Genesis Zonnequa Wind (Pty) Ltd

ENVIRONMENTAL NOISE IMPACT ASSESSMENT

Establishment of the Zonnequa Wind Farm near Kleinsee, Northern Cape Province

Study done for:

savannah environmental

Prepared by:

EAR Enviro Acoustic Research

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EXECUTIVE SUMMARY

INTRODUCTION AND PURPOSE

Enviro-Acoustic Research cc was commissioned to undertake a specialist study to determine the potential noise impact on the surrounding environment due to the establishment of the Zonnequa Wind Farm (WF) on various farms close to the town of Kleinsee in the Northern Cape.

This report briefly describes ambient sound levels in the area, potential worst-case noise rating levels and the potential noise impact that the facility may have on the surrounding sound environment, highlighting the methods used, potential issues identified, findings and recommendations.

PROJECT DESCRIPTION

Genesis Zonnequa Wind (Pty) Ltd (hereafter referred to as the developer) proposes the establishment of the Zonnequa Wind Farm and associated infrastructure on various farms within the Nama Khoi Local Municipal area in the Northern Cape.

The entire project site is located within Focus Area 8 of the Renewable Energy Development Zones (REDZ), which is known as the Springbok REDZ. Due to the location of the project site within the REDZ, a Basic Assessment (BA) process will be undertaken in accordance with GN114 as formally gazetted on 16 February 2018.

The footprint of the wind farm covers an area of approximately 44km^2, with the study area including an area up to 2,000 meters (m) from the closest wind turbine (WTG). It is extremely unlikely that a potential noise-sensitive receptor (NSD) staying further than 2,000 m from a WTG would experience any noise impact.

The wind energy facility will include up to 56 WTGs. Each turbine may have a generating capacity of up to 4.2 MW, each with a hub height of up to 130m and a tip height of up to 205m.

DESCRIPTION OF AMBIENT SOUND LEVELS – PREVIOUS MEASUREMENTS

The area has been visited during February 2018 where a number of ambient baseline sound levels were measured. The data indicates that the area has the potential to be very quiet at night, though ambient sound levels may increase as the wind speed increases. The visual character of the area is rural and it was accepted that the SANS 10103 noise district classification could be rural for the study area.

NOISE IMPACT DETERMINATION AND FINDINGS

The potential noise impact was evaluated using a sound propagation model. Conceptual scenarios were developed for construction and operation phases.

It is concluded that:

- The significance of the noise impact relating to daytime construction of the wind turbine generators will be low.
- The significance of the noise impact relating to night-time construction of the wind turbine generators will be low.
- The significance of the operational daytime noises will be low.
- The significance of the operational night-time noises will be low.
- The significance of the cumulative noise impacts will be low.

RECOMMENDATIONS

Considering the findings of this assessment, the increase in noise levels is not considered to be a fatal flaw and the development of the Zonnequa WF can be authorised from a noise perspective.

CONTENTS OF THE SPECIALIST REPORT – CHECKLIST

Contents of this report in terms of Regulation GNR 982 of 2014, Appendix 6 (as amended 2017)		Relevant Section in Specialist study
(1)	A specialist report prepared in terms of these Regulations must contain-	
(a)	details of-	
	(i) the specialist who prepared the report; and	**Section 1**
	(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae	**Section 1**
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	**Section 2** *(also separate document to this report)*
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	**Section 3.1**
(cA)	an indication of the quality and age of base data used for the specialist report;	**Section 5.2 and 5.3**
(cB)	a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	**Section 5.2 and 5.3 Update**
(d)	the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	**Section 5.2 and 5.3**
(e)	a description of the methodology adopted in preparing the report or carrying out the specialized process inclusive of equipment and modelling used;	**Section 3.6**
(f)	details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	**Sections 5.1**
(g)	an identification of any areas to be avoided, including buffers;	No buffers required. Noise rating levels calculated and illustrated.
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	No buffers required. Noise rating levels calculated and illustrated.
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	**Section 7**
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity or activities;	**Section 9** and **10**
(k)	any mitigation measures for inclusion in the EMPr;	**Section 11**
(l)	any conditions for inclusion in the environmental authorization;	**Section 11**
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorization;	**Section 13**
(n)	a reasoned opinion -	

Contents of this report in terms of Regulation GNR 982 of 2014, Appendix 6 (as amended 2017)		Relevant Section in Specialist study
	whether the proposed activity, activities or portions thereof should be authorized;	**Section 15**
	regarding the acceptability of the proposed activity or activities; and	**Section 15**
	if the opinion is that the proposed activity, activities or portions thereof should be authorized, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	**Section 15**
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	**Basic Assessment report**
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	**Basic Assessment report**
(q)	any other information requested by the competent authority.	None

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GLOSSARY OF ABBREVIATIONS

ADT	Articulated Dump Trucks
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
EARES	Enviro Acoustic Research cc
ECA	Environment Conservation Act
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EHS	Environmental Health and Safety
ENIA	Environmental Noise Impact Assessment
ENM	Environmental Noise Monitoring
ENPAT	Environmental Potential Atlas for South Africa
EPs	Equator Principles
EPFIs	Equator Principles Financial Institutions
FEL	Front-end Loader
GN	Government Notice
I&APs	Interested and Affected Parties
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
ISO	International Organization for Standardization
METI	Ministry of Economy, Trade, and Industry
NASA	National Aeronautical and Space Administration
NEMA	National Environmental Management Act
NCR	Noise Control Regulations
NSD	Noise-sensitive Development
PPP	Public Participation Process
PWL	Sound Power Level
SABS	South African Bureau of Standards
SANS	South African National Standards
SPL	Sound Power Level
SR	Significance Rating
TLB	Tip load bucker (also referred to as a back-actor or backhoe)

UTM	Universal Transverse Mercator
WHO	World Health Organization
WULA	Water Use Licence Application
WF	Wind Farm / Wind Energy Facility
WTG	Wind Turbine Generator

GLOSSARY OF UNITS

dB	Decibel (expression of the relative loudness of the un-weighted sound level in air)
dBA	Decibel (expression of the relative loudness of the A-weighted sound level in air)
Hz	Hertz (measurement of frequency)
kg/m^2	Surface density (measurement of surface density)
km	kilometre (measurement of distance)
m	Meter (measurement of distance)
m^2	Square meter (measurement of area)
m^3	Cubic meter (measurement of volume)
mamsl	Meters above mean sea level
m/s	Meter per second (measurement for velocity)
^oC	Degrees Celsius (measurement of temperature)
μPa	Micro pascal (measurement of pressure – in air in this document)

1 THE AUTHOR

The Author started his career in the mining industry as a bursar Learner Official (JCI, Randfontein), working in the mining industry, doing various mining related courses (Rock Mechanics, Surveying, Sampling, Safety and Health [Ventilation, noise, illumination etc] and Metallurgy. He did work in both underground (Coal, Gold and Platinum) as well as opencast (Coal) for 4 years. He changed course from Mining Engineering to Chemical Engineering after his second year of his studies at the University of Pretoria.

After graduation he worked as a Water Pollution Control Officer at the Department of Water Affairs and Forestry for two years (first year seconded from Wates, Meiring and Barnard), where duties included the perusal (evaluation, commenting and recommendation) of various regulatory required documents (such as EMPR's, Water Licence Applications and EIA's), auditing of licence conditions as well as the compilation of Technical Documents.

Since leaving the Department of Water Affairs, Morné has been in private consulting for the last 15 years, managing various projects for the mining and industrial sector, private developers, business, other environmental consulting firms as well as the Department of Water Affairs. During that period he has been involved in various projects, either as specialist, consultant, trainer or project manager, successfully completing these projects within budget and timeframe. During that period he gradually moved towards environmental acoustics, focusing on this field exclusively since 2007.

He has been interested in acoustics as from school days, doing projects mainly related to loudspeaker design. Interest in the matter brought him into the field of Environmental Noise Measurement, Prediction and Control. He has been doing work in this field for the past 10 years, and was involved with the following projects in the last few years:

Wind Energy Facilities	*Full Environmental Noise Impact Assessments for more than 90 different projects, including: Bannf (Vidigenix), iNCa Gouda (Aurecon SA), Isivunguvungu (Aurecon), De Aar (Aurecon), Kokerboom 1 (Aurecon), Kokerboom 2 (Aurecon), Kokerboom 3 (Aurecon), Kangnas (Aurecon), Plateau East and West (Aurecon), Wolf (Aurecon), Outeniqwa (Aurecon), Umsinde Emoyeni (ARCUS) , Komsberg (ARCUS), Karee (ARCUS), Kolkies (ARCUS), San Kraal (ARCUS), Phezukomoya (ARCUS), Canyon Springs (Canyon Springs), Perdekraal (ERM), Scarlet Ibis (CESNET), Albany (CESNET), Sutherland (CSIR), Kap Vley (CSIR), Kuruman (CSIR), Rietrug (CSIR), Sutherland 2 (CSIR), Perdekraal (ERM), Teekloof (Mainstream), Eskom Aberdene (SE), Dorper (SE), Spreeukloof (SE), Loperberg (SE), Penhoek Pass (SE), Amakhala Emoyeni (SE), Zen (Savannah Environmental – SE), Goereesoe (SE), Springfontein (SE), Garob (SE), Project Blue (SE), ESKOM Kleinzee (SE), Walker Bay (SE), Oyster Bay (SE), Hidden Valley (SE), Deep River (SE), Tsitsikamma (SE), AB (SE), West Coast One (SE), Hopefield II (SE), Namakwa Sands (SE), VentuSA Gouda (SE), Dorper (SE), Klipheuwel (SE), INCA Swellendam (SE), Cookhouse (SE), Cookhouse II (SE), Rheboksfontein (SE), Suurplaat (SE), Karoo Renewables (SE), Koningaas (SE), Spitskop (SE), Castle (SE), Khai Ma (SE),*

	Poortjies (SE), Korana (SE), IE Moorreesburg (SE), Gunstfontein (SE), Vredenburg (Terramanzi), Loeriesfontein (SiVEST), Rhenosterberg (SiVEST), Noupoort (SiVEST), Prieska (SiVEST), Dwarsrug (SiVEST), Graskoppies (SiVEST), Philco (SiVEST), Hartebeest Leegte (SiVEST), Ithemba (SiVEST), !Xha Boom (SiVEST), Spitskop West (Terramanzi), Haga Haga (Terramanzi), Vredenburg (Terramanzi), Msenge Emoyeni (Windlab)
Mining and Industry	*Full Environmental Noise Impact Assessments for – Delft Sand (AGES), BECSA – Middelburg (Golder Associates), Kromkrans Colliery (Geovicon Environmental), SASOL Borrow Pits Project (JMA Consulting), Lesego Platinum (AGES), Tweefontein Colliery (Cleanstream Environmental), Evraz Vametco Mine and Plant (JMA), Goedehoop Colliery (Geovicon), Hacra Project (Prescali Environmental), Der Brochen Platinum Project (J9 Environment), Brandbach Sand (AGES), Verkeerdepan Extension (CleanStream Environmental), Dwaalboom Limestone (AGES), Jagdlust Chrome (MENCO), WPB Coal (MENCO), Landau Expansion (CleanStream Environmental), Otjikoto Gold (AurexGold), Klipfontein Colliery (MENCO), Imbabala Coal (MENCO), ATCOM East Expansion (Jones and Wagner), IPP Waterberg Power Station (SE), Kangra Coal (ERM), Schoongesicht (CleanStream Environmental), EastPlats (CleanStream Environmental), Chapudi Coal (Jacana Environmental), Generaal Coal (JE), Mopane Coal (JE), Glencore Boshoek Chrome (JMA), Langpan Chrome (PE), Vlakpoort Chrome (PE), Sekoko Coal (SE), Frankford Power (REMIG), Strahrae Coal (Ferret Mining), Transalloys Power Station (Savannah), Pan Palladum Smelter, Iron and PGM Complex (Prescali Environmental), Fumani Gold (AGES), Leiden Coal (EIMS), Colenso Coal and Power Station (SiVEST/EcoPartners), Klippoortjie Coal (Gudani), Rietspruit Crushers (MENCO), Assen Iron (Tshikovha), Transalloys (SE), ESKOM Ankerlig (SE), Pofadder CSP (SE), Nooitgedacht Titano Project (EcoPartners), Algoa Oil Well (EIMS), Spitskop Chrome (EMAssistance), Vlakfontein South (Gudani), Leandra Coal (Jacana), Grazvalley and Zoetveld (Prescali), Tjate Chrome (Prescali), Langpan Chromite (Prescali), Vereeniging Recycling (Pro Roof), Meyerton Recycling (Pro Roof), Hammanskraal Billeting Plant 1 and 2 (Unica), Development of Altona Furnace, Limpopo Province (Prescali Environmental), Haakdoorndrift Opencast at Amandelbult Platinum (Aurecon), Landau Dragline relocation (Aurecon), Stuart Coal Opencast (CleanStream Environmental), Tetra4 Gas Field Development (EIMS), Kao Diamonds – Tiping Village Relocation (EIMS), Kao Diamonds – West Valley Tailings Deposit (EIMS), Upington Special Economic Zone (EOH), Arcellor Mittal CCGT Project near Saldanha (ERM), Malawi Sugar Mill Project (ERM), Proposed Mooifontein Colliery (Geovicon Environmental), Goedehoop North Residue Deposit Expansion (Geovicon Environmental), Mutsho 600MW Coal-Fired Power Plant (Jacana Environmentals), Tshivhaso Coal-Fired Power Plant (Savannah Environmental), Doornhoek Fluorspar Project (Exigo)*
Road and Railway	*K220 Road Extension (Urbansmart), Boskop Road (MTO), Sekoko Mining (AGES), Davel-Swaziland-Richards Bay Rail Link (Aurecon), Moloto Transport Corridor Status Quo Report and Pre-Feasibility (SiVEST), Postmasburg Housing Development (SE), Tshwane Rapid Transport Project, Phase 1 and 2 (NRM Consulting/City of Tshwane), Transnet Apies-river Bridge Upgrade (Transnet), Gautrain Due-diligence (SiVest), N2 Piet Retief (SANRAL), Atterbury Extension, CoT (Bokomoso Environmental)*
Airport	*Oudtshoorn Noise Monitoring (AGES), Sandton Heliport (Alpine Aviation), Tete Airport Scoping (Aurecon)*
Noise monitoring and Audit Reports	*Peerboom Colliery (EcoPartners), Thabametsi (Digby Wells), Doxa Deo (Doxa Deo), Harties Dredging (Rand Water), Xstrata Coal – Witbank Regional (Xstrata), Sephaku Delmas (AGES), Amakhala Emoyeni WEF (Windlab Developments), Oyster Bay WEF (Renewable Energy Systems), Tsitsikamma WEF Ambient Sound Level study (Cennergi and SE), Hopefield WEF (Umoya), Wesley WEF (Innowind), Ncora WEF (Innowind), Boschmanspoort (Jones and Wagner), Nqamakwe WEF (Innowind), Hopefield WEF Noise Analysis (Umoya), Dassiesfontein WEF Noise Analysis (BioTherm), Transnet Noise Analysis (Aurecon), Jeffries Bay Wind Farm (Globeleq), Sephaku Aganang (Exigo), Sephaku Delmas (Exigo), Beira Audit (BP/GPT), Nacala Audit (BP/GPT), NATREF (Nemai), Rappa Resources (Rayten), Measurement Report for Sephaku Delmas (Ages), Measurement Report for Sephaku Aganang (Ages), Development noise measurement protocol for Mamba Cement (Exigo), Measurement Report for Mamba Cement (Exigo), Measurement Report for Nokeng Fluorspar (Exigo), Tsitsikamma Community Wind Farm Pre-operation sound measurements (Cennergi), Waainek WEF Operational Noise Measurements (Innowind), Sedibeng Brewery Noise Measurements (MENCO), Tsitsikamma Community Wind Farm Operational noise measurements (Cennergi), Noupoort Wind Farm Operational noise measurements (Mainstream),*
Small Noise	*TCTA AMD Project Baseline (AECOM), NATREF (Nemai Consulting), Christian Life Church*

Impact Assessments	*(UrbanSmart), Kosmosdale (UrbanSmart), Louwlardia K220 (UrbanSmart), Richards Bay Port Expansion (AECOM), Babalegi Steel Recycling (AGES), Safika Slag Milling Plant (AGES), Arcelor Mittal WEF (Aurecon), RVM Hydroplant (Aurecon), Grootvlei PS Oil Storage (SiVEST), Rhenosterberg WEF, (SiVEST), Concerto Estate (BPTrust), Ekuseni Youth Centre (MENCO), Kranskop Industrial Park (Cape South Developments), Pretoria Central Mosque (Noman Shaikh), Soshanguve Development (Maluleke Investments), Seshego-D Waste Disposal (Enviroxcellence), Zambesi Safari Equipment (Owner), Noise Annoyance Assessment due to the Operation of the Gautrain (Thornhill and Lakeside Residential Estate), Upington Solar (SE), Ilangalethu Solar (SE), Pofadder Solar (SE), Flagging Trees WEF (SE), Uyekraal WEF (SE), Ruuki Power Station (SE), Richards Bay Port Expansion 2 (AECOM), Babalegi Steel Recycling (AGES), Safika Ladium (AGES), Safika Cement Isando (AGES), RareCo (SE), Struisbaai WEF (SE), Perdekraal WEF (ERM), Kotula Tsatsi Energy (SE), Olievenhoutbosch Township (Nali), , HDMS Project (AECOM), Quarry extensions near Ermelo (Rietspruit Crushers), Proposed uMzimkhulu Landfill in KZN (nZingwe Consultancy), Linksfield Residential Development (Bokomoso Environmental), Rooihuiskraal Ext. Residential Development, CoT (Plandev Town Planners), Floating Power Plant and LNG Import Facility, Richards Bay (ERM), Floating Power Plant project, Saldanha (ERM), Vopak Growth 4 project (ERM), Elandspoort Ext 3 Residential Development (Gibb Engineering)*
Project reviews and amendment reports	*Loperberg (Savannah), Dorper (Savannah), Penhoek Pass (Savannah), Oyster Bay (RES), Tsitsikamma Community Wind Farm Noise Simulation project (Cennergi), Amakhala Emoyeni (Windlab), Spreeukloof (Savannah), Spinning Head (SE), Kangra Coal (ERM), West Coast One (Moyeng Energy), Rheboksfontein (Moyeng Energy), De Aar WEF (Holland), Quarterly Measurement Reports – Dangote Delmas (Exigo), Quarterly Measurement Reports – Dangote Lichtenburg (Exigo), Quarterly Measurement Reports – Mamba Cement (Exigo), Quarterly Measurement Reports – Dangote Delmas (Exigo) Quarterly Measurement Reports – Nokeng Fluorspar (Exigo), Proton Energy Limited Nigeria (ERM), Hartebeest WEF Update (Moorreesburg) (Savannah Environmental), Modderfontein WEF Opinion (Terramanzi), IPD Vredenburg WEF (IPD Power Vredenburg)*

2 DECLARATION OF INDEPENDENCE

I, Morné de Jager declare that:

- I act as the independent environmental practitioner in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting environmental impact assessments, including knowledge of the National Environmental Management Act (107 of 1998), the Environmental Impact Assessment Regulations of 2010, and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in regulation 8 of the regulations when preparing the application and any report relating to the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I will ensure that information containing all relevant facts in respect of the application is distributed or made available to interested and affected parties and the public and that participation by interested and affected parties is facilitated in such a manner that all interested and affected parties will be provided with a reasonable opportunity to participate and to provide comments on documents that are produced to support the application;
- I will ensure that the comments of all interested and affected parties are considered and recorded in reports that are submitted to the competent authority in respect of the application, provided that comments that are made by interested and affected parties in respect of a final report that will be submitted to the competent authority may be attached to the report without further amendment to the report;
- I will keep a register of all interested and affected parties that participated in a public participation process; and
- I will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not
- all the particulars furnished by me in this form are true and correct;
- will perform all other obligations as expected from an environmental assessment practitioner in terms of the Regulations; and
- I realise that a false declaration is an offence in terms of regulation 71 and is punishable in terms of section 24F of the Act.

Disclosure of Vested Interest

- I do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2010.

____
Signature of the environmental practitioner:

Enviro-Acoustic Research cc
Name of company:

____
Date:

3 INTRODUCTION

3.1 INTRODUCTION AND PURPOSE

Enviro-Acoustic Research cc was commissioned to undertake a specialist study to determine the potential noise impact on the surrounding environment due to the proposed establishment of the Zonnequa Wind Farm (WF) and associated infrastructure on various farms in the vicinity of Kleinsee in the Northern Cape.

This report briefly describes ambient sound levels in the area, potential worst-case noise rating levels and the potential noise impact that the facility may have on the surrounding sound environment, highlighting the methods used, potential issues identified, findings and recommendations. This report did not investigate vibrations and only briefly considers blasting.

This study considered local regulations and both local and international guidelines, using the terms of reference (ToR) as proposed by SANS 10328:2008 to allow for a comprehensive Environmental Noise Impact Assessment (ENIA).

3.2 BRIEF PROJECT DESCRIPTION

Genesis Zonnequa Wind (Pty) Ltd (hereafter referred to as the developer) proposes the establishment of a commercial Wind Energy Facility and associated infrastructure on a site located approximately 19 km south-east of Kleinsee in the Northern Cape (refer to **Figure 3-1**).

A preferred project site with an extent of ~4434ha has been identified by Genesis Zonnequa Wind (Pty) Ltd as a technically suitable area for the development of the Zonnequa Wind Farm with a contracted capacity of up to 140MW. The entire project site is located within Focus Area 8 of the Renewable Energy Development Zones (REDZ), which is known as the Springbok REDZ. Due to the location of the project site within the REDZ, a Basic Assessment (BA) process will be undertaken in accordance with GN114 as formally gazetted on 16 February 2018.

The Zonnequa Wind Farm project site is proposed to accommodate the following infrastructure, which will enable the wind farm to supply a contracted capacity of up to 140MW:

- Up to 56 wind turbines with a maximum hub height of up to 130m. The tip height of the turbines will be up to 205m;
- Concrete turbine foundations and turbine hardstands;

- Temporary laydown areas which will accommodate the boom erection, storage and assembly area;
- Cabling between the turbines, to be laid underground where practical;
- An on-site substation of up to 150m x 150m (2.25ha) in extent to facilitate the connection between the wind farm and the electricity grid;
- An overhead 132kV power line to connect the wind farm to the existing Gromis Substation (to be assessed under a separate process);
- Access roads to the site (with a width of up to 10m) and between project components (with a width of approximately 8m);
- A temporary concrete batching plant; and
- Operation and maintenance buildings including a gate house, security building, control centre, offices, warehouses, a workshop and visitors centre.

The power generated from the project will be sold to Eskom and will feed into the national electricity grid. Ultimately, the project is intended to be a part of the renewable energy projects portfolio for South Africa, as contemplated in the Integrated Resource Plan.

3.3 PROPOSED WIND TURBINE

The wind energy market is fast changing and adapting to new technologies and site specific constraints. Optimizing the technical specifications can add value through, for example, minimizing environmental impact and maximizing energy yield. As such the developer has been evaluating several turbine models, however the selection will only be finalised at a later stage once the most optimal wind turbine is identified (factors such as meteorological data, price and financing options, guarantees and maintenance costs, etc. must be considered).

As the noise propagation modelling requires the details of a wind turbine, it was selected to use the sound power emission levels of the Vestas V136 4.2 MW wind turbine.

3.4 STUDY AREA

The proposed WF will be located in the Nama Khoi Local Municipality (Namaqualand District Municipality, Northern Cape). The study area is further described in terms of environmental components that may contribute to or change the sound character in the area.

3.4.1 Topography

The terrain description would be slightly undulating plains. Due to the height of the wind turbines it is unlikely that topographical features will limit the propagation of sound from the wind turbines.

3.4.2 Roads and rail roads

There are no major roads or rail roads in the vicinity of the proposed WF, with the local community using gravel roads to access their properties. Traffic volumes are very low and it is not expected that traffic noises would be of any significance in this area.

3.4.3 Land use

Land use is mostly wilderness with temporary agricultural activities (game and sheep farming). Existing land use activities are not expected to impact on the ambient sound levels. As the night-time noise environment is of particular interest in this document, current land use activities are not expected to impact on the current ambient sound environment.

3.4.4 Residential areas

There is no residential area close to the proposed development.

3.4.5 Ground conditions and vegetation

Most of the area falls within the succulent Karoo biome, with the area sparsely vegetated with shrubs and grasses being the main ground cover. Considering a worst-case scenario, 75% hard ground conditions were used for modelling purposes due to the sparse vegetation. It should be noted that this factor is only relevant for air-borne waves being reflected from the ground surface, with certain frequencies slightly absorbed by the vegetation.

3.4.6 Existing Ambient Sound Levels

The area is undeveloped with a rural character. Ambient sound levels would be typical of a rural noise district. Ambient sound levels were measured during February 2018 with the noise measurements discussed in **section 5.3**.

3.4.7 Available Information

Work was previously undertaken in the area for other developers proposing wind energy facilities in the vicinity, including for the Eskom Kleinsee WF and the juwi Kap Vley WEFs. The Eskom Kleinsee WF recently received environmental authorisation. The author compiled the ENIA for these WEFs and these documents are available.

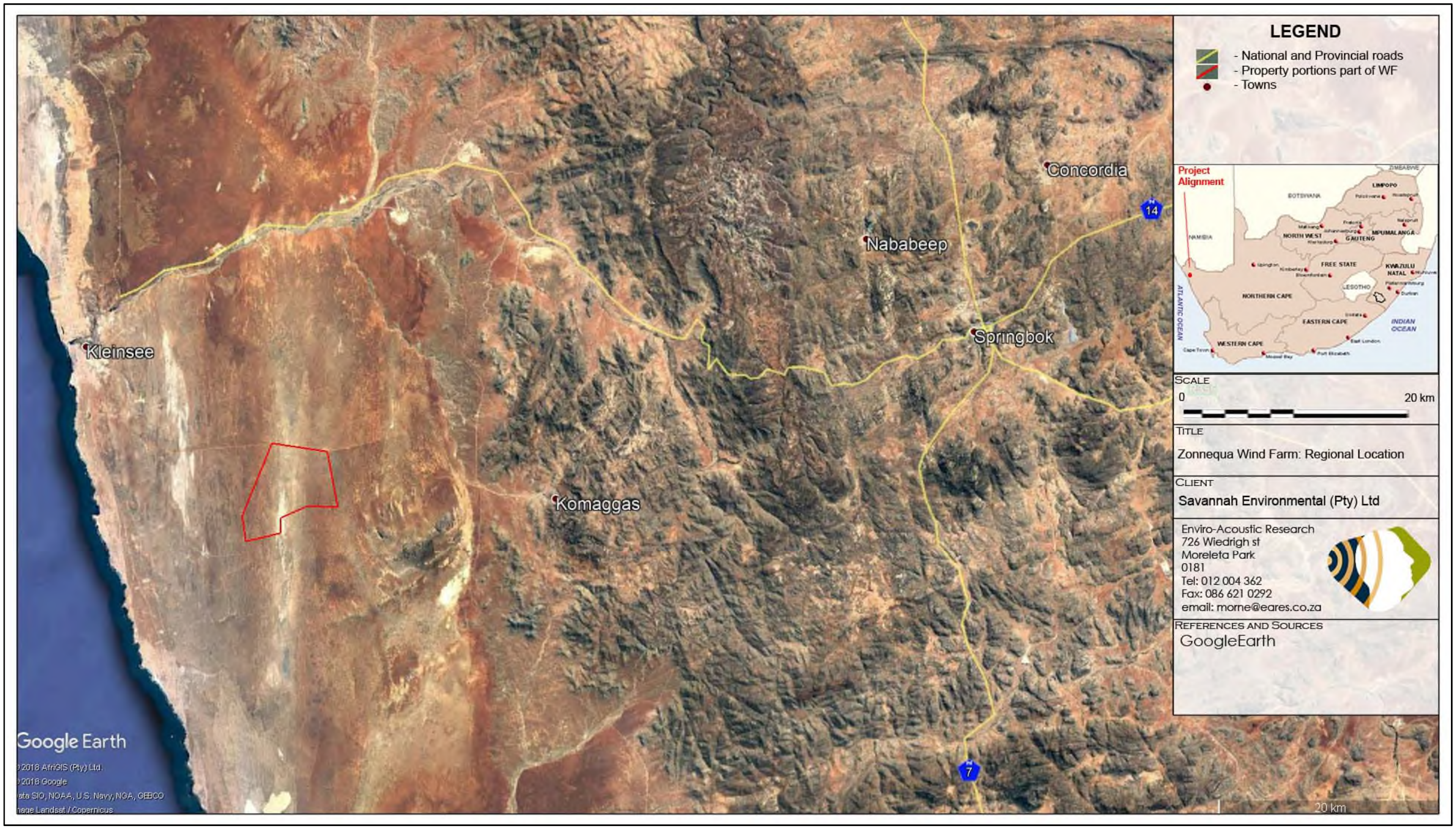

Figure 3-1: Site map indicating the location of proposed Zonnequa WF project site

3.5 NOISE-SENSITIVE DEVELOPMENTS

Available topographical maps were used to identify potential Noise-sensitive developments (NSD) in the area (within the area proposed, as well as potential NSD's up to 2 km from boundary of the facility). The data was imported into GoogleEarth® to allow a more visual view of the areas where noise-sensitive developments were identified. The assessment indicated there are a number of such developments that occur in the area. Noise-sensitive developments as identified are highlighted in **Figure 3-2**.

3.6 TERMS OF REFERENCE

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

- If there are potential noise-sensitive receptors staying within 1,000 m from industrial activities (SANS 10328:2008);
- It is a controlled activity in terms of the NEMA regulations and an ENIA is required, because:
    - It may cause a disturbing noise that is prohibited in terms of section 18(1) of the Government Notice 579 of 2010; and
- It is generally required by the local or district authority as part of the environmental authorisation or planning approval in terms of Regulation 2(d) of GN R154 of 1992.

In addition, Appendix 6 of GN 326 of December 2014 (Gov. Gaz. 38282 – as amended by GN No. 325 of 1 April 2017), issued in terms of the National Environmental Management Act, No. 107 of 1998 also defines minimum information requirements for specialist reports.

In South Africa the document that addresses the issues specifically concerning environmental noise is SANS 10103:2008. It has been thoroughly revised and brought in line with the guidelines of the World Health Organisation (WHO) during 2006 - 2007. It provides the maximum average ambient noise levels during the day and night to which different types of developments may be exposed.

Figure 3-2: Aerial Image indicating Noise-sensitive developments within 2,000 m from project site

In addition, the SANS 10328:2008 standard specifies the methodology to assess the potential noise impacts on the environment due to a proposed activity that might impact on the environment. This standard also stipulates the minimum requirements to be investigated for Scoping purposes. These minimum requirements are:

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

4 POLICIES AND THE LEGAL CONTEXT

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

The environmental right contained in section 24 of the Constitution provides that everyone is entitled to an environment that is not harmful to his or her well-being. In the context of noise, this requires a determination of what level of noise is harmful to the well-being of humans. The general approach of the common law is to define an acceptable level of noise as that which the reasonable person can be expected to tolerate in the particular circumstances. The subjectivity of this approach can be problematic, however this has led to the development of noise standards (see Section 4.5).

"Noise pollution" is specifically included in Part B of Schedule 5 of the Constitution, which means that noise pollution control is a local authority competence, provided that the local authority concerned has the capacity to carry out this function.

4.2 THE ENVIRONMENT CONSERVATION ACT (ACT 73 OF 1989)

The Environment Conservation Act ("ECA") allows the Minister of Environmental Affairs and Tourism ("now the Minister of Water and Environmental Affairs") to make regulations regarding noise, among other concerns. There are no provincial noise control regulations and the National Regulations will be used (see following section).

4.2.1 Noise Control Regulations (GN R154 of 1992)

In terms of section 25 of the ECA, the national Noise Control Regulations (GN R154 in *Government Gazette* No. 13717 dated 10 January 1992) were promulgated. The NCRs were revised under Government Notice Number R. 55 of 14 January 1994 to make it obligatory for all authorities to apply the regulations.

Subsequently, in terms of Schedule 5 of the Constitution of South Africa of 1996 legislative responsibility for administering the noise control regulations was devolved to provincial and local authorities. The National Regulations will be in effect in the Northern Cape Province.

The National Noise Control Regulations (GN R154 1992) define:
"**Controlled area**" as:
A piece of land designated by a local authority where, in the case of--

c) Industrial noise in the vicinity of an industry-

i. the reading on an integrating impulse sound level meter, taken outdoors at the end of a period of 24 hours while such meter is in operation, exceeds 61 dBA; or

ii. the calculated outdoor equivalent continuous "A"-weighted sound pressure level at a height of at least 1,2 meters, but not more than 1,4 meters, above the ground for a period of 24 hours, exceeds 61 dBA;

"**disturbing noise**" as:

Noise level which exceeds the zone sound level or, if no zone sound level has been designated, a noise level which exceeds the ambient sound level at the same measuring point by 7 dBA or more.

"**zone sound level**" as:

A derived dBA value determined indirectly by means of a series of measurements, calculations or table readings and designated by a local authority for an area. *This is the same as the Rating Level as defined in SANS 10103:2008.*

In addition:

In terms of Regulation 2 -

"A local authority may –

(c): if a noise emanating from a building, premises, vehicle, recreational vehicle or street is a disturbing noise or noise nuisance, or may in the opinion of the local authority concerned be a disturbing noise or noise nuisance, instruct in writing the person causing such noise or who is responsible therefor, or the owner or occupant of such building or premises from which or from where such noise emanates or may emanate, or all such persons, to discontinue or cause to be discontinued such noise, or to take steps to lower the lever of the noise to a level conforming to the requirements of these Regulations within the period stipulated in the instruction: Provided that the provisions of this paragraph shall not apply in respect of a disturbing noise or noise nuisance caused by rail vehicles or aircraft which are not used as recreational vehicles;

(d): before changes are made to existing facilities or existing uses of land or buildings, or before new buildings are erected, in writing require that noise impact assessments or tests are conducted to the satisfaction of that local authority by the owner, developer, tenant or occupant of the facilities, land or buildings or that, for the purposes of regulation 3(b) or (c), reports or certificates in relation to the noise impact to the satisfaction of that local authority are submitted by the owner, developer, tenant or occupant to the local authority on written demand";

In terms of Regulation 4 of the Noise Control Regulations:

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

4.3 THE NATIONAL ENVIRONMENTAL MANAGEMENT ACT (ACT 107 OF 1998)

The National Environmental Management Act ("NEMA") defines "pollution" to include any change in the environment, including noise. A duty therefore arises under section 28 of NEMA to take reasonable measures while establishing and operating the WF to prevent noise pollution occurring. NEMA sets out measures which may be regarded as reasonable. They include measures:

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

4.3.1 Procedures to follow for Environmental Authorisation for Large Scale Wind Energy activities (GG 41445 of 16 February 2018)

This notice provides a procedure to be followed in applying for environmental authorisation for large scale wind and solar photovoltaic energy development activities, identified in terms of section 24(2)(a) of the National Environmental Management Act, 1998.

It is based on the Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa (CSIR, 2015) report, which identified 8 Renewable Energy Development Zones (REDZs) that are of strategic importance.

This notice allows for Wind Energy Facilities to follow the basic assessment procedure contemplated in Regulation 18 and 20 of the Environmental Impact Assessment Regulations, 2014, in order to obtain environmental authorisation.

4.4 NATIONAL ENVIRONMENTAL MANAGEMENT: AIR QUALITY ACT ("AQA") (ACT 39 OF 2004)

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

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

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

(b) for determining –

(i) a definition of noise; and

(ii) the maximum levels of noise.

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

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

An atmospheric emission license issued in terms of section 22 may contain conditions in respect of noise. This however will not be relevant to the WF.

4.4.1 Draft Model Air Quality Management By-law for adoption and adaptation by Municipalities (GN 579 of 2010)

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

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

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

4.5 NOISE STANDARDS

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

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

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

4.6 STRATEGIC ENVIRONMENTAL ASSESSMENT FOR WIND ENERGY PROJECTS IN SOUTH AFRICA

This document identified eight Renewable Energy Development Zones (REDZs) that are of strategic importance for large scale wind and solar photovoltaic development. It allows the Department of Environmental Affairs (DEA) to utilise provisions in the NEMA to streamline environmental authorisation processes in pre-assessed geographical areas. The report used expected noise levels to determine sensitivity buffers, using this to assess the potential significance of noise impact as summarised in **Table 4-1** (guideline values that has not been gazetted).

Table 4-1: Interpretation of noise sensitivity and assessment requirements

<table>
<tr><th>Sensitivity</th><th>Interpretation</th><th>Assessment requirements</th></tr>
<tr><td>Within 300 m of temporarily or permanently inhabited residence

Very High</td><td>High likelihood for significant negative impacts that cannot be mitigated. Expected noise level of 45 dBA or more.</td><td rowspan="3">Proponents intending to develop a wind facility that triggers an environmental assessment process in very high to medium sensitivity areas (i.e. within 1 km of a permanent or temporarily inhabited residence as a receptor) must prove to the relevant competent authority that the proposed development will not have an unacceptable negative impact on a receptor. In order to do so, a comprehensive Noise Impact Assessment undertaken by a competent noise specialist, and in accordance with the National Environmental Management Act (NEMA) regulations pertaining to specialist reports and impact assessment, is required.</td></tr>
<tr><td>300 and 500 m from temporarily or permanently inhabited residence.

High</td><td>High potential for negative impacts that can potentially be mitigated. Expected noise level of between 45 and 40 dBA, 5 to 10 dBA increase in ambient noise level.</td></tr>
<tr><td>500 and 1000 m from temporarily or permanently inhabited residence.

Medium</td><td>Potential for negative impacts, and if there are impacts there is a high likelihood of mitigation. Expected noise level of between 35 and 40 dBA, 0 to 5 dBA increase in ambient noise level.</td></tr>
<tr><td>Further than 1000 m from temporarily or permanently inhabited residence.

Low</td><td>Expected noise level of less than 35 dBA resulting from a wind turbine at more than 1,000 m from the turbine, there are likely to be no noise impacts.</td><td>No assessment or authorisation for wind development in terms of noise impacts is required if the proposed development is further than 1 km from any temporarily or permanently inhabited residence.</td></tr>
</table>

4.7 INTERNATIONAL GUIDELINES

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

4.7.1 Guidelines for Community Noise (WHO, 1999)

The World Health Organization's (WHO) document on the *Guidelines for Community Noise* is the outcome of the WHO- expert task force meeting held in London, United Kingdom, in April 1999. It is based on the document entitled "Community Noise" that was prepared for the World Health Organization and published in 1995 by the Stockholm University and Karolinska Institute.

The scope of the WHO's effort to derive guidelines for community noise is to consolidate actual scientific knowledge on the health impacts of community noise and to provide guidance to environmental health authorities and professionals trying to protect people from the harmful effects of noise in non-industrial environments.

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

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

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

This report describes the findings of a Working Group on Wind Turbine Noise, facilitated by the United Kingdom Department of Trade and Industry. It was developed as an Energy Technology Support Unit[1] (ETSU) project. The aim of the project was to provide information and advice to developers and planners on noise from wind turbines. The report represents the consensus view of a number of experts (experienced in assessing and controlling the environmental impact of noise from wind farms). Their findings can be summarised as follows:

1. Absolute noise limits applied at all wind speeds are not suited to wind farms; limits set relative to the background noise (including wind as seen in **Figure 8-3**) are more appropriate
2. $L_{A90,10mins}$ is a much more accurate descriptor when monitoring ambient and turbine noise levels

[1] ETSU was set up in 1974 as an agency by the United Kingdom Atomic Energy Authority to manage research programmes on renewable energy and energy conservation. The majority of projects managed by ETSU were carried out by external organizations in academia and industry. In 1996, ETSU became part of AEA Technology plc which was separated from the UKAEA by privatisation.

3. The effects of other wind turbines in a given area should be added to the effect of any proposed wind energy facility, to calculate the cumulative effect
4. Noise from a wind energy facility should be restricted to no more than 5 dBA above the current ambient noise level at a NSD. Ambient noise levels is measured onsite in terms of the $L_{A90,10min}$ descriptor for a period sufficiently long enough for a set period
5. Wind farms should be limited within the range of 35dBA to 40dBA (day-time) in a low noise environment. A fixed limit of 43 dBA should be implemented during all night time noise environments. This should increase to 45 dBA (day and night) if the NSD has financial investments in the wind energy facility
6. A penalty system should be implemented for wind turbine/s that operates with a tonal characteristic

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

4.7.3 Noise Guidelines for Wind Farms (MoE, 2008)

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

The document defines:

- Sound Level Limits for different areas (similar to rural and urban areas), defining limits for different wind speeds at 10 m height, refer also **Table 4-2**[2]
- The Noise Assessment Report, including;
    - Information that must be part of the report
    - Full description of noise sources
    - Adjustments, due to the wind speed profile (wind shear)
    - The identification and defining of potential sensitive receptors

[2]The measurement of wind induced background sound level is not required to establish the applicable limit. The wind induced background sound level reference curve was determined by correlating the A-weighted ninetieth percentile sound level (L90) with the average wind speed measured at a particularly quiet site. The applicable Leq sound level limits at higher wind speeds are given by adding 7 dB to the wind induced background L90 sound level reference values

- o Prediction methods to be used (ISO 9613-2)
- o Cumulative impact assessment requirements
- o It also defines specific model input parameters
- o Methods on how the results must be presented
- o Assessment of Compliance (defining magnitude of noise levels)

Table 4-2: Summary of Sound Level Limits for Wind Farms (MoE)

Wind speed (m/s) at 10 m height	4	5	6	7	8	9	10
Wind Turbine Sound Level Limits, Class 3 Area, dBA	40	40	40	43	45	49	51
Wind Turbine Sound Level Limits, Class 1 & 2 Areas, dBA	45	45	45	45	45	49	51

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

It should be noted that these Sound Level Limits are included for the reader to illustrate the criteria used internationally. Due to the lack of local regulations specifically relevant to wind energy facilities this criteria will also be considered during the determination of the significance of the noise impact.

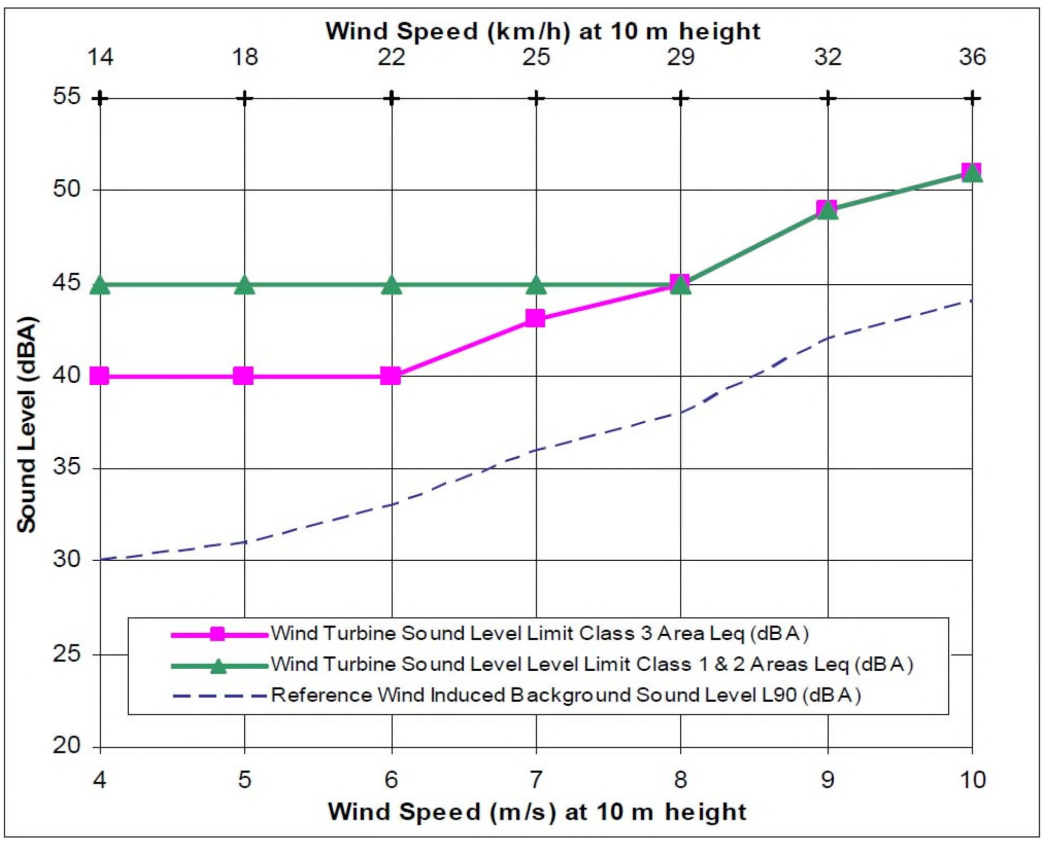

Figure 4-1: Summary of Sound Level Limits for Wind Turbines (MoE Canada)

4.7.4 Equator Principles

The **Equator Principles** (EPs) are a voluntary set of standards for determining, assessing and managing social and environmental risk in project financing. Equator Principles Financial Institutions (EPFIs) commit to not providing loans to projects where the borrower will not or is unable to comply with their respective social and environmental policies and procedures that implement the EPs.

The EPs were developed by private sector banks and were launched in June 2003. The banks chose to model the EPs on the environmental standards of the World Bank and the social policies of the International Finance Corporation (IFC). Sixty-seven (67) financial institutions (October 2009) have adopted the EPs, which have become the de facto standard for banks and investors on how to assess major development projects around the world. The environmental standards of the World Bank have been integrated into the social policies of the IFC since April 2007 as the IFC Environmental, Health and Safety (EHS) Guidelines.

4.7.5 IFC: General EHS Guidelines – Environmental Noise Management

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

It states that noise prevention and mitigation measures should be applied where predicted or measured noise impacts from a project facility or operations exceed the applicable noise level guideline at the most sensitive point of reception. The preferred method for controlling noise from stationary sources is to implement noise control measures at the source.

It goes as far as to propose methods for the prevention and control of noise emissions, including:

- Selecting equipment with lower sound power levels;
- Installing silencers for fans;
- Installing suitable mufflers on engine exhausts and compressor components;
- Installing acoustic enclosures for equipment casing radiating noise;
- Improving the acoustic performance of constructed buildings, apply sound insulation;
- Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimise the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective;
- Installing vibration isolation for mechanical equipment;

- Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas ;
- Re-locating noise sources to less sensitive areas to take advantage of distance and shielding;
- Placement of permanent facilities away from community areas if possible;
- Taking advantage of the natural topography as a noise buffer during facility design;
- Reducing project traffic routing through community areas wherever possible;
- Planning flight routes, timing and altitude for aircraft (airplane and helicopter) flying over community areas; and
- Developing a mechanism to record and respond to complaints.

It sets noise level guidelines (see **Table 4-3**) as well as highlighting the certain monitoring requirements pre- and post-development.

Table 4-3: IFC Table .7.1-Noise Level Guidelines

Receptor type	**One hour L_{Aeq} (dBA)**	
	Daytime 07:00 - 22:00	Night-time 22:00 – 07:00
Residential; institutional; educational	55	45
Industrial; commercial	70	70

The document uses the $L_{Aeq,1\ hr}$ noise descriptors to define noise levels. It does not determine the detection period, but refers to the International Electrotechnical Commission (IEC) Standards, which requires the fast detector setting on the Sound Level Meter during measurements for Europe.

5 ENVIRONMENTAL SOUND CHARACTER

5.1 INFLUENCE OF WIND ON AMBIENT SOUND LEVELS

Natural sounds are a part of the environmental noise surrounding humans. In rural areas the sounds from insects and birds would dominate the ambient sound character, with noises such as wind flowing through vegetation increasing as wind speed increase. Work by Fégeant (2002) stressed the importance of wind speed and turbulence causing variations in the level of vegetation generated noise. In addition, factors such as the season (e.g. dry or no leaves versus green leaves), the type of vegetation (e.g. grass, conifers, deciduous), the vegetation density and the total vegetation surface all determine both the sound level as well as spectral characteristics.

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

Unfortunately, current regulations and standards do not consider changing ambient sound levels due to natural events, such as can be found near the coast (from the ocean waves) or areas where wind induced noises (from vegetation) are prevalent, which is unfeasible with wind energy facilities, as these facilities will only operate when the wind is blowing. It is therefore important that the impact of wind-induced noises be considered when determining the impact of an activity such as a wind energy facility. This is discussed further in **Section 8.3.3**.

Ambient sound levels are significantly affected by the area where the sound measurement location (or a listener) is situated. When the sound measurement location is situated within an urban area, close to industrial plants or areas with a constant sound source (ocean, rivers, etc.), seasons and even increased wind speeds have an insignificant to massive impact on ambient sound levels.
Sound levels in undeveloped rural areas (away from occupied dwellings), however, are impacted by changes in season for a number of complex reasons. The two main reasons are:

- Faunal communication during the warmer spring and summer months as various species communicate in an effort to find mates, and

- Seasonal changes in weather patterns, mainly wind (also see **Sub Section 5.1.1** below).

For environmental noise weather plays an important role, the greater the separation distance, the greater the influence of the weather conditions, so, from day to day, a road 1,000 m away can sound very loud or can be completely inaudible. Other, environmental factors that impact on sound propagation includes wind, temperature and humidity, as discussed in **Sub-sections 5.1.1** to **5.1.3** below.

5.1.1 Effect of Wind

Wind alters sound propagation by the mechanism of refraction, that is, wind bends sound waves. Wind nearer to the ground moves more slowly than wind at higher altitudes, due to surface characteristics such as hills, trees, and man-made structures that interfere with the wind. This wind gradient, with faster wind at higher elevation and slower wind at lower elevation, causes sound waves to bend downward when they are traveling to a location downwind of the source and to bend upward when traveling toward a location upwind of the source. Waves bending downward means that a listener standing downwind of the source will hear louder noise levels than the listener standing upwind of the source. This phenomenon can significantly impact sound propagation over long distances and when wind speeds are high. Over short distances wind direction has a small impact on sound propagation as long as wind velocities are reasonably slow, i.e. less than 5 m/s.

Wind speed frequently plays a role in increasing sound levels in natural locations. With no wind, there is little vegetation movement that could generate noises and faunal noises (normally birds and insects) dominate, however, as wind speeds increase, the rustling of leaves increases which subsequently can increase sound levels. This directly depends on the type of vegetation in a certain area. The impact of increased wind speed on sound levels depends on the vegetation type (deciduous versus coniferous), the density of vegetation in an area, seasonal changes (in winter deciduous trees are bare) as well as the height of this vegetation. This excludes unanticipated consequences, as suitable vegetation may create suitable habitats and food sources attracting birds and insects (and the subsequent increase in faunal communication).

5.1.2 Effect of Temperature

On a typical sunny afternoon the air is the hottest near the ground surface and temperature decreases at higher altitudes. This temperature gradient causes sound waves to refract upward, away from the ground and results in lower noise levels being heard at a measurement location. In the evening, this temperature gradient will reverse, resulting in cooler temperatures near the ground. This condition, often referred to as a temperature inversion will cause sound to bend downward towards the ground and results in louder noise levels at the listener position. Like wind gradients, temperature gradients can influence sound propagation over long distances and further complicate measurements. Generally sound propagates better at lower temperatures (down to 10°C), and with everything being equal, a decrease in temperature from 32°C to 10°C could increase the sound level at a listener 600 m away by ±2.5 dB (at 1,000 Hz).

5.1.3 Effect of Humidity

The effect of humidity on sound propagation is quite complex, but effectively relates to how increased changes the density of air. Lower density translates into faster sound wave travel, so sound waves travel faster at high humidity. With everything being equal, an increase in humidity from 20% to 80% would increase the sound level at a listener 600 m away by ±4 dB (at 1,000 Hz at 20°C).

5.2 AMBIENT SOUND MEASUREMENTS PROCEDURE

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

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

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

- Compliance with the latest version of SANS 10103;
- The sound measuring equipment was calibrated directly before, and directly after the measurements were collected. In all cases drift[3] was less than 0.2 dBA between these two acoustical sensitivity calibrations.
- The measurement equipment made use of a windshield specifically designed for outdoor use during increased wind speeds;

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

- The areas where measurements were recorded was selected so as to minimise the risks of direct impacts by the wind on the microphone;
- Noise data was synchronised with the wind data measured onsite using an anemometer at a 1.5 m height.

Ambient sound levels were measured over a period of a few nights during February 2018 at three locations (20 – 22 February). The locations used to measure ambient (background) sound levels presented in **Figure 5-1**.

Photos taken during the measurement date is presented in **Appendix B**.

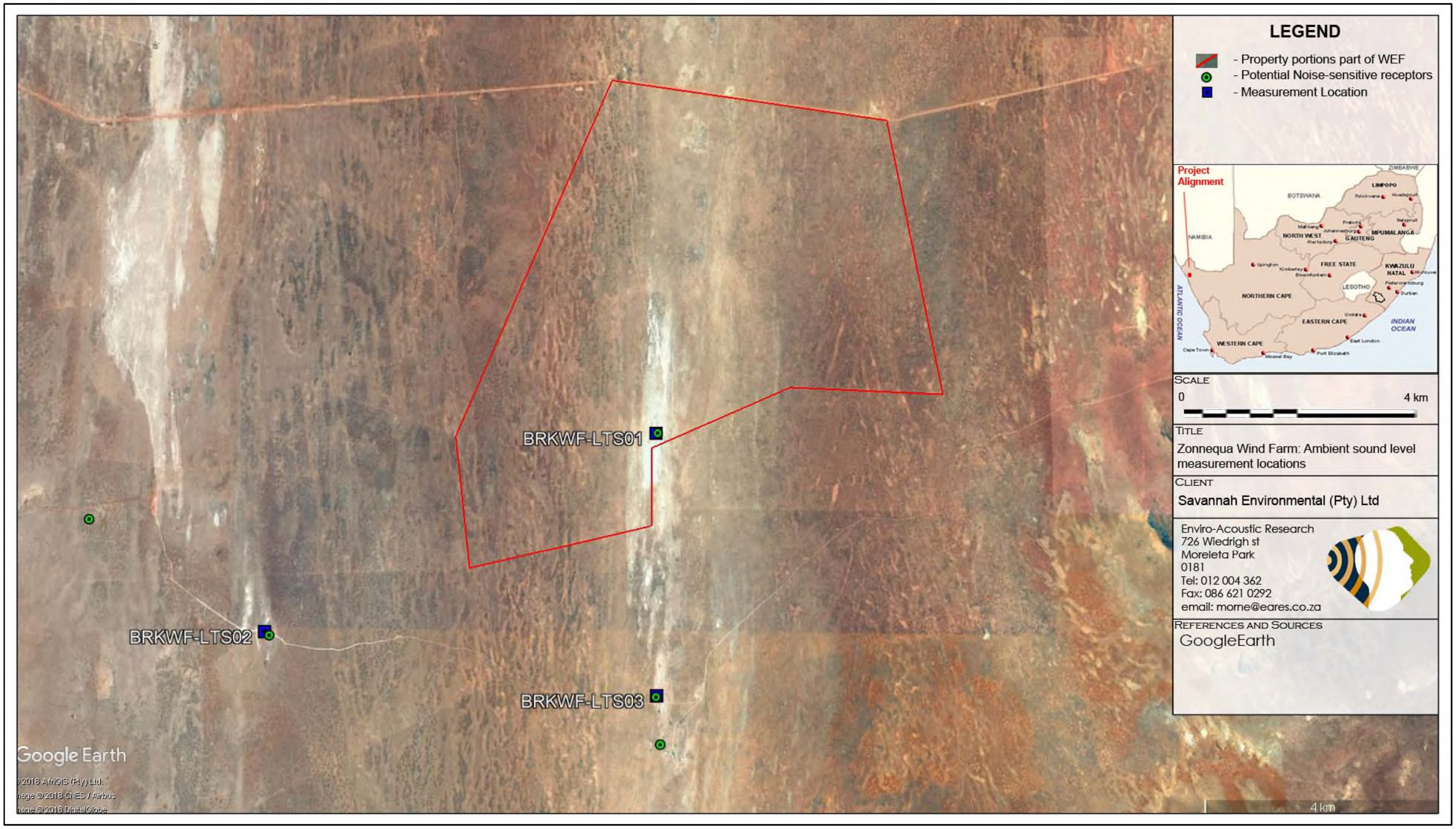

Figure 5-1: Localities of where ambient sound levels were measured

5.3 Ambient Sound Measurements Collected in the Area

5.3.1 Measurement Point BRKWF-LTS01

The equipment defined in **Table 5-1** was used for gathering data at this location. Measured sound levels are presented in **Figure 5-2** and **Figure 5-3** and defined in **Table 5-2**.

Table 5-1: Equipment used to measure sound levels at BRKWF-LTS01

Equipment	Model	Serial no	Calibration Date
SLM	Svan 977	34849	October 2017
Microphone	ACO Pacific 7052E	55974	October 2017
Calibrator	Quest CA-22	J 2080094	June 2016
Anemometer	W3081	-	-

* Microphone fitted with the RION WS-03 outdoor all-weather windshield.

The measurement location was selected to be reflective of the typical environmental ambient sound levels that the receptors living in this area may experience. The SLM was erected next to the fence away from the house. There was a windmill as well as a small wind turbine operational in the area that limited the potential locations where measurements could be collected. There was a tree and an aviary within 10m from the microphone.

Refer to **Appendix B** for photos of this measurement location. Sounds heard during the period the instrument was deployed and collected (approximately 60 – 80 minutes) are defined in **Table 5-2**.

Table 5-2: Noises/sounds heard during the site visit at receptor BRKWF-LTS01

		During Deployment	During Collection
Magnitude Scale Code: • **Barely Audible** • **Audible** • **Dominating or clearly audible**	**Faunal and natural**	Wind-induced noises from windmill and wind turbine. Bird communication.	Bird communication.
	Residential	-	-
	Industrial & transportation	-	-

Impulse equivalent sound levels (South African legislation): Figure 5-2 illustrates how the impulse-weighted 10-minute equivalent values changes over time with **Table 5-3** defining the average values for the time period. This sound descriptor is mainly used in South Africa to define sound and noise levels. The instrument is set to measure the impulse time-weighted sound levels.

Fast equivalent sound levels (International guidelines): Fast-weighted 10-minute equivalent (average) sound levels for the day and night-time periods are shown on **Figure**

5-2 with **Table 5-3** defining the average values for the time period. Fast-weighted equivalent sound levels are included in this report as this is the sound descriptor used in most international countries to define the Ambient Sound Level.

Statistical sound levels ($L_{A90,f}$): The L_{A90} level is presented in this report as it is used to define the "background ambient sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on the average sound level. **L_{A90}** is a statistical indicator that describes the noise level that is exceeded 90% of the time and frequently used to define the background sound level internationally. The instrument is set to fast time-weighting. It is illustrated against time on **Figure 5-3** and defined in **Table 5-3**.

Measured maximum and minimum sound levels: These are statistical sound descriptors that can be used to characterise the sound levels in an area along with the other sound descriptors. These sound level descriptors are defined in **Table 5-3** and illustrated in **Figure 5-3**.

Table 5-3: Sound levels considering various sound level descriptors at BRKWF-LTS01

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)	Comments
Day arithmetic average	-	49	45	34	-	-
Night arithmetic average	-	30	24	21	-	-
Day minimum	-	33	27	-	9	-
Day maximum	91	70	65	-	-	-
Night minimum	-	9	9	-	9	-
Night maximum	76	59	47	-	-	-
Day 1 equivalent	-	55	49	-	-	Late afternoon and evening only
Night 1 Equivalent	-	37	27	-	-	8 hour night equivalent average
Day 2 equivalent	-	56	49	-	-	16 hour day equivalent average
Night 2 Equivalent	-	46	35	-	-	8 hour night equivalent average
Day 3 equivalent	-	53	47	-	-	Early morning only

Bird sounds were clearly audible with wind-induced noises increasing the noise levels at times during wind gusts. Considering the development character and sounds heard, the area can be considered naturally quiet.

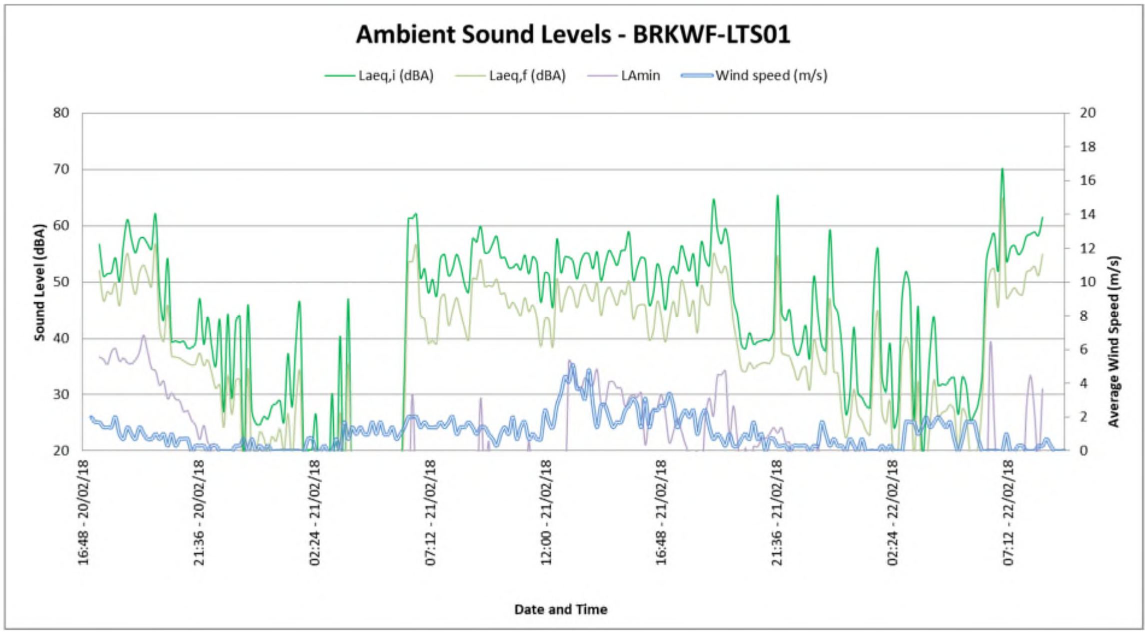

Figure 5-2: Ambient Sound Levels at BRKWF-LTS01

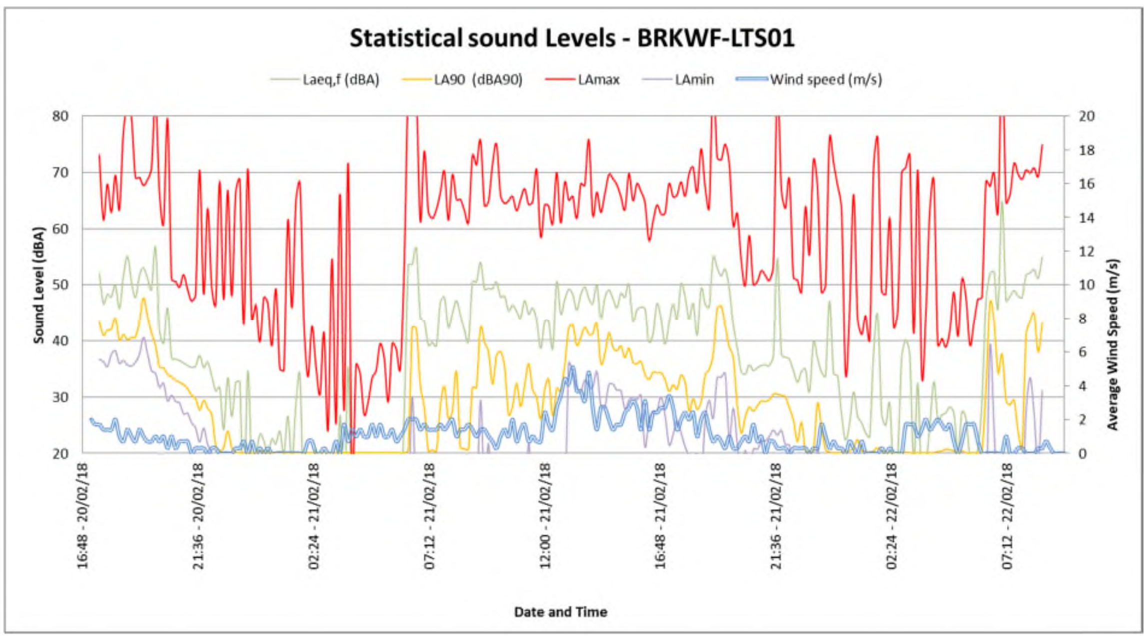

Figure 5-3: Maximum, minimum and statistical values at BRKWF-LTS01

Third octaves were measured and are displayed in **Figures 5-4 – 5-7**. Wind-induced noises had a significant impact on most of the measurements.

Lower frequency (20 – 250 Hz) – Noise sources of significance in this frequency band would include nature (wind and surf especially – indicated by a relative smooth curve) and sounds of anthropogenic origin and vehicles (engine sounds and electric motors – erratic bumps at certain frequencies). Lower frequencies tend to travel further through the atmosphere than higher frequencies.

Night-time data indicated a site with little acoustic energy in this frequency range (average of approximately 13 dBA). Wind-induced noises dominated this frequency band.

Daytime data shows some acoustic energy in this frequency band, with the energy due to wind-induced noises (average of approximately 20 dBA).

Third octave surrounding the 1,000 Hz (200 – 2,000 Hz) – This range contains energy mostly associated with human speech (350 Hz – 2,000 Hz; mostly below 1,000 Hz) and dwelling noises (including sounds from larger animals such as chickens, dogs, goats, sheep and cattle). Road-tyre interaction (from vehicular traffic) normally features in 630 – 1,600 Hz range.

Night-time data indicate some acoustic energy in this frequency range (average of approximately 19 dBA). There were two different and significant noise sources that contributed to the acoustic energy in this frequency band.

Daytime data shows significant acoustic energy in this frequency band from a number of different sources (average of approximately 38 dBA).

Higher frequency (2,000 Hz upwards) – Smaller faunal species such as birds, crickets and cicada use this range to communicate and hunt etc. There were significant peaks in the 3 150 – 6 300 frequency bands both night and day, likely from birds and insects.

Night-time data indicate significant acoustic energy in this frequency range (average of approximately 28 dBA). There were peaks in the 5,000 and 20,000Hz frequencies, with a slight peak at 10,000Hz.

Daytime data indicate significant acoustic energy in this frequency band (average of approximately 44 dBA). Most of the acoustic energy is in the 2,000 – 8,000Hz frequency band.

Compliance with international guidelines: Daytime ambient sound levels were typical of a rural noise district, with the site being extremely quiet at night. It is suspected that the sound levels will be lower during the day when there is less wind. Considering the developmental character of the area, the acceptable zone rating level would be typical of a rural noise district (35 dBA at night and 45 dBA during the day) as defined in SANS 10103:2008.

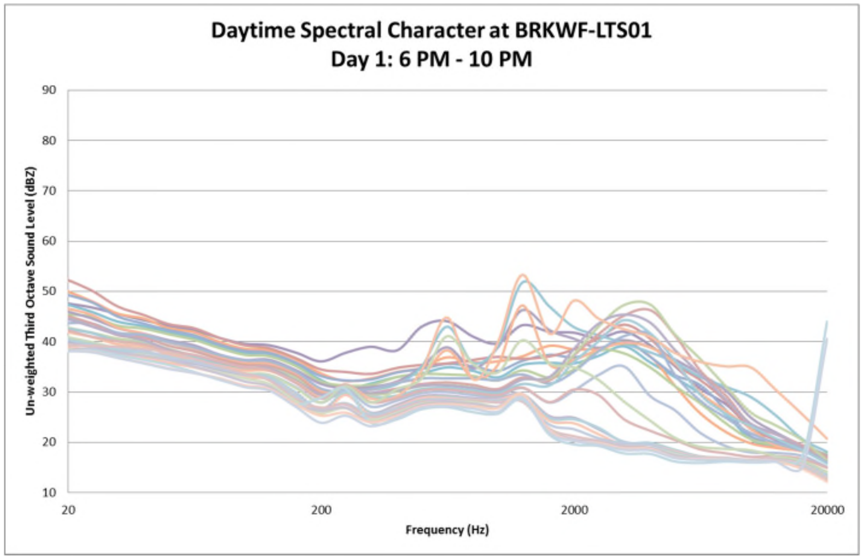

Figure 5-4: Spectral frequencies – BRKWF-LTS01, Day 1

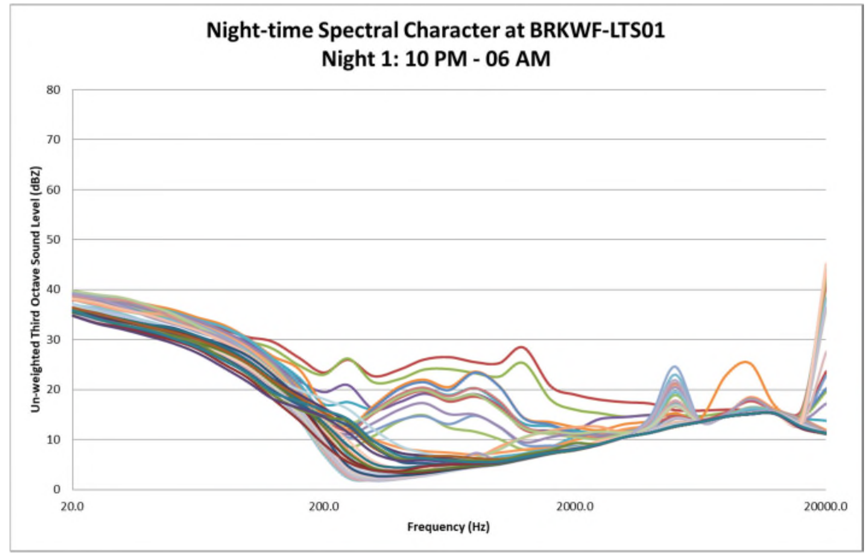

Figure 5-5: Spectral frequencies – BRKWF-LTS01, Night 1

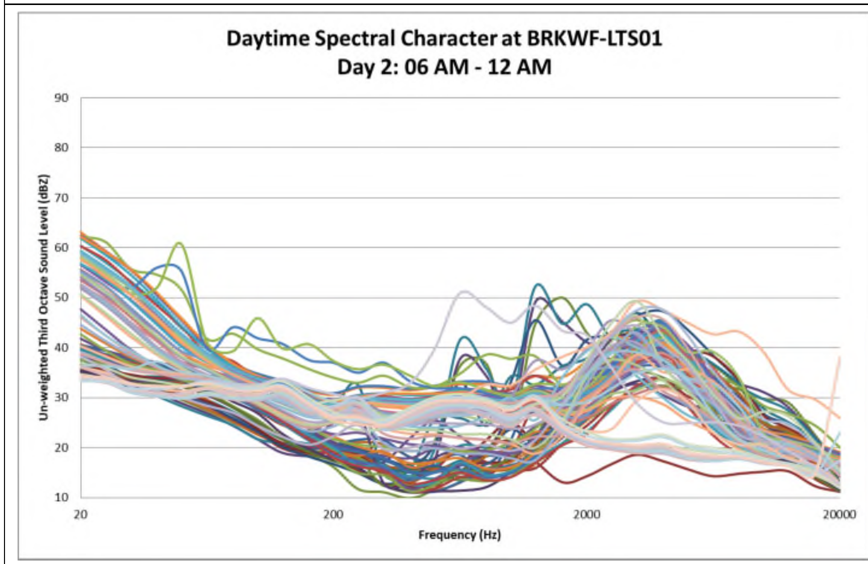

Figure 5-6: Spectral frequencies – BRKWF-LTS01, Day 2

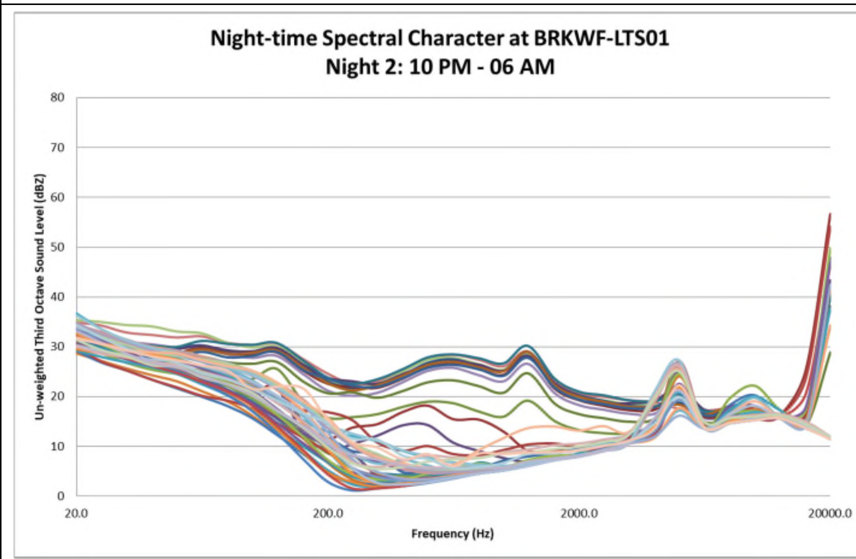

Figure 5-7: Spectral frequencies – BRKWF-LTS01, Night 2

5.3.2 Measurement Point BRKWF-LTS02

The equipment defined in **Table 5-4** was used for gathering data. Measured sound levels are presented in **Figure 5-8** and **Figure 5-9** and defined in **Table 5-6**.

Table 5-4: Equipment used to measure sound levels at BRKWF-LTS02

Equipment	Model	Serial no	Calibration Date
SLM	Svan 977	36176	December 2017
Microphone	ACO Pacific 7052E	49596	December 2017
Calibrator	Quest CA-22	J 2080094	June 2017

The SLM was erected close to the porch of the house as other measurement locations were exposed or close to vegetation. This is the location where the residents would be relaxing during the day. Refer to Appendix B for a photo of this measurement location. Sounds heard during the period the instrument was deployed and collected (approximately 60 – 80 minutes) are defined in **Table 5-5**.

Table 5-5: Noises/sounds heard during the site visit at receptor BRKWF-LTS02

		During Deployment	During Collection
Magnitude Scale Code: • Barely Audible • Audible • Dominating or clearly audible	**Faunal and natural**	Wind-induced noises at times. Bird calls audible.	Bird communication.
	Residential	Sheep bleating in the area.	-
	Industrial & transportation	-	-

Impulse equivalent sound levels (South African legislation): Figure 5-8 illustrates how the impulse-weighted 10-minute equivalent values changes over time with **Table 5-6** defining the average values for the time period. This sound descriptor is mainly used in South Africa to define sound and noise levels. The instrument is set to measure the impulse time-weighted sound levels.

Fast equivalent sound levels (International guidelines): Fast-weighted 10-minute equivalent (average) sound levels for the day and night-time periods are shown on **Figure 5-8** with **Table 5-6** defining the average values for the time period. Fast-weighted equivalent sound levels are included in this report as this is the sound descriptor used in most international countries to define the Ambient Sound Level.

Statistical sound levels ($L_{A90,f}$): The L_{A90} level is presented in this report as it is used to define the "background ambient sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on the average sound level. **L_{A90}** is a statistical indicator that describes the noise level that is exceeded 90% of the time and frequently used to define the background sound level internationally. The instrument is set to fast time-weighting. It is illustrated against time on **Figure 5-9** and defined in **Table 5-6**.

Measured maximum and minimum sound levels: These are statistical sound descriptors that can be used to characterise the sound levels in an area along with the other sound descriptors. These sound level descriptors are defined in **Table 5-6** and illustrated in **Figure 5-9**.

Table 5-6: Sound levels considering various sound level descriptors at BRKWF-LTS02

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)	Comments
Day arithmetic average	-	39	35	25	-	-
Night arithmetic average	-	30	25	20	-	-
Day minimum	-	22	21	-	19	-
Day maximum	78	60	50	-	-	-
Night minimum	-	21	20	-	17	-
Night maximum	68	46	35	-	-	-
Day 1 equivalent	-	45	40	-	-	Evening only
Night 1 Equivalent	-	34	26	-	-	8 hour night equivalent average
Day 2 equivalent	-	48	41	-	-	16 hour day equivalent average
Night 2 Equivalent	-	33	27	-	-	8 hour night equivalent average
Day 5 equivalent	-	60	50	-	-	Early morning only

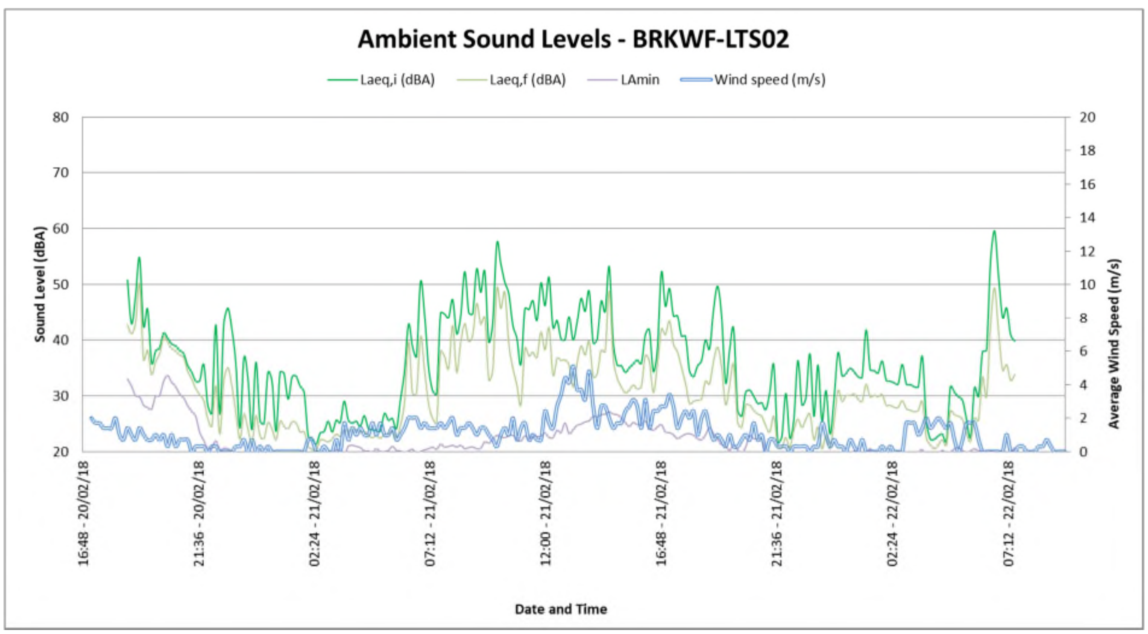

Figure 5-8: Ambient Sound Levels at BRKWF-LTS02

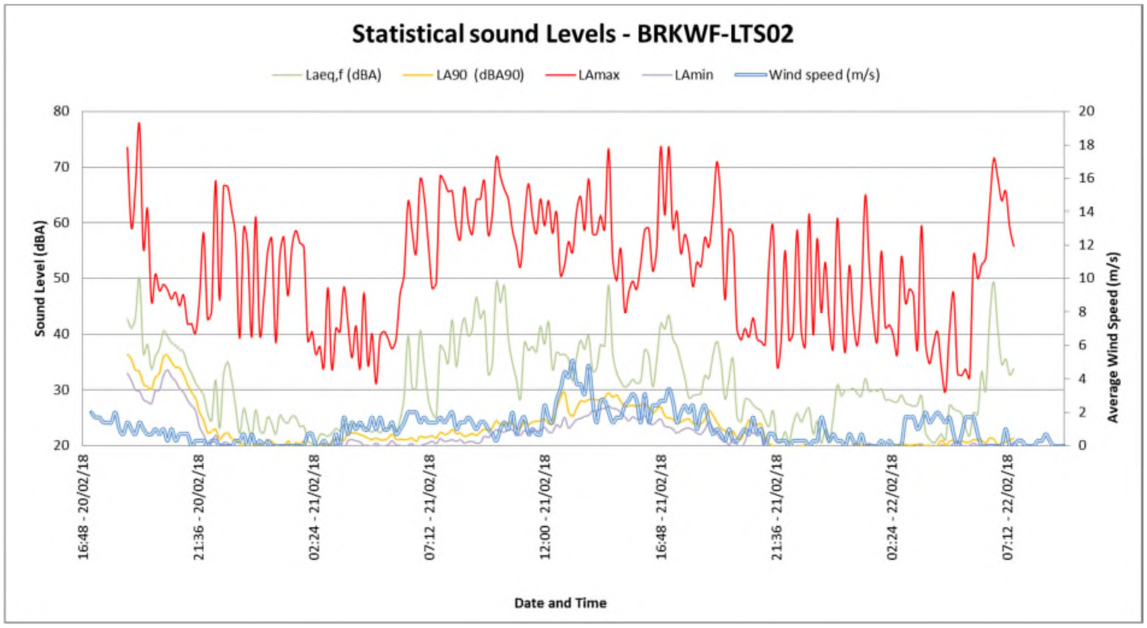

Figure 5-9: Maximum, minimum and statistical values at BRKWF-LTS02

Third octaves were not measured.

5.3.3 Measurement Point BRKWF-LTS03

The equipment defined in **Table 5-7** was used for gathering data. Measured sound levels are presented in **Figure 5-10** and **Figure 5-11** and defined in **Table 5-9**.

Table 5-7: Equipment used to measure sound levels at BRKWF-LTS03

Equipment	Model	Serial no	Calibration Date
SLM	Svan 955	27637	October 2016
Microphone	ACO Pacific 7052E	52437	October 2016
Calibrator	Quest CA-22	J 2080094	June 2017

The SLM was erected away from the house at the fence, with a large bush around 5m from the microphone. Sounds heard during the period the instrument was deployed and collected (approximately 60 – 80 minutes) are defined in **Table 5-8**.

Table 5-8: Noises/sounds heard during the site visit at receptor BRKWF-LTS03

		During Deployment	During Collection
Magnitude Scale Code: • **Barely Audible** • **Audible** • **Dominating or clearly audible**	**Faunal and natural**	Wind-induced noises audible and generally dominant. Birds audible.	Bird communication.
	Residential	Voices	-
	Industrial & transportation	-	-

Impulse equivalent sound levels (South African legislation): Figure 5-10 illustrates how the impulse-weighted 10-minute equivalent values changes over time with **Table 5-9** defining the average values for the time period. This sound descriptor is mainly used in South Africa to define sound and noise levels. The instrument is set to measure the impulse time-weighted sound levels.

Fast equivalent sound levels (International guidelines): Fast-weighted 10-minute equivalent (average) sound levels for the day and night-time periods are shown on **Figure 5-10** with **Table 5-9** defining the average values for the time period. Fast-weighted equivalent sound levels are included in this report as this is the sound descriptor used in most international countries to define the Ambient Sound Level.

Statistical sound levels ($L_{A90,f}$): The L_{A90} level is presented in this report as it is used to define the "background ambient sound level", or the sound level that can be expected if there were little single events (loud transient noises) that impacts on the average sound level. **L_{A90}** is a statistical indicator that describes the noise level that is exceeded 90% of the time and frequently used to define the background sound level internationally. The instrument is set to fast time-weighting. It is illustrated against time on **Figure 5-11** and defined in **Table 5-9**.

Measured maximum and minimum sound levels: These are statistical sound descriptors that can be used to characterise the sound levels in an area along with the other sound descriptors. These sound level descriptors are defined in **Table 5-9** and illustrated in **Figure 5-11**.

Table 5-9: Sound levels considering various sound level descriptors at BRKWF-LTS03

	$L_{Amax,i}$ (dBA)	$L_{Aeq,i}$ (dBA)	$L_{Aeq,f}$ (dBA)	$L_{A90,f}$ (dBA90)	$L_{Amin,f}$ (dBA)	Comments
Day arithmetic average	-	38	36	25	-	-
Night arithmetic average	-	23	20	17	-	-
Day minimum	-	21	20	-	16	-
Day maximum	88	75	65	-	-	-
Night minimum	-	15	17	-	15	-
Night maximum	70	47	40	-	-	-
Day 1 equivalent	-	53	47	-	-	Evening only
Night 1 Equivalent	-	31	25	-	-	8 hour night equivalent average
Day 2 equivalent	-	63	54	-	-	16 hour day equivalent average
Night 2 Equivalent	-	28	21	-	-	8 hour night equivalent average
Day 3 equivalent	-	36	27	-	-	Early morning only

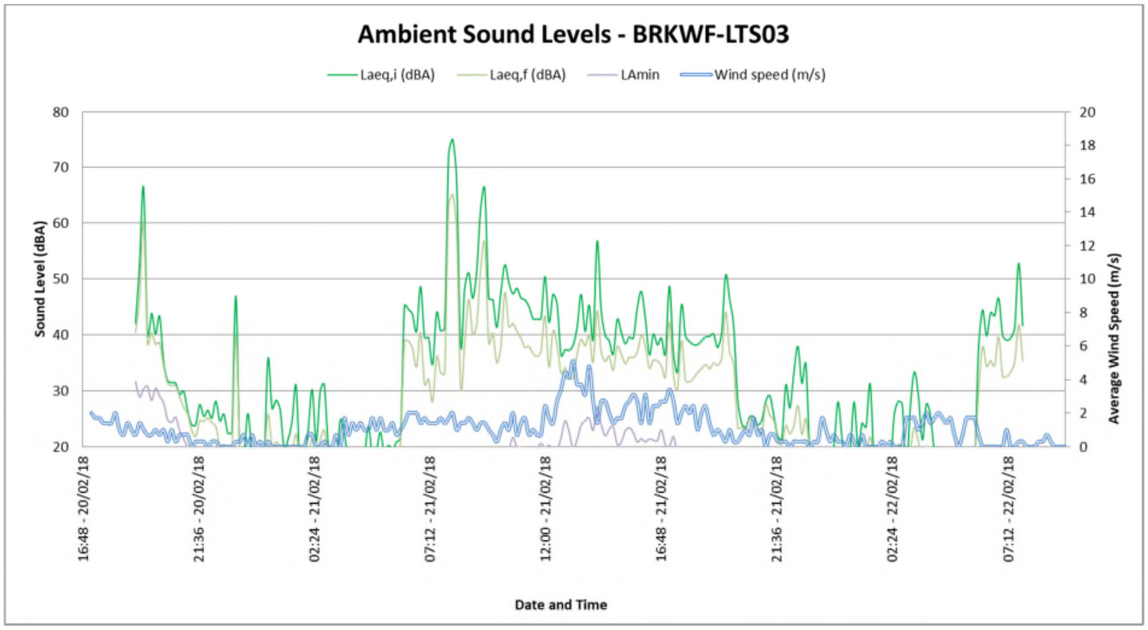

Figure 5-10: Ambient Sound Levels at BRKWF-LTS03

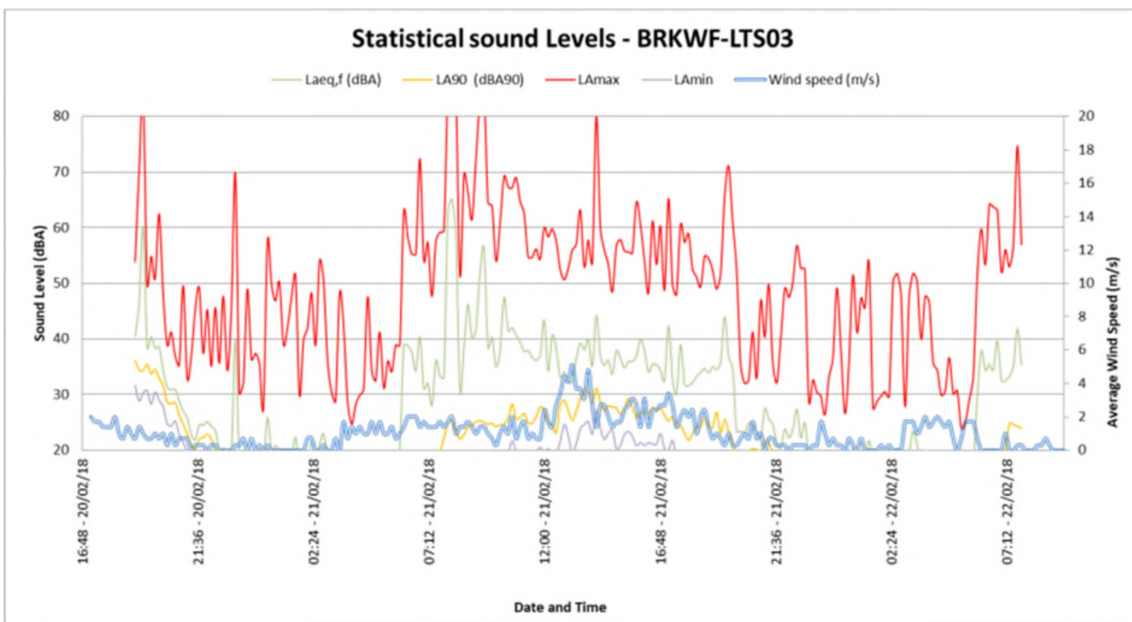

Figure 5-11: Maximum, minimum and statistical values at BRKWF-LTS03

Third octaves were measured and are displayed in **Figures 5-12 – 5-15**. Wind-induced noises dominated this location.

Lower frequency (20 – 250 Hz) – Noise sources of significance in this frequency band would include nature (wind and surf especially – indicated by a relative smooth curve) and sounds of anthropogenic origin and vehicles (engine sounds and electric motors – erratic

bumps at certain frequencies). Lower frequencies tend to travel further through the atmosphere than higher frequencies.
Night-time data indicated a site with little acoustic energy in this frequency range (average of approximately 10 dBA).
Daytime data shows some acoustic energy in this frequency band, with a few measurements indicating noises from various sources (average of approximately 19 dBA).

Third octave surrounding the 1,000 Hz (200 – 2,000 Hz) – This range contains energy mostly associated with human speech (350 Hz – 2,000 Hz; mostly below 1,000 Hz) and dwelling noises (including sounds from larger animals such as chickens, dogs, goats, sheep and cattle). Road-tyre interaction (from vehicular traffic) normally features in 630 – 1,600 Hz range.
Night-time data indicate a site with little acoustic energy in this frequency range (average of approximately 13 dBA).
Daytime data shows some acoustic energy in this frequency band. There are measurements indicating sounds from various different sources though wind-induced noises dominate (average acoustic energy of approximately 32 dBA).

Higher frequency (2,000 Hz upwards) – Smaller faunal species such as birds, crickets and cicada use this range to communicate and hunt etc. There was some acoustic energy in the very high frequencies during the evenings, likely due to bats.
Night-time data indicate some acoustic energy in this frequency range (average of approximately 17 dBA). Most measurements show significant acoustic energy at very high frequencies.
Daytime data indicate some acoustic energy in this frequency band (average of approximately 31 dBA).

Compliance with international guidelines: Ambient sound levels are very quiet at this location. Considering the developmental character of the area, the acceptable zone rating level would be typical of a rural noise district (35 dBA at night and 45 dBA during the day) as defined in SANS 10103:2008.

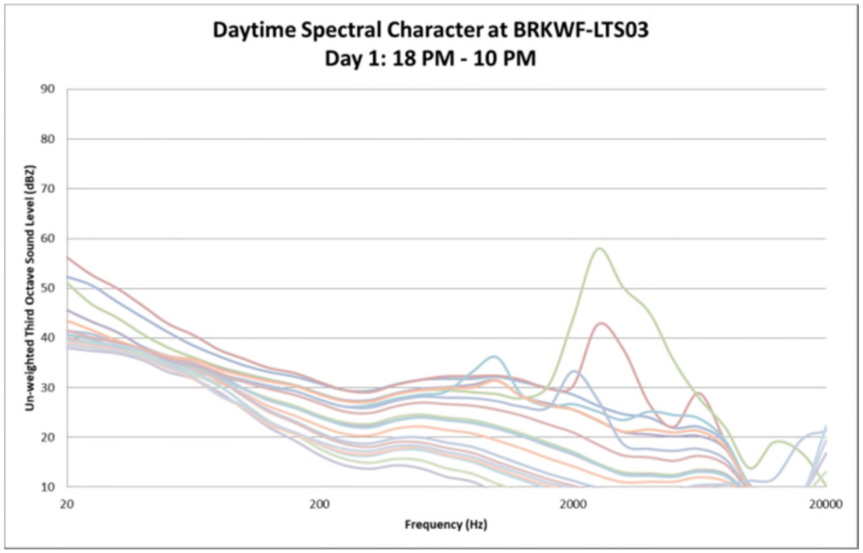

Figure 5-12: Spectral frequencies – BRKWF-LTS03, Day 1

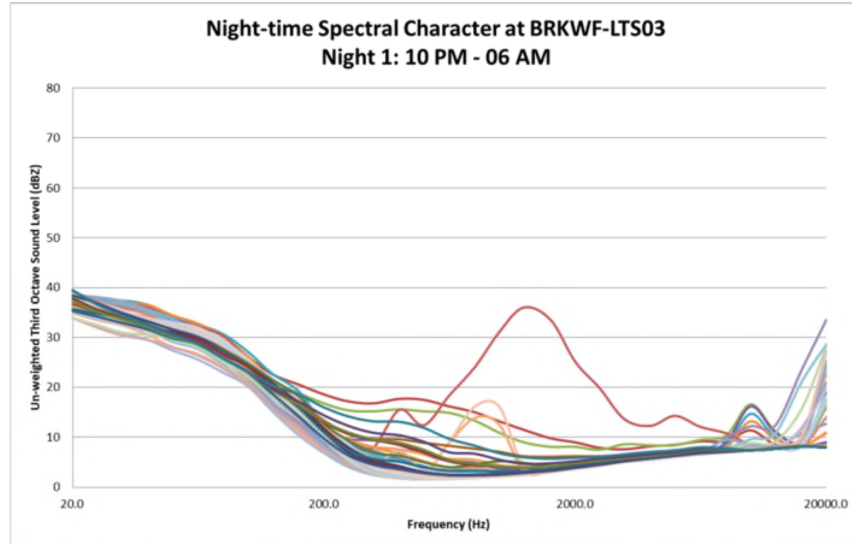

Figure 5-13: Spectral frequencies – BRKWF-LTS03, Night 1

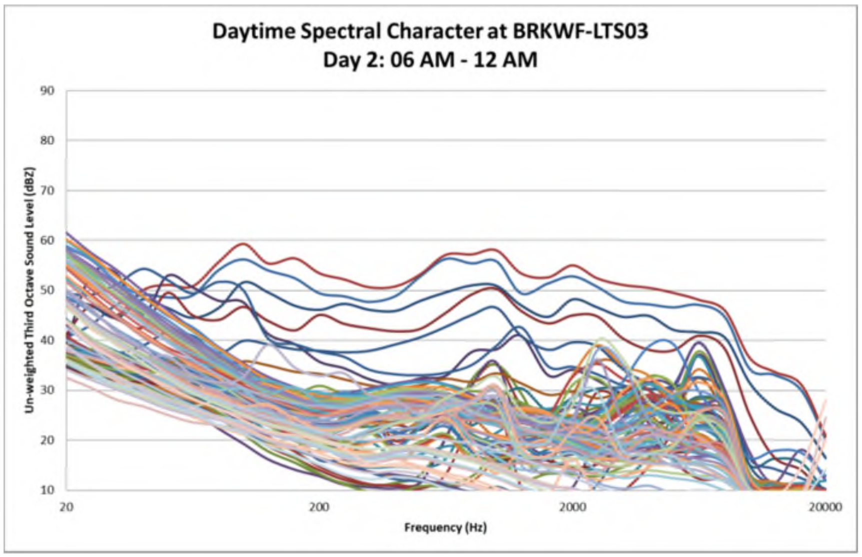

Figure 5-14: Spectral frequencies – BRKWF-LTS03, Day 2

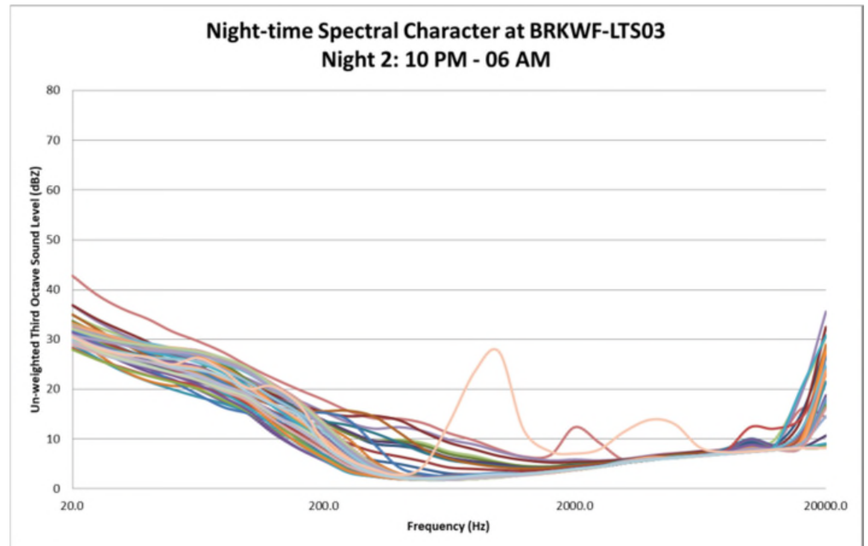

Figure 5-15: Spectral frequencies – BRKWF-LTS03, Night 2

6 POTENTIAL NOISE SOURCES

Increased noise levels are directly linked with the various activities associated with the construction of the WF and related infrastructure, as well as the operation phase of the activity. The potential noise impacts from the activities associated with these phases are discussed in the following sections.

6.1 POTENTIAL NOISE SOURCES: CONSTRUCTION PHASE

6.1.1 Construction equipment

It is estimated that construction will take approximately 18 - 24 months subject to the final design of the WF, weather and ground conditions, including time for testing and commissioning. The construction process will consist of the following principal activities:

- Site survey and preparation;
- Establishment of site entrance, internal access roads, contractors compound and passing places;
- Civil works to sections of the public roads to facilitate turbine delivery;
- Site preparation activities will include clearance of vegetation at the footprint of each turbine as well as crane hard-standing areas. These activities will require the stripping of topsoil which will need to be stockpiled, backfilled and/or spread on site;
- Construct foundations – due to the volume of concrete that will be required, an on-site batching plant will be required to ensure a continuous concreting operation. The source of aggregate is yet undefined but is expected to be derived from an offsite source or brought in as ready-mix. If the stones removed during the digging of foundations are suitable as an aggregate this can be used as the aggregate in the concrete mix.
- Transport of components and equipment to site – all components will be brought to site in sections by means of flatbed trucks. Additionally, components of various specialised construction and lifting equipment are required on site to erect the wind turbines and will need to be transported to site. The typical civil engineering construction equipment will need to be brought to the site for the civil works (e.g. excavators, trucks, graders, compaction equipment, cement trucks, etc.). The transportation of ready-mix concrete to site or the materials for onsite concrete batching will result in a temporary increase in heavy traffic (one turbine foundation up to 100 concrete trucks, and is undertaken as a continuous pour);
- Establishment of laydown and hard standing areas - laydown areas will need to be established at each turbine position for the placement of wind turbine components.

Laydown and storage areas will also be required to be established for the civil engineering construction equipment which will be required on site. Hard standing areas will need to be established for operation of the cranes. Cranes of the size required to erect turbines are sensitive to differential movement during lifting operations and require a hard standing area;

- Erect turbines - a crane will be used to lift the tower sections into place and then the nacelle will be placed onto the top of the assembled tower. The next step will be to assemble or partially assemble the rotor on the ground; it will then be lifted to the nacelle and bolted in place. A small crane will likely be needed for the assembly of the rotor while the large crane will be needed to put it in place;
- Construct substation - the underground cables carrying the generated power from the individual turbines will connect at the substation. The construction of the substation would require a site survey; site clearing and levelling (including the removal / cutting of rock outcrops) and construction of access road/s (where required); construction of a substation terrace and foundation; assembly, erection and installation of equipment (including transformers); connection of conductors to equipment; and rehabilitation of any disturbed areas and protection of erosion sensitive areas;
- Establishment of ancillary infrastructure - A workshop as well as a contractor's equipment camp may be required. The establishment of these facilities/buildings will require the clearing of vegetation and levelling of the development site and the excavation of foundations prior to construction. A laydown area for building materials and equipment associated with these buildings will also be required; and
- Site rehabilitation - once construction is completed and all construction equipment isremoved; the site will be rehabilitated where practical and reasonable.

There are a number of factors that determine the audibility as well as the potential of a noise impact on receptors. Maximum noises generated can be audible over a large distance, however, are generally of very short duration. If maximum noise levels however exceed 65 dBA at a receptor, or if it is clearly audible with a significant number of instances where the noise level exceeds the prevailing ambient sound level with more than 15 dB, the noise can increase annoyance levels and may ultimately result in noise complaints. Potential maximum noise levels generated by various construction equipment as well as the potential extent of these sounds are presented in **Table 6-1**.

Average or equivalent sound levels are another factor that impacts on the ambient sound levels and is the constant sound level that the receptor can experience. Typical sound power levels associated with various activities that may be found at a construction site is presented in **Table 6-2**.

Table 6-1: Potential maximum noise levels generated by construction equipment

Equipment Description[4]	Impact Device?	Maximum Sound Power Levels (dBA)	**Operational Noise Level at given distance considering potential maximum noise levels (Cumulative as well as the mitigatory effect of potential barriers or other mitigation not included – simple noise propagation modelling only considering distance) (dBA)**											
			5 m	10 m	20 m	50 m	100 m	150 m	200 m	300 m	500 m	750 m	1000 m	2000 m
Auger Drill Rig	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Backhoe	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Chain Saw	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Compactor (ground)	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Compressor (air)	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Concrete Batch Plant	No	117.7	92.7	86.7	80.6	72.7	66.7	63.1	60.6	57.1	52.7	49.2	46.7	40.6
Concrete Mixer Truck	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Concrete Pump Truck	No	116.7	91.7	85.7	79.6	71.7	65.7	62.1	59.6	56.1	51.7	48.2	45.7	39.6
Concrete Saw	No	124.7	99.7	93.7	87.6	79.7	73.7	70.1	67.6	64.1	59.7	56.2	53.7	47.6
Crane	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Dozer	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Drill Rig Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Drum Mixer	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Dump Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Excavator	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Flat Bed Truck	No	118.7	93.7	87.7	81.6	73.7	67.7	64.1	61.6	58.1	53.7	50.2	47.7	41.6
Front End Loader	No	114.7	89.7	83.7	77.6	69.7	63.7	60.1	57.6	54.1	49.7	46.2	43.7	37.6
Generator	No	116.7	91.7	85.7	79.6	71.7	65.7	62.1	59.6	56.1	51.7	48.2	45.7	39.6
Generator (<25KVA)	No	104.7	79.7	73.7	67.6	59.7	53.7	50.1	47.6	44.1	39.7	36.2	33.7	27.6
Grader	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Impact Pile Driver	Yes	129.7	104.7	98.7	92.6	84.7	78.7	75.1	72.6	69.1	64.7	61.2	58.7	52.6
Jackhammer	Yes	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Man Lift	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6
Mounted Impact Hammer	Yes	124.7	99.7	93.7	87.6	79.7	73.7	70.1	67.6	64.1	59.7	56.2	53.7	47.6
Paver	No	119.7	94.7	88.7	82.6	74.7	68.7	65.1	62.6	59.1	54.7	51.2	48.7	42.6

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

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

Table 6-2: Potential equivalent noise levels generated by various equipment

Equipment Description	Equivalent (average) Sound Levels (dBA)	Operational Noise Level at given distance considering equivalent (average) sound power emission levels (Cumulative as well as the mitigatory effect of potential barriers or other mitigation not included – simple noise propagation modelling only considering distance) (dBA)											
		5 m	10 m	20 m	50 m	100 m	150 m	200 m	300 m	500 m	750 m	1000 m	2000 m
Air compressor	92.6	67.6	61.6	55.5	47.6	41.6	38.0	35.5	32.0	27.6	24.1	21.6	15.5
Bulldozer CAT D10	111.9	86.9	80.9	74.9	66.9	60.9	57.4	54.9	51.3	46.9	43.4	40.9	34.9
Cement truck (with cement)	111.7	86.7	80.7	74.7	66.7	60.7	57.2	54.7	51.2	46.7	43.2	40.7	34.7
Crane	107.5	82.5	76.5	70.5	62.5	56.5	53.0	50.5	46.9	42.5	39.0	36.5	30.5
Diesel Generator (Large - mobile)	106.1	81.2	75.1	69.1	61.2	55.1	51.6	49.1	45.6	41.2	37.6	35.1	29.1
Dumper/Haul truck - Terex 30 ton	112.2	87.2	81.2	75.2	67.2	61.2	57.7	55.2	51.7	47.2	43.7	41.2	35.2
Excavator - Hitachi EX1200	113.1	88.1	82.1	76.1	68.1	62.1	58.6	56.1	52.6	48.1	44.6	42.1	36.1
FEL (988) (FM)	115.6	90.7	84.6	78.6	70.7	64.6	61.1	58.6	55.1	50.7	47.1	44.6	38.6
General noise	108.8	83.8	77.8	71.8	63.8	57.8	54.2	51.8	48.2	43.8	40.3	37.8	31.8
Grader - Operational Hitachi	108.9	83.9	77.9	71.9	63.9	57.9	54.4	51.9	48.4	43.9	40.4	37.9	31.9
Road Truck average	109.6	84.7	78.7	72.6	64.7	58.7	55.1	52.6	49.1	44.7	41.1	38.7	32.6
Rock Breaker, CAT	120.7	95.7	89.7	83.7	75.7	69.7	66.2	63.7	60.2	55.7	52.2	49.7	43.7
Vibrating roller	106.3	81.3	75.3	69.3	61.3	55.3	51.8	49.3	45.8	41.3	37.8	35.3	29.3
Water Dozer, CAT	113.8	88.8	82.8	76.8	68.8	62.8	59.3	56.8	53.3	48.8	45.3	42.8	36.8
Wind Turbine: Acciona AW125/3000	108.4	85.4	79.4	73.4	65.4	59.4	55.9	53.4	49.9	45.4	41.9	39.4	33.4
Wind Turbine: Enercon E-103 EP2 2350	105.0	80.0	74.0	68.0	60.0	54.0	50.5	48.0	44.5	40.0	36.5	34.0	28.0
Wind Turbine: Vesta V90 2 MW VCS	104.0	79.0	73.0	67.0	59.0	53.0	49.5	47.0	43.5	39.0	35.5	33.0	27.0
Wind Turbine: Vesta V66, ave	102.6	77.7	71.6	65.6	57.7	51.6	48.1	45.6	42.1	37.7	34.1	31.6	25.6
Wind Turbine: Vesta V66, max	108.0	83.0	77.0	71.0	63.0	57.0	53.5	51.0	47.5	43.0	39.5	37.0	31.0
Wind Turbine: Vesta V66, min	96.3	71.3	65.3	59.3	51.3	45.3	41.8	39.3	35.8	31.3	27.8	25.3	19.3
Wind Turbine: Vestas V117 3.3MW	107.0	82.0	76.0	70.0	62.0	56.0	52.5	50.0	46.4	42.0	38.5	36.0	30.0

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

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

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

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

1. The transport of "ready-mix" concrete from the closest centre to the development.
2. The transport of aggregate and cement from the closest centre to the development, with the establishment of a small concrete batching plant close to the activities. This would most likely be a movable plant. It may be possible to use some of the material obtained from foundation excavation as aggregate (if the material is suitable).
3. The development of a small aggregate quarry in the vicinity of the development.

6.1.3 Blasting

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

However, blasting will not be considered for the following reasons:

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

6.1.4 Traffic

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

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

6.2 Potential Noise Sources: Operation Phase

The proposed development would be designed to have an operational life of up to 25 years with the possibility to further expand the lifetime of the WF. During operation of the development, most of the site will continue with agricultural use as it is currently. The only development related activities on-site will be routine servicing (access roads and light traffic) and unscheduled maintenance. The noise impact from maintenance activities is insignificant, with the main noise source being the wind turbine blades and the nacelle (components inside) as highlighted in the following sections.

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

6.2.1 Wind Turbine Noise: Aerodynamic sources[5]

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

1. Self-noise due to the interaction of the turbulent boundary layer with the blade trailing edge.
2. Noise due to inflow turbulence (turbulence in the wind interacting with the blades).
3. Discrete frequency noise due to trailing edge thickness.

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

4. Discrete frequency noise due to laminar boundary layer instabilities (unstable flow close to the surface of the blade).
5. Noise generated by the rotor tips.

Therefore, as the wind speed increases, noises created by the wind turbine also increases. At a low wind speed the noise created by the wind turbine is generally (relatively) low, and increases to a maximum at a certain wind speed when it either remains constant, increase very slightly or even drops as illustrated in **Figure 6-1**.

The developer is investigating a number of different wind turbine models; not excluding the possibility of larger models that are not yet available in the commercial market. Therefore, this noise assessment will use the sound power emission levels of the Vestas V136 4.2 MW wind turbine. Vestas[6] report a maximum sound power emission level of 103.9 dBA.

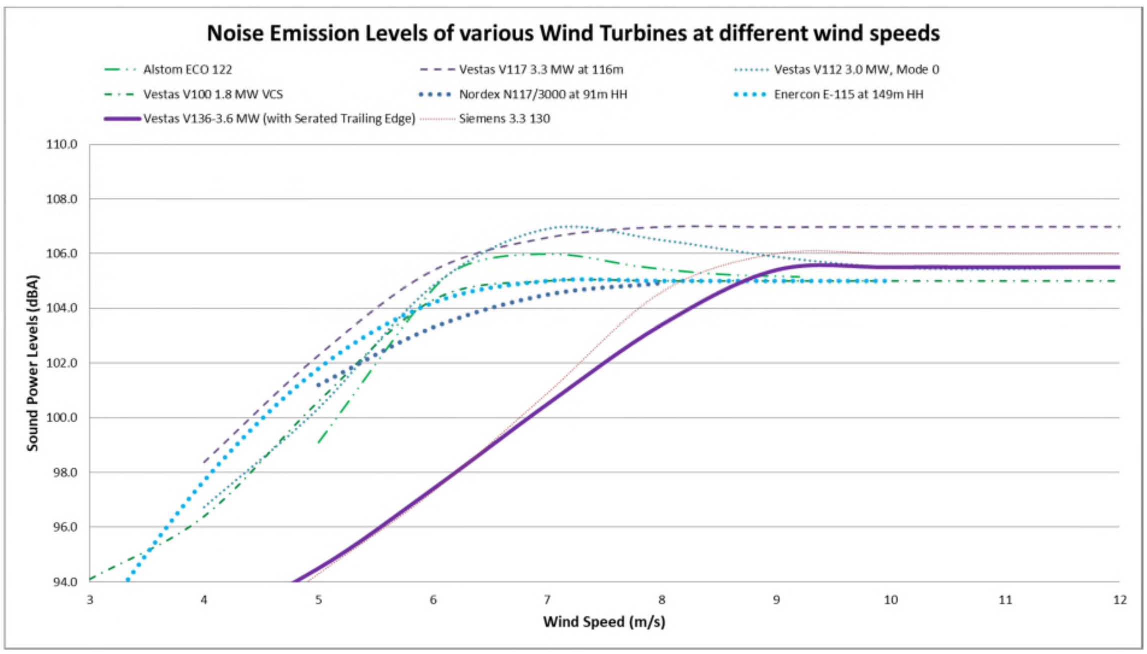

Figure 6-1: Noise Emissions Curve of a number of different wind turbines (figure for illustration purposes only)

The propagation model also makes use of various frequencies, because these frequencies are affected in different ways as it propagates through air, over barriers and over different ground conditions providing a higher accuracy than models that only use the total sound power level. The octave sound power levels for various wind turbines are presented on **Figure 6-2**. Being a relatively new WTG, octave sound power emission levels are not

[6] https://www.vestas.com/en/products/turbines/v136-_4_2_mw#!facts

available and this report uses the information of the Vestas V136 3.6 MW WTG (with serrated trailing edge). Being in the same wind turbine class, the octave sound power emission levels would be similar between the 3.6 and 4.2 MW turbines.

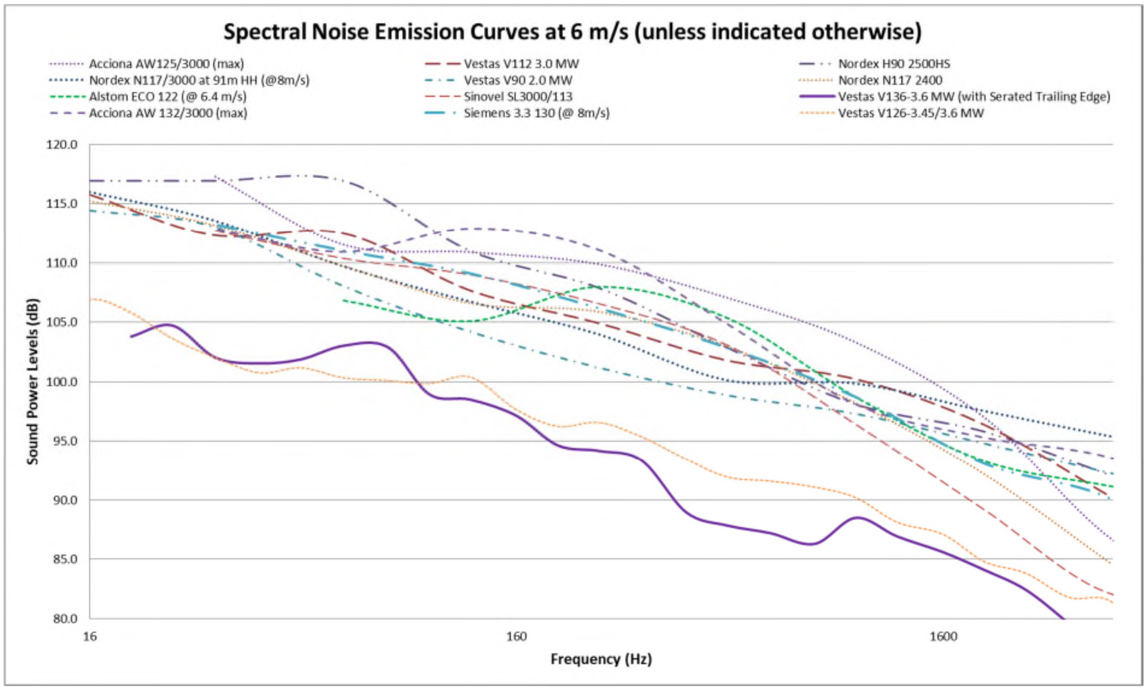

Figure 6-2: Octave sound power emissions of various wind turbines

6.2.1.1 Control Strategies to manage Noise Emissions during operation

Wind turbine manufacturers also provide their equipment with control mechanisms to allow for a certain noise reduction during operation that can include:

- A reduction of rotational speed;
- The increase of the pitch angle and/or reduction of nominal generator torque to reduce the angle of attack;
- Implementation of blade technologies such as serrated edges, changing the shape of the blade tips or the edge (proprietary technologies); and
- The insulation of the nacelle.

These mechanisms are used in various ways to allow the reduction of noise levels from the wind turbines, although this may also result in a reduction of power generation.

6.2.2 Wind Turbine: Mechanical sources[7]

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

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

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

Where complaints have been received due to the operation of wind farms, tonal noise from the installed wind turbines appears to have increased the annoyance perceived by the complainants and has indeed been the primary cause for complaint.

However, tones were normally associated with the older models of turbines. All turbine manufacturers have started to ensure that sufficient forethought is given to the design of quieter gearboxes and the means by which these vibration transmission paths may be broken. Through the use of careful gearbox design and/or the use of anti-vibration techniques, it is possible to minimise the transmission of vibration energy into the turbine supporting structure. The benefits of these design improvements have started to filter through into wind farm developments which are using these modified wind turbines. ***New generation wind turbine generators do not emit any clearly distinguishable tones****.*

6.2.3 Transformer noises (Substations)

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

[7] *Renewable Energy Research Laboratory, 2006; ETSU R97: 1996; Audiology Today, 2010; HGC Engineering, 2007*

away, the shape returns, only to try and deform in a different manner when the polarity is changed.

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

6.2.4 Transmission Line Noise (Corona noise)

Corona noise is caused by the partial breakdown of the insulation properties of air surrounding the conducting wires. It can generate an audible and radio-frequency noise, but generally only occurs in humid conditions, as provided by fog or rain. A minimum line potential of 70kV or higher is generally required to generate corona noise depending on the electrical design. Corona noise does not occur on domestic distribution lines.

Corona noise has two major components: a low frequency tone associated with the frequency of the AC supply (100 Hz for 50 Hz source) and broadband noise. The tonal component of the noise is related to the point along the electric waveform at which the air begins to conduct. This varies with each cycle and consequently the frequency of the emitted tone is subject to great fluctuations. Corona noise can be characterised as broadband 'crackling' or 'buzzing', but ***fortunately it is generally only a feature during fog or rain***.

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

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

As such Electrical Service Providers, such as ESKOM, go to great lengths to design power transmission equipment to minimise the formation of corona

discharges. In addition, it is an infrequent occurrence with a relatively short duration compared to other operational noises.

6.2.5 Low Frequency Noise[8]

6.2.5.1 Background and Information

Low frequency sound is the term used to describe sound energy in the region below ~200 Hz. The rumble of thunder and the throb of a diesel engine are both examples of sounds with most of their energy in this low frequency range. Infrasound is often used to describe sound energy in the region below 20 Hz.

Almost all noise in the environment has components in this region although they are of such a low level that they are not significant (wind, ocean, thunder). See also **Figure 6-3**, which indicates the sound power levels in the different octave bands from measurements taken at different wind speeds with no other audible noise sources. Sound that has most of its energy in the 'infrasound' range is only significant if it is at a very high level, far above normal environmental levels.

6.2.5.2 The generation of Low Frequency Sounds

There have been reports and complaints about low-frequency noise from wind turbines in the last few years, with various studies and articles covering this subject.

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

6.2.5.3 Detection of Low Frequency Sounds

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

- a weakening of pitch sensation as the frequency of the sound decreases below 60 Hz;
- perception of sounds as pulsations and fluctuations;
- a much more rapid increase of loudness and annoyance with an increasing sound level at low frequencies than at mid- or high frequencies;
- complaints about the feeling of ear pressure;

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

- annoyance caused by secondary effects like rattling of building elements, e.g. windows and doors or the tinkling of bric-a-brac;
- other psycho acoustic effects, e.g. sleep deprivation, a feeling of uneasiness; and
- reduction in building sound transmission loss at low frequencies compared to mid- or high frequencies.

The levels of infrasound radiated by the largest wind turbines are very low in comparison to other sources of acoustic energy in this frequency range such as sonic booms, shock waves from explosions, etc. The danger of hearing damage from wind turbine low-frequency emissions is non-existent. However, sounds in a frequency range less than 100 Hz can, under the right circumstances, be responsible for annoying nearby residents. However, except very near the source, most people outside cannot detect the presence of low-frequency noise from a wind turbine and low-frequency noise from natural events (especially wind related) which already exist all over and as illustrated in **Figure 6-3**.

It should be noted that a number of studies highlighted that these sounds are below the threshold of perception (BWEA, 2005), although this should be clarified. Most acousticians would agree that the low frequency sounds are inaudible to most people, yet, there are a number of studies that highlight that it can be more perceptible to people inside their houses as well as people that are more sensitive to low frequency sounds.

Thorne (2011) notes that;
"*Low frequency sound and infrasound are normal characteristics of a wind farm as they are the normal characteristics of wind, as such. The difference is that "normal" wind is laminar or smooth in effect whereas wind farm sound is non-laminar and presents a pulsing nature*."

Residents studied by Thorne often report that the low frequency sound is noticeably worse in their homes than it is outside[9].

[9] *Hubbard, 1990; Thorne, 2010; Ambrose, 2011*

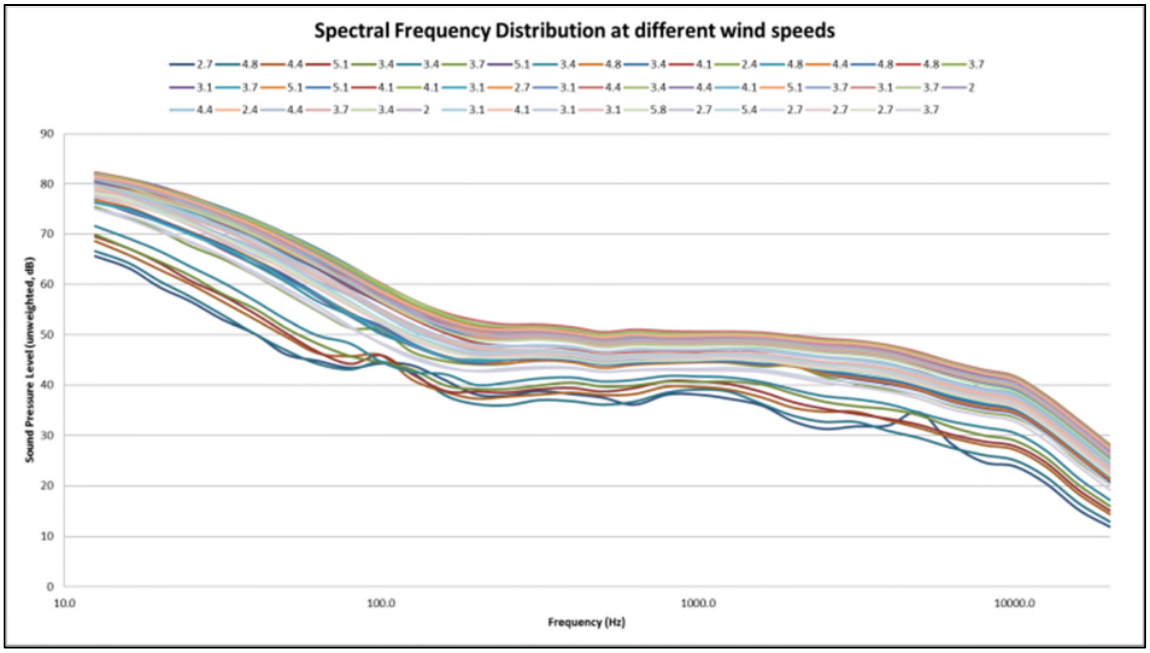

Figure 6-3: Third octave band sound power levels at various wind speeds at a location where wind induced noises dominate

6.2.5.4 Measurement, Isolation and Assessment of Low Frequency Sounds

There remains significant debate regarding the noise from WTG's, public response to that noise, as well as the presence or not of low frequency sound and how it affects people. While low frequency sounds can be measured, it is far more difficult to isolate low frequency sounds due to the numerous sources generating these sounds.

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

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

6.2.5.5 Summary: Low Frequency Noise[10]

Low frequency noise is always present around us as it is produced by both man and nature. While problems have been associated with older downwind wind turbines in the 1980s, this has been considered by the wind industry and modern upwind turbines do not suffer from the same problems. Low Frequency Noise however has been very controversial in the last few years with the anti-wind fraternity claiming measurable impacts, with governments and wind-energy supporter studies indicating no link between low-frequency sound and any health impacts. This study notes the various claims and as such follow a more precautious approach.

6.2.6 Amplitude modulation[11]

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

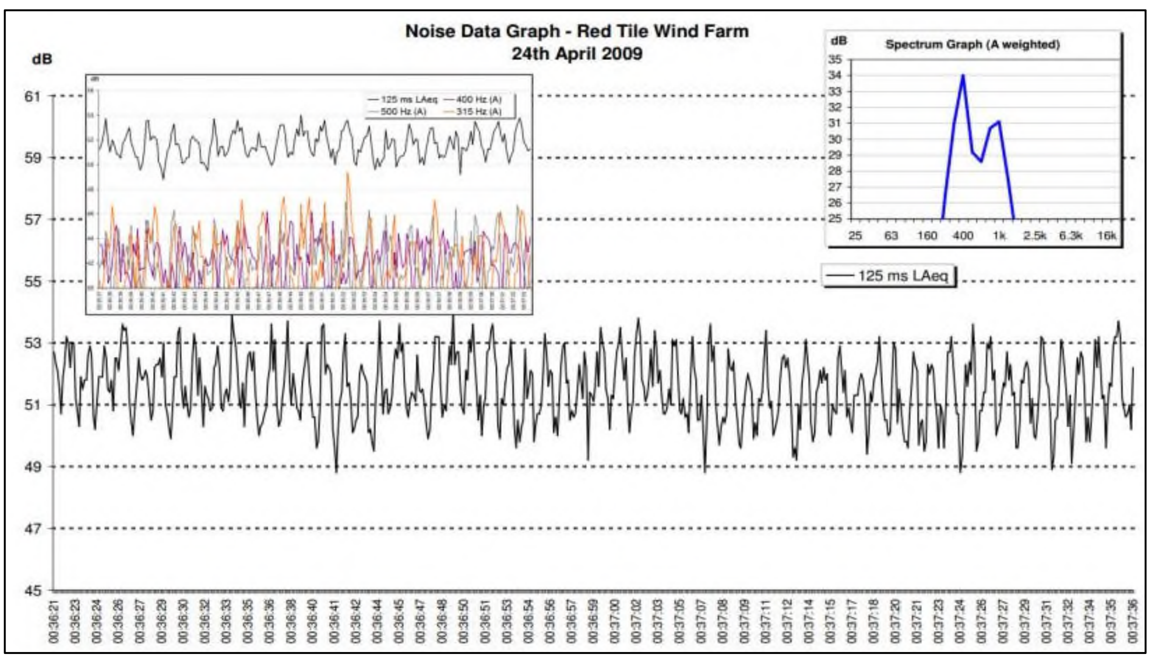

Figure 6-4: Example time-sound series graph illustrating AM as measured by Stigwood[12] (*et al*) (2013)

[10] *BWEA, 2005*
[11] *Renewable Energy Research Laboratory, 2006; Audiology Today, 2010; HGC Engineering, 2007; Whitford, 2008; Noise-con, 2008; DEFRA, 2007; Bowdler, 2008*
[12] Stigwood (*et al*) (2013): "*Audible amplitude modulation – results of field measurements and investigations compared to psycho-acoustical assessments and theoretical research*"; Paper presented at the 5th International Conference on Wind Turbine Noise, Denver 28 – 30 August 2013

Pedersen (2003) highlighted a weak correlation between sound pressure level and noise annoyance caused by wind turbines. Residents complaining about wind turbines noise perceived more sound characteristics than noise levels. People were able to distinguish between background ambient sounds and the sounds the blades made. The noise produced by the blades lead to most complaints. Most of the annoyance was experienced between 16:00 and midnight. This could be an issue as noise propagation modelling would be reporting an equivalent, or "average" sound pressure level, a parameter that ignores the "character" of the sound.

The word map (**Figure 6-5**) below categorises some of the many terms used by affected residents to describe AM, including physical likeness of the sound and musical terms describing the character of AM.

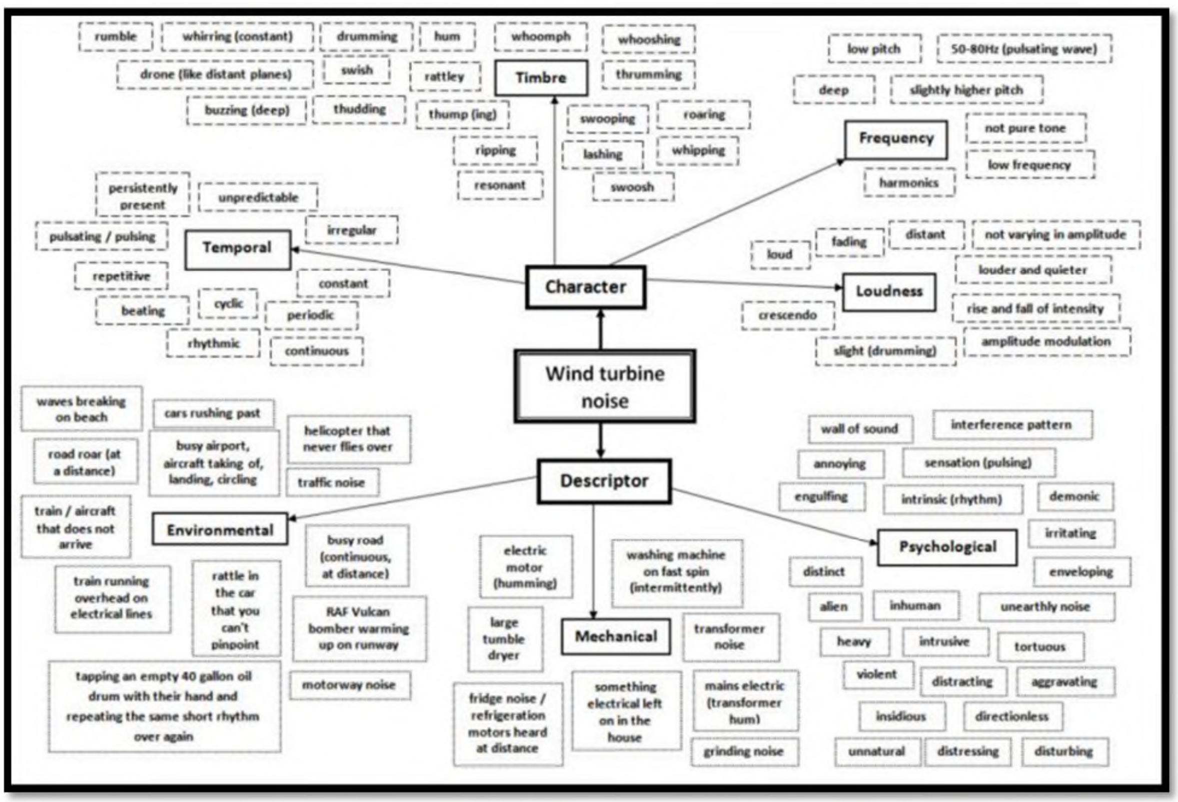

Figure 6-5: Word map of terms used to describe the sound of AM (source: Stigwood (*et al*) (2013))

The mechanism of amplitude modulated noises is not known although various possible reasons have been put forward. Although the prevalence of complaints about amplitude modulation is relatively small, it is not clear whether this is because it does not occur often enough or whether it is because housing is not in the right place to observe it.

Furthermore, the fact that the mechanism is unknown means that it is not possible to predict when or whether it will occur.

Bowdler (2008) concludes that there are probably two distinct mechanisms in operation to create AM. The first is swish which is a function of the observer's position relative to one turbine. The second is thump which is due to turbine blades passing through uneven air velocities as they rotate. In the second case the uneven air may be due to interaction of other turbines, excessive wind shear or topography. These two mechanisms are entirely separate though it is possible that they interact.

Stigwood (*et al*) (2013) also measured amplitude modulation at distances up to 1000 meters from the closest wind turbines at a number of wind farms in the United Kingdom and have summarised that:

- AM is more common than previously reported.
- AM should be measured during evening (after sunset), night time or early morning periods.
- Meteorological effects, such as atmospheric stability, which lead to downward refraction resulting from changes in the sound speed gradient alter the character and level of AM measured.
- AM is generated by all wind turbines including single turbines.
- Propagation conditions, mostly affected by meteorology and the occurrence of localised heightened noise zones determine locations that will be affected.
- Findings confirm that AM occurrence is frequent (at the eleven wind farms investigated) and can readily be identified in the field by measuring under suitable conditions and using appropriate equipment and settings.
- Audible features of AM including frequency content and periodicity vary both within and between wind farms.
- Noise character can differ considerably within a short time period. The constant change in AM character increases attention and cognitive appraisal and reappraisal, inhibiting acclimatisation to the sound.

That AM can be a risk and significantly increase the annoyance with wind energy facilities cannot be disputed. It has been reported with a number of recent studies confirming this significant noise characteristic. However, even though there are thousands of wind turbine generators in the world, amplitude modulation are still one subject receiving the least complaints and due to this very few complaints, little research went into this subject. Studies as recently as 2012 (Smith, 2012) highlight the need for additional studies and data collection.

However, because of these unknown factors (low frequency noises and AM), this noise study adopts a precautious stance and will consider the worst-case scenario.

6.2.7 Summary Conclusions on Wind Turbine Noise

Wind turbines do generate sound in both the inaudible and audible frequency range. However, the manner how this sound is perceived by people would range between people, communities as well as the surrounding environmental conditions in which they live. There are some studies[13] that show correlations between noise annoyance and a dislike to the facility, with other studies showing a link between wind turbines and increased annoyance levels[14]. Annoyance levels can be further subdivided into people that are annoyed by increased noise levels to the point where people report having to leave their houses to get relief from the noise.

How widespread annoyance and health issues reports are, are yet to be defined, as there has not been an industry wide scientific study covering noise from wind turbines. Values of 5 – 15% appear to be the most cited, although it depends on the source (it must be reiterated that these are simply reports[15]).

A search on the internet identifies groups that scour the internet for studies, reports and articles about wind energy; some focusing on the positive stories yet others gathering everything mentioned about the negatives, unfortunately also reporting all the negatives as fact without considering all the data. There are numerous wind farms where there have been no noise complaints (a UK study suggest that about 20% of wind farms generated noise complaints, (Cummings, 2011)), yet there has been no study assessing the differences between these wind farms.

Cummings (2012) also reports that:
"*it's notable that in ranching country, where most residents are leaseholders and many live within a quarter to half mile of turbines, health and annoyance complaints are close to non-existent; some have suggested that this is evidence of an antidote to wind turbine syndrome: earning some money from the turbines. More to the point, though, the equanimity with which turbine sound is accommodated in ranching communities again suggests that those who see turbines as a welcome addition to their community are far less likely to be annoyed, and thus to trigger indirect stress-related effects. Equally*

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[13] Gibbons, 2014; Crichton, 2014; Atkinson-Palmbo, 2014; Chapman, 2013; Pedersen, 2003.

[14] Thorne, 2010; *Ambrose, 2011; Pierpont, 2009; Nissenbaum, 2012; Knopper, 2011; Kroesen, 2011; Philips, 2011; Shepherd, 2011a; Shepherd, 2011b; Pedersen, 2011; Wang, 2011; Cooper, 2012; McMurtry, 2011; Havas, 2011; Jeffery, 2013*

[15] Cummings, 2012

important to consider, ranchers who work around heavy equipment on a daily basis are also likely to be less noise sensitive than average, whereas people who live in the country for peace and quiet and solitude are likely more noise-sensitive than average. And, there are some indications that in flat ranching country, turbine noise levels may be steadier, less prone to atmospheric conditions that make turbines unpredictably louder or more intrusive. When considering the dozens of wind farms in the Midwest and west where noise complaints are minimal or non-existent, it remains true that the vast majority of U.S. wind turbines are built either far from homes or in areas where there is widespread tolerance for the noise they add to the local soundscape."

However, on the other hand, there are reports of significant annoyance (that can lead to increased stress levels that can result in other health problems or increase existing problems) from individuals and communities, frequently from people that value the rural quiet and sense of place.

Therefore, when assessing the potential noise impacts one has to consider:

- the complex characteristic of noise from wind turbines (numerous factors that are not yet fully understood);
- previous reports about noise impacts from wind turbines;
- the rural character and existing sense of place from a noise perspective;
- the recommendations from recognised acousticians.

The assessment methodology does consider these factors as discussed in the following section.

7 ASSUMPTIONS AND LIMITATIONS

7.1 MEASUREMENTS OF AMBIENT SOUND LEVELS

- Ambient sound levels are the cumulative effects of innumerable sounds generated from a variety of noise sources at various instances both far and near from the listener. High measurements may not necessarily mean that noise levels in the area are high. Similarly, a low sound level measurement will not necessarily mean that the area is always quiet, as sound levels will vary over seasons, time of the day, faunal characteristics, vegetation in the area and meteorological conditions (especially wind). This is excluding the potential effect of sounds from anthropogenic origin. It is impossible to quantify and identify the numerous sources that influenced one 10-minute measurement using the reading result at the end of the measurement. Therefore trying to define ambient sound levels using the result of one 10-minute measurement will be very inaccurate (very low confidence level in the results) for the reasons mentioned above. The more measurements that can be collected at a location the higher the confidence levels in the ambient sound level determined. The more complex the sound environment, the longer the required measurement, especially when at a community or house. It is assumed that the measurement locations represents ambient sound levels in the area (similar environment), yet, in practice this can be highly erroneous as there are numerous factors that can impact on ambient sound levels, including:
  - the distance to the closest trees, number and type of trees as well as the height of the trees;
  - available habitat and food for birds and other animals;
  - distance to residential dwellings, type of equipment used at dwellings (compressors, air-cons, etc.) and people in the area;
  - general maintenance condition of houses (especially during windy conditions), as well as
  - numbers and types of animals kept in the vicinity of the measurement locations.
- Determination of existing road traffic and other noise sources of significance are important (traffic counts, etc.). Traffic, however, is highly dependent on the time of day as well as general agricultural activities taking place at the time of traffic counts. Traffic noise is one of the major components in urban areas and could be a significant source of noise during busy periods. This Study found that traffic in the area was very low, yet it cannot be assumed that is always very low;
- Measurements over wind speeds of 3 m/s could provide data influenced by wind-induced noises. While the windshields used limits the effect of fluctuating pressure across the microphone diaphragm, the effect of wind-induced noises in the trees in

the vicinity of the microphone did impact on the ambient sound levels. The site visit unfortunately coincided with a relatively windy period;

- Ambient sound levels are dependant not only time of day and meteorological conditions, but also change due to seasonal differences. Ambient sound levels are generally higher in summer months when faunal activity is higher and lower during the winter due to reduced faunal activity;
- Ambient sound levels recorded near rivers, streams, wetlands, trees and bushy areas can be high. This is due to faunal activity which can dominate the sound levels around the measurement location, and
- As a residential area develops the presence of people will result in increased sounds. These are generally a combination of traffic noise, voices, animals and equipment (incl. TV's and Radios). The result is that ambient sound levels will increase as a residential area matures.

7.2 CALCULATING NOISE EMISSIONS – ADEQUACY OF PREDICTIVE METHODS

The noise emissions into the environment from the various sources as defined were calculated for the WF, using the Sound Propagation Model described in ISO 9613-2 (operation phase) and SANS 10357[16] (construction phase).

The following was considered in the Noise Model:

- The octave band sound pressure emission levels of processes and equipment;
- The distance of the receiver from the noise sources;
- The impact of atmospheric absorption;
- The operational details of the proposed project, such as projected areas where activities will be taking place;
- Topographical layout, as well as
- Acoustical characteristics of the ground. Seventy-five percent (75%) hard ground conditions were modelled considering the recommendation of a number of studies.

The noise emission into the environment due to additional traffic was estimated using the Sound Propagation Model described in SANS 10210[17]. Corrections such as the following will be considered:

- Distance of receptor from the roads;
- Road construction material;
- Average vehicle speeds;

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

- Vehicle types, and
- Ground acoustical conditions.

It is important to understand the difference between sound, or noise level and the noise rating level (also see Glossary of Terms – **Appendix A**).

Sound, or noise levels, generally refers to a sound pressure level as measured using an instrument, whereas the noise rating level refers to a calculated sound exposure level to which various corrections and adjustments was added. These noise rating levels are further processed into a 3D map illustrating noise contours of constant rating levels or noise isopleths. In this project it illustrate the potential extent of the calculated noises of the complete project and not noise levels at a specific moment in time. It is used to define potential issues of concern and not to predict a noise level at a potential noise-sensitive receptor. For this the selected sound propagation model is internationally recognised and considered adequate.

7.3 ADEQUACY OF UNDERLYING ASSUMPTIONS

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

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

7.4 UNCERTAINTIES OF INFORMATION PROVIDED

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

- That octave sound power levels selected for processes and equipment accurately represent the sound character and power levels of these processes and equipment. The determination of octave sound power levels in itself is subject to errors, limitations and assumptions with any potential errors carried over to any model making use of these results;

- Sound power emission levels from processes and equipment changes depending on the load the process and equipment is subject to. While the octave sound power level is the average (equivalent) result of a number of measurements, this measurement relates to a period that the process or equipment was subject to a certain load (work required from the engine or motor to perform action). Normally these measurements are collected when the process or equipment is under high load. The result is that measurements generally represent a worse-case scenario;
- As it is unknown which processes and equipment will be operational (when and for how long), modelling considers a scenario where processes and equipment are under full load for a set time period. Modelling assumptions comply with the precautionary principle and operational time periods are frequently overestimated. The result is that projected noise levels would be likely over-estimated;
- Modelling cannot capture the potential impulsive character of a noise that can increase the potential nuisance factor;
- The XYZ topographical information is derived from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global DEM data, a product of Japan's Ministry of Economy, Trade, and Industry (METI) and the National Aeronautical and Space Administration (NASA). There are known inaccuracies and artefacts in the data set, yet this is still one of the most accurate data sets to obtain 3D-topographical information;
- The impact of atmospheric absorption is simplified and very uniform meteorological conditions are considered. This is an over-simplification and the effect of this in terms of sound propagation modelling is difficult to quantify, and
- Acoustical characteristics of the ground are over-simplified with ground conditions accepted as uniform. Seventy-five percent (75%) hard ground conditions will be modeled that should allow slightly precautionary values.

8 METHODOLOGY: ENVIRONMENTAL NOISE IMPACT ASSESSMENT AND SIGNIFICANCE

8.1 NOISE IMPACT ON ANIMALS[18]

A great deal of research was conducted in the 1960's and 1970's on the effects of aircraft noise on animals. While aircraft noise has a specific characteristic, the findings should be relevant to most noise sources.

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

- Various types of noise
- Durations of noise
- Sources of noise

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

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

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

From these and other studies the following can be concluded:

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

[18] Report to Congressional Requesters, 2005; USEPA, 1971; Autumn, 2007; Noise quest, 2010

8.2 WHY NOISE CONCERNS COMMUNITIES[19]

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

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

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

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

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

Severity of the annoyance depends on factors such as:

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

8.2.1 Annoyance associated with Wind Energy Facilities[20]

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

[19] World Health Organization, 1999; Noise quest, 2010; Journal of Acoustical Society of America, 2009
[20] Van den Berg, 2011; Milieu, 2010.

economic dependence on the noise source, attitude towards the noise source and self-reported noise sensitivity.

On the basis of a number of studies into noise annoyance, exposure-response relationships were derived for high annoyance from different noise sources. These relationships, illustrated in Figure 8-1, are recommended in a European Union position paper published in 2002, stipulating policy regarding the quantification of annoyance. This can be used in an Environmental Health Impact Assessment and cost-benefit analysis to translate noise maps into overviews of the numbers of persons that may be annoyed, thereby giving insight into the situation expected in the long term. It is not applicable to local complaint-type situations or to an assessment of the short-term effects of a change in noise climate.

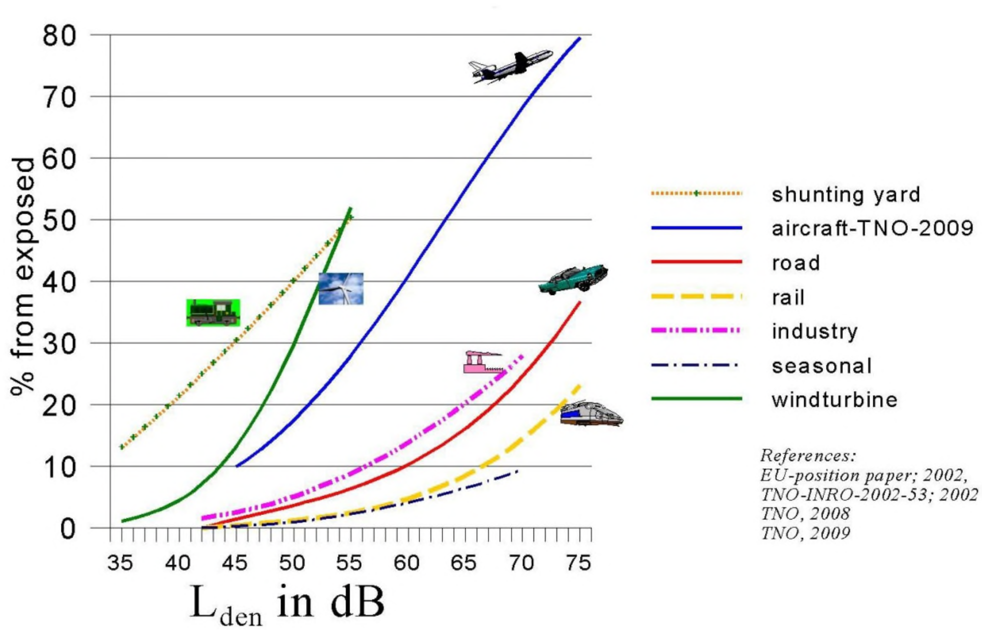

Figure 8-1: Percentage of annoyed persons as a function of the day-evening-night noise exposure at the façade of a dwelling

8.3 Impact Assessment Criteria

8.3.1 Overview: The common characteristics

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

- Intensity
- Loudness

- Annoyance
- Offensiveness

Of the four common characteristics of sound, intensity is the only one which is not subjective and can be quantified. Loudness is a subjective measure of the effect the sound has on the human ear. As a quantity it is therefore complicated but has been defined by experimentation on subjects known to have normal hearing.

The annoyance and offensive characteristics of noise are also subjective. Whether or not a noise causes annoyance mostly depends upon its reception by an individual, the environment in which it is heard, the type of activity and mood of the person and how acclimatised or familiar that person is to the sound.

8.3.2 Noise criteria of concern

The criteria used in this report were drawn from the criteria for the description and assessment of environmental impacts from the EIA Regulations, published by the Department of Environmental Affairs and Tourism (DEAT, 2002) in terms of the NEMA, SANS 10103 as well as guidelines from the World Health Organization (WHO).

There are a number of criteria that are of concern for the assessment of noise impacts. These can be summarised in the following manner:

- *Increase in noise levels:* People or communities often react to an increase in the ambient noise level they are used to, which is caused by a new source of noise. With regards to the Noise Control Regulations, an increase of more than 7 dBA is considered a disturbing noise. See also **Figure 8-2**.
- *Zone Sound Levels:* Previously referred to as the acceptable rating levels, it sets acceptable noise levels for various areas. See also **Table 8-1**.
- *Absolute or total noise levels:* Depending on their activities, people generally are tolerant to noise up to a certain absolute level, e.g. 65 dBA. However, anything above this level is considered unacceptable.

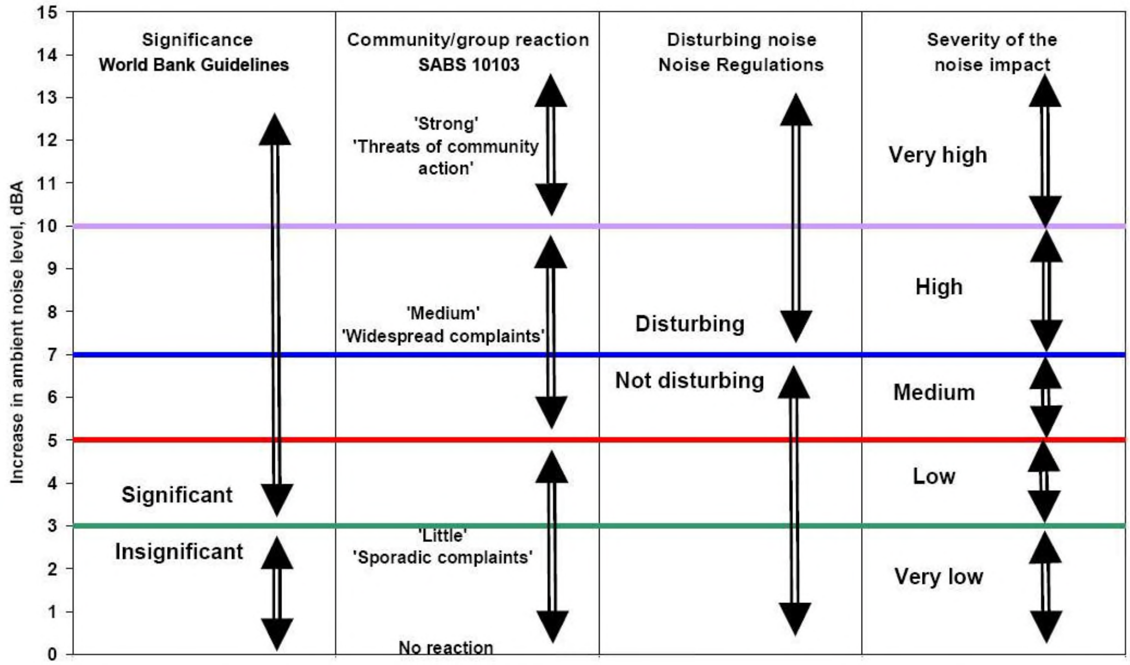

Figure 8-2: Criteria to assess the significance of impacts stemming from noise

In South Africa the document that addresses the issues concerning environmental noise is SANS 10103. See also **Table 4-3**. It provides the maximum average ambient noise levels, $L_{Req,d}$ and $L_{Req,n}$, during the day and night respectively to which different types of developments may be exposed. For rural areas the Zone Sound Levels (Rating Levels) are:

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

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

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

increase of more than 15 dBA the community reaction will be 'strong' with 'threats of community action'.

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

Table 8-1: Acceptable Zone Sound Levels for noise in districts (SANS 10103)

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

8.3.3 Determining appropriate Zone Sound Levels

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

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

8.3.3.1 Using International Guidelines to set Noise Limits

When assessing the overall noise levels emitted by a Wind Energy Facility, it is necessary to consider the full range of operating wind speeds of the wind turbines. This covers the wind speed range from around 3-5 m/s (the turbine cut-in wind speed) up to a wind speed range of 25-35 m/s measured at the hub height of a wind turbine. However, ETSU-R97 (1996) proposes that noise limits only be placed up to a wind speed of 12 m/s for the following reasons:

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

Available data indicates that wind-induced noises start to increase at wind speeds 3 – 4 m/s, becoming significant (and frequently the dominant noise source in rural areas) at wind speeds higher than 10 – 12 m/s/. Most wind turbines reach their maximum noise emission level at a wind speed of 8 – 10 m/s. At these wind speeds increased wind-induced noises (wind howling around buildings, rustling of leaves in trees, rattling noises, etc.) could start to drown other noises, including that being generated by wind turbines[21].

Sound level vs. wind speed data is presented in **Figure 8-3**[22]. It is based on approximately 13,500 measurements collected over a total of more than 90 nights at 13 quiet inland locations, areas similar to this location. There were no apparent or observable sounds that would have impacted the measurements at these locations with the figures presenting the A-Weighted sound levels. The figures indicate a trend where sound levels increase if the wind speed increase. This has been found at all locations where

[21] It should be noted that this does not mean that the wind turbines are inaudible.
[22] The sound level measuring instruments were located at a quiet location in the garden of the various houses. Data was measured in 10-minute bins and then co-ordinated with the 10 m wind speed derived from the wind mast of the developer. This wind mast was not close to the dwellings, being approximately 3,500m from the measurement locations.

measurements have been done for a sufficiently long enough period of time (more than 30 locations comprising of more than 38,000 measurements).

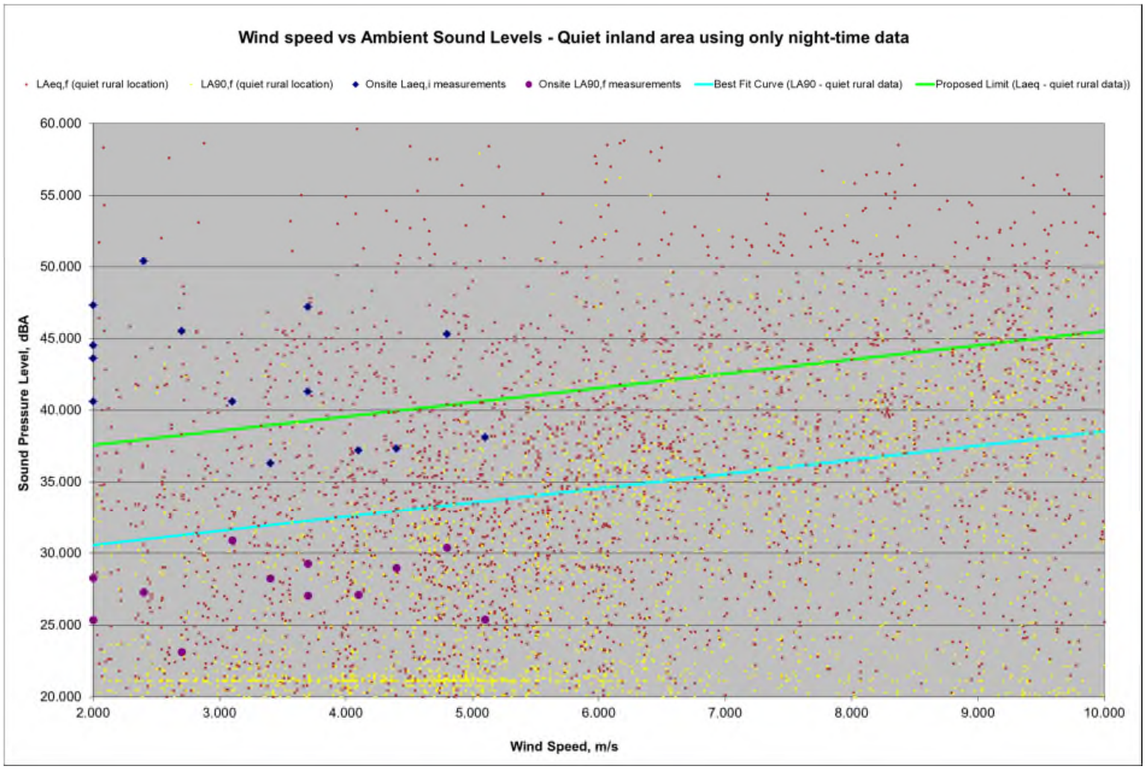

Figure 8-3: Ambient sound levels - Quiet Inland Location (A-Weighted)

Considering this data as well as the international guidelines (MOE, see **Table 4-2**; IFC, see **Table 4-3**), noise limits starting at 40 dB that increases to more than 45 dB (as wind speeds increase) could be acceptable. Project participants could be exposed to noise levels up to 45 dBA (ETSU-R97).

8.3.3.2 Using local regulations to set noise limits

Noise limits as set by the National Noise Control Regulations (GN R154 of 1992 – **section 4.2.1**) defines a "**disturbing noise**" as the Noise Level which exceeds the zone sound level or, if no zone sound level has been designated, a noise level which exceeds the ambient sound level at the same measuring point by 7 dBA or more.

Considering the average ambient sound levels measured at the three measurement locations, the night-time residual noise level was generally less than 35 dBA, typical of a rural noise district. This was at lower wind speeds, mainly between 0 and 5 m/s as there was only one measurement at higher wind speeds.

Accepting that the sound levels in the area may be typical of a rural noise district, night-time rating levels would be 35 dBA and a noise level exceeding this level may be a disturbing noise (therefore the noise limit). This would however be for conditions with no or low winds (less than 3 m/s). This study will use the 35 dBA as the potential background level to compare how a potential noise may change the ambient sound levels.

As can be observed from **Figure 8-3**, if ambient sound levels were measured at increased wind speeds, ambient sound levels will be higher as wind-induced noises increase (**cyan** line, **Figure 8-3**). These expected sound levels will be used to determine the probability for a noise impact to occur.

How wind-induced noises increase depends significantly on the measuring location and surrounding environment, but it is expected to be higher than 35 dBA closer to dwellings. The noise limit should increase with increased wind-speeds, but, considering international guidelines, an upper limit of 45 dBA must be honoured.

For modelling and assessing the potential noise impact the values as proposed in **Table 8-2** will be considered.

Table 8-2: Estimated ambient sound levels and proposed rating levels

10 meter Wind Speed (m/s)	Estimated ambient sound levels (night-time) (cyan line, Figure 8-3) (dBA)	Potential disturbing noise level (green line, Figure 8-3) (dBA)	MoE Sound Level Limits of Class 3 areas (Table 4-2) (dBA)	ETSU-R97 limit for project participants (dBA)	Night-time Zone Sound Level (SANS 10103:2008) (dBA)	Proposed Night Rating Level (dBA)
4	32.6	39.6	40	45	35 (at low wind speeds, this will definitely increase as wind speeds increase)	40
5	33.6	40.6	40	45		40
6	34.5	41.5	40	45		40
7	35.5	42.5	43	45		43
8	36.5	43.5	45	45		45
9	37.5	44.5	49	45		45

The report will in addition also consider the potential ambient sound levels as measured at this site to estimate the likelihood (probability) of a noise impact occurring.

8.3.4 Determining the Significance of the Noise Impact

The level of detail as depicted in the EIA regulations was fine-tuned by assigning specific values to each impact. In order to establish a coherent framework within which all impacts could be objectively assessed, it was necessary to establish a rating system, which was applied consistently to all the criteria. For such purposes each aspect will be assigned a value as defined in the third column in the tables below.

The impact consequence is determined by the summing the scores of Magnitude (**Table 8-3**), Duration (**Table 8-4**) and Spatial Extent (**Table 8-5**). The impact significance is determined by multiplying the Consequence result with the Probability score (**Table 8-6**).

An explanation of the impact assessment criteria is defined in the following tables.

Table 8-3: Impact Assessment Criteria - Magnitude

This defines the impact as experienced by any receptor. In this report the receptor is defined as any resident in the area, but excludes faunal species.		
Rating	**Description**	**Score**
Minor	Increase in average sound pressure levels between 0 and 3 dB from the expected wind induced ambient sound level (proposed rating level). No change in ambient sound levels discernable. Total projected noise level is less than the Zone Sound Level in wind-still conditions.	2
Low	Increase in average sound pressure levels between 3 and 5 dB from the (expected) ambient sound level (proposed rating level). The change is barely discernable, but the noise source might become audible.	4
Moderate	Increase in average sound pressure levels between 5 and 7 dB from the (expected) ambient sound level (proposed rating level). Sporadic complaints expected. Any point where the zone sound levels are exceeded during wind still conditions.	6
High	Increase in average sound pressure levels between 7 and 10 dB from the (expected) ambient sound level (proposed rating level). Medium to widespread complaints expected.	8
Very High	Increase in average sound pressure levels higher than 10 dBA from the (expected) ambient sound level (proposed rating level). Change of 10 dBA is perceived as 'twice as loud', leading to widespread complaints and even threats of community or group action. Any point where noise levels exceed 65 dBA at any receptor.	10

Table 8-4: Impact Assessment Criteria - Duration

The lifetime of the impact that is measured in relation to the lifetime of the proposed development (construction, operational and closure phases). Will the receptors be subjected to increased noise levels for the lifetime duration of the project, or only infrequently.		
Rating	**Description**	**Score**
Temporary	Impacts are predicted to be of short duration (portion of construction period) and intermittent/occasional (0 - 1 years).	1
Short term	Impacts that are predicted to last only for the duration of the construction period (1 - 5 years).	2
Medium term	Impacts that will continue for a part of the operational phase, well after the construction phase stopped (5 – 15 years).	3
Long term	Impacts that will continue for the life of the Project, but ceases when the Project stops operating (> 15 years).	4

Permanent	Impacts that cause a permanent change in the affected receptor or resource (e.g. removal or destruction of ecological habitat) that endures substantially beyond the Project lifetime.	5

Table 8-5: Impact Assessment Criteria – Spatial extent

Classification of the physical and spatial scale of the impact (defined as the area where the noise impact may change the ambient sound levels with 7 dBA or more)		
Rating	**Description**	**Score**
Site	The impacted area extends only as far as the activity, such as footprint occurring within the total site area.	1
Local	The impact could affect the local area (within 1,000 m from site).	2
Regional	The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns (further than 1,000 m from the site).	3
National	The impact could have an effect that expands throughout the country (South Africa).	4
International	Where the impact has international ramifications that extend beyond the boundaries of South Africa.	5

Table 8-6: Impact Assessment Criteria - Probability

This describes the likelihood of the impacts actually occurring, and whether it will impact on an identified receptor. The impact may occur for any length of time during the life cycle of the activity, and not at any given time. The classes are rated as follows:		
Rating	**Description**	**Score**
Very improbable	The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0 %).	1
Improbable / Possible	The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chances of this impact occurring is defined to be up to 25 %.	2
Probable / Likely	There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chances of this impact occurring is defined to be between 25% and 50 %.	3
Highly Probable / Likely	It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chances of this impact occurring is defined to be between 50 % to 75 %.	4
Definite	The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined to be between 75% and 100 %.	5

8.3.5 Identifying the Potential Impacts without Mitigation Measures (WOM)

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

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

8.3.6 Identifying the Potential Impacts with Mitigation Measures (WM)

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

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

9 PROJECTED NOISE RATING LEVELS

9.1 CURRENT NOISE LEVELS

The ambient sound levels were typical of a rural noise district (during low wind conditions) and the area is considered naturally quiet. It is too far from any significant roads or any other significant noise sources to consider the potential cumulative impacts. Other WEFs are proposed in the vicinity yet there are no operational facilities.

9.2 PROPOSED CONSTRUCTION PHASE NOISE IMPACT

This section investigates the conceptual construction activities as discussed in **Section 6.1**. The layout as provided by the developer for the WF is presented in **Figure 9-1**. As can be seen from this layout, a number of different activities might take place close to potentially sensitive receptors, each with a specific potential impact.

9.2.1 Description of Construction Activities Modelled

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

- General work at a temporary workshop area. This would be activities such as equipment maintenance, off-loading and material handling. All vehicles will travel to this site where most equipment and material will be off-loaded (general noise, crane). Material, such as aggregate and building sand, will be taken directly to the construction area (foundation establishment). It was assumed that activities will be taking place for 16 hours during the 16 hour daytime period.
- Surface preparation prior to civil work. This could be the removal of topsoil and levelling with compaction, or the preparation of an access road (bulldozer/grader). Activities will be taking place for 8 hours during the 16 hour daytime period.
- Preparation of foundation area (sub-surface removal until secure base is reached – excavator, compaction, and general noise). Activities will be taking place for 10 hours during the 16 hour daytime period.
- Pouring and compaction of foundation concrete (general noise, electric generator/compressor, concrete vibration, mobile concrete plant, TLB). As foundations must be poured in one go, the activity is projected to take place over the full 16 hour day time period.
- Erecting of the wind turbine generator (general noise, electric generator/compressor and a crane). Activities will be taking place for 16 hours during the 16 hour daytime period.
- Traffic on the site (trucks transporting material, aggregate/concrete, work crews) moving from the workshop/store area to the various activity sites. All vehicles to travel at less than 60 km/h, with a maximum of ten (10) trucks and vehicles each per hour

travelling to the areas where work is taking place (green dotted line, **Figure 9-3**). The solid blue line (**Figure 9-3**) is the projected noise levels for the same 20 vehicles travelling at 100km/h on a tar road.

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

As it is unknown where the different activities may take place it was selected to model the impact of the noisiest activity (laying of foundation totaling 113.6 dBA cumulative noise impact – various equipment operating simultaneously) at all locations (over the full daytime period of 16 hours) where wind turbines may be erected, calculating how this may impact on noise levels at potential noise-sensitive developments (see **Figure 9-2**). Noise created due to linear activities (roads) was also evaluated and plotted against distance as illustrated in **Figure 9-3**[23].

Even though most construction activities are projected to take place only during day time, it might be required at times that construction takes place during the night due to:

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

[23] Sound level at a receiver set at a certain distance from a road – 10 trucks per hour gravel and tar roads

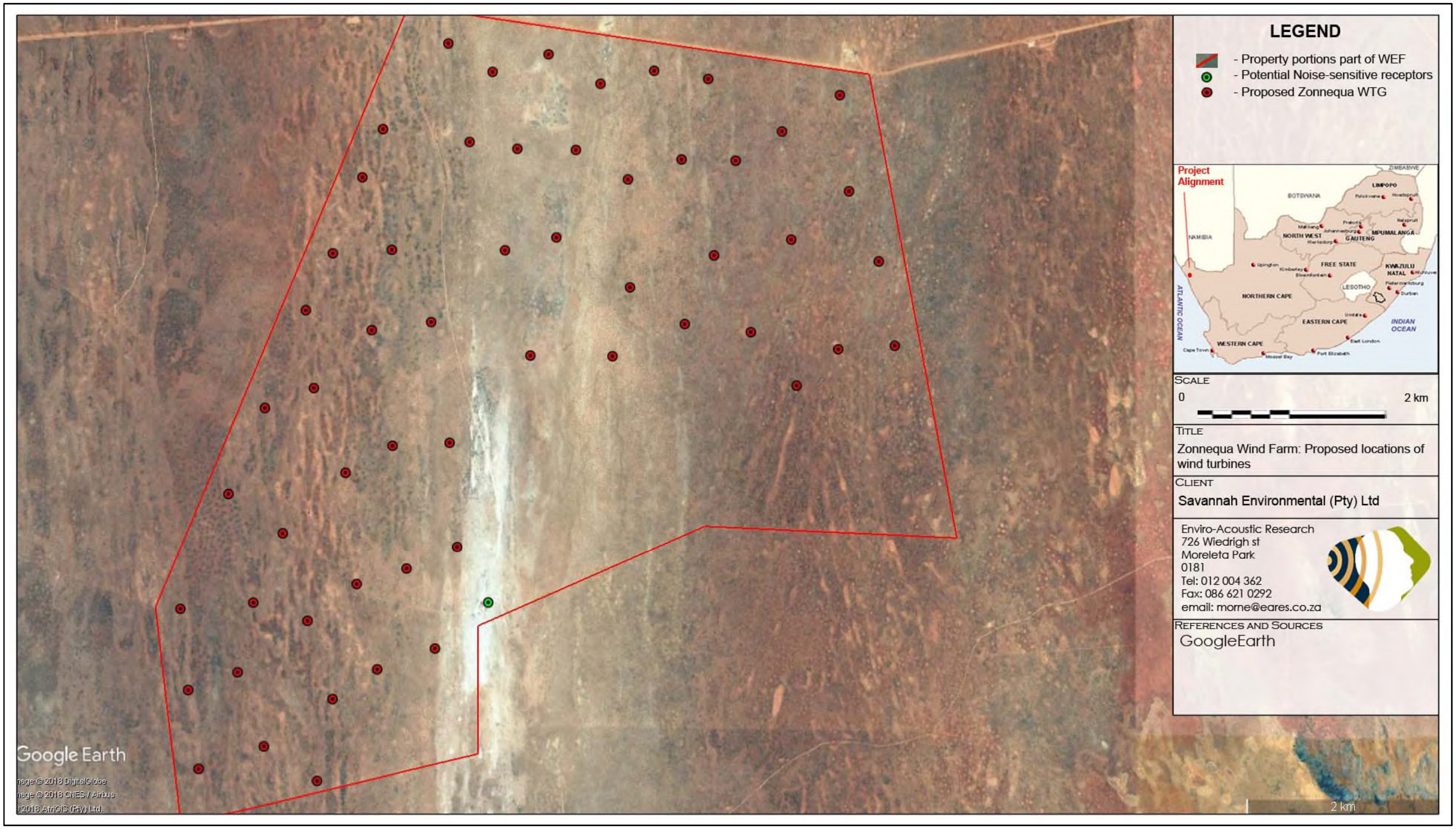

Figure 9-1: Proposed Wind Turbine Locations – Zonnequa WF, Layout received 2018-08-14

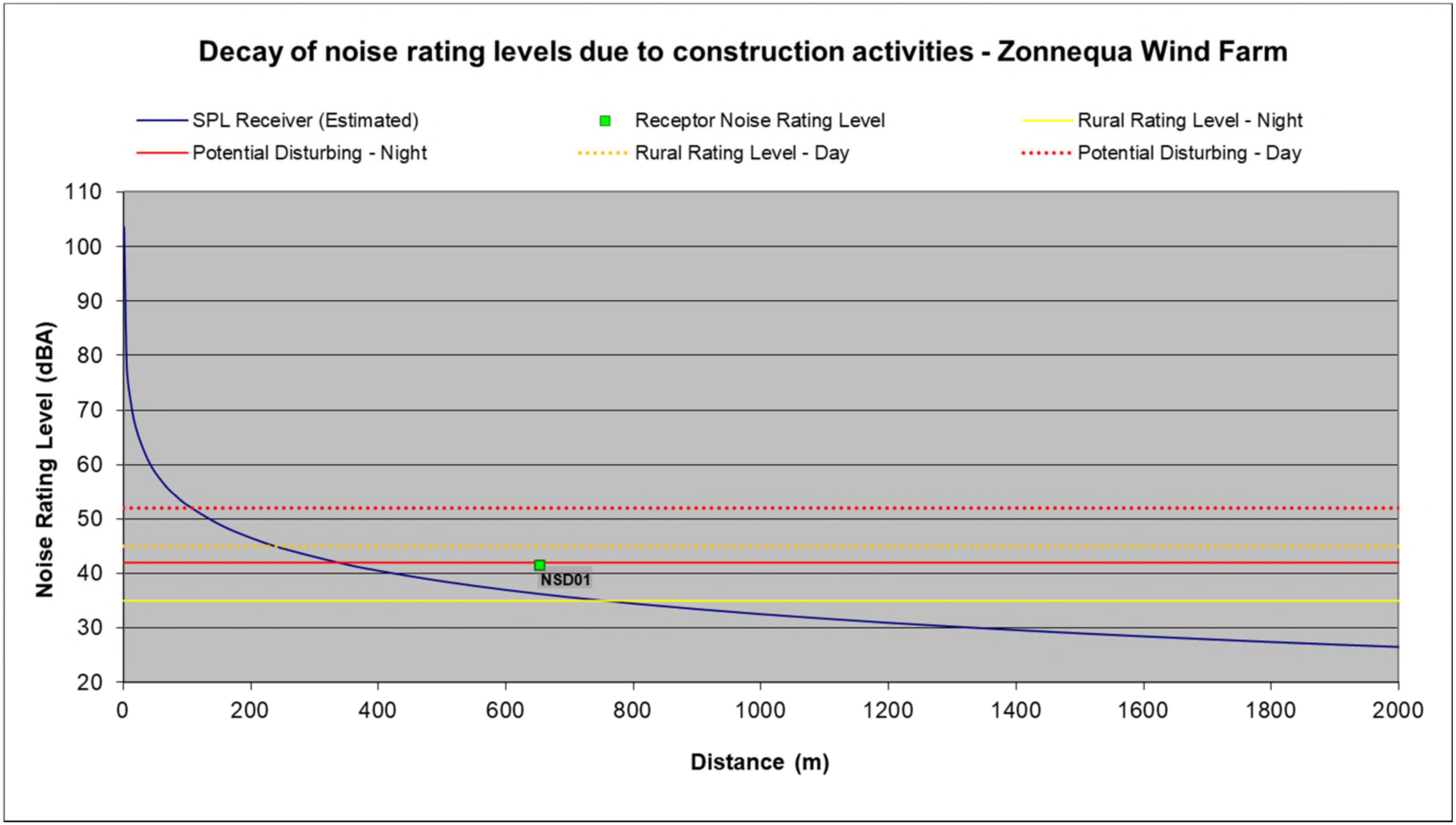

Figure 9-2: Projected conceptual construction noise levels – Decay of noise from construction activities

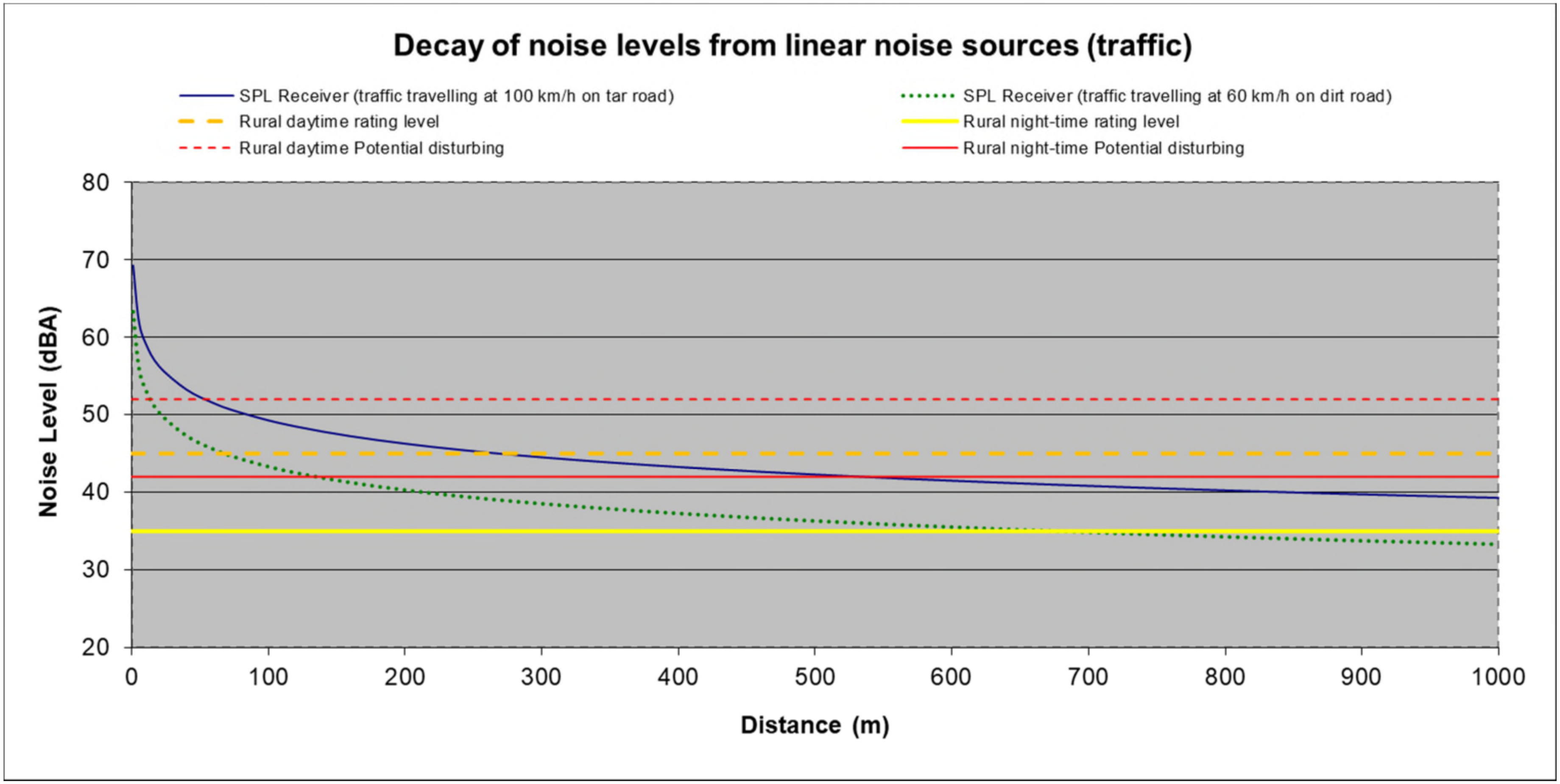

Figure 9-3: Projected conceptual construction noise levels – Decay over distance from linear activities

9.3 OPERATION PHASE NOISE IMPACT

While the significance of daytime noise impacts were considered, times when a quiet environment is desired (at night for sleeping, weekends etc.) are more critical. Surrounding receptors would desire and require a quiet environment during the night-time (22:00 – 06:00) timeslot and ambient noise levels are critical. It should be noted that maintenance activities normally take place during the day, but normally involve one or two light-delivery vehicles moving around during the course of the day, an insignificant noise source. As such maintenance activities will not be considered.

This noise impact assessment will evaluate the layout presented in **Figure 9-1** using the sound power emission levels presented in **Table 9-1**.

Table 9-1: Octave Sound Power Emission Levels: Vestas V136 3.6 MW

Wind Turbine: from Vestas V136-3.6 MW (with Trailing Serrated Edge)									
Maximum expected A-weighted Octave Sound Power Levels									
Frequency	31.5	63	125	250.0	500	1000	2000	4000	8000
L_W (dB)	107.8	107.4	103.0	98.9	92.8	92.1	89.0	81.6	67.1
A-Weighted Sound Power Levels (at wind speeds)									
Reference wind speed at 10m height				**Sound Power Level (for Vestas V136 4.2 MW)**					
All wind speeds				103.9 dBA					

The maximum noise rating level contours are presented in **Figure 9-4**.

9.4 POTENTIAL CUMULATIVE NOISE IMPACTS

The Eskom Kleinzee WEF received environmental authorisation but has not yet been constructed. This WEF is to be located west of the proposed Zonnequa WEF. While the latest layout for the Eskom Kleinzee was not available, the closest wind turbines of the Kleinzee WEF will be further than 2,000 m from the closest potential noise-sensitive receptor (NSD01). There will be no risk of a cumulative noise impact.

The juwi Kap Vley WEF is proposed to the south-east of the Zonnequa WF, with the closest WTGs located significantly further than 2,000m from NSD01, NSD02 and NSD03. There will be no risk of a cumulative noise impact.

The Genesis Namas WF is proposed to the north of the Zonnequa WF, with the closest WTG located further than 2,000m from NSD01. There may be a very slight risk of a cumulative noise impact (less than 1 dB).

This is because cumulative noise impacts generally only occur when noise sources (such as other wind turbines) are closer than 2,000m from each other. The cumulative impact also only affects the areas between the wind turbines of the various wind farms.

If the wind turbines of one wind farm are further than 2,000m from the wind turbines of a different wind farm, the magnitude (and subsequently the significance) of the cumulative noise impact is reduced. If the distance between wind turbines of two wind farms are further than 4,000m from each other, potential cumulative noise impacts are non-existent.

9.5 DECOMMISSIONING AND CLOSURE PHASE NOISE IMPACT

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

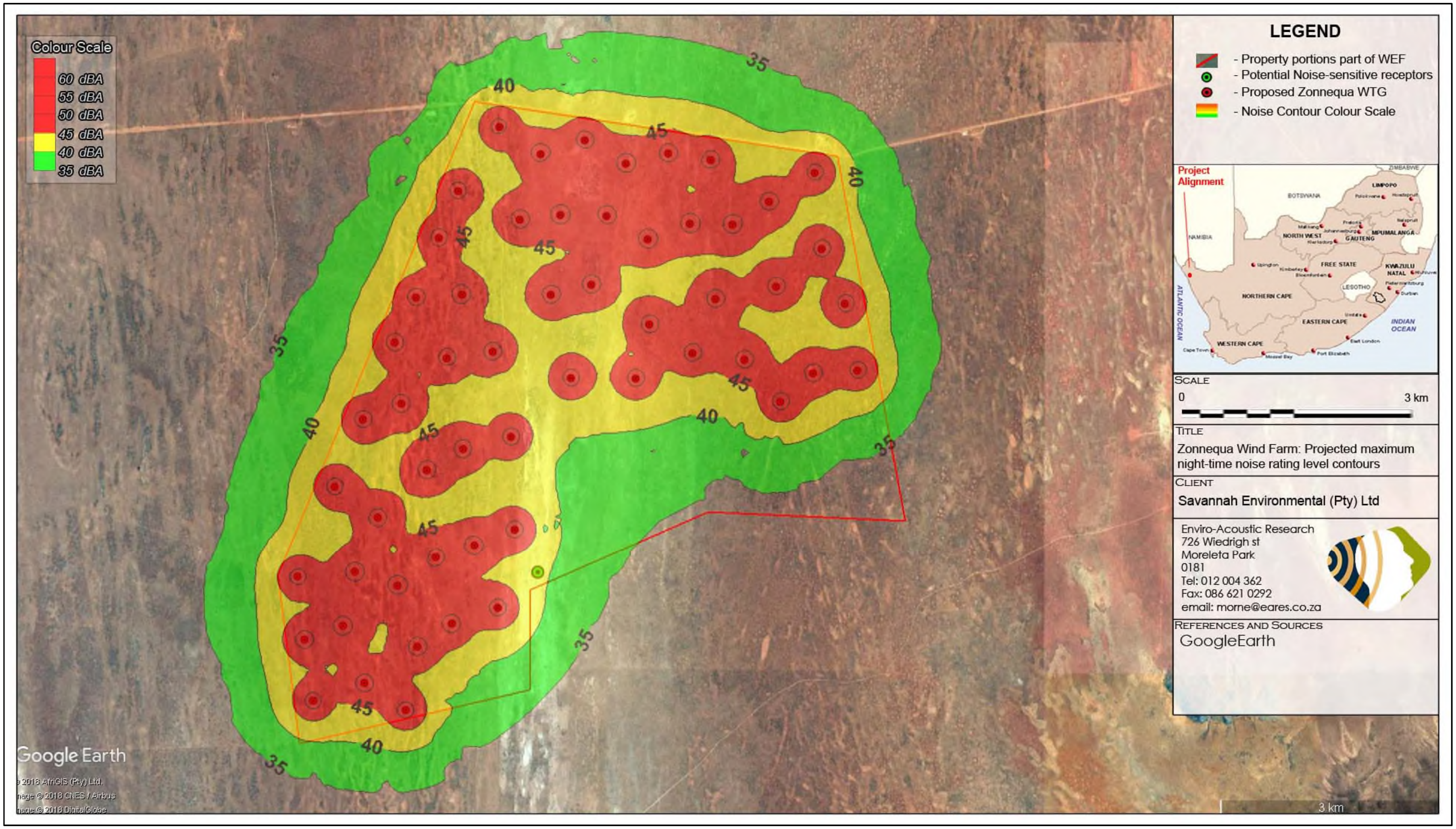

Figure 9-4: Projected conceptual maximum night-time operational noise rating levels

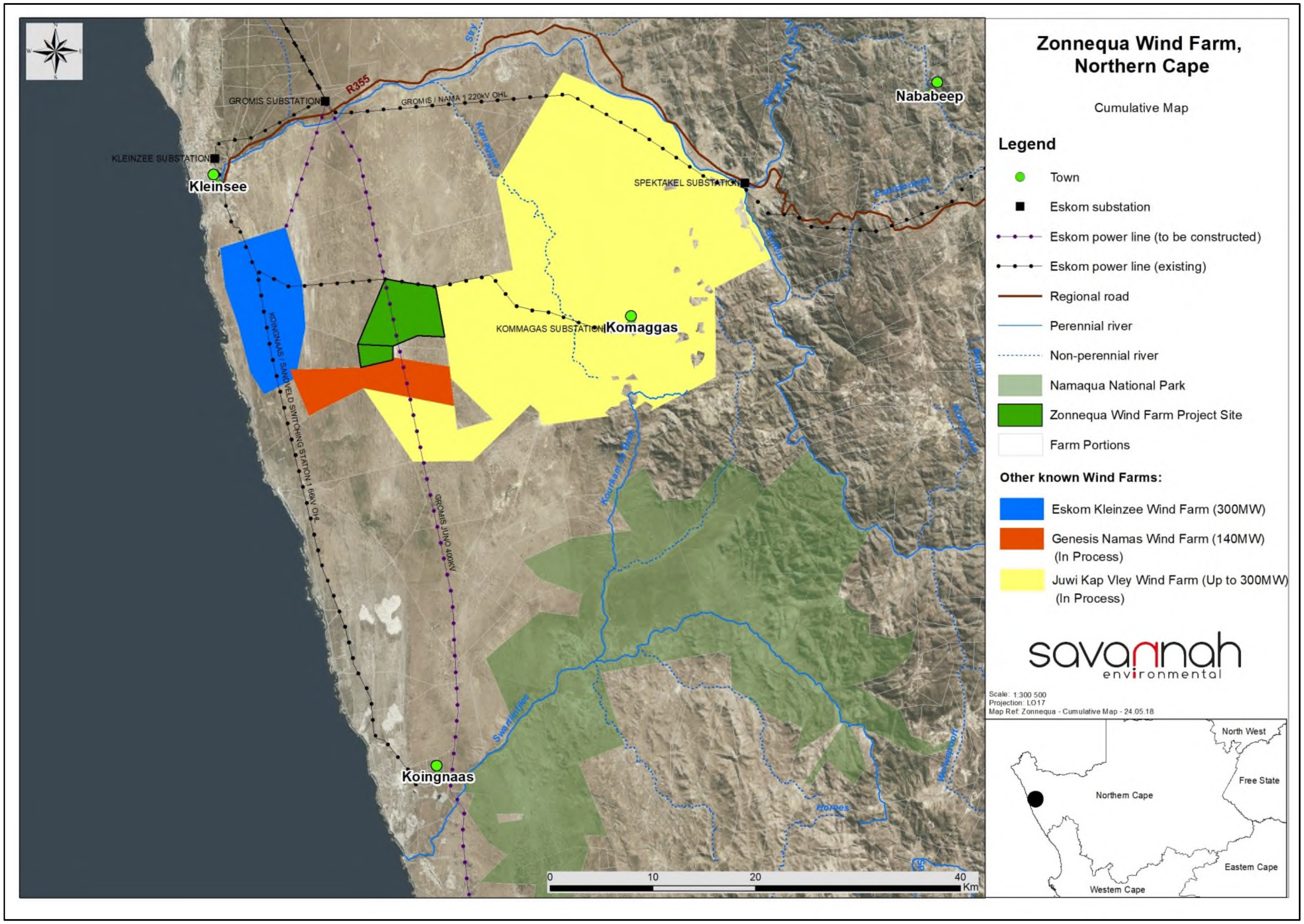

Figure 9-5: Other WEFs in vicinity of project area

10 SIGNIFICANCE OF THE NOISE IMPACT

10.1 PLANNING PHASE NOISE IMPACT

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

10.2 CONSTRUCTION PHASE NOISE IMPACT

The potential noise generating activities during construction are described in **Section 6.1** and the magnitude defined in **Section 9.2**. The expected daytime ambient sound levels would be around 40 – 50 dBA with night-time ambient sound levels around 25 - 35 dBA (see **Table 5-3** and **Table 5-6**) during low wind conditions.

The noise levels associated with the construction of the wind turbine generators was calculated for a worse-case scenario (see **Figure 9-2**). The significance of the potential daytime noise impacts are presented in **Table 10-1**, with **Table 10-2** presenting the significance of the potential noise impact for the night-time period.

Table 10-1: Impact Assessment: Daytime construction of Wind Turbines

Nature of impact: Increase in ambient sound levels that can raise the ambient sound level with more than 7 dB or daytime rating levels higher than 52 dBA.		
Description of impact: The proposed wind turbines will be constructed further than 500m from the identified receptors. Projected daytime noise levels could be as high as 41 dBA (see **Figure 9-2**) for a portion of the construction period at NSD01. This is because of cumulative noises from various activities taking place at more than one location close to these receptors.		
	Without mitigation	**With mitigation (not required)**
Status (positive/negative)	Negative	Negative
Magnitude (Table 8-3)	Minor (2)	Minor (2)
Duration (Table 8-4)	Short (2)	Short (2)
Extent (Table 8-5)	Site (2)	Site (2)
Probability (Table 8-6)	Improbable (2)	Improbable (2)
Significance	**Low (12)**	**Low (12)**
Reversibility	High - with the completion of the construction phase	High - with the completion of the construction phase
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, but not required.	
Confidence in findings: High. Worst-case scenario evaluated with all equipment operating under full load.		
Mitigation: Significance of noise impact is low for the scenario as conceptualised and mitigation is not required.		
Residual impacts: Potential of residual noise impact is low.		

Table 10-2: Impact Assessment: Night-time construction of Wind Turbines

Nature of impact: Increase in ambient sound levels that can raise the ambient sound level with more than 7 dB or night-time rating levels higher than 42 dBA.
Description of impact: The proposed wind turbines will be constructed further than 500m from

the receptors. Construction activities closer than 340m from receptors will result in noise levels higher than 42 dBA and the sounds may be highly audible during quiet times. Due to cumulative effects (numerous equipment operating simultaneously), noise levels could be as high as 41 dBA at NSD01. Temporary, very high noise levels (especially when it contains impulsive noises) at night could be disturbing and could impact on the quality of sleep of the closest receptors.		
	Without mitigation	**With mitigation (not required)**
Status (positive/negative)	Negative	Negative
Magnitude (Table 8-3)	Moderate (6)	Moderate (6)
Duration (Table 8-4)	Short (2)	Short (2)
Extent (Table 8-5)	Site (2)	Site (2)
Probability (Table 8-6)	Probable (3)	Probable (3)
Significance	**Low (30)**	**Low (30)**
Reversibility	High - with the completion of the construction phase	High - with the completion of the construction phase
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, but not required.	
Confidence in findings: High. Worst-case scenario evaluated with all equipment operating under full load. Low night-time ambient sound levels assumed.		
Mitigation: Significance of noise impact is low for the scenario as conceptualised and mitigation is not required.		
Residual impacts: Potential of residual noise impact is low.		

10.3 OPERATION PHASE NOISE IMPACT

The maximum noise level associated with the operation phase is illustrated in **Figure 9-4**. The significance of the potential daytime noise impacts are presented in **Table 10-3**, with **Table 10-4** presenting the significance of the potential noise impact for the night-time period.

Table 10-3: Impact Assessment: Daytime operation of Wind Turbines

Nature of impact: Increase in ambient sound levels that can raise the ambient sound level with more than 7 dB or daytime rating levels higher than 52 dBA.		
Description of impact: The proposed wind turbines are located further than 500m from NSD01, but cumulative effects due to numerous wind turbines operating within 1,000m these dwellings would experience an increase in noise levels. In the **unmitigated** scenario, noise rating levels could be as high as 41 dBA at NSD01, less than the proposed rating level at wind speeds exceeding 7 m/s (see **Table 8-2**). The change in ambient sound levels may be higher than 7 dB at wind speeds less than 7 m/s (depending on the sound power emission levels of the selected wind turbine). Ambient sound level measurements highlighted average daytime sound levels of more than 40 dBA (see **Figure 5-2**, **Figure 5-8** and **Figure 5-10**).		
	Without mitigation	**With mitigation (not required)**
Status (positive/negative)	Negative	Negative
Magnitude (Table 8-3)	Low (2)	Low (2)
Duration (Table 8-4)	Long (4)	Long (4)
Extent (Table 8-5)	Site (2)	Site (2)

Probability (Table 8-6)	Very improbable (1)	Very improbable (1)
Significance	**Low (8)**	**Low (8)**
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, but not required.	
Confidence in findings: High. Worst-case scenario evaluated with all wind turbines operating at a maximum sound power emission level. Ambient sound levels considered from **Figure 5-2**, **Figure 5-8** and **Figure 5-10**.		
Mitigation: Significance of noise impact is low for the scenario as conceptualised for daytime activities.		
Residual impacts: Potential of residual noise impact is low.		

Table 10-4: Impact Assessment: Night-time operation of Wind Turbines

Nature of impact: Increase in ambient sound levels that can raise the ambient sound level with more than 7 dB or night-time rating levels higher than 42 dBA.		
Description of impact: The proposed wind turbines are located further than 500m from the receptors, but cumulative effects due to numerous wind turbines operating simultaneously within 2,000m from a receptor would increase noise levels. In the **unmitigated** scenario the maximum noise rating levels could be as high as 41 dBA at NSD01 at night. This will depend on the sound power emission levels of the selected wind turbine. The change in ambient sound levels may be higher than 7 dB at wind speeds less than 7 m/s (see **Figure 8-3** and **Table 8-2** when ambient sound levels may be less than 35 dBA, as well as **Figure 5-2**, **Figure 5-8** and **Figure 5-10**).		
	Without mitigation	**With mitigation (not required)**
Status (positive/negative)	Negative	Negative
Magnitude (Table 8-3)	Low (4)	Low (4)
Duration (Table 8-4)	Long (4)	Long (4)
Extent (Table 8-5)	Local (3)	Local (3)
Probability (Table 8-6)	Improbable (2)	Improbable (2)
Significance	**Low (22)**	**Low (22)**
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, but not required.	
Confidence in findings: High. Worst-case scenario evaluated with all wind turbines operating at a maximum sound power emission level. Ambient sound levels considered from **Figure 5-2**, **Figure 5-8** and **Figure 5-10**.		
Mitigation: Significance of noise impact is low for an **unmitigated** scenario as conceptualised.		
Residual impacts: Potential of residual noise impact is low.		

10.4 CUMULATIVE NOISE IMPACT

Environmental authorisation was granted for the Eskom Kleinzee WEF in the vicinity of the proposed WF, but the potential for cumulative noises will be less than 1 dBA for all receptors. Other WEFs are proposed but they are in various stages of environmental authorisation.

Table 10-5: Impact Assessment: Potential cumulative impacts

Description of impact: Cumulative noise impacts from other WEFs or significant noise sources

will not increase the noise levels with more than 1 dB.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Status (positive/negative)	Negative	Negative
Magnitude	Low (2)	Low (2)
Duration	Long (4)	Long (4)
Extent	Site (2)	Site (2)
Probability	Low (1)	Low (1)
Significance	**Low (8)**	**Low (8)**
Reversibility	Reversible	Reversible
Irreplaceable loss of resources?	No	No
Confidence in findings: High.		
Mitigation: No mitigation required.		

10.5 Decommissioning Phase Noise Impact

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

10.6 Evaluation of Alternatives

10.6.1 Alternative 1: No-go option

The ambient sound levels will remain as is (relatively low) should the Zonnequa Wind Farm not be constructed.

10.6.2 Alternative 2: Proposed Renewable Power Generation activities

The proposed renewable power generation activities (worse-case evaluated) will slightly raise the noise levels at a number of the closest potential noise-sensitive developments. There is no alternative location where the wind farm can be developed as the presence of a viable wind resource determines the viability of a commercial WEF. While the location cannot be moved, the wind turbines within the WEF can be moved around, although this layout is the result of numerous evaluations and modelling to identify the most economically feasible and environmentally friendly layout.

The proposed layout will result in increased noise levels at a few receptors. Considering the ambient sound levels measured onsite, the projected noise rating levels will be higher than the onsite ambient sound levels. It is also possible that the noise rating levels could significantly exceed the ambient sound levels during certain periods and this may impact on the quality of living at night for the closest receptors. The closest receptors may lose the peace that they are used too and, in terms of acoustics, there is no benefit to the surrounding environment (closest receptors).

The project will greatly assist in the provision of energy, which will allow further economic growth and development in South Africa and locally. The project will generate short and long-term employment and other business opportunities and promote renewable energy in South Africa and locally. People in the area that are not directly affected by increased noises generally have a more positive perception of the renewable projects and understand the need and desirability of the project.

11 MITIGATION OPTIONS

11.1 Construction Phase Mitigation Measures

The study considers the potential noise impact on the surrounding environment due to construction activities during the day- and night-time periods. It was determined that the potential noise impact could be of low significance for night-time construction activities (road construction, though unlikely). Mitigation is not required but included to ensure that this potential noise impact is minimised and managed.

The developer must know that community involvement needs to continue throughout the project. Annoyance is a complicated psychological phenomenon; as with many industrial operations, expressed annoyance with sound can reflect an overall annoyance with the project, rather than a rational reaction to the sound itself. At all stages surrounding receptors should be informed about the project, providing them with factual information without setting unrealistic expectations. It is counterproductive to suggest that the activities (or facility) will be inaudible. The magnitude of the noise levels will depend on a multitude of variables and will vary from day to day and from place to place with environmental and operational conditions. Audibility is distinct from the sound level, because it depends on the relationship between the sound level from the activities, the spectral character and that of the surrounding soundscape (both level and spectral character).

11.1.1 Mitigation options available to reduce Construction Noise Impact

Mitigation options included both management measures as well as technical changes, with the following measures proposed to manage the potential noise impact associated with the construction of the WF. General measures that should be applicable for the construction phase includes:

- Where possible only operate during the day. If night-time activities are required, do not operate closer than 340m from any receptors (prevent noise impact of medium significance);
- Minimise simultaneous construction activities where possible, using the smallest/quieter equipment when operating near receptors (within 340 m);
- Access roads that are to be used at night should be relocated further than 140 m from receptors, or, if not possible, berms or walls should be erected close to identified receptors (located between the access road and receptors to break the line of sight with at least 1 m);
- Ensure a good working relationship between the developer/contractor and all potentially noise-sensitive receptors. Communication channels should be

established to ensure prior notice to the sensitive receptor if work is to take place close to them (especially if work is to take place within 500m from them at night). Information that should be provided to potentially sensitive receptor(s) includes:
  - Proposed working dates, the duration that work will take place in an area and working times;
  - The reason why the activity is taking place;
  - The construction methods that will be used; and
  - Contact details of a responsible person where any complaints can be lodged should there be an issue of concern.
- Ensure that equipment is well maintained and fitted with the correct and appropriate noise abatement measures, if available. Engine bay covers over heavy equipment could be pre-fitted with sound absorbing material. Heavy equipment that fully encloses the engine bay should be considered, ensuring that the seam gap between the hood and vehicle body is minimised.

11.2 OPERATION PHASE MITIGATION MEASURES

11.2.1 Mitigation options available to reduce Operational Noise Impact

The conceptual **unmitigated scenario** modelled the noise rating levels using the maximum sound power emission levels of the Vestas V136 4.2MW wind turbine (maximum sound emission level of 103.9 dB). The significance of noise during the operation phase for such an **unmitigated scenario** is low during the night-time period and projected noise rating levels are higher than the average ambient sound levels measured onsite (less than 35 dBA). While the projected noise levels will be acceptable during the day, this may be noticeable and potentially annoying at night. Due to the low significance, mitigation is not required.

11.3 SPECIAL CONDITIONS

11.3.1 Mitigation options that should be included in the EMPr

1. The developer must investigate any reasonable and valid noise complaint if registered by a receptor staying within 2,000 m from location where construction activities are taking place or from an operational wind turbine.

11.3.2 Special conditions that should be included in the Environmental Authorisation

1. The potential noise impact must again be evaluated should the layout be changed where any wind turbines are located closer than 1,000m from a confirmed NSD,

or if the layout is changed where additional wind turbines are added within 1,000m from any NSD.

2. The developer must ensure that no receptor is subjected to total noise levels exceeding 45 dBA at night due to the development of the WF.
3. The developer must investigate any reasonable and valid noise complaint if registered by a receptor staying within 2,000 m from location where construction activities are taking place or from an operational wind turbine.

12 ENVIRONMENTAL MANAGEMENT PLAN

12.1 CONSTRUCTION PHASE

Projected noise levels during construction of the Wind Farm were modelled using the methods as proposed by SANS 10357:2004. The resulting future noise projections indicated that the construction activities, as modelled for the worst case scenario will comply with the South African Noise Control Regulations for day- and night-time activities.

Various construction activities would be taking place during the development of the facility and may pose a noise risk to the closest receptors. While this study investigated likely and significant noisy activities, it did not evaluate all potential activities that could result in a noise impact. These activities could include temporary or short-term activities where small equipment is used (such as the digging of trenches to lay underground cabling). The impact of such activities is generally very low.

Using the available information the significance of the construction noise impact was defined to be of a low significance. Basic mitigation measures were proposed to ensure that noise impacts are minimised.

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

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

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

Performance indicator	• Construction activities must not change the existing ambient sound levels with more than 7 dB. • Ensure that maximum noise levels at potentially sensitive receptors are less than 65 dBA. • No noise complaints are registered
Monitoring	Ambient sound measurements are recommended to take prior to the construction of the facility.

12.2 OPERATION PHASE

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

The resulting future noise projections indicated that the operation of the facility may increase ambient sound levels with more than 7 dBA at lower wind speeds (when ambient sound levels may be less than 35 dBA, refer **Table 8-2**), but total noise levels will not be higher than 42 dBA. Mitigation is not required.

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

OBJECTIVE	**Control noise pollution stemming from the operation of the WF**
Project Component(s)	Operation Phase
Potential Impact	• Increased noise levels at potentially sensitive receptors; • Changing ambient sound levels could change the acceptable land use capability; and • Disturbing character of noise from the wind turbines.
Activity/Risk source	Simultaneous operation of a number of Wind Turbines
Mitigation Target/Objective	• Ensure that the change in ambient sound levels as experienced by potentially sensitive receptors is less than 7 dBA; • Prevent the generation of nuisance noises; • Ensure acceptable noise levels at surrounding stakeholders and potentially sensitive receptors. • Ensure that noises from wind turbines do not exceed 45 dBA at all NSDs.

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

Performance indicator	Ensure that the change in ambient sound levels as experienced by potentially sensitive receptors is less than 7 dBA
Monitoring	If a valid and reasonable complaint is registered relating to the operation of the facility additional noise monitoring should be undertaken as recommended by an acoustic consultant.

13 ENVIRONMENTAL MONITORING PLAN

Environmental Noise Measurement can be divided into two distinct categories, namely:

- Passive measuring – the registering of any complaints (reasonable and valid) regarding noise; and
- Active measuring – the measurement of noise levels at identified locations.

No routine environmental noise monitoring is recommended due to the low significance for a noise impact. However, should a reasonable and valid noise complaint be registered it would be the responsibility of the developer to investigate this complaint as per the following sections. It is recommended that the noise investigation be done by an independent acoustic consultant.

While this section recommends a noise monitoring programme, it should be used as a guideline as site specific conditions may require that the monitoring locations, frequency or procedure be adapted.

13.1 MEASUREMENT LOCALITIES AND PROCEDURES

13.1.1 Measurement Localities

Noise measurements must be conducted at the location of the person that registered a valid and reasonable noise complaint. The measurement location should consider the direct surroundings to ensure that other sound sources cannot influence the reading. A second instrument must be deployed at a control point away from the potential noise source during the measurement period.

13.1.2 Measurement Frequencies

Once-off measurements if and when a reasonable and valid noise complaint are registered. Results and feedback must be provided to the complainant. If required and recommended by an acoustic consultant, there may be follow-up measurements or a noise monitoring programme can be implemented.

13.1.3 Measurement Procedures

Ambient sound and noise measurements should be collected as defined in SANS 10103:2008. Due to the variability that naturally occurs in sound levels at most locations, it is recommended that semi-continuous measurements are conducted over a period of at least 2 night period (2 nights for the pre-construction measurements), covering at least a full day- (06:00 – 22:00) and night-time (22:00 – 06:00) period. Measurements should be collected in 10-minute bins defining the 10-minute descriptors such as $L_{Aeq,I}$ (National

Noise Control Regulation requirement), $L_{A90,f}$ (background noise level as used internationally) and $L_{Aeq,f}$ (Noise level used to compare with IFC noise limit).

Spectral frequencies should also be measured to define the potential origin of noise. When a noise complaint is being investigated, measurements should be collected during a period or in conditions similar to when the receptor experienced the disturbing noise event.

13.2 Relevant Standard for Noise Measurements

Noise measurements must be conducted as required by the National Noise Control Regulations (GN R154 of 1992) and SANS 10103:2008. It should be noted that the SANS standard also refers to a number of other standards.

13.3 Data Capture Protocols

13.3.1 Measurement Technique

Noise measurements must be conducted as required by the National Noise Control Regulations (GN R154 of 1992) and SANS 10103:2008.

13.3.2 Variables to be analysed

Measurements should be collected in 10-minute bins defining the 10-minute descriptors such as $L_{Aeq,I}$ (National Noise Control Regulation requirement), $L_{A90,f}$ (background noise level as used internationally) and $L_{Aeq,f}$ (Noise level used to compare with IFC noise limit). Noise levels should be co-ordinated with the 10-m wind speed. Spectral frequencies should also be measured to define the potential origin of noise.

13.3.3 Database Entry and Backup

Data must be stored unmodified in the electronic file saved from the instrument. This file can be opened to extract the data to a spread sheet system to allow the processing of the data and to illustrate the data graphically. Data and information should be safeguarded from accidental deletion or corruption.

13.3.4 Feedback to Receptor

A measurement report must be compiled considering the requirements of the National Noise Control Regulations (GN R154 of 1992) and SANS 10103:2008. The facility must provide feedback to the potential noise-sensitive receptors using the channels and forums established in the area to allow interaction with stakeholders, alternatively in a written report.

13.4 STANDARD OPERATING PROCEDURES FOR REGISTERING A COMPLAINT

When a noise complaint is registered, the following information must be obtained:

- Full details (names, contact numbers, location) of the complainant;
- Date and approximate time when this non-compliance occurred;
- Description of the noise or event;
- Description of the conditions prevalent during the event (if possible).

14 CONCLUSIONS

This report is an Environmental Noise Impact Assessment of the predicted noise environment due to the development of the proposed Zonnequa WF on various farms in the vicinity of Kleinsee. It is based on a predictive model to estimate potential noise levels due to the various activities and to assist in the identification of potential issues of concern.

It is concluded that:

- The significance of the noise impact relating to daytime construction of the wind turbine generators will be low.
- The significance of the noise impact relating to night-time construction of the wind turbine generators will be low.
- The significance of the operational daytime noises will be low.
- The significance of the operational night-time noises will be low.
- The significance of the cumulative noise impacts will be low.

15 RECOMMENDATIONS

This assessment indicated that the development of the Zonnequa WF could have a potential noise impact on the surrounding environment. The potential noise impacts can be mitigated to a low significance. The noises from the WTG will increase the ambient sound levels and may increase the annoyance levels of receptors that experience higher noise levels. Mitigation is available to reduce the potential noise levels.

Considering the findings of this assessment, the increase in noise levels is not considered to be a fatal flaw and the development of the Zonnequa WF can be authorised from a noise perspective, subject to the implementation of the recommended mitigation measures.

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APPENDIX A

Glossary of Acoustic Terms, Definitions and General Information

1/3-Octave Band	A filter with a bandwidth of one-third of an octave representing four semitones, or notes on the musical scale. This relationship is applied to both the width of the band, and the centre frequency of the band. See also definition of octave band.
A – Weighting	An internationally standardised frequency weighting that approximates the frequency response of the human ear and gives an objective reading that therefore agrees with the subjective human response to that sound.
Air Absorption	The phenomena of attenuation of sound waves with distance propagated in air, due to dissipative interaction within the gas molecules.
Alternatives	A possible course of action, in place of another, that would meet the same purpose and need (of proposal). Alternatives can refer to any of the following, but are not limited hereto: alternative sites for development, alternative site layouts, alternative designs, alternative processes and materials. In Integrated Environmental Management the so-called "no go" alternative refers to the option of not allowing the development and may also require investigation in certain circumstances.
Ambient	The conditions surrounding an organism or area.
Ambient Noise	The all-encompassing sound at a point being composed of sounds from many sources both near and far. It includes the noise from the noise source under investigation.
Ambient Sound	The all-encompassing sound at a point being composite of sounds from near and far.
Ambient Sound Level	Means the reading on an integrating impulse sound level meter taken at a measuring point in the absence of any alleged disturbing noise at the end of a total period of at least 10 minutes after such a meter was put into operation. In this report the term Background Ambient Sound Level will be used.
Amplitude Modulated Sound	A sound that noticeably fluctuates in loudness over time.
Applicant	Any person who applies for an authorisation to undertake a listed activity or to cause such activity in terms of the relevant environmental legislation.
Assessment	The process of collecting, organising, analysing, interpreting and communicating data that is relevant to some decision.
Attenuation	Term used to indicate reduction of noise or vibration, by whatever method necessary, usually expressed in decibels.
Audible frequency Range	Generally assumed to be the range from about 20 Hz to 20,000 Hz, the range of frequencies that our ears perceive as sound.
Ambient Sound Level	The level of the ambient sound indicated on a sound level meter in the absence of the sound under investigation (e.g. sound from a particular noise source or sound generated for test purposes). Ambient sound level as per Noise Control Regulations.
Broadband Noise	Spectrum consisting of a large number of frequency components, none of which is individually dominant.
C-Weighting	This is an international standard filter, which can be applied to a pressure signal or to a *SPL* or *PWL* spectrum, and which is essentially a pass-band filter in the frequency range of approximately 63 to 4000 Hz. This filter provides a more constant, flatter, frequency response, providing significantly less adjustment than the A-scale filter for frequencies less than 1000 Hz.
Controlled area (as per National Noise Control Regulations)	a piece of land designated by a local authority where, in the case of- (a) road transport noise in the vicinity of a road- (i) the reading on an integrating impulse sound level meter, taken outdoors at the end of a period extending from 06:00 to 24:00 while such meter is in operation, exceeds 65 dBA; or (ii) the equivalent continuous "A"-weighted sound pressure level at a height of at least 1,2 metres, but not more than 1,4 metres, above the ground for a period extending from 06:00 to 24:00 as calculated in accordance with SABS 0210-1986, titled: "Code of Practice for calculating and predicting road traffic noise", published under Government Notice No. 358 of 20 February 1987, and projected for a

	period of 15 years following the date on which the local authority has made such designation, exceeds 65 dBA; (b) aircraft noise in the vicinity of an airfield, the calculated noisiness index, projected for a period of 15 years following the date on which the local authority has made such designation, exceeds 65 dBA; or (c) industrial noise in the vicinity of an industry- (i) the reading on an integrating impulse sound level meter, taken outdoors at the end of a period of 24 hours while such meter is in operation, exceeds 61 dBA; or (ii) the calculated outdoor equivalent continuous "A"-weighted sound pressure level at a height of at least 1,2 metres, but not more than 1,4 metres, above the ground for a period of 24 hours, exceeds 61 dBA;
dB(A)	Sound Pressure Level in decibel that has been A-weighted, or filtered, to match the response of the human ear.
Decibel (db)	A logarithmic scale for sound corresponding to a multiple of 10 of the threshold of hearing. Decibels for sound levels in air are referenced to an atmospheric pressure of 20 μ Pa.
Diffraction	The process whereby an acoustic wave is disturbed and its energy redistributed in space as a result of an obstacle in its path, Reflection and refraction are special cases of diffraction.
Direction of Propagation	The direction of flow of energy associated with a wave.
Disturbing noise	Means a noise level that exceeds the zone sound level or, if no zone sound level has been designated, a noise level that exceeds the ambient sound level at the same measuring point by 7 dBA or more.
Environment	The external circumstances, conditions and objects that affect the existence and development of an individual, organism or group; these circumstances include biophysical, social, economic, historical, cultural and political aspects.
Environmental Control Officer	Independent Officer employed by the applicant to ensure the implementation of the Environmental Management Plan (EMP) and manages any further environmental issues that may arise.
Environmental impact	A change resulting from the effect of an activity on the environment, whether desirable or undesirable. Impacts may be the direct consequence of an organisation's activities or may be indirectly caused by them.
Environmental Impact Assessment	An Environmental Impact Assessment (EIA) refers to the process of identifying, predicting and assessing the potential positive and negative social, economic and biophysical impacts of any proposed project, plan, programme or policy that requires authorisation of permission by law and that may significantly affect the environment. The EIA includes an evaluation of alternatives, as well as recommendations for appropriate mitigation measures for minimising or avoiding negative impacts, measures for enhancing the positive aspects of the proposal, and environmental management and monitoring measures.
Environmental issue	A concern felt by one or more parties about some existing, potential or perceived environmental impact.
Equivalent continuous A-weighted sound exposure level ($L_{Aeq,T}$)	The value of the average A-weighted sound pressure level measured continuously within a reference time interval *T*, which have the same mean-square sound pressure as a sound under consideration for which the level varies with time.
Equivalent continuous A-weighted rating level ($L_{Req,T}$)	The Equivalent continuous A-weighted sound exposure level *($L_{Aeq,T}$)* to which various adjustments has been added. More commonly used as ($L_{Req,d}$) over a time interval 06:00 – 22:00 (T=16 hours) and ($L_{Req,n}$) over a time interval of 22:00 – 06:00 (T=8 hours). It is a calculated value.
F (fast) time weighting	(1) Averaging detection time used in sound level meters. (2) Fast setting has a time constant of 125 milliseconds and provides a fast reacting display response allowing the user to follow and measure not too rapidly fluctuating sound.
Footprint area	Area to be used for the construction of the proposed development, which does

	not include the total study area.
Free Field Condition	An environment where there is no reflective surfaces.
Frequency	The rate of oscillation of a sound, measured in units of Hertz (Hz) or kiloHertz (kHz). One hundred Hz is a rate of one hundred times per second. The frequency of a sound is the property perceived as pitch: a low-frequency sound (such as a bass note) oscillates at a relatively slow rate, and a high-frequency sound (such as a treble note) oscillates at a relatively high rate.
Green field	A parcel of land not previously developed beyond that of agriculture or forestry use; virgin land. The opposite of Greenfield is Brownfield, which is a site previously developed and used by an enterprise, especially for a manufacturing or processing operation. The term Brownfield suggests that an investigation should be made to determine if environmental damage exists.
G-Weighting	An International Standard filter used to represent the infrasonic components of a sound spectrum.
Harmonics	Any of a series of musical tones for which the frequencies are integral multiples of the frequency of a fundamental tone.
I (impulse) time weighting	(1) Averaging detection time used in sound level meters as per South African standards and Regulations. (2) Impulse setting has a time constant of 35 milliseconds when the signal is increasing (sound pressure level rising) and a time constant of 1,500 milliseconds while the signal is decreasing.
Impulsive sound	A sound characterized by brief excursions of sound pressure (transient signal) that significantly exceed the ambient sound level.
Infrasound	Sound with a frequency content below the threshold of hearing, generally held to be about 20 Hz. Infrasonic sound with sufficiently large amplitude can be perceived, and is both heard and felt as vibration. Natural sources of infrasound are waves, thunder and wind.
Integrated Development Plan	A participatory planning process aimed at developing a strategic development plan to guide and inform all planning, budgeting, management and decision-making in a Local Authority, in terms of the requirements of Chapter 5 of the Municipal Systems Act, 2000 (Act 32 of 2000).
Integrated Environmental Management	IEM provides an integrated approach for environmental assessment, management, and decision-making and to promote sustainable development and the equitable use of resources. Principles underlying IEM provide for a democratic, participatory, holistic, sustainable, equitable and accountable approach.
Interested and affected parties	Individuals or groups concerned with or affected by an activity and its consequences. These include the authorities, local communities, investors, work force, consumers, environmental interest groups and the general public.
Key issue	An issue raised during the Scoping process that has not received an adequate response and that requires further investigation before it can be resolved.
L_{A90}	the sound level exceeded for the 90% of the time under consideration
Listed activities	Development actions that is likely to result in significant environmental impacts as identified by the delegated authority (formerly the Minister of Environmental Affairs and Tourism) in terms of Section 21 of the Environment Conservation Act.
L_{AMin} *and* L_{AMax}	Is the RMS (root mean squared) minimum or maximum level of a noise source.
Loudness	The attribute of an auditory sensation that describes the listener's ranking of sound in terms of its audibility.
Magnitude of impact	Magnitude of impact means the combination of the intensity, duration and extent of an impact occurring.
Masking	The raising of a listener's threshold of hearing for a given sound due to the presence of another sound.
Mitigation	To cause to become less harsh or hostile.
Negative impact	A change that reduces the quality of the environment (for example, by reducing species diversity and the reproductive capacity of the ecosystem, by

	damaging health, or by causing nuisance).
Noise	a. Sound that a listener does not wish to hear (unwanted sounds). b. Sound from sources other than the one emitting the sound it is desired to receive, measure or record. c. A class of sound of an erratic, intermittent or statistically random nature.
Noise Level	The term used in lieu of sound level when the sound concerned is being measured or ranked for its undesirability in the contextual circumstances.
Noise-sensitive development	developments that could be influenced by noise such as: a) districts (see table 2 of SANS 10103:2008) 1. rural districts, 2. suburban districts with little road traffic, 3. urban districts, 4. urban districts with some workshops, with business premises, and with main roads, 5. central business districts, and 6. industrial districts; b) educational, residential, office and health care buildings and their surroundings; c) churches and their surroundings; d) auditoriums and concert halls and their surroundings; e) recreational areas; and f) nature reserves. In this report Noise-sensitive developments is also referred to as a Potential Sensitive Receptor
Octave Band	A filter with a bandwidth of one octave, or twelve semi-tones on the musical scale representing a doubling of frequency.
Positive impact	A change that improves the quality of life of affected people or the quality of the environment.
Property	Any piece of land indicated on a diagram or general plan approved by the Surveyor-General intended for registration as a separate unit in terms of the Deeds Registries Act and includes an erf, a site and a farm portion as well as the buildings erected thereon
Public Participation Process	A process of involving the public in order to identify needs, address concerns, choose options, plan and monitor in terms of a proposed project, programme or development
Reflection	Redirection of sound waves.
Refraction	Change in direction of sound waves caused by changes in the sound wave velocity, typically when sound wave propagates in a medium of different density.
Reverberant Sound	The sound in an enclosure which results from repeated reflections from the boundaries.
Reverberation	The persistence, after emission of a sound has stopped, of a sound field within an enclosure.
Significant Impact	An impact can be deemed significant if consultation with the relevant authorities and other interested and affected parties, on the context and intensity of its effects, provides reasonable grounds for mitigating measures to be included in the environmental management report. The onus will be on the applicant to include the relevant authorities and other interested and affected parties in the consultation process. Present and potential future, cumulative and synergistic effects should all be taken into account.
S (slow) time weighting	(1) Averaging times used in sound level meters. (2) Time constant of one [1] second that gives a slower response which helps average out the display fluctuations.
Sound Level	The level of the frequency and time weighted sound pressure as determined by a sound level meter, i.e. A-weighted sound level.
Sound Power	Of a source, the total sound energy radiated per unit time.
Sound Pressure Level (SPL)	Of a sound, 20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level. International values for the reference sound pressure level are 20 micropascals in air and 100 millipascals in water. SPL is reported as L_p in dB (not weighted) or in various other weightings.

Soundscape	Sound or a combination of sounds that forms or arises from an immersive environment. The study of soundscape is the subject of acoustic ecology. The idea of soundscape refers to both the natural acoustic environment, consisting of natural sounds, including animal vocalizations and, for instance, the sounds of weather and other natural elements; and environmental sounds created by humans, through musical composition, sound design, and other ordinary human activities including conversation, work, and sounds of mechanical origin resulting from use of industrial technology. The disruption of these acoustic environments results in noise pollution.
Study area	Refers to the entire study area encompassing all the alternative routes as indicated on the study area map.
Sustainable Development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of "needs", in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and the future needs (Brundtland Commission, 1987).
Tread braked	The traditional form of wheel brake consisting of a block of friction material (which could be cast iron, wood or nowadays a composition material) hung from a lever and being pressed against the wheel tread by air pressure (in the air brake) or atmospheric pressure in the case of the vacuum brake.
Zone of Potential Influence	The area defined as the radius about an object, or objects beyond which the noise impact will be insignificant.
Zone Sound Level	Means a derived dBA value determined indirectly by means of a series of measurements, calculations or table readings and designated by a local authority for an area. This is similar to the Rating Level as defined in SANS 10103:2008.

APPENDIX B

Photos of measurement locations

Photos 1: Measurement Location BRKWF-LTS01

Photos 2: Measurement Location BRKWF-LTS02

Photos 3: Measurement Location BRKWF-LTS03

End of Report