(A)	Comments
Windhoek Farmworkers Houses	13:15	15	41.6	44.6	36.4	• Music in background
Windhoek Main Farm House	14:00	15	39.9	41.8	34.8	• 3 turbines running (not audible)

Wind from the south at 4m/s Temperature 17°C

Table 10 - Ambient Noise Results – (Night)

Location	Start Time	Duration (minutes)	L_{eq} dB(A)	L_{10} dB(A)	L_{90} dB(A)	Comments
Windhoek Farmworkers Houses	22:00	15	41.4	46.0	32.1	• Cars on R27 very audible • Dogs Barking
Windhoek Main Farm House	22:15	15	44.9	40.8	34.5	• Cars on R27 very audible • Dogs Barking • Turbines not operational

Wind from the south east at 2m/s Temperature 10°C

The results indicate that the ambient noise is approximately between 41 and 45 dB(A) at between 2 -4m/s wind speed. The general ambient noise at each location varies substantially as the ambient sound is influenced by human activities as well as vehicles and animal sounds. It is thus extremely difficult to isolate just the wind component.

5.0 NOISE IMPACT ASSESSMENT

5.1. Predicted Noise Levels for the Construction Phase

The construction noise at the various sites will have a local impact. Safetech has conducted noise tests at various construction sites in South Africa and have recorded the noise emissions of various pieces of construction equipment. The results are presented in the Table 11 below.

Table 11 – Typical Construction Noise

Type of Equipment	$L_{Req.T}$ dB(A)
CAT 320D Excavator measured at approximately 50 m.	67.9
Mobile crane measured at approximately 70 m	69.6
Drilling rig measured at approximately 70 m	72.6

The impact of the construction noise that can be expected at the proposed site can be extrapolated from Table 12. As an example, if a number of pieces of equipment are used simultaneously, the noise levels can be added logarithmically and then calculated at various distances from the site to determine the distance at which the ambient level will be reached.

Table 12 - Combining Different Construction Noise Sources – High Impacts (Worst Case)

Description	Typical Sound Power Level (dB)
Overhead and mobile cranes	109
Front end loaders	100
Excavators	108
Bull Dozer	111
Piling machine (mobile)	115
Total*	117

*The total is a logarithmic total and not a sum of the values.

Table 13 - Combining Different Construction Noise Sources – Low Impacts

Description	Typical Sound Power Level (dB)
Front end loaders	100
Excavators	108
Truck	95
Total	111

The information in the tables above can now be used to calculate the attenuation by distance. Noise will also be attenuated by topography and atmospheric conditions such as temperature, humidity, wind speed and direction etc. but this is ignored for this purpose. Therefore, the distance calculated below would be representative of maximum distances to reach ambient noise levels.

The table below gives an illustration of attenuation by distance from a noise of 117dB measured from the source.

Table 14 – Attenuation by distance for the construction phase (worst case)

Distance from noise source (metres)	Sound Pressure Level dB(A)
10	89
20	83
40	77
80	71
160	65
320	59
640	53
1280	47

What can be inferred from the above table is that if the ambient noise level is at 45dB(A), the construction noise will be similar to the ambient level at approximately

1280m from the noise source, if the noise characteristics are similar. Beyond this distance, the noise level will be below the ambient noise and will therefore have little impact. The above only applies to the construction noise and light wind conditions. In all likelihood, the construction noise will have little impact on the surrounding community as it will most likely occur during the day when the ambient noise is louder and there are unstable atmospheric conditions.

5.2. Predicted noise levels for the Operational Phase

The effects of low frequency noise include sleep disturbance, nausea, vertigo etc. These effects are unlikely to impact upon residents due to the distance between the plant and the nearest communities. Sources of low frequency noise also include wind, train movements and vehicular traffic, which are all sources that are closer to the residential areas.

5.2.1 Predicted noise levels for the Wind Turbines Generators

The tables and figures below indicate the isopleths for the noise generated by the turbines at wind speeds from 3m/s to 12m/s. The areas shaded red in the tables indicate where the day / night 45dB(A) recommended limit is exceeded.

Table 15 - Results of the modelling for the various NSA's

NSA 1 - Windhoek (Main House)					
Wind Speed [m/s]	Maximum Noise Allowed [dB(A)]	Option 1 [dB(A)]	Noise Demand Fulfilled?	Option 2 [dB(A)]	Noise Demand Fulfilled?
3	45	35.3	Yes	34.2	Yes
4	45	36.2	Yes	35.2	Yes
5	45	37.2	Yes	36.2	Yes
6	45	38.2	Yes	37.2	Yes
7	45	39.2	Yes	38.2	Yes
8	45	40.2	Yes	39.3	Yes
9	45	41.2	Yes	40.6	Yes
10	45	42.2	Yes	42.0	Yes
11	45	43.2	Yes	43.3	Yes
12	45	44.2	Yes	44.7	Yes

NSA 2 - Windhoek (Workers Cottage)					
Wind Speed [m/s]	Maximum Noise Allowed [dB(A)]	Option 1 [dB(A)]	Noise Demand Fulfilled?	Option 2 [dB(A)]	Noise Demand Fulfilled?
3	45	36.6	Yes	35.4	Yes
4	45	37.6	Yes	36.4	Yes
5	45	38.6	Yes	37.4	Yes
6	45	39.6	Yes	38.4	Yes
7	45	40.6	Yes	39.4	Yes
8	45	41.6	Yes	40.6	Yes
9	45	42.6	Yes	41.8	Yes
10	45	43.6	Yes	43.2	Yes
11	45	44.6	Yes	44.7	Yes
12	45	45.6	No	46.1	No

NSA 3 - Kleinwindhoek					
Wind Speed [m/s]	Maximum Noise Allowed [dB(A)]	Option 1 [dB(A)]	Noise Demand Fulfilled?	Option 2 [dB(A)]	Noise Demand Fulfilled?
3	45	29.7	Yes	28.3	Yes
4	45	30.7	Yes	29.3	Yes
5	45	31.7	Yes	30.3	Yes
6	45	32.7	Yes	31.3	Yes
7	45	33.7	Yes	32.3	Yes
8	45	34.7	Yes	33.5	Yes
9	45	35.7	Yes	34.7	Yes
10	45	36.7	Yes	36.2	Yes
11	45	37.7	Yes	37.7	Yes
12	45	38.7	Yes	39.1	Yes

NSA 4 - Rory Richard					
Wind Speed [m/s]	Maximum Noise Allowed [dB(A)]	Option 1 [dB(A)]	Noise Demand Fulfilled?	Option 2 [dB(A)]	Noise Demand Fulfilled?
3	45	31.2	Yes	30.3	Yes
4	45	32.2	Yes	31.3	Yes
5	45	33.2	Yes	32.3	Yes
6	45	34.2	Yes	33.3	Yes
7	45	35.2	Yes	34.3	Yes
8	45	36.2	Yes	35.5	Yes
9	45	37.2	Yes	36.8	Yes
10	45	38.2	Yes	38.2	Yes
11	45	39.2	Yes	39.7	Yes
12	45	40.2	Yes	41.2	Yes

NSA 5 - Jacobus Kraal					
Wind Speed [m/s]	Maximum Noise Allowed [dB(A)]	Option 1 [dB(A)]	Noise Demand Fulfilled?	Option 2 [dB(A)]	Noise Demand Fulfilled?
3	45	27.8	Yes	27.1	Yes
4	45	28.8	Yes	28.1	Yes
5	45	29.8	Yes	29.1	Yes
6	45	30.8	Yes	30.1	Yes
7	45	31.8	Yes	31.1	Yes
8	45	32.8	Yes	32.3	Yes
9	45	33.8	Yes	33.5	Yes
10	45	34.8	Yes	35.0	Yes
11	45	35.8	Yes	36.5	Yes
12	45	36.8	Yes	37.9	Yes

NSA 6 - Die Padstal					
Wind Speed [m/s]	Maximum Noise Allowed [dB(A)]	Option 1 [dB(A)]	Noise Demand Fulfilled?	Option 2 [dB(A)]	Noise Demand Fulfilled?
3	45	26.5	Yes	25.4	Yes
4	45	27.5	Yes	26.4	Yes
5	45	28.5	Yes	27.4	Yes
6	45	29.5	Yes	28.4	Yes
7	45	30.5	Yes	29.4	Yes
8	45	31.5	Yes	30.6	Yes
9	45	32.5	Yes	31.8	Yes
10	45	33.5	Yes	33.3	Yes
11	45	34.5	Yes	34.7	Yes
12	45	35.5	Yes	36.2	Yes

NSA 7 - Slangkop					
Wind Speed [m/s]	Maximum Noise Allowed [dB(A)]	Option 1 [dB(A)]	Noise Demand Fulfilled?	Option 2 [dB(A)]	Noise Demand Fulfilled?
3	45	21.6	Yes	20.8	Yes
4	45	22.6	Yes	21.8	Yes
5	45	23.6	Yes	22.8	Yes
6	45	24.6	Yes	23.8	Yes
7	45	25.6	Yes	24.8	Yes
8	45	26.6	Yes	25.9	Yes
9	45	27.6	Yes	27.1	Yes
10	45	28.6	Yes	28.4	Yes
11	45	29.6	Yes	29.8	Yes
12	45	30.6	Yes	31.1	Yes

NSA 8 - Droevlei					
Wind Speed [m/s]	Maximum Noise Allowed [dB(A)]	Option 1 [dB(A)]	Noise Demand Fulfilled?	Option 2 [dB(A)]	Noise Demand Fulfilled?
3	45	15.4	Yes	14.4	Yes
4	45	16.4	Yes	15.4	Yes
5	45	17.4	Yes	16.4	Yes
6	45	18.4	Yes	17.4	Yes
7	45	19.4	Yes	18.4	Yes
8	45	20.4	Yes	19.5	Yes
9	45	21.4	Yes	20.8	Yes
10	45	22.4	Yes	22.1	Yes
11	45	23.4	Yes	23.5	Yes
12	45	24.4	Yes	24.9	Yes

NSA 9 - Swartwater					
Wind Speed [m/s]	Maximum Noise Allowed [dB(A)]	Option 1 [dB(A)]	Noise Demand Fulfilled?	Option 2 [dB(A)]	Noise Demand Fulfilled?
3	45	19.7	Yes	18.7	Yes
4	45	20.7	Yes	19.7	Yes
5	45	21.7	Yes	20.7	Yes
6	45	22.7	Yes	21.7	Yes
7	45	23.7	Yes	22.7	Yes
8	45	24.7	Yes	23.8	Yes
9	45	25.7	Yes	25.1	Yes
10	45	26.7	Yes	26.4	Yes
11	45	27.7	Yes	27.8	Yes
12	45	28.7	Yes	29.2	Yes

NSA 10 - Grootberg					
Wind Speed [m/s]	Maximum Noise Allowed [dB(A)]	Option 1 [dB(A)]	Noise Demand Fulfilled?	Option 2 [dB(A)]	Noise Demand Fulfilled?
3	45	19.1	Yes	18.2	Yes
4	45	20.1	Yes	19.2	Yes
5	45	21.1	Yes	20.2	Yes
6	45	22.1	Yes	21.2	Yes
7	45	23.1	Yes	22.2	Yes
8	45	24.1	Yes	23.3	Yes
9	45	25.1	Yes	24.5	Yes
10	45	26.1	Yes	25.9	Yes
11	45	27.1	Yes	27.2	Yes
12	45	28.1	Yes	28.6	Yes

Figure 6 - Raster Image of Option1 (8m/s wind speed)

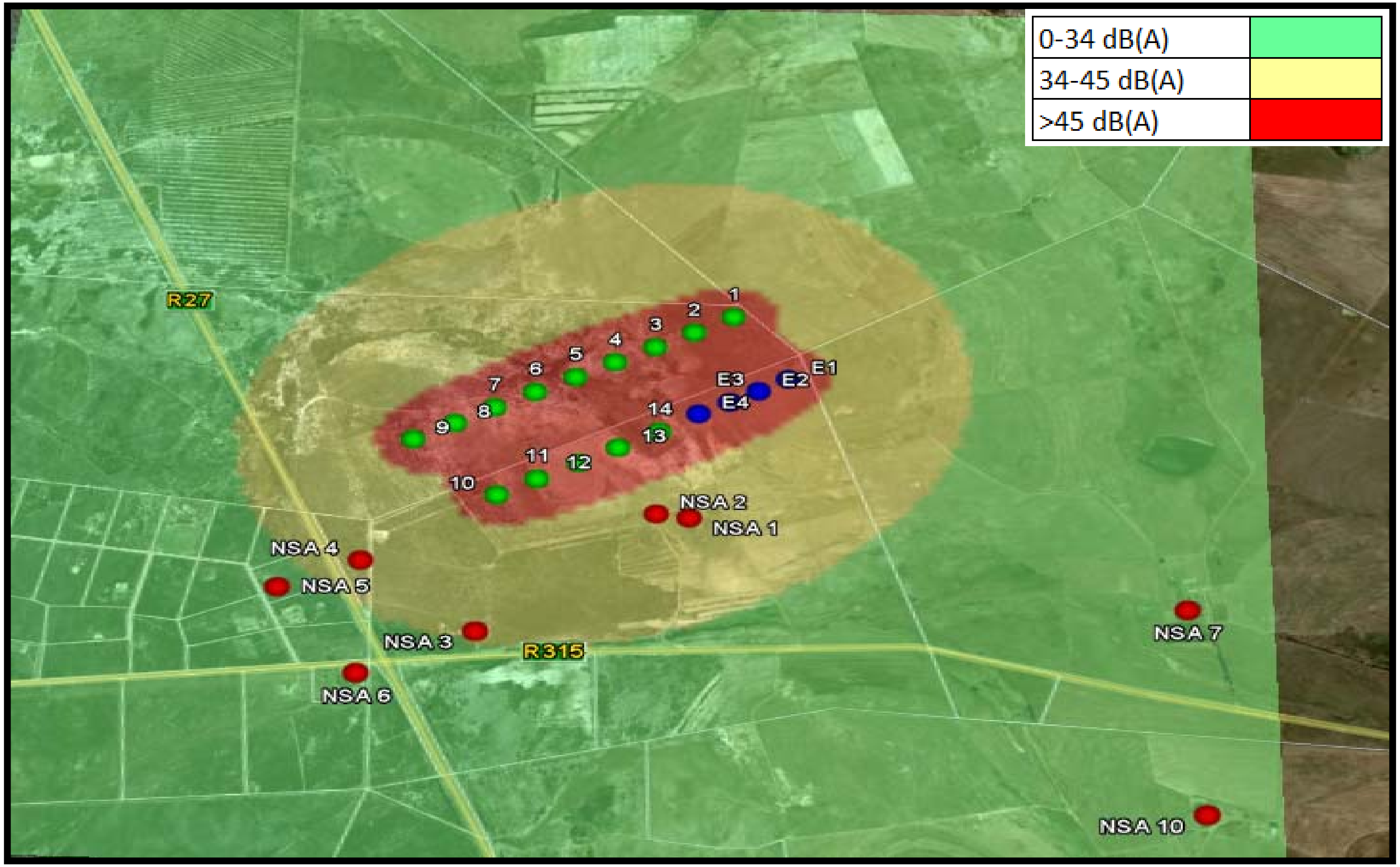
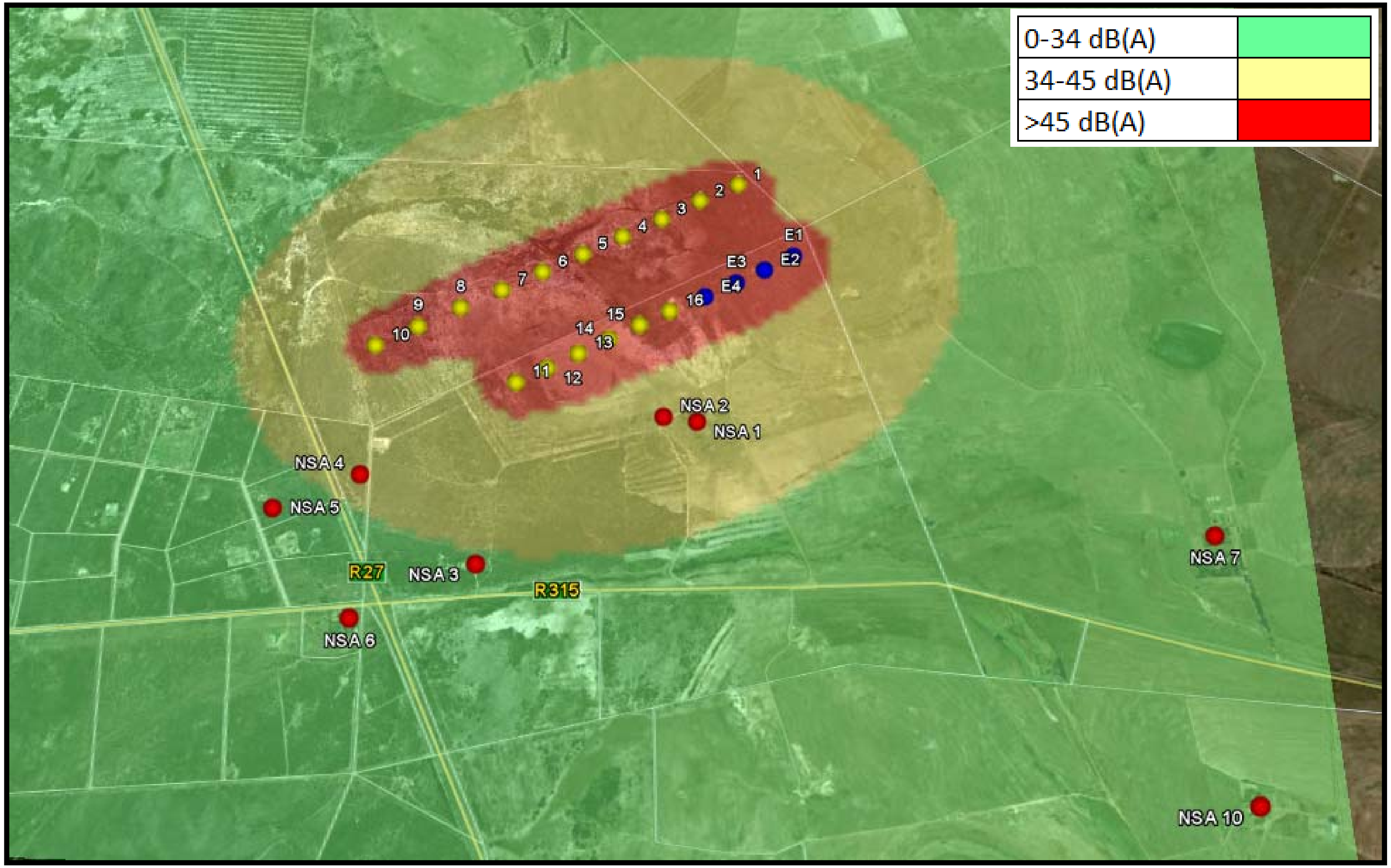


Figure 7 - Raster Image of Option 2 (8m/s windspeed)



5.3 Noise Impact Assessment Summary

The impact of the noise pollution that can be expected from the site during the construction and operational phase will largely depend on the climatic conditions at the site. The ambient noise increases as the wind speed increases.

5.3.1 Construction Phase

a) There will be an impact on the immediate surrounding environment from the construction activities, especially if pile driving is to be done. This however will only occur if the underlying geological structure requires this.
b) The area surrounding the construction site will be affected for short periods of time in all directions, should a number of main pieces of equipment be used simultaneously.
c) The number of construction vehicles that will be used in the project will add to the existing ambient levels and will most likely cause a disturbing noise.

5.3.2 Operational Phase

Table 16 - Summary of noise impacts on NSA's at various wind speeds

NSA	3m/s	4m/s	6m/s	8m/s	10m/s	12m/s	Turbine 500m setback distance criteria met
Option 1							
NSA 1 - Windhoek (Main House)	✓	✓	✓	✓	✓	✓	Yes
NSA 2 – Windhoek (Workers Cottage)	✓	✓	✓	✓	✓	X	Yes
NSA 3 - Kleinwindhoek	✓	✓	✓	✓	✓	✓	Yes
NSA 4 - Rory Richard	✓	✓	✓	✓	✓	✓	Yes
NSA 5 - Jacobus Kraal	✓	✓	✓	✓	✓	✓	Yes
NSA 6 - Die Padstal	✓	✓	✓	✓	✓	✓	Yes
NSA 7 - Slangkop	✓	✓	✓	✓	✓	✓	Yes
NSA 8 - Droevlei	✓	✓	✓	✓	✓	✓	Yes
NSA 9 - Swartwater	✓	✓	✓	✓	✓	✓	Yes
NSA 10 - Grootberg	✓	✓	✓	✓	✓	✓	Yes

✓ = Within Recommended Noise Limit   X = Exceeds 45dB (A) day/night Recommended Limit

NSA	3m/s	4m/s	6m/s	8m/s	10m/s	12m/s	Turbine 500m setback distance criteria met
Option 2							
NSA 1 - Windhoek (Main House)	✓	✓	✓	✓	✓	✓	Yes
NSA 2 – Windhoek (Workers Cottage)	✓	✓	✓	✓	✓	X	Yes
NSA 3 - Kleinwindhoek	✓	✓	✓	✓	✓	✓	Yes
NSA 4 - Rory Richard	✓	✓	✓	✓	✓	✓	Yes
NSA 5 - Jacobus Kraal	✓	✓	✓	✓	✓	✓	Yes
NSA 6 - Die Padstal	✓	✓	✓	✓	✓	✓	Yes
NSA 7 - Slangkop	✓	✓	✓	✓	✓	✓	Yes
NSA 8 - Droevlei	✓	✓	✓	✓	✓	✓	Yes
NSA 9 - Swartwater	✓	✓	✓	✓	✓	✓	Yes
NSA 10 - Grootberg	✓	✓	✓	✓	✓	✓	Yes

✓ = Within Recommended Noise Limit X = Exceeds 45dB (A) day/night Recommended Limit

Conclusion - Option 1

The noise produced by the wind turbines will exceed the 45dB(A) day/night limit at the Windhoek Farm Workers homes at 12m/s wind speed.

The location of the Option 1 wind turbine generators all met the recommended 500m setback distance from the existing noise sensitive receptors.

Conclusion - Option 2

The noise produced by the wind turbines will exceed the 45dB(A) day/night limit at the Windhoek Farm Workers homes at 12m/s wind speed.

The location of the Option 2 wind turbine generators all met the recommended 500m setback distance from the existing noise sensitive receptors.

As the wind speed increases, the ambient noise also increases and masks the wind turbine noise. The critical wind speeds are thus between 4-6m/s when there is a possibility of little masking. At 12m/s the wind speed is such that it is highly unlikely that the turbine noise will be heard.

5.3.3 Decommissioning

The decommissioning noise impacts will be the same as for the construction phase.

5.3.4 Noise Impact Rating

The noise impact assessment tables are presented below:

Table 17- Noise impact rating table – No Mitigation

DESCRIPTION OF THE IMPACT	NATURE / STATUS	EXTENT	DURATION	INTENSITY	PROBABILITY	SIGNIFICANCE (WITHOUT MITIGATION)	MITIGATION	SIGNIFICANCE (WITH MITIGATION)
CONSTRUCTION								
Impact of the construction noise on the surrounding environment	Negative	Local	Short Term	Medium	Probable	Medium	As per Section 6.1 below	Low
OPERATION								
Impact of the operational noise on the surrounding environment	Negative	Local	Short Term	Medium	Probable	Medium	As per Section 6.1 below	Low
DECOMMISSIONING								
Impact of the decommissioning noise on the surrounding environment	Negative	Local	Short Term	Medium	Probable	Medium	As per Section 6.1 below	Low

6.0 RECOMENDATIONS

The following is recommended:

6.1 Construction Activities

a) All construction operations should only occur during daylight hours if possible.
b) No construction piling should occur at night. Piling should only occur during the day to take advantage of unstable atmospheric conditions.
c) Construction staff should receive “noise sensitivity” training.
d) An ambient noise survey should be conducted during the construction phase.

6.2 Operational Activities

The following general recommendation is made for the operational phase:

e) The noise impact from the wind turbine generators should be measured during the operational phase, to ensure that the impact is within the recommended limits.

6.3 Decommissioning Activities

The recommendations for the decommissioning phase are the same as for the construction phase.

If any further information is required please feel free to contact me. Assuring you of our best attention at all times.

Thanking you.

Brett Williams

7.0 REFERENCES

1)	Australia Environmental Protect Agency - **Wind farms - environmental noise guidelines**. July 2009.
2)	Bell Acoustic Consulting. Low frequency noise and infrasound from Wind turbine generators: A literature review. George Bellhouse. June 2004.
3)	University of Cape Town Environmental Management Unit Report Number 8/10/306 of 14th December 2010: Final Scoping Report Kerriefontein And Darling Wind Farm
4)	DEFRA – United Kingdom A Review of Published Research on Low Frequency Noise and its Effects. Geoff Leventhall. 2003
5)	DTI – United Kingdom The measurement of low frequency noise at 3 UK Wind Farms. Hayes Mackenzie. 2006
6)	Gold Coast Desalination Alliance (GCDA) – 2006 Environmental Impact Assessment Queensland Desalination Plant (Chapter 11).
7)	International Finance Corporation – 2007 General EHS Guidelines: Environmental Noise.
8)	ISO 9613-2 - Acoustics – Attenuation of sound during propagation outdoors. Part 2 – General method of calculation.
9)	Renewable Energy Research Laboratory - Department of Mechanical and Industrial Engineering. University of Massachusetts at Amherst. **A White Paper on Wind Turbine Acoustic Noise.** Authors: Anthony L. Rogers, Ph.D. James F. Manwell, Ph.D. Sally Wright. Amended January 2006
10)	South Africa - GNR.154 of January 1992: **Noise control regulations** in terms of section 25 of the Environment Conservation Act (ECA), 1989 (Act No. 73 of 1989)
11)	South Africa - GNR.155 of 10 January 1992: **Application of noise control regulations** made under section 25 of the Environment Conservation Act, 1989 (Act No. 73 of 1989)
12)	South Africa - SANS 10210:2004 Edition 2.2 – Calculating and predicting road traffic noise
13)	South Africa - SANS 10357:2004 Version 2.1 - The calculation of sound propagation by the Concawe method
14)	South Africa - SANS 10103:2008 Version 6 - The measurement and rating of environmental noise with respect to annoyance and to speech communication.
15)	Swedish Environmental Protection Agency – **Noise Annoyance from Wind Turbines – a Review.** Authors: Eja Pedersen, Högskolan i Halmstad. August 2003.
16)	University of Groningen - 11th International Meeting on Low Frequency Noise and Vibration and its Control. Do wind turbines produce significant low frequency sound levels? GP. van den Berg. September 2003.
17)	World Health Organization – **Guidelines for Community Noise**. 1999

APPENDICES

APPENDIX A - AIA Certificate

DEPARTMENT
OF LABOUR

Certificate

This is to certify that

SAFETRAIN CC
TRADING AS T\A SAFETECH

has been approved as an

APPROVED INSPECTION AUTHORITY

in terms of the Occupational Health and Safety Act, 1993,
for the monitoring of

Physical Stress Factors and Chemical Stress Factors (including Lead and Asbestos, Ergonomic hazards and Ventilation Installation) and Biological Factors

2009-08-27
DATE

CI 049 OH
CERTIFICATE NUMBER

CHIEF INSPECTOR

APPENDIX B - Calibration Certificate

sanas
Calibration Laboratory
146 1202

M AND N ACOUSTIC SERVICES CC
VAT NO: 4300255876
P.O. Box 61713
[illegible] van Ryneveld
0045
Co. Reg. No: 2008/079193/23
Tel: 012 689 2007/8
Fax: 086 211 4690
E-mail: calservice@mweb.co.za

CERTIFICATE OF CALIBRATION

CERTIFICATE NUMBER	2010-1276
ORGANISATION	SAFETECH
ORGANOSATION ADDRESS	50 GLENFIELDS MANITOBA DRIVE, FAERIE GLEN, 0081
CALIBRATION OF	INTEGRATING SOUND LEVEL METER complete with ½" MICROPHONE
CALIBRATED BY	M.W. DE BEER
MANUFACTURERS	QUEST, BRÜEL and KJAER
MODEL NUMBERS	1200 and 4936
SERIAL NUMBERS	DKE 100001 and 2505174
DATE OF CALIBRATION	5 OCTOBER 2010
RECOMMENDED DUE DATE	OCTOBER 2011
PAGE NUMBER	PAGE 1 OF 4

This certificate is issued in accordance with the conditions of approval granted by the South African National Accreditation System (SANAS). This Certificate may not be reproduced without the written approval of SANAS and M and N Acoustic Services.

Calibrations performed by this laboratory are in terms of standards, the accuracies of which are traceable to national measuring standards as maintained by NMISA

The measurement results recorded in this certificate were correct at the time of calibration. The subsequent accuracy will depend on factors such as care, handling, frequency of use and the amount of different users. It is recommended that re-calibration should be performed at an interval, which will ensure that the instrument remains within the desired limits and/or manufacturer's specifications.

The South African National Accreditation System (SANAS) is member of the International Laboratory Accreditation Cooperation (ILAC) Mutual Recognition Arrangement (MRA). This arrangement allows for mutual recognition of technical test and calibration data by member accreditation bodies worldwide. For more information on the arrangement please consult www.ilac.org

M. W. DE BEER (SANAS TECHNICAL SIGNATORY)

7 October 2010
DATE OF ISSUE

Only Member : Marianka Naudé

Health and Welfare Sector Education and Training Authority
HWSETA

SAFETECH

APPENDIX C – Typical Sound Power and Sound Pressure Levels

Acoustic Power	Degree		Pressure Level	Source
32 GW	Deafening		225 dB	12” Cannon @ 12ft in front and below
25 to 40 MW			195 dB	Saturn Rocket
100 Kw			170 dB	Turbojet engine with afterburner
10 Kw			160 dB	Turbojet engine, 7000lb thrust
1 kW			150 dB	4 Propeller Airliner
100 W			140 dB	Artillery Fire
10 W	Threshold of pain		130 dB	Pneumatic Rock Drill
				130 dB causes immediate ear damage
3 W			125 dB	Small aircraft engine
1.0 W			120 dB	Thunder
100 Mw			110 dB	Close to train
10 mW	Very Loud		100 dB	Home lawn mower
1 mW			90 dB	Symphony or a Band
				85 dB regularly can cause ear damage
100 uW	Loud		80 dB	Police whistle
10 uW			70 dB	Average radio
1 uW	Moderate		60 dB	Normal conversational voice
100 nW			50 dB	Quiet stream
10 nW	Faint		40 dB	Quiet conversation
1 nW			30 dB	Very soft whisper
100 pW	Very faint		20 dB	Ticking of a watch
10 pW	Threshold of hearing		10 dB	
1 pW			0 dB	Absolute silence

Sound Perception

Change in Sound Level	Perception
3 dB	Barely perceptible
5 dB	Clearly perceptible
10 dB	Twice as loud