ENVIRONMENT
HEALTH
SAFETY

PROPOSED INYANDA - ROODEPLAAT WIND ENERGY FACILITY

IN THE EASTERN CAPE PROVINCE

DEA REFERENCE: 14/12/16/3/3/2/464

SPECIALIST STUDY ON NOISE IMPACTS

HW592A1000508

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DoL Approved Inspection Authority (OH0049-CI-09)

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Amendment History

Version 1	Original	18/02/2016
Version 2	Updates from reviewer comments. Added Batch Plant impacts and Groendal Nature Reserve impacts	17/03/2016

INFORMATION PAGE

CLIENT NAME	SRK Consulting
PROJECT	Inyanda – Roodeplaat Wind Energy Facility Eastern Cape Province
CONTACT PERSON	Ms. N. Rump
TYPE OF SURVEY	Noise Specialist Study as part of the Environmental Impact Assessment
DATE OF FIELD SURVEY	15th & 16th February 2016
REPORT PREPARED BY	Dr 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.

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Dr 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 Inyanda – Roodeplaat Wind Energy Facility, Eastern 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 study for an environmental noise impact assessment for construction of the Inyanda – Roodeplaat Wind Energy Facility in the Eastern Cape. The facility will generate approximately 140-158MW of electricity.

The study considered the site location as described in the Final Scoping Report (SRK Consulting, March 2015 Report # 478867). A literature review and desktop modelling was conducted. Baseline monitoring was done of the ambient noise levels at the site.

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

a) There will be a short term increase in noise in the vicinity of the site during the construction phase as the ambient noise level will be exceeded by vehicle operations. This is however only applicable to NSA 1, which is the homestead of the project developer. The two receptors on the neighbouring farm will be impacted by the Concrete Batching Plant.
b) The SANS 10103:2008 night limit of 35dB(A) and day/night limit of 45dB(A) will not be exceeded at any of the identified noise sensitive areas (northern portion of the project site) during the operational phase. This applies to the 52 turbine layout as well as the 48 turbine layout.
c) The existing hiking trails and camping sites of the Groendal Nature Reserve will not be impacted by the noise emissions due to the distance from the site. There could be a very slight night-time impact at one location on the Kwazunga River if hikers proceed in a westerly direction in the Groendal Nature Reserve. The impact is however highly unlikely.

The following is recommended:

a) The noise impacts are re-modelled when the final turbine layout is determined.
b) A separate study is conducted to determine the noise impact on the avifauna.
c) Periodic noise measurements are taken during the construction and operational phases.

Dr Brett Williams

ABBREVIATIONS AND DEFINITIONS

Ambient Noise (NMMB Noise Control Regulations)	Means the reading on an integrating impulse sound level meter taken at a measuring point, in the absence of any alleged disturbing noise, at the end of a total period of at least 10 minutes after such meter was put into operation ***Authors Note:*** *Ambient noise excludes the noise alleged to be causing a noise nuisance or disturbing noise.*
Ambient Noise (SANS 10103)	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.
dB(A)	Decibels weighted A scale - Value of the sound pressure level in decibels, determined using a frequency weighting network A (with reference to 20 µPa unless otherwise indicated).
Disturbing Noise (NMMB Noise Control Regulations	Means a noise level that causes the ambient sound level to rise above the designated sound level, or if no sound level has been designated, a sound level that exceeds the ambient sound level by 7 dBA or more or that exceeds the typical rating levels for ambient noise in districts, indicated in table 2 of SANS 10103
Equivalent Continuous Rating Level ($L_{Req,T}$)	The equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$) during a specified time interval, plus specified adjustments for tonal character and impulsiveness of the sound, and derived from the applicable equation. $L_{Aeq,T} + Ci + C_t + kn$ where $L_{aeq,T}$ is the equivalent A-weighted sound pressure level in decibels Ci is the impulse correction C_t is the correction for tonal character Kn is the adjustment for day or night (0dB for day and +10dB for night measurements
Low Frequency Noise	Means sound which contains sound energy at frequencies predominantly below 100 Hz.
m/s	metres per second
Noise Nuisance	Means any sound which impairs or may impair the convenience or peace of a reasonable person.
Noise Rating Level	Means the applicable outdoor equivalent continuous rating level indicated in Table 2 of SANS 10103.
Residual Noise (SANS 10103)	Means the all-encompassing sound in a given situation at a given time, measured as the reading on an integrated impulse sound level meter for a total period of at least 10 minutes, excluding noise alleged to be causing a noise nuisance or disturbing noise.
SANS 10103:2008	The South African national standards code of practice for the measurement and rating of environmental noise with respect to annoyance and to speech communication.
Sound Level	Means the equivalent continuous rating level as defined in SANS 10103, taking into account impulse, tone and night-time corrections.
NMBMM Noise Control Regulations	Nelson Mandela Bay Metropolitan Municipality: Noise Control By-Law LAN 37 - GN 2322 March 2010

1. Introduction

1.1. Background to the Study

Inyanda Energy Projects (Pty) Ltd proposes to construct a Wind Energy Facility (WEF) of up to 140 – 158 megawatts (MW) installed capacity on a number of properties situated in the Groot Winterhoek Mountains west of the town of Uitenhage in the Eastern Cape. The WEF falls within the Nelson Mandela Bay Metropolitan Municipality (NMBMM). The wind farm will host up to approximately 44-52 turbines, each with a capacity of up to 3.6 MW.

1.2. Technical Objectives/Scope of the Noise Impact Assessment

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 Environment Conservation Act: National Noise Control Regulations; and the NMBMM Noise Control Regulations.

- 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.

1.3. Structure of the report

This volume presents the findings of the noise impact assessment specialist study undertaken in the detailed EIA phase of the proposed development and the structure of the report is therefore as follows:

Chapter 1- Introduction: Provides brief background information on the proposed project as well as the objectives of the specialist studies. This Chapter also provides details on the structure of this report.

Chapter 2 – Project Description: Provides a detailed description of the proposed project based on the latest project plans provided by SRK Consulting.

Chapter 3 – Introduction to Noise: Provides a primer in order to understand the technical aspects of the report.

Chapter 4 – Methodology and Approach: The methodology to conduct the field study as well as the desktop study is discussed.

Chapter 5 – Applicable Legislation and Standards: The noise rating limits and the minimum setback distances are discussed.

Chapter 6 – Impacts during the Construction Phase: The noise impacts for the construction phase are suggested and calculated.

Chapter 7 – Impacts during the Operational Phase: The noise impacts for the operational phase are modelled.

Chapter 8 – Conclusion and Recommendation: The conclusion and recommendations are presented.

1.4. Assumptions and Limitations

The following assumptions and limitations are applicable to this study:

- The turbine positions were supplied by the developer and are accepted as an accurate layout for the purposes of the environmental impact assessment.
- The worst case scenario impacts were modelled i.e. wind from any direction, not only the prevailing wind, maximum turbine size as required for the site and the worst case meteorological conditions.

2. PROJECT DESCRIPTION

2.1. Location and Site Description of the Proposed Development

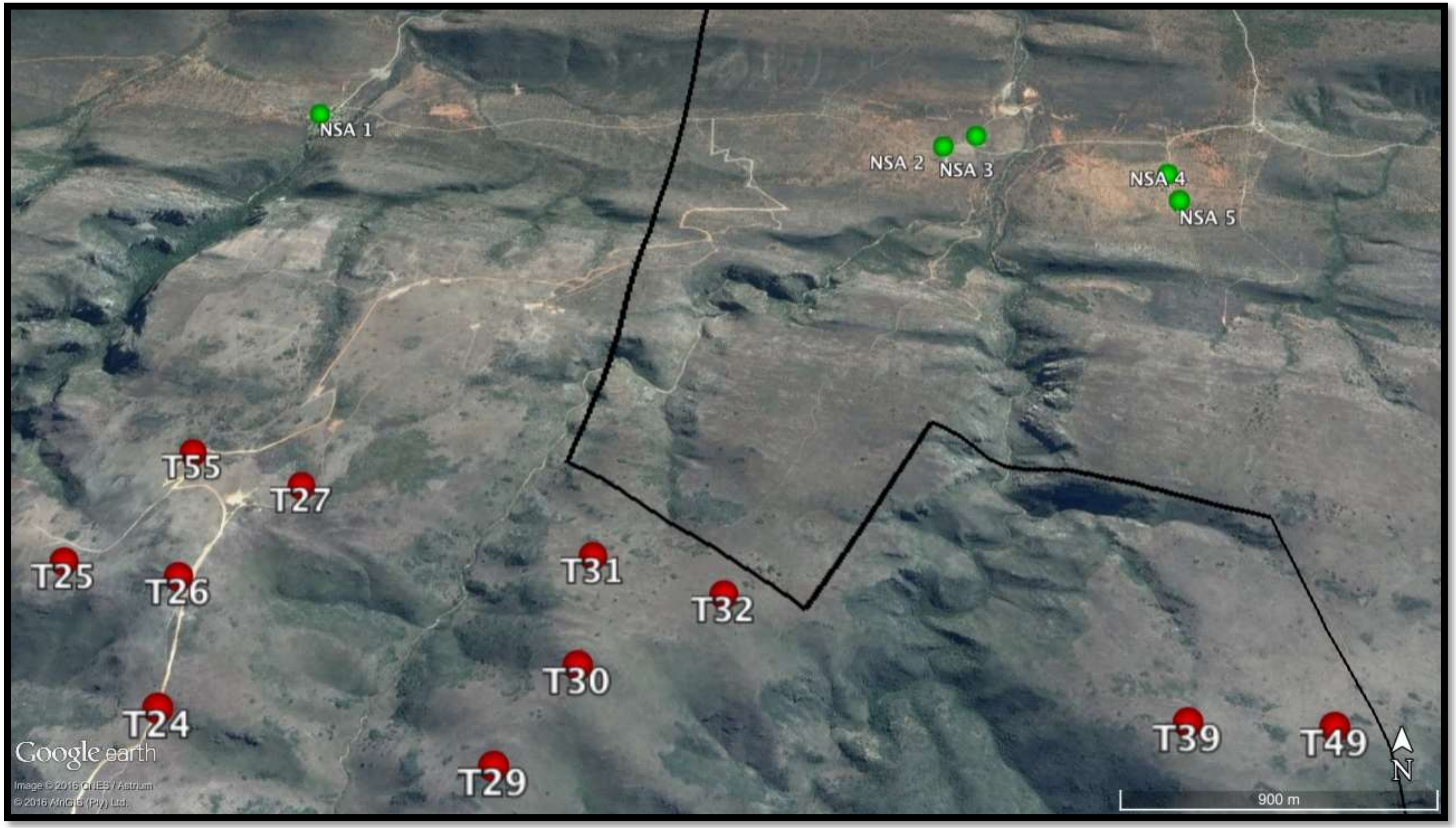
The location and position of the various wind turbine generators (WTG) are contained in the table and figures below. The project is located in a rural area and is situated on farmland. The terrain is extremely rugged with the turbine site on top of the Winterberg Mountains and farmhouses situated in the valleys below. A total of 52 WTG's were modelled in Option 1 and 48 WTG's in Option 2. This may be reduced to 44 WTG's in the final layout irrespective of the layout,.

Table 1 - WTG Co-Ordinates

Option 1			Option 2		
WTG Number	East	South	WTG Number	East	South
T01	25°02'12.58"	33°35'27.36"	T-01	25°02'14.30"	33°35'27.03"
T03	25°02'26.99"	33°35'29.79"	T-02	25°02'27.22"	33°35'29.93"
T04	25°02'41.89"	33°35'35.09"	T-03	25°03'10.37"	33°36'41.70"
T06	25°03'11.14"	33°35'43.38"	T-04	25°02'39.47"	33°35'34.08"
T07	25°03'26.66"	33°35'45.15"	T-05	25°03'15.39"	33°36'55.19"
T08	25°03'41.91"	33°35'41.33"	T-06	25°02'56.97"	33°35'44.13"
T09	25°03'54.89"	33°35'48.97"	T-07	25°02'47.24"	33°36'04.39"
T10	25°04'08.80"	33°35'51.49"	T-08	25°03'06.97"	33°35'58.02"
T11	25°04'16.51"	33°36'00.67"	T-09	25°03'12.21"	33°35'44.21"
T12	25°04'33.13"	33°36'05.27"	T-10	25°02'53.23"	33°36'51.82"
T13	25°04'49.87"	33°36'07.61"	T-11	25°03'28.42"	33°35'46.05"
T14	25°05'03.92"	33°36'14.32"	T-12	25°03'42.25"	33°34'51.37"
T15	25°05'17.44"	33°36'20.47"	T-13	25°03'42.25"	33°35'28.02"
T16	25°02'10.02"	33°35'39.36"	T-14	25°03'45.44"	33°35'06.45"
T17	25°03'06.79"	33°35'57.72"	T-15	25°02'51.97"	33°37'04.75"
T18	25°02'33.07"	33°35'18.46"	T-16	25°03'56.78"	33°34'55.69"
T19	25°02'45.74"	33°35'12.30"	T-17	25°03'54.42"	33°35'47.34"
T20	25°05'29.93"	33°36'20.76"	T-18	25°04'09.37"	33°35'50.30"
T21	25°05'44.19"	33°36'19.81"	T-19	25°04'10.31"	33°37'25.72"
T22	25°05'57.44"	33°36'20.44"	T-20	25°04'16.29"	33°36'01.70"
T23	25°03'42.46"	33°35'30.69"	T-21	25°04'15.04"	33°37'13.62"
T24	25°03'46.67"	33°35'19.39"	T-22	25°04'18.03"	33°37'01.23"
T25	25°03'30.42"	33°35'03.75"	T-23	25°04'18.99"	33°35'37.92"
T26	25°03'45.44"	33°35'06.45"	T-24	25°04'20.22"	33°36'32.76"
T27	25°03'56.78"	33°34'55.69"	T-25	25°04'23.12"	33°35'25.19"
T28	25°04'18.53"	33°35'39.50"	T-26	25°04'21.87"	33°36'45.65"
T29	25°04'23.44"	33°35'24.80"	T-27	25°02'45.92"	33°37'23.42"
T30	25°04'31.79"	33°35'15.46"	T-28	25°02'51.12"	33°37'38.82"
T31	25°04'32.68"	33°35'03.43"	T-29	25°04'32.53"	33°35'13.68"
T32	25°04'48.21"	33°35'07.66"	T-30	25°04'42.48"	33°36'05.06"
T33	25°04'46.80"	33°35'54.00"	T-31	25°04'46.66"	33°35'07.60"
T34	25°05'22.29"	33°36'01.33"	T-32	25°04'56.80"	33°36'09.96"
T35	25°05'26.68"	33°35'46.79"	T-33	25°05'09.61"	33°36'15.06"

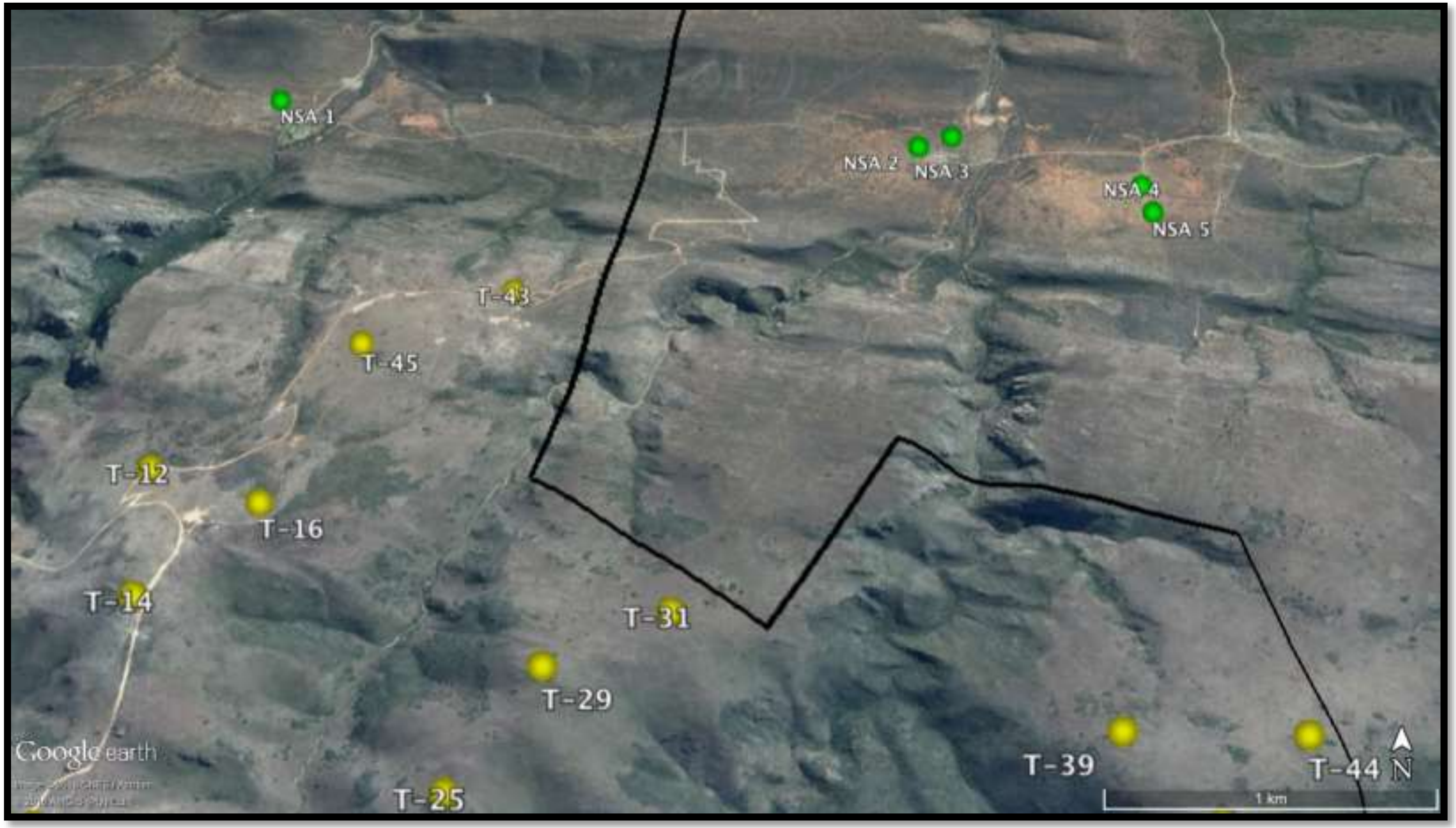
Option 1			Option 2		
WTG Number	East	South	WTG Number	East	South
T36	25°05'14.61"	33°35'38.49"	T-34	25°05'10.79"	33°36'49.20"
T37	25°05'43.72"	33°35'46.34"	T-35	25°05'17.22"	33°36'39.53"
T38	25°05'45.90"	33°35'33.78"	T-36	25°05'22.66"	33°35'58.54"
T39	25°05'39.28"	33°35'20.98"	T-37	25°05'26.46"	33°35'47.99"
T40	25°02'47.24"	33°36'04.39"	T-38	25°05'26.09"	33°36'23.98"
T41	25°03'12.92"	33°36'09.54"	T-39	25°05'36.59"	33°35'19.80"
T42	25°03'42.05"	33°36'01.26"	T-40	25°03'05.33"	33°37'55.70"
T43	25°03'42.05"	33°36'13.11"	T-41	25°05'43.10"	33°35'42.63"
T44	25°04'23.37"	33°36'16.39"	T-42	25°05'44.38"	33°35'28.79"
T45	25°04'20.61"	33°36'27.51"	T-43	25°04'23.61"	33°34'24.43"
T46	25°04'23.90"	33°36'40.06"	T-44	25°05'56.82"	33°35'20.50"
T47	25°05'21.33"	33°36'32.61"	T-45	25°04'04.07"	33°34'33.21"
T48	25°05'13.00"	33°36'44.23"	T-46	25°03'42.05"	33°36'01.26"
T49	25°05'55.24"	33°35'21.65"	T-47	25°03'41.49"	33°36'13.88"
T50	25°04'22.34"	33°36'52.37"	T-48	25°04'22.19"	33°37'34.05"
T51	25°04'19.55"	33°37'04.24"			
T52	25°04'17.27"	33°37'16.09"			
T53	25°04'15.34"	33°37'27.78"			
T55	25°03'42.29"	33°34'51.37"			

Figure 1 - WTG Positions (Option 1 – 52 Turbines)



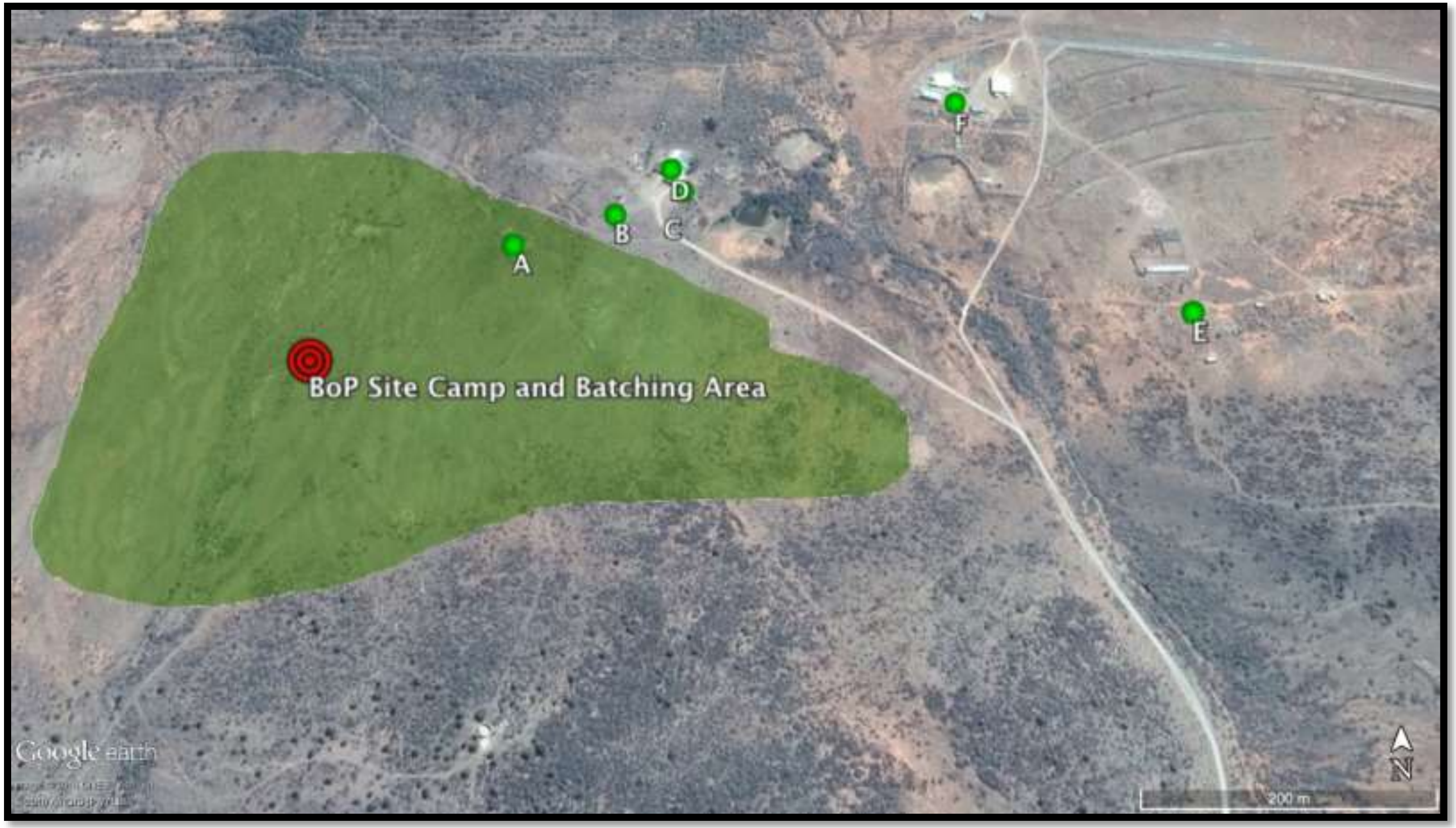
Option 1 WTG = Red dot   Noise Sensitive Area = Green Dot

Figure 2 - WTG Positions (Option 2 – 48 Turbines)



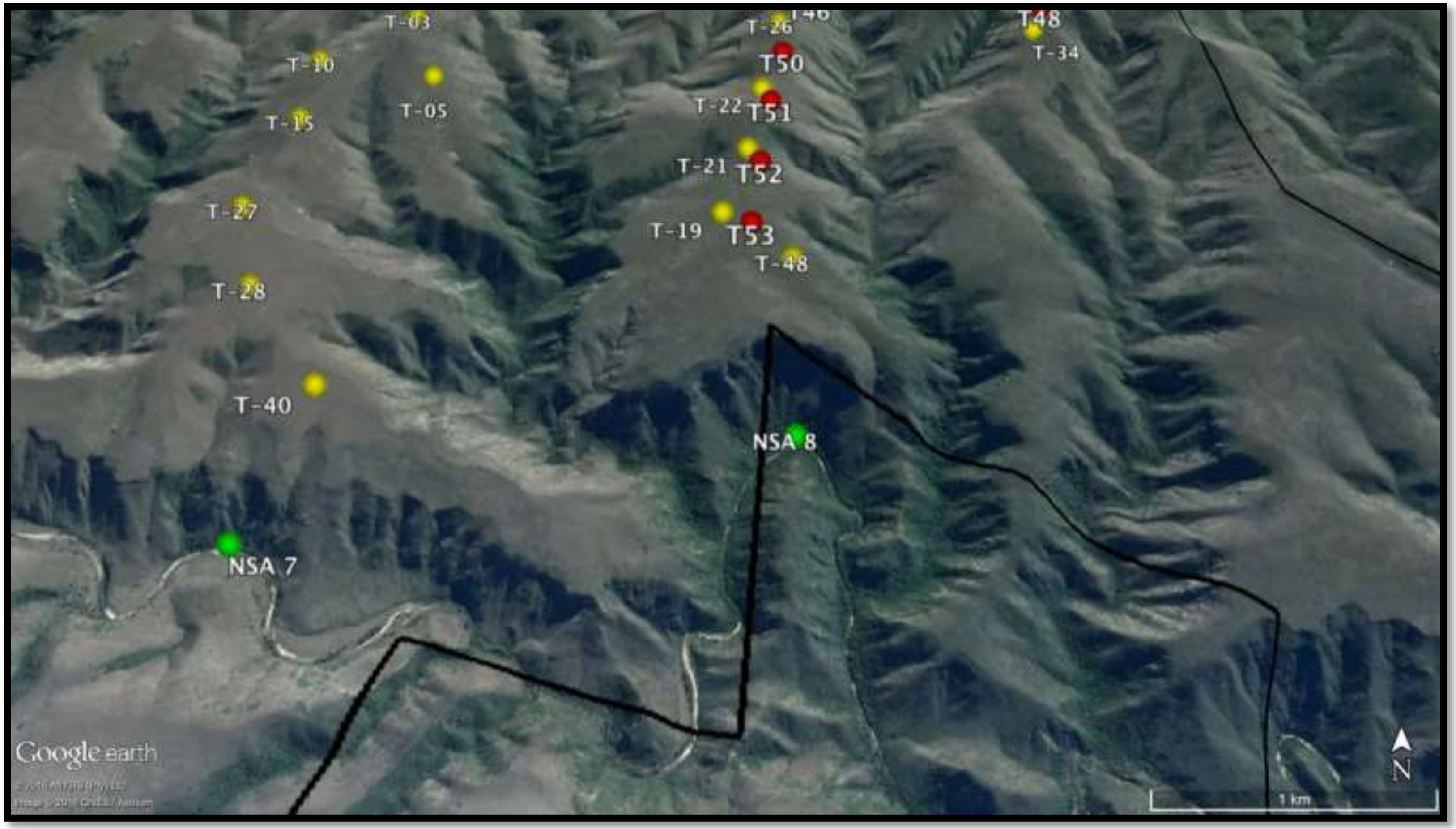
Option 2 WTG = Yellow dot   Noise Sensitive Area = Green Dot

Figure 3 - Batch Plant & Noise Sensitive Areas



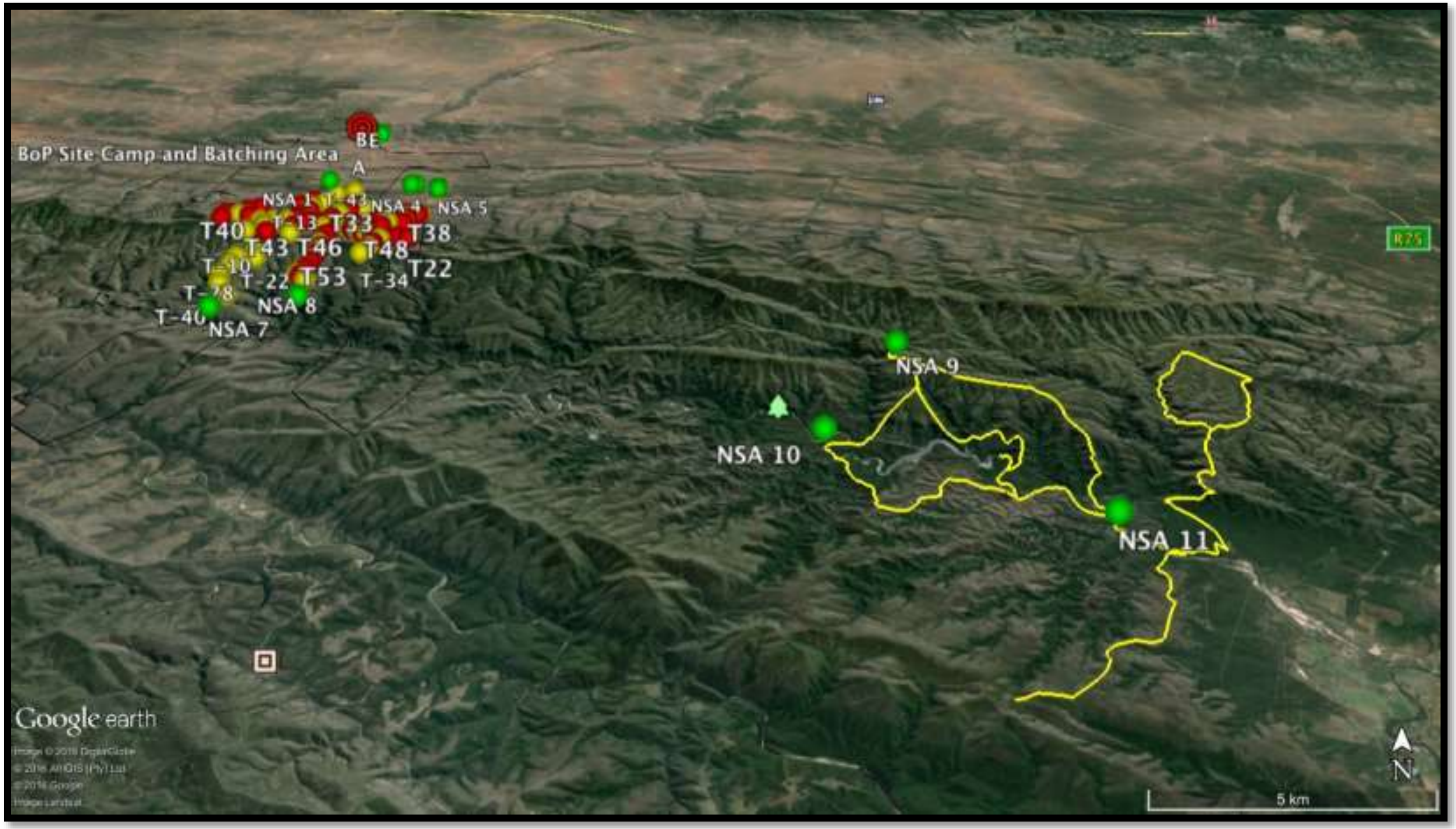
Noise Sensitive Area = Green Dot

Figure 4 - WTG Positions (Option 1 & 2) - Groendal Nature Reserve



Noise Sensitive Area = Green Dot
Windfarm Boundary = Black line

Figure 5 - WTG Positions & Groendal Nature Reserve (Existing Trails & Campsite)



Noise Sensitive Area = Green Dot
Groendal Hiking Trails = Yellow line

The project site 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.

2.2. Sensitive Receptors

2.2.1 Human Noise Sensitive Areas

Northern Portion – Operational Phase

The project area is situated in a rural farming community. Five homesteads are located in the vicinity where the turbines will be erected. The locations of the various noise sensitive areas (NSA's) are indicated in the table below and the figures above. A sixth farmhouse to the south of the project is abandoned and will not be occupied (as per communication with Mr Hylton Newcombe, representing the developer). These five receptors (NSA 1-5) are located to the north of the windfarm (Figure 1 & 2).

Northern Portion – Construction Phase

During the construction phase, a concrete batching plant will be operational on the northern side of the Cockscomb Road. The site is situated in the most northern portion of the study area. There are six noise sensitive areas that are identified in close proximity to the Batching Plant. These are numbered NSA A-F as shown in Figure 3. The operational phase of the windfarm will not affect these receptors due to the distance from the windfarm. In communication with Mr. Hylton Newcombe (representing the developer), the following was determined:

- NSA A is a staff house (of the developer).
- NSA B & C are store rooms with no occupants
- NSA D is a Cold Room / Abattoir and has staff sleeping quarters attached. This location will have its own noise sources such as refrigeration plants etc. that will be operated continuously.
- NSA E & F are farm houses on the neighbouring farm.

Southern Portion – Groendal Nature Reserve

The Groendal Nature Reserve is located to the east of the proposed wind farm. A map indicating the current hiking trails was obtained from the Eastern Cape Parks and Tourism Agency. The trails are located approximately 14km to the east of the proposed windfarm (See Figure 5). Two points closest to the proposed windfarm are marked as NSA 9&10. The Groendal Nature Reserve campground is located approximately 20km to the east of the proposed windfarm. The closest campground is marked NSA 11.

The Kwazunga River runs directly to the south of the proposed windfarm. The river makes two sharp bends in close proximity to the southern most turbines. It is conceivable that hikers could hike in a westerly direction using the river course. Two receptors have been marked in this area to determine the potential noise impact. These are marked as NSA 7 & 8. In Figure 4 it can be seen that NSA 7 is with the windfarm boundary. It is not envisaged that many hikers will traverse this area or camp directly below the closest turbines to the site boundary.

The location of the noise sensitive areas is shown in Table 2 below.

Table 2 - Location of NSA's

	East	South	Comment
	Main Receptors – Operational Phase		
NSA 1	25°03'40.48"	33°33'46.55"	Farmstead
NSA 2	25°05'25.53"	33°33'55.52"	Farmstead
NSA 3	25°05'31.31"	33°33'53.34"	Farmstead
NSA 4	25°06'00.83"	33°34'01.78"	Farmstead
NSA 5	25°06'01.26"	33°34'06.98"	Farmstead
NSA 6	-	-	Abandoned Structure
	Groendal Nature Reserve Receptors		
NSA 7	25° 2'54.15	33°38'15.22"	Kwazunga River
NSA 8	25° 4'21.86"	33°37'58.51"	Kwazunga River
NSA 9	25°14'48.18"	33°39'24.71"	Hiking Trail
NSA 10	25°13'26.60"	33°41'12.47"	Hiking Trail
NSA 11	25°17'25.83"	33°42'54.48"	Camp Site
	Batching Plant Receptors – Construction Phase		
NSA A	25° 3'46.42"	33°31'19.53"	Staff House
NSA B	25° 3'49.78"	33°31'18.53"	Store Rooms
NSA C	25° 3'52.08"	33°31'17.73"	Store Rooms
NSA D	25° 3'51.67"	33°31'16.89"	Cold Room / Staff Quarters

	East	South	Comment
NSA E	25° 4'8.31"	33°31'22.36"	Farmstead
NSA F	25° 4'1.83"	33°31'14.57"	Farmstead

2.2.2 Natural Environment Receptors

The fauna on the site includes bats, birds, commercial livestock and a variety of buck, leopard, reptiles etc. The noise impacts on the natural environment receptors are dealt with in separate specialist studies.

3. Introduction to Noise

3.1. 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 Hz 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

3.2. 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.

3.3. Mechanical Sounds

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

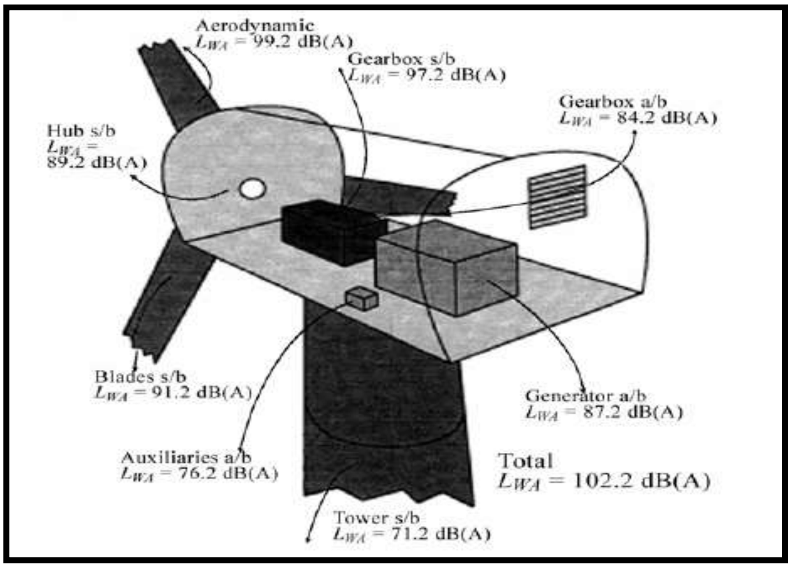
- Gearbox
- Generator
- Yaw Drives
- Cooling Fans
- Auxiliary Equipment (e.g. hydraulic systems, transformers etc.)

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.

The figure below shows the type of transmission path and the sound power levels for the individual components for a typical 2 MW wind turbine. The important information in the picture is not the sound power levels, but rather the various sources of noise from the whole assembly. The highest sound power level that was modelled for this project is 106.0 dB using the 3.3MW turbine.

Figure 6 - Typical Sound Power Levels of a 2MW Turbine

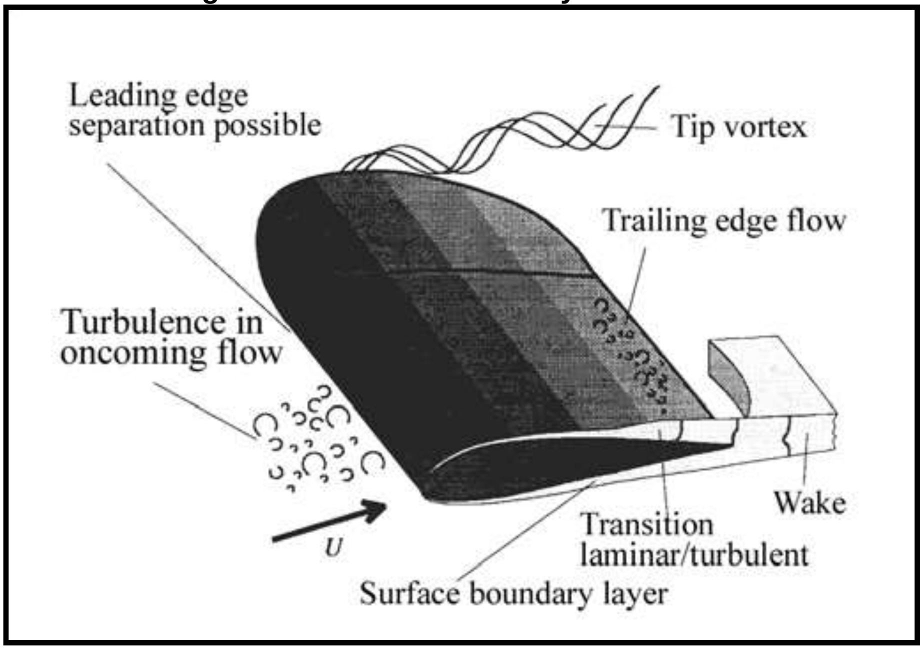


3.4. Aerodynamic Sound

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 7 - 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.

3.5. 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 generally masks the wind turbine sound above 8 m/s.

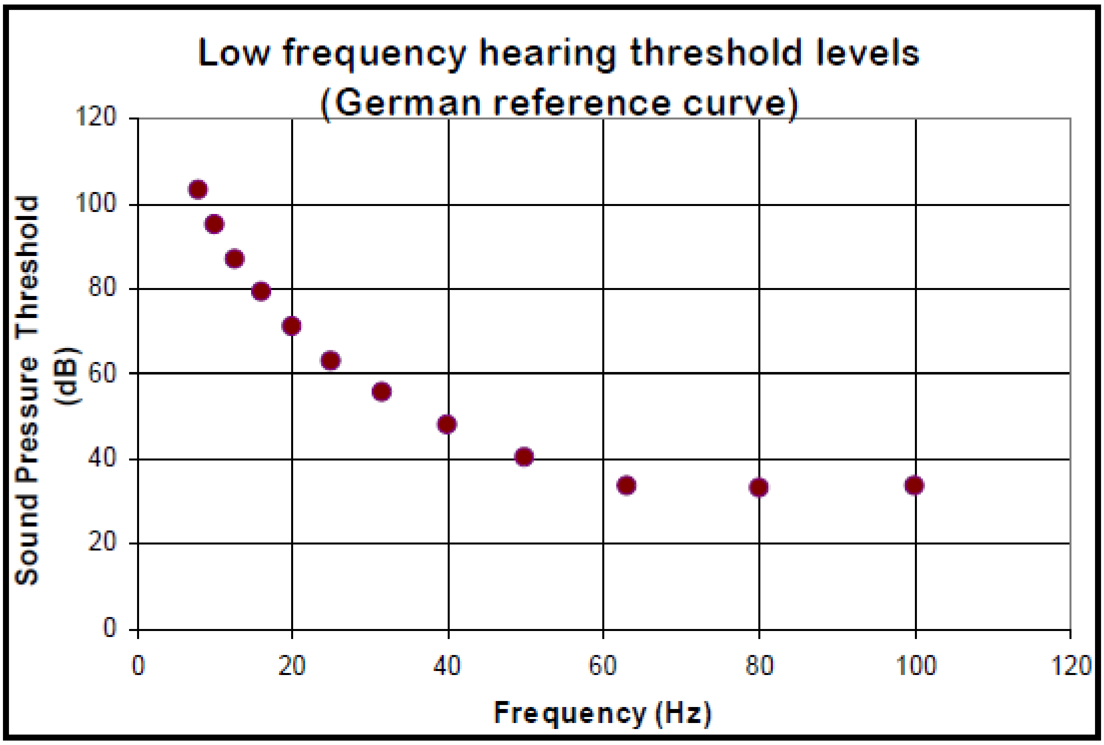
It should be remembered that average sound pressure measurements might not indicate when a sound is detectable by a listener. Just as a dog's barking can be heard through other sounds, sounds with particular frequencies or an identifiable pattern may be heard through background sounds that is otherwise 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.

3.6. 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 8 - 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 4 above.
- 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).

4. 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.

4.1. 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 2.9 which is specifically developed for modelling 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 <u>not</u> taken into consideration as the wind could blow from any direction at the speeds that were modelled. The following data was used for the WTG's that were modeled.

Inyanda Energy Projects (Pty) Ltd have not fully committed to a specific turbine model, although the Siemens SWT 3.6 – 130 is currently being considered. This is a new turbine that has not been fully validated in the WindPro 2.9 database. The closest similar turbine is the Siemens SWT 3.3 – 130, that has the same sound power emissions from 7m/s (106dB) and similar noise emission levels at lower wind speeds. The hub height that is being considered is 85m. The author is limited to the turbines in the officially released wind turbine catalogue in WindPro 2.9.

Table 3 - Proposed Turbine Specifications

Manufacturer	**Siemens**	**Siemens**
Type / Version	**SWT 3.3 – 130**	**SWT 3.6 – 130**
Rated Power	3.3 MW	3.6 MW
Rotor Diameter	126m	126m
Tower	Tubular	Tubular
Grid Connection	50 Hz	50 Hz

Hub Height	85m	85m
Various wind speeds (measured at 10m height)	Data below used in modelling	Data below not used in modelling
	Sound Power dB(A)*	Sound Power dB(A)**
3m/s	91.9	92.9
4m/s	96.1	97.1
5m/s	101.0	102.4
6m/s	105.2	105.8
7m/s	106.0	106.0
8m/s	106.0	106.0
9m/s	106.0	106.0
10m/s	106.0	106.0
11m/s	106.0	106.0
12m/s	106.0	106.0

* Sound Power Level dB(A) reference to 1pW from WindPro 2.9 Catalogue

** Sound Power level dB(A) reference to 1pW sourced from Siemens SWT-3.3-130 Preliminary Developer Package (29/1/2016) – Document Number: WP TE 30-0000-1787-00

4.2. Field Study

A field study to the project area was conducted on the 16th February 2016. The ambient monitoring points were chosen based on their proximity to the location of the proposed wind turbines. Ambient noise measurements were taken at the five noise sensitive areas that would be impacted during the operational phase. These were identified in Section 2.2.1 above. A further two monitoring points were chosen to determine the ambient noise closest to one of the turbine positions as well as one outside of the study area. The results are presented in Table 4 & 5 below. The measurement points are shown in Figure 6 below.

Table 4 – Ambient Monitoring Results - Day

Commencing at 12:47 ending at 16:10 on 16th February 2016

NO	AREA	Leq (dBA)	L_{90} (dBA)	Noise Source
Position 1	NSA 1 (33°33'42.82"S 25°3'42.8"E)	48.8	34.3	Noise from dogs barking. Noise from birds. Noise from trees blowing in the wind. Noise from pump running on farm. Noise from sprinklers.
Position 2	NSA 2 (33°33'54.47"S 33°5'26.22"E)	39.1	28.4	Noise from birds. Noise from trees blowing in the wind.
Position 3	NSA 3 (33°33'53.22"S 25°5'30.29"E)	38.7	25.1	Noise from birds. Noise from trees blowing in the wind.
Position 4	NSA 4 (33°34'1.48"S 25°6'0.89"E)	43.3	33.9	Noise from birds. Noise from trees blowing in the wind. Noise from paper bag rattling from wind. Metal gate rattling in the wind.
Position 5	NSA 5 (33°34'6.66"S 25°6'1.12"E)	38.4	27.5	Noise from roosters. Noise from metal door blowing in the wind. Noise from trees blowing in the wind. Noise from birds.
Position 6	South of NSA outside the site boundary (33°34'29.08"S 25°5'13.31"E)	47.0	26.4	Noise from birds. Noise from bush blowing in the wind.

NO	AREA	Leq (dBA)	L_{90} (dBA)	Noise Source
Position 7	WTG 14 (Option 2) (33°35’7.65”S 25°3’46.18”E)	44.8	30.8	Noise from birds. Noise from bush blowing in the wind.

Table 5 – Ambient Monitoring Results - Night

Commencing at 22:00 and ending at 23:45on 16th February 2016

NO	AREA	Leq (dBA)	L_{90} (dBA)	Noise Source
Position 1	NSA 1 (33°33’42.82”S 25°3’42.8”E)	34.4	26.8	Noise from crickets. Noise from bush rustling in the wind. Noise from trees rustling in the wind. Noise from dogs barking.
Position 2	NSA 2 (33°33’54.47”S 33°5’26.22”E)	30.6	18.8	Noise from crickets. Noise from bush rustling in the wind.
Position 3	NSA 3 (33°33’53.22”S 25°5’30.29”E)	36.6	26.4	Noise from crickets. Noise from bush rustling in the wind. Noise from metal gate rattling in the wind.
Position 4	NSA 4 (33°34’1.48”S 25°6’0.89”E)	35.7	29.1	Noise from crickets. Noise from bush rustling in the wind. Noise from metal gate rattling in the wind.
Position 5	NSA 5 (33°34’6.66”S 25°6’1.12”E)	30.2	15.8	Noise from crickets. Noise from bush rustling in the wind

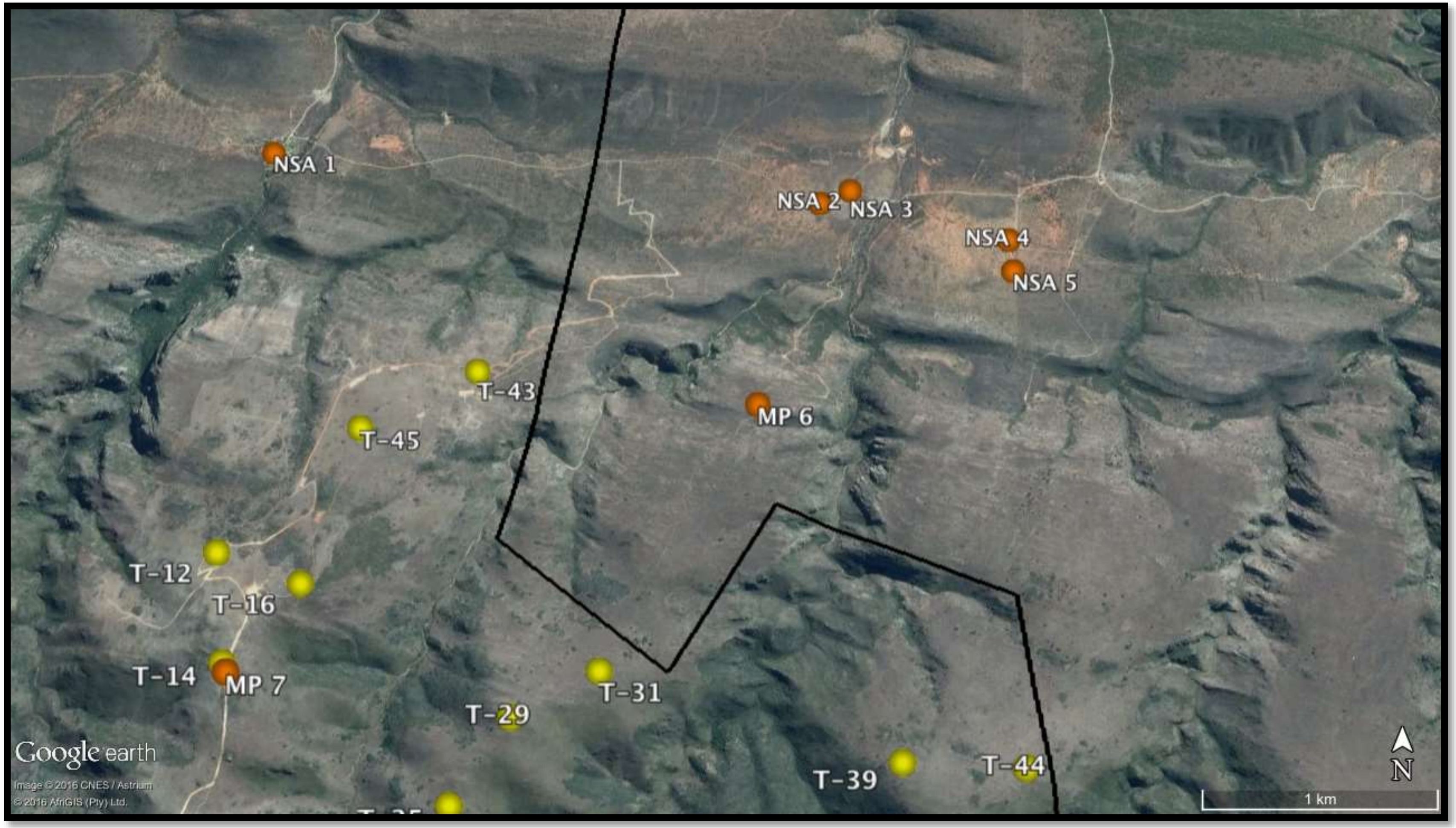
The measurements were taken by placing the noise meter on a tripod and ensuring that it was at least 1.2 m from floor level and 3.5 m from any large flat reflecting surface. All measurement periods were at least over 10 minutes, except where indicated. The noise meter was calibrated before and after 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 by M & N Acoustic Services in November 2015. 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.

Figure 9 - Monitoring Points (Orange dots)



5. APPLICABLE LEGISLATION AND 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 Government of the Western Cape – PN 627 (1998) Noise Control Regulations (used for reference only as Eastern Cape has no official provincial noise control legislation)

Local

- Nelson Mandela Bay Metropolitan Municipality: Noise Control By-Law GN 2322 March 2010.

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.

5.1. National & Provincial Legislation

The South African Noise Control Regulations (National) describe a *disturbing noise* as **any** noise that exceeds the ambient noise by more than 7dB. This difference is usually measured at the complainant's 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 legislation means any sound which disturbs or impairs the convenience of any person. The NMBMM Noise Control Regulations are similar to the National Noise Control Regulations in that the definition of a disturbing noise also refers to **any** noise that exceeds the ambient noise by more than 7dB.

The Eastern Cape has no Provincial Noise Regulations, therefore as a reference, the Western Cape Strategic Wind Initiative Document (May 2006) can be used for guidance. The Western Cape does not prescribe any noise limits other than to recommend a setback distance of 400m from residences (including rural dwellings). It is recommended that a setback distance of 500m be used for this project. This is based on this authors experience on similar projects. **The closest turbine to the occupied NSA's is approximately 2000m (Option 1 layout) and 1600m (Option 2 layout) .**

5.2. National Standards

The most applicable standard for planning purposes used in this study is SANS 10103:2008 which provides typical rating levels for noise in various types of districts, as described in the Table 6 below. It must be noted that there are no legislated limits for protected natural areas such as the Groendal Nature Reserve. Ideally, in such areas one does not want to experience any anthropogenic noise pollution.

Table 6 - Typical rating levels for noise in various types of districts

Type of District	Equivalent Continuous Rating Level, LAeq,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 the **guideline** 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. If the current ambient noise exceeds the rating limit, then actual ambient limit will be used when a noise complaint arises in terms of the Environment Conservation Act - Noise Control Regulations.

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 7 - 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

5.3. International Standards

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

- New Zealand – 40dB(A)
- Denmark – 42dB(A) (dwellings in open country)
- 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 (*LA90*) 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) (day/night limit) for rural districts.

6. IMPACTS DURING THE CONSTRUCTION PHASE

6.1. Potential Construction Noise Sources (General Equipment and Vehicles)

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

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 8 – 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

6.2. 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 below.

Table 9 - Typical Construction Noise

Type of Equipment	$L_{Aeq,T}$ 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 8. 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 10 - Combining Different Construction Noise Sources – High Impacts (Equipment with the highest sound power emissions i.e. 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 11 - Combining Different Construction Noise Sources – Low Impacts - Equipment with the lowest sound power emissions

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 12 – 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) during the day, 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. High wind conditions will have a masking effect on the construction noise. 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. Furthermore, none of the turbines are located closer than 1600m from the receptors.

A concrete batching will be located on the northern portion of the site. The sound power levels for Concrete Batching Plants have been derived from the United States Federal Highway Construction Noise Database. It is assumed that during the peak construction period the Concrete Batching Plant will be operational for 24 hours per day. The estimated sound power levels are as follows:

- Concrete Batching Plant 115 dB(A)
- Concrete Mixing Truck (whilst mixing) 117 dB(A)

The values above are very similar to the worst case construction equipment as described in Table 10 above. Table 12 (Attenuation by distance) can thus also be used to determine the impacts from the Batching Plant. The expected noise levels at NSA E is 48dB(A) and at NSA F is 50 dB(A). These two receptors are farmsteads on the neighbouring farms. The noise levels from the Concrete Batching Plant will exceed the 35dB(A) and 45dB(A) day and night limits as described in SANS 10103:2008.

NSA A-D are within the study area and Mr. Hylton Newcombe (representing the developer) states that these receptors will not be occupied during the construction phase.

6.3. Significance Statement – Construction Activities

The SRK Consulting impact rating methodology as described in the Final Scoping Report is used to determine the significance ratings.

Table 13 - Significance Rating Table – Construction Activities at Turbine Locations.

	Spatial Extent	Intensity	Duration	Consequence	Probability	Significance	+ -	Confidence
Before Management	Local (1)	Low (1)	Short-term (1)	Very Low (3)	Probable	Very Low	-	High
Management Measures								
Measures related to the construction phase: • All construction operations should only occur during daylight hours if possible. • No construction piling should occur at night where possible. Piling should only occur during the day to take advantage of unstable atmospheric conditions. • Construction staff should receive “noise sensitivity” training such as switching off vehicles when not in use, location of NSA’s etc. • An ambient noise survey should be conducted at the noise sensitive receptors during the construction phase.								
After Management	Local (1)	Low (1)	Short-term (1)	Very Low (3)	Possible	Insignificant	-	High
No-go Option	Local (N/A)	Low (N/A)	Short-term (N/A)	Very Low (N/A)	(N/A)	(N/A)	+	High

Table 14 - Significance Rating Table – Construction Activities at Batching Plant.

	Spatial Extent	Intensity	Duration	Consequence	Probability	Significance	+ -	Confidence
Before Management	Local (1)	Medium (2)	Short-term (1)	Very Low (4)	Probable	Very Low	-	High
Management Measures								
Measures related to the construction phase: • Noise levels from the reverse warning devices on all mobile equipment should be kept as low as possible • Construction staff should receive “noise sensitivity” training such as switching off vehicles when not in use, location of NSA’s etc. • An ambient noise survey should be conducted at the noise sensitive receptors during the construction phase.								
After Management	Local (1)	Low (1)	Short-term (1)	Very Low (3)	Possible	Insignificant	-	High
No-go Option	Local (N/A)	Low (N/A)	Short-term (N/A)	Very Low (N/A)	(N/A)	(N/A)	+	High

7. IMPACTS DURING THE OPERATIONAL PHASE

The potential effects of low frequency noise on humans include sleep disturbance, nausea, vertigo etc. These effects are unlikely to impact upon residents due to the distance between the turbines and the nearest communities. Sources of low frequency noise also include wind and vehicular traffic, which are all sources that also impact on the receptors.

7.1. Predicted noise levels for the Wind Turbines Generators

The tables and figures below indicate the noise generated by the turbines at wind speeds from 3m/s to 12m/s. It must be noted that above 7m/s the turbines have reached their maximum noise emissions (Sound Power Level106dB).

Table 15 - Predicted noise levels at the NSA's during the operational phase (Northern NSA's).

Name	Wind speed (m/s) 10m height	Option 1 (52 turbines) Sound Pressure Level from WTGs [dB(A)]	Option 2 (48 turbines) Sound Pressure Level from WTGs [dB(A)]	SANS 10103:2008 Night Limit
NSA 1	3	18.0	18.8	35
	4	22.2	23.0	35
	5	27.1	27.9	35
	6	31.5	32.0	35
	7	32.1	32.9	35
	8	32.1	32.9	35
	9	32.1	32.9	35
	10	32.1	32.9	35
	11	32.1	32.9	35
	12	32.1	32.9	35
NSA 2	3	17.8	18.2	35
	4	22.0	22.4	35
	5	26.9	27.3	35
	6	31.3	31.6	35
	7	31.9	32.3	35
	8	31.9	32.3	35
	9	31.9	32.3	35
	10	31.9	32.3	35
	11	31.9	32.3	35
	12	31.9	32.3	35
NSA 3	3	17.3	17.6	35
	4	21.5	21.8	35
	5	26.4	26.7	35
	6	31.0	31.0	35
	7	31.4	31.7	35
	8	31.4	31.7	35
	9	31.4	31.7	35
	10	31.4	31.7	35
	11	31.4	31.7	35
	12	31.4	31.7	35
NSA 4	3	16.9	16.8	35

Name	Wind speed (m/s) 10m height	Option 1 (52 turbines) Sound Pressure Level from WTGs [dB(A)]	Option 2 (48 turbines) Sound Pressure Level from WTGs [dB(A)]	SANS 10103:2008 Night Limit
	4	21.1	21.0	35
	5	26.0	25.9	35
	6	30.6	30.3	35
	7	31.0	30.9	35
	8	31.0	30.9	35
	9	31.0	30.9	35
	10	31.0	30.9	35
	11	31.0	30.9	35
	12	31.0	30.9	35
NSA 5	3	17.4	17.3	35
	4	21.6	21.5	35
	5	26.5	26.4	35
	6	31.0	30.8	35
	7	31.5	31.4	35
	8	31.5	31.4	35
	9	31.5	31.4	35
	10	31.5	31.4	35
	11	31.5	31.4	35
	12	31.5	31.4	35

Table 16 - Predicted noise levels at the NSA's during the operational phase (Groendal Nature Reserve)

Name	Wind speed (m/s) 10m height	Option 1 (52 turbines) Sound Pressure Level from WTGs [dB(A)]	Option 2 (48 turbines) Sound Pressure Level from WTGs [dB(A)]	SANS 10103:2008 Night Limit
NSA 7	3	14.4	22.9	35
	4	18.6	27.1	35
	5	23.5	32.0	35
	6	28.5	**35.8**	35
	7	28.5	**37.0**	35
	8	28.5	**36.1**	35
	9	28.5	**37.0**	35
	10	28.5	**37.0**	35
	11	28.5	**37.0**	35
	12	28.5	**37.0**	35
NSA 8	3	21.2	23.3	35
	4	25.4	27.5	35
	5	30.3	32.4	35
	6	34.3	**36.1**	35
	7	**35.3**	**37.4**	35
	8	**35.3**	**37.4**	35

Name	Wind speed (m/s) 10m height	Option 1 (52 turbines) Sound Pressure Level from WTGs [dB(A)]	Option 2 (48 turbines) Sound Pressure Level from WTGs [dB(A)]	SANS 10103:2008 Night Limit
	9	**35.3**	**37.4**	35
	10	**35.3**	**37.4**	35
	11	**35.3**	**37.4**	35
	12	**35.3**	**37.4**	35
NSA 9	3	0	0.0	35
	4	0	0.0	35
	5	0	0.0	35
	6	0	0.0	35
	7	0	0.0	35
	8	0	0.0	35
	9	0	0.0	35
	10	0	0.0	35
	11	0	0.0	35
	12	0	0.0	35
NSA 10	3	0	0.0	35
	4	0	0.0	35
	5	0	0.0	35
	6	0	0.0	35
	7	0	0.0	35
	8	0	0.0	35
	9	0	0.0	35
	10	0	0.0	35
	11	0	0.0	35
	12	0	0.0	35
NSA 11	3	0	0.0	35
	4	0	0.0	35
	5	0	0.0	35
	6	0	0.0	35
	7	0	0.0	35
	8	0	0.0	35
	9	0	0.0	35
	10	0	0.0	35
	11	0	0.0	35
	12	0	0.0	35

Figure 10 – Noise Emissions 52 WTG (3m/s wind speed) – Northern Portion

Black Line = Site Boundary

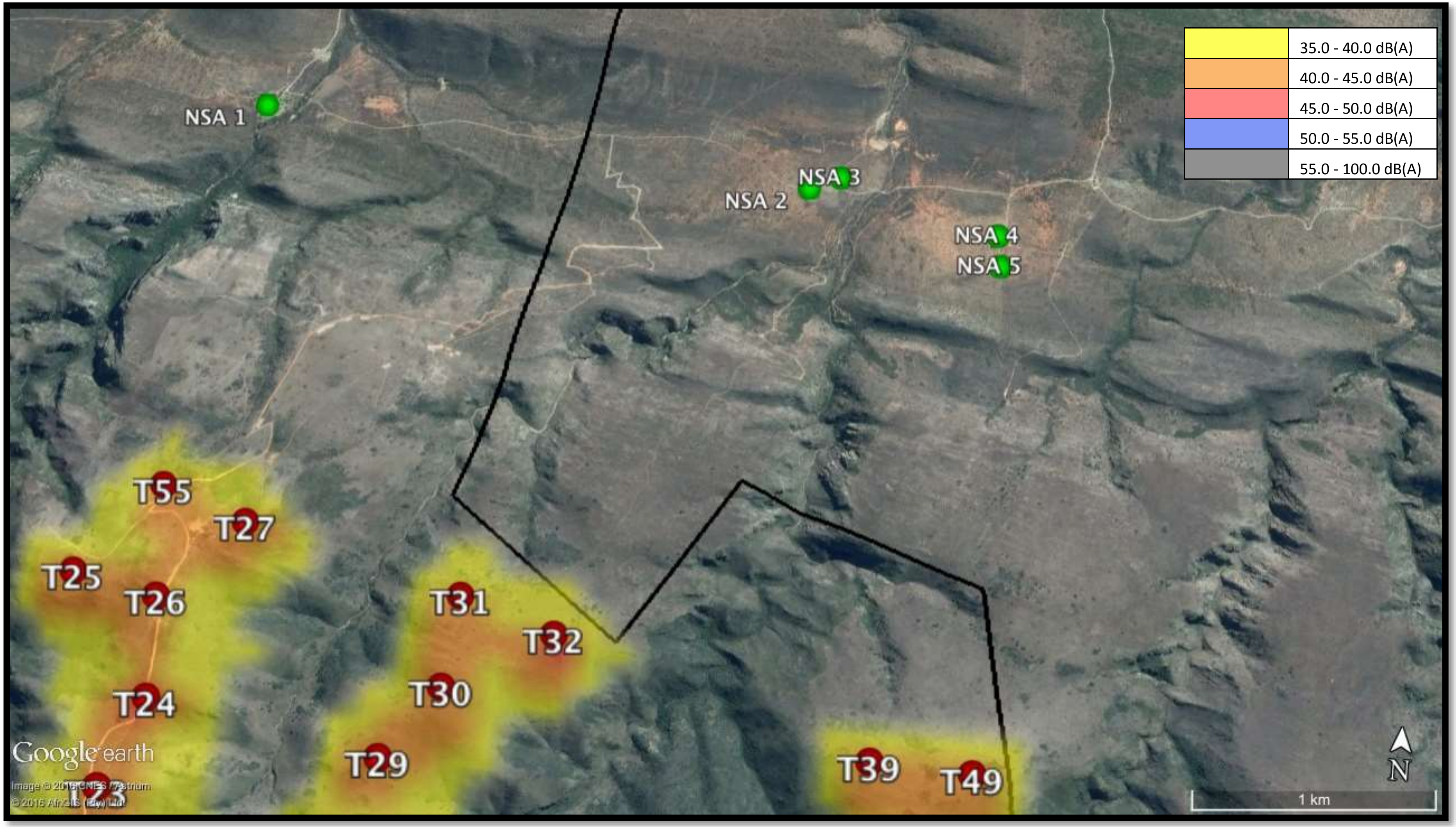


Figure 11 – Noise Emissions 52 WTG (3m/s wind speed)

Black Line = Site Boundary

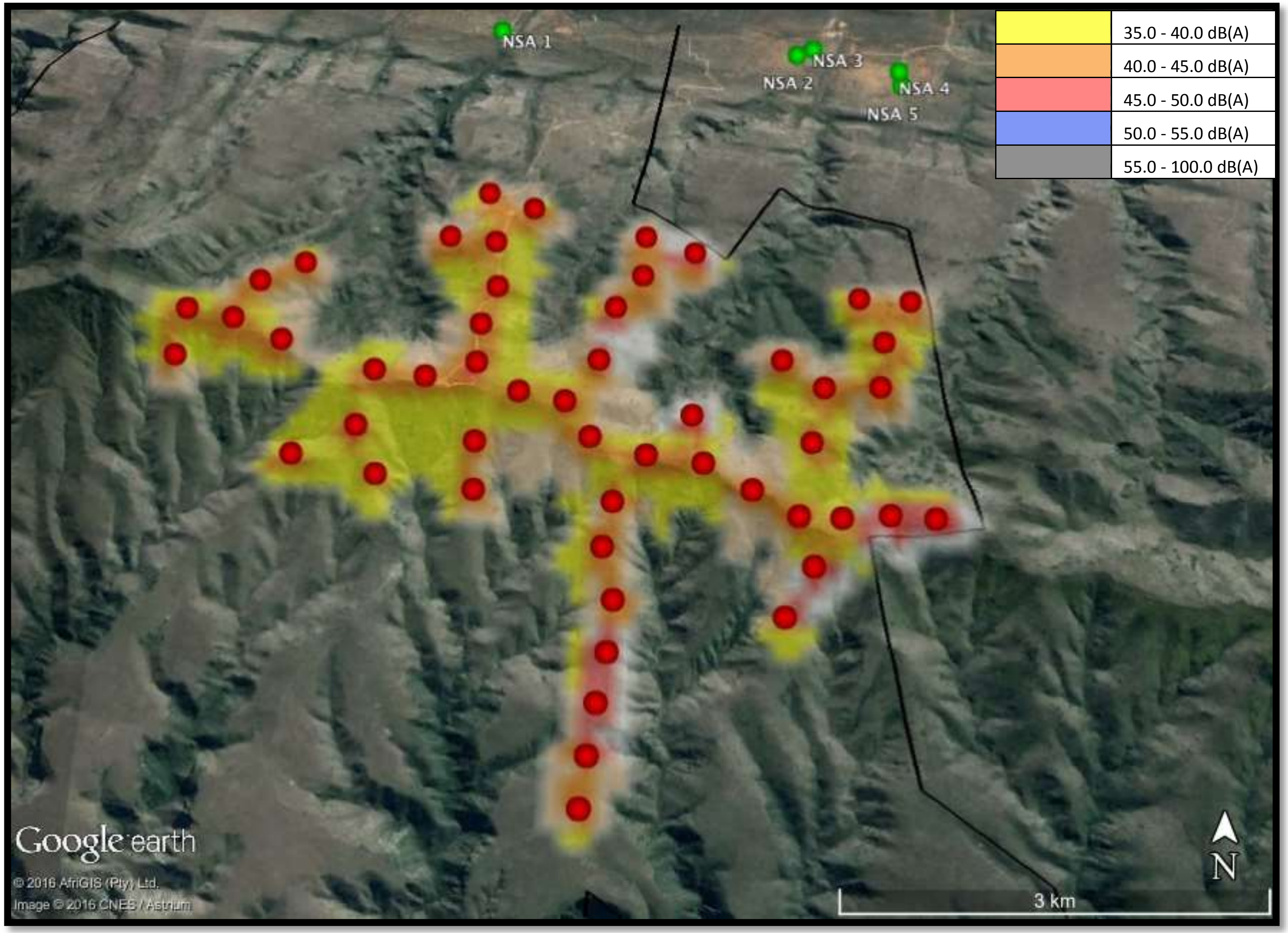


Figure 12 – Noise Emissions 52 WTG (12m/s wind speed)

Black Line = Site Boundary

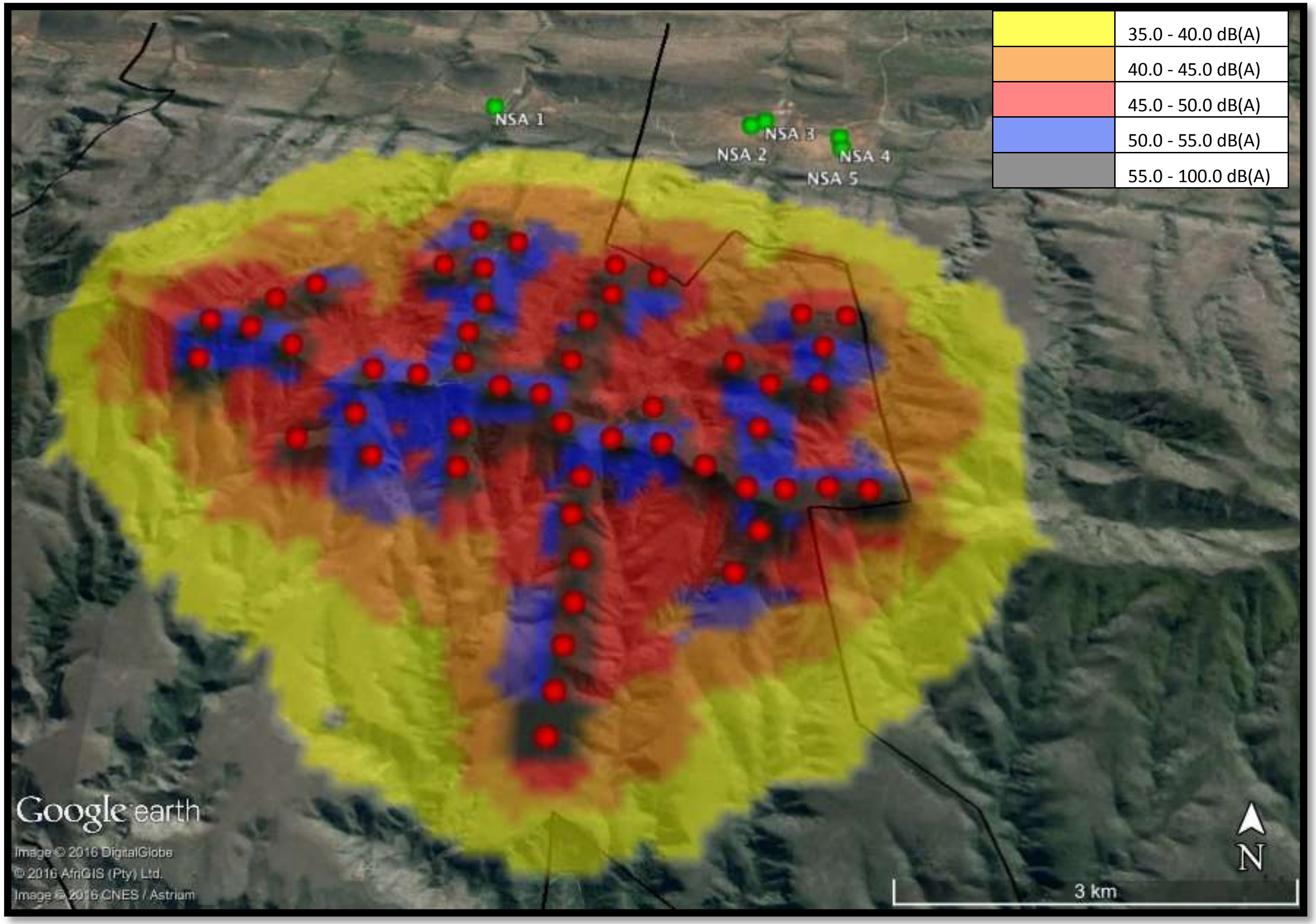


Figure 13 – Noise Emissions 52 WTG (12m/s wind speed) – Southern Portion

Black Line = Site Boundary

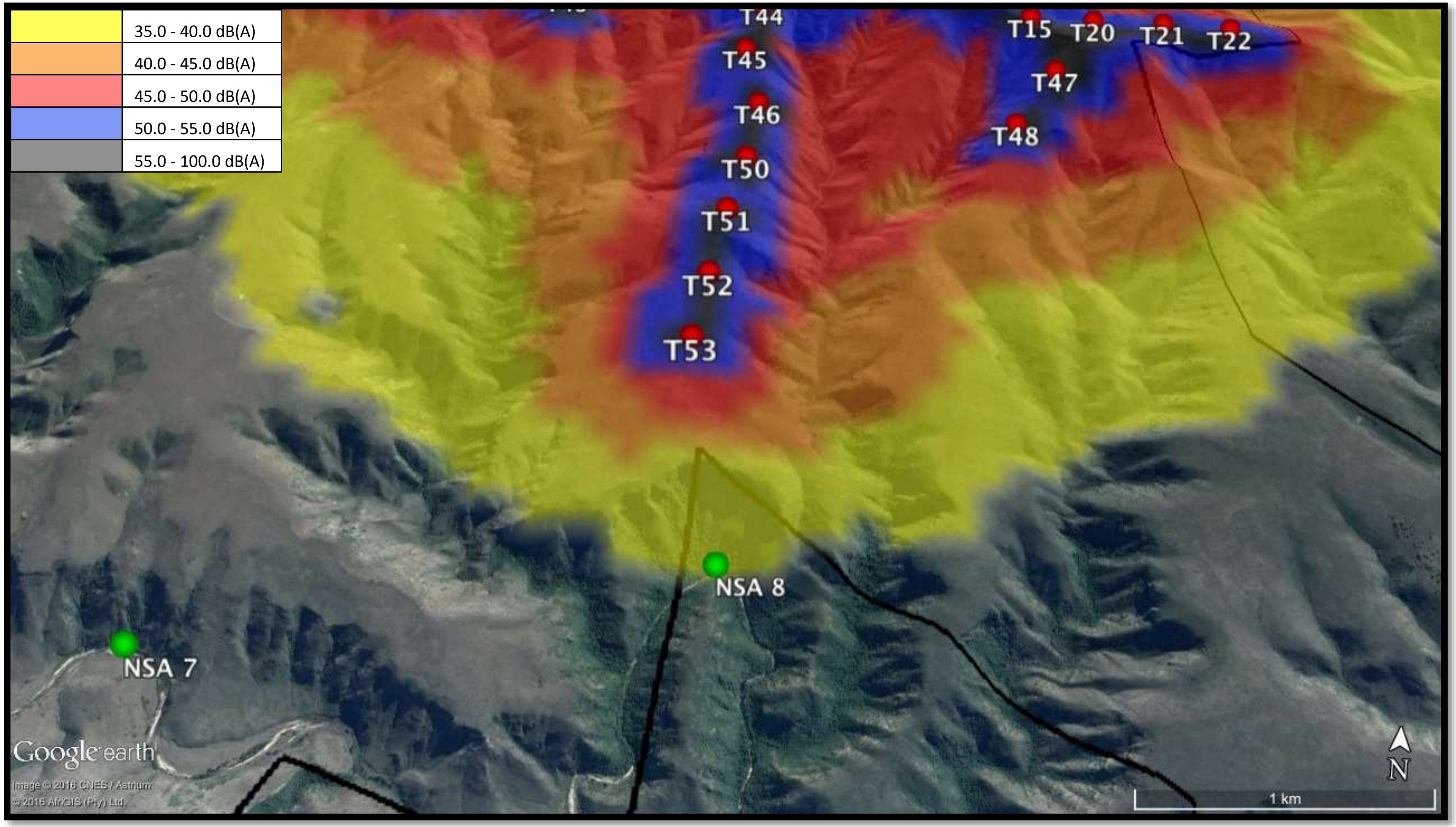


Figure 14 – Noise Emissions 48 WTG (3m/s wind speed)

Black Line = Site Boundary

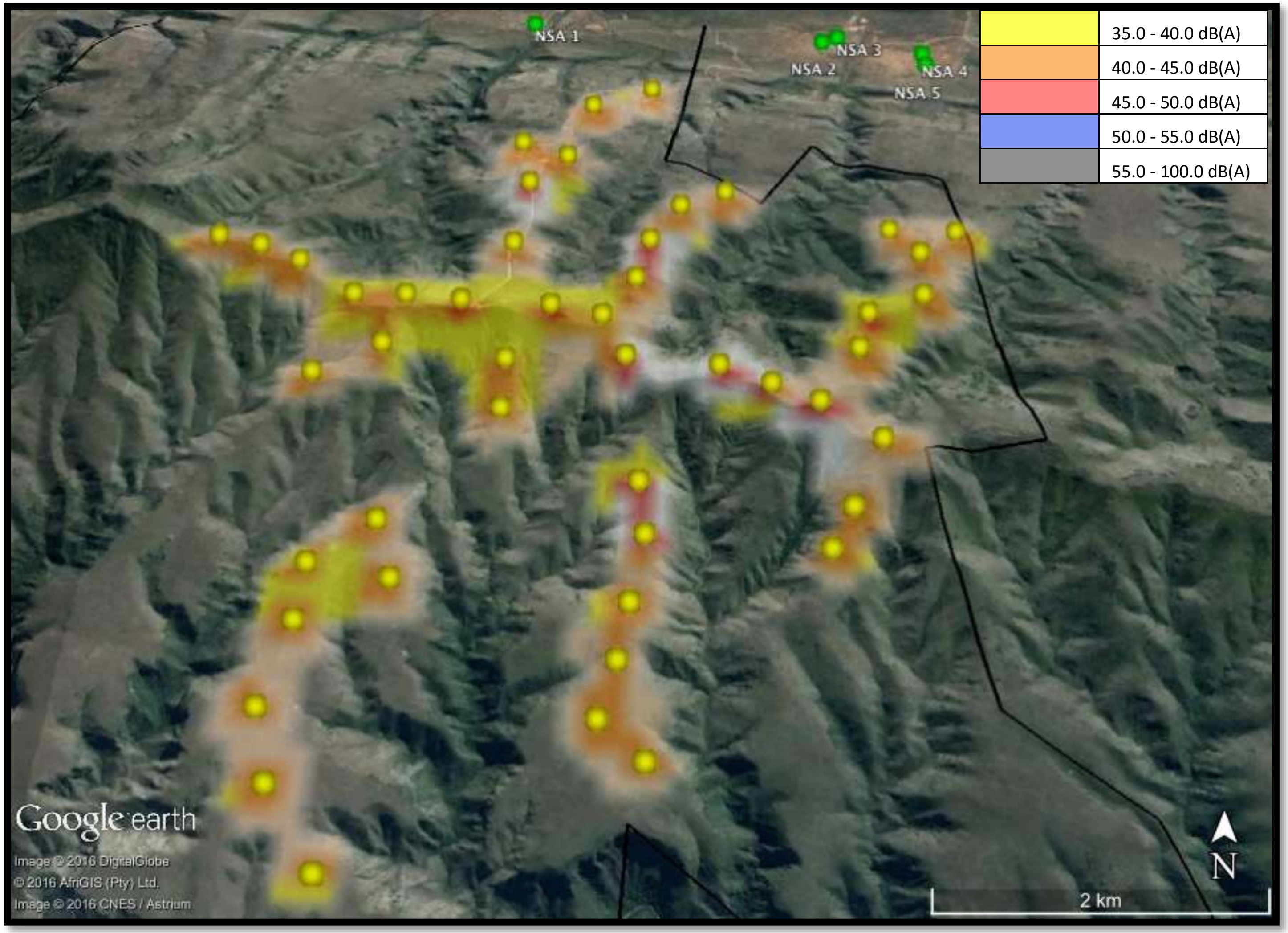


Figure 15 – Noise Emissions 48 WTG (12m/s wind speed)

Black Line = Site Boundary

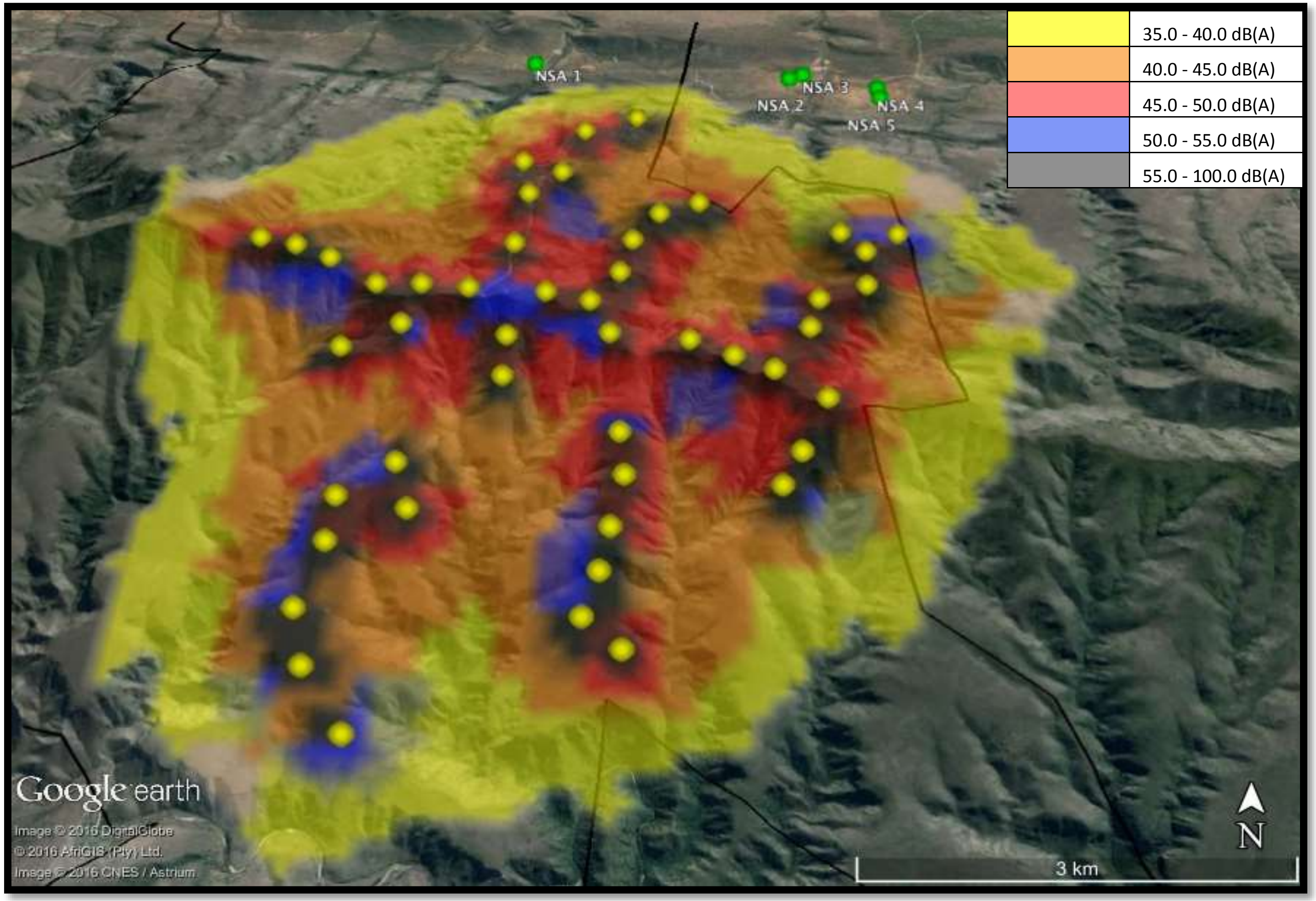


Figure 16 – Noise Emissions 48 WTG (12m/s wind speed) Northern Portion

Black Line = Site Boundary

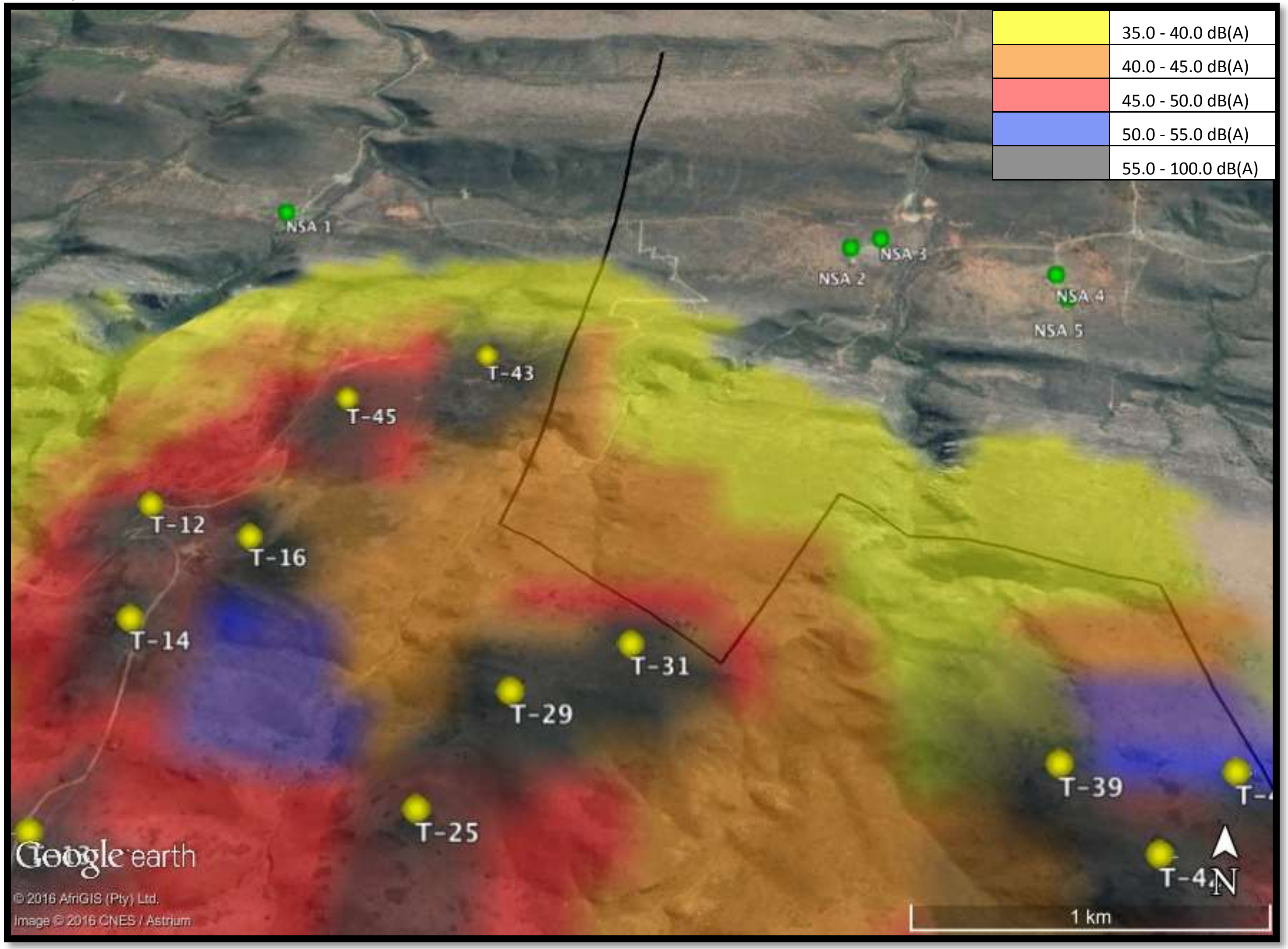
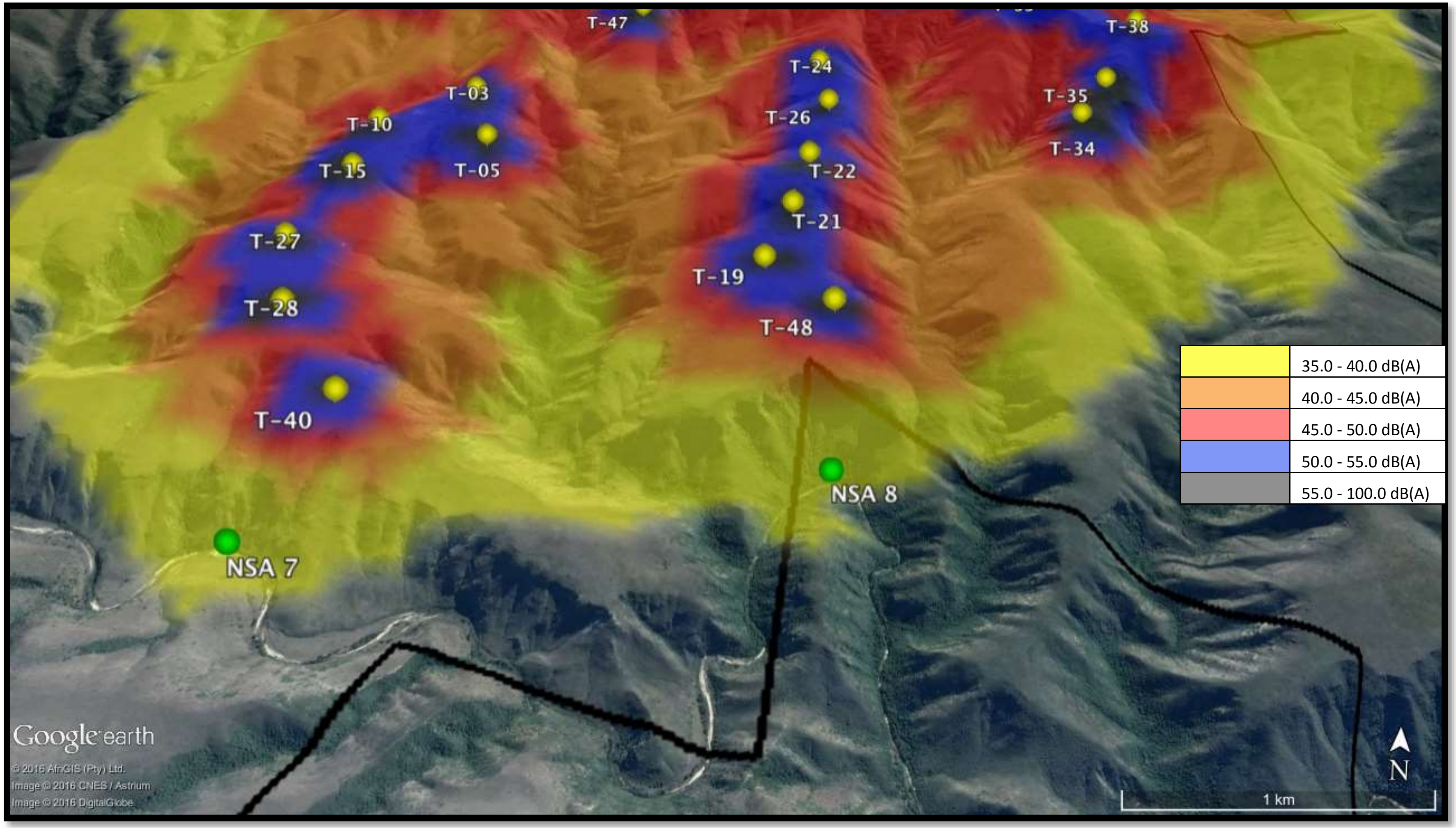


Figure 17 – Noise Emissions 48 WTG (12m/s wind speed) Southern Portion

Black Line = Site Boundary



7.2. Discussion of predicted noise levels

7.2.1 All NSA's including Groendal Nature Reserve (52 WTG's and 48 WTG's)

The results above indicate that the 24 hour 45 dB(A) limit for **day/night** operations will not be exceeded ay any of the noise sensitive areas (NSA.

7.2.2 NSA 1-5 (52 WTG's and 48 WTG's)

NSA 1-5 are the northern most receptors that are closest to the windfarm. The 35 dB(A) **night** guideline limit will not be exceeded at NSA 1-5 for either the 52 turbine layout or the 48 turbine layout. It is unlikely that the residents will perceive the noise as disturbing, as the wind noise, provides a masking effect. When the WTG's cut in at 3m/s, the modelled noise emissions is likely to be below the ambient noise at the receiver. It must also be noted that the number of turbines will be reduced to meet the Department of Energy's 140MW limit for windfarms. This will further reduce the noise impact. Furthermore, not all the farmhouses are permanently occupied.

If a noise impact survey during operations indicates that a noise disturbance is present (the turbine noise exceeds the actual ambient noise by more than 7dB(A)) then the turbines can be placed in a lower operational noise mode, when the surface wind speeds are low and the hub height wind speed has reached cut-in speed (3m/s).

7.2.3 Significance Statement – NSA 1-5 (52 WTG's & 48 WTG's) Night Limit

Table 17 - Significance Rating Table – Operational Phase (NSA 1-5 for 52 WTG's & 48 WTG's)

	Spatial Extent	Intensity	Duration	Consequence	Probability	Significance	+ -	Confidence
Before Management	Local (1)	Low (1)	Short-term (1)	Very Low (3)	Possible	Very Low	-	High
Management Measures								
Measures related to the operational phase: • The noise impact from the wind turbine generators should be measured during the operational phase, to ensure that the impact is within the required legal limit. • Wind turbine generators should be maintained to ensure the noise emissions are within the legal and design specifications.								
After Management	Local (1)	Low (1)	Short-term (1)	Very Low (3)	Possible	Very Low	-	High
No-go Option	Local (N/A)	Low (N/A)	Short-term (N/A)	Very Low (N/A)	(N/A)	(N/A)	+	High

7.3. Groendal Nature Reserve

The existing hiking trail and camping grounds of the Groendal Nature Reserve (NSA 9,10 and 11) will not be impacted by the noise emissions from the windfarm (Table 16) due to the distance from the noise source. This applies to both the 52 WTG and 48 WTG layouts.

The 48 turbine layout will impact two small areas (NSA 7 & 8) along the bends in the Kwazunga River. NSA 7 is within the windfarm boundary and NSA 8 is in the Groendal Nature Reserve. It is only the night limit that will be exceeded at NSA 8 which is outside the windfarm boundary. It is highly unlikely that hikers would stay overnight at this particular point (See Figure 17). The 52 WTG layout does not exceed the night limit at NSA 7, only at NSA 8.

7.3.1 Significance Statement – Groendal Nature Reserve

Table 18 - Significance Rating Table – Operational Phase (Groendal Nature Reserve)

	Spatial Extent	Intensity	Duration	Consequence	Probability	Significance	+ -	Confidence
Before Management	Local (1)	Low (1)	Short-term (1)	Very Low (3)	Possible	Very Low	-	High
Management Measures								
Measures related to the operational phase: • The noise impact from the wind turbine generators should be measured during the operational phase, to ensure that the impact is within the required legal limit. • Wind turbine generators should be maintained to ensure the noise emissions are within the legal and design specifications.								
After Management	Local (1)	Low (1)	Short-term (1)	Very Low (3)	Possible	Very Low	-	High
No-go Option	Local (N/A)	Low (N/A)	Short-term (N/A)	Very Low (N/A)	(N/A)	(N/A)	+	High

8. CONCLUSION AND RECOMMENDATIONS

8.1. Conclusion

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. The above modeling does not take into account any masking effect of the wind at the receiver, therefore it is a worst case scenario with respect to noise pollution.

8.1.1 Construction Phase

There will be a low impact on the residents at NSA 1-5 from the construction activities, especially if pile driving is to be done. This however will only occur if the underlying geological structure requires this.

a) 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.
b) 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 for a limited time. The exact number of construction vehicles is not known at present. The duration of impact will however be of short duration and most likely only impact NSA 1, who is the developer of the project.
c) The Batch Plant could affect the neighbouring farmsteads, especially if it is operational at night.

8.1.2 Operational Phase

The impacts from the operational phase are summarised as follows:

a) The day/night time SANS 10103:2008 noise limit of 45dBA will be not be exceeded at any of the noise sensitive areas.
b) The night time guideline noise limit of 35dBA will not be exceeded at any of the noise sensitive areas for Option 1 and Option 2 WTG layouts (Northern NSA's).
c) If a complaint is received it should be evaluated against the actual ambient noise at the complainants location. If the increase is more than 7dB(A) above the ambient noise, a noise disturbance will be present in terms of the Environment Conservation Act – Noise Control Regulations and the

NMBMM Noise Control Regulations. This is however unlikely due to the masking effect of the wind.

d) The noise emissions from the project will not impact on the existing Groendal Nature Reserve hiking trails or camping sites. There could be a slight impact on one part of the Kwazunga River at night, although this is highly unlikely.

8.1.3 Decommissioning

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

8.2. Recommendations

The following is recommended:

8.2.1 Construction Activities

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

8.2.2 Operational Activities

The following general recommendation is made for the operational phase:

- Re-modelling of the noise impacts will need to conducted on the final layout.
- The noise impact from the wind turbine generators should be measured during the operational phase, to ensure that the impact is within the required legal limits.

Dr Brett Williams

9. REFERENCES

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7)	International Finance Corporation – 2007 General EHS Guidelines: Environmental Noise.
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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.
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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
148 1302

M AND N ACOUSTIC SERVICES (Pty) Ltd
Co. Reg. No: [illegible] VAT NO: [illegible] BEE Status: Level 4
P.O. Box [illegible], Pierre van Ryneveld, 0045
Shop 13, [illegible] Centre,
cnr Fouche & [illegible], Pierre van Ryneveld, 0045
Tel: 012 689 2007/8 • Fax: [illegible]
E-mail: calservice@mweb.co.za

CERTIFICATE OF CALIBRATION

CERTIFICATE NUMBER	2015-2431
ORGANISATION	SAFETRAIN T/A SAFETECH
ORGANISATION ADDRESS	P.O. BOX 27697, GREENACRES, 6057
CALIBRATION OF	INTEGRATING SOUND LEVEL METER complete with ½" MICROPHONES and ⅓- OCTAVE/OCTAVE RTA CARD
CALIBRATED BY	ELECTRICAL TESTS: C. DE CLERCQ ½" MICROPHONE: W.S. SIBANYONI
MANUFACTURERS	RION
MODEL NUMBERS	NL-32, UC-53A and NX-22RT
SERIAL NUMBERS	00151075, 319366 and 00150957 V2.2
DATE OF CALIBRATION	24 NOVEMBER 2015
RECOMMENDED DUE DATE	NOVEMBER 2016
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.

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.

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Authorized/Checked by: [signature] M. NAUDÉ (SANAS TECHNICAL SIGNATORY)	Date of Issue: 04 December 2015

Director: Marianka Naudé

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

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